Minnesota's Timber Supply: Perspectives and Analysis

Proceedings of Conference

ALAN R. EK
HOWARD M. HOGANSON
editors

College of Natural Resources and Agricultural Experiment Station
Department of Forest Resources
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December 20, 1988

The Honorable Governor Rudy Perpich
130 State Capital
St. Paul, MN 55155

Dear Governor Perpich:

With this letter we are transmitting the results and proceedings of the September 1988 conference on Minnesota's Timber Supply: Perspectives and Analysis held in Grand Rapids, Minnesota. The conference was organized to accomplish a number of objectives, including the identification of issues, opportunities and constraints with respect to the use of timber as a means of fostering economic development. Given these objectives, the conference identified the following points of action:

* **Forest Resources Inventory**: Accurate and reliable inventories of timber resources are essential to industrial development and effective public and private timber management policies and programs. Especially important are inventories that are made sufficiently often (at least every ten years) so that data is current and appropriate for intended uses. Forest resource inventories in Minnesota should be given high priority and should be financed in accord with the value of the information they provide.

* **Transportation and Access**: Access to forests is critically important to the implementation of intensified timber management programs and to the transport of timber products to manufacturing facilities and distribution centers. Access for purposes other than timber management is also important (e.g., recreation, wildlife management, forest protection activities). A well-developed system of roads and highways in Minnesota should be the subject of statewide comprehensive forest transportation plans and programs. Investments in Minnesota's forest transportation systems should be commensurate with the considerable value of the forest products or services being accessed.

* **Forest Taxation**: Forest taxation policies often fail to recognize that private forestland ownership involves investments held for long periods of time, often at high risk, and that private forests provide many benefits in addition to timber. Forest taxation policies in Minnesota should be designed to encourage--not discourage--forestry investments that will enhance long-term economic development. Taxation of forest land should be based on the use and productivity of the land. In this respect, broader application of the Tree Growth Tax Law should be a high priority.

* **Legislative Organization**: A well-informed legislative system is critical to anticipation of timber and related forestry issues and to the design of policies and programs for addressing such issues. In the past, a most effective vehicle for doing so was the Joint Legislative Committee on Forestry. Serious consideration should now be given to reinstituting that committee.
* **Timber as a Land Use:** Timber is a major, renewable forest resource that should be intensively managed if current and expected demands for timber products are to be met. With increasing competition for land, production of timber should be recognized as a primary use of some Minnesota forest lands. Other major forest uses are generally compatible with timber management and, where such is the case, should be coordinated with it.

* **Investments in Timberland Management:** High-level, sustained investments in timber management are essential to the provision of timber yields sufficient to meet demands at reasonable prices. Because timber yields typically require long periods of time, sustained yields will not be realized in Minnesota if long-term timber management programs are interrupted due to inadequate investments. Funding of Minnesota's public and private timber management programs should be at adequate levels and should be sustained over long periods of time.

* **Forestry Research:** Strong, integrated, and multidisciplinary research programs are needed to solve a variety of current and future problems concerning timber resource planning and management. Forestry research programs in Minnesota should be carefully planned and should be funded in a sustained manner, commensurate with the importance of the timber management problems and opportunities of concern to the state. Special attention should be given to research that may result in development of new or improved products, markets or technologies that will give Minnesota a competitive edge in industrial and economic development, research on forest inventory methods that can provide timely resource updates, and research that will increase the productivity of Minnesota's forests in a manner sensitive to other uses of the forest, including recreation, wildlife, aesthetics and water production.

* **Geographic Information Systems:** Common and comprehensive databases are important to an accurate understanding of forest management potentials with respect to forest types, land uses, forest soils, topography, transportation systems and other resources. Since such understanding is critical to the development of comprehensive forest management programs in Minnesota, the development of statewide data bases and geographic information systems should receive special attention.

* **Citizen Information:** Citizens have a right to know about the importance of forest resources in Minnesota that are devoted to the production of timber. Products derived from timber are often the life-blood of community economic and social well-being. Citizens in both rural and urban areas of the state should be the focus of well-designed public and private programs that provide essential information on the type, magnitude and use of forests devoted to the production of timber. In particular, K-12 environmental education programs such as Project Learning Tree and Project Wild must be strengthened.

* **Education for Forest Landowners and Users:** Special education and assistance programs are an effective means of conveying important forest and timber management knowledge to public and private owners and users of forests. In addition, such efforts are an effective means of communicating the importance of forest products to broader general publics found in rural and urban settings. University and agency efforts can and should play a major role in these communication processes.
* Professional Education: Forest resource professionals are critical to the
development and implementation of effective timber management policies and
programs in Minnesota. Such professionals should have access to well-designed
academic and continuing education programs that will enable them to accomplish the
timber and related management objectives of various types of forest landowners and
forest land users.

* Resource Potentials: Minnesota is blessed with a variety of tree species that offer
significant potential as a timber resource. Aspen, for example, has played a significant
timber supply role in recent years; attention should also be directed to species such as
birch and oak. A variety of research and management programs should be designed
to identify and encourage the growth and use of species which have much to offer, but
which are relatively untapped.

* Coordination of Public and Private Programs: Forestry programs of importance to
timber management in Minnesota vary considerably in function (e.g., protection,
harvesting, transportation, research) and in organizational responsibility (e.g., various
public agencies, various private organizations). Mechanisms should be developed for
more comprehensive and coordinated development of forest management and related
policies and programs. The Minnesota Forestry Coordinating Committee is prepared
to take the lead in working with others in developing these mechanisms.

In summary, we found the conference extremely helpful in illuminating issues, and
provocative in terms of identifying priorities. The Minnesota Forestry Coordinating
Committee, listed below, offer this synthesis and the proceedings in the hope that it
will be useful to you and your Blue Ribbon Commission on Forestry.

Sincerely,

Gerald A. Rose, Chair
Minnesota Forestry Coordinating Committee
and Director, Division of Forestry
Minnesota Department of Natural Resources

Roy D. Adams, Associate Director
Natural Resources Research Institute

Lansin R. Hamilton, Chairman
Minnesota Association of
County Land Commissioners

M. Russ Allen, Executive Vice President
Minnesota Timber Producers Association

Ronald D. Lindmark, Director
North Central Forest
Experiment Station
USDA Forest Service

E. Robert Amborn, Chair
Forestry Committee
Minnesota Association of Soil & Water
Conservation Districts

Gary Nordstrom
State Conservationist
USDA Soil Conservation Service
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Bruce Barker
Assistant Vice President
Minnesota Forest Industries

Richard A. Skok, Dean
College of Natural Resources
University of Minnesota

Earl Barlow, Area Director
Bureau of Indian Affairs
USDI

William F. Spinner, Supervisor
Chippewa National Forest
USDA Forest Service

David Filius, Supervisor
Superior National Forest
USDA Forest Service

John R. Suffron
Executive Director
Minnesota Forestry Association

Steven B. Laursen
Natural Resources Program Leader
Extension Service
University of Minnesota

David Thompson
Minnesota Wood Minnesota
Council

Donald C. Willeke, Chairman
Minnesota State Shade Tree
Advisory Committee
Minnesota's Timber Supply: Perspectives and Analysis

Proceedings of Conference

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PREFACE

This publication documents the proceedings of the conference entitled Minnesota’s Timber Supply: Perspectives and Analysis. Most of the presentations at the conference are included as papers in the proceedings. Presentation topics ranged from policy questions to operational concerns and research. The papers are grouped into nine sessions corresponding to the conference format.

Papers in the proceedings were screened by the editors, first as abstracts and later as completed manuscripts. Most were received as camera ready copy and then scanned or otherwise copied and put into a standard format for publication. Some panel presentations were transcribed from tape and edited by the authors and the editors.

We feel the conference was an enormous success and that these proceedings will be of value to policy makers, practitioners and scientists. For that we thank the program planning committee, sponsors, moderators, the well-prepared presenters, the many active participants and the many persons who helped with arrangements. Special thanks also go to the Minnesota Forest Coordinating Committee for their direction in developing the conference and to the Minnesota Future Resources Commission for project support that facilitated the effort.

We also wish to thank Janet Larson for the cover design and Clara M. Schreiber for her invaluable word processing skills.

We are pleased to have been a part of the conference and to be able to help document it in this proceedings.

The Editors:

Alan R. Ek
Howard M. Hoganson
PROGRAM PLANNING COMMITTEE

Bruce Barker
Minnesota Forest Industries, Inc.
208 Phoenix Building
Duluth, MN

James L. Bowyer
Department of Forest Products
University of Minnesota
St. Paul, MN

Chris R. Brokl
Minnesota Forestry Association
Grand Rapids, MN

Alan R. Ek, Program Chair
Department of Forest Resources
University of Minnesota
St. Paul, MN

Lansin Hamilton
Lands and Forestry Department
Crow Wing County Courthouse
Brainerd, MN

Howard M. Hoganson
North Central Experiment Station
University of Minnesota
Grand Rapids, MN

Thomas M. Hoekstra
North Central Forest Experiment Station
USDA Forest Service
St. Paul, MN

A. Scott Reed
Cloquet Forestry Center
University of Minnesota
Cloquet, MN

Dietmar W. Rose
Department of Forest Resources
University of Minnesota
St. Paul, MN

W. Brad Smith
North Central Forest Experiment Station
USDA Forest Service
St. Paul, MN

Larry R. Hegstad
Division of Forestry
Minnesota Department of Natural Resources
St. Paul, MN
SESSION MODERATORS

Bruce Barker
Minnesota Forest Industries
208 Phoenix Building
Duluth, MN

David C. Lothner
North Central Forest Experiment Station
USDA Forest Service
1992 Folwell Avenue
St. Paul, MN

Frank Biltonen
North Central Forest Experiment Station
USDA Forest Service
1992 Folwell Avenue
St. Paul, MN

A. Scott Reed
Cloquet Forestry Center
University of Minnesota
175 University Road
Cloquet, MN

Paul Ellefson
Department of Forest Resources
University of Minnesota
1530 N. Cleveland Avenue
St. Paul, MN

Bob Stine
Cloquet Forestry Center
University of Minnesota
175 University Road
Cloquet, MN

Larry Hegstad
Division of Forestry
MN Department of Natural Resources
500 Lafayette Road
St. Paul, MN

John R. Suffron
Minnesota Forestry Association
220 First Ave. N. W.
Grand Rapids, MN

Thomas W. Hoekstra
North Central Forest Experiment Station
USDA Forest Service
1992 Folwell Avenue
St. Paul, MN

Bob Van Aiken
USDA Forest Service, Region 9
310 West Wisconsin Avenue
Milwaukee, WI
WELCOME AND CONFERENCE OBJECTIVES

John Suffron

Thank you and welcome to Grand Rapids. This conference in large measure is intended to be a constructive example of the Minnesota forestry community at work focusing upon a subject that demands visionary actions by decision makers and program managers alike.

It was about a year ago that a handful of people met to discuss revitalizing the Minnesota Forestry Coordinating Committee. The Committee had been established years ago as an informal organization for sharing information between the top leaders of several public and private forestry related institutions, but had lost enthusiasm over time and eventually dissolved. Last year, however, consensus was reached that success in rekindling and maintaining interest in this committee might be improved if the focus for the group would center upon fostering workshops, symposiums and other discussions on broad natural resource issues that have significant impact on Minnesota. This agreement formed the basis for calling the group back together. The new coordinating committee has resisted establishing formal bylaws and instead has adopted a general mission statement containing four components: (1) identify major policy issues affecting the management of our natural resources here in Minnesota; (2) to develop a support system to speak out on behalf of those resources that really cannot speak for themselves; (3) to seize upon opportunities to solve problems common to all the major forestry stakeholders; and, (4) to encourage dialogue like we are engaging in here. The timber supply issue, one of promise and hope for the future, is indeed one subject that clearly has the attention of a large audience here in Minnesota. Accordingly the new committee asked Alan Ek, Head, Department of Forest Resources, University of Minnesota, to provide the leadership in developing a conference on this topic. On behalf of the Forestry Coordinating Committee, I would like to express our appreciation to Alan and his Planning Committee for putting together this outstanding program. We have a promising opportunity to work together and hopefully out of this conference will come strong recommendations for action that can be taken forward and discussed further. In fact, the Coordinating Committee has set up a meeting later this week to do just that.

I have here before me a letter of welcome from the Mayor of Grand Rapids. It is very brief. I would like to read it for you all this morning:

"The City of Grand Rapids, home of Blanding Paper Company, welcomes the Minnesota Forestry Coordination Committee Conference of forest inventory and wood supply to our city and its fine facilities. Many of us take the supply of wood for granted. We see trees all around our community and country. However, the adequate supply of timber for industries is vital to our long-term existence. We commend you for your work in this field and best wishes from the city for a most successful and rewarding conference. From the City Council I remain Sincerely yours, John T. Craig, Mayor."

---

1 Executive Director, Minnesota Forestry Association, 220 First Avenue, N.W., Room 219, Grand Rapids, MN 55744.

Grand Rapids is indeed fortunate to have the opportunity to host this conference. On behalf of the Program Planning Committee Local Arrangements Chair, Howard Hoganson, I, too welcome you to what we call the heart of the forest country here in Itasca County. We hope to see other events coming out of the Forestry Coordinating Committee in the future that will discuss broad issues of concern which might be hosted in other communities that are also important to forestry. It is indeed a pleasure, however, for Grand Rapids to host this particular event.

It is expected that forceful leadership and pragmatic compromise will be necessary to forge new directions and opportunities for the timber supply picture. In this respect, I am fortunate to be in a position to introduce our conference keynote speaker who tackles issues with dogged determination, incessant review and compassion for all sides and who in the end consistently offers incisive recommendations that colleagues truly respect. Would you please join me by standing and welcoming Minnesota's congressional representative Congressman James Oberstar.
KEYNOTE ADDRESS

Congressman James L. Oberstar

You are gathered here for a very important purpose and I am delighted to see such a large turnout. I want to compliment the University of Minnesota, the Minnesota Department of Natural Resources, the U.S. Forest Service, timber industry participants and all of you who are here, on bringing this focus on such a crucial resource at a very important time in its history.

Forestry is, as we all understand, a renewable resource. But lately, it has seemed the only thing renewable about forestry is controversy. Management of the nation's timberlands has been the focus, over the last two decades, of intense, emotionally charged debates both at the state levels and in the congress, both within the ranks of professional foresters and on the part of urban environmentalists. At times, we even sensed a cloud over the future of professional forestry.

But today, I think we are at a watershed, a historical turning point in which, perhaps, we are seeing the beginning of a new period of a spirit of cooperation--cooperative dialogue, whether at the federal, state or local level in which foresters, from both the public and private sector and from environmental groups are beginning to sit down together for a reasoned look at the future needs of the current practices of forestry. In the Congress, I want to say that I feel very encouraged that we are working more at putting into practice the laws of the last two decades than we are working at writing new and more restrictive covenants for the nation's forest lands. A very considerable body of law has already been written on forestry issues over the last two decades--the Renewable Resources Planning Act of 1974 to promote long range planning and thinking about our forestry requirements at both the state and federal levels; the Timber Management Act of 1976 which really updated the original 1897 organic act of the U.S. Forest Service; the Redwood National Park controversy; the Alaskan D-2 lands; the Rare II; and, of course, in our own state and region, the Boundary Waters Canoe Area.

BACKGROUND ON THE ISSUES

Since passage of the 1964 Wilderness Act, we have seen the establishment of over 110 new wilderness areas, the removal of 19 million acres, an area about the size of New England. Some 80 million more acres were set aside in the Alaskan land issue. RARE II removed another 30 million acres of lands from multiple use. Now we seem to have reached the point at which there is a sense that we need to digest that which we have done over this past two decades. Administer those lands that are set aside and removed from multiple use and manage better the lands that are remaining in multiple use, and that is an encouraging note for all of us.

Ten years ago the debate in the wood fiber arena was over two rather widely diverted propositions: Wilderness versus sustained yield or all out multiple use of our nation's forest lands. Politically and practically neither of those viewpoints was workable in and by itself.

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1 U.S. Representative, Eighth District, Minnesota, Rayburn House Office Building, Washington, D.C. 20515.

What we have come to instead over the past two decades, is a policy of considering all the relative values of all of the competing uses in our national forests, resolving the differences and putting together a management plan that is workable and serves the overall best public interest. That is a product of the overall Timber Management Act of 1976, the new charter for the national forest system. It seems to be working, not without problems, but it is working. It is shaping attitudes and mindsets among policy makers, particularly at the federal level, and I think also at the state level. The U.S. Forest Service really has a new responsibility to determine the suitability of lands with all the various kinds of management and take into consideration both economic and environmental concerns and weigh them together and come up with a resource management plan that is scientifically sound, that is ecologically effective and that is responsive to the broad public’s needs and interests. As a result, I think we are seeing better forests, a stronger national wood fiber industry and somewhat less controversy.

Congress appropriated the first fund for a national forest system for private uses back in 1876. The first focus of congressional action was to strengthen and stimulate that private sector and to make those private lands more productive and more valuable. The U.S. Forest Service itself was established only in 1905. The first forestry research program was not established until 1928. All of those ventures have been very successful. I think they continue to play a vital role in the economic strength of our wood fiber sector and in the nation’s economy.

Yet, the 1980s have been difficult years for the forestry industry. The 1981-83 recession hurt the forest products industry very severely. We saw a 22 percent drop in employment, more than a one-fourth drop in lumber production, Canadian imports began to take foothold in the United States, and we began to see competition from nonrenewable resources—aluminum studs, plastic grocery bags. We saw competition that was displacing forestry products. We began to see the decline of U.S. forest products in world trade with the strong dollar. To overcome these and other problems that the wood fiber industry faced nationwide, the industry itself, and with a more understanding and supportive hand from the federal government and particularly state government across the land, has modernized and has built more efficient high productivity mills. It has increased its production percentage, it has made itself a more world class competitor in the wood products field than ever before, a more quality conscious industry than ever in its history.

The pattern in pulp and paper has been more efficient, modernized mills, though fewer but more skilled workers, and more output from the same number of workers. It is the same in the solid wood products area, more resource efficient products, like oriented strand board, that make better use of our forest resources and utilize them more fully, composite materials that join wood with other materials, and modern mills that employ fewer workers but have higher output and higher product quality.

All of those actions may not vastly increase the work force but they have more significantly stabilized local economies, strengthened those economies and diversified the economic base and have provided a more encouraging economic future. Yet, the Office of Management and Budget, under pressure from the White House to cut the deficit, has targeted forest products and forest practices in its annual budget requests to the Congress. The road construction cost factor and the below cost timber sales issue, with which we have had to deal in the budget process, as a member of the budget committee last year and again this year, we debated those issues one evening for at least six hours, trying to come to an understanding. It is difficult trying to talk to someone from New York who has not seen a tree except in Central Park and does not understand what a forest is, how it is managed and how sustained yield operates. It is difficult to get those people to understand what you are talking about when it comes to
issues like multiple use, and over what period of time should a road be amortized, and what you mean by below cost timber sales, and the differences in eastern and western resource use. Well we stopped them on both counts. With significant help from my good friend Chief Robertson of the U.S. Forest Service we mapped out a strategy and we put it together. But, we are not going to allow our forests to be economically disadvantaged with our competition from Canada or saddle local wood products managers with exorbitant costs in a year when they are struggling just now to break ahead and make some progress in the nation's economy.

What we did succeed in doing in Region 9, was not only to freeze the timber sale base at the 87 level (that was better than anywhere else in the country), but to get an additional 50 million board feet set in reserve if it is requested and needed. It will go forward and we will be in better shape in this region than others in this country, and better than we thought we would have been.

ISSUES IN THE COMING DECADES

An important thing to keep in mind is that the budget deficit is not going away. It is going to be here with us next year no matter who is elected President. We are going to have to deal with deficit reduction packages that focus on those areas of budget that few people understand and where there are probably relatively few advocates. We have to be ready next year to confront those two products of the deficit, cutting budgets and increasing so-called user fees or revenues to help reduce the deficit burden. We do not want that burden to fall exclusively or disproportionately on forestry.

Other issues that I see that will persist in the future include management of old growth forests, principally the Douglas fir forests of Washington and Oregon. How are they going to be protected? How much of the forest resource should be set aside? How much of the forest should be set aside for research? How much should be harvested? How are we going to handle again, this looming conflict over use and preservation?

Forestry research will continue to be an important issue for us in the years ahead. The chemistry of wood fibers, the practical new uses for wood fiber as a dimensional lumber, markets for wood products, all of these are subjects that are vital to the future growth of this industry. The question is what should be the proper mix and type of the research work force? How much should be done directly by the U.S. Forest Service? How much should be channeled out through state and university centers? How much through private sectors? Frankly, we are going to need the cooperative effort of all of those sectors—all of them working together. No one has an exclusive corner on ideas and ingenuities. We have got to be on the cutting edge of technology in forestry research to keep our products competitive and keep this industry ahead in the state-of-the-art. We certainly have to continue research on new harvesting and processing techniques to keep the industry and costs down. We need protection research on effective and less costly and safer strategies for control of fire and insects and disease. The lesson we have learned from the Yellowstone fire is that we have to think carefully through our management practices and not let fuel build up over a long period of time through neglect, through failure to harvest or through failure to control burn at the proper time.

Another crucial issue that I see facing us is forest decline or forest death. A challenge we dare not defer and we dare not overlook. We see foliage deterioration and tree mortality already showing up in the eastern U.S.—in upstate New York and New England, a result, very likely,
of acid deposition. Here, as in West Germany and Sweden, the effects of acid rain have been devastating for forestry, as well as water resources. We put those issues off at the peril of our future.

Forest products trade, I think, is another exciting area of great opportunity for the forest products industry. The total U.S. import/export trade in wood products last year was over $8 billion. It will grow at a rate of 3 to 4 percent annually, probably even faster as specific nations require greater kinds and varieties of wood product materials in their national economy. Canada was the largest supplier of wood products selling us over $3.7 billion and we sold them some $390 million, making Canada our second largest customer. The Pacific Rim is our largest customer. We sell over $4 billion of forest products. About half to Japan, the rest to Korea, Taiwan, China and New Zealand. The challenge for us is keeping their markets open to us and our markets open to them on an equitable basis.

There are some problems in the U.S.-Canadian agreement. Canadian restrictions on uses of U.S. plywood, particularly southern yellow pine in northern regions of Canada, is detrimental to the production and export of southern yellow pine plywood. On the tariff side, I think, we have it about offset through the memorandum of understanding. The cedar shake issue stays in place under the U.S./Canada free trade agreement. That will be a wash and will eventually work itself out with the tariffs that Canada will impose on its exports to achieve equity with the U.S. in wood products. But it is in the Pacific Rim area where I think we have a great opportunity, both for hardboard and hardwood products, as well as paper and pulp. Tariff barriers and metric standards in housing codes on dimensional lumber are the big obstacles in the Pacific Rim. I just made a review of this matter with the congressional trade caucus. The industry really needs to think more about how it is going to meet that challenge and handle the issue of metric dimensional lumber management.

**SUMMARY**

In brief summary, I think these are the highlights of the most visible issues facing forestry on the federal level, those that we are dealing with and those yet to come. My view is that forestry is probably in the most exciting and challenging phase of its very, very long and vital history. We may be facing bigger problems than ever before but we have so much more knowledge. I think we have so much more experience, we have so much more cooperation going at federal and state levels. This conference is an example of it. I think that we are at a take off point of increasing growth of exciting opportunities in the wood fiber sector. We have seen the vast economic potential of this great resource grow. We know that, unlike minerals which once dug from the ground, processed and exploited, are gone (except copper about which 80% is renewable and reusable), this wood resource, with our joint, wise management efforts and planning can always be there to restore, refresh and renew economies. That is the key, trees are a renewable resource. Our strength as people is our ingenuity, our creativity, the unstoppable power of the unfettered human mind. That is what we have to put to work on behalf of forest resources. That is what is uniquely American, and that is what is challenging and exciting about this field of wood fiber products. Our challenge entering the latter decade of the 20th century, as we harvest trees that started growing in our centennial year, is to keep that dialogue going, keep the creativity moving, put controversy behind us and put cooperation before us. The challenge for us is our opportunity to pass on to the next generation a greater forest resource than that which we inherited.

I am reminded of a story that a colleague from Alaska told of camping areas in remote parts of Alaska. The camper is greeted by a sign that says, "Take all the firewood you need from this
pile, but leave the pile a little bit higher when you depart." That is our task, to make that pile a little bit higher. A conference of this kind helps to put us on track for that goal. It was a pleasure being with you today. Good luck in your conference ahead.
IMPORTANT TIMBER SUPPLY ISSUES IN MINNESOTA

Gerald A. Rose

These are exciting times in forestry in Minnesota and the nation. They are challenging times, as Congressman Oberstar referred to. The excitement and the challenge result from the leadership provided by people like Congressman Oberstar, Governor Perpich, certain local legislators, forest industry that is willing to invest, to risk and take that chance necessary to see development occur, and the leadership of all of you in the forestry community. Indeed, it is a pleasure for me to be here this morning to address you on the important timber supply issues in Minnesota. It is an honor to be able to follow Congressman Oberstar in doing this. I have had a chance to work with the Congressman this last year and few months and he has helped us a lot on the federal scene in forestry issues. We owe him a lot.

I have been assigned the topic of important timber supply issues in Minnesota. I thought I would organize my discussion under three categories: 1) Is there a need for concern?; 2) What is the potential?; and 3) What can we do about it?

IS THERE A NEED FOR CONCERN?

Yes, there is a need for concern. Minnesota's forest industry is a very important industry. We see an industry (Figure 1) that is approaching $4 billion in value of shipments. I was in a meeting the other day where a CEO from one of our companies said that by 1995 or the turn of the century that is easily going to be $5 billion. It is growing and it is growing fast.

![Figure 1. Value of Minnesota's forest industry.](image)

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1Director, Minnesota Department of Natural Resources, Division of Forestry, 500 Lafayette Road, St. Paul, MN 55155-4044.

The forest industry is the second largest manufacturing industry in the state of Minnesota. Only machinery exceeds it as can be seen in Figure 2. This is 1987 information from the U.S. Department of Commerce.

![Graph showing manufacturing groups and their dollar value](image)

**Figure 2.** Minnesota forest industry as it relates to total manufacturing.

Employment in the forestry sector is very significant. Figure 3 shows 54,000 direct jobs in the industry; 62 percent of those in the pulp and paper industry, and 19 percent in lumber and wood products. Each of the direct jobs in the industry represents about 2.7 total jobs in the economy of the state (Figure 4). It ranges from 1.8 in lumber and wood products to 3.1 in the paper industry. So it is not only the direct jobs, it is those spinoff, service and support jobs, that make the enterprise so important.

![Pie chart showing 1986 forest sector employment](image)

**Figure 3.** Minnesota's forestry sector employment.
Figure 4. Impact of Minnesota's forestry sector employment.

The timber that is being harvested is very important to our economy. The values in Figure 5 are from 1981 and stumpage prices have come up some since then. But, for every dollar in stumpage receipts, we see an average of $37.70 of value to the economy of the state of Minnesota. It is a little higher in pulp and paper and a little less in solid wood products. But for every dollar of stumpage receipts, that is the value to the economy of the state.

Figure 5. How $1.00 in stumpage value multiplies (source: North Central Forest Experiment Station 1981).
This is one of the major reasons why, I think, as a state and nation, we cannot get caught in the trap of just looking at the cost of the timber sale and what we generate in revenue in the land owning and managing agency, but we have to look at the broader picture. Finland, Sweden and Canada would never be in the timber business if they initially only had looked at the stumpage revenues received for the timber. They looked at the total aspects of revenue that accrued from that timber resource and developed their forests to the point where they are contributing what they are today. Timber is the backbone of the economy in those three major nations.

Forest industry is an anchor industry in the northeast part of the state of Minnesota and it is an ancillary industry elsewhere. But of the 54,000 jobs about 31,000 of them are in the seven county metro region. That is pretty significant when you think of where the population balance is in this state now and where the political power rests as a result of that.

There is a need for concern because we have seen a lot happening in the last 10 years in the state of Minnesota in terms of forest industry development. Capital investments and officially announced expansions during the last 10-year period of moving on into 1990 or thereabouts is 1.5 billion dollars. But every bit as significant is that nearly 1.5 billion dollars that is being talked about seriously and quite likely will occur in the five years following (Figure 6).

<table>
<thead>
<tr>
<th>Period</th>
<th>Capital Investment ($ millions)</th>
<th>Additional Wood Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979-1986</td>
<td>$570</td>
<td>1.0 million cords</td>
</tr>
<tr>
<td>1986-1990</td>
<td>$975</td>
<td>.6 million cords</td>
</tr>
<tr>
<td>1991-1996</td>
<td>$1,475</td>
<td>.7 million cords</td>
</tr>
<tr>
<td>Totals</td>
<td>$3.020 billion</td>
<td>2.3 million cords</td>
</tr>
</tbody>
</table>

*Figure 6. Recent and projected capital investment and wood use in Minnesota’s new and expanding wood using industries.*

These expansions, of course, have generated significant additional wood needs. That is why the timber supply issue is before us today.

Relative to promoting future expansions, in light of what has happened, certainly aspen is not a species for which we are going to promote to major future expansions until we get a better handle on the resource; and only after that if we find out we have an opportunity. We still have some opportunities in some species--white birch, in particular. We really have an opportunity now before the inventory is available to focus on our secondary industry or the value-added industry. The secondary industry is that part of the industry that provides the basis for the jobs in the metro region.

There is a need for concern because our inventory was last conducted and published in 1977 and all these major changes have occurred since then. Of course, that has created
uncertainty. In addition to the increased wood use and the insect and disease impacts that we have seen over the last 10 years, have created uncertainty. Certainly forest inventory is a major issue in Minnesota. That is why the state has invested significant amounts of money in the program and that is why we are so concerned about getting that next inventory completed. That is why we have to support the inventory program in the federal budget and have to be concerned about using those dollars for maximum effectiveness in the inventory. Another concern is whether timber will be available for sale. The ownership of Minnesota forest land is summarized in Figure 7. Roughly 45 percent of the forest land is privately owned and 55 percent is owned by the public. Of the public land, one-third is managed by the counties, one-third is managed by the state, and one-third is part of the national forest system. Most of the private land is in the nonindustrial private ownership category.

**MINNESOTA COMMERCIAL FOREST LAND OWNERSHIP**

- 13.7 Million Acres -

![Pie chart showing forest land ownership](chart.png)

*Source: DNR-Forestry 2-1-1988*

Figure 7. Ownership of Minnesota's forest land.

My perceptions on the availability of wood from these owner classes are: (1) Counties will be managing strongly for timber production over time, being locally controlled. Local populations are concerned about employment and control is fairly direct. I would see the timber supply from county lands increasing, and increasing quite significantly because they have some of the more productive land in the state. (2) I believe the timber availability from state forests also will be strong. There may be a little bit more pressure from groups to set aside small tracts to protect unique values, but if that is handled right, I do not expect to see that be a major impact on timber supply. (3) Timber availability from national forests is a big question. I believe if timber demand is high a fair amount of timber will be available from these lands. Of course, other forest uses will also be strong and there is likely to be uncertainty. (4) Nonindustrial private forests are always a question mark. While at any one point in time it seems like there are quite a number of owners that are not interested in harvesting timber, studies in other parts of the country have shown that over time timber will become available because ownership changes and also the objectives of the owner changes. (5) And, of course, the industrial forest exists for the production of timber. So we need say no more about that.
I think an important consideration in the timber enterprise is a point that I have made a number of times and that is all segments of the timber enterprise must be financially sound in order for the entire enterprise to be healthy. And those segments are the grower, the harvester, the manufacturer and the marketer. They all need to be making a reasonable profit or the whole enterprise cannot be healthy over a long period of time. This is an important consideration in timber availability from those classes.

Another issue relates to forest productivity—will we maintain it and enhance it? It boils down to investment and investment orientation in the way we look at our forest lands. As landowners, as public officials, as state legislators and congress, I think we have a pretty good track record in this state that says "yes" we will enhance it. We have some good models to look at in doing this and I mentioned Sweden and Finland earlier. Their land has about the same potential productivity as the forest land here in Minnesota. The only difference is they are capturing the potential and we are not.

When considering forest productivity and investments, species of trees becomes a major factor. Aspen is the major cover type we are dealing with. We are very fortunate, at least in regard to regeneration, of being able to regenerate aspen without large investments. That is going to be a real benefit. A species that we need to be much more concerned about than we have been (we hear a little bit about it but we have not been doing a lot about) is oak. I would maintain that oak probably means nearly as much to Minnesota as aspen does, in terms of employment, in terms of economic activity with our large secondary industry, and that is an area we are going to have to focus on relative to timber supply.

Another issue is environmental considerations. There are two major components to this issue. The first is forest owners and managers. Forest owners and managers must recognize and provide for the multiple-use considerations in the management of the forest in order to maintain long-term control over the management of the forest. We must be concerned about long-term productivity and environmental quality. The other important group of actors in the arena are the preservationists. Many in this group would prefer to see no timber harvesting, especially on public land. They could be a significant factor in timber supply. They have a point and a role to play and maybe that role is to cause us to do a better job. Long-term, if we do our job right and show a concern for environmental quality, strong public support for timber growth and harvest will exist.

**TINBER SUPPLY - WHAT IS THE POTENTIAL?**

The biological potential, if we look at achieving fully stocked stands and harvesting the stands when they are mature, indicates that we can double our timber supply. The graph in Figure 8 shows the 13.7 million acres of commercial forest land classified by productivity class. The forest lands are classified by productivity as part of the classification that was done during the last forest survey. The acreage by productivity class indicates that we can move from growing an average of 25-1/2 cubic feet per acre a year to 57-1/2 cubic feet per acre per year (Figure 9) and that is by achieving full stocking and harvesting when mature. Under intensive management which would be constrained only by economics—who knows what the potential is? It could triple, it could quadruple. It would be interesting to analyze our forest land base in a systematic way and try to determine productivity potential for various intensive management strategies. We are also faced with social constraints. The social constraints consist of a failure to invest on the part of the owner. Failure to invest will be the constraint that is most significant to us and it is a constraint that we can do the most about. Second, the need for habitat provided by older trees may be a constraint. In
some places this may be significant. I do not expect it to be significant here in Minnesota based upon the discussions we have had with those who are concerned. I think it will be important but the acreages will be relatively small. Special and unique areas will be a constraint, but not a major constraint. The visual resource and recreation users may have to be considered. If we practice sensitive management I do not think there will be a large impact on the amount of total timber supply available. And, of course, the new issue that
is emerging is the need for biological diversity. Your guess would be as good as mine as to where that will end up, but it could have some impact. We also have the opportunity to stretch the supply through value-added manufacturing. I recall being over in Taiwan in the spring of 1987 at a furniture factory where all the wood used in manufacture was from the United States and every bit of furniture made was going back to the United States for retail. Then I went to another furniture plant and I saw partially finished panels being used, and I asked where is that wood coming from? They responded Singapore. I asked why they were buying manufactured panels from Singapore and rough lumber from the United States. They responded that Singapore will not export rough lumber.

TIMBER SUPPLY - WHAT CAN WE DO ABOUT IT?

There are three major things we can do. We can invest. We have invested but we need to invest wisely in the land, in the production of timber and in manufacturing facilities. I added that we need to continue to invest in manufacturing facilities because it is pretty hard to grow more trees if you cannot use what you have. And the balance between too much and not enough is always going to be a fine line. The growers are going to be on one side and the buyers on the other side. That needs to be taken into consideration. There needs to be a market for the wood and the stumpage price has to be at a point where the landowner can afford to produce the wood.

We must practice sensitive management. We must sensitively use the land. We must practice sensitive management as we look at the timber resource also as a visual resource. We need to be concerned about wildlife, recreation, water quality, and air quality in the management of our forest and facilities. We need to be concerned about environmental quality.

We must increase forest management and environmental awareness through education. This is a big challenge where I think we can do a lot. Legislative and congressional briefings must be continued. Media tours, forestry fairs, short courses for landowners, loggers and others, and probably the most significant from my perspective, is environmental education in K-12 with focus on such tools as Project Learning Tree and other sound materials.

CONCLUSIONS

What are my conclusions? We are going through a period of rapid, wide-scale expansion of the forest products industry--probably larger than we will ever see in a similar period of time. Biologically, we have the capability of doubling and even tripling the size of our existing industry through timber supply. Achieving additional expansion will depend upon several major factors: our willingness to invest in forest management, modern, cost-effective, up-to-date inventories, new manufacturing facilities and environmental education; our willingness to practice sensitive management that takes into consideration other forest uses and environmental quality. Our timber supply can be stretched to produce more social benefits in the way of jobs through the further development of our value-added secondary forest industries. I have confidence in our landowners and land managers, in our industrial leaders and in the public. I believe the future for timber supply is very bright. It will provide many opportunities. We just have to move to capture those opportunities.
TIMBER SUPPLY--IT'S EVERYONE'S BUSINESS

Ronald D. Lindmark

ABSTRACT. Minnesota's timber supply is of interest to a great number of this state's residents, because it directly relates to our state prosperity. Timber supply means different things to different people. Any discussion of the topic must include a discussion and agreement of terms. The responsibility of Minnesota's timber supply is shared among many groups, including elected officials, government agencies, industry, academia, and woodlot owners.

INTRODUCTION

"Who's Responsible for Timber Supply?" This question is significant, in that timber supply in this state is of major interest to many Minnesotans. Our state's abundant water resources receive a lot of press and are the source of good public relations. But there is a growing public awareness that Minnesota's timber resources are as important in terms of providing jobs--both in industry and recreation--as its "10,000 lakes."

Recent newspaper articles dealing with our timber resources, especially the "boom" in the past decade, have moved the forest products industry into second place in the manufacturing category as a contributor to Minnesota's gross state product.

So who is responsible for this important resource? Many groups share the responsibility for the state's timber supply.

Timber supply must be defined before it can be discussed, so that people are referring to the same thing. Timber supply can be defined several different ways.

Physical Inventory--All the timber in a given area, including the dead material.

Economic Supply--The more important, more elusive aspect of timber supply. It involves what is available after we take into account what is withdrawn from use (such as our state and federal parks). Economic supply also recognizes that portion of the physical inventory that is unavailable, either because owners (primarily small, nonindustrial owners) do not wish to sell at the prices users are willing to pay, or because the cost of bringing timber to market exceeds the price being paid for it. This type of supply also considers the uncertainty of what landowners will do at any given time.

Economic supply can be extended by new technology. Aspen was once a worthless "weed species" used only for fuel. Other examples include particle board, flakeboard, or new developments in pulping technology. These technological developments have influenced not only species but also size and quality.

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1 Director, North Central Forest Experiment Station, USDA Forest Service, 1992 Folwell Avenue, St. Paul, MN 55108.

Timber supply is a relative term describing a relative condition. In Minnesota, on any given day, timber supply depends on how much timber is being used in relation to its inventory.

In this context many are responsible for Minnesota's timber supply. Their roles and opportunities are different, but their responsibilities are the same: the assurance of an adequate timber supply for the State's economic and social needs.

Everyone has a stake in a healthy timber supply. Timber users, landowner/managers, researchers, extension specialists, and the general public all affect and at the same time are affected by Minnesota's timber supply.

On the demand side of timber supply, there is a mix of uses ranging from veneer to lumber to pulp to energy. On the supply side, there is a mix of species, size classes, stocking densities, growth rates, and timber quality. All this operates within a certain economic, social, ecological, and administrative setting.

KEY GROUPS AFFECTING TIMBER SUPPLY

More specifically, the following groups influence the management and monitoring of Minnesota's timber supply.

Elected officials (national, state and local)

County, state, and national elected officials play a critical role in developing and implementing forestry policies. Their influence is felt through changes in local, state, and federal laws, regulations, and budgets; for example: tax laws that influence corporate or landowner investment decisions, regulations that influence the harvest and handling of raw timber and the disposition or disposal of primary and secondary products and their storage, and county regulations that determine whether land is allocated to "memorial forests," as well as county policy for handling tax deferred land.

Minnesota has more land controlled by local authorities than any other state except Alaska.

Incentives in various forms can encourage all owners of forest land to change their contributions to either the demand for or inventory of timber. Use of federal, state and local dollars help in managing and monitoring the timber supply.

The Governor and his Department heads, including the State Forester, play a major role in assuring that the people and industries of the State of Minnesota have an adequate healthy timber resource to maintain the economic, environmental, and social benefits. They play a major role in managing the timber supply through optimization of the inventory and demand forces for the resource. They also are responsible for monitoring and planning the timber supply as a basis for decision making by industry, nonindustrial private landowners, and government at all levels.

Industrial landowners

Forest industry leaders have a variable influence on the inventory side of the ledger. Owned or leased timber land is managed in various ways to conform to corporate policies. Nonindustrial owner assistance and incentives programs provided by industry can change the availability of timber.
Forest industry plays a key role in establishing the demand, or use side, of the timber supply equation. Forestry industry is highly diverse in terms of the scale at which it influences timber supply. It ranges from multinational corporations that can use large quantities of different timber resources to small local wood producers that have a very specific niche in the market.

The statewide timber supply is and will be defined by the composite of these various industries. Industry decisions to open, close, change the capacity or alter the composition of timber to be used modify the definition of timber supply. National, state, and local political boundaries may or may not be an effective geographic organizing principle when evaluating forest industry’s influence on timber supply.

**Nonindustrial private landowners**

This group owns the largest acreage and volume of the current timber inventory in Minnesota. This segment of the timber supply equation is the most complex and difficult to evaluate because of varying size and objectives, and current physical stocks of timber. Private landowners may simply not want to harvest their timber, or their holdings may not be large enough to harvest economically with current techniques.

Collectively this group probably does not identify itself as responsible for the Minnesota timber supply. And that’s its right. This contrasts sharply with some European nations where landowners feel responsible to future generations for providing long-term investments such as timber.

**Federal, state and local forestry agencies**

This group has timber supply responsibilities that include many aspects of managing and monitoring the resource. Federal, state, and local agencies, especially counties in Minnesota, all contribute to the management of physical timber resources. Because the resources on these parcels of land are publicly owned, they are increasingly being managed for values besides fiber production.

What is the role of state and federal forestry agencies? States play a critical role in forest protection activities. Federal agencies also play an important role in assistance and cost-sharing. These agencies also share a major role in monitoring timber supplies. That includes estimating the changing physical inventory and uses with projected changes in the timber supply.

**Universities**

Universities in the Lakes States region affect and are responsible for timber supplies through their research, extension, and education missions. Research and extension activities are likely to be a major means by which state and federal agencies influence timber supplies in the future.

The extension arm of land grant universities plays a critical role in assuring timber supplies through transfer of technology to primarily nonindustrial private landowners. Research on forest resources at these universities is a significant force in the assurance of timber supplies. The universities have a major responsibility in this area. Education of forestry professionals is a crucial part of assuring, managing, and maintaining timber supplies.
The combination of reduced extension funding and fewer students in professional forestry curricula foretells major difficulties in the future timber supply of Minnesota and the nation. This is a real problem. The increasing demands on forest resources, and the complexity of these resources, require more research and more professionals to understand and manage forests to meet these demands.

The North Central Forest Experiment Station

Our responsibility is two-fold. First, the Station collects basic data about the forest resource in the 11-state North Central region. The old adage is true: decisions are only as good as the information they are based upon. Management decisions regarding our forest resources are only as good as the resource information they are based upon.

Secondly, our research in silviculture and economics improves management, and our research with insects, disease, and fire is aimed at protecting the resource. Our timber harvesting and utilization research is looking for ways to improve existing methods or provide new technologies that extend our timber supply.

Research results often create demand for different timber resources. New technologies developed through our research can often alter the demand for and the supply of the timber resource more rapidly than the forest manager's own manipulation of the forest.

Environmental organizations

Several state, regional, and national environmental organizations will play a growing role in this state's timber supply. The concern expressed by these well-organized groups has already changed the timber supply picture.

The environmental community has influenced timber harvesting practices, worked to withdraw land from the timber supply base, and gained much support in advocating increased recreation use, or "balanced" use.

Environmental concerns are the focus of many emerging issues that will affect timber supplies. Biological diversity is a good example of such an issue. Are timber management practices reducing the biological diversity of our forests? Environmental groups are saying yes, and they are saying so in Federal Courts.

We at the North Central Forest Experiment Station think this issue is important. To replace emotional arguments with hard facts, we've just established a research unit, based at our Rhinelander Forestry Sciences Laboratory, with a mission to study biological diversity.

But emotions, and court cases, won't go away. Another issue we face today--one we will face in the future--involves appeals of National Forest Plans. National Forest Land and Resource Management Plans are quickly becoming the focal point for groups debating the use of National Forests. For good reason--these plans decide how the National Forests will be managed for the next 10 years. The flood of appeals is proof to me that the various groups--including both timber industry and environmental groups--understand what is at stake.

But appeals--the long-drawn out process and the implications of settlements--can disrupt timber harvest schedules.
SUMMARY

Timber supply must be carefully defined, so that all involved in any discussion on this subject are referring to the same thing.

The responsibility for Minnesota’s timber supply is shared by many groups with varied roles and opportunities.

These groups must work together as partners to most effectively use and monitor the State’s timber supply. Increasingly, they must share financial and personnel resources to meet the growing responsibilities for Minnesota’s timber supply.
UPDATE ON MINNESOTA'S FOREST INVENTORIES

Michael R. Carroll

ABSTRACT. An ongoing cooperative project between the U.S. Forest Service North Central Forest Experiment Station and the Minnesota DNR Division of Forestry is updating Minnesota's forest statistics. A triple intensity of permanent plots on all ownerships in the state is being remeasured. The information is critical in support of the state's role in economic development, timber supply, multiple use management and environmental monitoring and protection. The permanent plots are one facet of the state's continuous forest inventory program that also includes stand assessments and continuing applications of remotely sensed data. Permanent plot data is critical now for timber supply and condition analyses; but it will also be used as point data for our operational Geographic Information System and as benchmarks for both environmental monitoring and developing ecological land classifications.

INTRODUCTION

The people of Minnesota, through their Legislature, have provided additional funding for the remeasurement of permanent plots on all ownerships in the state. The additional dollars will result in a triple intensity of data collection in the state as opposed to the single intensity mandated by federal law. Acceleration dollars will also shorten the survey cycle. This is a first in the North Central Region. The procedure followed is the Forest Inventory Analysis (FIA) system directed by the North Central Forest Experiment Station. The state feels this additional information is critical in support of its' role in economic development, timber supply, multiple use management and environmental monitoring and protection.

FORESTRY'S INVENTORY PROGRAM

The permanent plots (FIA) are one facet of the state's comprehensive and continuous forest inventory program. The program also includes stand assessments done in cooperation with the counties and continuing applications of remotely sensed data. New techniques in the acquisition and processing of remotely sensed data for operational inventory use are being developed cooperatively with the University of Minnesota Remote Sensing Lab. Our inventory offices are right here in Grand Rapids and we offer an open invitation to stop in and visit. The FIA permanent plot data is critical now for timber supply and condition analyses. However, it will achieve expanded utilization as point data for our operational Geographic Information System and as benchmarks for both developing environmental monitoring programs and ecological land classifications.

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1 Forest Resource Assessment and Analysis Supervisor, Minnesota Department of Natural Resources, Division of Forestry, 500 Lafayette Road, St. Paul, MN 55155-4044.

CURRENT FIA OPERATIONS

In the current FIA remeasurement in Minnesota, the state is involved in all aspects of the survey: photo interpretation, data collection, data processing and reporting. The cornerstone is a strong interaction between the Division of Forestry’s Resource Assessment Working Group and the NCFES’s FIA Working Group. There has been more openness, cooperation, training, personnel interaction, communications, change and trust involved than ever before. These factors require the investment of time and staff. In Minnesota the process is working and a quality inventory will be made available to users in a shorter period of time.

Current commitments and schedules are presented on Figure 1. Photo-interpretation work in the Aspen-Birch Unit is complete. Field work by state contractors will be done in the Aspen-Birch Unit in January of 1989. State work in the Northern-Pine Unit will be completed in January of 1990. Federal crews will enter Minnesota in early summer of 1989 and finish off their field work in the Central Hardwood and Prairie Units in October of 1991.

Figure 1. Current commitments and schedules for Minnesota’s forest survey units.
Steps in updating the FIA file are outlined in Figure 2. Upon submission of data to the NCFES, six months are needed to carry out quality checks, run expansion equations and produce preliminary reports. The first unit of each state establishes the template for processing and subsequent units are normally processed in a shorter time period. Preliminary reports are reviewed internally and then with the DNR and an expanded user group. Neal Kingsley will discuss the final report selection and publication process.

Figure 2. Steps in updating Minnesota's forest statistics.
The cooperative project allowed the state to identify and develop several refinements for use in the Minnesota resurvey. Six examples are listed in Figure 3. Each serves to maintain the quality of the survey, improve it where possible and expand the utility of the information.

### Minnesota FIA Refinements

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Traditional</th>
<th>State</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo Interpretation</td>
<td>9x9 Mosaic</td>
<td>NHAP</td>
<td>Current/Available</td>
</tr>
<tr>
<td>Disturbance Calls</td>
<td>9x9 ASCS</td>
<td>35 mm Photography</td>
<td>Easier to handle Update potential</td>
</tr>
<tr>
<td>Growth Estimates</td>
<td>Variable Radius Equations</td>
<td>Fixed Radius</td>
<td>Current Historical record Update potential</td>
</tr>
<tr>
<td>Insect &amp; Disease Coding</td>
<td>Standard Codes State Options</td>
<td>Expanded Codes Crew Training Special Projects -11 state standards -Aspen loss assessment</td>
<td>Comparison Remeasurement options Use by our Biometrician Need: Better, comparable &amp; quantifiable I&amp;D occurrences &amp; loss estimates</td>
</tr>
<tr>
<td>Field data collection</td>
<td>Federal/State crews</td>
<td>Contractors</td>
<td>Cost/Benefit Analysis Quality Comparisons Private Sector Jobs</td>
</tr>
<tr>
<td>Nonforested checks</td>
<td>Limited Ground Checks</td>
<td>100% aerial check Systematic ground check</td>
<td>Identify potentially productive sites</td>
</tr>
</tbody>
</table>

Figure 3. FIA refinements for Minnesota resurvey.
THE NEW MINNESOTA FOREST INVENTORY

Neal P. Kingsley and W. Brad Smith

ABSTRACT. The current Minnesota forest inventory applies the STEMS (Stand and Tree Evaluation and Modeling System) design, which substantially reduces overall costs by making modeled projections of a number of undisturbed remeasured plots. The new inventory will also permit localized analyses to be developed for small geographic areas in heavily forested regions without sacrificing accuracy. This is possible because each plot location is digitized. Information on timber removals and utilization standards in Minnesota has been monitored during the interim between inventories. Early indications from the inventory point to a bright future for Minnesota.

INTRODUCTION

The state's role in the current forest inventory and the excellent working relationship that exists between North Central Forest Inventory and Analysis (FIA) and the Minnesota Department of Natural Resources already have been discussed. Now I would like to provide some information about the sampling design of the new inventory and its implications for information accuracy and availability. I will discuss some of the recent work we have been doing in the area of monitoring annual growing stock removals from timberland in the Lake States. Also, I will make some predictions about what we expect the new inventory to reveal and how we will be reporting the results.

Traditionally, forest inventory plots are established, measured and then remeasured to provide estimates of forest condition and change. The process is both time consuming and expensive. Forest Inventory and Analysis (previously called Forest Survey) researchers are constantly trying to find ways to maintain and improve inventory reliability and utility while trimming costs. Integrating forest growth models into the inventory design offers one possibility to achieve this goal. Recently, a team of North Central FIA researchers developed and implemented a sample design that incorporates the STEMS (Stand and Tree Evaluation and Modeling System) individual tree growth model into the inventory process and reduces field data collection costs.

THE SURVEY DESIGN

The growth model design concept is simple, even though the mathematics of its implementation can get a bit involved. I will stick to the basic concepts here; but if you would like more detail, contact the North Central Forest Experiment Station and request a copy of Hansen and Hahn's (1983) article.

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1 Project Leader and Research Forester, Forest Inventory and Analysis Project, U.S. Forest Service North Central Forest Experiment Station, 1992 Folwell Avenue, St. Paul, MN 55104.

This integrated design is a variant of our standard 2-phase sample in which a subsample of ground-check plots is selected from a base sample of photo plots (Figure 1). A key difference is that the integrated design stratifies the ground-check photo plots as to whether or not they are "disturbed." "Disturbed" as it is used here refers to any change of condition since the last inventory that cannot be modeled with STEMS. This would include plots that were seedling stands at the last inventory, stands that have been clearcut or detectably thinned, or stands that are identified as having a high risk of change. An example of high risk would be an area in which spruce budworm has become endemic since photography. For instance, any balsam fir ground checks are classed as "disturbed" even though the photos show no evidence of disturbance because this type is highly susceptible to spruce budworm infestation.

![Figure 1. Simplified STEMS inventory design.](image)

Once all the photo ground-check points are classified and stratified, all of the "disturbed" check points are sent to the field to be measured. An additional subset of the undisturbed plots are also sent to be remeasured. These plots will be used later to adjust the growth on the modeled plots. Then the remaining undisturbed plots are "grown" with STEMS. The tree lists generated by the projections are "corrected" using information derived from remeasured undisturbed plots. To maintain sampling accuracy and provide an adequate base of plots for future inventories, a sample of new plots also is established. Because the cost of these new plots is less than the cost of remeasuring the modeled plots, a significant cost savings is realized while providing reliable new inventory information.

Will this new inventory be reliable? The 1977 Minnesota inventory was the most intensive inventory ever conducted in this country. The current inventory will be equally intensive. Our sampling design is based on a systematic sample on a uniform grid. It will provide about 17 inventory plots per township, a total of 44,000 ground plots for the state. Of these, an estimated 11,500 will fall on timberland. Approximately 5,500 of them will be remeasured plots, 2,500 will be new plots, and 3,500 will be modeled plots. Because forest land is not distributed evenly in Minnesota, we can expect the average number of timberland plots per township to range from 1 in the southwest to 11 in the northeast.
SURVEY DATA USAGE

Users of our data frequently request information about timberland areas smaller than states or survey units. Because of the high intensity of sampling in Minnesota and by digitizing the location of each plot, we can use the inventory data base to obtain this information easily. An example will illustrate what I mean. Let's suppose a forest products company is looking at four different locations in Minnesota for a new mill. Their mill will require some specified volume of wood, and the company wishes to know what the procurement area will have to be for each site given sampling errors of 5 percent for timberland area, 10 percent for volume, and 15 percent for growth. The area required to meet their need will, of course, depend on the abundance of forest land, and hence the number of timberland plots, surrounding the location. Figure 2 shows the approximate number of townships and circle radii from which inventory data would have to be drawn to achieve the desired accuracy for each of the locations. It should be noted that we have used circles just to keep the example simple. We might have added the criterion that the area boundaries be defined as the shortest hauling distance to the mill. In that case, we would have a somewhat amorphous-looking figure because rivers and highway routes would add distortions.

Figure 2. Request area required to achieve accuracy of 5 percent for area of timberland, 10 percent for volume on timberland, and 15 percent for growth on timberland in Minnesota.
The illustration shows that where we have more plots, we can provide more information for smaller areas. Thus, in the more heavily forested northern portions of the state we can provide estimates for small areas; in the central unit, county level data is as low as we dare go and maintain our desired accuracy; and in the Prairie unit multi-county areas must be used because of the small number of plots in this region.

Since the late 1970's forest industry has expanded tremendously throughout the Lake States. In light of this, FIA has devoted a great deal of effort to developing methods for monitoring growing stock removals on an annual basis through the use of annual production studies for pulpwood (Blyth and Smith 1988); periodic mill production studies (Blyth et al. 1980, Blyth and Smith 1986); and fuelwood production studies (Blyth et al. 1984). Using data from these production studies and timber utilization studies (Blyth and Smith 1980), we have been able to produce a fairly accurate picture of annual removals of growing stock from timberland in the Lake States. Since 1981, Michigan has led the expansion of timber production with an increase of 32 percent, Minnesota was right behind at 31 percent, and Wisconsin showed a 14-percent increase (Figure 3).

![Graph showing growing stock removals from timberland in the Lake States, 1981-1987.](image)

**Figure 3.** Total growing stock removals from timberland in the Lake States, 1981-1987.

By observing average cubic foot growing stock removals on a per acre of timberland basis (Figure 4), a different picture emerges. The removals pressure in Wisconsin in 1981 was significantly higher than in Michigan or Minnesota. Aggressive industrial development by both of the latter states, however, is closing the gap.

Based on inventory data, Minnesota's site potential is lower than that of Wisconsin and Michigan (table 1). Site potential is an estimate of the potential average annual growth of a stand between establishment and rotation age. This generalization about Minnesota's site potential is true only if maximum fiber production is the primary goal (i.e., pulp is the only product). Given the mix of products in the Lake States, along with other biological, social and political factors, only about 80 percent of this potential is realistically achievable.
Figure 4. Growing stock removals per acre of woodland in the Lake States, 1981-1987.

Table 1. Site potential and removals, Lake States, 1987.

<table>
<thead>
<tr>
<th>State</th>
<th>Site potential</th>
<th>Achievable site potential</th>
<th>1987 removals</th>
<th>Percent of achievable</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN</td>
<td>58</td>
<td>46</td>
<td>16</td>
<td>35</td>
</tr>
<tr>
<td>WI</td>
<td>67</td>
<td>54</td>
<td>22</td>
<td>41</td>
</tr>
<tr>
<td>MI</td>
<td>64</td>
<td>51</td>
<td>19</td>
<td>37</td>
</tr>
</tbody>
</table>

From this information, we see no reason why Minnesota could not easily achieve at least the per acre rate of current removals in Wisconsin (relative to potential). To do so would mean an increase of 19 percent over current levels, which translates to 41 million cubic feet, or about one-half million cords of additional removal, annually. If 80 percent of the potential is achievable as an average, then removals would increase 188 percent to 46 cubic feet per acre per year, which would add 410 million cubic feet to current annual removals. Such an increase in removals would imply a tremendous investment in intensified management throughout the state and would take 30 to 40 years to achieve. We are sure other papers presented at this conference will address Minnesota’s timber supply with more specific analyses of species and locales; but the basic data available today certainly indicate that Minnesota has an opportunity and perhaps slight competitive edge in the Lake States for developing or expanding timber markets in the near term. But, because of the similarity of forests and forest products across the Lake States, as removals begin to reach equilibrium in the region, factors other than just timber supply will probably play major roles in future forest industry development at the state level.
OUTPUT FROM THE NEW INVENTORY

Hard data from the inventory are still a few months off. However, we would like to make some predictions. We think the new inventory will look something like this when compared to the 1977 inventory:

- AREA - no significant change,
- VOLUME - up 15 to 18 percent,
- GROWTH - 20 to 25 percent improvement, and
- REMOVALS - up 40 to 45 percent.

You are now aware that the design of the inventory is new. The reporting procedure has also been changed somewhat from the last inventory. A significant change comes as a result of all of the FIA projects in the eastern United States developing a standard data exchange format. This means that directly comparable information will exist for each of the eastern states. Thus, it will be easier to compare Minnesota with Alabama, for instance. As part of this, the FIA units have agreed upon a set of 25 core tables that will be produced for each state. These tables are listed in the Appendix of this paper.

These core tables will form the basis of our unit reports and contain much more county level data than in the past. We hope that a standardized format will permit us to get unit reports out to our users faster than in the past.

In addition to the unit reports, we will publish a statewide statistical report with much more information. We will also have a report that analyzes the results of the inventory.

If this is not enough, we will be able to answer particular requests using the data base. We can do this in one of two ways. First, we can sell data base tapes to users to derive their own information and analyses. Second, we can do the job for a fee and on a time available basis. Although we will not produce reports similar to the old Minnesota county reports, the information needed to do this will be in the data base.

All things considered, the future of forestry and forest industry in the state looks good. We expect the new inventory data to verify our expectations and lay the groundwork for improved utilization of the forest resource.

LITERATURE CITED


Appendix

EASTWIDE CORE STATISTICAL REPORT TABLES

AREA
*Table 1.--Area of land by county and major land use class
*Table 2.--Area of timberland by county and ownership class
*Table 3.--Area of timberland by county and forest type
*Table 4.--Area of timberland by county and stand-size class
*Table 5.--Area of timberland by county and site class
*Table 6.--Area of timberland by county and stocking class of growing-stock trees
*Table 7.--Area of timberland by forest type, ownership class, and Forest Survey Unit
*Table 8.--Area of timberland by ownership class, stocking class of growing-stock trees, and Forest Survey Unit
*Table 9.--Area of timberland by forest type, stand-size class, and Forest Survey Unit

NUMBER OF TREES
*Table 10.--Number of all live trees on timberland by species group and diameter class
*Table 11.--Number of growing-stock trees on timberland by class of timber and major species group

VOLUME
*Table 12.--Net volume of timber on timberland by class of timber and major species group
*Table 13.--Net volume of growing stock in the sawlog portion of sawtimber trees on timberland by species group and diameter class
*Table 14.--Net volume of growing stock on timberland by species group and diameter class
*Table 15.--Net volume of sawtimber on timberland by species group and diameter class
*Table 16.--Net volume of live trees and growing stock on timberland by ownership class and major species group
*Table 17.--Net volume of growing stock and sawtimber on timberland by county and major species group
*Table 18.--Net volume of sawtimber on timberland by species group and tree grade

GROWTH
*Table 19.--Net annual growth of growing stock and sawtimber on timberland by county and major species group

REMOVALS
*Table 20.--Average annual removals of growing stock and sawtimber on timberland by county and major species group, 1966-1985
*Table 21.--Net annual growth and removals of growing stock on timberland by species group
*Table 22.--Net annual growth and removals of sawtimber on timberland by species group
*Table 23.--Net annual growth and removals of growing stock on timberland by ownership class and major species group
*Table 24.--Net annual growth and removals of sawtimber on timberland by ownership class and major species group

MORTALITY
Table 25.--Annual mortality of growing stock and sawtimber on timberland by species group
TRANSLATING THE PHYSICAL INVENTORY TO ECONOMIC SUPPLY

Dietmar W. Rose^1

ABSTRACT. Timber-based industries play an extremely important role in the economy of Minnesota. Possible future expansions of this sector depend on timber supplies which are the result of the complex interplay of investment decisions by timber producers and timber consumers. This paper examines the major factors that need to be analyzed to better understand the complexities of timber supply. They include the dynamics of forest cutting and growing, locational aspects, ownership characteristics, and market structures. This paper sets the stage for the following paper that describes specific models which can address questions related to timber supply.

INTRODUCTION

Estimation of timber supply has been and continues to be one of the most difficult problems faced by foresters. Since the timber famine of 18th century Germany, which signaled the beginning of the science of forestry, much effort has been expanded in identifying timber supplies. A number of questions arise in timber supply analysis. What is the current volume of available stumpage? Can the available stumpage volume meet the demands placed on it and at what prices? What are the impacts of different management regimes on available stumpage volumes over long periods of time? Can forecasted available stumpage volumes meet the forecasted demand? Answers to these questions are needed to formulate present forest management strategies.

With the recent expansions of the forest industry in Minnesota, there are different concerns being expressed by producers and consumers about the timber supply situation. The potential value of the timber resource for supporting the timber industry, for generating revenue for timber producers, and the importance as generator of employment makes it essential that we identify and evaluate the opportunities to support additional expansions. We are also concerned about the options for increased forest management to provide for additional development opportunities in the long run. To understand our options we need a basic understanding of the timber supply situation and the important associated economic considerations.

HISTORY OF TIMBER SUPPLY ANALYSIS

The determination of an allowable cut, i.e., the amount and timing of volume removals from a forest inventory, for any forest enterprise depends on specific management objectives. One of the overriding objectives that is accepted by most forest organizations in the world is to achieve sustainable yield. Sustainable yield refers to a balance in forest timber and nontimber outputs at annual or periodic intervals. The first formal model introduced in forestry was the famous model of a normal forest, a description of the ideal forest that forest managers should

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^1Professor, Department of Forest Resources, University of Minnesota, 1530 North Cleveland Avenue, St. Paul, Minnesota 55108.

strive to achieve through appropriate harvest and regeneration actions. The normal forest has a perfectly balanced ageclass distribution and permits sustainable cutting and other management activities. Real forest inventories of the time were far from this ideal, typically being heavily imbalanced with very few old stands remaining.

The normal forest model was used to formulate the first allowable cut formulas that could bring the imbalanced forest into a regulated state. The concept of area control was followed by a number of volume control methods. Some of the well known volume control methods include Hundeshagen's method, von Mantel's method, and the Austrian formula. Area control methods assume that regeneration is the overriding concern and harvest levels are set such that the appropriate acreage will be regenerated as a result of harvesting. This type of regulation will guarantee a fully-regulated forest in one rotation, but the flow of timber during the conversion period can be quite erratic. Volume control methods, as the term implies, give more attention to the flow of timber during the conversion period, but generally do not achieve full-regulation nearly as fast as area control. The elegance and power of these simple formula methods can only be appreciated when one understands the state of knowledge that existed in these early days of forestry. There was a general lack of inventory data and of growth or yield data.

**SHORTCOMINGS OF TRADITIONAL METHODS**

A potential problem with the traditional methods for allowable cut calculations is that they are very simplified methods that do not always apply well to the general case. For example, with the normal forest the annual or periodic harvest is equal to the annual growth. This has sometimes been suggested as a method for analyzing current harvest potential. The generalization suggests that a comparison of harvest and growth will help describe the timber supply situation; if harvest is greater than growth then supplies (the inventory) must be decreasing. This generalization can be extremely misleading for cases in which the age distribution of the forest is fairly imbalanced because tree growth varies significantly with tree age. Let's look at this concept in more detail just to illustrate how much periodic growth might vary. The table below (Peralta 1977) shows aspen yields and 10-year aspen growth rates for site index 70 sites in the Lake States.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Yield (cords/acre)</th>
<th>Future 10-year growth (cords/acre/10-years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>30</td>
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<td>17</td>
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<td>60</td>
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<td>10</td>
</tr>
<tr>
<td>70</td>
<td>65</td>
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</tbody>
</table>

A normal forest based on this table and a 60 year rotation would have a 10-year growth rate of 9.2 cords/acre. For a forest with an imbalanced age distribution this growth rate could be as low as zero--a forest composed of only stands less than 30 years old or greater than 70 years old--or as high as 22 cords per acre per 10-year period--if all stands were 40 years old. For a forest similar to what we might find in Minnesota shortly after a large increase in cutting, say 5 percent of the acreage in each age class from age 30 to 60 and all other acres in age classes without any appreciable volume growth--both stands less than age 20 or older than age 70--the 10-year growth value would be 3.25 cords per acre or only approximately 35 percent of the
growth for a fully regulated forest! In another 30 years when this same type of age distribution has most of its acres in the 30 to 50 age classes, the annual growth rate could easily be 150 percent of the growth rate for the corresponding normal forest. From this example, it should be clear that periodic growth by itself is a poor indicator of the general supply situation or a poor estimator for an allowable cut. For the current age distribution in Minnesota one would think that the allowable cut could be significantly greater than the current growth rate if indeed there are no other factors that need to be considered.

A major assumption with the traditional allowable cut models is that the desired end-state or ideal forest can be identified. Do we really know how many acres or which acres should be managed for timber production or which species are best to grow or whether the optimal rotation age or the optimal management intensity might change in the future? What if genetic tree improvement or technological change through new harvesting techniques or product development make the optimal rotation age much shorter after we invest heavily to regulate the forest for a much longer rotation? Will we then invest heavily to re-regulate and again find our estimate of the ideal forest changing. What options are we leaving available for managers to use in the future? Also, what are the costs of achieving this "ideal" forest? What are we giving up today to achieve it? Allowable cut policies are just means for achieving a goal—a long run sustainable yield. Are there less costly methods for achieving the goal? For example, can we harvest more today and still produce the same timber supply in the future at a low cost?

ECONOMIC TIMBER SUPPLY

In forestry the term "supply" is often applied to the physical volume of stumpage alone. Current physical timber inventories provide little insight into available or economic supplies. Future physical timber inventories depend on how inventories grow and on the current actions taken by forest managers. Economic timber supply, by definition, is a schedule of the quantity of timber that is available in the market during a specific time period for alternative market prices. A key point in this definition is that economic supply is a schedule of quantities available at different price levels and not simply a volume estimate describing the physical quantity of wood in the forest. Undoubtedly, there are a number of factors that could prevent stands from being available to the market at a price that consumers are willing to pay. Significant volumes of wood are not available to the market at current timber prices in Minnesota (Hoganson 1988). Also, to be relevant, one would be interested in not just "timber" but in a specific type of timber such as softwood sawlogs, or aspen pulpwood.

Vernon L. Robinson from the Department of Forestry at Clemson University makes the observation that the majority of timber supply studies describe a scenario of impending wood shortages and timber famine which so far have not come true. He traces this pessimistic projections back to the inadequate projections of future timber demands. The two most frequently used predictors of timber demand, gross national product and population growth, are shown to be poor predictors of timber demand. From 1900 to 1983, they have grown faster than wood consumption. Demand, given the intial price, has often been projected to rise more rapidly than supplies leading to a widening in the gap between demand and supply and to the expectation of physical shortfalls or deficits.

The relevant prices for describing economic supply refer to the prices paid by the consumer. These prices would be the delivered prices paid at the mill, not stumpage prices paid to the timber producers. In general, the maximum stumpage price a consumer is willing to pay for any specific stand is simply the value that the timber is worth at the mill (delivered price) less all the costs of obtaining that timber and bringing it to the mill. Stumpage prices can vary significantly between stands because of differences in these costs. For this reason, reports on average stumpage prices in a region can be somewhat misleading indicators of the timber supply situation. A central point of the 1980 Minnesota Timber Resource Study carried out by the Banzhaf Company for the Minnesota Legislative Commission on Minnesota Resources (Banzhaf 1980) is the potential problems of accessibility: sixty-five percent of Minnesota’s commercial forest land is more than one quarter mile from a maintained road.

Much has changed since that 1980 report. Minnesota has seen the establishment and growth of its waferboard industry. Most recently, the construction of a large, modern pulp and paper manufacturing plant, comprising an investment of over $500 million, has been announced. These expansions have increased cutting activities in the State and are significantly changing the physical characteristics of the timber resource. This industrial activity also is changing the economic climate for investments in timber production. It will be more difficult and more urgent than ever to properly assess both physical and economic timber supplies. It will require improved inventory and monitoring methods and better information collection methods.

Timber supply curves are difficult to estimate for several reasons. Two important factors to recognize are the interdependencies of timber supplies between different time periods and different products. Timber supplies between time periods are interdependent because trees are both the product and the factory. When timber is consumed in one period, the factory is destroyed (at least temporarily) and the quantity of timber available in the next period will be affected for at least some price levels. Therefore, in order to estimate future timber supplies one also needs to estimate consumption levels for all prior periods. Timber supplies between products can be interrelated for several reasons. First, individual timber stands can produce several products and the costs of producing these products cannot be separated in any meaningful way. Second, in the long run, much of the same land base can be used to produce either product. For example, how can one estimate how many acres will be regenerated as red pine if there is not also an understanding of the aspen market?

In considering economic timber supply it is important to recognize why society might be concerned about timber supply and some of the potential problems in the market. Economic analyses in contrast to financial analyses, are generally done from society’s viewpoint. In Minnesota, timber production supports a variety of forest industries. Forestry is the third largest industry. To support this industry, it is important that timber is produced in sufficient quantities and in an efficient manner. High timber prices, by themselves, whether stumpage prices or delivered prices are not necessarily of major concern. Prices paid are merely transfer payments between landowner and consumer. Naturally, forest industry would like to see low prices to help keep their operating costs low, but landowners would prefer higher prices. Low prices do very little to encourage additional investment in timber production and yet high prices do very little to stimulate industrial expansion. From society’s view, the real concern is the overall allocation of resources for timber production. Are they the most appropriate resources (lands) and in the right quantities?

Some of the potential problems of resource allocation decisions in a free market that have been cited as potential problems include the long payback periods of forestry investments; the nonmarket outputs associated with forestry; the potential economies of scale with forestry
production and the potential gains from coordinated management; the risks involved with timber production; and the lack of competition in the forest products industries.

The long payback periods can reduce the incentives for individuals to invest in forestry. Unless advance sales can be made or land is actually sold, it is difficult for landowners to realize returns from investment. Also, the risks involved to an individual landowner can be great. Insects, disease, or fire could cause a total lose to an individual investor. However, on a regional scale the risk is not necessarily large because many of the potential losses over only a relatively few number of acres. The lack of competition in the market can cause some allocation problems because the proper incentives are not present to encourage timber production in the right places. Questions about the degree of competition often arise in forestry because transport costs are a significant component of production costs and often an overriding factor in determining whether a stand is marketable (Hoganson 1988; Rose et al. 1983, 1984). In northern Minnesota, more money is often spent on transporting the wood to the market than is spent on buying the rights for harvesting the stumpage from the landowner. For example, consider a simple example illustrated below in which there are 2 mills, located at points A and B and three stands located at points 1, 2 and 3 that are identical except for location.

<table>
<thead>
<tr>
<th>Mill</th>
<th>Stand</th>
<th>Stand</th>
<th>Stand</th>
<th>Mill</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>B</td>
</tr>
</tbody>
</table>

Assuming no other mills are involved, each mill has approximately the same delivered price, and each mill would be willing to purchase any of the three stands, then stand 2 would likely sell for the highest price because it is the stand that is in the best position to sell to either Mill A or Mill B. Now if all three stands were owned by the same landowner, which one do you think would be allocated to timber production if only one stand is to be allocated? The potential higher price for stand 2 would suggest that it would be stand 2 because of the greater competition. But from society’s point of view this is an inefficient allocation of resources; production would occur at the point that is farthest from a market! Problems of this type can become quite complicated and controversial with the degree of market power likely to play a significant role in the outcome. From society’s point of view one might be interested in the policies that are available to influence this situation as well as the management decisions made on public lands that are under this type of situation.

From a regional perspective it is clear that economic timber supply is an extremely complex concept. At the project level, economic analyses and the related financial analyses are fairly common practices. An understanding of these tools and some of their weaknesses can be extremely useful for gaining a better understanding of the concepts and need for regional timber supply analyses as well as some of the characteristics of the methods used for regional timber supply analyses. The basic concepts of economics are the same whether one is analyzing a specific alternative for an individual stand or a regional analyses for an entire state. In practice, it should be possible to use some insights gained from one type of analysis as input into the other type.

**USING PROJECT ANALYSIS TO GUIDE DECISIONS**

Cash flow analysis is the basic tool used to help guide project analysis. Economic measures are calculated by estimating all costs and returns for a project and then discounting the values to a common base year to help compare the stream of benefits and costs over time.
Comparing net present value estimates of alternative projects can often help in selecting specific projects to implement.

A critical aspect of cash flow analyses are the sensitivity analyses that are done to compare alternative projects. Results often indicate that the most critical assumptions deal with future prices for timber products (Lothner, Hoganson, and Rubin 1987). Uncertainty about future prices often makes it difficult to rank alternative production methods with more intensive practices generally ranking higher with higher relative prices. On a regional level, the general level of management intensity itself will influence price by influencing the quantity of timber available to the market. Using cash flow analysis, it would be difficult to estimate how individual projects, taken together or summed over an entire region, would describe the overall economic timber supply situation. For a forest-wide or region-wide situation there are constraints on management that also must be of concern. For example, cash flow analyses of all individual stand types of a relatively old forest would likely indicate that the best alternative for all the older stands is an immediate harvest. But current market consumption levels or current management budget levels or existing sustained yield management policies are each potential limitations from implementing the projects that appear best strictly from a project analysis viewpoint. Clearly, methods for broader regional planning are needed to help coordinate the management between stands.

The College of Natural Resources is involved in several major efforts to improve on our ability to analyze timber supply questions. The results of several of these efforts can be viewed during the poster sessions. The following paper at this conference will describe some of the regional or forest-wide models that might be used. Here, we will simply try to identify some of the key criteria that should be used to evaluate these larger models.

**DESIRABLE CHARACTERISTICS FOR PLANNING MODELS**

Like the cash flow analysis methods used to evaluate specific forestry projects, regional models need to be based on the basic principles of economics. These methods should consider the economic returns for the alternative management options and the potential sacrifices that are made by selecting suboptimal alternatives for individual stands. As with cash flow analyses, results are likely to be sensitive to the assumptions to describe the future and the analysis methods should be capable of examining the sensitivity of the results to the assumptions made concerning future conditions.

A number of general rules can be stated concerning the adequacy of a selected model to answer specific questions:

1) The more complex the question, the more complex the model required.

2) The more complex a model, the more information required to run it. The trade-off between cost of information and collection and improvement in decision making ability need to be examined.

3) The simpler a model, the more assumptions needed concerning external factors that are outside the control of the model.

4) The simpler the model, the less predicted or estimated about the outside world.
With these observations, we can describe two key yet somewhat contradictory characteristics of a good planning model:

1) The model must be complex enough to give a good description of the real world. Unless the problem described by the model is a good description of the real problem, solutions or insights gained from the model are not likely to apply to the real world.

2) The model must be simple enough to be useful. In other words, it must be simple enough so that users can understand the critical assumptions, understand how the model works, collect the necessary input data, and not be so time consuming or costly to run so that users can test the potential impact of the various assumptions.

These modelling requirements are not unique to forestry. They are nothing more than basic common sense, yet it is amazing how difficult it often is to balance these concerns.

REFERENCES


USING MODELS TO EVALUATE
TIMBER SUPPLY POTENTIALS

Howard M. Hoganson

ABSTRACT. Computer models can help make decisions by synthesizing enormous amounts of data into forms that are easy to interpret. The range of potential model uses in forestry is large ranging from region-wide, long-range predictions to optimal, short-term, procurement strategies for individual firms. A major difficulty in modelling forestry problems is describing the many important aspects of the problem. Important aspects range from the biological complexity of timber stands to forest-wide management concerns to marketing considerations and uncertainties. Recent advances in computer technologies will help address this complex problem.

INTRODUCTION

Models are simply representations of reality. They can have an enormous value as a learning tool. For forest management, their use dates back to the forest regulation models of the 1800's developed in Europe. These early models basically described the ideal forest and the process of converting the forest to the ideal state. Many of the concepts of these models are still the backbone of some forestry programs in this country, but some major questions have arisen: Can we identify the ideal future state for the forest? Are the increased benefits from an ideal forest worth the cost of achieving it? Economic efficiency has become a major concern. Society today is more complex with many global interrelationships and changing technologies making many aspects of the future unpredictable, certainly in the long time frame of growing timber. But forest management decisions still must be made today. Fortunately, with the advent of the computer and constantly improving computer technologies, more complex models can be applied to help guide decision making. In general, computer models can help synthesize information into a form that is easier to interpret. Without computer models the enormous amount of information we collect would be difficult if not impossible to utilize.

A WIDE RANGE OF USES FOR "SCHEDULING MODELS"

The term "harvest scheduling model" has probably been the most common term used to describe the computer models used to aid forest management decision making. This expression is quite misleading because these models are not used just for scheduling harvests. A recent forest management text (Davis and Johnson 1987) suggests using the expression "forest management scheduling" for models that recognize a wide range of management activities and forest outputs besides timber.

Although an improvement, this term can also be misleading because the primary function of these models is often not to develop a specific management schedule for the forest. Computer models can help analyze forestry opportunities in a number of different ways. Besides being

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1 Assistant Professor, University of Minnesota, North Central Experiment Station, 1861 Highway 169 East, Grand Rapids, MN 55744.

used to help develop a management schedule for a specific forest, "scheduling models" can be used to:

1. help predict future timber availability for alternative industrial expansion opportunities at specific plant locations;

2. help predict the impact of industrial expansion on the timber procurement costs for other wood users;

3. help determine the mix of forest industries that might be best suited for the timber supply capabilities of a region;

4. help identify how forest management might be coordinated between land management groups to improve management efficiency;

5. help predict how forest production in a region will contribute to the national forestry situation;

6. help determine the impact of alternative forest budget levels;

7. help evaluate management policies such as even flow or designated wilderness or recreation areas;

8. help determine the impact of specific landowner groups on the overall timber supply situation--for example, nonindustrial private landowners,

9. help evaluate the potential of new or more intensive forest management practices such as new improved genetic stock, short-rotation intensive culture, or thinning or fertilization options;

10. help design and evaluate potential new forest road networks;

11. help evaluate the potential impact of new forest harvesting systems or changes in timber utilization standards;

12. help design and evaluate prevention and control programs for potential forest hazards such as insects and disease or fire;

13. help determine the need and emphasis for additional forest surveys or data collection efforts.

Looking at this list it is clear that "scheduling models" can have a wide range of potential uses. Perhaps the question of what models can’t be used for is more relevant! However, an important aspect to recognize is that models only help managers make decisions. The extent to which a model can help depends on how accurately and precisely the model describes the problem. Undoubtedly, a model is of little use if it does not reflect the real world problem. In an earlier paper presented at this conference (Rose, 1988) points out that the basic requirements of a good planning model are that it is simple enough to be useful and yet complex enough to accurately describe the problem. A major reason why timber supply situations are so difficult to analyze and understand is the complexity of the problem and the
associated difficulty in building a model that describes all the important aspects of the problem.

IMPORTANT ASPECTS OF FORESTRY PROBLEMS

The most difficult process of modelling a problem is "structuring the problem" or describing the problem in mathematical form. For most forestry problems it is difficult to determine how much emphasis should be given to the various aspects of the problem. To get an understanding of this modelling problem, one only needs to consider the many and interrelated aspects of most forestry problems that could be important:

1. *Multiple products*--the forest produces a wide range of products, both timber and nontimber. Usually it is difficult to analyze opportunities without considering all products.

2. *Distance to market*--the location of stands in relation to the market is extremely important. The costs of transporting the products to market are often a large proportion of the total production cost.

3. *Stand accessibility*--developing access to a stand can be a significant cost. Without higher prices, some biologically mature stands are not possible to harvest at a profit simply because roadbuilding costs would be too high. Other related factors are the seasonal limitations of access and harvesting. In general much more timber is available to the market when the ground is frozen.

4. *Multiple products in each stand*--harvesting a stand can produce multiple products, all of which are not necessarily shipped to the same market. Harvesting a stand for one product thus might help increase the supply of another product in another market. Methods for allocating production costs to the individual stands are arbitrary. The production process must be viewed as a joint process.

5. *Multiple markets*--seldom is there one buyer to consider for a specific product from a specific stand. Price differences between markets are the significant factor affecting the allocation.

6. *Substitutable stand outputs*--some stand outputs can be used for several products. For example, a large log might be shipped to either a sawmill, a pulp mill, or a fuelwood market. The end-use will depend on the differences in transport costs and delivered prices.

7. *Long production periods*--it takes time for trees to grow. Long planning horizons are generally needed.

8. *Uncertain timber demands*--Future timber supplies depend on prior harvest levels. Because harvest levels depend on timber demand, it is necessary to consider timber demand when analyzing timber supply. Predicting timber demand is extremely difficult because many factors are involved. Prices of both substitutable and complementary products can be important factors. Demand for many forest products are also tied closely to the cyclical construction industry or the potential for sales outside the region or even in foreign markets.

9. *Imports of timber supplies from other regions*--it is essentially impossible to define a study area and evaluate the timber supply situation in that region without also recognizing the supply
potential of other regions. Depending on the product, not only neighboring regions but world markets might be important.

10. **Differences in stand characteristics**—stands usually differ not only in age but also in terms of current species mixes, relative stocking levels and general site productivity potential.

11. **Future production opportunities**—an important consideration is the impact of immediate actions on future returns. Specifically, each stand has a landholding cost (or benefit) that is due to future opportunities foregone (or postponed) by not harvesting and regenerating the stand today. This cost depends on the current stand growth rate and the quality and location of the site.

12. **Alternative management intensities**—thinning is one potential management tool. Other tools are fertilization, weed control, and general timber stand improvement options. The number of alternatives available is generally large, especially if the timing and intensity of thinnings are important.

13. **Multiple harvest systems**—harvest options can range from traditional roundwood operations to tree-length logging to full-tree chipping to chip-and-sort operations. With some of harvesting methods there are also a range of plausible harvest equipment combinations.

14. **Multiple ownerships**—within a region, lands are seldom all under a single ownership or are managed for the same objective. Predicting landowner actions is a difficult task.

15. **Changing land base**—the amount of forest land changes over time. Marginal agricultural land might be converted to forest land or forest land might be converted to other land uses.

16. **Growth and yield uncertainties**—forestry deals with a biological process that is in itself difficult to predict. There are also potential catastrophic events of concern such as disease outbreaks, drought or fire. It is extremely simplifying to assume that all acres respond to treatment in an "average" manner.

17. **Spatial interactions**—the management of one stand is seldom independent of the management of nearby stands. For example, a new road will often access several stands or land uses like timber production and wilderness are often not compatible on adjacent acres.

18. **Limited resources for management**—although numerous options are available for forest management, available dollars, manpower or machines are often an important concern.

19. **Forest policy guidelines or directives**—many public land management agencies as well as some private landowners have management guidelines that they must follow. These guidelines can limit the options available for individual stands as well as the net product flows for the entire forestry program. For many, the guidelines or constraints are not necessarily fixed if analyses can show that their potential benefits are less than their costs.

20. **Sequential decisions**—forest management is a dynamic process. Only those decisions that require immediate action must be made today. Future actions can depend on how the future unfolds. However actions taken today can influence the range of options that will be available for future decisions.
From this list it should be clear that it is essentially impossible to develop a model that can accurately describe all aspects of the forestry situation. Certainly the conceptual forest regulation models seem extremely simplified after considering all these aspects of the problem. Obviously a real concern about the models used is whether the model is a too simplified representation of the problem.

**MAJOR MODELLING DIFFICULTIES**

The modelling process involves three basic steps: data collection, model development, and application and interpretation of results. Here we will focus on the problems of model development, but it is important to at least briefly point out the potential problems of the other steps. For data collection, it is important to recognize that most models are extremely data intensive. Data are required for all the important aspects of the problem. This usually includes information on the existing forest inventory; growth and yield projections including estimates for natural regeneration; and harvest, transport, roadbuilding, and regeneration costs. For the application and interpretation of results, it is important that users understand the model being used, especially the critical assumptions or weaknesses of the model. Unless users understand the model, its unlikely that they will understand how much they should rely on it or even fully understand how they can utilize it.

In selecting a general model form, models have the general characteristics (weaknesses) of the form selected. For forest-wide or "scheduling" problems, the two most common forms are linear programming (LP) models and simulation models. Numerous texts are available that describe in detail the characteristics of LP models. Davis and Johnson (1987) describe in detail these two modelling forms as they relate to forestry. LP models are desirable because they can find optimal solutions for the problem as formulated, but model size is a problem for many forestry applications. Simulation models are better suited for recognizing more complex relationships, but simulation models do not "solve" problems, they only mimic the situation. Recently Hoganson and Rose (1984) developed a modelling approach that uses some of the general characteristics of both model forms. Essentially the method decomposes the model into smaller problems and uses simple search techniques and an economic interpretation of the problem to search for the key variables of the problem. With this approach a large model does not necessarily imply a complex model because the large problem is broken into parts, each of manageable size. With this approach a large number of stand types can be recognized and thus recognition can be given to the significant differences between stands. A general description and example of this relatively new and specialized modelling method is given by Johnson and Davis (1987).

The three most challenging aspects of modelling forestry problems are: (1) the spatial aspects of the problem, (2) uncertainty as it relates to the basic data and the sequential nature of decisions and (3) the large size of the problem. Spatial aspects of the problem are difficult for two reasons. First, because of the potential interactions between stands, alternatives for neighboring stands need to be considered simultaneously. This does not necessarily increase the size of problem, but it adds considerable complexity. Second, locational aspects as to specific markets for products harvested can add another very large dimension to the problem and make the number of potential management options for some stands enormously large. For example, consider a management sequence for a single stand that has harvests in three time periods. If each harvest produces 5 different products, hardwood and softwood sawlogs, hardwood and softwood pulp, and fuelwood, and each product can be shipped to one of four possible markets, then by adding market destination as a descriptor to define management alternatives, the number of management alternatives increases from 1 to over 1 billion! And
this does not even consider the possibility of using higher quality material for "lower-valued" uses, i.e. pulpwod quality material as fuelwood! Using basic linear programming techniques, one variable is needed for each alternative.

Considering that almost all data used in the modelling process has some associated uncertainty surrounding it, it should not be surprising that uncertainty is a problem. For many aspects of uncertainty, very little information is available for developing confidence intervals on estimates or probability estimates for possible outcomes. The need to recognize uncertainty is fairly well documented in the literature, but relatively few methods are available for addressing it explicitly. In general, with an uncertain future, there is the need to keep options open and allow managers to react to uncertainty as it unfolds. Uncertainty is difficult to model because of the many aspects of uncertainty involved as well as the complexity of the process by which the future unfolds (Hoganson and Rose 1987). Also, once one recognizes uncertainty, one must also address ones attitude towards risk and the utility of the potential outcomes. For example, is the landowner risk neutral and thus interested in maximizing expected return, or is the landowner more concerned about the consequences of a worst case outcome? In general, problems are generally large even when the future is assumed to be known. Current modelling methods can recognize some simplified aspects of uncertainty, but even that usually requires a significant increase in both model size and complexity.

Model size is a problem because of the many aspects of the problem. Model formulations must often be simplified to keep formulations of practical size. A common problem is classifying the stands and aggregating the data to meet model size limitations. Balancing the emphasis given to each aspect of the problem is difficult with few guidelines available. Generally, the classification scheme is likely to significantly impact the ability of the model to be used to examine certain aspects of the problem. Unfortunately, the classification scheme used must be identified at the beginning of the modelling process when it is often not clear as to what questions are most important to address. Later, after more is learned about the problem, one can always go back and make changes, but changes can be costly because of the work required in data collection and synthesis.

STRATEGIES FOR SIMPLIFYING PROBLEMS

Models must be simple enough to be useful. Undoubtedly, one cannot expect that one model can be developed to answer all questions. The scope of modelling efforts can range enormously. One might want to minimize costs for a single mill or predict future timber supplies for an entire region. In each case, the overall objective, scope of analysis and time frame are likely to be significantly different. However, it is likely that many different models can share information and model components. A modular approach to modelling is thus highly desirable. Also, not only can different models share components, but it is likely that models can be linked such that results of one model can serve as input to another model. As an example, the resulting shadow prices describing regional concerns from a regional model could be very useful as price inputs to help recognize regional concerns in more site specific models. However, there is a danger of oversimplifying in attempting to decompose the forestry problem and solve it in parts. For example, it is difficult to separate the interdependencies of harvest decisions and regeneration decisions so separate models for harvest decisions and regeneration decisions are not likely to work well. In decomposing problems into subproblems, it is important that the linkages and associated assumptions are clear and their implications understood.
Another key aspect in model development and use is the understanding of exactly how the model will be used to help make decisions. For example, it is important to recognize which decisions cannot be delayed until more information becomes available. In general, it is desirable to give more emphasis in the model to the immediate future with the idea that more analyses can later be performed for decisions that are not needed until later. Also, it is important to recognize initially that multiple model runs are almost always needed to test model assumptions. To test some assumptions considerable savings might be possible by starting from an intermediate or even final solution for a prior set of assumptions. In some cases it might be possible to automate the process of performing a sensitivity analysis concerning assumptions. Also it is important to recognize that the final solution itself often contains an enormous amount of useful information besides an "optimal" solution or schedule. This is especially true with linear programming models.

NEW MODELLING TECHNOLOGIES

New modelling and computer technologies will be extremely useful for forestry problems. Concepts of artificial intelligence and expert systems could be extremely useful in the modelling process. With expert systems it is likely that it will be possible to incorporate an understanding of the problem into the modelling process so that the problem will never need to be specified or enumerated completely. This has already been applied by Hoganson and Rose (1984) to some extent in both their solution process and in their methods for valuing ending inventory. Another area to which this concept could apply is to model the spatial aspects of multiple markets and the combinatorial nature of that problem. New data base systems and geographic information systems should also greatly enhance our abilities to work with large amounts of data and give more recognition to spatial problems. Faster computers with multi-task processing should also help in addressing larger more complex formulations. Satellite imagery is also likely to play a major role in the near future in the inventory process and help overcome many of the data problems associated with analyses aimed at addressing specific questions related to timber supply.

CONCLUSION

Models play a large role in the forest management decision-making process. Computer models help synthesize enormous amounts of information that could not otherwise be recognized in the decision-making process. They can be used to help make decisions for a wide variety of forestry problems. The extent to which models can be used depends on how accurately the problem can be described in a modelling framework that is simple enough for users to use and understand. Forestry problems are challenging problems to modellers because most problems are extremely large and complex. It is not surprising that the timber supply situation in Minnesota is still so difficult to understand or predict. More research is needed to tackle some of the more difficult aspects of the problem, but increased experience and new advances in computer and modelling technologies make the outlook very promising for models that will help significantly in gaining a better understanding of the resource management opportunities.
LITERATURE CITED


TIMBER DEMAND: CHANGING UTILIZATION AND NEW PRODUCTS

James L. Bowyer

ABSTRACT. A historical examination of timber use in North America shows steadily increasing demand over time. Assessment of the factors which influence timber demand show that development of new technologies and new products have a major impact upon needs for wood raw materials. Technology developments will be pivotal in the further development of Minnesota's forest products industry.

INTRODUCTION

The U.S. has a substantial and dynamic forest products industry which consumes vast quantities of wood raw materials. Minnesota's forest products industry is likewise substantial and the Minnesota industry is one of the fastest growing in the country.

Given the fact that industry growth beyond the level that the forest base can sustain it is undesirable, a question which must be addressed is "how much industrial growth will our forest support?" The answer depends upon factors such as the rate of forest growth as well as, of course, the levels of wood demand on the part of industry. This second factor, industrial demand for wood, has historically been very much influenced by development of new technologies and new products. Changing utilization technologies and new product developments will be pivotal in the further development of Minnesota's forest products industry.

THE U.S. FOREST PRODUCTS INDUSTRY

Today, wood is an important raw material, used worldwide in the production of paper, shelter, furnishings, and virtually thousands of other products. In the U.S., wood is clearly the principal industrial raw material. Single family homes are almost all of wood frame construction, and the vast majority of interior furnishings are wood. Poles, posts, railroad ties, pallets, and shipping crates are made of wood, as are books, newspapers, tissue, and packaging of all kinds. Wood products even include plastics, lacquers, fabrics, and photographic film. Tremendous quantities of wood are used. In fact, wood products consumed annually in the U.S. have a combined weight that exceeds 100 million tons, and a value that approximates 27 percent of the annual value of all U.S. industrial raw materials combined. The U.S. forest products industry employs over 1,600,000 people and produces about $120 billion worth of goods annually in some 50,000 manufacturing plants.

MINNESOTA'S FOREST PRODUCTS INDUSTRY TODAY

Minnesota's wood products industry is large and growing. In 1986 the industry generated approximately $4 billion in sales and employed over 52,000 people.

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1 Professor and Head, Department of Forest Products, University of Minnesota, 2004 Folwell Avenue, St. Paul, MN 55108.

The State's industry is characterized by a vigorous paper manufacturing sector, which produces high value printing grades, the nation's largest concentration of OSB mills, the nation's sixth largest production of wood cabinets, two of the top three wood window manufacturers in the U.S. (Andersen and Marvin), a large number of small to medium sized hardwood and softwood sawmills, a growing furniture and fixtures sector, and substantial activity in paper printing, folding, and converting, wood moulding and millwork, hardboard and nonpaper fiber products, and specialty wood products. Overall, paper dominates the basic forest products picture, accounting for two-thirds of receipts. The economic contribution of secondary manufacturing (i.e. the further manufacturing of Minnesota forest products and the remanufacture of imported wood into such items as wood furniture, fixtures and paper products) is roughly triple that of pulp and paper (Table 1).

Table 1. Forest products industry in North America and Minnesota.

<table>
<thead>
<tr>
<th>Product</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulp And Paper</td>
<td>$870,972,000</td>
</tr>
<tr>
<td>Board*</td>
<td>213,068,000</td>
</tr>
<tr>
<td>Lumber, Logs, Bolts</td>
<td>82,502,000</td>
</tr>
<tr>
<td>Fuelwood</td>
<td>54,607,000</td>
</tr>
<tr>
<td>Specialty Wood Products</td>
<td>47,150,000</td>
</tr>
<tr>
<td>By-Products, Mill Residue</td>
<td>22,575,000</td>
</tr>
<tr>
<td>Christmas Trees, Wreaths, Etc.</td>
<td>13,440,000</td>
</tr>
<tr>
<td>Railroad Ties</td>
<td>2,695,000</td>
</tr>
<tr>
<td>Posts, Poles, Piling</td>
<td>2,125,000</td>
</tr>
<tr>
<td><strong>SUBTOTAL</strong></td>
<td>1,309,134,000</td>
</tr>
<tr>
<td><strong>Value Of Secondary Manufacturing</strong></td>
<td>2,677,091,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>3,986,225,000</td>
</tr>
</tbody>
</table>

* Waferboard, Oriented Strand Board, Hardboard.
**Further processing of Minnesota forest products and the remanufacture of imported wood (e.g. paper products, wood products, wood furniture and fixtures.)

Source: Minnesota Forest Industries (1988)

Growth of Minnesota's industry is rapid. Industry expansions and improvements since 1977 (including planned expansions) total over $2.3 billion, much of which has been announced in just the last two years (Tables 2 and 3).
Table 2. Minnesota forest industry expansion 1977-1986.

<table>
<thead>
<tr>
<th>Name</th>
<th>Product</th>
<th>Initial Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potlatch (Cloquet)</td>
<td>Pulp/Paper</td>
<td>$100 Million</td>
</tr>
<tr>
<td>Potlatch (Bemidji)</td>
<td>OSB*</td>
<td>$40 Million</td>
</tr>
<tr>
<td>Potlatch (Cook)</td>
<td>OSB</td>
<td>$40 Million</td>
</tr>
<tr>
<td>Northwood Panel Board (Bemidji)</td>
<td>Waferboard</td>
<td>$45 Million</td>
</tr>
<tr>
<td>Champion International (Sartell)</td>
<td>Paper</td>
<td>$250 Million</td>
</tr>
<tr>
<td>Blandin (Grand Rapids)</td>
<td>OSB</td>
<td>$50 Million</td>
</tr>
<tr>
<td>Louisiana Pacific (Two Harbors)</td>
<td>Waferboard</td>
<td>$30 Million</td>
</tr>
<tr>
<td>Lakewood Industries (Hibbing)</td>
<td>Veneer For Chopsticks</td>
<td>$6 Million</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$561 Million</td>
</tr>
</tbody>
</table>

Internal improvements and modernization at the locations listed above, as well as other existing facilities: $350 Million

*Oriented strand board


Table 3. Minnesota committed forest industry expansion 1987 to completion.

<table>
<thead>
<tr>
<th>Name</th>
<th>Product</th>
<th>Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blandin (Grand Rapids)</td>
<td>Paper</td>
<td>$350 Million</td>
</tr>
<tr>
<td>Potlatch (Cloquet)</td>
<td>Paper</td>
<td>$100 Million</td>
</tr>
<tr>
<td>Lake Superior Paper (Duluth)</td>
<td>Paper</td>
<td>$404 Million</td>
</tr>
<tr>
<td>International Bitrite (International Falls)</td>
<td>Sheathing Board</td>
<td>$12 Million</td>
</tr>
<tr>
<td>Potlatch (Bemidji)</td>
<td>OSB</td>
<td>$36 Million</td>
</tr>
<tr>
<td>Boise Cascade (International Falls)</td>
<td>Paper</td>
<td>$525 Million</td>
</tr>
</tbody>
</table>

Total: $1,427 Million

Source: Adapted from Minnesota Forest Industries, Inc. (1988).

A HISTORICAL VIEW OF FOREST PRODUCTS INDUSTRY DEVELOPMENT

Development of the U.S. and North American forest products industry has been greatly influenced by the introduction of new processing technologies and new products. Almost every new technology and product introduced has led either to an increase in the amount of raw material converted to useful product, or to an expansion of the type or form of raw materials that could be used. In the paragraphs which follow, industry development over a forty-year time span will be traced briefly, and the effect of technology changes upon development will be noted. For the first thirty-year period, observations of accomplishments in utilizing old growth Douglas-fir in Oregon (Bingham 1975) will be used. Data gathered by Bowyer et al. (1987) is used throughout this section.
1948

In 1948, one acre produced 17,900 ft$^3$ of logs which yielded:

- 3,600 ft$^3$ of lumber
- 14,300 ft$^3$ of waste

In that same year, roughly 50 percent of all kitchen cabinets produced were made of birch.

Hardboard, which had been introduced in 1926, was still little used, and hardboard siding accounted for less than 0.1 percent of the total siding market.

1963

By 1963, the 17,900 ft$^3$ of Douglas-fir timber yielded:

- 4,600 ft$^3$ of lumber
- 3,800 ft$^3$ of paper
- 800 ft$^3$ of plywood

Total: 9,200 ft$^3$ of products
- 8,700 ft$^3$ of waste (some of which was used for fuel)

-- The popularity of oak for kitchens and trim had begun to rise appreciably.
-- Particleboard, which had been introduced some eight years earlier was still insignificant in terms of market share.
-- Hardboard siding now accounted for 9 percent of the U.S. siding market.
-- Vinyl siding was shown at world's fair in 1963.

1973

By 1973, the 17,900 ft$^3$ of Douglas-fir timber yielded:

- 5,000 ft$^3$ of lumber
- 1,700 ft$^3$ of plywood
- 5,900 ft$^3$ of paper
- 1,500 ft$^3$ of particleboard

Total: 14,000 ft$^3$ of products
- 3,800 ft$^3$ of mostly wood fuel

-- Also by 1973, oak had assumed a dominant position in the cabinet industry, accounting for about 80 percent of U.S. sales.
-- The Chip-N-Saw, or chipper-canter, commercially introduced in the mid-1960's, was now a familiar scene in the nation's sawmills. Rajala Timber brought the first machine to Minnesota about 1970. The development led to a rapid increase in processing of small-sized logs to lumber.
-- Best opening face technology, which gave increased yield from logs in sawing through computerized log positioning, was introduced in 1971.
Development of the retractable chuck lathe made it possible to economically peel small logs to veneer. Introduced in the mid-1960's, this development led to the birth and rapid expansion of the southern pine plywood industry.

Hardboard siding had grown to a 20 percent market share (from 9 percent 10 years earlier); vinyl had grown to a 5 percent share, up from 0 ten years earlier.

Waferboard came to Minnesota, with the nation's first mill - 1971 (Blandin Wood Products). In that year, waferboard accounted for 0.05 percent of the U.S. structural panel market.

Patents were issued in 1968 and 1971, respectively for wood structural I-beams, and for laminated veneer lumber (LVL), respectively.

1983

By 1983 those 17,900 ft³ of Douglas-fir timber were supplemented by a substantial volume of smaller trees that could now be economically removed from the harvesting site.

In that year:

-- Particleboard was well established as core stock and underlayment. Serious challenge from MDF in core markets.
-- Oak accounted for roughly 95 percent of all wood cabinets produced.
-- Waferboard shared the market with OSB, and together the two products accounted for 5.5 percent of the U.S. structural panel market.
-- Wood structural I-beams and LVL were both being sold on the commercial market. This raised the possibility of regions with small diameter timber competing in structural lumber markets.
-- Hardboard siding had increased its market share to 31 percent of the U.S. siding market.
-- Vinyl siding had increased its market share to 12 percent.
-- A new product, the all vinyl window, was introduced in 1980. Market share was 3 percent by 1983.
-- Centerless lathe technology had been introduced.
-- Technologies for producing lightweight coated papers had been developed in Europe.

1988

-- Minnesota was the nation's leading composite panel (OSB) producer.
-- BOF technology was used in 40-50 percent of softwood sawmills in U.S., accounting for approximately 75 percent of production.
-- Veneer overlay technology has developed to very sophisticated level. Overlaid products was increasingly common in the market, challenging solid wood moulding, trim, and panel products.
-- LVL, I-beams increased in popularity in the market with wide application in homes where high strength needed and substitution for steel in commercial/industrial applications.
-- Parallel strand lumber (parallam) was introduced in 1986 and became an immediate competitor in structural lumber market. This development, along with LVL and I-beam technology bring into question the future value of large sawlogs.
-- Hardboard siding market share decreased to 24%, vinyl siding share increased to 23%.
-- Overlaid OSB siding was now on the market.
-- All vinyl windows commanded 7 percent of total domestic window market and 13 percent of window replacement market.
-- Paper honeycomb core panels were becoming common on the building panel, specialty panel market.
Lightweight coated paper mill was now in Minnesota (Lake Superior Paper).

Many more examples could be given. The message here is that technology is constantly changing, improving. And with each advance, we are able to use a greater and greater portion of available raw materials and with ever greater efficiency. What is happening today in the research laboratories and pilot plants will have a major impact upon both the volume and form of raw materials needed in the future. Moreover, technology development is increasing at an accelerated rate. New products of wood, and wood-nonwood materials, and new processing technologies will have a continued and major impact upon raw material needs.

We can get a glimpse of what lies ahead by looking at currently developing technologies:

-- Structural paper products
-- Lower basis weight papers
-- More use of hardwood in structural lumber
-- Increased popularity of composite lumber (as further technology developments lower processing costs and as juvenile wood concerns increase)
-- Low thermal bridging studs
-- Development of wood-nonwood composites
-- Biological pulping
-- Rapidly developing wood-based chemical technology
-- Surface enhancements for wood
-- Development of wood stabilization technologies

What will these developments mean to Minnesota’s wood products industry? The only thing we can say for certain is that these technological developments will bring change. On the one hand, we may view these as a threat. On the other, we can see these changes as opportunities to strengthen and diversify our already very vital industry. From the point of view of the forester, the future almost certainly means that we will be able to make more from less. It is also likely that forms of raw material and species not now in demand will become important and valuable raw materials.

LITERATURE CITED


FUTURE TRENDS IN LAND USE

Philip M. Raup

ABSTRACT. Major shifts in future rural land use will likely reflect residential and recreational demands originating in urban populations. Changes in when and where work is done and the rise of an economy based on services will appreciate the amenity value of waters and woodlands. The future growth sector in American forestry will probably focus on the production of services rather than timber.

AGRICULTURAL LAND USE

In dollar value of products and services, agriculture is the dominant use of America’s land. In acre terms, however, the 469 million acres of cropland enumerated in 1982 were only 20.7 percent of the total land area of 2,265 million acres for the 50 states. Grassland pasture and range comprised 597 million acres, or 26.3 percent, and forest land made up 655 million acres or 28.9 percent. The remaining 24 percent or 544 million acres included lands in transportation or recreation uses, urban areas, other special uses, and marsh, swamp, desert and waste lands (Frey and Hexem 1985).

Cropland planted or in summer fallow, in peak years, has rarely exceeded 80 percent of the area classified as cropland. In 1981 the 387 million planted or fallowed acres were 82.5 percent of total cropland acres. This can be regarded as the historical peak in national cropland capacity utilization.

A more interesting trend involves the acreage of cropland actually harvested. For the ten years, 1976-1985, harvested cropland averaged 334 million acres, slightly below the annual average of 336 million acres harvested in the ten years, 1911-1920. Since 1910, the maximum acreage harvested was 361 million acres in 1932 and the minimum was 286 million acres in 1969. With 1977 used as a base of 100, the index of total cropland acres used for crops was never above 102 and never below 87 in the 75 years from 1910 through 1984.

The remarkable nature of this relative stability is apparent if we remember that in this period corn production increased 2.7 times, wheat 2.95 times, and over 60 million acres were diverted to soybeans, a crop that was not even reported officially until 1924 (Raup 1987).

This national pattern of stability in the cropland base is mirrored in Minnesota, but with significantly greater variability. Minnesota’s harvested cropland acreage averaged 19.2 million acres in 1942-51, approximately 19.4 million acres in the 1950’s, and dropped below 18 million acres in the 1960’s. The low point was reached in 1969, with only 16.9 million acres used for crops (including crop failure and summer fallow). Crop acreage climbed rapidly in the boom days of the 1970’s, to a peak of 21.8 million acres used for crops in 1982 (USDA, Agricultural Statistics, various years). From 1969 to 1982 the increase was 5.9 million acres, or 28.9

1 Professor Emeritus, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul, MN 55108. Helpful comments by C. Ford Runge are gratefully acknowledged.

percent. Declines after 1982 brought this down to 19.0 million acres of land planted to crops (excluding summer fallow) in 1987 (Minnesota Agricultural Statistics, 1988), almost exactly to the level of the war years of 1941-1945.

Forecasting future trends is made doubly difficult by the current drought, and by the large acreage of cropland idled under government programs. The 1982 Census of Agriculture reported a total Minnesota cropland acreage of just over 23 million acres. Of this total, 4.8 million acres had been idled as of October 1987, including 3.3 million set-aside acres under the ACR programs and 1.5 million acres in the Conservation Reserve, for a total of 21 percent of all cropland acres. Most of the 3.3 million set-aside acres could quickly be returned to crops. It seems probable that the cropped area will increase in 1989 and could easily remain above 20 million acres into the 1990’s.

The magnitude of any increase from 1987-88 levels will be determined largely by export demand. Over two-thirds of Minnesota’s crop acres in 1987 were planted to corn, soybeans, and wheat. If we assume that Minnesota shared in exports of these crops in proportion to its share in national production, then approximately one-fourth of Minnesota’s crop acres produced for export in 1987, and this percentage could well increase if world demand continues strong and U.S. grains are competitively priced. In any case, land use shifts in Minnesota agriculture seem destined to be dominated by the ups and downs of foreign demand for grains and soybeans.

Will these trends in agricultural land use affect future timber supply in Minnesota? The answer probably is: not very much. The boundary between agriculture and forestry has undergone successive waves of agricultural expansion and contraction. Soil and climate determinants have shaped zonal boundaries in the northern part of the state that have been quite durable for the past half-century. It is noteworthy that very little of the expansion in cropland acreage of nearly 29 percent from 1969 to 1982 involved any conversion of forest land.

The more powerful trends affecting forest land use will arise outside of agriculture. They will involve basic shifts in cultural values and behavior patterns that go beyond the conventional limits of economic analysis. The remainder of the paper will explore some of these less tangible but more powerful variables.

THE RISKS OF RISK REDUCTION

A pervasive recent development in the U.S. economy, with long-run implications for land use, is the transfer of risk from individuals to the state. This takes many forms, and only a few can be discussed here.

The evidence is clear that government-supported guarantees of bank and savings and loan deposits have fostered careless lending. With fear of a "run on the bank" removed, lending officials have taken risks they would not take if loss of depositor confidence were still a constraint. In savings and loan associations, this reduction of risk fed directly through the credit system into the real estate market, first for housing and more recently for commercial real estate lending. The effect was especially great after about 1980.

A similar process has been at work in farming. Commodity price supports have removed one element of risk involved in farm production decisions. As a result, farmers have taken on
more debt to expand, and now embrace monoculture on a scale that they would not dare if the threat of product price collapse were real.

Social Security has resulted in a parallel response in household finance. The pressure on individuals to save for health reverses or for old age has been reduced. They can risk spending up to or beyond levels justified by current income, with the result that consumption expenditure takes precedence over savings and investment.

In each of these cases risk has been transferred from individuals to the state, which means to individuals as taxpayers. Risk, in short, has been socialized. One consequence is that the magnitude of risk is obscured and has become more difficult to calculate. A false sense of confidence has been established, and when reverses do come their psychological impact is severe. Adjustments to change are best made at frequent intervals, in small steps. The socialization of risk raises the possibility that small corrections will be postponed until the need reaches crisis proportions.

Change, and its twin sister risk, are facts of life. The transfer or postponement of risk is not equivalent to its elimination. If risk cannot be appraised accurately by individuals, and is transferred to the state, then a greater intrusion by the state into the economic decisions of individuals is inevitable. The danger is that the machinery of state will be unable to evaluate risk, or to act promptly upon evaluation, and that exposure to risk will simply accumulate until there is an explosion.

The implication of this danger for land use is that the suppression of risk has fostered over-lending and over-building in commercial and residential real estate, and over-expansion in agriculture. The risk that has been removed or disguised in profit-and-loss calculations has been capitalized into the value of land and structures, both by businesses and households. As a result, contemporary U.S. real estate contains an element of fictitious value. This must eventually be squeezed out, and the process is well under way but far from completion. The collapse of farm land values after 1981 was the first major readjustment. The current difficulties of banks and savings and loan associations in Texas and California continue the process. More is to come.

This process of revaluing real estate to acknowledge real risk will affect the speed and extent of urban expansion, and the pace of housing construction and farm recapitalization. The effect on rural lands is likely to be especially sharp. One of the most powerful demands in an affluent society is for space. Congestion is one of the negative dimensions of urban life that is most difficult to tolerate. Attempts to escape urban congestion have been driving forces in the use of land around urban-industrial centers, and often in more remote rural and forested regions. This demand for a rural life style has been fostered by easy credit and a defective evaluation of risk. The corrective process will dampen this demand for nonfarm residential and recreational uses of rural lands. It is unlikely to stop it, for reasons explored in the next section.

THE SEPARATION AND RECOMBINATION OF HOME AND WORKPLACE

The separation of where you live from where you earn your living is one of the great transitional milestones in human history. The social fabric in developed industrial economies is still dominated by agrarian behavior rules, social norms, and prescriptions for problem solutions that reflect a presumed coincidence of the residence and the workplace.
The industrial city involved a break in this connection. The growth of industrial labor forces in the 18th and 19th centuries required massive rural to urban migration, and the new migrants rarely owned their own homes. It had been presumed for two centuries that industrial workers did not have the mind-set acquired by the owners of landed property. In the Marxist creed, this presumption was incorporated into the definition of the working class: they were not property owners. The hall-mark of the industrial city was the separation of home and workplace.

A subsequent step in the evolution of urban-industrial life was the shift from rental to owner-occupied housing. The typical worker or employee in the U.S. today does not own tools nor have an ownership interest in the product or service produced, but home-ownership is the norm. In 1980, 65.6 percent of households lived in owner-occupied homes. This percentage slipped slightly in 1985, but with the entry of the baby-boom generation into the high ownership years, "the overall ownership rate will inexorably rise towards 70 percent or higher" (Diamond 1986).

The next step in separating the home from the workplace has been the move to the suburbs, and beyond. This expression of the residential demand for space has been heavily weighted with an associated demand for water, and for forests, or at least woodlands. Our cities exploded.

Expansion of the area that can be classified as "urban" is not an adequate measure of the resultant shift of rural land to urban uses. In terms of acres, the big impact of urbanization on land use is through the conversion of agricultural and forest land to rural residential or recreational use, at densities of settlement so low that the land is unlikely to be classified as "urban" for many years, if ever. We now have a growing category of land use that is "nonfarm" but also "nonurban."

Historically, and in many occupations, when a person worked has been intimately related to where the person worked and lived. The concept of a "factory" or an "office" required the concentration of labor and materials, enabling continuous production runs, and minimizing transport time. This dictated a clustering of land around the factory or office site, and created the commuting belt as the determinant of the spread and shape of cities.

This tie between when work is done--the temporal dimension--and where it is done--the spatial dimension--is now being relaxed. The revolution in communications and continued advances in transport permit greater decentralization of many types of productive activities. This enables residential amenities to play a larger role in determining where a labor force will live.

At the same time, the range of choices of when to work has been enlarged. The stereotyped concepts of the work day and the work week are being altered. Work in many professions and services can increasingly be done at a time most convenient for the worker, and at a location of the worker's choice. These changes alter fundamentally the determinants of rural land use, both farm and forest. They have already eroded the boundaries of cities, and have introduced demands for urban services into areas once considered distinctly rural.

Two transition streams in this growth in rural residential land use are converging. One is the continuing expansion of the demand for second homes for seasonal use. The other is the accelerating demand for second homes for uses that compete with or even supplant the uses of the primary residence. In past usage, the term second home was largely a misnomer. They were not really homes, but safety-valves or escape hatches, to meliorate the congestion and
frustration of city life or industrial jobs. Their distinguishing characteristic was a focus on leisure. What is relatively new in rural nonfarm land uses is the conversion of seasonal use into more nearly year-around use with an associated demand for year-around urban levels of services.

An even more recent development is the appearance of rural residences that really are second homes and whose location has been selected with both work and leisure in mind. This was always a feature of the "stock-broker" or "banker" belts around large financial centers, notably New York and Chicago in the U.S., and London, Paris, Zurich, or Geneva, in Europe. This pattern is now expanding to include more than an occupational group with favorable working hours. The modern second-home owner feels not only free to arrive at the urban office in mid-morning, but can increasingly elect to work at home. An urban residence becomes a convenience but not a necessity, even for those with "urban" jobs.

This transition in residential choice is accelerated by the growth of the service economy. The combination of a residence and a place of employment is increasingly feasible for many types of professional work. The computer age promises to expand this possibility. The "office in the home" introduces an increasing element of choice in where to live and where to work. By recombining the home and the workplace, the computer age and the information revolution are having a marked influence on the demand for residential land in areas once thought to lie outside conventional urban commuting belts.

This greatly expands the potential for urban sprawl. Recent evidence from England suggests that the second-home commuting belt around London, once defined by two hours of travel time, is now expanding to include regions reachable with three hours of weekend travel (The Economist, Aug. 13, 1988). By this standard major areas of rural farm and forested America would be included in the residential belts of our principal cities.

WASTE DISPOSAL AS A LAND USE TYPE

Among the types of land use that have escalated in importance with growing urbanization are toxic and hazardous waste disposal sites. Although sewage and garbage disposal problems are as old as civilization, they have acquired new dimensions in the past half-century. While the industrial era that began in the 1880's was inducted as the age of steel, the one hundred years ending in the 1980's mark the triumph of the age of chemistry. One consequence is the generation of waste materials that, both in quantity and degree of toxicity, are unlike any wastes in the past.

Add to this the more easily dramatized but less ubiquitous problems of nuclear waste disposal and the result is a witches' brew of land use problems that date primarily from the Second World War. In an exhaustive enumeration of land use problems in the 1930's, the report of a task force on land classification to the National Resources Planning Board did not even list sites for waste disposal as a category of land use (National Resources Planning Board 1941).

The situation is dramatically reversed today. Measured in terms of public awareness and citizen arousal, the search for waste disposal sites would probably rank at the top of any current list of intractable land use problems facing public authorities.

This problem set is peculiarly relevant to forestry, since remoteness is perhaps the single most important attribute of a potential site for hazardous waste disposal. Many of the sites that have been proposed are in forested areas. Almost by definition, the more remote the site the
less is likely to be known about soil and groundwater conditions, or about the ecological consequences of specific types of toxicity.

We can predict with virtual certainty that foresters in the future will be drawn into the controversy over waste disposal sites, and will be prominent among the custodians of an urban culture's preferred solution to the NIMBY problem - Not In My Backyard. Forest land classification in terms of suitability for waste disposal seems assured as an addition to the items included in the concept of multiple forest use.

**LIFE CYCLES OF CORPORATIONS, FARMS AND INSTITUTIONS IN THE MIDDLE WEST**

In the life cycle of corporations, many are now passing into the hands of the third or fourth generation of owners. The grandchildren and great grandchildren have little direct tie to the original founder and owners. Many of them have other things they want to do with the money value of their stock, and want out. They are ripe for takeover bids.

Something like this is also happening in the Midwestern rural economy. Pioneering great-grandparents may have been romantic characters but their grip on their great-grandchildren is weakening. Current heirs are likely to sell out if a good opportunity arises. The consolidation of corporations thus has a parallel in the consolidation of farms. Both trends in the Middle West may be a reflection of the speed with which the region from the Ohio-Pennsylvania border to the Rocky Mountains was settled.

The institutional structure in this region was largely put in place in about 75 years, from 1815 to 1890. State and local units of government, school districts, postal routes, railroads and road systems, church congregations, bank service territories, and many more forms of the institutional infrastructure date from this era. The closing of the frontier meant to Frederick Jackson Turner the disappearance of free land and the blocking in of unsettled territories. It was also a closing of a frontier of institution-building.

The creation of the basic institutional structure of the Middle West within the life span of an individual meant that these institutions would age at about the same rate. They went up together, and they are growing old together. This gives a cyclical character to many of the problems of institutional reform and adjustment in the Middle West. The region is certainly not homogenous, but it is united by the scope of its institutional history to a degree that sets it apart from the rest of the United States. This history plays a major role in any attempt to interpret trends in land tenure and land use in the area drained by the Mississippi and Missouri rivers.

This is especially true of the institutional structure supporting forest land uses. It was created to reflect the era of railroads, not the era of superhighways and jet air transport. It was designed to serve a forestry sector that was focused on the production of timber, in an era in which the rural population was overwhelmingly engaged in farming.

Today the rural population is predominantly nonfarm, and the demands on local institutions by rural land uses are primarily urban in character. In major regions of the U.S. the forestry sector is being managed under decision rules that reflect its primary status as a producer of services, not goods.
A new land classification is needed, setting out those areas in which the major purpose of forestry is to serve residential, recreational, and amenity goals. These are associated with a need for reform in the social, political, and economic structures of communities to support the massive decentralization of cities that is now technically possible. The most rapidly expanding sector in American forestry in the 21st century seems likely to be primarily in forestry as a producer of services, and only secondarily in its role as a producer of timber.

REFERENCES


POTENTIAL IMPACTS OF NATIONAL AND INTERNATIONAL TIMBER SUPPLY TRENDS ON MINNESOTA'S TIMBER SUPPLY

Perry R. Hagenstein

ABSTRACT. Minnesota timber producers face competition from other regions and from Canada. Tight western softwood timber supplies mean higher timber prices, but these are offset by innovations in the South and softwood lumber imports from Canada. Hardwood producers face abundant supplies except for some high quality timber of selected species. Minnesota's timber producers must find market niches to compete with producers in other regions.

INTRODUCTION

My task today is to comment on trends in competitive timber supplies and the factors that affect them. Minnesota's timber supplies and their use depend on competition from supplies in other states and regions, as well as on the demands for timber for various uses.

Timber supplies and the demands on them are truly intertwined. As shown by the rapid development of a waferboard industry in Minnesota, a large material inventory eventually attracts capital and creates a demand for the material. The demand for timber in turn creates a supply in the economic sense, that is, an offering to the market of a quantity of the material at a price.

THE RELEVANT COMPETITION

Minnesota competes in markets for softwood and hardwood lumber, structural panels, and woodpulp and paper, the three major primary wood uses. Its competition comes from all regions of the United States and from Canada. Even production from other regions of the world competes with that from Minnesota.

The most important indicator of timber supply trends is what is happening to timber prices. Pressure on softwood timber supplies is reflected in the trend toward higher prices for standing timber. Douglas-fir stumpage prices, for example, increased by about 3 percent per year in real terms from 1962 to 1986, western hemlock prices by about 4 percent, and southern pine prices by just under 1 percent. The Forest Service's recently released South's Fourth Forest study projects continued stumpage price increases of about 2.5 percent annually for both southern pine and Pacific Northwest softwoods over the next twenty-five years (U.S. Forest Service 1988a). Some of the reasons for these price increases are supply-side factors.

1 President, Resources Issues, Inc., Box 44, Wayland, Massachusetts 01778.

WESTERN TIMBER SUPPLIES

For one thing, the area of commercial timberland has gone down significantly over the past two and a half decades (U.S. Forest Service 1988a). In the four northwest states of Montana, Idaho, Oregon, and Washington, the timberland area has fallen by about 12 percent. Over 70 percent of the drop was on the National Forests. Most of this has been withdrawals of land from timber harvests in establishing National Parks and Wilderness Areas. The loss of timberland area in the South has been about 6 percent, due mainly to shifts of land out of forest and into farming.

In addition to the wholesale shifts in land use that preclude any timber harvests, restrictions on timber harvests on the western National Forests will have substantial impacts. One observer says that the annual cut on National Forests in 15 to 20 years will be some 20-25 percent below the present cut of about 11 billion board feet (Wilkinson 1986). One factor is probable additional shifts of timberland to other uses such as wilderness and parks. Another is restrictions on timber harvests to meet "minimum management requirements" on the so-called multiple-use National Forest timberland that is left after withdrawals for parks and wilderness areas. For example, on the Gifford Pinchot National Forest in Washington, the combined minimum management requirements for dispersion of logged areas, protection of riparian zones, and protection of northern spotted owl, pine marten, piledated woodpecker, and mountain goat habitat lead to an 11 percent reduction in the allowable timber sale volume (U.S. Forest Service 1987).

A significant drop is also likely in timber harvests from forest industry lands in the Northwest. One set of projections in 1980 forecast that timber harvests from forest industry lands west of the Cascades in Oregon and Washington would be nearly 40 percent lower in the 1990s than in the 1970s (Bruner and Hagenstein 1981). While some of the conditions on which that projection were based changed as a result of the recession of the early 1980s, the basic problem of high harvests relative to current ingrowth into merchantable timber sizes on these lands continues.

The problem of likely falloffs in timber harvests on forest industry lands is not limited to the Douglas-fir region. Two recent Forest Service studies say that harvests from timber industry lands in Idaho and Montana cannot continue at current levels for more than a decade or so (Flowers et al. 1987; LeVere et al. 1987). Continuing high rates of harvests from these lands suggest that when the falloff comes in the next decade, it will be sharp.

The Forest Service now appears to be waffling on its earlier forecasts, saying that forecasts of drops in harvests from industry lands in western Oregon and Washington may have been overstated (U.S Forest Service 1988c). But my guess is that forest industry timber supplies in the Northwest will be tight over the next decade or two and that a falloff in harvests from industry lands is probable.

SOUTHERN TIMBER SUPPLIES

Softwood timber supplies in the South appear to be getting tighter, too. The Forest Service forecasts increases in softwood timber supplies--the amount supplied to the market each year--from the South over the next several decades. But the projected rate of increase in timber supplies is slower than it has been in recent years (U.S. Forest Service 1988b). An assumption behind these forecasts is that there will continue to be "major progress" in forestry
in the South and in the assistance and education programs that have helped bring about past improvements (U.S. Forest Service 1988b). This is a very strong assumption.

It means that timberland owners in the South will adopt those practices for which Forest Service studies have shown some economic merit. The fact, however, is that many timberland owners have not adopted these practices in the past. So, the important implication of the assumption is that assistance and education programs will be more effective in the future in convincing landowners to adopt forestry practices that they have been unwilling to adopt in the past, even with such programs. Also, the availability of funding to expand these programs is also questionable.

The increases in pine timber prices in the South have already brought about some changes in the way timber is used. At one time, there were two major products—sawlogs and pulpwood. Now, boltwood for chip-N-saw sawmills—with an in-between price—is also a major timber product. The development of this new chip-and-saw technology was a response to the growing price of sawtimber. Average stumpage prices for southern pine sawtimber have fallen by at least a third since 1981 (Ulrich 1988). This fall has been due at least in part to the development of the chip-N-saw sawmill. In view of this kind of technological response, I am skeptical of reports that forecast more rapid timber price increases in the South than in the past twenty-five years.

Another change that is taking place is substitution of waferboard and oriented-strandboard for structural plywood. This change, too, is driven by timber price increases. Why produce southern pine plywood from timber that costs $0.70 per cubic foot on the stump when an equivalent board can be made from southern pine pulpwood that costs only $0.20 per cubic foot? I believe this difference in prices will lead to continued replacement of southern pine plywood production with waferboard and oriented-strandboard, much of it also made from southern pine. Neither lumber nor plywood from second-growth southern pine is inherently attractive enough to support high timber prices.

**SOFTWOOD LOG AND LUMBER EXPORTS**

Softwood log and lumber exports, mainly to Pacific Rim countries, are a major market for some timberland owners in the Pacific Northwest. While some owners are precluded from the export market by both federal and state laws, the export market affects all of them, as well as timber suppliers in the rest of the country, through its effect on timber prices.

Export markets have been very strong. The decline in the value of the U.S. dollar over the past three years has been an important factor in the growing export market. But the long-term outlook is also good because of our sizable softwood reserves, the growing markets in the Far East, and the inherent attractiveness of western timber.

Japan is still the biggest market in the Far East. It accounted for 61 percent of the softwood log exports and 84 percent of the softwood lumber exports to the Pacific Rim during the first four months of this year. China took 24 percent and Korea took 14 percent of the softwood log exports during this period. While these export markets fluctuate somewhat, the trend for softwood lumber has been steadily upward (National Forest Products Association 1988). Markets in Japan may be near their saturation point, but those in China and Korea are not there yet.
These export markets have a pronounced effect on timber prices. For one thing, restrictions on the export of logs from federal timber have led to a two-tiered price system for timber. Prices for export logs are substantially above the prices this timber would bring in domestic markets, and this helps timber owners. In fact, domestic demand for softwood lumber is down enough from last year so that timber prices would have fallen in the absence of the strong export market.

CANADIAN TIMBER SUPPLIES

In 1986, Canada agreed to adjust provincial timber prices as a result of a countervailing duty case brought by the United States. The agreement was that an initial 15 percent excise tax on softwood lumber exports to the United States would be replaced with increased stumpage charges by the major provinces. Two of the four provinces have now responded with increased stumpage prices. Despite this, softwood lumber exports to the U.S. have gone down only modestly.

Part of the explanation for the small change is that U.S. lumber consumption is still at a very high level, although lower than it was a year ago. The other part of the explanation is that Canadian sawmill capacity, much of it in new mills, exceeds actual production (Adams et al. 1988). These mills need markets.

Over the long term, Canadian lumber producers face real limits on the economically available timber resource. In the near term, however, they are likely to continue to push exports into the U.S. market. This helps to hold down lumber prices for the American consumer and timber prices for the American timberland owner.

HARDWOOD TIMBER SUPPLIES

Hardwood timber inventories continue to accumulate. The volume in the eastern United States of hardwood sawtimber for major species groups is up by anywhere from 25 to 130 percent from 1970 to 1987. The area of forest land in most hardwood types is also up somewhat. In light of these figures, Forest Service forecasts of lower hardwood stumpage prices over the next three decades seem reasonable (U.S. Forest Service 1988b).

At the same time, prices for some hardwoods have been quite strong. For example, stumpage prices of $400 to $500 per thousand board feet for red oak sawtimber are commonly quoted in the Northeast today, although the average prices are lower. As usual, prices for hardwoods vary widely, so that the median price for red oak stumpage in Massachusetts recently was five times that of northern hardwoods stumpage. Hardwood prices by species are also subject to wide changes, usually in relation to changes in furniture styles. So even high quality hardwood timber at times can be a drag on the market.

The export market for high quality hardwood sawlogs, veneer logs, and lumber has been strong for the past few years. Western Europe is still the largest market, but Pacific Rim countries are growing in importance. The whole hardwood export market will continue to be a good one for the eastern U.S. We have the largest volumes of temperate hardwoods in the world and supplies of competing tropical hardwoods have been depleted.

But export markets for hardwoods, as well as important parts of the domestic market, are choosy. Some species and qualities, those for which supplies are tight, bring high prices.
Nevertheless, the growing volume of other hardwoods assures that prices for hardwood timber overall will not increase rapidly.

PULPWOOD SUPPLIES

Supplies of both softwood and hardwood pulpwood, but especially hardwood, are plentiful. This is shown by the relatively low prices paid for pulpwood timber throughout the country. Where softwood supplies are somewhat tight, as in parts of the Southeast, softwood prices are held down by the general availability of hardwoods and the substitution of hardwoods for softwoods.

Two things limit the expansion of woodpulp production in parts of the country. In the West, timber values are too high to justify using much roundwood for making woodpulp. Thus, woodpulp production is generally limited to what can be made from lumber and plywood residues. In parts of the East, water and air quality concerns practically preclude construction of new "greenfield" pulp and paper mills. Thus, some of the nation's hardwood inventory that is otherwise suitable for making woodpulp will continue to be unmarketable.

A NEW CONCERN

In mid-September an Environmental Defense Fund representative told a congressional committee that planting trees in the United States is a solution to "global warming." He said that an additional 10 million acres of trees could absorb all of the carbon dioxide that will be emitted by the new fossil fuel plants needed to meet additional electricity demands in the next ten years.

This signals a move to view forests as part of the solution to a worldwide environmental problem. Whatever the merits of the case, this could affect timber supplies sometime, in some way. If trees are planted, and if they become available for harvesting sometime, they will add to timber supplies. But, if the solution to global warming is seen as greatly increasing timber inventories as a "carbon sink," this issue would work in the opposite direction.

This is an issue that could have a big effect on timber supplies and timber prices. But it is likely to be one of those issues that will initially be confused by conflicting information, which is sometimes used to support some predetermined position.

IMPLICATIONS FOR MINNESOTA

Rapidly rising timber prices indicate tight supplies and, more importantly for competing suppliers, the potential for innovations. Minnesota has already capitalized on one such instance when high prices for softwood veneer logs pointed the way to starting a waferboard/OSB industry. What can be learned from price trends now that are relevant to Minnesota's timber supply situation?

First, western softwood timber prices will continue to trend upward because of tight supplies and ready access to Pacific Rim markets. But, the softwood prices that are most relevant to Minnesota are those in the South and Canada. Supplies from Canada and the South will keep softwood timber prices in eastern areas from increasing rapidly. Waferboard/OSB will continue to penetrate plywood markets, but production of these products in the South will temper timber price increases.
Second, hardwood timber supplies are increasing throughout the eastern United States. Therefore, hardwood timber prices generally will not rise substantially. But, high quality hardwood timber of some species is in short supply and prices for this kind of timber will continue to be strong. Those timber producers who take time to learn and understand these hardwood markets could reap some benefits.

Third, it takes time to accumulate a timber inventory that is large enough to attract new investments in plant and equipment for new products. While the Minnesota's timberland area has fallen 12 percent in the past twenty-five years, softwood and hardwood timber volumes have increased by 21 and 59 percent (U.S. Forest Service 1988a). Even though timber inventories in other eastern states have also increased, Minnesota has the potential for continuing to combine capital and brains in finding new markets for the growing timber resource.

LITERATURE CITED


THE CHARGE TO THE PANEL
LAND MANAGERS' PERSPECTIVES

A Panel Discussion

INTRODUCTION

Tom Hoekstra¹, Moderator

This panel will look at the timber supply issue from the land managers perspectives. You might say that this is where the rubber hits the road-people that are going to be actually producing the timber supply. You are going to hear five quite varied and interesting perspectives on how land managers see timber supply. The panel members represent private nonindustrial, large industrial land managers, and public land managers for the county, state and federal ownerships. We have asked them to share their perspectives on what they see as the major issues, opportunities adn problem areas.

¹ Assistant Director, USDA Forest Service, North Central Forest Experiment Station, 1992 Folwell Avenue, St. Paul, MN 55108.

AN INDUSTRIAL LAND MANAGER'S PERSPECTIVE

David J. Ohms

Potlatch Corporation owns and manages 312,000 acres of land in northeastern Minnesota. We also procure over 750,000 cords of wood annually, of which, over 600,000 cords are aspen. Therefore, we have a vested interest in timber supply and forest management in Minnesota. Our jobs ultimately depend upon a stable and economical supply of timber.

From my perspective, there are three issues which I believe influence present forest management and future timber supplies in Minnesota. They are:

1. Current forest inventory information.
2. Management and retention of commercial forest land.
3. Increased species utilization: "Using the Forest as it Grows."

First and foremost is the availability of reliable and current forest inventory information. The forest industry and public agencies are making important business and forestry decisions based on the 1977 inventory, information that is eleven years old. Good decisions are hard to make even with current inventory data. We recognize that the latest inventory information will be available in 1990, but by then, many of the announced expansions will be reality. I hope we don't have to wait thirteen more years for an update. We must place high priority on updating Minnesota's forest inventory on a regular basis.

Second, the future timber supply is dependent upon intensive management of present stands, and retention of the commercial forest land base. The single most important action we can take to increase future wood supply, is to intensively manage present stands. Future aspen growth and supply can nearly be doubled by harvesting the overmature stands we have in the state.

This past decade we have lost an average of one township a year, or over 40,000 acres annually to alternate uses such as agriculture or other special uses. This is exclusive of the Boundary Waters Canoe Area. This acreage loss is significant when you consider the state's total aspen harvest of 1.6 million cords probably took place on roughly 80,000 acres last year.

How do we preserve the timberland base? Timberland tax policies are one area which can provide incentives for industrial and nonindustrial private landowners to invest in forestry. Tax policies such as the tree-growth tax law, and the reforestation tax credit need to be maintained and strengthened.

Commercial forest land will be retained only when the long term benefits to society are recognized. Benefits include not only the timber harvested, but the compatible management of wildlife, water, and outdoor recreation opportunities.

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1 Woodlands Manager, Potlatch Corporation, P.O. Box 510, Cloquet, MN 55720.

The state of Minnesota is commended for developing forest management plans for each of the DNR's major operating areas. Identifying forest management goals and funding requirements is the first step in achieving those goals. The counties also need to promote forest management plans and goals for their commercial forest land. Then, with support from the public, forest industry, and legislature, we need to implement those plans.

Finally, increased tree species utilization will also help sustain the timber supply. Our long term goal at Potlatch is to "Use the Forest as it Grows." However, the dilemma we face as land managers is that we do not dictate which species mills will utilize. Procurement foresters are at the mercy of the mill they supply and the processing technology used. But, we can identify opportunities and provide incentives for industry to consider using other species.

We are in the process of testing birch, maple, and basswood at our Cloquet pulpmill. Fortunately, in the kraft process, we can consider using these species. Market forces, including increased demand for wood, provide incentive for mills to use other species or potentially lose their competitive position in world markets. Frankly, Brazil, Spain, and Portugal would likely view a shortage of wood in Minnesota as an opportunity to sell Eucalyptus pulp. Hopefully, we can utilize some of the ideas suggested in this conference so that procurement foresters will not have to learn Portuguese in the near future.

In summary, we must commit to updating Minnesota's forest inventory on a regular basis. The state's wood supply can be increased by the management of present stands and retention of commercial forest acreage. We also need to strengthen tax policies to encourage forestry investment, and provide incentives for mills to increase species utilization.
THE NATIONAL FOREST PERSPECTIVE

William F. Spinner₁

ABSTRACT. Timber resource management programs on the National Forests are a part of the total integrated land and resource management objectives of the Forest Plans. Improved utilization of the timber resource is the best opportunity for extending supplies. A coordinated effort is needed by all public land management agencies to improve visual management and public information programs.

AGENCY/ORGANIZATION DIRECTION

Since the early 1970’s the management of the National Forest System has been the subject of many public debates, with much of the discussion focusing on the management of the timber resource on these public lands.

The central issues have been largely of national scope:

- Commodity vs noncommodity uses of National Forest lands
- Wilderness allocations
- Timber management practices and road management programs
- Threatened and Endangered Species management
- Below Cost Timber Sales
- Biotic Diversity

Congress dealt with many of these issues through passage of the National Forest Management Act (NFMA) in 1976—an Act of far-reaching consequences, which heralded a new era for the National Forest System, setting objectives and mandates for the coordinated management of all National Forest resources.

Among other things NFMA:

- Required an integrated Forest Plan, addressing all resource objectives for each National Forest.
- Required greater emphasis on public participation.
- Established limits on the use of clearcutting and other practices.
- Mandated an interdisciplinary approach to all management actions.

In Minnesota, Forest Plans for the Chippewa and Superior National Forests have been completed, and a series of appeals by several interest groups have now been resolved, with a few exceptions.

₁ Forest Supervisor, Chippewa National Forest, USDA Forest Service, Route 3, Box 244, Cass Lake, MN 56633.

Implementation of these plans began in 1986 through an approach we call Integrated Resource Management (IRM)—the on-the-ground application of the Forest Plan, to achieve the benefits of Multiple Use, in concert with public expectations.

In developing the Forest Plans, and addressing vegetative management objectives, an annual Allowable Sale Quantity (ASQ) for the timber resource was defined—similar to the old "allowable cut," but different from the "biological yield," in that it recognizes the constraints necessary for integrated multiple-use management. Although the Forest Plan will be updated and revised in ten years, the ASQ is projected out to 50 years.

Currently, the ASQ for the Chippewa is 77 MMBF, rising to 80 MMBF in 1991—and projected to 98 MMBF by 2001 and 103 MMBF by 2021. That will be an annual increase of 26 MMBF in 35 years. The aspen component of the ASQ is currently 60%, and is projected to increase to 77% by 2021.

Aspen is an important species on the Chippewa, because of its unique wildlife habitat values and its demand by the forest industry. Many of the vegetative management objectives for the Chippewa are based on an aspen emphasis. Since the development of the Forest Plan, however, demand for aspen has increased at a much greater rate than projected.

The ability to meet increased demand (see Table 1 below) is constrained primarily by the age-class imbalance situation. If more aspen is harvested now, it means less available in 20-30 years. The Forest has very little aspen in the 21-40 year age class, and this problem will never be resolved unless the harvest of older stands is spread out over a number of years. Other considerations include visual management, old growth and diversity objectives, and special coordination efforts to achieve integrated results.


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CONCERNS AND OPPORTUNITIES

The long-awaited bull market for the aspen resource has created many vegetative management opportunities on the Forest that did not exist ten years ago. It has also created some areas of concern that will require our attention in future years.

1. Timber Utilization -- Improvements in the utilization of currently marketable species would make important contributions to available supply.

   - Improved utilization could provide an additional 5-10% of the current harvested volume without cutting more area.

2. Use of Other Species -- The harvest and use of other species such as maple, white birch, basswood, balm-of-gilead, and pine pulpwood could substantially increase the harvested volume.

   - Much of this volume consists of hardwood species presently left on existing timber sale areas, which could be harvested without cutting more area.

   - Increasing the volume harvested from existing timber sale areas would reduce harvesting costs, increase revenues to the landowner, and lessen the visual impact of clearcut areas. The utilization of these species could amount to an additional 10-15% of the current harvested volume without cutting more area.

   - The utilization of small diameter pine and other softwood species from thinnings and improvement cuts is another opportunity which could provide an additional 10%.

   - Finally, an additional 15% of volume could likely be harvested from stands presently considered not-merchantable because of species composition--such as mixed hardwood stands.

   - The total potential of improved utilization and use of other species is a significant volume--possibly an additional 40-50% annually.

3. Environmental Effects -- Along with the increased demand, timber harvesting will become ever more visible to the public on all ownerships in Minnesota.

   - This will foster increased public concerns and issues regarding clearcutting, esthetics, road construction and wildlife habitat management.

   - Much greater emphasis will need to be placed on landscape management, especially along roads and waters; on road construction practices; and on wildlife habitat management coordination.

4. Coordination Among Public Agencies -- Greater emphasis will be needed on working together in timber sale planning and layout, road construction and landscape management practices. This will be critical where mixed ownership patterns exist.

   - A good neighbor policy is also essential, which recognizes the values of private landowners, resorters, and recreational users.
5. Public Benefits -- On the National Forests, we have found the need for doing a better job in explaining the multiple benefits of timber resource management to the public.

- As a result of the Below Cost Timber Sale issue, Congress directed the Forest Service to develop an improved cost accounting system, and to display the long term costs and benefits associated with the program.

- On August 31 of this year, we completed our first annual report, as directed by Congress. Although costs exceeded revenues by about about $633,000, before payments to States, total economic and multiple-use benefits to the public exceeded costs by a wide margin.

- For example, timber sales on the Forest generated 760 jobs and contributed $32 million to the economy. Long term multiple-use benefits exceeded costs by about $600,000.

- These are the stories that need to be told.

SUMMARY

The timber resource management programs on the National Forests are a part of the total resource management objectives as defined in the Forest Plans, and fully integrated with the wildlife, fisheries, recreation, watershed, and range management programs.

The best opportunities for increasing the timber supply on the Chippewa National Forest are in the area of improved utilization of all species. Substantial increases in volumes harvested are possible without cutting additional area.

We all need to direct our energies at improving the visual effects of timber harvesting and road construction. If we don't, the price to be paid will be high.

Public agencies need to do a better coordination job with each other.

We need to improve our public information efforts in all we do.
MAINTAINING THE NIPF TIMBER SUPPLY

Chris R. Brokli

ABSTRACT. Nonindustrial Private Forest (NIPF) landowners own a significant portion of Minnesota's commercial timber land and currently supply an even larger percentage of the timber to markets. More effort is needed to provide information and assistance to landowners to encourage them to better manage these lands. Changes in tax laws are needed to encourage increased management.

INTRODUCTION

In order to ensure a continued supply of timber from NIPF lands, the importance of the resource must be shown to all concerned. Timber resource data for NIPF lands is needed, but perhaps of equal importance to NIPF managers is knowledge of the human resource so that effective management programs can be conducted. Forest managers could conduct 100-percent forest inventories of NIPF lands, but the knowledge wouldn't mean anything in the long-run unless landowners, legislators and the general public are convinced of the importance of maintaining and enhancing the private forest resource. Also, there is a need for renewed debate on income and property taxes which affect NIPF land ownership and management practices. Forest managers need to combine field forestry skills with broad based educational programs, supported by the natural resource community as a whole, in order to be effective in managing the NIPF resource. Results of these efforts will also affect how people, in general, view all forestry activities regardless of the ownership.

In Minnesota approximately 120,000 NIPF landowners own 41% of the commercial forest land, making NIPF the single largest ownership group. According to Minnesota DNR Division of Forestry harvesting records, over 50% of the timber harvested in Minnesota comes from these lands.

IMPORTANCE OF NIPF RESOURCE

The importance of NIPF lands to the overall supply of timber in the state is obvious. However, to what extent these lands are being managed for timber and whether the timber will be available for harvest at maturity is less obvious. According to the Minnesota Department of Natural Resources, only 10 percent of the NIPF landowners are receiving any type of on-the-ground professional forest management assistance.

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1 Consulting Forester, Minnesota Forestry Association, 220 First Avenue North West, Grand Rapids, MN 55744.


The condition of NIPF lands varies from county to county and parcel to parcel. In some areas, past harvesting practices have left the forest understocked and dominated by poorly formed or inferior species. In other areas, mature timber is wasting away due to lack of markets for the wood. Data from an extensive pilot timber survey of NIPF lands in Aitkin, Carlton and Itasca counties will be available to NIPF managers in 1989. If NIPF managers find this a useful tool, there are plans to approach funding sources to expand the NIPF inventory statewide.

MANAGEMENT OPPORTUNITIES

The challenge to the forest managers working with NIPF land is that most landowners are unaware of the opportunities for management that exist on their land. Forest managers must combine a variety of skills to locate landowners, determine the management needs of the forest, probe the landowners about their goals for the land, and present a package of management options. These options must provide enough information that is understandable to the landowner so that management choices can be made. NIPF managers also need to be well versed in legal and tax implications of forest practices as well as federal and state cost sharing programs that will benefit individual landowners.

Many surveys have shown that landowners are influenced more by aesthetic and wildlife concerns than monetary gain. The challenge is to educate NIPF landowners to the benefits of a well managed forest property. NIPF land managers can accomplish this by a cooperative educational effort throughout the state and with a unified forestry community. The broad based forestry educational efforts of groups such as the Minnesota Forestry Association, Minnesota Tree Farm System, University of Minnesota Forestry Extension, Department of Natural Resources Division of Forestry, and the U.S. Forest Service must be continued and strengthened in order to provide a positive image of resource management. New alliances need to be formed, with wildlife as well as other environmentally concerned groups, to put forth a common message that multiple use management has many benefits.

A new program, the Minnesota Woodland Council, has arisen to promote forestry education at a county level. Currently, Aitkin, Cass, Carlton, Crow Wing and Itasca counties are served by committees of local natural resource people and landowners, brought together to plan and conduct forestry educational programs aimed at meeting perceived local educational needs.3

MANAGEMENT BARRIERS

Many NIPF landowners have come to me recently for forestry consulting assistance because they perceive their property taxes are becoming too much of a drain on their finances. Often, they are discouraged by the high annual costs of owning land to a point where they just want to cut the timber to receive the highest return without regard for regenerating a new stand of timber.

Minnesota has a Tree Growth Tax Law that rewards people who agree to manage their forest land under the law guidelines. However, many counties no longer offer this option and some of the law guidelines discourage NIPF participation in counties where it is still offered. An Ad Hoc Tax Committee chaired by Dr. Richard A. Skok, Dean of the University of Minnesota College of Natural Resources, has worked for a number of years to revise this law to allow

wider NIPF landowner participation. The most recent proposal of the task force, while not meeting all the concerns of all groups, deserves to be looked at again, modified as needed, and presented to the legislature.

Modification of the federal income tax laws, in particular the elimination of capital gains, is a disincentive to management of NIPF lands. Taxation of timber lands must take into account the long-term risks associated with managing crops where no income is realized for a generation or more.
IS THE ISSUE TIMBER MANAGEMENT OR TIME MANAGEMENT?

Bruce R. ZumBahlen

ABSTRACT. With responsibilities in private forest management, fire protection, and state land management, the Minnesota Department of Natural Resource’s Division of Forestry’s present work force will find it difficult to satisfy current workloads while increasing its contributions to the timber supply. With only a slim hope of expanding its work force in the austere budget climate that Minnesota has, increased contributions by the Division can only be achieved by efficiencies.

Becoming more efficient requires changing how we do business. The efficiencies gained should translate to more time available to do even more, hence, more productivity. Productivity can be achieved by minimizing barriers caused by administrative laws that regulate how state department’s must operate and policies governing personnel issues. More within our own influence though, is the opportunity to better plan and coordinate management activities to minimize impacts from widely distributed operations.

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1 Assistant to the Director, Minnesota Department of Natural Resources, Division of Forestry, 500 Lafayette Road, St. Paul, MN 55155.

A COUNTY LAND MANAGER’S PERSPECTIVE

Bill Brown¹

I have come here today to present the county perspective, therefore, I should come out with a disclaimer that says that my remarks this afternoon do not necessarily represent or reflect the viewpoints of the other 14 counties, including their county boards land commissions. I work for 5 people in Cass County, if they were here today, they would tell you that my viewpoints do not necessarily represent theirs either. So, what I should do is tell you that I am here to represent the Minnesota Association of County Land Commissioners.

Let us talk about the similarities and the differences in public land management between the federal, state and county. The similarities would be that the counties manage a third of Minnesota’s public commercial land, as does the state, and the federal government. With that, the similarities pretty much end. The rest of the presentation should address some of the uniqueness. I titled my remarks "The Golden Egg, Minnesota’s Opportunity." To understand why I talk this way, we should look at what we are managing and where it came from. Minnesota’s county land base is basically tax forfeited land. The tax forfeitures, well actually the tax delinquencies, started back about the late 1800’s, 1870 to 1880. There was a big agricultural forfeiture. Not forfeiture per se, but a delinquency in the ‘90’s, and continually into the early part of this century. There were efforts made to address tax delinquency, because the primary economy came from the land. But there was no market for land if you could not support yourself or generate an income from land. It was either service orientation or it was product orientation, and basically the land base served to produce a product. When nobody could sustain themselves on that, or support the taxes, there was no market for the land and it just went delinquent. Finally in 1935 the legislature had wrestled with the situation long enough, and they created a law to establish absolute forfeiture to the State of Minnesota for the nonpayment of taxes. Such lands would be administered by the counties held in trust for the local taxing districts, which included the township and the school district and the county, and at that time, the state. The state also had a share of real estate taxes, but not any longer. So basically that tax forfeited trust, if you would, is managed for the township government, for the school district, and for the county. I am criticized by the people I work for on the County Board, as it often sounds like I am working for the township. Well, I am working for the township, because that is part of that tax forfeited trust.

In the early 1940’s, the state legislature began to realize the amount of land involved in tax forfeited lands. It was well over 3 million acres at the time. They set up some capability through the Iron Range Resources Rehabilitation Commission at that time, to provide technical assistance to counties in managing those resources. In the late 40’s, of course, most of the counties began appointing land commissioners. There are now 14 counties in Minnesota that have land commissioners managing 2.8 million acres of land, or 2.3 million commercial forest acres. The legislature over time recognized the importance of the natural resources, and how they fed the economy of Northern Minnesota. Legislation evolved to

¹ Land Commissioner, Cass County Land Department, Courthouse, Walker, MN 56484.

emphasize the retention of the land, and the management of that land for natural resources, whether it be timber, or recreation, or wildlife, or what have you. But the responsibility for management was to lie with the counties. It is a unique opportunity in government. The county land department, to my knowledge, is the only county department, the only government that operates as an enterprise. It is totally self-sustaining, in order to feed its budget and cover its cost. To operate, it must sell a product. Originally, most of the financing of the department came from the sale of the land. Or, the goose, if you would. Over the years, the county land departments began to experience the value of these golden eggs that goose was laying. We no longer sell the goose. Primarily, we sell timber or the golden eggs. Now we do get some outside assistance on special resource projects, but the primary operation of the department is financed from the sale of timber. That should give you an idea of the importance of timber supply to county land departments, because it is obviously that golden egg which motivates us. There are some other unique things about county land management in that in rural counties in Northern Minnesota, the primary issue is jobs. And as we deal with our bosses, it is primarily jobs that we have to deal with, and it is not how much money we generate and turn back to local government, it is that economic activity that surrounds that. We do not sell any wood unless somebody is making a living harvesting that wood. Thus, economic multiplier factors are important, and that motivates county boards to look at the jobs factor as being very important. Like the Governor of the State of Minnesota, you may find county boards out soliciting companies to locate and build around the natural resources in that county.

There are other things that we might look at as far as the priorities in dealing with timber supply issues at the county level besides financing the department (incidentally, county land departments are thinly staffed, relative to the State of Minnesota, or the federal government-a ratio in the neighborhood of one to six). We look at the supply of that resource for existing forest industry and jobs, the availability of the resource for the expanding industries and job base. One of the primary things that we are concerned about is the utilization of the resource, not just of the trees that are harvested, but also of the species that we’re not utilizing. Another issue that is very important to us is the inventory issue, what it is we’re dealing with, how we can stay on top of it, and the efficiency of managing the resource, through utilizing emerging technology. I think that kind of describes what we see in land departments throughout Northern Minnesota as we move into the ‘90’s.
TIMBER SUPPLY ISSUES:
WOOD-USER’S PERSPECTIVE

A Panel Discussion

INTRODUCTION

Paul V. Ellefson¹, Moderator

It is our pleasure this afternoon to spend the next hour with you, listening to and discussing timber supply issues from the perspective of those organizations and institutions that are the wood users. These are the individuals or the organizations that actually are involved in processing the wood that we foresters are so fond of growing on public and private lands. As we have talked earlier this morning, wood users are the harvesters or consumers of over 4.3 million cords of wood in the state of Minnesota. These wood user operations make all kinds of products, ranging from pulpwood to fuelwood to poles to piling and various other things. They also employ nearly 54,000 people in this state. Attesting to their future commitment to forestry in the state of Minnesota, all you have to do is look at the kinds of plans these wood users have for capital investments, investments that we have talked about this morning.

Over the past 10 years the wood users have invested somewhere in the neighborhood of a billion to a billion and a half dollars in capital and processing activities, and they are planning on investing a like amount in the very near future. These wood users, as we have on our program panel, are obviously faced with a number of issues. Many of you in the audience are in this category, and you know some of these issues. The issues range all the way from concerns over transportation problems, to stumpage prices, to uncertainty over sustained public investments in timber management, to concern over the public interest in nontimber uses of forest land within the state. To address some of these issues we have assembled a panel of four individuals who I think are eminently qualified to speak to these kinds of things. We have a manager of a major forestry program for a private firm, we have the president of a consulting firm, we also have the manager of a lumber company within the state, and we have a development officer for a state economic development organization. These four individuals are going to give you rather interesting perspectives on timber supply within the state.

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¹ Professor, Department of Forest Resources, University of Minnesota, St. Paul, MN 55108

THE BLANDIN COMPANY'S PERSPECTIVE

Max D. Fulton

When my wife, Anne, and I decided Minnesota was the place we wished to raise our eight children, I was working for a Wisconsin firm purchasing pulpwood to send by rail to the Mosinee Paper Company. That was 22 years ago. Those years have produced a great deal of change and a lot of challenges for both the Fulton family and the wood business in Minnesota. While I was only shipping jack pine to Wisconsin, most of the timber sales involved in harvesting that pine contained aspen for which there was absolutely no market. The technology for large scale aspen use for groundwood mills such as Blandin had not yet been proven. Aspen was being used for some kraft pulp, match stick stock, excelsior bedding, and building board--it appeared the supply of aspen was endless.

I believe there are several reasons why this picture has changed to the point where we are now discussing a potential short fall of aspen in the future. In my estimation, these reasons are as follows:

1. Technology has allowed the development and use as fiber for waferboard and oriented strand board (OSB) as well as use as paper furnish. Since the supply of aspen exceeded the demand, the lower price accelerated the technological changeover to more aspen and less softwood.

2. Aspen is an easy species to manage since it sprouts prolifically. Landowners do not have to spend large amounts of reforestation dollars to obtain a new crop. A good logging job and allowing the site full sunlight provides the right conditions for reproduction.

3. The Minnesota mills that I am familiar with want their fiber supply from the stump as quickly as possible to retain the brightness characteristics in the paper required by today's market and the best quality wafers for OSB. A species such as aspen that can be logged year around helps provide that freshness. There are problems developing in that area that I will try to explain later in this discussion.

4. Aspen is easily logged and since it is logged consistently fresh, it can be weight scaled. This is an advantage both to the logger and the mill.

5. Whether you are a wood buyer or a hunter (and some of us are both) aspen serves to provide food and cover for our favorite wildlife as well as fiber for the mill.

Before I leave the subject of the aspen species in particular, let me say that there are some actions we as wood users can take to extend the resource. Species such as balm O'Gilead and birch and some of the other under-utilized species might serve to replace some aspen in the structural board marketplace as well as in the pulp and paper industry. There is, of course,

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1 Manager, Blandin Lands and Forestry Division, Box 407, Grand Rapids, MN 55744.

additional research that can be done in this regard, but we in industry already have the knowledge to begin the process and should be doing so.

We at Blandin feel a part of the answer lies in genetic improvement of aspen and we are attempting to act as a catalyst to other landowners in its establishment. The potential for growing better crops of trees better and faster is well established in agriculture. We have fallen behind in forestry.

Other management and harvesting techniques we feel should provide better stocked, higher yielding stands of native aspen are superior clonal selection and thinning of natural stands. The NNRI at Duluth is also doing some work on fertilization of stands in St. Louis County that should prove interesting and hopefully productive.

The conference planning committee had mentioned many suggested areas of concern wood users should respond to. I feel the best way Blandin can respond is to introduce some of the perceived problems and opportunities we perceive through an ownership woodpile slide presentation as follows:

MINNESOTA WOODPILE DATA

Area: 17 northeastern counties—woodshed for most of the major wood using companies.

Keep in mind that the following information is from the 1977 Phase I Inventory. We need current data badly and the sooner the better.

1. Contains 82% (11.2 million acres) of the total 13.7 acres of Commercial Forest Land (CFL) in Minnesota.

2. Growing stock volume according to the 1977 Inventory data was 120.8 million cords/all species.

3. Breakdown was 64% hardwoods; 36% softwoods. Aspen comprised 32% of total growing stock (38.7 million cords).

4. Growth per year was 3.5 million cords. This volume was predicted to rise and then level out to about 3.7 million cords by the year 2007.

5. Annual mortality was estimated at 1.5 million cords—72% of which was hardwoods.

6. Removals: (Jim Blyth 1986) 1.794 M cds pulpwood (78% - 1,395 cds aspen) 540 M cds sawlogs 100 M cds specialty 147 M cds export 600 M cds residential & commercial fuel

Total cds removed from growing stock/17 NE counties: 3,181,000
FEDERAL OWNERSHIP: 20% of CFL
2.3 million acres

National forests - 1.7 million acres - 15% of total CFL
Growing stock: 29.6 million cords
80% (23.7 million cords) on national forests
Growth: 866,000 cords/year
24.7% of total growth
all ownerships
*Removals: approximately 12% of total harvest in 1985

STATE OWNERSHIP: 21% of CFL
2.36 million acres
Growing stock: 22.0 million cords
Growth: 662,000 cords/year
19% of total growth
all ownerships
*Removals: approximately 20% of total harvest in 1985

COUNTY AND MUNICIPAL OWNERSHIP: 20% of CFL
2.28 million acres
Growing stock: 24.9 million cords
Growth: 679,000 cords
19.4% of total growth
*Removals: approximately 20% of total harvest in 1985

FOREST INDUSTRY OWNERSHIP: 7% of CFL
796,000 acres
Growing stock: 8.0 million cords
Growth: 200,000 cords
5.7% of total CFL growth
*Removals: approximately 10% of total harvest in 1985

NONINDUSTRIAL PRIVATE FOREST OWNERSHIP: 32% of CFL
349 million acres
Growing stock: 36.2 million cords
Growth: 1.07 million cords
30.6% of total CFL growth
*Removals: approximately 38% of total harvest in 1985

* Using MN DNR figures (Krantz and Prosek)
Problems we believe need to be addressed:

Most of the published and unpublished data we've seen concerning potential harvest volumes makes the same basic assumption: i.e., All volume on all ownerships is both accessible and available for harvesting. Those of us in this room know that is not the case, but the average citizen as well as those making our political decisions are unaware of the problems created by lack of timber accessibility and availability.

AVAILABILITY

In the Superior and Chippewa National Forest planning process, 37% of the commercial forest land (667,000 acres) has been classified as economically not appropriate to manage. That reduction comprises approximately 29% of the total federal portion of the Minnesota woodpile. We realize, of course, there are provisions in the planning process to accommodate changes if necessary and that the plans will be reviewed in 10 to 15 years. Nevertheless this uncertainty about a major land ownership creates a concern about the total resource availability.

The largest land ownership in northeastern Minnesota, the nonindustrial private forest ownership, is made up of a whole series of concerns. With the public ownership sector, we have identifiable land managers to meet with, both as individual companies and as an industry, to discuss such things as harvest schedules, sale volumes, forest management intent and the many other factors affecting the total timber resource. How do we do that with some 120,000 individual landowners?

As a matter of fact, we don't. The Minnesota Department of Natural Resources has a private forest management program utilizing about 45 person years annually. Although the CR program is competing with that effort. You have heard about the Blandin Woodland Management Assistance program. Other companies and other agencies are dealing with NIPF owners. The American Tree Farm program sponsored by the forest industry was designed to encourage good forest management.

Another encouraging program for the NIPF ownership currently is the private woodland program now organized under the Minnesota State Tree Farm program and being administered and coordinated by the Minnesota Forestry Association (John Suffron and Chris Brokl). This program is intended as an active exchange with NIPF owners to encourage good forest management. There are now county private woodland committees established in Aitkin, Cass, Carlton, Crow Wing and Itasca Counties.

These committees are made up of foresters from all areas of forestry employment. There are 1,214 million acres of NIPF commercial forest land in the present counties. This comprises 35% of the total NIPF commercial forest land in the northeast counties. The concern with this ownership is two-fold. Is the wood available for harvesting? Is the land being properly managed for future crops of timber? We also need to recognize the long term and risky nature of the forest investment in the tax structure system in Minnesota. The Banzhaf Study indicated we could expect the commercial forest land to decline at an annual rate of 3.1%. If that proves to be correct, by the turn of the century we will be down to 10.5 million acres or below. The newest RPA data I've seen disputes this reduction. It is critical that this trend be correctly interpreted in the next RPA assessment.
ACCESSIBILITY

With the increase in aspen usage and the need for fresh wood on a year around delivery basis, we are seeing increasing shortages of sales that are accessible with our current roading system. There is a definite need for an accelerated program of main-haul system road construction in northeast Minnesota. We are also experiencing problems with main-haul roads needing upgrading and repair. Specifically, we can point to highway 65 going north from Nashwauk and highway 6 going north from Deer River. Both are primary north/south arteries from the woodpile north of Grand Rapids. We certainly support the governor’s forest road funding effort and the transfer of the MVET funding.

OPPORTUNITIES

We have an excellent opportunity to improve our Minnesota forests through better management because of the increased demand for the forest products. Competition in any event brings out the best in people and products. This can be evidenced by the ongoing 24th Olympiad in Seoul.
WOOD COST: ESTIMATION DIFFICULTIES AND RESEARCH NEEDS

Samuel J. Radcliffe

ABSTRACT. Delivered wood cost is perhaps the most important measure of timber supply to wood users. Projecting wood cost is difficult not only because it involves describing the future, but also because there is little empirical information regarding the factors that have affected cost in the past or present. The Forest Survey is a potentially fertile source of such data. Developing the empirical descriptive data and conceptual models that explain timber producer and consumer behavior are important areas for forest economics research.

INTRODUCTION

When assessing the timber supply situation for a particular mill or potential mill site, wood users need to answer a variety of questions, but perhaps the "bottom line" question is, "What will be the delivered wood cost for this site over the life of the mill equipment?"

Wood users recognize the tremendous difficulty in projecting wood costs for what is usually a ten to thirty-year period. Nevertheless, wood cost estimates are needed by the corporation to rationalize its capital investment, which may exceed $500 million for a single project.

STUMPAGE COSTS

Total delivered wood cost has three principal components: stumps (the price/cost of standing trees), logging cost (the cost of converting standing trees to an f.o.b. product) and transportation cost (the cost of hauling the product from logging site to mill gate). Stumpage cost may be a relatively small component of total wood cost. For example, in northeastern Minnesota stumpage may be only 10 to 20 percent of the total cost of aspen pulpwood.

Stumpage price formation results from the interaction of a number of variables, including harvest conditions (accessibility, stocking levels, piece size, etc.) and distance from the mill. In fact, stumpage price is often thought of as a residual of mill price less logging and transport costs. In theory then, stumpage, logging, and transportation cost components are determined simultaneously and should be estimated simultaneously. In practice, however, data deficiencies and the lack of sophisticated models force the analyst to estimate component costs independently.

At the most general level, there is an intuitive sense that stumpage price is a function of inventory levels and harvest pressure (in a loose sense, "supply and demand"). So it seems reasonable to use empirical evidence to try to develop a statistical relationship among these three variables.

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1 President, George Banzhaf Company, Forest Resource Consultants, 225 East Michigan Street, Milwaukee, WI 53202.

In trying to develop a statistical relationship, one quickly runs into data difficulties. Although there are reasonably reliable annual surveys of stumpage price and harvest levels, in Minnesota there are only two estimates of regional inventories for the last 30 years, and the most recent estimate is more than ten years old. These inventory estimates are based on the forest survey conducted by the U.S. Forest Service North Central Forest Experiment Station.

One possible solution to this data problem involves the use of a projection model to generate artificial "observations" on inventory. For example, one could project the 1977 Minnesota inventory to 1988, yielding 12 "observations." These "observations" could then be used in an analysis of the statistical correlation among price, inventory, and harvest levels.

This approach was successfully used in Michigan, where relatively strong statistical relationships were estimated on the basis of only 8 years (1980-87) of evidence. Correlations were strengthened after certain adjustments were made to growing stock estimates to account for nonharvestable inventory. While this is a somewhat simplistic approach, it does provide some indication of how stumpage prices might move in response to future changes in inventory and harvest levels.

LOGGING COSTS

Logging cost projection is also a difficult exercise because of data problems. There is very little solid information on the economic characteristics of the logging industry in Minnesota or the other Lake States.

Hassler and Sinclair (1981), lacking empirical evidence on actual logging costs, examined the component costs of a typical Minnesota logging operation. By researching trends in component costs--fuel, labor, replacement parts, capital costs, etc.--and by assuming an equipment mix and productivity rate, the authors were able to estimate how per cord logging costs had changed during the 1970's.

Using component cost measures to build logging cost estimates is a good approach when stable logging productivity rates can be assumed. But because of changing technology and changing resource conditions, we can be fairly certain that productivity will change in the next 30 years, and perhaps drastically.

Logging technology changes are at least partially dependent on procurement decisions made by wood users. Shifts in wood form--shortwood to longwood, roundwood to chips, one species mix to another--all have impacts on equipment mix, productivity, and cost. Policies related to the size and length of wood contracts may affect the number of producers and the average producer size. This has a direct relationship to the degree of mechanization in the industry.

In spite of the wood user's ability to change procurement policies, a single consumer does not have enough market clout to shape the logging industry. Moreover, changes in logging productivity will not occur overnight. Any research effort to measure average logging productivity and changes in productivity must be designed as a long-term effort.

Resource conditions such as volume per acre, skidding distances, tract size, etc. are central to the concept of economic timber supply, as developed so well by Dietmar Rose in an earlier paper. As these conditions evolve, logging costs change.
One cannot describe how a resource might change unless there is a good understanding of current conditions. What sort of stands are being harvested today? Are the easy logging chances being systematically exploited, leaving only higher cost stands for the future? Or are some easy logging chances re-maturing after being harvested 40 years ago? The answers to these kinds of questions are not understood very well on a region-wide basis.

Spencer and others (1986) identified the operating characteristics of Forest Survey plots in order to categorize commercial forest acres by operability class. Their analysis showed that a significant portion of the total Minnesota timberland base is in a poor operability condition. These results cannot be extrapolated to harvested stands, since recently cutover stands were defined to be inoperable in the study. However, the approach could be extended to examine the characteristics of harvested plots. Once the distribution of harvest acres by operability class is known, a comparison to the distribution of mature acres would allow intelligent inferences about how harvest conditions might (must?) change in the future.

Examination of the Forest Survey harvested plot data may have additional benefits for timber supply analysts. For example, many timber inventory projection models are based on assumptions of scientific harvest prescriptions. Most practitioners understand that timber harvest is often (usually?) not conducted "according to the book." But there is no empirical basis for assuming anything other than "textbook silviculture." Analysis of harvested Forest Survey plots may provide the needed empirical base.

TRANSPORTATION COSTS

Much of the discussion of the difficulty in projecting harvest costs is directly relevant to projection of transportation costs. The key transportation questions relate to technology and policy changes (e.g. load limits) and to haul distances from forest to wood user.

There is a generally poor understanding of how wood actually flows through the state. Anecdotal evidence is often more confounding that illuminating. It is not uncommon, for example, to hear of timber harvested 50 miles outside of Grand Rapids being shipped more than 100 miles to International Falls.

The most commonly assumed wood transportation model is based on producers first harvesting the stands nearest to the wood consumer, and then moving successively outward to more costly hauls. This model ignores an important aspect of the producer's incentive system: most large consumers, particularly pulp mills, pay a haul allowance that essentially negates the extra cost involved in long hauls. In fact, some delivered price systems may even reward the long haul.

Obviously, there is a need for some empirical evidence on wood flows and the location of harvested stands relative to the major wood using centers. While analysis of Forest Survey plots may again be of some help, this sort of information might be best approached through a user or producer survey.

SUMMARY

The mechanisms by which wood costs "settle out" is complex. There are interdependencies among stumpage, harvest costs, and transportation costs, and the decision rules that guide logger choice are often dictated by a wide range of wood procurement policies. There is a poor understanding, in a quantitative sense, of how all of these factors interact. This is a vital
information need for wood users, and the cost issues deserve a high priority on forest economists' research agenda.

LITERATURE CITED


PERSPECTIVES FROM HEDSTROM LUMBER COMPANY

Howard Hedstrom

At Hedstrom Lumber, I am a part owner and Manager, and we share a lot of responsibilities there. We have been in business for about 74 years, going on 75. I just have a few comments, and my perspective. We want to get the best use of timber for the best purpose. To do so we need each other. We have got challenging issues, some of which we have talked about already, and competition.

My perspective on our forest resource is the best use for the best purpose. Pulpwood goes to the paper mills and the waferwood mills. Saw logs should go to the saw mills. In some cases you have specialty logs that go into log cabin logs, export, and other things like that. Taking the long view or short term view of things may be different, but the long view is the best view. The long term view should also lead to the highest economic value, and so give the greatest return to the land owner, and most profit to the logger. One thing about saw logs; we look for good logs, straight, clear, but in most cases we do not get them, but that goes into the adaptability of what we do in the market. We like white pine, it's been a good species. However, we have moved out of white pine and do not rely on it heavily now, it is only 20% of our production these days. White pine has not been widely propagated in this state for probably 40 years. Everybody's been afraid of the blister rust, what white pine we have is growing naturally. Not propagating white pine has been a mistake, it's well suited to the soil and the climate, and when it's found intermixed with other pines and other species, you find it growing very well.

Somebody made the comment, "what is the market going to be in 40-60 years?" I cannot predict that, none of us can, but all I know is, here again: the best use for the best purpose. It goes back to the soil, and the conditions, try to get the tree species in there that is the most productive in the soil, and hope that when it grows up, 40 or 50 years from now, you have made the right choice.

We need each other, the sawmills and the pulpmills. Just in general terms, 12 loads of logs come in to supply your mill for a day, 5 loads go out as chips, 2 loads go out as sawdust and bark, and 5 loads go out as lumber. The byproducts dictate that good chip markets are very necessary for a sawmill operation. On the other hand, sawmills help offset resource cost by the recovery of value and price from lumber, and having the chips go into the paper products. Through sawmilling we provide the chips for pulpmills and make useful building products.

We have got challenging and tiring issues because of a lot of things. I am very involved in forest use issues, particularly forest planning. We have seen planning for rivers, roads, road density, and all kinds of other things. Following the issues will take a lot of time and energy. Jim Bowyer mentioned quickly changing markets and technology and the need to stay competitive in this business. Other nuts and bolts things of the business are taxes, work comp,

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1 Hedstrom Lumber Company, Grand Marais, MN 55604.

wood dust, OSHA, employee relationships; any one of these taken alone is a challenge. Taken together, it's easy to wear down, and pull back away from the long range things which are the forest issues. I think we all must resist that temptation. A lot of the issues that I look at aren't your issues, but we've all got our own tiring things. We have got families, community involvements, there's all kinds of pressures. You come home at night and it's hard to keep up with all the issues. But I think because of our dependence on public forest land, and even on the private, we in the industry and all of you in the forest business, must work at having our forest serve the best purpose. There are certain areas I think we have all acknowledged that maybe should be set aside for wilderness. However, most of the land I think we want to see in multiple use, and properly so. It is going to take a big effort on all of our parts to maintain that objective.

The last thing is competition. We must compete in price and quality with the rest of the country, and with Canada and the off shore countries. We're challenged to keep our products unique, and keep working on different market penetration for our product. We talked some about species. Our mill started out using all white pine, and as times went on the white pine diminished and we made the transfer to other species. I think the industry will make the transfer from one species to another, from one size to another, because of price competition or market conditions. I think we will do that, as we are challenged to do it. The timber supply is there. If we want to stay in business, we have to work at all these things. We have to support each other, strive to make the best use of our lands and resources, stay competitive, and be involved in all resource planning to preserve the multiple use concept.
TIMBER SUPPLY IN ECONOMIC DEVELOPMENT; LONG-TERM EFFORTS FOR SHORT-TERM USERS

Dentley Haugesag

ABSTRACT. Often we are able to attract primary processors of timber by first attracting secondary manufacturers who at first obtain their raw materials elsewhere. Then we can work upstream toward primary suppliers who serve these markets. At that point, timber supply becomes a critical issue. We should remember, however, that companies take a shorter-term view than government foresters. All we can be sure of is that fiber will be in demand. Therefore, we should maximize the growth of fiber much as farmers maximize growth of foodstuffs: by matching species to sites, by planting, by harvesting at the right time, by cultivating, by adding land, by using hybrids, and so on, to make our state a tree garden. Expansions, especially in pulp and paper, will make intensive silviculture feasible economically. At the same time, we have to pursue new operations aggressively to maintain a strong, competitive forest economy.

I'd like to talk about timber supply from the standpoint of our ongoing economic development effort. The availability of timber often is an incentive to the economic development of the forest products industry, especially the primary industry. But you may be surprised to find out how often the availability of timber is irrelevant. Even when timber is relevant, it may be relevant to a company in a way we don't expect.

We often hear that we need to expand "value-added" industry in Minnesota. I agree, but we may not recognize how much value-added industry already is here.

The secondary wood products industry in Minnesota is twice the size of the primary in dollar volume, and more than that in jobs because secondary is more labor intensive. Two of the biggest secondary wood products companies in Minnesota--Andersen Corporation with 1987 sales of $1 billion, and Marvin Windows, with nearly $200 million--don't use any wood from Minnesota. Even a more resource-based company like Woodcraft Industries brings in most of its raw material from neighboring states.

This is not a bad situation. As Roy Adams of NRRI has said, it's better to bring in wood and make something out of it here than it is to ship wood from here to be manufactured someplace else.

Theoretically, of course, the optimal situation would be for us to grow the wood and to manufacture it right here in Minnesota. We call that value-added manufacturing. But that term can mislead us. It sounds like you start out with a raw material and then find ways to add

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1 Wood Products Specialist, MN Department of Trade and Economic Development, 900 American Center Building, 150 East Kellogg Boulevard, St. Paul, MN 55105.

operations downstream to "add value." We look for these linkages all the time in economic development.

But we can't afford to neglect a wealth of opportunities that, like Andersen and Marvin, don't link up with the resource at all—at least they don't for the time being.

Let me give you some nonwindow examples. We have, in one of the suburbs of Minneapolis, a manufacturer of paper-laminated particleboard ready-to-assemble furniture who buys over 60% of the total production of a Weyerhaeuser particleboard mill in Oregon. We are having serious discussions with three other companies interested in making similar products in Minnesota, all using particleboard from the west coast.

Now, you know we don't make any particleboard in Minnesota, but that doesn't stop these companies from moving into Minnesota as long as they can buy board from the west coast and ship it here by rail at a reasonable cost.

Once we have these value-added businesses here in Minnesota, though, then we have a real good market for a particleboard mill in Minnesota. It's easier to justify new primary operations on the strength of secondary users than the other way around—easier to go upstream than downstream. The "value-added" comes first, then the basic resource. The market, then the supplier.

One of our current prospects to build a primary mill illustrates that principle. A large forest products company plans a new plant to make a composite wood product that should have industrial applications as well as structural applications. So the presence of a lot of window and door manufacturers in the upper midwest is a plus for Minnesota. The secondary is attracting the primary.

As we work this linkage upstream, we come finally to the topic of this conference--the timber supply. The prospect company needs 200,000 cords of aspen each year. We had to show we had it, and how long we will have it.

John Krantz and his group at DNR ran the numbers, and Sam Radcliff's firm was hired to review them. When we showed the data to the company, their response surprised us. It probably will surprise you, too.

The company was not interested in the supply beyond ten years. Ten years! For a $70 million capital investment! A forest products company has to look at an investment this way: you pay for your mill in about four years, you get your ROI out in seven years, and anything beyond that is gravy. After ten years, the mill has to be rebuilt anyway, so at that point you have to make your investment decision all over again. Then you take another look at markets, technologies, and timber supply. If you cannot justify building your mill and tearing it down after ten years, you cannot justify building it at all. That does not mean, of course, that a company will cease operations in ten years, only that it has to consider this as a worst-case scenario before investing huge amounts of capital.

Foresters are not trained to look at the forest in ten-year bites. So what does this short-term orientation of the industry tell us about forest planning?

1. That we are entering a period of accelerating demand for fiber in an increasingly volatile free-market economy.
2. That we should maximize our production of fiber, regardless of species, in a process of intensive silviculture that resembles farming more than traditional forestry.

We know that demands on our forests will increase dramatically with expansions in pulp and paper. But it is hard to predict what species we should be growing because technologies are evolving so quickly. In an uncertain environment like this, it would be a mistake to plan rigidly for users thirty or forty years down the road.

It would be a mistake also to try to preserve the status quo. We have to pursue new users aggressively and let the free market sort things out. Inevitably, some existing users will become uncompetitive. But if we don’t accept that, the more competitive timber users will go elsewhere, leaving us with old-fashioned, uncompetitive users and they will go out of business anyway. Minnesota can’t opt out of the free-market environment we all live in. We have to get our share of the action. We need to see our resource put to its highest economic use. That way we keep our industry competitive with other states and we collect the greatest stumpage fees to finance more intensive management of the resource.

That brings us to our second point, that we need to maximize our production of fiber. We need to start thinking more like farmers than foresters. To realize its full potential as a timber-producing state, Minnesota has to become a big tree garden.

It’s ridiculous to think we are approaching the limits of our timber supply. That’s like saying we can’t get tomatoes out of a weed patch. We haven’t even scratched the surface of the timberland yet. Jerry Rose estimates we can double the production of aspen just by cutting it in a timely manner. What can we do if we go on to manage intensively with all the silvicultural methods we already know about?

Scandinavia offers a well-known example of successful management. Scandinavia has turned itself into a tree garden. In Sweden, for example, at the time when the lumber barons were mining the last of our old growth and moving on to the Pacific Northwest, the government was instituting strict measures to insure a sustained yield of timber on both public and private land. Today, more timber is being cut in Sweden than ever before in history. More timber is available to be cut than ever before. And more Swedish land is forested than ever before.

If you are going to grow a garden, you need to choose plants that are suited to your soil and climate. We need to do the same thing in our forests. Jim Bowyer has suggested a survey of soils so we can map out where the various species should grow. Alan Ek’s group is working on a GIS based on satellite data. As the pressure on the resource mounts, we can rationalize this kind of effort. We also can justify more work with hybrids. Hybrids have been a mainstay in farming for generations. They will be a mainstay in the forest of the future.

A farmer tries to grow crops that will sell. Here our analogy starts to break down. The farmer works on a one-year rotation, so he can--maybe--anticipate his markets. But the forester works with 50 to 100 year rotations. You can’t predict what species the industry will want 50 years from now, not when technology and markets change so rapidly.

The answer is to grow the maximum amount of fiber you can, and count on the companies to find ways to use it. Because they will--look at the history of aspen development here in Minnesota. That is why we have to study soils and promote hybrids. We need to get every bit of fiber out of our available land that we can by matching species with sites.
We also need to look at incentives to increase the amount of available land as well as its yield. There is a lot of marginal farmland that could add to our forest land base. Even now we have more forest land than we had ten years ago, through natural reforestation. We could accelerate that process through tax policies that reward the landowner for planting trees.

We tend to focus on northern Minnesota when we talk about forests, but we should remember that we are cutting oak in southern Minnesota three times faster than we are growing it. I contradict myself when I say we should make a special effort to reforest this one species rather than just maximizing fiber growth, but oak is so valuable to our cabinet and dimension industries that we need a special effort to promote it. No other species can be substituted because consumers are looking for oak’s distinctive appearance. So in this case we start with species and look for the best sites to grow it.

The forest products industry in Minnesota is at a turning point. Enough large users are gearing up that we now can justify an intensive effort to manage the resource, and collect the stumpage income to at least get started on that effort. Our immediate need is to muster our forces. This conference may be the first step in this exciting journey into the future forest. The Governor's new blue ribbon commission may be the next step. Beyond that, we need to create a permanent entity, cutting across agency and industry lines, that can move these ideas from the conferences and commissions into political action and public policy.
REGENERATION SURVEYS AND A CASE STUDY IN BELTRAMI COUNTY

Gregg P. Hove and Charles R. Blinn

ABSTRACT. To grow timber and furnish an even supply of this resource, land managers use a wide variety of silvicultural tools. Successful forest management requires that correct silvicultural treatments be prescribed according to species and site characteristics. Regeneration surveys are one method of determining the success of various site treatments. Steps are presented which should result in efficient survey design and implementation. Regeneration survey issues that can affect survey design decisions are presented and discussed as they relate to both general survey designs and to a specific study that is being conducted in Beltrami County, Minnesota.

INTRODUCTION

Forest land managers have as one of their management responsibilities the task of reforesting harvested land. An overall management goal is to produce an even supply of timber for the forest products industry. This even supply of timber must be produced on both a short term and a long term basis. A mill purchasing timber can achieve short term supplies by maintaining a large enough inventory to fill lulls in the timber supply or by foreseeing a shortage and increasing timber purchases. On the other hand, a long term sustained supply of timber, projected 40 to 80 years into the future (the rotation age span of most northern Minnesota timber species), requires a different approach and planning effort.

Management plans that are designed to supply an even flow of timber over the long term involve the consideration of many steps. These activities can be illustrated as a cycle where one step or activity leads to another and is dependent upon the prior step. An example of a management cycle involving artificial regeneration (a rotation) for red pine is shown in Figure 1.

Steps in the management cycle may include preparing the site for planting following a harvest, planting the site with the desired tree stock, releasing the newly planted seedlings from competition, various stand management activities throughout the rotation (e.g., thinnings, pruning, etc.), timber sale preparation activities, and the final harvest.

Approximately half of the steps within the management cycle (stand harvest, site preparation, planting, and release) are associated with the regeneration process. In fact, consideration of the regeneration process is an ongoing event that usually begins with the timber sale preparation and harvest operations and continues until the regenerating trees can survive on their own. Given that the managing agency may expend relatively large amounts of capital during the regeneration process, it is crucially important that limited funds be allocated judicially.

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1 Graduate Research Assistant and Assistant Professor/Extension Forerster, Department of Forest Resources, University of Minnesota, St. Paul, MN 55108.

Figure 1. Typical red pine stand management cycle involving artificial regeneration.

One method to evaluate the effectiveness of regeneration efforts is to conduct surveys on young, regenerating timber stands. In addition to determining the success of site treatments, regeneration surveys can provide land managers with other important management information. This additional information can include the status of regenerating species, information pertaining to future stand needs (replanting, thinnings, etc.), a strategy to plan rotation lengths and harvest schedules, and an initial forest inventory and data for yield projections (Stein 1983). To efficiently provide this information, surveys must be carefully designed and implemented. Incorrect decisions in the design of regeneration surveys can result in costs exceeding benefits.

This paper discusses some of the steps that should be conducted prior to implementing a regeneration survey. An example of some of the factors that need to be addressed is provided.

**REGENERATION SURVEY DESIGN**

To assist in the planning of a successful regeneration survey, a systematic approach should be followed. This approach should result in a survey that meets all needs while minimizing costs involved. It should also result in only necessary data being collected.

The following steps would be involved in this approach. Separate analyses might be performed for each regenerating species, depending upon the needs of the land manager.

1. **Define problem.** Why is the survey needed, or what situation has brought about a need for conducting the regeneration survey?

2. **Specify objectives.** What specific information do you want the survey to provide? What are your expected accomplishments and/or benefits that need to be attained? What management questions need to be answered? What do you plan to do with the data after it is collected? What is the timetable? What resources are available?

3. **Identify alternatives to meet objectives.** Given these objectives, a set of feasible alternatives need to be clearly identified. The exact procedures to be followed for each alternative should be defined. This involves consideration of many issues when developing each alternative.
4. **Analyze and compare alternatives.** For each alternative, comparison of the benefits derived versus costs involved should be evaluated. After each alternative is evaluated, the results should be compared and a decision made as to which alternative(s) are the "best."

5. **Implement selected alternative(s).** Conduct the regeneration survey utilizing the selected alternative(s).

6. **Monitor survey success.** As the survey process proceeds, monitor the effectiveness of the selected alternative(s) and resulting data. Make changes in survey procedures if necessary to more efficiently fulfill survey objectives. If radical changes are necessary, consider abandoning the alternative(s) and conducting other analyses.

**SURVEY ALTERNATIVE CONSIDERATIONS**

Regeneration surveys can vary as to the specific nature of their design. They can range from being purely observational to more experimental in design. Cochran (1983) defines observational studies as being those in which the investigator is restricted to taking selected observations or measurements that are appropriate for the survey objectives, either by gathering new data or using those already collected by someone else. A more experimental design would be one where some type of artificially prepared population is developed and utilized in the sampling procedure. For example, seedlings might be planted under specific conditions and used as a control group for comparison of data.

Additional considerations arise when making the decision of employing a purely observational regeneration survey or utilizing a more experimental design. First, in an observational study, available groups or sample populations that the investigator wishes to compare have already been created. For example, treatments have already been imposed upon selected sites and/or weather conditions have already affected regeneration success. Therefore, the investigator has no control over the status of selected sites and there may not be any true treatment replications. Second, with pure observational studies, the investigator has no "control" group to which sample data can be compared. The investigator is restricted to making comparisons among and between selected sites. Last, in observational studies, estimates from resulting data tend to be biased from factors outside the control of the investigator, such as climate or site characteristics. Considerations need to be given to the source(s) of this bias and how they affect results. It is difficult to ensure that bias is completely eliminated. However, consideration of bias should be taken during the planning and analysis of the study to minimize its effect on study results so that practical decisions can be made.

Difficulties may also arise when making inferences from observational study data. Because of the many variables present in the study population, conclusions may always be subject to some amount of error.

After deciding whether to conduct observational or experimental surveys, there are many issues that need to be addressed when alternatives are being defined. Some of these issues are described below. A discussion of how the issues have been addressed in a specific survey is presented.

An observational regeneration survey is being conducted by the Department of Forest Resources, University of Minnesota with the cooperation of the Beltrami County Land Department of Bemidji, MN. This study is being conducted to determine which silvicultural
practices work best under specific site conditions, and to provide recommendations as to the proper matching of timber species to site and soil type.

Species to survey

Separate decisions should be made as to how each species is to be treated. If the specified survey objectives for two or more species are the same, the systematic evaluation of issues for these species can be conducted together. Otherwise, separate analyses need to be performed. The species to be surveyed depend upon the objective(s) of the survey. In certain situations, it may be beneficial to consider more than one species in the survey. If the objective is to determine stocking or survival percentage of plantations, only one species might be surveyed. On the other hand, if the objective is to determine present and future stand composition (in terms of species present) all species present might be surveyed.

Three species will be evaluated for the Beltrami County survey. Data will be collected and analyzed from young red pine (Pinus resinosa Ait.), jack pine (Pinus banksiana Lamb.), and quaking aspen (Populus tremuloides Michx.) stands that are under the management of the Beltrami County Land Department. These three species were selected for the study because they are the timber species that are most actively managed by that landowner.

Age(s) to survey

The ages to include in the regeneration survey may be dependent upon several factors. First, survey objective(s) will dictate which ages should be included in the survey. The current age class structure of the forest may in itself eliminate some ages from being available for consideration. And finally, depending on survey objectives, the lack of reliable historical parent stand and treatment data may prevent certain age classes from being included in the survey.

Stands to be examined in the Beltrami County study had to be limited to certain ages because of the current age class structure of the forest as well as the lack of historical data. With an objective of determining which site treatment results in the most successful regeneration, it was imperative that all stands to be surveyed had complete and accurate historical parent stand and treatment data. Jack pine stands will range from age two to age twenty, red pine from age two to age ten, and aspen from age two to age ten.

Timing of the survey (seasonal)

Many factors can affect the decision as to when the survey is to be conducted. Some of these factors include weather conditions, personnel and/or equipment available, and species to be surveyed. For example, pine plantation trees can be more easily located during the dormant season, but one would have to deal with more adverse weather conditions during the fall and winter season. Project deadlines, budget constraints, or other conflicts may also dictate when the stands must be surveyed.

For the Beltrami County survey, all sampling will occur from June to September 1988 because of project deadline constraints and availability of personnel. Height measurements made during the active growing season will be assessed to the 1987 height to ensure standard evaluations throughout the growing season.
Type and intensity of sampling

Decisions will need to be made concerning the type, size, and distribution of plots to utilize. Plots can be either temporary or permanent, and can be either fixed or variable radius. Plot distribution between and among stands needs to be evaluated. The survey can be designed to sample many plots per stand in a few stands, to sample fewer plots in more stands, or some combination in between. While sampling many plots per stand in a few stands may provide very accurate information about those few stands, it generally does not address the variability between stands. Inferences across the entire ownership may, therefore, be limited. Sampling more stands with fewer plots per stand provides more information about variability between stands and, therefore, may better measure treatment response. However, this design does not provide as much detail for the individual stands. The literature details a number of survey methods. The one selected should be suitable for standard statistical methods which can be used to offer guidance in selection of plot size and number for a chosen error of estimate (Stein 1983).

These decisions for the Beltrami County survey were based upon the size (height and diameter) of regenerating species and the amount of time available to complete the survey. Because of the small size (height and diameter) of regenerating trees, circular fixed radius plots were employed. Plot size decisions were influenced by the expected number of trees per plot. Species with fewer trees per acre (pine stands averaged 800-1000 trees per acre) have larger plots (1/100-acre). Species with many trees per acre (aspen stands with 1,000+ trees per acre) were surveyed utilizing smaller plots (either 1/500- or 1/1000-acre plots). With an objective of determining differences between stand treatments, a relatively large number of stands (a guideline of eighty stands per species) will be examined with a relatively few plots per stand (one plot per three acres).

What is an acceptable tree

The specific objective may help answer this question. If the objective is to determine the status of the regeneration, only regenerating, preferred species need to be surveyed. But if the objective is to evaluate all species on the entire stand, then older trees may be included. Certain species which are present during the regenerating state of the stand may not be present when the stand reaches maturity. Other trees which are old or in poor health may soon die. Also, residual trees left standing on site after the harvest operation can affect regeneration success.

All tree species within sample plots will be surveyed and measured for the Beltrami County survey. This includes all residuals and trees as well as the preferred regenerating trees.

Weather condition variables

The specific weather conditions, before, during, and after site treatments and stand regeneration can affect success. These weather variables may include temperature, relative humidity, and precipitation available for growth and for affecting response to site treatments. In any regeneration study one has no control over how these factors may have impacted regeneration. Therefore, the only alternative is to be aware of these conditions, collect appropriate data, and use it to interpret differences in stand success.
For the Beltrami County survey, local weather conditions before, during, and after stand establishment will be obtained from the State Climatologist office. This data will be used to try to help explain differences in stand success.

**Tree damage and disease**

The survival and growth of trees is affected by the presence of damaging agents or disease. Insects or animals can cause stunted growth during times of prolonged exposure. Examples include deer browse on jack pine stands or insect shoot damage on red pine stands. Defoliation by caterpillars in an aspen stand can reduce growth of young trees. Disease can also cause severe damage in regenerating stands. Again, in a regeneration study, one has no control over such conditions. The only recourse is to record observations in hopes of explaining differences in regeneration success.

Observations relating to damage and disease will be recorded for individual survey trees as well as for the entire stand. Damage and mortality levels will be recorded as to how they fit into predetermined categories (e.g., 50% affected and 10% mortality). This data will be used to explain differences in regeneration success.

**Clonal variation among aspen**

This is a dilemma that is difficult to deal with. Do the tall heights and large diameters in one study plot relate to the fact that the trees may be from a superior clone? To evaluate this issue, one has to be able to answer the question of which trees belong to which clone. Some research has been done pertaining to the size and delineation of aspen clones, but answers are very dependent upon geographic location as well as many other variables. Barnes (1966) reported that clonal variation can be influenced by a number of factors, including the number of seedlings established, competition for light and moisture, rate of spread and intergrowth of root systems, frequency of disturbance, and relative suckering and rooting ability of the clones. Determining actual clone size can be very difficult and depends upon specific location. Black (1964) reported that the commonly accepted clone size of quaking aspen in the Chippewa National Forest averaged 4.05 acres. Barnes (1966) found the typical size of quaking aspen clones in Michigan was approximately 0.07 acres. An investigator needs to be very site specific about the size and delineation of aspen clones. Clonal variation cannot explain all differences in regeneration success. However, this factor can contribute to the data base needed in the analysis.

Aspen clones will be determined through several means for the Beltrami County study. Mainly, infra-red 35mm aerial photos of stands to be surveyed, taken during peak coloration, will be examined to delineate clone boundaries. Also, ground observations of leaf color and shape will be recorded.

**Unfavorable micro-sites**

The fact that some plots will fall in areas without regenerating trees has to be dealt with. These unfavorable micro-sites can include low, wet areas, summits or peaks on hills, places adjacent to or on landings or roads, or areas in very heavy competition. The specific objective of the survey probably will influence whether to include these areas in the survey or not. If the objective is to determine the status of just the regenerating trees, these unfavorable areas might be avoided. But, if the objective is to determine the composition of the entire stand, as
related to tree stocking and distribution by species, these areas should be included in the survey.

Areas of low stocking will be included in the Beltrami County study. Areas of both good and poor stocking are part of the success of the site treatment and will help determine the overall regeneration success of the management activity.

Storage and analysis of data

Regeneration surveys can provide invaluable information, if the data is stored and analyzed properly. Surveys that do not attempt to analyze the resulting data may never be cost beneficial. Regeneration surveys result in large volumes of data. A computerized data base system should be designed. Today, many data bases have been developed which can easily manage this task. Observational studies present particular difficulties when trying to draw sound conclusions from study data. The study results can only provide an estimate of the causal effect which is always subject to error. In the analysis of observational studies two major statistical aids are employed, tests of significance and confidence limits (Cochran 1983). Tests of significance answer the question of whether there is convincing evidence of some real effect. Confidence limits supply estimated upper and lower bounds to the size of the effect. The finding of a nonsignificant difference does not prove that there was no real effect. Along with the use of confidence limits, it may only show that the study failed to measure the size of the effect accurately enough for realistic decisions to be made. Different data collection procedures may then be required.

To aid in the analysis of the Beltrami County study, a data base will be utilized for data storage and retrieval. Decisions as to the success of site treatments will be based on:

1) mean values of tree stocking, height, and diameter;
2) statistical differences between study plot regeneration success for the various site treatments imposed;
3) statistical differences in financial criteria (relating to site treatments) existing between study plots.

CONCLUSION

Successful regeneration is the most important objective of those who manage forest resources on a sustained level. Even though increased sophistication has eliminated much of the guesswork involved in the reforestation process, regeneration surveys provide accurate information regarding the status of land management activities. A properly designed and efficiently run regeneration survey can and should provide the information required to make informed decisions. The completed analysis should fulfill the predetermined objectives of the survey as well as provide additional related management information which would increase the efficiency of the reforestation process.

Expected accomplishments within the Beltrami County Study include a determination of which silvicultural practices associated with regeneration efforts work best under specific site conditions. Survey results should also provide recommendations for matching species to site characteristics. The survey should also provide land managers with information necessary to plan for successful timber regeneration. Potential net benefits should include shorter rotations and lower regeneration costs.
LITERATURE CITED


ESTIMATING TIMBER SUPPLY ON NONINDUSTRIAL PRIVATE FORESTS

Chuck Niska and George Deegan¹

ABSTRACT. Existing forest inventory information is being used in a pilot project to determine the classification, location, and acreage of nonindustrial private forest land in three northeastern Minnesota counties. Using a modification of the Minnesota DNR Phase II inventory system, private lands in Aitkin, Carlton and Itasca counties have been mapped and classified by type, size and density. Where possible existing forest inventory information from adjacent public ownerships has been incorporated. Volumes per unit area by species-size-density class can be developed through the incorporation of plot data from past, ongoing or future forest inventories of similar cover types. This information is currently being digitized and will be available to resource managers, timber users and development groups for operational and activity level planning purposes.

¹ Itasca County SWCD, 516C South Pokegama Ave., Grand Rapids, MN 55744, and Minnesota Department of Natural Resources, Division of Forestry, 1201 East Hwy 2, Grand Rapids, MN 55744.

MINNESOTA HARDWOODS: FROM TREE TO KITCHEN CABINET

Steven G. Wilhelm

ABSTRACT. The nine major kitchen cabinet manufacturing plans in Minnesota assemble a total of 7,000 cabinets per day. These cabinets annually generate $127,750,000 of sales at the factory level and provide employment for 2,000+ individuals. The solid wood, primarily red oak, components of these cabinets require all the intermediate grade lumber produced from 30,660,000 board feet of red oak logs. This volume of logs is greater than the annual red oak sawtimber growth in Minnesota’s prime oak producing region in the southeastern portion of the state. Additional demands are being placed on Minnesota’s red oak resources by the furniture and millwork industries and exports to other regions of the U.S. and to foreign countries. In the future red oak demands are expected to increase while red oak sawtimber growth rates decrease—primarily because sawtimber harvest will greatly exceed sawtimber growth.

HARDWOOD LUMBER PRODUCTION

Minnesota’s primary hardwood—red oak—producing area is the southeastern quarter of the state. The forest land here is mostly owned by farmers and other nonindustrial private landowners. Timber harvesting is done by independent loggers that sell logs on the open market or by logging crews operated by individual sawmill operations. The sawmills are family owned and operated businesses that normally employ from 5 to 30 individuals. There are no large corporation operated sawmills in southeastern Minnesota. But, several large sawmill operations in western Wisconsin harvest logs in southeastern Minnesota.

Recent information developed by the Minnesota DNR and reports from Woodcraft Industries’ sawmill suppliers indicates the red oak sawlog resource is being over harvested in southeastern Minnesota. But, this is not a situation unique to Minnesota. Similar reports are originating in western Wisconsin, south central Indiana, southern Ohio and other hardwood producing areas. The volume of red oak lumber used in Minnesota’s kitchen cabinet industry exceeds the red oak sawtimber growth in southeastern Minnesota.

In addition to the strong domestic demand for red oak lumber some government agencies are actively encouraging export sales of raw products such as logs and lumber. The hardwood market is a world market and domestic firms must be able to compete for hardwood resources. But, a government bias toward exporting is detrimental to developing and maintaining a strong domestic hardwood industry. Exporting raw hardwood products is also exporting jobs and associated economic benefits. If hardwoods are exported the emphasis should be on value added products that will contribute to our local and national economies.

1 Marketing and Resources Manager, Woodcraft Industries, Inc., 525 Lincoln Ave. S.E., St. Cloud, MN 56304.

KITCHEN CABINET COMPONENTS--WOODCRAFT INDUSTRIES, INC.

Woodcraft Industries, Inc. operates two solid wood kitchen cabinet component manufacturing facilities in the central Minnesota cities of St. Cloud and Foreston. Each of these plants purchases approximately 9,000,000 board feet of green lumber per year and produce solid wood components for major kitchen cabinet manufacturing companies located throughout the U.S. The company employs approximately 200 individuals and has installed state-of-the-art lumber drying and processing equipment. Woodcraft Industries has grown about 15 percent per year since 1982 and the market is available to sustain this growth rate well into the future.

THE KITCHEN CABINET INDUSTRY

The U.S. kitchen cabinet market will require nearly 52,000,000 kitchen cabinets in 1988. Nearly half of these cabinets will be installed in new residential construction and the remainder will be used in the repair and remodeling market. The kitchen cabinet market has steadily increased from a low point of approximately 32,000,000 units in 1981 and the current market is nearly equal to the peak markets of the late 1970’s. Last year Minnesota’s nine major kitchen cabinet manufacturing companies produced approximately 1,750,000 cabinets which produced $127,750,000 sales at the factory level.

Solid wood cabinet doors and drawer fronts increased their market share over competing materials such as laminates and plastics during the eight year period from 1980 to 1988. At this time the consumer preference for solid wood is still increasing in the kitchen cabinet market and the primary demand is for open grained woods such as oak, ash, and hickory.

CONCLUSIONS

The supply of hardwood lumber for kitchen cabinet components, furniture and other uses is a primary concern of Minnesota hardwood manufacturing companies as the projected demand for hardwood lumber will increase while the supply decreases. Two courses of action are needed:

(1) Increase the growth of hardwood sawlogs on all land ownerships on productive hardwood sites.

(2) Free export market with emphasis on value added hardwood products.
LONG-TERM TIMBER SUPPLIES:
SOME KEYS TO FUTURE PRODUCTIVITY

Jeffrey N. Niese and J. Michael Vasievich

ABSTRACT. Lake States forests are likely to face increasing demands for timber in the future to support continued expansion of the forest products industry. Stable long-term supplies are critical, but increased productivity depends on society’s expectations about future timber needs and values. Future timber supplies can only be increased by wise timber production decisions and investments made today. This paper reviews current obstacles to increased timber supply, opportunities to expand timber production, and factors that influence the willingness of landowners to grow more timber.

INTRODUCTION

Stable long-term timber supplies are crucial to the future of forest industry in the Lake States, and to the overall health of the region’s economy. The enhancement of tomorrow’s timber supplies depends upon timber production decisions and investments being made by forest landowners today.

Growing timber demands can be met by four potential sources: National Forests, other public forests, forest industry lands, and other private forests. The extent of commercial timberland in these categories is illustrated in Figure 1. Growing public involvement in the planning process has hampered significantly the capability to expand timber production on the region’s National Forests because of management plans that place high values on non-timber benefits. State and county forests also suffer from non-timber constraints, but to a lesser degree. These forests are more capable than the national forests of being managed to meet the region’s needs for wood products. State foresters already are intensifying management efforts on the 7 million acres of state-owned commercial timberland, to help meet the timber needs of forest industry. Traditional low funding of state forestry programs has made it difficult for managers to invest in silvicultural practices that yield a high rate of return. One innovative effort—the Michigan Forest Development Fund—may soon issue bonds to make timberland investments in anticipation of future timber revenues.

Forest industry owns 9 percent of the Great Lakes forest. This highly productive component will be managed to produce optimal timber yields. Significant opportunities exist on the other private land, 52 percent or 23.5 million acres of the commercial timberland base. Numerous studies have shown that this land is producing timber at less than one-half of its capacity, so the greatest potential for increased timber outputs is to be found here.

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1 Research Forester and Project Leader, U.S. Forest Service, North Central Forest Experiment Station, 1407 S. Harrison Road, East Lansing, MI 48823.

Area of Commercial Timberland

![Area of Commercial Timberland](image)

**Figure 1.** Area of commercial timberland in the Lake States by ownership group in millions of acres.

**A Tale of Two Landowners**

Eighty percent of the timber supply problem is due to low productivity on the non-industrial private forests. We speak of the nonindustrial private "problem," but there are actually two problems—the need for sustained timber supplies and landowners' willingness to produce timber. The stories of two nonindustrial landowners illustrate these issues from a personal perspective. These include obstacles to timber supply, willingness of landowners to grow and harvest more timber, and opportunities to expand timber supplies, without unduly sacrificing other forest values.

Our first landowner, John, is a third-generation dairy farmer in northwestern lower Michigan. He and his brother manage 800 acres, with 220 acres of hardwoods. John’s grandfather homesteaded their land in 1890. When times were tough, both John’s dad and his granddad worked as river guides and loggers to keep the farm going.

Out of economic necessity, John has concentrated on making his cropland and cows more productive. He uses the resources of Cooperative Extension, Soil Conservation, and federal cost-sharing programs more than most farmers. John is both innovative and conservative in managing his farm. He and his brother milk 90 cows, practice minimum tillage farming, and participate in a computerized business management program. John also serves on the local Soil Conservation District board. He is widely respected for his expertise on land issues by other farmers and landowners.
Although John is an excellent dairy farmer and a respected leader in his community, he had ignored his fine woodlot for 15 years. But John recently decided it was time to manage his forest.

First, John and his family faced a declining income as the price of milk fell 20 percent between 1985 and 1987. To compensate, John tried more intensive farm management practices. He and his family tightened their budget and reduced their standard of living. Then, his wife took a job in town, as so many farm families have done. Another strategy, alternative crops, promised added income. John put in several acres of asparagus and some Christmas trees to diversify the farm, and negotiated the best possible oil and gas leases. Even so, the flood in 1986 and drought in 1987 reduced their crop yields at the same time milk prices fell again. Finally, almost as a last resort, he turned to his timberland. Most NIPF owners that do manage their land harvest timber at times of personal or financial crisis, rather than according to silvicultural prescription (Mullaney 1978).

John’s woodlot had been high-graded for the best red oak and hard maple logs over the years, but was a productive site. John never knew if he was getting a fair price for his timber. He and his family were too busy farming and had never sought competitive bids or professional forestry advice. But now economic necessity turned John’s interests to the profitability of his timberland.

In 1985, John attended a woodlot management tour and saw examples of high-grading, quality even and uneven-age management, and competitive versus noncompetitive prices received for the same types of timber. He couldn’t believe that similar nearby timber had sold for twice the price he had received in the past. Not knowing much about the value of his timber had cost him a lot. John realized that one of the biggest deterrents to timber management and reluctance to harvest has been that most landowners, like him, just don’t know what their timber is worth! This lack of market and management knowledge is one of the major causes of imperfection in timber markets (USDA Forest Service 1988). In a recent study of 203 NIPF’s in northern Michigan who chose not to participate in a targeted management program, 40 percent of those surveyed cited lack of economic return as their most important reason not to manage their woodlots (Kalisz 1987).

John’s story has a positive ending. After deciding to manage his woodlot, he hired a consulting forester to help improve his stands with a management plan. John and his brother are cutting the low-grade trees and selling them for firewood and pulp. He recently sold thirty acres of aspen at a competitive price. In a few years, he will market quality oak, ash, and maple sawlogs, at the best possible market price. His woodlot is a part of the farm enterprise now.

John is the classic example of what the researchers call an "early adopter" (Rogers and Shoemaker 1971)—a recognized community leader who learns from his mistakes and shares his experiences to help others. He is an opinion leader and key communicator; able to influence other members of the community (Haymond 1988). As the chairperson of the Soil Conservation District forestry committee, John organized three forestry education programs, and he talks to his neighbors about good woodlot management every chance he gets. John and his new interest in sound forest management may have done more good for area landowners and timber supplies than the efforts of agency and industry foresters in the past 10 years.

Our second landowner, Carl, is similar to John, but also strikingly different. Carl, now in his early 70’s, was born and raised on a livestock farm, mostly sheep and cattle. When Carl was a young man, his dad gave up on farming. Low commodity prices and worn-out pastures
drove him off the land. So Carl became one of the millions of rural Americans who left the farm in the Depression era to seek a new life in the city.

Carl moved to Detroit, married a city girl and raised his family in the city. Yet he was still a "country boy" at heart. In fact, for most of those forty years he had been an absentee landowner, returning to the old farm each year for deer hunting and to keep in touch with his heritage. He had done his part to restore the worn-out land by planting some jack and red pine on the sand hills where the overgrazing had done the most damage.

Two years after retiring Carl convinced his wife that it was time to go back to the country he loved. They built a beautiful retirement home, using native pine, oak, and ash, on their 250-acre farm. The forests covered all but 30 acres now; no commercial harvesting of timber had been done for more than 50 years.

Now that he was retired, Carl had more time to think about the farm. Because he was raised with the idea that land should produce something, it bothered him that his farm was not as productive as it might be. Living on the farm made him want to manage his forest rather than letting nature take her course. This inclination to more intensive management by resident NIPF’s is confirmed in the literature (Kurtz and Lewis 1981).

Carl's maturing timber has attracted nearly every wood buyer in the area. Chippers, short-wooders, veneer buyers, and buyers for hardwood sawmills have all sat around his kitchen table, drank coffee, and talked timber with Carl.

No buyer has yet been able to meet Carl's management objective. He believes that management in upland oak, aspen and pine needs to be complemented by management in lowland hardwoods. He told the loggers and foresters that he will harvest on the uplands only if they will also cut in his 100-acre hardwood swamp.

Because of his comfortable pension and frugal lifestyle, added income has not motivated Carl to cut his timber. As an avid grouse, turkey, and deer hunter, the needs of wildlife, however, do motivate him. Several foresters have shown him ways to improve wildlife habitat, and his interest in a timber sale has increased. Carl still insists that his lowland and upland areas be managed together.

Carl's view of the timber industry is complicated by another problem. Twice in the past 20 years, loggers have trespassed on his property. Two years ago loggers working on adjacent state land strayed onto his land and cut his good hardwoods. Carl was not compensated, but he is now getting a damage appraisal through a forestry consultant.

Carl is also opposed to having an intensive harvest. Much of the timber on state land that surrounds him—a mix of oak, white pine, and aspen on good sites—has been chipped for pulp recently. Carl can't understand why 10- to 15-inch red oak with a good growth rate are going down the throat of a chipper, or why the clearcuts surrounding him are 40 acres in size. He only knows that he will never permit that kind of intensive harvesting on his land.

Carl is not alone in his disdain for intensive forestry. One North Carolina landowner, frustrated by years of intensive management prescriptions for her woodlot, decided to fight back. She started a consulting firm that specializes in low-cost, less intensive forest and environmental management, more palatable to small owners like herself (Harberts, 1982). These "soft" silvicultural practices include techniques that minimize the impact on the site
itself. Some examples are: deadening hardwoods, underplanting pines, light burning and planting, using Round-Up in hardwood understories, shelterwood cutting, and carefully timing harvests to maximize regeneration. Her firm, named ForestCare, is based upon the reasoning that many more forest landowners could be lured into active forestry if foresters were more sensitive to their needs.

A final complication clouds the future productivity of Carl’s timberland. Carl is the resident manager of the family farm, but he must consider the wishes of this brother and sister who have a partial interest in the woodlot. In this case, they are less inclined to have a timber sale than Carl. Preserving the family heritage—whatever that means—is most important to them. So Carl not only has to sell himself on the idea of a timber sale, but also his sister and brother.

Meanwhile, out in Carl’s woods, mature and overmature aspen wait on the ridges. Big red and white oak, white pine, and the swamp’s big red maple, ash, basswood, and aspen all wait to be harvested and regenerated. It’s just a question of who will harvest first—Mother Nature or forest industry.

A lot of land out there is like John’s and Carl’s. Based on the most recent Forest Survey data, 11.5 million acres in the Lakes States are mature and suitable for harvest and regeneration (Table 1). Another 4.5 million acres need improvement cuttings, thinning, and partial cut harvesting to increase productivity (Vasievich 1988). Well over half of these opportunities are on private nonindustrial land.

Table 1. Area of commercial timberland on all ownerships in the Lake States with treatment opportunities in millions of acres.

<table>
<thead>
<tr>
<th>Treatment Opportunity</th>
<th>Michigan</th>
<th>Minnesota</th>
<th>Wisconsin</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearcut and regenerate</td>
<td>4.3</td>
<td>3.9</td>
<td>3.3</td>
<td>11.5</td>
</tr>
<tr>
<td>Convert to desirable species</td>
<td>2.1</td>
<td>2.3</td>
<td>1.6</td>
<td>6.0</td>
</tr>
<tr>
<td>Regenerate stands</td>
<td>2.3</td>
<td>2.2</td>
<td>2.1</td>
<td>6.6</td>
</tr>
<tr>
<td>Thin poletimber</td>
<td>1.2</td>
<td>0.3</td>
<td>0.9</td>
<td>2.4</td>
</tr>
<tr>
<td>Partial cut harvest</td>
<td>0.9</td>
<td>0.3</td>
<td>0.6</td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td>10.8</td>
<td>9.0</td>
<td>8.5</td>
<td>28.3</td>
</tr>
</tbody>
</table>

Obstacles to Timber Management

John and Carl symbolize many of the problems that will face the forestry community in the coming decades. What obstacles prevented them from managing their woodlots? First, ignorance and neglect. John was too busy farming; Carl was in Detroit working and raising a family. Most landowners simply don’t have the time or necessary knowledge to manage their forests. Professional foresters are needed to bridge the gap between landowners and industry.

Second, a poor image of the timber industry. High-grading, timber trespass, unnecessary damage to soils and regrowth—even the most uninformed landowners suspect when something is wrong. They may take out their wrath on the timber industry as a whole by "locking up"
their woodlots against future harvests. Perhaps Carl’s timber would be under productive management already if local loggers had respected his property lines.

Third, attractive alternative investment opportunities. John tried intensified farm practices, Christmas trees, and asparagus before he turned to his woodlot. Carl probably put his money in certificates of deposit or bonds. Neither of them had any dependable information on the economics of their timber.

Fourth, owner objectives that may limit or constrain timber production. In Carl’s case, his desire to harvest in his big swamp limited timber production from his uplands. Also, his siblings may veto his overall management plan.

There are additional obstacles to increased timber supply. Changes in land use resulted in an 8 percent reduction in the Lake States’ commercial timberland base between 1952 and 1977 (Gray et. al. 1985). These changes include land shifts between forest and agricultural use, wilderness designations, and subdivision of productive forest land in rural areas (State Foresters of the Northeast Region 1984).

Reductions in public funding have resulted in fewer public service foresters working directly with landowners. Some would argue that this is a positive development, that the private sector can pick up the slack. But Michigan’s experience contradicts this reasoning. A 70-percent reduction in Department of Natural Resources service foresters has occurred in the last decade. Where public service foresters have remained, more forest management activity has occurred than in unstaffed regions. Public foresters have been a vital link between landowners, consultants, and forest industry. Public foresters spend a great deal of time directing landowners in needed timber stand improvement, something the private sector does not often do (Hoeksema 1988).

Lack of investment capital for forest management practices affects public and private land alike. Many nonindustrial landowners don’t have the necessary cash to invest in the treatments that will bring them the greatest future dividends. Even if they do have it, their investment horizons are too short to channel scarce capital into long-term forest management activities. If society really needs the additional timber, it must find ways to “front-load” these investments.

Finally, inadequate or poor quality regeneration is a problem on 24 million acres or 53 percent of the Lake States timberland (Vasievich 1988). This is related to several previously cited obstacles. Unplanned timber harvesting, lack of professional forestry advice, lack of investment capital, and poor seed stock all contribute. An estimated 75 percent of all harvesting on private land in northwestern lower Michigan occurs without regard for regeneration. These timber sales are usually direct transactions between landowners and loggers, without the help of a professional forester (Figure 2). No wonder regeneration is such a large problem throughout the region.

Approaches to Increase Timber Supplies

Given these many obstacles, what approaches are most likely to help increase the region’s timber supply? The recommendations can be divided into several categories: direct financial incentives, tax policy, technical assistance, regulation, and education. All are aimed at increasing the capital committed to timber production.
First, direct financial incentive programs should be encouraged. These have been used for more than 50 years to combat perceived timber scarcity. Programs such as CRP, FIP, ACP, and state cost-sharing have all worked to varying degrees. But innovative approaches to these programs need to be discussed and encouraged at the local level. Instead of merely cost-sharing, tree planting could be offered free of charge if the landowner follows silvicultural guidelines and meets site productivity criteria. A second idea: landowners could be offered free management plans through soil conservation districts, as a paid FIP practice. This approach has worked in New Hampshire counties, where landowners who receive benefits are required to follow through on the foresters' recommendations within ten years (Lafor and Parker 1988). A recent approach in Michigan involves cost-sharing the harvesting of problem scotch pine and replanting these sites to red pine (Kalisz 1987).

Second, tax policy can be used to encourage needed forestry investments. Although no empirical studies have been made, many landowners believe that the restoration of federal capital gains treatment of timber is absolutely necessary. The reforestation tax credit (PL 96-451), rapid amortization of reforestation costs, and options to expense timber production costs greatly affect the profitability of timber management. Extension of these provisions is an important and potentially very effective policy option.

Property tax relief that gives landowners the incentive to grow timber rather than subdividing their parcels must be pursued aggressively. Since 1955, land values and ad valorem taxes have increased more than tenfold in northern lower Michigan; land fragmentation has similarly increased (Olson 1979). The number of NIPF's with 10 acres or more increased in Michigan to 180,000 by 1980, and average parcel size decreased from 80 acres to only 48 acres between 1964 and 1981 (Carpenter and Hansen 1985). Similar trends are occurring across Minnesota.
and Wisconsin. The Commercial Forest Act, the only Michigan law that provides substantial tax relief for Michigan forest landowners, should be strengthened. The part of the act that requires landowners to open their lands to public hunting and fishing discourages some landowners from participating. The Michigan forest community and other interests have failed in their efforts to revise the act.

Third, both the amount and the effectiveness of technical assistance programs in forestry need to be increased. Michigan has only 12 full-time employees in private lands forestry, but it has the largest commercial forest land base in the Northeast region. By combining service and extension forestry efforts into one program, as New Hampshire has done, benefits to landowners and industry could be more than doubled, while reducing agency overhead.

A crucial part in the success of service forestry programs is the referral of landowners to qualified consulting foresters. This referral process is a two-way street--service foresters must be ready and willing to refer clients to consultants, and consultants must be technically qualified, unbiased, and willing to provide the full range of needed services. Where service forestry programs are working most effectively, more business should be generated for forestry consultants. This translates into more managed timberland (Figure 3).

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**Figure 3.** Decision process for forest management involving professional foresters.
To make technical assistance programs more effective, specialized training could be held for foresters involved in helping landowners accept their first timber sales. More than 70 percent of all nonindustrial owners fall into this category. There is a need for counseling, hand-holding, follow-up, recognition, and affirmation to help many owners deal with their ambivalence toward timber sales. It's far more likely that foresters could do this than psychologists!

Fourth, a regulatory approach to achieve timber supply goals may not be popular in the Lake States, but regulations may be effective in addressing at least three thorny issues. The first issue is to assure regeneration after harvest. Nearly every country that has greatly improved forest productivity in this century has enacted laws that require regeneration following timber harvest (James 1986). The Virginia Department of Natural Resources administers a law that requires regeneration: either planting of pine, or the leaving of seed trees. In the Lake States, the regeneration problem is so large that conventional incentives and education programs do not appear to be sufficient. Numerous studies from the South have shown that landowners are not planting enough pine to meet projected shortfalls in the next century (Royer and Moulton 1987; USDA Forest Service 1988). When landowners do plant pine, there does not appear to be a positive correlation between economic opportunity and landowner behavior (Royer and Vasievich 1987).

What is needed is a regeneration law coupled with an appeal to landowner ethics and stewardship. This approach has worked in Germany, Scandinavia, and Australia (James 1986). Such a law should concentrate on the need for regeneration, not the need to plant softwoods. An approach that encourages softwood regeneration for reasons of ecological diversity and good stewardship will be more appealing than one that force-feeds softwoods for future needs.

Two other areas where a regulatory approach could yield good results are the registration of foresters and loggers. Registration of foresters gives nonindustrial owners some assurance that consultants are technically qualified, free of conflict of interest, and of sound character. Forester registration is practiced in Michigan, but not throughout the Lake States. Region-wide registration can help insure quality of services.

Registration of loggers may be even more controversial, but it should be carefully considered. Landowners need to know the qualifications of loggers, and they do not always have the benefit of a consultant when making a timber sale. One Illinois study has shown that the greatest barrier to the management of nonindustrial land in that state is the quality of loggers' work (Young et. al. 1985). Several New England states have passed forest practices acts in response to public perception of inadequate logging practices. Although it may be difficult to accept, the timber industry might find logger registration much more tolerable than forest practices acts in the Lake States.

Finally, and most importantly, a significant commitment to education programs is needed to improve the productive management of NIPF land. Nationally, and regionally, the Cooperative Extension Service is in a key position to lead this effort. Already the Renewable Resources Extension Act (RREA) of 1978 has taken a step in this direction. However, this initiative has not been adequately funded. If RREA were funded at the recommended $15 million level rather than less than 20 percent of that amount, Extension could begin to provide the educational leadership that most foresters agree is lacking.
Despite the abundance of available information, landowners are poorly informed of the benefits of woodlot management. Many landowners, like John, need to be shown the opportunities available to them. They need to know timber price trends, strategies for managing nontimber benefits, and methods to achieve land protection goals with good timber sales contracts. In short, they need a competent forester to help them manage their resource. One forestry consultant, in reviewing the woodlots of more than 500 landowner clients, found that 90 percent of his clients’ lands had been high-graded in the past twenty years, and 10 percent had woods that were stagnant because nothing had been done in the past 65 to 200 years. Incredibly, most of these landowners did not know they had harmed their woodlots through indiscriminate logging, nor did they realize they had not received fair market value for their timber.

**Nontimber Benefits Are the Key to Management**

Many landowners are held back from managing their forests by lack of knowledge, like John. What about landowners like Carl, who know what they want, but can’t seem to reach their objectives? Until foresters really start listening to landowners like Carl, lands will not be managed at all, much less for timber. One procurement forester for a large corporation, reflecting on 25 years of frustration in dealing with these private landowners, concluded that he hadn’t even been speaking the same language as his clients. He was preaching timber and economics; they were talking about wildlife and natural beauty (Ticknor 1986).

In the Lake States, we foresters believe that half a million owners of 24 million acres should be growing wood more effectively, but those owners don’t always agree with us. Most forest landowners, like Carl, are not primarily motivated by economic factors. So foresters need to stop talking economics as the major selling point of woodland management. Foresters need to be more sensitive to the actual bundle of resources that each owner values.

Increasingly, landowners are not interested in **producing** wood. What they are interested in is **consuming** tangible and intangible goods from their woodlots—morel mushrooms, deer, small game, berries, and the kinds of experiences that they can share with their grandchildren. Both foresters and economists need to change their perspectives on NIPF owners. Viewing NIPF’s as **consumers of utility** rather than as producers of timber would go a long way toward helping us achieve common goals.

The forestry community needs to bend more, to help landowners meet their objectives rather than the timber supply goals of policy makers. What is needed is a landowner education and recognition program that has room for all landowner objectives and needs. Alabama is trying a program like this called **TREASURE FOREST**. In Treasure Forest, timber, wildlife, outdoor recreation, aesthetics, soil and watershed protection, and environmental enhancement must all be considered in the landowner’s management program. The landowner must choose one of these as the primary management objective, and one or more of the others as secondary objectives. The landowner is under no pressure to choose any one objective or combination—the choice is his or hers alone. What’s the payoff for the landowner? He or she becomes a priority client for forest management assistance, as well as earning state-wide recognition (Alabama Forestry Commission 1983).

The success of Treasure Forest is indicated by the fact that Alabama recently enrolled its one millionth acre in the program. By allowing the landowner complete freedom to choose and develop nontimber objectives, and by giving equal recognition to good management for
nontimber benefits, Alabama is taking a risk. But as one Alabama forester has said, "If we truly meet the landowner's needs, the board feet and cords will take care of themselves."

Alabama's foresters are helping private landowners manage their woodlands for TREASURE benefits, not just commodities. I don't know if this approach will help Carl to manage his hardwood swamp, but it is a lot more consistent with Carl's view of why he owns his woodland. We need to take a noncommodity or TREASURE approach if we want landowners in the Lake States to manage. As foresters and resource managers, can we really afford to do anything less?

REFERENCES


THE REAL WORLD:  
A LOOK AT ONE MINNESOTA COUNTY

Terry Helbig

ABSTRACT. There are countless volumes of studies, summaries, and statistics showing various trends and projections. Generally, these studies are broad-based and designed only to show trends for regions, states, or the nation as a whole. This paper will look at what has happened and what is happening in one county of Minnesota. No inferences should be drawn by the reader that trends shown for this county are in any way representative of any other county. The only conclusion that may be made is the same one found in every research paper ever written: "More study is needed."

INTRODUCTION

In trying to arrive at a topic and title that would be of interest for this conference, I reflected back on an editorial I read in American Forests about 12 years ago. The editorial was titled The 260 Million Acre Myth.

The gist of the write-up was that the 260 million acres of commercial forest land that statistics show are present in the United States simply does not exist. The author based his opinion on statistics from counties adjacent to large metropolitan areas and stated that due to small ownerships and housing developments the land was no longer commercial forest. I don't recall the exact numbers or even county names, and they are not important. I do remember that I agreed his observations were valid both nationwide and, in my area of work, Wabasha County, Minnesota.

While Wabasha County is not adjacent to a metropolitan area, it does have both absentee woodland owners and resident owners that commute to work in Rochester. The major group of forest landowners, however, are farmers.

The amount of commercial forest land in Wabasha County is currently estimated to be about 77,000 acres. Perhaps instead of titling this talk "The Real World," a more appropriate title could be "The 77,000 Acre Myth."

This paper will cover a brief history of Wabasha County and then look at what has happened and is happening to the forest resource of Wabasha County. Numerous sources have been drawn on for data presented. Conversions of cubic feet, cords and board feet were standardized using the rate of 2 cords per thousand board feet (MBF) and 5 board feet per cubic foot.

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1Forester, Minnesota Department of Natural Resources, Division of Forestry, P.O. Box 69, Lake City, MN.

COUNTY ANALYSIS

Persons reading this paper should not draw any conclusions that the data and trends observed are in any way, shape, or form typical of what is happening in the rest of the state or nation. The only intent is to show that statistics and what is happening in "The Real World" may not always match.

General History

To better understand current trends in land management and the forest resource, it is interesting to look at some of the settlement patterns in the county.

The majority of settlement took place between 1860 and 1880. Wheat was the primary crop. As the county became more settled and transportation improved, diversified agriculture became prevalent.

The forests of the county were used for building materials and fuel. Sale of cordwood to steamboats provided a ready source of cash income to early settlers. Even in early settlement days, oak was the preferred species for numerous uses, most notably fuelwood and fences. One reference found shows that in 1860, oak was worth $18.88 per MBF as fence boards. I don't know the inflation adjusted conversion rate, but it is obvious that oak has been a valuable resource for over 125 years.

By looking at the data from the USDA Census of Agriculture, one can almost chart the development of agriculture in Wabasha County. The data, even though 10 years apart, also shows some of the fluctuations in the general economy.

The Forest Resource

As stated, the intent of this paper is to look at general trends in the forest resource of Wabasha County. This will be done by comparing data from reputable sources.

There are three categories of data on the forest resource this paper will look at: the overall forest resource, the estimated drain on this resource, and the Cooperative Forest Management Program.

Data on the total amount of forest land present first appear in the USDA Census of Agriculture in 1930. Figure 1 shows a comparison of the current estimated acreage or woodland from five different sources.

The five sources of information in Figure 1 are from left to right: USDA 1980 Census of Agriculture, the 1977 statewide forestry inventory, the Soil Conservation Service (SCS) 1970 Conservation Needs Inventory, a recent Wabasha County/Minnesota Extension Service report and the Minnesota DNR Lewiston Unit Management Plan (1988 draft)

The range in acreage is from 44,484 to 78,400. Converted to percentage of total land area, this range is from 13.3% to 23.5%. Quite a difference!
Figure 1. Current woodland acreage in Wabasha County by source.

How forested land is defined probably has a lot to do with how each bar on the figure is arrived at. I have no doubt on the validity of any of the five. I personally like to use a figure of 75,000 acres of woodland because it seems reasonable and is easy to remember. Even though it doesn’t match any of the five, I doubt anyone can dispute it.

Likewise, data on individual forest types has varied greatly depending on which source is used. The phase I inventory is probably the most accurate data. It must be remembered, however, that there can be discrepancies when this data is applied on a county basis rather than a region wide basis.

There have been four statewide forest inventories done; in 1937, 1953, 1962, and 1975. These also provide a basis for comparison on what is happening to the forest resource in Wabasha County.

The 1937 inventory stated that only about 1% of the woods in the county were managed. It went on to state that 85% of the woods were grazed and 36% of the woods were grazed so heavily that they retained only a few scattered trees.

It further documented that original woodland volumes ranged from 8 to 9,000 board feet per acre but that current volumes (1937) ranged from only 234 to 2,516 board feet per acre.

Many foresters today are concerned about the conversion of the oak resource to northern hardwoods and the loss in quality of the oak that remains. Figure 2 shows a comparison of the oak resource to the northern hardwood resource from the various statewide inventories.
Figure 2. Acres of oak and northern hardwood resources.

This data shows that acreage of oak has remained relatively stable while northern hardwoods have actually declined. Perhaps a change in definition of oak type vs. northern hardwoods was part of the reason for this trend. At any rate, on paper it certainly looks like the oak resource is in fine shape. In the real world, however, we are in danger also of losing our oak type.

Data from the inventory showed that in 1973 4% of oak logs were in Log Grade I. The 1975 phase I, however, showed 8% in Grade I. This would on the surface appear to be good news. The bad news is that there is a much higher percentage of Grade 3 today than there was 50 years ago.

Trends in Drain

As with the forest resource, several sources are available to compare the timber drain in Wabasha County. Figure 3 compares the annual drain from two sources.

The figures range from a low of 400,000 board feet in 1970 by USDA estimates to a high of 1.9 million board feet by DNR estimates today. Which data source chosen would make a major difference in what we retain (on paper) as a forest resource. In the real world, however, foresters have no control over drain from private lands.

The figure of 1.9 million board feet is accurate today. A better, longer term average to use would be about 1.2 million board feet/year.

There are several correlations that would be interesting to look at. One of the most obvious would be to compare stumpage price to amount of drain. A second one would be the correlation between the amount of drain and fluctuation in the overall economy. Space does
Figure 3. Drain estimates according to USDA Census of Agriculture reports and DNR internal report estimates (as per Utilization and Marketing).

not permit these comparisons. Figure 4, however, shows the correlation between the number of chickens and amount of timber drain as estimated by the USDA Census of Agriculture.

Figure 4. Correlations between the number of chickens and board feet of timber drain.
Except for a few years, there seems to be a very definite relationship. I feel more research should be done along these lines. It is probably also possible to correlate the number of laying hens to percent of veneer harvested.

Cooperative Forest Management

There have been efforts to work with Wabasha County farmers on management of their woodlots at least as far back as 1913. Good records of cooperative forestry work done by SCS and the Minnesota Extension Service date to 1936.

Extensive management on private woodlands work was done by Civilian Conservation Corps (CCC) crews. Records indicate that trees were planted and fence posts cut to improve woods on cooperating farms. I’ve run across several CCC tree plantings but haven’t as yet done a record search and follow up survey to see how many of these plantings remain.

The first documented record of timber stand improvement (TSI) I found was for 1941 when 16 acres were completed on five farms.

Programs to promote forestry also data way back in Wabasha County. The 1936 report of the Extension Agent shows that two programs on forestry were conducted—one on care of farm woodlots and one on the use and planting of farm shelterbelts. Some 86 farmers attended the two meetings.

The Department of Natural Resources (DNR) has had service foresters working in Wabasha County as long as it has done private forest management (PFM) work. In the early years, service foresters covered several counties and the forester covering Wabasha County was stationed at Winona, Preston, Faribault, and Red Wing prior to the establishment of the Lake City District, Wabasha County by itself, in 1968. Accurate records of accomplishment date only to that time. Consultant foresters have also played an increasingly important role as management of private forest lands has become more intensive.

Figure 5 tabulates number of landowners assisted over the last 20 years.

The graph is interesting to look at for a couple of reasons. First, look at general trends. As would be expected, there are a greater number of assists as the PFM effort has increased, especially the last several years with work on the Conservation Reserve Program (CRP) and Reinvest in Minnesota (RIM) programs. Second, and perhaps more interesting, is the sharp drop in landowner assists in 1982. This was at a time when PFM specialists were added to the staff. The reason for this sharp decline is not a decreased PFM effort. Rather it is due to a change in reporting.

In 1982 a directive was issued stating a landowner could only be claimed as assisted one time per year. By 1984 the policy was changed so that landowners could be claimed once every other month. Prior to 1982 they could be claimed monthly.

Distinction is also made now for field assists vs. incidental assists. Field assists have remained relatively constant at about 100 per year regardless of whether a landowner is claimed monthly, bimonthly, or annually.
Figure 5. Landowner assists by the DNR by year in Wabasha County.

Have we made any headway on managing private forest lands in the last 50 years? The numbers would certainly indicate we have. At least they indicate that until we start examining them a little closer.

For example, in the last 30 years some 3.5 million trees have been planted on private lands in the county. This would amount to about 5,000 acres of plantations. Our best estimate of plantation acreage based on an aerial survey, however, is only about 700 acres.

The number of landowners assisted also is interesting to look at. Many of the same landowners we assisted 25 years ago are still receiving assistance. That is good because it shows a long term commitment both on the part of DNR and the landowner. The flip side of the coin, however, is that in spite of concerted efforts to reach new clients, less than 5% of landowner assists are "new" rather than "repeat" assists.

When looking at all the data and records that have been kept over the years, a person has to make sure that he knows what the records are really showing.

In some cases, reports have been exaggerated to make the report look good. This has been documented happening at least as far back as 1870 (wheat estimates).

In some cases, reporting standards were changed causing drastic fluctuations in accomplishments shown (e.g., PFM assists).

In some cases, the numbers reported may appear to be artificially low because participants in surveys are worried the Internal Revenue Service or some other government agency may use data provided against them (e.g., USDA drain).
SUMMARY

Regardless of imperfections in all data, it still remains the most quantitative way we have to look at what is happening. In "The Real World," however, one must realize that such numbers and trends are meaningless. Fluctuations in the economy, stumpage prices, government programs, and numerous other factors all serve to change the annual numbers and render projections useless.

Field foresters will continue to plug away and do their part to bring every acre of woodland under management. Researchers will continue to plug data into their computers and analyze it in ways that no one cares about. "The Real World," however, will continue to ignore efforts to be managed or categorized. The forest resource will remain at 44,000 or 78,000 acres, the oak will continue to improve or decline, the harvest will continue to exceed or be less than the amount of growth, and, perhaps most importantly, foresters and researchers will continue to have conferences to learn about trends in the forest resource.

What else is new in "The Real World?"
WILL NONINDUSTRIAL PRIVATE FOREST LANDOWNERS SUPPLY THEIR FAIR SHARE OF TIMBER?

Melvin J. Baughman

ABSTRACT. Minnesota's nonindustrial private forest landowners own 39 percent of the growing stock, but harvest approximately 81 percent of the fuelwood, 49 percent of the sawlogs and 33 percent of the pulpwood. They are major owners and harvesters of hardwoods. Given their low level of management, there is a question as to whether or not they can sustain this high harvest level over a long period and whether they will continue to produce the species and timber quality desired. Technical assistance, cost-sharing, education and tax breaks may motivate them to practice forest management.

NIPF TIMBER RESOURCES

Minnesota's nonindustrial private forest (NIPF) landowners own 41 percent of the state's commercial forest land (Jakes 1980). This is more than any other ownership category. Their lands are distributed among the Forest Survey Units as follows: 39 percent in Northern Pine, 29 percent in Central Hardwoods, 24 percent in Aspen-Birch and 8 percent in the Prairie Unit. Compared to other ownership categories, however, their lands are most important in the Prairie and Central Hardwood Units where they own 89 percent and 83 percent respectively of the commercial forest land. Their lands contain 39 percent of the growing stock including 46 percent of the hardwoods and 22 percent of the softwoods. In terms of timber size classes, 29 percent of their land area is in sawtimber stands, 48 percent in poletimber, 22 percent in sapling and seedling stands and 1 percent is nonstocked. They own 43 percent of the sawtimber volume including 54 percent of the hardwood sawtimber and 24 percent of the softwood sawtimber. A closer look at sawtimber volume by species reveals that they own very high percentages of the more valuable hardwoods such as red oak (83 percent), white oak (87 percent), hard maple (61 percent), and ash (53 percent) compared to the less valuable quaking aspen (34 percent).

Among ownership categories, their site quality is about average or slightly below. They own 42 percent of the net annual growth of growing stock including 51 percent of the hardwood growth and 24 percent of the softwood growth. They own 42 percent of the net annual growth of sawtimber including 50 percent of the hardwood sawtimber growth and 25 percent of the softwood sawtimber growth.

Their timber sustains 40 percent of the annual mortality for growing stock including 45 percent of hardwood mortality and 25 percent of softwood mortality. Their timber accounts for 53 percent of the sawtimber mortality including 56 percent of hardwood mortality and 38 percent of softwood mortality.

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1 Extension Forester, Department of Forest Resources, University of Minnesota, St. Paul, MN 55108.

Annual timber removals are higher than expected considering that they hold 39 percent of the growing stock. They account for 54 percent of the removals from growing stock for all species including 63 percent of the hardwood removals and 38 percent of the softwood removals. Their removals from sawtimber are 51 percent for all species, 61 percent for hardwoods and 34 percent for softwoods. In 1976 the annual timber removal from growing stock as a percentage of net annual growth was 71 percent for NIPF landowners compared to 95 percent for forest industry and 40 percent for public landowners. These are trend level removals that include timber on land converted to nontimber uses, except that they do not include transfer of commercial forest land to productive-reserved status.

Although accused of not providing a fair share of the timber supply, NIPF owners in 1975 harvested 81 percent of the fuelwood, 49 percent of the sawlogs (61 percent of the hardwood sawlogs and 29 percent of the softwood sawlogs) and 33 percent of the pulpwood (38 percent of the hardwood pulpwood and 28 percent of the softwood pulpwood) (Jakes 1980). According to unpublished information from the Minnesota Department of Natural Resources, in 1986 NIPF landowners accounted for roughly 42 percent of the state's timber harvest.

Some foresters are concerned that the high harvest level on NIPF lands may include substantial acres harvested and converted to other land uses. This theory is difficult to prove or disprove. However, between 1977 and 1987, commercial forest acreage declined by 118,800 acres and NIPF landowners accounted for conversion of 88,900 acres or 75 percent of the change. NIPF acreage declined 6 percent over this 10 year period.

There is some evidence that NIPF landowners do not manage very intensively. A Forest Industries Council report (1979) indicates that on the average, NIPF landowners account for 18 percent of the acres receiving site preparation, 29 percent of the planting, 4 percent of the conifer release activity, 15 percent of the other timber stand improvement (TSI) and 23 percent of the thinning. Jakes (1980) reports that in the fifteen year period from 1962 to 1977 only .5 percent of NIPF land received a treatment for regeneration compared to 1.7 percent of forest industry land and .6 percent of public land. Only .3 percent of the NIPF land received TSI compared to .5 percent of forest industry land and .1 percent of public land.

This avalanche of timber resource statistics tell us that NIPF landowners contribute their fair share to the timber supply. Their lands are an important source of hardwood timber, especially oak, maple and ash. They are the most important source for fuelwood and sawlogs among all landowner categories. Their level of management, however, is not very intense. Although statistical evidence is lacking, most foresters would probably agree that the hardwood timber resource on NIPF lands is generally in need of TSI and at harvest time needs much more attention to regeneration practices to sustain production of desirable species.

**NIPF LANDOWNER CHARACTERISTICS**

Minnesota's NIPF landowners have been studied extensively. A very comprehensive survey (Carpenter et al. 1986) focused on the 130,800 individuals, partnerships, corporations, clubs, estates and trusts holding less than 5,000 acres each. (Private landowners holding more than 5,000 acres have been shown to behave much like forest industries and were excluded from their study.) Collectively these NIPF landowners own 37 percent (5,100,350 acres) of the state's commercial forest land. Their most important reasons for owning forest land were recreation and esthetic enjoyment (28 percent of land area), part of a farm or residence (28 percent), firewood for personal use (15 percent) and land investment (10 percent). Only one percent of the land was owned primarily for producing wood products for sale.
The low interest in timber production and high interest in recreation and residential use of forest land was also found by Baughman (1988) in a survey of persons who purchased woodland in northern Minnesota in 1983 to 1984. Woodland preferred by the greatest number of buyers most likely had some combination of these resources: paved road access, upland, lake or stream access, excellent fishing nearby, abundant wildlife, a mix of hardwoods and conifers, 40 to 100 percent tree cover and trees over 9 inches diameter or a mix of sizes. Factors such as road access, wildlife habitat, nearby fishing and hunting opportunities and topography were generally more important in decisions concerning which property to buy than timber characteristics such as tree species, crown cover, tree size and site potential for growing trees.

One difficulty faced by NIPF landowners in making timber investments is their short land tenure. Approximately 31 percent of the area has been held by the same owner for 12 years or less. Approximately 58 percent of the area has been held by the same owner for 22 years or less (Carpenter et al. 1986). This relatively short land tenure was also found by Ellefson, Palm and Lothner (1980) in their study of Itasca County, Minnesota tax forfeited land which was sold to private landowners. They surveyed individuals who had purchased land over the previous 17 years and learned that 31 percent of the parcels had changed hands at least once.

Individually owned properties account for 92 percent of the commercial forest land (Carpenter et al. 1986). Most of the remainder are held by corporations, partnerships and undivided estates. Forty-one percent of the NIPF land is part of an active farm. Many of these landowners are not farmers by occupation, however. By occupation, the largest percentage of NIPF lands are owned by professional, executive and white collar workers (30 percent); followed by farmers (24 percent); retired (20 percent); skilled trades (9 percent) and others (17 percent).

Carpenter et al. (1986) explored landowner attitudes toward timber harvesting. Fifty-seven percent of the owners indicated they had harvested some material. These harvesters owned an average of 47 acres of woodland compared to an average of 30 acres for nonharvesters. Among landowners who harvested at least 30 cords, their main reasons for harvesting were to obtain wood for personal use (own 32 percent of the acres), to harvest mature timber (20 percent), and to salvage timber (12 percent). Woodlands associated with a farm were more likely to be harvested than nonfarm woodlands. Eighty-three percent of the farm woodlands were owned by persons who had harvested, but only 30 percent of the nonfarm woodlands were owned by persons who had harvested.

The most common reasons given for not harvesting were that it would ruin the scenery (own 16 percent of the acres) and it would destroy hunting (13 percent). Twenty-one percent of the acres were owned by persons who had not harvested because of physical characteristics of the timber (immature, poor quality, low volume or small area). Only 1 percent of the land was owned by persons opposed to logging.

Landowners were asked when they expected to harvest timber in the future. Forty-two percent of the acres were owned by persons who expected to harvest within 10 years. 32 percent were owned by persons who were indefinite about when they would harvest and only 17 percent were owned by persons who never expect to harvest. A high percentage of those who never expected to harvest were retired persons. The average size of forest holdings is larger for those with positive harvest plans than for those who never plan to harvest.
One concern to the forestry community should be that foresters do not appear to influence timber harvesting on private forest lands to any great extent. Among landowners that harvested at least 30 cords, only 6 percent of the land was owned by someone who had a forester select the timber to be harvested; 66 percent of the land was owned by someone who selected the trees to harvest without other assistance (Carpenter et al. 1986).

Cubbage et al. (1985) found in Georgia that landowners who used a forester for timber marketing in pine stands not only received a higher timber sale income, but their stands were in better condition, silviculturally, following the harvest than stands harvested without a forester's assistance. A similar study in Minnesota (Henly et al. 1988) was less conclusive. There was no significant difference in silvicultural outcomes from timber harvests with and without a forester's help. Since most of the stands surveyed were stocked with aspen and aspen stands are generally clearcut, a large difference in stand conditions is not surprising. Those who used a forester earned a higher price for their aspen timber, although the sample size was too small to be very reliable.

It is generally believed that silvicultural treatments will be "better" when a forester influences management of mixed hardwood stands, because foresters are generally more knowledgeable than loggers in prescribing silvicultural treatments that will regenerate desirable species, but there is no clear evidence to support this hypothesis. Although the study by Henly et al. (1988) compared assisted and unassisted hardwood sales, the sample size was too small to be conclusive.

Only 21 percent of the NIPF land is owned by someone who has requested forestry assistance (Carpenter et al. 1986). The percentage of landowners requesting assistance increases as the size class of their land increases. Among landowners requesting assistance, 36 percent of the land was owned by landowners requesting general management assistance, 26 percent for timber sales and valuation, 10 percent for TSI and 9 percent for tree planting. Over 80 percent of those requesting assistance had harvested timber. A study by Stone (1969) also found that NIPF landowners in Michigan's Upper Peninsula were most interested in forestry assistance at the time of timber harvesting.

These surveys suggest that over a long period of time a very high percentage of NIPF land will be available for harvest. Although some landowners are not interested in harvesting, the turnover rate is high and sooner or later most timber will be available for harvest. NIPF lands are major suppliers of timber, especially fuelwood and hardwood sawtimber. Whether or not they continue to produce the mix of species, sizes and quality demanded by the forest products industry is open for debate. Timber management, especially in hardwood stands is most successful under guidance from a forester, but NIPF landowners show a low use of forestry assistance. They do not buy land with timber production in mind and evidence shows a very low level of management. Various incentives may be needed to sustain and improve timber productivity.

**FORESTRY INCENTIVES FOR NIPF LANDOWNERS**

Public incentives routinely available to NIPF landowners to stimulate more forest management include free or low cost technical forestry assistance, cost-sharing for tree planting and TSI, informal education through the extension service, property tax breaks and income tax deductions for forestry expenses. Although this package of incentives has not been studied as a whole, some individual incentives have been studied and their success documented.
As previously mentioned, studies of technical forestry assistance to NIPF landowners in Georgia and Minnesota show that landowners receive higher revenue from timber sales when using forestry assistance and in some cases their land receives a "better" silvicultural treatment. In Georgia the technical assistance program aimed at timber harvesting on pine lands was an economically efficient use of funds for both the state and federal governments. In Minnesota technical assistance on aspen sales was not an economically efficient use of funds by the government. More research is needed to determine whether or not technical assistance for management of other hardwoods is economically efficient in Minnesota.

A study of government cost-sharing for planting red pine in Minnesota under the REAP-A7 program concluded that the program as a whole was marginally justified on the basis of expected timber benefits (Gregersen et al. 1979). In addition 70 percent of the participants stated that a decrease in the amount of REAP monies available to them would not have made them plant fewer acres. However, 37 percent of the landowners claimed they would have increased the number of acres planted if the government would have paid a greater portion of the cost. The researchers concluded that the program could have been more economically efficient if targeted to larger acreages. This conclusion was re-affirmed when they surveyed this same group 10 years later and found that persons who planted larger acreages in 1972 also planted larger acreages during the following 10 years than persons who planted smaller acreages in 1972 (Gregersen and Walker 1985).

A national study of the Forestry Incentives Program (FIP) in 1979 had more favorable results (Risbrudt and Ellefson 1983). FIP provided cost-sharing for tree planting and TSI. It yielded an 8.3 percent internal rate of return when all direct costs, including administrative costs, were balanced against increases in future timber yields.

Another study of the 1979 FIP recipients by Reed (1987) identified the types of information these forestry investors wanted, the formats in which they preferred the information to be presented and the sources of forestry information they would most likely use. In descending order of importance they wanted additional information on financial returns, timber production, marketing, choosing options, wildlife/fish and recreation. When asked about the likelihood they would use different educational formats, their preferences in descending order were written materials, newspaper stories, field demonstrations, local meetings, television programs, correspondence courses, and radio programs. They were asked about the usefulness of various sources of forestry information and ranked the state service forester first. In second place was a university or extension service and a publication or book. Other sources with lower rankings were consulting forester, logger/timber buyer, industry forester, friend/neighbor and other public office. It should be noted that survey respondents were concentrated in southern states and own on the average much larger forest acreages than NIPF landowners in Minnesota. Their responses may differ from Minnesota landowners.

For example the Minnesota study by Carpenter et al. (1986) also asked landowners where they would go for forestry assistance. Forty-five percent of the owners, holding 45 percent of the commercial forest acres, did not know where to go for forestry assistance and another 26 percent with 19 percent of the acres, did not answer the question. Among those who cited a source, the state forestry department was overwhelmingly recognized.

There is little information available concerning the success of educational programs for NIPF landowners in the Midwest, however, a national Cooperative Extension Service task force identified educational thrusts they thought would be effective (Extension Committee on Organization and Policy 1985). They suggested forming forest owner associations, increasing
forest owner awareness of the importance and cost-effectiveness of professional forestry services, and developing educational materials and programs on: a) management practices to achieve specific owner objectives for timber, wildlife, aesthetics, recreation, forage, and environmental concerns, b) biology and economics of regeneration, c) integrated pest management, d) marketing forest products, and e) using economical, environmentally sound, and safe logging and utilization practices.

This Extension report was a response to a Nonindustrial Private Forest Lands Forum in 1983 (State and Private Forestry). A carefully selected national panel of woodland owners and agency representatives debated how best to motivate private woodland owners. The 187 options they identified can be grouped according to these objectives: provide national, state and local coordination, promote markets for wood, educate and motivate landowners, improve logging practices, increase the use of consultants, promote use of incentive and cost-share programs, develop and distribute information on profitability and economics, target specific ownerships or areas and update foresters on new technology and economic information.

There is little information available concerning the impact of property tax and income tax incentives to stimulate greater productivity on NIPF lands. A study of 1979 FIP recipients (Reed 1982), however, asked landowners what factors limited their forestry investments. The long investment period was rated as a limitation by 57 percent, availability of financial resources by 47 percent, and property and yield taxes by 42 percent.

**SUMMARY AND RECOMMENDATIONS**

NIPF landowners own forest land primarily for recreation and residential use, but they are interested in harvesting timber. Very few are strictly opposed to harvesting timber and because of their relatively short land tenure, most woodland will probably be available for harvest at some time in the future. They are substantial contributors to the hardwood harvest, especially for fuelwood and saw logs. At least part of their high timber harvest level may be attributed to clearing land for other uses. Their lands are average in site quality and their timber growth rates and mortality levels are at expected levels. Tree planting and TSI occur at low levels compared to forest industries, but are closer in scale to public forest owners. NIPF landowners are not frequent users of forestry assistance.

Technical assistance and cost-share programs have proven to be efficient methods for stimulating greater productivity. Evaluations of these programs, however, focused on timber types that are found on a relatively small percentage of NIPF land. Additional research would be helpful in determining how to motivate them to manage hardwood timber. In the absence of this information, it is speculated that landowners may be motivated by technical assistance, especially near the time of harvest and by cost-sharing for timber management, especially for TSI and site preparation for natural regeneration.

They may be stimulated by educational programs that link timber management, marketing and financial information to their strong interest in recreation and wildlife.

The impact of tax policies is unknown. Recently both the property tax system and income tax system have changed greatly with respect to forest land. Additional research is needed to determine their impacts.
LITERATURE CITED


FOREST INVENTORY DATA ON
A MICROCOMPUTER

Mark H. Hansen¹

ABSTRACT. Microcomputer versions of the North Central Forest Inventory data base are now available for four states—Minnesota, Wisconsin, Michigan, and Indiana. These data bases operate on XT or AT level IBM PC compatible microcomputers under the SIR data base management system.

INTRODUCTION

How much aspen is within 50 miles of Grand Rapids? How many acres of 20-to-40-year-old red pine plantations are in Minnesota? These questions can be answered by using data from periodic inventories conducted by the Forest Inventory and Analysis (FIA) World Unit of the North Central Forest Experiment Station, USDA Forest Service, in St. Paul, MN. Providing answers to questions like these is our job, and we are constantly searching for ways to provide clients all the information possible in a versatile and efficient form.

Recent advances in data base management software and the widespread use of microcomputers have given microcomputer users the same data retrieval capabilities once available only to mainframe computer users.

NORTH CENTRAL FOREST INVENTORY DATA BASE

Station researchers began to develop the North Central Forest Inventory Data Base (NCFIDB) in 1978 (Murphy 1981). Since the 1983 Wisconsin inventory, we have used the NCFIDB (Hahn and Hansen 1985) to store and process all FIA data and to answer special requests for information. This data base is maintained on a Control Data Corporation Cyber 750 mainframe computer through Academic Computer Services and Systems (ACSS) at the University of Minnesota. The system operates under the SIR Data Base Management System (DBMS) (Robinson et al. 1980).

For several years, outside users have been able to access our data base directly by obtaining an ACSS account, loading a portion of the data base from our tapes onto their account, and then retrieving the information they needed. The data base contains an interactive retrieval user interface that allows a user to penetrate forest resource tables by responding to questions and making selections from menus. Users with some computer programming experience and a knowledge of Forest Service inventory and the SIR DBMS, have more flexibility in the kinds of retrievals they can make.

¹ Research Forester, USDA Forest Service, North Central Forest Experiment Station, 1992 Folwell Avenue, St. Paul, MN 55108.

Several users have accessed our data base in this way. However, time on the mainframe was costly and users had to learn the operating system. Many users had their own computer system (mainframe, mini, and/or micro), which made it difficult for them to justify spending money on an outside computer. Therefore, we began searching for a system that would allow outside users to access our data on their own machines.

MICROCOMPUTER DATA BASE MANAGEMENT SYSTEMS

With the growing popularity and power of microcomputers, processing and analyzing large data sets on such systems are becoming more common. DBMS software programs allow users to perform a series of coordinated data handling functions, including describing the data and storing it in accordance with this description, extracting information from the data, and protecting the data from unauthorized or accidental modification. These systems make the data easier to use and more portable.

dBASE III

The first attempt to access FIA data on a microcomputer was a cooperative effort of the Forest Service, the North Central Computer Institute, and the Department of Forest Resources, University of Minnesota. In this effort, we used the popular dBASE III (Ashton-Tate Company 1984) DBMS. We developed a dBASE III data file structure and wrote procedures to download data from the mainframe SIR data base to dBASE III data files. In addition, "command files" or manipulation and reporting programs for dBASE III were written to facilitate user access and to provide a starting point for further analysis. This method of accessing FIA data with a microcomputer is described by Belli et al. (1986).

One problem with the dBASE III systems was that the many data retrieval programs written by FIA personnel for the mainframe data base are in SIR retrieval language, not dBASE III command files. To fully support the dBASE III system would require maintaining two sets of retrieval programs (SIR and dBASE III) and constant checking to ensure both systems were producing the same results when changes were made to the system. Therefore, only a few example dBASE III command files were written, and users were limited to working from them to obtain retrievals.

SIR

Recently the SIR DBMS (version 2.2) was released for use on IBM PC compatible microcomputers. Earlier versions of PC SIR did not support all the features of SIR that are used by the NCFIDB on the mainframe. But now we can directly download portions of the NCFIDB to PC's. The download procedure transfers any part of the data base, such as the data, data structure, retrieval procedures, or any other procedures used by the system.

The micro and mainframe versions of the data base operate identically, and PC SIR users have the same flexibility in working with the data as mainframe users. Once a PC user has obtained the SIR DBMS software, a copy of the relevant section of the NCFIDB, and a microcomputer capable of operating the software, there are essentially no additional costs.

The minimum computer requirements for using the SIR DBMS system are:
  o An IBM PC/XT, PC/AT or 100 percent compatible microcomputer
  o 640 kilobytes or more of available memory
  o One hard disk with at least 7.5 megabytes available
- 8087/80287 mathematical coprocessor chip
- one double-density floppy drive
- DOS version 2.0 or higher.

To efficiently use the NCFIDB on a PC, a larger (40+ megabytes) hard disk is highly recommended. Data bases for areas covering several counties in heavily forested regions can easily exceed 20 megabytes. A 20 megabyte 8 inch Bernoulli box is also very useful. Because of the large size of the data base files, it is easier to transport these files on Bernoulli cartridges than on floppy disks. We currently do not have the facility to write to storage devices other than floppy disks or Bernoulli cartridges from our PC's.

The SIR DBMS can be purchased directly from SIR Inc. (707 Lake Cook Road, Suite 120, Deerfield, IL 60015). It can also be obtained at a reduced rate through a group purchase contract. For details, contact Jerold T. Hahn, North Central Forest Experiment Station, 1992 Folwell Avenue, St. Paul, MN 55108.

Eventually, data for all 11 states in the North Central Region will be available to PC SIR users. Currently, only data for Minnesota, Wisconsin, Michigan, and Indiana have been downloaded to PC SIR data bases. I plan to download Illinois next.

On the mainframe, the NCFIDB is a single "logical" data base, stored as 15 physical units each covering a state or portion of a state (fig. 1, Table 1). For example, Minnesota data are split into two data bases (MINNOR and MINSOU). By a single logical data base, I mean that throughout the entire 11-state region the exact same data structure is used, and all retrieval programs will run on every state. The data base has been broken into these 15 portions for efficiency and because of storage limitations of the mainframe.

For use on the PC, the NCFIDB had to be broken into even smaller portions (fig. 2, Table 2). SIR data bases are limited to the 32 megabytes per disk drive partition imposed by the DOS operating system. I have tried to limit the size of each data base to approximately 20 megabytes for the loaded or operational form of the data base. When a data base is to be transported, it is unloaded into a compressed format. The unloaded form column of Table 2 shows how much space is needed to transport these data bases. Table 2 also shows the size of each PC SIR data base in its loaded form. For example, although the three data bases that make up the Michigan Lower Peninsula (MICH3N, MICH3S, and MICH4) can all be transported together on a single 20 megabyte Bernoulli cartridge, only one data base could be loaded and used on a 20 megabyte drive.

If you would like copies of any of the PC SIR data, contact me (612-649-5148). You must provide enough blank 20 megabyte 8 inch Bernoulli cartridges or 5 1/4 inch disks to hold the data base requested. A small charge will be made for any data requested, to defray the expenses we incur in providing this service. Data bases are shipped as SIR unload files and include not only the data, but also a complete data structure and a number of data retrieval and manipulation programs.

Access by the casual user

Once you have the required hardware, loaded SIR on your hard drive, and obtained a data base from us, you can retrieve forest inventory data without learning any special programming language or FIA methods. Using the interactive retrieval program that comes with each data base, you will soon be able to obtain forest resource tables for any area in the North Central
### Table 1. North Central Forest Inventory Data Bases on the Mainframe.

<table>
<thead>
<tr>
<th>Data base</th>
<th>Geographic area covered</th>
<th>Date of Inventory</th>
<th>Total plots</th>
<th>Forest plots</th>
<th>Trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>MICHUP</td>
<td>Michigan Upper Peninsula</td>
<td>1980</td>
<td>5,719</td>
<td>4,709</td>
<td>169,744</td>
</tr>
<tr>
<td>MICHLP</td>
<td>Michigan Lower Peninsula</td>
<td>1980</td>
<td>8,771</td>
<td>3,662</td>
<td>126,794</td>
</tr>
<tr>
<td>WISNOR</td>
<td>Northern Wisconsin</td>
<td>1983</td>
<td>6,754</td>
<td>5,333</td>
<td>197,533</td>
</tr>
<tr>
<td>WISO</td>
<td>Southern Wisconsin</td>
<td>1983</td>
<td>6,166</td>
<td>2,811</td>
<td>90,533</td>
</tr>
<tr>
<td>MINNOR</td>
<td>Northern Minnesota</td>
<td>1977</td>
<td>13,715</td>
<td>8,370</td>
<td>238,375</td>
</tr>
<tr>
<td>MINDOR</td>
<td>Southern Minnesota</td>
<td>1977</td>
<td>22,855</td>
<td>2,173</td>
<td>49,628</td>
</tr>
<tr>
<td>NEAROTA</td>
<td>North Dakota</td>
<td>1980</td>
<td>18,214</td>
<td>604</td>
<td>1,539</td>
</tr>
<tr>
<td>SDAROTA</td>
<td>South Dakota (eastern)</td>
<td>1980</td>
<td>23,206</td>
<td>519</td>
<td>2,924</td>
</tr>
<tr>
<td>NEBRASK</td>
<td>Nebraska</td>
<td>1983</td>
<td>14,449</td>
<td>515</td>
<td>5,004</td>
</tr>
<tr>
<td>KANSAS</td>
<td>Kansas</td>
<td>1981</td>
<td>23,705</td>
<td>1,807</td>
<td>36,306</td>
</tr>
<tr>
<td>MOCARX</td>
<td>Missouri Ozarks</td>
<td>1972</td>
<td>4,042</td>
<td>2,108</td>
<td>67,956</td>
</tr>
<tr>
<td>MCBRNW</td>
<td>MO Riverborder &amp; Prairies</td>
<td>1972</td>
<td>6,579</td>
<td>884</td>
<td>27,145</td>
</tr>
<tr>
<td>IOWA</td>
<td>Iowa</td>
<td>1974</td>
<td>12,607</td>
<td>756</td>
<td>16,276</td>
</tr>
<tr>
<td>ILLINI</td>
<td>Illinois</td>
<td>1985</td>
<td>10,957</td>
<td>1,327</td>
<td>42,496</td>
</tr>
<tr>
<td>INDIANA</td>
<td>Indiana</td>
<td>1986</td>
<td>11,440</td>
<td>2,829</td>
<td>94,171</td>
</tr>
</tbody>
</table>

### Table 2. North Central Forest Inventory Data Bases currently available on the FC.

<table>
<thead>
<tr>
<th>Data base</th>
<th>Counties</th>
<th>Total plots</th>
<th>Forest plots</th>
<th>Trees</th>
<th>Megabytes of storage a</th>
<th>Loaded</th>
<th>Unloaded</th>
</tr>
</thead>
<tbody>
<tr>
<td>MICH1</td>
<td>3</td>
<td>1,253</td>
<td>992</td>
<td>37,537</td>
<td>12.2</td>
<td>6.0</td>
<td></td>
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<tr>
<td>MICH2</td>
<td>4</td>
<td>1,487</td>
<td>1,182</td>
<td>46,698</td>
<td>16.1</td>
<td>8.3</td>
<td></td>
</tr>
<tr>
<td>MICH3</td>
<td>4</td>
<td>1,760</td>
<td>1,520</td>
<td>62,115</td>
<td>20.2</td>
<td>11.6</td>
<td></td>
</tr>
<tr>
<td>MICH4</td>
<td>4</td>
<td>1,219</td>
<td>1,015</td>
<td>43,394</td>
<td>15.9</td>
<td>11.2</td>
<td></td>
</tr>
<tr>
<td>MICH5</td>
<td>15</td>
<td>2,134</td>
<td>1,470</td>
<td>53,445</td>
<td>14.2</td>
<td>7.7</td>
<td></td>
</tr>
<tr>
<td>MICH6</td>
<td>18</td>
<td>2,610</td>
<td>1,441</td>
<td>47,597</td>
<td>13.0</td>
<td>7.1</td>
<td></td>
</tr>
<tr>
<td>MICH7</td>
<td>35</td>
<td>4,027</td>
<td>753</td>
<td>24,752</td>
<td>6.8</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>WASC1</td>
<td>5</td>
<td>1,626</td>
<td>1,105</td>
<td>56,211</td>
<td>16.1</td>
<td>8.5</td>
<td></td>
</tr>
<tr>
<td>WASC2</td>
<td>5</td>
<td>1,216</td>
<td>976</td>
<td>32,362</td>
<td>11.0</td>
<td>5.9</td>
<td></td>
</tr>
<tr>
<td>WASC3</td>
<td>7</td>
<td>2,525</td>
<td>2,164</td>
<td>76,776</td>
<td>23.0</td>
<td>11.8</td>
<td></td>
</tr>
<tr>
<td>WASC4</td>
<td>5</td>
<td>1,656</td>
<td>1,058</td>
<td>52,184</td>
<td>10.1</td>
<td>5.7</td>
<td></td>
</tr>
<tr>
<td>WASC5</td>
<td>13</td>
<td>3,195</td>
<td>1,939</td>
<td>114,455</td>
<td>16.5</td>
<td>8.8</td>
<td></td>
</tr>
<tr>
<td>WASC6</td>
<td>14</td>
<td>2,455</td>
<td>820</td>
<td>25,535</td>
<td>6.5</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>WASC7</td>
<td>23</td>
<td>2,516</td>
<td>452</td>
<td>13,543</td>
<td>5.8</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>IND1</td>
<td>14</td>
<td>1,803</td>
<td>581</td>
<td>19,385</td>
<td>6.7</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>IND2</td>
<td>17</td>
<td>2,113</td>
<td>1,107</td>
<td>40,820</td>
<td>11.8</td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td>IND3</td>
<td>9</td>
<td>802</td>
<td>367</td>
<td>11,310</td>
<td>4.5</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>IND4</td>
<td>52</td>
<td>6,722</td>
<td>774</td>
<td>22,666</td>
<td>9.6</td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td>MINN1</td>
<td>42</td>
<td>13,985</td>
<td>457</td>
<td>11,579</td>
<td>7.1</td>
<td>5.3</td>
<td></td>
</tr>
</tbody>
</table>

*a* Form the data base takes when in use on the user's hard disk.

*b* Form used to ship the data base on Bernoulli cartridge or floppy disks.
Figure 1. North Central Forest Inventory Data Bases on the Mainframe

Figure 2. North Central Forest Inventory Data Bases currently available on the PC.
Region. Tables can be constructed for a county or a group of counties, a circular area of any size and location, or an irregular area. Tables can be generated for all forest stands in an area or only for those of a selected forest type.

To obtain a particular resource table for any area, simply follow a few simple instructions to load the desired data base on your hard disk, then respond to questions, and choose from menus. You can choose from a list of available tables (42 tables are currently available, and more tables are being added). The table is then constructed and automatically saved as an ASCII file for later viewing, printing, and/or processing by some other software such as a spreadsheet or word processor. Then repeat the process for another table and/or a different area. Table 3, for example, is for a user interested in the forest resource of a four-county area in North Central Minnesota. The time required to produce a table will depend on the particular table desired, the size of the area selected, and the speed of your machine. Table 3 took 25 minutes to make on my AT&T 6310. Three minutes of this was the time it took to enter the data base, request the appropriate table, and define the four county area; the remaining 22 minutes was the processor time to make the table. Processor time will vary depending on table selected, method of selecting stand(s) (circle, counties, polygon, forest type, or all stands), and the speed of your machine.

Table 3. Example table produced by the interactive retrieval program.

<table>
<thead>
<tr>
<th>Code</th>
<th>County Name</th>
<th>PLOTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>204</td>
<td>CASS</td>
<td>503</td>
</tr>
<tr>
<td>205</td>
<td>CROW WING</td>
<td>262</td>
</tr>
<tr>
<td>207</td>
<td>HUBBARD</td>
<td>307</td>
</tr>
<tr>
<td>212</td>
<td>WADENA</td>
<td>74</td>
</tr>
<tr>
<td>ALL</td>
<td>COUNTIES</td>
<td>1146</td>
</tr>
</tbody>
</table>

CUSTOM TABLE FOR EXAMPLE FROM A LIST OF SELECTED COUNTIES

AREA OF TIMBERLAND BY FOREST TYPE AND STAND SIZE CLASS.
SELECTED COUNTIES, MINNESOTA, 1977
(IN THOUSAND ACRES)

<table>
<thead>
<tr>
<th>Forest type</th>
<th>All classes</th>
<th>Saw- timber</th>
<th>Pole timber</th>
<th>Sapling &amp; Seedling</th>
<th>Non-stocked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thousand acres</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jack pine</td>
<td>174.8</td>
<td>49.7</td>
<td>104.7</td>
<td>20.9</td>
<td>*</td>
</tr>
<tr>
<td>Red pine</td>
<td>104.2</td>
<td>28.0</td>
<td>16.8</td>
<td>59.4</td>
<td>*</td>
</tr>
<tr>
<td>White pine</td>
<td>9.0</td>
<td>2.5</td>
<td>5.5</td>
<td>8.6</td>
<td>*</td>
</tr>
<tr>
<td>Balsam fir</td>
<td>25.8</td>
<td>4.3</td>
<td>12.9</td>
<td>2.3</td>
<td>*</td>
</tr>
<tr>
<td>White spruce</td>
<td>1.7</td>
<td>1.1</td>
<td>1.1</td>
<td>12.3</td>
<td>*</td>
</tr>
<tr>
<td>Black spruce</td>
<td>3.8</td>
<td>3.3</td>
<td>30.4</td>
<td>19.8</td>
<td>*</td>
</tr>
<tr>
<td>Northern white-cedar</td>
<td>1.4</td>
<td>3.5</td>
<td>16.5</td>
<td>5.4</td>
<td>*</td>
</tr>
<tr>
<td>Tamarack</td>
<td>17.5</td>
<td>46.6</td>
<td>97.0</td>
<td>23.8</td>
<td>*</td>
</tr>
<tr>
<td>Oak-hickory</td>
<td>52.7</td>
<td>10.1</td>
<td>51.7</td>
<td>14.6</td>
<td>*</td>
</tr>
<tr>
<td>Elm-sap-maple</td>
<td>82.0</td>
<td>30.2</td>
<td>47.1</td>
<td>4.2</td>
<td>*</td>
</tr>
<tr>
<td>Maple-basswood</td>
<td>851.5</td>
<td>173.1</td>
<td>488.4</td>
<td>190.0</td>
<td>*</td>
</tr>
<tr>
<td>Aspen</td>
<td>137.8</td>
<td>13.6</td>
<td>13.6</td>
<td>19.2</td>
<td>*</td>
</tr>
<tr>
<td>Paper birch</td>
<td>24.7</td>
<td>8.7</td>
<td>10.3</td>
<td>5.7</td>
<td>*</td>
</tr>
<tr>
<td>Balsam poplar</td>
<td>7.9</td>
<td></td>
<td></td>
<td>7.9</td>
<td>*</td>
</tr>
<tr>
<td>Nonstocked</td>
<td>1,755.3</td>
<td>380.9</td>
<td>993.1</td>
<td>373.4</td>
<td>7.9</td>
</tr>
</tbody>
</table>
In the future, we plan to expand this program so that users with a basic knowledge of Forest Service inventory methods can also use the same program to construct files of inventory data for analysis by any statistical package, or for input to their own programs written in any language. By responding to questions and making menu selections, the user will select the items to be included in the file. Information about what items are available and definitions of each item will be available interactively from the program.

If you would like a personal demonstration of the PC SIR and the NCFIDB, contact me or stop by the North Central Station in St. Paul.

**Access by the programming user**

With a fundamental knowledge of FIA methods and the SIR DBMS, a user with computer programming skills has greater flexibility in the kinds of retrievals that can be made from the database and in the format of the table produced. For example, such a user could retrieve area and volume information for a specific geographic area. Suppose that the only stands of interest are those whose volume is composed of 20 percent aspen, and that the desired output is a table showing area by forest type and stand age, along with tables showing total volume (all species) and volume of aspen by forest type and owner. Suppose further that the geographic area is defined as all land within a 50 km radius of a proposed mill site. Such a task is relatively easy for the programming user and can be done using a program less than 50 lines long. However, this type of access does require the user to have a much higher level of knowledge, and data retrieved under these circumstances are more likely to be misinterpreted. For these reasons, we urge anyone seeking information from the database to try first to obtain it through the interactive retrieval program. Usually this program will satisfy the users' information needs; only rarely will they need to try the programming approach. For information on survey methods used and details of the data base structure, the programming user is referred to "Data Bases for Forest Inventory in the North-Central Region" (Hahn and Hansen 1985).

We hope that the PC version of the NCFIDB will help meet many organizations' information needs. We are trying to make FIA data more accessible to the user, and hope this effort will be useful to many of you. We welcome suggestions on how to improve the data base and retrieval programs to better meet your needs.

**LITERATURE CITED**


IMPLICATIONS OF DNR PLANNING FOR MINNESOTA’S TIMBER SUPPLY

David C. Zumeta

ABSTRACT. The State of Minnesota administers about one-fifth of Minnesota’s commercial forest land. Most of this land is managed by the DNR, Division of Forestry. To provide land management and program direction, over the past several years the Division has developed two major types of plans: the statewide Minnesota Forest Resources Plan (MFRP), and plans for each of its 19 administrative areas. Over the next seven years, the Division will thoroughly update the MFRP and complete plans for its four administrative regions. The regional plans will include detailed land management and program direction for all administrative areas within each region. These upcoming plans will have significant implications for Minnesota’s future timber supply. Due to increasing public demands, the DNR is likely to place increasing emphasis on recreation, wildlife, soil and water conservation, and aesthetics in its forest management programs. The challenge in coming years will be to maintain a strong, dynamic timber management program that responds in a positive way to increasing emphasis on other resource values. To influence DNR decisions that will directly affect the state’s timber supply, it is important that professional foresters outside as well as inside the DNR become more actively involved in DNR forest planning activities.

INTRODUCTION

The basic premise of this paper is that forest resource planning has a direct, major effect on Minnesota’s timber supply. Further, planning is likely to have a greater effect on timber supply in the future than it has in the past.

These may seem like strange and disturbing ideas to many professional foresters. Planning conjures up visions of endless boring meetings where abstract concepts are discussed with no clear, tangible results. What could planning possibly have to do with timber supply? In this paper, I will answer this question using the Minnesota DNR’s forest planning efforts as an example.

DNR FOREST PLANNING

About 20 percent of Minnesota’s commercial forest land is administered by the State of Minnesota. The Minnesota Department of Natural Resources, Division of Forestry manages most of this land. The Division also has programs that directly influence forest resource management on other state, county, and private land.

To provide land management and program direction, over the past several years the Division has developed two major types of plans: the statewide Minnesota Forest Resources Plan (MFRP), and plans for each of its 19 administrative areas.

1 Forest Planning Supervisor, Minnesota Department of Natural Resources, Division of Forestry, 500 Lafayette Road, St. Paul, MN 55155-4044.

MFRP

The first comprehensive MFRP was completed in 1983, as required by the Forest Resource Management Act of 1982. This MFRP included an assessment of Minnesota's forest resources on all ownerships, including timber, fish and wildlife, and recreation. It also included a program document that outlined six-year accomplishment and budget targets for all Division of Forestry programs. The program portion of the MFRP was updated in 1987, in accordance with the 1982 legislation.

The Division will again update the program portion of the MFRP by 1991, probably working on the update during 1989 and 1990. The way the next MFRP is developed is likely to differ somewhat from the approach used in the past. We hope to involve the entire Minnesota forestry community in developing a broad strategic plan. The plan will outline future direction for all forest resource management in the state. More emphasis will be placed on statewide strategic direction for all forestry organizations, and less emphasis on specific program direction for the Division of Forestry alone.

Area plans/regional plans

Since 1983, the Division has completed or nearly completed plans for six of its 19 administrative areas. These plans outline specific goals and objectives for management and protection of forest resources in a Division of Forestry administrative area. They include both land management and program direction for a 10-year period for all activities in the area.

Recently, the Division has reevaluated the types of administrative area plans it is developing. The area plans are taking longer to develop than is desirable, and in some cases may be too detailed. Planning at the regional level has received little emphasis. Over the next seven years, the Division intends to complete plans for its four administrative regions. The regional plans will include detailed land management and program direction for all administrative areas within each region. All the areas within a region will develop their part of the regional plan at the same time. This approach will increase the speed and efficiency with which plans are developed.

EFFECTS OF DNR PLANS ON TIMBER SUPPLY

The existing plans described above have had a direct effect on Minnesota's timber supply. The 1983 MFRP, for example, described future program direction as well as budget and staffing needs for the Division of Forestry's timber management, timber sales, and nursery and tree improvement programs. The plan indicated that timber management and timber sales program budgets would need to more than double between fiscal year 1982 and fiscal year 1989 to meet projected needs. The increase in staffing needed for these two programs was projected to be almost 50 percent. The two state nurseries were scheduled to become self-supporting in fiscal year 1985, thereby stabilizing funding for a critical program that produces over 30 million tree seedlings each year.

So what happened to these three programs between fiscal year 1983 and fiscal year 1989? Despite the use of the MFRP and other supporting information, the Division was unable to obtain legislative support to increase the budget for the timber sales and timber management programs. In fact, funding and staffing for these two programs dropped by 18 and 24 percent, respectively. The nurseries actually did become self-supporting in fiscal year 1985. Obviously, the MFRP alone was not responsible for these changes. But it did play an important
supporting role by documenting program and budget needs, and can be used as a benchmark for showing how far actual appropriations have fallen short of demonstrated needs.

A more positive case can be made about the relationship between the 1983 MFRP and other Division of Forestry programs that have a direct effect on Minnesota's timber supply (e.g., the state forest roads, private forest management, and timber utilization and marketing programs). The state forest roads program provides a good example. The Division maintains over 2000 miles of road which provide access to the 4.5 million acres of land it administers. These roads also serve several million acres of county, federal, and private forest lands. The 1983 MFRP called for a threefold increase in the state forest roads program budget between fiscal year 1983 and fiscal year 1989. Using the MFRP and a State Forest Road Plan that had been requested previously by the Legislative Commission on Minnesota Resources, the Division obtained legislative support to increase the budget for forest roads by 43 percent between 1983 and 1989. The plans helped obtain increased funding for a program that provides access to a significant percentage of the timber in Minnesota.

Each of the Division's administrative area plans have projected accomplishment targets and staffing needs for all of the Division's programs at the area level. In addition, specific timber harvesting schedules, road and timber management projects, and other land management projects have been proposed in the area plans. These plans have helped identify program and land management needs at the local level, while simultaneously carrying out statewide program direction described in the MFRP.

The upcoming MFRP strategic plan and the new regional plans are likely to have an even greater effect on Minnesota's future timber supply than the plans have in the past. The direct relationships between the plans and the timber-related programs cited above will still hold true. The reason for the increased effect of planning on timber supply is that the plans are likely to place increasing emphasis on recreation, wildlife, soil and water conservation, and aesthetics as part of the Division's forest management programs. Inevitable tradeoffs in budget, staffing, and accomplishments among the various programs will be evaluated as part of the planning process. Timber-related programs will face more and more stiff competition with other programs.

Significant changes have already occurred in the levels of support the Division's plans project for timber-related programs relative to recreation and fish and wildlife programs. For example, in the 1983 MFRP, timber management and timber sales budgets were projected to increase from 26 percent of the Division's budget in fiscal year 1983 to 35 percent of the Division's budget in fiscal year 1989. In the 1987 MFRP, however, timber management and timber sales budgets were projected to decrease from 28 percent of the Division's budget in 1987 to 26 percent of the Division's budget in 1991.

By way of the contrast, forest recreation and fish and wildlife budgets in the 1983 MFRP were projected to increase from 2 percent of the Division's budget in fiscal year 1983 to 4 percent of the Division's budget in fiscal year 1989. By 1987, however, these programs already accounted for 7 percent of the Division's budget, and in the 1987 MFRP were projected to increase to 10 percent of the Division's budget by 1991.

Why have these changes in the Division of Forestry's program emphasis occurred? The main reason is that an increasingly urban public has become more and more vocal in pressuring state legislators and DNR and Division administrators to make these changes. Given demographic projections of more and more Minnesotans living in urban areas, it appears
unlikely that this trend toward more emphasis on nontimber programs is going to change anytime soon.

PLANNING AS AN OPPORTUNITY FOR CHANGE

The challenge for the Division of Forestry as well as other forestry agencies in coming years will be to maintain a strong, dynamic timber management program that responds in a positive way to increasing emphasis on other resource values. Timber management is compatible with most other forest uses, including most forms of recreation. As Ek (1988) wrote in a recent issue of Minnesota Forests:

*We can probably have both a vital forest industry and an attractive environment for recreation. For example, many factors important to timber supply, for example, roads and access, are complimentary to recreation. However, to arrange this will require good communication among forest users and careful planning.*

To influence DNR decisions that will directly affect the state's timber supply, it is important that professional foresters outside as well as inside the DNR become more actively involved in DNR forest planning activities. There are many opportunities for involvement at the statewide, region, and area levels, both as plans are being developed and during plan review periods. DNR forest management plans provide an opportunity to help bring about positive change. These plans can help assure that Minnesota will continue to have abundant timber for many decades in the future, as well as diverse forest recreation, wildlife, and other forest uses and values. If you are not already involved, I invite you to become actively involved in DNR forest planning activities.

LITERATURE CITED


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WHEN YOU SAY HARVEST AND TRANSPORT COST, YOU’VE SAID IT ALL (OR NEARLY ALL)!

Dennis P. Bradley

ABSTRACT. Of the wide spectrum of timber management costs incurred over a rotation, harvest and transport costs consume up to 50 percent of the discounted total. Management decisions made throughout a rotation can result in more efficient use of existing harvest and transport systems, but these systems can also be made more efficient. Unless both steps occur--improved technology and early coordination of management and harvest plans--public or private landowners will be disappointed by the actual market outcome, and future timber supplies will be reduced. The "below-cost" timber sale issue, based on a real (or perceived) failure to economically manage today's timber, has already reduced tomorrow's timber investments. This paper discusses (1) the role of market structure, (2) future harvesting technology, (3) the effects of stand character on harvest cost, (4) the potential contributions from research and (5) how future costs may alter the regional distribution of timber management.

INTRODUCTION

Timber harvesting is the final, and some say most important step in a long, expensive process of providing raw material for the Nation. Yet few land managers or agencies consider how their management choices early in the rotation can make the eventual difference between profit or loss, or even whether an environmentally sound and economical harvest method for the stand exists. Unless revenues over a rotation can offset the costs incurred, timber management as we know it today may not be practiced and future timber supplies may be inadequate.

The sad fact is, today's harvest systems are socially and economically inefficient--costs are too high and too much wood is wasted. An advertisement by Louisiana-Pacific a few years ago suggested that if we harvested food in the same inefficient fashion, an apple would cost $2.50. The short- and long-term implications are serious. First, transport costs are increased for all firms that must now forage farther afield to meet their needs. Second, because all forests are mixtures, more or less, of low to high productivity, a larger total area must be committed to timber management, increasing the conflicts (perhaps needlessly) with users of wilderness or other nonconsumptive uses. The problem of mixtures is especially important in the glaciated areas of the Lake States.

Indeed, the "below-cost" timber sale issue is a shocking example of how we have lost control of costs. The term "below-cost" implies that revenues are below cost, as if people should voluntarily pay more for wood. Perhaps. But it is more accurate to say that costs are excessive. That is, the problem could be called the "above-revenue" timber sale issue. While

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1 Principal Economist, USDA, Forest Service, North Central Forest Experiment Station, 1992 Folwell Ave., St. Paul, MN 55108.

managers cannot insist on adequate compensation before the fact, they can at least attempt to understand and control costs.

A brief example from the Midwest suggests the relative importance of harvest costs and the urgent need for cost control. Bradley (1983) showed that discounted logging and sale administration costs over a 60-year red pine rotation can amount to 35 percent of all costs, including land purchase. And if a modest 25-mile one-way haul is added, more than 50 percent of all costs are a direct result of harvesting.

If costs can be reduced, timber supply can be enhanced both at the intensive margin (reflecting returns from added labor and/or capital investments) and at the extensive margin (reflecting returns from reaching farther for wood and from growing trees on marginal land).

FOREST INDUSTRY STRUCTURE AND MARKET POWER

Understanding the structure of the forest industry sheds some light on the problem. At the bottom of the industry are millions of forest landowners, public and private; they are largely unorganized; and (with the exception of a few large owners) they are "price takers." They seldom harvest their own timber and are largely unaware of the opportunities for cost reduction. As a result, returns to these landowners have traditionally been considered a "residual:" that is, the net revenue remaining, if any, after harvest and transport costs have been subtracted from the mill's log price. Contrast this situation with agriculture where farmers are extremely well informed about technology and its effect on their success. Imagine a farmer's reaction to learning that his corn picker left every other ear rotting in the field.

Next on the ladder are thousands of logging firms, usually small, independent contractors with few ties to either each other, landowners, or manufacturers. As a result they are also "price takers" and have few incentives to be efficient in the social sense of the word. Costs are simply passed on to the landowner, reducing the "residual."

A logger's resourcefulness is legendary; surely you've heard of Paul Bunyan, his blue ox Babe, Johnny Inkslinger and the rest? While they did not engage in formal research and development (at least they never published), much new technology originates in these small firms. But while any improvement in efficiency may temporarily help one logger compete against another, harvest technology is easily copied and exclusive advantages are short-lived. In fact, benefits from any long-term increase in harvest efficiency generally accrue to forest product manufacturers because of their oligopsonistic position at the top of the industry. That is, profits to loggers or landowners do not rise as loggers adopt new technology; instead, log prices decline.

In other words, only large forest industries and a few large landowners have the necessary market power and financial strength to undertake harvest research as well as reap its benefits. Because most forest industries own few acres, they do not directly bear the opportunity costs of inefficient harvests. However, every landowner, particularly the U.S. Forest Service, does—with annual timber sales of about $1.5 billion, taxpayers would be losing $150 million annually if costs were only 10 percent too high, or utilization similarly too low.

Given the reality of market structure and the difficulties of stimulating landowners, loggers, and wood industries to support harvesting research, how can we resolve this difficulty? One approach is to use conferences like this to emphasize the importance to all segments of society of maintaining forestry investments. Similar rationales support agricultural research. A
critical part of this focus should identify the opportunity costs of this inefficiency. Recent
controversies about consumptive and nonconsumptive uses of forests, such as the "below-cost"
timber sale issue and the appeals filed against many National Forest Plans, have had a
depressing effect on timber investments. It would seem in the best interests of public land
management agencies and forest industries to recognize their mutual responsibilities in
carrying out this important work. Indeed, all have much to gain. Despite these imperatives,
harvesting research has had a very difficult time getting adequate support. With similar
market structures in Scandinavia, cooperative efforts have achieved success not only in
improving harvesting technology but in reducing logging injuries and deaths, accomplishments
we would do well to emulate.

CURRENT AND PROJECTED HARVEST SYSTEM COSTS BY REGION

As part of a project to estimate technology change in the forest products industry for the next
RPA Assessment, a survey by the Forest Service’s harvesting research projects identified each
region’s major harvest systems and costs (Table 1). The table shows how cost is affected by
average tree diameter and volume per acre. Only a small portion of the cost data is shown.

Each system has been developed over many years under each region’s unique diameter,
volume, and terrain conditions. Generally, the regions rank from lowest to highest cost as
follows: South, North, Rocky Mountain, East mountainous, ponderosa pine subregion, and
finally the Pacific southwest and Douglas-fir subregions in a tie for highest.

Substantial shifts in system mix are expected in each region over the next 50 years. On the
flat terrain in the East, both in the North and South, loggers will rely increasingly on
mechanized felling, bunching, and grapple skidding to central landings for processing and
loading. Chain saw felling is generally being replaced by feller-bunchers in pulpwood
operations but will continue to be used on sawlog and veneer operations to protect valuable
butt logs. Grapple skidders are expected to replace most cable skidders by 2040 for
productivity and safety reasons, increasing their share from 43 to 63 percent in the South and
from 5 to 24 percent in the North. The South’s unique and very labor-intensive bobtail truck
and farm tractor systems are expected to decline slightly from 17 to about 12 percent of
roundwood output by 2040. In the North, forwarders are expected to expand from about 25
to 40 by 2040. Whole tree chipping is expected to increase modestly from 5 to 15 percent in
the South and from 9 to 21 percent in the North.

The East like the West, possesses considerable "mountainous" terrain. About 55, 6, 13 and
11 percent of the Northeast, North Central, Southeast, and South Central regions,
respectively, are considered mountainous. While not as rugged as the Rockies or Pacific
Coast, the East has a large, concerned population, highly erodible soils, and generally less
productive sites, all of which heighten the need for cost-effective and environmentally sound
harvesting equipment and methods. To date, several small-scale cable yarding systems,
adapted from European and West Coast equipment, have been applied with success. These
cable systems are expected to increase their share from 10 percent now to about 40 percent
by 2040. The remaining portion will be harvested with conventional skidders and forwarders.

On the Pacific Coast the rugged terrain and extremely large trees often require expensive
cable yarding systems. Highlead systems are expected to be gradually replaced by more
versatile skyline systems. Both use portable guyed steel towers but skyline running gear is
more complex. Almost all trees are hand felled in the West because of large diameters and
steep slopes. Ground skidding using rubber-tired or crawler tractors on more moderate slopes
Table 1—Baseline 1987 harvest and transport costs by region and system for selected volumes per acre and diameters.

<table>
<thead>
<tr>
<th>Section, Region and System</th>
<th>Volume per acre (MBF) and average diameter (inches)</th>
<th>5 MBF</th>
<th>15 MBF</th>
<th>20 MBF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10 in</td>
<td>22 in.</td>
<td>10 in.</td>
</tr>
<tr>
<td>East</td>
<td>(1982 dollars)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern flat terrain</td>
<td></td>
<td>$52</td>
<td>$36</td>
<td>$51</td>
</tr>
<tr>
<td>Cable skidders</td>
<td></td>
<td>$39</td>
<td>$54</td>
<td>$35</td>
</tr>
<tr>
<td>Grapple skidders</td>
<td></td>
<td>$50</td>
<td>$45</td>
<td>$42</td>
</tr>
<tr>
<td>Chippers</td>
<td></td>
<td>$36</td>
<td>$24</td>
<td>$33</td>
</tr>
<tr>
<td>&quot;Big Stick&quot;</td>
<td></td>
<td>$45</td>
<td>$35</td>
<td>$44</td>
</tr>
<tr>
<td>Farm tractors</td>
<td></td>
<td>$74</td>
<td>$52</td>
<td>$74</td>
</tr>
<tr>
<td>Northern flat terrain</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Misc. systems</td>
<td></td>
<td>$117</td>
<td>$73</td>
<td>$117</td>
</tr>
<tr>
<td>Eastern mountainous terrain</td>
<td></td>
<td>$144</td>
<td>$100</td>
<td>$140</td>
</tr>
<tr>
<td>Ground skidders</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable yarders</td>
<td></td>
<td>$215</td>
<td>$92</td>
<td>$149</td>
</tr>
<tr>
<td>Highlead; short</td>
<td></td>
<td>$205</td>
<td>$98</td>
<td>$166</td>
</tr>
<tr>
<td>Highlead; long</td>
<td></td>
<td>$211</td>
<td>$157</td>
<td>$139</td>
</tr>
<tr>
<td>Skyline; short</td>
<td></td>
<td>$215</td>
<td>$81</td>
<td>$176</td>
</tr>
<tr>
<td>Skyline; medium</td>
<td></td>
<td>$238</td>
<td>$96</td>
<td>$215</td>
</tr>
<tr>
<td>Skyline; long</td>
<td></td>
<td>$112</td>
<td>$58</td>
<td>$105</td>
</tr>
<tr>
<td>Tractor</td>
<td></td>
<td>$213</td>
<td>$86</td>
<td>$148</td>
</tr>
<tr>
<td>Highlead; short</td>
<td></td>
<td>$204</td>
<td>$92</td>
<td>$162</td>
</tr>
<tr>
<td>Highlead; long</td>
<td></td>
<td>$210</td>
<td>$151</td>
<td>$138</td>
</tr>
<tr>
<td>Skyline; medium</td>
<td></td>
<td>$215</td>
<td>$81</td>
<td>$176</td>
</tr>
<tr>
<td>Skyline; long</td>
<td></td>
<td>$238</td>
<td>$96</td>
<td>$215</td>
</tr>
<tr>
<td>Tractor</td>
<td></td>
<td>$100</td>
<td>$50</td>
<td>$95</td>
</tr>
<tr>
<td>Highlead; short</td>
<td></td>
<td>$215</td>
<td>$92</td>
<td>$149</td>
</tr>
<tr>
<td>Highlead; long</td>
<td></td>
<td>$205</td>
<td>$98</td>
<td>$166</td>
</tr>
<tr>
<td>Skyline; short</td>
<td></td>
<td>$211</td>
<td>$157</td>
<td>$139</td>
</tr>
<tr>
<td>Skyline; medium</td>
<td></td>
<td>$215</td>
<td>$81</td>
<td>$176</td>
</tr>
<tr>
<td>Skyline; long</td>
<td></td>
<td>$238</td>
<td>$96</td>
<td>$215</td>
</tr>
<tr>
<td>Tractor</td>
<td></td>
<td>$112</td>
<td>$58</td>
<td>$105</td>
</tr>
<tr>
<td>Pacific southwest subregion</td>
<td></td>
<td>$78</td>
<td>$58</td>
<td>$129</td>
</tr>
<tr>
<td>Rocky mountain subregion</td>
<td></td>
<td>$167</td>
<td>$71</td>
<td>$158</td>
</tr>
</tbody>
</table>

Source: Michael Thompson, NCFES, Houghton, Michigan; Donald Sirios and Bryce Stokes, SFES, Auburn, Alabama; Penn Peters, NEFES, Morgantown, West Virginia; Michael Gonsior; IFRES, Bozeman, Montana; Charles Mann and Robert Mcgaughey, PNWFRES, Seattle, Washington.

is expected to remain about the same in all Pacific regions. Tractors now account for 33, 79, and 63 percent of production in the Douglas fir, ponderosa pine, and Pacific Southwest subregions, respectively.

In the Rockies, movable skyline systems called tractor-jammers are now used for about 86 percent of the harvest but are expected to be supplanted by somewhat smaller cable yarders adapted from the Pacific coast. These new yarders will capture about 25 percent of the harvest by 2040.
Generally, all shifts in system mix in all regions are expected to be from less efficient to more efficient systems, and from more to less labor-intensive systems.

PROJECTING HARVEST AND TRANSPORT TECHNOLOGY CHANGE

The consensus of those surveyed was that future timber harvest systems will closely resemble today's systems regardless of technical change. This is because for many more years trees will continue to be harvested from widely separated stands on vast areas of remote and rugged land. More fertile or accessible land will be used for farms and housing. Thus, tomorrow's logging machines, regardless of their improved efficiency, will still have to move over rough surfaces, sever and maneuver heavy trees or logs, and carry them considerable distances in all kinds of weather. Within these constraints, equipment and system designers must seek to improve: 1) load capacity, 2) travel and process speed, 3) reliability and longevity, 4) species and product versatility, 5) terrain capability, and 6) operator comfort and safety. Again, while maximizing efficiency is appropriate within a factory environment, flexibility is often more important in the woods.

Specific changes now in progress or being contemplated for the felling-bunching, skidding-forwarding, processing, loading, and transport functions are stimulated by the following problems which current systems address inadequately:

1. Steep terrain and swamps.
2. Stands with significant portions of unmerchantable species, or multiple products.
3. Low density stands or stands with many small trees.
4. Small harvest tract size as required by law or due to fragmented ownerships.
5. Increasingly expensive road construction and hauling.
6. Need to recover branches, tops, bark, and other previously unmerchantable material.
7. Need to conserve energy and protect long-term forest productivity.

The list of specific improvements foreseen for the RPA Assessment is extensive. In general, major cost-saving opportunities are in ground skidding, cable yarding, and log transportation. These functions are the most capital- and energy-intensive and the most dangerous. Lighter machines and engines along with improved fuel efficiency will reduce costs significantly. As a result of these changes, longer economical skidding or yarding distances will reduce the need for expensive roads. Despite substantial safety efforts, worker's compensation costs frequently equal direct payroll expenses, due to a continuing poor safety record. Improved safety practices, following demonstrated European experience, can reduce costs and suffering dramatically.

PROJECTING HARVEST AND TRANSPORT COST AS STAND CHARACTER, EFFICIENCY, AND SYSTEM MIX CHANGE

Four factors were developed for the RPA Assessment to project average regional harvesting costs to 2040: (1) the baseline harvest and transport costs for the systems used in each region, as shown in Table 1, (2) the proportion of wood harvested with each system and the system mix projections by decade, (3) an assumed rate of productivity improvement for each harvesting system by decade, and (4) projected average tree diameter and volume per acre by decade (Table 2).
Using personal computer based spreadsheets, tables of average harvesting costs were computed for each region and decade by weighting individual systems' cost tables (i.e., Table 1) with the projected proportion of wood harvested by that system as described briefly above. A single average cost per thousand board feet (MBF) for each region and decade was then selected from this weighted table using the projected average tree diameter and volume per acre for that region and decade (Table 2). These last assumptions about diameter and volume per acre probably have the most crucial effect on future harvest cost projections. These diameter and volume assumptions are based on regional inventory and removal models.

Table 2-Trends in harvested tree diameter and volume per acre by region, 1985 to 2040.¹

<table>
<thead>
<tr>
<th>Section and Region</th>
<th>Diameter and volume projections for</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1985</td>
</tr>
<tr>
<td>South</td>
<td></td>
</tr>
<tr>
<td>Tree diameter (inches)</td>
<td>13.1</td>
</tr>
<tr>
<td>Volume/acre (MBF)</td>
<td>7.4</td>
</tr>
<tr>
<td>North</td>
<td></td>
</tr>
<tr>
<td>Tree diameter (inches)</td>
<td>11.3</td>
</tr>
<tr>
<td>Volume/acre (MBF)</td>
<td>7.5</td>
</tr>
<tr>
<td>West</td>
<td></td>
</tr>
<tr>
<td>Douglas-fir subregion</td>
<td></td>
</tr>
<tr>
<td>Tree diameter (inches)</td>
<td>24.9</td>
</tr>
<tr>
<td>Volume/acre (MBF)</td>
<td>26.5</td>
</tr>
<tr>
<td>Ponderosa pine subregion</td>
<td></td>
</tr>
<tr>
<td>Tree diameter (inches)</td>
<td>16.1</td>
</tr>
<tr>
<td>Volume/acre (MBF)</td>
<td>12.5</td>
</tr>
<tr>
<td>Pacific Southwest</td>
<td></td>
</tr>
<tr>
<td>Tree diameter (inches)</td>
<td>24.9</td>
</tr>
<tr>
<td>Volume/acre (MBF)</td>
<td>16.3</td>
</tr>
<tr>
<td>Rocky Mountains</td>
<td></td>
</tr>
<tr>
<td>Tree diameter (inches)</td>
<td>16.1</td>
</tr>
<tr>
<td>Volume/acre (MBF)</td>
<td>11.9</td>
</tr>
</tbody>
</table>

¹ Diameter trends consider softwoods only. Volume per acre trends consider both softwoods and hardwoods.

Based on these methods and RPA assumptions over the next 50 years, logging costs would increase at a slower rate than that experienced from 1952 to 1985 in all regions except the Pacific Northwest. But the cost increases would still be substantial! The rate of increase in logging costs would be greatest on the Pacific Coast, with 45, 53, and 49 percent cost increases projected for the Douglas-fir, ponderosa pine, and Pacific Southwest subregions. These increases would be due primarily to projected declines of approximately 40 percent in stand diameter between 1985 and 2040 (Table 2). In contrast, projected declines of 25 percent in average stand diameter in the Rocky Mountain region would be offset by increasing volume per acre, resulting in only a 23 percent increase in logging costs. Logging costs in the South would increase only slightly over the projection period as stand diameters are expected to decline only slightly and average stand volume is expected to increase by about 20 percent.

WHAT DIFFERENCE CAN HARVEST RESEARCH MAKE?

In the RPA baseline projections, only the regional system mixes and the anticipated diameter and volume per acre were assumed to change. That is, the RPA Assessment assumed no
increases in the productivity of individual harvesting systems from 1985 to 2040. Under those assumptions, when compared with 1985 costs, harvest costs in 2040 would decline slightly in the North, remain about the same in the South, and rise dramatically in the West. Despite the assumed shift to more efficient systems nationwide by 2040, the expected decline in average tree diameter in the West would cause this region’s harvest costs to increase by as much as 64 percent (Scenario A, Table 3).

However, under a different set of assumptions—i.e., the same stand diameter and volume changes, the same system mix changes, but modest improvements in productivity of 10 to 25 percent over 50 years (depending on region and process)—harvesting costs in the North COULD decline by as much as 19 percent, costs in the South COULD decline by 15 percent, and costs in the West COULD increase from only 1 to 30 percent (Scenario B, Table 3) instead of from 26 to 64 percent (Scenario A).

If diameter and volume per acre are assumed to remain constant (Scenario C, Table 3), and the same modest assumptions are made about increased future productivity, the cost of ALL systems could decline by 12 to 18 percent. If, however, the estimated regional changes in stand diameter and volume per acre come to pass, we can expect major regional shifts in timber management and timber sale activities. These will occur regardless of what happens to harvesting costs; even under the most optimistic assumptions of technological change, the relative cost increases in the West would be large. Couple these cost increases with other likely environmental restrictions which may arise on western public forest lands, and the implications are even more imposing. These difficulties in the West combined with recent evidence in the East of significant surpluses point toward an eastward shift in activity.

Table 3—The effect of various assumptions concerning stand conditions, system mix, and productivity on regional harvest costs to 2040.

<table>
<thead>
<tr>
<th>Section and Region</th>
<th>Baseline Scenario A</th>
<th>Scenario B</th>
<th>Scenario C</th>
</tr>
</thead>
<tbody>
<tr>
<td>(percent change in 2040 harvest and transport cost relative to 1985)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>0</td>
<td>-14</td>
<td>-12</td>
</tr>
<tr>
<td>North central</td>
<td>-6</td>
<td>-19</td>
<td>-18</td>
</tr>
<tr>
<td>Southeast</td>
<td>1</td>
<td>-15</td>
<td>-12</td>
</tr>
<tr>
<td>South central</td>
<td>1</td>
<td>-15</td>
<td>-12</td>
</tr>
<tr>
<td>Douglas fir subregion</td>
<td>43</td>
<td>17</td>
<td>-18</td>
</tr>
<tr>
<td>Ponderosa pine sub region</td>
<td>64</td>
<td>31</td>
<td>-14</td>
</tr>
<tr>
<td>Pacific southwest</td>
<td>48</td>
<td>19</td>
<td>-15</td>
</tr>
<tr>
<td>Rocky mountain</td>
<td>26</td>
<td>1</td>
<td>-14</td>
</tr>
</tbody>
</table>

Scenario A: Tree diameters, volume per acre, and system mix assumptions as provided to RPA Assessment. No improvements in productivity.

Scenario B: Tree diameters, volume per acre, and system mix assumptions as provided to RPA Assessment. Modest improvements in productivity of 10% to 25% over 50 years depending on region and process.

Scenario C: Tree diameters and volume per acre do not change. System mix assumptions as provided to RPA Assessment. Modest improvements in productivity of 10% to 25% over 50 years depending on region and process.
CONCLUSIONS

Despite many disincentives, harvesting technology has gradually improved and there is every reason to expect continued improvement. Indeed, several social and economic forces should result in more rapid progress, especially the recent emphasis on making timber management pay its own way and the growing concern for adequate future wood supplies.

First, land managers must increasingly recognize that their decisions today can reduce future harvest costs. They must focus now on more productive, accessible sites, emphasize silvicultural treatments that produce larger diameters rather than more biomass and, where necessary, provide incentives to use less desirable species and components.

Second, small logging firms, despite their lack of market power or operating flexibility, can seek to keep their systems operating closer to capacity, focus on employee training for production and safety, engage competent financial and management expertise, and form more aggressive development and lobbying associations.

Third, major forest land owners, agencies, and forest industries must recognize their immense stake in developing efficient harvest systems. The success of their forestry investments depends on support for formal, well-funded harvesting research in all major species and terrain types. It is safe to say that no similarly important industrial activity in the U.S. economy spends so little on research and development.

Finally, regardless of whether new harvest and transport cost efficiencies are realized, volume per acre and diameter trends now underway will have a major impact on the future regional comparative advantage of timber production in the United States.

LITERATURE CITED

Bradley, D. P. 1983. Foresters can do much to reduce red pine logging costs. In: Silviculture of established stands in North Central forests, p. 35-44. SAF Region V Technical Conference, Duluth, MN.
MICROCOMPUTER MODULES FOR ANSWERING TIMBER SUPPLY QUESTIONS

Daniel L. Erkkila

ABSTRACT. Three microcomputer programs have been developed to utilize USFS inventory data and Minnesota Department of Transportation distance data to develop and analyze economic supplies of timber available to user-specified markets. Program PROVE determines timber volumes available to producers either by distance or cost class. Program COMPARE develops measures of the degree of competition for stumpage between producers based on user-specified road, harvest, and transportation costs. Program PRICES estimates market-clearing supply schedules for each producer, i.e. supply curve tables showing volumes available at various delivered prices and seller profit margins. Example output is displayed.

INTRODUCTION

Timber supply analysis is typified by manipulation of large amounts of data drawn from sampled inventory plots. Such investigations can be frustrated by the analyst’s desire for inventory estimates based on combinations of a wide array of data descriptors such as stand age, site class, cover type, species, ownership, size class, and product type. Fortunately, mainframe computers alleviated most of the problems associated with such complex data analysis. Today, desktop microcomputers are quickly replacing mainframes for many analytical uses, leaving large systems to handle more sophisticated problems. There has been a proliferation of commercial software to support desktop systems, as well as an increasing library of analytical packages made available to the forestry community from the public sector, i.e. forest research organizations. The most successful software share one attribute: they are user-friendly.

This paper describes three computer modules (programs) that were initially developed for a mainframe computer and have since been adapted for microcomputer use. Each uses timber data drawn from Forest Service inventory plot records, as well as additional data that is discussed below. More detailed information about these programs and the assumptions supporting them is available (Montzka and Rose 1982).

DATA PREPARATION

Two core data sets are used to support each of the three timber supply analysis programs. The first is the appropriate U.S. Forest Service inventory records (e.g. 1977 Minnesota inventory: Unit 1) and the other is a matrix of distances between known points in the state.

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1Research Assistant, Department of Forest Resources, University of Minnesota, 1530 N. Cleveland Ave., St. Paul, MN 55108.

2Programs written in Microsoft FORTRAN 4.1 (Copyright 1982-1988, Microsoft Corporation).

Timber Inventory and Growth Projection

The data each of the three programs uses is pulled from Forest Service inventory records. The inventory data represent a static picture of the forest, i.e., they are a snapshot of an area at one point in time. As inventories are conducted every 10-15 years, the dating of this data is overcome by using the growth projection software RUNGROW (Weber et al. 1984) to pick up at the point in time represented by the inventory and update, through simulation, forest conditions to whatever timeframe is desired. RUNGROW is based on the GROW routine described by Brand (1981). At a minimum, the Minnesota 1977 inventory would likely be updated to the present, although projected future time periods could be simulated to evaluate cost assumptions and available volumes.

Transportation Analysis

USFS inventory records include the distance from each stand to the nearest road. This distance is supplemented by the distance from each plot to the center of the survey plot's (stand) township. A random access data file is used that is made up distances between 2062 locations in Minnesota, compiled by the Minnesota Department of Transportation. The locations represent "centroids" or population centers of gravity throughout the state. Each centroid represents a transportation zone coinciding with a township, although several townships may be represented by one centroid in areas of low population density. Where population density is high, the opposite may exist, i.e. one township may be represented by several centroids (transportation zones.) The distances reflect the shortest travel distance over the existing trunk highway system between any two centroids. They are used in the estimation of stumpage transportation costs to delivered mill locations.

Each of the three supply analysis programs requires information on mature (i.e. harvestable) timber stands. Program SCREEN reads the plot summary master file generated by the growth projection and screens plots according to ownership, covertype, and age classes specified by the user. SCREEN also accesses the random access centroid file in order to calculate the estimated cost to transport a unit of wood on the plot to each of the specified market centers.

SUPPLY ANALYSIS PROGRAMS

Each analysis program examines different aspects of the timber supply question. The three programs discussed here are Producer's Operable Volume Evaluation (PROVE), Competitive Overlap Matrix and Producer's Accessibility Rating Evaluation (COMPARE), and Producer's Individual Cost Estimate Schedule (PRICES).

Prove

PROVE principally creates a table showing timber volumes available to preselected markets by distance or cost classes. The stands that are selected by the SCREEN program, based on the user's specifications for ownership, covertype, and age classes, are categorized as sale stands. These stand records are used to develop the volume summaries by either distance or cost class. Also, use of PROVE requires that the analyst specify a forest type, species categories within the forest type, a minimum stand age, a range of site indices for the forest type, and forest ownership. Two types of tables are produced by PROVE. Volumes in the sale stands are accumulated in the designated distance or cost class, by species, under four product classes: sawtimber, sawbolts, pulpwood, and biomass. Supply schedules for each producer are then generated using this categorization.
The second table produced by PROVE is a cumulative supply schedule for each producer (market) based on cumulative volumes available within an upper limit of a given distance or cost class.

Table 1 displays a sample PROVE output for northern Minnesota. It should be noted that this analysis considers only transportation, road construction, and harvest costs. Stumpage values and increased costs incurred by producers to obtain public stumpage are not included.

Table 1. Sample output of volume distribution by discrete distance classes from program PROVE.

<table>
<thead>
<tr>
<th>DISTANCE ZONE</th>
<th>EXIT PULPWOOD VOLUME (CUBIC YARDS)</th>
<th>DESTINATION BOLT VOLUME (CUBIC YARDS)</th>
<th>EXIT SAWLOG VOLUME (CUBIC YARDS)</th>
<th>DESTINATION HARVESTABLE BIDFASS (DRIED-TOSS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(MILES)</td>
<td>ASH</td>
<td>STATE</td>
<td>ASH</td>
<td>STATE</td>
</tr>
<tr>
<td>&lt; 10</td>
<td>4360</td>
<td>0</td>
<td>11142</td>
<td>0</td>
</tr>
<tr>
<td>11 - 20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>21 - 30</td>
<td>29874</td>
<td>66916</td>
<td>211874</td>
<td>74063</td>
</tr>
<tr>
<td>31 - 40</td>
<td>52645</td>
<td>11445</td>
<td>26549</td>
<td>21593</td>
</tr>
<tr>
<td>41 - 50</td>
<td>85999</td>
<td>21924</td>
<td>40992</td>
<td>13417</td>
</tr>
<tr>
<td>51 - 60</td>
<td>249673</td>
<td>19730</td>
<td>183280</td>
<td>38080</td>
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<tr>
<td>61 - 70</td>
<td>144189</td>
<td>34580</td>
<td>45649</td>
<td>48344</td>
</tr>
<tr>
<td>71 - 80</td>
<td>71770</td>
<td>28701</td>
<td>49689</td>
<td>16217</td>
</tr>
<tr>
<td>81 - 90</td>
<td>72444</td>
<td>16428</td>
<td>29983</td>
<td>24350</td>
</tr>
<tr>
<td>91 - 100</td>
<td>68743</td>
<td>18047</td>
<td>56074</td>
<td>12533</td>
</tr>
<tr>
<td>101 - 150</td>
<td>845079</td>
<td>169917</td>
<td>452618</td>
<td>192578</td>
</tr>
<tr>
<td>151 - 200</td>
<td>290319</td>
<td>52470</td>
<td>111712</td>
<td>64414</td>
</tr>
<tr>
<td>201 - 300</td>
<td>137300</td>
<td>35910</td>
<td>123808</td>
<td>42372</td>
</tr>
<tr>
<td>&gt; 300</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Compare

The COMPARE program goes beyond synthesizing supply information by acting as a supply model. As pointed out by Montzka and Rose (1982), the conceptual underpinning of the COMPARE supply model is based on two assumptions:

1. Producers act as entrepreneurs (i.e. seek to gain their own wood directly from suppliers).

2. When the number of sale stands offered represent a total available wood volume greater than an individual producer’s mill consumption requirement, the producer will choose the least-cost sale stand combination to meet the consumption requirement.
Simply stated, COMPARE attempts to measure the degree of competition for stumpage between producers throughout the supply region. SCREEN provides the sale stand records for this analysis; road construction, harvesting, and transportation costs for each sale stand (incurred by all competing producers) is also required. In order to evaluate competition, COMPARE first performs, for each producer, a selection process of sale stands. Those selected enable each producer to satisfy wood consumption while minimizing road construction, harvesting, and transportation costs. These "prime sales" are compiled into a roster for each producer.

The second step in the COMPARE analysis involves a search of each producer's prime sales roster to locate sale stands that are desired by other producers (i.e. sale stands common to two or more producers). The average cost per unit volume acquired for each producer (prime sale roster) is also calculated.

Lastly, a matrix is constructed that reflects the percent volume overlap between producers. An individual producer's overlap volume is that amount from sale stands meeting consumption needs that is also a component of another producer's consumption list (i.e. common sales). These total volume overlap percentages may be considered as an index of competition.

As a measure of a producer's accessibility to sale stands, COMPARE also calculates an average weighted cost for each producer based on the total cost of harvesting and transporting the wood on the prime sale roster versus the roster volume. Examples of COMPARE output are displayed in Table 2.

Prices

In the field, entrepreneurs harvest stands and sell to producers who are attempting to meet consumption needs. Seller motivations are to make sales to producers that will generate the highest possible profit. At a minimum, they must cover all costs. Producers must determine how much they have to pay to procure the volume of wood needed to operate, motivated by a desire to minimize their procurement costs. Delivered prices offered by producers to entrepreneurs are adjusted by PRICES to determine minimum level "market-clearing" supply schedules. Given this, PRICES also functions as a supply model and considers the procurement interaction between buyer and seller. Program outputs are supply curve tables showing volumes available to each market considered at a given delivered price and profit margin. As with the previous programs, the user runs SCREEN to build the analytical data base of sale stands, specifying the desired species, covertype, ownership, and age class. Further, the number of markets to be investigated and the delivered wood prices for each must be given.

Conceptually, in order for a sale to take place a buyer must be willing to pay a price equal to or greater than the reservation price (Gregory 1972), the sum of market and nonmarket values of the stand. Market values would be all costs associated with harvest and transport; nonmarket values would include any nonpriced values associated with the stand (e.g. wildlife). (The reservation price is frequently equated with the appraisal price for public stumpage.) Consequently, a short term timber supply curve for mill-delivered wood can be determined by ranking potential stands according to their increasing reservation cost plotted against the accumulating wood volume.

PRICES takes this concept further in that it deals with multiple producers, or mill centers, thereby allowing for comparisons to be made between producers' locational advantage.
Table 2. Sample outputs from program COMPARE: (a) Partial desired ("prime") stand list; (b) Shared stand list between two markets; (c) Matrix of competition percentages between markets. (Analysis of six markets, aspen/hardwood pulp and bolts, stands older than 50 years.)

(a) DESIRED STAND LIST FOR INTERNATIONAL FALLS

<table>
<thead>
<tr>
<th>Plot no.</th>
<th>Twnship.</th>
<th>Range</th>
<th>Sec</th>
<th>Volume (cords)</th>
<th>Del.Cost $/CD</th>
</tr>
</thead>
<tbody>
<tr>
<td>104671</td>
<td>69</td>
<td>22W</td>
<td>33</td>
<td>39547</td>
<td>56.29</td>
</tr>
<tr>
<td>100053</td>
<td>67</td>
<td>21W</td>
<td>11</td>
<td>3199</td>
<td>56.67</td>
</tr>
<tr>
<td>500283</td>
<td>68</td>
<td>20W</td>
<td>26</td>
<td>43278</td>
<td>56.78</td>
</tr>
<tr>
<td>103984</td>
<td>68</td>
<td>19W</td>
<td>28</td>
<td>10548</td>
<td>56.80</td>
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<tr>
<td>102752</td>
<td>67</td>
<td>21W</td>
<td>3</td>
<td>11515</td>
<td>56.94</td>
</tr>
</tbody>
</table>

(b) SHARED STAND ROSTER BETWEEN MARKETS 2 (CLOQUET) & 6 (SARTELL)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>200552</td>
<td>46</td>
<td>28W</td>
<td>24583</td>
<td>61.49</td>
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<td>23W</td>
<td>7356</td>
<td>62.90</td>
<td>59.76</td>
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<tr>
<td>305170</td>
<td>41</td>
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<td>6345</td>
<td>62.94</td>
<td>61.03</td>
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<tr>
<td>203326</td>
<td>44</td>
<td>28W</td>
<td>3393</td>
<td>63.73</td>
<td>60.70</td>
</tr>
</tbody>
</table>

Percent of Market Demand Represented

|                | 1.1 | 11.9 |

(c) PERCENT OF DEMAND IN COMPETITION

-- COMPETING MARKETS --

<table>
<thead>
<tr>
<th>MARKET</th>
<th>INT.FALLS</th>
<th>CLOQUET</th>
<th>G.RAPIDS</th>
<th>BEMIDJI</th>
<th>COOK</th>
<th>SARTELL</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT.FALLS</td>
<td>0</td>
<td>0.7</td>
<td>4.8</td>
<td>2.3</td>
<td>11.1</td>
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<tr>
<td>CLOQUET</td>
<td>0.7</td>
<td>0</td>
<td>13.1</td>
<td>0</td>
<td>0.6</td>
<td>1.1</td>
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<td>G.RAPIDS</td>
<td>8.9</td>
<td>27.1</td>
<td>0</td>
<td>2.2</td>
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<td>0</td>
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<td>BEMIDJI</td>
<td>5.6</td>
<td>0</td>
<td>2.7</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>COOK</td>
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<td>6.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>SARTELL</td>
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<td>11.9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Multiple buyers (markets) may be competing for each stand, each reflecting a different profit margin for the seller as sale costs will vary depending on, among several things, transportation distances. The seller will logically choose the buyer that maximizes profit for the stand.

Producers, on the other hand, can affect the sellers profit by changing their delivered price offers. PRICES determines the amount by which a producer must change delivered prices in order to give the seller a profit margin equal to the best profit, given that all other producer price bid remain static. The stands, reflecting new delivered prices (adjusted reservation cost) for each producer are tallied by increasing cost and plotted against the accumulating stand volumes. These market-clearing supply curves for each producer reflect PRICES' underlying premise that every sale stand in a given region has a value to every producer. The curves represent a schedule of the marginal costs incurred by a producer to buy all available wood volume.
PRICES also produces a table that associates the resultant profits due to the delivered price adjustments with the stand volumes. Volumes are sorted by the profits received plotted against the cumulative stand volumes. The net effect is a table showing the volumes entrepreneur’s are willing to sell to various markets at set profit margins. As profit margins increase, more timber volume is available to the market.

Tables 3 and 4 display output from the PRICES program.

Table 3. Sample supply curve table from program PRICES for aspen pulp and bolts in aspen and hardwood covertypes based on all stands older than 50 years in Minnesota (cords).

<table>
<thead>
<tr>
<th>REL. PRICE</th>
<th>VOLUME AVAILABLE TO MARKET</th>
<th>PAID 00/CD</th>
<th>INT. FALLS</th>
<th>CLOUDET</th>
<th>GRAND RAP.</th>
<th>BERINGI</th>
<th>COKO</th>
<th>BARTELL</th>
<th>BIG FORK</th>
<th>VIRGINIA</th>
<th>ISABELLA</th>
<th>BREEZERED</th>
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</thead>
<tbody>
<tr>
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<td>1493</td>
<td>14159</td>
<td>10075</td>
<td>14329</td>
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<td>3626</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>0</td>
<td>0</td>
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</tr>
</tbody>
</table>

Table 4. Sample cumulative supply curve table from program PRICES for aspen pulp and bolts in aspen and hardwood covertypes based on all stands older than 50 years in Minnesota (cords).

<table>
<thead>
<tr>
<th>PROFIT BF-</th>
<th>VOLUME AVAILABLE TO MARKET</th>
<th>PAID 00/CD</th>
<th>INT. FALLS</th>
<th>CLOUDET</th>
<th>GRAND RAP.</th>
<th>BERINGI</th>
<th>COKO</th>
<th>BARTELL</th>
<th>BIG FORK</th>
<th>VIRGINIA</th>
<th>ISABELLA</th>
<th>BREEZERED</th>
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<tbody>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>33073</td>
<td>508220</td>
<td>33073</td>
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<td>4</td>
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<td>33073</td>
<td>508220</td>
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<td>33073</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
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</tr>
<tr>
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<td>33073</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

158 Minnesota's Timber Supply: Perspectives and Analysis
DISCUSSION

The ability to readily take physical inventory and incorporate road construction, harvest, and transportation costs provides the analyst with the ability to examine economic supply and the competition that exists between producers bidding on stumpage. In Minnesota, this has been demonstrated by numerous studies (e.g. Rose et al. 1983, 1984; Williams et al. 1982). As with any economic supply analysis, cost assumptions are critical. Further, the transportation distance estimation used in this analysis weighs heavily in determining available volumes at given prices. The distance matrix data used here was created in the early 1970's and is, therefore, critically dated. This limitation can be overcome with the use of arc-node geographical information systems and the quantification of more recent U. S. Geological Survey quadrangle maps representing new transportation networks.

LITERATURE CITED


FORECASTING INDUSTRY TRENDS IN NORTHEASTERN MINNESOTA

Richard W. Lichty and Raymond Raab

ABSTRACT. This paper reviews results of a forecasting project at the University of Minnesota, Duluth, assessing industry trends in northeast Minnesota. These projects were made with a large scale simulation model developed on the St. Paul Campus of the University of Minnesota by Wilbur Maki and others (1984-85). Forecasts were made under various assumptions concerning the anticipated performance of the industry for the nation as a whole, the productivity of labor in the State of Minnesota's forest products industries, and the anticipated northeast Minnesota market share of total forest products output of the United States. First, this paper will review the important assumptions concerning future forest product development. Next, the general structure of the IPASS model is discussed. The 1982 information base will then be updated through a simulation run incorporating the best information available through the year 1982. Finally, these forecasts will be reported and implications will be drawn from these forecasts.

INTRODUCTION

This paper presents a prototype of the Timber Assessment Model (TAM) currently being proposed for Northeast Minnesota. TAM contains three interactive components: the Industrial, the Timber Use, and the External Demand modules. A fourth component dealing with timber supply constraints on local production is also possible but will not be presented as a hypothetical addition to this model.

The existing portion of the model utilizes an input-output algorithm developed by Charles Lamphear, University of Nebraska, titled "ADDTMATR." Other algorithms, such as the Minnesota IPASS model may also be utilized in model development.

The TAM model is proposed for three Northeast Minnesota counties; Lake, Cook and St. Louis. The research region for such a model is flexible, however. The only stipulation is that the defined region consist of a group of counties in order to take full advantage of secondary data published at the county level, such as the County Business Patterns tapes which provide county employment for every state in the nation.

1 Department of Economics, University of Minnesota, 10 University Drive, Duluth, MN 55812.

2 IPASS was developed at the University of Minnesota, St. Paul. It is a large scale, user interactive model that can be used to simulate alternative futures for an identified regional economy. IPASS is input-output driven, i.e., the model's core represents the productive structure of a regional economy. The resulting multipliers are linked to several modules, such as employment, income, population, and labor force in order to present comprehensive projections of the regional economy. See Doug Olson, Con Schallau, and Wilbur Maki, IPASS: An Interactive Policy Analysis Simulation System, U.S. Department of Agriculture, Forest Service, General Technical Report PNW-170, July 1984, for additional details on this particular model.

3 A similar model was developed for the Lake Superior Water Policy Conference, Duluth, Minnesota, April 22-23, 1988. Portions of the paper for that conference [] are used in this presentation.

Models linking physical and economic elements are becoming more popular in the literature. Such models are necessary if environmental, resource supply, and resource demand issues are to be effectively addressed.

The prototype model will draw upon and describe linkages between physical and economic (dollar denominated) data within the Sawmills, Logging and Wood Products Industry. Exports of final product outside of the research region provide the external linkage to users outside of the local region.

THE MODEL COMPONENTS

As mentioned in the Introduction, TAM contains three components or modules. The Industrial and the Timber Use modules are the most important describing the structure of the local economy. The External Demand module is useful primarily in simulation or sensitivity types of analyses.

The industrial module

The industrial module represents the production relationships or input-output components of a regional economy. As such, it identifies a specific number of industrial sectors and then traces the interaction between these sectors through the purchases and sales between these sectors. Industrial multipliers are then calculated as interindustry purchases and sales required to satisfy specified levels of final demand.

An industrial module exists for the counties of Lake, Cook, and St. Louis in Northeast Minnesota. The interindustry components were constructed from secondary data sources by adjusting national patterns to reflect the N.E. Minnesota economic structure. This is analogous to adjusting the coefficients of a national table to reflect the local economic structure.

The eleven sectors and their definition are presented in Table 1 below.

Table 1. Sector definitions.

<table>
<thead>
<tr>
<th>Sector Number</th>
<th>Sector Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector One</td>
<td>Agriculture</td>
</tr>
<tr>
<td>Sector Two</td>
<td>Mining</td>
</tr>
<tr>
<td>Sector Three</td>
<td>Construction</td>
</tr>
<tr>
<td>Sector Four</td>
<td>Other Manufacturing</td>
</tr>
<tr>
<td>Sector Five</td>
<td>Logging, Sawmills, &amp; Wood Products</td>
</tr>
<tr>
<td>Sector Six</td>
<td>Paper &amp; Paper Products</td>
</tr>
<tr>
<td>Sector Seven</td>
<td>Heavy Industry</td>
</tr>
<tr>
<td>Sector Eight</td>
<td>Transportation &amp; Warehousing</td>
</tr>
<tr>
<td>Sector Nine</td>
<td>Utilities</td>
</tr>
<tr>
<td>Sector Ten</td>
<td>Trade</td>
</tr>
<tr>
<td>Sector Eleven</td>
<td>Services</td>
</tr>
</tbody>
</table>

The timber use module

This module provides the linkage between the economic interactions of the industrial processing sector expressed in value or dollar terms with the physical availability of a
particular resource. A similar approach was used in dealing with water inputs expressed in physical terms in order to value that resource in terms of its scarcity or abundance. This water valuation project was done for the Minnesota DNR and the Legislative Commission for Minnesota Resources.  

As is true in the construction of secondary data input-output systems, several steps are required to prepare the physical component of an essentially economic or monetized input-output system. In this way, resource demand levels can be simulated, and eventually given supply availability, physical resource constraints can be imposed.

The vector of resource coefficients are presented in Table 2 for the Logging, Sawmill, and Wood Products industry. For example, timber use coefficients are expressed in terms of cords of timber per dollar of industry output. These coefficients would need to be calculated for all of the industries in the system. Such calculations are not carried out for the purpose of this paper, however.

Table 2. Timber Use Coefficients.

<table>
<thead>
<tr>
<th>Timber Type</th>
<th>Aspen</th>
<th>Softwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logging, Sawmills, &amp; Wood Products</td>
<td>.024</td>
<td>.010</td>
</tr>
</tbody>
</table>

Timber use coefficients are in terms of cords per dollar of output.

These coefficients are applied against the industry row of direct and indirect output coefficients to obtain industrial timber demand multipliers. The adjusted direct requirements table incorporating the physical coefficients for industry 5: Logging, Sawmills, and Wood Products is presented as Table 3.

Table 3. Adjusted Direct Requirements.

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<th></th>
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<th>4</th>
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<td>0.010</td>
<td>0.000</td>
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<td>0.010</td>
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</table>

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The external demand module

The external demand module represents the typical final demand component of an input-output system. Such a component generally consists of some combination of household, investment, government, and net export demand for the region's industrial output.

In the case of TAM, the external demand component is the export activity of regional industries, in particular, of the Logging, Sawmills and Wood Products industry. These exports would be applied to the coefficients of TAM to assess economic and resource use impacts.

It should be emphasized that the strength of input-output analysis is that its impact estimations are consistent, i.e., consistent with levels of final demand. Therefore, assumed or given levels of final demand are crucial to accurate estimation of industrial activity and resulting timber use.

THE TAM MODEL

The TAM model presented here is not only a prototype model, but it is incomplete. To be complete, the timber use coefficients would have to be constructed for all eleven industries. It makes sense to say that most of those coefficients would have a value of zero since most industries do not use timber as a direct input to their production process. In order to facilitate the explanation of the model, it is assumed that only the Logging, Sawmills, and Wood Products industry directly uses timber resources.

Table 4 presents the completed prototype TAM system. This table represents the direct and indirect relationships between industries and the wood resource calculated by employing the Leontief inverse to the coefficients of Table 3. Demand based impacts may be derived by multiplying assumed levels of final demand (out of the external demand module) to the column of direct and indirect coefficients for sector 5.

Table 4. Timber Assessment Model (Prototype).

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SUPPLY CONSTRAINTS

A few words are in order regarding supply constraints in such a model. The next step in this research design will be to develop a supply model for the region. Such a model would require regional supply options as well as a component for import possibilities.
Such a system would include calculations of resource demands on the basis of TAM system as presented earlier in this paper. These demand estimates would be compared with supply availabilities out of a supply constraint module to be developed at a later time. If local supply is inadequate to meet resource demands, import potentialities would be involved in the model. If these potentialities are nonexistent in the region, then adjustments in final demand will be made to adjust resource demand to resource supplies.

Given the data, it would be a simple step to add a price determining component to such a supply constraint system to account for price effects from supply/demand imbalances. Assumptions could be built into such a system as to when price adjustments represent a supply constraint even when nominal resource supply would permit a simulated level of production. Other possibilities, such as including social accounts matrices could also be included in such a modelling effort.
TIMBER SALE PROGRAM INFORMATION REPORTING SYSTEM

Larry O. Gadt

The Timber Sale Program Information Reporting System (TSPIRS) is the result of Congressional direction to the Forest Service to develop a system to display the costs and benefits of all aspects of the timber sale program. Pressure and confusion about the extent of below-cost timber sales, and the inability of the Forest Service to display its arguments about the validity of these sales, prompted Congress to ask for the system. The information Congress sought is displayed in annual costs and benefits directly related to the timber program, costs and benefits related to other resources, and economic impacts on dependent communities.

TSPIRS assembles timber sale and related activity information at the National Forest administration level in three ways. Table 1 is financial. It displays the annual costs and revenues of the timber sale program for one year. Table 2 is a display of the economic effects of that timber sale program on the resources beyond the immediate year. Table 3 is a display of the effects of that timber sale program on local communities. Taken together, these three reports provide for the evaluation of the timber sale program including, as accurately as possible, all of the points the Forest Service has tried to display in the past. It's a good idea to look at these reports a little closer to understand the significance of the data that will result.

FINANCIAL ANALYSIS

Table 1 matches only the appropriate costs that generate the revenues received from harvesting timber in the reporting year. All revenues associated with the annual timber sale program are displayed, including items such as purchaser road credits established. To match costs against these revenues with any degree of accuracy, single-year and multi-year accounts are established. The single-year costs, of course, begin and end in the year incurred. Multiyear costs are allocated over time to individual sales. If these costs cannot be allocated in the reporting year, they are carried over to subsequent years. A classic example of this type of cost is the timber road built to serve numerous sales over more than one year.

The General Accounting Office, by Congressional request, worked with the Forest Service in the development of accounting methods associated with Table 1 and testified with the Forest Service when TSPIRS was presented to Congress. The multi-year costs, for example, were the creation of GAO. An explanation of GAO's involvement and how it arrived at the methodology for Table 1 are contained in GAO's report, "Timber Program: A Cost Accounting System Design for Timber Sales in National Forests." GAO will continue its involvement by monitoring TSPIRS' implementation and reporting.

---

1 Deputy Forest Supervisor, Superior National Forest, U. S. Forest Service, Box 338, Federal Building, Duluth, MN 55801.

ECONOMIC ANALYSIS

Table 2 identifies costs and benefits beyond the immediate year. In other words, it looks at the next few decades and shows how the forest is going to be different because of an annual timber sale program. These figures are derived mainly from forest plan data and are supported by the forest planning records. Of the three reports, this is the one that will be the most difficult to compile because it tries to capture not only the long-term timber values that will flow from the harvested lands over future rotations, but also the induced nontimber benefits and costs. The latter would include impacts, positive and negative, on resources such as wildlife and fisheries, recreation, water, and range. All values in Table 2 represent impacts directly attributable to the previous year's harvest and are derived from a "with" the sale and "without" the sale analysis. Resource outputs that would be generated naturally, without human intervention, are not included.

SOCIOECONOMIC ANALYSIS

Table 3 displays employment and income information and the quantities and values of timber products resulting from a national forest's timber program. This is where we recognize that the timber program stimulates a significant amount of economic activity in local communities as jobs are created in the woods, at the mill, and in the wide array of service industries that support the community. At each step along the "production line," income and jobs are stimulated as workers spend their paychecks in stores and suppliers step-up their business to deliver the new machines that help produce boards, toothpicks, or rocking chairs. Included in Table 3 are estimates of jobs generated, the value of income to the forest's impact area, and the total amount of 25-percent fund payments made to states. This report displays the socioeconomic implications of the financial activities described in Table 1. Congress is very interested in the results of this report.

DISCUSSION AND CONCLUSION

TSPIRS is being used on National Forests right now. The first users were forests that volunteered to help develop and test the system. By Fiscal Year 1989, every forest will be involved in the development of the reports. By December 1989, the first national report will be completed for presentation to Congress, and TSPIRS will be an integral part of Forest Service management of the national forests.

Forest Supervisors will be able to use the TSPIRS information to better evaluate their programs and explain program results to the public. Regional Foresters and the Chief will be able to present a regional and national perspective. We have identified six potential applications: stewardship reporting, accountability, public information, forest plan monitoring, timber sale planning, and programming. It will be a tool to evaluate the timber sale program and to determine if adjustments need to be made to strengthen the overall program. TSPIRS is just the beginning of improved resource accounting and financial management in the Forest Service. We expect, eventually, to have a multiple-use information system to better track and report all aspects of national forest management. TSPIRS, and any other systems developed, will enable us to explain and illustrate to the public and to Congress what national forest management costs and what it accomplishes. A national policy committee composed of associate deputy chiefs has been established to monitor and evaluate emerging policy applications of TSPIRS. The challenge to all of us is to use the information from TSPIRS to better communicate our activities to the public and improve on the management of the national forests.

<table>
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<tr>
<th>ACCOUNT DESCRIPTION</th>
<th>TIMBER RESOURCE SALES</th>
<th>OTHER RESOURCE SALES</th>
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<td>I. REVENUES</td>
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<td>$</td>
<td>$</td>
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<td>764,722</td>
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<td>0</td>
<td>143,171</td>
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<td>0</td>
<td>49,853</td>
</tr>
<tr>
<td>Interest &amp; Penalties</td>
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<td>0</td>
<td>0</td>
<td>15,544</td>
</tr>
<tr>
<td>TOTAL Revenues</td>
<td>971,548</td>
<td>515</td>
<td>1,027</td>
<td>973,090</td>
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</tbody>
</table>

| II. COSTS:          |                       |                      |                    |                 |
| Single Year:        |                       |                      |                    |                 |
| Sale Admin. Costs   | 219,337               | 502                  | 1,256              | 221,096         |
| Timber Program General Admin | 888,873 | 2,036 | 5,091 | 896,000 |
| Multiyear:          |                       |                      |                    |                 |
| Sale Activity Pool Allowance | 1,587,277 | 3,636 | 9,091 | 1,600,004 |
| Growth Activity Pool Allowance | 619,991 | 1,439 | 3,598 | 626,621 |
| TOTAL Operating Costs | 3,315,478 | 7,614 | 19,036 | 3,346,721 |
| Gain/Loss Before Payment To State | -2,343,930 | -7,099 | -18,009 | -2,379,038 |

| III. PAYMENTS TO STATES | | |
|-------------------------|-------------------|
| Net Gain/Loss From Timber Sales | -2,636,892 | -7,255 | -18,319 | -2,662,631 |

| IV. VOLUME HARVESTED (MBF) | 87300.0 | 200.0 | 500.0 | 88000.0 |

Table 2. Fiscal year 1987: Economic account (long range cost/benefits of timber sales).

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<th>PRESENT VALUE BENEFITS</th>
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<td>Wildlife</td>
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<td>TOTAL PRESENT BENEFITS</td>
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<td>Wildlife</td>
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<td>TOTAL PRESENT COSTS</td>
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<td>PRESENT NET VALUE (PRESENT BENEFITS MINUS PRESENT COSTS)</td>
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Table 3. Fiscal year 1987: Employment, income, and program level account.

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<th>EMPLOYMENT AND INCOME</th>
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<td>Employment Impacts (Jobs)</td>
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<tr>
<td>Direct</td>
<td>488</td>
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<td>Indirect</td>
<td>231</td>
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<tr>
<td>Induced</td>
<td>418</td>
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<td>TOTAL JOBS</td>
<td>1137</td>
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<tr>
<td>Value of Total Income to Local Communities</td>
<td>$48</td>
</tr>
<tr>
<td>Value of Federal Income Taxes Paid on Total Income to Communities</td>
<td>$7.2</td>
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<tr>
<td>25 Percent Fund Payments to State and Local Governments (Timber, K-V, Timber Purchaser Roads Credit)</td>
<td>$289,000</td>
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<table>
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<tr>
<th>RELATED TIMBER INFORMATION - PROGRAM LEVEL MEASURES</th>
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<tr>
<td>Timber Volume</td>
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<td>Sold</td>
<td>88.0</td>
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<tr>
<td>Harvested</td>
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<tr>
<td>Fuelwood</td>
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<td>Free Use</td>
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<tr>
<td>Value of Free Use</td>
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<td>Nonconvertible Products</td>
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<td>Christmas Trees Sold</td>
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<tr>
<td>Other</td>
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<td>TOTAL</td>
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<td>Subtotal</td>
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<td>TOTAL</td>
<td>13.0</td>
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<tr>
<td>Total road system miles closed year-round after harvest is completed</td>
<td>42.4</td>
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DEVELOPING AND ANALYZING
STAND-LEVEL ALTERNATIVES

Matthew H. Pelkki

ABSTRACT. An integrated forest planning system is currently under development at the University of Minnesota. Primary system its components are DTREES, a stand-level prescription writer, and, DUALPLAN, a microcomputer adaptation of the Hoganson-Rose harvest scheduling algorithm. Two additional modules, a database management system and a geographic information system will assist in the interpretation and analysis of the harvest schedule. The issues in developing the stand-level alternatives from which the optimal harvest schedule is derived are discussed as well as the approaches that are used to solve these problems.

INTRODUCTION

The timber harvest scheduling problem involves massive amounts of data and computations and is influenced by social, economic and biological factors interacting in a complex system. Long planning horizons further complicate modelling attempts with a large uncertainty element. Operations research techniques such as linear and dynamic programming have been applied in an attempt to produce an "optimal" harvest scheduling plan based on forest-wide objectives and constraints. In modelling systems such as Timber RAM (Navon 1971) and FORPLAN (Johnson et al. 1980), the search algorithm requires that a feasible solution space be defined, and from that solution space an "optimal" harvest schedule will be derived. In a forestry context, this solution space consists of a list of all feasible management alternatives for each management unit, bounded by a set of constraints. Attached to each alternative for each stand are economic, social, and biological parameters that define the characteristics of that alternative in terms of actions that are taken and the ensuing effects on the forest.

A microcomputer forest planning system is currently under development at the College of Natural Resources (Pelkki et al. 1987). Two components are in the late prototyping stage--DTREES, an automated stand prescription writer and harvest simulator (Pelkki and Rose 1987), and DUALPLAN, a microcomputer application of the Hoganson-Rose harvest scheduling algorithm (Hoganson and Rose 1984). Other components will include a database management system, and linkages with geographic information systems (Figure 1). The following is a description of the approach utilized by this system for developing a list of alternatives.

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1 Research Assistant, Department of Forest Resources, University of Minnesota, 1530 N. Cleveland Ave., St. Paul, MN 55108.

DEVELOPING STAND-LEVEL ALTERNATIVES

Both TIMBER RAM and FORPLAN require a list of alternatives or "prescriptions" for each management unit in the forest. A simple prescription list is shown on Table 1. As simple as the prescription alternatives look, there are a tremendous number of factors that must be considered in their development. The following is an abbreviated list of some of the principle questions that must be considered:

1. By what criteria (biological, economic, etc.) are harvesting decisions made when developing the solution space?
2. What criteria are used to define the management unit's size and composition?
3. How are growth projections, particularly during regeneration phases, made?
4. Should intermediate harvesting be considered, and if so, how should it be modelled?
5. What economic factors should go into determining harvest cost and timber value?
6. What type of inventory can best support the development of the prescriptions? What is the best inventory database design and structure?
7. What limitations in computer programming expertise exist? What are the limitations in existing computer hardware?
Table 1. A simple prescription list.

<table>
<thead>
<tr>
<th>Stand Number</th>
<th>Planning Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alt</td>
</tr>
<tr>
<td>01</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td></td>
</tr>
</tbody>
</table>

Key: DN = Do Nothing  
     CC = Clearcut  
     TH = THIN 1/3 Basal Area  
     RG = Regenerate

Both Timber RAM and FORPLAN are strict linear programming approaches. Thus, the problem size is severely limited, requiring that management units are aggregated into large forest "classes." These forest classes are usually defined by species or species group, site index, stand volume, age, and stocking. This data aggregation reduces the number of management units, but causes problems in modelling prescriptions (Pelki 1988), and increases the overall sensitivity of the final solution (Rose and Amano 1985). Additionally, the resulting harvest schedule is not usable as an operational harvest plan. Due to the aggregation, the harvest plan could be implemented in an infinite number of ways. The Hoganson-Rose algorithm, which is a decomposition of a linear programming formulation, is not restricted in problem size. Thus, a tremendous amount of detail can be included in the prescription list, in fact, allowing stand level prescription alternatives to be generated and used directly from a phase II planning level inventory database.

Timber RAM, FORPLAN, and early implementations of the Hoganson-Rose algorithm used normal yield tables for growth projection. These lookup tables provided a very fast method of stand projection, but were not well suited for the modelling of intermediate harvests. In addition, these tables had to be aggregated according to the classification, increasing the sensitivity of the problem formulation. DTREES (Figure 2) uses the GROW subroutine (Brand 1981a) in projecting an abbreviated tree list derived from the inventory data. Regeneration is modelled through two regression models (Ek and Brodie 1975; Belli 1986). Intermediate harvests are allowed in the form of random thinning operations. However, some new approaches in empirical yield equation projection methods are being investigated and appear to be very promising. These new projection methods will allow intermediate harvest operations to be modelled using only stand-level projection parameters.

The heart of DTREES consists of a set of silvicultural decision trees (Figure 2) based on management handbooks for Lake States' cover types (Brand 1981b). These decision trees are used to evaluate the stand during each planning period and make a harvest decision. The linkages between each of the DTREES' components is fully automated, with all silvicultural, product class, and regeneration parameters user accessible. The process of generating
multiple prescriptions is complex and will not be described here, but can be found in Pelkki (1988).

![DTREES Diagram]

**Figure 2.** DTREES linkages and decision tree example for aspen.

The DTREES system is integrated with the Minnesota DNR Phase II planning-level database. DTREES itself only models the biological aspects of creating stand level alternatives. Once developed, the prescriptions must be collapsed into cash flow values prior to input to DUALPLAN. This process is itself very complex and difficult, involving many factors such as:

1. Multiple products from each stand.
   - What product classes should be defined?
2. Multiple markets and transportation modelling.
   - What products will go to which mill?
   - What are the corresponding costs?
3. Modelling harvest costs.
   - What method and equipment will be used?
   - What are the site effects on costs?
   - How does the timber size affect costs?
4. The uncertainty of future market prices.
   - How do we estimate market prices over 50, 100, or 200 year planning horizons?
5. What are the seasonal effects on timber harvesting and market prices?

Currently, little data exists from which models can be developed to answer these questions. A geographic information system (GIS) tie-in is being developed to help with determining many of these costs. However, harvesting equipment and bid costs are difficult to collect due to the nature of the logging industry.

**ANALYSIS OF STAND-LEVEL ALTERNATIVES**

DTREES produces a list of alternative management sequences for each stand in the phase II database. For county size and larger forest areas, this prescription list is quite large. Since DTREES is a totally automated process, some method of analyzing the resulting prescription list, and editing the DTREES output, is necessary.

For analysis purposes, a prescription report writer is being developed. There are several types of analyses that will be possible including:

1. Summary listing of the "optimal" harvest schedule.
2. Comparison of silvicultural "optimal" with DUALPLAN "optimal" harvest plan.
3. Listing of harvest activities by administrative unit and planning period.
4. Detection of undesirable prescriptions such as:
   - Harvest activities with merchantable volume below some user specified limit or prior to some set stand age.
   - Harvesting activities in sensitive areas.
   - Harvesting reserved timber.

The user will also have the option of deleting any stand or stand alternative through the use of a prescription list editor. The editor will also allow the user to input a complete prescription list into the database, completely independent of the DTREES system. This will allow the user to "customize" the feasible solution space prior to any attempts at optimization.

The use of geographic information systems will also enhance the analysis of the prescription lists, allowing the consideration of spatial relationships. The GIS will be used for display purposes, but more importantly, aid in the modification of both the prescription list and "optimal" harvest plan through spatial analyses linked to an editing function.

**FUTURE DIRECTIONS**

The goal in developing prescription lists is to model the real world as accurately as possible. If every possible management alternative could be accurately modelled and included into the prescription list and all necessary biological and socio-economic assumptions held, the result would be an optimal harvest scheduling plan. Modelling limitations aside, the pure size and amount of data required to consider every factor and the computations required would make
the problem infeasible. There are, however, several areas that need immediate attention for this system to move from a modelling framework into a usable management tool.

New stand-level planning databases are needed in order to utilize the full potential of tree-list based growth projection systems. Research has indicated that a condensed tree list of 5-7 trees per species is adequate for modelling individual product class volume growth, and only 3 trees per species is necessary to track gross volume. The development of a "Phase III" inventory database, which would include individual tree data will allow more accurate growth projections and prescriptions from systems such as DTREES.

The development of new regeneration models for more cover types in the Lake States. Currently, regression-type models exist for only 4 cover types. It may be possible to develop empirical "look-up" tree lists for regenerating stands, which would provide a starting point from which the GROW subroutine could work.

Finally, the silvicultural decision trees have a fixed structure. Allowing the user to develop their own decision tree structure would greatly enhance the adaptability of DTREES. Work is also being started on development of new decision trees that will optimize economic rather than biological factors. The user would then be able to choose from either a financially- or biologically-optimized prescription list.

While DTREES has perhaps brought forth as many questions as it has answered, the system provides a framework upon which better prescription generators can be built. Furthermore, the system has identified areas where current models are performing adequately, and areas where the system requires improvements.

LITERATURE CITED


ASPEN FERTILIZATION AND THINNING RESEARCH RESULTS AND FUTURE POTENTIAL

William E. Berguson and Donald A. Peralta

ABSTRACT. Past research on aspen thinning and fertilization in North America is reviewed. The most recent research in Minnesota shows the potential to increase yields 84% over unmanaged stands through thinning and 30% through fertilization. Implications of increased aspen management to future supplies and recommendations for future management research are discussed.

INTRODUCTION

Quaking and bigtooth aspen (Populus tremuloides Michx.; P. grandidentata Michx.) form a cover type that accounts for 5.5 million acres of the 16 million acres of commercial forest land in Minnesota. A dramatic increase in the use of aspen for forest products, primarily for waferboard, has caused demand to double since 1978 and a heightened concern for the potential of aspen to provide raw material to meet anticipated demand. The main concern is the imbalance in age class of aspen acreage in the state. Using updated 1977 inventory data, approximately half of Minnesota's aspen resource is currently at or beyond the optimal rotation age of forty-five years with much of the acreage below rotation age in very young (0-15 years) age classes (Spencer and Ostrom 1979). As a result, a shortfall in harvestable acreage is projected during the next two decades.

To meet future demands for timber, management efforts on aspen must either be intensified or other species used to supply additional material. A number of options are currently being considered to increase aspen supplies including short rotation intensively cultured (SRIC) plantations of hybrid poplars and thinning and fertilizing natural aspen stands. The objective of this paper is to present results of aspen fertilization and thinning research in Minnesota and discuss implications of this research to future timber supply.

PAST RESEARCH

Forest fertilization research has been conducted worldwide on many species since the early 1960s (Bowen and Nambar 1984; Miller 1981). Past research has concentrated primarily on the nutrition of commercially important conifers in the Scandinavian countries and the southeastern and northwestern United States (Gessel and Atkinson 1979; Lea 1980). Since the 1970s, however, research on fertilizing hardwoods has increased partly in response to expanded interest in the management of SRIC plantations (Heilman et al. 1972). In contrast, field research in fertilization of natural quaking aspen stands has been limited. A number of

1 Scientist, BioProducts Division, Natural Resources Research Institute, 3151 Miller Trunk Highway, Duluth, MN 55811, and Principal Silviculturist, U.S. Forest Service, North Central Forest Experiment Station, Forestry Sciences Laboratory, 1831 Highway 169 E., Grand Rapids, MN 55744.

studies have shown variable aspen growth response to fertilization. The strongest response has been to nitrogen and much less to phosphorus, potassium, or calcium (Van Cleve and Oliver 1982; Harris et al. 1984; Safford and Czapowskyj 1986). Growth was increased from 33 percent over three years to 177 percent over 10 years with applications of 150 to 450 lbs/acre elemental N. Doucet and Veilleux (1982) reported the response of aspen to fertilization with NPK (0, 100, or 200 lb/ac) in factorial with thinning (unthinned, 300, or 600 trees/ac). Five year growth increased 15 to 30 percent from fertilizer but 15 to 70 percent by thinning. Van Cleve (1982) conducted fertilizer trials in Alaska on a post-fire aspen stand. Basal area of the nitrogen treated plots increased by a factor of 60% over untreated plots. Fertilizer trials in Wisconsin by the Institute of Paper Chemistry (Wycoff, personal communication) have shown a 34% increase from fertilizer alone with even greater growth when fertilizer is combined with irrigation. Safford and Czapowskyj (1986) reported a doubling of aspen volume over a ten year period.

Aspen thinning has the potential to greatly increase yields. Thinning at about age 10 to 15 years especially accelerates the radial growth of quaking aspen (Day 1958; Steneke and Jarvis 1966; Steneke 1974; Peral 1978). Stands 5 to 7 years old can also benefit (Hubbard 1972; Bella 1975) but stands older than 30 years respond little to thinning (Pike 1953; Schlaegel 1972; Peral 1978). Repeated thinnings at 10 to 20 year intervals maintain the growth response (Peral 1978). The primary objective of thinning is to shorten rotations. Sawtimber rotations can be reduced as much as 20 years (Peral 1978). Total bolewood yields can be increased by 10 to 37 percent by capturing anticipated mortality in thinnings and maintaining stands at near-optimum stocking (Day 1958; Peral 1978; Hocker 1982). Only Peral (1978) showed that height growth was improved by thinning.

The characteristics of aspen stands in Minnesota make them viable candidates for intensive management. Future stands, regenerated from previous clearcuts, will be large well-stocked contiguous stands with aspen predominating making efficient management possible. In contrast to these coppiced stands, current natural aspen stands are mixed with a wider variety of species. Past harvesting practices have created stands that are located nearer existing mills and more accessible than older aspen stands. Finally, in contrast to conifers, aspen leaf litter is easily decomposed and applied nutrients will not be tied up in litter but move more readily through the nutrient cycle (Pastor and Bockheim 1984).

CURRENT RESEARCH IN MINNESOTA

Study Descriptions

The studies were installed in aspen sapling stands near Marcell (variable rate study) and near Toivola and Greaney in north central Minnesota (thinning/fertilization study). The stands regenerated by root suckers after clearcutting in 1971 (Marcell and Toivola) and 1967 (Ganey). Associated tree species were paper birch (Betula papyrifera Marsh.), balsam fir (Abies balsamea L. Mill.) and balsam poplar (Populus balsamifera L.). The soils on the Toivola and Greaney site are unnamed well-drained clay loams. The soil on the Marcell site is a Warba fine sand, a moderately well to well drained upland soil.

Variable Rate Study

The site was divided into two main study areas differing in slope, referred to in this paper as upper slope and lower slope. The upper slope study area is level or near-level while the lower slope study drops 12% toward an adjoining peatland. Aspen dominates on both sites
accounting for approximately 93% of the total basal area (Table 1). Stocking density in 1978 averaged 6200 trees/acre of aspen and 7000 including all species.

Table 1. Characteristics of sites prior to fertilizer application.

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Species</th>
<th>Volume (cu ft)</th>
<th>Height (ft)</th>
<th>Diameter (inches)</th>
<th>Basal Area (ft²/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Slope</td>
<td>Aspen</td>
<td>319</td>
<td>19.5</td>
<td>1.08</td>
<td>39.4</td>
</tr>
<tr>
<td>Upper Slope</td>
<td>All</td>
<td>---</td>
<td>---</td>
<td>1.04</td>
<td>42.6</td>
</tr>
<tr>
<td>Lower Slope</td>
<td>Aspen</td>
<td>341</td>
<td>19.5</td>
<td>1.15</td>
<td>42.7</td>
</tr>
<tr>
<td>Lower Slope</td>
<td>All</td>
<td>---</td>
<td>---</td>
<td>1.11</td>
<td>45.0</td>
</tr>
</tbody>
</table>

Materials and Methods

Stands were fertilized in the spring of 1978 (seven years old) using four treatment rates in 150 lb increments ranging from 0 (control) to 450 lbs/ac of elemental nitrogen applied as ammonium nitrate (NH₄NO₃). Plots were randomly located to account for soil and slope variation within each study area.

Field measurements began in spring of 1978 and annually each fall through 1982 with a final measurement in 1986. Stocking and DBH (0.01 in) were collected on all species. Height (0.1 ft) of aspen was also measured to allow calculation of volume growth. Data were analyzed across all years with stand age and initial stocking as covariates. In this way, the overall effect of fertilization on growth can be more accurately determined. Results are reported for aspen only as this species is the dominant species on the site and analyses of all species mirrored those of aspen on both study areas.

Results and Discussion

Analysis of covariance showed that age was a significant covariate on yield but initial stocking was not. Therefore, results are adjusted for age only (Table 2). All results when expressed as percentage responses are expressed as the percentage of the treated plot over the control ((treatment/control)-1).

Table 2. Yield response of aspen to nitrogen application.*

<table>
<thead>
<tr>
<th>Rate (lbs/ac)</th>
<th>Volume (cu ft)</th>
<th>-- Upper Slope --</th>
<th>Volume (cu ft)</th>
<th>-- Lower Slope --</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basal Area</td>
<td>Height (ft)</td>
<td>Basal Area</td>
<td>Height (ft)</td>
</tr>
<tr>
<td>0</td>
<td>607</td>
<td>58.8</td>
<td>776</td>
<td>70.7</td>
</tr>
<tr>
<td>150</td>
<td>769</td>
<td>66.2</td>
<td>675</td>
<td>58.6</td>
</tr>
<tr>
<td>300</td>
<td>709</td>
<td>63.8</td>
<td>734</td>
<td>69.6</td>
</tr>
<tr>
<td>450</td>
<td>659</td>
<td>59.8</td>
<td>638</td>
<td>59.3</td>
</tr>
</tbody>
</table>

* All values adjusted to the average age of the study.
Growth responses were significantly different between the upper and lower slope. Volumes of aspen fertilized with 150 lbs/acre of N in the upper slope were increased by 28% over controls. The N effect leveled off at the higher rates. Volumes on the lower slope were decreased by 13% at the 150 lb rate. All volumes, basal areas and heights were significantly different (p=0.05) than controls except for basal area of the 300 lb treatment on the lower slope. Periodic volume increments varied markedly throughout the course of the study (Figure 1).

![Graph showing growth responses between upper and lower slope](image)

**Figure 1.** Annual volume increment of control and 150 lb/ac treatment.

It is difficult to explain the depressed yields on the lower slope study. Productive sites are less responsive to fertilizer additions but not depressed by them (Miller 1981). It is possible that lower slope treatments were contaminated from lateral movement of fertilizers from the upper slope although no attempt has been made to determine nutrient movement patterns. Fertilizer treatments appear to be effective through 1986 based on periodic incremental volume growth. Yields of the 150 lb upper-slope treatment during this period were 19% over controls while those on the lower slope site were 20% below controls.

Regression analyses determine that treatments did not affected self-thinning rates.

**THINNING/FERTILIZATION STUDY**

**Materials and Methods**

In early spring 1977, 1/5-acre treatment plots were established in 5-year-old saplings (11500 stems/ac) at Toivola and in 10-year-olds (5500 stems/ac) at Greaney. Dominant and co-dominant potential crop trees (550 per ac) were permanently numbered for measurement. Four treatments were applied in a completely randomized design: (1) no treatment (control), (2) fertilizer with 150 lb nitrogen/ac as NH₄NO₃, (3) thin to 550 crop trees/ac and (4) fertilize and thin (treatments 2 and 3).
Dbh and height of crop trees was measured in spring 1977, annually after each of the first five years growth, and after 11 years. Total volume under bark was derived from the product of basal area and height (Schlaegel 1975). Site index was estimated (Lundgren and Dolid 1971) to be 78 and 87 for the Toivola and Greaney sites, respectively. The entire data set was pooled and analyzed by multiple regression techniques (Perala, in preparation).

**Results and Discussion**

Thinning and, to a lesser extent, N accelerated aspen growth (Table 3). Mortality of crop trees was trivial.

Predicted values from equations adjusted for initial volume showed that thinning increased total crop tree volume by 84 percent at each site. Response to N, however, depended on site and thinning:

<table>
<thead>
<tr>
<th>Site</th>
<th>Thinned</th>
<th>Unthinned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-- percent change --</td>
<td></td>
</tr>
<tr>
<td>Toivola</td>
<td>+25</td>
<td>+38</td>
</tr>
<tr>
<td>Greaney</td>
<td>+16</td>
<td>-8</td>
</tr>
</tbody>
</table>

The response of quaking aspen to thinning and N-fertilizer was within the range of response reported elsewhere. It is impossible to attribute the response differences to N between the two sites to either site quality or stand age at treatment because neither was replicated. Nevertheless, site quality was probably the dominant factor because nutrient response is usually relatively smaller on fertile sites than on deficient sites (Allen 1987).

**Table 3. Initial stand characteristics and 11-year net growth by study site and treatment.**

<table>
<thead>
<tr>
<th>Site</th>
<th>Treatment</th>
<th>Basal Area (ft²/ac)</th>
<th>Diameter (inches)</th>
<th>Height (ft)</th>
<th>Volume (ft³/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toivola</td>
<td>Pretreat</td>
<td>3.5</td>
<td>1.1</td>
<td>15</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Growth:</td>
<td>Control</td>
<td>14</td>
<td>1.6</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N-fertilize</td>
<td>18</td>
<td>1.8</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thin</td>
<td>34</td>
<td>2.5</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thin + N</td>
<td>34</td>
<td>2.8</td>
<td>22</td>
</tr>
<tr>
<td>Greaney</td>
<td>Pretreat</td>
<td>12</td>
<td>2.0</td>
<td>28</td>
<td>138</td>
</tr>
<tr>
<td></td>
<td>Growth:</td>
<td>Control</td>
<td>27</td>
<td>1.8</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N-fertilize</td>
<td>27</td>
<td>1.8</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thin</td>
<td>55</td>
<td>2.8</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thin + N</td>
<td>60</td>
<td>3.0</td>
<td>27</td>
</tr>
</tbody>
</table>

Pulpwood rotations for quaking aspen can be shortened up to 15 years by thinning and by 5 years by fertilizing with nitrogen. The joint effect of these two practices may subtract another 5 to 10 years from rotations. Response to N may be greatest on medium to good sites and minimal on excellent sites. Relative thinning response appears to be less sensitive to site quality but absolute response will be greatest on the best sites.
PRELIMINARY ECONOMIC ANALYSIS OF INTENSIVE ASPEN MANAGEMENT

The land manager should select sites to maximize the return on investment. The economic potential of thinning or fertilizing aspen will depend on direct returns in additional volume and lowered transportation costs by selecting sites near mills. Sites should also be chosen to allow summer access. The difference in transportation costs between wood from natural stands and that obtained from managed stands will greatly influence the economic feasibility of intensifying aspen management. Assuming that sites can be selected for fertilization to produce a 30% yield increase, a preliminary analysis indicates that aspen fertilization may be an economically feasible management tool in the future. Using a stumpage price of $5.00 per cord, a transportation difference between natural and managed stands of 40 miles ($0.18 per cord per loaded mile), and a yield response of 30% over nonfertilized stands, an investment in aspen fertilization would produce an IRR of approximately 4%. This assumes an annual inflation rate of 4% and that the fertilization response will last fifteen years. Whether a response will persist that long is unknown at this time.

The yield response of aspen to thinning (84%) reported above is based on a uniform complete thinning done by hand. The technique assumed in the following analysis is a combination of mechanical strip thinning followed by hand thinning of the remaining strips. Cost assumptions are $19.50 and $44.50 per acre, respectively, for mechanical strip thinning and hand thinning the remaining strips (Peral 1983). Based on a yield response of 84%, an IRR of approximately 9.5% could be achieved at a stumpage price of $5.00 per cord. A one-time thinning at 10 years and a transportation difference between managed and nonmanaged stands of 40 miles is assumed. It should be stressed that economic analyses are preliminary and further testing of responses under a variety of stand conditions and verification of assumptions is needed before economic feasibility can be adequately determined.

FUTURE RESEARCH

If intensified aspen management is ever to become a reality in Minnesota, site selection criteria must be developed to predict yield responses to both fertilizer and thinning with acceptable certainty. The development of biologically sound growth models tested on properly constructed field trials will be necessary. It is imperative that such a program be designed from the beginning to gain an understanding of soils, stand characteristics and disease interactions. In addition, attention must be paid to the potential environmental consequences of fertilization and site selection criteria developed to minimize nutrient leaching. Without this holistic approach, the goal of gaining an adequate understanding of soil/stand productivity relationships and using this information to solve real world problems will not be achieved.

Future thinning research should concentrate on the effects of mechanical strip thinning in addition to uniform (hand) thinning. Universal growth and yield models are needed to better understand and predict aspen growth response to management throughout its range. To assist model development, the response of aspen to thinning on less productive sites needs to be studied. A more complete understanding of competition effects and inter-tree spatial relationships is also needed. Incorporation of these relationships in a model would allow a variety of strip- and hand thinning combinations to be tested and provide land managers a tool to assess a variety of management options to produce the greatest return on investment.
LITERATURE CITED


Doucet, R., and Veilleux, J. M. 1982. [Poplar research and development. XVIII-- Five-year results of thinning and fertilization treatments in natural poplar stands of various age classes.] Memoire, Service de la Recherche (Terres et Forêts), Quebec, No. 76. (in French).


THE POTENTIAL OF HYBRID ASPEN IN A BLANDIN INDUSTRIAL FOREST MANAGEMENT PROGRAM

L. C. Peterson

ABSTRACT. Since the mid-sixties Blandin Paper Company, Grand Rapids, Minnesota, has been participating in a hybrid aspen program initiated and coordinated by the Institute of Paper Chemistry, Appleton, Wisconsin.

A small triploid aspen planting was established on company land in 1965. This triploid was a cross between a 2n P. tremuloides female (upper Michigan) x 4n P. tremula male (Sweden). In the winter of 1980, this planting was cut and the growth was calculated at close to 250 cu.ft/ac/yr. The trees averaged over 7 inch dbh with the largest over 10 inches. The pulp was tested for its paper and board quality and the results proved very acceptable.

As a result of this initial trial, Blandin began operationally planting the triploid aspen and, to date, the company has established over 250 acres. Future plans call for planting up to 400 acres of hybrid aspen per year.

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1 Forester, Blandin Lands and Forestry, Box 407, Grand Rapids, MN 55744.

ASSESSING LOCATIONAL CONCERNS USING GEOGRAPHIC INFORMATION SYSTEMS

Greg J. Arthaud\(^1\)

ABSTRACT. Harvesting and transportation costs play a large role in determining the management of a forest. These costs have a distinct spatial component which has not been adequately analyzed. Use of a geographic information system (GIS) can aid in analyzing stand types, stand to road distances, road haul distances, skidding distances, future forest road placement, and areas fitting a specified set of conditions. GIS can play a large role in both the input and output ends of a harvest scheduling model.

INTRODUCTION

This paper discusses a general approach to use of a GIS as an aid in harvesting and transportation cost determination. The GIS will use a digitized stand map, with stand identification numbers attached to polygons, to tie the spatial location of the stand with the database information. Attributes in the database can be selected, processed and used in the GIS. This can be quite complex but is normally a relatively uncomplicated process.

A useful and central feature of the overall project is a commonly accessible data set. This data set is most easily managed with a relational database management system such as dBase III. Stand inventory data forms the core of the data and can be used to project stand growth and/or create management prescription alternatives (see Pelkki, these proceedings).

One of the key capabilities of the GIS is its ability to overlay maps. Overlaying is quite similar to a "join" in a relational database, except the common field is a spatial area. As maps are formed, their spatial arrangement becomes a key part of the data. A GIS accesses inventory data and other map data to provide aid in formation of spatial constraints and economic or management information. This information may be useful alone or can be entered into a harvest scheduling algorithm.

Once performed, the output of the harvest scheduling algorithm can be displayed in combination with any of the stand data in the database. This could be: showing the location of aspen stands with site indexes over 60 scheduled for harvest in the first period, locations of all harvests over time, state owned stands not scheduled for any management in the periods modelled along with their covery, volume, age, average diameter, harvesting costs and transportation costs, etc...

DATA SOURCES

For Minnesota, at least two large sources of inventory exist; permanent plot data (phase I) and complete inventory data (phase II). The permanent plot data is a good source of statewide, all ownership data and contains tree lists--helpful for growth and yield projections as well as

\(^1\) Research Assistant, University of Minnesota, College of Natural Resources, St. Paul, MN 55108.

product value determination. Unfortunately, the data represents large areas (using plot expansion factors) that do not adequately represent stand spatial arrangements.

Phase II inventory data is more conducive to spatial analysis because each stand is represented by a well defined location, shape and size. The tree data is aggregated for the stand, a tree list is not maintained, so growth and yield projections may be less precise. For large area analysis, storage of the large amount of data on a personal computer could be difficult. Raster systems provide a efficient means of storage. For township 144N-27W, the Minnesota DNR phase II digitized map (DLG) requires 1.3 megabytes storage, while a finely rasterized map (6 meter rasters) is stored in only 200,000 bytes. When working with large areas with many layers and fine detail, these storage savings can be important.

Other thematic maps such as digital elevation models, average precipitation maps, and digitized soil maps can provide additional information when analyzing access to stands and harvesting costs.

For Minnesota, a detailed digital elevation model is not yet available, digital precipitation maps should be available and soil data is currently available for much of state.

**MODELLING HARVESTING AND TRANSPORTATION**

Transportation costs are commonly determined as cost per mile for a unit of wood and sometimes allow variation due to stand variables (average stand diameter, basal area and volume) and different road classes. A networking program combined with a digitized road system, such as that offered by U.S.G.S., can be used to optimize movement (minimum distance) of wood through the road system. In a large model, such as the complete state of Minnesota, it is difficult to optimize the whole road system at one time. A potential way to solve the problem is to implement a hierarchical approach. The interstate and major highway system could first be analyzed and shortest distances or lowest cost (if costs for road travel are known) found from points on the road system to towns or mills. The information thus gained can be used at the next lower level. Polygons representing zones bordered by the higher level roads would then be optimized separately for the next lower level. The process would continue until all levels of roads and trails had been analyzed. If more than one mill may use the wood from the area, the process will need to be repeated for each mill.

The result of the process would be a road system with shortest distance or lowest cost stored at fixed increments (miles) along the roads. These points are entered into a raster system GIS. Assuming that wood would be transported to the nearest road, transport distance zones are created by implementing a FILL (LMIC/EPPL7) or VORONOI (TYDAC/SPANS) on the points. The on-road travel distance is found for each raster by giving it the value of the on-road point nearest to it.

Stand distance from the nearest road is found by placing corridors of known width around roads and locating the lowest valued corridor contained within the stand boundary. The assumption that the wood removed from the stand would be transported from the stand to the nearest point on the road system may not always accurately represent what would occur in an actual situation. The stand may be 0.2 miles away, through a swamp, from a low-class road and require transport of 35 miles to the mill, while a higher class highway is only 0.3 miles away, through upland, and require only 24 miles transport to the mill. It may be possible to create a more complicated model to handle the problem, but consideration should be given to the processing time needed and at what point economic parameters should be included in the
model. It might be advantageous to only deal with optimizing distances when creating an input model for a harvest scheduling model as this allows changes to the economic assumptions without changing the inputs from the GIS transportation analysis.

Average skidding distance for stands is found by assuming that landings are located at the point of minimum stand to road distance. Corridors are then placed around this landing and values (distances from landing) are average for the stand. Again, a more complicated method for analyzing stand skidding distances would be possible. The shape of the stand could be analyzed in determining the location of the landing. Soil types or slopes may change landing location. It is difficult to take into consideration noncussable boundaries (private land, lakes, rivers, ..., ) in all the distance determinations. For that problem, functions that look at boundaries, such as BORDER or EDGE commands in EPPL7, may be useful. In determining stand skidding distances, it is necessary to select out each stand individually for processing. This is where a either a looping command or capabilities to do programming in a common programming language (BASIC, FORTRAN, PASCAL or C) in the GIS's is needed, but glaringly absent.

Given the three distances: skidding distance, shortest stand to road distance and road transport distance, along with other available and pertinent data (soils, slopes, tree diameters,...) should provide the necessary noneconomic data for estimating transport and harvest costs. Further investigation of actual forest harvesting and transportation is needed to form the equations which will convert the stand and location data into economic values.

**ROAD LOCATION DETERMINATION**

The GIS can also help in determining the best location for new roads (to increase access to stands). All of the inventory and derived harvesting and transportation data are available. One method would be to create a map showing upland public ownership, lowland public ownership, upland private ownership, lowland private ownership, lakes and rivers, and the road system. The manager could then analyze the map for areas with poor access and interactively draw in a new road that minimizes private land and lowland crossings (less road building problems). The new road system could then be optimized and a new harvest scheduling model run made. Comparing results of the two harvest scheduling models (with and without new road) will yield information on the increased forest value benefits of the road and may help justify the building of the road. A program which ties into the GIS could potentially automate the process of determining new forest road location by iteratively changing the location of the new road until the road value (benefit minus cost) was maximized.

**SUMMARY**

The use of GIS's to provide harvesting and transportation analysis holds great promise in its ability to deal with spatial relationships and the possibility to process a large amount of data in an automated fashion. Road systems are best analyzed with a networking program or in a vector system GIS, while spatial analysis and overlays may be more efficiently handled with a raster system. The use of GIS’s for this type of analysis is in its infancy and can only be expected to expand further as increased GIS capabilities and availability of new digitized data allow more sophisticated analysis.
ASPEN SUPPLY--A DNR PERSPECTIVE

Carl Prosek

Many of the presentations at this conference have addressed broad issues of timber supply in Minnesota or have looked at the various tools available to assess the complex issue of timber supply. During this presentation, I intend to zero in on a small part of the timber supply picture, but a very important aspect of it and that is the aspen supply/demand situation.

Before I discuss the aspen situation, I would like to briefly review two other items. The first is how and why the DNR is involved in the timber supply issue to give you some background information on how we approach it and secondly, I'd like to quickly review the data sources we use in analyzing timber supply.

The State of Minnesota controls and manages 20% of the commercial forest land in the state. Timber harvesting is the only economic tool we have to manage that land and without adequate markets we cannot do the job. So, the management of our forest lands is the primary reason we have been involved in this timber supply/demand issue and why we have been quite active in economic development activities.

Our involvement in resource analysis also is strictly on a request basis. These requests come primarily from wood industries; however, we also have worked with various economic development groups and agencies. Another point I'd like to mention is that the information we develop and the requests themselves for that matter are considered on a confidential basis. We do not do resource analysis for research purposes or try to determine the long range (25-30+ years) supply/demand picture. There are many other people and agencies more capable of doing that type of thing than we are.

Our definition of timber supply is the difference between what we feel should be harvested annually and what actually is being harvested. Therefore, two types of data are necessary. One is the harvest data and the other is forest inventory information.

The harvest data we use is:

1. Pulpwood - Annual pulpwood production reports published by the North Central Forest Experimental Station.

2. Sawlog and other Industrial Wood Products - 1985 primary industry survey which was done cooperatively by the Division of Forestry, NRRI and the Minnesota Extension Service.

3. Fuelwood - 1984-85 fuelwood use survey conducted by the Division of Forestry.

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1 Utilization and Marketing Specialist, Minnesota Department of Natural Resources, Division of Forestry, 1201 E. Highway 2, Grand Rapids, MN. 55744

The forest inventory data we use is the same information that is available to anyone doing a timber supply/demand study. The basic data used is the 1977 Statewide Forest Inventory data collected and published by the North Central Experimental Station and the Minnesota Division of Forestry.

The present aspen supply situation as we view it is shown in Table 1. The table indicates a 1987 harvest of 1.84 million cords with an annual surplus of 120 thousand cords.

Table 1. Minnesota aspen resource and use - 1987.

<table>
<thead>
<tr>
<th>Item</th>
<th>Volume (Million Cords)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended Harvest</td>
<td>1.96</td>
</tr>
<tr>
<td>Actual Harvest</td>
<td>1.84</td>
</tr>
<tr>
<td>Annual Surplus</td>
<td>.12</td>
</tr>
<tr>
<td>Cumulative Unused (10 years)</td>
<td>5.66</td>
</tr>
</tbody>
</table>

This cumulative unused volume of 5.66 million cords indicates that our aspen resource has been underutilized in the past and is the reason for the age class imbalance. About 50% of the aspen type acres were over the rotation age of 40 years in 1977. The age class distribution of the aspen resource is shown in Figure 1.

Figure 1. Aspen age distribution (Minnesota forest survey (1977) all ownerships).
So, the concern about an aspen shortage is due to age of our aspen and not to a decline in volume or acres available. The acres of aspen in the state now are about the same as they were 50 years ago; however, the volume of aspen has increased significantly during this same period. The following table compares the acreage, volume and harvest of our aspen resource for each of the four surveys conducted in the state.

<table>
<thead>
<tr>
<th>Survey Date</th>
<th>Type Acres (Million)</th>
<th>Growing Stock (Million Cords)</th>
<th>Harvest (Thousand Cords)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1936</td>
<td>5.7</td>
<td>19</td>
<td>300</td>
</tr>
<tr>
<td>1953</td>
<td>5.1</td>
<td>23</td>
<td>600</td>
</tr>
<tr>
<td>1962</td>
<td>5.4</td>
<td>38</td>
<td>500</td>
</tr>
<tr>
<td>1977</td>
<td>5.3</td>
<td>41</td>
<td>900</td>
</tr>
</tbody>
</table>

Figure 2 shows the harvest of aspen from 1978-1987 and our projected demand to the year 1996. The graph indicates that we were only harvesting about 50% of our allowable harvest until the expansions occurred in the waferboard and OSB industries in 1983.

Figure 2. Aspen harvest from Minnesota (includes pulpwood, sawtimber and energy chips).

The projected demand of aspen of 2.87 million cords in 1996 is based on the anticipated expansions described below for the period 1987-1995:

- Blandin Paper Company
- Boise Cascade Corporation
- International Biltrite
- Lake Superior Paper Industries
Lakewood Industries
MacMillan Bloedel
Potlatch Corporation

Some of these expansions have already occurred, some are under construction and some are still being investigated. The total increased aspen use, however, if all occur, is 1.03 million cords.

In looking at the future supply/demand situation of aspen, the question I would like to answer is what effect this increased demand will have on the future aspen supply. Or, in other words, will and/or when will an aspen shortage occur. The assumptions I used in studying the issue are:

1. All aspen is available for harvest.
2. The oldest stands will be harvested first.
3. 90% of the aspen harvest is from the aspen type.
4. Aspen volume harvested per acre is 16 cords.
5. The increased aspen demand discussed earlier will actually occur.

The procedure used in analyzing this supply problem was quite simple. I began with the age class distribution in 1977, determined the demand for the next 10 year period and met that demand by harvesting the oldest stands first. In the next period, I then moved all age classes up 10 years and recycled the harvested acres to the 0-10 year age class.


Figure 7 summarizes this information and shows the demand and available supply for each of the 10 year periods looked at. It basically indicates that a shortage of aspen could occur around the year 2010 if the assumptions used are correct. However, I feel this will occur earlier primarily due to the fact that all aspen is not or will not be economically available for harvest.

The major effects of this aspen supply demand situation over the next 10-15 years will be:

1. Aspen price will increase.
2. Industry will have to accept as much rot or more than they presently do.
3. Any additional large scale use of aspen is very questionable and will not be promoted by the DNR.
4. Merchandising the necessary raw material for the aspen sawmill and veneer industry will become more difficult than it is today.
5. An effort has to be made by all landowners to harvest some of the older, poorer quality aspen stands along with the good site high volume stands.
Figure 3. Aspen type acreage by stand age class. (Minnesota statewide (all ownerships)—total: 5.3 million acres, demand based on 90% of aspen species harvested from aspen type).

Figure 4. Aspen type acreage by stand age class (Minnesota statewide (all ownerships)—total: 5.3 million acres, demand based on 90% of aspen species harvested from aspen type).
Figure 5. Aspen type acreage by stand age class (Minnesota statewide (all ownerships)—total: 5.3 million acres, demand based on 90% of aspen species harvested from aspen type).

Figure 6. Aspen type acreage by stand age class (Minnesota statewide (all ownerships)—total: 5.3 million acres, demand based on 90% of aspen species harvested from aspen type).
Figure 7. Aspen type acreage: projected demand and supply (statewide-all ownerships).
MINNESOTA'S HIDDEN FOREST PRODUCTS INDUSTRY

Jim Sparke¹

ABSTRACT. The economic impact of any individual sawmill in Minnesota appears to be quite minimal, yet when considered in aggregate with sawmill industry has annual revenues exceeding $80 million. The future of this industry will depend heavily on the efforts of the public sector foresters to manage the forest resource effectively.

¹Forester, Rajala Timber Company, Box 217, Deer River, MN 56636.

THE IMPACT OF TECHNICAL CHANGE ON THE TIMBER MARKET

David N. Bengston and Pamela J. Jakes

ABSTRACT. Examines the potential importance of technical change in analyzing the future timber situation. Four major sources of technical change in forestry are identified and discussed. The impacts of technical change at successive stages in the production process in the timber-based sector are then examined, from timber production through end use of wood products. To be accurate, long-run forecasts of the timber situation should explicitly consider the impacts of such change.

INTRODUCTION

Past forecasts of timber supply and forest resource use have typically been wide of the mark. For example, Marion Clawson (1979) has shown that the USDA Forest Service has persistently underestimated the timber production potential of American forests in its long-range assessments. Timber supply is obviously a function of many factors. An important and often overlooked determinant of future timber supply is technical change, or change in the techniques of production. Past assessments have not completely ignored the effects of technical change--it has long been recognized that technical and institutional change has significant impacts on both the supply of and demand for forest resources. But it has been implicitly assumed that the future rate and nature of technical change will be similar to past trends, so that technical change is adequately accounted for in projections of historical data (Tombaugh and Macdonald 1984). This paper asks whether that is a reasonable assumption and examines the potential importance of technological forecasts in analyzing the future timber situation.

Before proceeding, we need to define technical change and briefly address the question of how technological advances make themselves felt in the economy. To an engineer, technical change is simply change in the techniques of production. To an economist, technical change is the substitution of less expensive or relatively abundant resources for more expensive or scarce resources in a production process. As new technologies--including mechanical, biological, chemical, and managerial technologies--are adopted, they affect the processes by which goods and services are produced, reducing the amount or value of inputs needed to produce a given amount of output. The primary economic impact of technical change is thus to increase productivity and reduce per unit production costs.

An example of a major technical change that is especially relevant to Minnesota's timber supply is the substitution of structural particleboard for construction-grade plywood. Structural particleboard technology has permitted the substitution of relatively abundant aspen for increasingly scarce softwood peeler logs in the production of structural wood panels. This example illustrates that technology largely defines what is and what is not a "natural

1 Research Economist and Project Leader, USDA Forest Service, North Central Forest Experiment Station, 1992 Folwell Avenue, St. Paul, MN, 55108.

resource," in an economic sense. Aspen was previously considered an unusable "weed" species, not an economic resource. New technology—and the demand for structural wood panels—made aspen a valuable resource. The economic supply of timber has expanded significantly due to the development and adoption of structural particleboard technology. Another example is iron ore in the Mesabi Range. To the Indians who originally occupied it, that area was a hunting ground; its major natural resources were deer and fowl. Iron ore did not become a resource until another culture came along with the technology to utilize the ore and with a demand for that particular mineral. In an economic sense, technology creates resources.

**SOURCES OF TECHNICAL CHANGE IN FORESTRY**

Technical change comes from many sources, including (1) public and private research and development (R&D), (2) "informal" R&D, (3) technology imports from other countries, and (4) technology "imports" from other sectors of the economy. This section will briefly examine the potential importance of each of these sources.

Public and private research as a source of technical change has been analyzed extensively by economists in recent decades. The link between investment in research, technical change, and the resulting productivity growth has been repeatedly demonstrated in the agricultural sector and various industrial sectors. Recent studies have confirmed that forestry and forest products research also generates technical change that significantly affects productivity growth (Jakes and Risbrudt 1988).

An often overlooked source of technical change is "informal" R&D, sometimes called "blue-collar" R&D. Informal R&D consists of small-scale knowledge-gaining or problem-solving activities that take place outside of formal research departments or organizations. Informal research may be carried out by engineers, managers, production workers, farmers, and so on. This is a pervasive form of R&D and is likely to be an important source of technical change. Although informal R&D has been widely studied in agriculture and other sectors, the importance of this source of technical change in forestry has not been systematically examined.

An increasingly important source of new technologies in forestry is technology imported from other countries. Mergen et al. (1985) have shown that the U.S. share of global forestry research expenditures dropped from an estimated 23 percent in 1970 to 19 percent in 1981. Other countries are increasing their investment in forestry research (and other areas of research) more rapidly than the U.S. Imported technologies generated by forestry research abroad may have a growing impact on future U.S. timber supplies as other countries take the lead in certain areas of technology: "It is no accident that the leader in mechanical pulping technology is Scandinavia, and the leader in papermaking technology is Japan. This technology will be transferred to North America at an accelerated rate," (Styan 1980). The dominance of European equipment manufacturers in many areas of wood panel technology is another case (Anon. 1986). The economic impacts of imported research results and technology may be substantial.2

Finally, new technologies developed in other sectors of the economy have significant impacts on timber supply. The wood-based sector has been shown to be a net importer of R&D

2 Gregersen et al. (1988) quantified the economic benefits of foreign forestry research to the U.S. in two case studies and found significant benefits associated with foreign research input. They concluded that the foreign influence on U.S. research is increasing.
investments and technology. An estimated $275 million of R&D was carried out within the sector, and $337 million was used by the sector in 1974 (Scherer 1982). The lumber and wood products industry used an estimated $131.1 million of R&D in 1974, with only 49 percent of the total used ($64.2 million) originating within the industry itself (Figure 1). Major industries supplying lumber and wood products with research findings include: Motor vehicles and equipment; other machinery; and paints, explosives, and other chemical products. The paper and allied products industry used $206 million in research expenditures in 1974; only 42 percent ($86.4 million) originated within the industry: Other machinery; paints, explosives, and other chemicals; and synthetic resins, fiber, and rubber industries were major suppliers of research findings to the paper and allied products industry. An analysis of interindustry technology flows in the United Kingdom found that five core industries (chemicals, machinery, mechanical engineering, instruments, and electronics) are of major importance in generating technologies used in a wide range of industries (Robson et al. 1988). A trend toward greater interdependence in technology between industries was also found.

![Figure 1. Sources of company-financed research and development used by the lumber and wood products industry and the paper and allied products industry in 1974. (Source: Adapted from Scherer 1982).](image)

In addition to interindustry technology flows in the private sector, new technologies developed in nonforestry public research labs sometimes find their way into the forest-based sector. Moore and Fink (1984) analyzed the research programs at six nonforestry federal laboratories: Idaho National Engineering Laboratory, Jet Propulsion Laboratory, Lawrence Livermore National Laboratory, NASA Lewis Research Center, Oak Ridge National Laboratory, and Sandia National Laboratory, Livermore. They identified 38 areas of on-going research considered to be of potential significant benefit to the pulp and paper industry.

TECHNICAL CHANGE AT SUCCESSIVE STAGES IN THE PRODUCTION PROCESS

The middle column of Figure 2 shows successive stages of production in the timber-based sector, from timber production through end use of the wood-based product. Primary processing uses roundwood or residues as raw material (e.g., pulping, sawmilling). Secondary processing industries use the output of primary processing as raw material (e.g., paper and
furniture manufacture). The right side of Figure 2 lists examples of current and emerging technologies developed within the forest-based sector that are (or likely will be) affecting various stages of the production process. The left side of Figure 2 lists technologies developed in other sectors but with actual or potential application in the forest-based sector. These lists are by no means exhaustive, but are intended to illustrate the range of emerging technologies that affect the production of forest products. The purpose of this section is to make the point that the impacts of timber management and harvesting technologies on timber supply are widely recognized, but the impacts of technical change at other stages in the production process are often neglected and poorly understood.

<table>
<thead>
<tr>
<th>Other Sectors</th>
<th>Forest-Based Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examples of Current &amp; Emerging Technologies:</td>
<td>Examples of Current &amp; Emerging Technologies:</td>
</tr>
<tr>
<td>Electronic data recorders (hardware)</td>
<td>Improved growth modeling</td>
</tr>
<tr>
<td>Microcomputers (hardware)</td>
<td>Genetic tree improvement</td>
</tr>
<tr>
<td>Biotechnology</td>
<td>Containerized stock</td>
</tr>
<tr>
<td>Lifting vehicles and cranes</td>
<td>&quot;Small tract&quot; harvesting technology</td>
</tr>
<tr>
<td>Improved fuel efficiency</td>
<td>Smaller, lighter chippers &amp; chunkers</td>
</tr>
<tr>
<td>Lightweight machine construction</td>
<td>Mechanized delimbers</td>
</tr>
<tr>
<td>Materials handling systems</td>
<td>Power backup roller</td>
</tr>
<tr>
<td>Process control computers &amp; instrumentation</td>
<td>Sew, dry, and rip process</td>
</tr>
<tr>
<td>Anthraquinone (AQ) in pulpmaking</td>
<td>Best opening face process</td>
</tr>
<tr>
<td>Rapid curing adhesives</td>
<td>FPL Spoolboard</td>
</tr>
<tr>
<td>Process control computers &amp; instrumentation</td>
<td>Press dry papermaking technology</td>
</tr>
<tr>
<td>Automated warehousing systems</td>
<td>Improved woodworking technology</td>
</tr>
<tr>
<td>New construction materials</td>
<td>Truss framing</td>
</tr>
<tr>
<td>Improved energy efficiency</td>
<td>Engineered panel assemblies</td>
</tr>
<tr>
<td>Printing technology</td>
<td>All-weather wood foundation</td>
</tr>
</tbody>
</table>

**Figure 2.** Examples of current and emerging technologies affecting successive stages of the production process in forestry.

At the timber production stage, the full range of timber management technologies—including technology relating to site preparation; reforestation; control of fire, competition, and pests; fertilization; and genetic improvement—have an obvious impact on timber supply. Some of these technologies expand future timber supplies by increasing the productivity of the forest. Others—such as insect and disease control technology—expand future timber supplies by sustaining the existing productivity level.

Technical change in harvesting and transportation may critically affect future timber supplies. This is widely recognized. The Congressional Office of Technology Assessment has stated that "Improved harvesting systems could effectively increase timber supplies by removing more

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5 Sources of the technologies listed in Figure 2 are BLS (1984, 1985, 1986), FPL (1986), OTA (1983), and Tombaugh and Macdonald (1984).
removing more wood from harvest sites and by opening up areas that currently are too costly or environmentally sensitive to log," (OTA 1983). "Small tract" harvesting technologies and systems—common in Western Europe—may be especially important in increasing the contribution of private nonindustrial forests to timber supplies.

The effects of technical change in wood processing industries and in various end uses on timber supply and requirements are poorly understood. To shed some light on these effects, we can distinguish between several types of technical change. For the purposes of this paper, technical change can be wood-saving, labor-saving, or capital-saving. Wood-saving technical change results in a reduction of wood input per unit of output in a production process (labor- and capital-saving technical change have analogous effects). An example of wood-saving technical change at the primary processing stage is the "best opening face" technology that increases recovery of lumber through computer-assisted selection of sawlines during milling. An example of a wood-saving technology at the end use stage is truss framing in home construction. Some analysts estimate that truss framing could reduce lumber use by as much as 30 percent over conventional construction practices (OTA 1983).

Wood-saving technologies may have an unexpected impact on the timber market. Rather than decrease the quantity of timber required to equilibrate supply and demand, the adoption of wood-saving technologies will actually increase the equilibrium quantity of timber if demand for the final wood product is highly elastic. Wood input per unit of output declines, but expansion of the industry due to cost and price reductions associated with wood-saving technical change results in a net increase in the demand for timber and the equilibrium quantity. In other words, an expansion effect may offset the substitution effect. On the other hand, if demand for the final wood product is inelastic, wood-saving technical change results in a net decrease in the demand for timber and the equilibrium quantity of timber.

Empirical analyses have found mixed evidence with respect to whether the overall effect of past technical change in the forest products industries has in fact been wood-saving. But almost all the studies to date agree that technical change in forest products has been strongly labor-saving, reducing labor input per unit of output (e.g., see Martinello 1985 and studies cited therein). Perhaps we have focused too much on wood-saving technology and ignored the effects of labor-saving technology on the timber market. What are these effects? Labor-saving technical change lowers marginal production costs and thus induces an outward shift in the supply of wood products. As long as the demand for wood products is not perfectly inelastic, the supply shift results in a higher equilibrium quantity of wood products and an outward shift in the demand for timber. The net result in the timber market is an increase in the quantity of timber needed to equilibrate supply and demand.

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4 The elasticity of substitution between factors of production is another important determinant of the impact of biased technical change on the employment inputs.

5 Demand for pulp and paper is generally elastic (absolute value of elasticity > 1), whereas demand for solid wood products tends to be inelastic. Thus, wood-saving technologies in pulp and paper will likely result in a net increase in the demand for pulpwood. Wood-saving technologies in lumber and wood products that increase efficiency in the utilization of existing commercial timber species will likely result in a net decrease in the demand for timber and the equilibrium quantity supplied. But wood-saving technologies that make possible the use of species previously considered noncommercial—such as structural particleboard technology—will expand the economic supply of timber.
CONCLUSIONS AND IMPLICATIONS

The future supply of timber resources is a function of—among other things—the prospective level of technology. Is it reasonable to assume that technical change is adequately accounted for in timber assessments by trend projections of historical data? Or, must forecasts of the long-run timber situation explicitly include technological developments if they are to be reasonably accurate? The Office of Technology Assessment has stated that "technology probably will be instrumental in making wider, more efficient use of the U.S. forest resource than past assessments have assumed" (Gorte and Fletcher 1984).

What evidence exists in support of this position? The growing importance of some sources of technical change in forestry will be overlooked in assessments of the timber situation using trend projections of historical data. In the only study of its kind, Robson et al. (1988) found evidence of increasing interindustry technology flows over time. As production technologies become more sophisticated, forest-based industries are likely to use technologies developed in other industries to a greater extent than in the past. Yet past assessments of the timber situation have completely neglected the potential impacts of interindustry technology flows. Research capacity and investments have increased more rapidly in other countries than in the United States, suggesting that increased international technology flows will accelerate the rate of technical change in domestic forest-based industries. Once again, past assessments of the timber situation have ignored this source of technical change and its potential impacts on the timber market.

Finally, technical change at every stage in the production process can have substantial impacts on the timber market. The impacts of technical change in wood processing and the end use of wood products—especially labor-saving technical change—have often been ignored. For example, a recent analysis of the impacts of timber utilization technologies on the stumpage market included only the wood-saving impacts (Skog and Haynes 1987). Attempts to forecast the timber situation and peer into the future timber market will be inaccurate without explicit consideration of all types of technical change.

LITERATURE CITED


PRELIMINARY REVIEW OF THE ASPEN RESOURCE STUDY

John S. Gephart, William E. Berguson, and John E. Tevik

ABSTRACT: Demand for aspen (Populus tremuloides) by Minnesota's forest industry has almost doubled in the last ten years. This paper describes the three major project activities: information collection, data analysis and information dissemination, and presents a general discussion of the preliminary findings and conclusions. This project was undertaken by the Natural Resources Research Institute, University of Minnesota, Duluth at the request of the Minnesota State Legislature.

INTRODUCTION

Demand for aspen (Populus tremuloides) by Minnesota's forest industry has almost doubled in the last ten years. Further expansion is possible, resulting in the creation of hundreds of new jobs, provided that industry can be assured of long term aspen supply. This study was undertaken by the Natural Resources Research Institute, University of Minnesota, Duluth (NRRI) at the request of the Minnesota State Legislature.

The scope of this study is very broad. The general intent is to determine the future availability of aspen fiber to existing and proposed industries in Minnesota and to assess the impacts of public policy, resource characteristics and forest management on future resource availability. Input has been sought from public and private land managers along with wood procurement personnel to determine areas of greatest concern. These issues are being assessed through the development and use of a geographically specific wood procurement model. Results of analyses will be distributed to industry, public land managers and state legislators. The study will be completed in June of 1989. Included in this paper is a description of the three major project activities: information collection, information assessment, and information dissemination, and a general discussion of the preliminary findings and conclusions.

INFORMATION GATHERING

In order to identify major issue areas, input has been obtained through meetings with members of the forestry community. In addition, technical information is being gathered through literature searches and analyses of existing inventory data bases.

The literature search resulted in the development of a microcomputer-based aspen literature database which includes over 1750 citations for North America. This reference collection is being used by NRRI staff and can be made available to interested individuals from forest industry, land management agencies, and research organizations in the state.

1 Senior Scientist, Scientist, and Applications Programmer, respectively, BioProducts Division, Natural Resources Research Institute, 3151 Miller Trunk Highway, Duluth, MN 55811.

INFORMATION ASSESSMENT

Resource assessments of this magnitude are complicated by variations in the geographical distribution of land ownership, the resource, demand and location of mills, and differences in products manufactured. Discussions of how to approach this analysis led to the development of an integrated geographically-specific resource model. This model combines inventory data, transportation data, a forest growth model, a harvest scheduling model, and graphical display output. Each of these components are modules and can be modified to allow changing of assumptions and incorporation of new data as it becomes available.

Inventory plot data has been acquired from the U.S. Forest Service, North Central Forest Experiment Station for Minnesota and Northwest Wisconsin. The plot density on National Forest lands was found to be inadequate for the study and alternative techniques to obtain additional data are being investigated.

A transportation network was developed from existing 1:2,000,000 scale United States Geological Survey (USGS) data. The inventory plot data has been overlaid on this transportation network to calculate distances and transportation costs to major Minnesota mills. The 1:100,000 scale USGS data is being used to determine the distance of each plot off the highway system to evaluate forest road building costs.

The U.S. Forest Service "STEMS" forest growth model is being used for forest growth projections on inventory plots.

The harvest scheduling program, which selects plots for harvesting based on mill demand is currently being developed by NRRI. Characteristics of the inventory plots such as land ownership, species composition, species characteristics, harvest costs, and transport costs are considered in making the decision when a plot is harvested.

Computer programs displaying results of the analysis have been developed. These include animated programs to depict growing and changing forests, programs showing transportation distance and cost contours for specific mill locations and graphics depicting plot information geographically. Contours from inventory plots using variables such as site productivity and age can also be displayed.

INFORMATION DISSEMINATION

Information dissemination has been occurring through three activities. The first has been through a series of presentations held by NRRI and at conferences such as the Timber Supply Conference, the second will be through an Aspen Symposium, and the third will be a publication of the final report.

The Aspen Symposium is being planned for the summer of 1989 and will be similar to one held in Duluth in 1972. A decision to hold the symposium was based on the fact that a tremendous amount of information has been generated through research and industrial developments since that time.
PRELIMINARY FINDINGS

Concerns which have been expressed about the supply of aspen during the time period of 2000 to 2010 appear to be justified. Although final results are not available at this time, a number of observations regarding aspen supply and demand are worthy of mention:

1. Aspen is a short lived (60 to 90 years) intolerant (requiring full sunlight to establish and grow) pioneer species which establishes itself after a natural or man made disturbance and, unless another disturbance occurs, eventually undergoes succession to climax species (trees capable of reproducing themselves in the shade of other trees).

Currently the aspen resource is heavily skewed to older age classes. This is the result of aspen establishment resulting from the pine harvesting, agricultural land abandonments, and fires in the early part the century and the low utilization of Aspen prior to the mid 1970’s, leaving few acreages less than 40 years old. Today the aspen resource is beginning to succeed to climax forests species such as spruce/fir and northern hardwoods.

During the next twenty years the aspen resource will undergo significant successional changes. Some of which are:

a) increased species diversity of stands being harvested,
b) an increased average age of stands harvested,
c) a decreased volume of aspen per acre, and
d) a decrease in the quality of aspen harvested due to heart rot (*Fomes igniarius*)

2. The large acreage of mature aspen stands now available for harvest have allowed loggers and mills to select the most economical stands. These stands have generally been located near the mills, close to the all season highway system, and have been the lowest costs stands to harvest. During the next 20 years stands harvested will likely:

a) be located farther from mill sites and have a higher transportation cost,
b) be located further from all season roads and require increased forest road building programs,
c) have higher harvest costs due to reduced volumes per acre and poorer quality, and
d) have increased stumpage prices reflecting increased competition by mills as their procurement zones expand and the number of economical stands available for harvest decrease.

3. Aspen stands that have been harvested in the recent past have resulted in new aspen stands which have significantly higher yields per acre than the original stand. These stands will reach harvest maturity in 25 to 40 years and will result in additional forest industry expansion opportunities. These increased yields are due to a number of factors:

a) Many of the original stands were established from seed sources after fires on harvested pine stands and agriculture lands. Regenerating aspen stands sucker from the roots and take advantage of the nutrients in the root system resulting in early rapid growth.

b) Soils on harvested stands have had the nutrients replenished since original pine harvesting and agricultural abandonment. These replenished soils have greater nutrient availability resulting in greater yield from the new stand.
c) In most cases the stocking of these stands is greater due to the large number of suckers produced.

4. These aspen stands available for harvest in 25 to 40 years are likely to be:
   a) located near mill locations,
   b) located nearer all season roads, and
   c) smaller in diameter than stands harvested today.

5. Aspen demand which has increased very rapidly in the last ten years is likely to increase in the future. These increases in demand not only reflect the large amount of aspen available for harvest but changes in processes and products which have increased the desirability of aspen.

6. Concerns which have been expressed about the supply of aspen during the time period of 2000 to 2010 appear to be justified. These concerns are based on the following:
   a) The current age distribution of aspen is predominantly mature and will provide ample supply for the next ten years. However, significant volumes from younger age aspen, under current management levels, will not be ready for harvest for another 25 years.
   b) The inventory information currently available for determining resource supply is 12 to 15 years old. Due to the changes the forest undergoes and in particular the rapid changes occurring in aspen, the statistical accuracy of this information is very poor. In the past when demand was low the poor statistical accuracy was acceptable, i.e., when resource estimates are plus or minus 25% and utilization less than 50% of the resource, it was obvious that there was sufficient supply available. Forest industry and land managers must have new inventory information and the time periods between inventories must be shortened.

Currently the state DNR and the forest service are undertaking a new state wide forest inventory. A more accurate picture of future supply awaits the completion of this process.

7. The role that the legislature, forest industry, land managers, and researchers choose to take in addressing the opportunities and concerns will determine if the wood products industry can continue to grow. Some of these are:
   a) Increased forest road construction and maintenance efforts. Under current levels much of the aspen resource will not be available for industry further aggravating the supply problems previously discussed.
   b) Increased research efforts in intensified forest management. The age class distribution problem can be reduced by shortening the rotation age in natural aspen stands through fertilization and thinning and through the establishment of high yielding poplar plantations.
   c) Initial resource analysis indicates that nearly all of the commercial forest land, both public and private, will be needed to meet future supply needs. State, county, and federal government can directly influence the contribution of public lands to overall resource supply by the investment it makes towards forest management on their
respective lands. In addition it indirectly influences the role from private lands through land taxes and private forest management programs.

d) Evaluation and if necessary development of process and products to utilize other low demand species such as birch. This can result in reduced demand for aspen. Also, because aspen is a component of many birch stands additional aspen volume could be obtained.

e) Due to anticipated increases in delivered prices for aspen, efforts are needed to develop higher value products for some industries. For example raw material costs for the paper industry are approximately 10% of the manufacturing costs. In the oriented strand board industry raw materials represent 25% of the manufacturing costs. When raw material costs rise oriented strand board will become less profitable making these industries susceptible to closure. To maintain these industries a focus on developing higher value products is needed to reduce the percentage of raw material to manufacturing costs.

PRELIMINARY CONCLUSIONS

Minnesota's aspen resource is undergoing significant changes. These changes are due to a dramatic increase in demand during the previous decade and from successional changes that are occurring. There is no single solution to the problems of future resource supply. Instead the solutions to future supply challenges will be the accumulative impact from a large number of activities and efforts. Continued cooperative efforts between the public and private sectors to further identify the concerns and potential solutions to supply problems is needed. Some of these activities identified to date are:

a) continued emphasis and completion of land inventories,
b) increased forest road construction,
c) intensified land management (fertilization, thinning, and hybrid poplar plantations),
d) development of processes and products which will lead to substitution of aspen by other species such as birch,
e) development of higher value products for industries manufacturing products such as oriented strand board, and
f) evaluation of legislative initiatives which directly and indirectly impact resource management and supply.

Results of this study, as well as the efforts of other University and public agencies, will help provide a clearer picture of the opportunities and challenges to ensure an adequate supply of aspen for future industries in the state.
STAND LEVEL FOREST PLANNING USING EXPERT SYSTEMS

H. Michael Rauscher and Darrell Lauber

ABSTRACT. Forest managers need useful, instantly available, problem-solving knowledge in addition to inventory database management systems and geographic information systems. CHAMPS, a stand-level forest planning tool, pioneers the integration of research developed and maintained expert systems with stand-level forest planning to achieve widespread consideration of the best available scientific and technical knowledge to decision-makers.

INTRODUCTION

Forest management planning takes place on two levels: (1) strategic or forest-level planning, and (2) tactical or stand-level planning, also referred to as "plan implementation."

Since the mid-1960s, many computer programs that assist in forest-level planning have been available. In contrast, little research or development has focused on stand-level planning models (Sessions 1987). Interest is growing in this area, however (Rauscher 1986, White and Morse 1987, and Covington et al. 1988).

We have developed a prototype stand-level forest planning system called CHAMPS, the Computerized Habitat-analysis and Multiple-use Prescription System. The purpose of CHAMPS is to help field foresters implement forest-level plans by using multiple-use prescription recommendations generated by expert systems. CHAMPS has been developed for the foresters of the Itasca County, Minnesota, Land Department. The foresters of the Land Department manage 282,640 acres of forest land, divided into four management units of 60,000 to 85,000 acres each. Each management unit contains between 9,000 and 11,000 stands described by up to 75 measured and computed variables.

The purpose of this paper is to describe the development and present an overview of CHAMPS. A detailed description and a demonstration copy of the software will be available soon (Rauscher and Buech, in prep.).

SYSTEM DEVELOPMENT

Several important concepts affected the development of CHAMPS. Our overriding concern was to build a stand-level forest planning system that would assist rather than replace field foresters in the decision-making process. Experience has shown that forest planning software, no matter how sophisticated, is not capable replacing, only assisting decision-makers (Sessions 1987). Computer support tools assist managers by providing knowledge and explaining recommendations, but people are ultimately responsible for the decisions made. To be effective, a decision support system must be understandable. Output must be explained so that

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1 Research Forester, USDA Forest Service, North Central Forest Experiment Station, 1831 Highway 169 East, Grand Rapids, MN 55744, and Itasca County Land Commissioner, Itasca County Courthouse, Grand Rapids, MN 55744.

people can draw conclusions and alter the program-generated recommendations based on their own experience and intuition (Sedjo 1987). Based on this philosophy, we developed CHAMPS as a simulation model that does not guarantee optimality, but produces understandable and defensible solutions that can be implemented in the real world.

Our future productivity and competitiveness will depend to a largely on how successfully we can manage knowledge to supply information tailored to the specific and ever-changing problems of policy- and decision-makers (Dik and Travieso 1987). Scientific and research establishments must understand that their primary mission is to manage knowledge, not simply to create it. We wanted CHAMPS to illustrate that forest planning systems can effectively incorporate research knowledge in the decision making process. Although gaps in our human knowledge base will always be a problem, a far more serious problem is the gap between what is known by researchers, but not yet used by those who need it (Branscomb 1979). Frequently, decisions are made without benefit of the best available scientific and technical knowledge. Scientists are expected to theorize, experiment, discover, and innovate, but they must also make the information resulting from their research accessible to lay persons. Researchers must provide decision-makers with the best available knowledge to help them create forest management plans. There is an increasing demand for computer-based systems able to provide all the scientific and technological elements bearing on a problem (Winston 1984). We believe that expert systems are an important tool to help satisfy this demand.

Expert system software is a technology recently emerging from research efforts in the field of artificial intelligence (Harmon and King 1985). Sophisticated performance at a rapid rate (quality and speed) is not uncommon among people. Using expert system technology, we can, for the first time, realistically hope to emulate human problem-solving performance on nonhuman devices (Rauscher 1987). "There is considerable evidence that expert system technology, when applied to a well-focused, sufficiently well-defined domain of interest, can provide human workers who operate in the targeted domain with computer support at performance levels equal to or better than the best human experts in the domain" (Jacobson 1986). We believe that expert systems are most useful in advising nonexperts in that part of the domain of interest regarded by human experts as routine.

Like a mountain of unorganized or poorly organized bricks, our scientific, technical, and experiential knowledge is fragmented and unwieldy. We need to structure it, making it precise, comprehensive, and useful for solving specific problems. Expert systems (1) force us to organize and structure our knowledge; (2) train the developer and user to understand the knowledge structure; (3) provide a method to deliver research results to users in a timely, efficient, and usable manner; and (4) establish a baseline of knowledge independent of any specific person for the forestry community. Research developed and maintained expert systems linked to forest planning programs are the key to the widespread application of our best knowledge.

Although some forest-level planning functions may be centralized, we feel that a stand-level forest planning systems must be controlled by the field foresters using them to make daily decisions. In practical terms, this means that the system should execute on a forester's personal computer. Some support services, such as creating and editing map overlays or maintaining inventory records, can be centralized for efficiency; however, stand-level forest planning systems must be immediately available to managers when problems arise, not days, hours, or even weeks later.
Finally, we must recognize that change is the norm! Any system that is too slow or too expensive to keep up with the tremendously dynamic real world will not be used. In a static world, genotypes and computer models could evolve toward optimality with little danger of making species threatening decisions. In a chaotic world, however, the optimality must give way to flexibility; in such a world, good decisions may not be strictly optimal, but neither will they be drastically wrong. In a chaotic world, inflexibility and over-specialization leads to extinction for both species and models. The open architecture of the CHAMPS software, the increased knowledge it provides the user, and the emphasis on the user’s control of the final decision will help keep CHAMPS flexible, useful, and comprehensive.

SYSTEM DESCRIPTION

CHAMPS (Fig. 1) is designed to assist the field forester to implement the recommendations of a forest-level planning system. CHAMPS is not currently bound to any forest-level planning program such as FORPLAN. It is designed to help foresters select specific stands to satisfy

![Diagram](image-url)

**Figure 1.** Organizational schematic of the major components of CHAMPS.
management objectives for a forest habitat compartment (FHC) generated by a forest-level planning program (Table 1). The weighted average accomplishment for the FHC provides a simple and effective index of achievement for decision makers.

Table 1. Sample format of an objectives list FHC in CHAMPS.

<table>
<thead>
<tr>
<th>Objective Name</th>
<th>Units</th>
<th>Amount</th>
<th>Priority</th>
<th>% Accomplished</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red pine cut</td>
<td>CDS</td>
<td>300</td>
<td>2</td>
<td>12%</td>
</tr>
<tr>
<td>White spruce cut</td>
<td>CDS</td>
<td>100</td>
<td>3</td>
<td>0%</td>
</tr>
<tr>
<td>Aspen cut</td>
<td>CDS</td>
<td>500</td>
<td>1</td>
<td>39%</td>
</tr>
<tr>
<td>Convert to conifers</td>
<td>Acres</td>
<td>50</td>
<td>2</td>
<td>10%</td>
</tr>
<tr>
<td>Convert to hardwoods</td>
<td>Acres</td>
<td>50</td>
<td>1</td>
<td>20%</td>
</tr>
<tr>
<td>TSI aspen and birch</td>
<td>Acres</td>
<td>100</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>Create permanent openings</td>
<td>Acres</td>
<td>100</td>
<td>2</td>
<td>12%</td>
</tr>
<tr>
<td>Protect status quo</td>
<td>Acres</td>
<td>300</td>
<td>1</td>
<td>55%</td>
</tr>
</tbody>
</table>

Weighted Average Accomplishment: 31%

Note: Priority 1 = high and 3 = low.

CHAMPS is composed of four major sections: (1) Editing, (2) Habitat analysis, (3) Growth updating, and (4) Decision support. Following is a brief summary of the activities supported by each section. A detailed description may be found in the user’s and programmer’s guide (Rauscher and Buech, in prep.).

The editing section of CHAMPS helps the user to make changes to the stand-level inventory and the section-level maps. When field activities change either the stand inventory or the stand’s geographical shape, the editing system is used to record these changes. The habitat-analysis section allows the user to retrieve inventory data at the stand, forty, compartment, or township level. It allows the forester to make on-demand retrievals based on any combination of the 75 variables in the database, write the list of selected stands to the screen, printer, or disk file, and to display the section maps containing the selected stands on the screen. The growth-updating section is normally run only once a year. As each year passes, it updates the time-dependent variables such as age, volume, diameter breast height (dbh), basal area, etc., to the current year, and performs a new analysis to determine the wildlife community type and the timber, deer, and grouse treatment recommendations for each stand. The treatment recommendations are generated by expert systems.

Expert system software is used in CHAMPS to organize and store timber and wildlife management research knowledge and to use this knowledge to recommend stand-level silvicultural treatments. There are 12 timber management expert systems, one each for: jack pine, red pine, white pine, spruce-fir, black spruce, mixed swamp conifers, northern white-cedar, tamarack, aspen, paper birch, lowland hardwood, and northern hardwoods. The timber management expert systems are patterned after the decision trees reported by Brand (1981). Deer and grouse were selected as the two representative wildlife management expert systems (Buech et al., in prep.). One set of expert systems in CHAMPS is designed to obtain inputs automatically from the stand inventory database. The recommended treatments are in turn automatically saved back to the database.
The decision support section is used periodically to interactively select specific stands satisfying all the objectives for each forest habitat compartment (FHC). The FHC consists of 4 sections of 640 acres each for a total of 2,560 acres. Each township contains 9 FHCs. We start out with a list of the objectives to be accomplished in the FHC (Table 1). Each objective is given in terms of amount to be accomplished and priority. Based on the decisions made and the stands scheduled, an overall percent accomplishment is calculated and used as a weighted index of performance for that FHC.

To decide which stands in the FHC to select, we need to familiarize ourselves with the FHC. We do this by browsing through tables and figures summarizing the overstory cover type composition, the volume vs. species distribution, the volume vs. age distribution, wildlife community type vs. acreage distribution, acreage vs. age distribution. We also review profile of the management recommendations for timber, deer, and grouse generated by the expert systems. We might also want to review the map locations of the stands in the FHC and become familiar with their spatial arrangement.

Finally, we look at each stand individually. Another set of expert systems in CHAMPS operates interactively to explain how the recommendation for a particular stand was derived. We analyze the expert system recommendations and see if we agree with them. We can look over the spatial distribution again if we choose, and when we are satisfied, we can make a decision and record the activity code and the year we schedule it into the inventory database for later retrieval. When the decision is logged into the inventory database, the objectives screen (Table 1) is automatically updated so that the user always knows the average weighted accomplishment level for that compartment.

DISCUSSION AND SUMMARY

CHAMPS is a prototype currently adapted for use by one forest land management organization. Much can be done to improve it. Inventory and mapping data exchange standards need to be developed so that most inventory and mapping system can be used with CHAMPS by simply changing the data exchange programs (Fig. 1). An optimization algorithm could be added to decision support section of CHAMPS for those who feel more comfortable with solution sets derived by linear programming. The mapping system could be expanded to allow soils maps or habitat maps to be overlaid with timber type maps to form meaningful composites. Expert systems could be developed that produce recommendations for aesthetics, recreation, fish management, harvesting and logging considerations, insect and disease damage management, etc. Other, more fully developed silvicultural advisory systems (Rauscher and Benzie, in prep.) can also be linked into CHAMPS.

More development and evaluation of the interaction between forest-level and stand-level planning systems is needed. This is a problem of scale. It may be that another level of planning an aggregation of stands, should be added to CHAMPS. We need to pay more attention to the relation between FHC size units and stands because some resources react to differing assemblages of multi-stand units. Finally, the entire program needs to be error trapped to protect the user from making errors that will cause the program to crash.

In conclusion, forest managers need useful, instantly available, problem solving knowledge. Comprehensive, integrated computer software can be created and improved only through the symbiotic cooperation of forest managers and forest researchers. Forest managers need to understand more clearly what data and prediction accuracy they can afford. Forest researchers need to extend the definition of "research" from mere production to include the
effective management of information. Working together, we can boost productivity by improving the quality of forest management through the improved application of old and new research knowledge.

LITERATURE CITED


Rauscher, H. Michael and John W. Benzie. In prep. Transferring research knowledge to forest managers: A red pine forest management advisory system.


SOFTWARE

Program Name: CHAMPS - The Computerized Habitat-analysis and Multiple-use Planning System

Programer: H. Michael Rauscher

Hardware and Software Requirements:

- Computer model: IBM XT/AT/386 compatible
- Operating system: DOS 3.0 or higher
- Memory required: 640 K
- Disk drives: Harddisk, 5 1/4" floppy
- Graphics required: EGA capabilities
- Printer: Recommended

User’s guide and demonstration program available from:

H. Michael Rauscher
USDA North Central Forest Exp. Sta.
1831 HWY 169 E.
Grand Rapids, MN 55744

Cost: 7 - 5 1/4" 360 Kb floppy disks
or
2 - 5 1/4" 1.2 Mb floppy disks

Miscellaneous information:

To execute CHAMPS, the user needs no commercial software. To modify CHAMPS requires access to QuickBasic(tm), Turbo Prolog (tm), RBASE SYSTEM V (tm), R:Bridge 3.0 (tm), SAYWHAT (tm), and the computer software accompanying the book "SUPERCHARGED GRAPHICS: A Programmer's Source Code Toolbox" (Lee Adams 1988, Tab Books, No. 2959).
THE STATUS OF
THE GREAT LAKES FOREST GROWTH
AND YIELD COOPERATIVE

David K. Walters and Alan R. Ek¹

The Great Lakes Forest Growth and Yield Cooperative (GLFGYC) is designed to encourage the development of forest growth and yield information in the Great Lakes region of the United States and Canada. The primary objective of the cooperative is to foster the collection, pooling, and synthesis of such data within the region and to provide a strong data base for developing and refining forest growth and yield prediction methods. The cooperative also aims to identify priorities, provide direction, and encourage the development of new growth and yield models and the improvement of existing models. A number of specific projects are planned for the first two years of the cooperative. Although emphasis is on maximizing the utility of existing data, the GLFGYC is installing a number of permanent forest growth plots in the vicinity of weather stations. These plots will assist in monitoring the effect of changing climatic patterns, improving growth prediction, and understanding the impacts of acid deposition.

In order to better utilize existing data, the GLFGYC will be developing guidelines for the installation, maintenance, measurement and reporting of permanent plot records. This has been identified as a priority with the membership. Another priority is the maintenance of endangered data sets. The cooperative is developing a data storage and retrieval system for maintaining these data sets. A complete catalog system will be organized to describe other available data sets which may be too large for the cooperative to maintain. Although much work on growth and yield has been done in the Great Lakes Region, there is a need for simple, empirical yield equations and tables, especially for young stands. Such equations will be developed for the major forest types of the region.

To accomplish these tasks, membership has been solicited from public organizations (local, state, and federal in both the U.S. and Canada), private industry, and various universities. Currently, 7 universities, 12 government agencies, and 6 private organizations participate in the cooperative. This cooperative is headquartered at the University of Minnesota and was established with support from a grant from the Legislative Commission on Minnesota Resources and support from existing projects of the University of Minnesota Agricultural Experiment Station, the Minnesota Department of Natural Resources, and the USDA Forest Service North Central Forest Experiment Station.

¹ Research Specialist and Professor and Head, Department of Forest Resources, University of Minnesota, 1530 North Cleveland Avenue, St. Paul, MN 55108.

7. POSTER SESSION PRESENTATIONS

Geographic Information Systems
Steve Bensen, Minnesota Department of Natural Resources, Division of Forestry, 1201 E. Highway 2, Grand Rapids, MN 55744

Forest Inventory on a PC
Mark Hansen, USDA Forest Service, North Central Forest Experiment Station, 1992 Folwell Avenue, St. Paul, MN 55108

Identifying quality red oak using a GIS
Bryan Hargrave, Minnesota Department of Natural Resources, Division of Forestry, 1601 Minnesota Drive, Brainerd, MN 56401

The past, present and future supply and demand outlook for several major Minnesota species --a DNR perspective
John Krantz, Minnesota Department of Natural Resources, Division of Forestry, 500 Lafayette Road, St. Paul, MN 55155-4044

Chippewa National Forest timber situation
Fred Pick, USDA Forest Service, Chippewa National Forest, Route 3, Box 219, Cass Lake, MN 56633

Computer models for forest planning
Dietmar Rose, Matthew Pelkki and Greg Arthaud, Department of Forest Resources, University of Minnesota, 1530 North Cleveland Avenue, St. Paul, MN 55108.

An overview of assistance programs available to increase productivity of NIPF lands in Minnesota
Bob Tomlinson, Minnesota Department of Natural Resources, Division of Forestry, 500 Lafayette Road, St. Paul, MN 55155-4044

Great Lakes Forest Growth and Yield Cooperative
David Walters and Alan R. Ek, Department of Forest Resources, University of Minnesota, 1530 North Cleveland Avenue, St. Paul, MN 55108

The resource management information system of St. Louis County
Tom Zeisler, St. Louis County Land Department, Land Commissioners Office, Room 607 Government Services Center, 320 West 2nd Street, Duluth, MN 55802
GROWING THE FOREST:
DYNAMICS OF RESEARCH AND
A CHANGING ENVIRONMENT

Alan R. Ek, Edward I. Sucoff, and Glenn R. Furnier

ABSTRACT. Research is an on-going effort with a steady stream of products and spin-offs
that enhance the understanding of forest ecosystems and how they might be managed more
effectively. This paper describes the veritable revolution taking place in biology and computer
science and the important impacts these developments are having on forestry research.
Research progress is placed in the context of increasing technological capability and a complex
and changing forestry environment due in part to man's development of the earth's resources.
The implications for forestry research and practice are enormous.

INTRODUCTION

One needs only to follow the newspaper accounts of the developments in science to appreciate
that our understanding of the world has deepened immensely in the last several decades.
Progress in medical science and in computer technology have been astonishing. The
newspapers now speak of genetic engineering in terms that were virtually unknown or
inconceivable when most of us began our formal higher education. We have seen a revolution
in recent decades in biological research that has had and will have enormous implications for
what is possible in forestry research and what might eventually be the products of that effort.
The same is true for the area of computer technology. At the same time our world is changing
and we have been hard pressed even with these new tools to fully understand and deal with
the changes we see. This paper is an attempt to review forestry research as it is affected by
this biological and computer science revolution, to describe some of the near term implications
and to suggest some of the long term possibilities.

THE REVOLUTION IN BIOLOGY

The term "biotechnology" is a popular one today. It is used to describe the considerable new
knowledge and techniques we see being applied. One need only follow the popular news
stories on cancer or AIDS research to understand the tremendous growth in our knowledge
of human biology and how it is shaping research direction. Years of basic biological research
have been coupled with modern techniques in genetic engineering and immunology to aid in
identifying the causes of the disease and to understand how that disease might be treated. The
instrumentation of the modern biology laboratory allows rapid sensing, analysis and synthesis
which is leading to an ever faster accumulation of knowledge. These capabilities are being
widely applied in the plant sciences although perhaps not as rapidly in the less understood and
more experimentally intractable species common to forestry. But be assured that we will see
these techniques applied as some are already doing with gene mapping and genetic

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1 Professor and Head, Professor, and Assistant Professor, Department of Forest Resources, University of
Minnesota, 1530 North Cleveland Avenue, St. Paul, MN 55108.

Presented at Minnesota's Timber Supply: Perspectives and Analysis Conference, Grand Rapids, MN, September
engineering of tree species. In vitro techniques are also being used for the study of plant diseases.

Forest biology research

What has happened in forestry research? We have been able to identify and propagate fast growing species of trees. In particular, forest genetics techniques have progressed from seed orchard technology to micropropagation technologies to effectively shorten the many decade cycle of forest tree generations. What took decades to study may now be observed in a few short years and in some cases just a few months. That has enormous implications for our being able to produce large numbers of plant propagates with desirable growth or disease resistance properties. The same research promises to allow testing for disease resistance or mycorrhizae effectiveness in the laboratory in weeks so as to isolate promising strains for field application.

We are clearly moving to an understanding of the complex of tree growth interactions for at least the early life of trees. What have you seen so far? You have heard of herbicide resistant poplar clones being engineered. In the next few years we will see insect resistant strains of poplar. Fast growing varieties of many of our native species have already been identified through selection techniques. Mass propagation systems for these varieties are under development.

Does this mean forest regeneration is going to be easy? Unfortunately, we are just beginning to understand the complex of factors that inhibit and encourage seedling growth following harvesting and regeneration. The speed of advances in the laboratory has highlighted the difficulty of transferring laboratory and controlled environment results to the field. Researchers will say that we know how to achieve consistent regeneration success in the field, but not necessarily on a large scale or on a cost effective basis. Fortunately, this area of research also has new tools to assess research results in the field. As an example, new miniaturized and localized weather stations plus soil moisture and nutrient tracing capabilities promise more understanding of the complex of what has traditionally been very loud noise in forest ecosystems.

You will see forestry research gains come faster in the next decade than they have in the past. This is especially true for the field of forest genetics. Why? Forestry research laboratories are just now being equipped with the tools of modern biology. It's true all across our region. We are just now beginning to turn out meaningful numbers of specialized scientists who understand this technology. Further, we have spent the last number of decades in this region working on perhaps the most difficult plant materials, conifers. As interests shift to encompass hardwoods, we will see greater flexibility and research will evolve very quickly relative to the research on conifers. Hardwoods are simply easier plant materials to propagate than the gymnosperms we have been dealing with. The new tools to assess research results in the environment will also help.

ADVANCES IN COMPUTER SCIENCE

Advances in computer science have played a very enabling role in forest management and in research. New computers, especially fast microcomputers with broad graphics capability have literally brought the power of advanced statistical analysis and mathematical modeling to the scientist's desktop. The laboratory scientist is now able to analyze his research in a fraction of the time required in the past and with much greater depth than was ever possible. Further,
the scientist can postulate how the world might work in terms of a mathematical model and test that against observations from studies specifically designed for this purpose. That capability in turn has led to a combination of mathematical modeling and biology research to develop research direction and to code and communicate research progress.

Growing interest in computer modeling and analysis is linking the biologist and the mathematician. These capabilities are essential to deciphering genetic codes and linkages among plant processes. Further we are seeing experiments designed specifically to make or break very narrowly focused hypotheses. In turn we are seeing research results coded in terms of knowledge based or expert systems. Increasingly these will be more helpful in diagnosing ecosystem complexities and in choosing among management alternatives. They are now just in their infancy. These tools will also become a major means for transferring research results to land managers. As an aside, computers have already become, through telecommunications, a major means of communication among cooperating scientists. In fact, they have extended the cooperation sometimes globally. The researcher can scan library catalogs from his desk as well as probe the minds of colleagues who live at far distant research stations.

Forestry research planning and applications

Computer capabilities are allowing comprehensive analyses of research problems or management situations as a prelude to actual research. Statistical analysis of multidimensional data, time series and spatial relationships over wide areas, often a key to understanding in forestry, is now quite feasible. This will provide an effective capability in terms of directing research. For example, there may well be spatial patterns of soil quality, soil characteristics or other ecosystem elements that can be analyzed in research planning to direct that research so that it is more precise with respect to the questions at hand. At times such analyses may well lead us to discard or refine what were tentative research objectives or approaches. Computers used in this way are thus a tool for incorporating a description of your forest or forests over large areas so that research can be more meaningful. In turn that connection between research and the description of your forest can greatly speed implementation of research results and an understanding of their ecological and economic implications. In the long run this will mean that forest inventories or other characterizations of forests will have to become more detailed to both facilitate research and to enable effective use of research. In particular, management organizations will want to keep better records of harvest and silvicultural treatment and response data including pre-treatment conditions.

Resource assessment

Resource assessment technologies are changing rapidly and deserve special mention. Satellite based remote sensing has held much promise, but many were discouraged in the 1970's by a lack of sensor resolution and limited computer processing capability. Now we have satellites with higher resolution and mainframe and microcomputer capabilities plus statistical sampling methodologies that promise quite new and rapid approaches to forest resource assessment. The promise is now but a few years rather than decades away. We may no longer need to refer to Phase I and Phase II inventories in Minnesota. We may be able to accomplish both simultaneously, that is, we may achieve solid statewide, county and management unit estimates, including operational maps, in one pass...for all ownerships! This will have speed advantages for the inventory itself, for the frequency of inventories, and as a mode of input to geographic information systems. Such systems will operate in tandem with this resource assessment capability. This same geographic information capability with multiple layers
encompassing vegetation, soils, topography, land use, ownership and other features will aid us in solving complex questions of conflict between various types of forest use.

Growth and response models

Models of how forests regenerate and grow are also evolving rapidly. That capability will increase as we develop greater quantification through monitoring of weather and atmospheric change. Weather modelers have asked numerous times in the last decade why we did not have weather explicitly incorporated in many forest growth models. The appropriate response was that our growth models were better than the weather models. Now the weather models are showing signs of improvement and we may well see useful linkages between forestry and meteorological research. At first this will help most to analyze recent events and research results. With time the methodology will become more predictive.

Forest growth and yield models are becoming more available and detailed. We are also seeing more models that consider fundamental plant growth processes. Regeneration, both natural and artificial, is now receiving more attention. There is progress in the development of knowledge based or expert systems that seem especially appropriate to regeneration decisions, insect and disease diagnosis and fire planning. Attempts at constructing such systems show limitations in both data and methodology. However, the basic computer hardware and software capabilities for such approaches are still very much in their infancy.

Models for management and policy analysis

Forestry research emphasis in the past was heavily upon biological problems. However, the last two decades has brought computer based modelling of management and related policy analysis to the status of essential tools. How we make use of the information available for operational and strategic planning is now a significant area of research. Managerial resources (dollars, personnel and equipment, etc.) are often limited. How then do we decide how to allocate them among regeneration, thinning, protection, etc? How do we schedule forest stands for harvest or other treatment given location, species mix and access variations? How do we assess the implications of restricted land use on timber supply? These and many other questions are now amenable to careful study and modelling to aid decision-making. As examples of progress in the last decade, operational and strategic planning need no longer be considered as separate modelling efforts. Newly developed algorithms can simultaneously consider long term management questions and the details for each and every stand on the forest...on a microcomputer. The next few years will show increased availability and use of such tools in planning.

ECOSYSTEM STUDIES

Research capability has risen steadily in part in response to questions about changes in forests. However, much of the increase in our knowledge about forest ecosystems in recent times has evolved from attempting to study the impacts of a changing environment, that is increasing acid deposition, ozone or CO₂ concentrations or climate change. Many forestry and non forestry scientists are becoming involved in ecosystem research. Computer technologies, in particular, have made the handling of large and complex systems manageable. Large regional and national research projects have provided the funding for data collection for this work. In turn scientists have learned much about nutrient, water, and energy fluxes. Results have had little impact at a local level, but have influenced national and international policy and practices.
Acid deposition studies have identified pathways to tree damage and have led to the credibility of the concept of multiple stresses. As an example of that concept, acid clouds at high elevations can destroy leaf cuticle allowing ozone damage. Also, high nitrate concentrations can lower frost resistance and acid leaching of soils exacerbate drought conditions and can lead to increased susceptibility to insect damage. On the positive side, these studies have increased the understanding of tree nutrition and leaching processes.

Regarding increasing atmospheric CO₂ and the possibility of climate change, scientists are still learning a great deal about the role of forests in contributing to and buffering concentrations. The destruction of forests clearly releases carbon, but vigorously growing forests can be a carbon sink. Thus forest management may have an important role in dealing with this global problem. Some studies show that increased CO₂ will increase tree growth and moisture use efficiency. Other studies cast doubt on those results. Any climatic warming, however, could have significant effects on such subtle factors as hardness, insect damage and fire hazard. The negative impacts on the forest would seem to be a problem for both governments and industry. Industries have the capacity to move to more attractive forest areas (albeit with some difficulty for certain types of operations), but governments generally have to live with their boundaries. The solution to these changes seems to rest with government action. Unfortunately, in a constantly changing environment, both political and biologic, there is no easy resolution to the problem.

The steady and sometimes rapid increases in biological understanding, sensing and computer technologies has greatly expanded capabilities for understanding how ecosystems work. The expansion of monitoring to more natural and disturbed sites will eventually enhance our overall capability to understand and manage the subtle changes in site characteristics that take place as forests develop. As that happens we will see increased specificity and certainty in silvicultural prescriptions.

One very evident fact from this revolution in research is that scientists are often bypassing traditional "grow and see" approaches to examine instead the specific mechanisms and processes that lead to the results we might only see in years of observation. This is true both in biological research and in mathematical modeling. This does not mean that traditional grow and see approaches are being abandoned. They still provide for slow but steady improvements. The new advances allow traditional approaches to be designed to be more informative than they have been.

**DIRECTIONS**

Where is this all heading? Forestry research is becoming more and more a part of an worldwide environmental research effort with increasing links among scientists from a variety of backgrounds. This may mean research may become more discipline rather than resource oriented. It will be the responsibility of our research institutions to see that the specific forestry effort remains viable in terms of steady production of usable results for forest landowners and users. We can achieve that, however, by expanding both forestry and environmental research programs.

Regarding timber supply, research has led the way to many successes. Many in this room are users of forestry research results. Planting stock is improved and regeneration success is more certain than in the past. Plantations producing two cords an acre per year are now fairly common. Why not three? Why not four cords per acre? Why not greater flexibility in our
species x site x treatment prescriptions and a wider range of benefits? These will be some of the suggestions from maturing forestry research programs.

We would like to close on a note of organization. Rarely do scientists operate alone or in isolation in forestry today. There are strong teams and there are linkages between teams at different institutions or in different programs. Further, we see closer links with scientists who are not in forestry. One might surmise that administrators have brought this about, but that would not be entirely true. In fact the scientists have brought it about by their interest and growing communication capabilities.

We are also seeing targeted research efforts. For example, cooperatives are developing that involve a number of researchers. We are seeing cooperative programs addressing regionwide problems that are applied in nature and some joint ventures that emphasis very basic research questions. We should expect to see more of this. As we do so we will also see research move faster. Research must continue to focus on management problems and opportunities, but solutions to problems and realization of opportunities may more often come from new methods and novel approaches.

The ability to assemble a critical mass of scientific talent will be a key ingredient to success. The resources available to research in terms of personnel, equipment and operational support will be the chief limitation to more rapid progress. If Minnesota wants a growing and viable industry, significant investments in research are essential.

LITERATURE CITED AND REFERENCES


LAKE STATES FORESTRY ALLIANCE
REGIONAL PERSPECTIVES

Barbara G. Clark¹

ABSTRACT. The Alliance represents a regional, public/private, multi-interest organizational approach to forest policy issues. Its programs are aimed at improving economic uses of forest resources while maintaining environmental and amenity values. It seeks to establish greater public understanding and political support for multiple-use forest management.

INTRODUCTION

A regional approach to forestry issues among the three states of Minnesota, Wisconsin and Michigan makes good sense for a number of reasons. First, these states share the same geological and climatic history, including repeated glaciation. This alternate scraping and gouging, and then melting back and redepositing of soil has produced an extreme diversity of soil types within the area and resulted in a wide diversity of forest cover.

Our abruptly changing scenery, including the Great Lakes and the thousands of glacier-caused lakes and bogs, is the dominant characteristic of the area, making it attractive to a wide variety of wildlife as well as sportsmen, recreationists and tourists. Commercial forest management naturally tends to reduce diversity by favoring particular preferred species mixes. One goal of the Alliance is to direct attention to this diversity and to support management which will maintain it.

Secondly, these states share much the same human history. European settlement brought with it extensive clearing of land for timber and agricultural purposes. Industrial development and urban growth, surrounded by mostly agricultural land uses, occurred in the southern parts of the states, leaving wide-spread fires and failed farms in the north. The present pattern of extensive public ownership of forest land in the three states is largely attributable to the tax-reversion of decimated private lands to state and county ownership. Subsequent publicly funded fire suppression and replanting programs, and natural regeneration, then set the stage for the forest we are concerned with now.

Concentration of population and political power in the urban southern sections and a depressed, rural, resource-based economy in the north has resulted in some feeling of alienation common to the three states. There is an alleged lack of understanding of resource issues by many metropolitan legislators in a position to make critical decisions. Increasing communication and education of decision makers at all levels, especially the urban-oriented, is another goal of the Alliance.

There are also economic similarities within the region which strongly affect forest policy. Comparable efforts are being made in all three states to diversify their economies through specific development of natural resource-based industry, both product and nonproduct

¹ Chair of the Board of Trustees, Lake States Forestry Alliance, 265 Metro Square, St. Paul, MN 55101, and private forest land owner in Michigan's Upper Peninsula.

oriented. The Alliance goal is to improve and diversify the region's economy through use of forest resources while enhancing environmental, amenity and recreation values fits here.

A final similarity, and a crucial one to the establishment of the Alliance, is the consequence of the large and varied public ownership pattern in these states. County, state and federal managers, who were already cooperating in fire suppression, have established communication and cooperative programs in such areas as insect and disease control, wildlife and fisheries management, research and inventory data collection. The planners of the states and the three branches of the Forest Service have been meeting and comparing programs for years.

ISSUES

It was largely the impetus of the state and federal planners, supported by an interest in promoting regional approaches to natural resource planning by the Conservation Foundation, and State and Private Forestry, that resulted in a workshop in Rhinelander in 1984. In their deliberations on Lake States forest policy, the workshop participants defined a number of regional issues which, it was believed, could be addressed effectively only if the states worked together. To that end, the three-state Governors' Conference on Forestry was convened in April 1987, and the Alliance was born.

The issues which motivated the formation of the Alliance also affected its structure. It is organized around a Board of Trustees which includes the three State Foresters and the regional directors of the three branches of the Forest Service, agencies which manage nearly 40% of the commercial forest acreage of the region. But the majority of trustees represent other interests, like private industry and forest-related businesses, educational and research institutions, promoters of tourism and economic development, sportsmen and environmental groups and private landowner organizations. By design, this group is as diverse as the products, uses and values of the forest resource itself. This unique venture in partnership is the basis for both the hopes of success and the organizational challenges of the Alliance.

Here are some of the Trustees' priority issues and how we are gearing up to meet them.

Issue 1. There is no recognized regional identity and little coordinated congressional delegation support for forestry concerns in Washington. The Lake States National Forest budget is less than full share; the southern and western states are funded for Forest Survey and Inventory at 7 to 8 year intervals while ours stretch to 15 years. We need to develop political clout to change that.

Our proposed response is to conduct a workshop in D.C. early next year for congressional delegations, their aides, and personnel of the state offices there. We will provide them with information about regional forestry facts and potentials, and with opportunities to get acquainted with our Trustees. We hope to develop increased sensitivity to regional needs and facilitate a cohesive regional forestry caucus. We intend to coordinate with regional forest industries in the preparation and sponsorship of this visit which we hope will set a pattern for similar annual occasions. We are also developing continuous and consistent communications with the delegations through our Alliance Coordinator.

Issue 2. The Lake States are seeking to diversify their economies by making better economic use of the forest resource. We are, in fact, net importers of wood products. Except for the well developed pulp and paper and expanding composite products industries, we lack secondary processing and the associated jobs and value added.
The Alliance has a flexible and informative marketing folder in production now and the Marketing Committee has plans to tailor it to specific audiences for distribution. There will be efforts to create a regional identity for promotion to the investment community, international trade and national markets. This type of development will impact the timber supply less and the economy more than primary industry growth.

**Issue 3.** With greater public recreation and other nonproduct demands being put on the public forests, more interest and concern is developing for management on private, nonindustrial forest lands. This ownership makes up about half of the commercial forest acreage of the Lake States. Property tax abatement, management assistance and other tax-supported incentives are uneven among the states. While these are worthy of attention, the immediate intention of the Alliance is to direct efforts toward strengthening the state landowner associations.

The Minnesota Forestry Association, the Wisconsin Woodland Owners Association and the Michigan Forest Association all work with considerable success to promote management planning, facilitate technical assistance, improve harvesting methods and contracts and support general educational efforts. The organizations have begun working together to determine ways of cooperating and taking advantage of the Alliance coordinating role. Obviously the impact of these activities could be increased greatly if more of the close to half a million private woodlot owners in the three states became involved.

**Issue 4.** Everybody wants to use the woods, and not for the same purposes. Some of these purposes directly conflict and require regulation, but many are more compatible than the public recognizes. In order to broaden public understanding and acceptance of the more product-oriented uses of the forests, the Alliance will be convening a conference next May under the general chairmanship of John Suffron, Executive Director of the Minnesota Forestry Association.

The theme will be to demonstrate the benefits of coordinated forest management on rural stability and growth. Emphasis will be placed on examples of compatible uses and the favorable results of cooperation. The attendees will be representatives of community development, tourism, industry, environmental, sportsmen, developed and nondeveloped recreation, research, educational and management interests.

Out of this interactive program we expect to reach some areas of consensus and cooperative agreement, to identify real areas of conflict and to make a start on establishing some processes for resolution of these more intractable issues. We also hope to widen public understanding and support for forest management, including a recognition of the variety of management options and benefits.

In relation to this issue of multiple values of forest lands, we are proposing to develop a system for more accurately evaluating the impacts of different uses on the economies of the communities and region. So far, no acceptable assessment technique exists for fairly comparing such widely different uses as hunting and snowmobiling with dispersed recreation and the myriad of combinations of these with timber and fiber production. Without such a system, it is impossible to define quantitatively the real effects of these management options.
Issue 5. Movement of forest products within the region, where both resources and markets exist, is expensive. All three states would benefit from improved rail service, comparable highway restrictions and better coordination among transportation systems—truck to rail to water shipping. We haven’t begun to deal with this issue as yet, due to time and financial limitations.

Issue 6. Varying environmental regulations and other business climate influences may be causing nonproductive competition among the states. This is an issue we have recognized but so far have not determined how to approach.

More issues are out there, many controversial, some more expensive to pursue, others highly complex. The Alliance is developing a process to identify issues and determine consensus on proposed actions. Because of the varied interests and backgrounds of the Trustees, it is critical that we take care to maintain a united perception of what we are about.

We also must be able to obtain the financial resources to implement our goals and maintain the organization. It has been said that an organization’s goals are more clearly stated in its budget than its charter. Our sources of funding so far have been from the states and the Forest Service. A fund supplied by the three states’ Forest Management Divisions finances the Board of Trustees’ and Chair’s organizational expenses. All program activity, the office and the half-time Coordinator’s salary and expenses have been provided so far through State and Private Forestry Focus Funding sources. To obtain this money, all three states have placed Alliance program support on their first priority level for two years.

The resulting funding, not necessarily exactly as requested, determines what programs we can implement. The end result is that the state and federal agencies really control our priorities, not the Board of Trustees. Not only is this not an ideal situation, but we cannot depend on that first priority status in future funding cycles.

A Funding Committee is engaged in developing a strategy for seeking private corporate, foundation and individual contributions to provide the mainstay of the Alliance budget. The success of this project will determine the future of the Alliance. In another sense, the goals and successes of the Alliance will determine the success of this funding effort.

DIRECTIONS

I believe that forestry—the management of public and private forest lands for society’s needs—is at a crossroads. More and more people live far from the forests and have never experienced the changing, cyclical nature of tree growth, maturation and regeneration. Yet these people are the vast majority of the body politic, whose influence sways decisions reaching far into the woods. Their, our, attitudes toward the environment and natural resources have undergone a revolution in the last quarter century. We don’t even tolerate other people’s cigarette smoke in our breathing space! The misuse of air, water, soil, and forests strictly for private commercial gain is no longer acceptable practice.

Unfortunately, forest management, and particularly harvesting, has acquired a reputation on a par with toxic waste disposal. This is unrealistic and dangerous, but close to the truth. Restrictions, set-asides, private land nonmanagement and further inaccessibility to forest products on public and private land are most certainly in the future. Only by mobilizing all users of the forest to join in educational, research, and lobbying efforts can we change these
negative attitudes and misperceptions. And only if we do will there be a political and social climate conducive to the growth and availability of adequate timber supplies for the future.

This is my view of the mission of the Lake States Forestry Alliance, and why this discussion has a place at a conference on Minnesota’s Timber Supply.
SYNTHESIS AND COORDINATION

A Panel Discussion

INTRODUCTION

A. Scott Reed,¹ Moderator

The last two days have covered an immense amount of ground. Now it is appropriate to look ahead towards opportunities to work together on the many issues discussed. To proceed, we have asked a panel of thoughtful, visionary leaders to comment regarding the need for synthesis and coordination. They will discuss the challenges and prioritize what might be done to develop an action plan.

For this panel, yesterday's mid-conference evaluation provided several insights. I provided a summary of the questionnaire results to the panel for use in preparation of their comments. The first question was: "During the last decade, what were the events that had the greatest impact on timber supply?" Half of the responses focused on "industry expansion" and "changing manufacturing technology." Of course, the two are related. The third category, also related, in terms of frequency was "increased aspen utilization." Between 5 and 10 percent of you said, "legislation, set asides, or restricted timber policies" impacted timber supply. Of decreasing frequency were "changing public awareness, changing forest management and cultural practices, interest group conflicts, and poor business conditions."

The second evaluation question was: "For the next 10 years, what are some priority items that might stimulate timber supply?" The leading response was more diverse species utilization, mentioned by one-fourth of respondents. Between 10 and 20 percent of the responses inferred that higher quality management is needed to maximize fiber output including things like development of hybrid or improved timber species. Following that in decreasing order were "increase of public awareness, education and communication, acceleration and intensification of the forest inventory, cooperative agency planning, and improved road access and transportation considerations." The final two, "increased financial returns to timber production," and "tax incentives" have an obvious relationship.

The final question asked: "What are some barriers or other obstacles to programs which are oriented to timber supply?" The most common response was "lack of understanding, confidence, and limited information," representing one-fourth of all responses. Five to ten percent included "restrictive policies, single use preservation, increasing frequency of cooperative working sessions, economic limitations, market problems, and disincentives." Other responses included "uncertainty regarding supply projections, inadequacy of public dollars for research and management opportunities, a too narrow focus, especially on a single species, and poor tax policies."

Now on to our panel and their comments.

¹ Assistant Professor and Coordinator, Cloquet Forestry Center, College of Natural Resources, University of Minnesota, 175 University Road, Cloquet, MN 55744.

PRIORITIES TO STIMULATE TIMBER SUPPLY

Raymond B. Hitchcock

This has been an interesting challenge, an excellent conference, and I have learned a lot from it. It would like to organize my comments around the second question described by Scott Reed, i.e., "... what are some priority items that might stimulate timber supply." I also want to comment on the way people responded to the question. My comments are built around those responses.

PRIORITIES

The first one is a more diverse species utilization. The issue seems to be primarily that as each day passes we move closer to a tightening supply of wood. Much of our forest exists in mixed stands. An action that stood out for me follows from the typical wood procurement foresters lament about those engineers that decide on what is going to be in the mix. I think we need to get these engineers and upper management in the private sector involved in the solution to the problem. I suspect that the wood procurement foresters have made an effort at it, but I am suggesting that we use state, county, federal officials and people from education to help carry the message. We need to make an effort to inform and educate the engineers and managers in industry. I do not think we have done an adequate job there. We need to carry the message to those people and involve them in the process.

A second answer voiced to timber supply needs was higher quality management, maximize fiber output and hybrid development. The issues have to do with a level of investment, a consistency of investment and economic or biological justification for investments. There is not a clear message for upper management in the private sector, county boards, legislators, etc. They need to understand the reasons why they should support investment. It is not just the public sector that is erratic on investing on their forest lands, the private industrial sector does the same thing. We need a strong statement from the forestry community. Those people you see sitting here. We need logical, documented goals by agency, and by species. There is a lot of talk about Norway pine, white pine, hybrid aspen, and about aspen itself. How much? Where? Who? When? An example of what I think needs to come from this group now is something like the Forest Productivity Report which was put out by the NFPA in 1979, i.e., a blue book. That volume was quite detailed and a tremendous amount went behind that. It is what needs to come from this group. I do not hear a clear consensus on what we need to be doing with those four species mentioned, to say the least about others.

I guess the point here is that if we do not know where we are going, any road will get us there. But we sure as heck are not going to be able to convince legislators and business presidents and boards that we need to invest in XYZ species, if we cannot speak with a clear voice on where we are going down that road. Research has a strong role to play and I think that we

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1Assistant Commissioner, Operations, Minnesota Department of Natural Resources, 500 Lafayette Road, St. Paul, MN 55155.

need to make sure that we continue to have a lot of interaction between the private research and the people that are in the field and businesses and public research. Other industries are starting to tear apart their industrial research organizations, and piece them back together again. As near as I can understand it, they are doing so because people are not listening and they are not focusing research energies in the right place.

The third area on your priority items to stimulate timber supply is increasing public awareness through education and communication. This issue, I remind you, is the cost critical long-term issue that is facing you. Facing us! We have invested much time and energy into our program, but if we do not maintain and develop public support, everything else we have done is not going to work. We need to shift from a reactive to a proactive posture. We have had some recent articles in the Twin Cities papers about the importance of the forest industry and the jobs that come from that industry. There is a tremendous awareness in this state of the importance of forest industry and the jobs it creates and other benefits. You see that repeatedly. People understand that now. Decision makers understand that. What you do not see is any correlation with forest management. The same people that are saying, "Rah! Rah! Build more forest industry, create more jobs," do not understand the implications in forest management. There is very little that we are doing to inform the public about implications and benefits. There are other people standing in the wings who will raise the issue of locking up resources rather than managing them and they will get it to the public. We have go to get that controversy behind us. We have excellent programs in place, like Learning Tree, the Forestry Fair, Tree Farm Program, and others, but we need much more effort. If I have been hearing you right the last two days, we lack commitment and support of the whole forestry community. It cannot be the DNR carrying the ball for Project Learning Tree, it cannot be forestry industry carrying the ball for Tree Farm, it cannot be the University taking care of the Forestry Fair. We have got to get more energy and effort focused on public awareness. We have got to put more dollars behind it.

We need to accelerate and intensify inventory, the issue of the timeliness and utility of the forest inventory is critical. Another action item that is fairly apparent to me is sharing data. We have a lot of new opportunities with new technology including the desktop computer. The GIS systems may go a long way toward solving some of our management problems. We all need to develop the systems that will allow us to accomplish integration of our efforts. The intensity and compatibility of various ownerships on inventory can be a little bit of a problem. However, I think that there ought to be some hard tie between different agencies in the inventory process, so that we end up with an inventory for Minnesota's entire commercial forest from an aggregate of agency inventories.

The fifth area was cooperative agency planning. I think of all of the issues, this is an area where much more needs to be done. I would call that more than interagency planning. I would extend that to the whole forestry community. I think we have made excellent progress in this past decade, but it is evident that we need to achieve common goals and have actions for doing so. We now are divided into a lot of fairly independent actors. In response to the question of the panel on the first day, "What actions are different people, county, state, and private industrial sectors doing to take care of the tax legislation needs, the tax issue?" The response that we got was 'I am doing this, and the agency I am working with is doing this." But then the panel member would turn around and look at others on the panel to see what they were doing. That represented to me a case of what is going on in the forestry community. All four of those people should have said, "This is what we are doing to work toward a resolution of the forest taxation issue." That did not happen. To me that was symbolic, you need to pay
attention to that. We need to involve the program planners, the DNR, county land commissioners, and others.

PULLING TOGETHER TO ACHIEVE COMMON GOALS

We need to pull together specific actions to achieve common goals. The intermingled land ownership issue is something that is not going to be resolved over the short term, or probably the long term either. The action is there, we need more efficient, frequent communication, we need a forum to solidify the forestry community on common goals. For that I think the revitalization of the forestry coordinating committee was a positive change. It has moved from being just an information group to one that may have a charter to be an action group. Maybe that is the way that can get things done. We need a process and plan for forestry community direction. I do not see a place the plan is developing, other than perhaps the Governor’s Blue Ribbon Commission. I do not see plans developing with actions that require follow up. For a group of people that do as much planning as we do individually in our organizations, we sure as heck do not do a very good job of pulling together and developing a plan, a strategy, and a set of actions as a forestry community. We need a longer view. We need common forest harvest planning and forest growth planning.

There were several issues that came through that were legislative and policy agenda items, i.e., taxation and policy legislation monitoring. We have a lot of separate effort going on in the Capitol, and in county boards. There is a lot of separate huddling going on with all the different groups in the forestry community. We are not giving a unified response to the legislative policy issues. We need an emergency process to deal with policy issues in legislation, because some of them come up fairly fast. We need to have a timely presence. The transportation effort the last year was a good example of the forestry community working together. We had an appeal from the DNR Division of Forestry for assistance and legislation to get government more efficient and we were effective in doing so. Clearly, we can change things with help from the forestry community.

In summary, I think the conference is a positive step to laying a foundation for accomplishments. Thank you.
WORKING TOGETHER TO SOLVE COMMON PROBLEMS

Lansin R. Hamilton

Well we have heard much of problems, needs and opportunities. We have heard some good presentations and some inspiring informational comment. I guess I have some selfish motives this afternoon in the way I would like to pursue this. Bill Brown gave you a good overview yesterday of the history and evolution of the tax forfeited lands that 14 northeastern Minnesota counties largely administer. All those counties have professional and support staff. Not enough staffing, but that is a problem we all share, and I think the comments that I have to make about county forestry, really are problems that are shared in some degree by all of us. That means we all have to work together to resolve those problems that we share. And that has to do with financing, staffing needs, roads, all of those issues. But the one that I see as probably more important than anything else is education and information of the public, our legislative bodies, our government officials. Until recently, not too many people realized that counties administer as much forest land as the National Forest or the state of Minnesota. Of course, we are sort of Johnny-come-latelies, or we bloom lately if you will.

The State DNR and the National Forest System have been around since the turn of the century and have had rather extensive educational and promotional programs so that in general, the public is pretty well informed on what they are, who they are, what they are responsible for and so forth. County programs really are unique to Minnesota. They did not start until the 50's and even then it was kind of a plateau of activity until probably the mid-70's or about 1980. So people are not very aware of the counties, and certainly not aware of the important place that they could have in our timber supply, or in our recreational needs, and so forth. The advent of the Iron Range Resources and Rehabilitation Board in the 40's really initiated the county effort. Further, it is one of the real success stories that we have had. At any rate, the Iron Range Resources Program does not exist any more, as far as county programs, but the initiative they created, the information and assistance they have provided, has grown into a very good county administered forestry and resource program.

We are talking about 2.8 million acres of land, that is a lot of land and represents a lot of volume. We probably are cutting about half of our desirable cut, so it means we have a lot of room to expand to fill the timber supply need that we see. We have a lot of opportunity, we have a lot of problems. However, with your help and cooperative coordinated efforts, I am sure that we can resolve many of our common problems. Actually, I guess I would suspect that a lot of the things we see as problems today, will in the future be identified as opportunities. I hope that is the case.

There is a story about unloading the whole load. I do not think I want to unload the whole load. I want to close with one comment. I referred repeatedly to opportunity. And I guess that we talk about the fact that we have gained a lot of identity. We are gaining more support

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1 Land Commissioner and Department Head, Crow Wing County Lands and Forests Department, County Courthouse, Brainerd, MN 56401.

all the time plus awareness on the part of the public and on the part of our legislators. I think we have got to take advantage of that. Do not rest on our laurels. But get busy and charge full ahead on the programs that we have identified, that we have talked about today. Let us not lose that opportunity.
CHANGING TIMES IN THE
FOREST PRODUCTS INDUSTRY

Jack Rajala

Scott, I think that Lans took me seriously for saying at lunch, "Let's quit all this damn talking, let's get out and plant some trees." If you expect me to fill in your spot Lans, good luck. It's good to be here with you today. I have spent a little time in the halls, but this is the first session I have attended. First of all, I would like to know, of the group here assembled, how many of you are professional foresters, or have graduated from a forestry school? Would you raise your hand? Then I can assume that the rest of you have not, like me, and you no doubt belong here. I am not too sure I do, but I am really happy for the opportunity to be here just the same.

It seems like about 10 years ago. A lot of issues that I have heard addressed already this afternoon, and I see on the issue pages, are much the same as the issues that we were talking about 10 years ago. Many of you were here 10 years ago. There was a massacre at this hotel at about that time, there was a very, very hot meeting going on in this very room. Tempers were stretched tight, and were thin. There was a lot of anxiety. We in the industry knew that we were about to lose about a million acres of forest land that we had been able to operate before. It represented a very significant portion, we thought, of the timber supply for the industry, but certainly even more so for the industrial uses that we could envision. A lot of time has gone by, a lot of those visions have come true. These are exciting times in the forest products industry. They really are exciting. You cannot live in Grand Rapids and watch a huge new paper machine being put up without being excited. You cannot watch what happened in the building of a greenfield paper mill down there in Duluth using 150,000 cords of new wood, and addressing a whole new market. You cannot hear about things that are going to happen at Potlatch and not get excited. You cannot help but get excited when you hear the news that Boise finally decided to spend $525 million for plant expansion. It is exciting, and it is exciting for the small business in this industry as well as the large. Quite truthfully, I would like to be a manager at a Blandin or Boise or a Potlatch, and have all the excitement taking place. But on the highways and byways of Minnesota there are also a lot of things happening in the smaller side of the industry, in the sawmills, in the pallet plants, in the furniture plants. Please bear in mind as I make a couple of comments today that many, thousands of people in this industry, are concerned about trees, the fiber resource for tomorrow.

Along with this excitement, I definitely have some anxiety. You have all heard the saying that around every silver lining there is a cloud? That is one I use quite a bit. It is illustrative of my personality and the way I approach things. I spend a lot of time looking at the pessimistic side of things. I am trying to go to most of the industry meetings, as a member of the Minnesota Forest Industries, less directly to Timber Producers Association, but also there are people involved in the Minnesota Wood Promotion Council. For a small company we try and get inside the stream of what is happening within this industry. It is tough for me to address resource issues, because I am not a professional forester. And I do not have the rationale that

1Rajala Timber Company, Box 217, Deer River, MN 56636.

such study and background could give me. But what I have done this past 10 years is made it a point to study the forest resource, and see how it all fits with what I see as business management—the resources vs. the consumption side of this business. And that is the basis for my theories, because I fear that we do have a crisis on our hands, and if it is not her yet, it is going to be here darn soon. We cannot make any more acres, and it seems like we cannot produce any more trees per acre. I do not think we have gotten the job done of actually enhancing the value of each one of those trees that we have out there either. So I am going to be critical, and I am going to challenge your answers.

In terms of what we can do in the next 10 years. I am going to address some of the barriers that I see and things that we can do. I really do not think that your answers are saying a lot about just getting out there and pumping these forests to raise more timber. I do not think I see that. That is not what I am really hearing. Because we did not get that job done, the legislature is certainly not going to get it done. We might not always have a Governor who pays attention to us. I think the industry's list on what we can do here in Minnesota is going to be a tough one to accomplish. I have no fear that they can ride with the price increases that are going to take place as timber comes into shorter supply, and it is going to happen. For somebody that has been in the timber business practically every day of the week and every week of the year, I can guarantee you that prices are going to go up. I have got to believe that major industries who are standing right now, know that these prices are going to go up. But I fear for the many small shops up and down the highways who have no way to react to that. They, quite frankly, cannot change their product ratio that readily to absorb the kind of increases that are going to take place. I think that is the real crux of the crisis. We could have done a better job. I think we still can. We have some barriers. I do not think we have a good tax policy in Minnesota at this point. You could never get me to say that. And you could not get me to say that Minnesota is a good business environment. If I could pack up our timberlands and our mills today and move them to Wisconsin, I would. I would because I do not like the business climate in Minnesota. But the tax policy is something that we have been able to address. We have had an opportunity to talk about it from time to time. I agree with Ray Hitchcock. We have got many people divided and things we have to iron out. We have to have an understanding of what the tax policy in Minnesota is going to be. We cannot have capital gains one day and not have it the next. We cannot have it in the federal law and not have it in the state law. We cannot have it for individuals and not for corporations. I just do not think that is equitable, I do not think it is smart, I do not think it is going to work, and I think that is a definite disincentive to raising timber in Minnesota.

We should raise timber in Minnesota to the degree that we need to, to respond to the possibilities, the potentials that we have, that we are staring in the face today. We can do that if a) we have good incentives and reduce some of the disincentives, and b) if we have the money to put into forestry on the public lands to the degree that it has got to be done. Jerry Rose of the DNR said a while ago, "We can double timber production on public lands if we do it right." I did not hear him say we would necessarily have to double the cost, I do not think we can double the cost. I do not think we will get the money to do it. But we can do it just the same. I believe we just need to work harder at that part of it. It might mean that we need to be less bureaucratic. We will need less restrictions, we will have to resolve the herbicide issue. There are other issues. We need roads, I do not know if we need $6 million of roads in the next decade, but we need roads. If we dedicate ourselves to doing it on public lands, I think we can do it. Interestingly enough, on lands and with a climate that I think is very similar to Minnesota, Finland is raising twice as much timber per acre as we are in Minnesota. I believe, and I cannot prove it with any statistics, that we are far behind Wisconsin and Michigan in terms of timber productivity. Sure, they have got a jump on us, they started earlier, there was
more industry there, they are out ahead. I heard a fellow say the other day that they are 40 years ahead. That scares the heck out of me because I am not going to live another 40 years. If I live that long, like one person said, "Jack, you'll still not get it right." I am just not going to be around that long and I would like to see more of this take place during my lifetime. I am not sure I have all the answers. And I would not pretend that I do, but I really think that we can do a better job. We must do a better job.

Let me say a couple more things, I know that the forest products industry in Minnesota is dedicated to increasing dollars in public forestry. We take it on ourselves, presume that we can help the state of Minnesota, the DNR, get more budget dollars to raise more timber. We presume that we can take it on ourselves to help the U.S. Forest Service get more budget dollars to raise more timber on their land. Those are pretty damn big presumptions. And sometimes you feel just a little bit funny when you go in and talk to these people and say, we are going to help you. But our interests are great--our investments rely on the timber supply. I am glad to hear others on the panel talk about public educational needs, to help develop a greater, higher, better public perception of raising trees, and using trees, so that we can do it compatibly with other forest uses. We certainly need to continue to address compatibility. But I happen to think that this is really a good clean industry. We do not dig big holes in the ground and we do damn little polluting, too. In fact, I think we really help the environment. We need all of you to help industry get that story across. I think it plays better many times if it comes from the public sector. Those are issues too.

Now finally, if I could use six words to sum up how I feel this afternoon, what I want to say would be this, cooperation, cooperation, cooperation, and action, action, action. Thank you.
PROGRESS AND DIRECTION

Richard A. Skok

I am reminded of the fellow who said he thought he saw the light at the end of the tunnel, only to find out that it was a train bearing down on him. In a way that is how one feels in dealing with this question of timber supply. But I think that the organizers of the conference certainly are to be commended for what they have done. I am impressed with the scope of what is happening in this whole area of timber supply considerations. I think we have reached the stage where we have progressed from disorganized to organized chaos in addressing the issue. Let me make a few observations, and then suggest a few things that perhaps can be done as follow-up to what has been achieved at this conference.

BACKGROUND

First, Minnesota timber supply is an issue area that has had a lot of assessment and evaluation over time. It is not a new topic and I think you know that. In part we are a captive of some of our own definitional limitations. Commercial forest land sets definitional boundaries that are not widely understood but become a basis for all that follows. A high level of current interest in timber supply really reflects the growing competition for existing and prospective supply. This is not just the commercial competition for timber, but the set aside of timber for all the other kinds of legitimate uses that the public are saying they want from forest lands.

The obvious lesson you draw from this is that what we are dealing with a dynamic and not a static system. We better remember that. Timber supply is influenceable over time. The emphasis increasingly will be on sustainability of whatever it is we do, acceptable in terms of environmental, political, social, and cultural criteria established for us.

Let me touch on several additional things that I think are particularly important in this arena. We have heard these in one way or another the last couple of days. Timber supply involves different values, depending on ownership and its objectives. I really want to emphasize that ownership and objectives are a key element of timber supply. At issue perhaps is out limited understanding of the process by which ownership objectives change over time. Listening to Perry Hagenstein and his comments about the recent congressional hearing, one could foresee the day when allowable cuts are based not on what we commonly accept today in commercial product yields, but rather on the oxygen efficiency of forests, for example. Now that may be stretching a point, but those are the kinds of changes that could impact our view of the forest and that over time will be impacting how we manage forests.

We talked and heard about the $2-3 billion of new plants and equipment invested in Minnesota alone in the forest industry in the last several years. What is the appropriate level of investment in our forest resource that ought to accompany that kind of massive investment in plants and equipment? I do not know the answer, but I would guess most of us could agree, we are not really at the level that it will require to sustain the needs we can already identify. How and at what levels we invest in forest management is important. The knowledge and

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1 Dean, College of Natural Resources, University of Minnesota, 2003 Upper Bufford Circle, St. Paul, MN 55108.

capabilities to counter problems that develop and are associated with more intensive
management on forest lands in these regimes is crucial.

Technology and scientific development, particularly on the utilization side, still offer means
of effectively extending our resources base. We certainly heard the good news about this
alternative the last couple of days. Alan Ek touched on some research opportunities on the
timber production side today. These are exciting possibilities that we are only beginning to
realize and that will extend our timber supply through increased productivity. We said nothing
directly here about the derived demand nature for our timber supply. Timber demand is
derived from the end use products made from timber. One of the factors influencing derived
demand products is that of substitutes. One can see that tunnel light and it could be something
other than the timber supply train. The question of finding alternative nonfood uses for
agricultural products, as part of the solution to farm community problems, could impact on
the products that come out of the forest. Some of these agricultural utilization developments
could end up being timber substitutes. The Greater Minnesota Cooperation is going to have
a large agricultural utilization research institute that will be doing and looking at such
possibilities.

WHAT NEEDS TO BE DONE?

What needs to be done as follow up to this Conference? One observation is that we have
largely been talking to ourselves the last two days. We need to do that. But, we also need to
talk to those influential who affect what it is we want to see happen. So I propose we have
a small group identify in a formal way some of the direct conclusions that come out of this
conference, convert those into lay terms and make sure that we have a way of communicating
this to these kinds of publics. We need to seek to provide the Governor's Blue Ribbon
Commission on Forestry and Forest Products with action items that have a basis in public
policy. The Commission is charged with concerns regarding timber supply, value added,
management efficiency, and multiresource value objectives. We need to make sure our
community knows what the Commission is and how to make input to its work.

We need to encourage and cooperate in the development of an updated strategic forest
resource plan update for Minnesota. This includes all ownerships, not just state ownership.
We need to have activity in that area, and much of what we have heard here suggests that is
important. We need to plan ways to engage the total community in helping make that happen.

You have heard this before, but I am going to reemphasize it. We need to develop a
coordinated education plan directed at the influential public's regarding major issues discussed
at this conference. Next week, for two days, there is going to be a conference on the north
shore involving at least 50 people from the natural resoruce communications community in
Minnesota. Some are in this room today. This is a very exciting development. Getting that
group to come together, to find ways of sharing a limited resource base, and trying to do a
more effective job for the groups they do represent is a significant step. In a sense they
represent all of us in one way or another. Perhaps they can advise us on how to find better
ways to carry out our educational efforts.

We need a renewed commitment to provide adequate investment in public programs
important to forest resource management in Minnesota to meet Minnesota needs. Research
and technology transfer efforts are a critical part of meeting both present and future timber
supply needs. We must seek increased nonindustrial private ownership productivity. This part
of the agenda includes improved tax laws, stepped up educational programs and technical assistance to these people so that the necessary management practices will be achieved.

Finally, we should seek a Lake States Forest Resource Assessment Study, through the Forestry Alliance. The Lake States forest planners, people from the North Central Forest Experiment Station and the three state DNR's and others have proposed joining together to do for the Lake States what has been done in the South's assessment but, of course, do it better. If we can make such an assessment happen over the next 4-5 years, which is a realistic time frame, I think it will be of great value not only for the region but for the individual states as well.