FINAL REPORT

AUG 12 2002

1999 Project Abstract
For the Period Ending June 30, 2002

TITLE: MINNESOTA'S FOREST BIRD DIVERSITY INITIATIVE: CONTINUATION

PROJECT MANAGER: Lee Pfannmuller
ORGANIZATION: Division of Ecological Services
Minnesota Department of Natural Resources
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WEB SITE ADDRESS: http://www.nrri.umn.edu/mnbirds

FUND: Minnesota Environment and Natural Resources Trust Fund
LEGAL CITATION: ML 1999, Chap.231, Sec.16, Subd.12h.
APPROPRIATION AMOUNT: $350,000

Overall Project Outcome and Results:

The project's primary goal is to develop landscape management tools to maintain Minnesota's rich diversity of forest birds. During the FY00-01 biennium we completed the tenth and eleventh years of monitoring forest bird populations in the Chippewa National Forest and Superior National Forest, the ninth and tenth years in east-central Minnesota and the sixth and seventh years in southeastern Minnesota. A major objective of this study was to analyze forest bird population trends. Most breeding bird populations in northern and east-central Minnesota were relatively stable, while 15 species had a decreasing trend and eight were increasing. In the southeast region eight species showed long-term population declines, while eleven species increased. Most species in all regions showed considerable year-to-year variation in abundance. Another major objective was to refine and verify our predictions of forest bird distribution and abundance and to create links to LANDIS. Parameterization required by LANDIS was completed for the Nashwauk Upland subsection of the Ecological Classification System. Additionally, we tested our predictions using bird abundance on nine 1-square mile plots and these analyses indicated that our predictions had a high level of accuracy. We are unaware of any efforts elsewhere with similar predictions that have been evaluated with independent data. Progress was made on software components of the forest planning tool to make this a useful application for land managers. This includes a module that conducts Monte Carlo simulations to make predictions of bird abundance and a module that enables us to read the output of LANDIS directly.

Project Results Use and Dissemination:

Staff continued updating the initiative's web site (http://www.nrri.umn.edu/mnbirds) which provides public access to data and information collected by the project. Ten presentations highlighting the project's results were given during the Biennium. Four papers were accepted or published in final form and drafts of two additional manuscripts were completed.

Date of Report: July 1, 2002
LCMR Final Work Program Report

AUG 12 2002

I. PROJECT TITLE: MINNESOTA'S FOREST BIRD DIVERSITY INITIATIVE: CONTINUATION

Project Manager: Lee Pfannmuller
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Total Biennial Project Budget:

$LCMR:	$350,000	$Match:	$ 80,000
-$LCMR Amount Spent:	$350,000	-$Match Amount Spent:	$ 80,000
=$LCMR Balance:	$0	=$Match Balance:	$ 0

A. Legal Citation: ML 1999, Chap.231, Sec.16, Subd.12h.

Minnesota's Forest Bird Diversity Initiative-Continuation

Appropriation Language: $175,000 the first year and $175,000 the second year are from the trust fund to the commissioner of natural resources for the fifth biennium of a six-biennium project to establish benchmarks for using birds as ecological indicators of forest health. This appropriation must be matched by at least $80,000 of nonstate contributions. This appropriation is available until June 30, 2002, at which time the project must be completed and final products delivered, unless an earlier date is specified in the work program.

B. Status of Match Requirement: The majority of the project match ($65,000) was provided by the U.S. Forest Service to support the forest bird monitoring efforts on the Superior and Chippewa National Forests. The remaining portion of the match ($15,000) was provided through a grant to the Natural Resources Research Institute from the National Council of the Paper Industry for Air and Stream Improvement and will help support further development and field testing of the Initiative's bird-habitat model.

II. and III. FINAL PROJECT SUMMARY

The project's primary goal is to develop landscape management tools to maintain Minnesota's rich diversity of forest birds. During the FY00-01 biennium we completed the tenth and eleventh years of monitoring forest bird populations in the Chippewa National Forest and Superior National Forest, the ninth and tenth years in east-central Minnesota and the sixth and seventh years in southeastern Minnesota. A major objective of this study was to analyze forest bird population trends. Most breeding bird populations in northern and east-central Minnesota were relatively stable, while 15 species had a decreasing trend and eight were increasing. In the southeast region eight species showed long-term population declines, while eleven species increased. Most species in all regions showed considerable year-to-year variation in abundance. Another major objective was to refine and verify our predictions of forest bird distribution and abundance and to create links to LANDIS. Parameterization required by LANDIS was completed for the Nashwauk Upland subsection of the Ecological Classification System. Additionally, we tested our predictions using bird abundance on nine 1-square mile plots and these analyses indicated that our predictions had a high level of accuracy. We are unaware of any efforts elsewhere with similar predictions that have been evaluated with independent data. Progress was made on software components of the forest planning tool to make this a useful application for land managers. This includes a module that conducts Monte Carlo simulations to make predictions of bird abundance and a module that enables us to read the output of LANDIS directly.

Staff continued updating the initiative's web site (http://www.nrri.umn.edu/mnbirds) that provides public access to data and information collected by project staff. Ten presentations highlighting the project's results were given during the Biennium. Four papers were accepted or published in final form and drafts of two additional manuscripts were completed.

IV. OUTLINE OF PROJECT RESULTS

This is a continuation of a long-term project begun in FY92-93. The results listed below represent a continuation of the fundamental components of the initiative (population monitoring, development of a predictive model, and education). More details are available in the Research Addendum.

Result #1: Monitor forest bird population trends.

- Breeding bird data continued to be collected from 1,273 sampling points already established in northern, east-central and southeastern Minnesota. Data have now been collected from the national forests for eleven years, from the St. Croix River Valley for ten years and from southeastern Minnesota for seven years.

- We were able to test abundance trends for 72 species between 1991 and 2001. Forty-one species were tested in the Superior NF, 50 species in the Chippewa NF, 39 species in the St. Croix region, and 40 species in the southeast.

- Overall, we found almost twice as many species with a decreasing trend as compared to an increasing trend in the Chippewa, Superior and St. Croix study areas. In the Southeast, this result was reversed with more species increasing than descreasing. Eight (16%) of the species tested in the Chippewa NF had increased significantly while 15 (30%) decreased. Eleven (27%) of the species tested in the Superior NF also had significant decreasing trends, and six (15%) had increasing trends. In the St. Croix study area, five (13%) of the species tested increased significantly, and nine (23%) decreased. In southeast Minnesota, 11 (27%) species increased significantly and eight (20%) decreased.

- The combined regional analyses of the three national forests (Chippewa, Superior and Chequamegon in northwestern Wisconsin) showed four (11%) species increasing, the Yellow-bellied Flycatcher, Red-breasted Nuthatch, Northern Parula and American Redstart. The same analyses showed that 11 (31%) species declined significantly including the Eastern Wood-Pewee, Brown Creeper, Winter Wren, Hermit Thrush, Black-and-White Warbler, Ovenbird, Common Yellowthroat, Canada Warbler, Scarlet Tanager, Song Sparrow and White-throated Sparrow. These are all migrant species and most nest on or near the ground.

- A more detailed report of the Initiative's FY00-01 accomplishments has been prepared as an accompaniment to this LCMR Work Program report and includes a comprehensive analysis of forest bird population trends.

LCMR Budget:	$143,059	Match Budget:	$65,000
LCMR Balance:	$0	Match Balance:	$0
Completion Date:	June 30, 2002		

Result #2: Conduct a large-scale field application of the forest bird planning tool

- Validated the ability of our bird-habitat models to relate bird distribution and abundance to patterns of vegetation using an independent set of data from nine intensive study areas in northern Minnesota.

- Acquired necessary GIS data layers to parameterize an entire subsection of the Ecological Classification System, the Nashwauk Uplands, for LANDIS. Developed necessary input parameters such as the establishment coefficients for 18 tree species. All GIS coverages required for a LANDIS simulation where created:

    - landtype coverage for delineating ecologically homogeneous areas based principally on ECS Landtype Associations (LTA's);

    - management areas which delineate silvicultural prescriptions based on ownership patterns (e.g., state parks were designated as protected areas); and

    - existing forest cover coverage based on a statistical extrapolation of the Minnesota's DNR Cooperative Stand Assessment (CSA) data to a comtemporary satellite (TM) image of the Nashwauk subsection.

- Instead of meeting individually with stakeholders to develop forest management prescriptions for the LANDIS simulations, we collaborated with the Department of Natural Resources' Spatial Analysis Project which included stakeholders from the Department of Natural Resources, forest industry, northern counties, the U.S. Forest Service, the university, and conservation organizations. Prescriptions were developed that included a range of existing silvicultural systems and those which stakeholders endorsed as future goals.

- Due to unanticipated technical difficulties we were unable to complete the LANDIS simulation of the Nashwauk Uplands subsection. Data acquisition and processing took longer than anticipated in the original work plan largely because we were unable to process the simulation at the original 30-meter resolution as planned. The computational requirements of the simulation exceeded the capacity of our most powerful workstation. This necessitated reprocessing the GIS data to a resolution of 60-meter pixels. This effectively reduced the size of the problem by two-thirds. The simulation will be completed and the results will be made available to the Department of Natural Resources and any interested parties.

- As mentioned under Result #1, a more detailed report of the Initiative's FY00-01 accomplishments has been prepared as an accompaniment to this LCMR Work Program report and includes more detail about the project's efforts to model bird distribution and abundance and efforts to build a model for the Nashwauk Uplands for LANDIS.

LCMR Budget:	$186,328	Match Budget:	$15,000
LCMR Balance:	$0	Match Balance:	$0

Completion Date: June 30, 2002

Result #3: Prepare and deliver educational materials and application tools

- The project's web site that provides public access to the data and information collected as part of the initiative continued to be updated. The web site grew from 511 to 641 pages of information that has been viewed in 70 countries and in December 2001 served 4,491 pages to those visitors.

- Ten presentations highlighting the results of this project were given during this past Biennium. Six of these presentations were presented at scientific conferences, two talks were presented at a workshop on forest research in Minnesota at the Cloquet Forestry Center under the auspices of the Sustainable Forests Education Cooperative, and the other two talks were presented to lay audiences in Minnesota.

- A total of four papers were accepted or published in final form during this Biennium and drafts of two additional manuscripts completed. Two Masters of Science theses were completed during this period examining the ability to develop statistical models of species' distributions at large spatial scales and following the reproductive success of ground-nesting birds at multiple spatial scales. A complete list of all the publications produced during the duration of the initiative, from FY92 through FY01, is included in Appendix D of the accompanying report for the FY00-01 biennium.

- Developed software modules that are necessary in order to avoid the end-user having to supply expensive third-party software and extensive technical support of a dedicated GIS-technician. All will become part of the Forest Bird Planning Tool. They perform the following functions:

    - remove single pixel patches, which are essentially small anomalies from the standpoint of LANDIS, from the satellite imagery;

    - predict bird abundance using the probabilities derived from field data using a Monte Carlo (i.e., stochastic) simulation; and

    - convert GIS coverages between Arc/Info and ArcView grid and the LANDIS Erdas file formats, thus removing the end-user from owning either Arc/Info (ESRI Inc.) or Imagine (Erdas Inc.)

LCMR Budget:	$ 20,613	Match Budget:	NA
LCMR Balance:	$0	Match Balance:	NA

Completion Date: June 30, 2002

V. **DISSEMINATION**: Dissemination of project data and findings can be categorized as follows:

- Availability of Primary Data. Data sharing is being coordinated with LMIC and the U.S. Forest Service; the U.S. Forest Service national GIS data standards are being followed for quality control. Spatial data will be shared in compatible format with LMIC, DNR, the National Forests and other cooperators to allow for use in management and planning. On an operational basis, a GIS data coverage catalog has been created to index the many large data layers and provide for user access. Data are backed up and archived across the system on a weekly basis.

- World Wide Web. Information about the project is also accessible on the world wide web through the Natural Resources Research Institute (http://www.nrri.umn.edu/mnbirds). The project's web site is indexed in many of the top internet search engines (e.g., GOOGLE and MSN). Currently, our web site consists of 641 pages that are divided among 12 top-level sections. Eight of these 12 sections contain the majority of the information we are presenting while the remainder are devoted to acknowledging our funding sources, highlighting our project staff or providing links to other relevant web sites. Real-time queries can be conducted against the most recent version of our database.

- Professional Meetings and Technical Publications. Project results were presented to peers in the field at national, regional and state scientific meetings, as well as to resource managers and planners who will be users of the information and results. Results have been published in the peer-reviewed literature in the major national journals in the field.

- Application of Project Findings to Forest Management. Throughout the duration of the project, staff have worked closely with forest managers at the state, federal, county and private level, providing them with information tailored to meet their specific needs. This can vary from providing detailed survey results at particular locations or summarized by forest cover type, to developing broad forest management guidelines for private woodland owners. These cooperative efforts will continue during the next biennium.

- Application to Statewide Conservation Efforts. Project staff have used the information from this initiative to assist with the development of a statewide landbird conservation plan. The plan is part of a larger, international avian conservation program known as Partners In Flight. A steering committee of diverse stakeholders throughout the state was established in the fall of 1996 and work on the plan has begun. Data gathered by the Forest Bird Diversity Initiative provided the cornerstone of the plan's focus in Minnesota's forested region.

VI. CONTEXT

A. Significance: Minnesota lies in a narrow forest belt that supports the highest diversity of songbirds in North America. Although this diversity is an excellent indicator of forest ecosystem health, birds have received little management attention. Furthermore, the recent GEIS on Expanded Timber Harvesting (Jaakko Poyry Inc. 1994) predicts that some forest bird populations may decline. Accurate resource information is needed to properly direct management activities to prevent such declines while still accommodating sustained timber utilization.

Prior to the initiation of this study in FY92, efforts to assess the effects of forest management on songbird populations in Minnesota had focused only on limited questions at the local scale (e.g., Niemi and Pfannmuller 1979, Niemi and Hanowski 1984 and Engstrom 1990). The influence of the surrounding landscape on the bird community composition had only been considered in a few select studies elsewhere in the eastern United States (e.g., Askins et al. 1987, Blake and Karr 1987, Hejl 1992, Opdam et al. 1985, Robbins 1979). These latter studies began to suggest that a conservation model for forest birds requires a broad, landscape-level approach integrated with a more innovative approach that addresses a wider range of management options at the stand level.

Practical applications to demonstrate a conservation effort at this scale were lacking. This initiative fills that void and has been widely recognized as a national forest bird conservation model. It is the first comprehensive program to relate forest vegetation and landscape patterns to regional bird diversity with a long-term monitoring program. The large-scale, habitat-specific monitoring program is intended to complement the U.S. Geological Survey's Breeding Bird Survey (BBS), established in 1966, by gathering more detailed information on trends and habitat use by Minnesota's forest birds, especially those not efficiently sampled by the BBS. Gathering this data for a minimum of 10 years is essential for understanding natural population variations.

This monitoring effort is complemented by extensive research to identify factors responsible for observed population trends and modeling to analyze relationships between habitat at the stand level, vegetation patterns at the landscape level, and bird populations. For example, one research objective of the initiative is to link studies of reproductive success with bird relative abundance, habitat use and landscape context. Together, the results of these efforts are leading to the development of management prescriptions that ensure the maintenance of Minnesota's rich diversity of forest birds. The information gathered has and will continue to be important to many forest planning efforts including the efforts to conduct landscape-level planning by the Minnesota Forest Resources Council and the update of management plans for the Chippewa and Superior National Forests.

B. Time: The monitoring and research program established by this project will be operable for one additional biennium beyond FY00-01, for a total of six bienniums. Funding was acquired directly through the MN Department of Natural Resources.

C. Budget Context: Information to describe the project context and budget history is presented as follows: 1) **Funding History**, which summarizes expenditures for the previous four bienniums; 2) **Proposed and Anticipated Expenditures**, which summarizes expenditures for the FY00-01 and FY02-03 bienniums; 3) **Relationship to Other Projects**, which provides a summary of the primary projects that the Forest Bird Diversity Initiative has collaborated with since its inception in 1991; 4) a **Detailed Budget for FY00-01**; and 5) reference to **Attachment A.** which provides additional details on the Initiative's budget.

1. Funding History (FY92-FY98)

	FY92-93	FY94-95	FY96-97	FY98-99	FY00-01
LCMR Funds	$300,000	$500,000	$400,000	$350,000	$350,000
State Funds	-	$50,000	$60,030	$57,010	-
Non-State Funds	$200,000	$66,000	$191,680	$108,260	$80,000
In-Kind Support	-	$81,600	$81,600	$81,600	$82,000
Total	**$500,000**	**$697,600**	**$733,310**	**$596,870**	**$512,000**

2. Proposed and Anticipated Expenditures

	FY02-03
LCMR Funds	$ 0
State Funds	$350,000
Non State Funds	$ 50,000
In-Kind Support	$ 82,000
Total	**$532,000**

3. Relationship to Other Specific Projects that Contribute Matching Dollars

- USDA Forest Service Monitoring Efforts (1991-1999; $222,500)

This is a cooperative project with the North Central Forest Experiment Station and the Chippewa and Superior National Forests. We have established a habitat-specific monitoring program on 885 point samples that were proportionally, randomly selected based on available habitat. All points are censused annually. The results are used to assess habitat use and population trends for more than 50 forest bird species, serving as an early-warning system for potential population declines. The effort is complementary to the

Forest Bird Diversity Initiative monitoring efforts in the St. Croix Valley and southeastern Minnesota, forming a statewide monitoring network in the primary forested zones of Minnesota.

- <u>St. Louis County Monitoring Efforts</u> (1994-1998; $21,000)

St. Louis County is one of the largest forested counties in the U.S. and is much larger than many U.S. states. Because of the vast publicly-owned forests in St. Louis county we established a cooperative program to inventory and monitor birds on St. Louis County administered forestlands. The data gathered were the same as those used in the statewide bird monitoring effort and, hence, complementary with those data. The data have been used in the Initiative's analysis of habitat use by birds and to aid management of St. Louis County lands for the benefit of both sustained forest use and wildlife.

- <u>Minnesota Power - Boulder Lake Management Area</u> (1994-1998; $37,000)

The Boulder Lake Management Area, owned by Minnesota Power, is a cooperative effort of the University of Minnesota, St. Louis County and the Minnesota DNR to do research and provide "hands-on" environmental education on sound forest and water quality management to local schools and adults. At this site we have established a large research study plot (one mile square) and have conducted a number of studies on bird habitat relationships and nest productivity, in addition to studies on small mammals, reptiles and amphibians. The bird studies are complementary to the Initiative and the data gathered is being used in the development of bird, habitat and landscape models.

- <u>Forest Bird Biodiversity: Indicators of Environmental Condition and Change in the Great Lakes Watershed</u> - Great Lakes Protection Fund (1996-1998; $382,000 of which $80,000 is directly relevant to Minnesota)

This was a large, multi-investigator project that developed a standard protocol for monitoring birds and developed spatially-referenced data bases that will be used to develop conservation priorities for forest birds across the Great Lakes region. The project combines a series of GIS data layers to identify areas of high conservation concern in the forests of the Great Lakes watershed. Since portions of Minnesota are within this watershed, some of the work for this project will be highly beneficial to the Forest Bird Diversity Initiative in terms of identifying areas of high conservation value within Minnesota's forests.

- <u>The Contribution of Forested Wetland Communities to Maintaining Minnesota's Rich Diversity of Forest Birds</u> - Environmental Protection Agency (1992 -1994; $30,000)

The funds provided by this grant contributed to the required $200,000 match during the FY92-93 biennium. The project focused on documenting the contribution of forested wetlands (Types 7 and 8) to the regional diversity of forest birds. Funds were used to sample approximately 120 points in our larger monitoring program that were located in forested lowland cover types.

- Forest Bird Inventory and Monitoring: A tool to evaluate the relative importance of forested wetlands and to assist with watershed protection efforts in southeastern Minnesota - Environmental Protection Agency (1995-1997; $20,000)

Up until 1995 the initiative's monitoring efforts were focused entirely in northern and east-central Minnesota. Using LCMR funds a pilot (75 monitoring points) was established in three southeastern counties (Rice, Wabasha and Goodhue) during the 1995 field season. This pilot effort pointed out several new challenges that raised the costs of the monitoring program. For example, the more fragmented nature of the landscape in southeastern Minnesota results in census points being more widely dispersed and fewer points being censused each morning. EPA funds granted through the above contract agreement enabled us to expand the monitoring program in the southeast by an additional 136 sampling points for the 1996 and 1997 field seasons. Costs for the southeast monitoring program are now being supported by the trust fund contribution to the Initiative.

- Nesting success of forest birds in the Upper Mississippi River, Minnesota - National Biological Service (1996-1997; $54,560)

This grant was part of the U.S. Geological Survey's State Partnership Program. Its objective was to identify stand and landscape characteristics associated with successful nesting in southeastern Minnesota. Complementary work by the Forest Bird Diversity Initiative has been geographically restricted to the larger forested areas of northern and central Minnesota.

- Minnesota Forest Resources Council Research Committee - Riparian Birds (1996-1998; $100,000)

The effects of logging in riparian forest areas on wildlife are not well-documented and have been identified as an area of concern by the Forest Bird Diversity Initiative; monies however, have been inadequate to directly address this question through fieldwork and selected field experiments. Supported by the Minnesota Forest Resources Council, this study has gathered baseline data on bird distribution and abundance in riparian forests. The results provide essential information for carefully describing bird habitat relationships in this critically important forest community. A second study examining the response of birds to forest harvesting and management in riparian stands is now under consideration by the MFRC Research Committee.

- Forest Stewardship Program (1996-1997; $17,040)

The Forest Stewardship Program is considered a primary mechanism for delivering information on forest bird management. In 1996 project staff were awarded two small grants to work more closely with the stewardship program. The first grant ($7,940) was awarded to provide support to develop and present 5 workshops on forest bird management to stewardship plan writers in 1997. The second grant ($9,100) was awarded to help provide support for publishing **Planning for birds: things to consider when managing your forest.**

- FY00-01 LCMR Project: Predicting water and forest resource health and sustainability (1999-2001; $300,000)

This project will actually utilize breeding bird and classified TM forest cover data generated by the Forest Bird Diversity Initiative to develop a decision support model that will predict forest health.

4. Detailed Budget for FY00-01

Proposed Expenditures for the FY00-01 LCMR Funding Period:

	Percent Effort	Cost	
Personnel			$303,514
Research Associate (Jones)	100%	$89,469	
Research Fellow (Hanowski)	46%	$59,202	
Research Fellow (Wolter)	40%	$39,795	
Statistician	75%	$58,886	
Programmer	13%	$ 9,932	
Field Ornithologists/Biologists	50%	$22,675	
Junior Scientist	30%	$23,555	
Other			
Travel			$ 20,914
Equipment (field flagging, binoculars,etc.)			$ 2,100
GIS Fees			$ 11,160
Office Supplies			$ 2,200
Telephone			$ 1,000
Mail			$ 600
Printing			$ 900
Publications			$ 5,500
Other Supplies			$ 2,112
Total			$350,000

5. **Budget Detail**: Further detail on project expenditures, delineated by project results, are provided in **Attachment A**.

VII. COOPERATION: Minnesota's Forest Bird Diversity Initiative is overseen by a project steering committee that meets approximately 2-3 times per year to review the status of the project and discuss its future goals, objectives and products. Primary members of that team include: Lee Pfannmuller (Department of Natural Resources, Project Manager); Dr. Gerri Niemi (NRRI, Principal Investigator); JoAnn Hanowski (NRRI, Lead Field Investigator); Tim Jones (NRRI, Landscape Ecologist); Jan Green (Minnesota Ornithologists Union); and Tim O'Hara (Minnesota Forest Industry).

Additional cooperators include: 1)U. S. Forest Service, North Central Experiment Station; 2) Superior and Chippewa National Forests; 3) the Minnesota Ornithologists Union (MOU); 4) Potlatch, Boise-Cascade and Blandin paper companies; 5) Wolf Ridge Environmental Learning Center; 6) Minnesota Power and 7) the Wisconsin Department of Natural Resources. Together, it is anticipated that these cooperators will provide at least $80,000 of nonstate contributions, either in cash or in-kind.

Finally, of the total $350,000 of LCMR funds granted to this initiative we anticipate subcontracting all of the funds to the Natural Resources Research Institute, University of Minnesota-Duluth. The principal cooperators at NRRI include the following:

Dr. Gerri Niemi (10% of his time will be devoted to the initiative; this is donated)
Professor and Director, Center for Water and the Environment
Natural Resources Research Institute
University of Minnesota - Duluth

JoAnn Hanowski (46% of her time will be devoted to the initiative)
Research Fellow, Center for Water and the Environment
Natural Resources Research Institute
University of Minnesota - Duluth

Peter Wolter (40% of his time will be directed to the initiative)
Research Fellow, Center for Water and the Environment
Natural Resources Research Institute
University of Minnesota - Duluth

Malcom T. Jones (100% of his time will be directed to the initiative)
Research Associate, Center for Water and the Environment
Natural Resources Research Institute
University of Minnesota - Duluth

In addition, Lee A. Pfannmuller will be donating at least 5% of her time as project manager to the initiative.

VIII. LOCATION:

Project activities are underway throughout the forested region of the state map delineating the counties where the Initiative is working is provided in **Attachment B**.

IX. REPORTING REQUIREMENTS: Periodic work program progress reports were submitted December 31, 1999, September 15, 2000 and March 15, 2001. A final work program report and associated products will be submitted by August 9, 2002.

X. RESEARCH PROJECTS: Refer to attached Research Addendum

Literature Cited

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Blake, J.G., and Karr, J.R. 1987. Breeding birds of isolated woodlots: Area and habitat relationships. Ecology 68:1724-1734.

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Robbins, C.S. 1979. Effects of forest fragmentation on bird populations. In: Management of North-central and Northeastern Forests for Nongame Birds, Workshop Proceedings (R.M. DeGraaf and K.E. Evans, eds). pp. 198-212. North Central Forest Experimental Station Publication, U.S. Forest Service General Technical Report NC-51. St. Paul, MN.

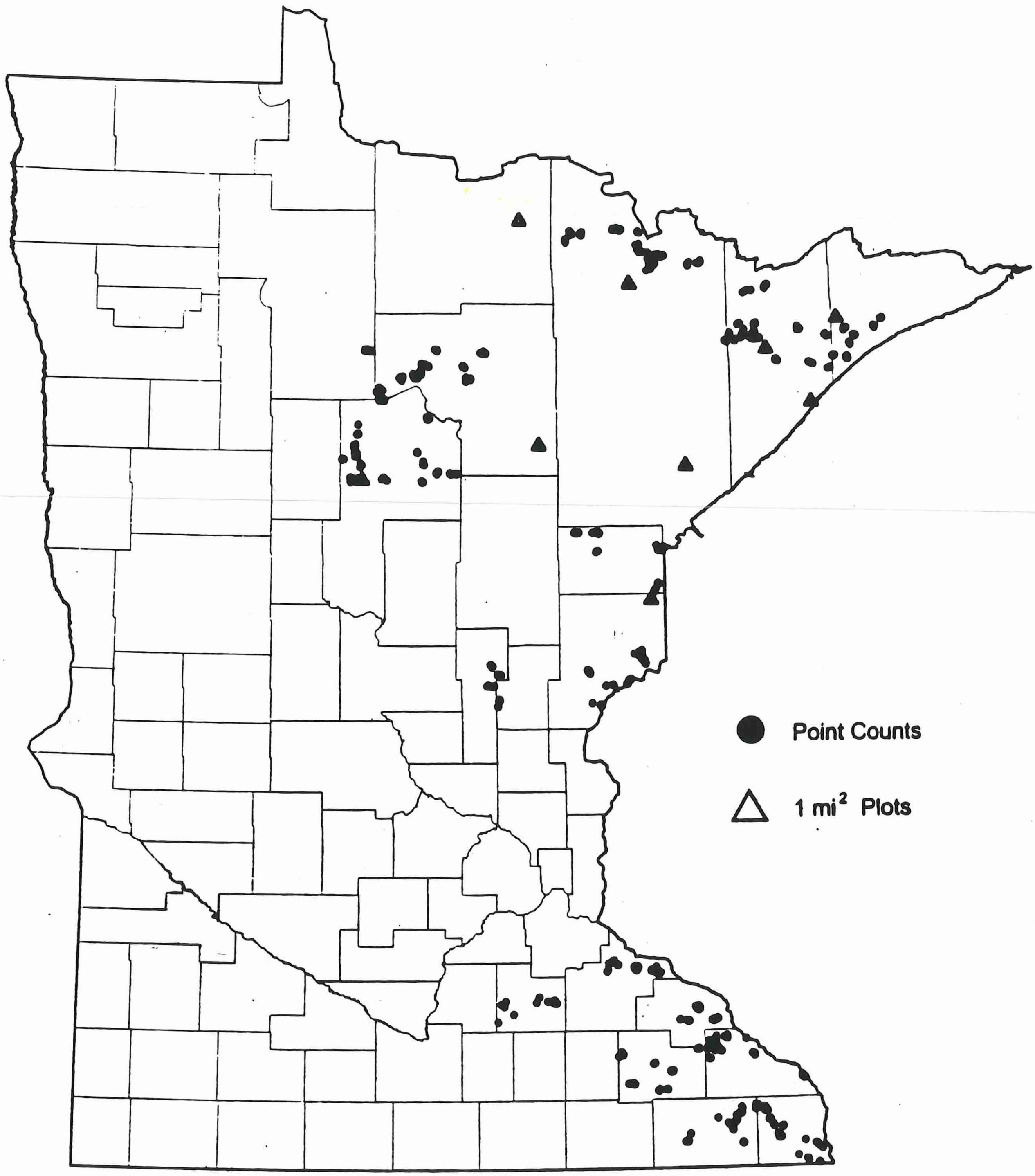
LCMR Work Program 1999
Attachment A.

Minnesota Forest Bird Diversity Initiative
FY00-01 Budget

	Result #1	Result #2	Result #3		
Budget Item	Forest Bird Monitoring	Large-scale Field Trial	Education	Row Total	% Effort
Wages, Salaries & Benefits					
Research Fellow, J. Hanowski	23,681	35,521	0	59,202	0.46
Research Fellow, P. Wolter	8,755	31,040	0	39,795	0.40
Post-doctoral Assoc., M. Jones	13,420	67,102	8,947	89,469	1.00
GIS Programmer, J. Sales	4,966	0	4,966	9,932	0.13
Statistician, N. Danz	29,443	29,443	0	58,886	0.75
Junior Scientist. J. Lind	23,555	0	0	23,555	0.30
Field Biologists	22,675	0	0	22,675	
Subtotal	*126,495*	*163,106*	*13,913*	*303,514*	
Travel					
Local Automobile Mileage Paid	3,897	750	2,000	6,647	
Other Travel Expenses In-state	7,567	1,000	2,500	11,067	
Travel Outside Minnesota	0	3,200	0	3,200	
Subtotal	*11,464*	*4,950*	*4,500*	*20,914*	
Communications					
Telephone	200	600	200	1,000	
Mail	100	300	200	600	
Publications	1,500	4,000	0	5,500	
Printing	300	300	300	900	
Subtotal	*2,100*	*5,200*	*700*	*8,000*	
Tools and Equipment					
GIS Fees	1,200	9,460	500	11,160	
Field Equipment	800	1,100	200	2,100	
Subtotal	*2,000*	*10,560*	*700*	*13,260*	
Other					
Office Supplies	600	1,200	400	2,200	
Other Supplies	400	1,312	400	2,112	
Subtotal	*1,000*	*2,512*	*800*	*4,312*	
Column Totals	**143,059**	**186,328**	**20,613**	**350,000**	

LCMR Work Program 1999
Attachment B.

Locations of Minnesota Forest Bird Diversity Initiative study sites for both the long-term monitoring program (point counts) and the intensive study plots (1 mi² plots)



PREDICTING WATER AND FOREST RESOURCES HEALTH AND SUSTAINABILITY

Research Prospectus Update: July 2002

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I. Abstract

We developed a decision support model (SUSTAIN) that can be used by resource managers to predict future forest ecosystem sustainability. We used existing databases for forest birds, amphibians, aquatic insects and native plant communities and created indicators of sustainability and health for northern Minnesota forests. The model quantifies health for a forest stand and predicts sustainability at the landscape level. Indicator response (e.g., population of a bird species indicator) was calculated for; current forest condition, historical condition (based on range of natural variation (RNV)), and future conditions. The model output is interpreted in the context of whether the planned management will move the forest toward or away from sustainability (based on RNV). The model incorporates information for two ecological classification system (ECS) sections in northern Minnesota (Drift and Lake Plains and Northern Superior Uplands), 55 bird species, and 12 ecosystem types. Watershed models were developed for aquatic insects and fish but were not included in the final version of the SUSTAIN model due to computation difficulties. Indicators of amphibian health and sustainability were not included in the final model because we lack information required to predict their response to forest management. The model will be available to local and regional land managers to aid in decisions regarding forest management activities (downloadable from web site). Training sessions for the model were attended by representatives from major landowners (USFS, DNR and St. Louis County), as well as Minnesota Center for Environmental Advocacy, and The Nature Conservancy. Staff involved with this project presented results and information about the project on approximately 12 different occasions, including scientific meetings and meetings with resource managers. We also provided information on RNV to two landscape planning groups in northern Minnesota coordinated through the Minnesota Forest Resources Council.

II. Background

Minnesota's forest and water resources are important contributors to the well-being of citizens located throughout the state. Maintaining these vital resources is a common goal among Minnesota's public because they provide a wide variety of benefits that contribute to the economy, local community and the natural environment. Measuring current, and predicting future forest and water resource health and sustainability is difficult because they are influenced by many factors (e.g., climate, geology, land use change, land management practices, soil type, natural disturbances) and complex interactions among these factors. In addition, coordinated planning for multiple-uses of these resources including resource management, tourism and recreation is difficult due to the existence of multiple regulatory bodies, existing land ownership patterns, and the inherent complexity of these ecosystems. Sound decisions regarding management of these systems is difficult because all of these factors must be considered simultaneously in an integrated fashion. This situation mandates the need to develop novel approaches to assess current, and to predict future conditions in forest ecosystems under different management scenarios.

We can begin to understand this complex picture by identifying the role that each factor (e.g., climate, natural disturbance) has and the scale on which they influence water and forest resource sustainability. Several ecological and physical data bases have been developed for Minnesota including a multiscale ecological classification of Minnesota (Ecological Classification System). Basic research on animal species has provided important information on distribution of these species, their response to environmental stress, and their relationship to stand and landscape features. Additional technological developments, including GIS, multivariate statistical methods, and spatially-explicit simulation models, provide analytical capabilities not previously available to integrate these data. This combination of spatial databases, statistical methods, and biotic databases provides the potential to develop predictive models and decision making tools for assessing the response of organisms to landscape conditions under a variety of management strategies and a method to assess water and forest resource health and sustainability.

Information for measuring forest and water resource health can be obtained directly by conducting a large number of individual measurements (a time-consuming and expensive procedure), or by compiling and analyzing existing data to identify important factors that will indicate ecosystem health. A large body of work has already been undertaken to quantify the response of sentinel organisms such as birds and aquatic insects to a range of environmental conditions.

Birds are key biological indicators of the health and stability of forest ecosystems and are relatively easy to study because their ecology is well known (Furness and Greenwood 1993). Breeding birds also represent 60 to 70% of the terrestrial species biological diversity in Minnesota's forests. The highest species richness in North America occurs in Minnesota (Niemi et al. 1996). Current knowledge indicates that birds have a strong link to the forest economy due to their insectivorous habits and declines in numbers would result in a reduction in forest productivity.

Although less is known about how amphibian populations respond to different stressors, information on this group could provide the crucial link between water and forest systems. Amphibians make use of both land and water resources throughout their life cycle and we are just beginning to understand how amphibians use these resources and how they may be affected by forest and agricultural conditions.

The use of benthic invertebrates for environmental monitoring also has long history due to their reliability and effectiveness as environmental indicators(Cairns and Pratt 1993). They are an integral part of riverine systems and play a large role in detrital processing, nutrient cycling and are also an important food source for higher trophic levels such as fish and birds. Macroinvertebrates are commonly used by resource managers in environmental monitoring and as indicators of habitat and water quality.

Investigators in this study have gathered a large data set on birds and aquatic insects in several Minnesota watersheds and are currently documenting changes in terrestrial and aquatic species due to a variety of forest and agricultural management practices. Wherever possible existing data from other sources was used to augment the databases used in the development of the environmental indicators. In addition, many GIS data layers have been acquired or developed for Minnesota including forest cover classification, elevation, hydrography, soils, surficial geology and wetland classification. These environmental databases were used to quantify associations between environmental conditions and bird, amphibian and insect communities. We integrated tools such as geographic information systems, satellite image analysis, multivariate statistical methods, and simulation models to predict forest ecosystem health and sustainability.

The overall objective of the project was to bring together the current environmental and biotic data bases for the regions of interest and to apply this knowledge in the development of indices that could be used to measure forest and water resource sustainability in a planning framework. This was accomplished by: 1) compiling existing information for forest birds, amphibians, aquatic insects and ecosystem conditions in two Ecological Classification System (ECS) sections, Northern Superior Uplands and Northern Minnesota Drift and Lake Plains; 2) compiling existing indicators or developing new indicators to measure ecosystem condition at appropriate spatial scales; 3) evaluating the influence of land use and underlying geology on these organisms under a variety of management scenarios and 4) bringing this information together into a cohesive, workable decision making system that could be used by a variety of land planning agencies and industrial groups. Specific hypotheses for this project were formulated in the development of the metrics and evaluation of scale on these metrics (numbers 2 and 3 above).

III. Methods

IIIa. Selection of study regions

Our original plan was to develop a "sustainability model" for three ECS (ecological classification system) subsections in the State. The subsections selected were North Shore

Highlands, Chippewa Plains, and Rochester Plateau. This plan was changed because relevant analyses (e.g., range of natural variation calculations) were only available at the ECS section level. The section level is the step above the subsection level and involves significantly larger areas of the State. For example, the Northern Superior Uplands section which we have chosen for this project includes four subsections (Border Lakes, Nashwauk Uplands, Laurentian Highlands, and North Shore). The Northern Minnesota Drift and Lake Plains which we also developed a model for, has four subsections (Chippewa Plains, St. Louis Moraines, Pine Moraines and Outwash Plains, and Tamarack Lowlands). Because of this change, we increased the area that our models will be relevant for by several thousands of acres.

Figure 1. Location of study areas in Minnesota.

Due to this change, we did not complete a model for the Rochestor Plateau subsection as originally planned. We analyzed relevant biotic data from the southeast region of Minnesota and were unable to identify relationships between physical and biological data. For example, with current land condition (e.g., the large amount of land in agriculture land use) in this area, we were unable to identify relationships between land cover in watersheds and stream condition (based on aquatic insects and fish). In addition, bird reproductive success in this region is not related to landscape condition (e.g., patch size). Therefore, models to quantify and predict sustainability could not be developed without relevant biological indicators and their relationship to land condition. We concluded that an effort similar to what we accomplished for a large portion of the forested area of northern Minnesota could not be achieved for the southeast area with the same methods.

IIIb. Database development

We identified and compiled relevant data for the biotic (amphibians, birds, fish and aquatic insects) and physical components (GIS data bases) required for the project. Data were compiled separately for each group and more specific details follow.

Amphibians: Little survey data exists for amphibians in Minnesota, therefore we compiled data from the primary literature and other publications to determine species-habitat relationships for Minnesota amphibian species and 2 turtles. We compiled a large bibliography and scanned many papers and books for appropriate information. Amount and quality of data pertaining to each species varied widely.

Birds: Several relevant data exists for breeding birds in both ECS sections. For this study we used forest bird monitoring data that has been collected by NRRI staff over the past 5-9 years. These data were chosen because: 1) they are linked directly to forest cover type and age; 2) they represent standardized counts conducted by qualified and trained observers; 3) relative abundance and probability of occurrence of over 90 species are available; and 4) it is the largest data base available for breeding birds in the upper midwest.

Aquatic insects and fish: We gathered existing macroinvertebrate data sets as well as some stream fish data sets. Both macroinvertebrate and fish data were less abundant for the Northern Minnesota Drift and Lake Plains section, but plentiful for the Northern Superior Uplands. Macroinvertebrate data sources included: 1) Northern Superior Uplandsstudy area collected by NRRI personnel; and 2) Northern Minnesota Drift and Lake Plains study area from Leech Lake Reservation and possibly Cass Lake Lab. Fish data sources included: 1) Northern Superior Uplandsstudy area from EPA (Duluth office) and MPCA; and 2) Northern Minnesota Drift and Lake Plains study area from USFS (Chippewa National Forest) and MnDNR. We gathered all data that were available.

Native ecosystems and range of natural variation. Another major task completed was defining "sustainability" and how it would be quantified for use in our models. We used the concept of natural range of variation in native plant communities as the basis for defining sustainability. In this sense, we infer that forest and water resources will be sustainable if we manage within the range of variation that they occurred on the landscape throughout time. Two steps were required to obtain this information. The first step, calculation of the range of natural variation for native plant communities was completed by Lee Frelich. The next step was to map locations and extent of native communities so that we were able to calculate the amount of area and location of the various native communities. This was completed for the Northern Minnesota Drift and Lake Plains study area by Dave Shadis and John Almendinger. The Northern Superior Uplands study area was mapped by personnel at NRRI. We used this definition of sustainability for the northern study areas where the map and range of variability has been completed.

In order to apply the range of natural variation calculations to determine the land area occupied by vegetation growth stages, a map showing the distribution of native ecosystem types is required. We used a statistical based modeling approach utilizing GIS, forest inventory, classified Landsat Thematic Mapper data and other vegetation plot data along with physical data such as soils, landform, climate and topography to predict the distribution of 8 native ecosystem classes in the Northern Superior Uplands ecological section. We acquired vegetation data from the following sources: the Superior National Forest, Minnesota DNR Resource Assessment, Minnesota DNR Non-Game Heritage Program releve plots, and classified satellite data from P. Wolter from the University of Minnesota, Natural Resources Research Institute. The physical data came from a variety of sources, including: Minnesota Soil Atlas, Geomorphology of Minnesota, USGS digital elevation models, and Zedex High Resolution climate data.

Analysis of current and future sustainability required that we map the current forest cover and composition. For public lands outside of the BWCAW data on current composition and age structure were derived from inventory data from the Minnesota DNR, counties, and the Superior

National Forest. Inventory polygons were augmented with compositional information from an existing satellite based classification (P. Wolter, NRRI/UMD). Specifically, this was used to indicate mixed conifer and deciduous patches. Private non-industrial forest conditions were estimated from Forest Inventory and Analysis located on private lands. Sample density was approximately one point per 1200 acres. Area expansion factors were applied to estimate age and forest type. Private industrial forests, which account for approximately 3% of the NSU area, were not included at this time, although these data could be incorporated at a later date. Note that for areas outside the Boundary Waters Canoe Area Wilderness (BWCAW), stand age is estimated from tree ages, and may not always reflect time since disturbance, especially in the older age classes.

For the BWCAW, a number of data sources were used to derive age and composition. Age in the BWCAW is based on time since disturbance data. We integrated stand origin data based on Heinselman's stand origin maps (S. Friedman, University of MN, Dept. of Forestry) with maps of timber harvest areas within the BWCAW that occurred from the 1940s to middle 1970s to estimate forest age. This map was then combined with a Landsat based classification (P. Wolter, UMD/NRRI) to estimate species/cover type composition.

IIIc. Calculate metrics to assess health and sustainability

Amphibians: Amphibian species life history characteristics and habitat requirements were assembled into a database and reviewed by five regional experts. This information was used to develop habitat association indicators for the amphibian group. For example, existing data relating amphibians to different wetland types was used to develop metrics of species-habitat relationships.

When we attempted to incorporate species-habitat relationships into the modeling framework, we found that there was a paucity of spatial data depicting location of vernal pools, one of the primary woodland habitats for amphibian. We attempted to use historic wetland data and soils maps, in conjunction with derived statistical relationships between landforms and prevalence of vernal pools (Palik, et al. *in preparation*) to develop a map that reflected the probability of occurrence of vernal pools in an area. This information was critical in the development of the general model structure in result 3. Although work will continue on this aspect of the project in coordination with work being conducted by Brian Palik at North Central Forest Experiment Station in Grand Rapids, it was not in a stage that was useful for SUSTAIN model development. Therefore, we did not include amphibian indicators in the final SUSTAIN model.

Birds: Indicator species for the two northern study sites were selected. Our intent for this exercise was to identify bird species that would best reflect changes in the amount of specific cover types in the landscape. Indicator values were calculated for all bird species by cover type and age category (when data were available). With this process, we selected three bird species that had the highest indicator value for each cover type and age class. Thirty-two species were selected for the Northern Minnesota Drift and Lake Plains and 33 species will be used as indicator species for the Northern Superior Uplands study area.

Aquatic insects and fish. Our objective was to develop predictive indicators of stream condition for the Northern Superior Uplands and Northern Minnesota Drift and Lake Plains Sections. The approach that we took was to relate land use/land cover of watersheds to stream macroinvertebrate metrics. The candidate metrics for these analyses were: Ephemeroptera taxa richness, Plecoptera taxa richness,Trichoptera taxa richness, EPT taxa richness, intolerant taxa richness, proportion of total abundance of tolerant taxa, Hilsenhoff Biotic Index (modified), ratio of Hydropsychidae to Trichoptera (abundance), proportion of abundance of dominant 3 taxa, total insect abundance,clinger taxa richness, proportion of total abundance of clinger taxa, proportion of total abundance of predator taxa, proportion of total abundance of Chironomid taxa, Index of Biotic Integrity. We used land use/land cover variables (using GAP data base with classes combined); agricultural, barren, conifer, deciduous, grassland, open water, wetland, forest (conifer + deciduous).

In the development of the indicators we used a variety of statistical analyses to address the following questions. Correlations between metrics and land use (Which metrics show the strongest relationships with land use?). Selection procedure within multiple regression (Using the selected metrics from #1, what are the best multivariate relationships?). Selected individual simple linear regressions (Using information from #1 and 2, what are the simplest and best univariate relationships between metrics and land use?). Correlations between individual metrics (Are the individual metrics selected above telling us the same thing? Which metrics might be universal?). Bivariate plots (Are there thresholds of stream ecological condition for either macroinvertebrate metrics or land use?).

From these analyses we found that Total insect taxa richness, EPT taxa richness, intolerant taxa richness, clinger taxa richness, and IBI were significantly correlated with the most land use classes. These relationships were also in the same direction and made ecological sense. Following a sensitivity analysis, we decided that the bird and plant ecosystem indicators were more sensitive to changes in forest cover type and age compared to the fish and macroinvertebrate indicators. In essence, if we have forests that are determined to be sustainable as measured by plant communities and birds, we infer that the aquatic resources will also be sustainable. Therefore, we did not include any of the fish and macroinvertebrate indicators in the final SUSTAIN model.

IIId. Integrate information into a GIS-based decision support system.

The structure of the general model that will predict forest and water resources sustainability was defined. The basic unit is a Population Metric (PM), a single number that represents the population of a single bird species, or amount of a particular forest cover type and age. The SUSTAIN application can interpret PM rule files, and we used it to predict the expected trends for bird species' abundance in response to changes in covertype. The current rules specify bird abundance in terms of cover types used by Lee Frelich in his work that calculated the range of natural variation of cover types in the two northern study areas.

We worked with Chad Skally of the Minnesota Forest Resources Council and created a more detailed version of the common format forest inventory data for RNV-SUSTAIN analysis in the Northern Superior Uplands and the Drift and Lake Plains. This comprehensive database for public forest lands now has more complete compositional information and consistent age data. This is significant because the RNV analysis relies on species composition and age structure for assessing current forest conditions. As we did for the Northern Superior Uplands, we used the new common format data along with FIA sample points to represent public and private forest land in the Drift and Lake Plains section in order to produce a more complete representation of current forest conditions. The RNV analysis feeds into the SUSTAIN model.

IV. Results and products

Results from this project will be to: 1) identify and compile existing data for specific biota and physical parameters in three regions of Minnesota; 2) develop metrics for biodiversity, soil productivity and water quality that can be used to assess ecosystem condition at different scales; and 3) simulate and then evaluate effects of land use changes on these metrics under a variety of management scenarios. These results will be used to develop the major product for this project, a decision making model that can be used by land managers for stand and landscape planning purposes.

Development of the GIS interface to run models and predict sustainability was completed. We chose ArcView with Spatial Analyst as the required user software for this application. The model was designed to be user friendly and requires a basic knowledge of ArcView. The model requires that the user input or select a number of candidate stands that will be harvested. After this step, the SUSTAIN model makes sustainability predictions for each bird and ecosystem type and successional stage indicators. Calculations are made for each forest stand for each indicator that is relevant to that stand. The score for each stand is scaled to a plus one to a minus one, indicating the deviation of the condition of the stand to future sustainability. Projections are made for bird and plant indicators immediately following harvest (age 0), twenty, and forty years after harvest. The stand scores can be sorted to determine which stands received the most positive scores. Harvesting these stands (positive scores) would move the landscape to a more sustainable condition. On the other hand, harvesting stands that had negative scores would move the landscape to a non-sustainable state.

Concise information, the stand score, as well as detailed output for each indicator in each stand is provided. Our intent is to provide the user with the information and not to dictate future harvest. The information output by the model provides an additional piece of information (in addition to stand age and condition) that land managers can use to plan harvests.

A steering committee was established to aid us in making decisions regarding the projects outreach activities. The committee met twice and provided important advice on how to approach land use planners with the SUSTAIN model concept. One on one meetings were held with personnel from United States Forest Service, Minnesota Department of Natural Resources and St. Louis County. The objective of these meetings was to confirm that ArcView extension that reports the RNV impact of possible management options would fit with existing planning and harvest selection processes.

Training sessions to teach users how to implement the SUSTAIN model were held in June, 2002 on the University of Minnesota-Duluth campus. Three, one-half day sessions were held and were attended by representatives from St. Louis County, United States Forest Service, Minnesota Department of Natural Resources, Minnesota Center for Environmental Advocacy, and The Nature Conservancy. In addition to the training sessions, a general email was sent to various agency personnel when the final SUSTAIN model was posted on our web site.

Staff involved with this project have given several presentations and provided information for Minnesota Forest Resources landscape planning committees. In addition, JoAnn Hanowski has presented results of the project at 1) Society of American Foresters meeting, Stevens Point, WI; 2) North American Forest Ecology meeting, Duluth, MN, 3) Practical Silviculture in and Ecological World; Management Planning Strategies for Forest Stewardship Plan Preparers, Cloquet, MN. Mark White and George Host have presented information on the Range of Natural Variation calculations and mapping at the North American Forest Ecology meeting, Duluth, MN and in Finland. Two reports were prepared for Minnesota Forest Resources Council landscape planning teams (attached).

V. Timetable

The project was extended for a year because the relevant RNV information was not available for the Northern Minnesota Drift and Lake Plains section.

VI. Budget

Researchers at the Natural Resources Research Institute had already gathered much of the information that contributed to the databases developed and used in this project. These were (but were not limited to the following: 1) Minnesota Forest Resources Council $120,000: Some baseline data on birds and aquatic insects as well as GIS information have been gathered for three watersheds in northern Minnesota. 2) Environmental Protection Agency $925,000: A project to develop aquatic macroinvertebrate indicator species models including work in the proposed site in SE Minnesota. 3) Minnesota Forest Bird Diversity Initiative $1,200,000: GIS forest cover data for the forested area of Minnesota and landscape models for breeding birds; 4) United States Forest Service $300,000: Trend and habitat information for breeding birds in the Chippewa and Superior National Forests, and $25,000: Effect of wetlands and forest harvest on stream insects. 5) Minnesota Sea Grant $94,828. 6) Lake Superior Decision Support Systems, $515,000: Development of detailed GIS databases and decision support tools for the Lake Superior Basin. 7) USFS Great Lakes Assessment $100,000: Development and data visualization and decision support tools for Minnesota, Wisconsin and Michigan.

We have developed a good working relationship with several forest product companies and Counties in northern Minnesota over the past 10 years. The companies and Counties have cooperated with us on several projects by: 1) providing property to conduct studies, 2) conducting forest experimental manipulations on these study areas, and 3) assigning representative foresters and biologists to participate in design and implementation of experiments. For this project, all three of the major pulp and paper companies in northern

Minnesota (Boise Cascade, Blandin-UPM and Potlatch) cooperated. Lake County also participated on this project. The value of the cooperators in-kind investment in this project wassabout $57,000. This represents costs for land-use, forest inventory and other data, and staff time.

The $300,000 allocation from LCMR was used to compile and analyze existing biotic data to develop indicators to assess forest and water resources health and sustainability. This information was applied to the development of a decision support program that can be used by resource planners across the State.

VII. Investigators

JoAnn Hanowski, NRRI contributed about 30% effort to the project. She managed project staff and led the avian portion of the data compilation and analyses (see attachment A).

George Host, NRRI contributed about 15% time to the project. He provided expertise and data for the ecological classification system. (see attachment B).

Lucinda Johnson, NRRI contributed about 10% effort to the project. She identified applicable data sources on amphibians and took the lead on developing water quality metrics (see attachment C).

Carl Richards, NRRI contributed about 5% in-kind support to the project. He supervised staff responsible for the aquatic invertebrate data and identified additional applicable data on in stream biota. (see attachment D).

Cooperators

Potlatch Corporation, Cloquet, MN was represented by Mike Houser on the advisory committee.

UPM-Blandin Company, Grand Rapids, MN was represented by. Jim Marshall and Cheryl Adams.

Tom Martinson will represented Lake County Land Department, Two Harbors, MN.

Boise Cascade, International Falls, MN, was represented by. Steve Earley.

VVI. Selected References

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Attachment A. JoAnn Hanowski short vita.

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EDUCATION:

M.S. Environmental Biology, University of Minnesota, Duluth. 1982
B.S. Biology and General Science (cum laude), University of Minnesota, Duluth. 1979

CURRENT POSITION:

July 1985-present Research Fellow - Avian ecologist, Center for Water and the Environment, Natural Resources Research Institute, University of Minnesota, Duluth.

SELECTED GRANTS AND CONTRACTS:

1997 Wildlife species: responses to forest harvesting and management in riparian stands and landscapes. Minnesota Forest Resources Council. $100,000. (Principal Investigator)

1996 Forest Bird Biodiversity: Indicators of Environmental Condition and Change in the Great Lakes Watershed. Great Lakes Protection Fund. $382,000. (Co-Principal Investigator)

1995 Avian population analysis for wind power generation regions. Legis. Comm. on Minnesota Research. $195,000. (Principal Investigator)

1995 Biomass production, management, and restoration of brushland habitats. Legis. Comm. on Minnesota Research. $200,000. (Co-Principal Investigator)

1995 Bird and mammal use of hybrid poplar plantations. Department of Energy. $350,000. (Co-Principal Investigator)

SELECTED PUBLICATIONS: (Total > 35 peer-reviewed; >45 technical reports)

Niemi, G.J., J.M. Hanowski, A.R. Lima, D.J. Mladenoff. 1998. Biogeographic patterns of breeding birds in Minnesota. Loon 70: 3-11.

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Attachment B. George Host short vita.

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EDUCATION

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M.S. Botany, Kent State University, Kent, Ohio, 1982.
B.S. Botany, Miami University, Oxford, Ohio, 1977.

RECENT PROFESSIONAL EXPERIENCE

1989 - Present Biostatistician/Research Associate. Natural Resources Research Institute, University of Minnesota, Duluth, MN.

1991 - Present Graduate Faculty, Department of Biology, University of Minnesota - Duluth

1987 - 1989 Research Plant Physiologist. North Central Forest Experiment Station, U.S. Forest Service, Grand Rapids, MN.

CURRENT GRANTS AND CONTRACTS

Lake Superior Decision Support System. MN Department of Natural Resources/US Environmental Protection Agency. Principal Investigator $514,619

Development and evaluation of multi-scale mechanistic indicators of regional landscapes. US Environmental Protection Agency, Office of Research and Development. Co-principal investigator - $998,964

Hierarchical parallel algorithms for simulating plant response to environmental stress. National Science Foundation. Principal Investigator $380,073

Water on the Web: Monitoring Minnesota Lakes on the Internet. National Science Foundation. Co-Principal Investigator $1,098,234

Modeling impacts of CO_2, ozone, and climate change on tree growth: an ecophysiological whole-tree growth process approach. U.S. Forest Service/U.S. Department of Energy. Principal Investigator - $226,000

Forest-Atmosphere Carbon Transfer and Storage - II (FACTS II): Interacting effects of elevated CO_2 and O_3 on aspen forest ecosystems. NSF/DOE/NASA/USDA Joint Program on Terrestrial Ecology and Global Change. Co-Principal Investigator - $498,997

Minnesota Environmental Indicators Initiative. Legislative Commission on Minnesota Resources. Principal Investigator - $60,000

Great Lakes Assessment: Spatial Analysis of Landscape Pattern, Decision Support and Data Visualization. U.S. Forest Service. Principal Investigator - $100,500

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1995 - Present

Host, G. E., J. G. Isebrands, G.W. Theseira, J.R. Kiniry, and R.L. Graham. 1996. Temporal and spatial scaling from individual trees to plantations: a modeling strategy. Biomass and Bioenergy 11:233-243.

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Host, G. E., P. L. Polzer, D. J. Mladenoff, M. A. White, and T. R. Crow. 1996. A quantitative approach to developing regional ecosystem classifications. Ecological Applications 6:608-618.

Isebrands, J.G., G. E. Host, L. Bollmark, J. Porter, S. Philippot, E. Stevens, and K. Rushton. 1996. A strategy for process modelling of short rotation *Salix* coppice plantations. Biomass and Bioenergy: 11:245-252.

Johnson, L.B., C. Richards, G.E. Host, and J.W. Arthur. 1997. Landscape influences on water chemistry in midwestern stream ecosystems. Freshwater Biology 37:193-207.

McDonald, M.E., C.A. Tikkanen, R.P. Axler, C.P. Larsen and G. E. Host. 1996. Fish simulation culture model (FIS-C): A bioenergetics based model for aquacultural wasteload application. Aquacultural Engineering 15:243-259.

Nute, D. E., H. M. Rauscher, D. A. Perala, G. Zhu, Y. Chang, and G. E. Host. 1995. A toolkit approach to developing forest management advisory systems in PROLOG. AI Applications in Natural Resources 9:39-58.

Perala, D. A., G. E. Host, J. K. Jordan, and C. J. Cieszewski. 1996. A multiproduct growth and yield model for the circumboreal aspens. Northern Journal of Applied Forestry 13:164-170.

Rauscher, H. M., D. E. Nute, D. A. Perala, G. Zhu, Y. Chang, G. E. Host, and J. W. Benzie. 1995. The Forest Management Advisory System. AI Applications in Natural Resources 9:60.

Richards, C., L.B. Johnson, and G.E. Host. 1996. Landscape-scale influences on stream habitats and biota. Can. J. Fish. Aquat. Sci. 53:295-311.

Richards, C., R.J. Haro, L.B. Johnson, and G.E. Host. 1997. Catchment and reach-scale properties as indicators of macroinvertebrate species traits. Freshwater Biology 37:219-230.

Attachment C. Lucinda Johnson short vita.

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Research Interests
Landscape influences on water quality and biological communities in aquatic systems; application of GIS in ecological research; Environmental factors influencing amphibian health and community structure.

Professional Experience
Assistant Director, Center for Water and the Environment: Natural Resources Research Institute, January 1991 to present
Research Assistant, Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan, September 1994 - 1995.
Geographical Information System Manager, Natural Resources Research Institute, Duluth, Minnesota. 1987 - 1991.
Assistant Research Biologist, Illinois Natural History Survey, Champaign, Illinois. 1985 - 1987

Education
Ph.D. Candidate, Department of Zoology, Michigan State University
Master of Science, State University of New York, College of Environmental Science and Forestry, 1984
Bachelor of Arts, Duke University, 1976

Recent Grants and Contracts
Environmental factors that influence amphibian community structure and health as indicators of ecosystem integrity. Environmental Protection Agency 1997-2000. $1,299,991. (To Dr. Val Beasley, University of IL), Co-Principal Investigator.
Development and evaluation of multi-scale mechanistic indicators of regional landscapes. Environmental Protection Agency 1997-2000. $925,000. Co-Principal Investigator.
Lake Superior Basin Land Use Decision Support. Minnesota Department of Natural Resources (Environmental Protection Agency prime) 1997-2000. $525,620. Co-Principle Investigator.
Evaluating riparian area dynamics, management alternatives and impacts of harvest practices. Minnesota Forest Resources Council 1996-1998. $106,471. Co-Principal Investigator.
Development of Watershed Ecological Criteria in Midwestern Streams. Environmental Protection Agency. 1993 - 1996. $499,702. Co-Principal Investigator.
Development of Biocriteria for regional watersheds through integrated landscape and reach-scale analyses. Environmental Protection Agency. 1991- 1993. $248,000. Co-Principal Investigator.
Analyzing the role of forested wetlands in mitigating effects of upland forest harvest on stream water quality. North Central Forest Experiment Station. $22,808. Principal Investigator.
Temperance River Watershed Study- Phase I. Superior National Forest, 1991-1992. $10,000. Co-Principal Investigator.
St. Louis River Database Development. Legislative Commission on Minnesota's Resources (subcontracted from Arrowhead Regional Development Corporation). 1992. $21,741.

Selected Publications

Richards, C. and *L.B. Johnson*. Landscape perspectives on ecological risk assessment. In: M.C. Newman and C. Strojan (eds.) *Risk Assessment: Logic and Measurement.* Ann Arbor Press, *in press*.

Johnson, L.B., C. Richards, G. E. Host and J. Arthur. 1997. Influence of landscape factors on water chemistry in agricultural catchments. Freshwater Biology 37:193-208.

Johnson, L.B. and S.H. Gage. 1997. Landscape approaches to the analysis of aquatic ecosystems. Freshwater Biology 37:113-132.

Richards, C., R. Haro., *L.B. Johnson,* and G. Host. 1997. Catchment and reach-scale properties as indicators of macroinvertebrate species traits. Freshwater Biology 37:219-230.

Richards, C., *L. B. Johnson*, and G. Host. 1996. Landscape scale influences on stream habitats and biota. Canadian J. Fisheries Aquatic Sciences 53(Suppl 1) 53:295-311.

Richards, C., L.*B. Johnson*, and G.E. Host. 1995. Using GIS to examine linkages between landscapes and ecosystems. Pages 131-141. In: *National Conference on Environmental Problem-Solving with Geographic Information Systems*, EPA 625/R-95/004.

Johnson, L. B., and C. Richards. 1992. Investigating landscape influences on stream macroinvertebrate communities. Water Resources Update 87:41-48.

Johnson, L. B. 1990. Analyzing spatial and temporal phenomena using geographical information systems: A review of ecological applications. Landscape Ecology 4:31-43.

Kokoska, S. and *L. B. Johnson*. 1987. A comparison of statistical techniques used to analyze growth curves. Growth 51:261-269.

Hoffman, R.A., *L.B. Johnson*, M.K. Vaughn, and R.J. Reiter. 1987. Influence of diet on photoperiod-induced gonadal regression in female hamsters. Growth 51:385-396.

Johnson, L.B. and R.A. Hoffman. 1985. Interaction of diet and photoperiod on growth and reproduction in male golden hamsters. Growth 49:380-399.

Hoffman, R.A. and *L.B. Johnso*n. 1985. Effect of photic history and illuminance levels on male golden hamsters; Possible pineal involvement. J. Pineal Res. 2:209-215.

Hoffman, R.A., *L.B. Johnson*, and G.M. Brown. 1985. Growth and development in the golden hamster: Influence of the pineal gland, melatonin, and photic input. Chapter 42, In: *The Pineal Gland: Endocrine Aspects,* G.M. Brown and S.C. Wainright (eds). Pergamon Press, NY.

Hoffman, R.A., *L.B. Johnson*, and R. Corth. 1985. The effects of spectral power distribution and illuminance levels on key parameters in the male golden hamster and the rat. J. Pineal Res. 2:217-233.

Attachment D. Carl Richards short vita.

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EDUCATION:

Ph.D.	Ecology, Idaho State University - 1986
M.S.	Biology, California State University, Los Angeles - 1978
B.S.	Biology, University of Southern Mississippi - 1975

PRESENT POSITION

1989 - Present **Research Associate**, Center for Water and the Environment, Natural Resources Research Institute, University of Minnesota, Duluth.

CURRENT RESEARCH SUPPORT:

U.S. Environmental Protection Agency. *Development and Evaluation of Multi-scale Mechanistic Indicators of Regional Landscapes*. 1997-2000. $925,000. Principal Investigator, with G. Host and L. Johnson.

U.S. Environmental Protection Agency. *Environmental Factors that Influence Amphibian Community Structure and Health.* 1997-2000. $498,338. Co-Principal Investigator, with L. Johnson, P. Schoff. Subcontract from University of Illinois. ($1,299,991 total)

National Science Foundation. *Key Connections in Arctic Aquatic Landscapes. 1997-2000.* $2,989,784. Co-principal Investigator; with John Hobie and 12 others.

Minnesota Department of Natural Resources. 1997-2000. $529,620. *Lake Superior Land Use Decision Support System.* Co-Principal Investigator, with G. Host and L. Johnson.

U.S. EPA Office of Environmental Justice. *Assessing and communicating risk: A partnership to evaluate a superfund site on Leech Lake tribal lands.* 1997-1999. $249,781. Co-Principal Investigator, with M. McDonald, R. Axler, J. Gunderson, and C. Hagley.

Minnesota Sea Grant Program. *Predicting Lake Trout Spawning Habitat Along the North Shore of Lake Superior Using Side-Scan Sonar.* 1996-1998. $86,448. Co-principal investigator; with K. Yi.

Minnesota Sea Grant Program. *Watershed Effects on Stream Productivity and Water Quality Discharge in Lake Superior Tributary Streams.* 1996-1998. $224,591. Co-principal Investigator; with A. Hershey and R. Axler.

National Science Foundation. *Landscape Control of Trophic Structure in Arctic Alaskan Lakes.* 1995-1998. $280,000. Co-Principal Investigator; with A. Hershey, M. McDonald, M. Miller, J. Pastor.

Minnesota Pollution Control Agency. *Sediment Toxicity, Contaminant Concentrations, and Benthic Community Structure as Indicators of Sediment Quality in the St. Louis River: A Test of EMAP Concepts Applied to a Great Lakes Area of Concern.* 1995-1998. $204,000. Principal Investigator.

Minnesota Sea Grant Program. *Potential Impacts of Invading Ruffe (Gynocephalus cernuus) on Benthic and Pelagic Ecosystems of the Great Lakes.* 1995-1998. $1,600,000. Principal Investigator; with R. Newman, A. Hershey, Y. Cohen, R. Axler, G. Lamberti, D. Lodge, M. Miller, and R. Rutherford.

Minnesota Department of Natural Resources. *Characterization of Near-Shore Benthic Habitats in Minnesota Waters of Lake Superior.* 1995-1998. $260,000. Principle Investigator.

U.S. Environmental Protection Agency. *Ecological Criteria for Midwestern Watersheds.* 1993-1998. $499,000. Principal Investigator; with L. Johnson and G. Host.

CURRENT REFEREED PUBLICATIONS:

Bradbury, S., J. Hermans, W. Karcher, G. Niemi, R. Purdy, and C. Richards. 1998. Obtaining data for ecological risk assessment. pp 29-38 In K.H. Reinert, S.M. Bartell, and G.R. Biddinger. (Eds) Ecological Risk Assessment Decision-Support System: A Conceptual Design. Proceedings from SETAC Ecological Risk Assessment Modeling Workshop; 1994; Pellston MI. Pensacola FL: Society of Environmental Toxicology and Chemistry. 120p.

Richards, C. and L.B. Johnson. Landscape perspectives on ecological risk assessment. In M. Newman (ed) Risk Assessment: Logic and Measurement. Ann Arbor Press, Ann Arbor, MI. *In Press.*

Yin, K. K, X. Li, J. Bonde, C. Richards, and G. Chelwek. Lakebed classification using acoustic data. Applied Mathematics & Computer Science. *In Press.*

Kutka, F., C. Richards, and G. Merrick. 1997. Habitat relationships and distribution of the crayfish, Orconectes propinquus, in the St. Louis River basin, Minnesota. Freshwater Crayfish. 11:73-82.

Gunderson, J., C. Richards, and M. McDonald. Soft crayfish production by eyestalk ablation: can it be profitable. Freshwater Crayfish. 11:567-576.

Kutka, F., and C. Richards. 1997. Short-term nutrient influences on algal assemblages in three rivers of the Minnesota Basin. Journal of Freshwater Ecology. 12:411-419.

Richards, C., R.J. Haro, L.B. Johnson, and G.E. Host. 1997. Catchment and reach-scale properties as indicators of macroinvertebrate species traits. Freshwater Biology 37:219-230.

Johnson, L.B., C. Richards, G.E. Host, and J.W. Arthur. 1997. Landscape influences on water chemistry in Midwestern stream ecosystems. Freshwater Biology. 37:193-208.

Richards, C., L.B. Johnson, and G. E. Host. 1996. Landscape scale influences on stream habitats and biota. Canadian Journal of Fisheries and Aquatic Sciences: 53 (Suppl. 1): 295-311.

Richards, C., F.J. Kutka, M.E. McDonald, G.W. Merrick, and P.W. Devore. 1996. Life history and temperature effects on catch of northern Orconectid crayfish. Hydrobiologia 319:111-118.

Attachments

A. Drift and Lake Plains: A comparison of range of natural variation and current conditions. Report to Minnesota Forest Resources Council. Note, the Council provided approximately $25,000 over the project period for staff support for their landscape planning teams.

B. Northern Superior Uplands: A comparison of range of natural variation and current conditions.

C. Statewide press release June, 2002.

A

Drift and Lake Plains:
A comparison of Range of Natural Variation and current conditions.

Prepared by Terry Brown and Mark White, NRRI,
for the Minnesota Forest Resource Council

October 11, 2001

Ecosystem type classification and the common inventory

The current condition is compared to the Range of Natural Variation (RNV) condition by assigning each stand polygon in the DNR's common inventory data set to the spatially corresponding ecosystem type mapped by Shadis (2000, figure 1). The percent of stands in each ten year age class is then plotted against the RNV from Frelich (2000). The common inventory combines DNR, County and Federal lands. To that we have added FIA data to account for private lands. Shadis's map identifies the dominant ecosystem type in relatively large areas. These areas also include other ecosystem types (for example lowlands in predominantly upland regions), so the common inventory does not cover all of the area mapped by Shadis. The area of the inventory area ("Mapped acres") within each ecosystem type is shown in table 1.

Frelich number	Shadis number	Percent mapped	Mapped acres	Name	System acres
7	1	94	1324183	Boreal Hardwood/Conifer	1414237
11	2	79	1581763	Dry Mesic Pine/Oak	2005706
12	4	57	654212	Dry Mesic Pine	1144130
13	5	73	245090	Dry Pine	336862
9	8	94	187573	Mesic Northern Hardwoods	200324

Table 1: *Between 44 and 69 percent of the area classified for each ecosystem type is included in the inventory data used.*

The composition in each ten year age range is broken down in the tables that follow the succession diagram and current vs. RNV plot for each type.

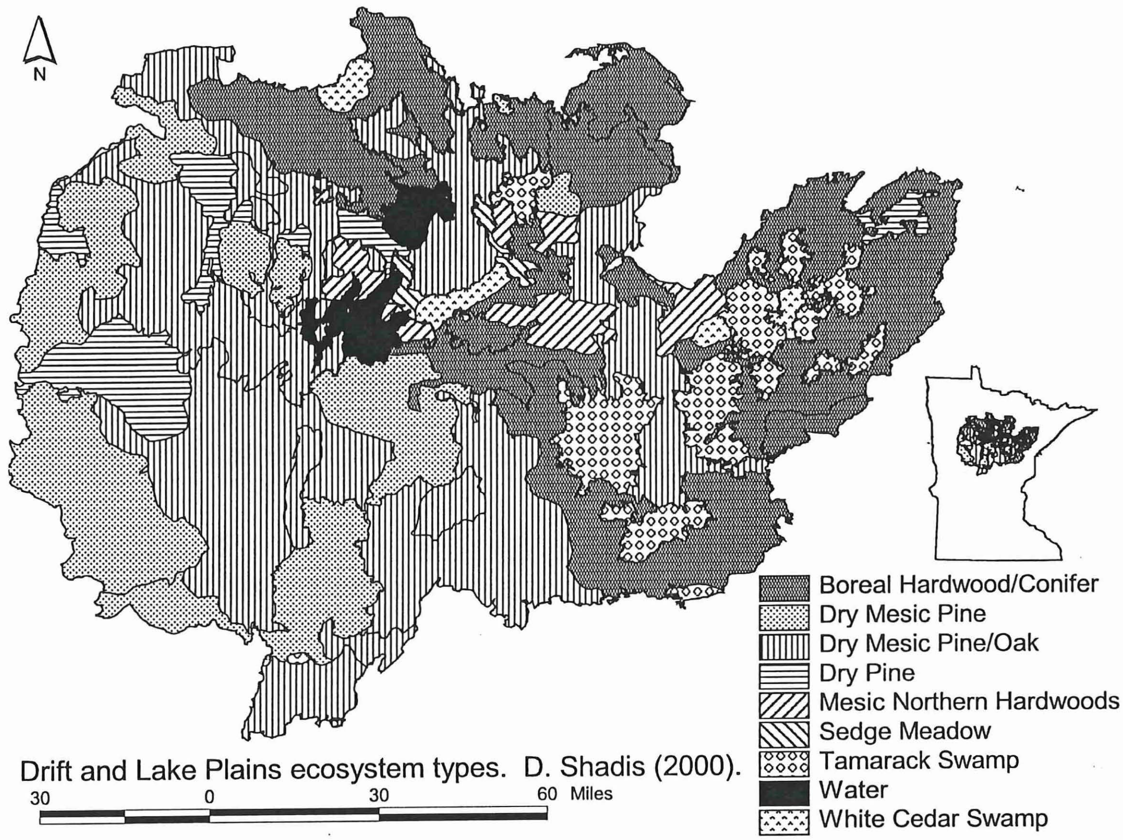

Figure 1: *Ecosystem types delineated by Shadis (2000) for the Drift and Lake Plains section.*

Older growth stages may contain more stands

When dealing with RNV analysis, many people ask how older Vegetation Growth Stages (VGS) can cover a greater proportion of the landscape than younger VGSs. This is a good question if you're used to dealing with tree age distribution plots. With the growth form specific stages defined by Lee Frelich (the box and arrow diagrams starting on page 5) the main answer is that the VGSs represent different lengths of time, and it's reasonable for a VGS that represents stands 20–100 years after disturbance to contain more stands than a VGS that represents stands 1–20 years years after disturbance, even though all the stands in the older VGS came from the younger VGS.

But in the bar-graphs included here, the distribution of stands is broken down into equal (10 year) intervals, and yet there are *still* later stages which contain more stands than earlier stages. This can arise from situations like that shown in figure 2. If movement from VGS 1 to VGS 2 is reasonably rapid (heavy arrow), perhaps due to succession, but movement from VGS 2 to VGS 3 (light arrow) is less rapid, perhaps because ground fire slows succession, and movement from VGS 3 back to VGS 1 is also less rapid, perhaps because of infrequent disturbance, then there is an accumulation of stands in VGS 2. *Remember that a stand can persist much longer than a tree.*

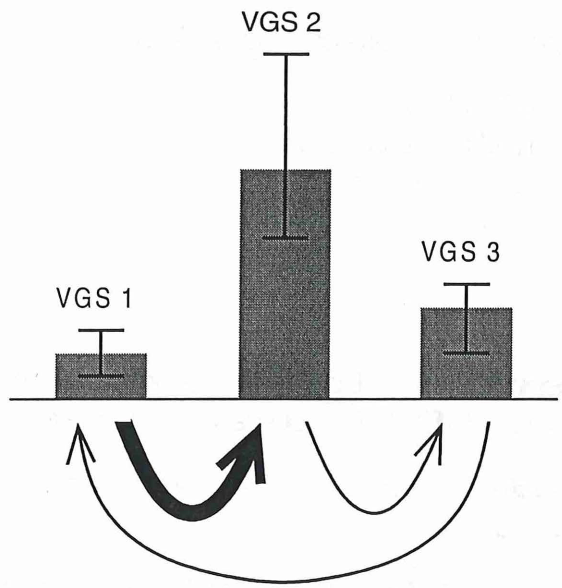

Figure 2: *Older growth stages may contain more stands: here the heavy arrow represents a rapid transfer and the lighter arrows less rapid transfers. The result of such a system would be an accumulation of stands in VGS 2.*

Status of data

It is important to realize that this data is provisional. Improved data sets and more detailed analyses regularly become available. Exact numbers are subject to change. On the other hand, we believe that this data is a good representation of the current situation overall, and in particular the relationship between the current condition and the RNV is unlikely to be significantly revised. Therefore this information can be used when considering management directions with respect to the RNV.

Questions about that data presented here can be addressed to:

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218 720 4345		218 720 2710

References

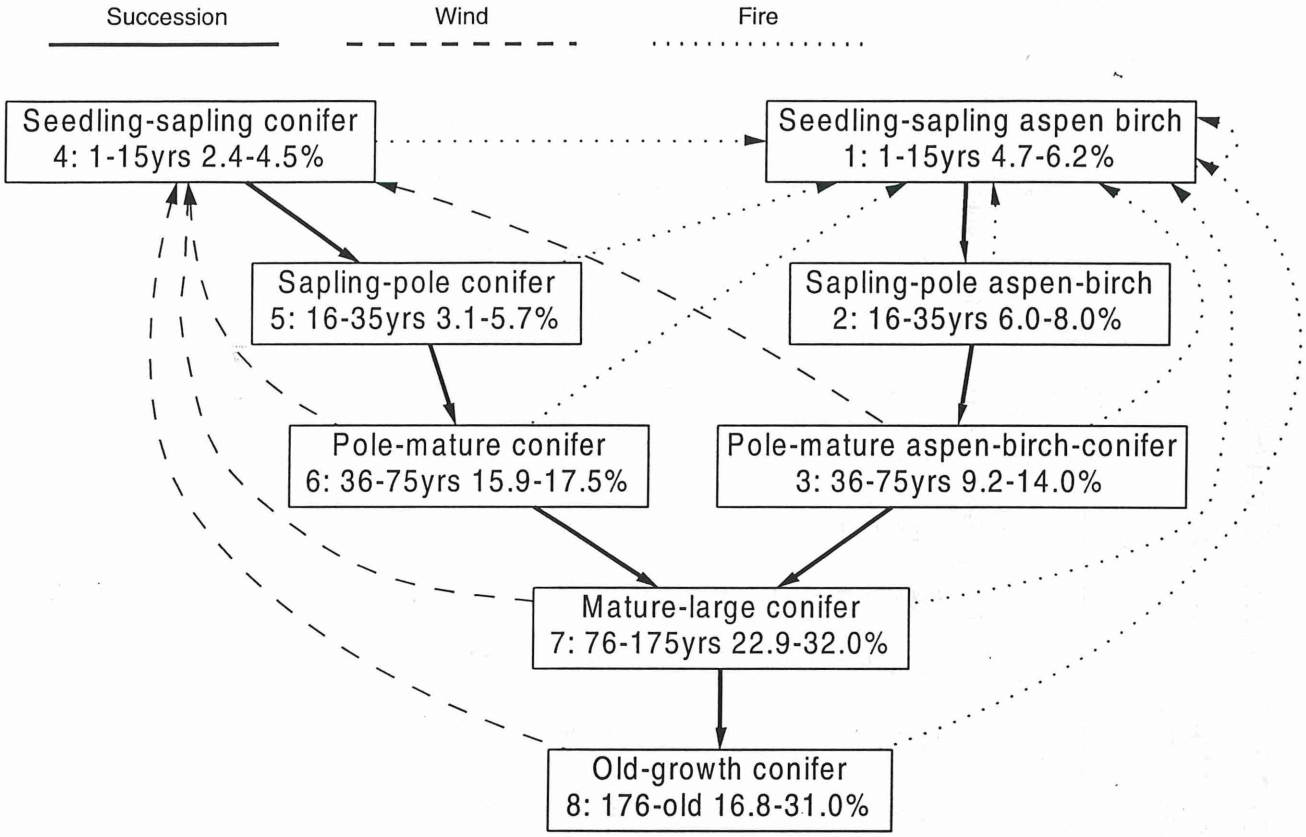
Almendinger, J. and Hanson, D. 1998 Ecological Land Classification Handbook for the Drift and Lake Plains. MNDNR Resource Assessment.

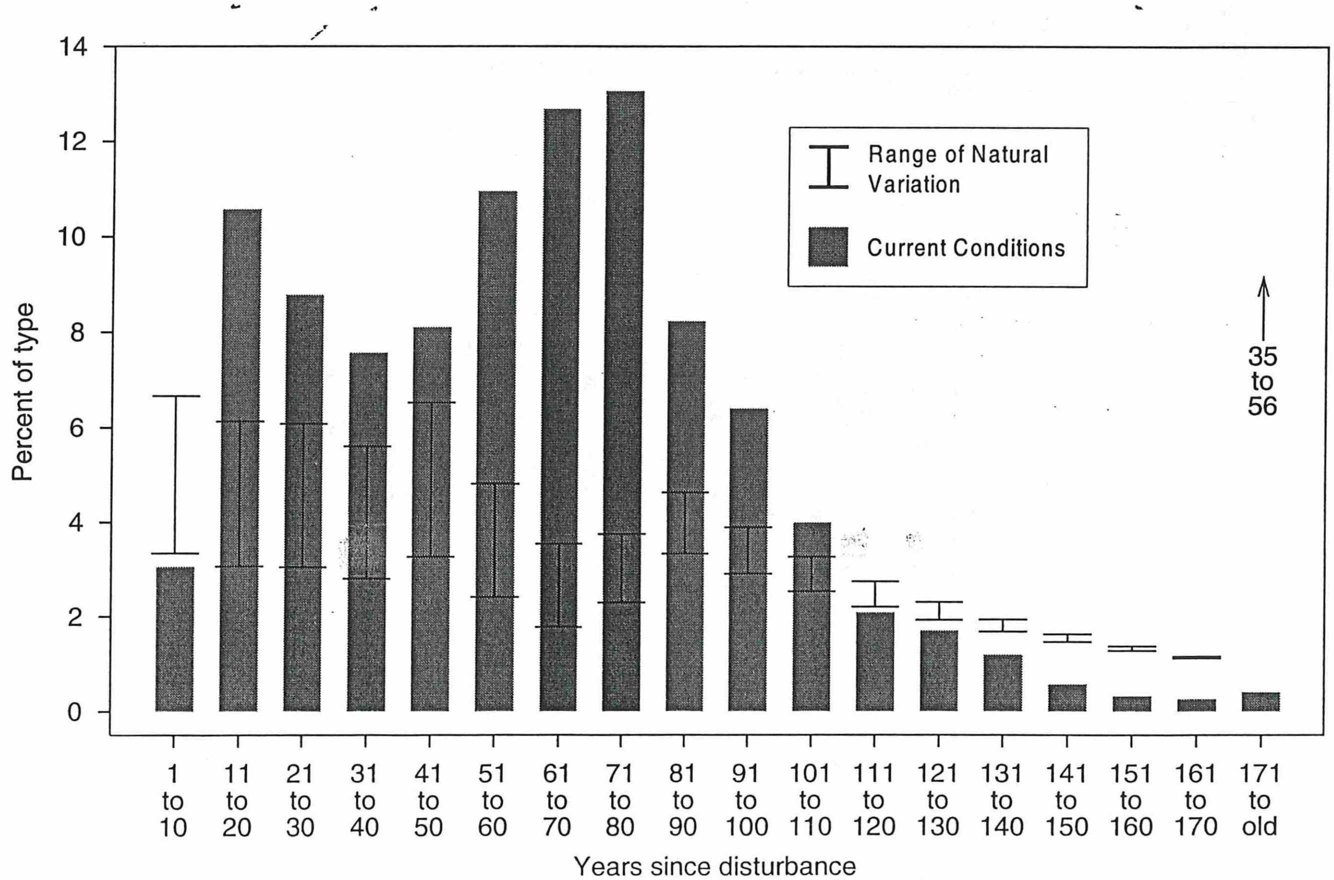
DNR Common Inventory Data Prepared by Chad Skally and others. See http://www.iic.state.mn.us/

Frelich, L. 2000. Natural Range of Variability estimates for forest vegetation growth stages of Minnesota's Drift and Lake Plains.

Shadis, D. 2000. Minnesota Drift and Lake Plains Natural Vegetation Map.

Frelich type 7: Mesic boreal hardwood forest
Shadis type 1: Boreal Hardwood-Conifer
Disturbace interval (years) - Wind: 250-500 Fire: 300-600 Ground Fire: N/A





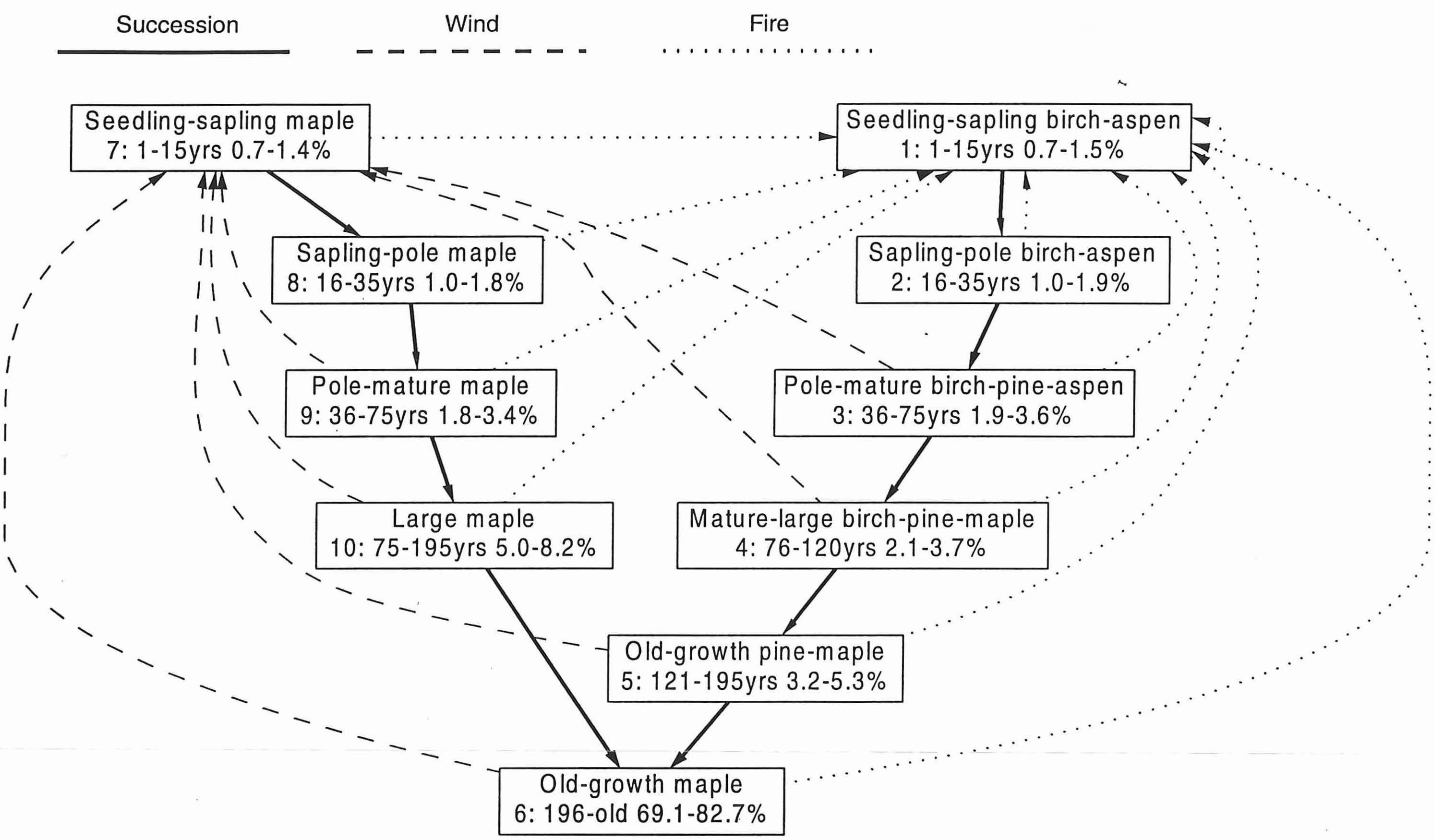
7: Mesic boreal hardwood forest
Percent cover breakdown
See also area breakdown

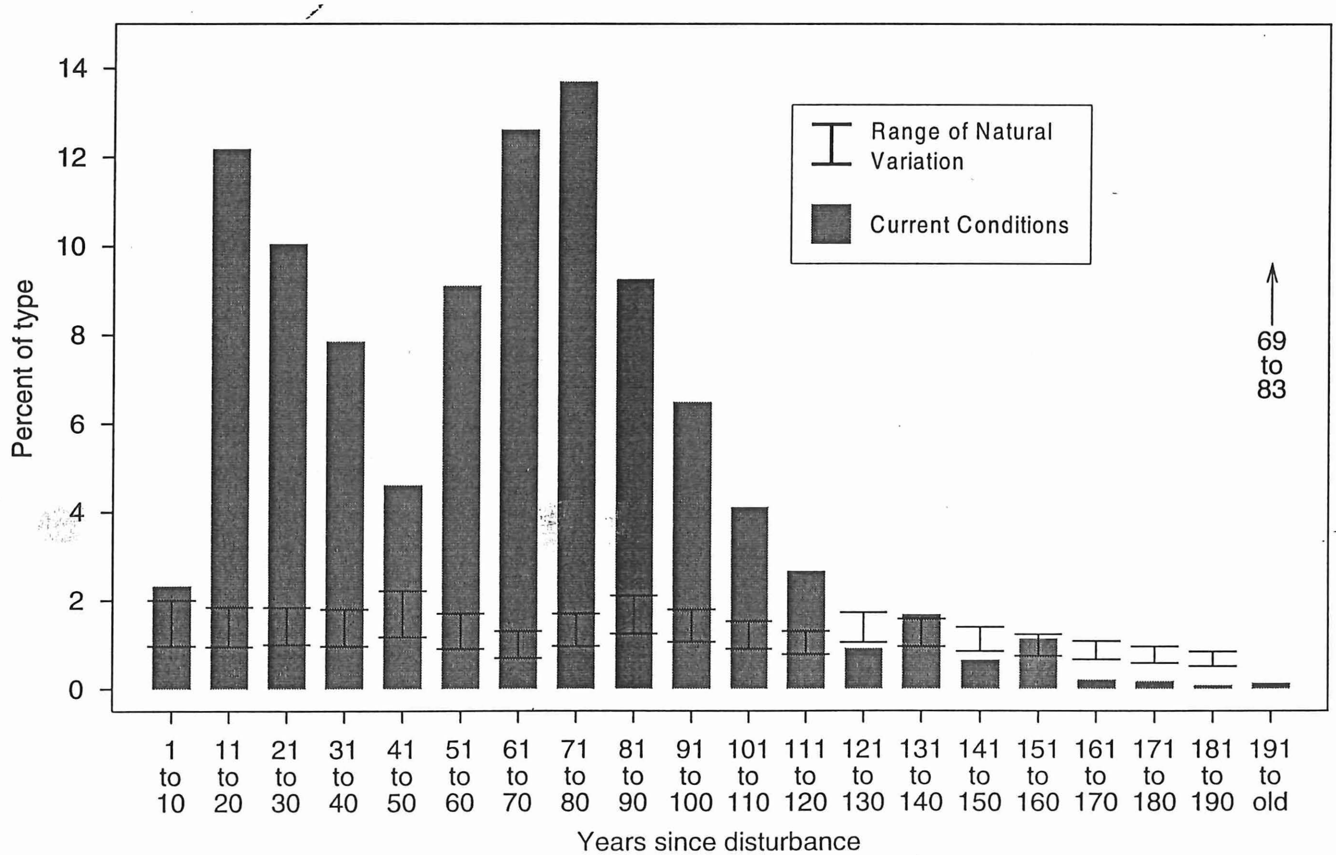
Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	old
Current acres (thousands)	41	140	116	100	107	145	168	173	109	85	53	28	23	16	8	4	3	5
Current % of type	3.1	10.6	8.8	7.6	8.1	11	12.7	13.1	8.2	6.4	4	2.1	1.7	1.2	0.6	0.3	0.3	0.4
RNV minimum % of type	3.3	3.1	3	2.8	3.3	2.4	1.8	2.3	3.3	2.9	2.5	2.2	1.9	1.7	1.5	1.3	1.1	35.8
RNV maximum % of type	6.7	6.1	6.1	5.6	6.5	4.8	3.5	3.7	4.6	3.9	3.3	2.8	2.3	1.9	1.6	1.4	1.2	57
	Breakdown of age class by current cover type percent of age class (≥ 10% in **bold**)																	
Balsam poplar		3	1	3	4	3	2	3	2	1	3					1	2	
Aspen	**62**	**55**	**53**	**45**	**52**	**41**	**32**	**33**	**22**	**14**	7	4	1	1	2	2	4	1
Aspen-spruce-fir	**24**	**19**	**17**	**18**	**18**	**16**	**15**	**12**	6	3	4	1	1	1	2	4	**10**	1
Paper birch		1		5		8	7	6	7	7	7	3	1			1	2	1
Paper birch-spruce-fir				1		1	1	1	4	4	2	1					1	
Oak		1	1	1		2	1	2	2	1		1		7	1		1	
Jack pine-hardwood	2	1		1		1	2	2	1									
Balsam fir-hardwood	2	4	3	2	3	5	**10**	8	7	3	2	1	1		1	2		1
Red pine-spruce-fir				2						2	1				1	1		2
Red pine-hardwood	2	3	3	4	3	2	2	1	2	1	3	4	5	3	2	1		9
White pine-spruce-fir																1	3	1
White pine-hardwood												1			**11**			1
White spruce-hardwood	1	3	3	4	1	2	1		1									
Northern hardwood	1	2	2	2	2	**10**	**10**	9	8	**17**	**12**	**10**	**10**	6	3	8	4	8
Northern hardwood-con		2	1				1	2	5	4	3	3	4	3	1	1	2	1
Lowland black spruce	3	2	4	8	8	4	6	8	9	**14**	9	**16**	**17**	**16**	**21**	**16**	**13**	**12**
Upland black spruce																	1	
Tamarack		2	6	2	3	1	2	2	4	3	4	8	8	**10**	4	6	1	5
Black ash		2	3		2	2	5	7	**13**	**12**	**25**	**18**	**24**	**21**	8	**11**	**11**	7
Black ash-conifer		2	3		3	2	1	3	3	6	5	5	5	7	6	4	**12**	8
White cedar							3	1	1	5	9	**15**	**13**	**16**	**25**	**37**	**29**	**38**
Mixed swamp conifers								1	2	3	3	8	**10**	**10**	**11**	6	4	3
Cut over	1																	
Upland grass		1																
Other		1																

7: Mesic boreal hardwood forest
Area breakdown

Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	old
Current acres (thousands)	41	140	116	100	107	145	168	173	109	85	53	28	23	16	8	4	3	5
Current % of type	3.1	10.6	8.8	7.6	8.1	11	12.7	13.1	8.2	6.4	4	2.1	1.7	1.2	0.6	0.3	0.3	0.4
RNV minimum % of type	3.3	3.1	3	2.8	3.3	2.4	1.8	2.3	3.3	2.9	2.5	2.2	1.9	1.7	1.5	1.3	1.1	35.8
RNV maximum % of type	6.7	6.1	6.1	5.6	6.5	4.8	3.5	3.7	4.6	3.9	3.3	2.8	2.3	1.9	1.6	1.4	1.2	57
	Breakdown of age class by current cover type area (thousands of acres) (≥ 10k in **bold**)																	
Balsam poplar	0.1	4.2	1.2	3.2	4.6	3.8	3.1	5.1	2.3	0.4	1.5						0.1	
Aspen	**25.1**	**76.6**	**61.2**	**45.2**	**55.4**	**59**	**53.9**	**56.3**	**24.4**	**12.2**	3.5	1	0.2	0.2	0.1	0.1	0.1	
Aspen-spruce-fir	9.8	**26.3**	**20.1**	**18.3**	**18.8**	**22.6**	**24.3**	**21.2**	6.6	2.8	2.3	0.4	0.1	0.1	0.2	0.2	0.3	0.1
Paper birch	0.1	1.1	0.1	4.5	0.2	**11**	**12.1**	9.5	7.3	5.9	3.5	0.8	0.1				0.1	
Paper birch-spruce-fir	0.1	0.1		1.2	0.1	1.9	1.5	2	4	3.7	1.1	0.3	0.1					
Oak	0.1	0.8	1	1.1		3.4	1.5	4.1	1.9	0.4	0.1	0.2		1.1	0.1			
Jack pine-hardwood	0.8	1	0.5	0.6	0.2	1.7	2.7	3.1	1.6	0.3	0.2	0.1						
Jack pine-spruce-fir		0.1			0.1	0.1	0.3	0.4	0.2	0.1	0.1							
Balsam fir			0.3	0.4	0.1	0.1	0.3	0.6	0.2	0.2								
Balsam fir-hardwood	0.6	4.9	2.9	1.8	3	7.3	**17.1**	**13.3**	7.8	2.1	0.9	0.2	0.2		0.1	0.1		
Red pine-spruce-fir		0.4	0.2	1.7	0.4	0.2	0.2	0.2	0.3	1.7	0.5	0.1	0.1	0.1	0.1			0.1
Red pine-hardwood	0.8	3.5	2.9	4.5	3.3	2.7	3.9	0.9	2.3	0.9	1.7	1.1	1.1	0.5	0.1			0.5
White pine-spruce-fir	0.1									0.1							0.1	
White pine-hardwood	0.2	0.1		0.1				0.1	0.1	0.1	0.1	0.2	0.1		0.8			0.1
White spruce		0.1	0.1	0.1	0.1													
White spruce-hardwood	0.5	3.7	3.7	4.4	1.6	2.2	0.9	0.5	0.6	0.1	0.1	0.1						
Northern hardwood	0.3	2.9	1.9	2.4	2.5	**14.3**	**16.5**	**16**	8.7	**14**	6.3	2.7	2.2	1	0.2	0.3	0.1	0.4
Northern hardwood-con	0.1	2.3	1.1	0.1	0.2	0.5	2	3.1	5.2	3.7	1.5	0.8	0.9	0.4	0.1	0.1	0.1	
Lowland black spruce	1.3	2.5	4.5	8.2	8.8	6.3	**10.3**	**14.3**	9.7	**11.9**	5	4.3	3.9	2.5	1.6	0.7	0.5	0.7
Upland black spruce							0.1	0.2	0.1				0.1					
Tamarack	0.2	2.8	6.4	2	2.9	1	2.7	3.1	4.8	2.6	2	2.3	1.9	1.5	0.3	0.3		0.3
Black ash		2.3	3.7	0.1	1.6	3	8	**11.4**	**14.2**	**10**	**13.3**	5.1	5.5	3.3	0.6	0.5	0.4	0.4
Black ash-conifer		2.1	3.8	0.1	3.2	3.5	2	4.4	3.4	4.8	2.6	1.4	1.1	1.1	0.5	0.2	0.4	0.4
White cedar		0.1		0.1	0.1		4.5	1.6	1.1	4.4	4.7	4.1	3	2.5	1.9	1.5	1	2
Mixed swamp conifers			0.1	0.1	0.2	0.3	0.2	1.3	2	2.2	1.6	2.3	2.2	1.5	0.8	0.2	0.1	0.2
Cut over	0.3	0.2																
Upland grass		0.7	0.4															
Lowland brush								0.1			0.1							
Water				0.1	0.1						0.1	0.1						
Other		1.2																

Frelich type 9: Mesic northern hardwood forest
Shadis type 8: Mesic Northern Hardwood
Disturbace interval (years) - Wind: 1000-2000 Fire: 1000-2000 Ground Fire: N/A





9: Mesic northern hardwood forest
Percent cover breakdown
See also area breakdown

Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	old
Current acres (thousands)	4	23	19	15	9	17	24	26	17	12	8	5	2	3	1	2	0	0	0	0
Current % of type	2.3	12.2	10.1	7.9	4.6	9.1	12.6	13.7	9.3	6.5	4.1	2.7	0.9	1.7	0.6	1.1	0.2	0.2	0.1	0.1
RNV minimum % of type	1	0.9	1	1	1.2	0.9	0.7	1	1.2	1.1	0.9	0.8	1	1	0.8	0.7	0.7	0.6	0.5	69.3
RNV maximum % of type	2	1.8	1.8	1.8	2.2	1.7	1.3	1.7	2.1	1.8	1.5	1.3	1.7	1.6	1.4	1.2	1.1	1	0.8	83.1
Breakdown of age class by current cover type percent of age class (≥ 10% in **bold**)																				
Balsam poplar		3	5			5	1	1				1								
Aspen	**59**	**49**	**45**	**20**	**53**	**32**	**34**	**14**	**25**	**15**	5	2		5					4	
Aspen-spruce-fir	**27**	**14**	**21**	**21**	6	7	3	**11**	**12**	5	**19**								**21**	
Paper birch	2	9		1		6	8	6	9	**10**	6	3	1							
Paper birch-spruce-fir	1			6		6	**14**	2	5	3	1	1								
Oak							**10**	6	3	2	**15**	2								
Balsam fir-hardwood	2		1		1	2	1	8	7	6	2	1								
Red pine-spruce-fir																			6	8
Red pine-hardwood	1	2	2	4	2	1				1	2	1	1	3	5					3
White pine-spruce-fir												1		1		4				
White pine-hardwood						8				2	1	3		2	2	1	2			
White spruce-hardwood	1	6	3	**14**	4			1												
Northern hardwood	1	1	1	**22**	**13**	**24**	**15**	**32**	**20**	**24**	**30**	**36**	**32**	**59**	**29**	2	**34**	6		**32**
Northern hardwood-con					1	1	**10**	**14**	5	7	3	7	**12**	7	**11**	1		2		
Lowland black spruce			8	**10**	1	6	1	1	1	3	4	4	4	6	3	3			**15**	
Tamarack			6		**17**			1	2	5	2	4	6			**66**	1	1	**18**	
Black ash							4	1	1	**10**	4	4	7	2	3	2	**11**	3	**17**	**11**
Black ash-conifer							1	1	1	2	2	4	4	2	4	1	4	2		
White cedar	1		8		2			1	7	5	5	**26**	**31**	**12**	**38**	**19**	**49**	**86**	**20**	**46**
Mixed swamp conifers									1	1	1	1	2	2	6	2				
Cut over	4																			
Upland grass		1	1																	
Lowland brush		5																		
Other		**10**																		

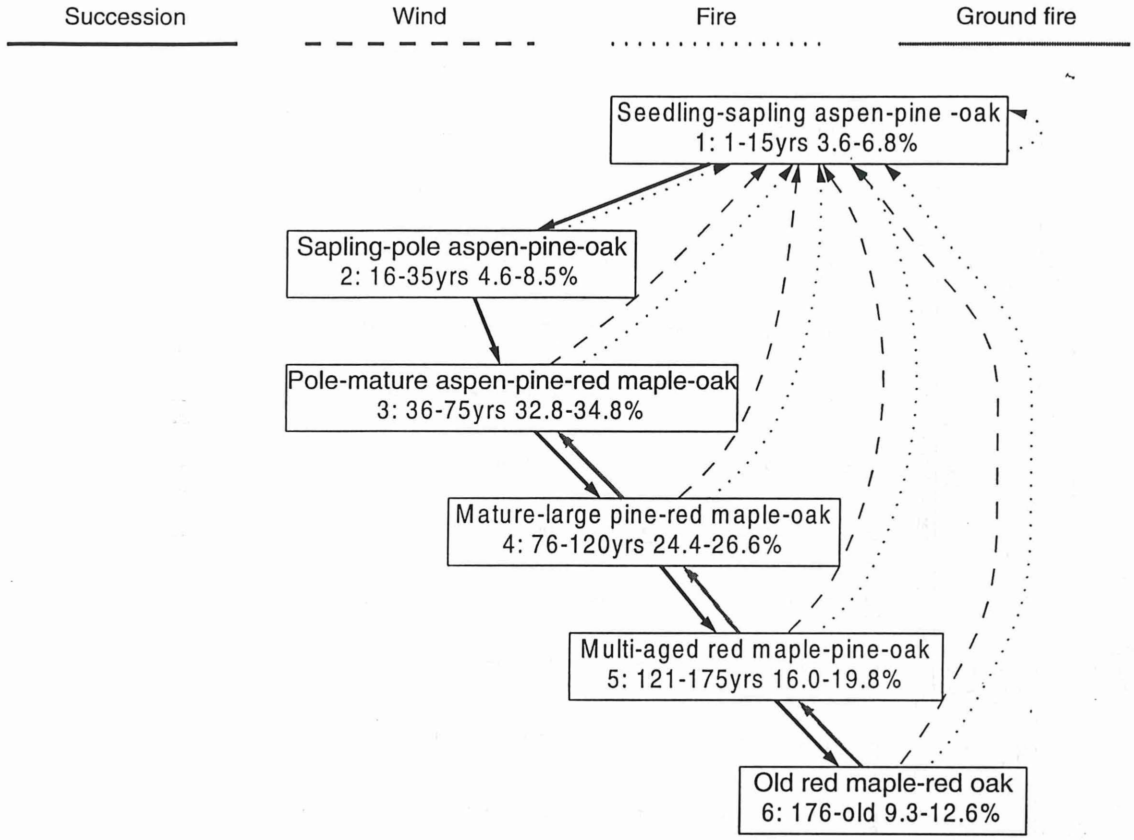
9: Mesic northern hardwood forest
Area breakdown

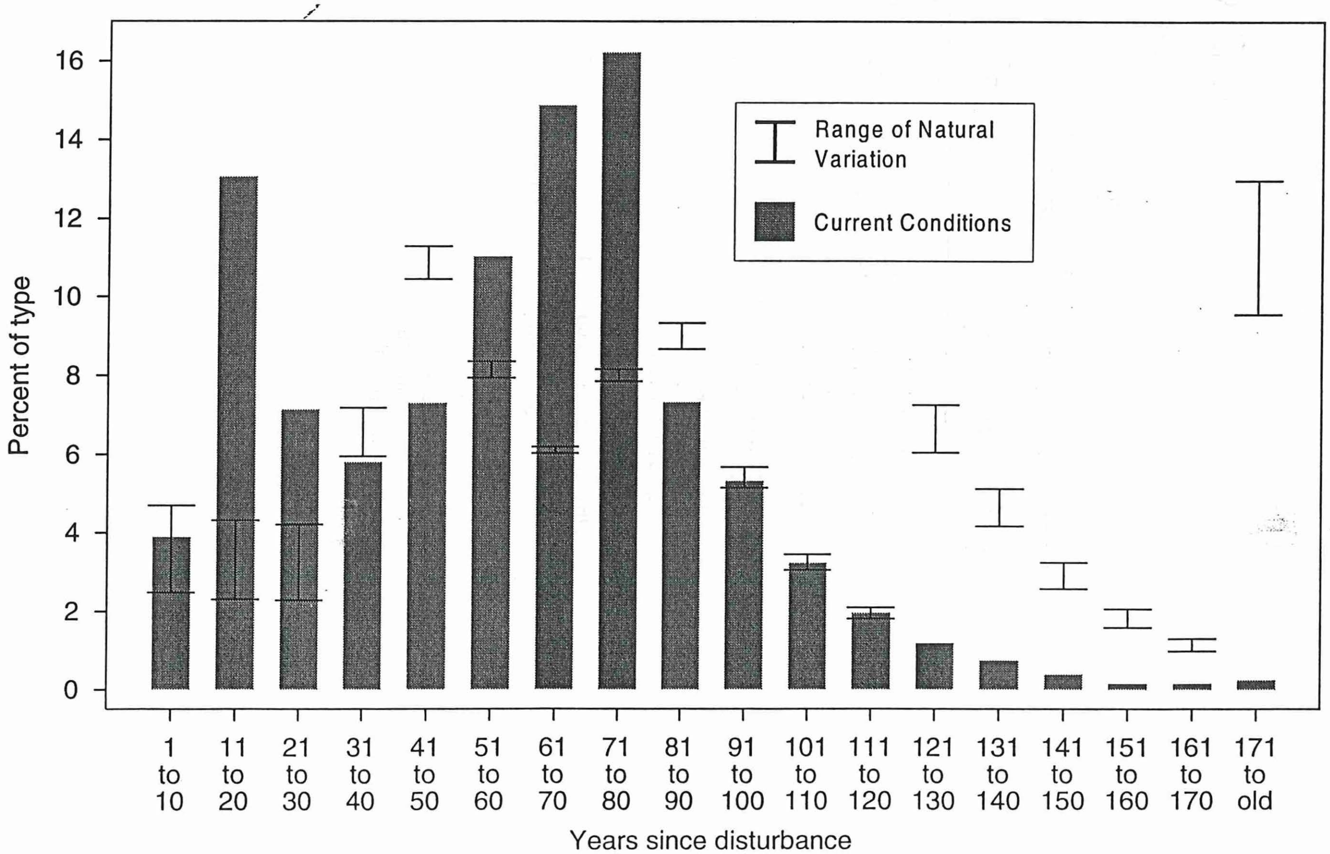
Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	old
Current acres (thousands)	4	23	19	15	9	17	24	26	17	12	8	5	2	3	1	2	0	0	0	0
Current % of type	2.3	12.2	10.1	7.9	4.6	9.1	12.6	13.7	9.3	6.5	4.1	2.7	0.9	1.7	0.6	1.1	0.2	0.2	0.1	0.1
RNV minimum % of type	1	0.9	1	1	1.2	0.9	0.7	1	1.2	1.1	0.9	0.8	1	1	0.8	0.7	0.7	0.6	0.5	69.3
RNV maximum % of type	2	1.8	1.8	1.8	2.2	1.7	1.3	1.7	2.1	1.8	1.5	1.3	1.7	1.6	1.4	1.2	1.1	1	0.8	83.1
	Breakdown of age class by current cover type area (thousands of acres) (≥ 10k in **bold**)																			
Balsam poplar		0.6	1			0.9	0.1	0.2	0.1											
Aspen	2.6	**11.2**	8.4	3	4.6	5.4	8	3.5	4.4	1.9	0.4	0.1		0.1						
Aspen-spruce-fir	1.2	3.2	4	3.1	0.5	1.2	0.6	2.8	2	0.6	1.4									
Paper birch	0.1	2	0.1	0.2		1	1.8	1.6	1.5	1.2	0.4	0.1								
Paper birch-spruce-fir	0.1			0.9		1	3.3	0.5	0.8	0.4	0.1	0.1								
Oak							2.3	1.4	0.6	0.2	1.1	0.1								
Balsam fir			0.1				0.1													
Balsam fir-hardwood	0.1	0.1	0.1	0.1	0.1	0.3	0.2	2	1.2	0.7	0.1									
Red pine-hardwood		0.4	0.3	0.6	0.1	0.2				0.2	0.1	0.1		0.1	0.1					
White pine-spruce-fir																0.1				
White pine-hardwood		0.1				1.4				0.2	0.1	0.1		0.1						
White spruce-hardwood		1.4	0.5	2	0.3		0.1	0.2												
Northern hardwood		0.1	0.1	3.2	1.1	4.1	3.5	8.3	3.4	3	2.3	1.8	0.6	1.9	0.3		0.1			0.1
Northern hardwood-con						0.2	2.3	3.7	0.8	0.9	0.2	0.4	0.2	0.2	0.1					
Lowland black spruce			1.5	1.5	0.1	1.1	0.1	0.3	0.2	0.3	0.3	0.2	0.1	0.2		0.1				
Tamarack		0.1	1.1		1.5		0.1	0.4	0.3	0.6	0.1	0.2	0.1			1.4				
Black ash							0.9	0.3	0.2	1.2	0.3	0.2	0.1							
Black ash-conifer						0.1	0.2	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.1					
White cedar			1.5		0.2		0.1	0.2	1.2	0.6	0.4	1.3	0.5	0.4	0.5	0.4	0.2	0.3		0.1
Mixed swamp conifers							0.1	0.1	0.2	0.1	0.1			0.1	0.1					
Cut over	0.2																			
Upland grass		0.1	0.1																	
Lowland brush		1.1																		
Other		2.2																		

Frelich type 11: Dry-mesic pine-oak forest

Kotar dis type 2: Dry-mesic pine-oak

Disturbace interval (years) - Wind: 1000-2000 Fire: 250-500 Ground Fire: 40





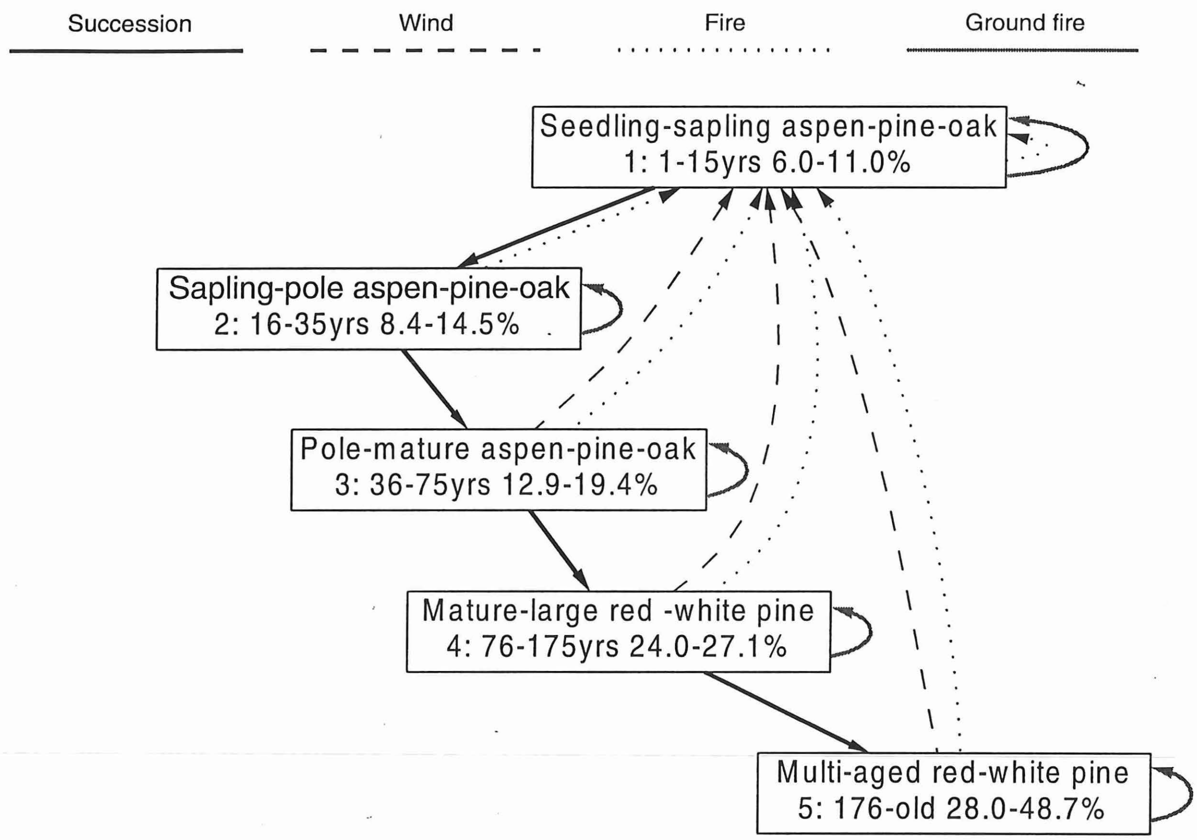
11: Dry-mesic pine-oak forest
Percent cover breakdown
See also area breakdown

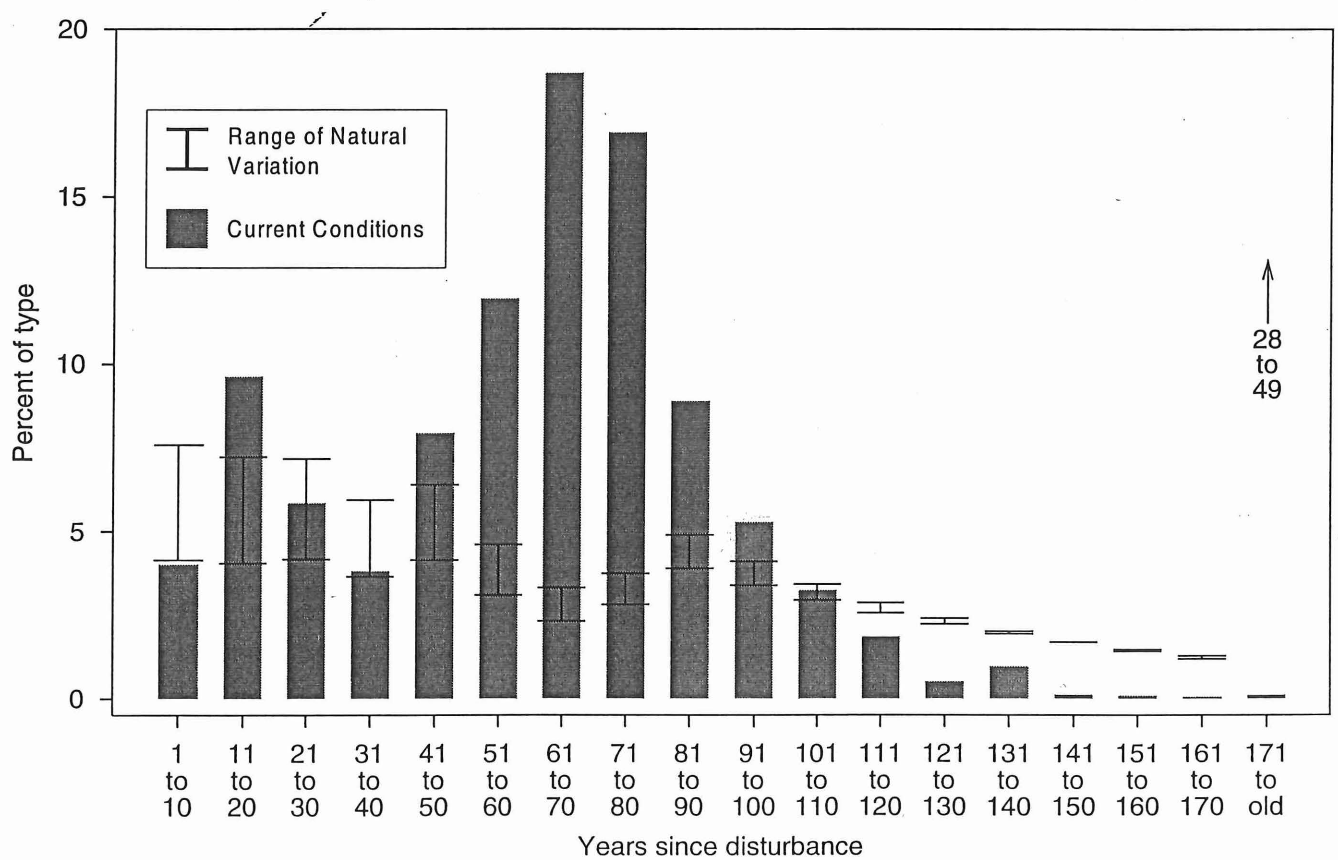
Age (years) from to	1 10	11 20	21 30	31 40	41 50	51 60	61 70	71 80	81 90	91 100	101 110	111 120	121 130	131 140	141 150	151 160	161 170	171 old
Current acres (thousands)	62	207	113	92	115	174	235	257	116	84	51	31	19	12	6	2	2	4
Current % of type	3.9	13.1	7.1	5.8	7.3	11	14.9	16.2	7.3	5.3	3.2	2	1.2	0.7	0.4	0.1	0.1	0.2
RNV minimum % of type	2.5	2.3	2.3	5.9	10.4	7.9	6	7.8	8.7	5.1	3.1	1.8	6	4.2	2.6	1.6	1	9.6
RNV maximum % of type	4.7	4.3	4.2	7.2	11.3	8.4	6.2	8.2	9.3	5.7	3.5	2.1	7.3	5.1	3.2	2.1	1.3	13
	Breakdown of age class by current cover type percent of age class (≥ 10% in **bold**)																	
Balsam poplar				4	1	1		1		1								
Aspen	**63**	**41**	**45**	**38**	**26**	**38**	**37**	**29**	**22**	5	7	4	2	4	2	6	**14**	7
Aspen-spruce-fir	**19**	**12**	**13**	8	**15**	**13**	**12**	7	6	4	3		1	1		8	1	4
Paper birch	1	3			3	2	7	9	7	4	6	6	1	**10**		2		3
Paper birch-spruce-fir				1	1	2	2	2	2	1	4	1	1			2	2	
Oak		3	2	3	3	9	**11**	**17**	**15**	**20**	8	3	2	1	1	**12**	1	6
Jack pine-hardwood	5	4	**12**	6	**18**	**15**	**14**	8	7	2	1				1	2		
Jack pine-spruce-fir			1	1	2	1	1									1		
Balsam fir-hardwood				1	1	2	2	2	2	1	1	1						
Red pine-spruce-fir		1	1	1	1				2	3	3	6	1	2	2		1	4
Red pine-hardwood	4	**21**	**14**	**20**	7	4	2	4	4	**14**	**13**	**12**	**14**	**25**	**15**	**10**	5	**17**
White pine-spruce-fir															1	2		1
White pine-hardwood	1		1	3			1		2	1	1	1	**12**	2	2	1	1	
White spruce-hardwood	1	2	1	1	3									1	1			
Northern hardwood		4	1	1	2	6	4	7	9	**12**	**10**	**15**	**10**	8	**26**	5	**16**	**28**
Northern hardwood-con		1		1			1		3	1	4	2	1	1	2	1	2	
Lowland black spruce	1	6	1	2	9	1	3	1	3	5	5	7	9	8	3	**11**	5	3
Tamarack		1	2	7	6	2	1	1	4	8	**11**	**11**	**15**	**11**	**11**	3	8	2
Black ash		1	4		3	4	2	**10**	9	**12**	**13**	**18**	8	5	8	**11**	**11**	9
Black ash-conifer			1				1	1	1	3	4	3	4	3	9	5	**13**	3
White cedar								1		2	4	6	**14**	**15**	**13**	**16**	**13**	**14**
Mixed swamp conifers										1	2	4	5	4	6	4	6	1
Cut over	4										1							
Other		1																

11: Dry-mesic pine-oak forest
Area breakdown

Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	old
Current acres (thousands)	62	207	113	92	115	174	235	257	116	84	51	31	19	12	6	2	2	4
Current % of type	3.9	13.1	7.1	5.8	7.3	11	14.9	16.2	7.3	5.3	3.2	2	1.2	0.7	0.4	0.1	0.1	0.2
RNV minimum % of type	2.5	2.3	2.3	5.9	10.4	7.9	6	7.8	8.7	5.1	3.1	1.8	6	4.2	2.6	1.6	1	9.6
RNV maximum % of type	4.7	4.3	4.2	7.2	11.3	8.4	6.2	8.2	9.3	5.7	3.5	2.1	7.3	5.1	3.2	2.1	1.3	13
	Breakdown of age class by current cover type area (thousands of acres) (≥ 10k in **bold**)																	
Balsam poplar	0.1	0.2	0.1	4	1	1.4	0.5	2.7	0.1	1.2								
Aspen	**38.5**	**83.6**	**50.6**	**34.5**	**29.7**	**66.1**	**86.9**	**73.8**	**25.4**	3.9	3.7	1.1	0.4	0.5	0.1	0.1	0.3	0.3
Aspen-spruce-fir	**11.6**	**25.3**	**14.5**	7.3	**17.6**	**22**	**27**	**17.2**	7.3	3.1	1.6	0.1	0.3	0.2		0.2		0.1
Paper birch	0.4	6.8	0.2	0.1	3.6	3.1	**17.1**	**22.5**	8.6	3	2.9	1.7	0.2	1.2				0.1
Paper birch-spruce-fir	0.1	0.1	0.1	1	0.8	2.9	4.4	5.6	1.8	1.1	1.9	0.4	0.1					
Oak	0.1	5.9	2.2	3.1	3.6	**15.1**	**24.8**	**42.9**	**17.3**	**17**	4.2	1	0.3	0.1		0.3		0.2
Jack pine-hardwood	3.2	9.1	**13.6**	5.8	**20.9**	**26.5**	**32.2**	**21.2**	8.1	1.6	0.5	0.1			0.1			
Jack pine-spruce-fir		0.1	0.6	0.7	1.7	2.5	1.7	0.9	0.1									
Balsam fir			0.1	0.2	0.2	0.3	0.7	0.3	0.2	0.2								
Balsam fir-hardwood	0.2	0.5	0.5	0.5	1.4	2.8	3.9	5.4	2.6	0.8	0.7	0.2						
Red pine-spruce-fir	0.1	1.2	1.1	1.3	0.6	0.7	0.7	0.6	1.7	2.6	1.3	1.9	0.2	0.2	0.1			0.2
Red pine-hardwood	2.7	**42.9**	**16.1**	**17.9**	7.9	6.3	5.7	9	4	**11.6**	6.6	3.8	2.7	2.9	0.9	0.2	0.1	0.6
White pine-spruce-fir	0.1						0.1			0.1	0.1	0.1						
White pine-hardwood	0.4	0.2	1.3	2.4	0.1	0.2	1.2	0.1	2.5	1.1	0.2	0.3	2.2	0.2	0.1			
White spruce				0.2	0.1	0.1												
White spruce-hardwood	0.8	3.9	1.2	1.2	3.5	0.4	0.2	0.1		0.1				0.1				
Northern hardwood	0.2	7.9	1.2	1.2	2.2	**11.2**	9.8	**16.8**	**10.9**	**10**	5	4.5	1.9	0.9	1.6	0.1	0.4	1
Northern hardwood-con		1.4		1.2	0.1	0.4	1.1	1.1	3.8	1	2.2	0.7	0.3	0.1	0.1			
Lowland black spruce	0.3	**12.3**	1.3	2.2	**10.1**	2.3	6.2	3	3.9	4.5	2.6	2.2	1.6	0.9	0.2	0.3	0.1	0.1
Upland black spruce		0.2																
Tamarack	0.1	1.5	2.1	6.6	6.6	3	2.5	2.9	5	6.4	5.6	3.4	2.9	1.3	0.7	0.1	0.2	0.1
Black ash	0.1	1.2	4.6	0.1	3.5	6.8	5.2	**25.9**	9.9	9.9	6.9	5.4	1.5	0.5	0.5	0.2	0.3	0.3
Black ash-conifer			1.4	0.1		0.1	2.7	1.3	1.5	2.6	1.8	1	0.8	0.4	0.5	0.1	0.3	0.1
White cedar							0.2	2.8	0.5	1.6	2.2	2	2.6	1.7	0.8	0.4	0.3	0.5
Mixed swamp conifers				0.1		0.2	0.2	0.4	0.4	0.7	1	1.2	0.8	0.5	0.3	0.1	0.1	
Cut over	2.3	0.4									0.2							
Upland grass		0.2	0.1															
Lowland grass			0.1	0.1														
Upland brush	0.1																	
Lowland brush		0.2						0.1										
Water					0.1		0.1		0.1									
Other		1.2																

Frelich type 12: Dry-mesic pine forest
Shadis type 4: Dry-mesic pine
Disturbace interval (years) - Wind: 500-1000 Fire: 175-350 Ground Fire: 30





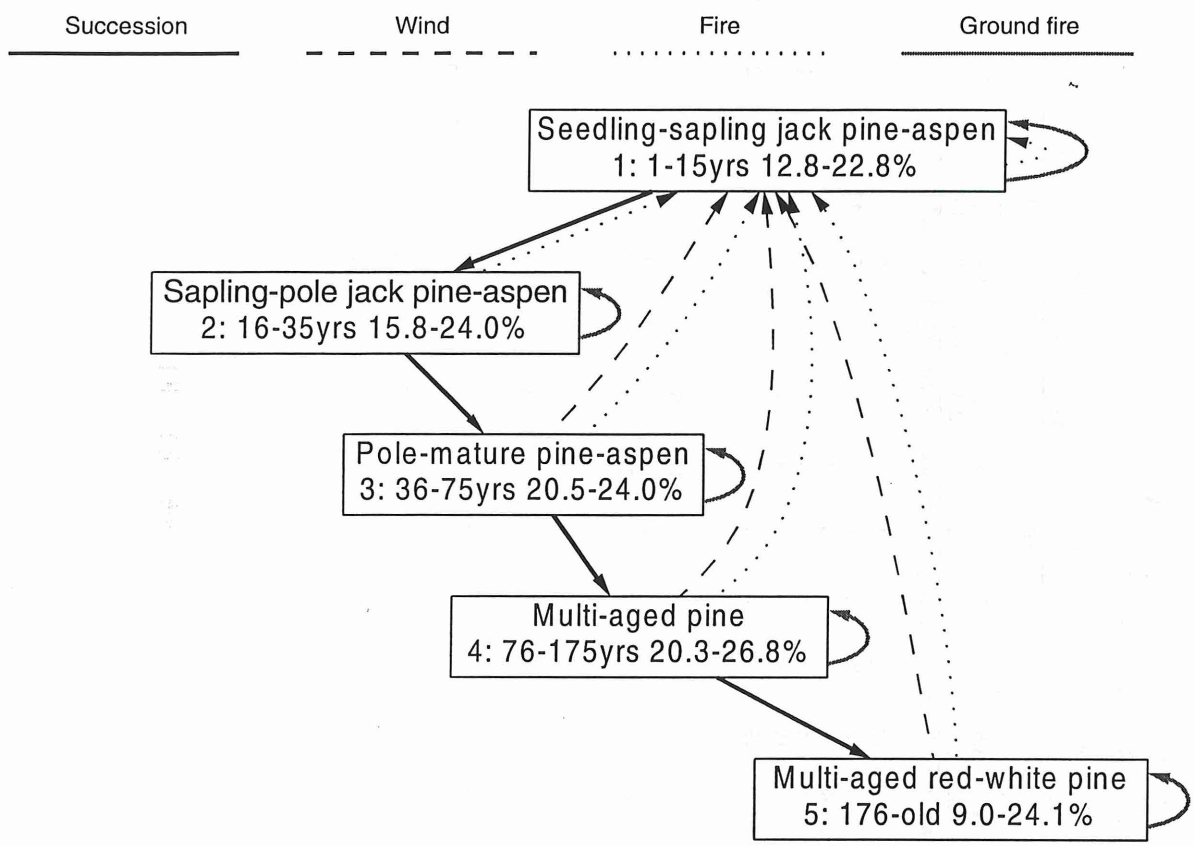
12: Dry-mesic pine forest
Percent cover breakdown
See also area breakdown

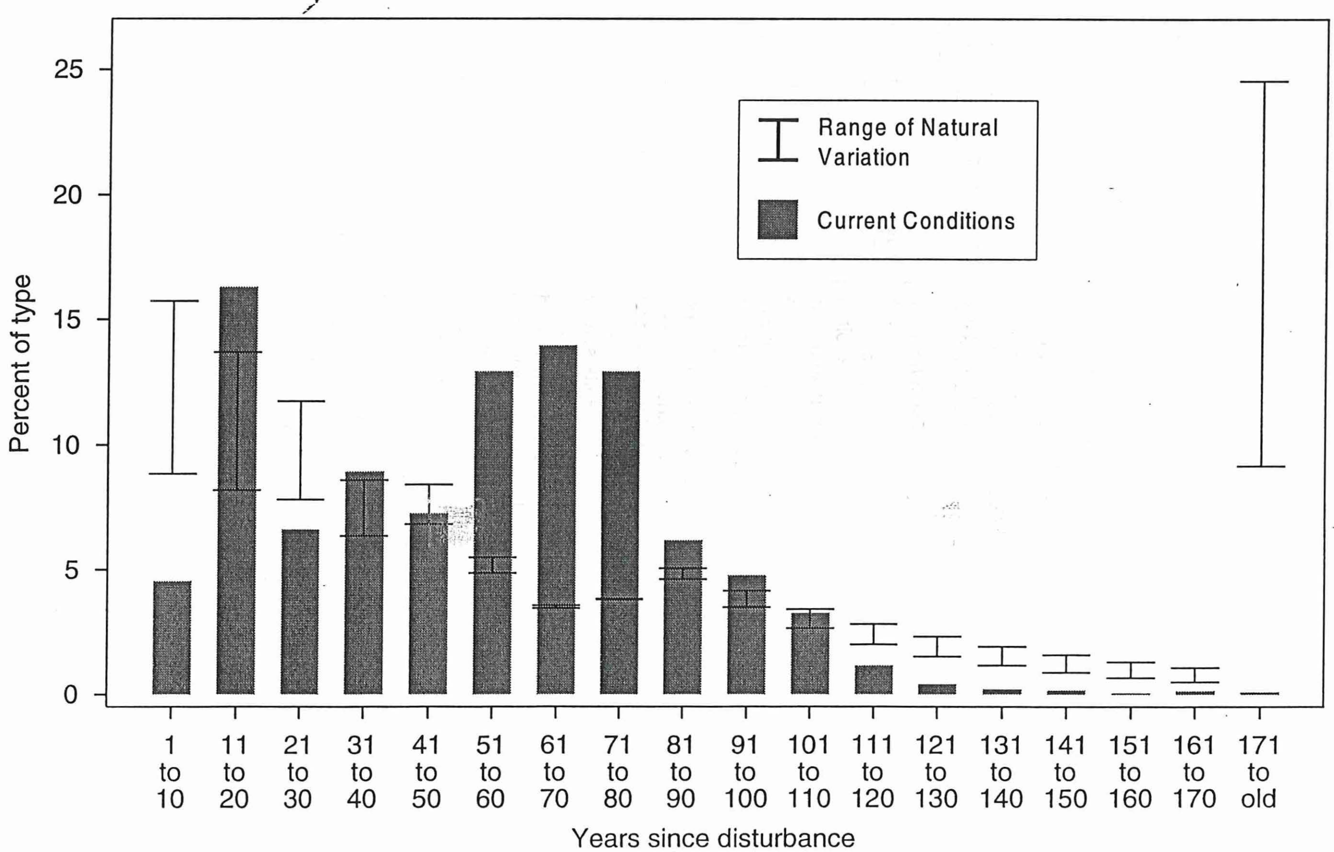
Age (years) from / to	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	101–110	111–120	121–130	131–140	141–150	151–160	161–170	171–old
Current acres (thousands)	26	63	38	25	52	78	122	111	58	35	21	12	3	6	1	1	0	1
Current % of type	4	9.6	5.8	3.8	8	12	18.7	16.9	8.9	5.3	3.3	1.9	0.5	1	0.1	0.1	0	0.1
RNV minimum % of type	4.1	4	4.2	3.6	4.1	3.1	2.3	2.8	3.9	3.4	2.9	2.6	2.2	1.9	1.7	1.5	1.3	28.6
RNV maximum % of type	7.6	7.2	7.2	5.9	6.4	4.6	3.3	3.7	4.9	4.1	3.4	2.9	2.4	2	1.7	1.4	1.2	49.2
	Breakdown of age class by current cover type percent of age class (≥ 10% in **bold**)																	
Balsam poplar		2		**10**	3	2	2	1										
Aspen	**76**	**54**	**62**	**46**	**51**	**42**	**44**	**36**	**23**	**25**	**10**		**42**	3	1	**20**	**16**	8
Aspen-spruce-fir	**16**	**15**	**15**	**11**	**16**	9	**10**	**10**	7	2	2	1	1		6	7	7	
Paper birch					2	**10**	5	7	9	9	7	1		**35**		5	4	7
Paper birch-spruce-fir						1	2	4	1	6	1	1						
Oak		2	5		2	6	**10**	**19**	**23**	**25**	8	**18**	3	**27**	5	**35**	**21**	**21**
Jack pine-hardwood	1				4	7	3	2	2									1
Balsam fir				1														
Balsam fir-hardwood				1	5	1	3	1	1	1	1	1	1	1	1			
Red pine-spruce-fir				1					1	2	1	1	1					**11**
Red pine-hardwood	1	4	2	4	3	2	2	1	3	2	6	6	**19**	1		8		1
White pine-spruce-fir													1					6
White pine-hardwood	1								2	4					1	1		1
White spruce																	3	
White spruce-hardwood		1	1	1	1											1		
Northern hardwood	1	5	1	**16**		4	**15**	**11**	**12**	**14**	**16**	**42**	8	2	3	8	**12**	2
Northern hardwood-con		3	4			3	2	3	3	3	**16**		1	1				**18**
Lowland black spruce				7	1	2				1	1	1	1	1	2	1	2	1
Tamarack			3	1	8	6	1	1	3	2	2	5	6	1	**22**	1	7	3
Black ash		5	3		3	3	3	3	7	2	**28**	**16**	6	**22**	**28**	3	1	1
Black ash-conifer		1	2						2	1	2	1	1		1	3		
White cedar									2	1	1	5	5	5	**13**	7	**19**	**14**
Mixed swamp conifers												1	4	2	**17**	1	8	5
Cut over	3										1							3
Lowland brush		4																
Other		3																

12: Dry-mesic pine forest
Area breakdown

Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	old
Current acres (thousands)	26	63	38	25	52	78	122	111	58	35	21	12	3	6	1	1	0	1
Current % of type	4	9.6	5.8	3.8	8	12	18.7	16.9	8.9	5.3	3.3	1.9	0.5	1	0.1	0.1	0	0.1
RNV minimum % of type	4.1	4	4.2	3.6	4.1	3.1	2.3	2.8	3.9	3.4	2.9	2.6	2.2	1.9	1.7	1.5	1.3	28.6
RNV maximum % of type	7.6	7.2	7.2	5.9	6.4	4.6	3.3	3.7	4.9	4.1	3.4	2.9	2.4	2	1.7	1.4	1.2	49.2
	Breakdown of age class by current cover type area (thousands of acres) (≥ 10k in **bold**)																	
Balsam poplar	0.1	1.2		2.4	1.5	1.6	2.4	1.3	0.1									
Aspen	**20.1**	**34**	**23.6**	**11.6**	**26.3**	**32.6**	**53.2**	**39.6**	**13.3**	8.5	2.1		1.4	0.2		0.1		0.1
Aspen-spruce-fir	4.2	9.2	5.6	2.7	8.4	7.1	**11.8**	**10.9**	4.1	0.8	0.4	0.1						
Paper birch	0.1			0.1	1.2	7.5	5.5	7.9	5.2	3.3	1.5	0.1		2.2				
Paper birch-spruce-fir						1.1	2.8	4.3	0.6	2	0.2	0.1						
Oak	0.1	1.1	2		1.2	4.9	**11.6**	**21**	**13.3**	8.8	1.6	2.1	0.1	1.7		0.2	0.1	0.1
Jack pine-hardwood	0.3	0.2	0.2	0.1	2.3	5.7	4.2	2.2	1.2	0.1								
Jack pine-spruce-fir						0.2	0.2	0.1										
Balsam fir			0.1	0.2		0.1	0.1	0.1										
Balsam fir-hardwood		0.1	0.2	0.1	2.6	1.1	3	1.2	0.5	0.5	0.1	0.1						
Red pine-spruce-fir			0.1	0.3			0.1	0.1	0.3	0.6	0.1	0.1						0.1
Red pine-hardwood	0.2	2.6	0.9	1.1	1.6	1.3	2.4	1.2	1.8	0.7	1.3	0.7	0.6	0.1				
White pine-spruce-fir				0.1			0.1											
White pine-hardwood	0.2						0.1	0.1	1.4	1.4								
White spruce							0.1											
White spruce-hardwood	0.1	0.4	0.2	0.3	0.4	0.3		0.1										
Northern hardwood	0.2	3.3	0.4	3.9	0.2	3.4	**17.7**	**12.5**	6.9	4.8	3.4	5.1	0.3	0.1				
Northern hardwood-con		1.7	1.4			2.6	1.8	2.9	1.6	0.9	3.4	0.1		0.1				0.1
Lowland black spruce			0.1	1.7	0.3	1.3	0.3	0.3	0.3	0.3	0.2	0.1		0.1				
Tamarack		0.1	1.1	0.2	4.3	4.9	1	0.5	1.7	0.6	0.4	0.6	0.2	0.1	0.2			
Black ash		3.4	1.2		1.6	2.3	3.4	3.7	4	0.8	5.9	1.9	0.2	1.4	0.2			
Black ash-conifer		0.6	0.8			0.2	0.3	0.4	0.9	0.4	0.3	0.1						
White cedar							0.1	0.1	1.1	0.2	0.2	0.6	0.2	0.3	0.1		0.1	0.1
Mixed swamp conifers										0.1	0.1	0.1	0.1	0.1	0.1			
Cut over	0.7	0.2									0.1							
Upland grass			0.1															
Lowland grass								0.1										
Marsh		0.1																
Lowland brush		2.4																
Water			0.1															
Other		2.1																

Frelich type 13: Dry pine forest
Landis type 5: Dry pine
Disturbace interval (years) - Wind: 1000-2000 Fire: 60-120 Ground Fire: 40





13: Dry pine forest

Percent cover breakdown

See also area breakdown

Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	old
Current acres (thousands)	11	40	16	22	18	32	34	32	15	12	8	3	1	1	0	0	0	0
Current % of type	4.5	16.3	6.6	8.9	7.3	12.9	14	12.9	6.2	4.8	3.3	1.2	0.4	0.2	0.2	0.1	0.1	0.1
RNV minimum % of type	8.8	8.2	7.8	6.3	6.8	4.9	3.5	3.8	4.6	3.5	2.7	2	1.5	1.2	0.9	0.7	0.5	9.2
RNV maximum % of type	15.7	13.7	11.7	8.6	8.4	5.5	3.6	3.8	5	4.2	3.4	2.8	2.3	1.9	1.6	1.3	1.1	24.5
	Breakdown of age class by current cover type percent of age class (≥ 10% in **bold**)																	
Balsam poplar			6	6		2			5								1	
Aspen	**38**	**25**	**40**	**22**	**14**	**31**	**17**	**19**	3	**12**	1			3	**15**		3	
Aspen-spruce-fir	**15**	**11**	**13**	6	**14**	**12**	**12**	**19**	2	1		1		7	**15**	**21**	**11**	5
Paper birch						4	4	6	1	3	4							
Paper birch-spruce-fir			7			4	1	1	1		1						**21**	
Oak			8			4	**17**	5	**20**	**11**	1	2		3				4
Jack pine-hardwood	**21**	**15**	3	**24**	**41**	**19**	**33**	**19**	**28**	**15**	5	1			**34**	3	**37**	**12**
Jack pine-spruce-fir			1	1	2	3	3	4								**12**	4	
Balsam fir			1	1	1				1									
Balsam fir-hardwood			1	7	1	1	6	9	3	1	**11**	1	2					
Red pine-spruce-fir	1	1	2	2	1		1	1	2	3	1	2	9	1	2		3	3
Red pine-hardwood	**10**	**44**	**13**	**23**	**16**	7	2	3	7	**27**	**21**	**51**	**14**	**28**	**19**	**27**	8	**14**
White pine-hardwood										1								
White spruce															2			
White spruce-hardwood	1	1	2	2														4
Northern hardwood						1	1	2	3	5		4						
Northern hardwood-con							1	1	1				3					
Lowland black spruce	1		1	1	6	6	1	5	**14**	**11**	**10**	5	**31**	**10**				5
Tamarack			1	7	3	4	2	1	4	4	**39**	**18**	**35**	**43**	3	**24**	**11**	**35**
Black ash								4	1	2	1	1	1					
Black ash-conifer								1	1	1	1	4		4		7		
White cedar									1	1	1	5	6		9	6	3	**18**
Mixed swamp conifers										1	1	6		2				
Cut over	**11**	1									2							
Lowland grass		3																
Lowland brush	1																	

13: Dry pine forest
Area breakdown

Age (years) from / to	1 10	11 20	21 30	31 40	41 50	51 60	61 70	71 80	81 90	91 100	101 110	111 120	121 130	131 140	141 150	151 160	161 170	171 old
Current acres (thousands)	11	40	16	22	18	32	34	32	15	12	8	3	1	1	0	0	0	0
Current % of type	4.5	16.3	6.6	8.9	7.3	12.9	14	12.9	6.2	4.8	3.3	1.2	0.4	0.2	0.2	0.1	0.1	0.1
RNV minimum % of type	8.8	8.2	7.8	6.3	6.8	4.9	3.5	3.8	4.6	3.5	2.7	2	1.5	1.2	0.9	0.7	0.5	9.2
RNV maximum % of type	15.7	13.7	11.7	8.6	8.4	5.5	3.6	3.8	5	4.2	3.4	2.8	2.3	1.9	1.6	1.3	1.1	24.5
	Breakdown of age class by current cover type area (thousands of acres) (≥ 10k in **bold**)																	
Balsam poplar			1	1.2		0.7		0.1	0.8									
Aspen	4.3	9.9	6.5	4.7	2.5	9.8	5.9	6.1	0.4	1.4	0.1				0.1			
Aspen-spruce-fir	1.7	4.2	2.1	1.2	2.5	3.9	4	5.9	0.4	0.1					0.1			
Paper birch						1.3	1.4	2	0.1	0.3	0.3							
Paper birch-spruce-fir			1.1			1.1	0.4	0.3	0.2		0.1						0.1	
Oak			1.2			1.2	5.9	1.7	3	1.3		0.1						
Jack pine-hardwood	2.4	5.9	0.5	5.2	7.4	6.1	**11.2**	6.1	4.2	1.8	0.4				0.1		0.1	
Jack pine-spruce-fir			0.1	0.1	0.3	1	0.9	1.1										
Balsam fir			0.1	0.2	0.1	0.1	0.1	0.1	0.1									
Balsam fir-hardwood			0.1	1.5	0.2	0.3	1.9	2.7	0.4	0.1	0.9							
Red pine-spruce-fir	0.1	0.4	0.3	0.4	0.2	0.1	0.2	0.2	0.3	0.3	0.1	0.1	0.1					
Red pine-hardwood	1.1	**17.5**	2.2	4.9	2.9	2.2	0.6	0.9	1	3.2	1.7	1.5	0.1	0.1	0.1			
White pine-hardwood										0.1								
White spruce-hardwood	0.1	0.2	0.4	0.5		0.1	0.1											
Northern hardwood			0.1		0.1	0.2	0.2	0.5	0.5	0.6		0.1						
Northern hardwood-con							0.2	0.3	0.2									
Lowland black spruce	0.1	0.1	0.2	0.2	1	1.9	0.4	1.5	2.2	1.3	0.8	0.1	0.3	0.1				
Tamarack		0.2	0.2	1.5	0.5	1.3	0.6	0.4	0.7	0.5	3.2	0.5	0.4	0.2				0.1
Black ash						0.1		1.4	0.2	0.2								
Black ash-conifer						0.1	0.1	0.3	0.2	0.2		0.1						
White cedar								0.1	0.1	0.1		0.1	0.1					
Mixed swamp conifers									0.1	0.1		0.2						
Cut over	1.2	0.3									0.1							
Lowland grass		1.1																
Lowland brush	0.1								0.1									

B

Northern Superior Uplands: A comparison of Range of Natural Variation and current conditions.

Prepared by Terry Brown and Mark White, NRRI,
for the Minnesota Forest Resource Council

February 26, 2002

Interim status of this data

This data is a re-issue of the data presented in 2001, with the following changes: age classes are presented in 10 year intervals, rather than Vegetation Growth Stages, Frelich's type 1 "Sugar maple" is replaced with type 9 "Northern Hardwood".

This data does not include the new FIA data, nor some updates recently received for some county lands. There are still some classification issues with the Lowland Conifer and Rich Swamp types. This re-release is being made to allow people to use a more compact and somewhat updated source — when the new FIA data is released a new version of this report with the most up to date information available will be prepared. It would be very inefficient to completely regenerate the data set prior to the release of the new FIA data.

Ecosystem type classification and the common inventory

The current condition is compared to the Range of Natural Variation (RNV) condition by assigning each stand polygon in the DNR's common inventory data set to the spatially corresponding ecosystem type mapped by White (2000, figure 1). The percent of stands in each ten year age class is then plotted against the RNV from Frelich (2000). The common inventory combines DNR, County and Federal lands. To that we have added FIA data to account for private lands, and stand age information for the BWCAW. The area of the inventory area ("Mapped acres") within each ecosystem type is shown in table 1.

In this version of the analysis Frelich's ecosystem type 1, Sugar Maple, has been replaced with type 9, Northern Hardwood, which better reflects the integration of this type with the rest of the landscape. As in previous versions, Frelich's ecosystem type 8, Jack pine Aspen Oak, is not included, as it exists almost exclusively on the Kabetogamma Peninsula, and is difficult to characterize.

Frelich number	Percent mapped	Mapped acres	Name	System acres
2	88	668886	Mesic white pine-red pine	756966
3	91	642828	Dry-mesic white pine-red pine	706731
4	61	683204	Lowland Conifer	1128056
5	45	71990	Rich swamp	161232
6	81	875113	Mesic birch-aspen-spruce-fir	1075332
7	98	1047592	Jack pine-black spruce	1069905
9	84	244575	Northern hardwoods	290670
			Open water	173305
			Unforested wetland	516521
			Developed land	18409

Table 1: *Between 45 and 98 percent of the area classified for each ecosystem type is included in the inventory data used.*

The composition in each ten year age range is broken down in the tables that follow the succession diagram and current vs. RNV plot for each type.

Older growth stages may contain more stands

When dealing with RNV analysis, many people ask how older Vegetation Growth Stages (VGS) can cover a greater proportion of the landscape than younger VGSs. This is a good question if you're used to dealing with tree age distribution plots. With the growth form specific stages defined by Lee Frelich (the box and arrow diagrams starting on page 5) the main answer is that the VGSs represent different lengths of time, and it's reasonable for a VGS that represents stands 20–100 years after disturbance to contain more stands than a VGS that represents stands 1–20 years years after disturbance, even though all the stands in the older VGS came from the younger VGS.

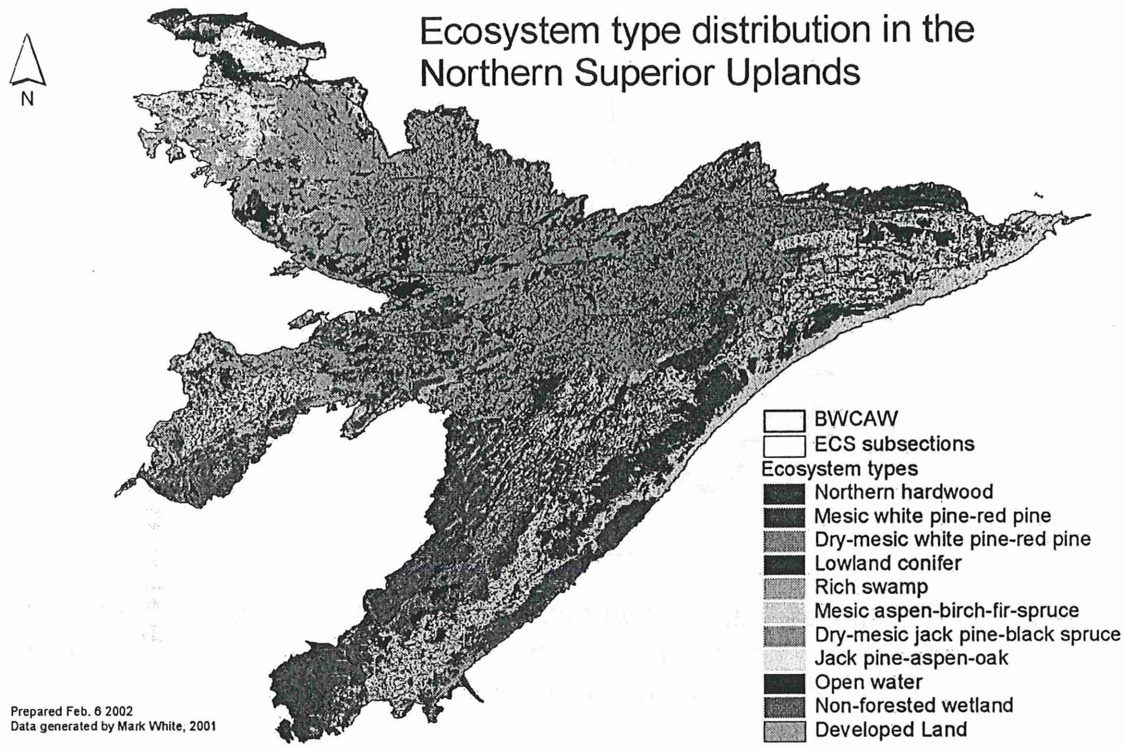


Figure 1: *Ecosystem types delineated by Frelich (2000) for the Northern Superior Uplands section.*

But in the bar-graphs included here, the distribution of stands is broken down into equal (10 year) intervals, and yet there are *still* later stages which contain more stands than earlier stages. This can arise from situations like that shown in figure 2. If movement from VGS 1 to VGS 2 is reasonably rapid (heavy arrow), perhaps due to succession, but movement from VGS 2 to VGS 3 (light arrow) is less rapid, perhaps because ground fire slows succession, and movement from VGS 3 back to VGS 1 is also less rapid, perhaps because of infrequent disturbance, then there is an accumulation of stands in VGS 2. *Remember that a stand can persist much longer than a tree.*

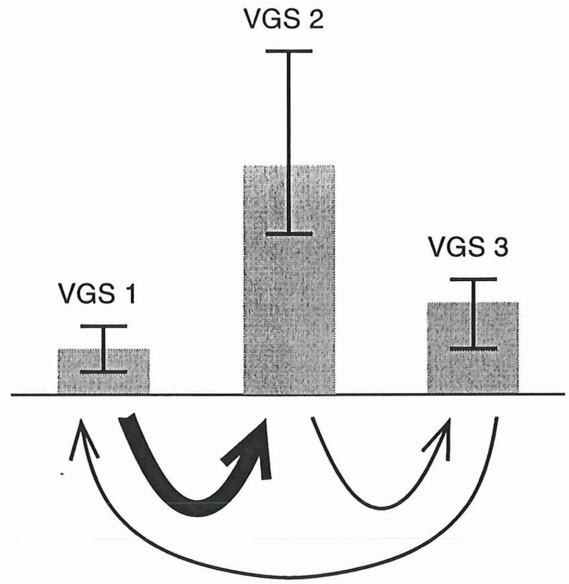


Figure 2: *Older growth stages may contain more stands: here the heavy arrow represents a rapid transfer and the lighter arrows less rapid transfers. The result of such a system would be an accumulation of stands in VGS 2.*

Nature of data

It is important to realize that this data is provisional. Improved data sets and more detailed analyses regularly become available. Exact numbers are subject to change. On the other hand, we believe that this data is a good representation of the current situation overall, and in particular the relationship between the current condition and the RNV is unlikely to be significantly revised. Therefore this information can be used when considering management directions with respect to the RNV.

Questions about that data presented here can be addressed to:

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218 720 2710

References

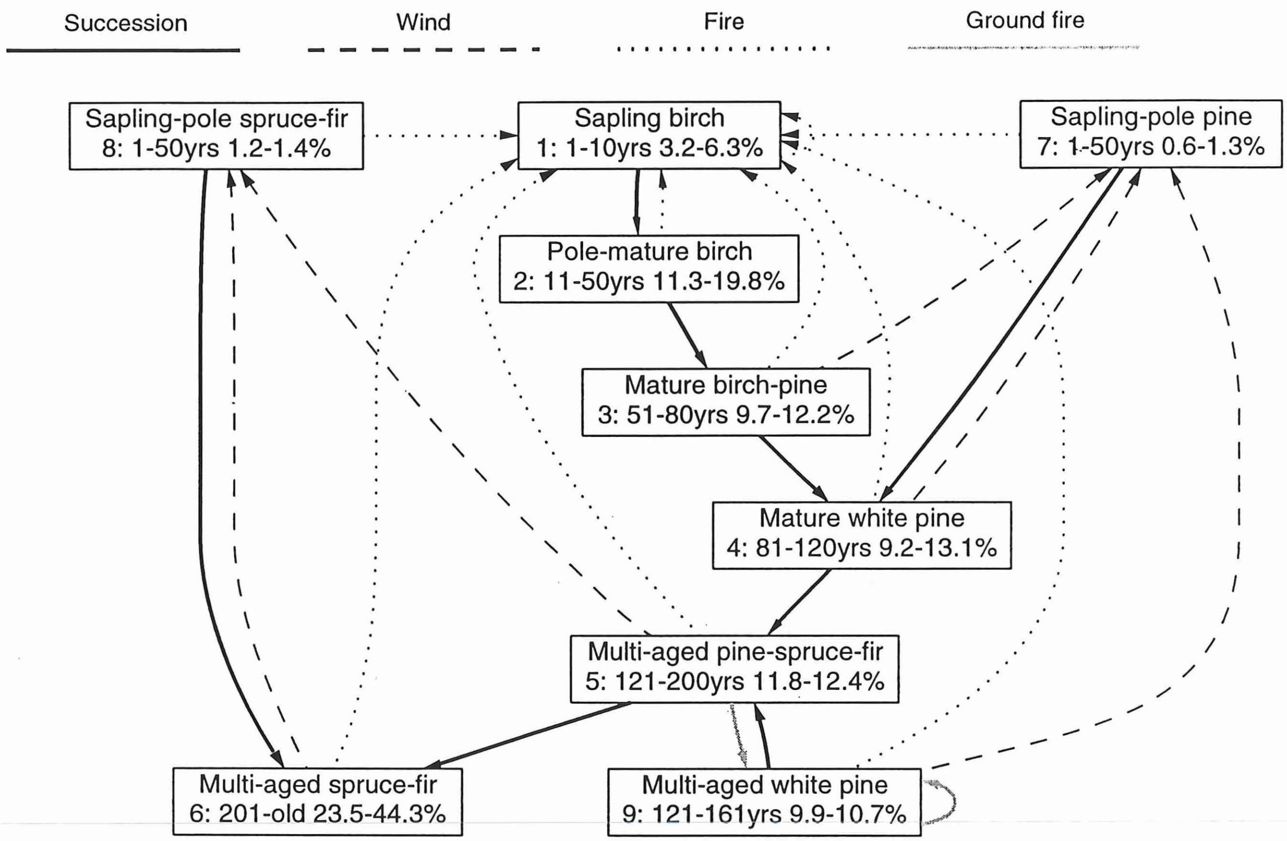
DNR Common Inventory Data Prepared by Chad Skally and others. See http://www.iic.state.mn.us/

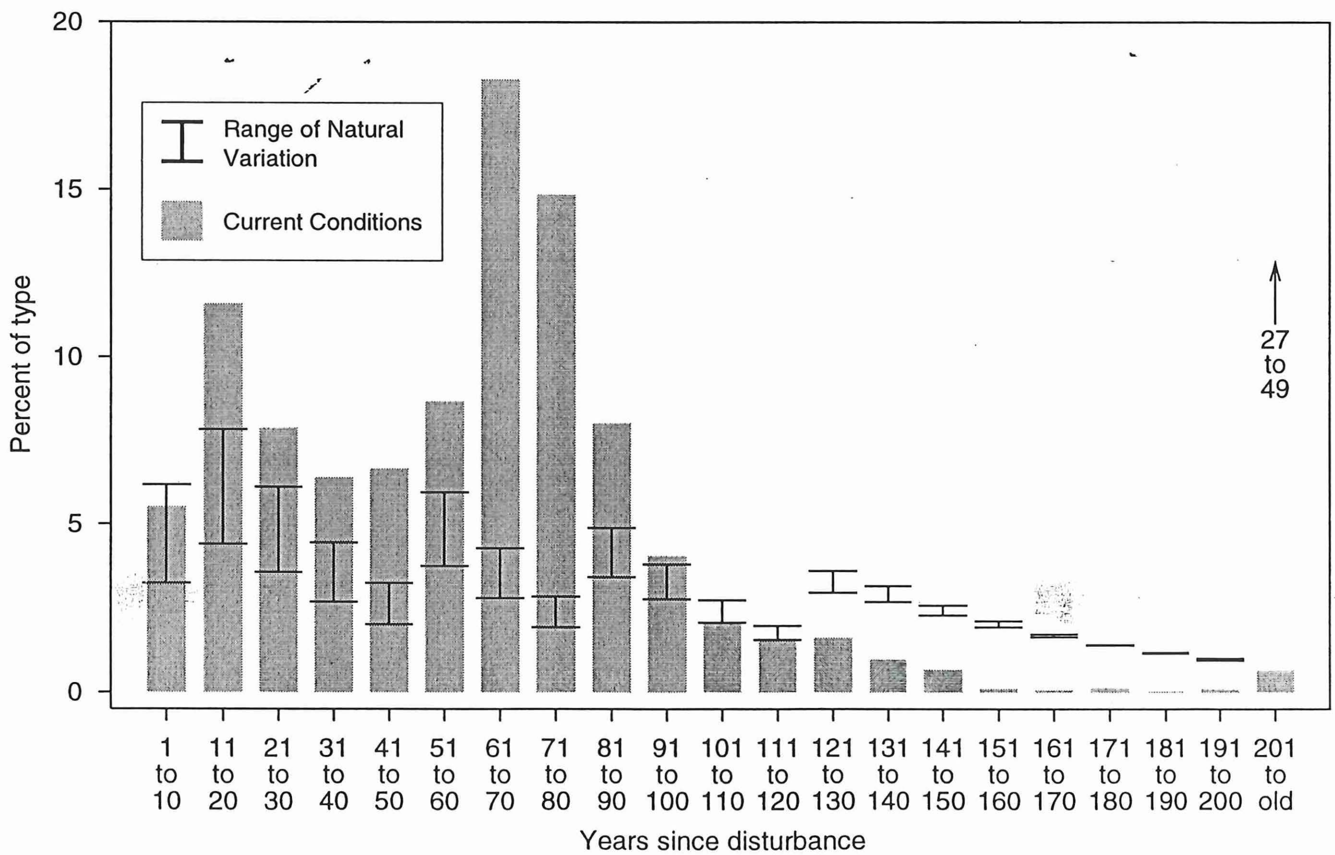
Frelich, L. 2000. Natural Range of Variability estimates for forest vegetation growth stages of Minnesota's Northern Superior Uplands.

White, M. 2000. Minnesota Northern Superior Uplands Natural Vegetation Map.

Frelich type 2: Dry red pine-white pine

Disturbace interval (years) - Wind: 1000-2000 Fire: 150-300 Ground Fire: 40





2: Mesic white and red pine
Percent cover breakdown
See also area breakdown

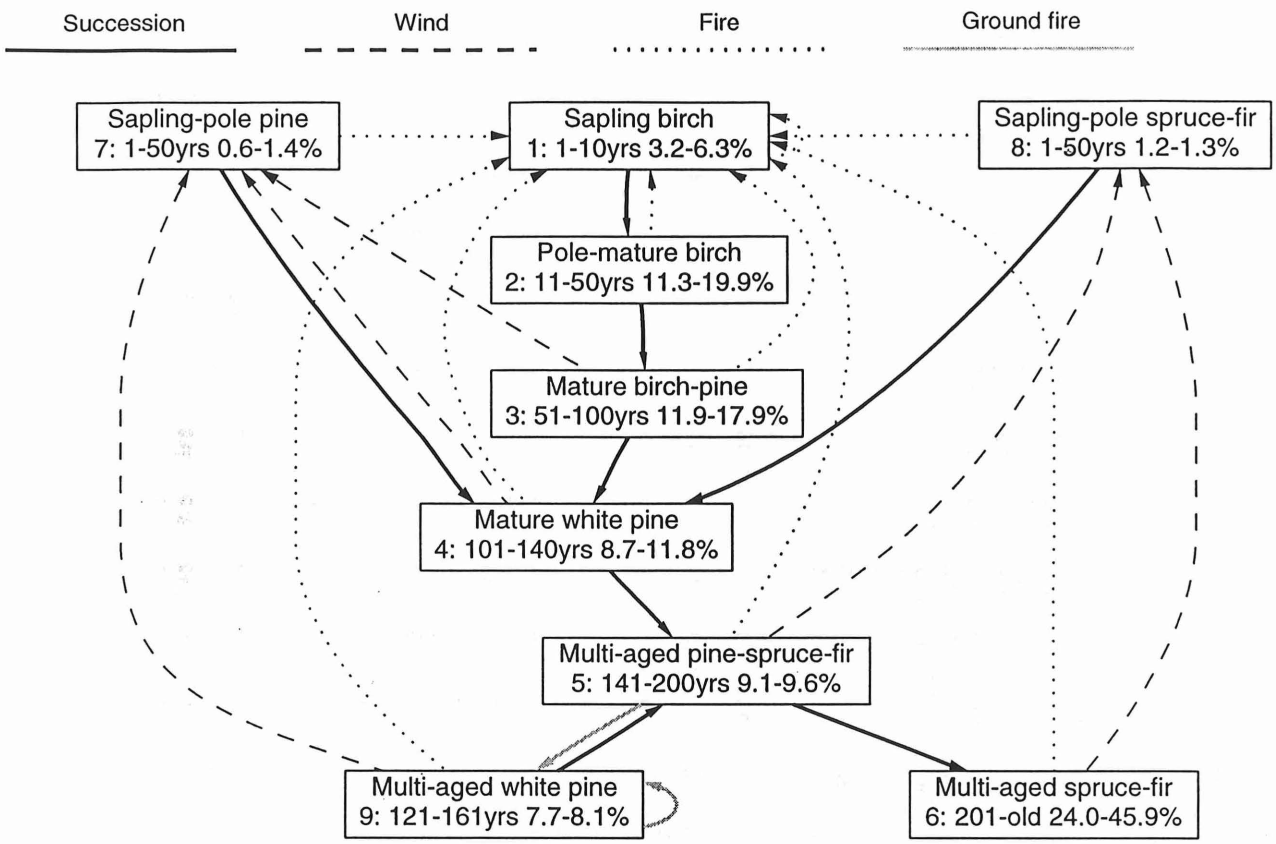
Age (years) from / to	1 10	11 20	21 30	31 40	41 50	51 60	61 70	71 80	81 90	91 100	101 110	111 120	121 130	131 140	141 150	151 160	161 170	171 180	181 190	191 200	201 old
Current acres (thousands)	37	78	53	43	45	58	122	99	54	27	14	11	11	7	5	1	0	1	0	1	4
Current % of type	5.5	11.6	7.9	6.4	6.7	8.7	18.3	14.8	8	4.1	2.1	1.6	1.6	1	0.7	0.1	0.1	0.1	0	0.1	0.7
RNV minimum % of type	3.2	4.4	3.6	2.7	2	3.8	2.8	1.9	3.4	2.8	2.1	1.6	3	2.7	2.3	1.9	1.7	1.4	1.2	1	27.5
RNV maximum % of type	6.2	7.8	6.1	4.5	3.2	6	4.3	2.8	4.9	3.8	2.7	2	3.6	3.2	2.6	2.1	1.7	1.4	1.2	0.9	49.7
	Breakdown of age class by current cover type percent of age class (≥ 10% in **bold**)																				
Balsam poplar		1	4		2	1	2		1	1		**13**	5								
Aspen	**47**	**63**	**56**	**33**	**44**	**30**	**23**	**16**	9	8	6	2	1								
Aspen-spruce-fir	**16**	6	9	**24**	**23**	**28**	**26**	**22**	**24**	**13**	**14**	5	3								
Aspen-birch-spruce-fir	5						1	1	1		2	**14**	**12**	**13**						1	**23**
Aspen-birch	2											5	3	4							1
Paper birch		2	2	3	6	7	**14**	**18**	**12**	8	2	1		1							
Paper birch-spruce-fir					5	5	**12**	**12**	**12**	**13**	8	5	1	3	1		8				
Jack pine	2	3	3	1	1	3	1	1	1	1	2	1	1	3						2	5
Jack pine-hardwood	1		1	1			1	2	1	1	1	1	1								
Spruce-fir	2		1	2	2	3	5	6	4	2	5	1	2	4	1					7	**21**
Spruce-fir-hardwood	2							1			1	4	5	6						9	**14**
Balsam fir	1		3	**11**	1	4	2	2	5	1	1			1							1
Balsam fir-hardwood		1	5	3		5	2	2	2												
Red pine	**10**	7	1					1	1	5	1	5	**26**	**26**						6	**26**
Red pine-spruce-fir										1		1							2		
Red pine-hardwood	1	1	2	7	4	1	2	1	1	3	5	1	2	1							1
White pine	1								1	1	2	1				**11**	5	**11**		**29**	3
White pine-spruce-fir		1									3	**11**		1		1		8		7	1
White pine-hardwood	1							1	4	9	6	3	8	2	1	6	2				
White spruce	2	4	1			1	1	1							1						
White spruce-hardwood	1	1	2	3	3	3	1			1	1	1					2				
Northern hardwood	4	6	3	**10**	2	3	3	7	4	8	6	2	8	2	**25**					3	
Lowland black spruce	1				6	3	2	2	4	4	6	5	3	3	2	5	5	1	2	**14**	
Upland black spruce	1			1				1	1	1	2	1	1								
Tamarack						2		2		1							2				
Black ash		1	7				2	2	8	**10**	3	3	**13**	2	**50**	**13**	4	**19**	7		
Black ash-conifer											1	1									
White cedar		1					1		1	8	**22**	**12**	5	**26**	**17**	**49**	**67**	**49**	**59**	**15**	3
Mixed swamp conifers									2	1	2	1	1	3	2	**16**	4	**12**	**30**	6	
Cut over	1																				

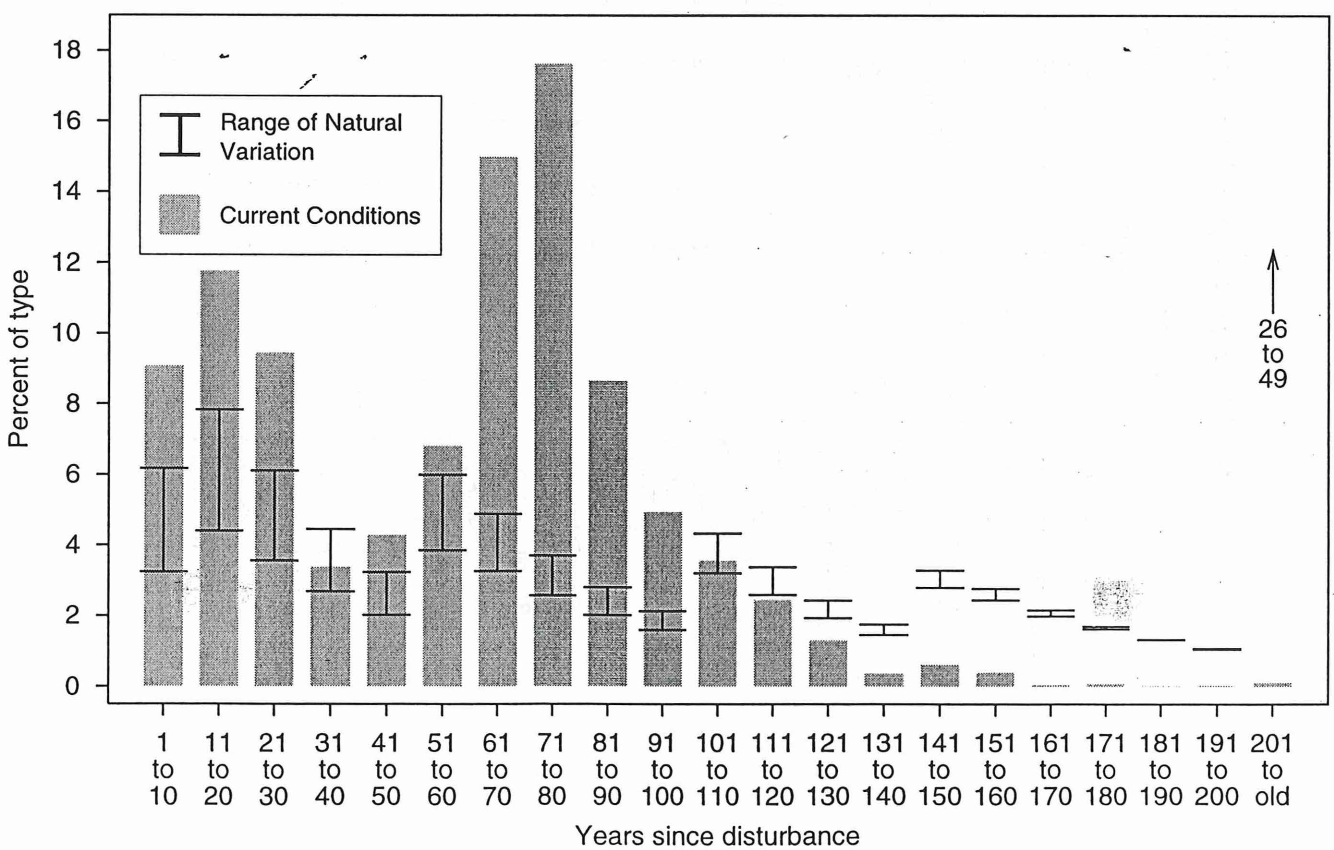
2: Mesic white and red pine
Area breakdown

Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191	201
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	old
Current acres (thousands)	37	78	53	43	45	58	122	99	54	27	14	11	11	7	5	1	0	1	0	1	4
Current % of type	5.5	11.6	7.9	6.4	6.7	8.7	18.3	14.8	8	4.1	2.1	1.6	1.6	1	0.7	0.1	0.1	0.1	0	0.1	0.7
RNV minimum % of type	3.2	4.4	3.6	2.7	2	3.8	2.8	1.9	3.4	2.8	2.1	1.6	3	2.7	2.3	1.9	1.7	1.4	1.2	1	27.5
RNV maximum % of type	6.2	7.8	6.1	4.5	3.2	6	4.3	2.8	4.9	3.8	2.7	2	3.6	3.2	2.6	2.1	1.7	1.4	1.2	0.9	49.7
	Breakdown of age class by current cover type area (thousands of acres) (≥ 10k in **bold**)																				
Balsam poplar		1	1.9		1	0.3	2.3	0.3	0.4	0.2		1.4	0.5								
Aspen	**17.5**	**48.6**	**29.5**	**14.3**	**19.4**	**17.3**	**27.9**	**15.5**	4.9	2.3	0.8	0.3	0.1								
Aspen-spruce-fir	6	5	4.9	**10.4**	**10.4**	**16.5**	**32.1**	**21.3**	**12.7**	3.5	2	0.6	0.4								
Aspen-birch-spruce-fir	1.8						0.9	0.7	0.7		0.2	1.5	1.3	0.9							1
Aspen-birch	0.6		0.1				0.2		0.2			0.5	0.4	0.2							0.1
Paper birch	0.1	1.2	1.2	1.4	2.8	4.2	**17**	**17.7**	6.2	2.2	0.3	0.1									
Paper birch-spruce-fir	0.1		0.1		2.2	2.8	**14.2**	**12.1**	6.6	3.6	1	0.5	0.2	0.2	0.1						
Oak								0.1	0.1												
Jack pine	0.8	2.1	1.4	0.2	0.6	1.8	1.3	0.8	0.6	0.2	0.2	0.1	0.1	0.2							0.2
Jack pine-hardwood	0.3	0.1	0.3	0.6	0.1	0.2	0.8	1.5	0.3	0.2	0.1	0.2	0.1								
Spruce-fir	0.7	0.2	0.3	0.6	0.8	1.7	5.8	6	2.3	0.6	0.7	0.1	0.2	0.3	0.1						0.9
Spruce-fir-hardwood	0.8						0.1	0.5	0.1		0.1	0.5	0.5	0.4						0.1	0.6
Balsam fir	0.4	0.2	1.5	4.6	0.3	2.1	2.8	2.3	2.5	0.3	0.2			0.1							0.1
Balsam fir-hardwood		0.8	2.5	1.1		3.1	2.1	2.1	0.9												
Red pine	3.5	5.8	0.7	0.2	0.1	0.1	0.2	0.6	0.4	1.3	0.2	0.6	2.8	1.7							1.2
Red pine-spruce-fir	0.1			0.1	0.2		0.1	0.1		0.1		0.1									
Red pine-hardwood	0.3	0.4	1	3	1.7	0.6	1.9	1.1	0.6	0.9	0.7	0.1	0.2								
White pine	0.4	0.1					0.1	0.1	0.3	0.3	0.2	0.1				0.1		0.1		0.2	0.1
White pine-spruce-fir		1.1							0.1	0.1	0.4	1.2						0.1			0.1
White pine-hardwood	0.2					0.1	0.2	0.5	2.2	2.3	0.8	0.3	0.9	0.1	0.1						
White spruce	0.9	2.9	0.5	0.2	0.1	0.4	0.8	1.1	0.1	0.1											
White spruce-hardwood	0.2	0.5	1	1.3	1.3	1.5	1.4	0.4	0.2	0.3	0.2	0.1									
Northern hardwood	1.3	4.8	1.4	4.3	0.9	2	3.6	7	2.3	2.2	0.8	0.2	0.8	0.1	1.1						
Lowland black spruce	0.2	0.2	0.2	0.1	2.5	1.5	2.3	1.7	2	1	0.8	0.5	0.3	0.2	0.1					0.1	
Upland black spruce	0.4	0.1	0.2	0.2	0.2	0.2	0.5	0.6	0.6	0.2	0.2	0.1	0.1								
Tamarack		0.1			0.1	1.1		2.4	0.2	0.1											
Black ash		1.1	3.8			0.2	2.1	1.9	4.2	2.7	0.5	0.4	1.4	0.1	2.3	0.1		0.2			
Black ash-conifer								0.1	0.2	0.1	0.1										
White cedar		1.1				0.1	1.6	0.2	0.5	2.3	3	1.3	0.5	1.8	0.8	0.3	0.3	0.4	0.1	0.1	0.1
Mixed swamp conifers			0.1			0.1	0.3	0.4	1.3	0.2	0.3	0.1	0.1	0.2	0.1	0.1		0.1	0.1		
Cut over	0.3	0.2																			
Lowland brush	0.1																				
Water			0.1																		

Frelich type 3: Mesic red pine-white pine

Disturbace interval (years) - Wind: 1000-2000 Fire: 150-300 Ground Fire: 40





3: Dry-mesic white and red pine
Percent cover breakdown
See also area breakdown

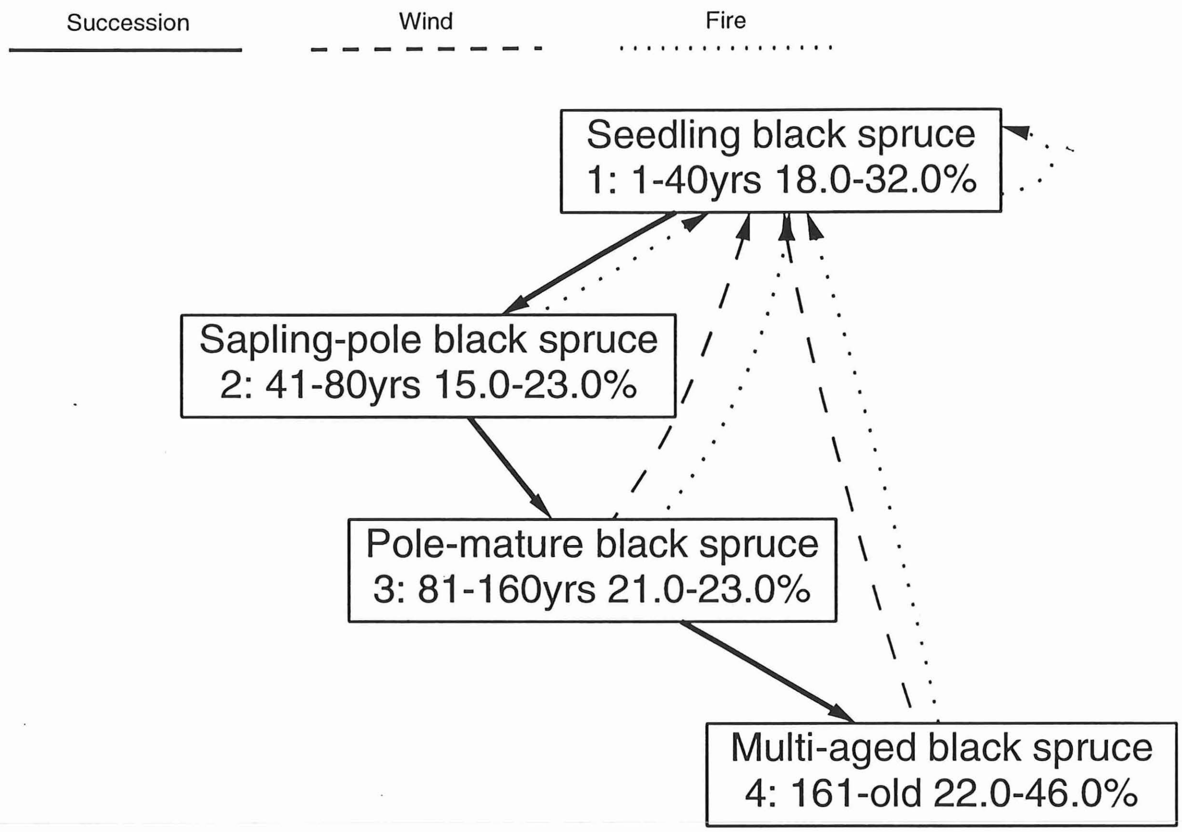
Age (years) from / to	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	101–110	111–120	121–130	131–140	141–150	151–160	161–170	171–180	181–190	191–200	201–old
Current acres (thousands)	58	76	61	22	28	44	96	113	56	32	23	16	8	2	4	3	0	0	0	0	1
Current % of type	9.1	11.8	9.4	3.4	4.3	6.8	15	17.6	8.7	5	3.6	2.5	1.3	0.4	0.6	0.4	0.1	0.1	0	0	0.1
RNV minimum % of type	3.2	4.4	3.6	2.7	2	3.9	3.3	2.6	2	1.6	3.2	2.6	1.9	1.5	2.8	2.5	2	1.6	1.3	1.1	27
RNV maximum % of type	6.2	7.8	6.1	4.5	3.2	6	4.9	3.7	2.8	2.1	4.3	3.4	2.4	1.8	3.3	2.8	2.2	1.7	1.3	1	49.4
Breakdown of age class by current cover type percent of age class (≥ 10% in **bold**)																					
Balsam poplar					4			1				1									
Aspen	**32**	**56**	**46**	**19**	**18**	**23**	**23**	**16**	**13**	7	2	1	1								
Aspen-spruce-fir	**10**	9	**15**	**16**	**42**	**33**	**41**	**26**	**30**	**31**	**24**	5	6			2					
Aspen-birch-spruce-fir	**26**							**13**			3	1	8	**16**				1			**34**
Aspen-birch	2							2			1		4								
Paper birch	2		2			7	2	4	2	6	6			1							
Paper birch-spruce-fir				5	6	4	**13**	8	6	**13**	**10**	9	6	**10**	3	1	**15**				
Oak											1										
Jack pine	**11**	7	2	2	2	2	2	6	3	4	**12**	**11**	3	**12**				**47**			**17**
Jack pine-hardwood	1	1	**10**	6	1	1	2	2	2	2	3	1	1	2							1
Spruce-fir			1	2	1	2	2	2	4	3	1	1	3								8
Spruce-fir-hardwood	2							1			1		4	2							5
Balsam fir		3	2	**10**	9	4	2	3	1		1		**18**								
Balsam fir-hardwood					4			2													
Red pine	5	8	2	1			2	1		1	2	1	2	5			2	3	**11**		9
Red pine-spruce-fir		1					1		1	1	1	1	2				5				
Red pine-hardwood	1	2	6	**16**	4	3	3	2	5	7	**12**	**11**	5	6				**10**			1
White pine	3	1								2	1	1	1	1	1	3	7				
White pine-spruce-fir										1	2	2	5	7							
White pine-hardwood	1							1	5	3	8	**14**	**11**		5	1	**24**	6			1
White spruce	1	4	1																		
White spruce-hardwood	1		1	3	4					1											
Northern hardwood		1	8	4			2	1	5			6									
Lowland black spruce		2	3	6	1	**18**	2	3	**13**	6	4	4	6	6	2	**42**	8	9	**31**	6	4
Upland black spruce	1	1		1	1			1	1	1	1	2	2	2			3	2			5
Tamarack												1									
Black ash		1	2	6	4		2	3	3	2	2	**14**	1	7	4	**42**	4	3	7		7
Black ash-conifer									1				1	1	1	2	**12**	4			
White cedar		2							3	7	3	**12**	9	**20**	**82**	8	**21**	**15**	8	**94**	4
Mixed swamp conifers						1				1	1	1	1	1	2			1	**44**		2

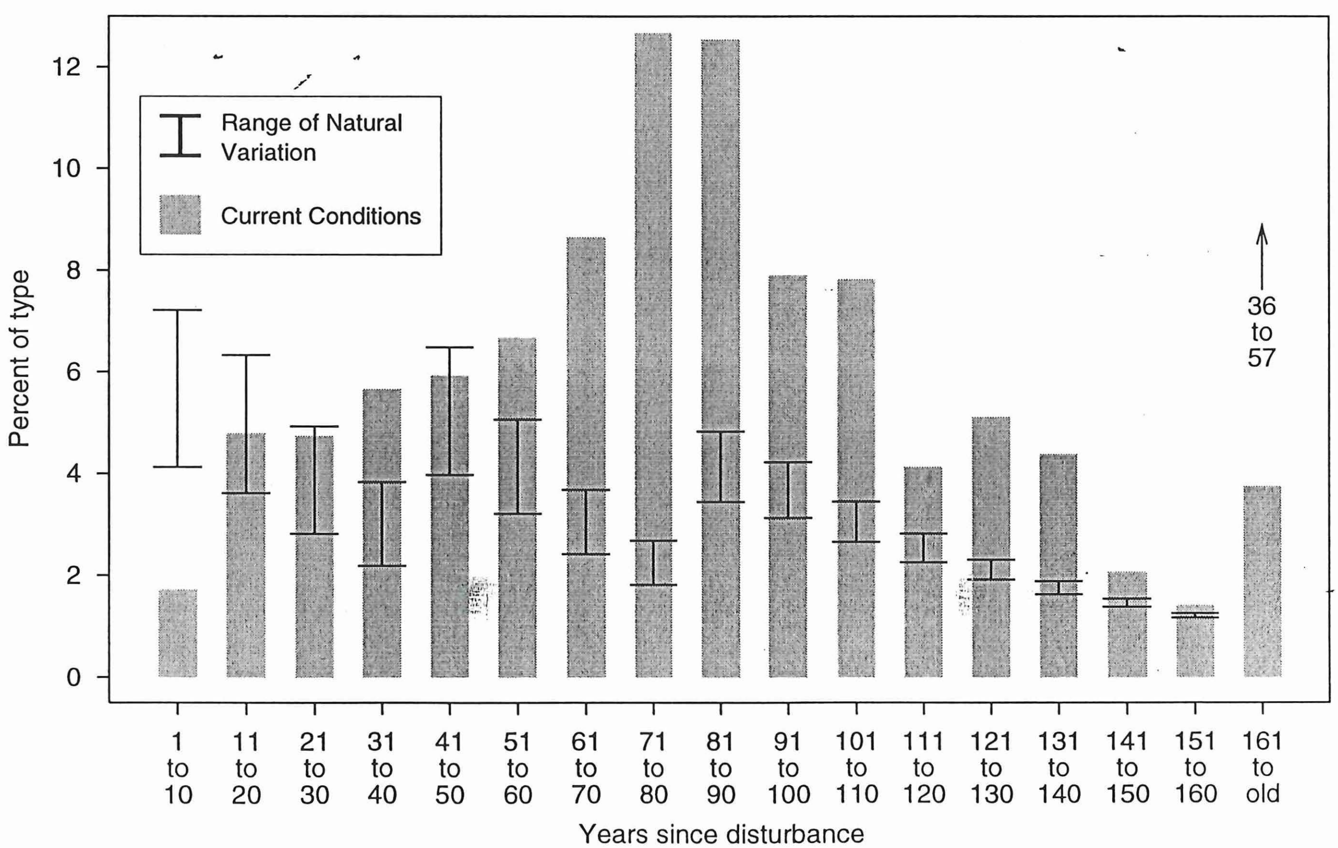
3: Dry-mesic white and red pine
Area breakdown

Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191	201
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	old
Current acres (thousands)	58	76	61	22	28	44	96	113	56	32	23	16	8	2	4	3	0	0	0	0	1
Current % of type	9.1	11.8	9.4	3.4	4.3	6.8	15	17.6	8.7	5	3.6	2.5	1.3	0.4	0.6	0.4	0.1	0.1	0	0	0.1
RNV minimum % of type	3.2	4.4	3.6	2.7	2	3.9	3.3	2.6	2	1.6	3.2	2.6	1.9	1.5	2.8	2.5	2	1.6	1.3	1.1	27
RNV maximum % of type	6.2	7.8	6.1	4.5	3.2	6	4.9	3.7	2.8	2.1	4.3	3.4	2.4	1.8	3.3	2.8	2.2	1.7	1.3	1	49.4
	Breakdown of age class by current cover type area (thousands of acres) (≥ 10k in **bold**)																				
Balsam poplar			0.2		1	0.1	0.4	1.1	0.2			0.1									
Aspen	**18.4**	**42.2**	**27.8**	4.1	5	**10.2**	**21.7**	**17.8**	7.1	2.3	0.4	0.2	0.1								
Aspen-spruce-fir	5.6	7	9.2	3.4	**11.7**	**14.3**	**39.8**	**29.6**	**16.6**	9.9	5.4	0.9	0.5								
Aspen-birch-spruce-fir	**15.3**		0.1	0.1				**15.1**	0.2		0.6	0.1	0.7	0.4							0.2
Aspen-birch	1							2.6			0.1		0.3								
Paper birch	1.1	0.3	1.1			3.1	2.2	3.9	1.2	1.8	1.4	0.1									
Paper birch-spruce-fir	0.1	0.1		1.1	1.6	1.7	**12.1**	9.4	3.5	4	2.4	1.4	0.5	0.2	0.1		0.1				
Oak								0.1			0.2										
Jack pine	6.2	5.1	0.9	0.5	0.5	0.8	2	6.7	1.7	1.3	2.6	1.8	0.3	0.3				0.2			0.1
Jack pine-hardwood	0.6	0.6	5.8	1.4	0.1	0.5	1.9	2.7	1.3	0.7	0.8	0.2	0.1	0.1							
Spruce-fir	0.2	0.2	0.6	0.4	0.3	0.7	2.2	2.7	2.1	0.9	0.3	0.1	0.2								0.1
Spruce-fir-hardwood	1.4							1.6			0.2		0.3								
Balsam fir		2.2	1.3	2.2	2.5	1.9	2.1	3.5	0.6	0.1	0.1		1.5								
Balsam fir-hardwood					1			1.7													
Red pine	3	6.3	1.1	0.3		0.1	1.6	0.6	0.2	0.3	0.4	0.1	0.2	0.1							0.1
Red pine-spruce-fir	0.2	1		0.1		0.1	1.3	0.3	0.4	0.2	0.2	0.2	0.2								
Red pine-hardwood	0.6	1.2	3.8	3.5	1	1.3	2.6	2.7	2.6	2.3	2.7	1.7	0.5	0.2							
White pine	1.6	0.6				0.1	0.2	0.1	0.2	0.7	0.3	0.2	0.1			0.1					
White pine-spruce-fir		0.1						0.1	0.2	0.2	0.4	0.3	0.4	0.2							
White pine-hardwood	0.6	0.1	0.1				0.1	0.6	2.7	0.9	1.8	2.2	0.9		0.2		0.1				
White spruce	0.8	3.1	0.3			0.1	0.3	0.1	0.1	0.1											
White spruce-hardwood	0.3	0.1	0.4	0.6	1.1	0.1	0.4			0.2											
Northern hardwood	0.1	1	4.6	0.9		0.1	1.5	1.2	3	0.1		1									
Lowland black spruce	0.2	1.6	1.9	1.3	0.3	7.8	2	3	7.1	2	1	0.6	0.5	0.2	0.1	1.1					
Upland black spruce	0.4	0.4	0.2	0.3	0.2	0.2	0.3	1.3	0.6	0.3	0.2	0.3	0.2								
Tamarack	0.1	0.1		0.1			0.1	0.4	0.1	0.1		0.1									
Black ash	0.1	0.9	1.1	1.3	1	0.1	1.4	2.8	1.9	0.7	0.4	2.2	0.1	0.2	0.2	1					
Black ash-conifer								0.3	0.3	0.1			0.1								
White cedar	0.1	1.4				0.1		0.2	1.5	2.3	0.6	1.9	0.7	0.5	3.2	0.2	0.1	0.1		0.1	
Mixed swamp conifers					0.1	0.2	0.2	0.3	0.2	0.3	0.3	0.1	0.1		0.1						
Cut over		0.1																			
Upland grass	0.1	0.1						0.4													
Upland brush			0.1	0.1				0.4													
Water			0.1																		

Frelich type 4: Lowland conifer

Disturbace interval (years) - Wind: 1000-2000 Fire: 150-300 Ground Fire: N/A





4: Lowland Conifer

Percent cover breakdown

See also area breakdown

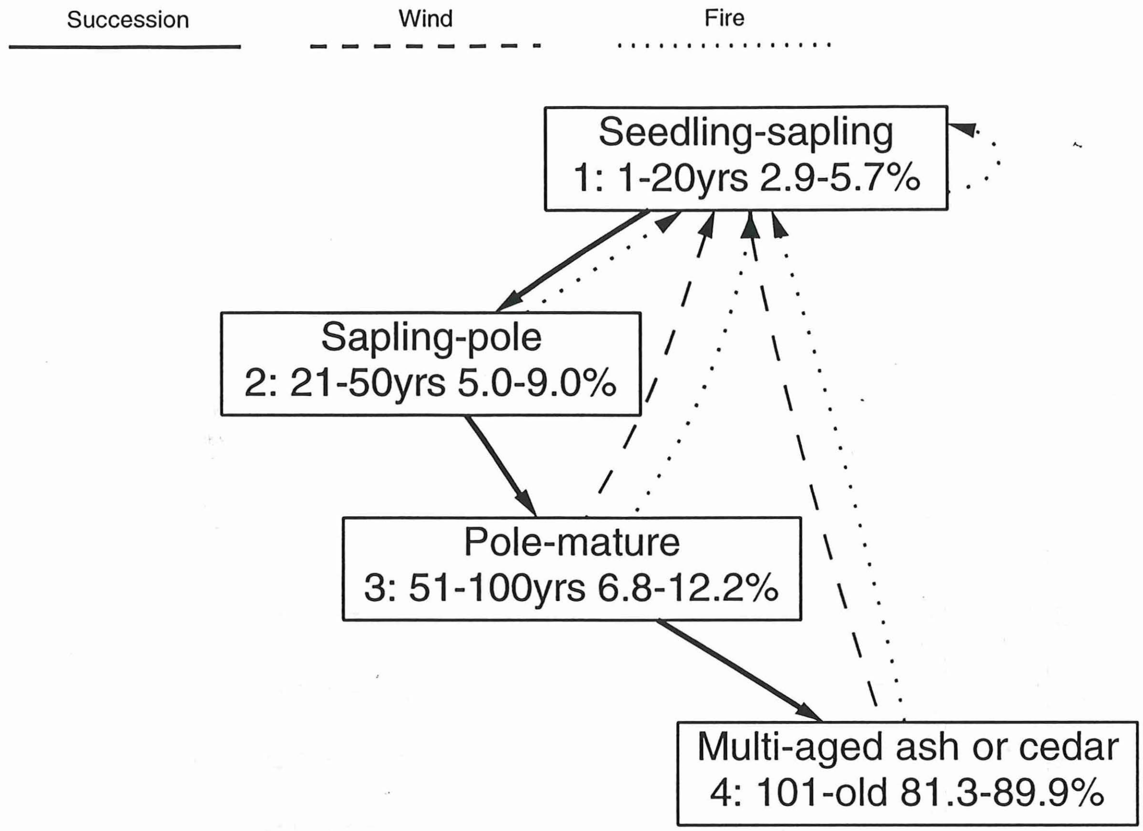
Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	old
Current acres (thousands)	12	33	32	39	41	46	59	87	86	54	53	28	35	30	14	10	26
Current % of type	1.7	4.8	4.7	5.7	5.9	6.7	8.6	12.7	12.5	7.9	7.8	4.1	5.1	4.4	2.1	1.4	3.8
RNV minimum % of type	4.1	3.6	2.8	2.2	4	3.2	2.4	1.8	3.4	3.1	2.7	2.3	1.9	1.6	1.4	1.2	36.5
RNV maximum % of type	7.2	6.3	4.9	3.8	6.5	5.1	3.7	2.7	4.8	4.2	3.5	2.8	2.3	1.9	1.5	1.3	57.7
	Breakdown of age class by current cover type percent of age class (≥ 10% in **bold**)																
Balsam poplar		3	7			3		2									
Aspen	**15**	**24**	**14**	**11**	**12**	8	**14**	4	3	4							
Aspen-spruce-fir	6	1	**13**	4	2	4	**10**	2	4	1							
Aspen-birch-spruce-fir	2							1			1		2	2	1		1
Aspen-birch	1												1	1			
Paper birch			4			1	2	4	2	2							
Paper birch-spruce-fir					3	1	4	1	2	1							
Jack pine	4	1	1	1	1	1	1	2	1	1	2	1	1	3	1		4
Jack pine-hardwood			1	1													
Spruce-fir	1	1	1	1	1	1	2	2	1	1							
Spruce-fir-hardwood	1													1			
Balsam fir	1	2	**11**	**18**	9	**10**	**14**	4	2	2							
Balsam fir-hardwood			8	3	3			1									
Red pine	2	1															
White spruce	1	3	5		3		1										
White spruce-hardwood			1														
Northern hardwood		3		2													
Lowland black spruce	**28**	**26**	**17**	**34**	**45**	**47**	**35**	**45**	**52**	**43**	**45**	**53**	**43**	**28**	**41**	**31**	**20**
Upland black spruce	**16**	1	2	2	2	1	2	5	4	4	8	1	**13**	**15**	4	1	**16**
Tamarack	4	7	5	8	**10**	9	4	8	6	8	6	7	3	6	2	1	3
Black ash	1	**19**	7	**10**		3	1	6	5	5	6	4	2	3	3	4	2
Black ash-conifer	1							2	2	1	1	2	1	1	1	1	1
White cedar	2		1	1	3	5	2	5	5	**19**	**13**	**21**	**25**	**25**	**38**	**51**	**37**
Mixed swamp conifers	6		1	3	5	6	7	6	**11**	7	**16**	9	8	**14**	9	9	**14**
Cut over	3																
Lowland grass	1	3															
Marsh	1																
Lowland brush	3																

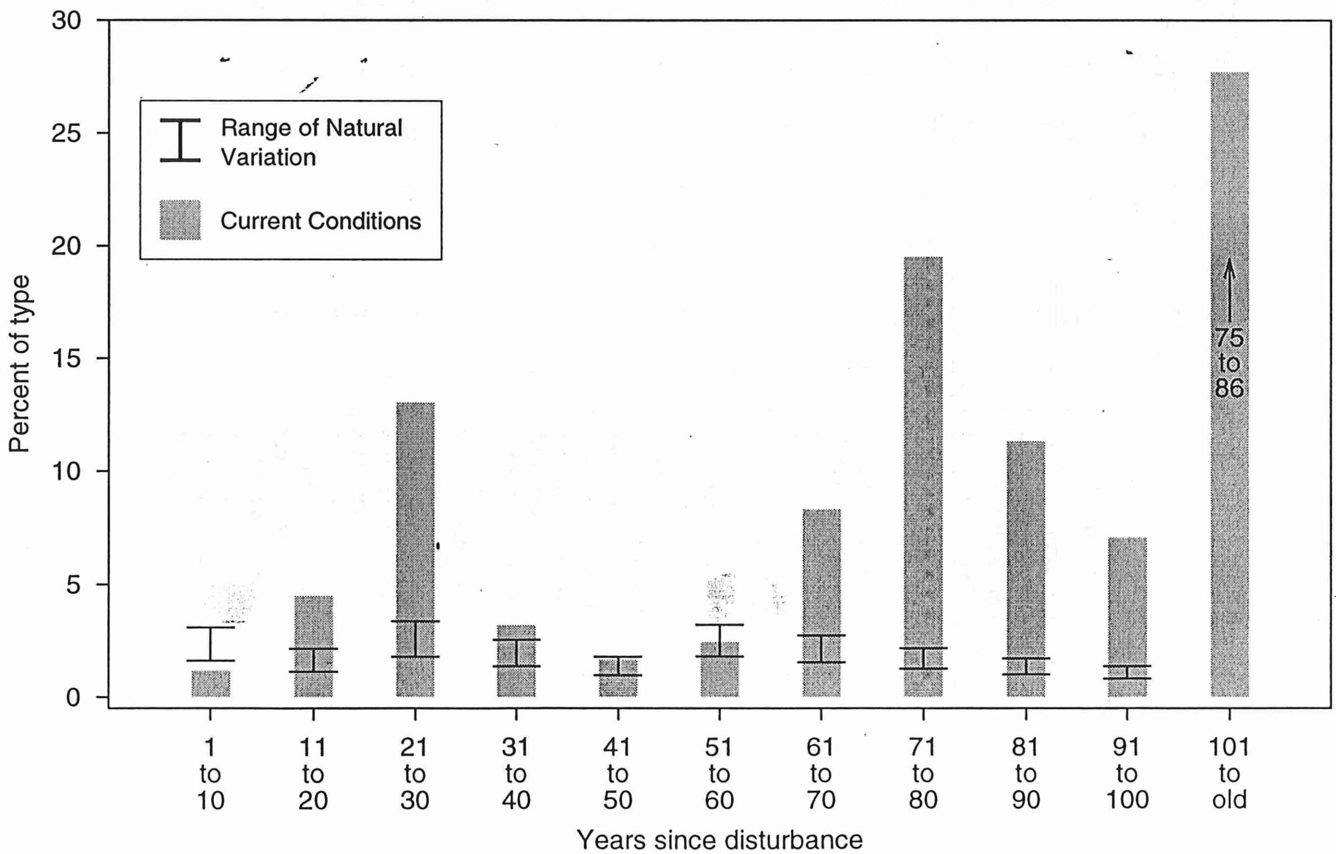
4: Lowland Conifer
Area breakdown

Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	old
Current acres (thousands)	12	33	32	39	41	46	59	87	86	54	53	28	35	30	14	10	26
Current % of type	1.7	4.8	4.7	5.7	5.9	6.7	8.6	12.7	12.5	7.9	7.8	4.1	5.1	4.4	2.1	1.4	3.8
RNV minimum % of type	4.1	3.6	2.8	2.2	4	3.2	2.4	1.8	3.4	3.1	2.7	2.3	1.9	1.6	1.4	1.2	36.5
RNV maximum % of type	7.2	6.3	4.9	3.8	6.5	5.1	3.7	2.7	4.8	4.2	3.5	2.8	2.3	1.9	1.5	1.3	57.7
	Breakdown of age class by current cover type area (thousands of acres) (≥ 10k in **bold**)																
Balsam poplar		1	2.4			1.3	0.2	1.8	0.2	0.1							
Aspen	1.8	7.7	4.6	4.3	4.7	3.6	8.2	3.6	2.8	2.1	0.2	0.1					
Aspen-spruce-fir	0.7	0.3	4.3	1.5	0.6	1.9	6.1	1.4	3	0.3	0.1	0.1					0.1
Aspen-birch-spruce-fir	0.2			0.1	0.2			0.7	0.1	0.1	0.3	0.1	0.6	0.7	0.1		0.3
Aspen-birch	0.1		0.1		0.1						0.1		0.2	0.1			
Paper birch			1.1		0.1	0.2	1	3.2	1.8	1.3	0.1	0.1					
Paper birch-spruce-fir				0.1	1.1	0.3	2.4	0.8	1.5	0.3	0.1	0.1	0.1				
Jack pine	0.5	0.4	0.3	0.2	0.4	0.3	0.4	2.1	0.7	0.4	1	0.1	0.5	0.8	0.2		0.9
Jack pine-hardwood		0.1	0.2	0.3		0.1	0.2	0.2	0.2	0.2							
Spruce-fir	0.1	0.2	0.3	0.3	0.3	0.4	1.3	1.7	1.1	0.6	0.1	0.1	0.1				0.1
Spruce-fir-hardwood	0.1			0.1				0.1			0.1		0.1	0.3			0.1
Balsam fir	0.1	0.5	3.6	7.1	3.6	4.4	8.3	3.1	2.1	1.1	0.2	0.1					0.1
Balsam fir-hardwood			2.6	1.1	1.1			1.1									
Red pine	0.2	0.4	0.1	0.1			0.1		0.2	0.1		0.1					0.1
Red pine-hardwood		0.1		0.1	0.1		0.1										
White spruce	0.1	1.1	1.7	0.1	1.1	0.2	0.4	0.1	0.1	0.1		0.1					
White spruce-hardwood		0.1	0.2	0.1			0.2			0.1							
Northern hardwood		0.9		0.8		0.1	0.1	0.2	0.1	0.2	0.1						
Lowland black spruce	3.3	8.6	5.6	**13.3**	**18.3**	**21.3**	**20.9**	**38.6**	**44.4**	**23.2**	**24.2**	**14.8**	**15**	8.5	5.8	3	5.2
Upland black spruce	1.8	0.4	0.6	0.7	0.9	0.7	0.9	3.9	3.2	2	4.3	0.4	4.6	4.6	0.5	0.1	4
Tamarack	0.4	2.2	1.7	3.1	4.2	3.9	2.1	6.8	4.9	4.3	3.3	2	1.2	1.7	0.3	0.1	0.7
Black ash	0.1	6.3	2.2	3.8	0.1	1.3	0.7	5.4	3.9	2.5	3	1.2	0.6	0.8	0.4	0.4	0.6
Black ash-conifer	0.2					0.1	0.2	1.3	1.5	0.7	0.5	0.4	0.4	0.3	0.2	0.1	0.2
White cedar	0.2		0.1	0.4	1.4	2.5	1.1	4.7	4.5	**10.3**	7	5.9	8.6	7.5	5.4	5	9.5
Mixed swamp conifers	0.8	0.1	0.4	1.1	2	2.8	4.1	5.5	9.1	3.9	8.6	2.5	2.6	4.3	1.2	0.9	3.6
Cut over	0.4	0.1															
Upland grass			0.1														
Lowland grass	0.1	1.1															
Marsh	0.1																
Lowland brush	0.3							0.1									
Water			0.1														

Frelich type 5: Rich swamp

Disturbace interval (years) - Wind: 1000-2000 Fire: 500-1000 Ground Fire: N/A





5: Rich Swamp
Percent cover breakdown
See also area breakdown

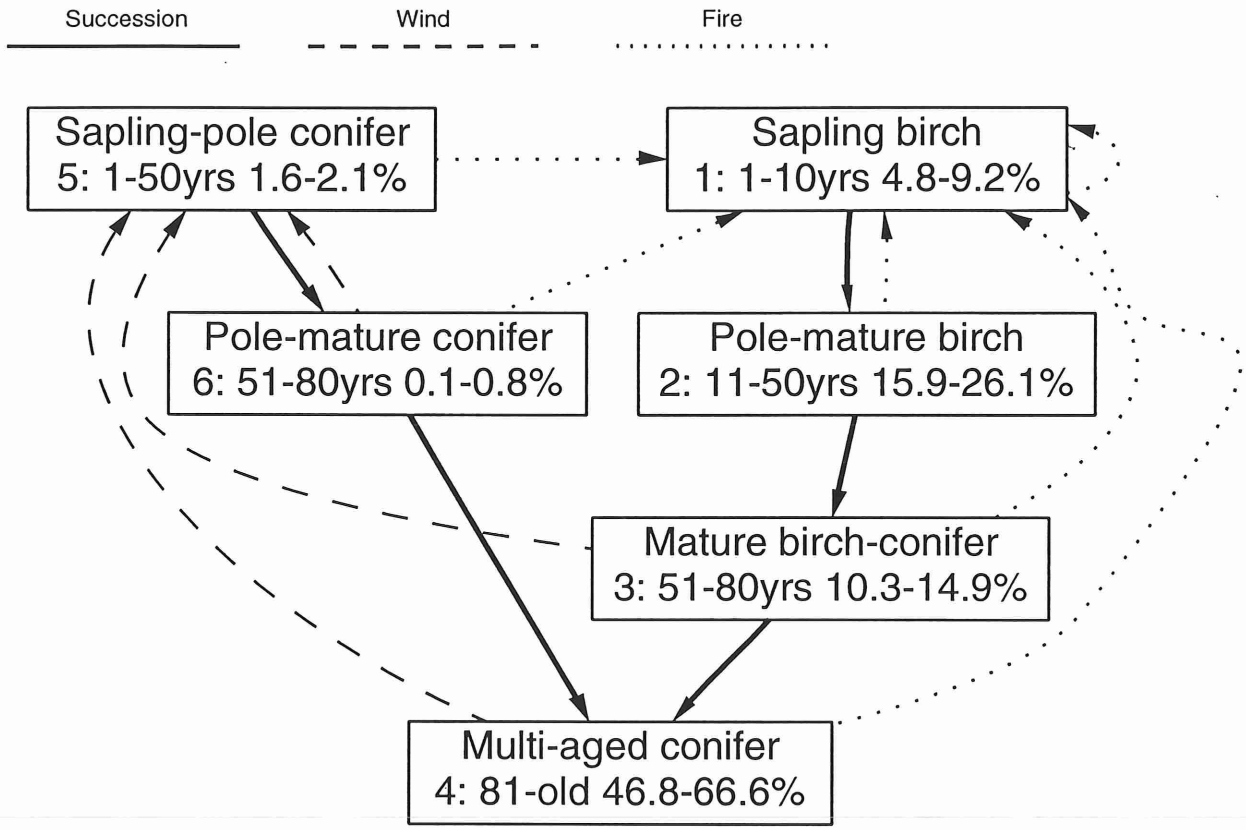
Age (years) from / to	1 / 10	11 / 20	21 / 30	31 / 40	41 / 50	51 / 60	61 / 70	71 / 80	81 / 90	91 / 100	101 / old
Current acres (thousands)	1	3	9	2	1	2	6	14	8	5	20
Current % of type	1.2	4.5	13	3.2	1.6	2.4	8.3	19.5	11.4	7.1	27.7
RNV minimum % of type	1.6	1.1	1.8	1.4	1	1.8	1.6	1.3	1	0.8	75.3
RNV maximum % of type	3.1	2.1	3.4	2.5	1.8	3.2	2.7	2.2	1.7	1.4	86.5
	Breakdown of age class by current cover type percent of age class (≥ 10% in **bold**)										
Balsam poplar	6	**34**	**26**	**53**		4	2	1	1	1	
Aspen	**20**	**11**	**44**	3	3	8	5	9	2	1	
Aspen-spruce-fir	5	1	**22**		6	**14**	4	1	1		
Aspen-birch-spruce-fir	5										
Aspen-birch	1										
Paper birch		**34**			2	2	1	6		1	
Paper birch-spruce-fir						2	1	1			
Jack pine	5	1						1			
Jack pine-hardwood	1	1						1			
Spruce-fir		1		1	5		1	1	1		
Balsam fir		1	2	6	**12**	3	3	2	2	1	
Balsam fir-hardwood							**23**				
Red pine	2	1	1								
Red pine-spruce-fir	1				1						
Red pine-hardwood					1						
White pine	1										
White pine-hardwood	1										
White spruce		1			1		**20**				
White spruce-hardwood							1				
Northern hardwood										1	1
Lowland black spruce	**31**	8	4	**25**	**43**	**49**	**27**	**30**	**47**	**53**	**34**
Upland black spruce	3			1			1	2			
Tamarack	7	2		9	3	6	1	5	4	2	1
Black ash	1	2		2	4	1	4	5	9	**11**	7
Black ash-conifer	1				9	4	1	2	4	5	5
White cedar	1	1			8	6	3	**28**	**19**	**23**	**47**
Mixed swamp conifers	3				3		2	4	9	1	4
Cut over		1									
Lowland brush	4			1							
Water			1								

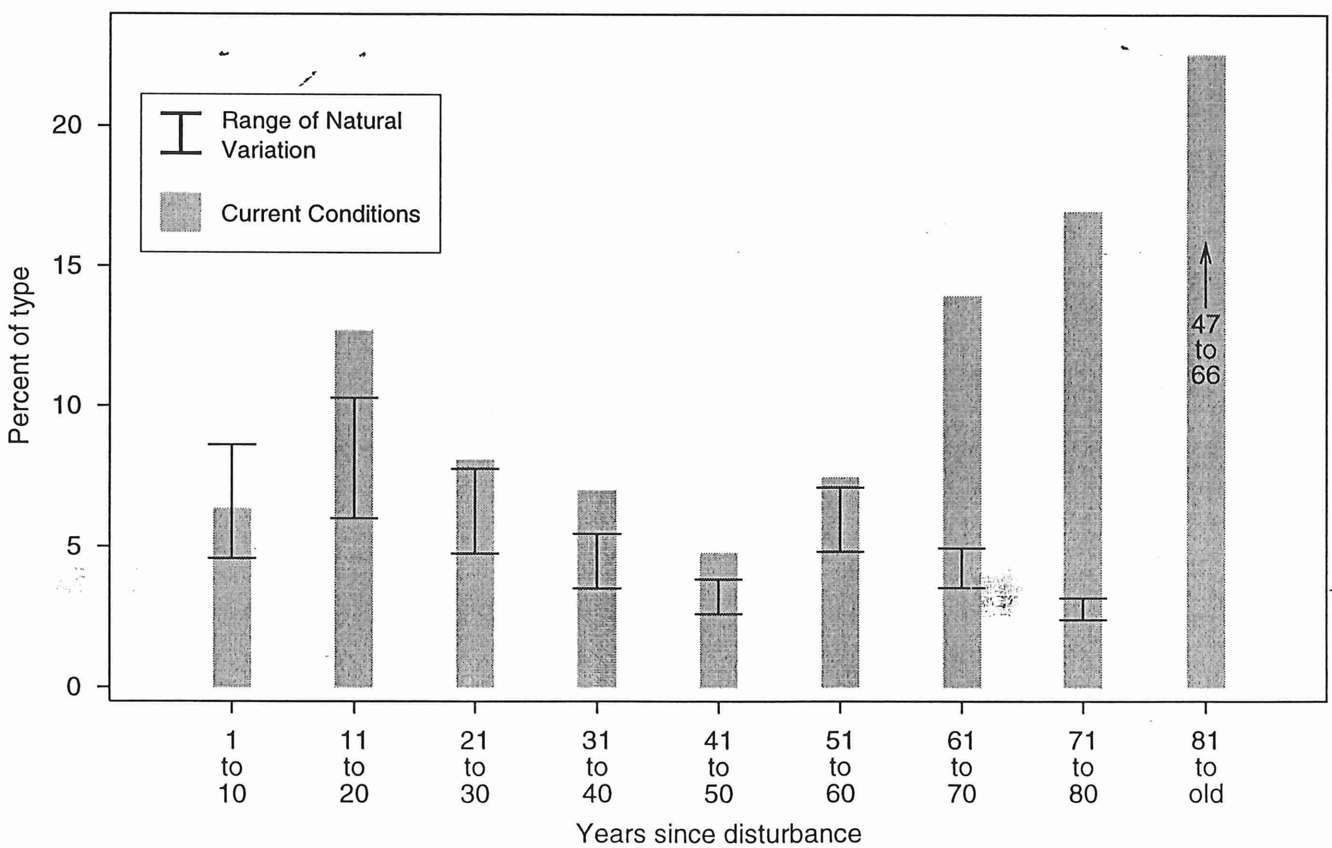
5: Rich Swamp
Area breakdown

Age (years) from	1	11	21	31	41	51	61	71	81	91	101
to	10	20	30	40	50	60	70	80	90	100	old
Current acres (thousands)	1	3	9	2	1	2	6	14	8	5	20
Current % of type	1.2	4.5	13	3.2	1.6	2.4	8.3	19.5	11.4	7.1	27.7
RNV minimum % of type	1.6	1.1	1.8	1.4	1	1.8	1.6	1.3	1	0.8	75.3
RNV maximum % of type	3.1	2.1	3.4	2.5	1.8	3.2	2.7	2.2	1.7	1.4	86.5
	Breakdown of age class by current cover type area (thousands of acres) (≥ 10k in **bold**)										
Balsam poplar		1.1	2.4	1.2		0.1	0.1	0.2	0.1		
Aspen	0.2	0.4	4.1	0.1		0.1	0.3	1.3	0.2		
Aspen-spruce-fir			2		0.1	0.2	0.2	0.1	0.1		0.1
Aspen-birch								0.1			
Paper birch		1.1					0.1	0.9			
Paper birch-spruce-fir							0.1	0.1			
Jack pine								0.1			
Jack pine-hardwood								0.1			
Spruce-fir					0.1			0.1	0.1		
Balsam fir			0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.1	
Balsam fir-hardwood							1.4				
Red pine			0.1								
White spruce							1.2				
White spruce-hardwood							0.1				
Northern hardwood										0.1	0.2
Lowland black spruce	0.3	0.3	0.4	0.6	0.5	0.9	1.6	4.3	3.9	2.7	6.7
Upland black spruce								0.3			
Tamarack	0.1	0.1		0.2		0.1	0.1	0.7	0.3	0.1	0.3
Black ash		0.1			0.1		0.2	0.7	0.7	0.5	1.5
Black ash-conifer					0.1	0.1	0.1	0.3	0.3	0.2	1
White cedar					0.1	0.1	0.2	3.9	1.5	1.2	9.3
Mixed swamp conifers							0.1	0.6	0.7		0.7

Frelich type 6: Mesic birch-aspen-spruce-fir

Disturbace interval (years) - Wind: 1000-2000 Fire: 100-200 Ground Fire: N/A





6: Mesic birch-aspen-spruce-fir
Percent cover breakdown
See also area breakdown

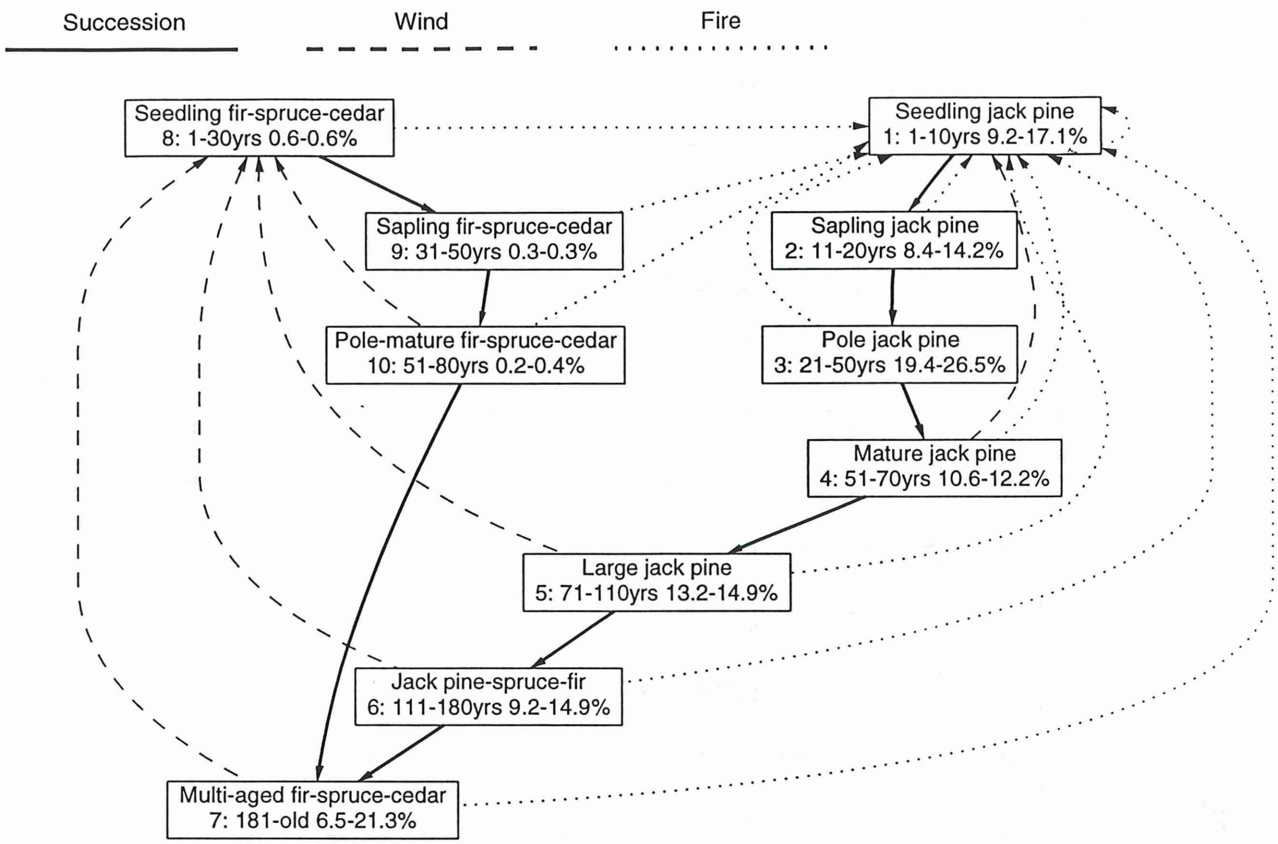
Age (years) from	1	11	21	31	41	51	61	71	81
to	10	20	30	40	50	60	70	80	old
Current acres (thousands)	55	111	71	61	42	65	122	149	198
Current % of type	6.3	12.7	8.1	7	4.8	7.5	14	17	22.6
RNV minimum % of type	4.6	6	4.8	3.5	2.6	4.9	3.6	2.4	47.1
RNV maximum % of type	8.6	10.3	7.8	5.5	3.9	7.1	5	3.2	66.8
	Breakdown of age class by current cover type percent of age class (≥ 10% in **bold**)								
Balsam poplar	1	1	5	9	1		3	1	1
Aspen	**51**	**51**	**45**	**27**	**39**	**34**	**17**	**12**	9
Aspen-spruce-fir	**15**	2	7	**14**	**27**	**18**	**20**	**20**	**13**
Aspen-birch-spruce-fir	2		1	1	1		2	4	3
Aspen-birch				2					1
Paper birch	3	5	4	2	4	9	**11**	**14**	9
Paper birch-spruce-fir	1			1	7	5	**10**	**13**	9
Jack pine	5	3	1	1	1	1	1	4	3
Jack pine-hardwood	1	1	3		1		1	1	1
Spruce-fir	2	1	1	2	4	6	7	**10**	6
Spruce-fir-hardwood	2							3	2
Balsam fir	3	6	1	3	3	4	9	3	3
Balsam fir-hardwood				9			4	2	
Red pine	3	7	1				1		1
Red pine-hardwood		2	3	7	4		2		
White pine	1								1
White pine-spruce-fir	1								1
White pine-hardwood									2
White spruce	2	**14**	4	1	1	1	1		
White spruce-hardwood	1	1	**10**	**13**	4	1	1	1	1
Northern hardwood	3	3	4	2	2	**12**	2	4	8
Lowland black spruce	1	3	1	1	1	7	3	2	3
Upland black spruce	1	1	1	1	1	1	2	2	2
Tamarack				2			1		
Black ash			7	4			4	5	7
White cedar								1	**13**
Mixed swamp conifers							1		3
Cut over	1	1							

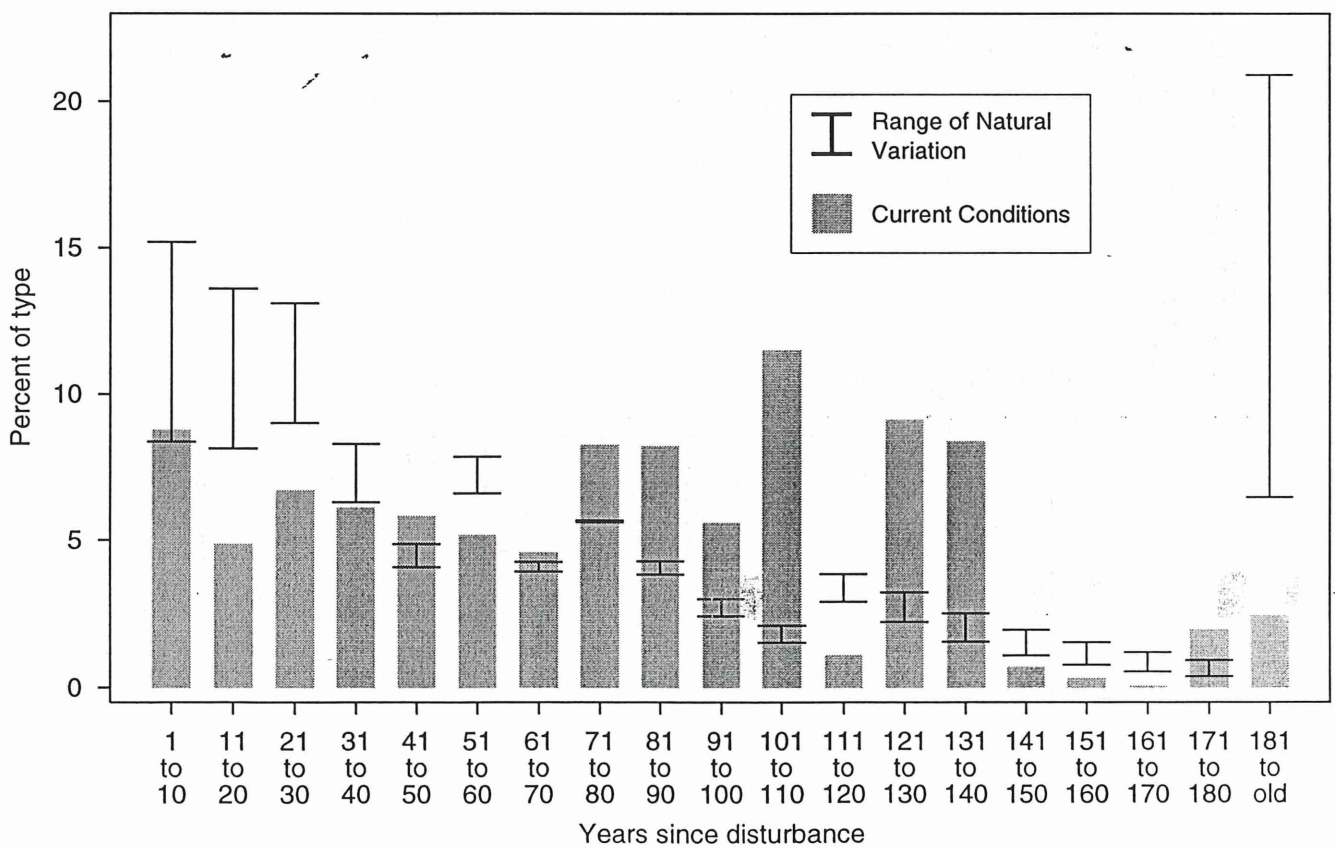
6: Mesic birch-aspen-spruce-fir
Area breakdown

Age (years) from	1	11	21	31	41	51	61	71	81
to	10	20	30	40	50	60	70	80	old
Current acres (thousands)	55	111	71	61	42	65	122	149	198
Current % of type	6.3	12.7	8.1	7	4.8	7.5	14	17	22.6
RNV minimum % of type	4.6	6	4.8	3.5	2.6	4.9	3.6	2.4	47.1
RNV maximum % of type	8.6	10.3	7.8	5.5	3.9	7.1	5	3.2	66.8
	Breakdown of age class by current cover type area (thousands of acres) (≥ 10k in **bold**)								
Balsam poplar	0.6	1.4	3.5	5.4	0.3	0.3	3.4	1	1.4
Aspen	**28.1**	**56.8**	**31.8**	**16.4**	**16.5**	**22.3**	**21.1**	**17.4**	**17.9**
Aspen-spruce-fir	8	2.1	5.2	8.3	**11.2**	**11.6**	**24.6**	**30**	**25.1**
Aspen-birch-spruce-fir	0.8		0.7	0.8	0.2	0.1	1.8	6	5.4
Aspen-birch	0.2		0.1	1.2			0.2	0.6	1.3
Paper birch	1.5	5	3.1	1.2	1.8	5.9	**13.5**	**20**	**17.3**
Paper birch-spruce-fir	0.5	0.1		0.7	2.9	3.4	**12**	**18.7**	**17.7**
Jack pine	2.5	2.9	0.6	0.4	0.5	0.5	0.8	5.3	5
Jack pine-hardwood	0.5	0.7	1.8	0.2	0.2	0.2	0.9	0.7	1
Spruce-fir	1.3	0.7	1	1.1	1.5	4	8.6	**14.7**	**11.8**
Spruce-fir-hardwood	0.8			0.1			0.3	4.1	3.1
Balsam fir	1.8	6.4	0.4	1.5	1.1	2.3	**10.6**	5.1	5.6
Balsam fir-hardwood				5.6			4.5	2.5	
Red pine	1.8	7.6	1	0.2	0.1	0.1	0.6	0.2	2.7
Red pine-spruce-fir					0.1		0.1		0.1
Red pine-hardwood	0.1	2.1	1.9	4.2	1.5	0.3	2.4	0.2	0.5
White pine	0.7	0.1						0.1	0.9
White pine-spruce-fir	0.8						0.1	0.1	2.2
White pine-hardwood	0.2					0.1		0.3	3.3
White spruce	1.1	**15.5**	3.1	0.4	0.2	0.4	1.1	0.5	0.7
White spruce-hardwood	0.5	1.5	7.1	8	1.8	0.5	1.1	0.7	2.4
Northern hardwood	1.9	3.3	3.1	1.1	1	7.6	2.7	6.5	**15.8**
Lowland black spruce	0.3	3.2	0.7	0.5	0.4	4.3	3.3	2.6	6.4
Upland black spruce	0.3	0.6	0.6	0.6	0.4	0.7	2	2.7	4.1
Tamarack		0.1	0.1	1.1			1	0.1	0.2
Black ash			4.7	2.3		0.2	4.3	6.7	**14.3**
Black ash-conifer									0.1
White cedar				0.1		0.2	0.4	0.8	**25.8**
Mixed swamp conifers	0.1		0.1	0.1	0.1	0.3	0.7	0.5	5.4
Cut over	0.4	0.8	0.1						
Upland grass	0.1		0.1					0.3	0.1
Lowland grass	0.1								
Upland brush	0.1		0.2				0.1	0.1	0.2
Lowland brush	0.2	0.1							0.1

Frelich type **7: Jack pine-black spruce**

Disturbace interval (years) - Wind: 1000-2000 Fire: 50-100 Ground Fire: N/A





7: Jack pine-black spruce
Percent cover breakdown

See also area breakdown

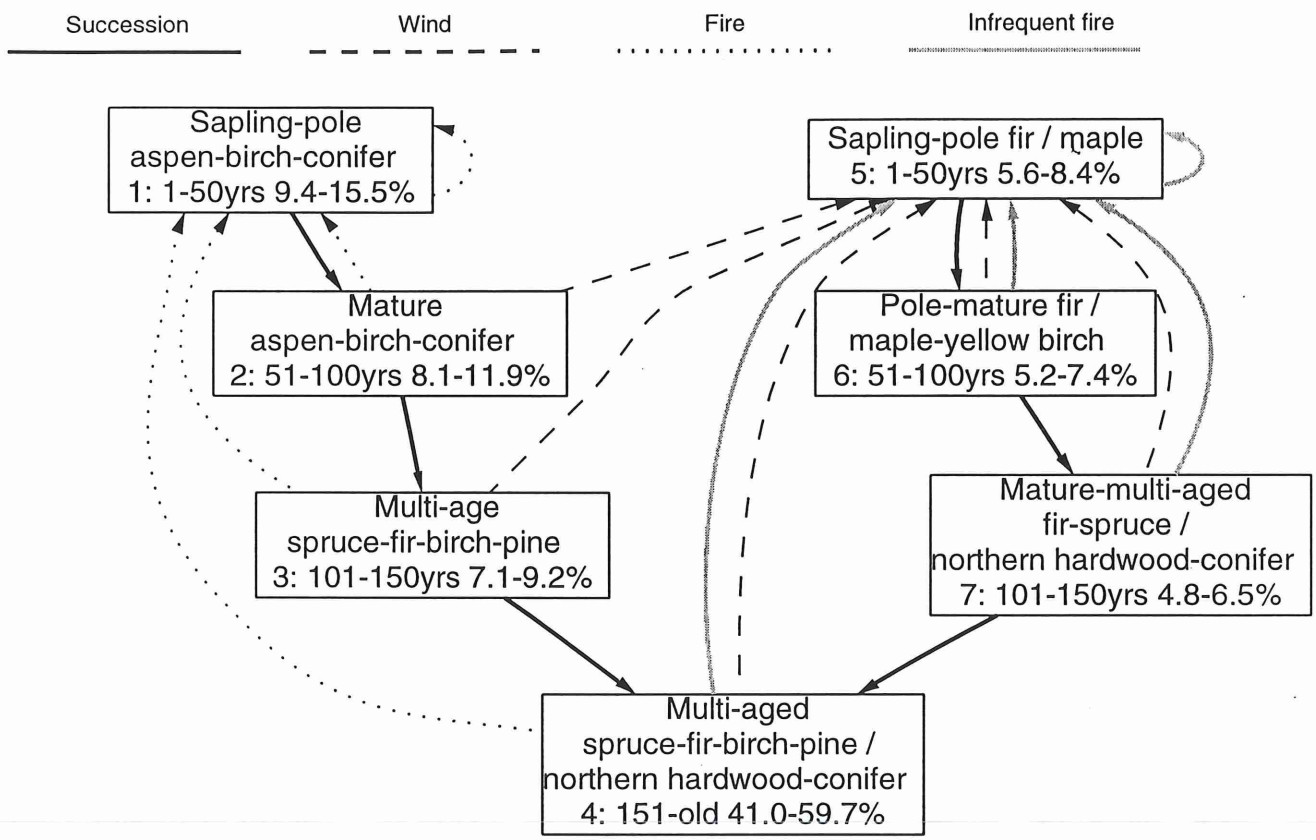
Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	old
Current acres (thousands)	92	51	70	64	61	54	48	87	86	59	121	12	96	88	7	4	1	21	26
Current % of type	8.8	4.9	6.7	6.1	5.8	5.2	4.6	8.3	8.2	5.6	11.5	1.1	9.1	8.4	0.7	0.3	0.1	2	2.5
RNV minimum % of type	8.4	8.1	9	6.3	4.1	6.6	3.9	5.6	3.8	2.4	1.5	2.9	2.2	1.6	1.1	0.8	0.5	0.4	6.5
RNV maximum % of type	15.2	13.6	13.1	8.3	4.9	7.9	4.3	5.7	4.3	3	2.1	3.9	3.2	2.5	2	1.5	1.2	0.9	20.9
	Breakdown of age class by current cover type percent of age class (≥ 10% in **bold**)																		
Aspen	**11**	**45**	**25**	7	6	5	9	7	7	4	4	2							
Aspen-spruce-fir	4	6	**14**	9	**12**	**18**	**34**	**22**	**18**	**12**	4	**12**	1			1			1
Aspen-birch-spruce-fir	**34**		5	**21**	**27**	**22**	9	**18**	**23**	8	**16**	**12**	**38**	**30**	**16**	**27**	**19**	**25**	**35**
Aspen-birch	5		4	**12**	**10**	5	1	1	1	1	1	1	**25**	3	6	1		1	1
Paper birch	1	3		2			5	2	1	1		2					2		
Paper birch-spruce-fir		2			2	2	8	5	3	2	1	4				2			
Jack pine	**28**	**15**	7	**10**	**14**	**15**	4	**15**	**21**	**41**	**55**	**12**	**18**	**45**	**59**	**41**	**31**	**59**	**37**
Jack pine-hardwood	1	9	**20**	8	6	6	5	4	4	6	2	5	1	1			1		
Spruce-fir	2	1	1	2	2	3	5	4	2	4	2	4	4	1	2	**13**		1	6
Spruce-fir-hardwood	4		1	3	3	1	1	5	2	3	6	3	5	7	4	5	8	**11**	**11**
Balsam fir		1	4	3	2	1	5	2	3	2		2							
Balsam fir-hardwood			3																
Red pine	3	6	1	1	2	2	1	1	2	1	1	3	1	5	1	1	6	1	3
Red pine-spruce-fir												1					4		
Red pine-hardwood		3	4	**12**	5	7	3	1	1	2	1	9							
White pine	2									1		2			1	2	4		
White pine-spruce-fir									1			1		3					
White pine-hardwood									2	2	1	3			1	1	3		1
White spruce		1																	
White spruce-hardwood			1	2	1		2					1							
Northern hardwood		2	2	2		3		1											
Lowland black spruce		2	2	4	5	6	5	5	4	4	1	**17**	1		3	2	**12**		
Upland black spruce	2	2	2	1	2	3	4	3	3	5	2	2	3	2	4	3		1	3
Tamarack								2											
Black ash		2	2					1			1	1					1		
White cedar										1		1		2	1	1	5	1	1
Mixed swamp conifers			1							1	1	1		1	1		4	1	
Upland grass			1					1			1								
Upland brush			1	1				1	1	1	1		1						1

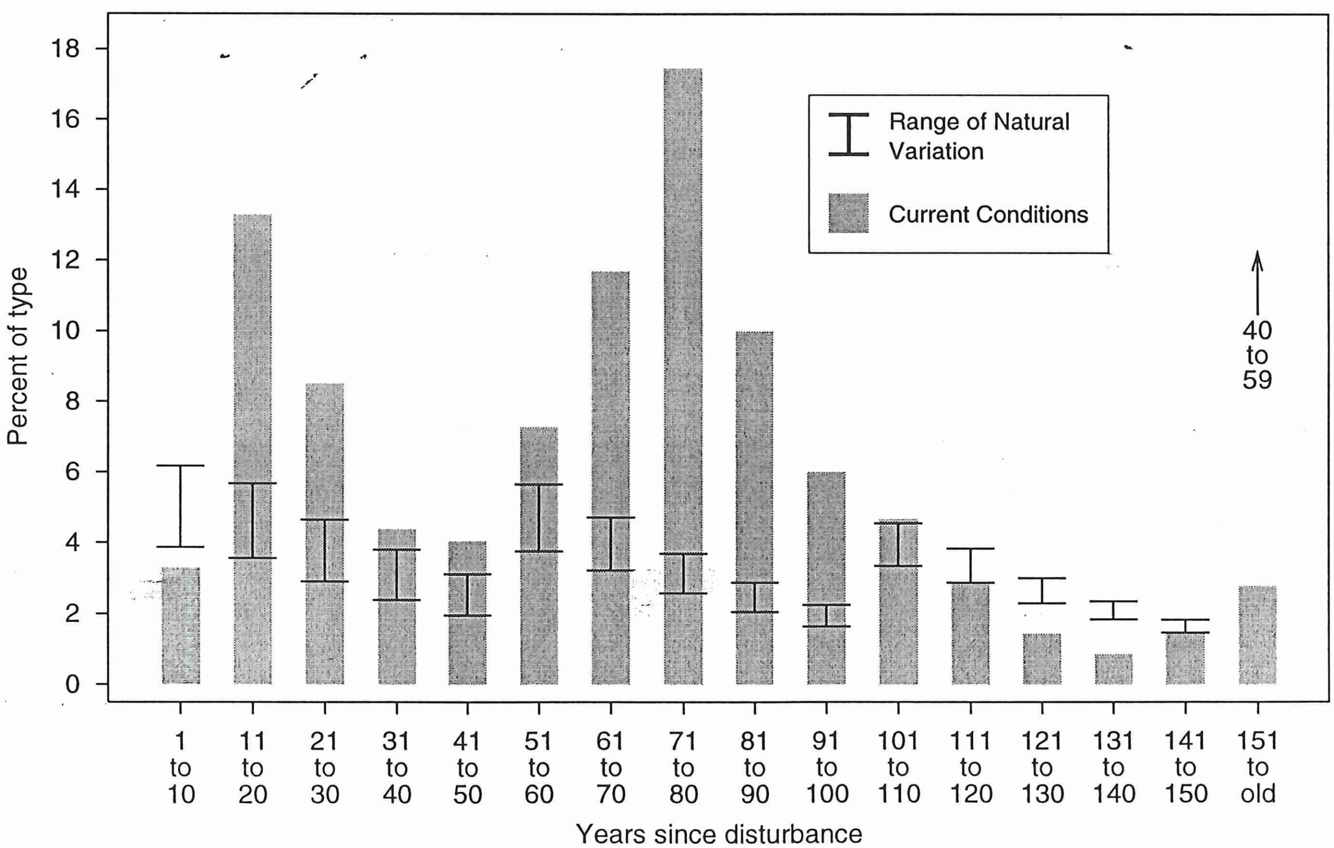
7: Jack pine-black spruce
Area breakdown

Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	old
Current acres (thousands)	92	51	70	64	61	54	48	87	86	59	121	12	96	88	7	4	1	21	26
Current % of type	8.8	4.9	6.7	6.1	5.8	5.2	4.6	8.3	8.2	5.6	11.5	1.1	9.1	8.4	0.7	0.3	0.1	2	2.5
RNV minimum % of type	8.4	8.1	9	6.3	4.1	6.6	3.9	5.6	3.8	2.4	1.5	2.9	2.2	1.6	1.1	0.8	0.5	0.4	6.5
RNV maximum % of type	15.2	13.6	13.1	8.3	4.9	7.9	4.3	5.7	4.3	3	2.1	3.9	3.2	2.5	2	1.5	1.2	0.9	20.9
	Breakdown of age class by current cover type area (thousands of acres) (≥ 10k in **bold**)																		
Aspen	**10.4**	**23.1**	**17.4**	4.3	3.6	2.9	4.4	5.8	6.1	2.4	4.2	0.3	0.1						
Aspen-spruce-fir	3.5	2.9	**10.1**	6	7	9.6	**16.3**	**19.5**	**15.3**	7.3	4.3	1.4	0.5	0.1					0.1
Aspen-birch-spruce-fir	**31.6**	0.1	3.5	**13.6**	**16.7**	**11.8**	4.2	**15.6**	**19.4**	4.5	**19**	1.4	**36.6**	**26.1**	1.2	1	0.1	5.2	9
Aspen-birch	4.1		2.9	7.8	6.3	2.9	0.3	0.9	1.2	0.4	1.4	0.1	**24.3**	2.7	0.4			0.1	0.2
Paper birch	1.1	1.4	0.2	1.1		0.1	2.5	2	0.7	0.3	0.3	0.2							
Paper birch-spruce-fir	0.1	1			1.2	1	3.7	4.1	2.6	1	0.6	0.4	0.2			0.1			
Jack pine	**26**	7.8	4.7	6.6	8.6	8.3	2	**13.4**	**18.2**	**24.3**	**66.4**	1.4	**17.2**	**39.3**	4.4	1.5	0.2	**12.2**	9.5
Jack pine-hardwood	1.3	4.4	**14.1**	5	3.6	3	2.4	3.6	3.8	3.4	2.4	0.6	0.7	0.5				0.1	0.1
Spruce-fir	2.2	0.3	0.8	1	0.9	1.5	2.5	3.2	1.8	2.2	1.9	0.5	4.1	1	0.1	0.5		0.1	1.6
Spruce-fir-hardwood	3.2		0.5	1.6	2	0.5	0.2	4	1.9	1.9	6.7	0.3	4.4	6.4	0.3	0.2	0.1	2.3	2.8
Balsam fir	0.1	0.2	2.6	1.8	1.1	0.6	2.2	1.5	2.8	0.9	0.3	0.2	0.1						
Balsam fir-hardwood			1.9																
Red pine	2.4	3.1	0.9	0.9	1.1	1.2	0.3	0.7	1.7	0.3	1.7	0.4	0.8	4.2				0.2	0.9
Red pine-spruce-fir					0.1	0.1		0.1	0.1		0.1	0.1							
Red pine-hardwood	0.2	1.5	2.6	7.9	3.2	3.6	1.3	0.8	0.5	1.1	1	1	0.3						
White pine	1.5	0.2				0.1		0.1		0.3	0.4	0.2				0.1			
White pine-spruce-fir									0.7	0.1		0.1	0.1	2.5					
White pine-hardwood	0.4	0.1	0.1				0.1		1.5	1.1	0.8	0.4	0.3	0.1	0.1				0.2
White spruce	0.3	0.7	0.3	0.1	0.2	0.2	0.1		0.2	0.1									
White spruce-hardwood		0.1	0.6	1	0.3	0.1	0.8	0.1	0.1	0.1	0.2	0.1							
Northern hardwood	0.1	1.1	1.5	1		1.5	0.1	1	0.2		0.1								
Lowland black spruce	0.2	0.8	1.6	2.7	3.1	3.3	2.2	3.9	3.4	2.4	1.3	2	1	0.4	0.2	0.1	0.1		0.1
Upland black spruce	2.2	0.8	1.2	0.5	1.2	1.6	2	2.3	2.3	3.2	2.6	0.2	3.2	1.4	0.3	0.1		0.2	0.7
Tamarack	0.2					0.1		1.7	0.2	0.1	0.2		0.2	0.3					
Black ash	0.1	0.9	1.2				0.1	0.6	0.3	0.2	1.1	0.1	0.1	0.1					
Black ash-conifer	0.1									0.1									
White cedar	0.1			0.1	0.2	0.2		0.2	0.3	0.4	0.2	0.1	0.2	1.8	0.1			0.2	0.2
Mixed swamp conifers	0.2		0.4	0.3	0.2	0.2	0.1	0.4	0.4	0.4	0.6	0.2	0.4	0.4	0.1			0.1	0.1
Upland grass	0.1	0.1	0.5	0.2	0.2			0.6	0.1	0.1	1		0.3	0.2				0.1	
Upland brush	0.1	0.1	0.7	0.3	0.2			0.8	0.5	0.3	0.9		0.7	0.3					0.1
Other	0.1																		
Flooded/burned	0.1							0.1		0.1	0.4			0.1					

Frelich type 9: Sugar Maple-Northern Hardwood

Disturbace interval (years) - Wind: 1000-2000 Fire: 200-400 Infrequent Fire: 600-1000





9: Northern Hardwood (MW)
Percent cover breakdown
See also area breakdown

Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	old
Current acres (thousands)	8	32	21	11	10	18	29	43	24	15	11	7	4	2	4	7
Current % of type	3.3	13.3	8.5	4.4	4	7.3	11.7	17.5	10	6	4.7	2.9	1.4	0.9	1.4	2.8
RNV minimum % of type	3.9	3.6	2.9	2.4	1.9	3.8	3.2	2.6	2.1	1.6	3.3	2.9	2.3	1.8	1.5	41
RNV maximum % of type	6.2	5.7	4.6	3.8	3.1	5.7	4.7	3.7	2.9	2.3	4.6	3.8	3	2.3	1.8	59.7
	Breakdown of age class by current cover type percent of age class (≥ 10% in **bold**)															
Balsam poplar		8				7	1	1	1	**10**						
Aspen	**53**	**68**	**47**	**33**	**44**	**17**	**27**	**14**	6	3	3					
Aspen-spruce-fir	7	2	5	**13**	**13**	7	5	7	4	**11**	3					
Paper birch	**12**	5			**13**	**27**	**20**	**22**	**29**	**13**	3	1	3			
Paper birch-spruce-fir					2	2	6	**10**	**10**	3	9	4	2			
Jack pine					1											
Spruce-fir	2		1	1	3	1	4	3	2	4	2	2	1	3		
Balsam fir				**11**			2	2	1			2				
Balsam fir-hardwood						7	4		3							
Red pine	1	2	2						4							
Red pine-hardwood		1	2	9	1	**14**	1							1		
White pine-hardwood														1		
White spruce	1	5	1	3	1			3								
White spruce-hardwood			6	7	1	1	1				1	2	1	3		
Northern hardwood	**18**	6	**12**	1	**11**	**15**	**27**	**31**	**34**	**46**	**62**	**59**	**52**	**34**	**53**	**18**
Lowland black spruce									1	1	1			2		
Tamarack				**10**												
Black ash			**23**	9	8	1	1	5	3	5	2	5	8	**27**	3	2
Black ash-conifer														1		
White cedar							1	1	1	2	**13**	**22**	**31**	**23**	**34**	**68**
Mixed swamp conifers								1		1	1	4	3	6	9	**11**
Cut over	4	2														
Upland brush	1															

9: Northern Hardwood (MW)
Area breakdown

Age (years) from	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151
to	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	old
Current acres (thousands)	8	32	21	11	10	18	29	43	24	15	11	7	4	2	4	7
Current % of type	3.3	13.3	8.5	4.4	4	7.3	11.7	17.5	10	6	4.7	2.9	1.4	0.9	1.4	2.8
RNV minimum % of type	3.9	3.6	2.9	2.4	1.9	3.8	3.2	2.6	2.1	1.6	3.3	2.9	2.3	1.8	1.5	41
RNV maximum % of type	6.2	5.7	4.6	3.8	3.1	5.7	4.7	3.7	2.9	2.3	4.6	3.8	3	2.3	1.8	59.7
	Breakdown of age class by current cover type area (thousands of acres) (≥ 10k in **bold**)															
Balsam poplar		2.6	0.1			1.2	0.3	0.3	0.3	1.5						
Aspen	4.3	**21.9**	9.8	3.5	4.4	3	7.7	5.8	1.5	0.4	0.3					
Aspen-spruce-fir	0.6	0.7	0.9	1.4	1.3	1.2	1.4	3	1	1.7	0.3					
Paper birch	0.9	1.5			1.3	4.9	5.7	9.4	7.1	1.8	0.3	0.1	0.1			
Paper birch-spruce-fir					0.2	0.4	1.6	4.4	2.4	0.4	1	0.2	0.1			
Oak							0.1		0.1							
Jack pine					0.1											
Jack pine-hardwood								0.1								
Spruce-fir	0.1	0.1	0.2	0.1	0.3	0.3	1.2	1.4	0.6	0.7	0.2	0.1		0.1		
Balsam fir		0.1	0.1	1.2		0.1	0.6	0.7	0.1	0.1		0.1				
Balsam fir-hardwood						1.2	1.2		0.7							
Red pine	0.1	0.8	0.4						1							
Red pine-hardwood		0.2	0.4	0.9	0.1	2.5	0.2									
White spruce	0.1	1.5	0.2	0.3	0.1	0.1	0.1	1.3								
White spruce-hardwood		0.1	1.3	0.8	0.1	0.1	0.1	0.1	0.1		0.1	0.1		0.1		
Northern hardwood	1.4	1.9	2.5	0.1	1.1	2.6	7.8	**13.1**	8.4	6.8	7.1	4.1	1.8	0.7	1.9	1.2
Lowland black spruce		0.1					0.1	0.2	0.2	0.1	0.1					
Upland black spruce		0.1					0.1									
Tamarack		0.1		1.1												
Black ash			4.8	1	0.8	0.1	0.2	2.2	0.8	0.7	0.3	0.3	0.3	0.6	0.1	0.2
White cedar							0.2	0.2	0.2	0.2	1.5	1.5	1.1	0.5	1.2	4.6
Mixed swamp conifers								0.3	0.1	0.2	0.2	0.3	0.1	0.1	0.3	0.8
Cut over	0.3	0.8														

D R A F T - Statewide Press Release

Sustain 1.1 Project: Forests for the future

Healthy and sustainable forests are like a beautiful cake—we want to have it and eat it, too. But thoughtful use of our forests today is critical if we want them to continue to provide products and habitats for future generations.

Minnesota has approximately 7.6 million acres of timberland managed by county, state and federal agencies. Researchers at the Natural Resources Research Institute (NRRI) University of Minnesota Duluth have pulled together decades of data to help public land managers make informed decisions about forest harvesting. The result is "Sustain 1.1" a software program that can predict how harvesting affects forest sustainability; in other words, meeting the needs of the present without compromising the ability of future generations to meet their needs.

"In some areas the current condition is outside the forests' range of natural variability and most management we do is not a good decision for the land," said NRRI's JoAnn Hanowski, coordinator of the Sustain 1.1 project. "But there are some choices that are better than other choices. This software will tell resource managers that harvesting one stand of trees is a better choice than another stand."

The forest's range of natural variability is based on its history—the trees and plants that grew there and the birds that flew there—before people started harvesting it. By studying historic data, researchers know that healthy forests have a variety of plant species of varying ages. Using tree succession and bird populations as indicators of the forests' health, the researchers plotted past forest conditions and compared them with current conditions.

"People seem to think Northern Minnesota was a landscape of pine," said Hanowski. "There were super huge canopy pine trees, but in several ecosystem types there was a lot of aspen, birch, fir and spruce that grew underneath and with the pine. Pine was the major tree species, but there were a lot of other trees, too. The diversity of trees and ages contributes to a sustainable forest."

Because our modern life requires the harvesting of wood, it's difficult to maintain diverse forests. Around 80 percent of Minnesota's forest-based economy is based on aspen, so an abundance of aspen is grown to meet people-driven needs. Mother Nature may force us to do something different.

"Maintaining the productivity of Minnesota's forest soils is critical for sustainable management of forests," said NRRI's George Host, a soil expert and co-leader of the Sustain 1.1 project. "Recent research has shown that damage to soils from compaction and other factors can cause significant reductions in the productivity and diversity of forest ecosystems. If we understand which soils are most sensitive, then manage carefully, we can maintain sustainable forest conditions and still contribute to our natural resource-based economy."

Bird studies were also used in the software program to understand how the forests grow after a natural or man-made disturbance. NRRI's bird monitoring data backs up the plant and tree data, noting how bird species change with changes in vegetation.

"A good example is the Blackburnian Warbler. Historically, we figured there were between 189,000 and 221,000 breeding pairs in northeast Minnesota," said Hanowski. "Today, we have around 149,000, so the population is below the historic range. If we're looking at sustaining populations, we need to look at how their habitats have changed and what types of habitats to provide in the future."

NRRI's Terry Brown wrote the software program for those who manage large tracts of land and who already have access to Geographical Information Systems (GIS) equipment. It was not designed for individual landowners.

"What we found wasn't a surprise," said Brown, an expert in ecosystem modeling. "We knew, for example, that old age forest growth is under-represented in this area, but this program gives us the numbers to work with."

The Sustain 1.1 program covers two areas of Minnesota: the Northern Superior Uplands and the Drift and Lake Plains areas. (See map) Land managers in those areas—St. Louis County, the DNR and the U.S. Forest Service—have embraced the concept of sustainability.

Paul Olson, GIS technician for the Minnesota DNR, thinks Sustain 1.1 will be a useful tool for the teams deciding what areas of the forest will be harvested.

"For the decision makers, it's another piece of the puzzle, another factor to consider, when they have to figure out where to cut wood," said Olson.

The project was publicly funded with $300,000 from the Legislative Commission for Minnesota Resources so the software is available free to public land managers. Future versions of the program may cover expanded land areas and may address individual landowner needs.

Word count: 766