A Review of the Availability of Information About Minnesota's Forests

Report to the Minnesota Forest Resources Council

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Minnesota Forest Resources Council

Revision

The original version of this report was submitted to the Minnesota Forest Resources Council (MFRC) by the Irland Group and was titled "Review of Availability and Accuracy of Information About Forests". The report was submitted with numerous typographical errors, writing inconsistencies, and a haphazard format. The MFRC's Information Management Committee requested that the report be revised and the MFRC hired Cameron Gerarden to perform the task. This version is the outcome of that revision. The effort to rewrite this report should not be confused as a reinterpretation of the research conducted by the Irland Group. All of the original researched information is still presented herein. The contents have been restructured to improve access for the reader.

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Introduction

The Minnesota Forest Resources Council (MFRC) has maintained an active interest in evaluating the information base for monitoring sustainability of Minnesota's forest resource and the communities, industries, and multiple uses that depend upon it.

In January 2000, the MFRC and the Environmental Indicators Initiative (EII) issued a Phase I report which summarized key questions about the availability of forest information in Minnesota. That report identified a series of indicators that would enable trends in resource health, condition, and sustainability to be measured. The Baseline Questions and Indicators given in the Phase I Report (See attachments) are the basis for this report. The report describes the methods and results of the inventory, description, and evaluation of the information. It also includes information from interviews on the policy and process issues, and offers a number of specific, as well as general, recommendations.

This report should not be examined with an expectation of either quantifiable, or absolutely complete information. It is a preliminary overview of the availability of forest information within Minnesota. The MFRC created the Information Management Committee (IMC) to examine and report the current state of forest information adequacy within Minnesota. The IMC's small budget and short time frame has yielded this document that generally explores questions of forest information and provides guidance to further study. Taken within that scope, this report provides a wealth of relevant information, observation and direction to the MFRC.

The MFRC felt they first needed an overview of the situation in a format for action this year. A thorough process of information inventory and analysis was supplemented by numerous interviews, and by outside peer review of a draft report. Extensive review was conducted during both the interview and draft phases. Projects currently underway were noted. We have identified many gaps and areas for improvement. These are not intended as a criticism of the agencies involved in data collection and management, as the agenda is huge and growing. It seems to us that Minnesota is in a better position on this issue than many other states.

The issue of accuracy of information will continue to be a concern for the MFRC and anyone else involved in forestry. The enormous complexity of solving the problem of accuracy assessment for all the available information leads most researchers to avoid it.

Major Findings

Our analysis shows significant gaps in Minnesota's forest information. Several activities, notably the GAP Project, the MFRC Landscape effort, and ongoing MFRC sponsored and other research will contribute to filling in the gaps.

The most appealing immediate information prospect lays in further analysis of the FIA dataset, which is the most useful, yet dramatically under-analyzed forest resources dataset. Significantly improved access to this dataset and the new annual FIA design now make it straightforward to use to analyze many problems.

We found that the majority of the indicators studied did not have information available that was complete. In some instances, this is the result of unclear or unrepresentative indicators selected within the review. The extent of Minnesota's forest area is well measured, with the exception of spatial pattern. However most of the other indicators within our knowledge of forest base information are lacking. The indicators of forest ecosystem health suggest numerous data gaps. 9 out 12 ecosystem health indicators did not have available information. The indicators for the forest economy and manufacturing are well measured. But forest-based tourism, visitation, economic impacts, and available facilities and resources are not well measured. 7 out of 10 indicators of community economics did not have complete information. Management and Enabling Conditions indicators show information gaps and widespread weaknesses.

Minnesota has a second-to-none geographic information system (GIS) capability, which seems well coordinated on technical matters. However, the system often becomes an end rather than a means. A strong focus on spatial detail needs to be augmented by a similar focus on change detection if the GIS is to fulfill its potential for tracking trends over time.

According to DNR estimates, timber removals are approaching the estimated Annual Allowable Cut "AAC." This should motivate an intensive effort to ensure better measurement of removals and to develop more sophisticated estimates of AAC, that include the many factors that affect AAC calculations. Plans to increase resource analysis capability at the College of Natural Resources deserve support.

Major Recommendations for Minnesota Forest Information Development

The Irland group has identified the following eight major summarized recommendations from its interviews and information review of Minnesota forest information. These are intended to be generalized organizational recommendations. They are augmented by the more specific Technical Recommendations section of this report.

1. Create a Biennial Report on Minnesota Forest Condition, Outlook, and Issues

Minnesota should institutionalize, as a tradition, the delivery of a biennial report that provides a broad overview of the forest conditions and issues important to Minnesota. The report should be 20 – 30 pages in length, include a budget summary, and be presented by a trio of high profile public figures in a widely publicized press event. A list of core indicators should be examined as well as biennially varying topics on one to three key resource issues, threats, or concerns. The Landscape Assessments process should be an abundant source for ideas for creating a lean set of indicators and descriptors meaningful to a wide range of people.

2. Review Goals and Indicators for Clarity, Consistency, and Completeness

The MFRC staff should review the key indicators from Phase I that have been identified in this Phase II report as needing further definition and clarification. After sorting these indicators into priorities for action, technical committees should be assigned to create operationally meaningful, specific, and measurable definitions that are consistent with national and regional C&I efforts.

3. Strengthen Forest Resource Analysis Capability

The Irland group stresses the need to achieve significant improvement in Minnesota's capacity for forest resource analysis. The best way to achieve this is by supporting programs already underway at the College of Natural Resources. Specific activities should include: a) a full analysis of untapped existing FIA data, b) refined analysis of long term sustainable forest yield, c) identification of improvements in forest data, d) the use of improved data analysis technologies, and e) statistically grounded and analytical topic reports on current issues.

4. Define an Expanded Role for Internal and Third Party Audit

The MFRC should examine the use of outside audit and certification. Priorities should be set for better-focused and practical use of the outside audit concept in several areas. Outside experts could advise on the issues in the area of common data formats and systems. For example, selected, qualified outside groups could audit the methods and systems used to obtain and report key forest, wildlife, and water data, and perhaps recommend some interim solution to the dilemma posed by the dissatisfaction with indicator species versus the impossibility of measuring everything. The independent review of issues, performance, and priorities has repeatedly shown its value.

5. Create a Recreation Resource/Impact Assessment Process

The MFRC should design a focused assessment process to address the recreational resource impacts identified in the Phase I report. In the past, SCORP reports supplied much of this information. However; there is now no current or meaningful data about recreation resources, tourism, and related economic impacts.

6. Review the Data Recommendations of the GEIS

The GEIS reports should continue to be reviewed. Questionable issues should be summarized and information and data gaps from individual technical reports should be reported.

7. Improve Information in Minnesota's Primarily Nonforest Landscapes

The MFRC should consider empanelling a technical group to examine any needed improvements in maintaining information on area and condition of the tree, forest, and shrub resources, and related values, of the state that are not primarily forested. Minnesota's ability to track change in area and composition for these lands is weak. Consequently, these areas may not be receiving adequate attention with respect to environmental and resource management information and programs. Minnesota's highest proportional representation of exotic species affecting trees and forests occurs in this area.

8. Strengthen Planning, Coordination, and Cooperation in Information Sharing

The MFRC should examine additional ways to promote information sharing concerning local or regional successes in coordination, cooperation, and planning and its immediate practical benefits. The MFRC's role would be one of promotion and facilitating the sharing of best-practice ideas. Some possibilities include; a package of case studies, using the IIC to improve data standardization, or an occasional mini-conference.
Whatever examples are chosen, they should illustrate practical coordination and cooperation that delivers identifiable near-term as well as long-term benefits. Roads are one of the most important and widespread examples.

Technical Recommendations to the MFRC Compiled from the Review of Indicators

Recommended Task Teams

Forest Base

1. A technical team should be charged with evaluating the existing program of maps and other data collection efforts on DNR and county lands and other lands to determine the costs and feasibility of updating this data, improving its compatibility with other type definitions and data standards, and making available primary plot and tree information for analysis by others. This team could also assess the extent to which further analysis would enable this large database to be employed to measure the Council's Phase I Indicators. (A2. Extent, Location, and Spatial Pattern of Areas of Continuous Forest Cover - page 16)

2. A technical team should be empanelled to develop a crosswalk between the principal vegetation/ land cover classifications in use in Minnesota (e.g. Aaseng et al 1993). This would enable inventory planners to improve compatibility in the future, and would enable information users and managers to choose the data and map sets most suited to their needs. This team also should consult with the GIS staff to determine the potential for making use of aggregated information from ChangeView or other vehicles as one information element in tracking forest conditions. (A2. Extent, Location, and Spatial Pattern of Areas of Continuous Forest Cover - page16)

Ecosystem Health

3. The MFRC should assign a qualified team to evaluate Table 5 Biodiversity Mitigation Strategies and Significant Impacts (page 26), analyze trends, and design a system of indicators and steps that could track both the impacts and the mitigations. While there is an abundance of specialized knowledge and microdata, there appears to be no overall assessment of terrestrial habitat condition in Minnesota's forests. (B. Ecosystem Health, Some Problems with the Use of Indicator Species – page 26)

4. The FIA dataset is the most under analyzed resource of information in existence in forestry today. Many opportunities to shed light on important resource and ecological issues are being missed. The MFRC should task a technical panel with examining the possibilities (see, e.g., Allen and Plantinga, 1999; Miles, forthcoming). The College of Natural Resources, with its close links to the FIA program and experience with FIA data should be staffed to lead in analysis of this information and related data for the state and region. The College should raise funds to support a rotating graduate or post-graduate fellowship in Forest Resource Analysis. Minnesota should continue the County Biological Survey,

with closer linkages to the efforts of FIA analysis. (B1. Extent, Location and Spatial Pattern of Natural Plant Communities – page 29)

5. The MFRC should empanel a technical team to review existing knowledge and ongoing monitoring activities and develop a sample-based, cost-effective means of measuring what needs to be measured to track trends in condition of forest-related streams and waters in Minnesota. This will require attention to a sampling scheme in time and space, to artful selection of variables to be measured, and to innovative and cost-effective measurement methods. (B5. Index of Biological Integrity (IBI) & Ecological Indicators – page 32)

6. A team should be empanelled by the MFRC to examine the use of FIA and agency information to develop status and tracking measures for composition and stocking of forest regeneration. (B10. Composition and Stocking of Forest Regeneration – page 39)

Economies and Communities

7. The MFRC might consider empanelling a team to develop a methodology to periodically develop a total Materials Balance for the Minnesota forest-based manufacturing sector. This Balance would depict instate output, all trade flows of logs, intermediate and end products, and all residuals, including waste streams. A valid Materials Balance would be a valuable Assessment tool. (C4. Import and Export Levels of Raw Materials and Products – page 45)

Sustainability

8. The MFRC should consider the "outside audit" model for a major assessment of conditions, trends, outlook, and issues in the Minnesota forest. This would entail a full assessment, with a modest staff, to be led by a respected individual or group, certainly from outside the forestry community and perhaps even from outside the state. There is no need for another GEIS, but more for an analytical and tightly focused Assessment instead. The MFRC may wish to prepare tightly focused terms of reference for this Assessment. Key topics might include analyzing the AAC/harvest investment situation using the latest data and models and management assumptions, with links to habitat suitability issues, possible changes in the existing system of protected areas, and possible trends in availability. (MFRC Goal # 3: Forests are Sustainably Managed, Sustaining Political Support – page 70)

Surveys to be Conducted

Ecosystem Health

1. The MFRC should conduct a new harvesting and silvicultural practice survey, with provisions for improved coverage of treatments on NIPF lands, and plan for follow-up in three to five years. (B8e. Fire – page 34)

2. The MFRC should conduct a feasibility study of a preharvest /notification /postharvest cut report program for Minnesota. It should view the experiences in other states, and likely administrative and compliance costs. Alternatives should be examined, and suitable consultation should be conducted with affected parties as a part of the process. (B11. Growth, Mortality, and Removals by Species – page 40)

3. When the FIA's annual survey permits a reasonable update of forest growth, and when new estimates of removals can be prepared, a new simulation of future Long Term Sustained Yield and Annual Allowable Cut's (AAC) should be conducted. It should be based on a range of assumptions concerning management intensity, nontimber values, resource protection guidelines, and uncertainties for long-term productivity such as climate change and the changing landbase. It should also consider any needs for updated/improved yield tables and growth yield models. (B12. The Extent of Forest Land With Productivity Levels Below Potential Productivity – page 40)

Economies and Communities

4. The MFRC should create some improved variant of the SCORP assessment process. The process could operate on a rotating basis, taking up in detail one key topic or issue each year, instead of doing everything in two years and then setting the task aside. The effort should be funded so that needed case studies or survey research tasks can be performed. (C6 Number and Type of Facilities for Recreation and Tourism – page 47)

5. The Council might consider designing and developing a cost estimate for a visitor and business survey that would yield valid estimates. Case studies of selected local areas might be a worthwhile approach, rather than attempting to develop statewide estimates. (C4. Import and Export Levels of Raw Materials and Products – page 45)

Suggested Reviews

Forest Base

1. Based on sound field-based policy evaluation, the effectiveness of selected policies in retaining forest land should be evaluated. MFRC could select for analysis those that it considers most in need of review. (A. Forest Base – page 14)

Ecosystem Health

2. Consider whether there is merit in initiating monitoring of specific organisms or conditions, where sufficient baseline data exists to enable the detection of a "signal" of climate change effects, or where a convincing argument can be made that such monitoring has high chances of detecting such an effect in the future. (B8e. Fire, Overview Disturbance – page 34)

3. Review the staffing, procedures, and funding of the state's efforts in monitoring insect, disease and other forest health concerns and issues related to exotic and invasive species. Determine whether improvements are needed. (B8e. Fire Overview Disturbance – page 34)

4. The entire program of tracking removals needs to be reviewed and strengthened. Using a suitable method, the estimating method for removals from growing stock and nongrowing stock sources should be carefully reviewed and, if necessary, new estimates prepared. (A project on FIA removals estimates is being planned at UMN.) (B11 Growth, Mortality, and Removals by Species – page 40)

Management Planning

5. The Council, based on the results of this and other studies, should set priorities for topically focused strategic assessments that appear to offer the greatest leverage on public understanding and on current policy issues. These should be linked to the FIA and other analyses noted earlier. (E3. To What Extent is Strategic Planning Occurring – page 55)

Management Rights

6. An initial screening of existing policies for their effects on public/private rights should be conducted, and based on priorities emerging from that screening, more focused policy evaluations might be considered. (F2. List of LRA that Affect Public Rights and Responsibilities - page 56)

Enabling Conditions

7. The Council should consider conducting a periodic inventory of funding and organizations involved in forest-related research in Minnesota and should be an active advocate for improved funding and effectiveness. In order to examine researcher and practitioner perceptions as to the transfer of information, a brief scoping study could be performed to determine if scientists, research administrators, and practitioners perceive important shortfalls or needs in the area

of priority setting or information transfer. (H2. Researcher and Practitioner Perceptions as to the Transfer of Information – page 62)

Enabling Conditions

8. MFRC should consider conducting a review to assess the importance of having a common data standard, identify existing needs in this area, and estimate the costs of increasing standardization. The standards would naturally vary for biological, timber, ownership, or economic data. (Informal Reflections on GIS – page 84)

9. The Council should construct a comprehensive program budget table showing the organizations and funding levels devoted to forest programs (Table 7 - page 74). Major functional areas could further disaggregate this. The result should be a comprehensive natural resources budget, including a separate capital budget. It should render a public report on the adequacy, trends, and sustainability of funding as revealed by this analysis. (MFRC Goal # 11 Program Funding is Committed and Sustained – page 73)

Political Actions

Economies and Communities

1. The MFRC should work with the Governor's office, the USFS, and the state's congressional delegation to vigorously advocate the continued and timely production of import and export levels of raw materials and products information. This work serves a distinctive federal role in tracking and promoting commerce and enables an effective regional system of observing wood flows to continue. (C4. Import and Export Levels of Raw Materials and Products – page 45)

Enabling Conditions

2. Consultation between the Council, the EII, the LMIC, and the IIC should proceed to identify to what extent existing integration efforts can support the Council's proposed indicators, particularly in the area of time series comparisons. The term indicator may also need refinement. (H4. List of Efforts and Accomplishments to Coordinate Common Data Standard and Information Reporting – page 63)

A. Minnesota Forest Land Base

Question: **What Laws, Rules, Administrative (LRA) Policies Exist to Protect the Extent of Existing Forest? (BQ)**

Results: There is no comprehensive listing or evaluation of forest laws, rules, or policies designed to protect the extent of existing forest.

Noteworthy Observation: "Insiders" know where all of this information is, but a newcomer to the subject would have to expend considerable effort. While state laws are on the website and plans and documents of land managing agencies are generally available, county and local information, as well as for private and nonprofit sector landowners, must be obtained from each separate entity.

Recommendation for Forest Policy: Based on sound field-based policy evaluation, the effectiveness of selected policies for retaining forest land should be evaluated. The MFRC could select those policies for analysis that it considers most in need of review.

The Indicators of Minnesota Forest Land Base

A1

Indicator: **A1. Area of Forest Land, Timberland, and Total Land Area**

Results: The extent of the area covered by forest is well measured at a state level, at least since the initial FIA inventory of Minnesota in 1936. Timberland area is well measured.

Noteworthy Observation: At the state level, sampling errors of total forest land and commercial timberland are very small. Sampling errors within counties vary depending on county size and extent of forest area. Heavily forested northern counties can detect small changes in timberland because they have sampling errors of 2% or less. Many counties in the prairie unit could fail to detect large percent changes in timberland as 16 of those counties have shown sampling errors exceeding 20%. Plot intensification has helped improve this information. The MFRC's landscape program will likely show high sampling errors for the region with less forest area.

Additional Information: The U.S. Bureau of Census is the authority concerning land area. Sometimes aerial photo coverage improves, or definitions change, and these are reflected in the estimates used in the FIA publications. The definition of "Timberland" (formerly termed commercial forest land in FIA publications) is based on two characteristics of a field plot, whether it is "reserved," by law or owner policy from cutting, and whether it is judged to be capable of producing 20 cu. ft./A/yr. or more of commercial wood crops. Subject to vagaries of the definition itself, timberland area is accurately measured. The status of certain lands may be uncertain for periods of time, and even some private owners may have small areas where they do not plan to harvest.

On the other hand, there are nonprofit "reserves," where some low level of production may occur from time to time.

On the National Forests, plans call for defining areas that are not "suitable" for timber production based on natural characteristics, potential for erosion, and economic productivity. In the 1990 inventory, 1.1 million acres of forest were identified as "Reserved." Views as to timber suitability and potential productivity can change with time.

Reserved lands were omitted from the field plot portion of the inventory in the past. This means that there is no ability to characterize past forest conditions on these lands in terms comparable to what can be done on "Timberland." Starting with year 2000 measurements, the AFIS system now has "wall-to-wall" coverage, so that at the end of the first AFIS cycle, the large area of reserved lands will be measured in detail for the first time.

The FIA definition of timberland does not account for effects on operability of regulations or BMP's in riparian areas, for example. The definition also does not address economic availability in terms of landowner plans. To expect a field plot-based survey like the FIA to cast much light on the issue of landowner intention to cut is not realistic. But in other regions, various "screens" have been applied to the data to develop estimates that shed some light on the prospects for availability. Several studies in the south are cited in Cubbage, et al. (1995).

Proxies for Land Use Change

There is no statewide systematic tracking of changes in land use. A recent land use/cover map exists that could be a basis for tracking change, but it requires frequent updating and analysis to serve this purpose.

Subdividing and changing development pressures are important determinants of the land in Minnesota's forest base that are available for public use, resource production and habitat. Means of tracking trends in development would seem critical. Building permit data, supplemented by occasional benchmarking to determine average lot sizes, can be useful as a proxy for development pressure, to examine trends over time and comparisons across regions. There are some 300 permit-issuing places in Minnesota. Changing work commuting patterns, retirement living, improved roads and formerly remote regions becoming hotbeds of development make it important to track change. It seems likely that tracking permit information for a purposive sample of 50 or so jurisdictions would allow the development of trend information that would be a useful proxy for this important influence on the forest (George Orning, UMN, pers. comm.). A general study of land use change includes Minnesota estimates (Mauldin, Plantinga, and Alig, 1999).

A2

Indicator: **A2 Extent, Location, and Spatial Pattern of Areas of Continuous Forest Cover**

Results: The term "Areas of Continuous Forest Cover" needs to be defined. Spatial forest traits by landowner are not available in any comprehensive and uniform source. A precise "spatial vocabulary" is lacking.

Noteworthy Observation: The MFRC's Spatial Analysis Project aims to improve the information base in this area. (http://www.frc.state.mn.us -- "Spatial Analysis" button)

Recommendations for Indicator A2: A technical team should be charged with evaluating the existing program of maps and other data collection efforts on DNR and county lands and other lands to determine the costs and feasibility of updating this data, improving its compatibility with other type definitions and data standards, and making available primary plot and tree information for analysis by others. This team could also assess the extent to which further analysis would enable this large database to be employed to measure the Council's Phase I Indicators.

A technical team should be empanelled to develop a crosswalk between the principal vegetation/land cover classifications in use in Minnesota (e.g. Aaseng et al 1993). This would enable inventory planners to improve compatibility in the future, and would enable information users and managers to choose the data and map sets most suited to their needs.This team also should consult with the GIS staff to determine the potential for making use of aggregated information from ChangeView or other vehicles as one information element in tracking forest conditions.

Additional Information: The objective of the FIA program is to achieve high levels of statistical reliability for estimates of area, timber volume, and other forest characteristics at a state level. It cannot produce information as to the characteristics of stands, mosaics, or landscapes in any detail, by itself. These datasets have been used to characterize a few landscape traits such as average stand area, extent of edge, or distance to roads, but only general and aggregate information can be obtained from this dataset. Plot data have been applied to a number of vegetation analysis tasks.

This indicator's concern is spatial since it addresses pattern across a landscape in map format and this can only be accomplished using different methods. Such methods are very costly, and subject to definition, landscape pattern is usually studied only at local levels, usually for research or to answer some extremely localized management question. A number of programs are underway to identify and track changes in vegetation pattern in local areas. Individual landowners can often do this with their own type maps and GIS systems, but usually the data do not include a long run of history.

Analyses of vegetation patterns for local areas can make use of maps and databases from the ongoing "Cooperative Stand Assessment" program for every DNR unit and most counties. These supply management-level type maps and provide "in-place" (stand–by-stand) volume data. The information is updated to account for cutting

or other management activity. This is often available in GIS format and on CD-Rom. A description can be found at www.ra.dnr.state.mn.us/forestview/csa_doc.html. This information should not be used for other analyses without first gaining a detailed understanding of the inventory system, the levels of statistical precision that are attained, the age of the data in any given case, and any changes in circumstances since the inventory date.

An extensive analysis on presettlement vegetation has produced a statewide map (Anon. 1988). This mapped information is being compared to current vegetation at the Regional Landscape level. For Northeast Minnesota, studies have been completed defining "natural vegetation," which is the equivalent of potential natural vegetation under natural disturbance regimes (discussed below). It is not assumed that past vegetation as identified for the 19th century is necessarily identical to potential vegetation, nor to earlier time periods.

Minnesota provides unusually ready access to a huge set of the traditional 9x9 airphotos, each covering about 2 square miles (DNR Website, ForNet). These are crisp Color IR images, that can be viewed from the website on a user's PC screen and then originals can be ordered. This is very valuable for place specific inquires. Some sort of interpretation and summary would be needed to examine conditions over a wider area. Ecologically significant vegetative differences are often not readily apparent on a photo.

For analyzing change, the DNR website's ForestView area offers satellite image coverage of the entire forested region of the state. A user can enter a selected area and view changes in land cover between two available images (ChangeView). This is an extraordinary capability, and one that can supply valuable visual cues to landscape change. These visual comparisons become mere anecdotes that are difficult to use to make rigorous statements about resource change in the absence of numerical summaries, and of somewhat more detailed interpretations.

A shared vocabulary for discussing spatial pattern exists. It includes such concepts as, interior habitat, riparian habitat, patches and fragments, patch geometry, movement corridors, source and sink areas, biodiversity reserves/old growth areas, and edge.

A3

Indicator: **A3. Changes in Ownership Within Areas of Continuous Forest Cover (ACFC)**

Results: As used here, "ownership" means both owner <u>category</u>, and owner <u>identity</u> for areas larger than 1,000 acres. If the ACFC's referred to were mapped, there would be no way that detailed ownership identity at a given time, or changes in ownership, could be tracked with information as it stands today.

Noteworthy Observation: We have made efforts, in the past, to identify the major landowners in Minnesota and have been told that no list exists. If there is no list for the state, then there is none for "areas of contiguous forest cover" either, much less any map of the properties. Listings of large public owners holdings by finely divided geographic

areas that would correspond to areas of contiguous forest cover may be detailed but awkward to use.

A4

Indicator: **A4. Extent and Location of Forest Land by Landowner and Administration Category**

Results: The FIA report contains ownership category data by county for 1989. Current data are not available. The GAP database also contains owner by category by "40's."

Noteworthy Observation: The MFRC needs to define the meaning it intends for the term "administration category."

Recommendations For Indicator A4: Minnesota should schedule an update on ownership by category and identity from existing information not less frequently than every five years. The increasing importance of easements, mineral rights, and other nonfee interests needs to be attended to in any such survey. The nonprofit sector's ownership likely needs more detailed attention.

The State also needs an updated forest landownership survey. The NCRS FIA project has completed these for Wisconsin and Michigan (Leatherberry, Kingsley, and Birch, 1998) and it could be done at a modest cost (informal estimate, $10,000).

Additional Information: Extensive small ownerships exist in many areas, and subdividing is creating more every year. County land recordation systems contain the primary data on private lands but such systems are costly to use for the purpose of tracking statewide or regional ownership changes.

When State Comprehensive Outdoor Recreation Plans (SCORP's) were being prepared, they usually contained the best single inventory of landownership within a state. At a state level, agency documents and federal agency reports indicate ownership and are usually fairly current. However, it has proven difficult and time consuming to inventory holdings of the many "nonprofit sector" nonprofits and local governments holding lands.

Information on Area by Ownership Category

Several sources of forest area by ownership category are available. These may not always yield identical estimates for total forest area, or for ownership in a given owner type. For example, in the past the NRCS Natural Resources Inventory (NRI) estimates of forest acreage did not always match FIA estimates. Estimates of forest land owned by farmers in the Census of Agriculture did not always match those shown in FIA documents. In some states, FIA numbers do not match those from other sources for lands owned by tribal groups or tribal members.

Availability of FIA Data

Availability of the FIA dataset is good and improving. It can be obtained in the standard USFS publications (Miles, Chen, and Leatherberry, 1995), on a CD-ROM, and

from the national FIA website. For more technical detail and questions, agency staff is available to assist.

Timeliness has not been a major issue in the Lake States in the past since the resource changes slowly and historically the growth has far exceeded the cut. For a variety of reasons, though, the agency has shifted the basis of the FIA to an annual survey that will produce estimates of the statewide forest condition each year. The first brief report under this new system has just been released (Schmidt, n.d.). Once this Annual Forest Inventory System (AFIS) is fully in place, it will enable analysts to track forest conditions in more detail and in a more timely way. Annual reporting is essential. Considering the changing balance between overall growth and cut, this is most timely.

It must be said, however, that the level of future federal commitment to the FIA program's funding needs should not be taken for granted. The AFIS system relies on a level of commitment from the States that has not been demonstrated in the past. While Minnesota's record of contributions to "plot enhancement" in the past has been commendable, a similar commitment to an annual funding item is a different matter. Further, given the movements of wood across state lines, resource conditions in nearby areas affect Minnesota's economy.

Recent work at the NCRS has produced a capability for geographic presentation of FIA plot data in a variety of flexible formats (Pat Miles, NCRS, St. Paul), although this will not yield type maps suited to depiction of spatial pattern in the sense that the Council is seeking. But it will provide a flexible base for depicting vegetation at the level of counties, any specified ecological or administrative regions, or any user-defined polygon (e.g., a procurement radius around a mill). Since this system relies on plot data, users are not confined to any standard set of type definitions but can define their own (On the web, see http://www.ncrs.fs.fed.us, data distribution tools; mapmaker). NCRS is also exploring developing type maps by nearest-neighbor methods (Franco-Lopez, et al. 2001).

Very general statewide data on forest ownership are available for 1994 from the last national survey (Birch, 1996). Sampling intensity within the state was low as this was a national survey. Wisconsin and Michigan have paid the USFS to conduct detailed forest landowners surveys. These surveys can be conducted very economically from the state's perspective. A working cost estimate would be $10,000 (see Leatherberry, Kingsley, and Birch, 1998).

A5

Indicator: **A5. Extent and Location and Spatial Pattern of Forest Land Protected from Conversion to Non-Forest Uses by Laws, Rules and Administrative Policies**

Results: There exists no information on which to base an answer to this question. This could be readily compiled.

Additional Information: The maps that exist at various scales of various parks, research areas, etc, do not consistently or thoroughly identify forest versus nonforest lands, nor do they always identify degrees of protection, without reviewing file data in detail (e.g., National Forest Land allocations).

A6

Indicator: **A6. Listing of Land Taxes**

Results: It would not be particularly difficult to develop a list of land taxes.

Additional Information: A list of land taxes would include local property taxes, and multiple provisions of the state and federal personal and corporate income taxes, and state and federal estate, gift, and death taxes. Other levies might be considered to have less direct but occasionally significant effects, such as local benefit assessments for roads, flood control, or infrastructure. Then there are use-value tax programs for forest and open-space lands, and circuit breakers for specific classes of citizens. The federal income tax contains a provision for expensing up to a certain amount of planting expense each year, and at one time contained capital gains tax provisions that were clearly helpful to timberland owners. It is conceivable that other tax levies exist that arguably have some effect on the retention of land in forest, or at on least on how that land might be managed.

A7

Indicator: **A7. The Degree to Which They Impact the Amount of Forest Land**

Results: There exists virtually no accepted base of policy analysis that would enable anyone to determine, even very roughly, the extent to which any of these taxes or tax provisions actually affect the amount of land retained in forest, or to indicate in any very precise way how that tax affects how the land is managed. This is such a complex and difficult problem of economic analysis and policy evaluation that it is probably beyond the scope of any realistic research program for any one state.

Noteworthy Observation: Assessing the impact of tax policy on the amount of forest land is beyond current knowledge.

Additional Information: A recent review by the MFRC suggests that the state's Tree Growth law should be replaced by a new policy (MN Dept. of Revenue, Dec. 2000).

Table 3
Minnesota Information Review: Summary on Forest Land Base Data

Source		Item No.*	Timely	Accurate	Spatial Detail	Level of Detail	Availability to Users
Forest Area -- USDA FS, NCRS, FIA		A1	A	A	M	A	A
Forest Cover Map -- MNDNR		A2	I	M	M	I	A
Forest Cover Maps -- Counties		A2	I	M	M	I	A
Forest Cover Map -- USDA FS Chippewa, Superior NF's		A2	I	I	M	I	M
Forest Cover Map -- Industry			M	A	M	M	N
	Totals	A	1	2	0	1	3
		M	1	2	5	1	1
		I	3	1	0	3	0
		N	0	0	0	0	1

A = Adequate M = Marginal I = Inadequate N = Nonexistent

* Item number is a reference to numbering in Data Inventory (attached).

B. Minnesota Ecosystem Health

An Overview of the Issues Relevant to Understanding the Study of Ecosystem Health

Any effort to monitor ecosystem health presumes a clear and widely accepted definition. Even the narrower concept of "forest health" has had extensive and largely inconclusive debates among specialists about what exactly health means. The MFRC's Phase I Indicators do not attempt an exhaustive inventory of all possible topics. Definitions of forest and ecosystem health may be less important if people can agree on proxies and measures of important aspects of those concepts, and if those measures can actually be measured in ways that are credible.

A small group of specialists in forest inventory practice can come to grips with the adequacy of forest data, and they need to refer to only a small number of datasets. To achieve such a level of comprehensiveness for all other organisms, it would be necessary to assemble an entire football stadium full of specialists on individual genera and species.

Noteworthy Observation: For many resource values consistency over time and comprehensiveness is lacking (Table 4). For the most part, information products fully meeting information needs are available only for a portion of the state.

This situation does not apply for nonarboreal plants, aquatic life, fish and game, insects, fungi, and other orders of life that make up the biodiversity of the state. There is no one survey and bulletin to which users can turn for comprehensive data, consistent over time, covering decades of change in populations and condition. A number of national overviews provide a useful comparative snapshot of current conditions, and offer various measures of distinctiveness or "degree of threat" to biodiversity (Langner and Flather, 1994; Flather, Joyce, and Bloomgarden, 1994; Loftus and Flather, 2000). To understand the condition and prospects for a rare species, a great deal of demographic and habitat data must be known, and many of the important factors affecting population viability may be unknown or in contention. There are many efforts underway and some of these are potentially useful for sustainability tracking. However, some are mere "snapshots," and still others cover only portions of the state. There are valuable discussions about birds in Sauer and Cooper (2000), and subsequent papers in the same volume.

Population monitoring and tracking of proxies for population condition have been in place for some time for some taxa. This is the case for the Audubon Christmas Bird Count, the BBS, and some of the insect population monitoring. Long term records exist for some bodies of water and individual fish species. Particular land units, such as Wildlife Refuges or National Forests, have extensive information bases on particular species that are made available in periodic reports (e.g., Vora, 1997; Chippewa NF, 1998). An extensive bird count database is available on NRRI's website.

For the forest, an extensive FIA database exists on species composition, number of individuals, and numerous important biological and economic characteristics. This dataset is not only published in a single bulletin, but it is available on the Web. In addition, the information has been developed using consistent methods over time that is

familiar to a wide variety of information users. When changes in methods are made, the effects of those changes can often be estimated. This data could support much more exploration to shed light on forest health.

The U.S. Geological Survey is current leading a regional GAP analysis. This analysis is expected to provide a detailed map, and informational data on regional ecosystems and species, and to offer a sound basis for judgments about ecosystem condition. The Gap analysis is to be completed in the year 2002 (see http://www.gap.uidaho.edu and follow menus to Minnesota). Completion of the GAP analysis may also improve the informed basis for setting priorities for biodiversity monitoring.

Pending completion of the GAP analysis, a useful guide to priorities would be to begin with the checklist of concerns identified in the biodiversity technical paper of the GEIS (Jaakko Pöyry, 1992). That report listed 12 possible significant impacts of increased timber cutting and intensified management. It also noted 11 mitigations that could be applied (Table 5). Knowledge gained since 1992 might lead to adjustments to both lists, but at least they offer a starting point for monitoring the effects of timber management on biodiversity. It does not appear that any systematic tracking of either the significant impacts or the mitigations has been conducted.

Table 4
Minnesota Information Review: Summary on Ecological Indicators

Source	Item No.*	Timely	Accurate	Spatial Detail	Level of Detail	Availability to Users
Minnesota's Ecological Classification System - DNR	B1, B2	A	A	A	A	A
Multi-Scale Mechanistic Indicators of Terrestrial & Aquatic Systems	B1, B2	A	A	A	A	M
Forest Resources Council Spatial Analysis Project - MFRC	B1, B2	I	A	A	A	I
Forest Type x Growth Stage Matrices -- Chippewa NF	B2D	A	A	A	A	A
Forest Type x Growth Stage Matrices-N. Superior Uplands - NRRI	B2D	A	A	A	A	I
Forest Type x Growth Stage Matrices-NMN&Ontario Peatlands - NRRI	B2D	A	A	A	A	A
MN Wildlife Resource Assessment Program (in progress - DNR)	B2D	A	A	A	A	M
Native Plant Communities of Minnesota's Drift and Lake Plains	B1I	A	A	A	A	A
Native Plant Communities of Northern Superior Uplands	B1H	A	A	A	A	A
NRRI Forest Landsat Classification	B2C	A	A	A	A	A
SUSTAIN - Predicting Water & Forest Health & Sustainability, subunits of MN. J. Hanowski, ongoing	B5C	A	A	A	A	A
Totals	A	10	11	11	11	7
	M	1	0	0	0	2
	I	0	0	0	0	2
	N	0	0	0	0	0

A = Adequate M = Marginal I = Inadequate N = Nonexistent

* Item number is a reference to numbering in Data Inventory (attached).

Some Problems with the use of Indicator Species

Land managers and ecologists seeking to measure trends over time must resort to a number of simplifications. There are many different species and conditions that could be considered to play a role in ecosystem health. Reliable information on their population status or condition barely exists for most of them. For a few organisms, these matters may be in contention even in the presence of a large body of research. The sheer quantity of observations to be made is daunting.

Funding and staff always limit what can be measured. Choices must be made, and agencies and research staff often make those choices without a comprehensive framework for setting priorities. Sometimes it is necessary to carry on with whatever measurements are already available as baseline. The Breeding Bird Surveys have been widely used to indicate population status and to suggest trends in habitat condition. These have the virtue of a consistent method and familiarity to the profession, as well as offering various possibilities for treating large numbers of species in reasonable groups.

Some agencies have solved these challenges by trying to designate a short list of "Indicator Species" that can be monitored cost-effectively and reliably and that can be taken to reflect overall ecosystem condition, or that may themselves be species of concern. The selection of indicator species has always led to controversy because there are always important species or issues left out (Morrison and Marcot, 1995).

Recommendation for Forest Ecosystem Health: The MFRC should assign a qualified team to evaluate Table 5, analyze trends, and design a system of indicators and steps that could track both the impacts and the mitigations.

Table 5

Biodiversity Mitigation Strategies and Significant Impacts

Significant Impacts	Mitigations/Suggestions
Decline of Old Growth Swamp Conifer Forest	Inventory Improvements
	Silviculture to Retain Conditions
Likely Decline of Hemlock, Yellow Oak, Honeylocust, Sycamore, Kentucky Coffeetree and Rock elm	Extended Rotation Forest
	Harvest and Silviculture to Retain Species
Potential Loss of Conifers in Mixed-Species Stands	Connected Landscape
Decline of Tree Species Near the Range Edge	Biodiversity Maintenance Area
Decline of Rare Communities	Prescribed Burning
Effects of Fragmentation on Forests Herbs	Return of Red and White Pines, and Upland White Cedar
Effects of Fragmentation During Climate Change	Favor Tree Species Near the Edge of Their Range
Deer Browsing	Careful Use of Exotics and Hybrids, Protection Strategies
Potential Displacement of Native Species by Hybrids	Silviculture to Retain Conifers in Mixed Species Stands
Decline of Rare Plants Species	Careful Harvest Near Rare Species and Communities
Decline of Red-Shouldered Hawk	Management to Produce or Mimic Desired Conditions (e.g., Fire)
	Resolution of Conflicting Management Goals
Decline of Pine Marten	

Source: Jaakko Pöyry, 1992, p. 97, with extensions by authors.

Availability: Ecosystem Health

In the area of Ecosystem Health, the gap between the existence of immense quantities of data and observations in files of one kind or another, and "information" in the sense of this report, seems to be very wide. We therefore concluded that many important indicators in the Phase I Report lack "information," as we use the term in this report. The absence of a shared definition of "ecosystem health" contributes to the difficulty of mobilizing information to describe what it is and how it is changing.

Summarizing information on the populations and habitats of so many different organisms, terrestrial and aquatic, and so many different potential stressors, into usable "information" is a formidable challenge. The strategy of focusing on a short list of "indicator species" has been so widely criticized that few seem to support it any more, yet no consensus exists on an alternative.

Availability of the raw data on all of these topics is improving, and more and more primary information is becoming available on the Web. For example, it is possible to download population estimates for wolves. More and more reports and assessment documents are becoming available. Yet, simply placing primary documentation and datasets on the Web does not transform the material into "information" useful for tracking trends in sustainability at the state level.

In the well-established area of insect and disease survey, abundant maps and data exist, in some instances for decades. Availability is improving. Aggregating the shifting incidence, severity, and impact (which is often elusive) of dozens of insect, pathogens, declines, and occasional weather events into some overall picture of forest health is a baffling task. Simply adding up areas affected, or other indices of extent/severity is not likely to produce a very compelling synoptic view. This information does not generally translate readily into estimates of mortality or growth impact.

Baseline Question: What is the Condition of Terrestrial Habitat in Forested Areas?

Results: While there is an abundance of specialized knowledge and microdata, there appears to be no overall assessment of terrestrial habitat condition in Minnesota's forests.

Noteworthy Observation: This BQ uses the term "habitats" as an overall descriptor of conditions, yet the term habitat does not appear in the indicators. Also, it uses the undefined term "in forested areas."

Baseline Question: What is the Condition of the Aquatic Resources in Forested Areas?

Results: The costs of systematically monitoring physical, chemical, or biological parameters have prevented extensive monitoring over the landscape as a whole beyond temporary regulatory inquiries or research studies.

Noteworthy Observation: The monitoring of water quality and aquatic communities has been recognized as a key means of tracking ecosystem health since the time of the Hubbard Brook Experiment. There is growing recognition that "bio-indicators" may, at times, be more useful indicators of quality than physical or chemical parameters commonly measured in the past.

Additional Information: The cooperative effort on the Upper Mississippi River and its tributaries (USGS, 1999) is an excellent example of building a base for long-term monitoring on a major waterway. Unfortunately, this effort deals primarily with heavily modified waterways and special conditions, and does not address the concerns found in first order forested watersheds. Another cooperative effort now underway, called MARIS (Multi-State Aquatic Resources System), is planned to cover six Midwestern states. Minnesota data is reportedly being entered (Loftus and Flather, 2000, p. 40 ff). MARIS will be able to produce time series showing trends.

The Indicators of Forest Ecosystem Health

The indicators on Ecosystem Health include topics concerning terrestrial and aquatic ecosystems, disturbance, growth, mortality, and removals, and potential productivity.

B1

Indicator: **B1. Extent, Location and Spatial Pattern of Natural Plant Communities**

Results: A number of maps provide the broad distribution of ecosystems (see data inventory). A Forest Atlas (Beltz, et al., 1992) shows distribution of major species by counties. Maps shown in the Data Inventory can meet various graphic needs. The Ecological Classification System (ECS) is a valuable framework.

Noteworthy Observation: The FIA dataset is the most underanalyzed resource of information in existence in forestry today. Many opportunities to shed light on important resource and ecological issues are being missed.

A considerable base of data and mapped information is available for individual management units, including County lands, State Forests, and the National Forests. Quite detailed depictions of condition and spatial pattern can be made using this information, though the statistical precision of the estimates must be considered in drawing conclusions from any primary information of this kind. In some instances, this information can be used to draw conclusions as to change over time if successive inventories on a common type mapping scheme and plot design are available. Since these lands together cover a significant portion of the state's forested area, they could loosely be viewed as a proxy for conditions over wider areas, and they are large enough that their situation deserves observation in its own right.

Several projects have attempted to define natural vegetation conditions, or natural ranges of variability, in portions of the state. These have been done by Blandin and Boise Cascade, and for the Northern Lake Plains and the Superior Uplands (White and Host, 2000; White, Host and Brown, 2001; and see Table 4). As funding becomes available, it is hoped that such assessments will cover the entire State. Forest type and growth stage matrices have been prepared for these two areas plus the Chippewa National Forest. When all of this work has been completed, there will be a need to carefully review the

information, assemble a statewide picture, and identify information gathering and management implications.

For other important situations, such as wetlands and unmapped streams, important areas are not well mapped and measured. There is no vegetation, land use, or topographic digitized information that permits a subtle and rich depiction of existing conditions in riparian areas, much less change detection over time. A new series of 1:24,000 USGS maps with topography, may materially improve this situation. FEMA flood frequency maps have been used.

Recommendations for Indicator B1: The MFRC should task a technical panel with examining the possibilities of developing existing FIA information (see, e.g., Allen and Plantinga, 1999; Miles, forthcoming).

The College of Natural Resources, with its close links to the FIA program and experience with FIA data, should be staffed to lead in analysis of this information and related data for the state and region. The College should also raise funds to support a rotating graduate or post-graduate fellowship in Forest Resource Analysis.

Minnesota should continue with the County Biological Survey, with closer linkage to the FIA analysis efforts.

General Observation: In this section, the Council intends "natural plant communities" to indicate a concept such as "habitat type" or "potential natural vegetation." The precise technical definition adopted may not be important. More important will be whether the resulting analysis and mapping proves to supply meaningful information that can be employed in assessment and in on-the-ground management.

Additional Information: An emerging source for land cover, ecological condition, and vegetation typing is satellite imagery. The College of Natural Resources Remote Sensing and Geospatial Analysis Laboratory conducts important research in this area (Bauer, et al., 1994). Other agencies, such as the University of Minnesota NRRI, are also working on improvements in techniques (Wolter, et al., 1995).

The FIA process relies on plot data analyses that use rules to classify each plot into a forest type group and then a forest type. In forests such as those of the Lake States, such rules inevitably oversimplify. Stand composition can in actuality range from 1% to 99% of a given cluster of species as a percent of basal area or number of stems. A typing algorithm requires that an arbitrary point be chosen on a spectrum of composition. Above this percentage, a stand is in Type Group X, below it, in Type Group Y. So long as this is recognized -- well and good. But in analyses of change detection, it can happen that a very small shift in stand composition over a wide area can result in large areas apparently changing type, when on visual inspection they appear quite similar. It is possible to analyze the primary FIA data in terms that yield a more rich depiction of composition than a two-way classification. An example would be to depict type composition in terms of deciles. This would mean sorting the plot data into categories, reflecting, for example, 0-10% white pine BA, 11-20%, 31-40%, etc. Analyzing the data in this manner would provide richer comparison of changes in composition than relying on any particular typing definitions. This is readily done but requires specialized expertise and time, and would benefit from a larger sample size.

Shifts in type composition are important indicators of ecological change. Measurements of those shifts that recognize the continuum of vegetation composition might be useful for many applied tasks. Further, comparison of compositions at different years is useful. But even more valuable are transition matrices that depict the changes in each direction, which is much more revealing than just knowing the net change. Existing depictions of understories in the FIA plot data have rarely been fully exploited for the insight they might provide into successional trends.

A statewide inventory cannot be expected to produce accurate area estimates for forest types or conditions that are rare, occur in tiny patches or stringers, or are thinly but widely distributed over the landscape. Of course, some of the rare and threatened ecosystems most interesting in the area of biodiversity conservation fit into this category. Also, some valuable timber species occur in this manner. Accurate area estimation for such types or conditions requires more focused surveys using different methods (see, e.g., Elzinga and Evenden, 1997). The County Biological Survey is a program of in-place inventory of rare, threatened, and endangered biological features started in 1987. Products include maps, reports, and various databases. Work is complete in 41 counties and in progress in 23 more (http://www.ndr.state.mn.us/fish_and_ wildlife/mcbs.html). The Natural Heritage Information System (NHIS) provides for storage and retrieval of this and related information.

Vegetation Type and Land Cover Definitions: Because of different sources and information needs, differing systems of land cover definitions and vegetation classifications have arisen (see, e.g., maps noted in Data Inventory). There may be a need to develop a crosswalk or reconciliation between these varying systems. For example, the USFS FIA program has a standardized set of classifications, but there is no reason why the primary plot data could not be re-formatted to correspond to any desired set of classifications. The definitions used for FIA probably differ from those used on many land management agency maps, and in turn these may differ from those used by the ECS and from the vegetation type definitions used by the County Biological Survey (Aaseng, et al., 1993; also, discussion in Pregitzer, Goebel, and Wigley, 2001).

The extent, condition, and management of riparian areas are a significant concern for forest management, wildlife and fish habitat, and forest practice regulation. The measurement of the linear extent of such areas related to mapped streams and ponds is fairly straightforward (SGS water layer). In their assessment of forest practice regulations, Vasievich and Edgar (1998, pp. 25, 26) ventured preliminary estimates. They found that depending on the riparian widths used, between 516,000 and 980,000 acres of forest land lay within the buffers. This would be 3.5 to 6.7% of all timberland. Similarly, between 3.2 and 6.3% of all timber volume was found within such buffers. But depicting conditions in these areas in any greater detail, or detecting change, is essentially impossible at present except where landowner maps supply detailed data for local areas.

A USFS regional project is developing a survey-level quantification of riparian resources for the seven Midwestern states (Brian Palik, USFS, Grand Rapids, pers. comm.). In Minnesota, for a sample of six drainage basins, two each in agricultural, urbanized, and forested areas, a detailed assessment is underway that will permit the use of a range of definitions of riparian areas. When this project is completed and results

reviewed, it will be possible to develop a well-founded approach to measuring conditions and trends in riparian areas.

B2

Indicator: **B2. Extent, Location and Spatial Pattern of Forest Types, Age Classes, Size Classes, Site Index, Basal Area, and Productivity Classes**

Results: Information base on these topics is very good, except for spatial pattern, and ability to detect change at a state wide level is high.

Noteworthy Observation: The FIA dataset provides for extensive crosstabulations of this information by Survey Units and in many instances by county. Site quality and productivity class do not change materially on a decadal time scale, except in unusual circumstances.

B3

Indicator: **B3. Status of State and Federal Endangered/Threatened/Special Concern Species**

Results: The U.S. Fish and Wildlife Service and the DNR maintain lists of species in these categories. Minnesota maintains a statutory list of species of concern. The latest version (1996) is on the web at http://www.dnr.state.mn.us/fish_and_widllife/endangered_species/ The state list contains 439 species, across many taxa. There are at present 13 federally listed T&E species in Minnesota. The state's list is to be updated in several years (R. Baker, pers. comm.).

Noteworthy Observation: Reviews of species Recovery Plans done at the federal level to date have often criticized the scientific base of population dynamics knowledge and the technical basis for recommendations. This should not be surprising considering the meager information base that exists on most of these species, except for the "charismatic megafauna" such as eagles or wolves that have been heavily studied.

An objective of comprehensiveness in this area would probably be misguided. The concern should be for priorities. There will never be enough funding or enough scientists to obtain answers to all the important questions concerning all of these species. The issue, rather, is how to set priorities so that funds and talent are expended where they will arguably "do the most good." Of course, opinions will vary on how to achieve "the most good."

Additional Information: Carnivores, whether listed or not, are often of public interest and can be considered an indicator of habitat condition. A useful summary of trends in populations shows how a web-based presentation of occurrence and trend data can be done (Sargent, Berg, and Johnson, n.d.).

B4

Indicator: **B4. Listing of Sensitive Species that are Monitored by Agencies, Institutions, and Programs**

Results: We have found no overall listing of species being monitored by all agencies, institutions, and programs.

Noteworthy Observation: It is likely that much of the monitoring of even the species of special concern is informal or incident-based due to lack of resources. Assembling a list for this indicator would entail a detailed poll of agencies, research stations, scientists and naturalists around the state. This probably would have to be done one major taxon at a time in order to be a workable project.

According to the DNR's administrator of nongame species, "We conduct formal monitoring of status and trend for very few species. That is, for most species we cannot say, for example, 'We have a 95% confidence that the distribution and abundance of species x is stable or increasing.' Having said that, however, we are continually gathering information on many listed species. This information allows us to assess whether or not the listing of a species is needed and reasonable. Whether or not this ability is the same as 'sufficiently well to track status and trend' depends on definitions" (R. Baker, pers. comm.).

Additional Information: An annual summary on wildlife populations (Dexter, 2000) covers the gray wolf, which is one of the threatened species.

Recommendations for Indicator B4: The MFRC should inventory research and monitoring now underway for all species on the list. One objective would be to develop an overall directory of agencies, groups, individuals and datasets. When complete, an assessment of key gaps should be made.

B5

Indicator: **B5. Index of Biological Integrity (IBI) & Ecological Indicators**

Results: The concept of an Index of Biological Integrity is a powerful scientific and monitoring tool. But it does not appear that existing efforts will soon yield a sensitive detection tool for assessing trends in ecological health of forest-related waterways.

Noteworthy Observation: An IBI requires detailed development of a database customized to particular ecological conditions (see, e.g., Lyon, 1992, esp. App. 2).

Recommendations for Indicator B5: The MFRC should empanel a technical team to review existing knowledge and ongoing monitoring activities and develop a sample-based, cost-effective means of measuring what needs to be measured to track trends in condition of forest-related streams and waters in Minnesota. This will require attention to a sampling scheme in time and space, to artful selection of variables to be measured, and to innovative and cost-effective measurement methods.

Additional Information: The Index of Biological Integrity has its roots in efforts to characterize condition and trend in aquatic ecosystems. A similar concept is now being applied to wetlands within Minnesota (Mark Gernes, PCA, pers. comm.; EPA, 1998). Additional work is now underway to characterize wetlands in the North Central hardwoods ecoregions, and an assessment of the more northerly fens is being proposed. These assessments are quite detailed. Completion of the state is years away and frequent monitoring is unlikely on any scale in absence of a focused need.

Monitoring of streams is farther along than wetlands, but only two major watersheds (Lake Superior and St. Croix) are done. The Upper Mississippi is underway. The measurements cover many taxa in different categories, and sampling is done on a range of reaches from first-order to mainstream reaches. Due to cost, these measurements will be repeated only at eight to ten year intervals and hence, will only be useful for the most general long-term trend detection. Also, since some organisms may be highly sensitive to year-to-year differences in flow or temperature, there may be uncertainty in interpreting some biological changes. A useful example is given by Goldstein, et al. (n.d).; see also, Niemela and Feist (2000).

B6

Indicator: **B6. Status of State and Federal Endangered, Threatened, and Special Concern Aquatic Species**

Results: The status of many of these species is not known in detail.

Noteworthy Observation: The aquatic habitats in first-order watersheds are those most likely to be affected by changing forest conditions and by management. The sense that water quality issues and aquatic habitat loss issues are less critical in the forested zones has resulted in far less research and monitoring on these topics in remote forested settings than on larger streams and in the agricultural areas.

Additional Information: Conditions for aquatic species have improved in the fringe zones where farming and forest have met over the years and in the many areas where livestock production and row crop farming have dwindled. Also, see remarks made above on terrestrial species.

B7

Indicator: **B7. Listing of Aquatic Species that are Monitored by Agencies, Institutions, and Programs**

Results: There appears to be no comprehensive listing of all aquatic species whose populations and habitat conditions and trends are regularly monitored.

Noteworthy Observation: Monitoring of fish populations and habitat is conducted at 28 field offices based on local issues, needs, and resources. No need has been perceived at DNR for any statewide sampling program or assessment.

Additional Information: Periodic surveys could be used to assess changes in conditions for given streams (Mark Ebbers, DNR, pers. comm.). Extensive work on lake and stream water quality and ecological conditions is also relevant.

The Fisheries Division has assembled results of the established system to conduct a detailed analysis for trout habitat and trout productivity in southeastern Minnesota from 1970 to 1996 (Anon., 1997; and Thorn, et al. 1997). This analysis yielded important management implications. It offers an excellent example of how volumes of occasional surveys and other records can be turned into valuable trend assessment information through careful analysis. It also illustrates resource analysis at an ecologically and managerially relevant geographic scale. Choosing this specific region enabled the production of a much more valuable analysis than would have emerged from an attempt to incorporate all available information about the entire state's trout resource. **This point deserves consideration as the Council proceeds to develop its indicator system.**

Overview: Disturbance

It is not clear that lack of comprehensive statewide data on extent and spatial pattern of disturbance is a major problem. There may be, however, some circumstances in which a more regular or more standardized assessment would be useful and might yield either important scientific insights or improved management decisions. An example might be an effort to detect some signal of the effects of past climate change in the ecosystems of Minnesota. The methodological difficulties are extreme, and issues of extrapolation into the future would be significant. But the growing interest in this problem, and increasing polarization over causes of recent climatic changes, might motivate attention to this question. Recent research validates what we know from casual observation, which is that ice-out dates have changed significantly over this century. It would be strange if there were no biological effects. The recent release of the IPCC Third Assessment Report, predicting larger temperature increases than previously, will certainly re-invigorate this debate (IPCC Policymaker Summary; NAST, 2000; and Joyce and Birdsey, 2000; and Great Lakes Regional Assessment Group, 2000).

Recommendations for Indicator B8:

1. Exploit existing FIA data to analyze recent harvesting and related disturbance.
2. Conduct a new harvesting and silvicultural practice survey, with provisions for improved coverage of treatments on NIPF lands, and plan for follow-up in three to five years.
3. Consider whether there is merit in initiating monitoring of specific organisms or conditions, where sufficient baseline data exists to enable the detection of a "signal" of climate change effects, or where a convincing argument can be made that such monitoring has high chances of detecting such an effect in the future.
4. Review the staffing, procedures, and funding of the state's efforts in monitoring insect, disease and other forest health concerns and issues related to exotic and invasive species. Determine whether improvements are needed.

B8

Indicator: **B8. The Extent, Location and Spatial Pattern of Disturbance by Type and Severity Class**

Results: While there is a large volume of primary data on disturbances, reducing the various forms of data to understandable information on forest condition is a complex task that remains to be undertaken.

Noteworthy Observation: For purposes of its indicator system, and as used in this report, the Council employs the term "disturbance" in its broadest sense to include weather, insects and disease, air pollutants, cutting, and fire.

Additional Information: Disturbance is not generally measured with precision in the FIA dataset. One reason is that plot measurement often takes place long after a disturbance occurs. Field crews may see that a tree is dead, but may not be able to determine the cause. It is commonly found in surveys of spruce budworm damage, for example, that field crews cannot identify the cause of death of a large proportion of the trees found dead on plots. Nor can the date of death be precisely recovered. A tree on a plot may have a broken top, but the cause of that broken top may not be identifiable. Further, disturbances display a wide range of degrees of extent, severity, and frequency. These are not readily measured in a fixed plot inventory system. No doubt, however, more detailed analysis of the FIA dataset could yield insights.

Changes in land use are one form of disturbance, and at an aggregate level these can be followed over the years in the FIA data (and see Mauldin, Plantinga, and Alig, 1997; and discussion elsewhere in this report). The periodic NRI reports offer a general view for private lands at the state level (USDA, NRCS, 2000).

B8a

Indicator: **B8a. Timber Harvesting**

Results: There is no annual, statewide monitoring of timber harvest activity.

Noteworthy Observation: Harvesting disturbance has been analyzed in other regions based on the FIA dataset (cf, Gansner, et. al, 1990), but this has not regularly been done in the North Central Region. The FIA dataset captures the necessary information, but it has not been analyzed.

Additional Information: As part of the GEIS, a survey of harvesting and silvicultural practices was conducted. This survey was updated and improved in a project sponsored by the MFRC. That survey, for 1996, contacted loggers and landowners and measured many aspects of cutting and silvicultural practice (Puetmann, et al. 1998). However; it was not possible to fully account for all cutting on small private ownerships. A need for a more comprehensive periodic survey of this kind is well recognized. Another source of information on planting and TSI is the annual US Forest Service survey (USDA Forest Service, *Tree Planters' Notes*, 1999). That survey has been found to differ from state surveys in other instances, as it seems to do for Minnesota as well.

B8b

Indicator: **B8b. Weather Events**

Results: The measurement of weather event impacts is episodic. It is costly and difficult to do so comprehensively and in detail.

Noteworthy Observation: The staff and funds are not available to conduct post-event assessments in rigorous detail for most disturbances. Salvage cutting or other later treatments can obscure effects and change paths of recovery. Most instances of localized or low-level chronic impact never receive any assessment at all.

Additional Information: Dramatic and extensive disturbances, such as the July 4, 1999 BWCA windstorm, widespread and damaging insect outbreaks, and tornadoes or ice storms, usually prompt extensive and often detailed assessment on the spot and occasionally in terms of later forest recovery (Foster Wheeler Environmental Corporation, 2000). Disturbance of highly valued resources such as old growth stands, historic trees, major urban parks, or sugarbushes is often assessed promptly and in detail. (For a valuable literature review, see papers in the *Science of the Total Environment*, No. 262, 2000).

A number of the leading types of disturbances have long-term consequences. The 1988 drought, the large windthrow events of the 1990's, and occasional ice storms are prominent examples. Simply measuring their extent and severity in the immediate aftermath of the event may not indicate at all what the long-term consequences will be. Given the patchiness, high variability from place to place in immediate damage, differing effects of salvage, and difficulty of monitoring these events, a good factual understanding of long-term consequences is elusive (e.g., Foster, et al. 1997; Maass, 1989; and MN DNR, Div. of Waters, 1989).

B8c

Indicator: **B8c. Forest Insect and Disease Surveys**

Results: At the state level, it appears that Minnesota has adequate capabilities and data for tracking trends and condition for major forest insects, diseases, and the major damaging weather events. Quantifying the elusive "Forest Health," however, remains a challenge.

Noteworthy Observation: An important aspect of forest health is the extent, intensity, and trend of populations of damaging insects, diseases, and decline syndromes (see, e.g., Millers, Shriner, and Rizzo, 1989). Minnesota conducts extensive ongoing survey work in this field, summarized in periodic regional reports such as those issued by the NE Area, USDA Forest Service, State and Private Forestry, and topical reports issued by the DNR (MDNR, 1998; 2000a). The professionals concerned have largely made the transition from thinking exclusively in terms of forest pests, to thinking more broadly in terms of forest health. But, measurement is elusive and costly. The ability to

comprehensively quantify "forest health" has not caught up with the general recognition of its importance. As one staffer observes,

> *"We have many documents and sources that provide 'bug and crud' incidence and severity data but these do not provide a balanced view of forest health."* (M. Ostry pers. comm., 12/5/00)

Recent years have seen an increase in concern about exotic and invasive species. Established pest management staffs have always devoted attention to this concern (see, e.g., http://www.invasivespecies.gov; Mattson, n.d.; Kaiser, 1999; Niemela and Mattson, 1996; and Anon., 1999).

There is a tendency for ongoing functions like insect and disease survey and health assessment to be seen as routine, uninteresting, arcane, and as areas of lower priority in budget decisions. It may be a timely moment to ensure that Minnesota does possess the capabilities it needs to maintain the needed expertise and data on these issues in the future. The gypsy moth strategy (MDA, et al., 2000) is an example of a trend in coordination.

Additional Information: A system of Forest Health Monitoring Plots has been measured for several years, and results are available through DNR. A set of 344 plots has been established in Minnesota; these are periodically measured to determine crown conditions, presence of lichens, diversity, and other variables (http://www.fs.fed.us/na/briefs/fbm99). The FHM plots are now integrated into the AFIS program.

Authorities recognize that while it is essential to track insect and disease conditions, there is a role for them as natural ecological factors in the landscape. It is becoming more and more clear that a certain amount of standing and down dead wood is critical to forest and aquatic ecosystems functions. A "healthy" forest is not a forest devoid of standing dead and down trees. Many authorities believe that extensive areas of younger, and more heavily managed forest ecosystems have been impoverished in exactly these habitat elements. Determining the proper management response to information about pest conditions is a separate matter, and cannot be done intelligently without sound information on condition and trend.

The Great Lakes Assessment (GLA) website has a series of map slideshows. These slideshows show annual maps of the distribution and severity of pests. Interpretation on local detail is hindered by different levels of detail in past surveys, but state-level patterns can be seen.

B8d

Indicator: B8d. Air Pollutants Affecting Forests

Results: Data on air pollutants affecting forests is readily available.

Noteworthy Observation: In our consultations our informants did not perceive a major priority for organizing and tracking this information in relation to forests. Still, we would think that tracking available information on the state's "chemical climate" would be useful (e.g., GAO, Mov. 2000).

Additional Information: Specific measurement of the impact of pollutants occurs on FHM plots but only occasionally elsewhere.

B8e

Indicator: **B8e. Fire**

Results: General fire data is readily available, but ecologically significant detail needs to be retrieved from primary documents.

Additional Information: The Great Lakes Assessment has placed recent fires of 10 acres or larger on a digital map which can be downloaded at (www.ncrs.fs.fed.w/gla/natdist/firesge10.htm). The underlying information is also available from the DNR in summarized form; the contact people on the website can be consulted as to availability of data products for further analysis. The GLA database has not been updated past 1995, and soon users may require more detailed information or more refined characterization of fire effects than this source can supply.

To obtain a useful view of fire impacts, information on a number of details would be needed:

- Pre-fire vegetation type, including canopy, ground cover, fuel load
- Month of occurrence
- Cause
- Pre-fire hazard rating
- Intensity of fire
- Uniformity of impact within burned area

Without some of these details, knowing location and size of fires is only of fairly general interest. At present, these details must be retrieved from primary files (Bard Meyer, DNR Fire Information Office, Grand Rapids).

B9

Indicator: **B9. Land Use and Cover Class of Disturbed Areas**

Results: Except for major events, as noted above, there is no widespread and ongoing monitoring on this indicator. (We assume this means cover class both pre- and post-disturbance.)

B10

Indicator: **B10. Composition and Stocking of Forest Regeneration**

Results: We know of no statewide, current tracking of composition and stocking of forest regeneration, other than the FIA dataset and agency internal data.

Noteworthy Observation: This is a major information gap. The FIA dataset does not specifically identify regenerating stands, though its plot records include understory vegetation, and cutting disturbance can be retrieved. Also, a microplot is measured for seedlings, but the data have never been analyzed. For the National Forests and some public ownerships, regeneration certification results are available in periodic monitoring reports. The concern is not the absence of regeneration, but its species mix and conditions, and what these portend for the future covertype and species mix.

Additional Information: On some landownerships, it is standard practice to check regeneration in a systematic way to ensure adequate stocking. On the National Forests, regulations require this. For some issues, such monitoring is often a useful proxy for indications of some regionally important condition, such as regeneration failure of some species due to overpopulations of deer.

Recommendation for Indicator B10: A team should be empanelled to examine the use of FIA and agency information to develop status and tracking measures for this indicator.

B11

Indicator: **B11. Growth, Mortality, and Removals by Species**

Results: These variables are measured, periodically, on a statewide basis by FIA. Removals are estimated annually by DNR using a variety of sources.

Noteworthy Observation: It may be time to consider a new approach, such as some other states use. We suggest a mandatory preharvest notification and subsequent report of volumes cut for all harvests above some minimum volume or area. However, such reporting is not a substitute for other removals surveys and requires several years to institutionalize.

Additional Information: The FIA program measures gross and net growth by stand type, species, survey unit, and for growing stock and sawtimber. In addition, it shows averages over the survey interval, as well as the growth for the current year. Sampling errors are high for survey units, however. Under the AFIS program, it will be several more years before any comparable measures of growth can be estimated, because only 20% of the plots are being measured each year.

The FIA also measures mortality. As noted above, this is not always a simple matter, but the estimates are generally considered reliable. Annual average mortality from 1977-89 was roughly 3 million cords of all species, taking a large slice of gross growth. It is extremely difficult and costly, however, to update mortality estimates over any large geographic area. A sense of possible growth impact can be gained if sound monitoring of pests is being conducted. A number of major storms have caused significant damage over hundreds of thousands of acres since the 1990 survey. No estimate of their possible effects on growth and mortality has been made.

The periodic FIA surveys also measure removals. The low statistical precision of past FIA removals estimates, and poor agreement with end user surveys indicate a need for improvement in this area. Timely annual tracking of removals has surfaced as an

emerging interest. Building upon the existing FIA pulpwood and other surveys, the DNR Utilization and Marketing staff prepares an annual estimate of removals. This relies on occasional surveys of sawmill and other wood users. Periodically, surveys of firewood usage are conducted. Funds and staff available for this effort have dwindled, which is surprising in view of how close the recent harvest estimates are to the calculated Annual Allowable Cut (AAC). Delays in staying on schedule with the USFS pulpwood surveys have also hurt this effort. The most recent published pulpwood report is for 1997 (Piva, 1999).

Removals from nongrowing stock (poor quality) trees accounted for 25% of estimated 1988 timber products output (NC-158, p. 128). The basis for this estimate needs updating, as it has a large impact on how close the growth/removals balance is.

Recommendations for indicator B11: The MFRC should conduct a feasibility study of a preharvest notification/postharvest cut report program for Minnesota in view of experience in other states, and likely administrative and compliance costs. Alternatives should be examined, and suitable consultation conducted with affected parties as a part of the process.

The entire program of tracking removals needs to be reviewed and strengthened. Using a suitable method, the estimating method for removals from growing stock and nongrowing stock sources should be carefully reviewed and, if necessary, new estimates prepared. (A project on FIA removals estimates is being planned at UMN.)

B12

Indicator: **B12. The Extent of Forest Land With Productivity Levels Below Potential Productivity**

Results: Measuring this indicator presupposes a precise definition of "potential productivity." Consensus on this definition does not exist at the moment.

Noteworthy Observation: A definition of "productivity," considered as an Annual Allowable Cut over time that suitably considers nontimber values, would encounter technical difficulties in calculation and would entail many contentious judgments about policy. This is not merely a technical problem. Nonetheless, a definition of "productivity" in such terms, with explicit assumptions, should be considered as the standard for reference whenever the question of "current versus potential growth" is considered.

Large disparities are evident when this measure of productive potential is compared with current growth. Productive potential is defined as the rate of growth of timber that would occur in stands that are fully stocked and at productive stages of their growth cycles. Such a definition, if implemented at a landscape level, implies some assumptions about future management intensity and about the age class distribution of stands that meets the Desired Future Condition of the forest. It also implies, at a landscape or timbershed level, some basis for defining an "Annual Allowable Cut" that represents an arguably sustainable harvest level, given likely management intensities and

realistic constraints on timber management activities (e.g. riparian buffers, extended rotation prescriptions).

Additional Information:

FIA data present estimates of forest area by broad productivity classes and by ownership, shown as potential wood yields per acre (see NC-158, table 31). Acreage by site index class and Survey Unit is also provided (NC-158, table 37). Site index is another indicator of potential wood productivity. Both measures are designed to be independent of current stand condition (see Sec. IV below).

In our interviews, we encountered statements that some experienced silviculturists and foresters in Minnesota believe that growth in some young stands under minimal management may actually be lower than the unmanaged natural growth of the past. On the other hand, some foresters believe that current yield tables underestimate future growth for some types. It should be a high priority to review this question and see if there are situations in which this is true, and determine for which situations updated or revised natural and managed stand yield tables and growth models are needed. As the AFIS program proceeds, it will provide a growing dataset containing tree records at three points in time, which would provide a valuable resource for such an effort.

Recommendations for Indicator B12: When the FIA's annual survey permits a reasonable update of forest growth, and when new estimates of removals can be prepared, a new simulation of future Long Term Sustained Yield and AAC's should be conducted. It should be based on a range of assumptions concerning management intensity, nontimber values, resource protection guidelines, and uncertainties for long-term productivity such as climate change and the changing landbase. It should also consider any needs for updated/improved yield tables and growth yield models.

C. Minnesota Forest Economics and Communities

General Observations: The area of economic statistics, although rich in data, does require data users to contend with informational weaknesses. Additionally, several important employers are "invisible" at the county level due to disclosure issues. Tourism and recreation industries are well characterized in the data, but the degree to which they depend upon forest-based activities is not. The major gap in this area is the lack of any thorough and ongoing measurement of tourism activity based on forests, and the related economic effects on industries and communities. There is a gap between data and information. Individual agencies have information on campsite visits and other measures, or at least proxies, for recreation visits. In the past, SCORPs were used to assemble, evaluate, and report all of this scattered information. SCORP represented "information" in the sense we are using the term in this report.

Table 6
Minnesota Information Review: Summary on Economy

Source	Item No. *		Timely	Accurate	Spatial Detail	Level of Detail	Availability to Users
Roundwood Harvest -- DNR Estimates	B11C1		A	A	M	A	A
Roundwood Cut (TPO) - NCFES	B11C2		I	A	A	A	A
Pulpwood Receipts	B11C3		A	A	A	A	A
USFS Regional Pulp Report	B11D		A	A	A	A	A
Energy Chips	B11E		A	A	A	A	A
Firewood Cut	B11F		I	A	M	M	A
Lumber Production -- Census	C1C		A	M	I	I	A
Lumber Production -- DNR	C1C2		A	M	A	A	A
Paper Production	C1C3		I	A	N	N	I
Manufacturing -- County Business Patterns	C3		A	M	M	A	A
Census Employment by Occupation	C3		I	A	A	A	A
Employment -- US Manufacturing Census	C3		M	A	M	A	A
State Employment Data	C3		A	A	A	A	A
BEA Employment -- Manufacturing	C3		M	A	M	M	A
Wage Rate Data	C3		A	A	A	A	A
County Business Patterns, Employment	C2A		A	A	A	A	A
Tourism Visitors -- USFWS Survey **	C7A7		M	M	I	A	A
Tourism Expenditures -- USFWS Survey **	C7A7		M	M	M	A	A
Tourism Expenditures -- US Economic Census **	C7A8		A	M	A	A	A
Tourism Expenditures -- US Economic Census **	C7A8		A	M	A	A	A
Tourism Visits and Spending - Travelscope	C7A4						
	Totals	A	12	13	11	16	19
		M	4	7	6	2	0
		I	4	0	2	1	1
		N	0	0	1	1	0

A = Adequate M = Marginal I = Inadequate N = Nonexistent

* Item number is a reference to numbering in Data Inventory (attached).

** For tourism, judgments depict adequacy for the industry as a whole; relation to the forest base is unclear in all cases.

The Indicators of Minnesota's Forest Economics and Communities

C1

Indicator: **C1. Location, Capacity and Products Produced by Facilities of Minnesota's Wood-Based Industry**

Results: Information on location, capacity and products produced by facilities of Minnesota's wood-based industry is readily available. Information on location and products produced at a plant level is available through the Minnesota's effective program of directories. Information on capacity is difficult to obtain. Estimates of volumes of production must be assembled from a number of, sometimes, imperfect sources.

Additional Information: Supplementary information on location is available in privately produced directories, such as Random Lengths Big Book. However, these cannot guarantee complete coverage since they receive their information from companies that do not always deliver current or complete data. Interestingly, trends in end product production volumes are not mentioned in the indicators.

C2

Indicator: **C2. Economic Value, Number of Employees and Wages Paid in Primary Manufacturing of Minnesota Fiber and Raw Material**

Results: The term economic value is not defined. Presumably it means dollar sales in this context, but there are multiple possible meanings.

C3

Indicator: **C3. Economic Value, Number of Employees and Wages Paid in Secondary Manufacturing of Minnesota Fiber and Raw Material**

Results: Economic information on primary and secondary wood products is adequate as to accuracy, timeliness, and availability. It is not always adequate for substate areas.

Noteworthy Observation: An analyst can track conditions and trends in both primary and secondary industries provided that they remain conscious of the limitations in the production, labor market, and other economic data available. The information in these sources shares a number of well-recognized weaknesses, including undercounting in logging and other small businesses, and disclosure problems that often prevent release of some substate data.

Additional Information: Distinguishing between primary and secondary industries requires availability of at least three-digit industry detail, if not more.

There are a number of sources of information on value of product, number of employees, and wages paid. These include; (1) the five-year *Censuses of Manufactures* with valuable periodic benchmarks of detailed economic information, detailed industry and different substate areas, (2) the *Minnesota Department of Labor* has monthly data on employment and wages with significant industry detail at the state level and for some labor market areas, but without production information, and (3) *County Business Patterns* have annual data by county on number of firms, employees, and wage payments.

C4

Indicator: C4. Import and Export Levels of Raw Materials and Products

Results: The information about the import and export of raw materials and wood products in Minnesota is not adequate, complete, or timely.

Recommendations for Indicator C4: The MFRC should work with the Governor's office, the USFS, and the state's congressional delegation to vigorously advocate the continued and timely production of this information. This work serves a distinctive federal role in tracking and promoting commerce and enables an effective regional system of observing wood flows to continue.

The MFRC might consider empanelling a team to develop a methodology to periodically develop a total materials balance for the Minnesota forest-based manufacturing sector. This balance would depict instate output, all trade flows of logs, intermediate and end products, and all residuals, including waste streams. A valid materials balance would be a valuable assessment tool.

Additional Information: "Export and import," as used here, are assumed to be used relative to the boundaries of the State, and do not refer to offshore or international trade only. Movements of lumber, paper, panel products, and secondary products to and from Minnesota are not being measured in any statistical system. A periodic survey that would estimate the total flows in and out of these products might be of marketing value to businesses and for economic development programs. Previous examples include Stier (1989) and Gray, Ellefson, and Lothner (1985).

There are several ways of tracking export and import of logs, chips, and products. In the Lake States, the USDA Forest Service, FIA has periodically prepared an exhaustive Timber Products Output (TPO) report that shows by product and by state and province the details for flows of pulpwood, sawlogs, and veneer logs. These have often included valuable time series data and detail by species. The latest published report for Minnesota is for 1992 (Hackett and Dahlmann, 1997 – update pending). Over time, the FIA TPO reports for adjacent states would also shed light on trends in movements into and out of Minnesota.

The annual pulpwood production reports (Piva, 1999), based on industry surveys, also include extensive detail on interstate movements of wood. These reports have not

been conducted recently, though they are expected to resume. The Forest Resources Association, formerly APA, also conducts an annual survey.

The movement of logs and products to and from Canada, using the Harmonized System (HS) codes, can be tracked readily in volumes and in dollars using the Canadian Strategis system, which enables users to directly obtain information on the Web. Data are available state by state. More detailed tabs can be purchased from Statistics Canada. These can be useful for following trends, but many weaknesses have been found in the accuracy of HS codes, so they cannot be relied on for species and product details. Dollar values of foreign trade in wood products are reported annually by the Minnesota Department of Trade and Development (Annual Export Statistics). Similar data can also be found on the Web from U.S. sources, but these are organized by customs districts and do not ensure that the state of origin of the products can be tracked.

C5

Indicator: **C5. Amount of Forest Land Available for Public Use**

Results: Compilation of this information would be a substantial clerical task of both data gathering and summarizing. It would also require extensive surveys of landowner posting behavior and recreationist perceptions of land availability for various uses. Much of the needed data exists in various forms. A geo-referenced inventory of campgrounds in the region has been created (Leefers and Vasievich, n.d.).

Noteworthy Observation: Evaluating access is no simple matter. A particular property may be open to one activity and not another. Changing landowner policies, and continued parcel fragmentation affect access. Effective access may require some infrastructure improvement. For example, areas that are without parking availability, or are in areas where roadsides are completely developed by housing, make a large area for cross-country skiing and landlocked backland use merely theoretical.

C6

Indicator: **C6. Number and Type of Facilities Available for Recreation and Tourism**

Results: There is no current information source providing a comprehensive, detailed, and geographically subdivided information set on the number and type of facilities available for recreation and tourism.

Noteworthy Observation: The most recent State Comprehensive Outdoor Recreation Plans (SCORP), a federally supported inventory and analysis, remains the most complete assessment on these questions, yet even there all aspects of the question have not been explored.

Recommendations for Indicators C5 and C6: Some improved variant of the SCORP assessment process should be re-created. The process could operate on a rotating basis, taking up in detail one key topic or issue each year, instead of doing everything in two years and then setting the task aside. The effort should be funded so that needed case studies or survey research tasks can be performed.

C7

Indicator: **C7. Number, Expenditures of Individuals, Participating in Forest Recreation and Tourism, and Employment**

Results: Data is readily available on the industries serving tourism and on total tourism spending. But there is no comprehensive and authoritative information on the expenditures of forest-based recreationists and tourists.

Noteworthy Observation: Trends in forest uses and sustainability issues could be tracked with a system relying on the best visitor counts and usage estimates for a range of activities.

The College of Natural Resources Cooperative Park Studies Unit has a large project underway to study recreation visitation and to estimate expenditures associated with the state parks.

Recommendations for Indicator C7: The Council might consider designing and developing a cost estimate for a visitor and business survey that would yield valid estimates. Case studies of selected local areas might be a worthwhile approach, rather than attempting to develop statewide estimates.

Additional Information: A discussion, with estimates for Minnesota in about 1990, is given in Stynes (in Vasievich and Webster, 1997). As Stynes (1997, p. 139) observes: "Inconsistency of data across sources and a general lack of time series data for recreation preclude quantitative measures of recent trends."

1. Defining "tourism" is difficult. Many trips taken combine business and pleasure so that most national statistics on tourism define tourism as a trip with a stay of one night away from home. Tourism statistics do not discriminate between leisure and business travel, because it is hard to do.

2. *It is difficult to define what portion of leisure travel is truly "forest-based*." Much of small game and upland bird hunting occurs in farm landscapes, and some fishing occurs in arguably urban settings. Some specific examples, such as trout fishing, are easy to identify as likely forest-based.

3. *No ongoing data exists counting leisure travel.* Analysts use a variety of proxies such as highway traffic, visit counts at parks, or lodging tax revenues. Data by county, urban region, and other geographic subdivision can easily be obtained from a number of different sources. Businesses that serve the traveling public are counted in various

census reports, such as the Census of Wholesale and Retail Trade. Some of these sources may undercount establishments.

4. Some of the many *local or regional surveys of expenditures by individuals on particular activities such as snowmobiling, fishing, hunting, or bird watching may be too inaccurate*. The Fish and Wildlife Service conducts a national survey of expenditures periodically. Detailed summaries are published by category of activity and state, including both participant days and expenditures. However; these surveys are vulnerable to issues of accuracy and provide no basis for allocating expenditures on hunting, for example, between forest-based areas and nonforested areas. There have been instances where these results seem inflated when compared with other tourism surveys. Other than for mere "literary" purposes, this survey should not be used to meet this information need until it has been extensively "ground-truthed" against independent sources.

5. *It is difficult to measure employment in the resort and tourism sector with published datasets* because these sources probably severely undercount the numbers involved. This is because sources, like the County Business Patterns series, are based on the ES-202 file, which counts covered employees only. Family workers, subcontractors, and proprietors are not covered under the employment security law. So in sectors like tourism, which is dominated by small and often seasonal family businesses, published sources give low estimates of employment.

The Office of Tourism's (2000) annual TravelScope survey produces a detailed annual snapshot of tourism in Minnesota. This supplies a rich and valuable overview. However, it is not designed to measure how much tourism is forest-based, and it does not provide substate detail. Because of the sample size, it is not clear that this data can be used effectively for time series tracking for outdoor recreation. An annual survey of Office of Tourism inquirers supplies considerable data on activities. The Bureau of Economic Analysis, Department of Commerce prepares estimates for total employment including proprietors at a state level. They also estimate labor and proprietors' incomes. Whether these estimates fully account for the weaknesses in estimates of tourism employment and earnings has not been validated. Valuable reviews of these issues, with estimates on jobs and spending, were given in Pedersen and Chapelle, and two papers by Chapelle (Vasievich and Webster, eds., 1997).

The IMPLAN Dataset

IMPLAN, a data set available for purchase from a private firm, provides detailed data from existing sources in a common source and format, including a recent input-output table (see, http://www.implan.com). This dataset covers all sectors of the economy. The DNR has acquired and is using this information now. IMPLAN was also used in the GEIS.

C8

Indicator: **C8. List of Special Products Produced**

Results: We were unable to locate either a listing of all such special forest products, or any estimates of annual production volumes and values for Minnesota.

Noteworthy Observation: A 1993 report by Mater Engineering to the DNR provides a starting point for such an assessment. Several workers at the North Central Station are working on these resources (Beth Collins, Elizabeth Navertz, and John Zasada).

C9

Indicator: **C9. Gross Sales of Special Products Produced from Minnesota's Forest Resources**

Results: There is no estimate of dollar sales or the gross sales of special products produced from Minnesota's forest resources.

Additional Information: A trend of major increase in interest in special forest products, items ranging from mushrooms to leaf sprays and decorative products to specialty herbs and foods, has been supported by Internet marketing and increased entrepreneurship in the microbusiness sector. Considerable effort has been invested nationwide in studies of markets for and production of these products. Because they are so numerous, and so dominated by microbusinesses that often operate seasonally, inventorying physical and dollar volumes of production is a daunting task.

C10

Indicator: **C10. Dependence of Regions and Communities and Forest Base**

Results: There is no current, thorough, and methodologically sophisticated assessment of individual community reliance on the forest. A preliminary assessment using accepted methods could be developed at modest costs.

Noteworthy observation: The availability of information on economics and communities has excellent accessibility. The economic censuses conducted every five years, have a serious problem of timeliness. Although this it mitigated by the prompt availability of annual employment, wage, and County Business Patterns data, there are weaknesses in characterizing economic activity at the community level.

Local Areas - The Invisible Industry Problem

Federal rules on disclosure of data require that any geographic unit that has three or less facilities in a given industrial grouping may not have its employment or other data separately published. This creates the effect that another unit will have to have this detail

suppressed so that data users cannot simply fill in the missing numbers by subtraction. The extraordinary result is that in a state like Minnesota, for industries with large production units like paper mills or OSB plants, industries may be important at a state level but their data cannot be published in local areas. This is true even if the company's public relations office issues press releases containing the figures. It is possible to obtain special data tabulations from the Census Bureau that aggregate counties together to avoid this problem.

The University of Minnesota's Web-based bibliography of social and economic information about forests is a valuable tool for information access, especially as it includes a large amount of so-called "grey literature" (informally issued working papers, occasional documents or file reports) that is not often well indexed in traditional sources.

Additional Information: There are large quantities of census and other data available and a great deal of social science research has been done on this question (see, e.g., Marcouillier and Mace, 1999; and Beckley and Burkosky, 1999). **"Communities" is mentioned as a broad category of concern, but there is no corresponding indicator.**

D. Minnesota Forest Practices Management

The Indicators of Minnesota's Forest Practices Management

D1

Indicator: **D1. List of Sources that Provide Guidance**

Results: There is no accessible and well-annotated list of sources that provide guidance at present. It would be an easy task to assemble one.

Noteworthy Observations: Something similar to the Resource Directory (Baughman & Borst, 1999), which provides a thorough listing of organizations where forest owners and others can obtain information and includes addresses, phone numbers, and websites, would be a good start.

Additional Information: A guide covering specific documents of use to landowners and others could be readily prepared and would be very useful. Minnesota has a number of excellent guidelines documents, including the MFRC Voluntary Site-Level Guidelines, Blinn, et al's Temporary stream crossing and wetland crossing options (1998) bulletin, and others.

One could envision a series of lists addressing the information needs of different classes of users, ranging from technical staff in management agencies, to small landowners, to regulatory staff. These lists could be annotated to enable users to know what information items would be most useful to them. Much of this information is available on the University's Forest Resources Extension website: http://www.cnr.umn.edu/FR/extension.

D2

Indicator: **D2. Forest Area Managed in Accordance with Guidelines**

Results: The forest area managed in accordance with guidelines is not currently known. However, the MFRC's monitoring program will be useful in determining the area.

Noteworthy Observations: It is important to allow for some ambiguity in any system of guidelines and recognize that some conditions may require applied judgment while others cannot be measured without extensive plot work.

D3

Indicator: **D3. Number of Loggers and Forest Managers Who Participate in Guideline Education Programs**

Results: There is no current and complete listing of the number of loggers or forest managers who participate in guideline education programs. However, this could easily be assembled from the information maintained by the SFI Committee, logger training programs, and other organizations.

Additional Information: Information is available in the files of Barbara Coffin, College of Natural Resources Continuing Education Center, University of Minnesota, and Mike Turner, Minnesota Logger Education Program.

D4

Indicator: **D4. Compliance Monitoring Results**

Results: Information on compliance monitoring results is not yet available. The MFRC/DNR compliance assessment, currently underway, will answer this question and provide guidance to address future concerns and design modifications for ongoing monitoring.

D5

Indicator: **D5. Effectiveness Monitoring Results**

Results: Effectiveness monitoring results are not currently available. They are in progress.

Noteworthy Observation: Effectiveness monitoring requires replicated, well-designed, intensively measured trials and experiments, often extending over several years. Costs are accordingly high.

D6

Indicator: **D6. Cost of Guidelines for Loggers, Managing Agencies, and Landowners Groups**

Results: The cost of guidelines for loggers, managing agencies, and landowners groups has proven to be too complex to be answered at this time, although several groups have examined it.

Noteworthy Observations: Progress on measuring cost impacts of forest practice rules is not likely unless the problem can be broken into pieces that can be tackled one at a time. In their report to the MFRC, Blinn and co-authors observe:

> *"Because logging businesses and site and stand conditions are so variable across Minnesota, it is not possible to present one value which represents the total additional cost of guideline application under all situations. To get a true picture of the costs to logging contractors associated with guideline implementation in Minnesota, very detailed on-the-ground study of individual sites and practices is necessary to quantify*

the marginal cost of implementing the most frequently occurring guidelines under a variety of circumstances." Blinn, et al., 2000, p. 14.

Additional Information: Measuring the cost of forestry guidelines is a complex and demanding matter (Irland, 1996; Henly and Ellefson, 1986). Minnesota has the benefit of two of the most thorough such studies that have ever been conducted in this country (Blinn, et al., 2000; Vasievich and Edgar, 1998). Operating costs have already become a significant industry concern (Anon., 1998).

Vasievich and Edgar (1998) reviewed the possible cost effects of the proposed guidelines on landowners, loggers, and industry. Although they encountered many data weaknesses, they did observe that cost estimates depend upon what is taken as baseline. This is important since operators are already following some of the recommended practices. They suggested that costs to loggers could reach $3 per cord, a significant sum when almost 4 million cords are cut in the state each year. They observe that there are many opportunities to ensure that guidelines are applied in a cost-effective manner.

E. Minnesota Forest Planning Management

E1

Indicator: **E1. List of Groups, Their Purpose and Geographic Extent**

Results: No overall list of collaborative planning among multiple owners exist.

Noteworthy Observations: Because most groups have non-negotiable demands within their policy objectives, they are disinclined toward collaborative compromise of those demands. Public lands are constrained by rigid planning and decision-making processes and are therefore least able to participate in collaborative landscape level problems.

Additional Observations: The landscape program sponsored by the Council is as excellent collaboration example, and current planning processes on the National Forests and State Forest Areas are additional ones. This has been an emerging issue nationally (Sample, 1993).

E2

Indicator: **E2. Area of Forest Land Where Planning and Management Activities are Influenced by Landscape Level Planning and Coordination**

Results There is no measure of the area of forest land where planning and management activities are influenced by landscape level planning and coordination activities.

Noteworthy Observations: Defining the area of land whose management is subject to collaboration in the spirit of this indicator is not a clear-cut matter. Area may not be the most sensible measure to examine for collaboration.

E3

Indicator: **E3. To What Extent is Strategic Planning Occurring**

Results: Statewide strategic planning is not occurring today.

Noteworthy Observations: If the MFRC Landscape Analysis project is considered "strategic," then the answer to the indicator is 100%. The link between wildlife management and forest management is not well developed in the DNR. This is surprising since the management of the forest cover type and age class structure is typically the major determinant of forest wildlife habitat value. This suggests resource and habitat analysis deserves additional development. Improved analysis could contribute to better public understanding, better public policy, and improved private decision making in a number of areas.

Recommendation for Indicator E3: The Council, based on the results of this and other studies, should set priorities for topically focused strategic assessments that appear to offer the greatest leverage on public understanding and on current policy issues. These should be linked to the FIA and other analyses noted earlier.

Additional Information: In our interviews, we heard repeated statements that a lack of a suitable strategic mindset was a problem, giving a sense that nobody really can articulate what the big issues are and how to address them. **Seeking a solution to this dilemma should be on the MFRC's agenda.**

Meaningful strategic planning should include strategic time spans, ranges of future options, and a likelihood that the preferred options will be implemented. The current polarized environment of forest policy inhibits the realization of these needs and no policy will cure it. This may not be a particularly serious problem. A listing of land units where some long-term planning has occurred, or is occurring, could be developed to rate those areas where the planning involved can be considered strategic.

"Strategic Planning" may have gotten a bad name. Among the possible causes are the following;

1) **Suspicions of "Big Government"** potentially overreaching (just mind the store attitude).
2) **Unimplemented past strategic planning** (report on the shelf syndrome).
3) **Control down leadership strategies** without support from operating levels or outside constituencies (resistance to direction/leadership syndrome).
4) **Vague strategies** that emerged were so nebulous that no one would be able to tell whether they were implemented or not (feet in the clouds syndrome).
5) **Outside strategy recommendations** (Not Invented Here Syndrome).

F. Minnesota Landowner Rights and Responsibilities

F1

Indicator: **F1. List of LRA That Affect Private Landowner's Rights and Responsibilities**

Results: A list of the laws, rules and administrative policies that affect private landowner's rights and responsibilities is not listed anywhere.

F2

Indicator: **F2. List of LRA That Affect Public Rights and Responsibilities**

Results: A list of the laws, rules and administrative policies that affect public landowner's rights and responsibilities is not listed anywhere.

Recommendations for Indicators F1 and F2: An initial screening of existing policies for their effects on public/private rights should be conducted, and based on priorities emerging from that screening, more focused policy evaluations might be considered.

Additional Information for Indicators F1 and F2: The policies that could fit into either of these indicators could be very diverse, some very closely focused, others quite remote. It is more than likely that there exist public policies that, at least on a local basis, have outcomes that are arguably undesirable. Policies would include those from all levels of government. Binational policies such as efforts to manage Lake Superior water quality might be included. Policies, or policy proposals that would affect trade in logs, chips, or processed wood products might also be considered to affect private and public rights.

Much of the uncertainty and contention in this area appears to involve policies being proposed or advocated, or individual decisions such as endangered species listings that take a long period of time to percolate through administrative and court processes.

G. Minnesota Forest Policy

General Observation: Interviewees felt that Minnesota does possess an "effective and supportable" policy process for forests. However; many are concerned that lack of public and legislative interest, absence of strong leadership, and uncertainty of funding pose major risks for the future.

The Indicators of Minnesota's Forest Policy

G1

Indicator: G1. List of Processes, Their Purpose, and Geographic Extent

Results: There is no comprehensive listing of forest policy processes, their purpose, and geographic extent.

Noteworthy Observation: The list of processes involved in Minnesota Forest Policy is well known to people already familiar with the process, and is easily learned by newcomers. An initial listing and comparative review is in Ellefson and Moulton (2001, draft).

The evaluation of policy development is a matter of understanding and evaluating a policy process, not data review. The indicator mentioned encompasses only a portion of the concern raised in the Goal and the related Baseline Question. To explore these in greater detail, we interviewed a number of individuals with extensive experience in forest policy in Minnesota. In depth, structured interviews of up to 40 minutes were conducted. The interviews were based upon selected Baseline Questions from the Phase I Report, additional questions about the policy process.

Information in the broad area covered under "Management" in the Phase I Report is readily available.

Additional Information: - Discussion of Interview Results

<u>Managing the "Forest Policy Funk"</u>

Interviews with policy insiders leave this author with a sense that in Minnesota today there is something of a "forest policy funk." There is a sense that there is little public understanding of and interest in the issues, and little enthusiasm about governmental initiatives. There is a concern that legislative interest in forestry issues is minimal, except when some bitter controversy arises. The MFRC should consider some process of systematic outreach and consultation in which, over a period of six months to a year, they attempt to diagnose underlying causes of this "funk" and identify ways and means of addressing those causes in an active way.

<u>Does the FPP (Forest Policy Process) address all the issues/concerns that it should?</u>

Most interviewees agree that, given adequate funding, the system could address the issues.

One observer felt that the total policy process has not effectively addressed all-important issues; they felt that finishing the Guidelines took far too long. The difficulty of reaching agreement on issues consumes time that could go into working on anticipating problems and on interpreting issues and policies to the public. Observers agreed that the issues are a "moving target" and you never get on top of all of them; it is necessary to pick and choose.

An interviewee noted that the Council's mission as a source of policy coordination and guidance is being routinely sidestepped today. This seems to indicate that it has become accepted as part of the operational structure, conducting more routine tasks, but has been overlooked as a source of coordination and policy debate.

There is a concern that without some more urgent sense of the importance of forest condition, land use change, and a need for better information, the funding available for addressing the problems will dwindle.

Several respondents perceive a lack of awareness of and interest in the local economic needs of rural Minnesota outside the growing metro areas. This seems to be both a cause and an effect of the fact that there is little clear economic information readily available on resource-dependent communities.

One observer felt that Minnesota has the means to get a handle on condition of terrestrial habitat, but we are not there yet. This person believed that there is room to boost productivity and maintain environmental values.

Another observer felt that the regional landscape planning groups working under MFRC sponsorship could become effective means for promoting ongoing management coordination at a meaningful landscape scale.

One respondent sees the absence of current, complete, and detailed information on forest management activities across the state as a problem.

The lack of good technical data on resource tradeoffs and the place-specific impacts of forest practices over time is seen as a major hindrance to effective policy decisions.

<u>Does the process make suitable use of facts and science?</u>

The consensus is yes.

<u>Does the FPP identify key issues in advance, or is it reactive?</u>

Most interviewees feel the process is currently largely reactive, which they attribute largely to the low funding and staff level leaving no time for new issues. Also, some contentious issues tend to "bog down" in the system.

<u>Does the FPP involve all relevant Constituencies?</u>

Interviewees all agreed that the FPP does involve all relevant constituencies that care to become involved. There may be some concern in some quarters that broader public interests that are not well represented by statewide lobbying groups may not receive vigorous or effective advocacy for their interests. Examples might include the variety of forest and tree interests that exist in the farming areas of the state, and the interests of the general public in day use recreation opportunities.

Does the process have access to a respected and independent source of technical advice?

All interviewees agreed that the process has good access to independent advice through the DNR, the University, NRRI, the USDA Forest Service, and other agencies. While there are individual points where one group or another challenges the accuracy or independence of advice, there is no general sense of an issue here.

It is generally recognized outside of the state that the University's capabilities in forestry and related areas, are on a very high plane compared to other states, particularly other states with similar forest area, populations, and wealth.

Urban-Rural Divide

A number of our interviewees noted that there is a gap of perception and awareness between urban and suburban Minnesota and the rural areas where farms, forests, and tourism are important to local economies and sense of place. The MFRC may wish to consider whether its information and education activities, and its indicator process may play some role in providing information across this divide.

Interviewees:

Patty Burke	Former Legislative Director, DNR
Paul Ellefson	University of Minnesota, College of Natural Resources
Tim O'Hara	Minnesota Forest Industries
Ron Harnak	Environmental Quality Board
Gregg Knopff	Minnesota Senate Research
Ron Nargang	The Nature Conservancy
Garnett Ous	Itasca County
Lee Pfannmuller	DNR, Division Ecological Services
Gerald Rose	Division of Forestry, DNR
John Thompson	St. Louis County
Terry Weber	MN Forestry Association
Henry H. Webster	University of Minnesota, College of Natural Resources, Emeritus

H. Enabling Conditions For Minnesota Forest Research

General Observation: Forest research is multi-dimensional, long-term, and includes many basic and applied elements. One basic, but often overlooked, benefit of forest research is that it maintains a base of expertise on forest conditions and issues in an area.

The right amount of "adaptiveness" in forest research programs is difficult to define. At a given moment, it is easy to develop a long list of topics that would benefit from additional research. There has never been enough funding to progress far down this list. The American Forest Council conducted extensive questionnaire research with forest managers to identify their perceptions of research needs (see. e.g., AFPA, 1993). They gave up because it was almost impossible to elicit any meaningful response to these listings of priorities, within private companies or elsewhere. Various National Conferences on Research needs have also yielded little meaningful change. The lists of priorities, however, may still be worth consulting as a starting point (see, e.g., Gregersen, et. al 1989; USDA Forest Service, 1989; RNRF, 1977; Fox, 1986; Hodges, Jakes, and Cubbage, 1988; Page and Brassard, 1993; Jaakko Pöyry, 1994 (GEIS); and Forest Research Advisory Council, 1999).

Forest Research inherently maintains momentum as the result of the following conditions:

- the long time horizon of many of the needed projects;
- the commitment to a skill mix through scientist contracts and tenure;
- commitments to facilities and equipment which are hard to change; and
- funding variability makes it difficult to sustain present commitments and often impossible to initiate new ones outside of mainstream funding sources.

These real conditions cannot be wished away and they may even be useful in inhibiting the chasing of short-term fads and trends.

One criticism of forestry research is that it has often been unable to sustain commitments to the truly rewarding long-term projects. The East is littered with supposedly "long-term" cutting treatments and plots that were established decades ago and measured at great cost. Many of these will be lost in time because funding support has withered away, researchers have retired, and the tasks involved are not considered "cutting edge." Commitments have also been minimal to basic but unglamorous tasks such as developing improved growth and yield models and data. It would be sobering to review all of the recent economic and silvicultural research and see to what extent it has all been based on ancient yield tables, often from unrepresentative locations, that do not reflect current wood utilization practices or likely future silvicultural regimes. Yet this kind of work is not considered "sexy" by research evaluators and funding sources.

The Indicators H1 and H2 discussed in this section are not very useful questions when posed at the level of "all forestry research." They do become useful when focused on a specific topic, such as effectiveness of BMPs, stand responses to treatments, or management effects on wildlife populations. Generally, a lack of focus has hindered the usefulness of many past attempts to set research priorities (For a counterexample, see

Fox, 1986). The Forestry Research Advisory Council Report (1998) noted that management of nonfederal lands is a major concern. It identified priorities in the following areas:

1. Improvements in productivity consistent with sustainability
2. Improved monitoring technologies
3. Better tools and approaches to tradeoff analysis

The Indicators of Enabling Conditions for Minnesota Forest Research

General Observation: The existing information in the enabling conditions area is readily available to those seeking it.

H1

Indicator: **H1. Researcher and Practitioner Perceptions as to the Adequacy and Applicability of Research**

Results: We found no current information within Minnesota that explored this issue in detail using primary research.

Noteworthy Observations: The GEIS led to a set of research priorities. The Council, more recently, commissioned a group to explore forest research needs for the 1998-2008 decade (MFRC, 1998; see also Forest Research Advisory Council, 1999; University of Minnesota, Dept. of Forest Resources 1998-99 Biennial Report, 2000). The MFRC estimated that forestry research accounted for roughly $18-20 million, just above a dollar an acre each year. They found this amount inadequate by any standard and advocated a significant increase.

Additional Information: A National Panel on Forest Research also advocated a nationwide increase (NRC, 1990), as did a more recent group (National Coalition for ... Forests, 2000).

We are not convinced that applicability is a priority concern at the present time, though it could be an issue within particular, focused fields or problem areas. The adequacy of funding remains an issue. One topic that merits consideration is, “What research would aid in developing truly informative scenarios for the future of Minnesota’s forest and related resources?”

H2

Indicator: **H2. Researcher and Practitioner Perceptions as to the Transfer of Information**

Results: There is no current reporting of researcher and practitioner perceptions regarding transfer of information within Minnesota.

Noteworthy Observations: We think that the capability to transfer information between researchers and practitioners (and the policy community) has never been better. The University, the MFRC, industry, and the USDA Forest Service all have various research advisory committees working at different levels of their operations, including that of individual projects.

The Web has also revolutionized information, synthesis, storage and transfer. Minnesota has a regular program of ongoing technical and continuing education seminars, workshops, and conferences that facilitate information transfer in both directions. What has not increased in similar measure is land manager and scientist time to devote to information transfer. In more than a few instances, there may be questions about the need to devote more resources to information transfer. These are concerns of leadership and management.

Recommendation for Indicator H2: The Council should consider conducting a periodic inventory of funding and organizations involved in forest-related research in Minnesota and should be an active advocate for improved funding and effectiveness. A brief scoping study could be performed to determine if scientists, research administrators, and practitioners perceive important shortfalls or needs in the area of priority setting or information transfer.

H3

Indicator: H3. Periodic Review of Availability and Accuracy of Information

Results: This IMC project, "A Review of the Availability of Information About Minnesota's Forests" is responding to this concern.

H4

Indicator: H4. List of Efforts and Accomplishments to Coordinate Common Data Standard and Information Reporting

Results: There appears to be no such list. A systematic effort does exist, but its effectiveness in creating and enforcing expanded data coverage to a common standard is not clear.

Noteworthy Observations: Several existing mechanisms are providing coordination and data exchange. The Interagency Information Cooperative maintains an excellent web-index allowing access to many data sources. A valuable "metadata" system provides capsule information about each data items. An active Governor's Council on Geographic Information provides coordination on data management issues. One of its missions is to provide for geographic data standards. The Land Management Information Cooperative (LMIC) is also active.

A promising effort to integrate inventory data together from a variety of sources has been conducted (IIC, 1997; Skally, n.d.). This effort involved assembling basic data

that could be found for a variety of different ownerships, and assembling those into a common dataset. For some planning and assessment purposes, this approach seems to yield a useful product. The nature of the underlying data, however, prevents extending the coverage of this system to include the extensive list of variables covered in the Phase I Indicators.

Recommendation for Indicator H4: Consultation between the Council, the EII, the LMIC, and the IIC should proceed to identify to what extent existing integration efforts can support the Council's proposed indicators, particularly in the area of time series comparisons. The term indicator may also need refinement.

Additional Information: The issue of database management has had a long history of attention, especially in Minnesota (Lewis and Ellefson, 1983; USDA FS NEA, 1998; Wills and Waldon, 1997;GAO, 1999; Wendt, Turner, and Manolis, 1999; and various papers in Aguirre-Bravo and Franco, 1999; MNDNR, 2000b).

H5

Indicator: H5. List of Programs and Their Purpose

Results: We found no listing answering to this description.

Noteworthy Observations: The 1992 GEIS report, "Public forestry organizations..." provides a useful baseline for this question.

Recommendations for Indicator H5: The Council should construct a comprehensive program budget table showing the organizations and funding levels devoted to forest programs (Table 7 above). Major functional areas could further disaggregate this. The result should be a comprehensive natural resources budget, including a separate capital budget. It should render a public report on the adequacy, trends, and sustainability of funding as revealed by this analysis.

Additional MFRC Research Information Goals

MFRC Goal # 3: **Forests are Sustainably Managed**

Responses: Sustainable management is a critically important public policy. We explored forest sustainability by examining issues of long-term sustainability among timber supply, biodiversity, and rural communities. We also considered the importance of diverse public values and political support.

Sustainable Timber Supply

Timber sustainability is a key question. If timber sustainability cannot be assured, then sustainability for some communities could be at risk, and future habitat for creatures depending on the forest would be uncertain. To show the significance of these uncertainties we introduce the data on estimated removals, and compare it with a range of estimates related to potential future harvest levels. We can then see that without validating the accuracy of data on both issues, we cannot say whether the gap between removals and allowable harvesting is narrow or wide.

The first results of AFIS (Schmidt, n.d.) showed that while the forest's area seems to have increased since 1989, its total growing stock has declined slightly, though the change may not be statistically significant. The AFIS data cannot yet support conclusions as to whether the situation is due to increases in removals, in mortality, or decreases in growth.

Based on GEIS and other analyses, the DNR suggested 4.79 million cords/yr. as a provisional approximation to an Annual Allowable Cut (AAC). AAC's by species have also been identified (Krantz, 2000). The DNR's projected 2001 harvest of 4.29 million cords comes to within 10% of this estimate. Assuming 25% of the cut is from nongrowing stock sources (NE-158, p. 128), the margin would be much wider. Timber supply analyses typically concern themselves with "growing stock" trees, those of desirable size, species, and form. But if 25% of total timber products came from nongrowing stock sources, then the cut from growing stock is well below the estimated removals. This percentage is now more than a decade old and could be on the high side, based on the wood requirements of the industry today. Some suggest that "net growth" can be augmented by considering annual cull increment and mortality. Though it will never be possible to salvage all mortality, an estimated outer limit based on "gross growth" (net growth plus mortality) can be viewed as a hypothetical upper limit. Yields from intermediate cuttings (like thinnings) are likely to increase in importance.

The naive estimate (Table 8) yields a high average rate of growth – 0.7 cords/A/yr. Such a growth rate implies much higher levels of management than are currently being made. Schmidt (1998) has developed the "naïve" model of productivity a bit more fully, discounting the results by 20% to account for deviations from full stocking. He also considers only stands with current average diameter above 5", which reduced that acreage included in his calculations from 14.7 million to 10.2 million. His adjusted potential net growth is 48% above recent "realized" growth. Alternatively, he

expresses this by saying that realized net growth has been at 67% of potential for the state. This estimate of potential growth would be about 5.3 million cords. Schmidt (pers. comm.) agrees that this estimate does not account for the effect of Voluntary Guidelines, other current management practices and rules, or recent major damage events.

Several points about the results of Annual Allowable Cut (AAC) calculations need to be emphasized. The AAC may not be a rigid straight line but may vary from decade to decade. It should be considered as a range that reflects many complex assumptions and uncertainties, some of which need public debate. The levels and impacts of future intensive management are of critical importance. Accurate and current removals estimates are crucial. A rough assessment of "quality renewal" (log quality) is important – is log quality improving, or decreasing? Regional detail may be desirable.

Table 8
"Naive" Potential Timber Productivity Estimate

Productivity Class Midpoint Cu.Ft./A/Yr.	Thousand Acres	Total Annual Growth, MCF	Growth in M Cords
165	11.7	1,930.5	24.1
142	254.1	36,082.2	451.0
102	2,948.0	300,696.0	3,758.7
67	5,355.2	358,798.4	4,485.0
35	6,154.2	215,397.0	2,692.5
Totals	14,723.2	912,904.1	11,411.3

Source: NC-158, p. 76 (assumes 80 cu. ft./cd).

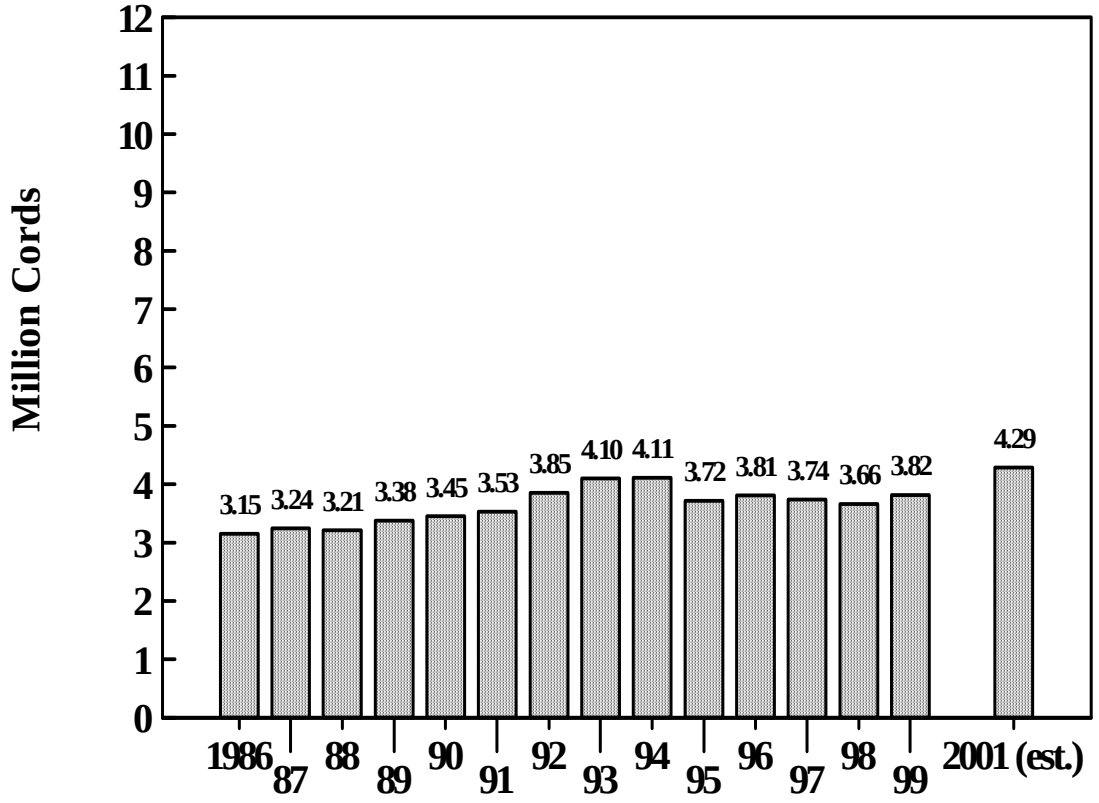

Figure 2

Actual & Projected Timber Harvest in Minnesota from MN Timberlands, All Ownerships, All Species

Source: DNR, Division of Forestry.

Harvest data compiled by NCFES and DNR.

*** 1995 adjustment due to decrease in fuelwood use since 1989/90.**

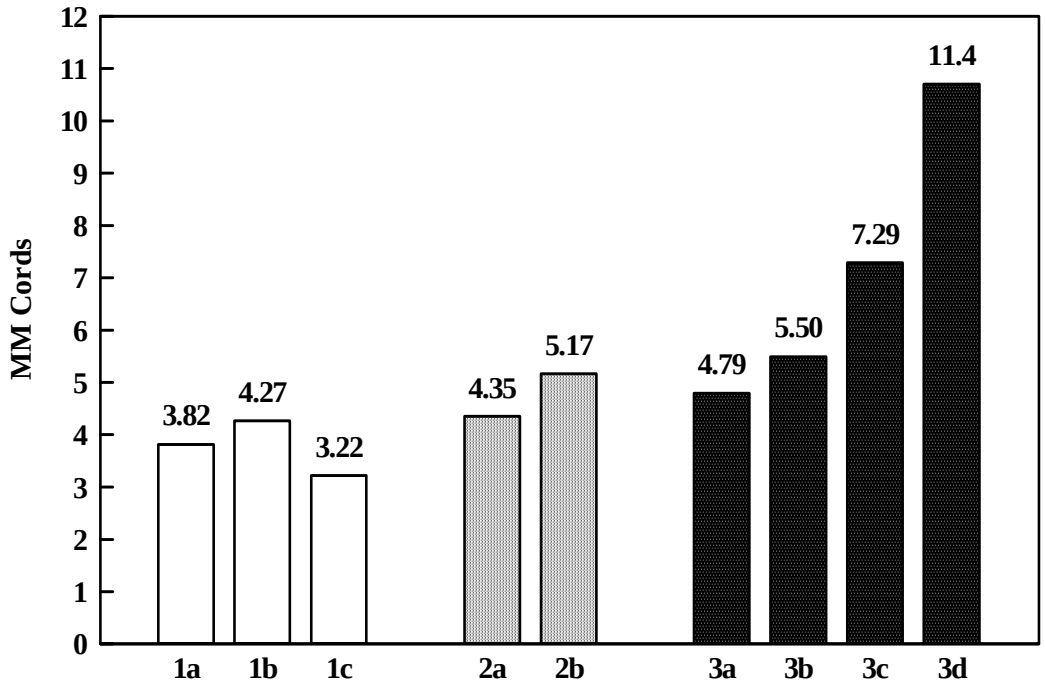

Figure 3
Harvest Estimates and Alternate Productivity Measures

1. Harvest Data
   a. Harvest 1999 (1)
   b. Projected Harvest 2001 (1)
   c. Harvest from Growing Stock (6)

2. Past Growth
   a. Average Annual Net 1977-1989 (2)
   b. Current Net Growth 1989 (2)

3. Calculated "AAC's"
   a. DNR "AAC" (3)
   b. GEIS "AAC" (4)
   c. 1989 Growth Plus Mortality (5)
   d. "Naive" Productivity (6)

Sources:

(1) DNR, Bureau of Forestry, Oct. 2000.
(2) NC-158, p. 116, 128.
(3) DNR.
(4) GEIS Summary, 1994.
(5) NC-158, p. 121.
(6) NC-158, Table 8 below.

The most sophisticated AAC's available statewide are those calculated for the GEIS. The issue of growth/cut balance was raised in a recent paper mill emissions proceeding (Boise Cascade, International Falls). Analysts have been predicting for years that harvestable aspen growing stock volumes across the northern Lake States are likely to decline after the year 2000 due to their age class structure and the cutting rates (e.g., Leuschner, 1972; Gephart, et al., 1990; Jaakko Pöyry, 1991; 1992; Rural Policy Panel on SRWC's, 2001). So the decline in hardwood growing stock showing in the latest AFIS report (Schmidt, n.d.) should not be a surprise. Increases in real prices can serve as indicators of shifts in "scarcity" or supply-demand balance. The price trends based on USFS and DNR timber sales are already widely used for this and other purposes.

Considering the narrowing gap between the DNR AAC, current growth, and removals, the concerns noted elsewhere about tracking removals take on added weight. The ability to more precisely track removals will not be completely solved by the AFIS. Growth/cut balances are likely to differ across the state, so statewide totals will be useful but not entirely enough. The ability to track pulpwood/OSB wood is essential given the structure of wood usage in Minnesota. It is critical for this reason that the USFS pulpwood and TPO surveys be brought up to date and continued.

Considering that Minnesota's wood products industry consumes logs, chips, and other primary products from outside the state, a brief attempt should be made to characterize the current and likely supply/demand conditions in those adjacent areas, as future trends in those locations could materially affect Minnesota. This should be updated every five years.

The State and adjacent areas could be divided into plausible timbersheds in the same way that it has been divided into ecological regions. The Survey Units were not designed to reflect timbersheds. It would be a fairly simple matter to design supply regions within and beyond the state that roughly reflect geographic wood flow relationships, and to reformat FIA information along those regions. These may differ for sawlogs, pulpwood, or firewood, and may differ by species. This might yield some interesting insights that are submerged when using the information only at a State or Survey Unit level. It would even be possible to identify separate timbersheds for major species groups given the ease of formatting data today.

There can be no sustainable forest management if there is uncertainty about the harvest of wood from the forest, and about likely future growth.

Sustainable Biodiversity

Sustaining biodiversity is a complex challenge beyond the ability of science and practice to fully guarantee at present. Most of the ingredients for sustaining biodiversity are well understood in general, if not yet aggressively implemented. The present forest results from a history of dramatic change that will continue. These key elements are important to sustaining biodiversity:

- **a clear definition of sustainability** based upon population viability,
- **adequate monitoring** of key taxa and habitat conditions to indicate trends and early warnings,
- **protected and lightly managed areas** of sufficient area and distribution for retention of localized, rare, or endangered species or ecosystems and the selected areas of habitat that can change naturally to steadily regain characteristics of mature and "old-growth" forests,
- **sound forest practice in individual stands** with sensitive areas,
- **links** from habitat considerations to forest cover type, age class, and management treatments, and
- **inclusion of landscape scale issues** in practical management in a way that is active and effective.

Sustainable Communities

Rural areas of Minnesota will remain resource dependent (agriculture, forests, tourism, mining) for the foreseeable future, although that dependence is likely to change. It may not be possible to increase employment by cutting more wood as Minnesota approaches its AAC.

Competing supplies of wood imported from Russia, South America, and New Zealand already affect some Minnesota sawmills, at least indirectly. The increase of these and other competitive pressures will result in jobs per unit of wood throughput declining, or plants will close entirely. Competitive pressures may make it difficult to offset reductions in primary jobs by boosting "value added" employment. Many of the established value added industries, a group already under pressure to increase productivity, are ironically located in urban areas, not in rural ones.

The effects upon rural communities by changes in manufacturing, trade, and tourism require analysis that goes beyond simply collating existing statewide and

regional data. **A new indicator system, based on analysis of meaningful communities and labor markets, could track relevant economic changes**.

Preserving Other Public Values

Although many nontimber values of forests are of critical public importance and play major roles in forest policy, the ability to actually measure many of these values is limited to nonexistent. These values range from nontimber products, (such as wreath tips and mushrooms), to aesthetic values of the landscape, to vicarious enjoyment of pristine wilderness.

There is no simple way to convert these many issues and concerns into measurable indicators, but with a suitable effort, it might be that meaningful proxies could be developed and pilot tested on a local basis. More research and development is required for implementation with this topic than others, which are less broad and have more of a technical base for progress.

Political Support

The divisiveness of forest management issues within our society makes it essential that the sources of data, and also of their interpretation, possess high credibility. As Minnesota looks to the future, there may be a role for an innovative approach to assessing these issues, thus the following recommendation.

Recommendation for Political Support: The MFRC should consider the "outside audit" model for a major assessment of conditions, trends, outlook, and issues in the Minnesota forest. This would entail a full assessment, with a modest staff, to be led by a respected individual or group, certainly from outside the forestry community and perhaps even from outside the state. There is no need for another GEIS, but more for an analytical and tightly focused Assessment instead. The MFRC may wish to prepare tightly focused terms of reference for this Assessment. Key topics might include analyzing the AAC/harvest investment situation using the latest data and models and management assumptions, with links to habitat suitability issues, possible changes in the existing system of protected areas, and possible trends in availability.

Indicators of Whether Forests are Sustainably Managed

There is no widely accepted, detailed definition of sustainability. Judgments as to what is sustainable are subject to different views and many scientific uncertainties. The ability of the information base to answer the question "is the Forest Sustainably Managed?" will depend on the definition of sustainability chosen and the persuasiveness of the entire suite of indicators when assembled into one package. Some of the data that would enter into the MFRC indicators would seem to be available in levels of accuracy, timeliness, and geographic detail that would satisfy many data users. For other items

there are complete gaps, or there are questions about the validity of the information on the part of at least some interested parties.

The Criteria and Indicators (C&I) movement has provided examples of systems of indicators suggested for tracking resource conditions. The Environmental Indicators Initiative has collated relevant systems into a useful spreadsheet form of comparative tables that summarize indicators used by the North American C&I Test, the Indicators for the Montreal Process, the Great Lakes Alliance, and a draft of Regional Standards developed by the Regional Working Group of the Forest Stewardship Council. An additional set of indicators was developed by the Lake States Forest Alliance. The "Smart Signals, Assessment of Progress indicators" report by Minnesota Planning and the Environmental Quality Board (March, 2000, pp. 25, 27, 30) makes a tentative effort to develop some more compact indicators of progress on environmental matters and provides a useful discussion of the difficulties of measuring trends in social and economic well being. The list of questions posed in the Phase I Report, and around which this report is built, could be said to offer an extended definition of sustainability. It is difficult to aggregate all of the disparate detail into some index that says "Sustainability is up this year" or "Sustainability is down this year"

MFRC Goal # 8: Forest Research Programs are Effective and Adaptive

Response: There is no way to summarize how "effective" or "adaptive" forest research is in Minnesota.

MFRC Goal # 9: Multi-Resource Information Systems are Compatible and Comprehensive

Response: Multi-Resource Information Systems are not fully compatible and comprehensive. Issues of reliability, sources of error, common format, compatibility of computer systems and interpretation have not received extensive attention.

Additional Information: Several initiatives underway respond to this concern. There is a growing quantity of all kinds information becoming available on the Web (see, e.g., DNR – ForestView, Forest Resources Extension, MFRC, etc.). Current efforts have largely been devoted to inventorying and using existing datasets. Issues of reliability, sources of error, and interpretation have not received extensive attention. Nor have issues of common format and compatibility of computer systems.

The Environmental Indicators Initiative

This effort is assessing indicator systems and supports DNR efforts to track progress on its strategic plans (Wendt, et als., 1999, n.d.).

The Smart Signals Report

This report produced by the Minnesota Planning Sustainable Development team has addressed forest sustainability issues, but in a more narrative manner. It did not

construct specific indicators of conditions, activities, or trends. Improved availability of trend indicators would result in their being used in such overall sustainability evaluations.

Interagency Information Management Cooperative

This is an ongoing cooperative effort to improve data coordination and availability (http://www.iic.state.mn.us). The metadata archive has demonstrated its usefulness, but it is not clear that by itself it has created common data standards.

The Terrestrial Vertebrate Wildlife Information System

The Terrestrial Vertebrate Wildlife Information System is being created by the Division of Wildlife in the DNR and has a planned completion date 2002. However; it is not yet clear how big of a problem is caused by the absence of common data standards. There are degrees of compatibility. The need for cross data integration may be sporadic. For instance data on mercury in the water must being "integrated" with data on the amount of pulpwood in St. Louis County or the number of visitors last year to Itasca State Park.

Undigested data being placed on the Web can be a much bigger problem. Potential users may have no idea, and no ready way to find out, about the constraints and limitations of the information. As a result, we can have the situation in which researchers are running complicated analyses, reporting high significance levels for findings, when in fact the underlying county data have large standard errors. **The tendency of data, once placed on a server, to free itself from its history of normal sampling error, bias, and other limitations needs to be addressed.**

MFRC Goal #11: Program Funding is Committed and Sustained

Response: The number of programs is so numerous and diverse that there is no easy way to track this question.

Natural resource agencies face inevitable funding uncertainties as the result of election cycles, changes in government and public priorities, and swings in state government fiscal position. Although Minnesota has a range of agencies that provide funding for various forest programs, there can be little assurance over time that key priorities continue to be adequately funded over the fiscal cycles of both federal and state governments.

So far as we can determine, there exists no comprehensive picture (e.g., Table 7) of how forest-related programs are funded in Minnesota. Hence, there is no basis for determining, in a historical sense, how stable funding from those programs has been over time. Such an analysis would not necessarily be valid as a predictor of conditions in the future.

The federal commitment to traditional resource programs has continued to erode. In the future, states will be more on their own to fund these programs with their own revenue sources and through more effective development of private and foundation sources of funding. It will be critical to ensure stable funding for the AFIS program of forest resource data, and for improved monitoring of removals.

Table 7

Proposed Forest Program Budget: Entities Concerned with Forest and Related Resource Programs in Minnesota and Funding Sources

	Federal	State	Private Industry	Foundations
Land Management and Planning				
DNR				
USFS				
NPS				
Industrial owners				
Counties				
Local governments				
MNFRC				
Assistance to Private owners				
DNR				
UMN, Extension				
NRCS				
Other				
Resource Monitoring				
USFS - Research	(A comprehensive budget like this does not exist)			
USFWS				
USGS				
EPA				
DNR				
PCA				
UMN				
Research				
University of Minnesota System --				
Agr. Experiment Station				
College of Natural Resources				
NRRI				
LCMR				
MN Forest Resources Council				
USFS, NCRS; NFS (occasional)				
Soft money funders, foundations, etc.				
USDA, EPA, DOE, NASA, USDI				
Other academic institutions				
Other				

Note: This budget should be separated into a capital budget and an operating budget. This should include existing assets as well as current/planned capital outlays.

Additional Observations and Suggestions on Information Management For The MFRC

Indicator Improvement Examples and Suggestions for the MFRC

The Irland group suggests that many of the indicator problems could be solved by adding indicators, providing formal sub-indicators for extremely broad indicators, or by narrowing the focus of the general goal statements. Here are a few other observations on indicators that emerge from their review.

1. It is striking that the level of timber inventories does not appear anywhere in the indicators.

2. Considering the level of interest in the topic, it is also striking that there is no specific indicator of the area of forest and related lands in Reserves of various kinds. This would seem to be a material consideration for both resource condition as well as for policy process. An adequate system of Reserves is considered an essential element in any ecosystem management program. A listing of reserves would correspond to the listing of species called for in two indicators. If reserves are considered an "administrative category," this can be indicated in a definition.

3. In Indicator A6, the BQ asks, "To what degree does land taxation influence the amount of forest land?" Yet the indicator itself calls only for a list of taxes, which would not appear to be responsive to the question.

4. Similarly, a Goal states, "Program Funding is Committed and Sustained." Yet the associated Baseline Question and Indicators do not mention funding at all, and the indicator does not respond to the Baseline Question.

5. A broad category of Goals is described as "Economies and Communities," yet no indicator refers specifically to communities.

6. In Indicator Group D, the Baseline Question asks, "How efficient are the guidelines?" Yet, the related indicator speaks only to <u>costs</u> of the guidelines. Efficiency cannot be discussed without considering <u>benefits</u> as well as costs.

7. Indicators using undefined terms such as "Areas of Continuous Forest Cover," or "Forested Areas" indicate a desire to focus on heavily forested areas. This suggests a lack of interest in the forest and tree resources and issues in that portion of the state containing the bulk of the state's land area and population. If these terms are given specific, measurable definitions, this will become evident. The Council should carefully consider the balance of attention to be devoted to the 2/3 of Minnesota land area that is lacking in continuous forest.

8. These and similar points could be addressed either by adding indicators, by providing formal sub-indicators where an indicator is extremely broad (as for Ecosystem Health or Disturbance), or by narrowing the focus of the general goal statements.

Some Strategies for Managing the Indicator Agenda

a. Priority Geographic Areas

Identify top priority geographic areas or exogenous/ management/resource/ activity issues and measure those.

- e.g., many rare/concern species are of extremely limited distribution and can be located.

b. Proxies

The IMC should identify acceptable proxies for the issue of concerns that are most readily measured. Analyze the relation between the proxy and the real concern.

- e.g., temperature as proxy for global climate change or, crown opacity (transparency) as a proxy for tree vigor;
- a group of "indicator species" as a means of assessing change; and
- level and trend in building permits as a proxy for land use change.

c. Mine the Files

The MFRC should organize information already available, such as fish surveys, and develop a routine for capturing that information in a useful way.

d. Sample in the Time Domain

Some items that are costly to measure can be done at suitable intervals to obtain statistically sound results.

e. Sample in the Geographic Domain

Use existing monitoring at a given research forest, as an indicator of condition over some wider area.

- e.g. Mauna Loa as indicator of C content of atmosphere.
- sample townships as indications of forest change or landuse change.

f. Cost-Effective Techniques

The MFRC should develop new, cost-effective research techniques that can indicate if a standard has been met or exceeded.

Examples include the ozone passive samplers (Cox and Malcolm, 1999), the use of indicator plants for air pollution, some indicator of sediment content in a stream, or the use of lichens as a proxy for old-growth condition.

g. Where Possible, Avoid Reliance on Averages

The averages for many of the items considered important are usually subject to some degree, often large, of sampling variation or other uncertainty. This means that annual differences in a statewide average may mean little. Various ways of smoothing by multi-year averages may be useful. Ways of showing variation in substate means should be considered. As an example, if a sample of 50 permit issuing places is summarized as a proxy for subdivision and development pressure, the total would be interesting, the average permits per county virtually useless. Even more useful would be to also indicate, of the 50 places, how many increased, and how many decreased. When averages are to be used, they should often be volume or area-weighted in order to yield the most meaningful results.

h. Avoid Aggregating Apples and Oranges

Unlike indicators should not be aggregated. Attempts to create aggregate indices are not likely to lead to improved understanding of the issues, conditions, or trends in the resources of concern. Condensing varieties of information into a single index may increase the risk of the inclusion of assumptions about what should be included and what shouldn't, and how different items should be weighted into an index.

i. Provide a Glossary

The Phase I Report represents a considerable amount of work designed to close in on a manageable set of indicators. This review has encountered a number of situations in which a general concern for resource conditions cannot be measured until the concern has been defined more completely and in more detail. A few terms and concepts that need further definition before they can be meaningfully measured include:

- *Spatial pattern*. At one level, the meaning is obvious, but in order to measure pattern, and change in pattern, a great deal of additional definition must be provided. A "spatial vocabulary" needs to be adopted. This vocabulary would necessarily build on existing maps and spatial data.

- *Location.* Again, the term implies some degree of spatial and classification resolution that must be specified. In some topics, location by county may be adequate. For others, location by pixel or "40" may be needed.
- *Riparian.* This term may refer to a vegetation condition, or simply to an area within some distance of a stream of some defined character (e.g. single-line on a USGS quadrangle sheet). Ongoing debate onstream protection buffer BMP's requires better definition and measurement.
- *Administration Category*. The Council needs to set forth a list of categories that it considers useful before this item can be measured.
- *Area of Continuous Forest Cover; Forested Areas*. To implement the indicators concerned with this situation, a working definition needs to be adopted. A straightforward approach would simply list the <u>counties</u> included. When this is done, existing GIS capabilities will enable a map to be prepared, and other information such as ownership, can be cross-classified with it. Are these two terms equivalent? Exactly how will a line be drawn defining percent forest cover, degree of "continuousness," and patch size or degree of "perforation" to be included/excluded in this area? What then becomes of the rest of the state?
- *Potential Productivity*. As discussed at several points in the body of this report, "potential productivity" is a concept that requires detailed definition before it can be measured and discussed. It is not merely a biological concept. If by "potential productivity" the Council means the naïve model represented by Forest Service potential annual growth estimates, that would lead to one result. If it means to adopt the DNR or some other calculation of AAC as a standard, that would lead in another direction. There is no escaping the need to make some assumptions on this matter. If this proves too complex or contentious, the use of this indicator could be deferred.
- *Disturbance.* This term is used in a very broad way in the Phase I Indicator list, and this broad coverage needs to be clearly indicated. Since disturbance is ubiquitous, some size or significance threshold will need to be set to enable measurement to begin.
- *Ecosystem Health.* This is a term whose definition has bedeviled a generation of scientists and managers. While there may be no perfect, ultimate definition, it is essential that the Council's further work on indicators supply a tentative, working definition.
- *Forest Type, Natural Vegetation or Natural Plant Communities.* These terms imply not only a specific definition for each one, but some well-worked out classification system attached to each. Since more than one such system is in use in Minnesota, the Council's further publications on these points will need to indicate precisely which system is to be used. This merges with the issues of "continuous cover," of data standards, and of a "spatial vocabulary."
- *Ownership.* This term is often used to describe <u>categories</u> of ownership, while in common usage it may imply the <u>identity</u> of an owner as well as a category. In the FIA data, ownership data is presented as to categories. Information systems providing the identity of owners are much less easy to access, and to

keep up to date. It remains a question to what extent owner identity is really needed for most Assessment purposes.

- *Economic value* is a term used in one of the indicators; its meaning needs to be defined.

Further versions of the Phase I Report that seek to implement its indicator system need to ensure that clear definitions of these and other terms are included, otherwise, there will not be a clear agency and public understanding of what is being measured. Some of these terms are used to describe contents of databases or GIS layers available on the Web, in FIA data, and in other forms. Consistent definitions throughout the statistical system will be important.

Build the Indicator System Around Conditions, Trends, Activities and Results

The EII program has prepared a tentative "Table Indicator Summary" by assembling indicators proposed by a number of different C&I systems. The box diagram shown in Figure 1 illustrates the concept of conditions, trends, activities, and results. Many C&I schemes are designed in different ways, but this way of classifying the topics being monitored would seem to offer benefits in communicating with policymakers and the public.

As an example:

- A condition would be the inventory of spruce-timber.
- A trend would be the change, increase or decrease, in the inventory and quality of spruce-timber.
- An activity would be planting or thinning spruce stands.
- A result would be the impact on acreage, growth, or inventory volume achieved by the activity.

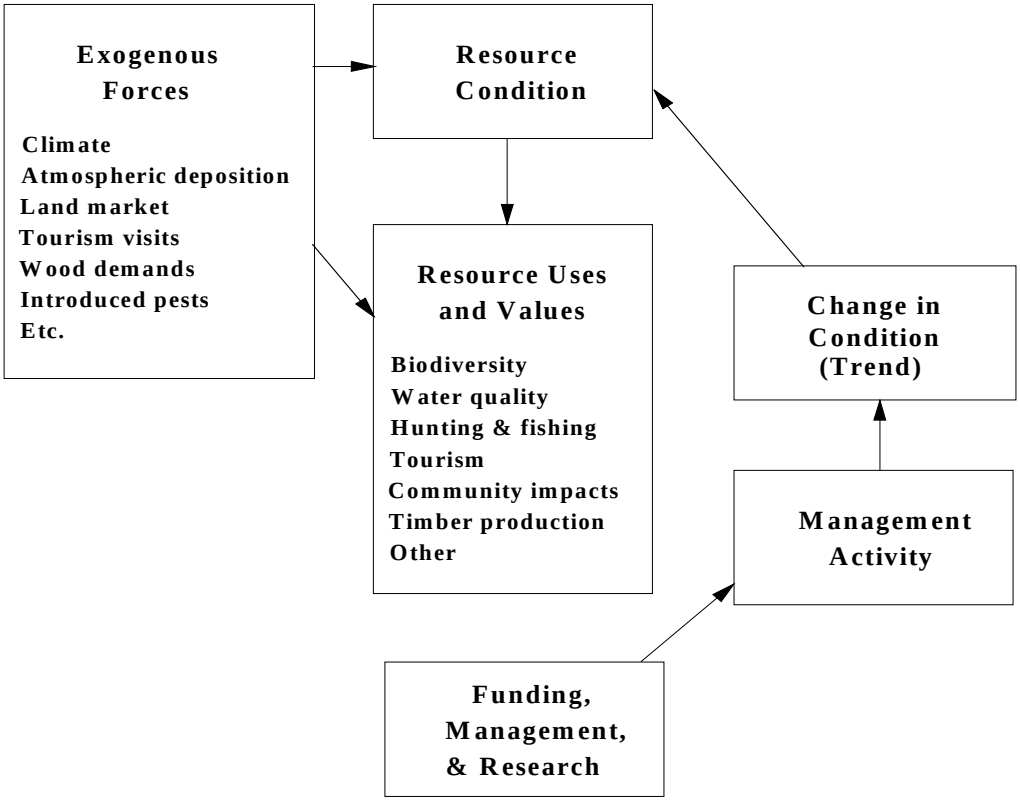

Figure 1
Elements of Sustainability Monitoring System

An adequate monitoring system would include relevant items from each of the boxes in this chart.

MFRC should take indicator development one step at a time. Based on the Council's own assessment of priorities, the Council should take to heart the maxim that "Comprehensiveness is a trap" and begin developing a workable system, one step at a time, according to whatever practical considerations seem most compelling. Such an approach would allow the approach to benefit from the completion of current projects, such as the Gap Analysis Guideline Implementation Monitoring; and the MFRC Spatial Analysis Project.

At each stage, the system should start small with existing information and be designed for expandability, as new measurements permit adding indicators. A key step will be to provide clear definitions for all indicators for which this is noted as a need. Action would be taken at each step to initiate measurement on the remaining top priority topics.

Further discussion on Forest Spatial Analysis Adequacy and Technology

Imaging and Software for Spatial Assessments: Strengths and Limitations

Many aspects of the landscape-based planning for forest ecosystems require analysis of spatial pattern. The primary issues for spatial assessments are:

- Forest fragmentation
- Riparian zone management
- Maintaining adequate patch size for viable populations of plants and animals
- Maintaining "connectivity" or corridors in the landscape for metapopulation stability

There are questions that arise about the suitability of different spatial databases for spatial analyses. This section reviews the dominant metrics of landscape structure, the primary available databases, and their strengths and limitations. While the technical capabilities and limitations of landscape metrics are well understood, the application of these metrics to resolving particular forest or wildlife management problems are not. We tend to study the landscape at the scale that we manage forests: stands to regions. The spatial requirements of populations or metapopulations of plants or animals, in terms of required patch size, diversity, connectivity, and buffer considerations are only now under study. There will be a time lag in the completion of this new wave of landscape research, and its translation into forest management.

It should be possible to make a better judgment about the capabilities in hand for measuring and tracking changes in vegetation pattern when the GAP analysis, Spatial Analysis Project, Landscape Planning, and other ongoing work is complete.

Judgments will still be required of exactly why spatial pattern information is needed to answer what specific questions concerning biodiversity, habitat, and productivity. Efforts are already underway to develop a specific "spatial vocabulary" for measuring and discussing spatial pattern. This information should supply a basis for setting monitoring priorities, which could entail:

- Measurement at time intervals, check pattern every 5-10 years;
- Focusing on pattern only in localized areas where species are at risk; or
- A quality control/sampling method where changes in pattern would be checked frequently but only in a sample of typical areas.

Developing a shared empirical vocabulary for analyzing spatial pattern will be a major challenge and will test the limits of available resource information as well as the limits of storage, retrieval, and display capabilities.

Adequacy for Spatial Analysis

Landsat TM data, and to a lesser degree MSS data have been used to conduct spatial analyses in numerous studies. Unlike forest inventory data by ownership, which is often collected according to different specifications, TM data is synoptic and available across large regional areas. The key attributes of these data sets is that the spatial resolution of the data tends to be finer than the objects of analysis, which are generally forest patches generally mapped in polygons 10 acres or larger. Typically, forest patches

are identified by filtering or otherwise generalizing the classified TM pixels into patches of some specified minimum area, and assigning these to forest cover classes. These patches are then subjected to spatial analysis at the individual patch, patch class, or landscape scale. Numerous metrics have been developed to describe landscape structure; these generally fall into five general classes: area metrics, patch metrics, edge metrics, and diversity metrics.

Several programs are available to calculate landscape metrics; two commonly used packages are FRAGSTATS (McGarigal and Marks 1994) and APACK (Boeder et al. 1995). Many of the more simple indices can be calculated directly in a GIS environment, using combinations of vector and raster format data.

A key limitation of using LANDSAT classifications (and in conducting spatial analysis in particular) is the relatively poor temporal resolution of the classified imagery. At best, 2-3 age classes (generally regenerating forest, even age canopy, and all-aged canopies) can be discriminated using this type of imagery. Thus, it is difficult to conduct analyses of patches discriminated by forest age class. One mechanism to reduce this limitation is to use classified imagery in conjunction with stand-level inventory classifications; White, et al. (2000) used this approach in a recent analysis of northern Minnesota forests. This technique requires considerably more effort than the analysis of an existing classified data set.

AVHRR

The Advanced Very High Resolution Radiometer (AVHRR) is a scanner, sensing in the visible, near-infrared, and thermal infrared portions of the electromagnetic spectrum and is carried on NOAA's Polar Orbiting Environmental Satellites (POES).

The AVHRR sensor collects global data (pole to pole) from all spectral channels. Each pass of the satellite provides a 2399 km (1491 mi) wide swath. The satellite orbits the Earth 14 times each day from 833 km (517 mi) above its surface. Spatial resolution is 1 km.

The AVHRR data have been used for broad-scale spatial analyses, generally from continental to regional scales, and in areas where detailed aerial coverage and ground truth data are scarce or absent (Host et al. 1996). Because of its high temporal resolution (biweekly composites), the primary use of AVHRR is to calculate Normalized Difference Vegetation Index (NDVI) for broad landscapes. This 'greenness' index shows seasonal patterns of plant development. NDVI images are directly based on values from the biweekly composite of AVHRR sensor data from the NOAA-14 weather satellite.

Because it integrates information over relatively large pixels, the classification resolution from AVHRR is relatively low, the USFS recognizes eight forest classes in the north central US. A comparison of AVHRR with Landsat TM classification showed a relatively poor correspondence in these classifications (Host et al. 1996).

Landsat MSS

Landsat Multispectral Scanner (MSS) sensors were deployed on the first five Landsat satellites, from the early 1970s to the early 1990s (Landsat TM was introduced on Landsat 4). MSS data has an 80 m pixel resolution with radiometric coverage in four spectral bands from the visible green to the near-infrared (IR) wavelengths. Only the MSS sensor on Landsat 3 had a fifth band in the thermal-IR wavelength. Data were

collected at a 16 d time interval. MSS data represent the longest record of image acquisition over a major portion of the earth. Like AVHRR, the primary use of MSS data has been temporal change detection, best exemplified in the EPA's North American Landscape Characterization (NALC) project. Specific research and development tasks in NALC include: a) acquiring Landsat MSS images with less than 30% cloud cover, b) assembling the individual scenes from 1973, 1986, and 1991, ideally plus or minus one year, to be used for generating co-registered "triplicate" scenes, c) creating triplicate scenes georeferenced to a 60 x 60 meter (m) Universal Transverse Mercator (UTM) ground coordinate grid, d) generating derivative products from the georeferenced image data, such as NDVI and land cover categorizations, e) developing capabilities to facilitate archive/management, and distribution of the image data and attendant descriptions of the data or "meta" database, f) disseminating products to researchers via EDC, and g) conducting research on important issues such as image categorization, change detection, and landscape indicators using the NALC data sets and landscape ecology as a theoretical base. A number of studies have been based on the MSS triplicates. A relatively high classification resolution can be obtained with MSS data, and MSS data have been used to refine Landsat TM classifications (Wolter et al. 1995).

Landsat TM

Landsat Thematic Mapper (TM) has a 30 m pixel resolution, and, when used as part of a multi-temporal classification, has the highest classification resolution as well. As a result it has been used in a numerous landscape-scale spatial analyses. The National GAP program (Scott et al 1993) initiated the objective of having individual states undertake TM-based classifications of their forest lands – active programs for this exist in Minnesota, Wisconsin, and Michigan. Forests are generally classed according to standard forest cover type categories, and crosswalked to existing systems. More detailed classifications, based on multi-temporal imagery, attempt to classify 30m pixels at the genus or species level (Wolter et al. 1995)– such classifications have been completed for portions of northern Minnesota and Wisconsin. Also, progress has been made in adapting nearest neighbor methods, using TM data to mapping Minnesota forests by FIA species group and timber volume classes (Franco-Lopez et al. 2001).

Minnesota GIS

General Observation: Having extensively rummaged in state websites, and interviewed many data producers and users, we have arrived at a few hunches about the condition of the Minnesota GIS situation. We offer observations as initial hypotheses that we feel deserve consideration. Further discussion among those better informed about the details of these matters may invalidate some of these hypotheses. But we suspect that some benefit might emerge from the discussion.

Noteworthy Observations:

- There is a tendency to see the GIS as an end instead of a means, and to see any data element online as filling the need. So the website contains 1983 landownership data. Why? Will anybody really use this?

- It seems that technical GIS coordination is well under control. Other matters of data and metadata management, coordination, and archiving are perhaps receiving less attention.
- The system seems heavily oriented to technical and in-house users familiar with terminology and organizations, who are already well oriented to the information and are well equipped to download, format, analyze, and print materials from the Web. For example, there are numerous maps and vegetation datasets on line and in print, many using different definitions, scales, and formats. How should users decide what is best for them?
- There is a tendency to focus on the static spatial properties of GIS information and not on the issue of time series format for information to detect trend. This is partly due to data weaknesses/incompatibilities over time, but there are often solutions to these problems.
- There is a tendency to not date information Web documents.
- There is a tendency to think in terms of "planning" instead of Assessment. Overemphasizing planning as decision making can lead to under emphasis on data useful for assessment.
- Continued massaging of "existing data" instead of getting after the most important unmet data needs. (This is partly because GIS Staff cannot control the agencies generating primary data.)
- A tendency to avoid thinking in terms of useful assessment/analytical products, as defined by users.

Recommendation For GIS: The MFRC should consider conducting a review to assess the importance of having a common data standard, identify existing needs in this area, and estimate the costs of increasing standardization. The standards would naturally vary for biological, timber, ownership, or economic data.

SUMMARY TABLES

These Tables (1 and 2) attempt a brief summary of our results. They should be read in light of the discussion in our "Methods" section. The notation "definition not clear" appears frequently. This simply shows that an indicator has been stated as a general concern, and cannot be measured until a more specific definition is developed. This situation arises repeatedly when tests are made of proposed Criteria and Indicators (see, e.g., Woodley, et al., 2000).

Table 1
Summary of Indicators

	Indicator Group	Number of Indicators	Available Statewide	Not Available	Definition Not Clear	In Progress*
A	Forest Land Base	7	2	5	2	1
B	Ecosystem	12	3	9	4	3
C	Economics &	10	3	7	4	2
D	MGT: Practices	6	2	4	2	3
E	MGT:	3	0	3	2	0
F	MGT: Rights &	2	1	1	2	0
G	MGT: Policy	1	0	1	0	0
H	Enabling	5	1	4	3	4
	Totals	46	12	34	19	13

Note: More than one trait (column) may apply to a given indicator, so the last four columns may sum to more than the number of indicators in first column.

* Means that activity is underway in Minnesota on the topic.

Table 2
Summary of Data Availability, by MFRC Phase I Indicator

A. FOREST LAND BASE

	MFRC Indicator	Available	Substate Detail	Portion of State	Definition Not Clear	In Progress	Remarks
1	Area of forest land, timberland, and total land area	X	X				FIA
2	Extent, location, and spatial pattern of areas of continuous forest cover	N		X	X	X	Ownership maps
3	Changes in Ownership within	N					General, not current
4	Extent…..by landowner and administration	X		X			Categories available; current
5	Extent, location, and spatial pattern of forestland protected from conversion to non-forest uses by laws, rules, administrative policies, land use plans and local ordinances	N			X		Few have this goal
6	Listing of land taxes	N					Readily compiled
7	The degree to which they impact the amount of forest land	N					Complex research required

X = Available N = Not Available

Table 2 (cont.)
Summary of Data Availability, by MFRC Phase I Indicator

B. ECOSYSTEM HEALTH

	MFRC Indicator	Available	Substate Detail	Portion of State	Definition Not Clear	In Progress	Remarks
	TERRESTRIAL						
1	Extent, location, and spatial pattern of natural plant communities	N		X	X	X	
2	Extent, location, and spatial pattern of forest types, age classes, size classes, site index, basal area, and productivity classes	X	X		X	X	FIA Dataset; all but spatial
3	Status of state and federal endangered/threatened/special concern species	N	X	X			Huge task; known for some
4	Listing of sensitive species that are monitored by agencies, institutions, and programs	N					By DNR
	AQUATIC						
5	Index of Biological Integrity & Ecological Indicators	N				X	Not useful at present
6	Status of state and federal endangered/threatened/special concern species	N	X				Huge task; known for some
7	Listing of sensitive species that are monitored	N					By DNR
8	The extent, location, and spatial pattern of disturbance by type and severity class	N	X		X		Not tracked compre-hensively *
9	Land use and cover class of disturbed areas	N					" *
10	Composition and stocking of forest regeneration	N		X			" *
11	Growth, mortality, and removals by species	X	X				FIA
12	The extent of forest land with productivity levels below potential productivity	X			X		FIA

* Obtainable in part from FIA databases.

X = Available N = Not Available

Table 2 (cont.)
Summary of Data Availability, by MFRC Phase I Indicator

C. ECONOMICS AND COMMUNITIES

	MFRC Indicator	Available	Substate Detail	Portion of State	Definition Not Clear	In Progress	Remarks
1	Location, capacity, and products produced by facilities of Minnesota's wood-based industry	X					Directories exist
2	Economic value, number of employees, and wages paid in the PRIMARY manufacturing of Minnesota fiber and raw material	N	X		X *		Abundant data
3	SECONDARY for (2) above	X	X				Abundant data
4	Import and export levels of raw materials and products.	N				X	TPO Program - FIA; DNR
5	Amount of forest land available for public use	N		X	X		Not available since SCORP
6	Number and type of facilities available for recreation and tourism	N		X	X		Not available since SCORP
7	Expenditures of individuals participating in forest recreation and tourism	N			X	X	Data exist for industry, not actively
8	List of special products produced (including non timber products)	N					Some work is ongoing
9	Gross sales of special products produced from Minnesota's forest resources	N					
10	Dependence of Communities on Forest Base	N					

Table 2 (cont.)
Summary of Data Availability, by MFRC Phase I Indicator

D. MANAGEMENT: PRACTICES EFFECTIVE

	MFRC Indicator	Available	Substate Detail	Portion of State	Definition Not Clear	In Progress	Remarks
1	List of sources that provide guidance	X					Easily compiled
2	Forest area managed in accordance with guidelines	N				X	MFRC Monitoring
3	Number of loggers and forest managers who participate in guideline education programs	N					Easily compiled
4	Compliance monitoring results	N		X		X	Recently completed
5	Effectiveness monitoring results	N			X	X	Costly *
6	Cost of guidelines for loggers, managing agencies, and landowner groups	X			X		Very general info. only.

* Would require extensive measurement in replicated, well-designed experiments.

X = Available N = Not Available

Table 2 (cont.)
Summary of Data Availability, by MFRC Phase I Indicator

E. MANAGEMENT: PLANNING

	MFRC Indicator	Available	Substate Detail	Portion of State	Definition Not Clear	In Progress	Remarks
1	Lists of groups, their purpose and geographic extent	N					Easily compiled
2	Area of forest land where planning and management activities are influenced by landscape-level planning and coordination activities	N		X	X		Much is informal; growing
3	Area of forest land that is part of strategic planning effort (assessment, issue identification, goals, and strategies)	N			X		Difficult to define

X = Available N = Not Available

Table 2 (cont.)
Summary of Data Availability, by MFRC Phase I Indicator

F. MANAGEMENT: RIGHTS AND RESPONSIBILITIES

	MFRC Indicator	Available	Substate Detail	Portion of State	Definition Not Clear	In Progress	Remarks
1	List of laws, rules, administrative policies, local ordinances, land use plans, and guidelines that affect private landowner's rights and responsibilities	X			X		Easily compiled
2	List of laws, rules, administrative policies, local ordinances, land use plans, and direction documents that define public rights and responsibilities	N			X		Easily compiled

X = Available N = Not Available

Table 2 (cont.)
Summary of Data Availability, by MFRC Phase I Indicator

G. MANAGEMENT: POLICY DEVELOPMENT

	MFRC Indicator	Available	Substate Detail	Portion of State	Definition Not Clear	In Progress	Remarks
1	List of processes, their purpose and geographic extent	N					Readily assembled

X = Available N = Not Available

Table 2 (cont.)
Summary of Data Availability, by MFRC Phase I Indicator

H. ENABLING CONDITIONS: RESEARCH, INFORMATION SYSTEMS, FUNDING

MFRC Indicator	Available	Substate Detail	Portion of State	Definition Not Clear	In Progress	Remarks
RESEARCH PROGRAMS						
1. Responsive to practitioners	N			X	X	Some activities underway
2. Mechanism to identify needs	N			X	X	Some activities underway
INFORMATIONAL SYSTEMS						
3. Periodic review of information	N				X	This project ongoing
4. Efforts to coordinate	X				X	
FUNDING: STABLE AND ADEQUATE						
5. List of programs and purposes	X			X		Not current; no compre-hensive program budget

X = Available N = Not Available

Methods

The MFRC contracted with The Irland Group to inventory and review data sources that could be used to measure the indicators identified in the Phase I report. This section outlines the methods used in this review

WHAT DO WE MEAN BY "INFORMATION"?

Information terminology can be confusing. In order to distinguish between "data", "files", "research" and "information" we applied a very specific definition. We consider "information" to mean: data and interpretation that can be readily used to support conclusions about conditions and trends of a resource, habitat, or species on a statewide or regional scale. The information must include data or judgments that can be directly understood and used without further data gathering or analysis. Data must be in a form suited to making comparisons over time. Material does not become "information" until it has been aggregated into some meaningful totals, averages, or distributions, and made available to others in comprehensible form, preferably with some indication of its assumed degree of reliability, and preferably in a timely manner.

In this report we were asked to make judgments as to whether information is available on all of the topics listed in the Phase I Report. When we say that "information" is lacking, we are not saying that nothing is known, or that there is no file data or material of any kind. We are evaluating whether readily usable summaries exist that an observer, such as the MFRC or the Environmental Indicators Initiative, could directly use to track conditions and trends.

We developed a three-page description and evaluation form to capture the key traits of the data and the source, as well as full source citations and Web information, and reviewed them with the Information Management Committee (IMC).

DATA INVENTORY

A group with expertise in different fields was assembled to conduct an initial inventory of available forest information sources. After searching documents and websites, conducting interviews with experts, and reviewing many past reports, the results of this initial inventory were shared with 20 additional specialists. A copy of the current version of the Inventory was submitted to the Council in early December. A few selected experts reviewed a working draft of this report.

The Data Inventory is built around the **indicators** shown in the Phase I Report. For each indicator, there are potentially one or more **data items**. There may be none, one, or more **data sources** for obtaining that data item. For example, there are several slightly different sources for the number of employees in different wood processing and forest-based tourism industries. Each known source was described in a description sheet. As another example, the USDA FS FIA reports are a single source for many of the data items concerning the forest resource. For some of the indicators, no known information or data are currently maintained.

DATA DESCRIPTION AND EVALUATION

The core of our assignment is to evaluate the availability and adequacy of data and information for tracking forest condition and trends in sustainability. After filling in the description sheets, we filled in an evaluation sheet for each source. The source was evaluated according to several criteria:

Timeliness

Data time units vary widely. Lumber and pulp prices are weekly, while some wildlife inventories and harvest information are obtained annually at the appropriate season. Until recently, Forest Inventory (FIA) data became available every 10 or 15 years.

Employment information is available monthly with a short time lag, but in many statistical programs, compilation and corrections mean that annual totals are not available for some time. It is not uncommon for compilations of administrative data to be years behind, and certain items of product output information currently can be obtained only with long time lags.

Time grain is a different issue from timeliness of release, but they are not unrelated. This week's lumber prices are useful next week, but not very useful three years from now.

Accuracy

Accuracy is commonly discussed in terms of two statistical concepts: bias and precision. Bias refers to whether the mean of an estimate is systematically different from, or identical to, the population mean being measured. Precision, on the other hand, refers to the "sampling error" of the estimate, whether that error is large or small. The sampling errors for the FIA data, are either published in the bulletin or can be obtained on request. The information for many kinds of wildlife population and harvest data is purportedly based on enumeration of one kind or another. There may be no certainty, however, of 100% coverage, and statistically precise sampling errors may not be available. A number that looks very precise may not be accurate, due to under coverage or some other source of bias.

For other series, such as most of the employment data, the information is compiled by enumeration and not by sampling. Therefore, sampling errors or rigorous statements about accuracy cannot be made. In some of those instances, users are more concerned about being certain that the definitions of the terms and coverage of the data are correctly understood.

Accuracy becomes important to trend detection because small amounts of sampling error, or lack of knowledge of sampling errors, can make it difficult to make scientifically precise statements about change from one period to another. For many conditions and trends that are important in judging sustainability, the inherent uncertainty in the data prevents very precise statements being made about year-to-year trend or comparison with calculated sustainable use levels.

In making our judgments about accuracy, we rely on the published descriptions of how the data is gathered, and often on judgments by those responsible for producing it.

Spatial Detail

Spatial detail is important for supporting the Council's regional approach to evaluation of landscapes, and it is critical for many of the economic measurements needed. Since the forests cover only a portion of Minnesota, data on total employment in motels, guide services, or sawmills would tell us little about the connection between the forest and the well-being of these industries. The spatial availability of data varies considerably. Some economic data are made available by county and subregions. Some forest resource information is available by county and Survey Unit, though statistical precision is much lower for substate units and for individual species data. While we note these where relevant, we focus primarily on a state level of analysis for this project. For describing spatial pattern of vegetation, the relevant metrics and needed spatial detail vary widely from species to species. Developing a workable "spatial vocabulary" will be a challenge.

For some data items, a geographic boundary of concern extends beyond Minnesota's state line. A prominent example is the tracking of flows of wood into and out of the state. Another would be the population status and trend for migratory birds. Managing such information in tabular and map formats will be a challenge.

Level of Detail

The level of detail of information can be important in other than geographic ways. For example, a survey telling us that Minnesota produces so and so much lumber is good, but it would be even better to have this by species. A number telling us how many ungulates are in the Minnesota woods, by the same token, would be of little interest unless we knew how may were deer, moose, or wild horses.

In the economic data, there is often a considerable amount of detail by tiny subdivisions of industries. For example, the Census of Retail Trade purports to tell us how many bed and breakfasts there are by county.

Availability to Users

Information can be made available in a variety of ways. Different approaches may meet the needs of different data users. Minnesota's information on the Internet and in GIS formats. The FIA data can now be accessed by CD-ROM and on the Eastwide Database website. US Census and state economic information is increasingly available on the Web. Other forms of information, such as remotely sensed images, however, remain costly to duplicate and distribute. There remain examples of information, such as many kinds of permitting data, that to this day remain buried in individual agency files and are never summarized so that they could become useful information.

At times, information is best released in a publication that describes sources and methods, interprets the information, and supplies context. Finally, there is probably some information for which needs are so rare and obscure that simply retaining it in files for occasional reference is adequate.

Ratings: Adequate to Nonexistent

To rate each source according to these criteria, we assigned ratings based upon our judgment, taking into account available descriptions of the data source, and where applicable, views of experts familiar with the data. The ratings used were Adequate, Marginal, Inadequate, and Nonexistent. This approach recognizes that "Adequacy" of a set of data is a multi-dimensional trait and that there is no useful way to capture all dimensions in a single rating.

Another rating criterion is whether the information is available for a portion of the State. Such information could provide a useful proxy for trends in ecologically similar areas.

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REVIEWERS

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ACRONYMS

AAA	Annual Allowable Cut
ACFC	Area of Continuous Forest Cover
AFIS	Annual Forest Inventory System
BBS	Breeding Bird Survey
BQ	Baseline Question
C&I	Criteria and Indicators
CNR	College of Natural Resources, University of Minnesota
ECS	Ecological Classification System
FIA	Forest Inventory and Analysis
FHM	Forest Health Monitoring
FPP	Forest Policy Process
GAP Analysis	Program by USFS to identify gaps in habitat protection
GEIS	Generic Environmental Impact Statement (on timber harvesting and forest management)
GIS	Geographic Information System
GLA	Great Lakes Assessment
LRA	Laws, Rules, and Administrative Policies
MFRC	Minnesota Forest Resources Council
NCRS	North Central Research Station, USDA Forest Service (formerly North Central Forest Experiment Station)
NRCS	Natural Resources Conservation Service, formerly Soil Conservation Service (SCS)
NRI	Natural Resources Inventory (a five-year assessment of farm and forest landuse and conditions)

OFV	Off Road Vehicle
SCORP	State Comprehensive Outdoor Recreation Plan
TPO	Timber Products Output Studies (by FIA group)
UMN	University of Minnesota

ATTACHMENTS

Review of Availability and Accuracy of Information About Forests

Report to
Minnesota Forest Resources Council

By

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April 10, 2001

Review of the Availability and Accuracy of Information about Forests: Phase I Report

Prepared by

Minnesota Forest Resources Council
Forest Resource Information Management Committee

In partnership with the

Environmental Indicators Initiative

January 25, 2000

Introduction

This report is the culmination of the first phase of a two-phase review of the availability and adequacy of information on the state's forest resources. The report was prepared through a partnership between the Minnesota Forest Resources Council Forest Resources Information Management Committee (IMC) and the Minnesota Department of Natural Resources Environmental Indicators Initiative (EII). The report includes one or more baseline questions for each of the eleven MFRC goals developed in conjunction with the vision statement (see Common Vision and Major Goals section below). Indicators are identified for each baseline question. Together the baseline questions and indicators presented in this report represent a major step forward in identifying the information needs for achieving the common vision for Minnesota's forest resources.

Background

In fall of 1998, the MFRC created the Forest Resources Information Management Committee (IMC). The origins of the IMC date back to the MFRC's development of a vision statement in late 1997 and early 1998. Eleven goals for achieving the vision and twenty-one major forest resource topics – topics that have considerable influence over the state's ability to realize the vision – were identified by the MFRC along with the vision statement. The topic *availability and accuracy of information about forests* was judged important enough by the MFRC to warrant immediate study. The IMC was constituted shortly thereafter and charged with studying the availability and adequacy of the state's forest resources information. The IMC has adopted a two-phase review process (described below), of which this report marks completion of the first phase.

Phase I Review Process

The phase I review process entailed three major steps. First, questions by which progress toward achieving the goals can be measured were developed. These questions were called *baseline questions* in order to signify their importance. They were derived from interpretation of goals by EII staff; consultations among EII staff, the IMC, IMC staff, and MFRC staff; and EII staff's collective experience in the field of environmental monitoring.

Second, the EII undertook a review of several regional, national, and international Criteria and Indicator (C&I) projects underway or recently completed. A total of five C&I projects were reviewed (see Sources). The review 1) provided the means to compare and contrast the goals with C&I developed by international, national, and regional forestry groups addressing sustainability, and 2) suggested additional information that might make the information review more comprehensive.

Finally, indicators – quantitative or qualitative measures that provide information – were developed for each baseline question. Indicators reported are a select set of all possible

indicators – those judged to be most effective at answering the question. Several questions, particularly those related to process type goals, were such that quantifiable indicators were not readily discerned.

Proposed Phase II Review Process

The second phase will build on the first phase through the examination of the state's ability to provide the information necessary to answer the baseline questions and indicators. A sampling of questions that may be addressed in the second phase include:

Are programs in place to collect the information needed?
Where are the gaps between information needed and that which is available?
Is the information accurate?
Is the information collected at frequent enough intervals and at appropriate scales?
Is the information collected in a manner that allows the identification of trend?
Is the information comparable to historical data sources?
Is the information available to the policy makers, planners, managers, and citizens who may need the information?

The IMC plans to initiate the second phase in February 2000 and complete it by August 2000. A final report that highlights major findings of the information review along with IMC recommendations for programmatic responses will be submitted to the MFRC by November 2000.

Common Vision and Major Goals

Common Vision
Minnesota's forests are managed with primary consideration given to maintaining 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

Major Goals for Achieving a Common Vision
Minnesota's Forest Land Base is Enlarged and Protected. No net loss of forest land occurs and some previously forested areas are returned to forest cover. The forest land base is protected from decreases and fragmentation caused by land-use changes.
Forest Ecosystems are Healthy, Resilient, and Functioning. Forests are composed of appropriate mixes of cover types and age classes required to maintain wildlife and biological diversity.
Forests are Sustainably Managed. Forests are managed to ensure economic, social, and ecological sustainability. Forest management activities enhance the diversity of the state's forests and support the long-term sustainability and growth of the many sectors that depend on them.
Forest-Based Economic and Recreational Opportunities are Large. The role and contribution of forests to the state's economic and social well-being are acknowledged. Economic opportunities for Minnesota's forest-based industries, including tourism and wood-based businesses, are large, sustainable, and diverse.

Forest Practices are Implemented in Effective and Efficient Ways. Forest practices are implemented in ways that maximize their effectiveness while minimizing the costs of their administration. Guidelines suggesting appropriate practices are scientifically based, practical, easy to understand, their rationale clearly stated, and their application consistent where possible and appropriate.

Forest Landscape-Level Planning is Coordinated and Involves Collaboration. Landscape-level planning is based on ecological landscapes and involves collaboration among landowners, users, stakeholders, and the public.

Public and Private Rights and Responsibilities are Recognized. Forest practices that achieve certain public benefits recognize and respect the inherent rights, responsibilities, interests, and financial limitations of public and private forest landowners.

Forest Research Programs are Effective and Adaptive. Information is provided by effective and coordinated basic and applied research programs. Forest practices and landscape planning/coordination activities are based on the best available information and technology and can be readily adapted to new information or changing resource conditions.

Multi-Resource Information Systems are Compatible and Comprehensive. Landowners, managers, and stakeholders have access to information systems that are capable of providing comprehensive information about forest resources.

Forest Policy Development is Effective and Supportable. Policies and programs focused on forest resources are developed and supported by processes that collaboratively move forward to resolve issues and accommodate a wide-range of constituencies.

Program Funding is Committed and Sustained. Sustainable, adequate, and long-term funding is available to accomplish the vision and the goals for the state's forests.

	FRC Goals	Baseline Questions	Indicators
Forest base	**Minnesota's Forest Land Base is Enlarged and Protected**	How much forest land is there?	Area of forest land, timberland, and total land area.
		How extensive are areas of continuous forest cover?	Extent, location, and spatial pattern of areas of continuous forest cover. Changes in ownership within areas of continuous forest cover.
		What laws, rules, administrative policies, land use plans, and local ordinances exist to protect the extent of existing forest?	Extent, location, and spatial pattern of forest land by landowner and administration category. Extent, location, and spatial pattern of forest land protected from conversion to non-forest uses by laws, rules, administrative policies, land use plans, and local ordinances.
		To what degree does land taxation influence the amount of forest land?	Listing of land taxes and the degree to which they impact the amount of forest land.
Ecosystem Health	**Forest Ecosystems Are Healthy, Resilient and Functioning**	What is the condition of the terrestrial habitat in forested areas?	Extent, location, and spatial pattern of natural plant communities. Extent, location, and spatial pattern of forest types, age classes, size classes, site index, basal area, and productivity classes. Status of state and federal endangered/threatened/special concern species. Listing of sensitive species that are monitored by agencies, institutions, and programs.
		What is the condition of the aquatic resources in forested areas?	Index of Biological Integrity. Status of state and federal endangered/threatened/special concern species. Listing of sensitive species that are monitored by agencies, institutions, and programs.
		How extensive are disturbances in forested areas?	The extent, location, and spatial pattern of disturbance by type and severity class.
		How are disturbed forests recovering?	Land use and cover class of disturbed areas. Composition and stocking of forest regeneration.
		How does tree growth compare to mortality and removals?	Growth, mortality, and removals by species.
		To what degree are forest land productivity levels in-line with potential productivity?	The extent of forest land with productivity levels below potential productivity.

	FRC Goals	Baseline Questions	Indicators
Economies and communities	**Forest-Based Economic and Recreational Opportunities Are Large.**	What is the status and economic value of manufacturing of fiber and raw materials from Minnesota's forests?	Location, capacity, and products produced by facilities of Minnesota's wood-based industry. Economic value, number of employees, and wages paid in the primary manufacturing of Minnesota fiber and raw material. Economic value, number of employees, and wages paid in the secondary manufacturing of Minnesota fiber and raw material. Import and export levels of raw materials and products.
		What is the availability of recreational opportunities and their economic value?	Amount of forest land available for public use. Number and type of facilities available for recreation and tourism. Expenditures of individuals participating in forest recreation and tourism.
		What is the status and economic value of special products (non-timber) from Minnesota's forests?	List of special products produced. Gross sales of special products produced from Minnesota's forest resources.
Management	**Forests Are Sustainably Managed.**	Please see questions for (1) Forest Ecosystems are Healthy, Resilient, and Functioning, and (2) Forest-Based Economic and Recreational Opportunities are Large.	
	Forest Practices are Implemented in Effective and Efficient Ways.	Are guidelines (e.g. Best Management Practices, silviculture guides) that suggest appropriate practices to promote sustainability in place?	List of sources that provide guidance.
		To what extent are existing guidelines that promote sustainability implemented?	Forest area managed in accordance with guidelines. Number of loggers and forest managers who participate in guideline education programs. Compliance monitoring results.
		How effective are existing guidelines that promote sustainability?	Effectiveness monitoring results.
		How efficient are guidelines that promote sustainability?	Compliance monitoring results.
		What costs are borne by loggers, managing agencies, and landowners for implementing guidelines?	Cost of guidelines for loggers, managing agencies, and landowner groups.

	FRC Goals	Baseline Questions	Indicators
Management	**Forest Landscape-Level Planning Is Coordinated and Involves Collaboration.**	What groups are dealing with forest resource issues that affect large areas and multiple landowners?	List of groups, their purpose and geographic extent.
		To what extent are landowners coordinating forest planning and management activities?	Area of forest land where planning and management activities are influenced by landscape-level planning and coordination activities.
		To what extent is strategic planning occurring?	Area of forest land that is part of strategic planning effort (assessment, issue identification, goals, and strategies).
	Public and Private Rights and Responsibilities are Recognized.	Do existing laws, rules, administrative policies, local ordinances, land use plans, direction documents, and guidelines recognize public and private rights and responsibilities?	List of laws, rules, administrative policies, local ordinances, land use plans, and guidelines that affect private landowner's rights and responsibilities. List of laws, rules, administrative policies, local ordinances, land use plans, and direction documents that define public rights and responsibilities.
	Forest Policy Development is Effective and Supportable.	Are processes in place to provide collaboration in forest policy development?	List of processes, their purpose and geographic extent.

	FRC Goals	Baseline Questions	Indicators
Enabling conditions	**Forest Research Programs Are Effective and Adaptive.**	Are research programs responsive to the need of practitioners?	Researchers and practitioners perceptions as to the adequacy and applicability of research?
		Are mechanisms in place so researchers know what's needed?	Researchers and practitioners perceptions as to the transfer of information and needs between the communities.
	Multi-Resource Information Systems Are Compatible and Comprehensive.	How comprehensive are the existing information resources in the state?	Periodic review of the availability and accuracy of information on forests in Minnesota.
		To what extent are information from multiple landowners compatible?	List of efforts and accomplishments to coordinate common data standards and information reporting.
	Program Funding Is Committed and Sustained.	What activities are missing or are performing inadequately?	List of programs and their purpose.

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MN Data Description Form

Data Item: _____

Goal: _____

Indicator: _____

Agency Contact: _____

(name address, phone, e-mail) _____

Data History **Year Initiated:** _____ **Year Ended (if appl.)** _____

Spatial Detail (county, subregion [describe], or circle interval)

Time Grain (monthly, quarterly, annual, periodic [circle interval] comments:

Publication Lag

Accuracy/Precision

Principal Limitations, known or asserted (esp. as trend indicator)

Method of Obtaining Data

Coverage by "Forest" (timberland, reserves, farm regions, urban)

Industry Detail (where applicable)

Form (titles, published, article, web, other)

Citation to Other Published Review(s) of the Data

MN Data Description Form

Data Item:

Recommendations (our own, or by others)

"Sustainability" of Data: Any Risk to Continued Availability?

Titles and Full Citation of Publication(s) Containing Data:

Website, if applicable:

Other Points and Remarks

MN Data Evaluation Form

Data Item:

Data Quality for Each Trait	Trait of Data				
	Timeliness	Accuracy	Spatial Detail	Level of Detail	Availability to Users
Adequate					
Marginal					
Inadequate					
Nonexistent					

Remarks

MINNESOTA FORESTRY INFORMATION DATA INVENTORY

This inventory is the basic listing of information and data sources used in this evaluation. In some instances, individuals and agencies are given as sources. In others, documents are cited. Extensive citations in the full report are also provided.

The Inventory is slightly modified for clarity from the version shown in the table of the Phase I Report.

The indicators are taken from or modified from the Phase I Report.

The information items are types of information that would relate to the indicator.

The information sources represent the document or other source from which the item can be obtained.

For different items there may be no source, one source, or multiple sources. Also, many specific items may come from a single source (e.g., the various items provided by the FIA).

The counts for sources are counted to avoid duplication (as, e.g., for FIA which is the common source for many information items).

	No. of Indicators	No. of Info. Items	No. of Info. Sources
A. Forest Land Base	6	16	13
B. Ecosystem Health	12	40	46
C. Economics and Communities	9	27	40
D. Management: Practices Effective	7	10	15
E. Management: Planning	3	6	5
F. Management: Rights and Responsibilities	2	2	0
G. Management: Policy	1	1	0
H. Enabling Conditions	5	5	0
TOTAL	45	107	119