1995 RESEARCH PROJECT ABSTRACT

For the period ending December 31, 1997
This project was supported by the Minnesota Environment and Natural Resources Trust Fund

Title:	**Minnesota's Forest Bird Diversity Initiative, I-6**
Program Manager:	Lee A. Pfannmuller
Organization:	Minnesota Department of Natural Resources
Address:	Box 25, 500 Lafayette Road, St. Paul, Minnesota 55155
Web Site Address:	http://www.nrri.umn.edu/nrri/land_bio.html
Legal Citation:	M.L. 95, Chpt. 220, Sec. 19, Subd. 7(d)
Approp. Amount:	$400,000

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 FY96-97 biennium were to: continue and expand the forest bird monitoring program; conduct bird productivity studies; model relationships of forest birds to landscape characteristics; and promote forest bird conservation and management.

OVERALL PROJECT RESULTS

During the FY96-97 biennium project staff completed the sixth and seventh years of monitoring forest bird populations in the Chippewa National Forest and Superior National Forest, the fifth and sixth years in the St. Croix Valley study region and the second and third years in southeastern Minnesota. Statistical analysis to detect significant linear trends in population abundance show that most breeding bird populations in northern and east-central Minnesota have been relatively stable and more species have shown an increasing trend compared with those that are decreasing. Preliminary results in the southeast, however, indicate that several species may be experiencing long-term population declines.

Studies of overall productivity revealed that nest success of forest birds can be highly variable between years. A detailed study of Least Flycatchers showed a nest success of 67% on a study plot in 1996 compared with only 24% on the same study plot in 1994. In southeastern Minnesota study results show that most forest bird species west of the extensively forested region of the Mississippi River experience low reproductive success. Brood parasitism by the Brown-headed Cowbird was very high in this region. Other studies estimate that nest success for migratory songbirds needs to be a minimum of 60% to maintain viable breeding populations. Based on most studies of nest success in forested areas of Minnesota, this minimum is not being attained. Exceptions may be certain years when nest success is relatively high.

Significant progress was made on the development of many components of the forest landscape simulation model, LANDIS. Eventually the model will allow forest managers to describe how bird populations respond to changes in forest cover types and landscape level vegetation patterns as a consequence of logging, land use change and natural disturbances to the forest environment. The first tier of the bird habitat model that relates bird distribution and abundance to forest stand cover type and age was completed and work continues on the second tier that will relate bird distribution and abundance to vegetation patterns at the landscape level. Five other model components related to the input and utilization of forest cover type data were also developed. Finally, a test application of the model was conducted on the Pine County square mile study plot.

PROJECT RESULTS USE AND DISSEMINATION

Following publication in late 1995, nearly 1725 copies of the award-winning book, **Birds and Forests: A Management and Conservation Guide** by Janet Green were distributed, free of charge, to forest land managers throughout the state. Project staff were also an integral component of five logger education workshops that reached nearly 600 loggers in 1996. A total of 33 presentations on forest bird management and conservation, highlighting the results of this project, have been delivered to local, regional and national audiences this biennium. Eight papers have been published, five in peer-reviewed publications. Four Masters of Science graduate projects were completed this biennium and one is underway. A new forest stewardship publication on forest birds and a series of five workshops on Birds and Forests are also in progress, with completion scheduled in FY98.

Date of Report: March 15, 1998

LCMR Final Work Program Update

I. **Project Title and Project Number**: MINNESOTA'S FOREST BIRD DIVERSITY INITIATIVE, I-6

Program Manager:	Lee Pfannmuller
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A. Legal Citation: ML 95, Chp. 220, Sec. 19, Subd. 7(d).

Total Biennial LCMR Appropriation: $400,000
Balance: $ 0

Appropriation Language: This appropriation is from the trust fund to the commissioner of natural resources for the third biennium of a proposed six-biennium project that develops management tools to maintain diversity of forest birds and establishes benchmarks for using birds as ecological indicators of forest health. Data compatibility requirements in subdivision 14 apply to this appropriation.

B. 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 over 60% 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 chance 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 1000 sampling points distributed across the northern forest region. During the FY96-97 biennium these efforts will be further expanded to the forested landscape of southeastern Minnesota where between 100-200 sampling points will be added. Data on bird distribution and abundance is then coupled with data on nesting success to provide an accurate assessment and description of healthy bird communities. Geographic Information System (GIS) techniques are used to

*Objective D. **Promote forest bird conservation and management.***

- *A book, **Birds and Forests: A Management and Conservation Guide** by Janet C. Green, was published. It was distributed free of charge to over 1725 forest land managers in Minnesota. A half-day conference on forest bird management was organized for the book's release in November 1995.*

- *Project staff were an integral component of five workshops that launched the Minnesota Logger Education Program and reached over 600 loggers and three one-day workshops on forest birds that reached over 200 forest stewardship plan writers.*

- *Work began on a new forest stewardship publication, **Planning for Birds**, to be published in March 1998.*

- *A total of 33 presentations on forest bird management and conservation, highlighting the results of this project, were delivered to local, regional and national audiences this biennium.*

Problems: To date there have been no significant problems.

LMIC Data Compatibility Requirements: Project staff in the GIS lab at the Natural Resources Research Institute have provided LMIC staff with a summary of their data standards and procedures. No problems are anticipated as data gathered by the NRRI lab have always been compatible and consistent with LMIC data bases and data standards.

IV. Statement of Objectives:

Objective A. Continue and expand the forest bird monitoring program.
Data on forest birds will be collected by a long-term monitoring program established in northern and east-central Minnesota. It will be expanded to the southeastern forest region in FY96.

Objective B. Implement bird productivity studies.
Past efforts tested a variety of field methods for assessing reproductive success. In FY96-97, one method will be selected and efforts focused on common species whose nests can be efficiently located.

Objective C. Model relationships of forest birds to landscape characteristics.
Work began in FY94-95 to develop a model to predict bird presence and abundance based on landscape relationships. This work will continue and the resulting model will be merged with a computer simulation model to allow interactive assessment and prediction of bird species across forest landscapes.

Objective D. Promote forest bird conservation and management.
Educational materials and management prescriptions for forest birds will be developed for established delivery systems (e.g. DNR Forest Wildlife Guidelines, Forest Stewardship Program).

Timeline for Completion of Objectives:

	7/95	1/96	6/96	1/97	6/97	12/97
Objective A. Continue and expand forest bird monitoring program.	****		**********		*******	******
Objective B. Implement bird productivity studies.	****		**********		*******	******
Objective C. Model relationships of forest birds to landscape characteristics.	**********					
Objective D. Promote forest bird conservation and management.	**********					

V. Objectives/Outcome:

A. Title of Objective/Outcome: Continue and expand the forest bird monitoring program.

A.1. Activity: Data on the presence and abundance of forest birds have been gathered since 1991 and includes over 1000 sampling points in three major study sub-areas; the Superior National Forest, Chippewa National Forest, and St. Croix River Valley. Because of a lack of coverage in southeastern Minnesota, an additional study sub-area will be added to monitor changes of forest birds in this forested region.

A.1.a. Content within the project: Data on bird population gathered in the past have been inadequate to accurately assess the response of Minnesota's forest birds to changes across the forest landscape. The coverage provided by the U.S. Fish and Wildlife Service roadside counts are useful for a national level, but not sufficient to relate to habitat changes for specific regions of the state. Because many factors can affect population levels in a given year (e.g. weather, food availability, and habitat), data for a minimum of 10 to 15 years are essential to accurately assess the relationship of birds to forest landscapes.

Long-term population data are also important in helping to delineate the relative importance of factors operating on the breeding grounds, wintering grounds and along the migration routes of many forest birds, the large majority of which are long-distance migrants. One reason this study is collecting long-term population data at a variety of spatial scales and in different regions is to identify what factors may be responsible for population changes. For instance, if a species is declining in all three study subregions (e.g. the Chippewa National Forest, the Superior National Forest and the St. Croix River Valley) this would likely indicate that the decline may be associated with wintering or migratory habitats. In the absence of some common factor of change (e.g. drought) in each of these breeding areas, it is unlikely for the population decline to occur over such a broad area based only on breeding season events within that region. In contrast, if a species is declining within only one subregion and not the others, then this would likely indicate a breeding ground issue within that subregion (e.g. change in habitat for the species). The study design, therefore, has attempted to ensure that observed population changes are correctly attributed to factors operating on the breeding grounds.

A.1.b. Methods: The field sampling protocol established for the long-term monitoring program during the previous two bienniums will continue. The methods have proven to be effective at detecting changes in annual abundance for more than 50 forest bird species. The three primary study sub-areas were selected to represent variation in basic landscape parameters that are known to affect forest bird distributions: intensity of agricultural activities and other developed land use, habitat composition, land ownership, and intensity of forest management activities. Sampling points within the three sub-areas were distributed as follows: Chippewa

National Forest (400 points), Superior National Forest (525 points), and St. Croix River Valley (100 points). We anticipate adding 100 to 200 points in southeastern Minnesota.

Within each study 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. Three point counts, with nonoverlapping 100 meter radii, are located in each sampled forest stand. Each area and each point is permanently marked in the field

Trained observers census all points for 10 minutes during the breeding season between ½ hour before to 4 hours after sunrise. Types of stands censused are stratified by time of morning. All birds seen or heard from the center point are recorded with estimates of their distance from the center point. Weather data are also recorded (e.g. cloud cover, temperature, and wind speed) and time of the census. The following information on habitat structure and plant species composition at the center point are also gathered: canopy height in meters; tree and shrub species present; estimates of tree and shrub density; percent coverage of vegetation in the canopy, subcanopy, understory, and ground layer; and special topographic features and habitat features such as snags, rock outcrops, and downed logs.

Several points of quality control are built into the field monitoring program. First, an individual testing and training program has been developed to evaluate and select field assistants. Individuals who apply for the field survey positions are tested on their bird song identification skills; a minimum of 85% of approximately 80 tape recorded songs of northern Minnesota forest birds must be correctly identified. Applicants must also pass a auditory hearing exam to insure that their auditory range includes the high frequencies characteristic of many warbler songs. Individuals who pass these two exams then spend one week in the field with an experienced field ornithologist to further sharpen and test their listening skills and learn the proper methods for data recording. Finally, as stated above, three replicate sampling points, with nonoverlapping radii, are located within each sampled stand.

All data are entered into a Paradox file directly from the field data sheets. Several checks are made by individuals other than those who originally enter the information. Analyses of these data are considering a variety of issues that are important for monitoring data including different spatial and temporal trends and observer variability. With recent advancements in statistical methodology, project staff have been able to develop a relatively sophisticated statistical model using repeated measures analysis of variance. This technique allows us to specifically test for annual trends (temporal) in species as well as test for the effects of changes by habitat (spatial) and differences in observers.

A.1.c. Materials: Field materials necessary to accomplish this objective are limited to vehicles (rental of University of Minnesota vehicles and mileage reimbursement on private vehicles), permanent station markers, field maps, data forms and binoculars. No equipment purchases are necessary to support this activity.

A.1.d. Budget

Total Biennial LCMR Budget: $81,000

LCMR Balance: $0

A.1.e. Timeline:

	7/95	1/96	6/96	1/97	6/97	12/97
Continue monitoring program	****		**********		********	
Initiate monitoring program in southeastern Minnesota	****		**********		********	
Enter and analyze data	**********			**********		**********
Prepare annual summary		****		****		*****

A.1.f. Work Program Update: March 15, 1998

1. Status of the Monitoring Program

During the FY96-97 biennium we completed the sixth and seventh years of monitoring forest bird populations in the Chippewa National Forest (399 sampling points) and Superior National Forest (486 sampling points), the fifth and sixth years in the St. Croix Valley study region (170 sampling points), and the second and third years in southeastern Minnesota. In addition to the 75 sampling points that were established in southeastern Minnesota in 1995, an additional 136 sampling points were established and monitored, bringing the total effort to 211 points in seven southeastern counties. Statewide, there are now 1,266 sampling points distributed throughout the forested regions of Minnesota.

In collaboration with researchers from Wisconsin (Bob Howe), the U.S. Fish and Wildlife Service (Steve Lewis), and the Canadian Forest Service (Dan Welsh), we completed a document that describes in detail a standard method for monitoring songbird populations in the Great Lakes region that is modeled after the protocol developed for the Minnesota Forest Bird Diversity Initiative (Howe et al., manuscript, *A standard method for monitoring songbird populations in the Great Lakes Region*).

- Past Publications and Manuscripts on the Monitoring Program

  Hanowski, J. M. and G. J. Niemi. 1995a. A comparison of on and off-road bird counts: do you need to go off road to count birds accurately? J. Field Ornithol. 66(4): 469-483.

  Hanowski, J. M. and G. J. Niemi. 1995b. Experimental design considerations for establishing an off-road, habitat-specific bird monitoring program using point-counts. USDA Forest Service Gen. Tech. Rep. PSW-GTR-149. 145-150.

  Niemi, G. J., J. M. Hanowski, A. Lima, K. Montgomery, T. J. Nicholls, R. Hawrot, and C. Pearson. Manuscript. Detecting annual changes of breeding birds through habitat-specific monitoring in the Western Great Lakes Region.

- Current Publications or Reports on the Monitoring Program

  Howe, R. W., G. J. Niemi, S. J. Lewis, and D. A. Welsh. Manuscript. A standard method for monitoring songbird populations in the Great Lakes Region.

2. Trends Analysis

Project staff previously summarized the first three years of the monitoring program in Hanowski and Niemi 1994 and focused on changes in relative abundances for breeding birds in the Chippewa National Forest and the Superior National Forest. Because of the short-term nature of the data available early in 1994 (i.e. only three field seasons) statistical analyses focused on assessing significant changes between years. Overall bird species composition and abundance patterns were also assessed. Results from the St. Croix Study area were not included but were reported in the FY94-95 biennial report.

This biennium project staff conducted a major analysis of population trends on all four study areas in Minnesota. Unlike previous analyses, statistical techniques were employed that allowed researchers to assess linear trends over several years. Included in the analysis were data from 384 sample points on the Chequamegon National Forest in northwestern Wisconsin, which was collected by project staff under a different contract. Inclusion of data from both northern Wisconsin and northern Minnesota allows for a broader assessment of regional population trends. Two primary analyses were conducted: first, species were analyzed to detect population trends on each individual study area and second, data for each species were combined for all four northern study regions (Chippewa National Forest, Superior National Forest, St. Croix River Valley and the Chequamegon National Forest) to analyze for significant regional population trends. Species that do not illustrate a significant trend on any one study area may still demonstrate an overall trend in the region and vice versa.

In general, the analysis indicates that most breeding bird populations have been relatively stable and more species have shown an increasing trend compared with those that are decreasing (Hawrot manuscript, *Forest Bird Population Trends in Minnesota and Northwestern Wisconsin Forests, 1991-1997*). A total of 57 species had significant linear

trends in one or more study areas during the monitoring period: 31 species (54%) increased, 16 species (28%) decreased and 10 species (18%) showed both significant increasing trends on one or more study areas **and** significant decreasing trends on other study areas. When data were combined across the four northern study regions a total of 24 species had significant linear trends: 15 (62%) species increased and 9 (38%) decreased. The breakdown by study region is shown in Table 1.

In northern Minnesota only two species have shown a consistent pattern of change in all three study regions - the Chippewa National Forest, the Superior National Forest and the St. Croix River Valley. The Red-eyed Vireo and the Yellow-rumped Warbler both significantly increased in each of these three areas. Both species also significantly increased on Wisconsin's Chequamegon National Forest. Four additional species increased on Minnesota's two national forests but demonstrated no significant trend on the St. Croix study area: the Red-breasted Nuthatch, Winter Wren, Solitary Vireo and Magnolia Warbler. No species declined in all three areas.

Table 1. The number of species with significant linear populations trends in each study area

	Chippewa	Superior	St. Croix	Chequamegon	Southeast	Northern Region (combined northern study areas)
No. of Species with Increasing Trends	15	22	9	26	2	15
No. of Species with Decreasing Trends	5	6	5	3	14	9

When data for all four northern study regions were combined (i.e. the three in Minnesota and one in Wisconsin) both the Red-eyed Vireo and the Yellow-rumped Warbler demonstrated a significant region-wide increase in addition to significant increases on all four northern study areas. The Red-eyed Vireo's population trend parallels trends observed with statewide BBS data from Minnesota; however, the BBS data shows no significant population trend for the Yellow-rumped Warbler in Minnesota. Thirteen other forest bird species also demonstrated significant region-wide increasing population trends.

There were no species that demonstrated significant declines in each of the three northern Minnesota study regions. Only three species decreased in two of Minnesota's northern study areas. Two species, the Golden-crowned Kinglet and Purple Finch, both demonstrated significant declines on the Chippewa and Superior National Forests. The third species, the Brown-headed Cowbird, showed significant declines on the Chippewa National Forest and in the St. Croix River Valley as well as in southeast Minnesota. Because this species is a brood parasite and is implicated as a cause in the decline of many songbird populations a decline is certainly not regarded as a problem.

When data for all four northern study areas was combined a total of nine species demonstrated significant regional declines. These included the Downy Woodpecker, Black-capped Chickadee, White-breasted Nuthatch, Brown Creeper, Ruby-crowned Kinglet, American Redstart, Indigo Bunting, Brown-headed Cowbird, and Purple Finch.

Although the analytical methods for assessing linear trends permitted us to use the short-term data for southeastern Minnesota (two years of data available for 195 points) more years of data will be needed before we can have complete confidence in some of the observed trends in this region. Of the sixteen species that showed significant linear population trends 14 of those declined. Many of these species are short-distance migrants and permanent residents and it is speculated that the severe winter of 1995-1996 may have negatively impacted 1996 breeding populations. A broader discussion of the work in southeastern Minnesota is included in a full report by Pearson (1997).

In summary, our monitoring data from 1991 to 1997 for the four northern study areas (the three national forests and the St. Croix study area) indicate that overall population trends are increasing or relatively stable. This holds true for population trends at the regional level as well. Over half the species with significant regional trends are increasing. Minnesota statewide BBS trends also indicate relatively stable populations since most trends for forest birds, although increasing or decreasing, were not significant. In contrast, the Southeast study area had many species declining from 1995 to 1997. Nine of the 14 species with significant linear declines are continental migrants or permanent residents, hence, severe winter weather in 1995-1996 may have been responsible.

- Past Publications and Manuscripts on Population Trends

  Hanowski, J.M. and G. J. Niemi. 1994. Breeding bird abundance patterns in the Chippewa and Superior National Forests from 1991 to 1993. The Loon 66: 64-70.

- Current Publications or Reports on Populations Trends

  Hawrot, R. Manuscript. Forest bird population trends in Minnesota and Northwestern Wisconsin Forests, 1991-1997.

  Pearson, C. 1997. Bird Monitoring in Southeastern Minnesota - Status Report: 1997.

3. Analysis of the Breeding Bird Survey data

Periodically project staff compare the state-wide and regional population trend data for forest birds that are collected by the federal Breeding Bird Survey (BBS) program to those collected from our habitat-specific, point count monitoring program. Collected on a broad, national scale since 1966, BBS data are not sufficient to address land management issues at small scales, however, the trend data provide a useful comparison to that collected by Minnesota's forest bird monitoring program.

A detailed analysis of the BBS data collected in Minnesota from 1966-1993 was included in our FY94-95 biennial report and published in 1996 (Niemi et al. 1996, *Recent trends of breeding birds in Minnesota and Minnesota forested regions*). This biennium we briefly examined trends for 133 Minnesota species from 1966 to 1996. During this period, 14 Minnesota species have declined while 22 have increased. However, during the more recent period from 1980 to 1996, 23 species have declined in Minnesota and only 13 have increased. This recent increase in the number of species that have declined is accentuated even more in an examination of regional strata 28 (a broad forested region extending from Minnesota to northeastern U.S. and eastern Canada). A total of 165 species were examined in this region and 54 species (33%) showed significant declines, while only 30 species have increased from 1980 to 1996. Many of the species that have declined during this period (1980-1996) are forested-associated species such as the Broad-winged Hawk (-5.5% decline in strata 28, -8% decline in Minnesota), Red-headed Woodpecker (-15.6% decline in strata 28, -8.5% decline in Minnesota), Olive-sided Flycatcher (-6.3% decline in strata 28, -8% decline in Minnesota), and Veery (-3% decline in strata 28, -2.6% decline in Minnesota). Specific comparisons of the BBS trend data for Minnesota forest species with the population trend data collected by the Forest Bird Diversity Initiative is included in the Hawrot manuscript cited above.

Staff have also prepared and submitted two manuscripts for publication that describe additional analyses of the BBS data. The first completes an analysis that was initiated during the FY92-93 biennium to identify biogeographic regions of the state using a combination of the relative abundance and distribution of breeding birds on the BBS routes (Niemi et al. manuscript, *Biogeographic patterns of breeding birds in Minnesota*). The analysis identified six biogeographic regions for Minnesota's breeding birds that closely resemble the major physiographic regions of the state and can be valuable for providing an appropriate context for biodiversity management.

The second analysis examined how well the North American Breeding Bird Survey roadside counts sample the regional landscape (Mladenoff et al. manuscript, *How well do U.S. Geological Survey Breeding Bird Survey (BBS) routes sample regional landscapes?*). Roadside BBS routes are randomly selected, but the counts are completed from roads. Since the BBS data are used for detecting population trends and for setting conservation priorities for birds, we were interested in what bias existed by using roads as the sampling network. Briefly, the analysis demonstrated a bias in both the habitat sampled along the BBS routes compared to what exists along all roads throughout the region and a bias in the habitats sampled by BBS compared to their abundance across the regional landscape. For example, forested wetlands are under-represented by the BBS routes in relation to their overall abundance in the forested region. Agriculture, on the other hand, is highly over represented in relation to its overall cover. These two types reflect likely bias in the placement of roads. Agriculture, as a human land use, is logically more associated with road locations. Wetlands on the other hand are a land cover type that would tend to be avoided in road placement. These biases must be taken into account when extrapolating bird population trends from BBS sampling and relating those changes to actual changes in land use.

- Past Publications and Manuscripts on BBS data

  Niemi, G.J., A. Lima, J.M. Hanowski and L. Pfannmuller. 1996. Recent trends of breeding birds in Minnesota and Minnesota forested regions: 1966-1993. The Loon 67: 191-201.

- Current Publications or Reports

  Mladenoff, D.J. and G.J. Niemi. Manuscript. How well do U.S. Geological Survey Breeding Bird Survey (BBS) routes sample regional landscapes? Landscape Ecology: submitted.

  Niemi, G.J. ,.M. Hanowski, A.R. Lima, and D.J. Mladenoff. Manuscript . Biogeographic patterns of breeding birds in Minnesota. The Loon: submitted.

4. Assessment of Species at Risk

One of the primary purposes of the Initiative's monitoring program is to enable researchers and land managers to identify, at a relatively early stage, if a species is experiencing a population decline. Among our concerns is the need to identify species that are not monitored well with either the state breeding bird survey or with our more detailed, habitat-specific, point count monitoring program. In past years project staff have made several efforts to better delineate potential species at risk, including:

a. Conducting a comprehensive review of the effectiveness of our monitoring program and identification of species that are not monitored effectively by either the BBS or point count monitoring program. This resulted in a list of twenty-two species considered most at risk in northern Minnesota (Niemi et al. manuscript, *Detecting annual changes of breeding birds through habitat-specific monitoring in the Western Great Lakes Region*). Many of the species on this list depend on coniferous forests (e.g. Boreal Chickadee, Palm Warbler, Cape May Warbler, etc.) or are forest raptors (e.g. Northern Goshawk, Merlin, Northern Saw-whet Owl, etc.).

b. We increased the sample size for coniferous forest habitats during the summer of 1994 on the Superior National Forest in an attempt to improve our detection of the rare conifer-dependent birds. The increase, however, did not greatly improve the power of the monitoring effort for these targeted species.

c. During one field season we experimented with tape recorded playbacks of two raptors in an effort to increase detection levels. Again, the results were not very effective.

During the FY96-97 biennium two new efforts were undertaken to improve our ability to detect and identify species considered at risk and/or species that are not adequately monitored by our existing monitoring program. These are briefly reported on below.

- Rare Species Analysis Using BBS and TM data

Our first effort explored the possibility of predicting forest areas where rare breeding bird species might occur. Using classified satellite images we examined the image at stops along the roadside, Breeding Bird Survey (BBS) routes where some of these rare species were observed over the past 30 years to determine if the site had a unique "signature" based on the satellite TM data. Unfortunately, there was no unique signature from the raw TM satellite data for any of the species tested. The results quickly illustrated that there were too many places (thousands) in the landscape that had signatures of potential suitable habitat.

There are several reasons why this approach may not be useful in this application. First, the specific location where the observation was made has considerable error. For example, the specific stop on a BBS route is somewhat variable. In most cases we could only provide a rough estimate of where the stop was located. It would be best to use a global positioning system to precisely locate the stop. Hence, the match between the actual observation and the satellite TM data used is likely imprecise. Second, satellite data may not provide enough information to properly characterize the signature of the location of the observation. Additional information such as landscape features, special characteristics (e.g., residuals, beaver dams, or rock outcroppings), or other important species-specific features are likely not quantified. Finally, a single observation of an individual of a rare species does not necessarily mean the species is using the habitat. The individual may have been a transient or simply flying over the site and the nature of the observation is not distinguished on the BBS routes.

- Principal Component Analysis to Detect Species at Risk

Our second effort this biennium was the development of a priority scheme to identify bird species at risk in Minnesota's forests (Niemi et al. manuscript, *Ranking of potential extinction risk for Minnesota forest bird species*). We ranked 132 bird species that are dependent on the forests of northern Minnesota based on four factors associated with potential risk: 1) their relative abundance in Minnesota forests; 2) the number of habitats they use; 3) the extent of their overall range in North America; and 4) their population trend over the past 30 years based on the roadside Breeding Bird Survey (BBS). These four factors were analyzed using principal components analysis. Many of the species identified with high risk values, such as the Solitary Sandpiper, Loggerhead Shrike and Eastern Screech Owl, are at the edge of their range within Minnesota's forests and limited suitable habitat may exist. If such species are excluded, the 10 species with the highest risk in Minnesota's forests include the Bay-breasted Warbler, Northern Goshawk, Ruby-crowned Kinglet, Boreal Owl, Olive-sided Flycatcher, Northern Saw-whet Owl, Boreal Chickadee, Spruce Grouse, Long-eared Owl, and Red-headed Woodpecker. Seven of these species were also identified as high risk in our analysis last biennium. In general, higher risk was associated with narrow habitat specificity, low relative abundance, declining or unknown trends, or a combination of each. This analysis technique will require more discussion and review; project staff are already discussing means to improve the assessment next biennium.

- Past Manuscripts on Species at Risk

  Niemi, G. J., J. M. Hanowski, A. Lima, K. Montgomery, T. J. Nicholls, R. Hawrot, and C. Pearson. Manuscript. Detecting annual changes of breeding birds through habitat-specific monitoring in the Western Great Lakes Region.

- Current Manuscripts/Reports on Species at Risk

  Niemi, G. J., J. Hanowski, M. Kuitunen, P. Wolter, A. Lima, L. Venier, and D. Welsh. Manuscript. Ranking of potential extinction risk for Minnesota forest bird species.

5. Other Monitoring Efforts

In addition to monitoring forest bird populations at each of the 1266 habitat-specific monitoring points, birds have been monitored on other study plots as well. During the previous biennium a total of nine, one square mile study plots were established across the northern study region to analyze changes in the spatial distribution of birds and relate those changes to the size, shape, composition and distribution of forest stands. All nine study plots were censused during the 1996 field season. The bird data collected from these plots are not a component of the monitoring program (so they are not collected every year) but are being used to expand our understanding of bird-habitat relationships. The next time all nine plots will be censused will be during the 1999 field season. Forest industry, however, provided us with $5000 to continue collecting census data on the three plots owned by Boise-Cascade, Blandin and Potlatch in 1997.

Future Efforts

During the FY98-99 biennium project staff will continue to monitor breeding bird populations in the Chippewa and Superior National Forests, the St. Croix Valley, and southeastern Minnesota. In addition we will continue to analyze data on breeding bird population trends and compare the data collected by our habitat-specific monitoring program to that collected by the federal Breeding Bird Survey program. We will also examine factors that may be associated with population trends and continue our assessment of species at risk.

B. Title of Objective/Outcome: Implement bird productivity studies.

B.1. Activity: Detailed information will be gathered on the distribution of nests and nest success in different forest types, in different landscape contexts, and in relation to different types of forest edges.

B.1.a. Context within the project: Monitoring changes in forest birds through habitat-specific censusing provides valuable information on the distribution and relative abundance of birds within the forest landscape. However, the best measure of a healthy forest bird community is whether populations are maintaining themselves through successful nesting. Although the ability to find nests in forest situations has been very difficult, our preliminary findings during FY94 have been highly encouraging. Using a combination of artificial nests and active searching for natural nests, a reasonable protocol has been developed to assess nesting success of forest birds.

B.1.b. Methods: During FY93 three large (one square mile) plots were established in the Chippewa and Superior National Forests. Within these plots, systematic census data were gathered for breeding birds seen or heard on the plot on transacts established at 200 meter intervals, along with a detailed location of each individual observed. Nest searching, by following behavioral cues, was also completed on a portion of two plots. All of the observations of birds and nests have been georeferenced and entered into a GIS database so that information can be compiled on habitat distribution and responses of birds to different edge characteristics.

All field data collected and entered into the Paradox data files will be checked for accuracy by staff who did not gather the data. In addition, all nest locations will be precisely located with a geopositioning system. This system allows the location of the nest to be identified to within a half a meter. These data are then checked for accuracy by locating each of the nests on a map and the individual that gathered these data verifies the location.

Nest searching activities during FY94 located more than 350 natural nests. To complement this field effort, about 200 artificial nests with quail eggs were placed in different forest settings to quantify nest predation. Cameras were used on some of the artificial nests in an effort to identify and quantify nest predators found within these areas. In cooperation with several industries (e.g. Blandin, Boise-Cascade, Minnesota Power, and Potlatch) and the Wolf Ridge Environmental Learning Center, six additional large plots were established for further field study in FY94.

Because of the success of previous efforts, during FY96 and FY97 we will increase: a) nest searching efforts, b) the experimental placement of artificial nests, and c) the number of cameras with motion sensors. The exact number and location of sites

where these efforts will be increased will be determined later in FY95, following a more complete assessment of field studies currently underway.

Censuses of each of the large plots that have been established also will be conducted in FY96-97 to analyze changes in spatial distribution of birds. These data will be analyzed in the content of forest stands of different sizes and shapes to address questions on how forest management activities can enhance the biodiversity of forest birds and increase nesting success. For each of these large plots, standard aerial photographic interpretation of habitat types has already been completed and entered into a GIS system. These data will form the basis for these detailed analyses.

B.1.c. Materials: Materials are relatively limited to items such as vehicles (see note above), field maps, artificial nests and quail eggs. The most expensive items are the purchase of cameras with a motion sensor, for detecting nest predators. The latter are considered supply items in the University budgets (accomplishment of this objective is the responsibility of staff at the Natural Resources Research Institute, University of Minnesota-Duluth).

B.1.d. Budget:

Total Biennial LCMR Budget: $120,000

LCMR Balance: $0

B.1.e. Timeline:

	7/95	1/96	6/96	1/97	6/97	12/97
Collect baseline data on plot	*********					
Initiate productivity assessment	***		*********		*********	
Relate productivity to habitat features		*********		*********		******
Relate productivity to management					**********	

B.1.f. Work Program Update: March 15, 1998

1. Nest Productivity Studies

- 1996 Field Season

Our productivity study of natural nests during the 1996 field season was initially designed to focus on two common forest songbirds: the Red-eyed Vireo and the Least Flycatcher. Both species are long-distance neotropical migrants, highly dependent on Minnesota's forest

habitats, and are species for whom it is reasonably easy to locate nests. The 1996 breeding season, however, proved to be a very poor one for Red-eyed Vireos with overall nest initiation apparently delayed because of the cool spring. As a result, the study focused almost exclusively on the Least Flycatcher.

The study had three major objectives: 1) to repeat the 1994 nest success study by Hanski et al. (1996) to assess annual variation in nest success in the same area (Lake Erin square mile study plot); 2) to examine microhabitat characteristics associated with nest success; and 3) to assess regional variability and the influence of forest landscape-level effects on nest success. To address these objectives nest searching was conducted on seven research plots distributed throughout northeastern and central Minnesota. Artificial nests (20 placed on the ground and 20 placed in the shrub layer) were placed in six of the study plots.

Study results indicates that nest success can be highly viable (Niemi and Hanowski manuscript, *Least Flycatcher nest success: microhabitat, habitat and landscapes*). Least Flycatcher nest success in 1996 was 67% at the Lake Erin site in contrast to 24% at the same location in 1994. Moreover, Least Flycatcher nest success was greater than 75% on each of the other six study plots. Predation rates on artificial nests showed similar results - i.e. relatively low rates of overall predation.

The results of Hanski et al. (1996) and the research on Least Flycatchers in 1996 are alsoconsistent with the results of an intensive nest success study conducted by Perry et al.(1997)[1] in the Chippewa National Forest. They report that overall nest success from 1992 to 1996 was 54% for all species studied, but only 38% for cup-nesting, long distance migrants (like the Red-eyed Vireo and Least Flycatcher). Perry et al. (1997) also noted a marked increase in nest success in 1996 to 63% for the Least Flycatcher even though the overall nest success from 1992 to 1996 was only 38%.

Most Least Flycatcher nests were found in sugar maple, paper birch, red oak, or white pine at a mean height of about 9 to 11 m. Most successful nesting was recorded in northern hardwood stands dominated by sugar maple. Because of the relatively high nest success within all study sites, landscape effects on nest success were inconclusive.

- 1997 Field Season

During the 1997 field season our nesting study was focused in southeastern Minnesota in a cooperative study with the USGS Biological Resources Division (Knutson et al. 1997)[2]. The

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[1] Perry, E. F., J. C. Manolis, D. E. Anderson, and F. Cuthbert. 1997. Biodiversity monitoring: breeding productivity and habitat requirements on nongame birds in north-central Minnesota. Report to USGS Biological Resources Division, Reston, VA.

[2] Knutson, M.G., R.K. Hines, C.M. Svenum, and C.E. Korschgen. 1997. Nesting success of passerine birds in the Upper Mississippi River Basin, floodplain and upland forests. Report on the 1997 UPO/STATE partnership with the State of Minnesota. USGS Biological Resources Division, LaCrosse, WI.

goals of this study were to: 1) determine the effects of landscape context and forest patch size on the nesting success of forest birds; 2) identify microhabitat features associated with nesting success; and 3) assess the level of predation and parasitism on nesting forest birds in southeastern Minnesota. Eight study plots were located in Houston and Fillmore counties, representing different configurations of plot size and landscape fragmentation. In addition to searching each plot for natural nests, artificial nests baited with Bobwhite Quail eggs were placed in each plot and monitored with an infrared-censored camera.

A total of 382 nests for 25 different species were found and monitored through the breeding season (Hammer et al. draft manuscript, *Fragmentation, patch size, and nest-site characteristics: are they important factors in the nest success of forest birds in southeastern Minnesota?*). The effects of fragmentation and forest patch size on nest success were inconclusive. Nest success of natural nests was significantly higher on plots in small forest patches but, predator visits to artificial nests also were significantly higher on these same plots compared to the number of predator visits to artificial nests on plots in large forest patches. The full report explores possible explanations for this discrepancy.

In general, study results show that most forest bird species in southeastern Minnesota, west of the extensively forested region of the Mississippi River, did not reproduce effectively in 1997. Nest success rates for open cup nesters ranged from 12 to 56%. The most common nest visitor was the raccoon. Brood parasitism by the Brown-headed Cowbird was very high for many species (e.g., 92% of 15 Wood Thrush nests, 60% of 10 Red-eyed Vireo nests, and 90% of 9 Indigo Bunting nests were parasitized). With the exception of the Black-capped Chickadee, the only species that nested successfully were cavity nesters. The results of this effort were also comparable to the results of Knutson et al. (1997). They observed an overall nest success of 46% but there was considerable variation among species.

- Summary Assessment of Forest Songbird Nest Productivity

Other studies have suggested that a general value of 60% is a benchmark to indicate populations of long-distance neotropical migrants that are at least replacing their populations on an annual basis. Based on most studies of nest success conducted in forested areas of Minnesota, this minimum is not being attained and, hence, populations may not be maintaining themselves. Exceptions may be certain years when nest success is relatively high. Yet, the amount of information on nest success is still relatively meager considering the millions of acres of forested area that exist in the state. Our knowledge of nest success will only improve through a combination of carefully designed field experiments to address fundamental hypotheses on nest success and a substantial increase in monies to gather data over larger areas of the forest. This information is critical, however, to improve our understanding on how forest management activities affect reproduction in forest birds and how we can manage Minnesota's forests to maintain these populations.

- Past Publications and Manuscripts on Nest Productivity

  Fenski-Crawford, T. J. and G. J. Niemi. 1997. Predation of artificial ground nests at two types of edges in a forest-dominated landscape. The Condor 99: 14-24.

  Hanski, I. K., T. J. Fenske, and G. J. Niemi. 1996. Lack of edge effect in nesting success of breeding birds in managed forest landscapes. The Auk 113(3): 578-585.

- Current Publications or Reports on Nest Productivity

  Hammer, M., A. Lima, and G. J. Niemi. Draft manuscript. Fragmentation, patch size, and nest-site characteristics: are they important factors in the nest success of forest birds in southeastern Minnesota?

  Niemi, G. J. and J. M. Hanowski. Draft manuscript. Least Flycatcher nest success: microhabitat, habitat and landscapes.

2. Evaluation of Tools for Assessing Nest Predation

In Minnesota the major factors influencing forest bird populations are habitat change, which directly influences the available breeding habitat of birds, and nest predation, which is the primary factor associated with nest success. Although nest parasitism by the Brown-headed Cowbird is relatively low in northern Minnesota (<10%), preliminary results suggest that nest parasitism may be a significant factor in southeastern Minnesota. However, even in this region, nest predation remains the most important factor influencing overall nest success. Therefore, a key research effort is to identify the potential predators of nests in the forested areas of Minnesota and to design the most cost-effective technique for evaluating nest predation. During the FY96-97 biennium project staff evaluated the effectiveness of two tools - infrared-sensored cameras and artificial nests - in helping us better assess nest predation.

- Infrared-sensored Cameras as a Tool for Identifying Predators

During the 1996 field season project staff tested the use of infrared-sensored cameras for identifying predators on active, naturally-occurring songbird nests (Hammer, draft manuscript, *The infrared-sensored cameras as a tool for identifying predators on open-cup nesting birds: nest predators and predation rates in the Chippewa National Forest*). Although numerous field techniques have been used over the years to identify nest predators, this is the first time cameras on natural nests have been investigated. The system employed was originally designed to detect large mammals such as white-tailed deer. Therefore a major focus of our investigation was to assess the applicability of using the system on forest songbird nests.

A total of 49 nests were monitored on five study plots in the Chippewa National Forest. Nest height varied from 0 to approximately 35 feet. The cameras were more successful at capturing visits to nests located on the ground (80%) than they were at capturing visits made to off-ground nests (33%). Nine species of nest predators were documented including eight

mammals and one bird. Results suggest that the system does not detect avian predators with the same efficiency as mammals. Overall, the camera monitoring system proved to be an effective method for identifying predators raiding ground nests. Minor changes to the system were suggested to increase the efficiency and flexibility of its use.

The effectiveness of these changes were tested during the 1997 field season on a sample of artificial nests (Hammer 1997, *Camera performance update-1997*). Rain was a major reason for camera failure in 1996 so the manufacturer provided rain shields for use in 1997. Although the shields were effective in protecting the cameras from direct exposure to rain and protected the film from exposure to water, condensation inside the camera was still a problem. Staff also tested whether increasing the level of sensitivity of the camera's detector could enhance the ability of the system to document avian predators at varied distances and detector sensitivity levels. Unfortunately this did not improve the system's capabilities. The infrared-sensored system is designed to detect heat in motion. A bird's feathers are effective insulators and appear to inhibit detection by the monitoring system. This is also why reptilian predators, such as snakes, cannot be detected. Overall, the technique provided valuable information on nest predators of ground-level nests that are disproportionately visited by mammals (using smell as a cue to finding nests) but more work is needed to improve the technique for identifying all nest predators on the full array of songbird nests.

- Value of Artificial Nests as a Tool for Assessing Nest Predation

Graduate student Mary Hammer is also completing work on a Masters Thesis that investigates means for improving the procedures for using artificial ground and shrub nests to determine predation rates for breeding birds. Past efforts to use artificial nests may have been biased because of the researcher's inability to perceive and duplicate the characteristics of naturally occurring nests. This could be due to differential foraging cues provided to predators by natural and artificial nests which result in differences in the predator species who are attracted to the nests as well as their rates of predation. Since determining reproductive success of natural nests is so important to understanding the relationship between forest birds and forest habitats, yet so difficult and expensive to collect data on, defining protocols for effective use of the less costly artificial nest can be extremely valuable. The purpose of this study, therefore, was to test the efficacy of the commonly used artificial nest protocol for estimating predation rates on natural nests and to assess whether more accurate simulation of the natural state of active nests will improve the accuracy of results. Parameters tested were nest placement and egg size.

Work was conducted on upland oak forest plots in southeastern Minnesota. Field staff located and monitored over 60 natural nests. Each natural nest was paired with 3 artificial nests. Two Japanese Quail eggs were placed in two of the nests and 4 Zebra Finch eggs were placed in the third nest (Zebra Finch eggs more closely approximate the size of most forest songbird eggs). One Quail nest and the Zebra Finch nest were placed so as to simulate the placement of the reference natural nest; the second Quail nest was randomly placed.

Preliminary results suggest that Zebra Finch eggs are a poor experimental egg for the study of predation on natural passerine nests because predation rates on Zebra Finch egg containing nests were much greater than that on natural nests (Hammer, draft manuscript, *The value of artificial nests as a tool for studying predation on the nests of cup-nesting birds*). Analysis is still underway to determine if nest success is correlated with the placement parameters measured.

- Current Reports

Hammer, M. Draft manuscript. The infrared-sensored cameras as a tool for identifying predators on open-cup nesting birds: nest predators and predation rates in the Chippewa National Forest.

Hammer, M. 1997 Report. Camera performance update - 1997.

Hammer, M. Draft manuscript. The value of artificial nests as a tool for studying predation on the nests of cup-nesting birds.

Future Efforts

The high variability in the nest success studies we have completed thus far accentuates the difficulty of studying nest productivity of forest birds. Because of this high variability, large sample sizes will be necessary to increase our understanding of how forest cover and forest landscapes affect nest success. The expense of gathering such large sample sizes is a limitation for this Initiative. As a result, as the project moves forward. we cannot afford to place increasing emphasis on this aspect of the overall study and will focus, instead on the development of applied management tools for forest managers. Our studies do confirm that nest predation is a significant factor influencing overall nest success. Therefore, a small effort will be directed at analyzing the distribution and abundance of nest predators, using a combination of scent post data that have been collected for over 10 years by the Minnesota Department of Natural Resources and our habitat classification data. The goal will be to identify broad categories of predation pressure on nests based on the relative abundance of the various predators and their favored habitats across the forested regions of the state.

C. Title of Objectives/Outcomes: Model relationships of forest birds to landscape characteristics.

C.1. Activity: The prior work in processing Landsat TM data for the St. Croix River Valley, Chippewa National Forest, and Superior National Forest will be integrated with the data described in Objectives A and B at different spatial scales to develop a landscape computer simulation model (LANDIS).

C.1.a. Context within project: The overall goal of this aspect of the work program is to describe and analyze the forest landscape so that we can develop a predictive model to describe how bird populations respond, over time, to changes in landscape-scale habitat patterns. The model will enable us to define areas of high priority and concern for forest birds, and areas where forest management efforts should be considered. This assessment of forest bird diversity needs to be considered at several spatial scales and levels of analysis. For instance, we are not simply interested in defining specific stands or landscape regions with high numbers of species. The linkage between the field data and LANDIS must also consider the inherent vulnerability of species - the identification of forest species that are highly vulnerable to forest change and forest management activities.

The application of GIS techniques provide the cornerstone for these analyses. They are the only tools that allow us to answer important questions about changing populations over large spatial and temporal scales. Most efforts at monitoring the effects of forest management on various wildlife species have focused only on the local habitat scale. Attempts at making any larger landscape, forest-wide, or regional assessments have merely treated habitat data in aggregate fashion (for example, summing acreages in tabular form for various forest cover types or habitats). However, new research has shown that it is not only the specific local habitat and its characteristics that constitute quality, but the overall landscape context (Ambuel and Temple 1983, Crow 1991, Hansen et al. 1991). The total acreage is important, but it is also important to know how that acreage is distributed on the landscape. This includes habitat patch size, shape, and placement in relation to other patches of the same and different types (Franklin and Forman 1987, Mladenoff et al. 1993).

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 (forest bird data samples located each 0.5 mi along twenty-eight 25 mile routes randomly distributed across the northern forest region; Robbins 1986) and the USGS Land Use/Land Cover data (land cover mapped to a 16 ha resolution; United States Geological Survey, 1986). 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 were used to refine our ability to relate bird species to habitat. The three sub-areas that were selected for establishment of the long-term monitoring program were 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 (185 km x 185 km). The images for these three areas were classified following well-established procedures of digital image analysis producing a land cover and forest type classification.

Another major development during the FY94-95 biennium was the use of point count data to begin the development of bird habitat models. These data, which have been gathered since 1991, provide a large sample to analyze habitat relationships of forest birds and the regional landscape context of their distribution and abundance.

These actions have all helped to establish the foundation of the work activity that will begin in earnest in FY96-97 - development of the LANDIS model. The bird habitat models derived from the point count data will form the first tier of evaluation for linking with this simulation model. The second tier of analysis will consist of applying these bird-habitat modeling results to the one square mile plots.

Since the one square mile plots provide a better context for landscape patterns at a local scale, we anticipate that the second tier of analyses will allow us to better understand the importance of edges and the influence of surrounding habitats on forest birds within a stand. Significant work in preparation for this second tier was also begun in FY94-95. One to three of these square mile plots have been established in each of the three Landsat study areas. Forest types have been mapped, including tree size and density classes, which define important habitat classes. Bird sampling transects across the study plots have been established at 200 meter intervals, and spatially located using a satellite based geographic positioning system (GPS). The spatially-located bird transect data are allowing us to analyze forest landscape characteristics with bird species presence and abundance. These data are being used to develop the predictive model of habitat use, at both the square mile plot scale and the larger landsat scene scale.

The specific questions that project staff will address with the model are as follows:

- How does a) the composition and relative abundance of the forest bird community and b) the relative abundance of select, uncommon birds that are indicative of the northern forest landscape (e.g. many conifer-dependent species) respond to differing landscape patterns resulting from forest management and defined by the following parameters:

    1. Landscape composition at the regional landscape scale (i.e. relative proportions and patterns of coniferous vs. deciduous vegetation);

2. Forest patch size at the smaller landscape scale (i.e. square mile);

3. Forest patch configuration of age classes and patch sizes; and

4. Forest succession.

Relationship to the LINKAGES modeling effort in LCMR Project: *Forest Management to Maintain Structural and Species Diversity (Sud. 5(n)):* The LINKAGES model used in this LCMR project is a forest plot (1/12 ha) model that simulates all individual tree stems of all sizes in a plot, based on soil characteristics and tree growth. As such, it is useful for simulating the effects of different harvesting strategies on within-stand forest structure. The explicit purpose of the $160,000 appropriation that LCMR has recommended is to assess the long-term effects of current and alternative timber harvest practices on structural aspects of biological diversity at the stand level. A related effort by the program managers, funded by the National Science Foundation, is evaluating the application of LINKAGES model to predicting the distribution and abundance of a select number of forest birds, using field data collected by the Forest Bird Diversity Project. LANDIS, on the other hand, simulates changes in the pattern of forest patches or stands across a landscape. The project described in this work program will analyze bird habitat relationships at different spatial scales of the landscape - at the regional landscape level (hundreds of square miles) and at a smaller scale of approximately one square mile. Stands within these landscapes are mapped as dominant cover types, by stand age class. Trees within a stand, or within-stand structure, are not simulated. Both approaches are useful, but address questions at different scales relevant to both forest changes and habitat. LINKAGES simulates within-stand structure; LANDIS simulates habitat distribution and configuration on the landscape.

Eventually both models will be evaluated, but the current state of the science, understanding of both landscapes and the response of forest birds, compels us to rely primarily on LANDIS at this point in time. Because birds respond to factors at several landscape scales and at the stand level, both efforts have value in ultimately delineating the response of forest birds to different logging and management scenarios. Depending on how well they perform in comparisons with data gathered in the field, we anticipate some merging of these two models at a future date.

C.1.b. Methods: During the FY96-97 biennium work will focus first on completing the first iteration of these predictive models of bird habitat use. During this analysis the bird data will be overlaid with the land cover classification (at the regional scale) and the forest cover mapping (at the square mile study area scale) and the relationship of various bird data variables (e.g. species, guilds, life history characteristics) to various habitat and landscape scale 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 characters.

The second and primary focus will be the development of the computer simulation model (LANDIS) of bird response to forest landscape changes. There will be several stages to this effort. First, project staff will program a bird response module to the forest landscape succession model they have developed under separate U.S. Forest Service funding. (The latter project was a landscape scale study of the Chequamegon National Forest in northern Wisconsin designed to assess the effects of different management strategies and different land ownership patterns on forest change.) This specific task will involve integrating a map of current forest conditions in Minnesota with a data layer describing bird distribution, abundance and/or reproductive success from data obtained in Objectives A and B and inputting both into the forest succession model. This can be done at varying spatial scales - i.e. either at the regional landscape scale (using the Landsat image forest classification) or at the smaller square mile scale (using the forest vegetation mapping done from aerial photography).

Second, staff will 'custom-fit', or parameterize, the forest succession model developed for Wisconsin for Minnesota conditions. For example, some species included in the Wisconsin model do not occur or are very rare in Minnesota forests and need to be deleted from the model (e.g. eastern hemlock). Other species that may be common in both states may respond differently (i.e. as forest succession progresses) under the site and climatic conditions that characterize Minnesota or even different regions of Minnesota. The staff's knowledge in and experience with forest ecology throughout the Great Lakes region will be critical in shaping the model to Minnesota conditions. Like the task above, this can be accomplished at varying spatial scales.

Third, staff will begin work to develop a forest harvesting module for the LANDIS. This task basically consists of defining the parameters for a number of "What If" scenarios for timber management - scenarios that realistically depict potential land management opportunities. For example, one might assume that all 40-60 year old aspen within a given geographic area (again, at varying scales) was harvested in cuts of a predetermined size and shape. Building those parameters into the model, the LANDIS would then predict how forest birds in the area respond. Once again, this activity could be implemented at various scales.

Finally, predictive statistical models developed in the FY94-95 biennium will be used to parameterize the bird simulation model. These include relationships of birds with forests at two scales, both within stand scale and landscape scale. Parameters will include the relationship of bird species presence and abundance with forest types, tree size (age) class, stand density (stocking), and forest landscape patterns.

Ultimately, the LANDIS development must be undertaken at both the regional landscape level and at the level of the square mile study plot to provide a comprehensive understanding of how birds respond to temporal and spatial forest change. Both levels of analysis cannot be undertaken and completed in the coming

biennium with existing resources. As project staff evaluate the results of the past four years of work, they will assess and establish priorities for the allocation of available funds and staff to the different spatial scale analyses.

Once a LANDIS model is developed, project staff will implement two types of model output testing. This will include: 1) reliability testing of model output against real data, and 2) sensitivity analysis to assess model output response magnitude to variability in model parameters. The latter test addresses how the model itself behaves. For example, if a run of the model shows that one species becomes too dominant while another one is eliminated, and project staff know that such a scenario is unlikely in the "real world", the parameters of the model will be appropriately adjusted.

Development of the LANDIS model will provide the first version of a predictive tool whose power is realized over time. The model accuracy can be improved iteratively each year that the bird monitoring continues and as project staff are able to more accurately define habitat and landscape characteristics and their relationships to one another and to forest birds. The ultimate value of the model is to help guide land management decisions that potentially impact forest bird diversity. The model, however, is stochastic, not deterministic. In other words, it is not valid to try to use the model to predict what will happen after a certain spruce stand is cut. There are too many things that may or may not happen, each influencing the result. But the model is extremely useful for predicting what will happen over a landscape, of perhaps many spruce stands, and estimating what the general result or pattern would likely be. With that knowledge, the project is well positioned to develop meaningful management recommendations for incorporation into regional forest management plans.

Data Archiving: GIS data acquired or created for this project are archived to 8mm tape by the project staff at the Natural Resources Research Institute (NRRI) in Duluth. Data are also archived to 8mm tape by NRRI GIS laboratory staff on a weekly basis. A catalogue of major GIS data sets using Paradox database software is also maintained. The catalogue includes the origin of the data, kind of data, geographic location, map projections, where data is stored, and who is responsible. Data used for analysis are stored in Paradox database files and archived to floppy disks. Paradox is a flexible and powerful program that allows downloading into almost any format such as for use in dBase, Lotus, etc. All data used in the project are compatible with the LMIC GIS.

C.1.c. Materials: Materials for this objective consist largely of data created in current and prior phases of the project, including forest classification maps from Landsat imagery, GIS maps at a finer scale from aerial photography and Phase II data, and bird monitoring field data. The simulation model is programmed in the C++ programming language, as will be the bird and harvest modules that will be developed. Hardware will include MS-DOS computers with expanded memory and hard disk capacity for modeling use, and the UNIX-based SUN workstations for

GIS analysis. All this equipment is already available at the GIS lab at the Natural Resources Research Institute, University of Minnesota - Duluth. No additional equipment is being purchased with this appropriation.

C.1.d. Budget:

Total Biennial LCMR Budget: $158,000

LCMR Balance: $0

C.1.e. Timeline:

	7/95	1/96	6/96	1/97	6/97	12/97
Complete development of the bird-habitat models	**********					
Begin development of LANDIS						
• Program bird response module to forest succession model			**********			
• Parameterize the bird simulation component of LANDIS		**********				
• Parameterize the forest succession model for Minnesota conditions			**********			
• Develop a forest harvesting module					**********	

C.1.f. Work Program Update: March 15, 1998

1. Development of the Bird Habitat Model

   - Tier 1: Bird Habitat Relationships at the Forest Stand Level

   The point count data collected as part of the Initiative's long-term monitoring program provide a large sample for analyzing general habitat relationships of forest birds and developing simple bird habitat models. The models will form the first tier for linking bird distribution and abundance with the landscape computer simulation model LANDIS. They primarily account for two factors that influence the distribution and abundance of forest birds - forest stand cover type and age.

   Analysis focused on the distribution and relative frequency of breeding birds in 365 forest stands where the Forest Bird Initiative's habitat-specific monitoring program has been in operation since 1991-1992. Initially we included stands sampled in the Chippewa and Superior National Forests in Minnesota as well as in the Chequamegon National Forest in

northwestern Wisconsin, to increase our overall sample size for the far northern region. Specifically, the analysis identified the differences in bird communities and the relative frequency of breeding birds in: 1) similar cover types of different ages and 2) different forest cover types, especially between different deciduous and coniferous forest cover types.

Briefly, many differences in overall species richness and relative abundance were observed among the cover types and many differences were observed among the three national forests analyzed (Niemi et al.draft manuscript, *Habitat distribution and relative frequency of breeding birds in northern Minnesota and Wisconsin forests*). Most species exhibited relatively strong habitat selection with 66 of 78 species (77%) in the Chequamegon National Forest, 56 of 67 species (84%) in the Chippewa National Forest, and 43 of 71 species (61%) in the Superior National Forest showing significant habitat associations at the stand level. Only three species, Downy Woodpecker, Common Raven, and Cedar Waxwing, did not have significant habitat associations within any of the forests. Comparisons of age-classes within the same cover type had few differences in bird communities or the relative frequency of bird species in contrast to comparisons among different cover types. This was especially true in comparisons between deciduous and coniferous forest cover types in which many differences were observed.

These simple bird-habitat models were summarized for use by forest management staff on each of the national forests. Each forest was provided with a habitat profile for each species analyzed and a bird community profile for each forest cover type (Niemi et al. 1997, *Superior National Forest: species-habitat profiles and habitat-bird community profiles).*

Although the analysis described above will become a primary component of the Initiative's predictive model, several complementary studies have provided project staff with additional information that helps describe how forest birds respond to vegetation at the forest stand level. During the FY94-95 biennium a Master's Thesis was completed that examined the relationships between breeding birds and reserve timber in aspen clearcuts (Merrill 1994). This biennium a second Master's project documented the differences in bird communities on recently burned and logged mature aspen habitats in northern Minnesota (Schulte, 1996). Results indicate that overall bird species richness and the number of individuals per unit area were higher in burned forest compared with logged forests. Many species-specific changes in birds were also observed between the two types of habitats and most could be explained by the differences in vegetation.

Finally, since the Forest Bird Diversity Initiative began in FY92 project staff have been censusing birds in a select number of old-growth forest stands in northern and southeastern Minnesota that were part of another LCMR project on old-growth forests. Work during the FY96-97 biennium focused on 12 study areas in southeastern Minnesota. A final compilation of data from all stands sampled during the past six years was prepared (Niemi et al. 1998, *Monitoring bird populations of old-growth study plots in Minnesota).*

- Tier 2: Bird Habitat Relationships at the Landscape Level

Many recent studies have demonstrated that forest birds respond not only to habitat features at the stand level (Tier 1 of the bird habitat model) but also to vegetation patterns at the landscape level (Tier 2 of the bird habitat model). Work during previous bienniums began to examine this second tier of analysis. Hawrot and Niemi (1996) examined the effects of edge type and patch shape on avian communities in mixed conifer-northern hardwood forests. Niemi et al. (*Forest fragmentation and bird species distribution on roadside counts in Minnesota and Wisconsin,* manuscript) utilized the Breeding Bird Survey (BBS) data to examine whether forest bird species in Minnesota were associated with fragmented or unfragmented forested landscapes. Of the 58 species analyzed, four species were associated with highly fragmented stops (Mourning Dove, American Crow, Common Grackle and Northern Oriole) while six species were found at stops in the least fragmented areas (Veery, Hermit Thrush, Red-eyed Vireo, Nashville Warbler, Chestnut-sided Warbler, and Ovenbird). This provided some of the first evidence that species in this region of the United States respond to forest fragmentation at the landscape level. Montgomery (1995) demonstrated the possible use of satellite imagery for the identification of suitable breeding habitats for forest birds which could eventually allow us to efficiently refine our models for predicting changes in forest birds as a result of forest change. Finally, Pearson (1994, Pearson and Niemi 1998) tested whether both within-stand habitat characteristics and landscape patterns influenced the abundance of seven bird species in contiguous forests. Results indicated that species with the most general habitat associations within these forests were least influenced by landscapes, while species that were more habitat specific (e.g. the highly conifer-dependent Blackburnian Warbler) were most influenced by the surrounding landscape.

The techniques utilized by this latter study are now being applied to 52 breeding bird species across northern Minnesota. The proportion of cover types in a 500 m and 1000 m radius circle surrounding each stand were calculated based on Landsat satellite thematic mapper imagery. Logistic regression analysis was used to predict the presence of 52 breeding bird species within these forests based on the proportion of the various cover types in the surrounding buffers. One of our hypotheses is that habitat selection by those species that have demonstrated a weak stand/cover type relationship may be more influenced by landscape variables. Briefly, all 52 species showed significant ($P<.05$) logistic regressions and most showed relatively consistent regressions when analyses were completed for each national forest separately. Explained variation ranged from about 6% to 65% with a mean of 32% using a 500 m buffer and 30% using a 1000 m buffer. The general pattern of responses observed generally followed the habitat preferences of the species. For instance, species that were highly associated with coniferous forests were more likely to be present in deciduous stands when the deciduous stand was surrounded by coniferous forests. Many species were less likely to be found in otherwise suitable forested stands when the stand was surrounded by unsuitable habitat such as recently logged areas, agricultural areas, or open wetlands. These analyses indicate that both stand composition and landscape context should be considered in the management of most forest birds. A manuscript describing these relationships is being prepared.

- Past Publications and Manuscripts on Bird-Habitat Relationships:

  Hawrot, R. Y. and G. J. Niemi. 1996. Effects of edge type and patch shape on avian communities in a mixed conifer-hardwood forest. The Auk 113(3): 586-598.

  Merrill, S.B. 1994. Reserve timber management in northern Minnesota aspen clearcuts: an evaluation based on forest bird diversity. M.S. thesis. University of Minnesota - St. Paul.

  Montgomery, K. L. 1995. Discrimination of breeding habitats of forest birds in north-central Minnesota using satellite imagery. M.S. thesis. University of Minnesota-Duluth.

  Niemi, G. J., D. J. Mladenoff, J. M. Hanowski, A. R. Lima, and M. White. Manuscript. Forest fragmentation and bird species distribution on roadside counts in Minnesota and Wisconsin.

  Pearson, C. W. 1994. Effects of habitat and landscape patterns on avian distribution and abundance in northeastern Minnesota. M.S. thesis. University of Minnesota - Duluth.

- Current Publications or Reports on Bird Habitat Relationships

  Niemi, G. J., J. M. Hanowski, A. R. Lima, and R. Y. Hawrot. 1997. Superior National Forest: species-habitat profiles and habitat-bird community profiles. Excerpts from a report to the Superior National Forest.

  Niemi, G. J., J. M. Hanowski, A. R. Lima, R. Y. Hawrot and D. J. Mladenoff. Draft manuscript. Habitat distribution and relative frequency of breeding birds in northern Minnesota and Wisconsin forests: implications for biodiversity management.

  Niemi, G. J., C. W. Pearson, and J. M. Hanowski. 1998. Report. Monitoring bird populations of old-growth study plots in Minnesota.

  Pearson, C. W. and G. J. Niemi. 1998. Effects of within-stand habitat and landscape patterns on avian distribution and abundance in northern Minnesota. In: Disturbance in boreal forest ecosystems: human impacts and natural processes. Proc. IFBFRA Conference, August 4-7, 1997. Duluth, Minnesota USA. USDA Forest Service. General Tech. Rept. NC Forest Experiment Station. In press.

  Schulte, L. 1996. Bird communities of early successional burned and logged forest in northeastern Minnesota. M.S. thesis. University of Minnesota - Duluth..

2. Development of LANDIS model

The effort to link the data gathered on birds with a landscape model (LANDIS) has been an on-going process throughout the current biennium. The project is now entering a mature stage where models, field data results, and management and decision-support software links are being created in a detailed pilot application on the Pine County study area (one of nine square mile study plots where intensive field studies are underway by project staff). The specific components of the LANDIS model that have been developed this biennium are outlined below. This work has only been possible with support from other funding sources, above and beyond those cited as matching dollars for the project. Outside funding for the model development and related work totals over $750,000 and has been provided by the U.S. Department of Agriculture, Great Lakes Protection Fund, and the National Science Foundation.

- Parameterization of the forest succession component of the LANDIS model

The forest succession component of the LANDIS model was parameterized (or "custom-fit"), simulated and field-checked for its first test application on the Pine county square mile study plot. This work built on related projects funded by the U.S. Forest Service Northern Global Change Program and past LANDIS development work funded in part by the U.S. Forest Service North Central Experiment Station and developed at Dr. Mladenoff's lab. The process involved joining two models, LINKAGES (Pastor and Post 1986), a forest ecosystem process model, and LANDIS, our landscape-scale model (Mladenoff et al. 1996; He and Mladenoff, in press; Mladenoff and He, in press). LINKAGES was used to derive tree species establishment coefficients and rankings of species growth ability based on climate and soil data for each land type association (i.e. ecoregion subareas of homogeneous soils and climate). These data were automated so multiple runs for LINKAGES could serve as input to run the LANDIS model to implement large-scale forest succession on the landscape. This procedure was checked for the Pine County landscape as a pilot simulation and the results were checked with field data.

- Creation of forest cover input data for LANDIS

Another important component of initializing the LANDIS model is to create appropriate input data that defines cover types for the current forest conditions. Project staff developed an automated procedure to use various data sources, depending on appropriate scale, and process them for LANDIS input. For the Pine County study area this procedure used the Minnesota Comprehensive Stand Assessment (CSA) data which includes data fields for tree species, age, size and stocking. For our eventual simulations at larger scales, we also developed a procedure to link data from the statewide Forest Inventory Assessment (FIA) plots and our Landsat TM forest classification as input (He et al., in press). The latter procedure has been tested for northwestern Wisconsin and the process is completely transferable. Since the Landsat TM forest classification is now complete for most of the forested areas of northcentral and northeastern Minnesota, this will be a primary database for input in large simulations, especially where CSA data are unavailable.

- Conversion of LANDIS forest type maps to bird habitat class maps

A major task was developing an algorithm to convert forest type data maps, such as from LANDIS, or from databases like CSA or Landsat classifications, to bird habitat maps. This step essentially identifies the forest types and age classes that are important to bird species and depended on the years of previous data collected by bird monitoring program. It represents the first step in linking the bird field data with the succession model output, and constitutes perhaps the most innovative and important product of this project, both scientifically and for management. While first tested as a manual process on the Pine County site, we have programmed the necessary model and GIS links so that it can now be automated and applied elsewhere. Flexibility is built into the program to accommodate input at various scales from the LANDIS model or other data sources and to include changes in bird habitat classes as scale, need, and improved information are developed.

- Development of a spatial forest harvesting module for LANDIS

The module was tested from June to September and then reviewed in a joint workshop in Madison (Gustafson et al., in prep.). Following a few minor recoding changes we will have the module ready to use in the Forest Bird Diversity Initiative. This work was also funded through a cooperative project with the North Central Forest Experiment Station (NCFES) in Columbia, Missouri, cooperators in the NCFES Rhinelander Lab, and Mladenoff.

- Redesign, recoding and testing of a spatial analysis package for LANDIS

A spatial analysis package known as APACK, previously developed by Mladenoff, was completely redone over the past eighteen months. New landscape indices needed for habitat analysis have been added, as well as a more user friendly interface. Detailed testing was also conducted. This work was carried out in a project funded through the Wisconsin Department of Natural Resources.

- Preliminary development of decision-support systems

Finally, a critical aspect of this research is moving the research tools from the laboratory to the hands of managers through the development of decision-support systems. This involves developing user-friendly software for LANDIS so managers can examine the consequences of different management scenarios. During this biennium we developed the first step of this process by programming an ARCView application to allow easy "point and click" viewing of LANDIS output maps of forest landscapes, as well as related habitat maps. This work was funded by the U.S. Forest Service, North Central Experiment Station Lab in Columbia, Missouri in related collaborative work with Mladenoff.

- Master's Thesis

Finally, Michelle Barlow completed a thesis (Barlow 1996) that showed how breeding bird distribution and vegetation data gathered on one large research plot, Bandana Lake, could be incorporated into a geographic information system (GIS). These data were then used to develop probability distribution functions for a species or a bird community over the entire plot. The analytical techniques developed and applied in the thesis will be extremely useful for building the model that links our remote sensing data with the information we have been gathering on bird distribution and abundance over the past six years.

- Current Publications or Reports on the Modeling Component of the Initiative funded by LCMR

Barlow, M. 1996. Habitat selection by forest birds using geostatistically modeled and spatially classified vegetation data. M.S. Thesis. University of Minnesota - Duluth.

Mladenoff, D. J., G. J. Niemi, and W. A. White. 1997. Effects of changing landscape pattern and land cover data variability on ecoregion discrimination across a forest-agricultural gradient. Landscape Ecology 12: 379-396.

- Publications and references that are products of studies funded by USDA, Great Lakes Protection Fund and NSF that have been essential to the LANDIS model development.

Gustafson, E., S. Shifley, D. J. Mladenoff, and K. Nimerfo. Spatial simulation of forest harvesting with the LANDIS model. Ecological Modeling: in preparation.

He, H. S., and D. J. Mladenoff. Dynamics of fire disturbance and succession on a heterogeneous forest landscape: A spatially explicit and stochastic simulation approach. Ecology: in press.

He, H. S., D. J. Mladenoff and T. R. Crow. Linking a forest ecosystem process model and a spatial landscape model. Ecological Modeling: submitted.

He, H. S., D. J. Mladenoff, and V. C. Radeloff. Integration of GIS data and classified satellite imagery for regional forest assessment and landscape modeling. Ecological Applications: in press.

Mladenoff, D. J., G. E. Host, J. Boeder, and T. R. Crow. 1996. LANDIS: A spatial simulation model of forest landscape disturbance, management, and succession. Pp. 175-179 In: Second International Conference on Integrating GIS and Environmental Modeling. NCGIA. Santa Barbara, CA.

Mladenoff, D. J. and W. L. Baker. (in press). Development of forest modeling approaches, in D. J. Mladenoff and W. L. Baker (editors). Advances in Spatial Modeling of Forest Landscapes: Approaches and applications. Cambridge Press, UK.

Mladenoff, D. J. and H. S. He. (in press). Design and behavior of LANDIS, an object-oriented model of forest landscape disturbance and succession, in D. J. Mladenoff and W. L. Baker (editors). Advances in Spatial Modeling of Forest Landscapes: Approaches and applications. Cambridge Press, UK.

Pastor, J. And J. Post. 1986. Influence of climate, soil moisture and succession of forest carbons and nitrogen. Biogeochemistry 2:3-27.

Future Efforts

Work during the coming biennium will focus on three primary work elements. First, we will complete the second tier of the bird habitat model, relating bird distribution and abundance to forest vegetation patterns at the landscape level. Second project staff will begin the complex process to parameterize the model for the large and diverse landscapes of those Minnesota study regions that have been defined by Landsat satellite imagery: 1) the eastern Superior National Forest; 2) the Chippewa National Forest, and 3) the St. Croix region. We will modify and extend methods developed in Mladenoff's lab and so far applied only in Wisconsin. This will involve: 1) developing pilot applications as we did on the Pine County plot, within plots on the Superior National Forest and/or the Chippewa National Forest; 2) integrating large-scale data and preparing forest input maps for the model from FIA, CSA and Landsat classifications; 3) generating tree species parameters by again joining the LINKAGES model with LANDIS; 4) model testing and field checking of correct successional dynamics within the different regions; and 5) testing of the bird habitat generation module for the various regions. Finally, we will conduct a pilot test of the model and ARCView application with field forest land managers.

D. Title of Objectives/Outcome: Promote forest bird conservation and management.

D.1. Activity: Continue development of educational materials and forest management prescriptions that integrate the needs of birds into traditional forest management practices.

D.1.a. Context within the project: The data collected in Objectives A and B and the simulation model developed in Objective C will enable project staff to assess the effects of changes throughout the forest landscape on Minnesota's 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 simulation model, however, will only begin during the FY96-97 biennium. In the interim, one priority is to educate land managers about the regional and statewide significance of Minnesota's forest bird resource. Work begun in FY93 to develop an educational management guide, titled *Birds and Forests in Minnesota: A Guide for Conservationists, Managers and Planners*, will be completed. Opportunities to publicly present and distribute the information contained in the booklet to land managers, industry representatives, the logging community and the general public will occur throughout the biennium.

A second priority during this interim period is to develop management prescriptions that integrate the needs of forest birds into traditional management practices. The project has and continues to produce many results and several graduate student theses that focus on aspects of the monitoring program, nest productivity studies and landscape analysis (e.g. Merrill 1994, Pearson 1994 and Montgomery 1994). As these studies are completed it is essential that their results and conclusions are widely disseminated, not only through the recognized channels of peer-reviewed publications and annual meetings of professional societies, but also through delivery systems that directly reach forest land managers.

D.1.b. Methods: First, during the first few months of the biennium, project staff will oversee the final publication of the book, *Birds and Forests*, and its statewide distribution. Second, project staff will work with the primary forest land management information that will reach the largest number and widest diversity of forest land managers. Once identified, the results of the specific graduate studies as well as the general forest bird diversity project will be compiled and summarized in a manner most appropriate to the targeted mechanism of delivery (e.g. through the Forest Stewardship Program and/or the Department of Natural Resources Forest Wildlife Management Guidelines). These efforts will incorporate and build upon the foundation of information contained in *Birds and Forests*. This activity will also include efforts to summarize other recent literature and field studies conducted in other regions of the Great Lakes that are relevant to the issue of forest bird management.

D.1.c. Materials: No major materials are needed for completion of this activity. Basic literature and management materials that are already published and/or written through the auspices of this initiative will provide the core of information utilized for this objective. The majority of the budget covers staff time.

D.1.d. Budget

Total Biennial LCMR Budget: $41,000

LCMR Balance: $0

D.1.e. Timeline:

	7/95	1/96	6/96	1/97	6/97	12/97
Oversee final publication of book	****					
Distribute book statewide		*******				
Investigate delivery systems for management information	**********					
Prepare management information for distribution			**********	**********	**********	
Prepare and deliver a minimum of eight forest bird presentations	**********	**********	**********	**********	**********	**********

D.1.f. Work Program Update: March 15, 1998

1. Birds and Forests: A Management and Conservation Guide.

   Written by Janet C. Green and published by the Minnesota Department of Natural Resources as a part of this initiative, this 118 page book provides detailed information on the distribution and abundance of forest birds, selected life-history characteristics and a compilation of local and regional bird studies. During the first year of the work program (July 1995 - June 1996) the book was distributed, free of charge, to approximately 1725 forest managers associated with federal agencies, state agencies, county land departments, Soil and Water Conservation Districts, forest industry, reservations and private forest management. Individual copies were also distributed to interested citizens for a suggested donation of $15.00. Since July 1996 the book is being distributed to wholesalers and distributors for a suggested retail price of $25.00

   Birds and Forests has been recognized with two awards. In August 1996 it won first place in an international writing and design competition sponsored by the Association of Conservation Information.

Then, in December 1996, the author received the Brother Theodore Voelker Award from the Minnesota Ornithologists' Union in recognition of the publication's contribution to Minnesota ornithology.

2. November Conference on Forest Birds

A half-day conference, titled "Birds and Forests: Research from Minnesota and Maine", was organized for forest land managers on November 28, 1995 at the Cloquet Forestry Center. Two of the initiative's principal investigators, Dr. Gerald Niemi and Dr. David Mladenoff, were among the speakers and were accompanied by Dr. Peter Reich, UM, and our featured guest, Dr. John Hagan, from the Manomet Observatory for Conservation Sciences in Massachusetts. Dr. Hagan spoke about his cooperative forest bird work with several large industrial forest owners in Maine. The symposium was attended by forest land managers and wildlife biologists from the DNR, forest industry and county land departments.

3. Logger Education Program

Project staff participated in the new Minnesota Logger Education Program in 1996. A day-long workshop, one hour was devoted to forest wildlife management with a special emphasis on forest birds. Although the original goal was to reach 250 loggers the five workshops reached nearly 600. Copies of **Birds and Forests** were distributed at each workshop.

4. Comprehensive Timber Harvesting and Forest Management Guideline Development

Under the auspices of the Minnesota Forest Resources Council four technical teams have been established to prepare guidelines for riparian zone management, forest soils productivity, site-level forest wildlife habitat, and historical/cultural resources. **Birds and Forests** was used extensively by the forest wildlife technical team and one of the project staff members also served on the team.

5. Forest Stewardship Program

Project staff received funding for two proposals submitted to the Forest Stewardship program in February 1996: 1) to develop and deliver workshops to stewardship plan writers that focus on forest birds ($7940); and 2) to develop a stewardship brochure on forest birds ($9100).

- Forest Stewardship Workshops

A team of 18 representative forest stewardship plan-writers was organized and met twice to identify the informational needs and desires of the intended audience and to determine the most effective methods of providing information on birds and forests to workshop participants. The team included representatives from DNR forestry, wildlife, and nongame; forest industry; county land departments; independent forestry consultants; and nonindustrial private forest landowners. Five one-day workshops were organized and scheduled for June and July of 1997. Project staff served a major role in the workshops' organization and in the

preparation of talks and field exercises. Over 210 forest stewardship plan writers attended the first three workshops held in June. Feedback from the participants was excellent. A complete report and evaluation will be included in the FY98-99 LCMR report.

- Stewardship Booklet

A 40 page booklet titled, **Planning for Birds**, is being developed by project staff, using much of the applied management information contained within Janet C. Green's book, *Birds and Forests*. During this biennium three major drafts of the booklet were prepared and reviewed by more than 20 reviewers including DNR foresters, wildlife managers, nongame specialists, private forest consultants, representatives of Minnesota's forest industries, avian ecologists and research scientists. Release of the publication is scheduled for March 1998.

6. Presentations

In addition to the presentations given at the five logger education workshops in 1996 and the three forest stewardship workshops held in early 1997, a total of 33 presentations on forest bird management and conservation have been delivered by project staff since July 1995.

7. Publications

Publications that the Forest Bird Diversity Initiative has prepared have been summarized earlier under the other project objectives. In total, eight manuscripts have been published, five in peer-reviewed publications, and 13 others are being prepared or have been submitted for publication. In addition, several additional papers have been published as a part of related research that is underway by project investigators (see below).

Future Efforts

In addition to completing the forest stewardship projects mentioned above during the FY98-99 biennium, project staff will continue to place a priority on dissemination of project results through presentations and publications to the forest industry, forest resource professionals and the general public.

E. Related Research

In addition to our major efforts in monitoring bird populations and studies of nest success, we have completed a variety of studies that are complementary to the overall effort to improve our understanding of forest bird biodiversity issues. Each of these related studies is briefly described below.

- In an invited review in a major book titled, Conservation of Faunal Diversity in Forested Landscapes, Helle and Niemi (1996) completed a synthesis of the information that exists on bird succession in northern forests with examples from a wide variety of geographic locations around the world.

- In a cooperative effort with Dr. Robert Howe from the University of Wisconsin, Green Bay, and Dr. John Probst of the USDA Forest Service, North Central Forest Experiment Station in Rhinelander, Wisconsin (Howe et al. 1996), Niemi participated in a review of the many issues associated with managing neotropical migrant birds in the upper Midwest, including Michigan, Minnesota and Wisconsin.

- In a collaborative experiment involving the Natural Resources Research Institute, University of Minnesota, Duluth and several scientists from the country of Finland, we tested an idea known as the heterospecific attraction hypothesis (Monkkonen et al., in press, 1997). This hypothesis states that migrating birds use resident birds as a cue to identify the best sites for breeding because residents have already selected higher quality sites. We tested this hypothesis on several forested lake islands in northern Minnesota by increasing resident bird numbers through winter feeding or by decreasing residents through mist-netting and displacing them from the islands. The results supported the heterospecific attraction hypothesis because the relative abundance of several migratory species changed consistently following the manipulations. This is especially true for species such as the Black-and-White Warbler that most likely would be affected by the manipulation of residents (e.g. nuthatches).

- In November of 1995, Niemi and Hanowski (1997a, 1997b) organized a special symposium on *Raptor Responses to Forest Management: a Holarctic Perspective* at the annual meeting of the international organization, The Raptor Research Foundation, held in Duluth, Minnesota. The symposium consisted of 12 oral presentations on six raptor species that have holarctic distributions. Two papers were presented on each species with one each from an expert in North America and Northern Europe. The results were published in a special issue of the Journal of Raptor Research (Vol. 31, No. 2).

- The concept of indicator species has been a popular, but a highly debated topic among those concerned with multiple species management. The idea of indicator species is a relatively old concept and it is intuitively pleasing because management for many species may be simplified and made more cost-effective by considering only

a small group of indicator species (Niemi et al. 1997). We critically examined the habitat distributions of both management indicator and sensitive species being used by the USDA Forest Service and whether other bird species were positively associated with these species. Even though there were potentially 25 management indicator species that could have been examined, only 7 species were possible to analyze even though we had gathered over 30,000 observations of birds. Only 2 of the 7 species examined had non-random distributions and many inconsistencies were found on whether other species could be positively associated with these species. The lack of consistent patterns cast doubt on the ability to use a few species as indicators for the well-being of many other species. We concluded that developing more comprehensive techniques that improve habitat classifications and combine monitoring of trends in habitat and birds within those habitats likely will prove more fruitful than focusing on a few representative species.

Related Research Publications

Helle, P. and G.J. Niemi. 1996. Bird community dynamics in boreal forests. In R.M. DeGraaf and R.I. Miller (ed.) Conservation of faunal diversity in forested landscapes. Chapman and Hall, London, Great Britain. Pages: 209-234.

Howe, R.W., G.J. Niemi and J.R. Probst. 1996. Management of northern hardwood-conifer landscapes for the conservation of neotropical migrant birds. In: F.R. Thompson III (ed.). Management of Midwestern Landscapes for the Conservation of Neotropical Migratory Birds. USDA Forest Service, North Central Forest Experiment Station, Gen. Tech. Report NC-187, St. Paul, MN. Pages 144-167.

Monkkonen M., P. Helle, G. Niemi and K. Montgomery. Manuscript. Heterospecific attraction affects community structure and migrant abundances in northern breeding bird communities. Can. J. Zool.: in press.

Niemi, G.J. and J.M. Hanowski. 1997a. Preface to Raptor Responses to forest management: a holarctic perspective. Journal of Raptor Research 31(2):93-94.

Niemi, G.J. and J.M. Hanowski. 1997b. Concluding remarks on raptor responses to forest management: a holarctic perspective. Journal of Raptor Research 31(2):191-196.

Niemi, G.J., J. M. Hanowski, A. Lima, T. Nicholls, and N. Weiland. 1997. A critical analysis on the use of indicator species in management. J. Wildl. Manage. 61(4): 1240-1252.

VI. **Evaluation:** For the FY96-97 biennium the program can be evaluated by its ability to:
1) continue and expand implementation of the long-term monitoring program;
2) successfully assess nest productivity for common forest birds; 3) complete development of the forest bird habitat and landscape models; 4) begin development of the predictive simulation model; 5) educate land managers about the importance of the forest bird resource; and 6) provide managers with tools for use in their land management operations.

In the long-term, the project should be evaluated by its ability to successfully develop landscape management practices that are fully integrated into forest management activities for the purpose of maintaining and improving the status of the regional avifauna while still providing a sustainable resource base for industry.

VII. **Context within the field:** Prior to the initiation of this study in FY92, most of the work on forest birds had focused on individual forest stands (e.g., Niemi and Pfannmuller 1979, Niemi and Hanowski 1983, 1984 and Engstrom 1990). The influence of the surrounding landscape on the bird community composition had only been considered in a few selected studies (e.g., Askins et al. 1987, Blake and Karr 1987, Hejl 1992, Opdam et al. 1985, Robbins 1979). As part of this project, Pearson (1994) completed a thesis that showed how habitats in the landscape could influence the presence of selected forest birds within a stand. Pearson (1994) studied aspen stands and showed how birds that depend on coniferous trees were primarily found in these aspen stands when the surrounding landscape contained a substantial proportion of coniferous habitat. Another major limitation in linking forest birds with habitat, either within a stand or at the landscape scale, is the amount of detailed habitat information that needs to be gathered on the ground. In a thesis by Montgomery (1994), also prepared as part of the Forest Bird Initiative, the author showed that it is possible to make reasonably accurate predictions of the presence of many bird species using Landsat thematic mapper (TM) directly without the need for ground data. Both of these studies have provided encouraging results, but they have been completed in relatively limited areas of the state's forests. The next phase of this project will allow much broader coverage. We will use our bird data from the more than 1000 bird point counts and the data from the nine, square mile plots to address additional questions about landscape and management effects on forest birds in the extensively forested regions.

An additional longer term objective of this overall study is to begin linking the nest productivity results with bird relative abundance, habitat use, and landscape context. Since most prior work on nest productivity has been completed in fragmented landscapes or without the explicit consideration of the landscape, there is considerable effort that needs to be completed over a variety of spatial scales to relate the nest productivity results with habitats and landscapes. This will ultimately be a critical phase of the study because of the need to determine how or if counts of singing birds (commonly used as a monitoring technique) relate to nest productivity and to assess the ecological conditions that allow forest birds to successfully reproduce. The development of management recommendations for the forests will especially be weighted by these studies of nest productivity.

The work described for forest birds complements a number of additional studies that Dr. Gerald Niemi has in progress. These include: 1) continued monitoring of forest bird changes in the Chippewa and Superior National Forests which began in 1991 - sponsored by the U.S. Forest Service, 2) a study to examine the habitat and landscape effects on birds and mammals of possible increased use of hybrid poplar as a biomass fuel in the upper Midwestern United States - sponsored by the Department of Energy, National Audubon, and the U.S. Forest Service; and 3) a recently initiated study to link an ecosystem-based model of solid, forest development, and global climate change with bird data gathered by this project and previous work by Niemi - sponsored by the National Science Foundation.

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 totaling 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 other major initiatives including the Grant Lakes Biodiversity Task Force and the development of an Ecological Classification System (ECS) 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. One the Chippewa National Forest the bird-habitat relationships delineated by this study will contribute to the interpretation of ecological classification units.

III. Budget Context:

A. FY94-95 Funding History

- $500,000 An appropriation from the Minnesota State Legislature as recommended by the Legislative Commission on Minnesota Resources.

- $ 54,000 Funds provided by the North Central Forest Experiment Station for implementing the forest bird monitoring program on the Superior and Chippewa National Forest.

- $ 21,000 Funds provided by the Minnesota Department of Natural Resources, Division of Forestry for expanding the bird monitoring program on the Chippewa National Forest in association with the development of their ecological classification system.

- $ 50,000 Funds available through June 30, 1995 for assisting with public outreach efforts. The source of the funds is internal reprogramming dollars within the Department of Natural Resources. They were made available on a one time basis for the Department's integrated resource management pilot projects. One of these pilot projects is the Forest Bird Diversity Initiative. Depending on the scheduling for the publication of the Forest Bird Primer, the project may only use 50-75% of the funds.

B. FY96-97 Funding History: Anticipated

- $ 54,000 Funds provided by the North Central Forest Experiment Station for implementing the forest bird monitoring program on the Superior and Chippewa National Forest.

C. Additional Notes

Some additional monies that were raised by the project in FY92-93 and in the early half of FY94 are still available to cover project expenses. At this time, approximately $27,400 is available on hand, and pending completion of two challenge grant agreements, an additional $25,800 should be received before December 1995. These monies will be used to cover the publication costs of the Forest Bird Primer (which will occur either late in FY95 or early in FY96) and to help cover the costs of a temporary unclassified assistant whose primary responsibilities will be public outreach efforts. The exact distribution of these funds into the FY94-95 biennium or the FY96-97 biennium will be unknown until late in FY95. These funds are deposited in accounts that roll forward between bienniums.

IX. 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 presentation of results at such meetings, they will be published in the peer-reviewed literature in the major national journals in the field. Objective D 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 are 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.

X. 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 approximately 12 years (or six bienniums). Funding began in the FY92-93 biennium. As recommended by the Legislative Commission on Minnesota Resources in August 1993, project staff are investigating avenues for incorporating the project costs into the state agency's budget. If these efforts are unsuccessful, we will continue to pursue future funding from LCMR as well as other appropriate sources.

XI. 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 C). Dr. Mladenoff will commit 5% 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 and nest productivity studies (Objective A and B). Dr. Niemi will commit 10% of his time during the biennium to this project.

Note: The Program Manager, Lee A. Pfannmuller, will be spending 5% of her time on Objective D 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). Dr. Niemi will have several staff and graduate students working full-time on the project under his direction.

XII. Reporting Requirements: Semiannual six-month workprogram update reports will be submitted not later than January 1, 1996, July 1, 1996, January 1, 1997, and a final six-month workprogram and final report by December 31, 1997.

XIII. Literature Cited

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XIV. REQUIRED ATTACHMENTS

Resumes of program manager and key cooperators are attached and the Staffing Summary Sheet.