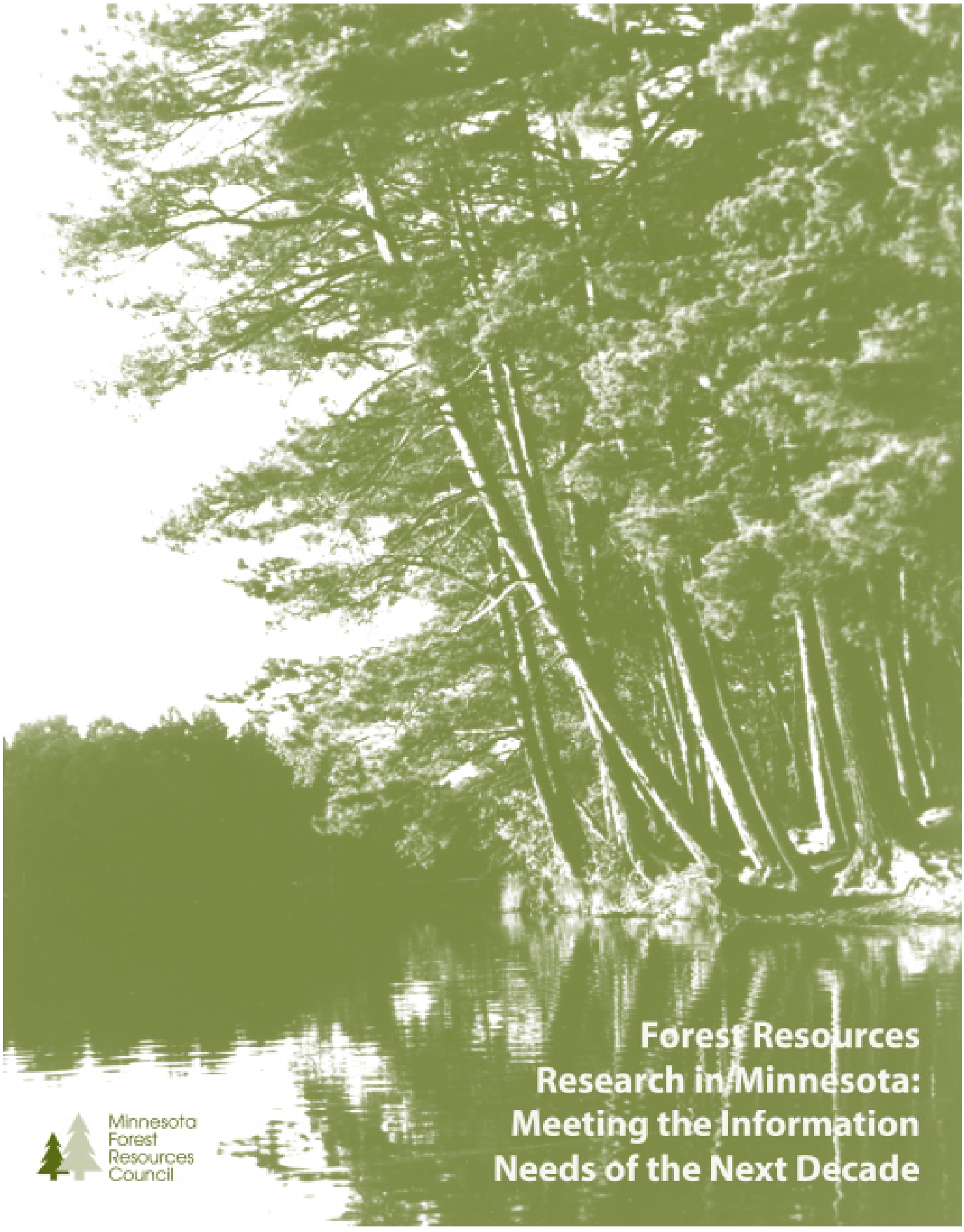

Forest Resources Research in Minnesota: Meeting the Information Needs of the Next Decade

Minnesota Forest Resources Council

This information is available in an alternative format upon request.

Forest Resources Research in Minnesota: Meeting the Information Needs of the Next Decade

Report Prepared by
Research Advisory Committee
Minnesota Forest Resources Council

Report Prepared in Response to Statutory Requirements of the
Minnesota Sustainable Forest Resources Act of 1995
(Minnesota Statutes Chapter 89A.08 Subdivision 3)
Minnesota Forest Resources Council Report #RP-0798

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Executive Summary

The sustainability of Minnesota's 17 million acres of forests is dependent on informed decisions about their use, management and protection. Critical to such decisions is abundant accurate, authoritative scientific and technological information. As expressed through various laws and policy directives, Minnesota has a rich history of commitment to carrying out forest resources research. Although research is conducted by several public and private organizations, engagement in forest resources research is of special concern to the University of Minnesota Agricultural Experiment Station, the University of Minnesota, Duluth Natural Resources Research Institute, the USDA-Forest Service North Central Research Station, and the MN Department of Natural Resource Division of Fish and Wildlife. In total, these organizations are responsible for annually investing $18 to $20 million in forest resources research.

The Minnesota Forest Resources Council envisions long-term integrity of the state's forest ecosystems and through this the sustaining of robust economies and communities that are dependent on the forests. To realize this vision, the state's forestry community must have access to ever-greater amounts of information. To meet this informational need, the research community should emphasize four broad areas of study over the next decade:

- forest ecosystem functions and integrity;
- economic and social aspects of forest resources;
- information and technology development pertaining to forests; and
- policies, programs and planning focused on forest resources.

Accomplishing this forest resources research agenda requires that the state address important challenges facing the research community. Most notable are the needs to plan and set priorities for research, provide sustained investments in research, establish mechanisms for coordinating research programs, provide access to talented and knowledgeable researchers, and transfer information generated by research programs to users and managers of the state's forests.

Based on research investments in comparable sectors, Minnesota's public and private forestry sectors have an opportunity to annually increase investments in forest research by at least $12 million during the period 2000 through 2010. Given the importance of forests to citizens of the state, such an increase is appropriate and very understandable.

Forest Resources Research in Minnesota: Meeting the Information Needs of the Next Decade

"... think of science and democracy as navigational aids in the quest for sustainability. Science linked to human purpose is a compass: a way to gauge direction when sailing beyond the maps. Democracy is a way to maintain our bearing through turbulent seas. The prudent voyager profits from the virtues of both science and democracy."[1]

Introduction

Minnesota is blessed with nearly 17 million acres of forests that provide a wide variety of goods and services to residents of the state. The use, management and protection of these resources - which range from intensive management for fiber production to wilderness designation - are dependent on wise and informed decisions by citizens and the many resource managers who have been asked to ensure the continued sustainability of the state's forests. If such decisions are to further the public's interests, they must be advised by accurate, authoritative scientific and technological information.

Examining Minnesota Forestry Research Initiatives

Research organizations and the products they generate are relevant to the extent that they provide information that enables more informed decisions about the use, management and protection of forests. To ensure this relevancy, Minnesota's public and private research organizations can benefit from periodically assessing, as a community, the status and overall direction of forest resources research. Doing so can foster long-term forward thinking about the research establishment, clarify the direction and focus of research organizations and programs, and generally improve research organization performance. In addition evaluation will promote coordination of research goals and objectives, enhance dialogue and discourse among research organizations, and build greater unity among the research efforts of diverse organizations.

The importance of periodically reviewing the status and direction of Minnesota's forestry research enterprise is acknowledged by the Minnesota Sustainable Forest Resources Act of 1995 (SFRA). For the state of Minnesota the SFRA calls for an assessment that:

- examines the current status of forest resource and related research;
- identifies important forest resource issues in need of research; and
- monitors progress towards addressing priority forest resources research needs.

The Research Advisory Committee to the Minnesota Forest Resources Council (MFRC) is responsible for carrying out this assessment and subsequently circulating information about needed research to the public, forest users and managers, and the state's research community. This document is, in part, a response to the research assessment called for by the SFRA.

Current listings of ongoing forest related research projects in Minnesota as well as detailed public comments and input on priority forest research needs are available by calling the MFRC Offices at 651-603-0109 or forwarding questions to seliason@forestry.umn.edu

Benefits of Scientific Research

The fundamental aim of science is to improve our comprehension of the natural and human worlds. This goal is accomplished by scientific research, wherein knowledge is added to the foundations of previously accumulated experiences. Specifically, problems are defined, testable hypotheses are formulated, experiments are conducted, and results are documented.

Scientific research applied to forest environments is the systematic search for new knowledge about the natural and human aspects of forests. Information provided by research enables Minnesota's forest users and managers to:

- enjoy a fuller and richer set of options for the use, management and protection of forest resources;
- appreciate the uncertainty and risk associated with various land-management, -protection and -use strategies applied to forests;
- understand with greater clarity the evidence and rationale for decisions about the use, management and protection of forests; and
- strengthen future decisions by providing insight to the consequences of former actions regarding the use, management and protection of forests.

Although forest research can and often does contribute to scientific understanding, it is primarily an applied science. It uses the results of other scientific studies to develop new knowledge and technologies that can be readily employed to adjust the way we use, manage and protect forests. These advances are often the cornerstone for ensuring sustainability of Minnesota's forests and the economies and communities that depend on them.

Minnesota's Forest Resources Research Enterprise

Commitments to Forest Resources Research

Minnesota has a rich history of interest in expanding knowledge about the state's forests and related environments. State agencies and state and national legislative bodies have addressed the need for focusing research on various aspects of forest use, management and protection. This is evident in language that establishes or describes various research units:

Agricultural Experiment Station, University of Minnesota

.... authorized to conduct, support, and cooperate in research activities deemed necessary to obtain scientific information about forest resources. Activities shall include, but not be limited to, forest resource management research, ... forest environmental research, ... forest protection research, forest utilization research, and ... forest resource assessment research. (MN Statutes Chapter 89.86 Subdivision 1)

USDA-Forest Service, North Central Research Station

.... authorized to conduct, support, and cooperate in investigations, experiments and tests necessary to obtain and disseminate scientific information about protecting, managing, and utilizing forest resources in rural, urban, and suburban areas. (Public Law 95-307, as amended)

MN Department of Natural Resources [forest wildlife]

.... conduct investigations to determine the status and requirements for survival of a species of wild animal or plant ... management programs for endangered or threatened species include research and census ... shall collect, compile and disseminate statistics related to wildlife conservation. (MN Statutes Chapter 84.0895 Subdivision 5; Chapter 97A.045 Subdivision 6)

Legislative Commission on Minnesota Resources

.... sponsor research that contributes to increasing the effectiveness of protecting or managing the state's environment or natural resources, including collection and analysis of information that assists in developing the state's environmental and natural resources policies. (MN Statutes Chapter 116P.08 Subdivision 1)

Natural Resources Research Institute

.... via research, promote economic development of Minnesota's natural resources in an environmentally sound manner to foster private sector employment.

All departments and agencies of state government

.... undertake, contract for or fund research as is needed to determine and clarify effects of suspected pollutants which may be detrimental to human health or to the environment, as well as to evaluate the feasibility, safety and environmental effects of various methods of dealing with pollutants. (MN Statutes Chapter 116D.03 Subdivision 2).

State government science and technology policy

.... government must play a significant role in supporting applied research and development initiatives. To maximize the impact, these initiatives in research and development must be closely tied to the research needs of the state's technology-based companies. (MN Statutes Chapter 3.222 Subdivision 4).

Research Conducting Organizations

Scientific information on forest resources in Minnesota has accumulated from the work of thousands of individual scientists who are affiliated with or sponsored by hundreds of research organizations worldwide. Minnesota has its share of locally based researchers and research organizations focusing on problems involving the use, management and protection of forests. Some, such as the USDA-Forest Service North Central Research Station concentrate primarily on forest resources. Others produce information that is applicable to forest conditions, even though doing so may not be central to their mission, for instance, the University of Minnesota Center for Transportation Studies. Listed below are four of the state's major public research organizations and examples of their forest resources research programs.

Agricultural Experiment Station, University of Minnesota. Research sponsored by the station is carried out via three major departments of the University of Minnesota College of Natural Resources: **Forest Resources** - research involves ecology, genetics, silviculture, protection, recreation, management, water resources, forest biology, resource assessment, and economics and policy; **Wood and Paper Science** - research encompasses primary and secondary manufacturing, including structural design with wood, composite products, paper and fiber science and technology, biotechnology, wood preservation, recycling, wood chemistry, energy conservation, and efficient use of wood; and **Fisheries and Wildlife** - research comprises fish and wildlife and their habitats, including forest-wildlife interactions, maintenance of biodiversity, and ecosystem analysis of forest wildlife conditions. Other university units addressing forest

resource questions include ecology, evolution and behavior; entomology; plant pathology; horticulture; plant biology; and applied economics.

Natural Resources Research Institute, University of Minnesota, Duluth. Research is carried out via programs within three centers: **Applied Research and Technology Development (CARTD):** *Forest Products* - research for forest industries on bio-based composite products, non-destructive evaluation of wood materials, and secondary wood products manufacturing including product and process design and improvement;. *Forestry* - Research for forest managers on hybrid poplar genetics, nutrition, and production systems, and on aspen productivity and management; **Water and the Environment (CWE) -** research on forest/aquatic interactions, landscapes, animal use of forests, conservation of forest biological diversity, ecosystem processes, forest productivity and health, and modeling forest structure and function; and **Economic Development (CED) -** technical assistance to businesses and organizations supported by training, education, and research.

North Central Research Station, USDA-Forest Service. A number of research work units at various locations carry out research in: atmospheric-ecosystem interactions and the social aspects of managing ecosystems, central hardwood silviculture and ecology, forest biotechnology, forest diseases, forest economics, forest insects, forest inventory and analysis, forest operations, ecophysiological processes, silviculture, human dimensions of ecosystem management, landscape ecology, managing forest environments for urban populations, and ecology and management of riparian/aquatic ecosystems.

MN Department of Natural Resources. Research focused on forest wildlife is carried out by three major administrative groups in the Division of Fish and Wildlife: **forest wildlife population and research group** - design, coordination and analysis of surveys involving forest wildlife, development of models relating population changes to forest management practices; **wetland wildlife population and research group** - forest wetland wildlife surveys and analyses, forest wetland restorations and influence on abundance and composition of waterfowl and waterfowl foods; and **farmland wildlife population research group** - coordination and interpretation of population surveys, wildlife population and habitat relationships (especially critical habitats), and evaluation of wildlife management plans and programs.

Private organizations also see the need to develop a larger body of knowledge about forests and related resources within the state. For example, The Nature Conservancy Ecosystem Research Program looks at ecosystem function in critical forest and related ecosystems. Also, Minnesota's forest industry engages in research on growing trees, utilizing wood fiber, and managing

sensitive wildlife species such as migratory birds. In addition, a variety of private organizations sponsor forest resources research. Notable in this respect are foundations such as the Blandin Foundation and the Northwest Area Foundation.

Presuming that all research-based knowledge about Minnesota's forests results from the efforts of researchers or organizations located within the state would be a mistake. It would also be a blunder to presume that organizations specifically charged with forest resources research are the sole sources of information relevant to forest issues. Broad interest in forest resources research is apparent from the plethora of organizations that sponsor research on forests and other associated resources. Examples of organizations in Minnesota that have provided funding for forest related research are:

Federal Agencies:
Agency for International Development, Department of Agriculture (Forest Service; Cooperative State, Education, and Extension Service), Department of Energy, Department of Interior (Bureau of Indian Affairs, Fish and Wildlife Service, National Park Service, USGS Biological Resources Division), National Aeronautics and Space Administration.

State Agencies:
Department of Natural Resources, Agriculture Utilization Research Institute, Department of Transportation, Pollution Control Agency, University of Minnesota Extension Service.

State Boards and Commissions:
Iron Range Resources and Rehabilitation Board, Forest Resources Council, Legislative Commission on Minnesota Resources, Board of Soil and Water Resources. County and Regional Governments: various counties and regional development commissions.

International Organizations:
International Energy Agency, International Society of Arboriculture, International Union of Forest Resources Organizations, United Nation's Environment Program. Corporations: Blandin Paper, Boise Cascade, Champion International, Dupont de Nemours, Lake Superior Paper, Louisiana Pacific, Mead Paper, Menominee Tribal Enterprises, National Council of Paper Industry for Air and Stream Improvement, Northwood Panelboard, Potlatch, Weyerhaeuser.

Foundations:
Blandin Foundation, Bush Foundation, James Ford Bell Foundation, McKnight Foundation, MN Four-H Foundation, Northwest Area Foundation, National Science Foundation, Wilderness Research Foundation.

Private Interests:

MN Deer Hunters Association, Association of Soil and Water Conservation Districts, National Urban and Community Forestry Advisory Council, The Nature Conservancy, Ruffed Grouse Society.

Clients of Forest Resources Research

The products of forest resources research are as diverse as the users of research. The users range from the state agency that needs to know about the status of water quality flowing from forested areas, to the conservation organization that hopes to learn about the diversity of wildlife in forested settings; and from the general public that wants to understand opportunities for recycling wood-based fiber products, to researchers who seek details about new quantitative models used to forecast future forest stand structures, to the forest products industry that looks for information on how to manage wood supplies in order to meet consumer demands.

Public agency clients for forest resources research in Minnesota include: various committees of the state legislature; state boards and commissions such as the MN Environmental Quality Board, Board of Soil and Water Resources, and MFRC; various units of state agencies such as divisions and bureaus in the MN Department of Natural Resources and the MN Pollution Control Agency; county forest land managing agencies; and the Chippewa and Superior National Forests. Private customers for forestry research include Minnesota's forest products industry and forest landowners, environmental and conservation nonprofit organizations, and natural resource consultants.

Research Investments

Considerable financial and professional investments in research involving forest and related resources are made in Minnesota. As described above, these investments come from a variety of research sponsoring and conducting agencies that are located both within and beyond the state's boundaries. Some of these organizations are core research units charged specifically with researching forest resource problems in Minnesota. Others have broader geographic responsibility for forestry research, although the information they provide has definite application to forestry issues within the state.

The University of Minnesota College of Natural Resources annually administers approximately $9.4 million of state and federal formula funds and grants for forest resources and related research. These funds provide support for approximately 55 to 60 scientist years of effort. Research investments made via the Natural Resources Research Institute which are focused on problems involving forest resources totaled $2.5 million in 1998. These funds supported approximately 15 to 20 scientist years of research effort. Wildlife research projects within the

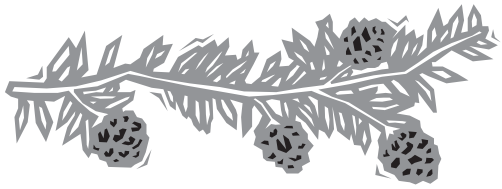
Department of Natural Resource Division of Fish and Wildlife also contribute to greater understanding of forest conditions. In 1998, forest wildlife projects in the division involved about $800,000 which supported 4 to 5 scientist years of effort.

Although responsible for conducting forest resources research in a seven-state region, the North Central Research Station of the USDA-Forest Service engages in research and development that leads to information directly applicable to Minnesota forests. In 1998, the station was responsible for guiding the investment of $15.3 million in 16 research work units. This engaged the talents of researchers whose annual combined efforts total 52 scientist years. An estimated $4 to $5 million (about 20 to 25 scientist years) of these total investments is focused on Minnesota conditions.

Private organizations also invest in forest resources research. They do so by sponsoring and conducting research within their own laboratories or field stations. Examples of private concerns that directly carry out research are wood-based companies within the state. These companies annually invest about $1.5 million in forestry and forest products research, a sum supporting 9 to 10 scientist years of effort.

Total investment in research that deals primarily with questions and opportunities pertaining to forest and related resources in Minnesota is probably in the range of $18 to $20 million and involves 100 to 120 scientist years of effort. Approximately one-third of these investments originate from public organizations within the state. Trends indicate that investments in forest resources research in Minnesota have not increased dramatically (except for inflationary adjustments) over the past decade.

Agenda for Forestry Research in the Next Decade



Agenda for Forestry Research in the Next Decade

Forces at Play in Setting Research Agendas

Minnesota's forests and the people and organizations interested in them exist within a world of rapidly changing human needs, available resources, and economic and social conditions. As consequence of these striking changes, sustainable management of the state's forests has become more and more complex. Contributing to this complexity is that conditions in Minnesota are not isolated events. State-level focus on particular forest resources issues is influenced by national and international incidents. This is apparent in matters such as the interest in old growth forests, attention to forest fragmentation, and concern over riparian area management — issues which originated in other states and countries and rapidly progressed into topics of discussion in Minnesota.

For the state's forest resources research enterprise to maintain a position as a significant source of scientific information, it must foresee and subsequently respond to the leading locally, nationally or internationally generated concerns regarding the use, management and protection of the state's forests. The research community's challenge is to properly identify and appropriately respond to these issues and problems.

Minnesota faces a collection of forest resource concerns about which knowledge is limited and which subsequently prompt the directions of state-based research. The state's forest resources community consistently expresses a need for expanded information about: how to ensure the biophysical health of the state's forest resources, how to foster the vitality of forested rural communities and regions, how best to capture positive advances in technology and information management, how to grapple with the growing complexity of policy and program development, and how to wisely and sufficiently invest in the state's forest resources and the economies and communities that depend on them. Not all of these concerns need the attention of research. Many may simply need existing information packaged and delivered in a useable form. Others are deserving of a more formal research approach.

Minnesota Forest Resource Council's Vision and Goals for Minnesota

The MFRC has identified several information-demanding topics concerning forest resources. [2] Many of these have implications for the state's research community. To assist those interested in Minnesota's forests in focusing on these topics, they have been embedded in a desired vision for the state's forest resources and a set of goals considered necessary to accomplish that vision.

The vision expresses a desired future for the state's forests and the people that depend on them, namely that:

> Minnesota forests are managed with primary consideration given to long-term ecosystem integrity and sustaining healthy economies and human communities. Forest resource policy and management decisions are based on credible science, community values, and broad-based citizen involvement. The public understands and appreciates Minnesota's forest resources and is involved in and supports decisions regarding their use, management and protection.

Specific goals set out by the MFRC that must be accomplished in order to realize this vision are to: enlarge and protect Minnesota's forest land base; ensure healthy, resilient and functioning forest ecosystems; sustainably manage forests; secure sustained and extensive forest-based economic and recreational opportunities; implement forest practices in effective and efficient ways; base landscape-level planning on ecological boundaries and collaborative decision making approaches; recognize public and private rights and responsibilities in forest management; develop effective and adaptive forest research programs; provide for compatible and comprehensive multi-resource information systems; accommodate a wide-range of constituencies in developing effective and supportable forest policy; and strengthen durability of and commitments to funding that accomplish the goals for the state's forests.

Information Demanding Topics

The MFRC has also identified a number of information-limited topics that may be impeding the state's ability to accomplish the forest resource goals listed above. Research could fill these information voids. Examples of topics identified are:

- extent and ecological integrity of forest resources;
- availability and accuracy of current information about forest resources;
- forest resource planning and organizational arrangements;
- use and management of private forests;
- funding investments in forest resource programs;
- use and management of state publicly-owned forests;
- long-term health and resiliency of forest resources;
- management and protection of urban and community forests;
- use and management of county-administered public forests;
- access required to use and manage forest resources;
- timber productivity of forest resources;
- forest-based economic development;

- alternative policy and practice influences on future forest resource conditions;
- opportunities for continuing education for natural resource professionals;
- global atmospheric change implications for forest resources;
- recycling of wood and related fiber;
- valuing and pricing nonmarket forest resource outputs;
- public funding implications for forest resource management organizations;
- educational initiatives to increase awareness of forest resource issues; and
- technological innovations needed to meet society's wood fiber demands.

Focused Research Emphasis for the Next Decade

The Research Advisory Committee (RAC) to the MFRC has reviewed the many forest resource topics that may be hindering the state's ability to accomplish the MFRC forest resources vision. In addition, the RAC requested comments from major public and private forest resource organizations in Minnesota and conducted two public forums to solicit citizen input on forest resource issues deserving of additional research.

After reviewing this information, the RAC identified four broad areas of research emphasis for the next decade. These are: ecological functions and integrity of forests; economic and social aspects of forest resources; information and technology development; and policies, programs and planning focused on forests. Within each overarching area the RAC describes one or more subareas of specific research. Each of the four research directions mentioned below represents one portion in an interlinked system of research needs. Research goals and objectives in the four areas intricately interconnect. Information limitations, associated research, and subsequent findings in one component impact and direct the focus of research and decision making in the three others.

Ecological Functions and Integrity

Protecting the ecological integrity of forests is fundamental to achieving long-term sustainability for Minnesota's forests. As an area of research emphasis, understanding ecological changes to Minnesota's forests must be accomplished by considering both landscape- and site-level interactions.

Landscape-Level Patterns and Interactions

Forested landscapes are defined as large (tens of thousands of acres), heterogenous areas dominated by forest cover and generally incorporating one or more geomorphic units and ecosystems. Minnesota has a strong interest in considering forest resource sustainability from a landscape context. The Generic Environmental Impact Statement (GEIS) on Timber Harvesting and Forest Management in Minnesota highlighted many landscape-level issues.

It recommended a comprehensive program to address forest resource sustainability at a landscape scale. Efforts are currently underway through the MFRC to develop a citizen-based program that facilitates analysis and dialogue on issues to promote sustainability across large forested landscape regions of Minnesota.

Reasons for emphasizing forest resource sustainability across forest landscapes are compelling. Landscape-level changes can significantly affect resource goals such as forest productivity, wildlife habitat, biological diversity, and long-term forest health. Limitations in data have restricted landscape-scale analyses of changes in forest resources. As a result, knowledge about how the accumulation of individual practices across a large area affect long-term landscape-level sustainability is quite limited.

Needed Research Response

Specific research needed to better understand landscape-level patterns and interactions includes:

- **Changing Vegetation Patterns and Conditions.** Forest age-class and cover-type structure along with spatial patterns of their distribution are examples of important information required in assessing landscape-level patterns and interactions. Research is needed to better assess and predict changes that are occurring to the composition and structure of Minnesota's forests. Additionally, research is needed to provide a better understanding of the cumulative effects of natural succession, timber harvesting, and forest management practices on broad-scale changes to forest vegetation patterns and conditions.

- **Fragmentation of Minnesota's Forest Land Base.** Forest fragmentation changes the structural diversity of forested landscapes, and can have a pronounced effect on floral and faunal biodiversity. Among the notable are: altered habitats that may exclude certain species, increased competitive relationships among species, loss of local or regional genotypes or ecotypes through inbreeding, and disrupted structure and function of component ecosystems. Research is needed to assess the historic frequency of fragmentation resulting from natural causes, current magnitude of forest fragmentation in the

state, and the primary causes of forest fragmentation and their impact on the overall health and productivity of forest landscapes.

- **Changes to the Minnesota Forest Land Base.**
  Forest land presently occupies nearly 17 million acres, or approximately one-third of the state's land area. This is one-half of the total forest land that existed prior to European settlement. While much of the change in Minnesota's forest land base coincided with the settlement of the state, changes to forested lands still continue. The most significant factor contributing to the loss of forest area has been land conversion for agriculture and urban purposes. In some cases, however, land once forested and converted to a non-forest use has been returned to a forested condition. Research is needed to accurately assess the degree to which forest land conversion is occurring today, specific areas in Minnesota where this conversion is most rapid, primary agents responsible for loss of forest land, effects of forest land conversion on regional biodiversity, and appropriate policy tools to encourage retention of land in a forested condition.

Site-Based Practices and Interactions

Site-based forest practices are the cornerstones for sustainable forest resources. If forest practices are not sustainable at the site, they likely will not be sustainable across large forest landscapes. The MFRC is responsible for developing voluntary timber harvesting and forest management guidelines for use by the state's timber harvesters, forest landowners, and natural resource professionals. These guidelines will address a variety of resources and values associated with forests by suggesting a range of scientifically sound, voluntary forest practices. The MFRC guideline development process has identified a significant number of information gaps related to specific management practices and their impact on the health, productivity and use of Minnesota's forests. Directed research is needed to better understand the relationships between various timber harvesting and forest management practices and desired resource management and protection objectives. Such information also provides insight into the short- and long-term effects identified with alternative timber harvesting and forest management practices.

Needed Research Response

Specific research is needed to better understand relationships between various timber harvesting/forest management practices and the following:

- **Riparian Zone Integrity and Function.**
  Riparian areas are the interface between surface water and adjacent land area. In a forested setting, they serve a number of important functions. They protect water bodies from pollutants, soil erosion, and exposure to

strong sunlight; provide habitat and diversity for both aquatic and terrestrial systems; and maintain recreational, aesthetic, and cultural values. In Minnesota, riparian forest management has been identified as a critical component of forest sustainability. Development of the MFRC timber harvesting and forest management guidelines has highlighted the limited availability of information about the science of riparian zone management and the long-term effects of applying harvesting and management practices in these areas. For example, what is the appropriate width of a riparian management zone for a particular site, and what types of practices will protect the riparian management zone without compromising silviculture and regeneration objectives? Research is needed to assess the short- and long-term effects of alternative harvesting and forest management practices on riparian zone integrity and function, long-term site productivity, and future stand composition.

- **Soil Productivity.**
  Soil productivity is the capacity of soil, in its normal environment, to support plant growth. Soil properties are a primary determinant of the productivity of forests in terms of timber volume, regeneration potential, and the production in the understory and ground-flora layers. It is also a key determinant of the potential diversity of plants and associated wildlife on a site. It is recognized that forest management activities can have considerable influence over soil physical, chemical and biological properties. It is further noted that the greatest impacts to soil productivity result from physical damage due to the development of harvesting infrastructure (roads, landings, and skid trails), as well as from compaction and rutting resulting from on-site trafficking. Certain soils in Minnesota may also be susceptible to nutrient loss from harvesting. The degree to which soils can withstand (or be enhanced by) forest management, however, is poorly understood. Research into the long-term effects of forest management on soil productivity, incorporating the key physical, chemical, and biological attributes of soil is needed. Additionally, research is needed to examine influences to soil productivity under various harvesting systems and utilization levels.

- **Wildlife Habitat Availability and Quality.**
  Minnesota's forests provide important habitat for five large and 22 small and medium-sized mammals, 150 birds, and 12 amphibians and reptiles. Timber harvesting and forest management activities can both enhance as well as reduce the quantity and quality of wildlife habitat found in a forested setting. Suggested harvesting practices that enhance forest

wildlife habitats are to retain dead and certain live trees as habitat for cavity nesting birds, to leave groups of trees or related vegetation considered especially important as wildlife habitat, and to alter timber harvesting patterns over large landscapes. However, precise relationships between these practices and long-term effects on wildlife habitats are often unclear. Research is needed to determine the long-term effectiveness of various practices on forest wildlife habitat availability and quality. Research is also needed to clarify the relationship between wildlife habitat quality and forest cover-type, stand age and species composition.

- **Forest Stand Composition and Quality.**
  Many site-based practices are directed toward the protection of a particular forest resource value, for example, forested riparian zones. These practices can have a profound impact on the future extent and patterns of forest vegetation which, in turn, can both positively and negatively influence biological diversity, wildlife habitat, and forest health and productivity. Many of these practices emphasize greater residual vegetation left on a site. Research is needed to assess the long-term effects of alternative harvesting and silviculture systems on forest stand composition and quality. For example, to what extent does residual vegetation management affect the productivity of forest stands managed for even-aged species?

Economic and Social Aspects

Forests enhance the quality of life in Minnesota. They contribute significantly to the economic and social fabric of the state. For example, the wood product manufacturing industry is the state's 3rd largest, directly employing 61,000 persons or about 3 percent of all employment in the state. In many forested regions of Minnesota, the contribution of this industry is quite important to local and regional economies. Forests are also a setting for a wide range of outdoor recreation opportunities including hiking, camping, picnicking and cross-country skiing. The state's tourism and recreation industries employ approximately the same number of people as the wood products manufacturing sector. Although forests are acknowledged as essential to the state, information about their role in Minnesota's economic and social well-being is incomplete. Additionally, the nature of linkages between various sectors dependent on forest resources is unclear.

Needed Research Response

Specific research needed to better understand sector-by-sector economic importance of Minnesota's forest resources includes the following.

- **Interactions Involving Wood Products and Tourism/outdoor Recreation Industries.**
  Both the state's wood products and tourism industries depend on sustainable forests —the former for their high quality wood fiber; the latter for their contribution to an visually pleasing environment and high quality recreation opportunities. Determining the relationships and interactions between these two industries that are dependent on the same forest resource base is often difficult; there are many factors beyond forests themselves that influence overall economic health and prosperity of these industries. However, knowing these connections helps to identify effective resource management and economic development policies for these industries. Research is needed to assess how different levels of timber harvesting and forest management affect the state's outdoor tourism/recreation industry. Additionally, research is needed to identify those policies and programs that are complimentary, compatible and mutually exclusive to these two industries.

- **Local and Regional Economic Contributions of Forest Resources.**
  The communities where forest management is the dominant land use are often heavily dependent on economic activity derived from forests. This activity is generated by both wood products and forest-based tourism and recreation industries. In northern Minnesota, the contribution of these forest-dependent industries to local economies is significant. Research is needed to assess the extent to which forest-dependent industries support local and regional economies. Research is also needed to determine the impact of changes in forest-dependent industries on specific local and statewide economic sectors. Further, research that improves the ability to forecast adjustments to the structure and growth of local and regional economies as a result of alterations in the state's forest-dependent industries is needed.

- **Timber Productivity and Management Opportunities.**
  Demands on Minnesota's forest resources will increase in the future. As communities grow demand for paper and building products will expand placing greater pressure on local and global forest resources. A better understanding of silivicultural opportunities to increase timber productivity of natural stands and plantations in an environmentally sound manner is crucial. Research is needed to learn more about the effects of silvicultural techniques, such as thinning and alternative harvesting options, on productivity. Research is also needed on the genetic improvement of plantation species, and the role of soils and nutrition in determining growth rates of commercially important tree

species. Land managers and policy makers can use research results to assess opportunities for forest-based economic development and options for management of the state's forest resources to support the multiple uses expected by the public.

- **Forest Products Development/Utilization.**
  Minnesota's forest resource base can be more effectively utilized through wood processing methods which use a greater part of the entire tree and leave less waste at the production mill. More efficient use of forest resources, especially underutilized species, would also extend supplies. The wood industry has great potential for automation of processing systems to reduce overall cost and improve productivity in manufacturing. Scanning devices for quality assessment are capable of greatly improving out-puts and reducing waste. Research with Minnesota companies is needed to evaluate new technologies that will improve productivity and yield. Additionally, research is needed that will focus on developing higher value products from Minnesota's less used and currently lower value species to improve local and regional economies.

Information and Technology Development

Forest ecosystems are complex. Consequently, a bulk of information is needed to support sustainable forest management and planning. Land managers, landowners and others depend on timely and accurate knowledge to make informed decisions about the management and use of forest resources. Unfortunately, the information and technology required to support effective planning and management of forest resources is often fragmented, incompatible with other similar data, or simply nonexistent.

Needed Research Response

Specific research needs related to technology and information on forest resources include:

- **Modeling Forest Resources Conditions.**
  Uncertainty exists regarding the long-term consequences associated with significant adjustments to forest resource management. This is particularly true for large forest areas with diverse ecological conditions and multiple ownerships. Research is needed to understand how forests function ecologically and how these

systems respond to management activities. Further research is then needed to develop models that will help landowners and managers better understand the short- and long-term ecological and economic consequences of alternative management and policy Agenda for Forestry Research in the Next Decade scenarios.

- **Monitoring Changes to Forest Resource Conditions.** Minnesota's forests continue to change in response to natural processes and human induced disturbances, for example, exotic species, air pollution, fuel buildups, insects and diseases. Although these changes are often gradual and difficult to detect, they can have a profound effect on the extent and character of forest resources over time. Currently there are a number of programs that periodically monitor the condition of Minnesota's forests. Most of these have been developed in response to specific information needs—Forest Inventory Analysis, for example, which is a highly successful and relied upon source of forest data. Still, incompatible monitoring objectives, data collection protocols, spatial coverage and resolution, and monitoring frequency makes establishing comprehensive assessments that report changes in the state's forests quite difficult. Research is needed to identify key indicators of overall health and productivity of Minnesota's forest resources; develop protocols for collecting and integrating information on forest resources; and build more effective methods of detecting and monitoring changes in Minnesota's forest resources.

- **Enhancing Access to and Quality of Information Describing Forest** Resources. Information technology has greatly expanded the availability of information on forest resources. Minnesota's Interagency Information Cooperative and ForNet Project are examples of recent initiatives designed to increase utility of forest resources data. Research is needed to develop cost-effective and useful means of providing access to this data; assess data users' needs, skill levels, and capacity to obtain forest resources data; and develop effective ways of integrating and displaying forest resources data.

- **Timber Harvesting and Forest Management Technology.** Timber harvesting activities in Minnesota can have a significant influence on the condition of the state's forests. The nature of this influence are very much dependent on the type of timber harvesting equipment being used and how it is applied. Research is needed to develop harvesting technologies that are effective while at the same time are cost efficient to operators and to landowners. Experimentation with new equipment

made in other parts of the nation and in foreign countries could prove to be particularly fruitful. This should complement research on the development of new harvesting systems that are designed to meet conditions unique to the state's forests, for example, extensive riparian areas.

Policies, Programs and Planning

Minnesota's forest land is owned by a variety of public and private interests. Its two national forests (Superior and Chippewa), the state Department of Natural Resources, and 14 county land departments collectively manage approximately one-half of Minnesota commercial forest land base. Forest industry owns around 750,000 acres, American Indian tribal forest lands account for about 500,000 acres, and private individuals and corporations other than forest industry own approximately 6.4 million acres, or 43 percent of all timberland in Minnesota. These public and private interests often have differing land management objectives, legal mandates, access to capital for investment in land management, and professional expertise and to carry out specific land management practices. Consequently, an array of policy and program instruments are needed to encourage sustaining a well-balanced range of forest values and uses. The utility and efficacy of various policies and programs to urge specific practices or the production of particular outcomes is limited.

Needed Research Response

Explicit research is needed to better understand the utility of various policies and programs directed at the use, management and protection of Minnesota's forest resources, including:

- **Public-Land Policy and Program Design.**
  Minnesota's public forest resource management organizations are guided by a myriad of federal-, state- and local-level laws, policies, and rules. Research is needed to investigate alternative land use and management scenarios for public forests; different processes for determining the use, management and protection of public forests; various mechanisms for coordinating policies and programs both within and among public land management organizations. Further, research is needed in social and biological consequences of alternative levels of investment in public forests and means for sustaining these investments; various options for distributing to private interests the many goods and services produced by public forests; and alternative ways to assess the effectiveness of public-sector forest resource policies and programs.

- **Private-Land Policy and Program Design.**
  Privately-owned forests in Minnesota are spotlighted by several public and private programs. These consist of educational programs, technical

assistance, fiscal and tax incentives, and regulatory initiatives. To assure that these programs best accomplish their objectives, research is needed to look at: public versus private responsibilities for promoting the sustainability of private forests; goals of private landowners and the appropriateness of myriad programs to further these goals; policies and programs for securing broader public interests in private forests (for example, biological diversity or long-term timber production); approaches to making the many risks associated with investments in private forests more acceptable (for example, fire, insects and diseases); financial and economic costs associated with the application of forest practice guidelines; institutional arrangements for coordinating management activities and achieving economies of scale (for example, regional partnerships, landowner associations); and ways of evaluating the effectiveness of policies and programs focused on private forests.

Challenges to Accomplishing Research in the Next Decade

Challenges to Accomplishing Research in Next Decade

Accomplishing an agenda for forestry research in the next decade will be complicated unless a variety of challenges are addressed. These are framed by fundamental issues that confront the research community in Minnesota. Such issues include the reality of long payback periods for investments in forestry research, high risks and uncertain consequences of research investments, rising absolute costs of implementing forest resources research programs, and capturing the economies of scale that are necessary for successfully conducting certain types of research. Given these conditions, consider some special challenges that face Minnesota's forest resources research community and the users of information provided by the community.

Research Planning and Priority Setting

Research organizations in Minnesota must be capable of responding to the information needs of users and managers of the state's forests. To do so successfully, the states' research organizations must have a collective outlook on what forest resources issues are most critical to making wise decisions about the use, management and protection of forests. In this regard, the research community in Minnesota should engage in processes that lead to the identification of forest resource problems and associated information needs.. Together they should the define priority research required to address these needs, enumerate forest research goals and objectives, and specify financial and professional resources necessary to carry out the research. Engaging in research planning and priority setting should be a cooperative activity that fully acknowledges each research organization's mission and special capabilities to contribute to overall state strategies for research. Planning and priority-setting processes should engage the users of research as well as those who carry out research activities.

In the context of research planning and priority setting Minnesota should promote:

Periodic assessment of the status and direction of forest resources research.

Additional and more current information about the magnitude and direction of forest resources research can improve decision making about potential directions for research programs in Minnesota.

Focus of research on high priority information needs.

Carefully designed and well implemented planning processes can help the research community focus more effectively on important information needs concerning Minnesota's forests.

Linkage of research plans to research sponsoring organizations.
Effective connections between funders of research and implementers of research programs can help guide investments toward pressing information problems involving Minnesota's forests.

Monitoring and evaluation of research program performance.
Reviewing the products of research programs in the context of community-wide research objectives can provide an opportunity to make necessary adjustments in research directions and emphasis.

The Minnesota SFRA established a Research Advisory Committee (RAC) to the MFRC. Among its many responsibilities is periodic review of forestry research programs in Minnesota, including identification of high priority research needs. In addition, it will communicate with research sponsoring organizations about these high priority research needs and the financial and professional resources required to address them.

Research Program Funding

Forest resources research programs in Minnesota require appropriate levels of financial support to accomplish their missions. Mechanisms for financing research programs in Minnesota include gifts, grants, contracts, appropriations, and, in the case of some industrial forestry research, direct investments through company sponsorship of research and development. The state's forest resources research community has taken advantage of these and many other sources of funding.

In the context of research program funding Minnesota should provide:

Access to long-term core research funding.
A base level of funding is necessary to support a research infrastructure (for example, state-of-the-art facilities and equipment; and highly trained scientists and staff) that can make research activities in Minnesota possible. Additional funds to address new issues or to strengthen existing research can periodically be added to this base.

Stability in research funding over long periods.
Long-term commitment to financing research in Minnesota is critical for building up competent research staff and carrying out forestry research that may take decades to complete, as is the case with research involving forest growth and change, watershed systems, and vegetative management.

Research funding commensurate with the value of the information produced.

Adequate funding is necessary to effectively conduct forestry research in Minnesota. The amount invested should be directly related to the value of the information provided and the importance of the problem addressed.

Innovative mechanisms for funding research.

New and creative methods of financing research in Minnesota (for example, competitive funding mechanisms) are important for fostering efficient research focused on important forest resource questions.

Incentives for private sector research activities.

Fiscal and tax incentives encouraging private organizations in Minnesota to undertake forest resources research or to contribute to research by, for instance, donating equipment, can stimulate research and provide needed resources to certain research organizations.

Current public and private investments in forest resources research in Minnesota are approximately $18 million to $20 million. This is less than one percent (0.3 percent) of the value of products manufactured by the state's wood-based industry. Minnesota investments lag considerably behind: (a) the national average for all industries (4.7 percent); (b) the average for leading wood-based corporations across the nation (1.9 percent); and (c) the average for the U.S. Bureau of the Census' lumber, wood products and furniture major industry group (0.7 percent). If the state's forest research investments are viewed as a proportion of the combined economic value provided by the state's wood-based ($7.2 billion) and tourism ($2.7 billion) industries, the percent slips to less than 0.2 percent.

The current level of investment in forest and related research in Minnesota is also less than research investments being made in agriculture. Public sector research investments in the state's agriculture industry totaled $55 million in 1996. This amount is nearly two percent (1.8 percent) of the value of the products produced by agriculture - considerably more than the comparable figure (0.3 percent) for forestry research. The agricultural percentage would be even higher if private sector research investments were included.

The magnitude of the lag in forest resources research funding in Minnesota is notable. If the state were comparable to the average for leading wood-based corporations nationwide (research investments 1.9 percent of sales), annual public and private investments in forest resources research would be in the range of $135 million to $140 million. When compared to the agricultural sector, the level of statewide investment would be in the range of $125 to $130 million. These gaps in forest research investment are significant. Current investments certainly do not reflect the importance of forest resources to citizens of Minnesota.

Using the state's agricultural sector as a benchmark, Minnesota's public and private forest resource sectors should increase investments in forest and related research by at least $12 million annually (excluding inflation) during the period 2000 through 2010. This would support an additional 40 to 50 scientist years of effort each year — a nearly four-fold increase over the 11 year period. Increases of this magnitude are not unrealistic, given the importance of forests to citizens of the state and the numerous industries that depend wholly or in part on forests for their existence, such as the tourism and wood-based industries.

Research Program Focus and Coordination

Scientific knowledge regarding the use, management and protection of Minnesota's forests comes from the activities of many organizations and researchers from diverse disciplines. Although this arrangement enables research responses to various and disparate problems, it can also fracture research responsibilities to the point that major interdisciplinary, large scale problems are bypassed. In such a context it is important to take advantage of the special abilities of individual research organizations, yet at the same time ensure that the research enterprise in general is addressing important broad problems involving the use, management and protection of the state's forests.

Coordination of forestry research programs and activities in Minnesota has provided a variety of benefits to cooperating organizations and their clients. Advantages include capturing important economies of research program scale, more efficient use of limited resources such as equipment and scientific talent, achieving desirable uniformity and standardization in data gathering and research design, and reducing individual risk associated with research and development. The organizational response needed to capture benefits of collaborative research programs are: formally established research centers, cooperatives, and advisory structures; informal cooperation among researchers in the design and analysis of research; exchange of personnel among research organizations; special research grants linking many research organizations; and joint ventures between public and private research groups.

The opportunity for greater coordination among Minnesota's research community is significant. Within the state there are numerous scientific laboratories and field research centers, various research clients that have a history of providing "in kind" research assistance, four major research organizations that administer more than 100 forestry research projects, and more than 40 public and private colleges and universities that carry out research and education activities that directly or indirectly involve forests. The virtues of coordination between organizations and client groups is highlighted by the successes of cooperatives such as the Minnesota Tree Improvement Cooperative, The Wilderness Research Center, Environmental Resources Spatial Analysis Center, University of Minnesota Cooperative Park Studies Unit, Minnesota Hybrid Poplar Research Cooperative, and the Aspen-Larch Genetics Project Cooperative.

While the complex nature of procuring funding and carrying out research projects precludes absolute central organization of the forest resources research community, Minnesota should provide:

Incentives for research program coordination.
Coordination of research activities undertaken by different organizations can be fostered by assorted incentives such as special short- or long-term financial rewards and periodic conferences on the status of forestry research. For the private sector, incentives might be special tax and fiscal programs. Incentives are especially important for focusing research organizations on large multi-disciplinary problems involving forests.

Opportunity for establishment of centers of scientific emphasis.
Special centers and cooperatives can encourage focus on pressing forest resource problems that require specific equipment, information and the talents of multi-disciplinary teams of scientists.

Opportunity for multi-disciplinary research activities.
Forest resource problems involving complex physical, economic, and social conditions can best be addressed through creative solutions achieved by groups of researchers from several disciplines.

In the context of research program coordination, the Research Advisory Committee to the MFRC is required by the SFRA to encourage collaboration between organizations responsible for conducting forest resources research and to foster linkages between researchers in different disciplines conducting forest resources research. The RAC will continue to pursue such responsibilities in the spirit of promoting scientific study that broadly deals with problems involving Minnesota's forests.

Availability of Knowledgeable Researchers

Critical to Minnesota's forestry research organizations are appropriate levels and types of research expertise. Experienced researchers are essential to structuring research questions and to subsequently applying necessary research technologies and interpretive skills to these problems. The ability to do so is typically acquired during many years of academic education and a like number of years of professional experience in research organizations. Complementing education and experience is a researcher's access to special work environments where there is the opportunity to collaborate with other researchers, availability of technically advanced equipment, and access to processes for distributing the results of research.

In the context of the need for well-educated and highly experienced researchers Minnesota should:

Strengthen recruitment of talented students to careers in forestry and natural resources.
Specialized recruitment efforts focused at high potential students can provide a rich source of talent from which to draw future scientists.

Enhance availability of financial support for graduate education.
Availability of scholarships, fellowships and research assistantships can be critical to attracting potential scientists to graduate education.

Promote student-scientist mentor programs.
Opportunities for students to work with experienced scientists can provide an invaluable educational experience in learning how to design and carrying out research activities and disseminate research results.

Bolster efforts to retain talented research scientists.
Highly productive research scientists are steadily in demand and should be offered incentives to remain in Minnesota.

Technology and Information Transfer

The products of research are useful only to the extent that they are made available to those that are making decisions about the use, management and protection of Minnesota's forests. It makes little sense to provide the state's research organizations with resources to conduct research and, in turn, ignore the importance of distributing the products of these research efforts. Improved linkages between the Minnesota research community and the state's many users of research can serve several purposes. Among these are improved research planning and priority setting, better design of research needed to generate new technologies, enriched communication of research results, and overall strengthening of a research organization's capacity.

Numerous audiences for the products of research can be listed. Other scientists (commonly communicated with via scientific journals and technical conferences) as well as practitioners and the general public (typically reached by newsletters, field demonstrations, print media and electronic means) are all users of research findings. If research investments are to result in useful products, there must be steady interaction between researchers and these audiences. In Minnesota, the Minnesota Extension Service has traditionally played a major role in facilitating these links.

In the context of linking the products of research to various users Minnesota should promote:

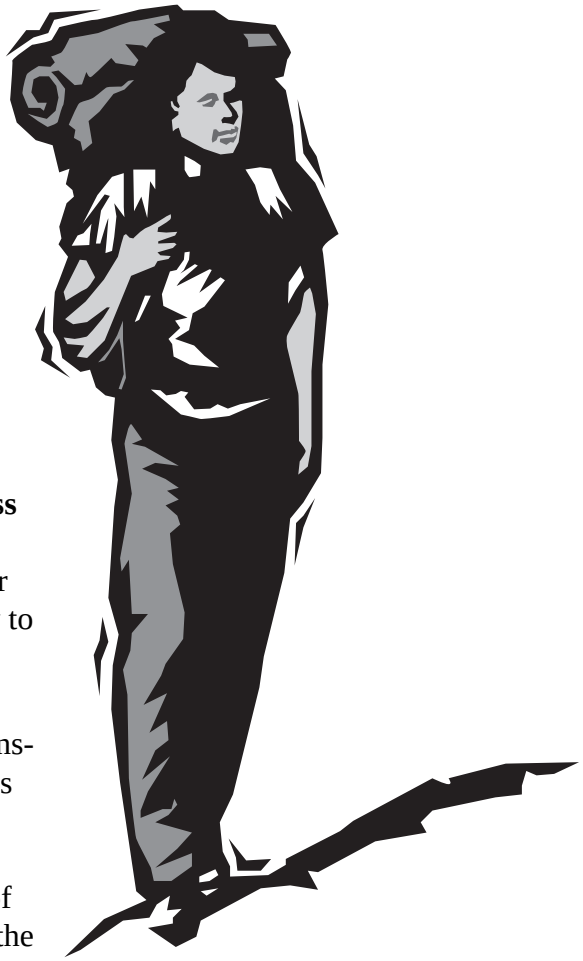
Scientist-practitioner collaboration in research program planning.
Contacts between scientists in the early stages of research planning can help identify researchable problems, establish priorities, define possible research commitments, and increase awareness of information-user expectations. Assembling existing knowledge into coherent, systematic summaries and distributing this to practitioners is also quite critical to forging ties.

Advisory-partnership arrangements involving research organizations and user groups.
Formal arrangements, such as advisory committees, can promote long-term commitments to passing on the results of research to various users.

Advanced technologies for distributing the results of research.
Use of advanced technologies (for example, internet and satellite-based distance learning approaches) can improve the effectiveness of information distribution and broaden access to a wider audience.

Education-training to introduce potential users to new technologies developed by research.
Informing users about new technologies, and training for skills necessary to use them, can improve technological innovation and the overall usefulness of research results.

Monitoring and evaluation of the effectiveness of technology transfer programs.
Assessing the abilities of information transfer techniques can lead to adjustments necessary to improve their effectiveness.



In the context of information and technology transfer, the Research Advisory Committee to the MFRC is required by the SFRA to encourage interaction and communication between researchers. The RAC will steadily pursue these responsibilities with the intent of fostering more science-based decision making about the use, management and protection of Minnesota's forests.

Summary and Conclusion

The forests are significant contributors to the quality of life experienced by Minnesotans. In acknowledging this importance, it is imperative that the state's public and private forests be put to appropriate uses and be well managed and protected. Doing so requires abundant scientific information, much of which is provided by the state's forest resources research community. The need for this knowledge has been expressed in a number of ways, including through an assortment of legal and administrative directives. These have lead to the establishment of several research programs and organizations that over the years have provided a stream of information used to further the sustainability of Minnesota's forests.

The future sustainability of Minnesota's forests and the economies and communities that depend on them will require a renewed emphasis on forest resources research. The Research Advisory Committee to the Minnesota Forest Resources Council suggests that future research involving forests should emphasize the ecological integrity of forests, their relationship to economic and social conditions within the state, the advancement of information and technology development, and the design of creative forest resource policies and programs.

The state's forest resources research community faces many challenges. Forestry research should be planned, prioritized and well funded. In addition, the state's many research programs need incentives to coordinate and together focus on important information needs. Minnesota should also provide for many talented researchers and effective avenues for distributing the products of their research.

[1] Lee, K. N. 1993. *Compass and Gyroscope: Integrating Science and Politics for the Environment*. Island Press: Washington, DC.

[2] MN Forest Resources Council. 1998. "A Vision for Minnesota's Forest Resources," and "Achieving a Vision for Minnesota's Forest Resources: Major Topics to Consider in Accomplishing Minnesota Forest Resources Council Established Goals." St. Paul, MN.

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Mr. James Marshall
Member, Minnesota Forest Resources Partnership
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Dr. G. David Tilman
Member, Minnesota Forest Action Network

MN Forest Resources Council

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Joe Day	American Indian Affairs	American Indian Affairs Council
Robert Dunn	Conservation Organization	The Nature Conservancy
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Steve Eubanks	USDA - Forest Service	Chippewa National Forest
Janet Green	Environmental Organization	Several Environmental Organizations
Judy Hewes[2]	Resort and Tourism Industry	Hospitality Minnesota
Alan Knaeble	Commercial Logging Contractor	MN Timber Producers Association
Richard Knoll	Nonindustrial Private Forest Land	MN Forestry Association
Marcie McLaughlin	Agricultural Woodlot Owner	MN Rural Partners
Norman Moody	County Land Commissioner	Cass County Land Department
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Gerald Rose	Department of Natural Resources	Division of Forestry
Joseph Wood	Game Species Management	MN Deer Hunters Association

[1] Council chair
[2] Council vice-chair