1978 MINNESOTA SCIENCE

Agricultural Experiment Station
University of Minnesota

Special Forestry Issue

Forestry Research After 75 Years

KEITH HUSTON
Director, Minnesota Agricultural Experiment Station

MINNESOTA'S FORESTS long have been valued and harvested as a great economic resource. Minnesotans have cherished the forests, lakes, streams, and wildlife for their beauty and privacy. Communion with nature contributes to our sense of well-being, to the importance of our individuality, and to a mysterious restoration of our spirit.

Out of our experience and research, we have come to learn that our forests still have much to contribute to the state's economic growth and substance. More research is needed on unused, overaged trees and species. We should find ways of tapping the potential productivity of all our forest lands. New products might be developed from under-utilized tree species and heretofore wasted bark, leaves, small branches, and other parts. New manufacturing processes for wood products should be explored. Wood as a renewable fuel source needs more investigation.

Managing forests and related natural resources for esthetic values and recreation and maintaining intricate ecological balances affecting climate, water resources, land productivity, and species balance are still only fragmentarily understood.

As the articles in this special issue show, our scientists have a broad understanding of the opportunities that exist and the talent to seek them out. Top scientific talents and adequate funds are keys to future accomplishments. But research leadership is important, too. Minnesota has been fortunate in this regard.

Since World War II, the period of signal accomplishments in Forestry, two men, first Frank Kaufert and now Dick Skok, have provided outstanding local and national leadership for forestry research. We salute them and the forestry researchers who have contributed to the strength of our forestry resources.

MINNESOTA SCIENCE
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Cover: Close-up photo of a red pine bud by Marsha Samways.

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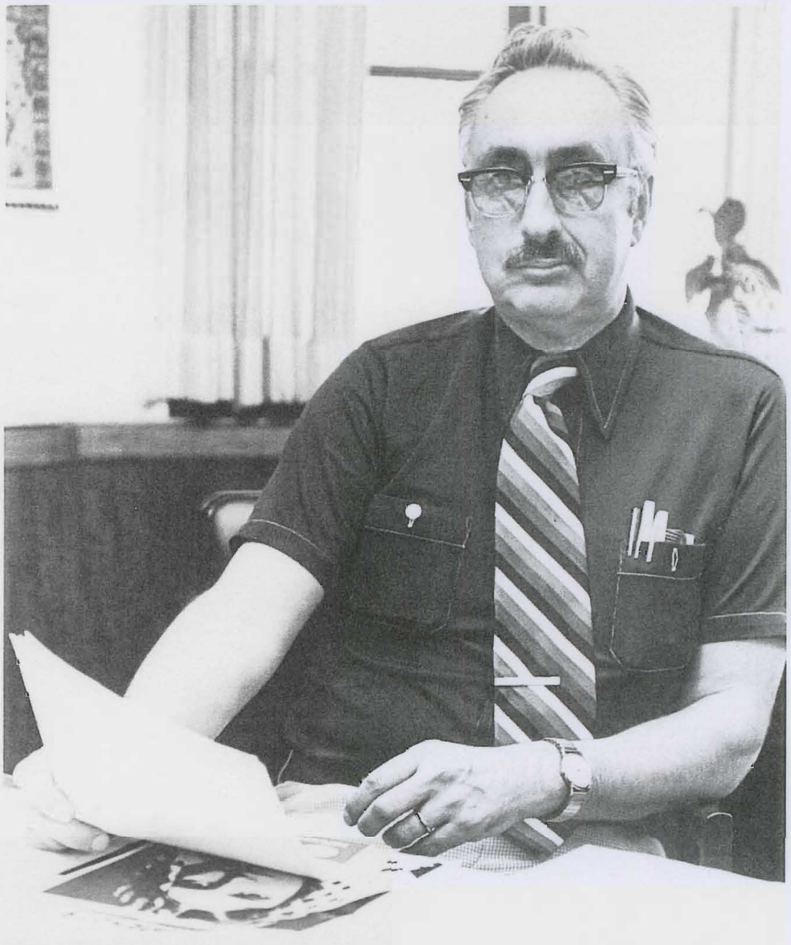
Diamond Jubilee of Forestry Research

RICHARD SKOK
Dean, College of Forestry



Dean Richard Skok (photo by Dave Hansen).

WHEN THE COLLEGE of Forestry was established in 1903, it was commissioned by President William Watts Fowell to undertake research ". . . in all phases of forestry" as well as ". . . the training of foresters to manage forest lands." In 1978 we can look back on 75 years directed to fulfilling these very missions.

The College, in partnership with the Agricultural Experiment Station, has had a continuous and rich forestry research program begun at the turn of the century under the leadership of Samuel B. Green. Space does not permit tracing this research program in detail. Establishment of the Cloquet Forest Experiment Station (now Forestry Center) in 1910 provided an important impetus for forestry research in Minnesota. Efforts of the College were minimally funded, however, over the first 50 years. Despite this, substantial study results were achieved in such diverse areas as tree species adaptability, wood preservation, shelterbelt design, reforestation techniques, and forest land use and taxation.

From 1950 to 1975 substantial growth in both state and federal support for forestry research occurred through the Agricultural Experiment Station. Much of this expanded research effort logically is being conducted by faculty of the College of Forestry. The rapidly growing demands on our forests and related resources in Minnesota and the declining acreage base of forest land require the continual search for information and knowledge that will unlock the problems these trends pose. Our current research efforts, partially described in the articles in this issue, are focused on two broad needs:

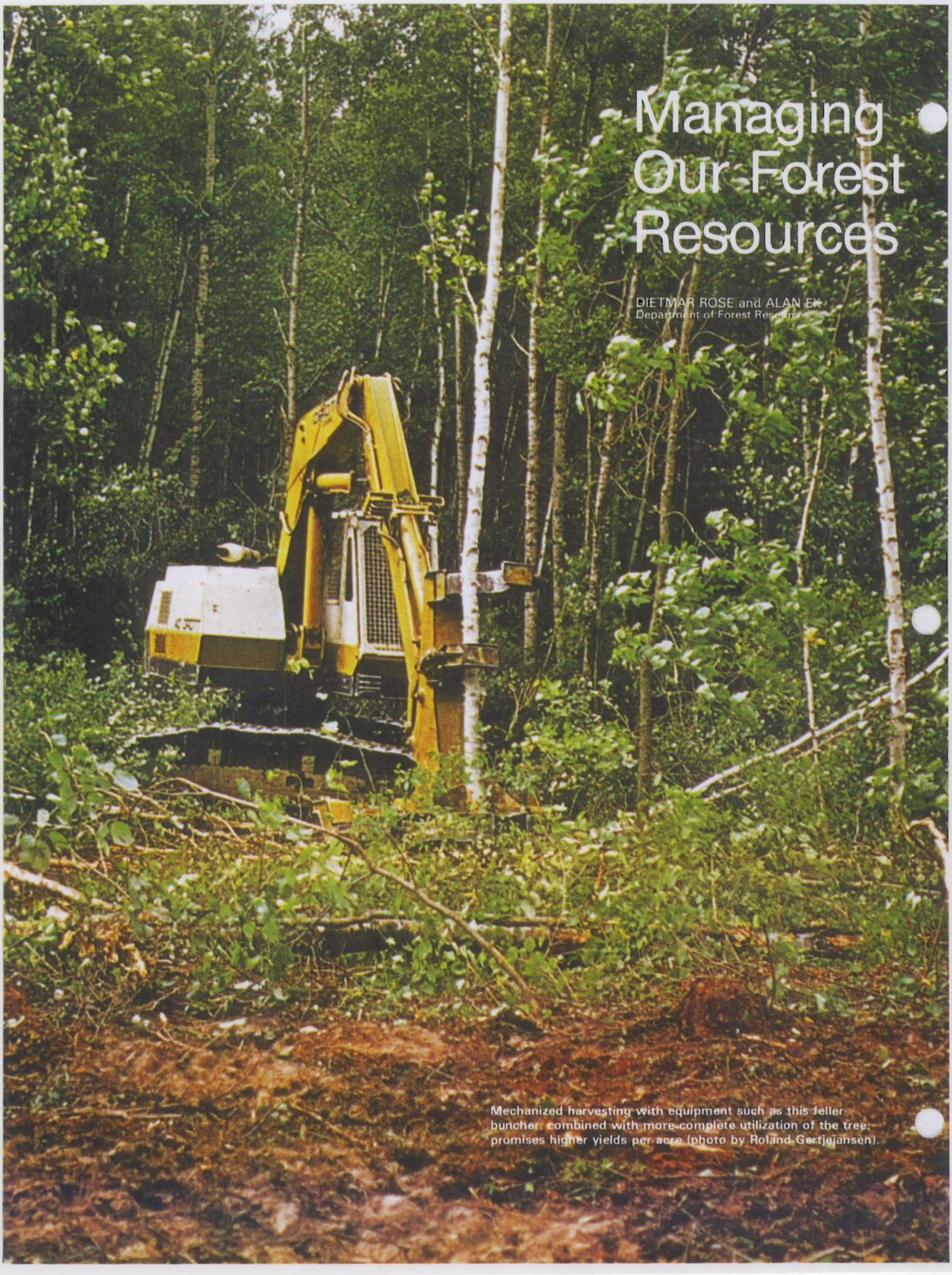
- increasing the productivity of forest land for those products, services, and amenities it is best capable of yielding or designated to produce, and
- improving the utilization and usefulness of available timber, recreation, wildlife, water, and scenic resources.

At present about 40 percent of the land area of Minnesota is forested. Of this, more than six million acres of forest land is owned and administered by the state and counties. The industry based on forest and wood products produces well over $1 billion of value in the state annually. Minnesota's forests provide vast outdoor recreation opportunities, extensive wildlife habitat, and a significant portion of our water supply. *Forests and forestry are important to Minnesota.*

It is estimated that less than one-half of one percent of the total identifiable annual dollar value produced by our forests and forest products industry is spent annually on forestry research. Because of the nature of forest resources many of our research projects are long term undertakings depending on a continuity of effort and support. We firmly believe the record of past and current accomplishment and the importance of this resource merits the continued support of this program by the people of Minnesota.

Managing Our Forest Resources

DIETMAR ROSE and ALAN EK
Department of Forest Resources



Mechanized harvesting with equipment such as this feller-buncher, combined with more complete utilization of the tree, promises higher yields per acre (photo by Roland Gertjejansen).

MINNESOTA'S FORESTS contribute in many ways to the social and economic well being of the state. The growing forest products industry contributes substantially through taxes and business investments to the state's economy. The role of forests in determining the quality of life, especially in terms of recreation opportunities, is also well known.

Minnesota's forests have the potential for yet increased contributions to the state's economy; they are presently growing more wood each year than is being harvested. The present annual surplus of almost 2.5 million cords is mostly in overmature aspen and low quality northern hardwoods. The aspen surplus poses a problem, however, because if it is not harvested in the next one or two decades, a substantial portion will be lost to natural death and decay and the sites will revert to less productive vegetation. Unbalanced stand age-class distributions as well as less than optimal distributions of species and cover types across the state present other problems forest managers must face in the coming years.

In contrast with the present surplus of timber is the long-range prediction of timber shortages in the state. By the year 2000, the demand for our forest resources by the forest industries may exceed the supply. Such a situation is based on the assumption of current standards of harvest, management, and utilization. Increased adoption of full-tree harvesting, improved efficiencies of resource utilization in manufacturing, and utilization of currently unused wood wastes can change the long range outlook for timber supplies in the state. New uses such as energy production, however, could add to the pressures on the resource.

One important area of research is the assessment of the impacts of increased harvesting activities on the forest resource. There is evidence that increased cutting of the overmature age-classes and transition to more balanced levels of growing stock by stand age-class could increase growth by as much as 25 percent. Additionally, growth increases of 20 to 40 percent are possible through intensified management practices. Intensive culture of selected forest tree species including hybrid poplars promise yields five to eight times higher than present timber stands. The economic feasibility of such intensive fiber production systems is under investigation. They have the most potential for currently marginal agricultural land.

To avoid losses in overmature timber and speed the conversion to full regulation of our forest resources, new uses for wood such as particle products and energy production should be considered. Wood can contribute to the solution of pending energy shortages and appropriate conversion technology is available for immediate implementation.

Wood can be a technically and economically feasible source of energy for electric power generation in Minnesota today. Several areas in the state with large surpluses of overmature aspen and underutilized low quality hardwoods have the potential to supply small wood-fueled power plants on a continuous basis. The most suitable region is the northwestern part of the state. Small, local wood-fueled power plants are almost competitive with fossil fuel plants of the same size and offer many advantages. Adverse environmental impacts of the plants are small because of the low sulphur content of wood and there is the possibility of capturing the wood ash for recycling as fertilizer. The economic impacts of small power plants based on local, renewable resources are estimated to be substantial. More than 200 permanent jobs would be generated with the construction and operation of a 25MW power plant, for example. Such a plant could provide electricity for about 25,000 people. The electricity is produced closer to the consumption area and in many cases could be carried along existing power lines, eliminating the need for new high voltage lines. Regional energy self-sufficiency is one of the greatest positive benefits of utilizing a local, renewable resource. Increases in basic employment, and revitalization of regional wood industries would contribute to regional economic stability. Increased cutting of low quality stands can lead to improved growth, improved habitat for wildlife, and improved recreational access.

Current timber surplus, projected timber shortages, and unbalanced inventories by age-class pose challenging problems for research on forest resource development. Recent progress has provided unique opportunities to assess our forest resources and analyze opportunities for investing in our timber lands. As an example, the 1976-77 forest inventory data are giving us an up-to-date picture of forest conditions on a regional basis. Techniques are also just becoming available to facilitate more complete stand description at the local or management level and to project future conditions of forest inventories under alternative silvicultural treatments. Following the identification of economically promising management alternatives via investment analysis, regional economic models are being utilized to assess the potential economic, social, and environmental impact of alternatives after their implementation.

There exist many more opportunities to improve our forest resources than there are funds or manpower to handle the job. The limited availability of manpower and capital emphasizes the need to consider the trade-offs among alternative management strategies. Strategies that contribute the most to the public welfare are being identified. Projections of supply and demand under reasonable assumptions concerning timber utilization, population growth, and overall economic conditions will help identify the funding for management programs required to meet the needs of all users of the forest resource.

Utilizing Low Grade Hardwoods

STEVEN SINCLAIR, ROBERT ERICKSON,
and JAMES BOWYER
Department of Forest Products

MINNESOTA IS BLESSED with abundant forests. Its forest products industry employs over 56,000 people who produce over $1 billion of products annually. However, Minnesota utilizes less timber per acre than any other Lake State. Hardwood trees are growing much faster than they are being cut. For example, from 1960 to 1977 in Carlton, Cook, Koochiching, Lake, and St. Louis counties, the volume of hardwoods increased 19 percent. Many species such as aspen and paper birch are short lived and, even though their volume may increase, their quality will decrease after they reach maturity. There is an increasing need to effectively utilize our hardwoods as they reach maturity.

The Department of Forest Products in the College of Forestry has long been aware of the need for increased utilization of hardwoods and for a more integrated approach toward the utilization of hardwoods and softwoods in our state. In responding to this need, a continuing effort in hardwood utilization has centered around investigating the use of aspen for many purposes. However, the use of other species has not gone untouched. Research efforts have been directed towards the kiln drying of oak and the marketing of other low grade hardwoods, especially elm. Recently there has been an emphasis toward an integrated approach to the harvesting, processing, and marketing of our timber. This will increase the number of trees and proportion of each which are utilized from a site and will insure trees are used for those products which provide the greatest economic return. A training program for the continuing education of sawmill operators, dry kiln operators, and others complements the research program.

Aspen, our state's most abundant timber resource, was for many years thought to be of value only as a fiber source. However, with potential shortages in spruce, pine, and fir for house framing lumber, research was begun to evaluate the suitability of aspen as a substitute for these species. Various sawing techniques were examined to determine the ones

Equipment that chips harvested trees for particle products allows greater use of low quality trees and makes the utilization of a much larger proportion of the tree more economical (photo by Richard Skok).

which would produce the straightest lumber after kiln drying. Test homes were built with aspen lumber, and marketing surveys of lumber dealers selling aspen were conducted. Drying problems with aspen lumber have been studied and visual criteria for sorting the lumber before kiln drying have been identified. The use of presorting shows great promise for increasing drying efficiency and product recovery. The economic feasibility of a variety of different manufacturing methods for aspen were studied, and the most profitable methods identified. Research in aspen utilization and processing has been fruitful, for aspen has now become an important species to the lumber industry in Minnesota.

Problems in utilizing other hardwoods are also being studied. The kiln drying of two-inch thick green oak lumber can take as long as three to four months. The expenditures of time and energy involved in this process are prohibitive. However, recent research in the Forest Products Department has shown that it may be possible to shorten the commercial drying time by about 20 percent without increasing drying degrade of the lumber. This constitutes a significant savings which can increase our lumber industry's competitive position.

A Finnish product, blockboard, is being adopted to utilize hardwood species in Minnesota. This panel product can be used similarly to plywood and particleboard and will be made from combinations of native hardwoods. A major advantage of blockboard, in addition to using our native woods, is that a blockboard plant requires only one fourth to one third as much money to build as a plywood plant.

A beautiful example of research matching native forest resources with local needs is the pioneer work in the use of elms killed by Dutch elm disease. One project is evaluating the use of elm lumber as a facing for highway noise abatement walls in the Twin Cities. An elm wall has just been erected and results are promising. The potential market for elm and other native hardwoods used in this manner approaches 500,000 board feet per year. The Forest Products Department has also provided technical assistance on the fuel potential of diseased elm and its availability to the Stillwater wood pelletizing project.

In addition to single species research, work is being done to integrate the use of Minnesota's forest resource. The thrust of this effort is to insure the best economic return from each part of the tree. For example, the department recently completed an economic evaluation of the gains to be derived from sorting the high quality portions of trees for lumber during whole-tree chipping operations. Work in this area emphasizes the total tree biomass and evaluates the best use of all parts of the tree, even down to the bark.

In addition to its research activities the Forest Products Department operates training programs for members of the wood industry. Several sawmill clinics are held each year in various parts of the state. Short courses on kiln drying, hardwood lumber grading, the retail lumber business, and other topics are also offered annually. By keeping industry members informed of new developments and techniques, the department hopes to help Minnesota's industries remain efficient, productive, and competitive.

A cross section view of blockboard shows the use of native hardwoods laid edge to edge and overlayed with veneer (photo by Steven Sinclair).

Even with its abundant forests, Minnesota still imports more forest products than it sells outside the state. With markets existing close to home, the prospect of growth for our state's industry seems good. Our program of forest products research combined with vigorous training programs will continue to provide the technical information needed for the forest products industry to grow, remain competitive, and provide an increasing number of jobs in the state.

Water, Forests, and Research: A Minnesota Partnership

KENNETH N. BROOKS and
JOHN C. CLAUSEN
Department of Forest Resources

FORESTS AND WATER coexist in a partnership not unlike the bond between man and water. Forests need water to exist. Likewise, forests regulate runoff and to some extent help purify flow to streams and lakes. If this balance is altered in any way, changes occur. Thus the management of forests encompasses the water resource as well as timber, wildlife habitat, outdoor recreation and forage production.

The primary research goal of forest hydrologists at the College of Forestry has been to understand the linkage between forests and water in Minnesota and explain how changes in the forest environment affect the water resource. Nowhere is the association between forests and water more evident than in Minnesota. Forests provide the setting for most of our 15,000 lakes (10 acres in size or greater) and form the headwater areas to three major watersheds: the Mississippi River, Red-Rainy Rivers, and Great Lakes.

Research in forest hydrology over the past several years has addressed many multi-disciplinary resource problems facing the State and region. Some resource problems which the College has studied include:

What are the effects of mechanical harvesting of timber on soils and on water movement into and through forest soils?

How does outdoor recreation in the Boundary Waters Canoe Area affect water quality?

How do users of recreational areas perceive water quality?

Can we dispose of wastewater from small communities in the Iron Range and, at the same time, revegetate mine spoils?

Can aerial photography be used to detect and monitor the quality of lakes in Minnesota's remote areas?

Can we develop better computer models capable of predicting snowmelt and streamflow from forested watersheds for better flood forecasts?

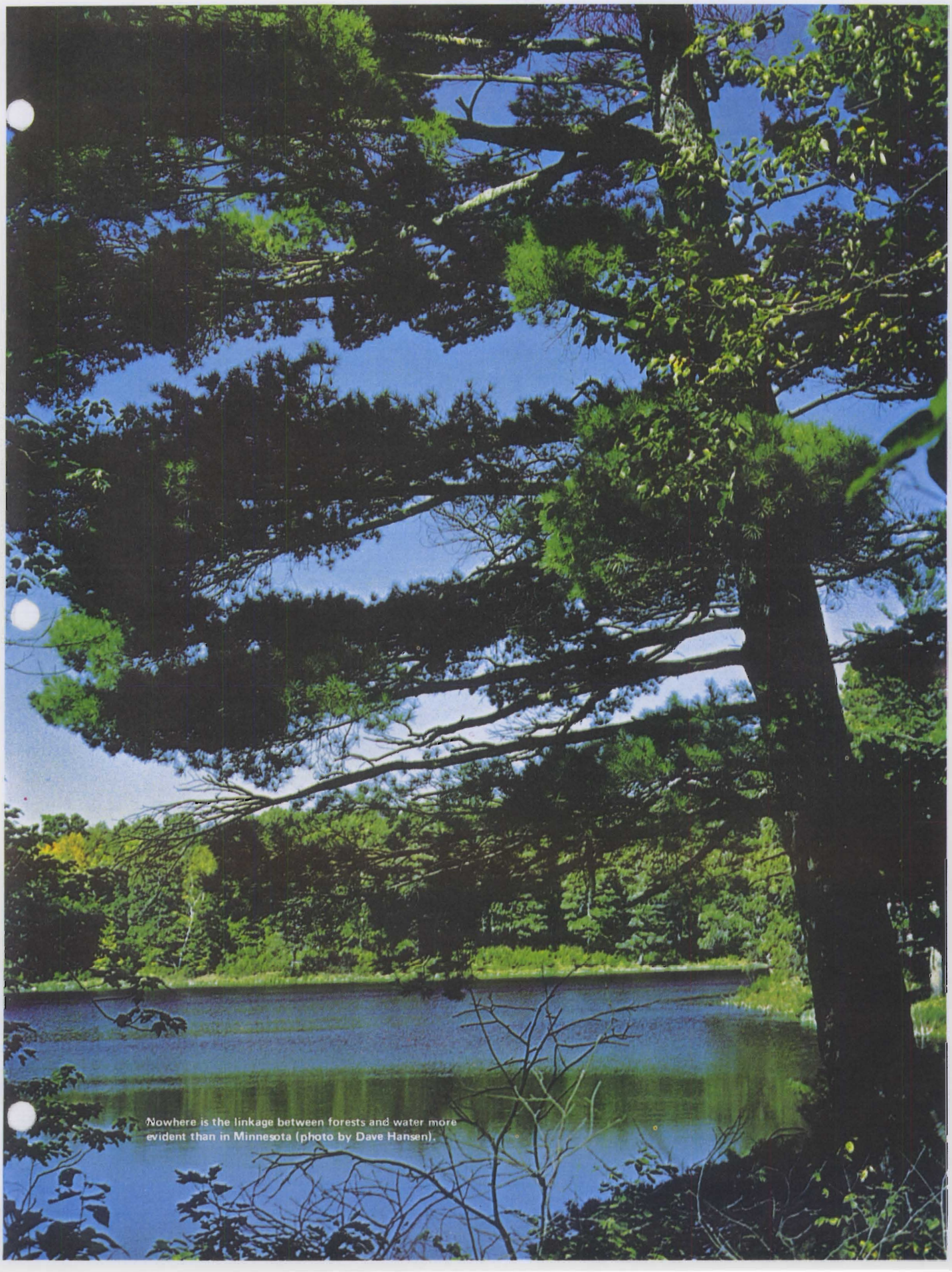
What are the effects of various forest management alternatives on water quality and what are the economic effects of changing water quality?

As evidenced by this list of recent research activities, forest hydrology studies frequently involve other disciplines such as soils, recreation, remote sensing and economics, to name a few. The common denominator in most of the past and present research is the water quality problems which accompany man's activities in the forest.

Presently, forest hydrologists at the College of Forestry are involved with two major water quality-land use research projects. One project is aimed at understanding water quality characteristics of streamflow from forested watersheds. Three watersheds in northeastern Minnesota on the Superior National Forest, have been instrumented to measure streamflow and water quality characteristics such as suspended sediment, nitrogen, and phosphorous. These watersheds will be monitored for several years to determine natural water quality characteristics. Timber will then be harvested on two of the watersheds and monitoring will continue to determine the harvesting effects on non-point pollution. The lack of such information today is hampering efforts by the State of Minnesota to establish management guidelines to meet water quality goals.

The second major project involves evaluating projected peatland development. Potential large scale harvesting of peat for such uses as fuel or horticulture poses several hydrologic and other environmental questions. Peatlands cover about 12 percent of Minnesota and up to now have remained relatively undeveloped. Will harvesting peat on thousands of acres increase flooding during wet years such as 1978? Or, will such harvesting reduce streamflow during drought periods such as 1976? Also, will nutrients be released from such harvesting and if so, how will the quality of downstream lakes and streams be affected? To provide answers to these and other questions, the College established a centralized field laboratory at the Cloquet Forestry Center and established several study sites scattered throughout major peatland areas in northern Minnesota.

Information leading to a better understanding of the Minnesota partnership between forests and water has been developed. Many of Minnesota's water resource problems have been resolved by such research. Many have not and are yet to come. With continuing research in forest hydrology perhaps we can utilize the extensive natural resources in Minnesota without damaging one of our greatest resources and one for which we are famous — our water.



Nowhere is the linkage between forests and water more evident than in Minnesota (photo by Dave Hansen).

Wood Products for Farm Structures

FRANK KAUFERT
Dean Emeritus, College of Forestry

THE FOREST HAS BEEN the source for wood in its great variety of forms — from posts for fences and logs for log cabins through lumber and such panel products as plywood, particleboard, hardboard, and insulating fiberboards. These have been and continue to be the principal materials used in structures on farms and ranches in the U.S. and many other countries. Farm and ranch construction is one of our largest wood uses and one that will continue to be important even though the number of farms and ranches is decreasing and such substitutes as steel and concrete are finding added use.

Because of the magnitude of the use of wood for farm structures, the increasing cost of wood products, and the need to conserve our forest resources, it is important that we make every possible effort through forest products research to stretch the supply of wood products. In addition, we should pursue forestry research directed toward growing more and better trees and forests for the production of wood products. The potential for such forest products research is indicated by the following examples taken from the research program of the Department of Forest Products, College of Forestry, over the past 30 years.

Experimental farm buildings, such as this turkey shelter at the Rosemount Experiment Station, demonstrate new techniques in slabbed pole construction and building insulation, as well as the use of preservative-treated wood poles (photos by John Neetzel).

Wood Preservation Research

Wood preservation research is designed to increase the durability or service-life of wood products. Increased durability can sometimes be obtained through changes in the design of structures and by using wood only in applications for which it is well suited. However, most of the increased durability of wood products is obtained by treating the wood prior to use with various chemicals — commonly called wood-preserving chemicals. Such treatment can be applied by farmers or ranchers to posts and other wood products used in contact with the soil or in other uses where decay and insect attack are likely to occur.

Farm and other fencing, such as that for highway right-of-ways, provide examples of how wood preservation research has paid rich dividends. Treatments have been developed to increase the durability of wood fencing and treated wood fence posts are generally recognized to be superior to substitutes in most ways. However, treated posts are harder to set. This short-coming has been overcome by the development of a low cost power driver that can be used on farms, ranches, and other locations.

Mechanical Fence Post Driver

The mechanical fence post driver was developed by the University in cooperation with the Danuser Company of Fulton, Missouri, and involved research extending over five years. By combining their expertise and facilities, the University and the Danuser Company were able to complete this successful research effort in probably half the time and at half the cost it would have taken either of the cooperators working alone.

Development of the multiple-post "Rosemount fence corner" has given farm and right-of-way fences a sturdy, economical foundation.

The mechanical driver is presently being manufactured in large numbers (many thousands) by the Danuser Company and is sufficiently economical for use by larger farmers or ranchers, by groups of smaller farmers, and by highway departments. This development has not only kept the long-lived treated wood fence post competitive, it has done away with much hard labor formerly involved in digging or drilling post holes.

Vacuum Treating Wood

Although fence posts and other wood products can be treated by cold soaking in vats, drums, or tanks of preservative solutions, better penetration of preservatives can be obtained if the treating process includes a vacuum period to remove the air from the wood. The construction of a simple and economical vacuum treating tank was first researched after World War II. The first plant using such a vacuum treating tank was built at the College of Forestry's Cloquet Forestry Center in 1948-1950. This small experimental treatment plant has been used annually since construction and has more than lived up to the expectations of those who designed and built it. However, more important than how this experimental plant has performed is the fact that it has been the model for larger vacuum treating tanks that have become the basis for large wood preserving plants treating millions of dollars of forest products annually.

Examples of other research projects that were equally as successful and productive as the fence post driver, wood preservation, and vacuum treating tank work include the Rosemount fence corner, the slabbed wood pole for farm buildings, preservative stains for farm buildings, the so-called "inside-out barn," and a variety of other farm structures involving special features aimed at better performance, longer service life, and the use of lower cost raw materials.

These examples of what has been accomplished through research on improving the use of wood in farm structures indicate what could be accomplished in the future through a much expanded program of research. If such an expanded program of farm structure improvement research could be undertaken in the 1978-1988 decade, the estimated cost-benefit ratio of 1 to 25 for the 1948-1958 farm structures research described above would, no doubt, be surpassed.

Intensive Forest Management Insures Future Wood Supply

ALVIN ALM, CARL MOHN, and EDWIN WHITE
Department of Forest Resources

Alvin Alm examines black spruce plugs grown in cavities of styro-blocks (photo by Al Hallgren).

MORE WOOD FROM FEWER acres is the challenge which foresters in Minnesota and elsewhere will face in the future. These pressures will result from an increase in the demand for forest products associated with a rising population and a reduction in the area of commercial forests as land is set aside for recreational purposes, highways, power lines, pipe lines and a multitude of other uses. Economists have projected a nationwide shortage of wood by the year 2000. In Minnesota we are particularly concerned with the future availability of wood from conifers needed to keep our pulp and paper industries healthy.

Intensification of forest management is perhaps the most promising way of insuring our future wood supply. Growth on much of our commercial forest land is well below its potential, and relatively modest investments could raise productivity significantly. College of Forestry scientists are deeply involved in the development and evaluation of practices which can be used to achieve these gains. Three areas in which members of the College have initiated research because of their potential value as components in intensive management systems are: genetic improvement of planting stock; development of planting systems using containerized seedlings, and use of fertilizers to accelerate tree growth.

Genetic improvement of planting stock is one of the most potent tools for increasing the productivity of forest plantations. Genetic gains are obtained at a modest cost. This is illustrated by tree improvement programs in the South and Pacific Northwest which have consistently paid dividends. Research in this area by the University began on a sustained basis in the mid-1950's, and it has produced an information base for long-term breeding programs. The work has also identified the best materials for immediate use in reforestation. The College of Forestry's program has involved at least 20 native and exotic tree species, and test plantings have been established at numerous locations in the state.

Recently the University has joined with public agencies and the forest industries in the establishment of applied improvement programs. There are now over 30 acres of plantings designed to yield both improved seed for commercial use and valuable genetic information. More plantings are being added each year. Materials in these plantings include both grafts and seedlings which in many cases were derived from earlier studies initiated by the University. Some of these special plantings, known as seed orchards, should begin to yield commercial quantities of improved seed within the next five to ten years. White spruce gains should be substantial with increases in growth rates from 10 to 15 percent. Similar work with black spruce is underway but scientists are less sure of the level of gain which might be achieved.

The containerized seedling concept offers a means of

maximizing the potential of genetically improved seed as well as increasing the effectiveness of planting programs. A containerized seedling is a tree grown in a container under controlled environmental conditions in a short time period. There are a number of different types of containers ranging from plastic bullet-shaped containers to styro-blocks in which the trees are grown in cavities and extracted as soil-root plugs for planting.

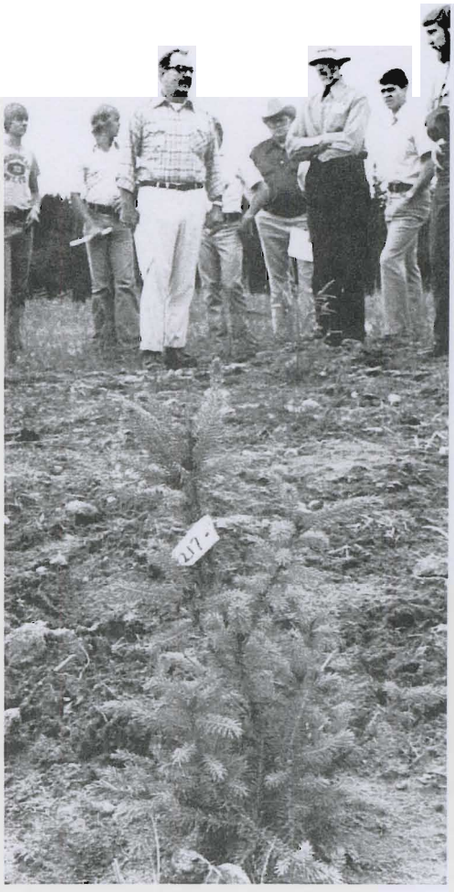
There are several advantages in using containerized seedlings in planting programs. One major advantage is the extension of the planting season which, with bare rooted stock, is squeezed into a very short time span in the spring. A second advantage is the reduction of "planting shock" because trees are planted with minimal root disturbance. In addition, plantable containerized stock can be produced in four to six months instead of the usual two to four years required to produce conventional stock and this gives more flexibility in planning. A final advantage to containerized seedlings is the rate at which they can be planted — it is nearly double that of the bare rooted stock now being used.

Research programs have been underway at the College of Forestry testing the various container systems, cultural techniques, and related planting site needs for several years. Minnesota reforestation programs are now ready to move ahead with use of container-grown stock. Several large-scale operational programs are currently underway with involvement of both private industry and public management agencies.

While genetically improved planting stock and containerized seedlings can contribute significantly to the productivity of plantations, combining these measures with other intensive management practices can multiply their beneficial effects. Among these other practices is fertilization, which has gained in popularity during the past 25 years and is currently operational in the forests of the Pacific Northwest and southeastern United States.

Investigations of the use of fertilizers in Minnesota to increase forest production are currently underway in the College of Forestry. In northern Minnesota fertilization trials are being conducted in cooperation with scientists of the Chippewa and Superior National Forests, Diamond International Corporation, Potlatch Corporation, and the Blandin and St. Regis Paper Companies. To date, 186 experimental plots have been established in stands of red and jack pine, white and black spruce, and trembling aspen over a wide variety of soils. Although it is too early to determine growth response, visual observations and preliminary data on nutrient uptake, increased foliage, and branch size indicate that species native on northern Minnesota sites are responding well to the added fertilizers. Similar fertilizer trials in southern Canada have resulted in nearly a 50 percent increase in merchantable jack pine and white and black spruce growth.

Producing more wood on less land will demand a variety of tools to accelerate growth. University scientists are working to develop or modify these tools to meet Minnesota conditions. With continued efforts we can insure a level of productivity in our forests which will meet projected demands.



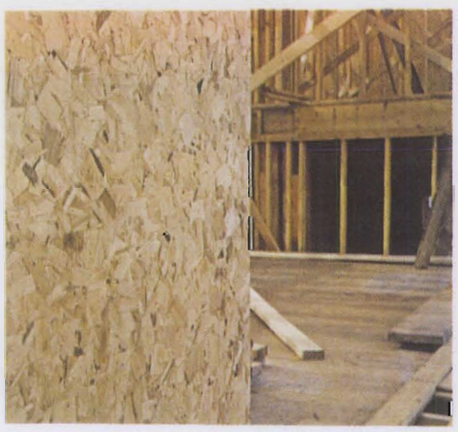
Visitors tour a black spruce seed orchard established at the University's North Central School and Experiment Station in Grand Rapids (photo by Dave Hansen).

Potential for Particleboard Production

ROLAND GERTJEJANSEN and
JOHN HAYGREEN
Department of Forest Products

SOFTWOOD PLYWOOD is the primary structural panel material used in housing construction. Principal applications are for flooring and roof and wall sheathing. The projected increase in the demand for housing in the U.S. and the world, coupled with a growing shortage of softwood peeler logs, means that sometime in the not-to-distant future there could be insufficient quantities of softwood plywood to supply the housing market. Therefore, other types of structural panels will have to be substituted for softwood plywood. Those that show the most promise are structural type particleboards. The advantage of structural particleboards is that they can be manufactured from wood residues and small diameter trees. In contrast, the plywood industry is dependent on a supply of relatively large diameter logs.

Waferboard offers promise as wall sheathing in residential construction (photo by Roland Gertjejansen).



Particleboard versus Plywood

Although structural particleboard has potential as a substitute for softwood plywood, the realization of this potential is dependent on the ability to design and manufacture structural particleboards with the properties needed for various construction applications. But what properties are necessary and how can the many manufacturing variables be manipulated to achieve these properties? These are the questions that researchers in the College of Forestry Department of Forest Products and other university, industry, and government laboratories are attempting to answer.

One of the ongoing research programs in the Department of Forest Products is an evaluation of raw materials, treatments, and manufacturing conditions to determine how to make structural particleboards as serviceable and permanent as plywood. Plywood is an accepted construction panel with a long history of satisfactory performance. Therefore building code officials, engineers, architects, and consumers will be measuring the properties of structural particleboard against those of plywood.

Loading Properties

The Department of Forest Products has done considerable research on the long-term loading properties of particleboard. For example, researchers are investigating how well particleboard performs when subjected to large concentrated loads, such as those exerted by deep freezers and hot water heaters. Relatively little is known about how particleboard reacts under these conditions of loading, and this information is important, if not necessary, when designing structural particleboards for specific uses.

Product Standards

The development of adequate yet realistic standards and test methods is important to the competitive position of any new structural product such as structural particleboard. Forest Products Department researchers are involved in work to establish nationally recognized standards for these products. They have been involved in developing and evaluating test methods to measure internal bond and impact strength. Much work remains in bringing the state of product standards for particleboard to the level of those for plywood. This is very important to ensure the consumer knows the nature of the product he is using.

Durability

Researchers in the Department of Forest Products also are concentrating on improving the durability of structural particleboards. In certain applications where relative humidities are high or where the product may receive periodic rainfalls, the structural integrity of the board must be maintained. To accomplish this, the board must withstand the degrading effects of swelling stresses, decay fungi, insects, and sometimes ultra-violet light. Impregnating phenol formaldehyde resins and tempering oils have been demonstrated to be effective in reducing swelling stresses. Currently, a study is underway that will assess the performance of several wood preservatives in minimizing or eliminating deterioration by decay fungi and termites.

Aspen Waferboard

One structural particleboard familiar to many Minnesotans is waferboard. These panels are manufactured from large aspen wafers bonded together by a waterproof adhesive. There presently is only one waferboard plant in the U.S., and that is located in Grand Rapids, Minnesota. Canada has several waferboard plants, primarily because of their abundant aspen resource. One manufacturer's waferboard has approval for wall and roof sheathing in U.S. residential construction and is now used to some extent for those applications. Waferboard is even more widely used for housing in Canada.

Minnesota has several species that can be used for the manufacture of various types of structural particleboard. However, aspen is a preferred species because of its relatively low density. This means that panels manufactured from aspen will weigh less than those with the same properties manufactured from higher density species.

Minnesota, like Canada, has a relative abundance of aspen. The U.S. Forest Service recently concluded that northern Minnesota has the aspen resource to readily support a large structural particleboard plant. It is estimated that approximately three times more aspen could be cut in Minnesota than is presently being cut on a sustained yield basis. Not all of this aspen is presently available for cutting, but the figures do indicate that a fairly large reserve is available for the expansion of our state's structural particleboard industry.

Paper Birch Waferboard

An under-utilized wood species in Minnesota that shows potential as a raw material for waferboard is paper birch. Paper birch and aspen grow together in mixed stands, and harvesting both species rather than only aspen has economic advantages. It is estimated that paper birch could comprise up to 25 percent of the wood from an average aspen stand. The primary disadvantage of using paper birch for waferboard is that its density is approximately 45 percent higher than that of aspen. However since only 25 percent of the panel would be birch, it may be feasible to utilize it, for example, as the core for a three-layer board. The panel would consist of aspen faces (top layers) and a birch center or core. Although this idea has merit, considerable research will be required to determine if there is a set of manufacturing variables that will result in a panel with properties comparable to those of an all-aspen waferboard.

Markets

The two major market areas for Minnesota structural particleboard plants producing panels for construction would be Minneapolis/St. Paul and Chicago. These markets are relatively close, and freight costs would be substantially less than those for softwood plywood from the South or West Coast. The first extensive use for structural particleboards in construction probably will be for roof sheathing. Flooring will follow. Although structural particleboard will be used for wall sheathing to some extent, low density fiberboard sheathing (insulation board), because of its insulating properties, low cost, and availability, will continue to be the most widely used panel for wall sheathing.

Samuel Okoro, research assistant, operates a hot press which is used for making particleboard in laboratory experiments (photo by Dave Hansen).

Forests for Recreation

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FORESTS, LAKES, PLAINS, and hills abound in Minnesota. The changing climate adds another dimension to the varied landscape. In the past, these ingredients provided for seemingly limitless outdoor recreation opportunities. There was plenty of room for everyone and everything; recreation planning consisted primarily of adding a few amenities like picnic tables here and there.

Times have changed. The outdoors is becoming crowded. Incompatible forms of recreation are competing for space and recreational use is making significant impacts on the environment. New technology has created additional demands. Recreation planners and administrators can no longer operate under the assumption that anything they do will be appreciated. Questions of equity, efficiency, and sensitivity to human needs have become more important. These questions can only be answered through a better understanding of our recreational resources and the people who use them.

Through its research program the College of Forestry has made important contributions to our knowledge of how people relate to the outdoor environment. Some projects have focused on the impacts of recreational use on the environment and how these impacts can be minimized. These studies provide recreation managers with guidelines for selecting suitable sites for campgrounds and other recreational developments, for laying out recreational facilities, and for controlling the use of these facilities.

Other investigations have attempted to determine the benefits people derive from outdoor experiences, their preferences for various types of activities and development, and patterns of use. These "people studies" help us to understand conflicts and public response to different management policies. They also guide recreation planners in allocating recreational resources to various uses and types of development.

A few examples of the contributions made through recreation research follow.

Park Ecological Studies

Visitors to Itasca State Park have long been attracted by the area's large, old-growth red pine. A study by the College of Forestry has documented the lack of pine reproduction to replace these old growth stands. Experiments have been conducted on how to convert the second growth aspen stands that are taking over old-growth sites back to the pine. The College of Forestry is now cooperating with Minnesota Department of Natural Resources personnel in a 15-year program to restore pine to several thousand acres in the park.

On Isle Royale moose are one of the major attractions. Drastic fluctuations in the numbers of these animals have been shown to be a consequence of changes in forest condition, browse supply, and incidence of fire resulting from park management and forest succession.

The College of Forestry provided a baseline description of the vegetation in Voyageurs National Park to aid the planning of future developments and evaluation of the effects of management policies and use. The preservation of natural ecosystems is a primary park objective; the information resulting from this study is essential to

meeting that goal. The description of vegetation will also contribute to the development of interpretive programs for park visitors.

Community Reaction to Park Development

Four Minnesota communities — International Falls, Virginia, Duluth, and Roseville — were sampled to obtain a cross section of attitudes towards Voyageurs National Park. As distance from the park increased, residents tended to have more favorable attitudes toward establishment of the park although, even in International Falls, over half were neutral toward or supported the park.

A number of factors helped to explain differences between the communities. Those closer to the park tended to believe that its establishment would have an adverse economic impact on the region. They also felt it would limit their recreational opportunities. Respondents living in more urban areas farther from the park tended to prefer those forms of recreation which would be favored by the park development.

Kettle River Study

The Kettle was the first river designated as part of Minnesota's Wild and Scenic Rivers System. In 1975 the College of Forestry embarked on a three-year study of the river in order to establish baseline data on use patterns and user preferences. The investigators also developed techniques which facilitate a comparison of use and preferences over time, space, and different groups of people. The results are in a form which can be readily translated into planning and management objectives.

Ski touring is growing rapidly in popularity and becoming an important use of public lands (photo by Tim Knopp).

Hunter Attitudes

Consideration for others can effectively reduce conflicts among those who share the outdoors and increase the capacity of our resource base to accommodate a variety of activities. To develop an effective educational program it is first necessary to know who holds particular sets of values and why. Hunting is one outdoor activity which lends itself to an investigation of this sort.

The tentative results of a College of Forestry study show a lack of consensus in attitudes, even among a select group of concerned hunters. This was especially true in their responses to items which indicated an appreciation for competing values. The study provides insights on the scope of the problem and suggests refinements for future research.

Ski Touring Study

Ski touring is a rapidly growing, resource-based outdoor recreation activity which has caught land use planners and area managers unprepared. There is an obvious need to gather information on user preferences, the type of people who are participating in the sport, and the potential for additional growth.

A study focusing on these questions was begun in the spring of 1978. The survey is designed to obtain data on motivations, environmental preferences, patterns of participation, the involvement cycle, skill level, and socio-economic characteristics of skiers.

County Forest Lands: Our Rip Van Winkle

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MINNESOTA has a long and colorful history of events shaping the uses and management of its 18 million acres of forest land. Of major importance have been the political and economic circumstances which led to the 2.9 million acres of land currently held by the state in trust for county governments. Part of this acreage reflects policies of land acquisition. The overwhelming portion, however, is the consequence of large scale tax delinquency which occurred during the 1920's and 1930's. More than three-quarters of this acreage is forested. As a landowner category, Minnesota county governments administer 20 percent of the commercial forest land found within the state.

Public policy regarding the use and management of county administered forest land began to unfold in the late 1930's and continues to evolve today. In the 1930's county administered land was the subject of debate which focused on the pros and cons of public versus private ownership of land. The preponderance of opinion suggested that tax forfeited land should be returned to private ownership as quickly as possible. This was understandable in light of county governments' desire for a tax base from which to secure much needed operating revenue.

The hoped-for surge in private demand for county land — anticipated for the late 1940's — failed to fully materialize. County governments found themselves continuing as custodians of large acreages of land. Public ownership had become a policy not by design, but by default.

The economic environment of the 1960's and especially the 1970's fostered renewed private interest in the purchase of county administered lands. Itasca County, for example, sold land at an average of 3,000-4,000 acres annually during the 1950's. Annual sales in the 1960's, however, rose to 15,000-20,000 acres, with a peak annual sale of 27,000 acres occurring in 1970.

Some county governments, like that of Pine County, have taken advantage of renewed private interest in purchasing county land by selling substantial acreages. In part, this reflects a continuing county desire to return such lands to the private sector where, hopefully, they would become generators of tax revenue. Other counties, like Itasca County, have been reluctant to dispose of the land they administer — or at least they have become so in the last 5-10 years. In all likelihood these counties view public ownership of forest land as a policy consistent with the interests of the publics they serve.

Private interest in the purchase of county administered land, reflected by increases in acreage sold and rises in the sale price per acre, surfaces very basic questions regarding long-range, forest landownership policy in Minnesota. The difficulty in developing such policy has been well stated by S. T. Dana, J. H. Allison, and R. N. Cunningham in *Minnesota Lands*:

> ". . . advocates of change (i.e., county ownership) in every conceivable direction exist. Some think that public ownership has already gone far enough, perhaps too far. Others see virtue in the expansion of public ownership at various levels of government. The differences in point of view are due largely to the diversity of emphasis placed on different objectives and to ignorance of the efficiency of various classes of owners in attaining those objectives."

The extent to which adjustments ought to be made in the amount of forest land administered by county governments is far from clear. Regardless of the direction taken, policies should be founded on a thorough understanding of forestry objectives being sought and the relative efficiency of various public and private landowner categories in achieving these objectives.

Such an understanding implies research that addresses questions like: what benefits and what costs result when forests are placed in various landowner categories? Are certain forest outputs like water, wildlife, timber, and recreation produced more efficiently by one landowner category than by another? What units of

government should be involved in decisions to sell county administered forest land — are more than county interests at stake? What guarantee against "poor" forest practices should county governments secure from purchasers of county forest land? What sort of policies would prevent forfeiture of previously forfeited forest land? And, which user groups would benefit from the sale of county land and which would be burdened with additional costs?

Adjustments in the amount of forest land administered by county governments is not the only county policy that is in need of attention. Equally important are state and county policies concerning levels of investment in county-administered forest land. For example, what is the physical potential of county forests to produce the many outputs that most forests are capable of supplying? The evidence is clear that county forest land is capable of producing greater timber volumes per acre per year than other Minnesota forest lands. To what extent should limited public financial resources be directed toward forest practices that will enable Minnesotans to capture this productive potential? Equally important, who in the public sector should supply these financial resources and what segments of the public should reap the benefits of such investments? Questions of this nature are difficult to address. They must, however, be confronted if effective policies toward county administered forest land are to be maintained and in most cases improved.

Minnesota's county forest lands are truly a major state resource. Whether or not they continue as "Our Rip Van Winkle" remains to be seen. Sound research programs fused with enthusiastic public leadership and an informed public will go far toward awakening this sleeping giant. The result could very well be an enhancement of the social and economic well-being of all persons within the state.

Science Notes

FIRE AS A TOOL

Because much time and money is devoted to fighting wildfires, it may seem foolhardy to light fires deliberately. But, carefully used, fire can be an important and safe land management tool. It has been successfully used to control insects and diseases, to control competing vegetation in forest plantations, to promote tree regeneration in forest understories, and to maintain certain vegetation types such as prairies.

The College of Forestry is now involved in developing a prescribed burning plan for the Mille Lacs Wildlife Management Area. The investigation includes the collection and analysis of information on the effects of fire on wildlife habitat and a study of regional patterns of weather suitable for prescription fires. The effort will produce technical descriptions of the major fuel types to permit more precision in the development of fire prescriptions. It will also outline a planning process for the use of fire and control of wildfires to improve wildlife habitat.

Another study underway is an analysis of fuel consumption and vegetation changes resulting from systematic burns on the University's Cedar Creek Natural History Area. Information on the effects of different burning treatments on plant species composition will provide a basis for predicting effects of wildfires and will also document the vegetative changes that result from fire exclusion on the Anoka Sand Plain. Burning differences being investigated are differences in frequency of burns (from once each year to once in ten years) and differences in intensities of burns. Fire intensities are determined from estimates of fire rate of spread and estimates of fuel consumption derived from before and after fire fuel measurements.

FIELD WINDBREAKS: ARE THEY DOING THE JOB?

Most of the field windbreaks in western Minnesota are single-row belts of Siberian elm. Trees within each row are usually spaced five or six feet apart. This close spacing, along with the

A student helps set a prescribed fire at the University's Cedar Creek Natural History Area (photo by Marsha Samways).

widespread branching habits of Siberian elm, results in a dense windbreak.

Dense windbreaks serve their primary purpose of reducing soil erosion, but they do not give uniform snow distribution over the protected cropland. Uniform snow distribution means uniform soil moisture for spring crops. Dense windbreaks cause snowdrifts to pile up next to the trees on the leeward side.

Besides depriving the protected cropland of additional soil moisture, deep snowdrifts near trees have two other disadvantages. When most of the protected cropland is ready for spring tillage and sowing, the land which was under the drift is still too wet to work. Therefore, this area must be worked and sowed later. And, when the snowdrift melts, the soil underneath is leached of valuable nutrients. As a result, this land area will require heavier fertilization.

Snow distribution patterns to the leeward side of dense Siberian elm windbreaks can be temporarily improved by thinning and/or pruning. This will allow some wind to filter through and spread out the snow. This practice is only a temporary solution, however, because Siberian elm sprouts heavily on cut stumps and on pruned trunks.

Second to Siberian elm in field windbreak use is green ash. This species has a more open crown which allows more wind to filter through resulting in better snow distribution. In addition, green ash does not require pruning. However, five- or six-foot spacing is also too dense for green ash. Studies indicate that green ash spaced at 10 feet will do the job.

Although green ash is well suited to windbreaks, it is risky to depend on only one species — a single disease could take a heavy toll. The College of Forestry, in cooperation with the University of Minnesota Agricultural Experiment Stations and the Soil Conservation Service, is testing other tree species which might be used in Minnesota field windbreaks.

DEICING SALTS AND TREES

Deicing salts, largely sodium chloride, are used to provide a dry pavement for safe, high-speed traffic movement during winter months.

As with other chemicals, deicing salts have costs beyond purchase and application. The College of Forestry with support from the Minnesota Highway Department is studying how much damage salt does to roadside trees and shrubs and how to minimize the damage.

Along salted highways, salt sprayed onto twigs was found to be the major cause (except for Dutch elm disease) of twig dieback in deciduous trees. Salt spray is the major cause of the very visible spring-browning of red, white, Scotch, and Austrian pines. Salt spray reduces the growth, worsens the appearance, and lowers the economic value of trees, although it seldom kills established plants.

Along city streets, salt entering the soil was the culprit causing marginal leaf scorch, branch dieback, and possibly plant death.

NO NITROGEN-FIXATION ON LEAVES

Extensive sampling over two summers in Minnesota and one week in Oregon showed virtually no nitrogen fixation occurring on the leaf surfaces of over 40 species of trees, shrubs, or herbs. Nitrogen deficiency, which is almost universal in Minnesota forests, is not alleviated by this type of nitrogen fixation.

In England large amounts of nitrogen are fixed from the atmosphere by bacteria living on the leaf surfaces of spruce and Douglas fir. These bacteria take the gaseous nitrogen from the air, biochemically reduce it and make it available to the trees. The bacteria do not form symbiotic relations as is the case with *Rhizobium* and soybean. Instead they live freely as do the *Azotobacter* bacteria which fix nitrogen in the soil.