I. Minnesota old-growth forests: characterization and identification

Program Manager: Kurt A. Rusterholz
Natural Heritage Program
Department of Natural Resources - Box 7
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A. M.L. 91, Chpt. 254, Art. 1, Sec 14, Subd. 7.a

Appropriation:	$150,000
Balance: June 30, 1993	$ -0-

Minnesota Old-Growth Forests - Character and Identification: This appropriation is to the commissioner of natural resources to develop quantitative, structural definitions of Minnesota old-growth forest types, examine the importance of old growth as sensitive habitat, and evaluate old-growth forest stands that are identified as the department of natural resources old-growth guidelines are implemented.

B. Compatible Data: During the biennium ending June 30, 1993, the data collected by projects funded under this section that have common value for natural resource planning and management must conform to information architecture as defined in guidelines and standards adopted by the Information Policy Office. In addition, the data must be provided to and integrated with the Minnesota Land Management Information Center's geographic data bases with the integration cost borne by the activity receiving funding under this section.

C. Match Requirements: none

II. Narrative

Old-growth forests are important reservoirs of biological diversity, yet old growth is becoming increasingly rare in Minnesota. There is currently much confusion among resource managers about what old growth looks like. Structural and compositional definitions of old growth based on an ecological definition are needed for each old-growth forest type in Minnesota. In addition, implementation of DNR Old Growth Guidelines will require hiring forest ecologists to evaluate potential old-growth stands for protection. Information obtained by this research will be essential for management of old-growth ecosystems by state, federal, and local resource managers.

III. Objectives

A. Develop quantitative structural and compositional standards for identification of several important Minnesota forest types

A.1 Narrative: Although the ecological definition of old growth as a natural forest that has not experienced a catastrophic disturbance for a long period of time is widely accepted, this general definition has not been translated into a set of standards that can be easily used by field land managers to identify old-growth stands. The focus of this objective is to develop objective descriptions of old-growth red pine stands, white pine stands, and northern hardwood stands that fit this ecological definition.

A.2 Procedures: The first step is to identify ten old-growth stands and ten younger (mature) stands of each of the three forest types. These stands will be chosen from stands in the Natural Heritage Database and stands in state and federal forest inventory databases and field checked before extensive sampling begins. Mature stands will be chosen from stands between 70 and 100 years old and may exhibit significant human disturbance. Mature stands selected will be near the old-growth stands and on similar site ecosystems.

Both old-growth and mature stands will then be quantitatively sampled using procedures designed to measure important old-growth features including stand age, tree species composition and size-class distribution, and size and volume of coarse woody debris.

Within each plot one or two standard releves will be completed. Data collected in each releve include cover and abundance estimates for all vascular plant species in several height strata.

Multivariate statistical analysis will then be used to determine which structural and compositional features of forest stands are most appropriate for distinguishing old-growth from mature stands. Detailed procedures for data analysis that address the problem of small sample size in multivariate analysis will be developed in consultation with the Section of Wildlife's Biometrician and Dr. Thomas E. Burk in the Department of Forest Resources at the University of Minnesota. Minimum standards for old growth in each of the three forest types will then be developed. Data on rare vascular plants and lichens gathered within releve plots will be used to assess the importance of old-growth as a sensitive habitat for these species.

A.3 Budget

a. Amount Budgeted:	$120,000
b. Balance: June 30, 1993	$ -0-

A.4 Timeline for Products/Tasks

Products/Tasks	July 91	Jan 92	Jun 92	Jan 93	June 93
Selection of stands	*****		****		
Vegetation sampling	*********		********		****
Data analysis		********		*********	**
Reports (status and final)		****	****	****	****

A.5 Status: This research is the basis of a Master of Science Thesis by Scott A. Stai to be submitted to the Graduate School of the University of Minnesota at Duluth. Copies of this thesis, a detailed project report, and forthcoming papers resulting from this project will be submitted to LCMR.

a. Sites sampled. Sixty sites, representing a broad range of geographic locations and geomorphic regions, were sampled (see map). Twenty red pine stands were sampled; ten stands were old growth and ten were mature.

Footnote: 1. We are well aware that each forest type includes several ecosystem types, however, management of state forest lands is currently based on the forest type concept, and an ecological classification system (ECS) for Minnesota forests does not yet exist. Information gathered from these stands, however, will allow these stands to be classified when an ECS is developed.

Of the 20 white pine stands, eight were old growth and 12 were mature. The twenty northern hardwood stands sampled were composed of trees of many age-classes; eleven stands were considered old growth and nine were mature. The number of stands with cut stumps, which indicated logging history, was low in old-growth stands but higher in mature stands.

b. **Structural characteristics of old growth.** Total basal area of living trees did not differ significantly between mature and old-growth stands in both red pine and northern hardwoods but was greater in old-growth white pine than in mature stands. Mean canopy cover was independent of age in all three types.

Size-class distributions and density of trees. Old-growth red pine and white pine stands contained larger and fewer trees than mature stands. Old-growth northern hardwood stands supported lower tree densities than mature stands. Old-growth northern hardwoods, however, had a significantly lower density of sugar maples < 34 cm dbh and a significantly higher density of sugar maples > 34 cm. Average diameters of sugar maples did not differ between mature and old-growth stands.

Regeneration. Very little red pine and white pine regeneration occurred in red pine stands, regardless of age. There were few pine seedlings, large seedlings, and saplings in old-growth pine stands, and few to many in mature stands. All northern hardwood stands had sugar maple regeneration in all three size classes. Seedling/sapling densities for all species combined showed no correlation with stand age, but the density of basswood seedlings increased significantly with age.

Coarse Woody Debris (CWD). The mean volume of CWD (snags and down logs) was much higher in old-growth red pine and white pine stands than in mature stands. In northern hardwoods, there was no significant relationship between the amount of CWD and stand age.

c. **Vascular plant species composition of old-growth stands.** The vascular species composition of old-growth stands was indistinguishable from that in mature stands for all three forest types. Major differences in species composition in each of these forest types were related to geography, not to differences in stand age.

d. **Sensitive plant species in old-growth stands.** One state-listed rare species, Barren Strawberry (*Waldsteinia fragariodes*), was recorded within a plot sampled in this project. No state-listed species of lichens or mosses were observed within any of the plots sampled.

e. **Contributions to the Natural Heritage Information System.** Releves and element occurrence records for 60 sites have been entered into the Natural Heritage Information System. These releves provide key information that will be used in future revisions of the Natural Heritage Program's Natural Community Classification.

f. **Discussion.** This project provides quantitative data for baseline comparisons to other sites and for development of management guidelines for older forests. There are significant structural differences between mature and old-growth stands of red pine and white pine forest, such as the higher volume of coarse woody debris in old-growth stands of both pine types. Such

differences suggest that old-growth sites provide more extensive habitats and microhabitats for species that rely on coarse woody debris. Also, old-growth sites may support different nutrient cycling patterns than mature sites.

The lack of significant differences between old-growth and mature northern hardwood stands for most structural features is problematical and raises the possibility that stand age assignments may not be accurate. Factors that may contribute to inaccurately labeling an old-growth stand as a mature stand are: 1) an inherently patchy stand structure 2) rapid stump decay and 3) a possible disparity between oldest tree ages and the stand age (based on time since the last catastrophic disturbance). However, old-growth stands do have a signficantly higher density of sugar maples > 34 cm dbh. Nevertheless, the results suggest that old-growth northern hardwood stands may not always contain particularly large amounts of large snags and down logs.

This project will continue into the next biennium with funding recommended by LCMR. The continuation of the project will characterize old-growth in three additional forest types: maple-basswood forest, oak forest, and black ash forest. The complications raised by the nature of northern hardwood forests are relevant to the forest types being studied in the continuation of the project and will be addressed by determining ages of a greater number of trees.

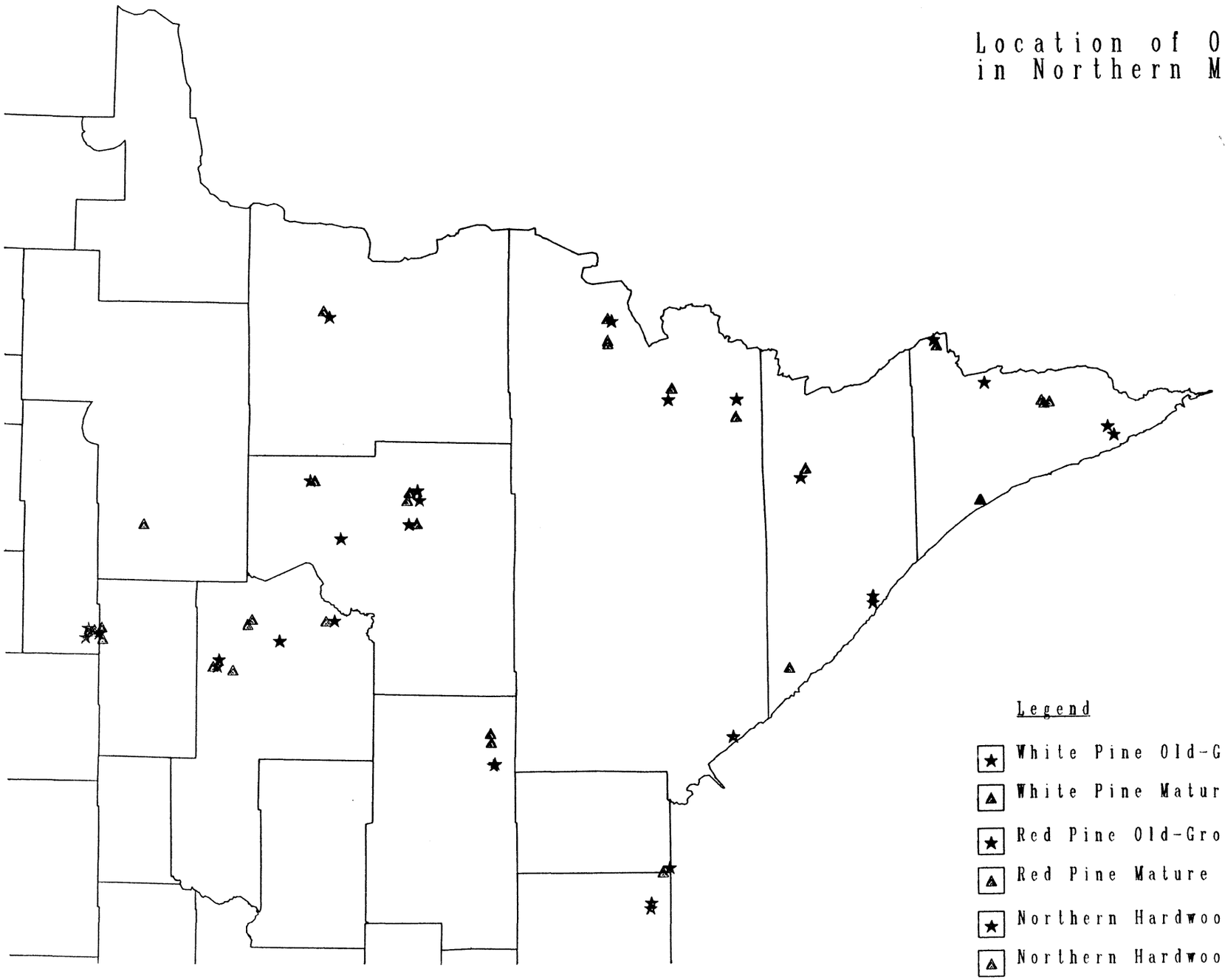
A.6 **Benefits:** This research will provide important information that will allow the Department of Natural Resources to manage and protect old-growth forests and the biological diversity associated with these forests. More specifically, the results of this research will: 1) provide forest managers with objective criteria necessary to identify old-growth forest stands, 2) provide empirical data for revision of the Department of Natural Resources Old-Growth Guidelines, and 3) provide data on the nature of old-growth forests that can used to integrate management for old-growth features and associated biological diversity into the management of commercial forests.

B. Evaluate candidate old-growth stands identified during implementation of DNR Old-Growth Guidelines.

B.1 **Narrative:** The Department of Natural Resources Old-Growth Guidelines call for identification of candidate old-growth stands by field managers in each management area. Selection of these candidate stands is based largely on preliminary criteria included in the guidelines. The guidelines then require that candidate stands be evaluated by natural resource professionals under the direction of the Natural Heritage Program to determine whether a stand qualifies as old growth. The Natural Heritage Program lacks the staff and funds to carry out this requirement. One or two ecologists will be hired to participate in and supervise the evaluation of old-growth candidate stands.

B.2 **Procedures:** DNR natural resource professionals will first be trained to evaluate old-growth forests by the Natural Heritage Program Forest Ecologist. This training will include field visits to a number of old-growth stands. These natural resource professionals will then visit and evaluate candidate old-growth stands. Those stands judged to be significant old-growth stands will be recommended for designation as Scientific and Natural Areas, Natural Heritage Registry Sites, or some other form of protection. Reasons for rejecting or selecting each candidate stand will be documented in a written report.

Location of Old-Growth Study Areas in Northern Minnesota (1991-1992)



Legend

- White Pine Old-Growth Stands
- White Pine Mature Stands
- Red Pine Old-Growth Stands
- Red Pine Mature Stands
- Northern Hardwoods Old-Growth Stands
- Northern Hardwoods Mature Stands

Budget:
a. Amount Budgeted $30,000
b. Balance: June 30, 1993 $ -0-

B.4 **Timeline for Products/Tasks** **July 91** **Jan 92** **Jun 92** **Jan 93** **June 93**

Train evaluator(s)	**				
Evaluate candidate stands		******		*******	****
Prepare reports		*****		****	**

B.5 **Status: Evaluation of red pine and white pine candidate stands.**
In 1991 a forest ecologist was contracted for several weeks to assist the Natural Heritage Program in developing standardized evaluation procedures and in training interdisciplinary teams of DNR resource professionals to evaluate red pine and white pine Old-Growth Candidate Stands. During the 1991 field season DNR evaluators field-checked 47 old-growth candidate pine stands. Stands that met minimum criteria based on preliminary field reconnaissance were sampled and assigned a stand score according to: 1) age, 2) size and context, 3) degree of human disturbance, and 4) structural characteristics.

Management recommendations for Candidate Stands evaluated in 1991 were presented by the Natural Heritage Program to the Division Directors of Fish and Wildlife, Forestry, and Parks following the 1991 field season. All stands were ranked on their ecological significance within the ecological region of the state in which they occurred. At that time, 21 stands were recommended for protection, 19 stands were recommended for other management, three stands were recommended for future old growth, and recommendations were deferred on four stands pending additional information.

A more complete and final analysis of the DNR's forest inventory records in 1992 revealed an additional 69 old-growth candidate pine stands, many in state parks. With the addition of new Candidate Stands in 1992 and the adoption by the DNR of new ecological regions in 1993, final recommendations for management of red pine and white pine Candidate Stands will be made following the 1993 field season.

Evaluation of Old-Growth Candidate Stands of types other than pine.
Based on a progress review in early 1993, the DNR Old-Growth Committee concluded that Candidate Stand evaluations needed to be accelerated for timely completion within two to three years. Although the format used for pine Candidate Stand evaluations provided good results and fostered an integrated resource management approach among DNR resource professionals, work was proceeding too slowly. It was difficult for teams of DNR evaluators to coordinate schedules and take on the additional workload. At the current rate of Candidate Stand evaluation, we anticipate that funding would be exhausted long before all Candidate Stands were evaluated. Therefore, the committee decided to increase the efficiency of Candidate Stand evaluation by contracting the data collection. Contractors experienced in forest inventory and trained by DNR ecologists will sample the majority of the remaining Candidate Stands. DNR personnel will sample a small number of stands in southern and northern Minnesota.

In April and May 1993 evaluation procedures for other forest types were modified from those used for red pine and white pine. Unlike pine forests, old-growth forests of northern hardwoods, lowland hardwoods, and black ash typically contain all-aged stands with rapidly decaying hardwood stumps, thus

co nding determination of a stand's age and logging tory. A new plot sam ing procedure, developed with Dr. Lee Frelich of t University of Minnesota, will be used to determine a size-class distribution within each candidate stand. Old-Growth Candidate Stands of all types other than pine will receive scores based on stand age, size and context, degree of human disturbance, and structure.

A training session on old growth sampling was held in May 1993 for contractors and DNR personnel. Contracts have been signed for field-checking 142 northern hardwood Candidate Stands, 99 white cedar Candidate Stands, 51 black ash Candidate Stands, and 143 lowland hardwood Candidate Stands. As a result, 435 additional Old-Growth Candidate Stands will be evaluated within the next year. The remaining 51 Candidate Stands of oak, white spruce, and northern hardwoods will be sampled by DNR personnel during the continuation of the funding for this project. Data from these field-checks will be analyzed by the Natural Heritage Program and a score will be assigned to each stand. This information will be used to make management recommendations for Old-Growth Candidate Stands.

B.6 **Benefits:** Completion of this objective will facilitate implementation of the Department of Natural Resources Old-Growth Guidelines. Effective implementation of the guidelines will result in 1) protection of ecologically significant old-growth stands and 2) release for other management of old-growth candidate stands that do not qualify as old growth.

C. **Coordinate with the LCMR-funded project "Effects of Changes in the Forest Ecosystem on the Biodiversity of Minnesota's Northern Forest Birds" in order to assess the importance of old-growth forests as sensitive habitats for forest birds.**

C.1 **Narrative:** Forest bird populations in old-growth and mature forest stands selected for sampling of vegetation and old-growth features will be censused during the breeding season. These data will be used to assess the importance of old-growth as a sensitive habitat for forest birds.

C.2 **Procedures:** Data gathered using bird census techniques adopted by the Forest Birds LCMR Project will be used to assess 1) whether old-growth forests support distinctive assemblages of birds and 2) the importance of structural features found in old-growth forests to individual bird species.

C.3 **Budget:** Not applicable

C.4 **Timeline for Products/Tasks:** **July 91** **Jan 92** **Jun 92** **Jan 93** **June 93**

Bird population sampling			***		
Data analysis				******	

C.5 **Status:** Six old-growth red pine and white pine stands sampled as part of this project during the 1991 field season (see Section A.2) were censused in June 1992 by researchers with the Forest Birds LCMR Project. All old-growth pine and northern hardwoods stands sampled during the 1992 field season of at least 15 acres in size are scheduled to be censused by the Forest Birds Project in 1993.

Preliminary results of these censuses indicate a relatively high diversity of

forest bird species associated with these stands, but results are difficult to put in perspective because of the limited sampling. However, as the sample number increases over time, results may be compared with forest bird communities from a variety of habitats to allow a determination of whether old-growth forests contain a unique assemblage of forest birds.

C.6 **Benefits**: Completion of this objective will provide data essential to managing bird species characteristic of old-growth forests. Both those species most closely associated with old growth and the features of old growth with which those species are associated can begin to be identified for future management.

IV. **Evaluation**: This project can be evaluated based on 1) the development of practical definitions of old growth for three forest types that describe and quantify old-growth features of each forest type and 2) whether these descriptions become widely accepted (e.g. are incorporated in revisions of the DNR Old-Growth Guidelines). Successful completion of objective B will result in the review of a significant number of old-growth candidate stands during FY 92-93.

V. Context

A. Protection and management of old-growth forests is a nationwide issue that has become an issue of concern in Minnesota. In order to protect and manage old growth, it must first be identified. The only existing descriptions of Minnesota old-growth forests based on structural and compositional features are found in a Natural Heritage Program preliminary report on Minnesota old-growth forests and in the DNR Old-Growth Guidelines. These descriptions are sketchy and are not based on systematic study of old growth. At the present time information on the key structural features of old growth necessary to develop useful descriptions of old growth in Minnesota forest types does not exist.

B. As discussed above, there has been almost no research directed towards developing descriptions of old-growth forest types in Minnesota. Information on old-growth sites in the Natural Heritage Program Database is not quantitative. The current project supplements these data by providing additional information on Minnesota old growth.

C. The current project will be coordinated with the LCMR funded project "Effects of Changes in the Forest Ecosystem on the Biodiversity of Minnesota's Northern Forest Birds" (Wildlife 20) such that old-growth and mature forest sites selected in the current project will be sampled in the forest birds project. Data on forest birds collected from these sites will be used to determine whether old growth is a sensitive habitat for these bird species. Selection of study sites and the overall project will be coordinated with the DNR Division of Forestry. Some (and perhaps all) of the study sites will be included in the LCMR funded nutrient cycling study (Forestry 5) conducted by researchers from the University of Minnesota College of Forest Resources. The study sites may also be used in a detailed study of the importance of old growth as a sensitive habitat for lichens conducted by Dr. Clifford Wetmore at the University of Minnesota College pending available funds. Lichens are the one group of macroscopic organisms that is most likely to have species limited to old-growth forests.

The Natural Heritage Program has received a Challenge Grant from Superior National Forest to study white cedar forests. This grant has allowed us to study 15 old-growth stands. The LCMR has not previously funded old-growth

research. The current proposal addresses three forest types: red pine forest, white pine forest, and northern hardwood forest. Following successful completion of this project, additional funds may be sought to study other old-growth forest types in Minnesota.

D. Not applicable.

E. Biennial Budget System Program Title and Budget: MN Old-Growth Forests $150,000

VI. **Qualifications**

1. **Program Manager**

Kurt A. Rusterholz
Forest Ecologist, Natural Heritage Program
Section of Wildlife - Minnesota Department of Natural Resources

Ph.D. Community Ecology, University of Wisconsin, 1979
M.S. Zoology, University of Wisconsin, 1973

The program director's area of expertise is forest community ecology, especially avian and plant ecology. For the last three years he has been a plant ecologist with the Natural Heritage Program studying and evaluating forest communities and providing ecological expertise as a member of the DNR Old-Growth Task Force. He has also conducted research on forest birds published in several major refereed journals. His current research is on the ecology of white cedar forests.

Principal publications related to the current project:

Rusterholz, K.A. 1990. Minnesota's old-growth forests. Minnesota Forests 3 (3): 12-16.

Rusterholz, K.A. 1989. Old-Growth Forests in Minnesota: A Preliminary Report. Minnesota DNR Natural Heritage Program Biological Report No. 5.

2. **Major Cooperators**:

Dr. David J. Mladenoff
Research Associate, Natural Resources Research Institute
University of Minnesota - Duluth

Ph.D. Plant Community Ecology, University of Wisconsin, 1985
M.S. Land Resources, University of Wisconsin, 1979

Dr. Mladenoff has published in refereed journals and conducted research in the areas of forest ecology of the Lake Superior region, biodiversity, and landscape scale analysis using Geographical Information Systems. He has studied old-growth northern hardwood forests in Michigan and Wisconsin, and his current research includes projects on old-growth forest biodiversity funded by the U.S. Forest Service and The Nature Conservancy, and work funded by the National Science Foundation and the National Park Service. Besides research, his experience includes nearly eight years working cooperatively with state and federal land management agencies on biodiversity issues. Dr.

Mladenoff will advise the graduate student who will conduct much of the field research for the current project.

Principal Publications related to current project:

Mladenoff, D.J. and E.A. Howell. 1980. Presettlement vegetation, land use and present vegetation of the Gogebic Range, Wisconsin. Trans. Wisc. Acad. of Science, Arts, Letters 68: 74-89.

Mladenoff, D.J. 1987. Dynamics of nitrogen mineralization and nitrification in a hemlock and hardwood treefall gaps. Ecology 68:1171-1180.

Mladenoff, D.J. 1991. The relationship of the soil seed bank and understory vegetation in old-growth northern hardwood-hemlock tree fall gaps. Canadian Journal of Botany (in press).

Pastor, J. and D.J. Mladenoff. 1991. The southern boreal forest border. 41 pp. In: Ecosystems analysis and simulation of the global boreal forest. H.H. Shugart, ed. Cambridge University Press. (in press)

VII. Reporting Requirements

Semiannual status reports will be submitted not later than January 1, 1992, July 1, 1992, January 1, 1993, and a final status report by June 30, 1993.

I. Minnesota old-growth forests: characterization and identification

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Appropriation:	$150,000
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C. **Match Requirements:** none

II. Narrative

Old-growth forests are important reservoirs of biological diversity, yet old growth is becoming increasingly rare in Minnesota. There is currently much confusion among resource managers about what old growth looks like. Structural and compositional definitions of old growth based on an ecological definition are needed for each old-growth forest type in Minnesota. In addition, implementation of DNR Old Growth Guidelines will require hiring forest ecologists to evaluate potential old-growth stands for protection. Information obtained by this research will be essential for management of old-growth ecosystems by state, federal, and local resource managers.

III. Objectives

A. Develop quantitative structural and compositional standards for identification of several important Minnesota forest types

A.1 **Narrative:** Although the ecological definition of old growth as a natural forest that has not experienced a catastrophic disturbance for a long period of time is widely accepted, this general definition has not been translated into a set of standards that can be easily used by field land managers to identify old-growth stands. The focus of this objective is to develop objective descriptions of old-growth red pine stands, white pine stands, and northern hardwood stands that fit this ecological definition.

A.2 **Procedures:** The first step is to identify ten old-growth stands and ten younger (mature) stands of each of the three forest types.[1] These stands will be chosen from stands in the Natural Heritage Database and stands in state and federal forest inventory databases and field checked before extensive sampling begins. Mature stands will be chosen from stands between 70 and 100 years old and may exhibit significant human disturbance. Mature stands selected will be near the old-growth stands and on similar site ecosystems.

Both old-growth and mature stands will then be quantitatively sampled using procedures designed to measure important old-growth features including stand age, tree species composition and size-class distribution, and size and volume of coarse woody debris.

Within each plot one or two standard releves will be completed. Data collected in each releve include cover and abundance estimates for all vascular plant species in several height strata.

Multivariate statistical analysis will then be used to determine which structural and compositional features of forest stands are most appropriate for distinguishing old-growth from mature stands. Detailed procedures for data analysis that address the problem of small sample size in multivariate analysis will be developed in consultation with the Section of Wildlife's Biometrician and Dr. Thomas E. Burk in the Department of Forest Resources at the University of Minnesota. Minimum standards for old growth in each of the three forest types will then be developed. Data on rare vascular plants and lichens gathered within releve plots will be used to assess the importance of old-growth as a sensitive habitat for these species.

A.3 **Budget**

a. Amount Budgeted:	$120,000
b. Balance: June 30, 1993	$ -0-

A.4 **Timeline for Products/Tasks**

Products/Tasks	July 91	Jan 92	Jun 92	Jan 93	June 93
Selection of stands	*****		****		
Vegetation sampling	*********		********		****
Data analysis		********		*********	**
Reports (status and final)		****	****	****	****

A.5 **Status:** This research is the basis of a Master of Science Thesis by Scott A. Stai to be submitted to the Graduate School of the University of Minnesota at Duluth. Copies of this thesis, a detailed report of this project, and forthcoming papers resulting from this project will be submitted to LCMR.

a. **Sites sampled.** Sixty sites, representing a broad range of geographic locations and geomorphic regions, were sampled (see map). More than 40 additional sites were field-checked and rejected as unsuitable. Twenty red pine stands were sampled; ten stands were old growth, ranging in age from 177 to 326 years old, and ten stands were mature (90-122 years old). All of the

Footnote: 1. We are well aware that each forest type includes several ecosystems types, however, management of state forest lands is currently based on the forest type concept, and an ecological classification system (ECS) for Minnesota forests does not yet exist. Information gathered from these stands, however, will allow these stands to be classified when an ECS is developed.

old-growth red pine stands were primary forest stands with no evidence of past logging, whereas four of the ten mature red pine stands contained cut stumps. Of the 20 white pine stands, eight were old growth (120-273 years old) and 12 were 98 to 117 years old. Two old-growth white pine stands contained cut stumps, whereas three of the 12 mature white pine stands contained cut stumps. The twenty northern hardwood stands sampled were composed of trees of many age-classes. Eleven northern hardwood stands, in which the oldest tree aged range from 124 to 197 years old, were considered old growth. Nine stands were mature, with ages for the oldest tree ranging from 77 to 116 years. Three old-growth northern hardwood stands and six mature stands had cut stumps (Table 1.)

b. **Structural characteristics of old growth.** Total basal area of living trees did not differ significantly between mature and old-growth stands in both red pine and northern hardwood stands but was greater in old-growth white pine than in mature stands. Mean canopy cover was independent of age in all three types. (Table 1).

Size-class distributions and density of trees. The size-class distribution of red pines was normally distributed in both old-growth and mature stands. As expected, old-growth stands contained significantly larger and fewer trees (Table 1). In old-growth red pine stands the range of diameters was narrow, and only two of the old-growth plots contained red pines < 30 cm dbh.

Whereas the size-class distribution in mature white pine stands was normally distributed, the size-class distribution in old-growth stands typically approximated a normal distribution but with additional trees present in small size classes. In the oldest stand, all 10-cm size classes between 10 and 90 cm were present. The average diameter of white pines was greater in the old-growth stands than in mature stands, and the density of pines was higher in mature stands (Table 1).

In northern hardwoods both old-growth and mature stands exhibited a negative exponential distribution of sugar maple size classes. Old-growth stands, however, had a significantly lower density of sugar maples < 34 cm dbh and a significantly higher density of sugar maples > 34 cm. Average diameters of sugar maples did not differ between mature and old-growth stands. As in the pines, old-growth northern hardwood stands supported lower tree densities than mature stands (Table 1).

Regeneration. Very little red pine regeneration occurred in red pine stands, regardless of age; only the mature stands contained saplings. White pine regeneration was present in both old-growth and mature red pine stands, but saplings were essentially absent from old growth. There was a significant negative correlation between stand age and pine sapling density. Overall, white pine regeneration was generally sparse. There were few pine seedlings, large seedlings, and saplings in old-growth pine stands, and few to many in younger stands.

All northern hardwood stands had sugar maple regeneration (Table 1) in all three size classes. Seedling/sapling densities for all species combined showed no correlation with stand age, but the density of basswood seedlings increased significantly with age.

Coarse Woody Debris (CWD). The mean volume of CWD (snags and down logs) was much higher in old-growth red pine and white pine stands than in mature stands (Table 1). In northern hardwoods, there was no significant relationship

between the age of the oldest tree in a stand and the amount of CWD. The volume of down logs and the volume and basal area of snags was higher in old-growth stands than in mature stands in both red pine and white pine forests, but these values were independent of stand age in northern hardwoods (Table 1.)

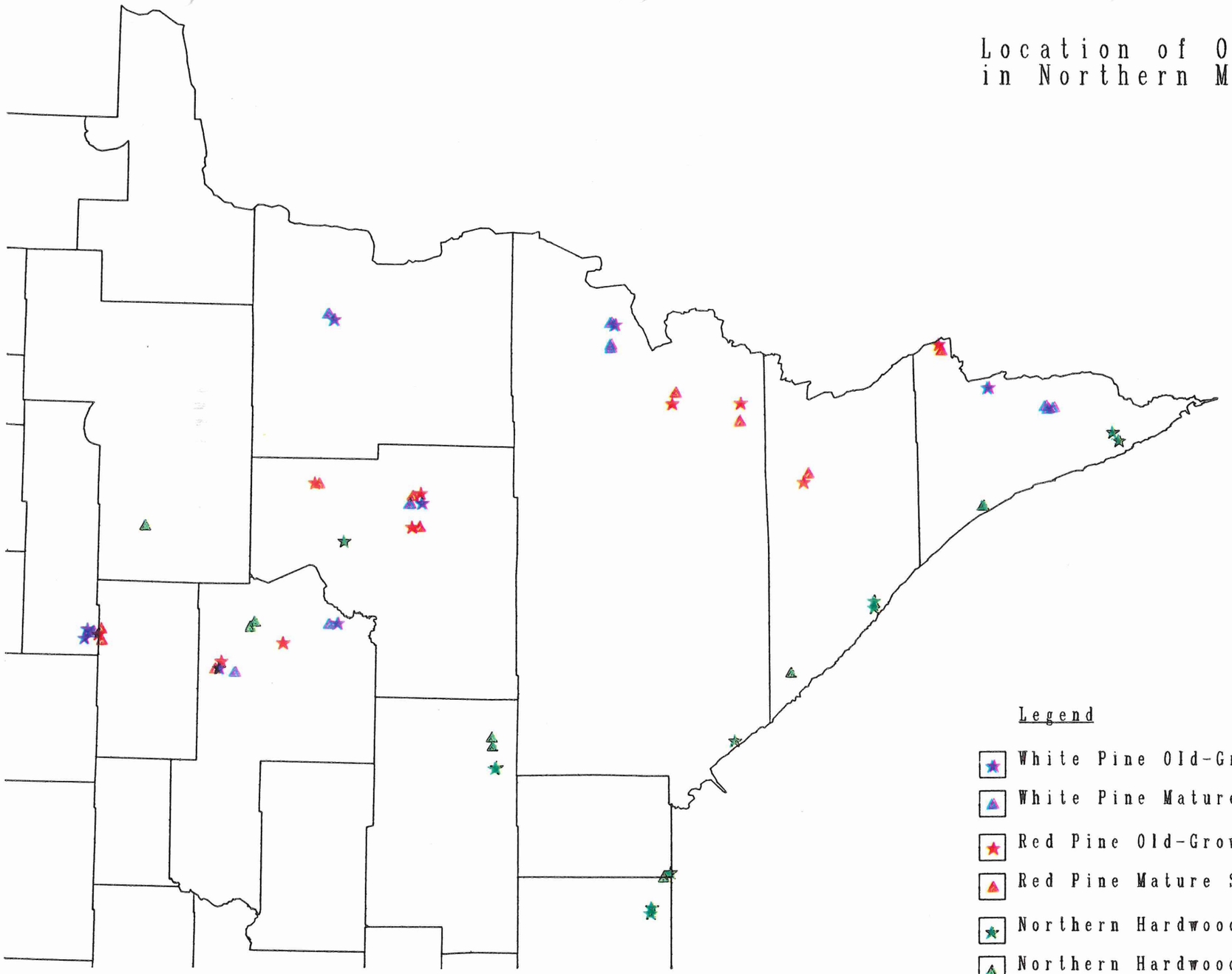
Table 1. Structural characteristics of Red Pine, White Pine, and Northern Hardwoods Forests

	RED PINE		WHITE PINE		NORTHERN HARDWOODS	
	Mature	Old-Growth	Mature	Old-Growth	Mature	Old-Growth
Number of Stands	10	10	12	8	9	11
Number of Stands with Cut Stumps	4	0	3	2	6	3
Mean Basal Area-all species (m^2/ha)	43.1	46.5	33.1	56.7	34.0	30.3
Mean Canopy Cover(%)	54.7	60.8	54.3	54.9	87.7	84.7
Mean Diameter of Trees (cm)	27.7[r]	48.7[r]	30.7[w]	53.3[w]	20.0[s]	21.9[s]
Tree Density(#/ha) (Pines or Map/Bass)	539	170	298	221	702	508
Number of Stands with tree regeneration	2[r]	1[r]	12[w]	4[w]	9[s]	11[s]
Mean Total CWD Volume (m^3/ha)	27.2	96.7	50.3	118.8	43.4	42.4
Mean Down Log Volume (m^3/ha)	15.9	48.7	25.7	61.4	32.4	27.3
Mean Snag Volume (m^3/ha)	11.3	48.0	24.7	57.4	11.0	15.2
Mean Snag Basal Area (m^2/ha)	2.7	6.1	4.4	6.7	2.4	3.0

r - red pine
w - white pine
s - sugar maple

c. **Vascular plant species composition of old-growth stands.** The vascular plant species composition of old-growth stands was indistinguishable from that in mature stands for all three forest types. Multivariate analysis of releve data from red pine, white pine, and northern hardwood forests indicated that the major differences in species composition in each of these forest types were related to geography and not to differences in age between mature and old-growth sites.

Location of Old-Growth Study Areas in Northern Minnesota (1991-1992)



Legend

- White Pine Old-Growth Stands
- White Pine Mature Stands
- Red Pine Old-Growth Stands
- Red Pine Mature Stands
- Northern Hardwoods Old-Growth Stands
- Northern Hardwoods Mature Stands

d. **Sensi plant species in old-growth stands.** Only one stat isted rare species, Barren Strawberry (*Waldsteinia fragariodes*), was recorded within the stands sampled in this project. A new population of this state species of special concern was located in northern St. Louis County. No state-listed species of lichens or mosses were observed within any of the plots sampled.

e. **Contributions to the Natural Heritage Information System.** Releves and element occurrence records for 60 sites have been entered into the Natural Heritage Information System. These releves provide key information that will be used in future revisions of the Natural Heritage Program's Natural Community Classification.

f. **Discussion.** This project provides quantitative data describing the range of structural features found in old-growth forests. For example, information on the mean and range of values for snag volume in old-growth white pine forests will provide a useful baseline to compare with other sites and to develop management guidelines for managing older forests. These values, however, are guidelines only. Some structural features, such as the volume of coarse woody debris, are quite variable in old-growth stands.

In spite of this variability, there are significant structural differences between mature and old-growth stands of red pine and white pine forests. The volume of coarse woody debris (both snags and down logs) was greater in old-growth stands of both pine types. Such differences suggest that old-growth sites provide more extensive habitats and microhabitats for species that rely on coarse woody debris. In addition, the greater volume of coarse woody debris in old-growth stands is likely to result in qualitative, if not quantitative, differences in patterns of nutrient cycling in old growth as compared to younger stands. It should also be recognized the pine stands studied in this project have generally been protected from natural fires for many years. The structural characteristic of these stands is likely to differ from most presettlement old-growth stands that typically experienced more frequent fire.

The lack of significant differences between old-growth and mature northern hardwood stands for most structural features (e.g. total basal area, mean tree size, volume of coarse woody debris) is problematical. However, old-growth stands do have a signficantly higher density of sugar maples > 34 cm dbh. Old-growth northern hardwood forests are inherently more patchy and uneven aged than old-growth pine stands, and in many cases, the period since the last catastrophic disturbance may be much greater than the age of the oldest tree in the plot or even the stand. In addition, sugar maple logs and stumps decay considerably faster than pine. Thus, some of the stands identified as mature may actually have been part of an old-growth stand. The lack of a greater volume of coarse woody debris in old-growth could be due to past logging that is no longer evident because the cut stumps have decayed, or it could be simply due to rapid decay of coarse woody debris following moderately intense natural disturbances. Nevertheless, the results suggest that old-growth northern hardwood stands may not always contain particularly large amounts of large snags and down logs.

This project will continue into the next biennium with funding recommended by LCMR. The continuation of the project will characterize old-growth in three additional forest types: maple-basswood forest, oak forest, and black ash forest. The complications raised by the nature of northern hardwood forests are relevant to the forest types being studied in the continuation of the project and will be addressed by determining ages of a greater number of

trees.

As stated above (A.5.a), only eight old-growth white pine and nine mature northern hardwood stands were sampled rather than 10 each as planned. This situation resulted from sampling a plot before the actual age of the stand was determined. This problem was compounded by 1) the inherently difficult and time-consuming nature of field work to select appropriate study sites and 2) the unavailability of funding until July 1, well into the field season. In order to minimize the problems associated with selection of appropriate sites, site selection for the continuing portion of this project began in May 1993, and field work began in June 1993. In addition, stand ages will be verified earlier in the project to assure that at least ten mature and ten old-growth stands are sampled of each type.

One procedure outlined in the work program was dropped during the second field season. The contractor was unable to accurately assess soil texture and depth of soil horizons. Soil samples were collected but not analyzed for pH because this information alone would provide little value.

A.6 Benefits: This research will provide important information that will allow the Department of Natural Resources to manage and protect old-growth forests and the biological diversity associated with these forests. More specifically, the results of this research will: 1) provide forest managers with objective criteria necessary to identify old-growth forest stands, 2) provide empirical data for revision of the Department of Natural Resources Old-Growth Guidelines, and 3) provide data on the nature of old-growth forests that can used to integrate management for old-growth features and associated biological diversity into the management of commercial forests.

B. Evaluate candidate old-growth stands identified during implementation of DNR Old-Growth Guidelines.

B.1 **Narrative:** The Department of Natural Resources Old-Growth Guidelines call for identification of candidate old-growth stands by field managers in each management area. Selection of these candidate stands is based largely on preliminary criteria included in the guidelines. The guidelines then require that candidate stands be evaluated by natural resource professionals under the direction of the Natural Heritage Program to determine whether a stand qualifies as old growth. The Natural Heritage Program lacks the staff and funds to carry out this requirement. One or two ecologists will be hired to participate in and supervise the evaluation of old-growth candidate stands.

B.2 **Procedures:** DNR natural resource professionals will first be trained to evaluate old-growth forests by the Natural Heritage Program Forest Ecologist. This training will include field visits to a number of old-growth stands. These natural resource professionals will then visit and evaluate candidate old-growth stands. Those stands judged to be significant old-growth stands will be recommended for designation as Scientific and Natural Areas, Natural Heritage Registry Sites, or some other form of protection. Reasons for rejecting or selecting each candidate stand will be documented in a written report.

B.3 **Budget:**

a. Amount Budgeted	$30,000
b. Balance: June 30, 1993	$ -0-

B.4 Timeline for Products/Tasks

	July 91	Jan 92	Jun 92	Jan 93	June 93
Train evaluator(s)	**				
Evaluate candidate stands		******	*******	****	
Prepare reports		*****	****	**	

B.5 **Status: Evaluation of red pine and white pine candidate stands.**
In 1991 a forest ecologist was contracted for several weeks to assist the Natural Heritage Program in developing standardized evaluation procedures and in training interdisciplinary teams of DNR resource professionals to evaluate red pine and white pine Old-Growth Candidate Stands. Fourteen DNR resource professionals were trained during a 3-day session. During the 1991 field season DNR evaluators field-checked 47 old-growth candidate pine stands. Stands that met minimum criteria based on preliminary field reconnaissance were sampled and assigned a stand score according to: 1) age, 2) size and context, 3) degree of human disturbance, and 4) structural characteristics.

Management recommendations for Candidate Stands evaluated in 1991 were presented by the Natural Heritage Program to the Division Directors of Fish and Wildlife, Forestry, and Parks following the 1991 field season. All stands were ranked on their ecological significance within the ecological region of the state in which they occurred. At that time, 21 stands were recommended for protection, 19 stands were recommended for other management, three stands were recommended for future old growth, and recommendations were deferred on four stands pending additional information.

A more complete and final analysis of the DNR's forest inventory records in 1992 revealed an additional 69 old-growth candidate pine stands, many in state parks. Additional candidate stands were identified because: 1) archived forest inventory data for several state parks were not available to field managers when the original Old-Growth Candidate Stands were identified and 2) scrutiny of inventory records for potential red pine and white pine future old-growth stands revealed several likely old-growth stands that were not apparent when the original lists of Old-Growth Candidate Stands were compiled. Sixty-one of these newly identified Candidate Stands were evaluated in 1992, for a total of 108 stands during the biennium. The remaining Candidate Stands in Scenic and Jay Cooke State Parks have been scheduled for evaluation this summer. (Old-Growth Candidate Stands in Itasca State Park have not yet been evaluated because of the large number of stands and because they are already protected.)

With the addition of new Candidate Stands in 1992 and the adoption by the DNR of new ecological regions in 1993, final recommendations for management of red pine and white pine Candidate Stands will be made following the 1993 field season.

Evaluation of Old-Growth Candidate Stands of types other than pine.
In early 1993 the DNR Old-Growth Committee reviewed the progress of the Old-Growth Candidate Stand evaluations and concluded that the evaluations needed to be accelerated in order to complete the evaluations within two to three years. Although the format used for pine Candidate Stand evaluations provided good results and fostered an integrated resource management approach among DNR resource professionals, the work was proceeding too slowly. It was often difficult for teams of DNR evaluators to coordinate schedules and take on the additional workload. At the current rate of Candidate Stand evaluation, we

anticipated that funding would be exhausted long before all Candidate Stands were evaluated. Therefore, the committee decided to increase the efficiency of Candidate Stand evaluation by contracting the data collection. Contractors experienced in forest inventory and trained by DNR ecologists will sample the majority of the remaining Candidate Stands. DNR personnel will be used to sample a small number of stands in southern Minnesota and a few scattered stands in the north.

In April and May 1993 evaluation procedures for other forest types were modified from those used for red pine and white pine. Unlike pine forests, old-growth forests of northern hardwoods, lowland hardwoods, and black ash are typically all-aged stands, and it is more difficult to determine stand age. In addition, hardwood stumps decay more rapidly than pine stumps, thus confounding determination of a stand's logging history. A new evaluation procedure was developed with guidance from Dr. Lee Frelich of the University of Minnesota, an expert on old-growth northern hardwood ecosystems. The sampling procedure incorporates plot sampling of canopy trees in order to determine a size-class distribution within each candidate stand. These data will be used to score Old-Growth Candidate Stands of all types other than pine. As with pine stands, scores will be based on stand age, size and context, degree of human disturbance, and structure, but the method of assigning points will differ.

A training session on old growth sampling was held in May 1993 for contractors and DNR personnel. As of June 15, 1993, six contracts have been signed for field-checking 142 northern hardwood Candidate Stands, 99 white cedar Candidate Stands, 51 black ash Candidate Stands, and 143 lowland hardwood Candidate Stands. As a result, 435 additional Old-Growth Candidate Stands will be evaluated within the next year. The remaining 51 Candidate Stands of oak, white spruce, and northern hardwoods will be sampled by DNR personnel during the continuation of the funding for this project. Data from these field-checks will be analyzed by the Natural Heritage Program and a score will be assigned to each stand. This information will be used to make management recommendations for Old-Growth Candidate Stands.

B.6 **Benefits:** Completion of this objective will facilitate implementation of the Department of Natural Resources Old-Growth Guidelines. Effective implementation of the guidelines will result in 1) protection of ecologically significant old-growth stands and 2) release for other management of old-growth candidate stands that do not qualify as old growth.

C. **Coordinate with the LCMR-funded project "Effects of Changes in the Forest Ecosystem on the Biodiversity of Minnesota's Northern Forest Birds" in order to assess the importance of old-growth forests as sensitive habitats for forest birds.**

C.1 **Narrative:** Forest bird populations in old-growth and mature forest stands selected for sampling of vegetation and old-growth features will be censused during the breeding season. These data will be used to assess the importance of old-growth as a sensitive habitat for forest birds.

C.2 **Procedures:** Data gathered using bird census techniques adopted by the Forest Birds LCMR Project will be used to assess 1) whether old-growth forests support distinctive assemblages of birds and 2) the importance of structural features found in old-growth forests to individual bird species.

C.3 **Budget:** Not applicable

C.4 **Timeline for Products/Tasks:**

	July 91	Jan 92	Jun 92	Jan 93	June 93
Bird population sampling			***		
Data analysis				******	

C.5 **Status:** Six old-growth red pine and white pine stands sampled as part of the Old-Growth Forest project during the 1991 field season (see Section **A.2**) were censused in June 1992 by researchers with the Forest Birds LCMR Project. All old-growth pine and northern hardwoods stands sampled during the 1992 field season 15 acres in size and larger are scheduled to be censused by the Forest Birds Project in June 1993.

The results of these censuses "indicate a relatively high diversity of forest bird species associated with these stands (e.g. 10 or more species observed in two or three 10-minute point counts). Two species were observed in each of the six stands. In general, the results of this initial census are difficult to put completely in perspective because of the limited sampling. However, as the number of samples increases over time, the results can be compared with forest bird communities from a variety of habitats. These data will then allow a determination of whether old-growth forests contain a unique assemblage of forest birds" (Final Report of LCMR Forest Birds Project).

C.6 **Benefits:** Completion of this objective will provide data essential to managing bird species characteristic of old-growth forests. Both those species most closely associated with old growth and the features of old growth with which those species are associated can begin to be identified for future management.

IV. **Evaluation:** This project can be evaluated based on 1) the development of practical definitions of old growth for three forest types that describe and quantify old-growth features of each forest type and 2) whether these descriptions become widely accepted (e.g. are incorporated in revisions of the DNR Old-Growth Guidelines). Successful completion of objective B will result in the review of a significant number of old-growth candidate stands during FY 92-93.

V. **Context**

A. Protection and management of old-growth forests is a nationwide issue that has become an issue of concern in Minnesota. In order to protect and manage old growth, it must first be identified. The only existing descriptions of Minnesota old-growth forests based on structural and compositional features are found in a Natural Heritage Program preliminary report on Minnesota old-growth forests and in the DNR Old-Growth Guidelines. These descriptions are sketchy and are not based on systematic study of old growth. At the present time information on the key structural features of old growth necessary to develop useful descriptions of old growth in Minnesota forest types does not exist.

B. As discussed above, there has been almost no research directed towards developing descriptions of old-growth forest types in Minnesota. Information on old-growth sites in the Natural Heritage Program Database is not quantitative. The current project supplements these data by providing additional information on Minnesota old growth.

C. The current project will be coordinated with the LCMR funded project "Effects of Changes in the Forest Ecosystem on the Biodiversity of Minnesota's Northern Forest Birds" (Wildlife 20) such that old-growth and mature forest sites selected in the current project will be sampled in the forest birds project. Data on forest birds collected from these sites will be used to determine whether old growth is a sensitive habitat for these bird species. Selection of study sites and the overall project will be coordinated with the DNR Division of Forestry. Some (and perhaps all) of the study sites will be included in the LCMR funded nutrient cycling study (Forestry 5) conducted by researchers from the University of Minnesota College of Forest Resources. The study sites may also be used in a detailed study of the importance of old growth as a sensitive habitat for lichens conducted by Dr. Clifford Wetmore at the University of Minnesota College pending available funds. Lichens are the one group of macroscopic organisms that is most likely to have species limited to old-growth forests.

The Natural Heritage Program has received a Challenge Grant from Superior National Forest to study white cedar forests. This grant has allowed us to study 15 old-growth stands. The LCMR has not previously funded old-growth research. The current proposal addresses three forest types: red pine forest, white pine forest, and northern hardwood forest. Following successful completion of this project, additional funds may be sought to study other old-growth forest types in Minnesota.

D. Not applicable.

E. Biennial Budget System Program Title and Budget: MN Old-Growth Forests $150,000

VI. **Qualifications**

1. **Program Manager**

Kurt A. Rusterholz
Forest Ecologist, Natural Heritage Program
Section of Wildlife - Minnesota Department of Natural Resources

Ph.D. Community Ecology, University of Wisconsin, 1979
M.S. Zoology, University of Wisconsin, 1973

The program director's area of expertise is forest community ecology, especially avian and plant ecology. For the last three years he has been a plant ecologist with the Natural Heritage Program studying and evaluating forest communities and providing ecological expertise as a member of the DNR Old-Growth Task Force. He has also conducted research on forest birds published in several major refereed journals. His current research is on the ecology of white cedar forests.

Principal publications related to the current project:

Rusterholz, K.A. 1990. Minnesota's old-growth forests. Minnesota Forests 3 (3): 12-16.

Rusterholz, K.A. 1989. Old-Growth Forests in Minnesota: A Preliminary Report. Minnesota DNR Natural Heritage Program Biological Report No. 5.

2. **Major Cooperators:**

Dr. David J. Mladenoff
Research Associate, Natural Resources Research Institute
University of Minnesota - Duluth

Ph.D. Plant Community Ecology, University of Wisconsin, 1985
M.S. Land Resources, University of Wisconsin, 1979

Dr. Mladenoff has published in refereed journals and conducted research in the areas of forest ecology of the Lake Superior region, biodiversity, and landscape scale analysis using Geographical Information Systems. He has studied old-growth northern hardwood forests in Michigan and Wisconsin, and his current research includes projects on old-growth forest biodiversity funded by the U.S. Forest Service and The Nature Conservancy, and work funded by the National Science Foundation and the National Park Service. Besides research, his experience includes nearly eight years working cooperatively with state and federal land management agencies on biodiversity issues. Dr. Mladenoff will advise the graduate student who will conduct much of the field research for the current project.

Principal Publications related to current project:

Mladenoff, D.J. and E.A. Howell. 1980. Presettlement vegetation, land use and present vegetation of the Gogebic Range, Wisconsin. Trans. Wisc. Acad. of Science, Arts, Letters 68: 74-89.

Mladenoff, D.J. 1987. Dynamics of nitrogen mineralization and nitrification in a hemlock and hardwood treefall gaps. Ecology 68:1171-1180.

Mladenoff, D.J. 1991. The relationship of the soil seed bank and understory vegetation in old-growth northern hardwood-hemlock tree fall gaps. Canadian Journal of Botany (in press).

Pastor, J. and D.J. Mladenoff. 1991. The southern boreal forest border. 41 pp. In: Ecosystems analysis and simulation of the global boreal forest. H.H. Shugart, ed. Cambridge University Press. (in press)

VII. Reporting Requirements

Semiannual status reports will be submitted not later than January 1, 1992, July 1, 1992, January 1, 1993, and a final status report by June 30, 1993.