FORESTS

Minnesota
DEPARTMENT OF NATURAL RESOURCES

Natural Resources Management Series

WHY THESE MATERIALS?

DATE	ISSUED TO

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Rover, Ron.
Forests /

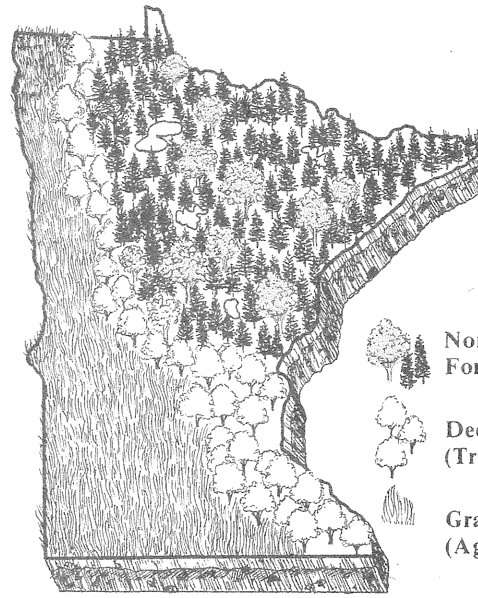
WHO WILL USE THESE MATERIALS?

The Natural Resource Management Series is for secondary-level educators and students in traditional biology classes and in such electives as problems courses, environmental science, sportsman's biology, natural resources, etc. The series is intended for educators who want their students to gain a better understanding of Minnesota's natural resource management principles, practices, and concepts.

There are no specific activities for students in this series. Why? Because approach, content, and methods of teaching natural resources vary so widely across the state. Instead, this packet provides background information and reference material for discussion, lectures, and class activities of **your design.**

Managing Forests in Minnesota's Lake Country

A Case Study in Forest Management



Minnesota's lake country is unique in North America. Three great biomes meet there – the northern coniferous forest or "taiga," the deciduous forest of the transition zone, and the expansive prairie grassland. Each of these contributes to the state's rich diversity of forest types, wildlife, and natural beauty. It is the diversity and natural purity of Minnesota lakeland that attract visitors from all over the United States.

The natural beauty of Minnesota is a great gift to its citizens – and also a great responsibility. The state's rapidly diminishing forests must provide work for thousands of loggers and timber product workers. Yet they must also be managed for the enhancement of wildlife habitat, watershed control and recreational value. Often these needs are in direct conflict with one another. For this reason, among others, forest management is far more than the simple processes of planting, pruning, thinning, protecting, and harvesting trees.

In truth, the most important aspects of forest management are not in controlling such field procedures but in the area of policy formation – deciding just which management demands are to be met and in which areas. In the lakeland part of Minnesota, this process of policy formation is perhaps more difficult than in any other part of the state, for it is there that all the major criteria and demands for management come into play at once. And it is there that all three biomes and their specific management needs converge.

In most of Minnesota lake country, the present major forest type is aspen. With 50-year rotation cycles considered the ideal, frequent harvests are called for in order to maintain a proper diversity of aspen age groups. In another area, the high degree of interest in hunting that is peculiar especially to Minnesotans has caused hunters and wildlife managers to seek more and more young aspen stands to provide the best possible deer and ruffed grouse habitat. All the while, the state's unique geographic position demands absolute care in watershed management, since Minnesota's lakeland feeds three continental watersheds at once.

Management demands coming from each of these areas of concern naturally do not always agree. For example, although the economics of timber harvest and the preferences of wildlife management call for clear cutting aspen, camping and clear cuts are simply not compatible. Policy for a given forest area must thus be formed on the basis of some sort of compromise between such conflicting demands.

In a nutshell, then, this is the story of high-level forest management – weighing conflicting demands on an increasingly limited forest resource and determining policies that best compromise the demands and needs of all parties.

In forming these compromise policies, the forest manager looks at several general factors which may limit or alter usual management plans for a given area – in our case the lake country of northern Minnesota. In order to understand how a compromise policy is arrived at, let's take a look at a few of those factors.

Economics

The DNR's Division of Forestry has two major sources of income – taxes and timber sales. Both are severely limiting. Since taxes are quite unpopular, and since they are levied by politicians who want to be popular, the Division of Forestry works within a very tight budget. This means that only a very small portion of desirable management plans can actually be implemented in the field.

And it means understaffing even at the planning level – too few workers for the massive job of determining the very policies we're talking about.

Funds from timber sales might alleviate part of this money problem, but in many cases the forest manager knows already that the forest is largely economic "principal." The "interest" taken out of it by harvest must not eat into this principal or the already diminishing forest resource will diminish even faster. That is one compromise the forest management planner clearly cannot afford to make.

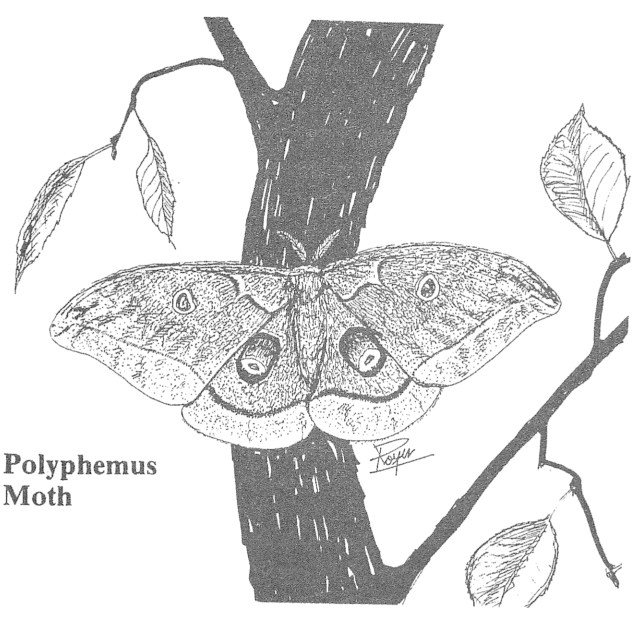
Money shortage is thus a major problem in forest management policy formation. And since forest management has turned continually away from the early logger's philosophy of exploitation toward one of stewardship, harvest is first and foremost wise use. To cut trees to manage what is left is self-defeating.

Unfortunately, there are still those who think of wild forest land as unproductive unless every marketable tree has been removed. On the other hand, there are those who will refuse dogmatically to harvest timber that management programs say should be cut, simply because the operation would be too costly to provide an adequate profit.

Politics

Working with financially limited resources, forest managers also face a grizzly world of opinionated forest users. Hunters want good deer and grouse habitat. Skiers want more trails. Soil conservationists call for thinning some stands – but not too much – and planting other areas to eliminate erosion and pollution of nearby lakes. Loggers want to clear cut, while others refuse, for aesthetic reasons, to accept even temporary clearing of forest land. All these forces seek political control of the state's forests.

Starting with a plan that is based upon sound forest management principles, and upon a limited budget, the manager must expect to alter the plan several times and in several ways after consulting with representatives from each of these political forces.



Polyphemus Moth

Ethics

There is a dignity about wild land that demands preservation. Thus, Itasca State Park and more than 150,000 other acres of Minnesota land have been set aside strictly for the purpose of saving our wilderness heritage. There are those people and organizations, however, that demand more than this. There is a wilderness philosophy which calls for preservation of land even to the point of not cutting mature or over-mature timber. This sort of land use comes under the heading of wilderness recreation. And of course it has its place.

But ethics also apply to society. There are clearly commercial needs to be met at the saw and paper mill, for example. Society needs wood and paper. Just where the line is to be drawn between cutting and leaving for aesthetics and recreation is largely a matter of conscience.

Unfortunately, economics sometimes get in the way of conscience. Powerful conflicts, like the one in the 1970s over logging in Minnesota's Boundary Waters Canoe Area, can result from such a meeting of mind and money. The forester, of course, is in the middle making the compromise decisions. Most often, a ban on logging in one area simply means more intensive management of another.

Social

Right now, Minnesota lakeland forest managers are looking at a vast surplus of overmature aspen, no money to cut it themselves, and no market for the uncut wood. Wildlife managers would love to see the timber cut, because cutting would greatly improve deer and other game habitat. But there is not a sufficiently large aspen market to warrant the expense of cutting in many areas. When markets for harvestable timber do not match the stock of available types, the conflict may be considered a **social** factor in management policy determination.

Fortunately, through cooperation, market projections, and mutual planning, future forests may more closely meet market needs. This will substantially reduce waste of raw timber.

These are just a few of the non-biological factors which influence forest management in Minnesota's lake country. Let's put them together, now, in a theoretical situation, and see what the forest manager actually faces.

To begin with, let's take an imaginary 500,000-acre forest district in the north-central part of the state and put it in your hands. You are capable, of course, because you have completed your M.S. degree in forest management and have three years of management experience behind you. But you've just been assigned to this new and unfamiliar district. Your major job: coordinate a comprehensive management plan that meets the needs of all forest users in your district.

Your first days on the job will probably be spent compiling an overall picture of the district and the various uses to which the forests are already being put. Let's say roughly half the land is forested and half is either urban, rural agricultural, or other non-forest land (lakes, streams, roadways, etc.). In your new district there are two state parks, 18 state forest lakeshore access sites, and about 100 miles of state-managed recreation trails which include a part of the planned corridor system of trails not yet completed.

Let's say the bulk of the forested part of the district (about 85 percent) is aspen-type, much of it with a balsam fir understory. Of the remaining 15 percent, 5 percent is pine type and 10 percent is hardwood forest.

According to your best estimate, then, there are about 210,000 acres of aspen-type forest. Only 15 percent of that, however, is state forest land and under your direct control. The rest is either private, federal, county, or tax-forfeit state land on which your management control is limited.

From this sort of land base, how do you answer the demands of all the varied forest users in your district. Let's see.

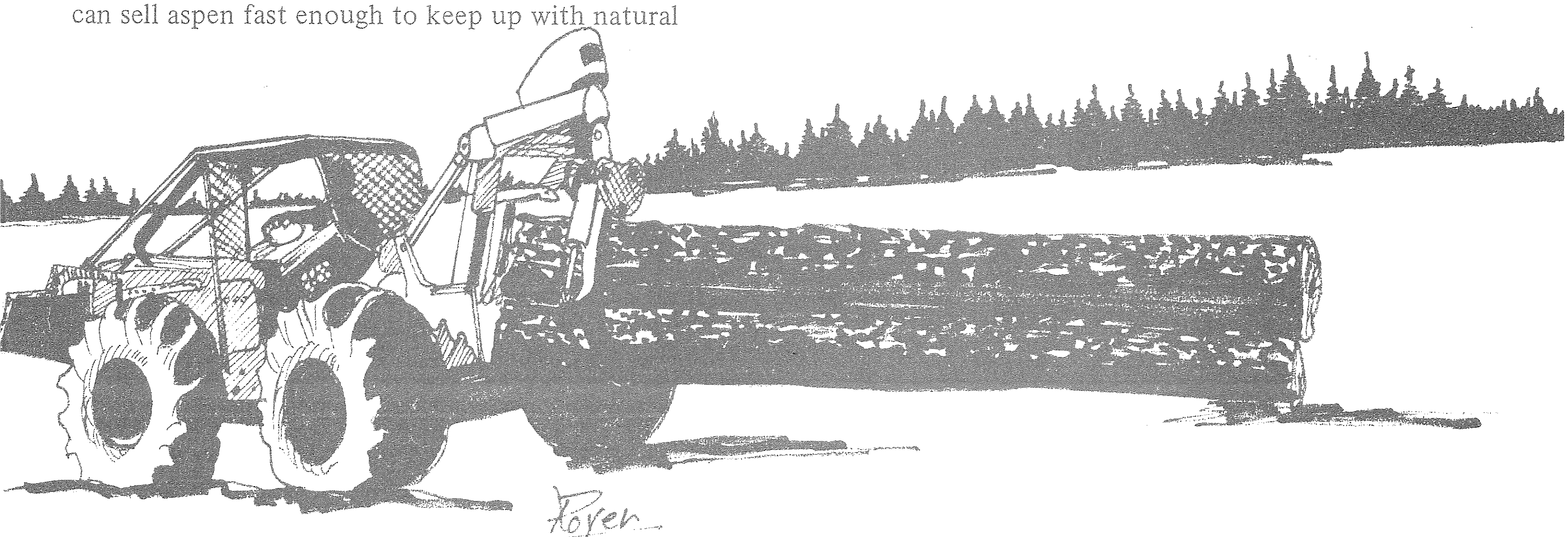
Loggers

You have about 31,500 acres of state forest aspen land in your control. On a 50-year rotation cycle, you could only sell 1/50 of that (approximately 630 acres) per year for clear cut harvest. Fortunately, you learn by consulting DNR statewide inventory data, that there is a surplus of overmature aspen in your district. For now, you can provide for harvest of perhaps one-third the total acreage in aspen, simply because it is going to waste.

Such a procedure will also agree with wildlife management policy for deer and ruffed grouse habitat improvement. But market demand for aspen pulpwood is not great enough so that you can sell aspen fast enough to keep up with natural growth. For the foreseeable future, there will be a surplus of aspen. If there are enough available funds, you may even bulldoze down several hundred acres of older aspens to provide for regrowth, a better age-class distribution, and better wildlife habitat. Alternatively, if wildlife managers would agree, you might allow natural conversion to balsam fir to continue or even convert some of the land artificially to pine-type, for which there is a greater market demand.

Snowmobilers and Cross-Country Skiers

Outside the two state parks in your district, there are dozens of miles of logging roads available for use as winter trails. Since these roads are already cut, you can provide nearly 500 miles of additional recreation trail at little expense to the taxpayer. But some acreage will be under harvest



each year, and you will have to keep skiers and snowmobilers aware of your plans to avoid misunderstanding.

Resort Owners and Summer Users of Lakeshore

No one likes to canoe along a clear cut shoreline or drive through slash piles into a favorite resort spot. So you will have to manage your aspen harvest in such a way that major avenues and lakeshores are relatively undisturbed. Fortunately, this agrees with the plans of watershed managers and soil conversationists for erosion control throughout your forest district. Here, much of your pine-type forest may be found, providing recreational value without discouraging wildlife managers who favor aspen-type forest.

Hunters

Without altering the forest type from aspen to poorer habitat types like fir or pine, you are already answering the demands of hunters in the best possible way. With the exception of "big woods" species like the gray squirrel, favored game animals and birds abound in the aspen forest where food and nesting cover are at a maximum. Here, public education is an essential management tool. It will help erase the erroneous stigma against clear cutting.

Special Interest, Study and Recreational Groups

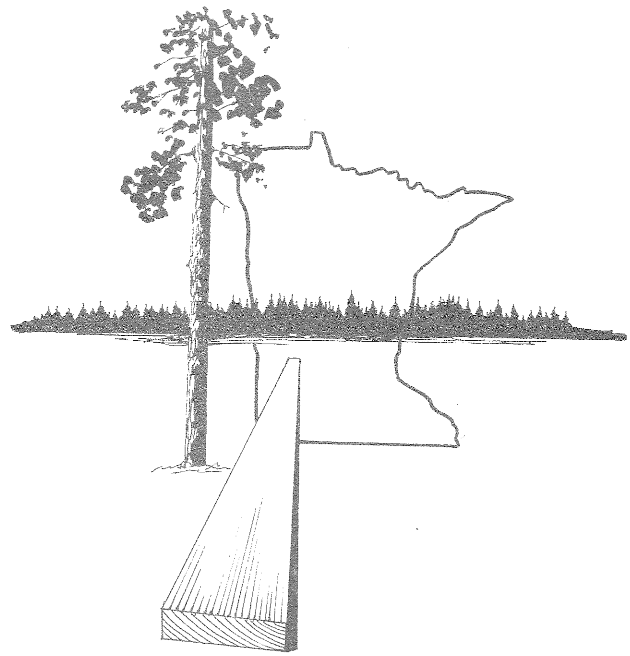
Bird watchers, naturalists, and wildlife photographers demand a special sort of pristine setting. Large, hollow, denning trees, rich forest litter and duff, and relatively undisturbed acreage best fit their needs. These users you will refer to the state parks and recreation areas in your district where management priorities are for aesthetics rather than economics.

Non-State Land Use

In all the above cases, management plans simply involve making tradeoffs and compromises. Though they may make you unpopular with some groups, such decisions are final and totally under your control. But what about the three-fourths or more of forest land in this theoretical lakeland district that is not within your control? What effect are decisions there having on your jurisdiction?

Fortunately, a great deal of non-state land is either federal or county owned. In most cases, since management is based on fairly universal scientific principles, other governmental agencies will have management plans that closely harmonize with your own.

It is the private sector that a major problem looms for you and all forest users. The problem – diminishing forest land base.



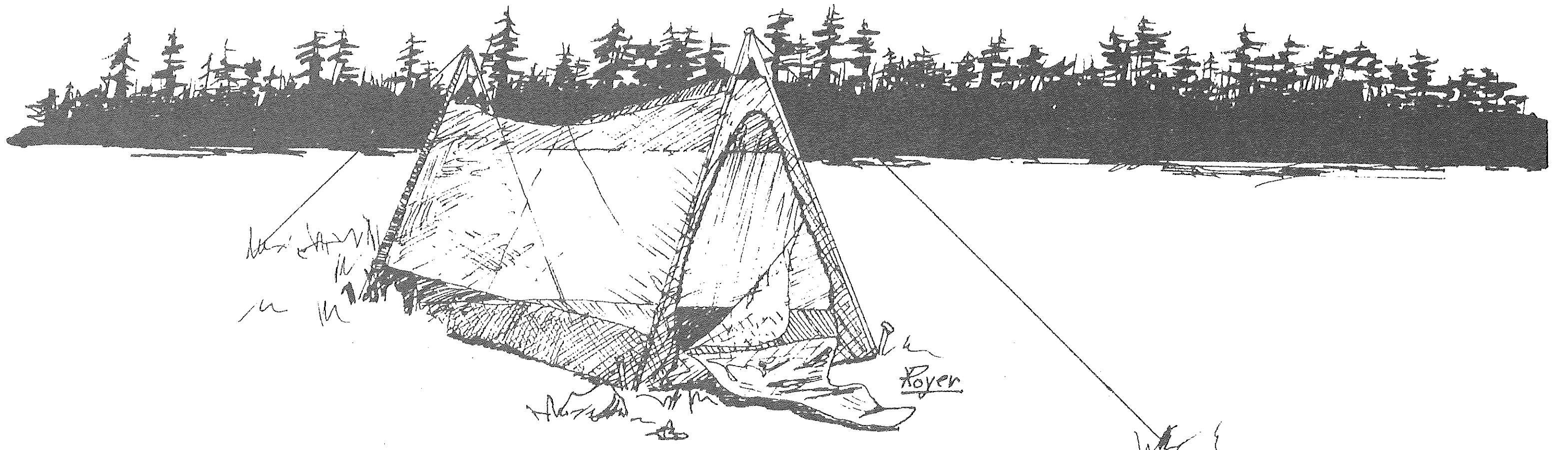
In 1850, nearly two-thirds of the area of Minnesota was forest land. Now, less than one-third is forested and the amount is diminishing rapidly. Much forest land today is under private control, and much of that is unmanaged. Only about 10 percent, on a statewide basis, is controlled by the DNR. Perhaps 6.5 percent statewide is federal land, and less than two percent is county land. The remainder is privately owned – approximately 82.5 percent statewide.

We've made the assumption that in the theoretical lakeland district we're considering, 15 percent is state land. Let's say, then, that 75 percent of land in the district is private land.

Competition for lakeshore property, both for resorts and private cottages, pushes land values far above levels at which timber management – public or private – is worthwhile. Coupled with the continued loss of forest land to roadside "screens," usually Norway or jack pine, and unmanaged private "investment" holdings, this means an overall loss of manageable forest land.

It is thus estimated that by the year 2000, supply will equal demand for forest products. After that, shortages are a real possibility. This is perhaps the greatest problem the lakeland forest manager faces, for the solution is out of direct control, either by management practices or policy formation.

Written and illustrated by Ron Royer. Published by the Education Section, Bureau of Information and Education, Minnesota Department of Natural Resources.



Managing Forests for Recreation

What would a northern Minnesota lake look like without a tree-lined shore? Conceive of thousands of miles of roadside and right of way without any trees. Feature a totally treeless summer campsite. None is very appealing, is it?

Beyond their economic value as wood producers, and beyond their value to watershed and wildlife management programs, Minnesota's forests have a powerful impact on the state, simply in terms of aesthetics. Every season offers the forest visitor new vistas. From winter birches on a sunlit hillside to autumn-golden tamarack stands, from the flowery world of spring to the green lushness of summer, the wild forest today provides our most varied outdoor recreational resource.

But it was not always so. When trappers and explorers first entered Minnesota, they found the native Americans an integral part of the forest ecosystem. To the Indians, the forest was not merely a place for recreation but the source of their very life. They built their homes from the trees and animals that lived there. Boats, tools and weapons were forest products at least as important to the Indians as lumber and paper are to us today.

Indians used the forest directly for medicine, dyes, food, shelter, and in many other ways. We, too, use the forest. But for us the forest is also a source of recreation and escape from the bustle of 20th century life. It is ironic indeed that our recreational uses of the forest quite often are those very activities the Indians relied upon for their day to day living. Hunting, fishing, boating, and wilderness hiking are for most of us weekend or vacation pastimes. For the Indians, these activities were essential.

Perhaps it is our need to maintain contact with the land, or to preserve our mental health through a sense of belonging to the natural order, that draws us to the forest for recreation. Whatever the reasons, millions of people annually use the state's nearly 900 campsites, more than 8,000 miles of existing trails and canoe routes, and hundreds of lakeshore accesses, picnic grounds, and roadside parks. To all these places and to the people who frequent them, the forest is indispensible. And management of Minnesota's 18 million forested acres must therefore be conducted with recreation in mind.

It is not only the DNR Division of Forestry that is involved in recreational forest management. The DNR's Division of Parks and Recreation provides Minnesota residents and visitors with ways to reap the aesthetic benefits of their wild land and forest heritage. Thus, aside from the 4.5 million acres of forested land managed by the Division of Forestry, there are countless "natural" and "recreational" state parks, thousands of miles of snowmobile, bicycle, cross-country skiing and hiking trails, and numerous wilderness areas, wildlife management areas, wild and scenic rivers, rest areas, and historic sites for people to enjoy. Almost all these facilities include at least some forest land and must be managed in part by foresters. But the goals of management for such forests are vastly different because the basic priorities are different.

Itasca State Park, in Clearwater County, offers a good example. Inspiring Preacher's Grove, tall-grown with virgin white and Norway pines, hosts thousands of visitors annually. Unfortunately, the grove will not always be there. Partially through natural changes and partially because the land has been heavily walked over by park visitors, the understory in Preacher's Grove is thin and will not replace the mature forest when it begins to die.

Without management, park users might be faced in a few decades with the loss of the natural wonder of towering mature pines. But forest managers are already planning far ahead, providing for replacement of the grove in another area of the park. In 100 years, another grove of mature pines will be available because of this careful management.

This sort of planning, of course, is not for economic harvest at all. Nor is it primarily for watershed or wildlife management. It is, rather, for the recreational pleasure of future park users that intensive forest management is going on in Itasca State Park and other parks throughout the state.

On the other hand, that doesn't mean, when state park or other primarily recreational land is managed for aesthetics, that the wood from lost trees is not used. It means that use is not the **primary** aim of management. In opening a new campsite or river access, for example, it may be necessary to cut away a few trees. Those trees may either directly or indirectly become picnic tables, a shelter, or even just firewood for campers. The important thing, of course, is that they are used and not wasted.

Even where management for logging or wildlife habitat are primary goals, recreational value may be a secondary product. The nearly 1,500 miles of Minnesota forest roads, for example, may be used in winter as cross-country ski and snowmobile trails, and in summer as bicycle or hiking paths. While it is producing trees for economic use later on, a growing forest may also provide recreational value to hunters for many intervening years. And an in-progress corridor trail system, when it is completed, will link major park and forest areas throughout the state. Along with tributary trails built by other organizations and partially funded by the DNR, this corridor system will ultimately provide more than 10,000 miles of multiple-use trail, much of it forested.

Of course, opening millions of acres of wild land to public use necessitates a strong sense of stewardship on the part of all. It demands that those using all the wild lands and forests in Minnesota do so with respect for the fragile ecosystems they contain. Furthermore, recreational use of Minnesota forest land will increase by more than 30 percent in the next decade. While that is happening, the state's forest land base will undoubtedly continue to diminish. Recreational pressure on the remaining forest will thus be unbelievably intense. The best way to prepare for such a future is to educate the recreational forest user.

If these programs are successful, your grandchildren too will be able to enjoy the whisper of wind in Minnesota pines, the spring call of the woodcock, or the thrill of seeing a deer in the wild.

The awesome possibility of a treeless shoreline or campsite may or may not become reality. Even with the best forest management, responsibility for the health of tomorrow's recreational forest rests on your shoulders.

No privilege comes without responsibility.

Written and illustrated by Ron Royer. Published by the Education Section, Bureau of Information and Education, Minnesota Department of Natural Resources.

Managing Forests for Wildlife

Few events in the forest have the impact of a timber harvest. Only the destruction of a stand of trees by fire or pests can rival the impact of cutting. Changes in the forest that follow any of these are bound to be dramatic ones, especially for the animals that live there.

Of course, such changes can't possibly be favorable for all wildlife. Some species will naturally be harmed by a fire or harvest in a large timber tract. But if the forest manager and wildlife manager have been putting their heads together, a timber harvest can mean real long-term gains for the majority of wildlife species. What the forester terms a timber harvest the wildlife manager thus may recognize as an overall "habitat improvement." It is, in fact, within the scope of all forest managerment plans to provide for such integration of purposes whenever possible.

Let's look closely at a specific example:

The white-tail deer faces a great deal of hardship during Minnesota's harsh winters. A deer can reach only six or seven feet above the ground for food – mostly the leaves and young twigs of plants within that height.

During winter, however, the lower two or three feet of available food is beneath the snow and out of the deer's reach. To make matters worse, in a mature or over-mature forest stand the remaining food is at a minimum because most twigs and leaves are in the treetops, also out of the deer's reach.

On the other hand, in young aspen stands, especially those regenerated by suckering or sprouting, a great abundance of food may be found within easy reach of hungry deer. Clear cutting an aspen stand, the most extreme and complete of timber harvest methods, is therefore one of the best possible wildlife management techniques to increase the amount of available white-tail deer browse, and consequently for increasing any deer herd whose range includes the stand. Aspen sprouts themselves are a frequent winter food of the deer, but the removal of older trees in a stand does much more than produce a surplus of aspen sprouts. Without shade on the forest floor, many other species of plants get a chance to reproduce. Many of these plants serve to balance out the deer's year-round menu. And other species of wildlife, like the ruffed grouse and varying hare, also enjoy an increase in food supply after an aspen clear cut.

Working together, the wildlife manager and the forester thus help each other in a single operation. Deer habitat is improved for the wildlife manager, and the newly emerging aspen stand gets a natural thinning and pruning from the healthy deer herd that results. This approach to integrating forest management and wildlife management is of course favored by both foresters and wildlife managers. Often, by modifying standard forest management procedures only slightly, the forester can greatly improve wildlife habitat in other ways too – with little additional work or expense. The cut of timber throughout a large area, for example, can be managed in such a way that it redistributes wildlife. Thus, animals can be dispersed from an area where they might otherwise congregate and compete too heavily for limited food and cover. Also, selective harvest methods, like strip and patch cutting, substantially increase the amount of forest fringe available to wildlife and create openings within which favored food plants may thrive.

In addition to food, new growth within a forest stand also provides nesting cover. In a mature forest, the ground is only sparsely covered with vegetation because tall trees shade the ground and inhibit growth. But once the sun reaches the ground after a harvest, dense new growth begins almost immediately. It is such growth that provides nesting and protection sites for wildlife of all sorts.

The life history of the ruffed grouse, like that of the deer, is closely linked to the forest. It demonstrates the importance of forest management in wildlife habitat improvement. After fire or cutting, a newly regenerating aspen stand between two and ten years old may have as many as 10,000 stems per acre. This lush growth offers nearly perfect brooding cover for grouse chicks. Then, when new trees are about ten years old and 20-30 feet tall, their density is just about perfect to provide habitat for adult birds on a year-round basis, so long as there are also a few mature trees nearby to provide buds for winter feed. Older trees, 20 to 30 years old and 40 to 50 feet tall, generally are managed in densities too low for year-round grouse habitat. But such stands make the best possible nesting areas. Finally, after a stand is more than 30 years old, some trees will produce the male or staminate flower buds that are a favorite winter food source for the adult grouse.

Thus, virtually every age class of aspen has a specific value to the grouse at some stage of its life. Knowing these facts, the forest manager can plan timber sales in such a way that they provide all age classes of aspen for the grouse population in a given area. Short-term rotation cycles and cutting in patches rather than large areas are favorite ways to enrich grouse habitat through timber harvesting without actually changing the net volume of wood harvested.

Harvest is hardly the only forest management operation that affects wildlife habitat, however. And it is therefore only a part of the relationship between forest management and wildlife habitat improvement. Reforestation practices, in particular, are a vital avenue to habitat management. Generally the wildlife manager views widespread artificial regeneration of forest stands as detrimental to wildlife, for at least two reasons: 1) like agricultural fields, most coniferous forest plantations are relatively sterile places and poor wildlife habitat; and 2) the filling of forest clearings by plantation removes a vital part of the wild forest ecosystem.

Wildlife managers recommend leaving at least some part of a forest plantation open in order to provide breaks in an otherwise continuous vegetation type. For similar reasons, they favor mixed stands over large uniform stands.

Where mature aspen stands are beginning to convert themselves to a balsam fir type, wildlife managers favor clear cutting all tree species so that the aspen will be naturally favored as the stand regenerates. Because much northern Minnesota aspen land is thus converting to fir type, deer browse is on the decrease in many areas. Fortunately, most forest managers agree with the clear cutting plan for such lands, providing it is economically feasible.

There are issues on which wildlife managers and foresters do not entirely agree, however. For instance, what is an ideal rotation schedule for the forester may not provide enough young aspen stands at any one time to suit the wildlife manager. In another situation, the forester may even favor conversion from low-value aspen to a more valued timber-type like pine. Of course the wildlife manager might disapprove of such a conversion on the grounds that it would lessen good deer and grouse habitat for the future.

To help coordinate wildlife and forest management goals, each of the regions within the DNR's Division of Forestry has a task force whose job it is to incorporate wildlife management objectives and priorities into forest management plans whenever practical. It may be possible in some situations to accomplish the goals of both without conflict.

Managing for "big woods" wildlife like the gray squirrel offers a good example of such conflict. The gray squirrel seldom ranges farther from its home than a few hundred feet. It requires hollow, usually dead or dying over-mature trees for its winter dens. Clear cutting methods generally do not provide for the selectivity that would leave good denning trees for the gray squirrel. The clear cut is obviously a poor management technique for production of squirrel habitat. In many locations the choice must therefore be made between managing the forests for deer and managing them for squirrel. Because the deer is currently a much more popular game animal in Minnesota, wildlife managers strongly favor the clear cut. In fact, clear cutting is the approved harvest method on approximately 85 percent of Minnesota forest land.

But if hunters and wildlife managers suddenly changed their minds and favored the squirrel, there would be a real conflict!

Written and illustrated by Ron Royer. Published by the Education Section, Bureau of Information and Education, Minnesota Department of Natural Resources.

Urban Forest Management

During the 1970s, millions of American elms in Minnesota died from infection with Dutch elm disease. Once green boulevards, arched with the branches of hundred-year-old elm trees, are now barren, hot in summer and almost unrecognizable as the same streets. In many cities, blocks upon blocks are thus treeless in the wake of the disease.

Minneapolis alone lost an estimated 137,000 elms in 1977. The number was nearly 9,000,000 trees lost statewide that year.

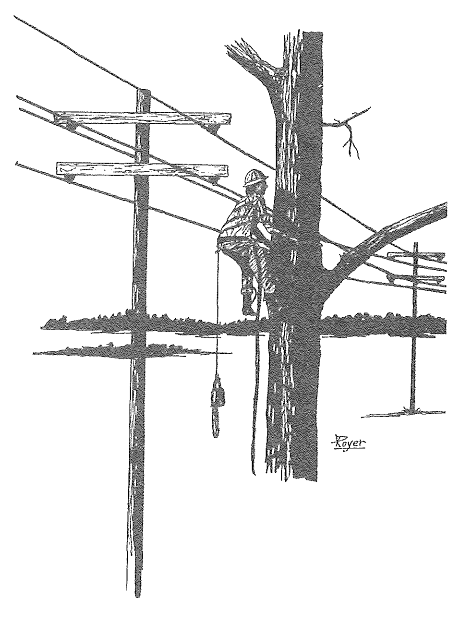
Such tremendous losses teach us how to manage trees in the city. The price for the lessons has been high, but in many cities replanting is already being done in ways which significantly lessen the chance of such an epidemic in the future.

Of course there is much more to urban forestry than just fighting and preventing tree diseases. In fact, the science of urban forest management is even more complex than that of rural forest management. Trees in the city are not usually managed for harvest on the basis of a sustained yield, but tree removal is often necessary nonetheless, especially after loss because of disease. Because of the proximity of buildings and other obstacles, managing trees is frequently a very tricky job.

In the rural forest, wind and insect damage are expected losses, but in the city they cannot be tolerated at all. Trees there are grown primarily for shade and beauty. Insecticides and fungicides can be and sometimes are applied even to single trees, because trees in the city are much more valuable and the cost can be justified.

Finally, trees grown for city beautification and shade are often costly "horticultural varieties," rather than the timber-producing species which do well on wild land where they get little attention for long periods of time. One tree for the yard or boulevard in front of a suburban home may cost $300. It may grow for 10 or 15 years at a nursery before planting, and be transferred along with a ton of soil and its complete root system to the planting site. Of course such practices would be impossible to carry out on any scale in the millions of acres of open forest in northern Minnesota.

Dutch elm disease came to the U.S. sometime early in this century, probably in the bark of logs from Europe. The disease is caused by a fungus which plugs up the water-conducting vessels in the wood of most species of elm trees. It is often transferred by a small species of beetle which in-



habits the bark of the tree. But once the disease is established, trees whose roots have naturally grafted themselves to roots of nearby infected trees may themselves be infected through the joined roots, even without the beetle.

This has given urban foresters one very important clue to sound management of trees in the city. When entire blocks of trees are planted close together – all of the same species – the possibility of disease claiming all of them is much greater. That, of course, is just what happened with the American elm.

Now, as elm-less cities are faced with the job of reforestation, city foresters are planting greater variety and in widely dispersed patterns rather than in uniform stands. In southern Minnesota, cities with high elm densities even have programs to thin their elm stands and thus minimize the spread of the disease through grafted roots. Combined with early pruning of diseased branches, immediate removal and disposal of dead wood, and combating the beetles which carry fungus spores, this is the best management program currently available for dealing with Dutch elm disease.

Since even wood and bark from disease-killed trees may be a source of infection for other trees, an important management practice is the swift detection and immediate removal of entire sick trees. In the case of elms, wood may be burned, buried, or chipped for processing into pulp or other wood products. If the bark is removed, elm logs can be kept indefinitely without danger. But law demands use or disposal of diseased raw elm logs by April 1 each year. Use of disease-loss wood is very similar to salvage cutting in the wild forests of the state.

Growing and planting trees for the city are vastly more complex practices than for the wood-producing, wild forest. Since the shade and beauty of a mature tree is what the city forester seeks, the taller a tree is the better it is for planting. Trees are seldom grown at the nursery longer than four years for rural forest planting. City-bound trees, on the other hand, may be 15 years or even older before they reach their final destination. They are usually dug up carefully, roots and all, with soil and roots bound together in a tight ball and wrapped in burlap before transportation to a planting site.

The tree horticulturist provides the city forester with beautiful decorative varieties like red-leafed Swedler and Crimson King maples, flowering crabs, and junipers. Often these trees are not reproduced by seeding but by grafting in much the same way horticultural fruit trees and show roses are grafted. These varieties, called "cultivars," may cost several hundred dollars per tree.

Pruning or removal of dead, diseased or damaged trees likewise pose special problems in the city. They also may be very costly. In the wild forest, selective thinning costs an average of $32 per tree when it is done by the Minnesota DNR. In the city, removal cost for a single selected tree averages $120.

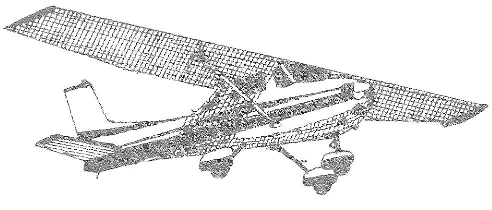
The high cost of city tree removal is due primarily to the presence of many hazards and obstacles not found in the wild forest. In the absence of a market for cut timber, disposal of wood may also be a contributing factor to high removal costs. Another factor may be the risk to the remover who often must use special and dangerous techniques to remove trees cleanly from someone's front yard or the path of a power line.

Typically, a large tree in the city is removed by first "limbing" it. That usually means using a "high-ranger," a hydraulically-lifted bucket that can place one person with a chain saw within easy reach of the top of a tree. Trees are also often pruned away from telephone and power lines in this same way. If a site is particularly troublesome, it may be necessary to use ropes to lower cut limbs slowly to the ground and thus minimize damage to sidewalks, buildings, and lawns.

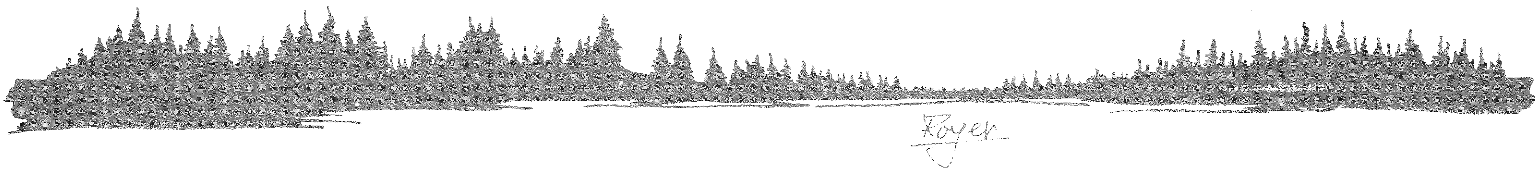
Small tree removal operations sometimes employ climbers instead of costly "high-rangers." These workers wear spurs similar to those worn by telephone linemen for climbing poles. Climbing 50 feet or even higher into a tree, they cut off limbs weighing 200 pounds and more, then lower them carefully to the ground with ropes and help from ground workers.

In the past decade, Dutch elm disease has pushed the science of urban forestry ahead quickly. It is as if a blackboard has been wiped clean. Now foresters must create a new world in place of what was there. It will be many years before their work will bear fruit as beautiful as the elm-lined streets of a decade ago.

Written and illustrated by Ron Royer. Published by the Education Section, Bureau of Information and Education, Minnesota Department of Natural Resources.



Forest Protection Techniques



Tree Diseases and Their Control

Just like people, trees get sick.

Various human diseases affect virtually every organ and cell in the body. And so it is with tree diseases. In trees, leaves may wilt, needles may fall off, roots and wood may decay, vessels may be clogged or damaged, and flowers or fruits may be harmed, slowing natural regeneration.

Just as people suffer from bacterial, viral, fungus, and many other types of diseases, so do trees. There are tree fungus diseases like Dutch elm disease, bacterial diseases like wetwood of elm, and even viral diseases. Most important tree diseases in Minnesota, however, are fungus diseases.

Forester checks tree for bark beetle infestation.

Finally, just as cures vary according to each human disease, so do cures differ for tree diseases. Minnesota foresters use a variety of means to cure diseases which damage the forests.

Bubonic plague in humans is caused by a microorganism which is carried by fleas that live on rats in unclean places. The terrible disease is best controlled by eradication of the carriers – the rats and consequently the fleas. In the same way, Dutch elm disease is caused by a beetle-carried fungus which clogs vessels in the sapwood of elm trees. One way foresters are fighting this disease is by destroying the beetles. Another way is by removing diseased elms before they can infect healthy trees.

Another important fungus-caused tree disease in Minnesota, white pine blister rust, is sometimes controlled by destroying the fungus' alternate host – gooseberry. Sometimes young infected white pines may also be pruned to remove the diseased twigs. This prevents the rust from spreading.

Many tree diseases, like the parasitic dwarf mistletoe which stunts black spruce, can only be controlled by removing an entire stand of infested trees. With black spruce, this means clear cutting all trees in a diseased stand and also cutting a good distance into the surrounding healthy trees.

Some diseases can be controlled by spraying fungicides from the air. But concern for the environment usually causes the modern forester to favor other means.

Forest Disease Research

One big step in dealing with human diseases is what the physician calls diagnosis – finding the problem and where it is located. Then the next step is the cure.

Controlling most forest diseases by spraying fungicides is not economically practical, even if the problem is correctly diagnosed. But like the physician, forest pathologists (those who study forest diseases) look first at ways to locate tree diseases. Other researchers then seek ways to apply good cultural practices, such as the planting of resistant trees, to cure a whole stand.

Remote sensing, or specialized aerial photography, is the forest doctor's stethoscope. It allows him or her to spot problem areas before they can grow to economic importance. Although still in an experimental stage, infrared photography, for example, shows even slight differences in the temperature of trees. And the temperature of diseased trees is usually different from that of the healthy ones around them.

Once a problem area has been located, the "doctor" may prescribe pruning, removal of alternate hosts, or even "major surgery" like clear cutting or even burning. Researchers are mainly concerned with finding out which are the best cures – those which are the most inexpensive and which are at the same time the most environmentally sound.

Replanting with disease-resistant trees is probably one of the best ways to accomplish this, because the forest must be regenerated anyway.

But researchers are looking at many other things, too, like controlling insects which transfer disease organisms and eliminating alternate host plants.

Salvage after Fire, Disease, or Weather Damage

Logging after a fire is dirty work. And trees knocked down by a storm can be a tangled mess. Loggers like neither.

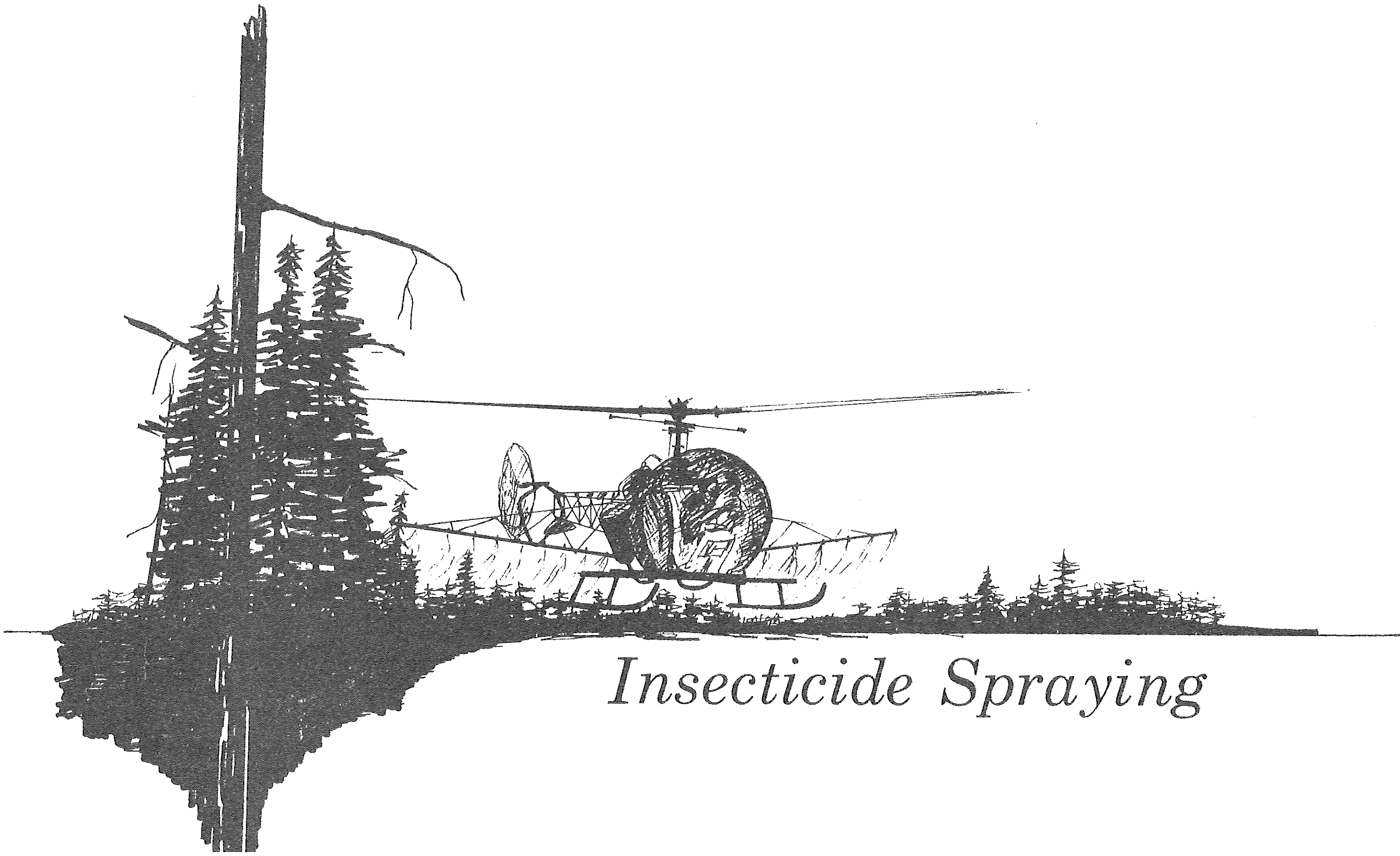
But when fire, tree disease or high winds destroy or damage forest areas, it is the job of a forester to salvage the damaged trees. This is usually done through sales at a reduced price.

Sometimes, however, it is possible to salvage even the standard price of timber. For example, a common management practice for controlling dwarf mistletoe on black spruce is clear cutting the diseased stand. Generally nothing is wrong with the wood in mistletoe-infested spruce – the disease causes the tree to grow slowly and thus be less productive. The wood, however, remains sound. And since the harvest method is clear cutting, loggers expend minimum effort to produce their product.

In such cases, salvage cutting is often the natural outcome of good management.

But if all else fails and no one will buy damaged wood for pulping, chipping, or lumber, it can be sold as fuelwood so that some value can be derived.

That, after all, is the aim of forest management – the best use of resources with the least environmental damage.



Insecticide Spraying

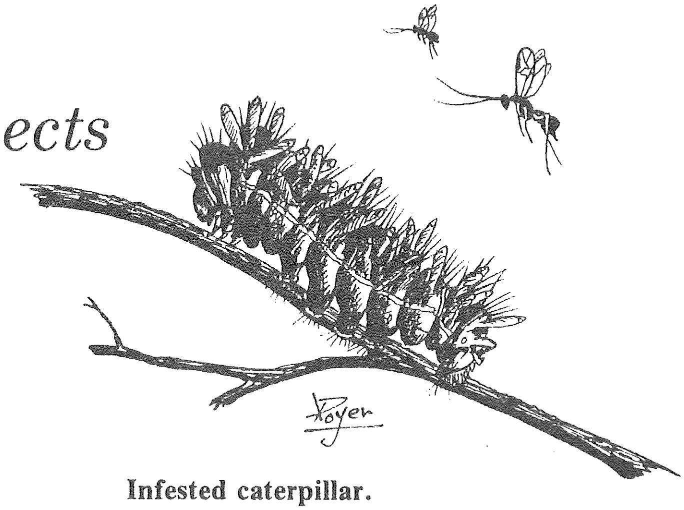
Before 1961, the pine tussock moth was only occasionally a problem in jack pine plantations in northern Minnesota. Wasps – whose larvae prey on the needle-hungry tussock caterpillars – held the population naturally in check for years. Then, in 1961, defoliation destroyed nearly 1,000 acres of jack pine trees near Willow River. No one is certain why the outbreak occurred, but the situation was so bad that it was necessary to use chemical insecticides in 1962 and 1963 to bring the epidemic under control.

Today, spraying insecticides is the forester's last resort. With environmental awareness at a peak, DDT and many other long-lasting insecticides have been banned because of their ill effects on fish and wildlife other than insects. Only those chemical insecticides like the carbamates and organophosphates, which break down quickly to harmless forms, are sprayed today – and then only as a last resort.

When insecticides are used, aircraft – helicopters and airplanes – are the only practical tool to reach large forest areas. They spread chemicals thinly and in an even film across the forest. Pilots always work to stay clear of areas where there might be damage to beneficial birds, fish, and other wildlife.

Foresters keep a constant watch on potentially epidemic insect populations changes and, whenever possible, they use natural means of control like forest cultural practices and introduction of parasitic insects to keep populations below the level that would require use of insecticides.

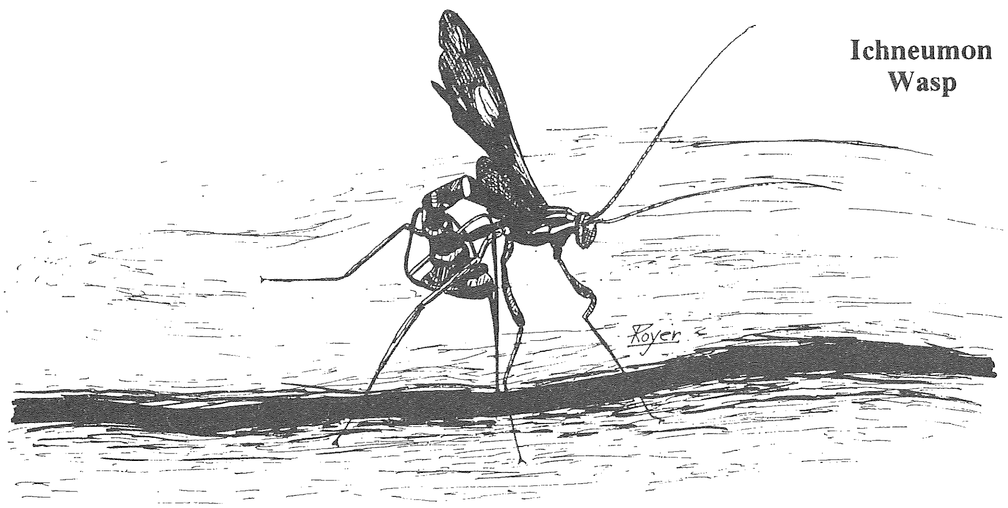
Natural Enemies of Insects



Infested caterpillar.

Imagine you are a forester in northeastern Minnesota faced with a growing insect pest problem. Larvae of an accidentally imported moth are eating every pine needle in sight over hundreds of acres of your district. The situation is bad, but it is not bad enough yet to warrant the use of chemical insecticides. And insecticide treatment could be a touchy political issue.

Your supervisor informs you that you will be trying a new form of "natural control" which may



Ichneumon Wasp

bring the pest population into check. Materials will be coming in about a week.

You wait the week expecting to receive ten gross of tweezers and as many collecting bottles. And then you are even more confused when you receive thousands of tiny wasps in screen-covered containers. But you read the instructions which say to disperse the wasps by air across the affected areas of your forest district.

In its native country, you learn later, the wasp has for years been an effective parasite of the moth's larvae. The female wasp lays eggs on the young caterpillars and the wasp larvae slowly consume them as they grow. The moth larvae die after they form their cocoons, and the next generation of wasps emerges from the cocoons instead of the moths.

All insects have such natural enemies. They may be other insects or they may be diseases. As an insect pest population grows, so does the population of a natural enemy – under normal circumstances. So, when an accidentally introduced pest begins to create a real problem for the forester, often it is possible to introduce one of the pest's natural enemies for control.

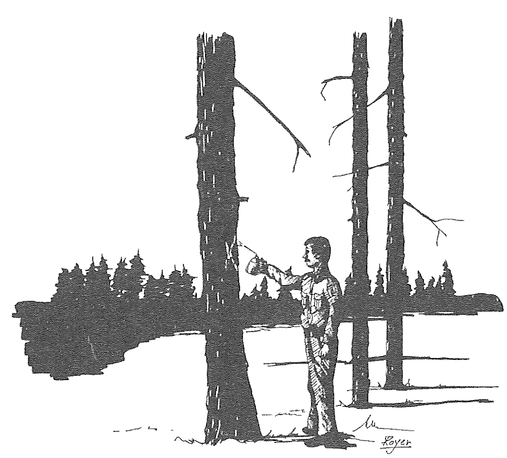
But when a native insect population suddenly bursts into epidemic status, something is wrong. Often the forest is not healthy enough to withstand the pest so the insect population grows too fast for the natural enemy to keep up.

Foresters thus know the importance of keeping tree stands healthy so they won't be susceptible to pest epidemics.

Whenever it is possible, an insect pest's natural enemies can be used to help keep it under control. That is one good alternative to spraying expensive and possibly harmful chemical insecticides.

Salvage after Insect Damage

Imagine you are a DNR district forester and large tracts of timber in your district are falling victim to an outbreak of the forest tent caterpillar. Hundreds of acres are affected, so insecticides are sprayed and you are left with thousands of dead trees. What can you do with them?



The best thing, of course, is to hold a timber sale. But damage, though widespread, may be sporadic. You can't justify selling all the trees, and selective harvest means a lot of extra work for the logger – for a lot less wood.

In buying timber, the logger must look at costs. To make a profit, he must get a certain amount of wood in return for the expense of making logging roads and running expensive equipment. If only a partial harvest is practical, standard prices won't attract a single buyer. The timber will go to waste.

But above all you are a forest manager. So, to attract buyers for the salvage timber, you will probably lower the price substantially. You'll go into the affected areas of your district and mark the affected trees, then specify in the terms of the sale agreement that only marked trees are to be cut down.

It means more work for everyone. But the end result is the best for both the forest and the forest products industry.

Forest Insect Research

Minnesota forest managers are faced with a constant dilemma. Nearly ten percent of annual wood growth in the state is lost to insects and diseases. But that loss is so spread out – over 18 million acres – that it is hard to pinpoint it. It is so spread out, in fact, that combating it by spraying insecticides is often not economically possible or environmentally wise.

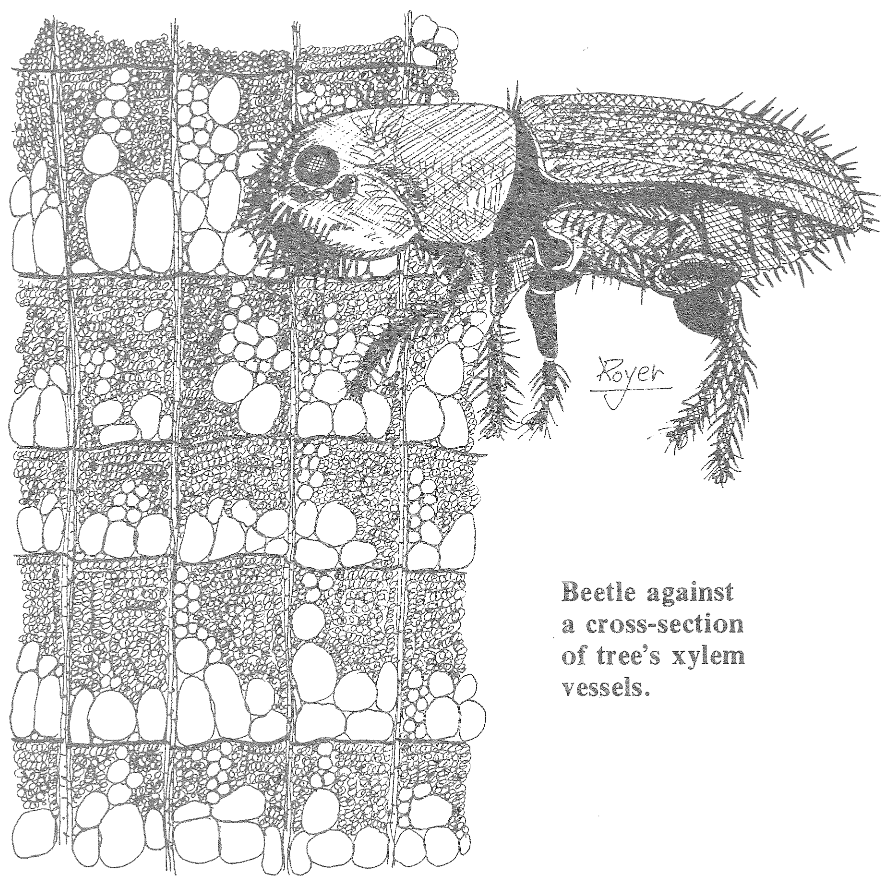
Forest pest research faces this problem head on. Some of it is aimed at finding safe ways to control the insects themselves using natural means. Other research looks for ways to manage the state's forests so that tree stands are more resistant to insect damage.

Some insects can be controlled by cultivating their own natural enemies. Researchers are always studying insect pest life cycles, looking for natural weaknesses or natural enemies. They have found how to manufacture the chemicals, called pheromones, which insects produce to attract each other for mating. Some insects, like the bark beetle which carries Dutch elm disease, may be attracted to these artificial pheromones and then destroyed.

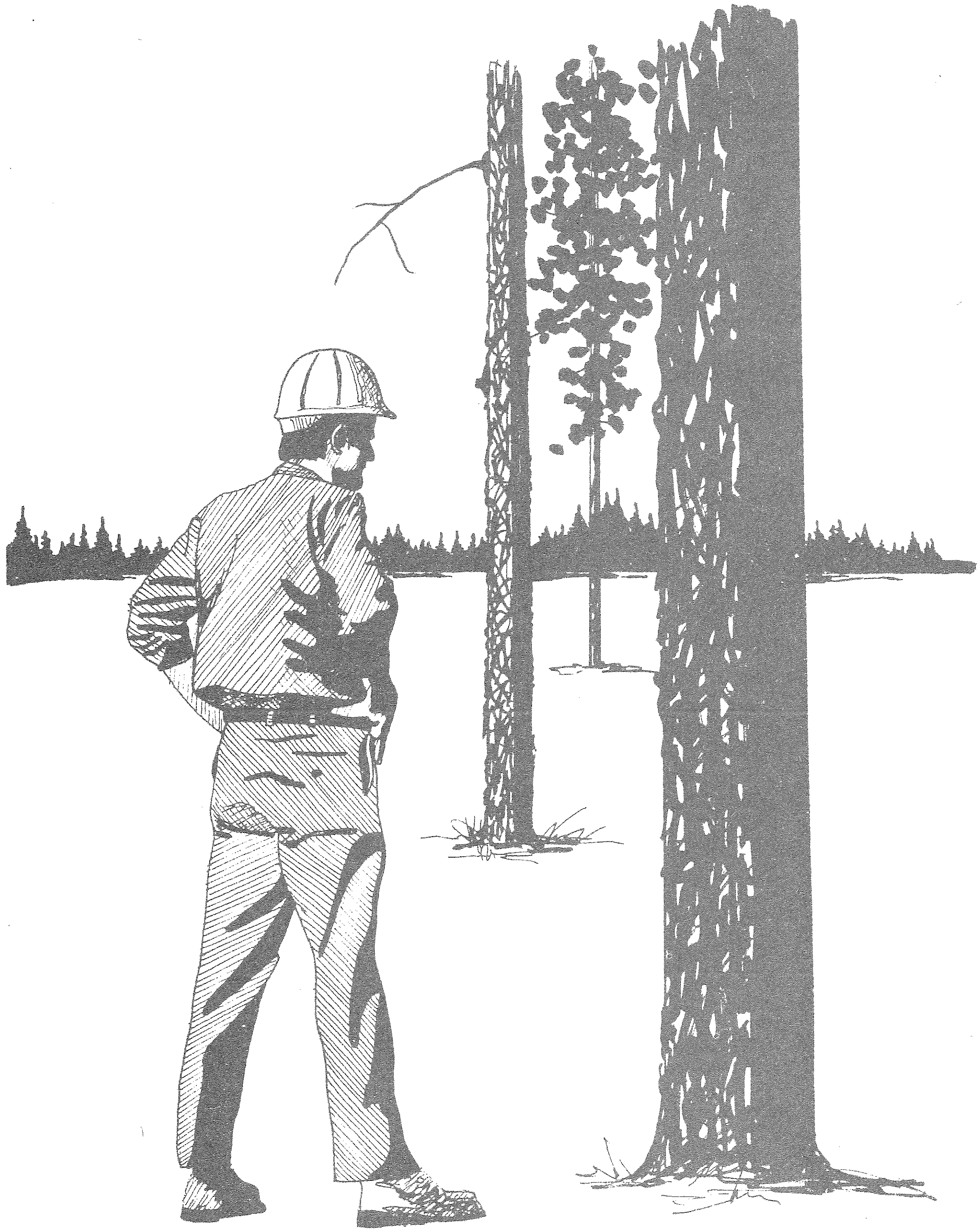
Good forest management practices also help control insects. Research is going on all the time to find which trees are most resistant to insect damage. Researchers have discovered, for example, that by removing balsam fir trees early enough from stands of white spruce the pesky spruce budworm can be controlled.

More and more, the aim of research is to replace insecticide control with good forest management practices and natural control techniques. Often this means early detection of insect damage. Remote sensing is now being used, thanks to research, to pinpoint small patches of diseased trees so they can be removed before an epidemic starts.

Beating the insects to the trees is often the most effective way to keep them at bay, because mature trees seem to be the ones insects like best.



Beetle against a cross-section of tree's xylem vessels.



Written and illustrated by Ron Royer. Published by the Education Section, Bureau of Information and Education, Minnesota Department of Natural Resources.

Forest Management in Minnesota

Beginnings

Between one and two million years ago, during the Pleistocene epoch, a change was slowly brewing that would erase half of the land surface that is now Minnesota and change the entire continent.

It would drive into extinction such evolutionary masterpieces as the American mastodon and the saber-toothed cat. And then, throughout Minnesota, it would bring about a new beginning so absolute that almost nothing to follow would be the same.

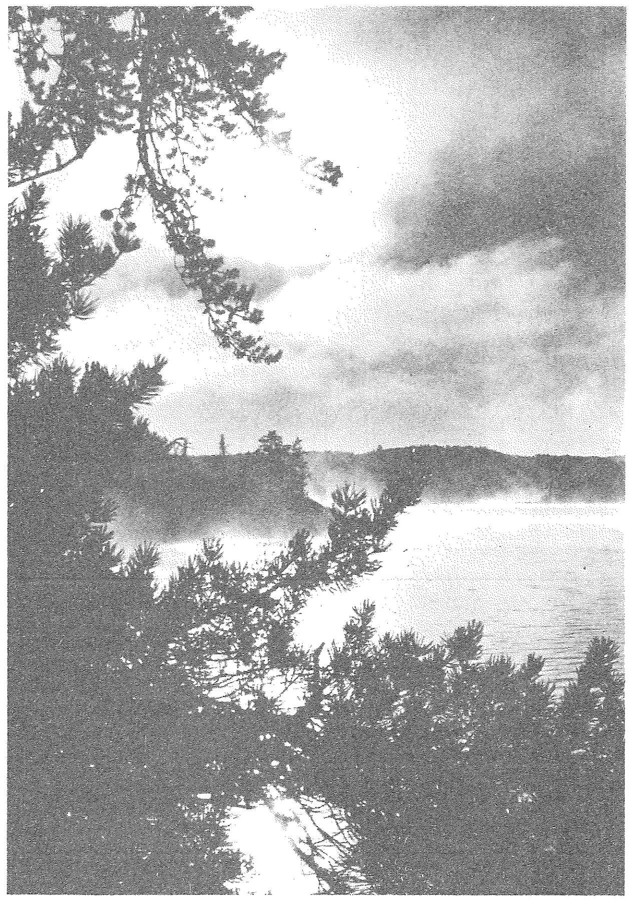
Far to the north, the great polar ice cap was growing. The climate of the entire earth was cooling markedly. Each winter more snow fell across northern latitudes than melted during spring and summer. Relentlessly it fell and piled up, year after year, decade after decade, century after century. Until, under its own weight, it turned to clear blue ice – a mile thick. This ice was so heavy that it moved across North America, in the words of one geologist, "like pancake batter in a skillet."

No one is yet certain what caused the great ice ages through which the earth has already passed many times. But during the Pleistocene epoch alone, four expansions of the polar cap covered the northern United States, including much of Minnesota. As they advanced, like giant bulldozers these massive ice sheets scraped the soil away clear down to bedrock. And they took some of that too. They chewed it up like so much fodder, spit it back out, and left it lying. There might be a boulder from northern Ontario, for instance, on the ground now in Wisconsin or Minnesota, carried there under sheer glacier power – over a thousand years at a few inches a day, until the ice finally melted and left it, hundreds of miles from its original home.

Then, as it began melting, perhaps 15,000 years ago, the last glacier left behind an eerie, lifeless world of water, gravel, and rock, which must have looked like a wet moonscape.

There was absolutely no life there. For thousands of years ice had covered the bedrock. Nothing could have grown. No sunlight reached the rock. No air. Just rock and ice.

In fact, the ice cap is still retreating to this day,



melting a bit at a time. Far to the north on the Bering Sea coast, one can see it and imagine what Minnesota must have looked like 10,000 years ago – wind, water, ice, and rock everywhere.

But nature leaves nothing empty for very long. Soon enough, the yearly alternation of summer sun and winter cold worked to crack the exposed rock and grind it. Then came the faintest beginnings of soil as primitive plants called lichens attached themselves to the bare rock, died, and mixed with the ground-up minerals in the cracks.

Thus, while the earth quickly warmed again, living things began to fill these cracks in the rocks, the crystal-clear pools of melt water between them, and the many lakes left behind by the melted glaciers. Lichens, algae, mosses, and other primitive plants began to pioneer their way into this new and rocky land. As closely as possible they followed the retreating ice.

As they filled the land once more with green, those plants began the long process that biologists call **succession**. One kind of plant competed with another for the new space as it opened, and the scene changed continually for centuries.

Finally, the soil was thick enough to support the first trees, and true forests began to appear. The climax of succession across most of northern Minnesota was the great coniferous – "evergreen" – forest that was ultimately used to build houses for thousands of European settlers in middle America.

It all was a slow process. Over most of the boundless Canadian shield country through which the glaciers passed, there still lies less than a foot of soil. This soil accumulated since the last ice left more than 10,000 years ago.

To the south of this great shield country, hills of piled up glacial debris, called moraines and eskers, and great glacial rivers shaped the land in a different though equally dramatic way. There, soils may be as much as three feet thick. And still farther south and west, parts of the state remained pretty much as they were before the glaciers, though in places they are heavily covered with rich prairie soils deposited by glacial runoff and wind.

Thus, after the glaciers left, three growth areas remained within the state. The northern coniferous or softwood forest was characterized by a thin soil layer supporting white and Norway pines, spruces, tamarack, and cedar. Thickly-soiled central and southeastern hardwood forests offered not only building materials but plenty of rocks and hardship for pioneering farmers who later came to clear the land. And finally there were the unforested prairie lands of the southwest.

In the north, the economics of logging shaped the land and life of the people. Farming reshaped it and largely removed the great post-glacial hardwood forest of the central and southern regions. The nature of these areas determined the growth of all Minnesota.

Thus, the key to knowing Minnesota today lies in understanding its original forests – what they were like, how settlers used and began to destroy them, and finally how a few farsighted people stepped in to point the way back toward stable, healthy forests and wise use of the state's most important natural resource.

The Forested Land

Rare these days is the place where one can find a foot-thick carpet of pine needles under a canopy of 200-year-old white and Norway pine trees. Such spots are still found, for example, at Itasca State Park and in a few remote parts of the Minnesota-Canada borderland. But most are gone now.

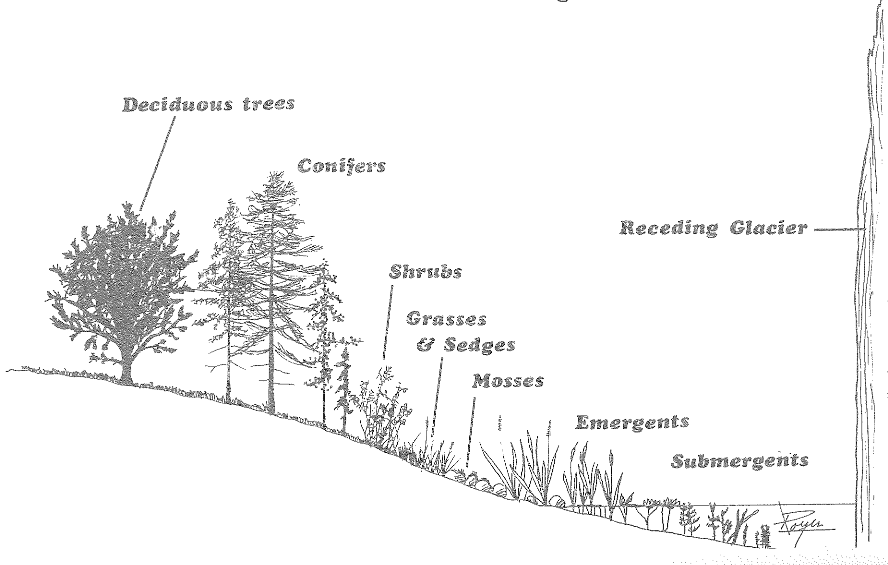
There is an island on Remote Lake, in Savanna Portage State Park, that is entirely forested with white and Norway pines. It is the only part of the immediate area so forested, and it stands out sharply. Trees there are monstrous, but even they are the offspring of trees cut by the first loggers. Still, one can go there alone just about any time and get the feeling that gave the place its name – Remote Lake Solitude Area. The weight of centuries seems to be there, beneath the boot, filling the nostrils.

For thousands of years, most of northern Minnesota was like that island. From Little Falls to the Canadian border, from Beltrami County to Lake Superior and the St. Croix River, the land was a sea of pine, interrupted only by lakes, spruce bogs, and a few stands of hardwoods like maple and oak.

To the west and south, especially along the river valleys, great forests rich in oak, maple, basswood, and other hardwoods faded reluctantly into western prairies that were a sea of their own sort, six feet deep with grasses, stretching a thousand miles and more toward the Rockies.

It is no wonder the American Indians loved this land and fought so hard for it. And it is no less wonder that European immigrants fought to take it from them. To these settlers it must have seemed

Plant Succession Following Glaciation



an inconceivably rich land, full of opportunity. One tree alone would have built nearly an entire house. And game abounded.

Thus, to a land where the Indians had for at least 80 centuries housed themselves beneath animal skins, leaving the forest to its own fate, settlers came from the east and felled millions of trees each year for cabins, mills, and barns.

But long decades of fur trading and exploration preceded the actual systematic plunder of those towering pine giants. Names like Champlain, Nicollet, Radisson, Duluth, La Verendrye, Pike, Snelling, and dozens of others now dot maps of Minnesota, markers not of settlement or logging, but of trade, exploration, and the struggle that took place for political control of the vast land that finally became Minnesota.

In the summer of 1849, when Minnesota had just attained territorial status, fewer than 6,000 people of European descent lived within the territory.

Logging Comes

Of the nearly 52 million acres that were Minnesota Territory, 38 million (almost 75 percent) were once covered with forest. White pine was undisputed master of the north woods, and it was to become the logging industry's major resource. But the hardwood forest, or "Big Woods," was the land setters first choice. It was much like familiar land farther east; the rich soil would grow their crops.

Most often, immigrants into Minnesota had to cut away the Big Woods with an axe and whipsaw – by hand. They needed to clear the land for farming, so they used the lumber to build homes and other buildings. But trees in the hardwood forest were something to be gotten rid of, and only secondarily a resource to these people. So the first sawmill built in Minnesota, in 1821 at St. Anthony Falls on the Mississippi, was built not privately but by the Federal government to supply lumber for Fort Snelling to the south.

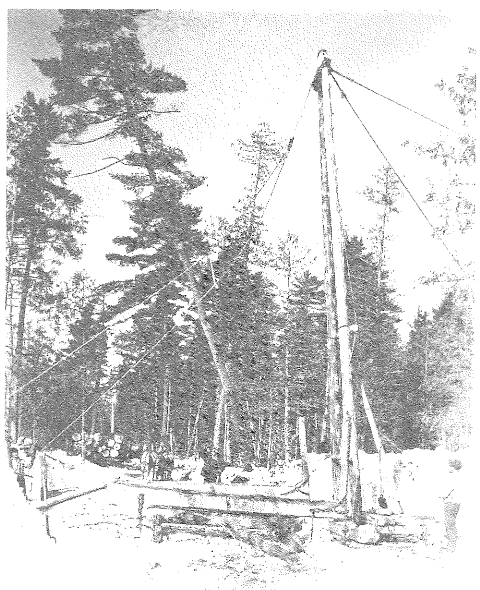
The real beginning of the logging thrust came in 1838 when the first commercial mill was constructed at Marine-on-the-St. Croix. People who fed and powered that mill were commercial loggers who had come from the forests of Maine and the eastern states. In the great North Woods of Minnesota, they saw not just trees or farmland, but money.

They needed a market, however, but the territory's 6,000 inhabitants were not enough to provide it. Local settlers had trees of their own to cut The real demand lay farther south, in Iowa and Missouri. Thus, the Mississippi was the avenue these commercial loggers first used to send their product to market.

The system that grew was very much like that used in the cattle drives of the west. Each year, more and more logs were floated downstream. A system for branding logs evolved so that owners could keep their property sorted on the way to market. A state law, passed in 1858, made it mandatory that these "brands" be recorded. At the logging industry's peak in Minnesota, more than 20,000 such "brands" or so-called "log marks" were on record with the Surveyor General of Logs and Lumber.

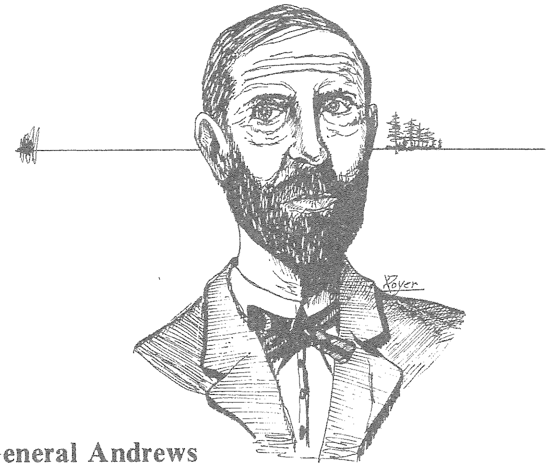
By the middle 1800s, commercial mills had sprung up all over – at Stillwater, St. Anthony Falls, upstream on the Mississippi at Princeton, and as far north as Little Falls.

Railroads, which also came to the state during this period, helped get logs past treacherous rapids and falls between the north woods and shipping sites at Duluth and Minneapolis. The most remote northern pine woods, which had stood untouched for thousands of years, began to fall beneath the logger's axe.



Above: Early logging operation.
Below: Log drive on the Mississippi River.

Although most timber was cut for saw logs to make boards, by 1859 paper was being made at St.


General Andrews

Anthony Falls from rags, setting the scene for wood-based paper later on. In 1898, when white pine logging was at its peak, the first wood-using paper mill was built at Cloquet. Soon enough there were others – at International Falls, Brainerd, Grand Rapids, Little Falls, and Sartell. These mills began to use spruce and balsam, trees often left behind by the pine loggers. Later, with the introduction of sulphite processing, smaller trees like black spruce, jack pine, and aspen were also used for papermaking.

By 1870, virtually all forests in Minnesota became – or would soon become – a prine commercial resource. But the forest was thought to be so vast that it would never run out. Systematically, often deviously, the land was bought, cut over, burned to clear it, and then resold in an endless cycle of exploitation.

Awakening

Until the 1870s, there clearly was very little conscience in logging. In buying forest land, many were ready to cheat to get a good buy on timber. In the north, the common belief that timber was inexhaustible continued to prevail. But in 1871, the first sign of foresight appeared in the form of a "tree bounty" law. It provided for payment of $2.50 per acre, not to exceed $25 per year, to those who planted trees on prairie land.

Public opinion was finally beginning to swing. People were starting to see that the forest was not inexhaustible, but had to be replenished. Still, nothing more happened in the way of legislation until 1891 when Itasca State Park was set aside to preserve a small portion of the original forest undisturbed. People were also starting to realize that a truly beautiful heritage was quickly vanishing.

Then, on September 1, 1894, everyone sat up and took notice. A runaway fire swelled up near Hinckley, Minnesota. Four hundred and eighteen people were killed, even as they sought refuge in root cellars, wells, swamps, and the nearby Grindstone River.

Using the story of that terrible disaster as his main platform, one man led an appeal for public control of the state's forested land. That man, General Christopher Columbus Andrews, has been called Minnesota's "Apostle of Forestry," because his many appeals were finally heard. The legislature appointed Andrews the state's first forest commissioner.

Small as it was, that beginning was the first step toward true forest management in Minnesota. But instead of naming a separate professional forest commissioner, the legislature gave the job to the state auditor – at no increase in salary. The auditor was authorized to appoint a Chief Fire Warden, who would be paid a salary of $1,200 a year. Of course he named General Andrews the first Chief Fire Warden.

Andrews' job, as stated by the law, was to preserve the forests and to prevent and suppress forest fires. He was also required to inventory all the state's forested land and to seek methods for reforesting cut over land. To help him in fire prevention work, the law called for mayors and village officials to be local fire wardens. These people each got $2 a day.

Altogether, the state set aside $5,000 per fire season (April 15 to November 1) to be used for fire prevention. But none of that money was to be used for paying full-time employees besides General Andrews. Many historians think that this was very short-sighted, because in 1908 another whole town went up in smoke as the result of a runaway forest fire.

On September 4, 1908, 20,000 acres of forests burned around and including most of Chisholm. No one died, but the statewide scare the blaze created caused the legislature to amend its earlier fire law the very next session. Twenty-four forest rangers in 1909, and 26 in 1910, were paid five dollars per day plus expenses to range over forest districts defined by the amendment, seeking out and containing forest fires before they could get out of hand.

But in 1910, because of a lack of money, the rangers were laid off on September 1, in spite of an explosive fire danger that year. On October 4, another fire disaster struck the towns of Baudette and Spooner, burning a million acres of timber and killing 42 people.

That did it. The Minnesota Forest Service was set up in 1911. Almost all responsibility for protecting the forests of Minnesota was moved from the state auditor's office to a special governor-appointed State Forestry Board. The board's first duty was to hire a full-time State Forester who was professionally trained in forestry. At 82, General Andrews became secretary to the State Forestry Board. He held that position until his death at 93.

Meanwhile, as fires burned millions of acres of forest, millions of trees had also been logged for

profit and the land left empty. When General Andrews died in 1922, just as he had predicted for almost 50 years, the original white pine forests of the north had all but disappeared. What nature had taken thousands of years to make after the glaciers left, a few loggers and a handful of uncontrolled forest fires had almost completely destroyed in less than a century.

Forest Management Since 1911

From 1911 to 1925, the state's forests were managed through the State Forestry Board. Then, in 1925, the first Department of Conservation was formed. It was reorganized in 1931 and again in 1937. The system set up in 1937 remains pretty much the same today, although the Department of Conservation is now called the Department of Natural Resources (DNR), and the DNR Division of Forestry is now directly responsible for forest management.

Headquartered in St. Paul at the Centennial Office Building, the Division of Forestry is now a large organization with many duties the original State Forestry Board never dreamed of. The Division Director has a staff in the St. Paul office and also a large group of foresters who work permanently in forests throughout the state. The staff advises and works with the director to make forest management policies and programs. These various policies and programs are then passed on to foresters in the field.

Field workers report back to a regional administrator in each of the state's six forest regions. In each region there is a Regional Forest Supervisor, and beneath him is a staff including Regional Staff Foresters, Area Forest Supervisors, Area Staff Foresters, District Foresters, District Assistants, Forest Guards, and office workers. All told, from the job of one Chief Fire Warden in 1895, the responsibility for managing the state's forests has expanded today to include nearly 400 permanent positions in Minnesota.

Never will we be able to rebuild the original forests completely, of course. But that is not the real aim of modern forest management. The true purpose of management is to provide a "sustained yield" of timber while providing also for good wildlife habitat, recreational use, and for many other uses. That means putting back at least as much volume of the state's timber resource as logging takes away. That volume, measured most often in "board feet" or "cubic feet," is constantly changing due to tree growth and planting on one hand and removal or loss on the other.

Because of much-improved fire protection and other management practices, nearly 1.3 billion board feet of timber grow on stand land alone. (More than half the forested land is publicly owned in Minnesota. One third of that is state land, one third is Federal, and one third is county.) The amount of timber is again on the rise. But so is the demand for wood and other forest products. As demands change and increase, new plans must be sent from the director's office to each of the district foresters. Forest inventories, assessment of fire damages and of losses to insects and other natural factors must all be studied by district foresters. They in turn report their findings to the director and St. Paul staff. Each district forester must find out where mature, harvestable timber is located, and then know when and how it should be harvested. Information that district foresters report is used to make those decisions and for many other aspects of long-range planning and management of all state-owned forest land.

For example, based on district foresters' reports, we now know that nearly one-third of Minnesota forest land is supporting aspen trees. And we know that almost half the aspen trees are over 40 years old. Modern forest management techniques tell when and how these trees will be harvested. Other information will help foresters decide how to replace the harvested trees in the best way to plan for future needs. With this kind of information, district foresters can direct and oversee the actual harvest of trees through timber sales. And then, after the sales, they can control the process of reforestation through seeding and planting.

But just as farming is much more than planting and harvesting, modern forest management includes many operations. Foresters keep constant watch on growing timber stands to improve their health and yield. There are techniques for thinning and pruning trees, for instance, which enhance both the quantity and quality of the wood produced.

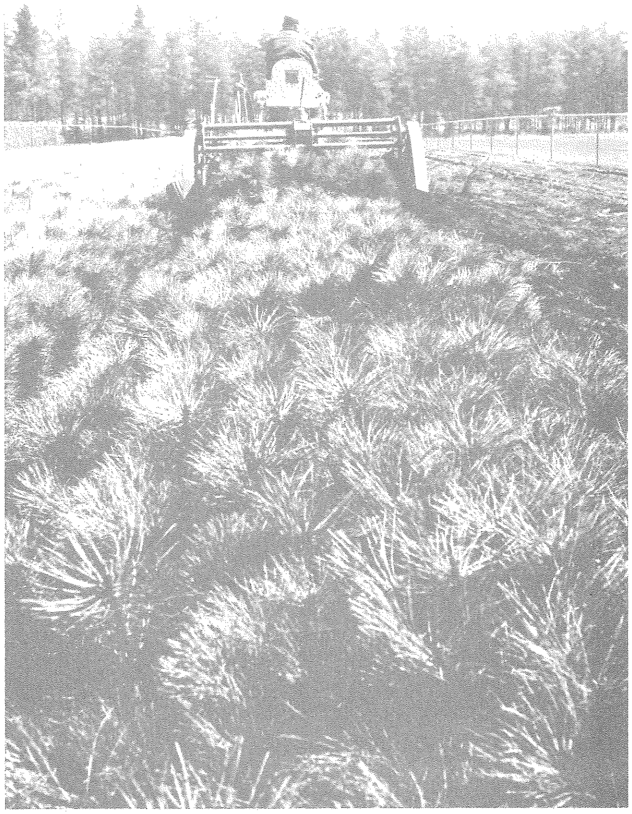
And, of course, fire protection is still very important. Wildfires today have less impact on forests because modern fire control is more effective. Even so, when a wildfire does occur it will wipe out a stand of trees faster than anything else.

Even more important in a modern forest management program are disease and insect control. District foresters are always on the lookout for fires and pest-related damage. In addition, research is often directed at improving spraying techniques and other forms of forest protection.

But the most important of all management work will probably always be controlling methods of harvest and selecting trees for harvest along with the reforestation practices that naturally follow. For example, clear cutting (removing all marketable trees from an area) is a currently favored management method, especially for harvesting aspen. Present inventories show that we are clear cutting about 120,000 acres of state forest land per year. Of those, about 20,000 acres are actually replanted. Some 100,000 acres will regenerate themselves naturally.

Much recent replanting effort has been done to convert poor quality aspen land back to pine forest. It is one job of the forest manager to decide whether or not that is a good idea. In making the decision, the manager employs methods to determine what forest type would be best for a given soil, or what type might be best for long-term sustained yield, wildlife habitat, erosion control, and many other things.

All the while, market and environmental trends



A modified potato digger lifts pine trees from nursery beds.

may change, making one type of tree more attractive than had previously been thought.

All these things and more are of concern to the modern forest manager in Minnesota. Thus, the field of forest management is vastly more complex than General Andrews ever could have imagined.

And still, far from all Minnesota forest land is truly "managed." Millions of acres within the state are privately owned and managed. In totally unmanaged land, succession is again hard at work. If it were untouched, in a few thousand years the coniferous forest of a century ago would return to the North Woods. In fact, that very thing is already beginning to happen in some unmanaged northern aspen forests where new seedlings are often not aspen, but spruce and fir.

Foresters from the Department of Natural Resources thus not only outline and conduct management programs for state lands, but often work as advisors to private forest owners, producing far-sighted programs of management for them to follow to get the most from their trees.

But trees are hardly the only concern of modern forest management. Today, "multiple use" is a term heard more and more frequently in conversations among Minnesota foresters. Multiple use of forest lands includes their use for human recreation, wildlife habitat, management of water, and protection of soils. Ironically, we have learned, cutting a stand of trees usually provides better habitat for wild animals because new growth is low and thick, offering much more food, cover, and

Above: Vigorously growing forest only eight years after planting.

Left: Modern tree harvester severs trunk, removes limbs, and cuts spar into pulpwood lengths.

nesting potential. On the other hand, there is a beauty in a stand of mature trees that the hiker or cross-country skier wants to save. Views often conflict, and "multiple use" of forest areas is one way many wishes may be fulfilled.

In the end, forest use has progressed over the past century from exploitation to wise and well-planned management of a renewable resource. It is as though the first loggers used the state's forests as a miner used the ore fields – taking without a thought of putting back. And now, forest use is more like gardening, where trees are viewed as simply a crop that not only can, but must be reproduced – for the good of all.

The Future

If a rich uncle gave you $1,000, would you spend it right away or save it?

If you spent it at the rate of $10 a week, in less than two years it would be gone forever. But if you put the money in a bank and let the banker use it for other things, he or she would pay you interest at perhaps five percent a year. That is, the banker would give you $50 a year – almost a dollar a week – free, forever. And the $1,000 would always be there.

Of course if you didn't take advantage of the interest the banker would just add it to the $1,000 and it would go unused. On the other hand, if you took too much of the money too soon, you would begin to erode away the original $1,000 – the very basis of a dollar-a-week guaranteed earning. Sure, there would be plenty of money for a while. But in a few years you would be broke. The bank's doors would close to you and you would be out of luck.

Forest management is something like wise banking. A very rich "uncle" gave Minnesota enough white pine timber alone to build at least ten million two-bedroom homes by today's methods. But as we have seen, without wise forest management practices almost all of it was gone by 1920. Then the cut of Minnesota virgin pine was down to 576 million board feet, hardly anything like the crop of 1899 when 2,341,619,000 board feet of lumber were removed from the "bank." At that rate, just as General Andrews predicted in his first annual report to the State Forestry Board, it would take only 20 years to remove all the "principal" – all of Minnesota's virgin pine forest.

But, fortunately for us, forest management is not entirely like banking, at least in the example we have been using. The original forest was not just like a savings account with one deposit made every ice age. In addition to the interest, that "rich uncle" is making little deposits all the time, too. And we can help him by setting aside some areas and letting them grow. The island on Remote Lake is a good example. It took only about a hundred years to put it back in pretty good shape – a lot less than an ice age.

Fact is, like a bank account the forest comes and goes according to how we use it and care for it. Human history is written in the use of natural resources. We talk about the Stone Age or the Bronze Age for instance. But throughout history no resource has been more consistently used than wood. Yet wood is still around because wood is renewable. Most of the homes in Minnesota were, in fact, built from white and Norway pines and hardwoods that once covered the land. But long before that, American Indians used wood for fires, to frame their homes, to make their weapons. Today, paper draws ever more heavily on wood resources to feed data-hungry computers and a news-hungry public. Who knows what the future will bring? For uses change but the demand on our forests continues, grows. And sometimes it grows faster than the forests themselves.

By the year 2000, Minnesota forest managers now predict, our supply of trees will equal the demand for all our combined forest products. After that? Even with the best management practices we may be cutting down trees faster than they can be grown back. In planning for such a future, Minnesota's forest managers must look at soils, climate, tree types, market demands, tree diseases, and public opinion, to name just a few things.

Choosing when to cut, how to cut, where to cut, and what to cut; when to replant, what to replant, how to replant, and where to do it all will then be more important than ever before.

In making such decisions, the forest manager must serve many masters. The papermaker, the builder, the logger, the conservationist, the bird-lover, the canoeist, and backpacker – each has an opinion. Not all agree. The forest manager walks the thin line that separates each opinion from the others. Ultimately, he or she is expected to satisfy all of them. But of course that is impossible.

Written and illustrated by Ron Royer. Published by the Education Section, Bureau of Information and Education, Minnesota Department of Natural Resources.

Forest Management Techniques

In the spring, the farmer fires up a tractor to plow and disc the land. The crop planted, he hopes, will be the one that meets market demands next fall. But whatever the crop, in June it is time to apply insecticides and herbicides to control crop pests and diseases. Drought in July and August may call for irrigation. And in the fall, harvest and sale.

The farmer thinks in seasons.

The forester thinks in decades.

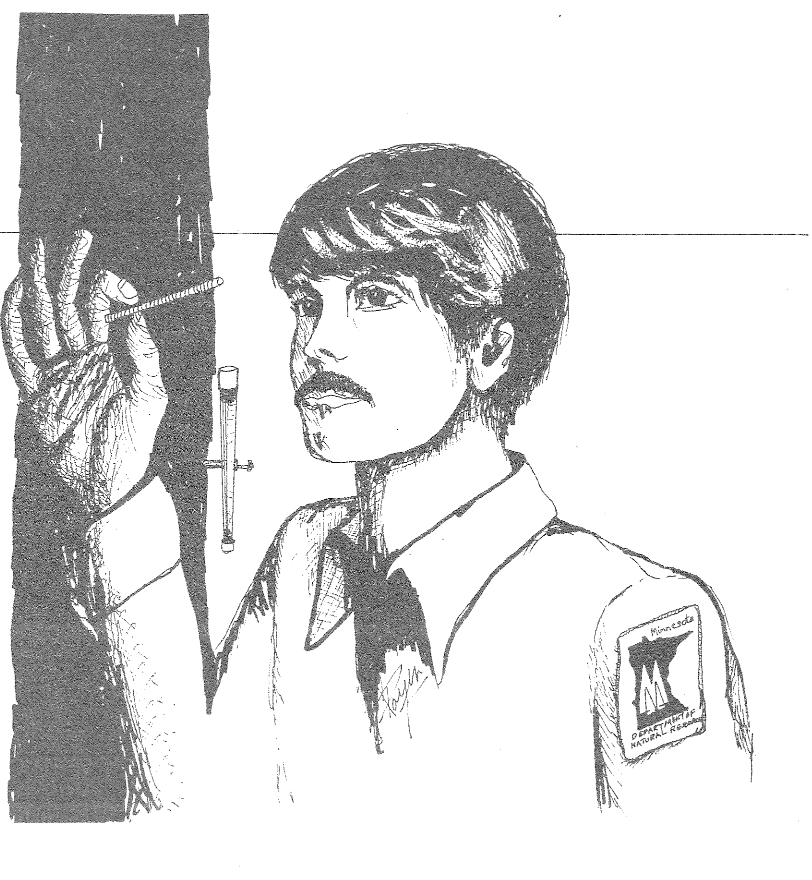
But the job is the same.

Beginning with a freshly cut over forest area, the forest manager must regenerate a crop of trees either naturally or by artificially seeding or planting some new type of tree. And, just as the farmer tends fields all summer, the forester watches over a timber stand year after year, pruning, thinning, and looking out for forest pests and diseases. And then comes the forest harvest, the timber sale. Finally, the forest manager must have planned far enough ahead to meet market demands many years after the planting or regeneration of a stand. Will the forest-product market years hence call for more paper production, more fuelwood, more sawlogs? And in the meantime, what about wildlife habitat? How will the growth and harvest of a stand of trees affect deer, grouse, and other wildlife and game?

Tools and techniques may be different for managing the forest, and time spans may be greater, but essentially the forest manager is a farmer of trees, the manager of a crop. Management techniques may call for use of an airplane rather than a tractor; a Bitterlich stick or chain saw rather than a disc or combine. But the job is the same in principle as that of the farmer – growth for market according to plans that will leave the land healthy crop after crop.

It's a big job. And, like farming, forest management has come a long way in recent years. Instead of exploiting millions of acres of virgin timber, loggers today harvest crops created and sustained by foresters whose tools and tricks are varied and fascinating.

Their product is the paper you are holding. The chair on which you sit, the syrup on your pancakes, the house in which you live.



Forester examines a boring taken from a tree. He counts the rings to determine the tree's age.

Natural Regeneration of Forest Lands

We in Minnesota are now harvesting a second, even a third, crop of trees since the original virgin forests were logged in the 1800s. That is because forests are a renewable resource. They regenerate themselves naturally. And the forester can help them in the process. If trees are harvested properly and with foresight, the natural process of regeneration may require almost no help at all.

All trees produce seeds, and seeding is often the most important way a forest type sustains itself. In a white pine forest, cones drop their seeds to the ground beneath. The lower level of young trees they produce grows to replace the parent trees after they have died. Most tree seeds have helicopter-like wings so that the wind can scatter them far from the parent tree. Thus, the planned harvest of trees often calls for leaving scattered individual "seed trees" or rows of trees so the wind can disperse their seed to regenerate the stand. Since this was not done when Minnesota's virgin pine forest was logged, much of the original pine-type forest has been naturally replaced with other types.

Once tree seeds hit the ground, conditions there must be exactly right for germination and growth of the seedlings. Site is important for germination, and ideal sites may be different for different tree species. The forest manager can do a great deal to prepare a site for seeding. For instance, if a pine type stand is desired where hardwood has predominated, bulldozers may be called in to clear off and pile up the stumps which otherwise might re-sprout. On the bare soil, then, pine seeds may take better hold.

Stump sprouting is one form of natural regeneration.

Pine Seedling

Some tree species germinate best after a fire has burned over the site. Jack pine cones must have a fire open them up so the seed can be released. If a forester wants to replace aspen-type forest with jack pine, he or she may prescribe a burning of the land after harvest and follow that with periodic spraying to control any aspen sprouts which might crowd out the new pine seedlings.

If hardwoods like oak, maple, and basswood are clear cut at harvest, often the stumps will produce new sprouts. Thus, if the forester wants to regenerate an aspen or oak stand, little has to be done. For that very reason, almost 85 percent of logging in Minnesota is done by clear cutting. Since sprouts produce tight clumps of trees, however, future thinning of the extra trees is nearly always necessary.

Suckering, or production of new sprouts from old roots, is another important way aspen is regenerated. Again, clear cutting helps suckering work best.

All these methods of reproduction, though they may be helped along by the forester, are natural ones. Naturally growing trees produce the seeds, sprouts, or suckers. Whatever the forester does to prepare the soil so it can get the right amounts of light and moisture, is called site preparation.

If all else fails, it may be necessary to resort to artificial seeding or planting. But those operations can be much more expensive. So whenever it is possible, the Minnesota forester favors natural regeneration.

Artificial Regeneration of Forest Lands

What if, suddenly, there was no more demand for paper or paper products? The pulpwood industry would fold up overnight. Millions of acres of trees would have little economic value. Forest product markets never change that drastically, of course. But they do change. And as they do, Minnesota's forest managers are faced with the task of changing one forest type to another. Rarely can that be done by natural regeneration alone.

The alternative is to artifically create new types through seeding or planting.

What if an area is too slow to regenerate naturally after a harvest of timber? The alternative may be to cut away unwanted brush and stumps, prepare a seedbed and artificially seed or even plant the land with seedlings of a desirable tree species.

Where the earth has been prepared for it, or where it is naturally favorable, seed can be planted in any of several ways. Over large areas it may be best to use an airplane or helicopter to disperse the seeds. In smaller tracts, seeds may be planted by hand or, with a system developed in Minnesota, from a snowmobile.

In all cases, the soil must be prepared to receive and germinate the seed. This may require burning or actually cultivating the land.

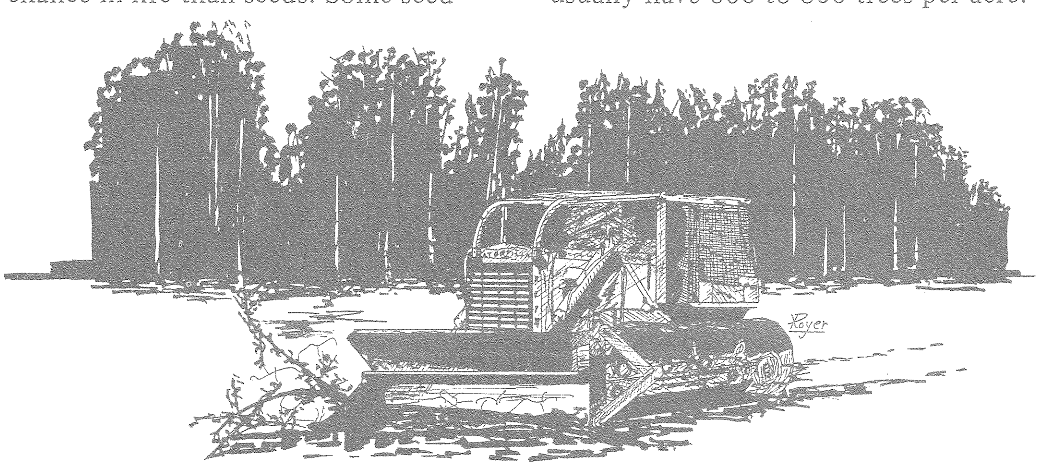
Most direct seeding in Minnesota is done to replace hardwoods with conifers like pine and spruce. For many years after seeding, treatment is usually necessary to keep broadleafed hardwood seedlings and other plants from crowding out and shading the young evergreens.

Seeding is much less expensive than planting, but planting is a more sure way to get a stand of trees started. Seedlings for planting on state lands have usually been grown at one of the state's three tree nurseries. Usually seedlings are two to four years old before they are planted so they have a much better chance in life than seeds. Some seedlings are even transplanted at the nursery for another year or two so they can develop stronger root systems before they are planted on the final site. Valuable trees like Norway pine and white spruce, for instance, are usually transplanted in this way, at wider spacing, so they will have plenty of room for root and top growth.

Planting Seedlings

Final planting at the site may be by hand or machine. Often scout, 4-H, church or other groups will volunteer their time to plant seedlings on state land. Hand planting is usually better for the seedlings, but machine planting is much faster. It is the nature and size of the site that most often decide which way to go.

How far apart trees are to be planted depends largely on their intended use. Christmas trees are usually planted six feet apart. Forest plantings usually have 600 to 800 trees per acre.



Heavy equipment is used to remove competing vegetation prior to planting seedlings.

Thinning

We hear talk nearly every day about over population — too many people and too few natural resources to go around. Everyone feels the pinch in an overpopulated world.

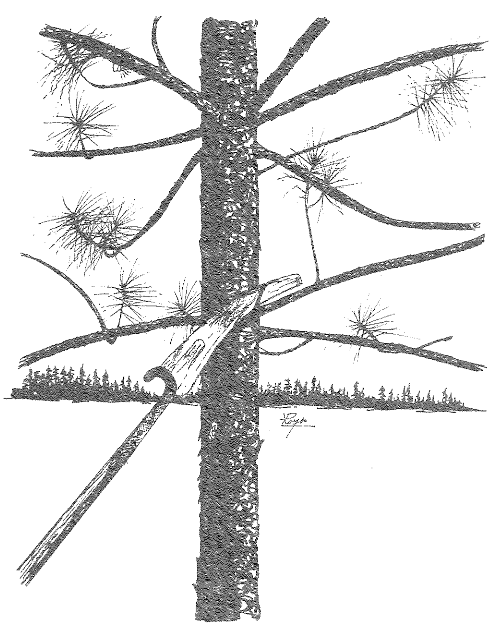
Just like people, trees can be overpopulated. When a forest has too many trees in it, there may not be enough water, light, or soil nutrients to go around. The result can be less than the best health for all trees in the forest. In some cases, the most valuable trees may even be lost altogether.

The number of trees per acre, called "density" or "stocking" by the forester, is crucial to production of marketable wood and good wildlife habitat. There is an optimum degree of stocking for each tree species and site. The forester works always to reach that optimum, because the result will be the best possible use of the land.

If a young stand of trees is overstocked, it is the forester's job to remove some of the trees. This process is called "thinning."

The first step in thinning is to decide which trees are to be saved for harvest at maturity. Then the other trees are systematically removed. They are usually cut and the salvaged wood may be used to make fence posts or paper pulp. Then those trees left will quickly grow to fill in the space cleared. They will be bigger, healthier, and much more valuable because they will no longer be crowded by their neighbors.

In the end, a well-thinned stand of trees will produce more wood in fewer but larger trees. And that is just what the logger and forest market are looking for.



Pruning

Have you ever walked through a pine forest and wondered why all the lower branches on the trees were dead?

In very old stands of pine, the tree tops may form a canopy nearly a hundred feet above the ground. But most of the trunks are without branches, straight and clean. Lower branches usually die because they are shaded by upper ones. After they die, they either fall or rot off. The process is called "natural pruning." It is the tree's way of conserving growth energy and re-routing it into vertical growth.

Of course, clean vertical growth is just the thing a forester likes to see in timber, especially saw timber, because it means solid straight-grained wood from long, straight logs. Foresters thus hasten the process of natural pruning by removing lower branches earlier. The maximum amount of the tree's energy is then used to expand the main trunk — where all the marketable wood is.

Usually trees are first pruned when they are between 20 and 30 feet tall. They are never pruned more than half the way to the top, and trees along the edges of a stand are usually not pruned at all. Instead, they act as guardians of the stand, protecting it from wind and moisture loss.

Written and illustrated by Ron Royer. Published by the Education Section, Bureau of Information and Education, Minnesota Department of Natural Resources.

Water and the Forest

Next time there is a cloudburst or heavy rain in your area, put on your raincoat, and take a walk. Notice how the water moves along the ground seeking the lowest point. It either collects in depressions and soaks in or, where the land is steep enough, runs off into nearby streams and gutters.

The area you're watching is called a "watershed." It in turn is part of a larger watershed that feeds local streams and rivers. And those in turn feed larger rivers which eventually flow to the oceans. Regardless of size, the principle of a watershed is the same – water flowing downhill toward the sea.

In Minnesota, we have watersheds that flow in three different directions. Very few states have that distinction. Meltwater from a snowflake falling in Minnesota may go south through the Mississippi to the Gulf of Mexico, east through streams that feed Lake Superior and from there to the Atlantic, or north through Canada to Hudson Bay and the Arctic Ocean. Each of those systems is a separate watershed. Truly, Minnesota is a land blessed with water.

Still out in the rain? Hold out your hand. The raindrops that you catch are distilled ocean water, carried a thousand miles to you in the air. If you let them fall to earth, they will eventually return to the ocean through one of Minnesota's watersheds, completing the water cycle.

What they carry with them in the form of sediments is the concern of watershed management and consequently of forest management. Let's follow those drops to the ground and see what happens.

As a drop falls to earth, it may strike either a piece of vegetation or the bare soil. About 15 percent of falling raindrops are intercepted by vegetation (leaves, twigs, and branches). They never reach the ground. They may evaporate unless the rain is hard and long. Of the other 85 percent portion, a great deal is absorbed by the material on the soil surface called humus. This water, in turn, is absorbed by plant roots, later to be used by the plant or transpired through its leaves back into the air. On a very dry day, a large broadleaf tree may absorb two or three thousand gallons of soil water, much of which simply passes back into the air.

Some water evaporates directly from the soil surface after a rain is over. The "muggy" feeling after a summer storm is caused in part by this evaporation.

Some water clings tightly to soil particles and cannot evaporate unless the soil is oven-dried. This water, called "hydroscopic" water, is always present in the soil. The water that evaporates is called "capillary" water because it can flow through the soil from an area of wetness to one of relative dryness.

Finally, some of the water drains downward through the soil, just like water in a coffee percolator goes through the grounds. In fact, the process is often called "percolation" by the watershed manager. This percolating water is called "gravitational" water because gravity causes it to flow instead of the difference in wetness. When it reaches an area where it can no longer flow downward, it becomes the "water table."

Water in the water table flows through the underground portion of the watershed. It may come out again in springs or wells to re-enter the surface portion of the watershed, or it may come to rest in one of many natural underground reservoirs. Because it has percolated through many feet of porous mineral particles in the soil, this water is very clear and pure. Thus it is underground flow, or "seepage", that produces the cleanest water. Watershed management aims at maximizing the absorption of water by the soil so the resulting watershed will produce this very clean water.

That is where forest management enters the picture. It is not possible to control things like soil type or slope on a watershed to any large degree. Nor is it possible to control rainfall over the watershed area. What can be controlled is the amount of absorption at the soil surface. The tool for this is vegetation – the forester's stock in trade.

The effect of trees on soil water is a complex business. On one hand, a dense stand of trees shades snow on the forest floor, allowing for slow melting and almost complete soil absorption in spring. But a dense stand of trees also draws heavily on soil water, depleting delivery to the underground portion of the watershed where the cleanest water comes from. And the 15 percent intercepted by vegetation is lost almost entirely in a very dense stand.

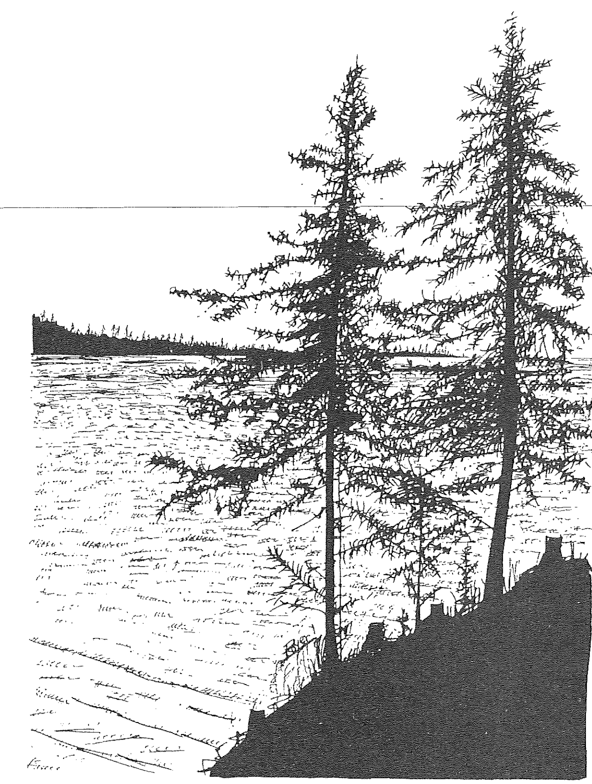
The complete absence of vegetation because of fire or incorrect management methods seriously reduces the possibility for much rainfall to be absorbed. Instead, raindrops spatter on the surface, breaking soil into tiny particles. As water builds up, it carves away at the unprotected soil, making gullies and washes that look like miniature canyons. Through these canyons, most of the water flows quickly on the surface watershed, carrying soil particles with it. The process, called "erosion", is the watershed manager's arch-enemy.

The forest manager seeks an optimum stocking (number of trees per acre) for good watershed management. Thinning an overstocked stand may thus have many benefits beyond providing optimum wood production. Too much thinning, however, can give rise to the dangers of erosion and flooding from too-swift runoff. By allowing soil to absorb water, a well-stocked forest plantation may save many tons of topsoil over the years by eliminating runoff.

The importance of the forest to watershed management becomes even more significant when we realize that more than 80 percent of the state's total water yield comes from its own forested areas. For this reason, foresters are concerned with harvest methods that may leave bare ground on skid trails or logging roads. These are prime targets for erosion. And they are likewise concerned with good fire prevention not only to save trees but because burned-over land is extremely susceptible to erosion.

Some programs call for "anchoring" the soil on logging roads after a harvest by planting or providing for the natural growth of herbs and grasses. A properly located and designed logging road will eliminate almost all erosion problems while providing additional benefits, such as access for fire control and forest recreation.

Clearly, sound forest management and watershed management go hand in hand. In the concept of multiple use, water is a prime concern to both fields. Think of that next time you turn on a faucet – or stand in the rain.



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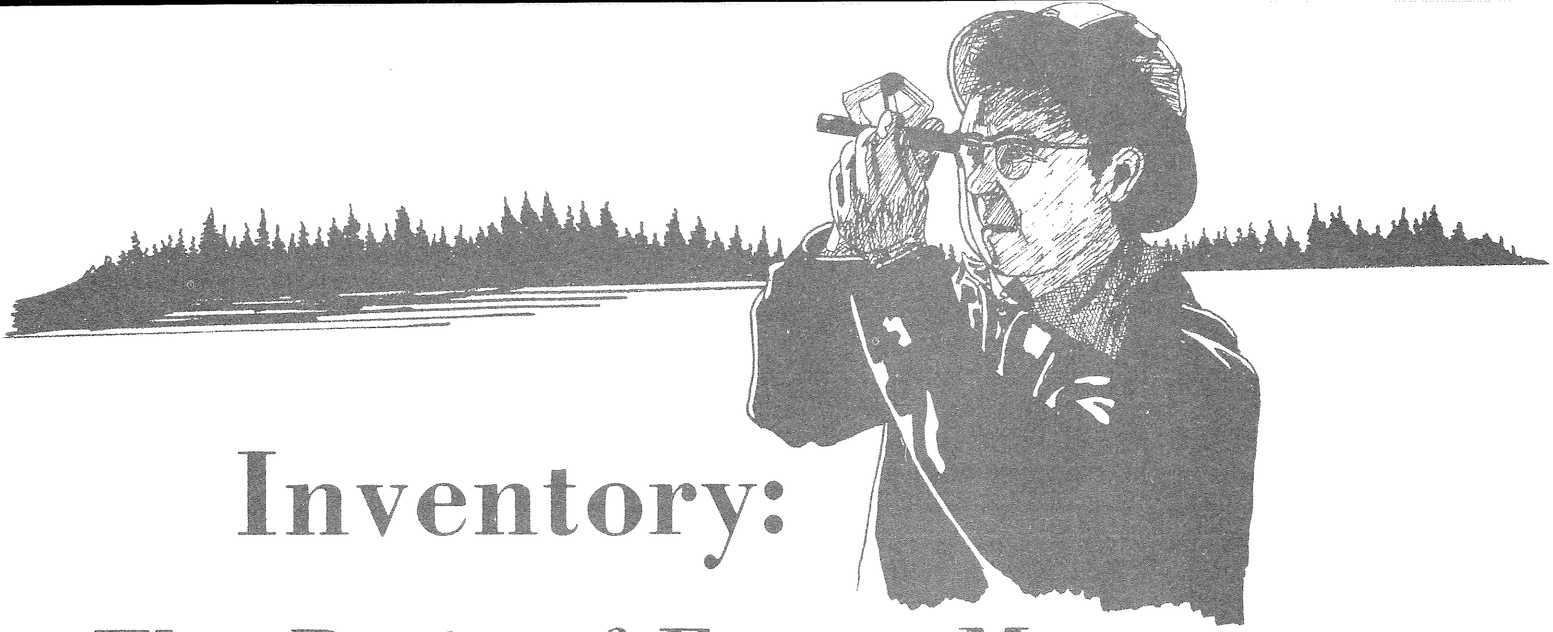


Inventory:

The Basis of Forest Management

Besides the forester, probably no one spends more time taking inventories than a grocer. Almost every time we go into a supermarket, somewhere there is a clerk with clipboard and pen in hand, counting. You'd expect that grocery clerks would learn some shortcuts over the years. And they have. No clerk possessed of all faculties would count every can of peaches in the store. Instead, counting by rows, stacks, or cases, and then using a little math, the wise grocery clerk can save hours of work.

The value of inventory to a grocer is impossible to guess. Without it, the only way to know peaches are needed is to wait for the screaming customers to announce their absence. But careful grocery management provides information on when and how much to buy, how fast an item gets sold, and even when an item should be taken off the shelves entirely.

Inventory is bread and butter to the forester too. It is the basis of all other work. But several million acres of trees is a lot to inventory. So, like grocery clerks, foresters have learned some shortcuts.

Instead of counting all trees, the forester takes only a sample of the trees in a given stand. There are tables and formulas which tell how many samples are needed per acre to get a realistic estimate of just how many trees are actually there. Then the work begins.

First, an aerial photo is taken of the forest to be inventoried. The forester can tell a lot, just from that. On a clear plastic sheet laid over the photo, tree types can be marked on each square mile (section) of land. Then, using the plastic overlay as a guide, the forester can go into the field and begin actual sampling, just as the grocer goes to the shelves to do an actual inventory.

Most foresters use a technique called "point sampling" which tells immediately how much lumber or pulpwood there is in an area. But sampling shows a lot more than just that. In just a few minutes, a forester can find out for sure what species of trees are present and their relative numbers, what approximate age they are, the density of the forest and of each species within the forest, and the number of diseased or dead trees in the whole forest.

Sometimes, instead of point samples, well-measured plots are marked off in order to get exact figures. Most often these plots are circular with a fixed radius. One-tenth-acre plots allow a forester to easily convert figures to cords or board

Forester estimates useable tree height.

feet per acre in just a few seconds. But one-fifth, one-hundredth, and one-thousandth-acre plots are also sometimes used.

Once all the samples are taken for a section of forest, the forest manager can tell even more about the land. For instance, how tree species are distributed within the area becomes clear and can be mapped. And, by comparing age with tree height, it is possible to tell how well suited a tree type is to a given soil or some other condition. Even how certain forest conditions may affect wildlife can be estimated from the final inventory.

From just a few samples taken on an afternoon walk through a small stand of timber, the far-sighted forester can make years-ahead plans for pruning, thinning, or harvesting. And it might come to light that a certain stand of trees is just not right for the site it is on. Maybe it is not growing as well as it might on another site. Perhaps, after the trees are harvested, pine would grow better there.

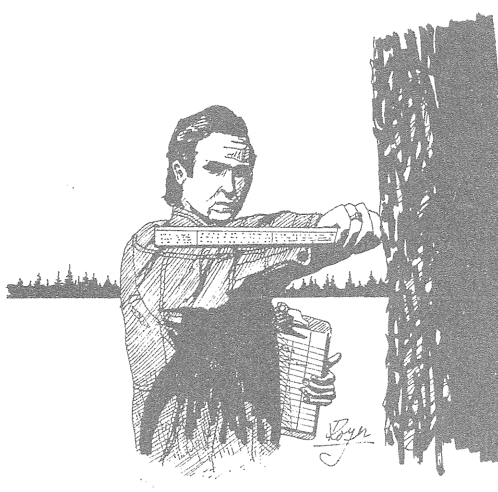
Most important, the inventory, when added to all inventories statewide, allows us to manage the entire forest resource intelligently, to budget our use of timber. So, when the timber goes up for sale from a given piece of land, just as a grocer's shelf is already filled when the peaches are sold, the land can go immediately back into production.

Plot Sampling

Suppose you were a Minnesota DNR district forester and your regional forest supervisor called one Friday afternoon with orders to get an exact inventory of mixed timber in a 1,000-acre tract of private forest land in your district. The landowner has asked the DNR to provide a long-range management plan for the land, and your supervisor's orders call for an exact count of each species of tree in the forest as well as a precise figure for the volume of marketable timber, in board feet, for each species. How would you go about making the inventory?

If you didn't know your business, chances are you wouldn't sleep much that weekend. But there is a way around every problem, and inventory of a mixed stand of timber is no exception.

The usual point sampling procedure for inventorying a uniform stand of trees won't work, of course, because you'll have to count separately for each tree species. And that could be really difficult to do while sighting down a Bitterlich stick or through a prism — especially if there are several different kinds of tree. Instead, to get the data your supervisor is requesting, you'll probably discover that fixed-radius plot sampling is the best way to go.



Measuring tree diameter with Biltmore stick.

At first, plot sampling looks like a lot of work. In fact, it is. Instead of using math to do most of the work for you, you'll do all the work yourself and then use math anyway.

Like a Las Vegas gambler, you'll play the odds. Odds tell you that it takes so many draws to be sure of getting a flush in the game of poker. And odds will also tell you how many samples it takes to be sure of getting a true estimate of tree distribution and spacing within a forest.

So, on a clear plastic overlay sheet, you'll begin by marking off the number of plots the odds tell you you'll need on an aerial photograph of the 1,000-acre timber tract. Of course the size of each plot is critical in figuring the odds, just as in the size of a poker hand (five or seven cards).

If your 1,000-acre stand is pulpwood, you'll probably use 1/10-acre plots because it is easy to convert your figures to cords per acre by moving the decimal point. If you're working with saw-timber, likely you'll use 1/5-acre plots to get a larger sample area, since the trees will probably be larger too.

Rather than setting up square plots, you'll use circular plots because it is easier to measure one radius than four sides and four angles in a square. For 1/10-acre plots, for instance, the radius would be 37.2 feet.

Starting from the center of your first plot, you'll mark off the entire circle and **physically** inventory each and every tree in the circle. You'll count all the birch, aspen, oak, pine, basswood, maple, and whatever else may be there – tree by tree. You'll measure the diameter of each tree at breast height (four feet). And you'll use a hypsometer or some other device to estimate height for each tree within the circle.

And you'll do all that dozens, perhaps hundreds of times in the tract, so you can average the results to get the precise figures your supervisor wants. You'll probably use a calculator to do the averaging. Finally, you'll have a species-byspecies inventory of trees according to age class, average diameter at breast height, density within the forest, and timber volume. In fact, just about everything you could know about any individual tree in the stand can be known for the theoretically average tree of each species and all species combined.

Even with all that work, plot sampling will probably be quicker than point sampling. Because your results from each sample will be more precise, far fewer samples will be needed in order to get reliable figures.

From the results, you may determine which kinds of tree might best be thinned out of the stand, or which kinds might benefit from pruning or replacement. And finally it will be up to you to provide the landowner with long-range advice for managing the stand.

Point Sampling

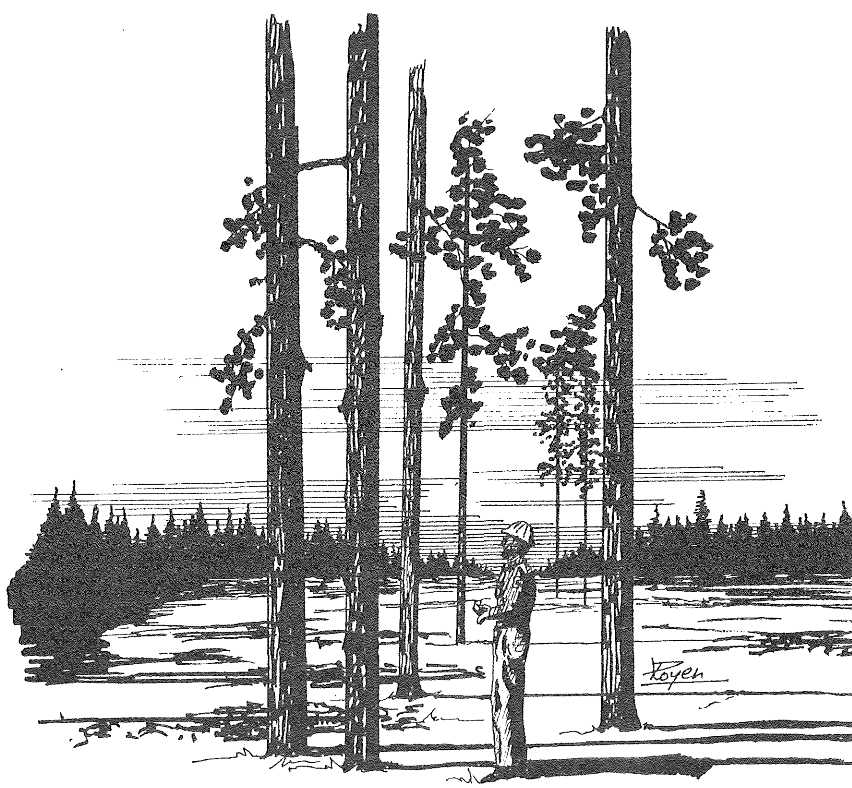
If you were standing in one spot in a forest, and someone asked you to determine how many trees there were per acre, could you provide an answer? How about if you were given a prism? A yardstick?

The average person confronted with such a task would probably just throw his or her yardstick up in dismay. Or at best take it and start measuring off an acre in which to count all the trees.

But there is a very quick and simple way, using either a prism or a measured stick, to estimate not only tree density but average per-acre basal area (total area of sections cut through all tree trunks at breast height), and even the volume of wood in board feet or cubic feet per acre. A good forester can figure all those things in just a few minutes. And that is very important in inventorying a large stand of trees.

A man named Walter Bitterlich originated the system in 1947. Today, most Minnesota foresters use it most of the time. Since the person taking inventory doesn't have to move a step in taking the sample, the system is called **point sampling.** It works like this:

The forester stands at the sample point, holding a stick of known length (usually 33 inches). At the end of the stick is a cross bar (usually one inch wide). Looking down the stick in the same way one sights a rifle, the forester turns a complete circle slowly, counting all the trees in sight that appear wider than the cross bar.



Since the cross bar is so far away from the viewer's eye, only the largest trees will be counted. But that is the trick. A tree ten inches in diameter must be within 27.5 feet to be counted, if the forester uses a stick 33 inches long with a one-inch cross bar. Otherwise it will appear to be narrower than the cross bar.

Starting with the number of trees that were counted at any point, the forester first can use a formula to compute basal area per acre. Of course, the first sample may be in a part of the forest which has more than its share of trees, so the answer won't be correct for the whole forest. But by taking samples at several points, it is possible to calculate an average basal area for the whole forest that is quite accurate.

Just how many points must be taken can be determined from tables, and where they should be taken within the forest can, too. Before going into the field, the forester determines both the number of points needed and where they should be located for the most accurate results. The locations are then marked on a map which usually is made beforehand from an aerial photo.

In a similar way, using tree height also, the volume of timber per acre can be estimated. And, using another formula, the average number of trees per acre can be figured, too.

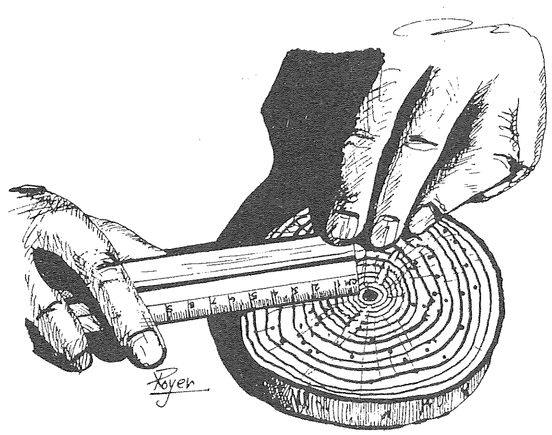
The system is simple because the angle between ends of the cross bar takes everything into account. A six-inch tree at ten feet looks just the same as a 12-inch tree at 20 feet.

Some foresters prefer to use the angle made by light diffraction through a prism for counting, but the result is the same. All the forester does is count trees. The formulas do the real work!

Site Quality and Site Index

Let's imagine you've completed an inventory of aspen timber in a section of state forest, and as district forester you're responsible for managing the site. Is aspen the right tree type for the site it is on? Would jack pine be better? Could the land produce more and better timber if it were replanted with jack pine?

Let's say the trees there now are 50 years old, on the average, and badly in need of harvest because 20 percent have died already from hypoxylon canker, a disease of aging aspens. The trees are going to waste. You'll have to conduct a timber sale soon. Should you leave the site to regenerate aspen naturally after the sale, or should you replant with the pine?



These are questions a forester asks every day. But the questions aren't blind ones. It is very easy for a forester to find out how well-suited a tree type is for a particular site – the **site quality** for that tree type. The answer to all the questions is found in what is called a "site index" for each tree type.

There have been several kinds of site index used by foresters over the years. But the basic idea is the same. It is to compare growth with age. On a good site for a particular tree type, the trees will grow faster and larger. On a poor one, they will be smaller at the same age. In Minnesota, foresters have measured growth by determining the average height of the largest trees in a stand each year as they grow – up to 50 years of age. The site index for any stand is just the height of the tallest trees at 50 years of age.

Now, back to that aspen stand in your district. Let's say you measured the height of trees in your inventory and found the site index was poor, about 50. Just across the road is another stand of aspen, on a different type of site, with a site index of 65. That is, the 50-year-old trees there are 65 feet tall. And let's say that just down the road, on a third site, is a stand of jack pine with a site index of 60.

If the jack pine is on a site that is very similar to the first one, you would probably reason that it would be a good idea to harvest the aspen right away and then plant jack pine.

Of course there are many variables in site quality. Soil type, water table, slope of the land, and many other factors add up to make site quality. And no two sites could ever be exactly alike. So the only way to be sure of the site index for a tree type in a particular site is to grow it there.

But experience with soils and other site factors can make an intelligent guess. So you'll probably hold a timber sale to harvest the aspen and then replant jack pine.

Remote Sensing

Let's imagine you are a DNR area forester assigned the task of managing a million-acre forest tract in northeastern Minnesota. You have a month to provide your supervisor with a preliminary map and inventory of the forest, showing distribution of trees and percentage of diseased timber in the area. A million acres is a lot of ground to cover. Where do you start?

From the air, of course. Aerial photos of large forest tracts can be the only way to plan for large-scale management. From large black and white photographs, on a scale of four or eight inches to the mile, DNR foresters make inexpensive prints, called "bluelines," which they use to plan for logging road construction and other large-scale operations.

But that is far from the only use of aerial photography or "remote sensing" in Minnesota forest management projects. Just like people, sick trees run a temperature. Infrared photography records even slight differences in the temperature of trees, and thus infrared photographs of large forests may clearly show the locations of diseased trees. They may even show areas of insect infestation and provide information that allows the forester to estimate insect pest populations. Even the effects of drought can be measured by remote photography.

During fire seasons, fire fighting foresters can use infrared television and photographs to detect "hot spots" – areas which need fast attention.

Of course, the bird's eye view provided by remote sensing has its limitations, too. It is not possible to tell the age or volume of timber within a stand from aerial photographs alone. The size of the area covered by most aerial photographs is just too large for such detail. But remote sensing and aerial photography form the foundations of almost all later work – actual on-the-ground sampling of smaller areas and disease control, for example.

As an area forester, you would have no problem providing your supervisor with reasonably accurate data on a million-acre forest in very short time. And you might even get the chance to ride in an airplane while you did the job!

Stand-Volume Tables

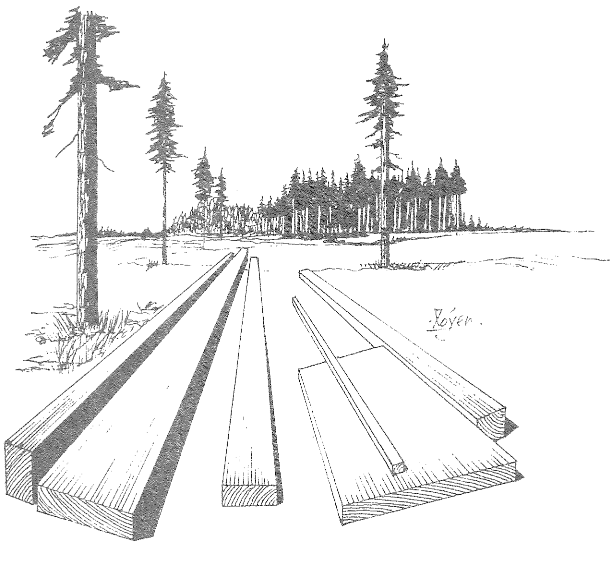
If you are a Minnesota forester and have inventoried a stand of trees and know the number, height, and diameter at breast height of the trees, how can you estimate the volume of wood present?

One way would be to cut up an average-sized tree from each diameter class and physically measure the volume of wood in cords, board feet, or cubic feet. Then, using a little math you could figure out volume per acre for the whole stand.

In fact, that has already been done. The result is called a tree-volume table. Tree-volume tables list the volume of wood for single trees at a site index of 60 (trees that would be 60 feet tall if they reached age 50 years). For example, a tree-volume table for white pine might list the number of board feet of saw timber in a white pine tree when its diameter is four, five, six inches, and so on. You would consult your inventory to find out how many four-inch trees there are per acre and then multiply to determine the board feet per acre – from just the four-inch trees. Then you would do the same for the five-inch trees and so forth. Your total would give you the volume of wood in the whole stand on a per-acre basis.

But that is a lot of work. Fortunately it is possible to estimate volume of the whole stand directly, without using tree-volume tables. Foresters in Minnesota use what are called "stand-volume tables."

One problem with stand-volume tables is that trees don't always grow the same way in different situations. On some sites, trees grow faster and with different shapes than on others. The density of a stand of trees will also affect the shape and volume of individual trees. Trees too densely stocked will be tall and spindly, while trees on a poor site may not be as tall as those of the same type on a better site. These things must all be taken into consideration when stand-volume tables are made.



As a standard, for stand-volume tables in Minnesota, a site index of 60 is assumed. That is, the table assumes the trees inventoried would be 60 feet tall if they grew to be 50 years old. Similarly, there must be different figures for different densities, since most stands are not stocked to the maximum density. The end result is a graph which shows the optimum volume of wood for each density of each kind of tree by diameter-class.

At best, the stand-volume table gives an intelligent estimate of volume. It is a quick and reasonably accurate way to tell how much marketable timber is present. You'll probably use stand-volume tables to estimate how much timber there is on state forest land for a timber sale. If you overestimate, the state will have to repay the buyer for the timber he or she expected but didn't get. And if you underestimate, the buyer will have to pay the state for the extra timber. You'll find out which it is when you stop by the site to scale the logger's product after the sale.

Written and illustrated by Ron Royer. Published by the Education Section, Bureau of Information and Education, Minnesota Department of Natural Resources.

Selecting Forest Products for Sale

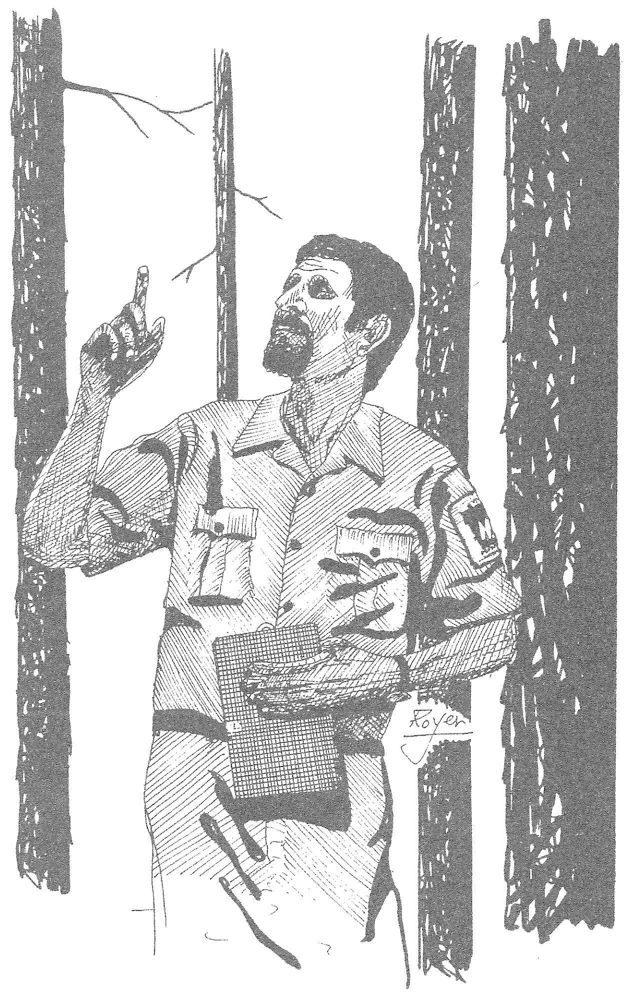
Imagine you are a DNR forester with loggers beating down your door looking for state-owned timber to cut. One wants 1,000 cords of pulpwood. Another needs 50,000 board feet of pine saw timber. And a third just wants to cut half a dozen cords of firewood. How are you going to deal with all those requests?

Part of the answer, of course, is to know your inventory – what you have that is actually harvestable. Another equally important part is to know what is not harvestable and why. Naturally, since the forest is a resource, trees that mature and become susceptible to disease and decay can be removed. Those that are young should remain unless they are part of an overstocked stand in need of thinning. A good harvesting plan calls for keeping the forest healthy and providing good wildlife habitat while also allowing for use of the mature timber.

Foresters spend a good deal of their time, especially in winter months, "cruising" timber to find out just what is mature and can be harvested to meet market demands. If you have been doing your job well, you will know just how to handle each request that comes across your desk.

Let's say you have 40 acres of harvestable Norway pine, and the request for 50,000 board feet is only one of many you have had for pine saw timber, a high-demand product. If the demand is that high, you will probably **auction** the timber. Auctions must first be advertised three times in a legal newspaper. The advertisement will have to include all information on the prospective sale – when and where it is to be and how much timber is to be sold. You will set a base price for the timber. When the auction comes around, the highest bidder beyond that price will have the right to log the pine.

Since pulpwood trees like aspen and jack pine make up nearly 90 percent of the value of Minnesota forest production, you probably have a lot of them to go around. Supply probably exceeds demand in your district, so you will likely sell pulpwood through what is called a "section one sale." Here, you must get a written application from the logger requesting the 1,000 cords of pulpwood. If the application is approved, you will set the price on the basis of the DNR's manual. You may not be able to provide all the 1,000 cords at once, but, remember, as the forester you're in control of just what may be harvested and when.



To the fuelwood buyer you can issue a simple permit which allows him or her to cut up to 25 cords of off-site, dead or diseased timber. The permit will be good from July 1 of the year of issue until June 30 of the next year.

You might expect your work to stop there, but it doesn't. For the saw timber, at least, you personally will have to scale what the logger cuts. Scaling is simply measuring the logger's product – checking up. If the logger takes too much, you will have to charge extra. And if he or she takes timber from outside the cutting boundaries specified in the sale, it will mean extra charges for trespass.

Scaling the pulpwood is usually done for each load right at the mill where the logger delivers the wood. Mills won't even accept a load of pulpwood without a special ticket which records the delivery.

Fuelwood permits will be issued for a specific area, and you will have to check the area from time to time to be sure no one is cutting the wrong trees or cutting outside the allowed boundaries.

In making all those choices, you will be keeping a constant eye open to the possible effects of harvest on wildlife habitat, always one of your biggest concerns. Some forms of wildlife suffer from inappropriate harvesting. But often a timber harvest means a much richer habitat for animals like deer and hare, for instance, which thrive on new aspen growth. As forester, your decisions on harvest affect not only human but animal life as well.

And, as always, you must keep an eye on the future of the forest. How the harvest is conducted will have far-reaching effects. For the aspen, clear cutting and natural regeneration from sprouts and suckers will probably be the prescription. But the Norway pine may have to be cut so seed trees will be left to provide seed for regeneration. Or it may be best to plan for artificial regeneration on the pine site. You'll have to specify which it is in the terms of the sale, knowing that what you decide will determine tomorrow's forest.

Pulpwood Logging

If you had to pick up a 100-inch aspen or balsam fir log, you'd immediately wonder why the logger calls it a "stick." But that's the name: Most small pulpwood logging operators cut logs into these 100-inch sticks for delivery to the pulp or paper mill.

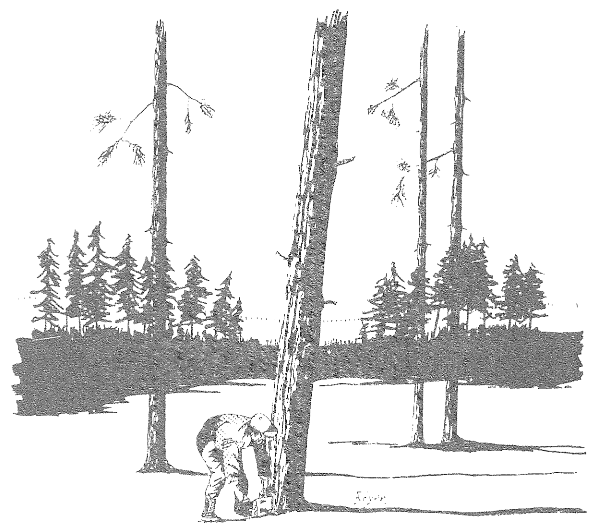
Their tool is the chain saw, and with it they cut an incredible million and a half cords of pulpwood per year in Minnesota. That's a lot of sticks!

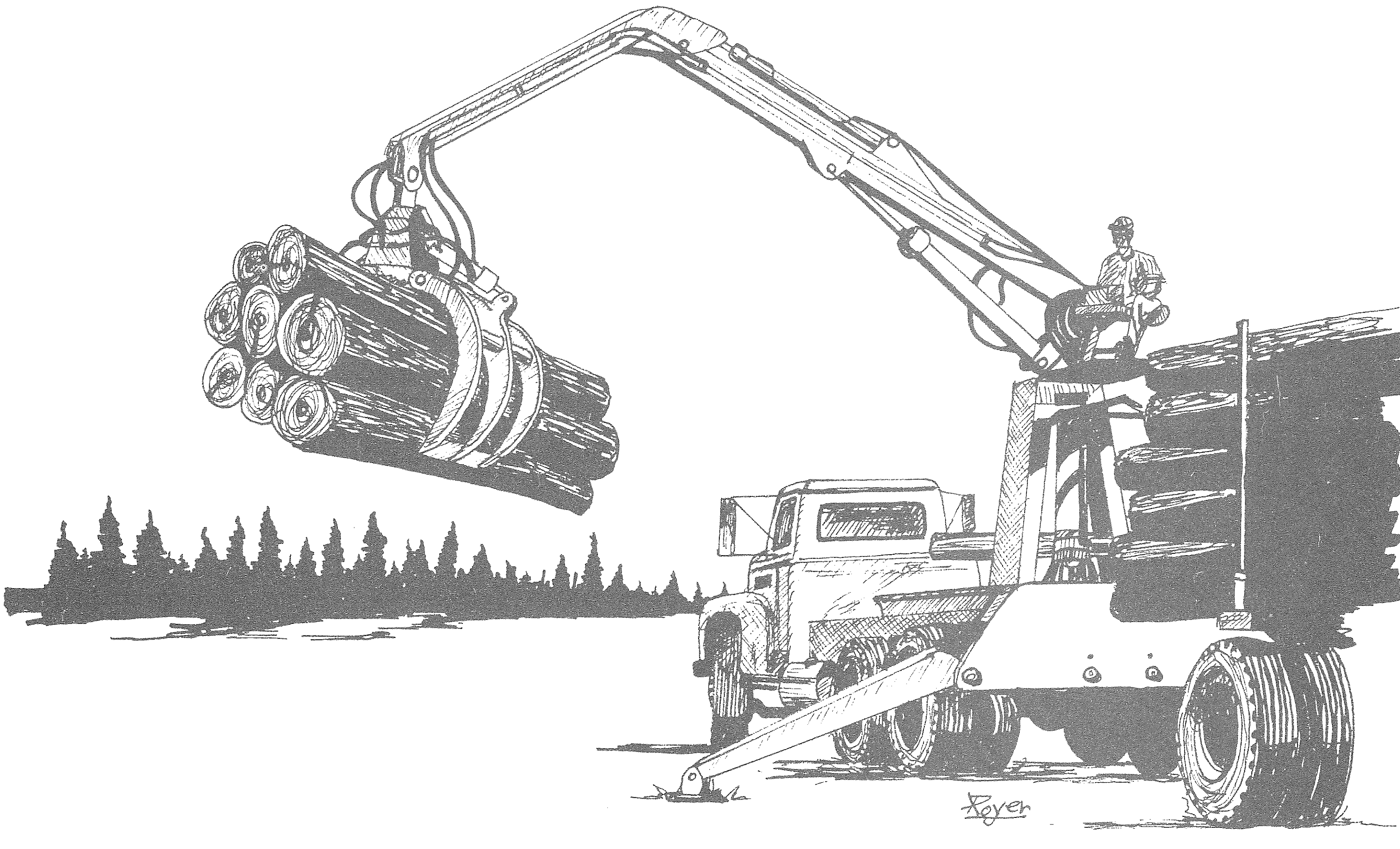
First, a logger fells each tree by cutting out a wedge on the side toward which the tree is to fall. Then, cutting from the other side just above the wedge-shaped cut, the logger drops the entire tree. A good saw operator can fell a 60-foot tree on a dime.

Next, the limbs are removed on the spot and the entire trunk is then pulled or "skidded" to a central loading area called a "landing." There it is cut into the 100-inch sticks that will be sold to the mill. Machines called skidders do the moving.

Then, pulpwood logging trucks, which may belong either to the logger or an independent pulpwood trucker, load the 100-inch sticks crossways with a giant hydraulic grabber that looks like a lobster's claw. These trucks may carry the sticks directly to the mill or to a railway siding where they are transferred to railroad cars for long-range shipment.

Trees are also sometimes hauled whole and fed into giant chippers which grind them up and sort out the bark.





And some large-scale operators have machines which do it all right in the forest. They grab an entire tree at ground level, shear it off with giant hydraulic scissors, and then feed it into a grinder which spits out the limbs and grinds the wood to chips while sorting the bark out.

In such modern equipment, one person can do the work of half a dozen loggers, all the while sitting in a heated cab.

Cutting Saw Timber

In the old days of Minnesota logging, just about every tree cut went to make boards. Loggers cut giant pines with axe and old fashioned crosscut saw or "misery whip." Logs most often were transported over the state's waterways, especially the Mississippi.

As you might expect, such practices went out with the horse and buggy – and the virgin forests.

Today, just about every kind of tree grown in Minnesota can be used to make lumber of one sort or another. But nearly ninety percent of logging these days is for pulpwood. Even sawmill wastes are sold to the pulp or paper mill. The chain saw has almost entirely replaced the crosscut, and rivers have given way to highways and logging trucks.

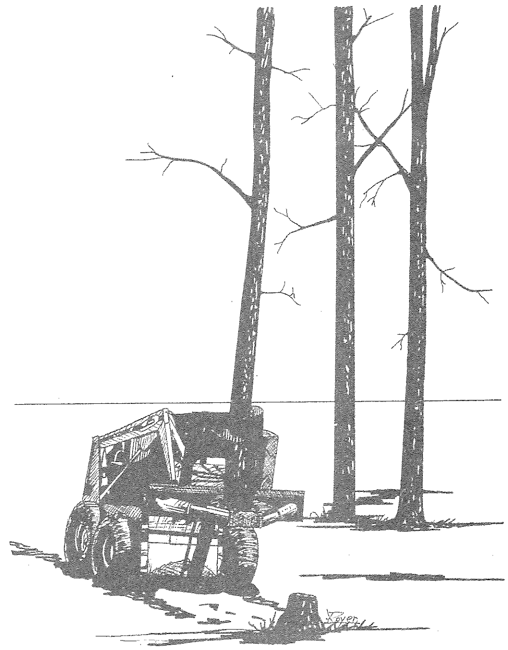
Once it's on the ground, the logger "limbs" the tree and then cuts the main trunk to lengths. This operation is called "bucking." Generally speaking, the longer the log the better it is for saw timber. Logs eight, ten and even up to 24 feet long may be sought by Minnesota timber mills.

Once bucking is completed, logs are skidded over the ground to a "landing" or central loading area. Then they are loaded onto a truck and hauled to the mill buying the logs.

Some operators just cut and then contract haulers to have the logs hauled to the mill. Others do their own hauling. Some small operators even do their own sawmill work.

Sometimes logs cut from a mixed stand are sorted for sale to both pulp and lumber mills. Generally, a log must be at least eight inches in diameter before it will be considered for sawing into lumber. Smaller logs contain too much waste to make sawing worthwhile. Favored sawlog trees in Minnesota today are Norway pine, white spruce, and oak.

There are single-person operations and large logging companies with thousands of dollars worth of equipment and large payrolls. But their job is always basically the same – buying timber, cutting, limbing, bucking, skidding, loading, and hauling logs to the sawmill.



Mechanical Logger.

Sawlogs and Sawmills

After an independent logger has felled, limbed, bucked, and skidded a bunch of sawlogs to a central landing, the forester may come into "scale" or measure the logs. Measuring both diameter and length, and using formulas which account for taper in the logs, the forester can very quickly and accurately estimate the total volume of usable wood they contain. In fact, for state-sold timber, that is the way the final bill to the logger is figured.

But scaling doesn't stop there. The sawmill must know what it is buying from a logger, and so logs may be graded when they arrive at the mill. They are graded not just on the basis of volume but also into "use classes" which determine the quality of the unsawed logs – whether they will be sawed for fine woodwork, construction, or for use locally in building barns, skids, crates, railroad ties, building timbers, or a host of other things.

Once the mill operator knows how the logs are to be cut, they are sorted and sent to the saw room. Saws there may be either circular or band saws. Most small mills in Minnesota have the circular type.

In a modern mill, everything is either mechanically or hydraulically operated. One person, called the sawyer, sits in a protected room operating the saw. The sawyer's control panel looks like it came out of a Boeing 747 cockpit.

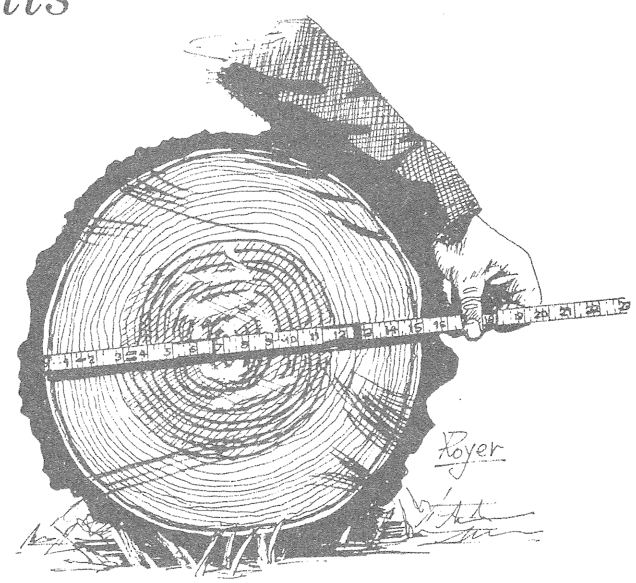
Logs are rolled one at a time onto a ramp at the head of the saw and turned over and over by a rotating chain and then hydraulically clamped into position for a cut.

The first cut produces a strip that looks like a board on one side but has the outer bark on the other. These pieces are called slabs. Slabs may be chipped up for sale to pulp or other wood product manufacturers, or they may be sold or used at the mill for firewood.

After the rounded log is squared off by removing the slabs, it is reclamped into position to make actual boards. It is the sawyer's job to decide what size boards should come out of each log and in what order. A good sawyer doesn't waste one bit of a log. Being a sawyer is sort of like being a sculptor of rectangles.

Big band saws cut in both directions. It is not the saw but the log that moves. So a double-sided band saw is faster than a circular saw because it can cut in both directions.

As boards come off the saw table, they are carried away on a conveyor called the "greenchain." It is on the greenchain that the rough lumber is usually graded. Certified lumber graders may be under contract in small mills or be full-time employees in larger ones. They check boards as they come down the greenchain and assign grades to them based on their quality. The appropriate grade is marked on the board with a crayon on the end of a long stick.



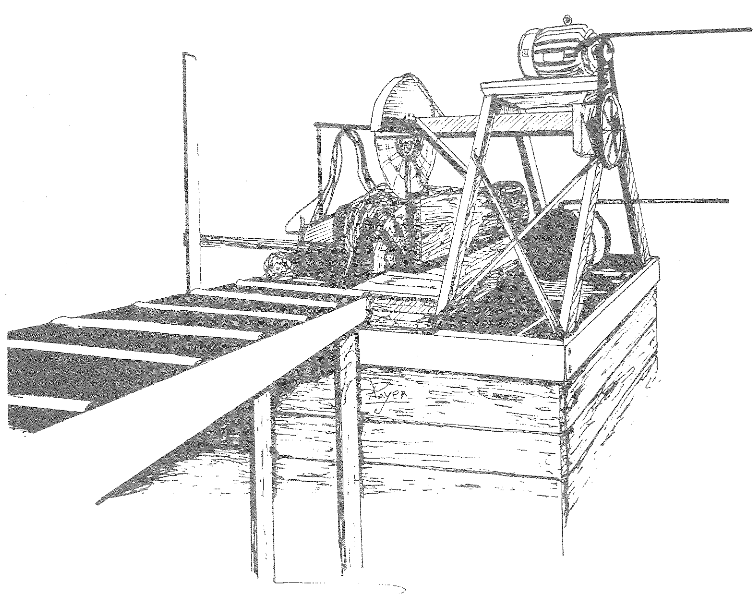
For hardwood boards, there are "firsts" and "seconds." They are the very best grade, with clean, tight grain and no knots. Selects are clear on one side, but may be not quite good enough to be "seconds" on the other. Then there are number 1 and number 2 common boards, boards that are sound but wormy (have worm holes), and finally 3A and 3B common boards, the poorest grades.

The softwoods, like white pine, also have select grades, and number 1-5 common grades.

After boards are graded, the next step is trimming. Boards are trimmed to exact lengths and exact widths as they come off the greenchain. In Minnesota, most boards are trimmed to eight foot lengths.

Trimmed boards are planed and then cured either in the air or in heated kiln driers. Sometimes both curing processes are applied.

Dried and graded lumber bears a certified grading stamp. Look for the stamp next time you are in a lumber yard.



Pulp and Paper-making

Can you conceive of an industry in which everything is recycled, even the waste? The modern pulp or paper mill is the closest thing to recycling perfection you are likely to find. Let's look at one.

Timber from the pulpwood logger usually comes to the mill in 100-inch lengths called "sticks." Some processors simply chip these up and sell the chips. Others process them into pulp which is dried and baled for sale to the paper mill. And some mills start from scratch, with the whole sticks, and end up with finished paper.

At a full-scale paper mill, logs are fed into a machine called a "drum barker" which removes the bark. Sometimes the 100-inch sticks are cut down to 25-inch lengths for easier handling before they are debarked. Once the bark is off, some of the logs may be sent to a machine called a "chipper" which chops them into potato-chip sized slices for storage. Other debarked logs may be sent to grinders, machines which grind them down, under tremendous pressure, adding water to make "groundwood pulp."

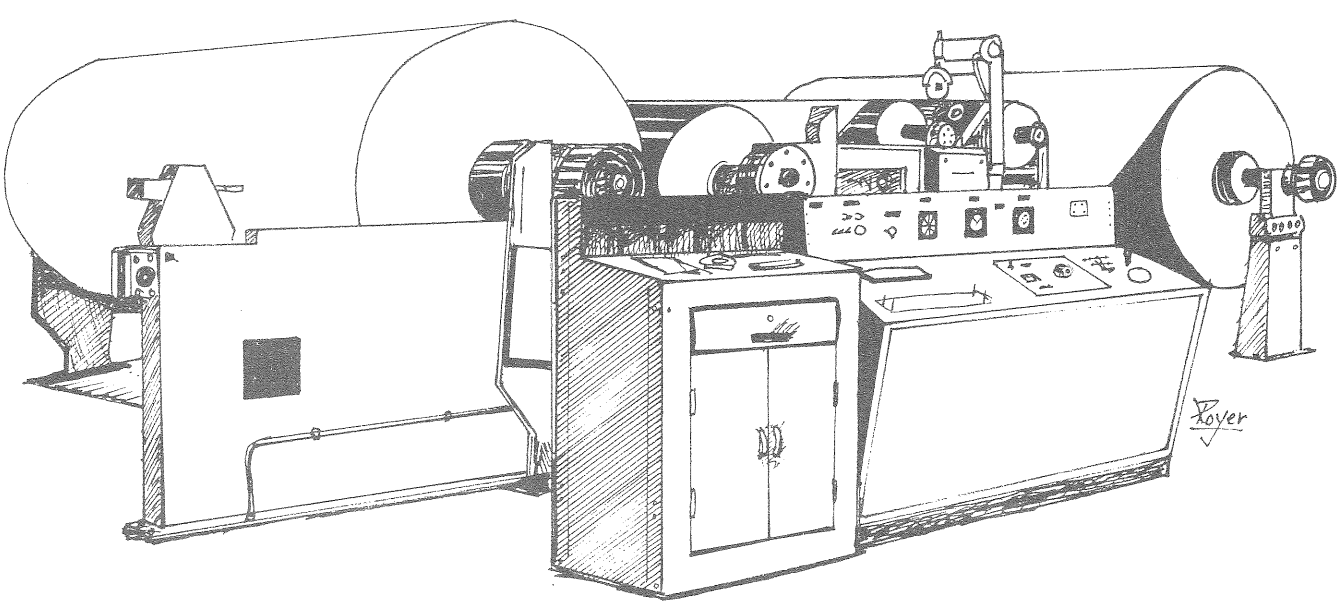
Groundwood pulp has very short fibers in it because of the grinding process. Usually only newsprint and magazine papers are made from groundwood pulp.

Fine bond papers are made by another process, called the "chemical" or "kraft" process wherein wood fibers are separated by slow cooking with lye under pressure. This separates the fibers from the cement (lignin) which binds them together in the tree. Since they are not ground up so much, kraft fibers are long and lacy. The paper they make is much harder to tear and is much longer lasting.

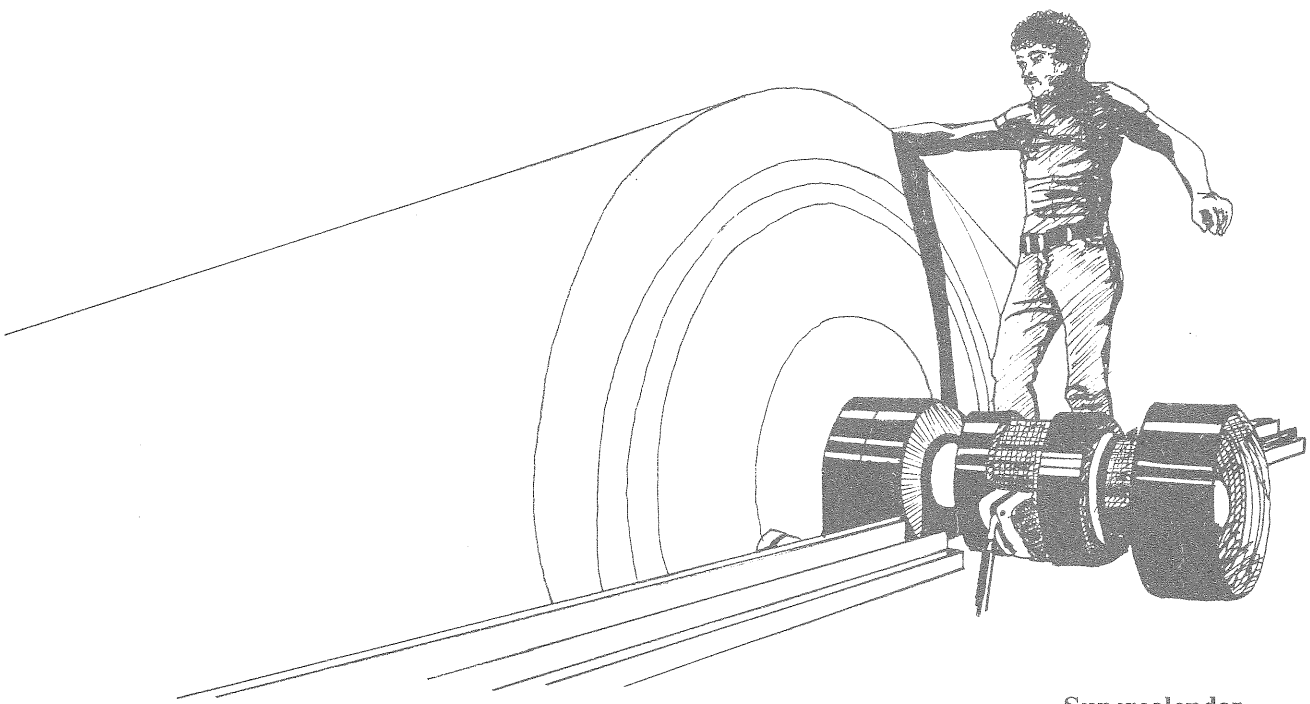
The starting point of the kraft process is the wood chip stage, and the end point is a soft and fluffy popcorn-like pulp. This valuable pulp is often dried and sold to other papermakers.

Almost all papers are just blends of different kinds of wood pulp. Pulps from balsam fir, aspen, jack pine and spruce all have different characteristics. And we have already seen the difference in quality between groundwood and kraft pulp. These different pulps are carefully blended according to time-honored recipes in giant vats in order to make different kinds of paper. They may be bleached, refined, and cleaned a final time to be made ready. By this time, the pulp mixture is more than 99 percent water. It looks like cream of potato soup.

Then comes the most fascinating process – the actual making of paper from the pulp. The soupy pulp mixture, called "slurry," is sent to a giant machine called a "Fourdrinier." The Fourdrinier has two ends, a "wet end" where the pulp arrives, and a "dry end" where the paper comes out. At the "headbox" on the wet end, the slurry is squirted in a constant stream onto a fast-moving plastic screen. The screen may be many feet wide and more than a hundred feet long. It moves along sometimes as fast as 30 miles an hour carrying the water and suspended wood fibers. As it moves, it also oscillates from side to side, interlacing the fibers evenly as the water drains down through the screen to be recycled. Some Fourdriniers have



Slitter-Rereeler in paper processing.



Supercalendar.

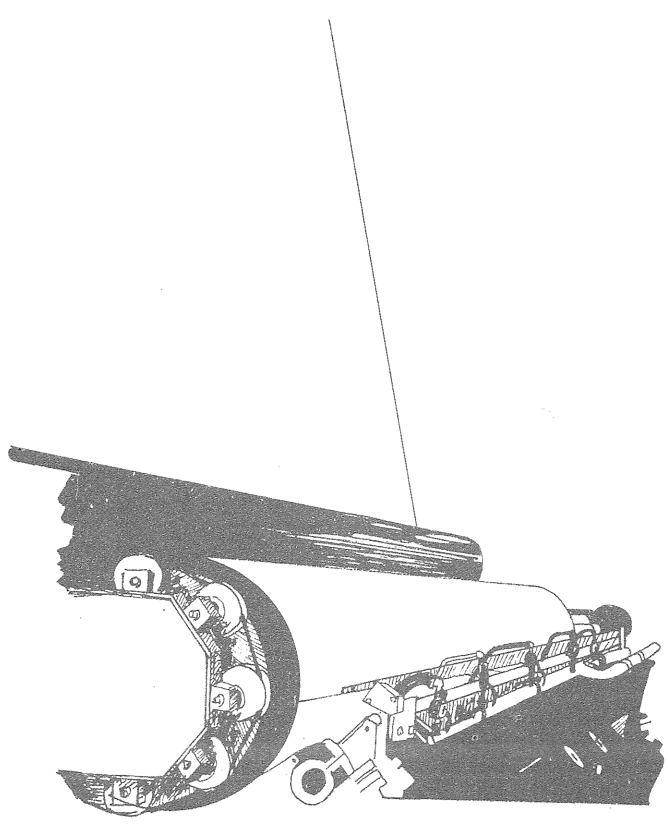
sections with vacuums to actually suck moisture out of the moving slurry. At the wet end near the headbox you can see the water dancing like raindrops on a sidewalk. But at the dry end of the screen the fibers are so well interlaced and so much drier that the pulp mass can support itself without the screen – so long as the machine is moving at high speed. Here, water content may be down to 80 percent.

The pulp stream is stripped off the screen by a "dandy roller" and applied to a felt-covered cylinder which squeezes out more of the water, down to about 60 percent. Then the rest of the way down the machine the paper is dried on steam-heated drums. By the end, water content is down to less than three percent.

The resulting paper is soft and dull white. If it is to become newsprint, it will be the finished product. Other kinds of paper may be coated, smoothed, and cut to sheets.

All the way through the process, things are recycled. The bark may be dried and used to fuel boilers at the mill. At all points, fibers and wood not ready for the next step in processing are simply sent around again. Water that falls through the Fourdrinier screen is recycled through the headbox. And at all phases a product that does not meet standards is simply turned back into pulp and the process is repeated.

Finally, all materials not used are recovered from the water before it is released from the mill into the environment.



Paper-coating machine.

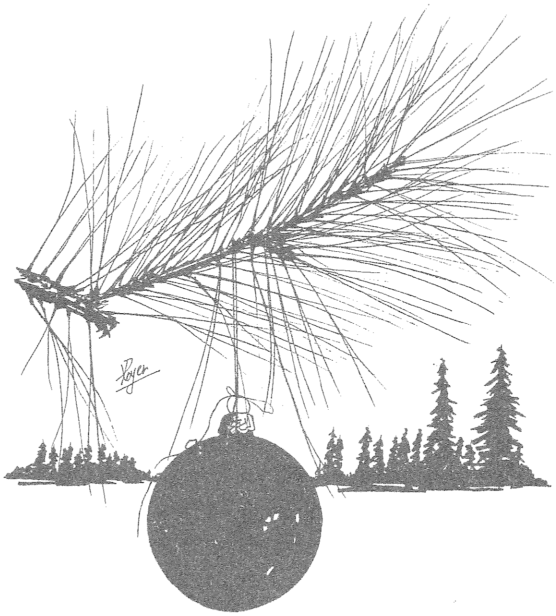
Other Forest Products

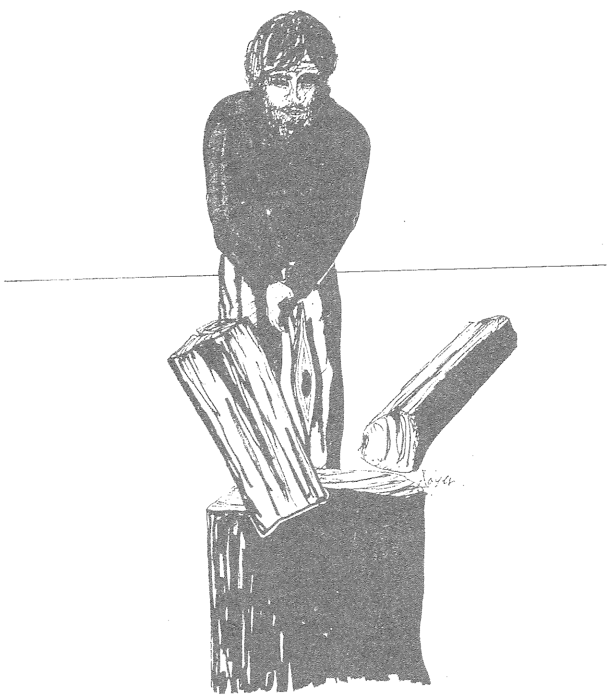
A lot more than paper and lumber come out of Minnesota's forests. True, paper and lumber are number one and two on the forest product list. But Christmas trees take a close third place.

Planting Christmas trees is one way for the small landowner to make good use of poor soil. But it wasn't always the case that Christmas trees were purposely grown. Just a few years ago, nearly all Christmas trees were wild trees – either black spruce or balsam fir. Some people today still prefer those species.

Since Christmas trees must be shapely and full, very few wild trees meet market demands. Not many can be harvested from a wild stand. Most spruce and balsam Christmas tree harvest does little environmental harm, and even may be of benefit. Black spruce, for example, are usually taken from stunted and overstocked stands in stagnant, swampy areas. Those trees left have more room to grow and actually benefit from the cutting. Also, since balsam fir is a favorite host of the pesky spruce budworm, thinnings of young trees from susceptible spruce stands benefit both the Christmas tree buyer and the spruce trees.

Today, carefully trimmed and shaped red and Scotch pine are Christmas tree favorites because they grow more quickly and hold their needles





longer than either spruce or balsam fir.

Another important forest product is maple syrup. All species of maple, and even birch, are good syrup producers, although black and sugar maples make the sweetest sap.

Trees are tapped in early spring to get the sweet sap. First a hole is drilled about three inches into the tree about three feet above the ground. Hollow sprouts are then hammered part of the way into the holes. Then, buckets, plastic bags, or plastic tubing are attached to the sprouts in order to collect the sap.

Tapping does no damage to the trees, and trees can later be used for lumber.

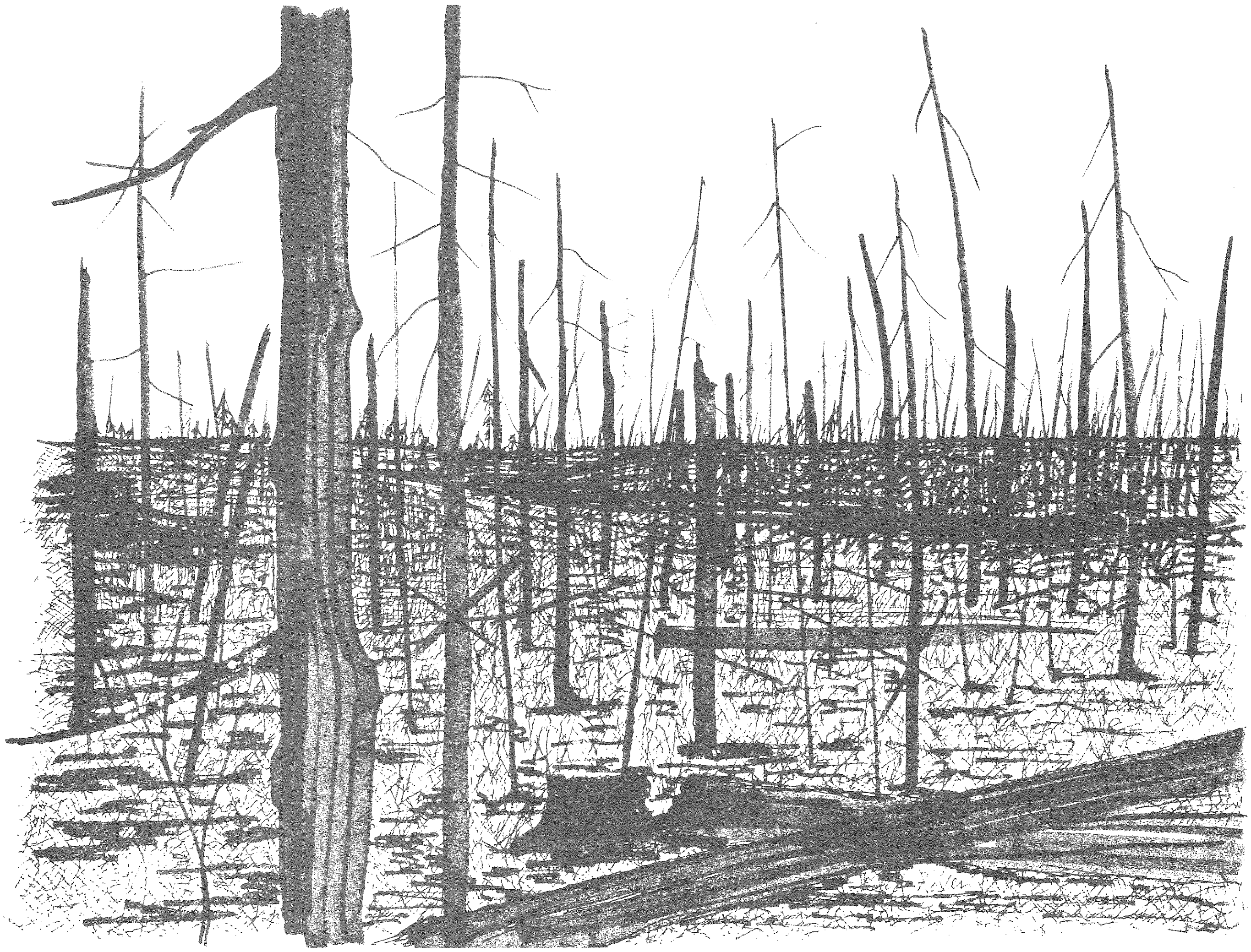
It takes a lot of sap to make a little syrup. On the average, a ten-inch tree with one tap hole will yield less than 15 gallons of sap per season. When it's boiled down to make syrup, that will produce less than half a gallon because sap is mostly water.

The syrup can be boiled down even more to make such treats as maple sugar, maple butter, candy, and maple flavoring.

But forest production doesn't stop here. Trees are also used to produce matches, cardboard, railroad ties, fence posts, barrel staves, fruits, nuts, and a multitude of other things.

And the best part is that the raw material is always renewable.

Written and illustrated by Ron Royer. Published by the Education Section, Bureau of Information and Education, Minnesota Department of Natural Resources.



Protecting the Forest from Fire

Forest fires have killed hundreds of Minnesotans and cost millions of dollars over the past century. They are still a major economic threat to the forest resource. In recent years, however, fire has taken a back seat to diseases and insect destruction. A major job of the forester is to protect the state's 18 million forest acres from each of these threats.

Since more than 90 percent of forest fires are caused by human carelessness, a great deal of forest protection work is fire prevention. But once a fire has started, the forester calls up every possible resource, from buckets to bombers, to bring it under control.

Unlike fires, insects work slow, steady damage on trees. They leave no part of a tree safe. Some kinds of insects attack foliage. Others bore into fruits and cones, hampering natural regeneration. And still others destroy the wood itself, by boring into it. Though spraying insecticides can be effective, it is also tricky. Wildlife and fish may suffer from insecticides, so research is continually directed at finding safe ways to control insects without threatening other forest creatures.

Both infectious and noninfectious diseases of trees can wipe out a forest more permanently than just about anything else, so the forester must also be a doctor of trees. Diseases of trees are often epidemic, however, and difficult to control by spraying or other treatment. Dealing with tree diseases often means harvesting a stand of trees before they become diseased, and then changing the threatened forest type entirely.

Whether by fire, insects, diseases, damage to the forest need not be total. For example, sometimes a wildfire moves only through the crowns of trees, burning hot and quickly. When that happens, the wood may still be usable. Saving the timber after a fire, pest infestation or disease epidemic is called "salvage cutting."

Like the inventory in a store, the forest is continually turning over. Trees are harvested and then replaced. But loss due to fire, pests, and diseases depletes the forest to no one's benefit.

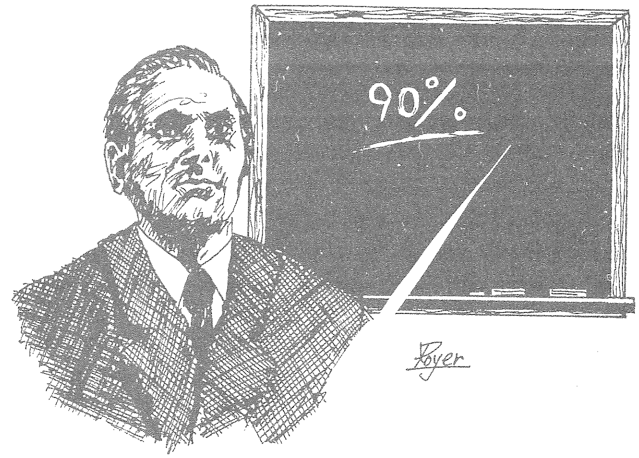
Forest Fire Prevention

They all seem to start so innocently. Sparks from the exhaust of a motorcycle or tractor might do it. Or a momentarily untended campfire could be the cause. Forest fires usually start like that – in one place. At first they are small. But then they grow. They cost us millions.

More than 90 percent of forest fires could be prevented, however, since they are caused by human carelessness. The best form of fire protection, of course, is fire prevention. A lot of fire prevention in Minnesota is indirect, by public education. We are all familiar with the "Only you can prevent forest fires" Smokey Bear campaign of the U.S. Forest Service. And Minnesota DNR foresters frequently make fire prevention presentations to scout and other community groups.

But as forest management becomes more sophisticated, there is also a lot the forester can do directly to prevent large-scale fire losses – just in the way the forest is managed. For example, a wise forester would never plant valuable pine in the middle of a fire-susceptible peat bog area. Instead, leaving frequent breaks in fire-susceptible forest stands makes potentially costly fires immediately controllable.

Foresters are always working to pinpoint problem fire areas and to identify the types of wood that fuel wildfires. Fire susceptibility is one important factor in choosing site for a forest stand, and in changing one forest type to another.

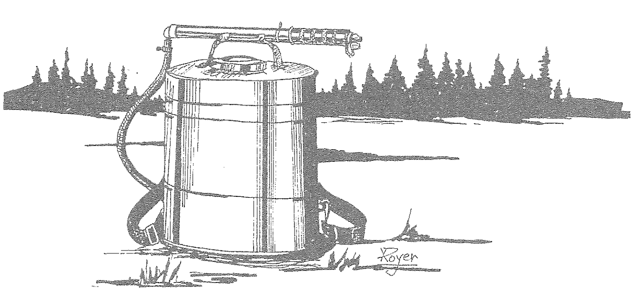


Another important means of fire prevention is the issuance of burning permits by state fire wardens. Permits to burn are required in all the state's rural areas, and all controlled fires are thus on record so the forester can keep track of them.

Fire prevention even extends beyond the forest to the rural home. Nothing is more dangerous than to place a new house too close to a pine plantation. If a fire did start in the nearby forest, the result could be disastrous. So the forester acts also as an advisor to the private forest owner who, with good intentions, may be endangering human lives.

In any case, if forest fire prevention fails, it may be the forester and fire fighter who risk their lives.

Presuppression -- Getting Ready



Back-pack sprayer.

When Paul Revere made his famous midnight ride, it didn't take long for the citizens of Lexington and Concord to come to arms. It didn't take long because they were ready. They were "minutemen" – ready at a minute's notice.

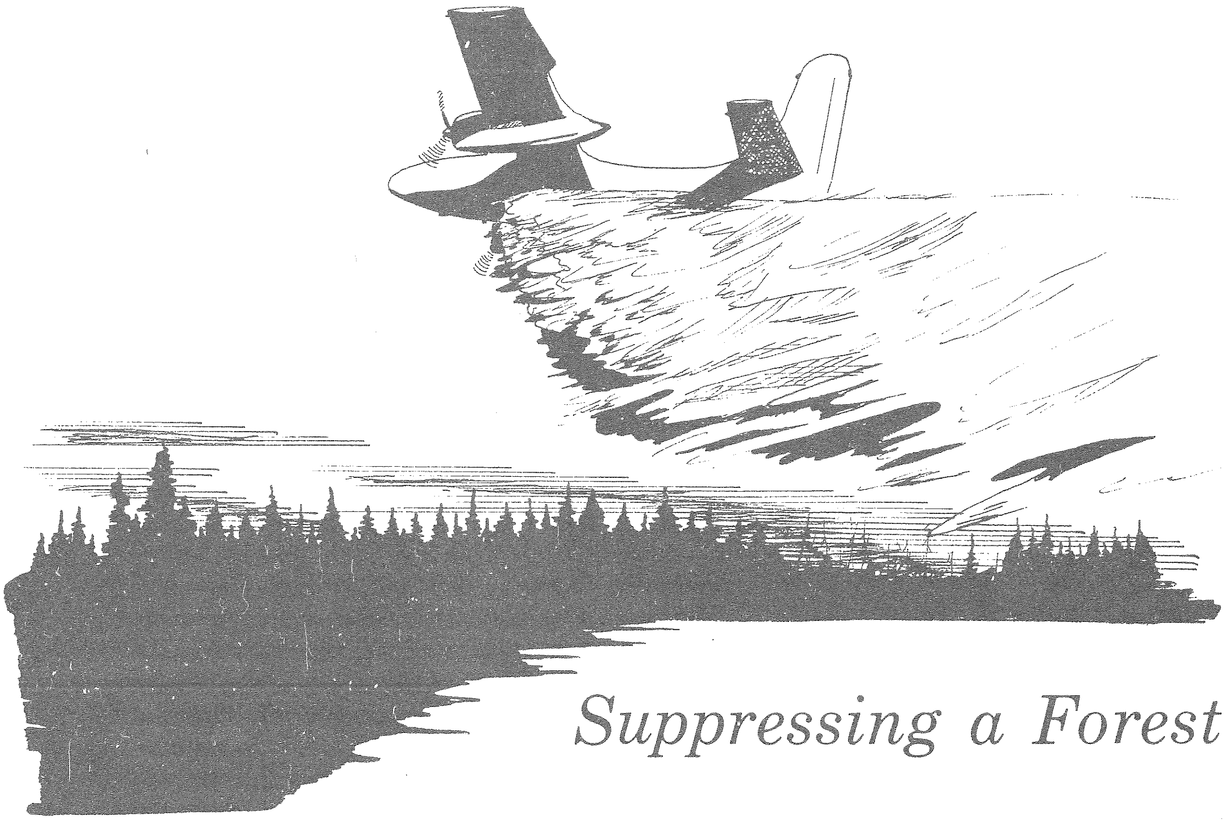
If you were a DNR forester with the job of protecting the state's forests from fire, what might you do to be ready, to be among the "minutemen" of the revolution against forest fires?

One plan would be to place fire fighting equipment strategically around the most fire-susceptible areas of the state. And that is just what has been done. Helicopters with buckets that can pick up water from nearby streams and lakes are stationed each fire season in explosive areas. They are ready on a moment's notice to take to the air and quelch a blaze before it gets out of hand. World War II bombers, equipped with tanks of fire-suppressant chemicals are also on call to fight major fires. And each Minnesota forest district has contracted with local heavy equipment operators who may be called in to bulldoze fire breaks and assist in other ways once a fire is under way.

In some districts, pickup trucks with pump tanks cruise fire-susceptible areas during periods of peak fire danger. They are linked by radio to any of dozens of fire towers or aircraft spotters. When a "smoke" is reported that doesn't appear on the local fire warden's burning permit list, these cruising pickups are often first on the scene. The fire-fighting capacity of such equipment is limited, but there is nothing like being right on the spot to assess the danger and fire fighting needs of a wildfire.

Cooperating with local weather bureaus, DNR forest offices keep the public continually aware of the degree of fire danger through news releases and radio broadcasts. Their alertness to dangerous wind and weather conditions, too, is presuppression.

Both prevention and presuppression have become more and more effective in recent years as is evidenced by the tremendous decrease in losses due to forest fires.



Suppressing a Forest Fire

It is a hot, dry day in August. There has been no rain for three weeks, and the forest around you is explosive tinder. As district forester you are in charge of combating all fires. Tensely, you go about your routine, expecting with each crackle of the radio or ring of the phone that this is the time.

The call may come from the tower south of town. Perhaps it will come from a neighbor. Or it could come from the DNR-contracted airplane that flies fire watch across your district. You never know which it will be, but only hope it will come soon enough to avert disaster.

"Say, we've got a smoke over here, south of Johnson's store. Doesn't look good . . ." Blankly, you set your coffee cup down and step to the radio microphone. "What do you think?"

"Better cover it."

"I'm on my way."

Like lightning, you're in the pickup truck and on the radio again. "What's the story?"

"It's bad all right," comes the word from the airplane pilot. "I'm ten miles north and I can see it already. Grass fire. Half an acre. Close to that big jack pine stand."

You know that fire wardens have not been issuing permits to burn for two weeks. It must be a wildfire.

Your first step is to alert the DNR helicopter stationed 60 miles away. It can be there in less than a half-hour. Then you call city hall to sound the fire alarm. You give the dispatcher all the particulars on the way out of town.

The fire danger is so extreme that a second fire call could come in at any time. Should you have stayed behind to watch the radio or sent someone else out in the truck. Yes. No . . . if that jack pine starts with the wind the way it is today, half your district could go up. Tom can handle things at the office.

Nervous, you call the pilot again. He is now right over the fire. "Jim, what's the wind like? How's it look?"

"Not good at all. Twenty-five miles an hour. Gusts to 30. Northwest. Right into the trees. We have 15 minutes, maybe 20."

You are sweating now. Where is the best place to refill your pickup's water tank? That's right, Johnson's have a pond.

"How'd it start, Jim? Any ideas?"

"Looks like the trash burner back of the store. Still sparking."

You roll into the road behind Johnson's Corner Store. It's bad all right. In seconds you must make decisions that can lose or save thousands of dollars, maybe even human lives.

You cut across the field toward the fire front. The hose is out and you're spraying, wetting the unburned grass along the front. Instinctively you work, and in minutes your tank is dry.

Then you're in the truck again and on the radio. "We can't cut it, Jim. No way. Where's the chopper?"

"Five miles out. Be there soon."

You head for the pond to refill the pickup truck's water tank, and you're back at the fire in minutes. Your first efforts have clearly slowed part of the advancing front, but now several limbs of the fire are within a hundred yards of the first trees.

Back and forth you go, spraying water across the 20-acre field wherever the fire threatens most. Other fighters have arrived and you have hardly noticed them as they work beside you with water cans strapped to their backs. You don't notice the arrival of the 'copter at all as the pilot dips the 500-gallon bucket into Johnson's pond and heads for the blaze.

In one drop, the bucket-carrying helicopter does what ten ground fighters would do alone in half an hour. In ten drops, it stops the advancing fire a dozen yards from the pines. You wave the pilot off with a tired smile and a nod of thanks.

Without the help of the helicopter, you would have been in big trouble. Wearily you issue orders for final cleanup and start back to headquarters. It might only be a matter of minutes before another call comes in.

It could have been much worse. If the fire hit the trees, you would probably have had to call in the B-26 bomber from Duluth. Dropping a fertilizer-like water solution of fire retardant, the bomber could have bought time while ground workers cut a firebreak.

You might have used aerial sensing to identify "hot spots" within the fire, spots where the bomber and helicopter would be most effective. If the fire had reached the peat lands southeast of Johnson's acreage, you might have used the district's track vehicle, called a Bombardier, to cut a track around the fire.

In some locations, you would have used individual ground fighters, some working two shifts without a break, with shovels, rakes, and even wet gunny sacks. The fire could have demanded more than a hundred fire fighters.

As you pull into the headquarters lot, you wipe a sooty face and breathe a momentary sigh of relief. Odds are, you tell yourself, that there won't be another call today. But then you reconsider. Often during such days you have had half a dozen fires to fight.

When will one get really out of hand? All you can do is hope it never happens – and do your best if it does.

Researching Forest Fires

Researching forest fires and their effects is not like studying other things. Your laboratory is usually a crisis in which you don't have time to step back and theorize about what is going on or how to do things better.

But looking backward after a fire can provide important data for future study. A lot of research is done to evaluate fire conditions. The result is a computerized fire danger rating system which takes into account such things as fuel types, weather, and wind conditions.

Other research evaluates equipment and adapts already available machines to fire fighting. In Minnesota, helicopters with buckets, World War II bombers with massive fire-retardant tanks, pontoon planes called "water bombers," and the "bombardier" track vehicle for fighting lowland fires are all products of this sort of research.

Research discovered the fire-retardant properties of liquid fertilizers like ammonium sulfate which may be dumped on larger fires from bombers.

Safety for the fire fighter is another subject of research. Fire shelters and protective clothing are the outcomes.

And infrared photography or television can be used to detect "hot spots" within an extensive blaze as well as the characteristics of fire spread.

As our knowledge of fires grows, prevention, and presuppression become more effective than ever. Someday, fire suppression may be almost a thing of the past. That is the ultimate goal of fire research.

Written and illustrated by Ron Royer. Published by the Education Section, Bureau of Information and Education, Minnesota Department of Natural Resources.

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