1993 RESEARCH PROJECT ABSTRACT

For the period ending June 30, 1995
This project was supported by the Minnesota Environment and Natural Resources Trust Fund

Title:	**G1-5 Minnesota's Forest Bird Diversity Initiative-Continuation**
Program Manager:	Lee A. Pfannmuller
Organization:	Minnesota Department of Natural Resources
Legal Citation:	M.L. 93, Chpt. 172, Sec 14, Subd. 6(b)
Approp. Amount:	$500,000

STATEMENT OF OBJECTIVES

Designed as a long-term initiative that began in FY92-93, the project's primary goal is to develop landscape management tools to maintain Minnesota's rich diversity of forest birds. Major objectives in the FY94-95 biennium were to: implement the monitoring program that began in FY92; continue work to assess the relationship of forest birds to landscape patterns and composition; and promote forest bird conservation and management.

OVERALL PROJECT RESULTS

A total of 1,025 point counts in the Superior and Chippewa National Forests and in the St. Croix River Valley were censused in 1993 and 1994. Analyses reveal that the program can detect annual population changes for 56 species in the Chippewa National Forest, 51 species in the Superior and 40 species in the St. Croix region. These results are among the best reported for established monitoring programs. At present, most species are maintaining relatively stable populations with only slight annual variations. Although the monitoring program is extremely comprehensive, project staff identified 22 species that are not adequately monitored. Efforts are underway to improve the ability to track their populations. After experimenting with two field techniques, nest searching was selected as the preferred method for estimating reproductive success in 1994. Results indicated that nest loss due to predation was relatively high. If the trends observed in 1994 are widespread and continue in future years there is concern about the long-term ability of some species to maintain viable populations. Motion sensitive cameras also documented eight mammals predating on artificial ground nests; fisher were reported most frequently. The widely held premise that nest predation is higher near forest edges was not clearly supported by field data. Assessments of the ecological effects of edges created by forest management activities will continue. After completing analysis that began in FY92-93 of the relationships between birds and vegetation at the statewide scale, work focused on analyzing relationships at the regional and site-specific scales. Preliminary work concluded that forest birds respond to factors both at the site level and landscape level. Satellite images of the three primary study regions (i.e. the Chippewa and Superior National Forests and St. Croix region) were classified and, following verification, will be the basis for expanding these preliminary analyses to bird data from the entire suite of 1,025 point counts. At the site-specific level, nine study plots (one mi^2 each) were established in cooperation with the national forests, forest industry and private landowners. Birds were censused on each plot and vegetation was classified using aerial imagery. These plots will form the basis for addressing site-specific forest management issues next biennium. Data at all three levels (i.e. statewide, regional and site) will begin to be integrated with data from the monitoring program in the coming year to develop a model that predicts how forest bird populations change in response to forest management, forest succession and natural disturbance. One M.S. thesis was directed at developing management guidelines for residuals trees left in clearcuts to address the needs of forest birds and a book, "Birds and Forests: A Guide", will be released this fall. Funding will continue in FY96-97.

PROJECT RESULTS USE AND DISSEMINATION

A total of 23 presentations have been given on the status, conservation and management of forest birds and results of the Initiative's findings have been presented as technical papers or posters on 21 different occasions. Three M.S. theses have been completed and three new ones initiated. Eleven publications are in preparation, *in press*, or have been submitted to least five different peer-reviewed periodicals. The project was also featured again on the Venture North TV series in the fall of 1994.

I. **Project Title:**   G1-5 MINNESOTA'S FOREST-BIRD DIVERSITY INITIATIVE-
CONTINUATION

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A. Legal Citation M.L. 93 Chpt. 172, Sec. 14, Subd. 6(b)

Total Biennial LCMR Budget: $500,000   Balance: $0

Appropriation Language: This appropriation is from the trust fund to the commissioner of
natural resources to monitor forest songbird populations and to utilize geographic
information system tools to correlate forest bird populations with dynamics of the forest
landscape.

B. LMIC Compatible Language: During the biennium ending June 30, 1995, the data
collected by the 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. Data review committees
may be established to develop or comment on plans for data integration and distribution and
shall submit semiannual status reports to the legislative commission on Minnesota resources
on their findings. In addition, the data must be provided to and integrated with the
Minnesota land management information center's geographic data bases with the integration
costs borne by the activity receiving funding under this section.

C. Status of Match Requirement: Not applicable.

II. **Project Summary:**

The overall goal of Minnesota's Forest Bird Diversity Initiative is to develop landscape
management tools to maintain Minnesota's rich diversity of forest birds. Forest birds are good
indicators of diversity since they comprise 70% of all forest vertebrates. Minnesota's rich
abundance of forest birds is of national significance. The state lies in a narrow forest belt that
supports a greater diversity of songbirds than anywhere else in North America. Regardless,
forest birds have received little management attention.

This initiative is the first comprehensive U.S. effort designed to relate habitat patterns and
change to regional bird diversity using a long-term monitoring program. The program, begun
in FY92, is designed as a 10-15 year monitoring effort. It collects data on the presence and
abundance of forest birds through a network of over 1,000 sampling points distributed across
the northern forest region. Geographic Information System (GIS) techniques will then be used
to correlate bird population data with regional forest cover and land use information and to
develop predictive models that assess the impact of future forest change. The knowledge
gathered will be applied to the development of forest management tools that integrate the
diverse habitat needs of forest birds.

III. **Statement of Objectives:**

A. Implement the forest bird monitoring program.

B. Assess the relationship of forest birds to landscape patterns and composition.

C. Promote forest bird conservation and management.

IV. **Research Objectives**

A. **Title of Objective:** Implement the forest bird monitoring program.

A.1. **Activity:** Data on the presence and abundance of forest birds will be collected by a
long-term monitoring program that began in FY92 and includes over 1,000 sampling points
in three major study sub-areas: the Superior National Forest, the Chippewa National
Forest and the St. Croix River Valley.

A.1.a. **Context within the project:** Data currently available on Minnesota's northern
forest songbirds are inadequate to accurately assess their response to major changes
across the forest landscape. This objective will provide the baseline population data
critical to making this assessment. Because many factors can affect population levels in
a given year (e.g., weather, food availability and habitat) data for a minimum of 10-15
years are essential to accurately assess the relationship of birds to the forest landscape.

A.2. **Methods:** The field sampling protocol established for the long-term monitoring
program during the FY92-93 biennium will continue in FY94-95. Sampling points within
the three major study sub-areas are distributed as follows: Chippewa National Forest (400
points), Superior National Forest (525 points) and St. Croix River Valley (100 points).

Within each sub-area, habitats are sampled in direct proportion to their total acreage. Sampling is limited to forest stands greater than 40 acres in size and to stands typed as commercial forest land (even though their stocking index may be poor). Three count points, with nonoverlapping 100 meter radii, are located in each sampled forest stand.

Trained observers will conduct one bird count (10 minutes in duration) at each point during the breeding season between .5 hours before to 4 hours after sunrise. Types of stands censused will be stratified by time of morning. All birds heard or seen from the center point will be recorded in a circle with estimates of their distance from the center point (up to 100m). Information on habitat structure and plant species composition at the center of each point will also be collected. All data will be entered into a Paradox file directly from the field data sheets.

A.1.c. Materials: Field materials necessary to accomplish this objective are limited to vehicles, permanent station markers, field maps, data forms and binoculars.

A.1.d. Budget: $90,115   **Balance:** 0

A.1.e. Timeline:	7/93	1/94	6/94	1/95	6/95
Implement monitoring program	****		******		****
Enter data into Paradox datafiles	****		****		
Prepare annual summary of survey information	*****		*****		

SUMMARY REPORT FOR OBJECTIVE A.1.

1. **Summary of Monitoring Efforts on the Chippewa and Superior National Forests and on the St. Croix River Valley Study Region**

   Over the course of the monitoring period a total of 112 species have been identified in the Chippewa National Forest, 115 in the Superior, and 79 in the St. Croix Valley. The low number of species observed in the St. Croix Valley is primarily due to the lower number of points sampled and one less year of sampling. The number of individuals observed are sufficient to statistically analyze changes in abundance for 56 species in the Chippewa National Forest, 51 species in the Superior, and 40 species in the St. Croix Valley. These results are among the best reported for monitoring programs and will help us relate changes in bird populations to changes in the forest landscape.

The analyses have detected many annual changes in species populations thus far, yet few have been consistent from year to year or among study regions. Overall, the majority of species are maintaining relatively stable populations with only slight annual variations. The exceptions include the White-breasted Nuthatch (Chippewa NF), Red-breasted Nuthatch (Superior NF), and White-throated Sparrow (St. Croix Valley) which have all significantly increased since sampling was initiated within each respective area. In contrast, the Hairy Woodpecker, Eastern Wood Pewee, and Brown Creeper have all declined in the Chippewa National Forest, while the Veery has declined from 1992 to 1994 in the St. Croix Valley. The federal Breeding Bird Survey data for Minnesota (see Section 3, below) revealed similar statewide trends for some of these species.

Future Efforts: Monitoring efforts will continue on all 1,025 sampling points during the 1996 and 1997 field seasons. During the next biennium we will also be able to move beyond a simple analysis of annual changes in population numbers between years to a more sophisticated trend analysis.

2. **Pilot for Extending the Monitoring Program into Southeastern Minnesota**

   One of the primary goals of the FY96-97 Work Program is to expand the monitoring efforts into the southeastern region of the state. To better prepare for the 1996 field season project staff initiated a pilot effort to familiarize ourselves with some of the unique challenges of working in this region. Using the same sampling protocols that were established for the northern forest study regions, a total of 75 census points were established in three counties: Rice, Goodhue and Wabasha. Fifty-four species of birds were detected and an additional 10 species were recorded between points, flying overhead or at distances greater than 100 m from the points. Of particular interest were a Brown Creeper, Mourning Warbler and Chestnut-sided Warbler in Wabasha County, a Nashville Warbler and Broad-winged Hawks in Goodhue County and Acadian Flycatchers in all three counties. Brown-headed Cowbirds were recorded at most census points.

   Field work in southeastern Minnesota presents us with two new challenges that were not encountered in the northern forest. The more fragmented nature of the forest landscape results in census points being more widely dispersed and fewer points being censused each morning. Also, the smaller size of many of the forest tracts limits our ability to replicate survey points in each stand.

   Future Efforts: Over the course of the winter, project staff will consider where additional survey points will be established in the southeast region - in light of the constraints of working in the regioon that we experienced in 1995 - and be prepared to initiate a full-scale effort for the 1996 field season.

3. Statewide Trends: Breeding Bird Survey Analysis

The federal Breeding Bird Survey (BBS) represents the only quantitative, statewide data available on forest birds in Minnesota. Although it was not highlighted as a specific task in the work program, project staff will be continually analyzing these data to understand statewide trends and to compare these statewide trends to the regional trends we observe with the more intensive, habitat-specific monitoring program. Our final report for the FY92-93 biennium provided a critique of the BBS and summarized an analysis of statewide trends for the years 1966-1990. During FY94-95 this analysis was updated to include data from 1991 to 1993.

Briefly, trends were analyzed for the entire state and for those routes sampled in the primary forested area of the state (strata 20 and 28). For 121 species examined, 50 (41%) have shown no change in the state or in strata 20 and 28. A total of 43 (36%) have shown a significant increase and 28 (23%) have shown a significant decline in either the state, strata 20 and 28, or both. Project staff examined possible causes or commonalities among species that were increasing or declining. Among the possible explanations noted were changes in agriculture, wetlands, forests and urbanized habitats and landscapes over the past 28 years. As mentioned above, only a few species censused with our habitat-specific monitoring program showed significant increases or decreases in the past four years.

In addition to allowing us to compare regional species trends with statewide population trends, the BBS data also allows us to effectively monitor some less common forest species that are not adequately monitored by the habitat-specific monitoring program.

Future Efforts: Every two years the most recent BBS data will be added to the long-term data set, analyzed for statewide trends, and compared to survey data the Initiative is collecting in Minnesota's forested regions. Our FY96-97 report will include an analysis of data collected from 1966-1997.

A.2. Activity: Conduct complementary field investigations.

A.2.a. Context within the project: The long-term monitoring program is designed to adequately sample the majority of over 125 bird species present in the northern forest. It is likely, however, that analysis of results from the 1992 and 1993 field seasons will reveal that rare species and/or species that depend on special habitat types or features are not adequately sampled. Once these species are identified, field investigations will be initiated to collect data describing their distribution, relative abundance and habitat requirements so that data on the full suite of forest songbirds is collected by the program.

Several other complementary studies are also planned. One will be the ongoing coordination with the LCMR Old-Growth Forest Study (Description and Evaluation of Minnesota Old-Growth Forests). Old-growth sites where vegetation data is collected in a given field season will be surveyed for birds the following field season. Another study will focus on assessing the reproductive success of forest birds. Although birds may be present in a variety of habitats, the forest stands that are most important to their survival are those where they successfully reproduce. A third study will delineate the interrelationships between habitat selection factors that operate within a forest stand versus those that operate at the landscape level.

A.2.b. Methods: Population data collected during the FY92-93 biennium will be analyzed to identify species that are known to be present in the northern forest but which were not adequately sampled by the point count methodology. Field methods that provide the necessary information for each species, or group of similar species, will be selected and field investigations initiated on those identified as the highest priorities. For the old-growth field plots, the point count methodology used as part of the broader forest bird monitoring program will be implemented.

Two techniques will initially be employed to assess reproductive success - nest searches and mist-netting. During the first field season (1993) the effectiveness and efficiency of these two techniques will be compared. Depending on the results, field methods may be modified for subsequent field seasons. This work will be conducted within a subset of pre-selected forest stands on the Chippewa and Superior National Forests.

Finally, the study of habitat selection factors will be conducted in approximately 2-4 one square mile study areas located within the major sub-areas. Initially, the focus will be limited to the Superior and Chippewa National Forest sub-areas. Birds will be intensively sampled within each square mile a total of three times during the breeding season. Low-level aerial photography will be used to classify the vegetation within and surrounding each study area.

A.2.c. Materials: Existing databases of forest birds prepared by NRRI staff for the Generic Environmental Impact Statement Scoping Document on Timber Harvesting will be used to assess the first two years of survey results. Materials needed for subsequent field studies are likely to be limited to vehicles, field maps, data forms, aerial photographs, and binoculars. Song tapes and mist nets will also be used.

A.2.d. Budget: $90,115   **Balance:** 0

A.2.e. Timeline:

	7/93	1/94	6/94	1/95	6/95
Identify species in need of additional sampling	********				
Select appropriate field methods		******			
Initiate field investigations			*****		****
Sample old-growth study sites			*****		****
Assess reproductive success	****		*****		****
Initiate study of habitat selection factors	****		*****		****

SUMMARY REPORT FOR OBJECTIVE A.2.

1. Species at Potential Risk

Identification of Species

Following a detailed analysis of the breeding bird data from the national forests, combined with data from the St. Croix River Valley, project staff identified the following twenty-two species at potential risk in the north and northcentral forested regions of Minnesota:

Common Goldeneye	Whip-poor-will
Hooded Merganser	Red-bellied Woodpecker
Common Merganser	Three-toed Woodpecker
Northern Goshawk	Black-backed Woodpecker
Merlin	Boreal Chickadee
Spruce Grouse	Philadelphia Vireo
Yellow-billed Cuckoo	Palm Warbler
Great Gray Owl	Cape May Warbler
Long-eared Owl	Bay-breasted Warbler
Boreal Owl	Red Crossbill
Northern Saw-whet Owl	Pine Siskin

These species were selected for the following reasons: 1) they are not monitored effectively (>75% power of detecting an annual change) with the BBS roadside routes, primarily because they are rarely detected on the routes and 2) they are not monitored effectively with the habitat-specific point count monitoring program (>50% power of detecting an annual change) established within the Chippewa or Superior National Forests or in the St. Croix Valley, again primarily because they are rarely detected. They are considered at risk because, should their populations decrease significantly, our current monitoring programs would be unable to detect

the decline.

Field Sampling Efforts

During the summer of 1994 two additional censusing activities were evaluated in an attempt to increase our ability to monitor several of these species. One activity was to increase our sample size for coniferous forest habitats because many of the species, such as Boreal Chickadee, Palm Warbler, Cape May Warbler, Bay-breasted Warbler, and Pine Siskin, are highly associated with coniferous trees. A total of 18 points were added in a variety of upland and lowland coniferous stands. However, only one of the potentially sensitive species - two Cape May Warblers - was observed. The conclusion was that a substantial increase in the number of stands would need to be added to increase the sample size for these species. The increase in field effort for these few species alone, would be significant and costly.

The second activity to improve the gathering of data for many of these susceptible species was to experiment with tape recorded playbacks of the Broad-winged Hawk in the Chippewa National Forest and of the Northern Goshawk in the Superior National Forest. These playbacks were added at the third and last point of each daily census route of the monitoring program. Studies suggest that some hawks and owls will respond to these recorded calls - the number of responses providing an index of population abundance. Even though our censusing program can adequately monitor the Broad-winged Hawk, we selected this species to increase the probability of having some success with the method. In general, the results were not very effective. Only four responses total, on both the Superior and Chippewa National forests, were recorded. Since there is limited knowledge on how best to get raptors to respond in these forested environments, we will continue to seek other means to increase their detection.

Future Efforts: Project staff have initiated another effort in an attempt to optimize our ability to find species at potential risk. The effort is designed to do the following: 1) identify potentially suitable breeding habitats for these species by identifying stops along the BBS roadside routes where these species have been observed over the past 28 years; 2) use the Landsat TM scenes to identify the landscape "signatures" associated with these stops; 3) identify additional areas that have these "signatures" to increase our probability of finding these species; and 4) survey these additional areas in an attempt to identify whether these species are present. The results will be completed during the next biennium.

2. Old-growth Forest Plots

In cooperation with an LCMR funded Old-Growth Forest Project, project staff sampled selected old-growth plots to identify bird species using these stands. Only those stands in the project that were reasonably sized (e.g. greater than 15 acres) were sampled using the same protocols as described in Section A.1.b.

A total of seven stands in northern Minnesota were sampled in 1993 and five stands in southeastern Minnesota in 1994. Total individuals ranged from 7.5 to 14.3 per point while the number of species observed ranged from 6 to 9. Eastern Wood-Pewee, Red-eyed Vireo, and Scarlet Tanagers were observed on all stands. Species which were only observed on pine stands were the Gray Jay, Solitary Vireo, Blackburnian Warbler and the Pine Warbler.

Future Efforts: With the six old-growth stands that were sampled in the FY92-93 biennium, a total of 18 stands (53 census points) have now been sampled. A few additional stands in southeast Minnesota will be sampled during the 1996 field season. These were originally scheduled to be sampled in 1995 but could not be completed because of the length of time it took to access the new census points established in southeast Minnesota. Once the sampling is completed, project staff will assess how distinct the assemblage of forest birds is in Minnesota's old-growth stands.

3. **Nest Productivity Studies**

As mentioned above, two techniques for assessing reproductive success were tested during the 1993 field season - nest searching and mist-netting. In general, the success rates for nest searching proved to be highly variable and depended greatly on the experience level of the searcher. Mist-netting was conducted on three plots; capture rates were similar among the plots and quite low, ranging from 0.09 birds/net hr to 0.13 birds/net hr.

Following a comparison of the two methods, project staff decided to focus on the nest searching method primarily because it provides a direct measure of reproductive success. To improve our effectiveness in searching for natural nests we hired personnel with experience in nest searching. Two studies were then initiated in 1994. The first focused on assessing the reproductive success of natural nests. The second was an experiment using artificial nests as a means to assess predation rates of ground nesting birds. Motion sensitive cameras were also employed in this latter project in an attempt to record the identify of predator species.

The results of the study on artificial nests indicated that they are a useful tool for assessing reproductive success and for identifying the pool of mammalian predators in an area. In this particular study area, fisher were identified as the most frequent predator on ground nests. The results of the study on natural nests indicated that experienced nest searchers could find nests efficiently (347 nests were found) and nest-searching success rates varied from about 2 to more than 10 nests found per day. Most nests were found for the most common shrub and tree nesting species in an area (e.g. Least Flycatcher and Red-eyed Vireo); however, ground nests even for relatively common species (e.g. Ovenbird) were extremely difficult to find.

Results also revealed that the loss of nests was relatively high. The artificial nests on the ground experienced a nest predation rate of 72% after seven days of exposure and 85% after

14 days. The study on natural nests documented an overall mean nest success for the most common species as 0.43. Nest success for individual species ranged widely, however, from a high of 0.76 for the Yellow Warbler to a low of 0.18 for the Red-eyed Vireo. If the high level of nest loss observed for some species in 1994 is widespread and consistently high in future years, there is concern about the long-term ability of these species to maintain viable populations.

Although these two studies were conducted in the same general area of the Chippewa National Forest, they came to different conclusions regarding the effect of forest edges on reproductive success. The study using artificial nests found that predation rates on artificial ground nests were higher near edges than 50 and 100 m into the forest interior. In contrast, the study on natural nests concluded that there was no relationship between nest success and forest edges. The assessment of the ecological effects of edges created by forest management activities in an extensively forested landscape will continue.

Future Efforts: Due to limited funds, no nesting data were gathered during the 1995 field season. Given the importance of this issue, however, we will be establishing an experimental framework over a large area in 1996 that will rely on using a combination of artificial nests and nest searching.

4. **Habitat Selection Studies**

A review of the work that was initiated on the square mile study plots described in the methods for Objective A.2. is provided in the summary report for Objective B. It is presented as part of an overview of the work that is underway to describe the relationship between birds and vegetation at the statewide, regional and site-specific scales. Briefly, project staff worked with a diversity of stakeholders, including forest industry, the national forests, the Minnesota DNR and Minnesota Power, to establish a total of nine study plots (one mi^2 each). Field studies on these plots are designed primarily to address concerns about how forest bird populations respond to specific forest management activities at the site level.

Habitat selection studies were also initiated as a part of several other project components. They include a study of the relationship between the management of residual timber and forest birds (Objective C.), a study of the response of bird populations to a natural disturbance regime caused by fire (Objective B.), a study of the effects of habitat and landscape patterns on bird distribution and abundance (Objective B.), a study of the applicability of satellite imagery to discriminate suitable habitat for breeding birds (Objective B.), a study relating avian abundance and distribution patterns with ecological land types on the Chippewa National Forest (Objective B.), and a study of the birds inhabiting forested wetlands.

Future Efforts: Field work on the square mile study plots will continue and efforts to classify and ground truth the vegetation on each of these plots will be completed. Both the bird and vegetation data will be integrated with another level of bird habitat relationships analyzed at the level of the regional landscape. Together the two data sources will become integral components of the landscape computer simulation model (LANDIS) that will predict how forest bird populations change in response to forest management, forest succession and natural disturbance. Several of the complementary studies will also continue into the next biennium.

5. **Other Complementary Studies**

A Comparison of On- and Off-road Bird Counts: On- and off-road point counts were established in two National Forests in northern Minnesota to determine whether breeding bird parameters derived from two different types of counts conducted on- or off-road were comparable. Results of the study concluded that censuses can be conducted on the roads with the restriction that points be selected randomly and placed within distinct habitat types, and that the roads selected for sampling have a closed canopy.

Experimental Design Considerations for Establishing an Off-Road, Habitat-Specific Bird Monitoring Program using Point Counts: Details and an analysis of the experimental design of the habitat-specific monitoring programs established on the Superior and Chippewa National Forest have been prepared and published in an upcoming, peer-reviewed symposium proceedings.

Management Indicator Bird Species of the Chequamegon National Forest: Uses and Limitations: With partial funding from the USDA Forest Service, Chequamegon National Forest, project staff completed a study to examine the ability to use management indicator species. The results highlight the inherent difficulties of designating and utilizing indicator species as management tools. The results are directly applicable to work in Minnesota and the use of indicator species on the Chippewa and Superior National forests.

Monitoring Bird Populations on St. Louis County Lands: As part of our overall monitoring effort we have been seeking additional partners and cooperators from other governmental agencies. With partial funding from St. Louis County, census points were established on 70 biophysical plots and monitored for forest birds. Results will be integrated into the Initiative's larger database on bird-habitat relationships.

B. **Title of Objective:** Assess the relationship of forest birds to landscape patterns and composition.

B.1. Activity: Stand level information in three primary study areas will expand GIS development and analysis work begun in FY92-93.

B.1.a. Context within the project: In the first phase of the project (FY92-93), work focused on describing and analyzing the forest landscape using broadly available, but coarse resolution data sources. These were the USFWS Breeding Bird Survey Routes and the USGS Land Use/Land Cover Data. The utility of these data in detecting differences in bird species abundance with changes in landscape characteristics was assessed. During the FY94-95 biennium finer resolution bird and land cover data will be used to refine our ability to relate bird species to habitat. This will be accomplished with GIS techniques that allow broader landscape scale assessments and predictions to be made.

B.1.b. Methods: The three sub-areas that were selected for establishment of the long-term monitoring program will also be used for analyzing finer resolution land cover data (i.e. the Superior National Forest, the Chippewa National Forest and the St. Croix River Valley). Each sub-area is approximately equivalent to the size of the land cover data source - a single Landsat satellite thematic mapper (TM) image (185km x 185km). Using well-established procedures of digital image analysis, the images for these three areas will be classified to produce a land cover and forest type classification. The classification will form one major data layer in the GIS.

The finer resolution bird data will constitute another data layer. It will consist of the actual field point count samples (Objective A) which have been collected during the first phase of the project. These point count locations will be spatially located and digitized into an ARC/INFO GIS coverage.

The bird data will then be overlaid with the land cover classification and the relationship of various bird data variables (e.g., species, guilds, life history characteristics) to various landscape scale habitat variables will be analyzed. These analyses will include simple co-occurrence of bird species with cover type and habitat structure and spatial relationships which can be analyzed with GIS, such as habitat patch size, juxtaposition and association of types, and other landscape characteristics.

From these relationships a predictive model using techniques such as logistic regression will be developed. Applying this technique spatially and over time allows staff to predict the effect of future or proposed forest management changes on birds. The predictive model will estimate changes in forest bird distribution and abundance given some set of habitat and landscape structural changes. Complementary studies conducted in A.2. will also contribute significantly to improving the model's predictive

capabilities. Projected negative impacts to forest birds can then be prevented or mitigated by developing appropriate management and planning tools to guide forest management.

B.1.c. Materials: Materials to be used for this objective consist largely of the digital Landsat imagery. Most of this has already been obtained and project staff are already experienced in classifying and analyzing these data from other research projects underway for the U.S. Forest Service. The major equipment is also in place and use, and consists of a SUN work station computer with high capacity disk storage and ERDAS and ARC/INFO software. ERDAS is a raster or pixel-based GIS and image analysis package, and ARC/INFO is a vector or polygon-based GIS package with extensive spatial analysis capability.

B.1.d. Budget: $281,770 **Balance:** 0

B.1.e. Timeline:	7/93	1/94	6/94	1/95	6/95
Classify Landsat imagery for sub-areas	**********************				
Digitize point count locations into an ARC/ INFO GIS coverage	**********************				
Analyze the relationship between birds and landscape scale habitat variables			********************		
Develop predictive model				**********	
Improve modelling capability by gathering additional vegetation data				*******	

SUMMARY REPORT FOR OBJECTIVE B.

1. Status Overview

Classification and Digitization: Briefly, the three Landsat scenes for the Chippewa National Forest, the Superior National Forest and the St. Croix River Valley Study Regional have all been classified. Verification of the classification, however, remains to be completed and is scheduled to be finished in the next few months. In addition, all 1,025 point counts in the extensive, habitat specific monitoring program have been digitized.

Analysis of Bird -Habitat Relationships: The analysis of the relationship between birds and landscape scale habitat variables is a work task that will continue into the next biennium. Work at the regional scale was limited to completion of two Master's thesis projects that demonstrated that the distribution and abundance of selected bird species is related to the vegetation within the plot and to the habitat cover types in the landscape surrounding the plot. Another level of analysis was initiated this biennium at the site-specific, local scale by the establishment of nine square mile study plots designed to address more specific questions regarding the impact of forest management activities on the local forest landscape and forest bird community.

Development of Predictive Model: Because of the length of time it has taken to classify the Landsat imagery, and the intensive level of field work required by the square mile study plots, work on the development of the predictive model will not begin until FY96.

Collect Additional Vegetation Data: A thesis project begun in 1994 is designed to test whether more detailed quantitative vegetation data can improve our ability to explain bird community attributes.

The following three sections briefly describe the work that has been completed or which is underway to analyze the relationship between birds and habitat at three different scales: statewide, regional and local.

2. Statewide Analysis

Manuscripts for two studies initiated during the FY92-93 biennium were completed during this reporting period. The preliminary findings were reported in the FY92-93 final report. Briefly, the purpose of the first study was to determine if digital USGS land use/land cover (LUDA) data, of a relatively coarse resolution (16 ha) and land cover classes, can be used in analyzing the importance of landscape-scale variables to the success of forest birds in both entirely forested regions as well as in areas transitional with agriculture. Results indicated that differences in landscape pattern that were discernable using the LUDA data describe characteristics that are important to forest birds, and are most useful in describing broad biogeographic patterns of species distribution. However, the analysis also reveals that several characteristics important to birds at different scales are not discernable using the LUDA data. The study identifies six areas where LUDA data do not adequately capture important landscape features that are likely important to forest birds.

The second study utilized two statewide data sources, the federal Breeding Bird Survey (BBS) data for Minnesota and the LUDA land use/land cover data to conduct a preliminary examination of the sensitivity of Minnesota birds to landscape fragmentation. Of 58 bird species analyzed four (the Mourning Dove, American Crow, Common Grackle and Northern

Oriole) were associated with highly fragmented stops. Two species, the Gray Catbird and European Starling, were found at stops in moderately fragmented areas, while six species, the Veery, Hermit Thrush, Red-eyed Vireo, Nashville Warbler, Chestnut-sided Warbler and Ovenbird were found at stops in the least fragmented areas. These data provide some of the first evidence that the Hermit Thrush, Nashville Warbler, and Chestnut-sided Warbler may be sensitive to forest fragmentation in this region.

Future Efforts: Much of the work at the statewide level is now completed and emphasis during the next biennium will be entirely on the regional and site-specific level.

3. Regional Analysis

At the regional scale of analysis we are primarily interested in relating the regional bird monitoring data gathered for the Chippewa and Superior National Forests and St. Croix River Valley with forest vegetation data provided by the classified Landsat images. Once the classification of these images is verified, all data from the 1,025 point counts will be coupled with the Landsat data for analysis. In the interim, two preliminary studies initiated during the FY92-93 biennium were completed.

The first examined the potential influence of landscapes on the distribution of forest birds within a stand. Conducted by Ms. Carol Pearson, the study concluded that the proportions of different habitat types within a region are probably not very important to species such as the Veery and Ovenbird, with relatively generalized forest habitat needs, as long as some minimum requirement of forested area is satisfied. When sufficient forest is present, vegetation structure within the individual forest stand is the best predictor of abundance for these "forest habitat generalists". However, the proportions of different forest types within the landscape surrounding a stand may be of major consequence to species that have more specific associations with a particular forest type, especially conifer-dependent species like the Blackburnian Warbler.

The second study examined the potential applicability of remote sensing data to discriminate suitable breeding habitat for forest birds. The identification of potentially suitable habitat for birds over large forested areas is a complex and expensive task. If, however, satellite data can be related to the distributions of forest birds, the use of satellite imagery may substantially reduce this complexity and cost. Conducted by Mr. Kent Montgomery, this study selected 13 bird species for analysis in the Chippewa National Forest. The results were highly encouraging; 45% and 89% of the points were correctly classified as present or absent, respectively, for all 13 species. The results, however, indicate that relatively large sample sizes (>50 stands) will be necessary to construct more robust and reliable models.

Future Efforts: Our future efforts are to considerably expand the preliminary analyses completed by Pearson and Montgomery by conducting similar analyses for all of the point count, habitat-specific monitoring data using the classified satellite imagery. These analyses will include simple co-occurrence of bird species with habitats as well as an analysis of their spatial relationships to landscape patterns, such as habitat patch size. Like the data collected at the statewide and site-specific levels, these analyses will be integral to development of the model that predicts how forest bird populations respond to changes in the forest landscape.

4. Site-specific, local studies - large scale study plots

The square mile study plots were established to examine such questions as how bird species respond to forest edges created by logging practices or how bird species diversity or density are related to the size of logged areas. It is critical to address these questions because among the aspects of management that foresters can control are the size, shape, and spatial or temporal distribution of logged areas.

Following an assessment of considerations for plot size and plot location, three square mile study plots were established for initial testing in 1993 on national forest lands. During the field season, the plots were censused three times to verify that they could be covered in 4 or 5 days. During the winter methods were developed to quickly synthesize the information gathered in the field and relate the spatial observations of the birds to forest cover types and ages. Then, in the winter and spring of 1994 six additional sites were identified. An effort was made to distribute the plots throughout the northern forested region of the state and to include a variety of ownerships. In all, the nine study plots include three in federal ownership on national forest land, three on private ownership, one on state land, and two under mixed ownership - private and county and private and state.

All nine plots were censused in 1994. All census points and transect lines have been identified precisely with a geopositioning system and photo interpretation and digitizing of the cover types have been completed for seven of the nine plots. Field reconnaissance to ground truth the aerial photo interpretations is also underway.

Future Efforts: Aerial photo interpretation and ground truthing will be completed for all nine plots by December 1995. The plots were also censused in 1995 and will be censused again in 1996 and 1997. These data will form a key element of our analyses of the effects of forest harvesting and will be essential to our development of the predictive model.

5. Complementary Studies

Avian Community Response to Habitat Disturbance in Northeastern Minnesota: This Master's thesis project, begun in 1994, will investigate whether bird populations respond differently to recent burning or logging in northern Minnesota. The Tower burn of 1991 provided the primary study area for the investigation. Since fire represented the dominant natural regenerating force in Minnesota's northern forests, a better understanding on how logging compares or can be more similar with fire regenerated areas is highly desirable. The thesis will be completed in 1996.

Predicting Forest Bird Community Attributes using Geostatistically Modeled and Spatially Analyzed Habitat Data:: The habitat data that have been gathered for the large study plots has primarily been forest cover types and age classes with some qualitative data gathered at each census point. This Master's thesis project, also begun in 1994, will gather more detailed quantitative data for one of the large plots, Bandana Lake, to identify the extent to which these data could better explain bird community attributes. Work should be completed in late 1995.

Ecological Classification System - Integration with Forest Birds: With partial funding from the Minnesota DNR, the objective of this project is to relate avian abundance and distribution patterns across landscapes on the Chippewa National Forest with features defined by their newly developed Ecological Classification System (ECS). The basic goal of the ECS is to better incorporate ecological information into management strategies. Project staff synthesized much of their bird data gathered in this region and gathered selected additional information for areas not adequately covered by our habitat-specific monitoring program. At this time, work has been completed on three land type associations (LTAs): Bena Dunes, Guthrie Till Plain and Itasca Moraine. Additional cooperative work will be considered when these three LTAs have been completed.

C. Title of Objective: Develop educational materials promoting forest bird conservation and management.

    C.1 Activity: Develop educational materials promoting forest bird conservation and management.

        C.1.a. Context within the project: The data collected in Objective A and the model developed in Objective B will enable project staff to assess the effects of changes throughout the northern forest landscape on Minnesota's northern forest birds. The model will provide biologists with the ability to assess the long-term impacts of current forest management decisions and develop management prescriptions that insure the long-term maintenance of Minnesota's rich diversity of forest birds.

Development of the predictive model, however, will not begin until late in the FY94-95 biennium. In the interim, the first priority is to educate land managers about the regional and statewide significance of Minnesota's forest bird resource. Work begun during the FY92-93 biennium on *'A forest bird primer for land managers'* will be completed. Opportunities to publicly present and distribute the information contained in the booklet will continue.

C.1.b. Methods: It is anticipated that the first draft of the booklet will be completed by July 1994. Project staff and a representative sample of forest land managers at the private, county, state and federal level (including forest industry representatives) will review and provide comments on the draft. A member of the project's steering committee will be responsible for incorporating the comments and preparing the final document. The DNR's Information and Education Bureau will be responsible for final layout and design. The booklet will be distributed, free of charge, to private, county, state and federal forest land managers throughout the northern forested region of the state.

Throughout the biennium, project staff will also actively seek opportunities to deliver talks and presentations to land managers, industry representatives, the logging community and the general public promoting forest bird conservation.

C.1.c. Materials: Information that has already been collected by amateur ornithologists and professional biologists that document the significance of Minnesota's forest bird community will provide the basic content of information presented in the booklet and in public presentations. Important data from other Great Lakes States will also be incorporated as will the extensive field experience of members of the project's steering committee.

C.1.d. Budget: $28,000   **Balance:** $0

C.1.e. Timeline:	7/93	1/94	6/94	1/95	6/95
Complete Forest Bird Primer text	********************				
Prepare and deliver a minimum of eight forest bird presentations		***********************************			

SUMMARY REPORT FOR OBJECTIVE C.1.

1. Birds and Forests: A Guide

Preliminary work to develop a general information guide on forest birds for planners, biologists, foresters and others responsible for forest management began during the FY92-93 biennium. Work continued throughout the FY94-95 biennium and final publication is now scheduled for the fall of 1995. Written by Ms. Jan Green, the document is approximately 140 pages in length and includes 130 color photos of forest habitats, landscapes and forest birds and six appendices summarizing a variety of technical information on the distribution, abundance and life history traits of Minnesota's forest bird community. Once completed, this will be the only reference guide of its kind in the Upper Great Lakes.

Future Efforts: "Bird and Forests" will be widely distributed during the next biennium to private, county, state and federal land managers throughout the forested region of the state. The materials in the book, coupled with the results of the specific graduate studies and other components of the Initiative, will be compiled and summarized for other targeted delivery systems that will be identified in the coming months.

2. Public Outreach and Dissemination of Results

Project staff have placed considerable emphasis on public outreach and dissemination of results. A total of 23 presentations have been given on the status, conservation and management of forest birds and results of the Initiative's findings have been presented as technical papers or posters on 21 different occasions. Three M.S. theses have now been completed and three new ones have been initiated this biennium. A total of eleven publications have been completed, are in press, have been submitted and/or are in preparation.

Other highlights include the organization of two regional monitoring workshops held in Duluth in the winters of 1994 and 1995 to bring together all field biologists in the Great Lakes region who are actively collecting field data on breeding birds to establish some standard protocols. The project was also featured, for the second time, on the Venture North TV series.

Future Efforts: An emphasis on public outreach and dissemination of results will continue throughout the FY96-97 biennium.

C.2. Activity: Begin development of forest management prescriptions that integrate the needs of birds into traditional forest management practices.

C.2.a. Context within the project: As mentioned in the **Project Summary** and in C.1.a., the ultimate goal of Minnesota's Forest Bird Diversity Initiative is to develop landscape management tools to maintain Minnesota's rich diversity of forest birds. The predictive model developed in Objective B will enable project staff to identify management prescriptions that are tailored specifically to the conditions in Minnesota's northern forest landscape.

In the interim, residual tree management remains one of the principal management tools forest land managers have to provide for the habitat needs of forest birds - including cavity nesting species (e.g. woodpeckers, chickadees and small owls). Current forest wildlife guidelines for cavity nesting species are out-of-date, focus entirely on the nesting needs of these species (not the foraging needs) and are derived largely from studies in the Pacific Northwest. Much progress can be made in Minnesota by reviewing and updating snag and residual management guidelines.

C.2.b. Methods: All recent literature on cavity dependent species that nest in northern Minnesota will be reviewed, as will all available literature and materials on snag and residual management. Policies currently being practiced in other Great Lakes and northeastern states on county, state and federal lands will be compiled and reviewed. Recent timber sales will be visited to assess how current guidelines are implemented and loggers and foresters will be interviewed to identify the practical limitations and constraints of their operations in the field. Based on this work, project staff will prepare revised residual management guidelines and work with industry representatives, loggers and public forest managers to insure that the guidelines are practical and achievable.

C.2.c. Materials: Basic literature and management materials already published will provide the core of information utilized for this objective. Field materials necessary to accomplish this objective are limited to vehicles and field maps.

C.2.d. Budget: $10,000   **Balance:** 0

C.2.e. Timeline:	7/93	1/94	6/94	1/95	6/95
Review literature and current guidelines	*****************				
Visit timber sales, loggers and foresters		**************			
Prepare draft guidelines				*******	
Seek input from affected stakeholders				******	
Finalize guidelines					****

SUMMARY REPORT FOR OBJECTIVE C.2.

One Master's thesis was directed specifically at this activity and was completed in November 1994 by Mr. Sam Merrill. Conducted on the Superior National Forest, the goals of the field study were to: 1) examine relationships between breeding birds and reserve timber in aspen clearcuts; and 2) develop management recommendations regarding characteristics of the reserve areas if maximizing bird diversity is a management goal. Regarding the first study goal, Mr. Merrill concluded that, at best, reserve areas can be considered small forests, and cannot be expected to sustain large numbers of forest interior bird species. However, total number of species, and total number of individuals were all significantly higher in reserve areas than in clearcut edges. Reserve areas therefore represent valuable contributions to forest bird diversity in northern Minnesota aspen clearcuts. With respect to the second study goal, Mr. Merrill recommended the following for reserve areas in aspen forest types: 1) that they be $\geq$ 0.8 hectares with an additional 0.1 hectares per 2 hectares of clearcut over 16.2 hectares, 2) that they be as close to circular as possible, 3) that they be placed close to the center of the clearcut, and 4) that they be composed of 20-30% conifer components where possible. It is also recommended that scattered reserve trees be 1) left in the ratio of one coniferous to three deciduous trees, 2) in good health at the time of marking, and 3) left under the current guideline of 2.4 - 4.9 reserve trees/hectare (6-12 reserve trees/acre).

Future Efforts: Gradate student's Lisa Schulte's field project, comparing breeding bird usage of sites that have been recently logged with those that have been recently burned, will continue and expand on Mr. Merrill's work. The results of both of these studies will be integral to our efforts during the FY96-97 biennium to integrate the various findings of the Forest Bird Initiative into traditional forest management practices.

V. **Evaluation**: For the FY94-95 biennium the program can be evaluated by its ability to: 1) continue full implementation of the long-term monitoring program; 2) identify species that are not adequately sampled by the point count methodology and develop complementary studies to assess their population status and habitat requirements; 3) identify Minnesota forest birds that may be at risk because of population declines; 4) assess and utilize relevant stand level and landscape level data to predict population changes in forest songbirds; 5) sample old-growth forest study sites; 6) assess the reproductive success of forest birds; and 7) educate land managers about the importance of the forest bird resource.

In the long-term, the project should be evaluated by its ability to successfully develop landscape management practices to maintain and improve the status of the regional avifauna while still providing a sustainable resource base for industry.

VI. **Context within field**: To date, work on forest songbirds in Minnesota, and elsewhere in the Great Lakes region, has focused primarily on delineating species presence and abundance in individual forest stands (Engstrom 1990). The influence of the surrounding landscape on the bird community's composition has not been considered. However, recent work in the eastern deciduous forest has repeatedly demonstrated that vegetation patterns and composition across the landscape are important predictors of the abundance and diversity of many forest birds within individual stands (e.g., Askins et al. 1987, Blake and Karr 1987, Robbins 1979). Nevertheless, the majority of work conducted in the east has suffered from three major deficiencies: 1) it has been short-term in duration; 2) it has been conducted in forest areas that are extensively fragmented; and 3) it hasn't simultaneously tracked changes in the forest vegetation and changes in bird populations (Askins et al. 1990). The current project will address all three of these problems; it is a long-term monitoring project that will track changes in forest cover and bird populations in Minnesota's extensively forested northern landscape.

The long-term monitoring work complements extensive avian monitoring work that Dr. Gerald Niemi and his staff at NRRI have had underway for several years. Principal among his efforts have been: an investigation underway since 1984 to monitor the effects of the ELF antenna system on bird species and communities in northern Michigan and Wisconsin; efforts to monitor avian forest bird indicators on national forests in the Great Lakes states; and an assessment of the effects of mosquito control agents on breeding birds in wetland communities.

Dr. David Mladenoff will take the primary lead with the GIS development and analysis work. Dr. Mladenoff has had extensive experience in the use of spatial data. He is principal investigator on several past and current projects that are utilizing the USGS Land Use/Land Cover data as well as landsat imagery and aerial photography with GIS. These are major projects funded by the U.S. Forest Service, North Central Experiment Station and by The Nature Conservancy, with funding totalling over $500,000. Dr. Mladenoff also is a co-principal investigator on a landscape ecology project funded for three years by the National Science Foundation.

This project will complement and integrate with three other major initiatives: the Great Lakes Biodiversity Task Force, the development of an Ecological Classification System (ECS) on the Chippewa National Forest, and a U.S. Fish and Wildlife Service (USFWS) songbird productivity study also underway on the Chippewa National Forest. The project will provide technical information integral to the Biodiversity Task Force's goal to establish common forestry and wildlife objectives for forest management throughout the Great Lakes region. On the Chippewa National Forest the bird-habitat relationships delineated by this study will contribute to the interpretation of ecological classification units. Data on

reproductive success gathered by the USFWS songbird productivity study will add to the productivity data collected by this study and enhance our ability to more accurately assess the suitability of given habitats to forest birds.

VII. Benefits: The integration of wildlife management concerns and forest management practices has focused principally on game species, a select number of rare species and a few other special interest species (e.g., cavity nesters). The public and resource professionals alike are now calling for a broader, holistic approach to forest management that maintains the richness of animal and plant diversity while accommodating sustained resource utilization.

This project begins to address this concern by focusing research and management efforts on one of the most important contributors to forest diversity - forest birds. Forest birds are excellent indicators of diversity since they comprise 70% of all forest vertebrates. Minnesota's rich abundance of forest birds is also of national significance. As mentioned earlier, the state lies in a narrow forest belt that supports a greater diversity of songbirds than anywhere else in North America. Regardless, this important group of species has received little management attention. This initiative is the first comprehensive, U.S. effort designed to relate habitat patterns and change to regional bird diversity using a long-term monitoring program. The knowledge gathered will be applied to the development of forest management tools that integrate the diverse habitat needs of forest birds with other traditional forest management practices. The results will be applicable throughout Minnesota and other Great Lakes states and will insure that we maintain and improve the status of this important natural resource.

VIII. Dissemination: Results from this project will be presented at national, regional and state scientific meetings to peers in the field, as well as to resource managers and planners who will be users of the information and results. Following presentations of results at such meetings, they will be published in the peer-reviewed literature in the major national journals in the field. Objective C of the project specifically addresses dissemination of the results to land managers.

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.

Several mechanisms will be used for disseminating the management recommendations and policies that are ultimately developed over the long-term by this project. First and foremost, project staff will work with DNR staff who responsible for updating and revising the

Department of Natural Resources' Forest Wildlife Guidelines Manual to insure that prescriptions for forest birds are incorporated. It is Department policy that all wildlife management on state lands will be conducted according to the guidelines established by this manual. The manual is also the standard wildlife management reference for county forest managers and private industrial forest managers throughout the state. Management recommendations will also be incorporated into the State Forest Stewardship Manual, which provides forest land management recommendations to private land managers. At the federal level project staff will work closely with the forest biologists on both the Superior and Chippewa National Forests to revise their current forest practices. The supervisors on both forests are very supportive of this initiative. At the regional level project staff will work with state representatives on the Upper Great Lakes Biodiversity Committee to disseminate the work throughout the Great Lakes States. As mentioned above, staff also will pursue all opportunities to present findings at national, regional and statewide symposia and conferences and will work to present the information in referred journals.

The groundwork for successful dissemination of our work is already being laid. One of the project's most important accomplishments in 1991 and 1992 was the establishment of strong partnerships with all important stakeholders who will ultimately be responsible for implementing the results of our efforts.

IX. Time: Proper stewardship of the forest landscape requires long-term monitoring of forest changes. The intent of this project is to establish a monitoring and research program that will be operable for a minimum of 10-15 years. Funding beyond the FY94-95 biennium will continue to be requested from LCMR.

X. Cooperation:

1. Dr. David J. Mladenoff
    Research Associate, Center for Water and the Environment
    Natural Resources Research Institute, University of Minnesota

    A forest landscape ecologist with extensive GIS experience, Dr. Mladenoff's primary role will be to utilize GIS techniques to correlate the bird data and vegetation data (i.e. Objective B). Dr. Mladenoff will commit 40% of his time during the biennium to this project.

2. Dr. Gerald Niemi
    Director, Center for Water and the Environment
    Natural Resources Research Institute, University of Minnesota

    An ornithologist and statistician, Dr. Niemi's primary role will be to supervise the implementation of the long-term monitoring program (Objective A). Dr. Niemi will

commit 10% of his time during the biennium of this project.

Note: The Program Manager, Lee A. Pfannmuller, will be spending 5% of her time on Objective C and an additional 5% on overall program administration (i.e., budget administration, report preparation and coordination among the principal program cooperators and other partners participating in the project).

XI. Reporting Requirements

Semiannual status reports will be submitted not later than January 1, 1994, July 1, 1994, January 1, 1995 and a final status report by June 30, 1995.

XII. Literature Cited

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