1995 Project Abstract
For the Period: Ending June 30, 1997
This project was supported by Minnesota Future Resources Fund

TITLE: Biomass Production, Restoration, and Management of Brushland Habitats
PROJECT MANAGER: JoAnn M. Hanowski/Donald P. Christian
ADDRESS: Natural Resources Research Institute (JMH), Department of Biology (DPC), University of Minnesota , Duluth, MN 55812 (Present address of DPC: Division of Biological Sciences, University of Montana, Missoula, MT 59812)
WEB SITE ADDRESS: n/a
LEGAL CITATION: ML 95, Ch. 220, Sec. 19, Subd. 10d
APPROPRIATION AMOUNT: $200,000

Statement of Objectives

Objectives were to 1) investigate feasibility of harvesting brushlands for biomass production, including preliminary assessment of equipment, determining biomass availability, and assessing effects of biomass removal on nutrient availability; 2) assess brushlands as wildlife habitat, including enhancing knowledge of distribution of sharptailed grouse and other birds in brushlands and identifying landscape and habitat features that characterize sharptailed grouse dancing grounds; and 3) increase awareness of brushland management issues.

Overall Project Results

Portions of brushland sites may contain 4-32 dry tons/acre of biomass, with average biomass across entire sites 1-18 dry tons per acre. Removal of the average annual biomass increment (1.47 tons/acre/year) should have only slight negative impact on nutrient availability. A theoretical harvesting system for brush would consist of a harvester that cuts woody stems near the ground using a rotating horizontal "drill" type felling head, coupled with a mobile chipper. Chips are forwarded to a land site using a tipping box pulled by a tracked low-ground-pressure vehicle. Measured values of biomass availability, engineering estimates of the travel speed of the harvester, and estimates of operating, loading, and transportation costs were used to estimate the cost of brush biomass at about $16 per ovendry ton delivered to a small electrical power generation facility. This is a relatively low cost compared to other biomass energy options. These results suggest that brushland harvesting in Minnesota may be a potentially attractive alternative energy source. Several demonstration brush removal projects were conducted.

Habitat analyses indicated that active sharptailed grouse dancing grounds occur in landscapes that have lower coverage of various brush and tree cover types and more native grass than either former (abandoned) dancing grounds and random points in the landscape. Differences in landscape composition are recognizable at distances ranging from 200 m to 3000 m from the dancing ground center. Vegetation profiles around dancing grounds are lower, and contain less planted conifer. Many, but not all, of the open areas in which dancing grounds occur also were openlands at the time of the original land survey in the state. Songbird communities differ between managed and unmanaged brushlands, as a function both of local habitat and the surrounding landscape.

Project Results Use and Dissemination

Project results were described in several formal presentations and workshops during the course of the project, and were used as input for a number of newspaper articles, press releases, and radio programs. Results were discussed with numerous landowners. Project results are being written for submission to scientific journals such as Journal of Wildlife Management, Biomass and Bioenergy, and others.

Date of Report: 31 December, 1997

LCMR Final Work Program Update Report

I. Project Title and Project Number: C52/C12 BIOMASS PRODUCTION, MANAGEMENT, AND RESTORATION OF BRUSHLAND HABITATS

Program Manager: JoAnn M. Hanowski/ Donald P. Christian
Agency Affiliation: University of Minnesota, Duluth (JMH)
Mail Address: Natural Resources Research Institute
5013 Miller Trunk Highway
Duluth, MN 55811
Phone: (218) 720-4311; jhanowsk@sage.nrri.umn.edu
Present address (DPC): Division of Biological Sciences
University of Montana, Missoula, MT 59812
(406) 243-4432; dchristi@selway.umt.edu

A. Legal Citation: ML 95, Ch. 220, Sec. 19, Subd.10d.

Total Biennial Budget: $200,000
Balance: 0

Appropriation Language: This appropriation is from the future resources fund to the commissioner of natural resources for an agreement with the University of Minnesota-Duluth in cooperation with the natural resources research institute and the Minnesota Sharptailed Grouse Society, to assess brushland harvesting, brushland as wildlife habitat, and habitat management strategies.

This project must be completed and final products delivered by December 31, 1997, and the appropriation is available until that date.

B. LMIC Compatible Data Language: N/A

C. Status of Match Requirement: N/A

II. Project Summary:

The overall goals of this project are to 1) enhance understanding of biological resources and develop management approaches for brushland ecosystems in Minnesota, 2) investigate the feasibility of harvesting brush as a biomass energy source, and 3) increase awareness of brushland management issues and opportunities. Continuing loss of early-succession brushlands through maturation and senescence has resulted in declining populations of sharp-tailed grouse and other wildlife species dependent on young, open brushlands. Funding to reverse this succession has been inadequate, and an effective, long-term strategic plan for maintaining these habitats is lacking. In this project, we will analyze existing databases on sharptails, conduct field studies on grouse and songbirds, and use Geographic Information System (GIS) analysis to assess landscape and habitat factors that affect sharptail and songbird distribution and abundance. These data, along with existing information and other data to be obtained in this project, will be used to develop strategies for managing brushlands and educational information about the ecology and management of brushland ecosystems.

There currently are serious initiatives to increase use of biomass as a renewable, nonfossil energy source. This project would establish an information base for commercial harvesting of brushlands to produce woody biomass. This approach would be used as a site-specific alternative to, or along with, prescribed burning. We will measure on-ground biomass abundance on selected brushlands, and identify capabilities and features of currently available harvesting equipment to evaluate the technological and biological feasibility of incorporating this approach into an integrated approach to managing brushlands.

III. Final Project Results:

In this project, we developed a wide variety of information sources and perspectives that strengthen our knowledge base for managing brushlands in Minnesota and that indicate future opportunities for brush harvesting and management. This information is presented in more through detail in a technical report submitted to the Minnesota Department of Natural Resources and is summarized here. Using field measurements and standard diameter-biomass equations, we estimated that fully stocked portions of brushlands contain between about 4 and 32 dry tons of above-ground biomass per acre. Taking into account the percentages of brush stands that are stocked with brush (range of about 10 to >60% of area in brush), we estimated overall biomass ranging from <1 to >18 dry tons per acre. The average biomass increment for a range of brush sites is 1.47 tons/acre/year. We analyzed nutrient content of soils and above-ground woody biomass collected during winter. These analyses suggest that brush harvesting would have only slight negative impact on site-level nutrient availability, with potassium showing the highest removal rate (1.26% of the total pool removed over a 10-year period). However, a conservative approach would be to replace nutrients every two harvest rotations to assure long-term site productivity.

We used information on a theoretical harvesting system designed by equipment engineers familiar with logging equipment design and manufacture to evaluate the economic feasibility of harvesting brush as an energy source for electrical power generation. We estimated the cost to deliver brush biomass to a power generating facility, incorporating results of our field measurements of brush biomass and dispersion, the projected travel speed and harvesting capacity of the harvesting system, and assumptions about harvesting, loading, and transportation costs. These analyses resulted in estimated delivered costs of about $16 per oven-dried ton, which is low cost compared to other biomass energy alternatives. In addition, as discussed below, brush harvesting likely would contribute to habitat management programs. These analyses suggest that brushland harvesting in Minnesota may be a potentially attractive alternative energy source that warrants further exploration.

We conducted a variety of analyses of brushlands as wildlife habitat, with particular focus on sharptailed grouse. We conducted several analyses of sharptailed grouse census data collected by Minnesota Department of Natural Resources wildlife biologists since about the mid 1970s. These analyses fully confirm the view that sharptails have declined precipitously in the past few decades, and point to habitat changes on and around localized courtship dancing grounds as a key factor in those declines. Through those analyses, we identified dancing ground sites that birds have continued to use ("active" sites), and others that previously were used by grouse but from which they have disappeared ("defunct" dancing grounds); these sites formed a significant part of the basis for analysis of habitat. We completed a series of extensive analyses of satellite imagery to understand the possible differences in landscape configuration among active and defunct dancing grounds, and between dancing grounds and random points in brushland landscapes. We identified and classified 42 cover types on the imagery, and calculated the landscape composition within different buffer distances (200 m, 500 m, 1000m, and 3000m radii) around dancing ground centers and random points.

Most of the statistically significant differences among active and defunct dancing grounds and random points reflected differences between dancing grounds (both categories) and random points. These results indicate that sharptailed grouse dancing grounds do not occur randomly on the landscape but instead are found in areas with particular configurations of vegetative composition. These differences, recognizable at all four buffer widths, reflected a variety of measures of lower frequency of tree cover types (several coniferous and deciduous cover types) and several brush types (both upland and lowland), and greater coverage of lowland native grass, ericaceous brush, and stagnant acid bog conifer surrounding dancing grounds, compared with random points. Results of these analyses should enhance our ability to prioritize management areas.

Beyond the differences between active or defunct dancing grounds and random points, these analyses also indicate features that distinguish active from defunct dancing grounds. There were no statistically significant differences in landscape composition between active and defunct dancing grounds for the 200 m buffer. These differences were most pronounced at 500 m and 1000 m buffers, and include greater coverage by native grass and lower coverage by some brush and tree types on active, compared to defunct dancing grounds. Nearly all of the features that distinguish active from defunct dancing grounds also differed between active dancing grounds and random points. For most of these variables, the mean value for defunct dancing grounds was intermediate between that for active dancing grounds and for random points. This pattern is consistent with the view that the defunct dancing grounds represent a successional transition between active grounds and the overall landscape, and many of the variables involved are known to change in the absence of disturbance such as fire. Landscapes around active dancing grounds have fewer cover types and lower cover-type diversity indices, suggesting that they are less fragmented than landscapes surrounding defunct dancing grounds. In many instances, statistically significant differences between active or defunct dancing grounds and random points, or between active and defunct dancing grounds, involve only slight differences in the percent coverage by different vegetative types, suggesting that sharptails are sensitive to or are affected by subtle changes or differences in the landscape. Nearly all of the differences between these site categories involve differences and directions that are fully consistent with our understanding of habitat needs of sharptailed grouse. This information will be beneficial in managing brushland landscapes for sharptails and other wildlife, including helping to understand the spatial scale over which effective management must occur, and identifying areas where management of woody vegetation is most likely to produce desired habitat configurations.

We analyzed vegetation height-distance relationships around defunct dancing grounds and grounds on which either many ("active large") or few ("active small") grouse have been observed in recent spring censuses. In the east-central sharptail range, these results showed significantly taller or nearer vegetation and greater development of planted conifer around defunct and "active small" dancing grounds than around areas containing large numbers of birds. These differences are fully in accord with the landscape/satellite imagery analyses, which showed greater development of brush and tree cover around defunct dancing grounds in the east-central range. Analyses of height-distance relationships in the sharptail range of the northwestern part of the state showed no significant differences in vegetation height between active small, active large, and defunct dancing grounds. However, all dancing ground categories in the northwest have vegetation profiles typical of active large dancing grounds in the east-central range. Thus, in the northwest, it seems that changes in landscape composition, irrespective of vegetation height, may be more important in explaining sharptail declines.

We examined the effect of brushland management on songbirds, in the context of trying to understand the possible effects of large-scale brush harvesting on other species of wildlife. We were particularly interested in identifying individual species or species complexes that might be affected either positively or negatively by brushland management. In 1996, we surveyed birds on active and defunct grouse dancing grounds, and on managed and unmanaged brush. We observed little difference in bird communities on active and defunct dancing grounds, confirming the view that landscape-scale considerations are critical in management of brushland ecosystems. Differences in bird communities between managed and unmanaged brush identified species that may be affected negatively by brush harvesting, such as the golden-winged warbler and gray catbird. In 1997, we surveyed birds on brushland sites with different management histories: some sites had not been managed, others had been managed either by shearing brush or by both shearing and subsequent burning. Sites varied in time since management. Unmanaged sites had more species and individuals than managed sites, and 12 of 20 individual species tested differed in abundance between groups. Management type (burning versus shearing) and time since management had little effect on bird species composition. Bird species associated with more open areas were more abundant on managed sites, and species that require shrubs were more abundant on unmanaged sites. Part of the difference among sites was related to surrounding landscape context. Unmanaged sites were surrounded by more upland forest and more lowland forest types, whereas managed sites were in landscapes dominated by brush and bog forests. Thus, the effect of large-scale brush management or removal on songbirds will depend in part on the surrounding landscape. Although specific management recommendations should depend on further studies of the relationship between habitat size requirements and configuration for individual bird species, an interim recommendation would be to create and maintain large patches of open area but leave large areas of brush habitat required by brush-dependent species.

Three demonstration brush removal projects were conducted during winter 1996-97 in the east-central portion of the state. Each project resulted in the creation of an 8 acre cleared area in the center of a larger sheared area. One project (20 acres total) was on state land, adjacent to a Minnesota DNR brush management project completed simultaneously. This project connected the DNR brush-shearing project with an adjacent open area. The other two projects were on private land. One involved shearing a total of 40 acres of brush, adjacent to an open pasture where sharptailed grouse have been observed and in close proximity to an active dancing ground. In the other project, 110 acres of young aspen and brush were sheared adjacent to lowland conifers and near a dancing ground, with a cleared area in the center. These areas are available to demonstrate the results of brush removal, and control areas for further ecological study are available near each of these projects.

We completed analyses of bearing-tree maps to assess the prevalence of openlands habitat prior to European settlement. Analysis of bearing-tree map data has identified that sharptail distribution in some, but not all, of the current range in the state is in areas (sections) that were more open, less-forested than the surrounding landscape at the time of the original land survey. This result is not consistent with the thinking, espoused by some land managers in the state, that sharptail distribution is an artifact of human activity such as agricultural land clearing and lumbering. The latter may be the case in some parts of the state, but is not universal. These analyses showed considerable complexity in the pre-European landscape vegetation in sharptail areas, not all of which is easily interpretable. However, this approach could be refined to delineate areas of the state that should receive priority for management as openlands habitats, and in educating the public and land managers about managing for openlands habitats within the forested part of the state. Proper refinement of these approaches is dependent on having bearing-tree data available in electronic form.

During the course of the project, we engaged in a variety of education and outreach efforts that included formal presentations at a DNR workshop (joint Forestry and Wildlife) on brushland ecology and management; presentations at the Minnesota Sharptailed Grouse Society; university seminars; radio interviews; providing information on sharptailed grouse and brushland management to several newspaper reporters; and individual contacts with many landowners. A press release to about 40 local newspapers in the northern part of the state, soliciting information on dancing ground localities, provided additional exposure to brushland management issues.

IV. Statement of Objectives:

A. Investigate feasibility of harvesting brushlands for biomass production

Outcomes:

- Assessment of features, capabilities, and suitability of existing equipment that might be used in future large-scale harvesting of brush.
- Determination of on-ground biomass type and availability on selected brushlands, to identify biological capacity of brushlands to sustain commercial harvest.
- Assess effects of biomass removal on site-level nutrient availability.

B. Assess brushlands as wildlife habitat

Outcomes:

- Enhanced knowledge of abundance and distribution of sharp-tailed grouse and other birds in a variety of managed and unmanaged brushland habitats.
- Identification of landscape and habitat factors that characterize sharptailed-grouse dancing grounds.
- Identification of previously un-mapped sharp-tailed grouse dancing grounds.

C. Develop educational information and planning/management approaches for brushland landscapes

Outcomes:

- Application of information developed in fulfilling objectives A and B to identify particular brushland sites that should receive management priority, with particular focus on sharp-tailed grouse.
- Development and implementation of programs for enhancing brushland habitat at these prioritized sites; these programs will produce demonstration projects of brushland landscape management, to include experimental harvesting of brush from key areas; these areas, along with appropriate control sites and burned areas, also will serve as sites for future study of long-term ecological responses to brushland harvesting.
- Development and dissemination of information about brushland ecosystems and management opportunities to landowners, land managers, and the public.

Timeline for Completion of Objectives

	7/95	1/96	6/96	1/97	6/97	11/97
Objective A. Investigate feasibility of harvesting brushlands for biomass production	********	********	********			

Timeline for Completion of Objectives (Continued)

	7/95	1/96	6/96	1/97	6/97	11/97
Objective B. Assess brushlands as wildlife habitat	********	********	********	********		
Objective C. Develop educational information and planning/management approaches for brushland ecosystems	********	********	********			

V. Objectives/Outcome:

A. Title of Objective: Investigate Biomass Availability, Nutrient Relationships, and Harvesting Technology

A.1. Activity: Investigate Biomass Availability

A.1.a. Context within the project: Results of this activity will provide estimates of total standing biomass for use in the evaluation of the feasibility of harvesting brushlands for commercial energy production. Also, biomass measurements will be used to ground-truth remote-sensing data. On-the-ground measurements of total standing biomass and variation in biomass will be evaluated against satellite image data to determine the feasibility of estimating biomass using satellite imaging. Statistical analysis of the relationship between remotely sensed data and ground measurements will be done and prediction equations developed. Assuming that a relationship exists between ground and satellite data, results of this work would allow estimation of biomass abundance and density over a larger geographic area.

A.1.b. Methods: A total of forty-five sites will be chosen to determine brush density and occurrence. These sites will be located in the same landscapes used to determine relationships between sharp-tailed grouse occurrence and landscape features (see **B.1**) to maximize the linkage between biomass data and habitat assessments. Sites selected for biomass measurements will be located within landscapes containing known, active dancing grounds; within landscapes that previously contained dancing grounds but have been vacant in recent years; and in brushland landscapes randomly located on satellite images (see **B.1**. and **B.2**. below). Sampling will emphasize mature or senescent stands to enhance understanding of variation in biomass among stands that have the highest potential for commercial brush harvesting. However, we also will include some young and intermediate-aged stands in the sampling to develop understanding of the pattern of increase in brush biomass with stand age.

Sites will be located in three brushland areas; glacial lake Upham (Toivola-Meadowlands area), glacial lake Aitkin (Aitkin, Carlton counties) and glacial lake Agassiz (Marshall, Pennington counties). Sampling will be done by measurement of the diameter of all stems at a height six inches aboveground. Equations to estimate biomass will be developed for ten of the dominant species on the site and checked against published equations. The genus and species of all shrubs on the site will be recorded. Plots to be sampled will be chosen by laying out cruise courses prior to measurement. Depending on uniformity of these stands, sampling may be stratified by density as identified on the aerial photographs. This will provide more accurate estimates of total stand biomass.

A.1.c. Materials: Materials for this project include field sampling equipment and aerial photography. Equipment for preparation, drying and weighing of samples for development of biomass estimation equations exists at the Natural Resources Research Institute (NRRI) and will be used in this project. Data management and statistical analysis will be done using computers and existing software at NRRI.

A.1.d. Budget: $26,000
Balance: $0

A.1.e. Timeline:	7/95	1/96	7/96	1/97	6/97
Selection of Sites:	***************				
Field Measurement:	**********************************				
Data Analysis:				********************	

The deliverables for this and other activities have been discussed with DNR personnel. These will consist of semiannual progress/technical reports submitted to DNR; the timing of delivery of these reports will coincide with semiannual reports to LCMR. The technical reports will be more detailed, including data summaries (graphical, tabular, maps), results of statistical analyses, and tentative conclusions. For this activity, the report in 1/96 will include description of procedures and results of sites selected for biomass harvesting; in 7/96, preliminary results of field measurements; in 1/97, final analyses of field measurements and initial analyses; final report to include data, full results of analyses, and conclusions.

A.1.f. Workprogram Update:
As pointed out in the previous report, it was not possible to sample 45 sites because of the spatial heterogeneity of brush distribution at each site and the extremely high stem densities. Thus, each site had to be sampled more intensively than we had intended, and sampling was more labor intensive. We sampled intensively at 16 sites in the three major study areas noted in the original workplan.

We measured stem diameters and densities at these sites, and calculated site-level aboveground biomass using published equations relating stem diameter to biomass. We estimated that fully stocked portions of brushland stands contain between about 4 and 32 dry tons per acre of above ground biomass. A range of about 10 to over 60% of stands is stocked with brush, resulting in an overall biomass of less than 1 to over 18 dry tons per acre. The average biomass increment for a range of brush sites is 1.47 tons/acre/year. These data emphasize the importance of determining both the biomass/acre for fully stocked plots, and the aerial extent of these fully stocked areas, to develop a reliable estimate of biomass available for harvest at each specific site. The methods we developed should provide appropriate tools for doing so.

A.2. Activity: Determine Nutrient Status of Representative Sites and Estimate Nutrients Removed through Harvest

A.2.a. Context within the project: A potential negative impact associated with harvesting of brushlands is the removal of nutrients through brush harvest and the potential to reduce long-term productivity of the site. In response to reviewer's comments, we have chosen to include a research task to address this issue. The purpose of this research is to sample soils and vegetation to estimate the nutrient capital in each component and determine the impact that brushland harvesting may have on nutrient levels and site productivity. Data generated from this task will be integrated with biomass, age and species data from task A.1 to estimate nutrient removals on a per-acre basis and variation in nutrient levels with age and species composition.

A.2.b. Methods: Soil and vegetation sampling and nutrient analyses will follow standard procedures. We propose to select six representative sites for sampling from the forty-five sites sampled for biomass determination (Activity A.1). These sites will be chosen to encompass the range of site conditions found supporting shrubland vegetation in our studies. Criteria for site selection will be based on dominant soil texture, soil parent material and uniformity of vegetative cover. Soil texture is used to select sites because it is closely associated with other important site properties such as organic matter content, nitrogen content and drainage. Once sites are selected, samples of the dominant soil type on each site will be done at five sampling locations at two depths (0-18, 19-36 inches) on each site. Soil samples will be collected at five subplot locations at the two depths and the five samples of each depth pooled to produce one bulk soil sample for each depth at the five locations at each site. Using this sampling scheme, the effects of microsite variation in soils will be minimized. Because shrubland vegetation is relatively shallow rooting, we expect that most of the soil nutrients available to the vegetation will be found in the surface soil layers.

Soil nutrients to be analyzed include total nitrogen, nitrate-nitrogen, ammonium-nitrogen and a suite of secondary and minor elements as measured by the ICP analyzer at the Soils Analytical Laboratory on the UM-St. Paul campus. Vegetation samples will be collected at each of the five sampling locations. Three samples of the two dominant shrub species (as measured by plot basal area) at each sampling location will be collected. All vegetation samples will be analyzed for the same complement of nutrients mentioned above. Of particular interest are rates of nitrogen and calcium removal in vegetation compared to the total site nutrient capital for those elements. In addition to soil and vegetation analyses, we will use equations to predict nutrient inputs through precipitation and dryfall based on MPCA monitoring data published by Dr. Dave Grigal (UM-Soil Science). From these data, we will calculate a nutrient budget for each site that includes estimates of soil nutrient mineralization rates, total soil nutrient pool sizes, biomass nutrient content, and atmospheric inputs. These data and calculations will be used to estimate a minimum recommended harvest interval.

A.2.c. Materials: Materials for this project include field sampling equipment and soil augers. This equipment is currently owned by NRRI and will be used in this project. Equipment for sample preparation (soil sieves, Wiley mills) and drying of samples for chemical analysis exists at NRRI and will be used in this project.

A.2.d. Budget: $29,500
Balance: $0

A.2.e. Timeline:

	7/95	1/96	7/96	1/97	6/97
Initial Sampling:	******************				
Soils/Vegetation Sampling:	**				
Laboratory Analysis:				********	
Data Analysis/Preparation of Report:				***************	

The deliverables for this and other activities have been discussed with DNR personnel. These will consist of semiannual progress/technical reports submitted to DNR; the timing of delivery of these reports will coincide with semiannual reports to LCMR. The technical reports will be more detailed, including data summaries (graphical, tabular, maps), results of statistical analyses, and tentative conclusions. For this activity, the report in 1/96 will include description of procedures and results of sampling that establishes the basis for final selection of sites for nutrient sampling, and of progress on vegetation and soil sampling; in

7/96 and 1/97, updates on the progress of those analyses; final report to include data, full results of analyses on nutrient patterns, and conclusions.

A.2.f. Workprogram Update:

Soil samples were collected during fall and brush biomass samples during winter. Samples were prepared using standard methods, and nutrient analyses were completed during spring 1997. We used this information to assess nutrient removals from a site through biomass harvest, relative to site-level nutrient pools. We assumed a rotation age of 10 years, and an average biomass increment of 1.47 tons/acre/year (determined from our field measurements), thus a biomass removal of 14.7 tons/acre at harvest. Atmospheric inputs were estimated using published equations. Total soil nutrient pool weights were calculated using the measured soil density and the concentration data for each element measured in the laboratory. Estimated nutrient removals varied substantially among sites. Nutrient-budget calculations indicated that removal exceeded input for all elements measured, with the deficits being greatest for nitrogen and calcium. However, when harvest removals are compared to the total pool size, potassium shows the highest removal rate at 1.26% of the available pool over a 10-year period. Thus, it seems unlikely that nutrients would be removed at a rate sufficient to alter soil fertility substantially. However, a conservative approach would be to replacement nutrients through fertilization every two rotations or twenty years.

A.3. Activity: Summary Evaluation of Current Harvesting Technology

A.3.a. Context within the project: Based on input of the review team, we have significantly reduced the scope of work related to any aspects of the economics of brush harvesting. In this activity, we will conduct a limited review of published literature on harvesting technology that may be applicable to future large-scale commercial harvesting of brush from lowland brush areas. Equipment availability or design constraints on appropriate harvesting equipment represent potential limitations on applying the overall approach being addressed in this project. The results of this activity will represent an initial step in understanding the features and availability of equipment needed to harvest brush. It is not feasible or desirable in this project to design or develop machinery for harvesting brush. We will obtain estimates of equipment acquisition and operating costs where these are readily available, as well as estimates of transportation costs and potential markets for brush biomass, to the extent that these figures are readily obtained. We agree with peer reviewer comments that it is beyond the scope of this project to conduct a full analysis of costs or the economic feasibility of harvesting lowland brush. Although this activity will be restricted to a literature review, it will provide a starting point to begin analysis of the economic feasibility in the event that results of our initial project warrant continued interest in commercial use of biomass from brushlands.

A.3.b. Methods: The purpose of this task is to evaluate equipment previously developed for harvesting of small-diameter woody biomass in the United States, Sweden and Finland. This equipment has been developed for harvesting of willows and poplars grown on short rotations in plantations. Publications by the US Forest Service, the US Department of Energy-Biomass Feedstock Development Program, the International Energy Agency and the Tennessee Valley Authority as well as journal articles and University technical publications will be the main source of information for this review. This information will be interpreted in light of suitability and limitations for use in shrubland harvesting.

We will evaluate machinery with respect to a variety of features, including 1) ground pressure, as it relates to harvesting on frozen ground in lowland habitats; 2) swath- vs. row harvesters (in relation to differences between plantation rows and natural brushlands); 3) capabilities of the machinery with respect to the maximum diameter of stock that may be harvested; this evaluation will be in the context of the diameter distribution of brush measured in activity A.1; 4) handling and collecting systems (what form of material can the machine accept, what does it produce, and how does it collect it [baggged chips, bundled stems, etc.])? We will evaluate as many machines as possible with respect to these properties, to develop an understanding both of availability of existing machinery and of the general requirements for machinery to harvest lowland brush on a large scale.

A.3.c. Materials: Materials used for this activity are publications available through the NRRI library staff and through Minitex requests. Also, contacts will be made with colleagues in the Department of Energy at Oak Ridge, Tennessee to obtain unpublished information gathered from visits to research sites worldwide. This activity will use computer equipment and software existing at the NRRI to perform literature searches and requests.

A.3.d. Budget: $3,000
Balance: $0

A.3.e. Timeline:

	7/95	1/96	7/96	1/97	6/97
Information Gathering:			****************		
Preparation of Final Report:				*****************	

The deliverables for this and other activities have been discussed with DNR personnel. These will consist of semiannual progress/technical reports submitted to DNR; the timing of delivery of these reports will coincide with semiannual reports to LCMR. The technical reports will be more detailed, including data summaries (graphical, tabular, maps), results of statistical analyses (where applicable), and tentative conclusions. No product will be delivered on this activity until 1/97, when preliminary summary of information sources and assessment of harvesting equipment will be presented in outline form. The final report will include the full results of this literature review, along with recommendations about the requirements for efficient and effective brush harvesting equipment and conclusions about the availability of this equipment.

A.3.f. Workprogram Update:

Although we gathered information on available harvesting and brush-cutting equipment, we found this information of limited utility in evaluating equipment needs for brush harvesting in the settings envisioned in this project. For example, some currently available equipment is designed to harvest plantation willow, which is planted in straight rows and requires row-type harvesters. Other equipment is available for harvesting wild-growing mesquite, but is likely to heavy for use on saturated, frozen soils that would be traversed during winter harvest of lowland brush in northern Minnesota. Equipment available for cutting brush in wide swaths does not include components for harvesting chips or brush, but instead scatters material on the site. Thus, we found little merit in evaluating harvesting equipment currently available in North America, and as a result deviated somewhat from the stated workplan in completing this objective.

We evaluated a theoretical harvesting system designed by equipment engineers familiar with logging equipment design and manufacture. The technology and assumptions of equipment operating costs rely on components of prototype equipment which have been tested on a limited scale. This system would include a harvester that cuts woody stems near the ground using a rotating horizontal "drill" type felling head, coupled with a mobile chipper. Chips are forwarded from the chipper to a landing site using a tipping box pulled by a tracked low-ground-pressure vehicle. The chipped biomass would then be loaded into chip vans and transported to an energy facility. Our experience with demonstration harvests during winter 1996-97 suggests that mobility on frozen soil on lowland brush sites is much more feasible than we had thought initially, even with relatively deep snow.

We used estimates of biomass availability from our field studies, and engineering estimates of the travel speed of the harvester (1 mph harvesting in stocked areas, 5 mph moving from one stocked brush area to another). These estimates indicate that this machine (with an 8 foot wide swath) could harvest 3.5 acres per hour or 24.7 dry tons/hour. We estimated hourly operating costs (including equipment rental, operator wages and benefits, and fuel), loading costs, and transportation costs. The latter were based on estimates of brush availability over large areas of northern Minnesota and the energy needs of a relatively small electrical power generation facility. Combining all costs, total estimated delivered cost of brush biomass is about $16 per ovendry ton, which is relatively low compared to other biomass energy options. These analyses suggest that brushland harvesting in Minnesota may be a potentially attractive alternative energy source that warrants more detailed exploration.

B. Title of Objective: Assess brushlands as wildlife habitat

B.1 Activity: Analysis of sharp-tailed grouse population data and assessment of site- and landscape-level characteristics that affect abundance and distribution of sharp-tailed grouse using Geographic Information Systems (GIS) and related analyses.

B.1.a. Context within the project: Sharp-tailed grouse and a variety of other wildlife species associated with open grass-brush habitats have been declining in the state. However, detailed information and understanding of habitat relationships of sharp-tailed grouse in Minnesota is lacking. Maintenance and enhancement of habitat quality for sharp-tailed grouse must be considered as a major component of plans for integrated management of lowland and upland brush landscapes. This activity will contribute enhanced understanding of habitat and landscape-level factors affecting sharp-tailed grouse, for use in brushland management planning efforts.

B.1.b. Methods: Sharp-tailed grouse have been surveyed on their traditional spring dancing grounds since the mid 1970s by wildlife biologists with the DNR. Although the data are summarized annually, they have not been intensively or extensively analyzed. We will work closely with DNR biologists to synthesize these data so that they can be used as part of the basis for analyzing factors affecting distribution and abundance of sharp-tailed grouse.

These censuses include roughly 200 dancing grounds in the east-central sharptail range, and at least this number in the northwest range; we will emphasize the east-central range in our analyses because of the complex habitat mosaic there (extensive lowland brush complexes intermixed with upland habitats, compared to the arguably more simple, vast lowlands in the northwest). We will include in our analysis sites from the northwest range to the extent possible. The dancing grounds include three groups: 1) sites that have been occupied by grouse consistently every year since counts began; 2) sites that previously contained grouse but have been vacant in recent years (i.e., no birds observed on the site during spring surveys in several consecutive years); and 3) intermittent "satellite" dancing grounds that contain birds in some but not all spring breeding seasons. This classification is based on differences in consistency and duration of grouse presence; in addition, within these categories there are differences in grouse abundance. In the analyses described below, we will seek to develop an understanding of habitat and landscape features associated with differences in both the presence and abundance of grouse at dancing grounds.

Landscape-level features will be determined for as many as possible of these three types of sites and for randomly selected points in lowland brush complexes that do not contain known dancing grounds; a sufficient number of randomly selected points will be used to allow statistical comparison of features of these different categories of sites. During the course of our other field work, brush and grass cover will be determined for a subset of the points included in each dancing-ground category, as well as for a subset of the randomly located points used in this analysis. Relationships of sharp-tailed grouse presence and abundance will be analyzed with respect to relevant landscape-scale features. These analyses will be conducted at a variety of spatial scales up to 3 km (see next paragraph) away from the dancing-ground or sample-point center to quantify the spatial scale(s) most relevant to sharp-tailed grouse habitat use; it is likely that the relevant spatial scale may vary among landscape and habitat features. Habitat and landscape-level features to be analyzed will include the following: 1) proportion of area in different cover classes (open grass, lowland brush, etc.; see next paragraph); 2) indices of fragmentation of open grass cover types, reflecting presence of a continuous expanse of open habitat; 3) analysis of adjacency (spatial association of) cover classes; 4) distance to nearest other known dancing ground; 5) cover conditions at the dancing-ground (or randomly located point) center. Staff at the GIS Laboratory at NRRI, to be hired on this project, will contribute to these analyses; these individuals have had extensive experience with a variety of GIS applications on other ecological and natural resources-related projects.

Landscape-level analyses will be based on data obtained from Landsat thematic mapper (TM) images. All land within a 3.0 km radius of each known dancing-ground center and each randomly selected point will be classified to provide a cover classification of the landscape surrounding the dancing ground. Land cover will be classified following established procedures of digital image analysis. Preliminary cover classes will include 1) open grass; 2) lowland brush (if feasible, classified by species); 3) upland brush; 4) conifer forest; 5) regenerating deciduous forest; and 6) deciduous forest. Experienced staff at the GIS Laboratory at NRRI, to be hired on this project, will complete these classifications; staff have had extensive experience with imagery classification on other ongoing projects. Classification will be done using ERDAS GIS and image classification software. Land-cover classifications will be verified by random ground truthing and by consultation with DNR wildlife biologists familiar with known dancing grounds. As indicated above (**A.1**), we will assess relationships between classified images and on-ground measurement of biomass. It will be necessary to manually re-classify some cover types on dancing grounds that have been managed by burning (or by shearing followed by burning) or tree planting since the satellite images were produced. This re-classification will be done in consultation with DNR biologists familiar with the management history of these sites.

Information from these analyses will enhance our understanding of landscape features of habitat mosaics used successfully by sharp-tailed grouse, relative to sites not used by this species and to sites previously used but currently vacant. These analyses will provide a basis for identifying other sites in lowland brush complexes that contain appropriate landscape configurations to support sharp-tailed grouse. These other sites may include 1) some that contain grouse but have not been identified in previous surveys and 2) areas that should receive priority for management to enhance habitat quality for sharp-tailed grouse.

B.1.c. Materials: It will be necessary to purchase one scene of Landsat imagery (Path 27 Row 27) for use in the analyses (estimated cost $4,500), and a portable global positioning system (GPS) unit (estimated cost $1,200) for use in the field. All necessary equipment for the landscape classification and GIS analyses is present at the NRRI. Other materials to be purchased are limited to those needed to complement the GIS analyses and basic field supplies (such as field maps and data forms). Imagery and GPS unit will remain in the inventory of the University of Minnesota, Duluth, Department of Biology and/or NRRI for use in future projects.

B.1.d. Budget: $25,000
Balance: $0

B.1. e. Timeline:	7/95	1/96	6/96	1/97	6/97	11/97
Classify Landsat imagery	**************					
Digitize dancing ground locations into an ARC/INFO GIS coverage	***************					
Analyze relationships between sharptails and landscape/habitat variables			*************************			

The deliverables for this and other activities have been discussed with DNR personnel. These will consist of semiannual progress/technical reports submitted to DNR; the timing of delivery of these reports will coincide with semiannual reports to LCMR. The technical reports will be more detailed, including data summaries (graphical, tabular, maps), results of statistical analyses, and tentative conclusions. For this activity, the report in 1/96 will include preliminary results of image classification and digitizing dancing ground locations into GIS coverage, and of supporting field measurements; in 6/96, an updated progress report on those activities; in 1/97, results of preliminary analyses of landscape patterns and relationships to sharptailed grouse and songbird distributions; in 6/97, refined analysis on relationships between landscape data and sharptailed grouse distribution, and with respect to songbird distribution based on data from spring and summer 1996; in 11/97, final analysis of landscape patterns including avian distribution data from both years of monitoring; final report to include conclusions about landscape and habitat patterns, data transfer.

B.1.f. Workprogram Update:

As a basis for a substantial part of the work on this objective, we tabulated and analyzed sharptail dancing ground census data obtained from DNR Wildlife Research. These analyses quantify the dramatic decline in sharptails in Minnesota during the past several decades, and point to habitat changes on and around localized dancing grounds as a major factor in those declines. Evidence for these patterns includes consistent disappearance of birds from dancing grounds; finite rates of change in numbers of birds indicating declines in 14 of 15 census routes; years of population decrease not being offset by increases in other years; most dancing grounds surveyed showing fewer birds in final years of census than in the first year of census. The results of these analyses also were used to categorize dancing grounds as previously active but defunct, or as currently active; there was enough detail in the data that it was possible to subdivide the latter category into "active-small" and "active-large" subcategories for some analyses.

We completed an extensive series of analyses of satellite imagery to understand the possible differences in landscape configuration among active and defunct dancing grounds, and between dancing grounds and random points in brushland landscapes. We identified and classified 42 cover types on the imagery, and calculated the landscape composition within different buffer distances (200 m, 500 m, 1000 m, and 3000 m radii) around dancing ground centers and random points. Locality information was entered onto topographic maps of each area area, and subsequently digitized on a base map for use in landscape analyses. Aerial photos of portions of the study areas were obtained and scanned into the computer databases. Cover types on two Landsat TM foot prints were classified; forest types were classified using signatures developed for other projects. Brush complexes were classified with the aid of winter imagery to stratify brush from mature forest and grasses. Brush types were classified into willow, alder, and miscellaneous, both for upland and lowland subdivisions. Landscape analyses were conducted on 53 defunct sites, 58 active sites, and 100 randomly located points in brushland complexes. Dancing ground centers were digitized into a GIS system.

Most of the statistically significant differences among active dancing grounds, defunct dancing grounds, and random points reflected differences between dancing grounds (both categories) and random points. These results indicate that sharptailed grouse dancing grounds do not occur randomly on the landscape but instead are found in areas with particular configurations of vegetative composition. These differences were recognizable at all four buffer widths, and reflect a variety of measures of lower frequency of various tree cover types (both coniferous and deciduous) and brush types (both upland and lowland), and greater coverage of lowland native grass, ericaceous brush, and stagnant acid bog conifer on dancing ground areas compared to random points. The results of these analyses should prove useful in prioritizing areas that should be managed for sharptails, including targeting areas on which intensive brush removal might produce maximal habitat benefits.

In addition, these analyses indicated features that distinguish active from defunct dancing grounds. There were no statistically significant differences in landscape composition between active and defunct dancing grounds for the 200 m buffer, although trends were apparent in several variables that did differ significantly between active and defunct grounds at larger buffers. Differences were most pronounced at 500 and 1000 m buffers. They included greater cover by native grass and lower coverage by some brush and tree types on active, compared with defunct dancing grounds. Nearly all features that distinguish active from defunct dancing grounds also differ between active dancing grounds and random points. This pattern is consistent with the view that defunct dancing grounds have succeeded towards the condition characteristic of the overall landscape. Many of the variables involved are known to change in the absence of disturbance such as fire, in the direction reflected by the difference between active, defunct and random points.

Landscapes around active dancing grounds have fewer cover types and lower cover-type diversity indices, suggesting that they are less fragmented than landscapes surrounding defunct dancing grounds. Many of the differences between active and defunct dancing grounds, or between dancing grounds and random points, involve extremely small percentage differences in coverage by vegetative types, suggesting that sharptails are sensitive to or are affected by subtle changes or differences in the landscape. Nearly all of the differences between these site categories involve vegetative features varying in ways that are fully consistent with our understanding of habitat needs of sharptailed grouse. This information should prove useful in managing brushland landscapes for sharptails and other wildlife, including helping to understand the spatial scale over which effective management must occur. Furthermore, the presence of highly significant differences involving aspen/birch and other "wooded" cover types (deciduous and coniferous) and upland brush indicates that focusing management efforts solely on removing lowland brush probably will not reverse the changes or differences between active and defunct dancing ground landscapes.

During these analyses, the need became apparent to develop an additional approach to analyzing habitat that would allow characterization of vegetation height-distance relationships perceived by sharptailed grouse on the dancing ground to further discriminate differences among defunct, active small, and active large dancing grounds. Photographic scans were made of vegetation on the horizon of dancing grounds in the east-central and northwest sharptail ranges. Vegetation height and degree of conifer plantation development were analyzed. For the east-central range, these analyses demonstrated that active large dancing grounds have much lower vegetation on the horizon (implying lower vegetation or greater distance to vegetation) than either active small or defunct dancing grounds. The active large dancing grounds also had much less conifer development than the other grounds. These results emphasize the association of sharptailed grouse with open landscapes and/or with low vegetation, and are fullly consistent with the landscape-scale analyses. In the northwest, these differences did not occur. However, all dancing ground categories in the northwest have vegetation height-distance profiles typical of active large dancing grounds in the east-central range. Thus, in the northwest, it seems that changes in landscape composition, irrespective of vegetation height, may be more important in explaining sharptail declines.

B.2. Activity: Analyze avian abundance in lowland brush habitats.

B.2.a. Context within the project: A number of bird species in Minnesota depend entirely or in part on the openlands habitats that are an essential component of sharp-tailed grouse habitat. There is concern about the conservation status of some of these bird species in the midwestern U.S. Thus, habitat management programs that enhance habitat quality for sharp-tailed grouse probably also benefit these other species. Brushlands have not been studied as extensively as other major habitat types in the state, and our understanding of brushland fauna is very poor. Better inventory of avian populations and communities occurring 1) on sharp-tailed grouse dancing areas and 2) on brushlands that are not occupied by sharptails is needed to understand the effects of habitat management on brushland birds.

B.2.b. Methods: Birds will be inventoried during spring and early summer 1996 and 1997. Study sites will include a subset of the sites used in landscape-level analyses discussed above, to include active dancing grounds, defunct dancing grounds, and randomly selected points; the active dancing ground roughly represent "managed" brushlands, the latter two categories correspond approximately with "unmanaged" brushlands. Sites will be selected using a modified random approach, with consideration given to ease of access to facilitate maximum efficiency in field sampling. Replicate study sites in each habitat category will be located in each of two major study regions (Cromwell area; Meadowlands area). One sampling point will be located in each site. Trained observers will conduct one bird count (10 minutes duration) at each point during the breeding season between 0.5 h before and 4 h after sunrise. All birds heard or seen from the center point will be recorded in a circle with estimates of their distance from the center point, using a protocol of unlimited distance counts. Weather data (cloud cover, temperature, and wind speed) and the time of the count will be recorded at each point. Habitat data will be collected at the center of each sample point, including percentage grass cover, percentage deciduous shrub cover, average shrub height, dominant shrub species, distances to nearest forest stand, presence of tall, individual trees within 1 km. Either at the same time that songbirds are being counted or earlier in the spring, presence of dancing sharp-tailed grouse will be assessed by playing sounds of dancing male grouse over a loudspeaker; the observer will listen for responses during a 10-minute period. This approach has been used successfully for assessing presence of grouse in other studies in the midwest. Members of the Minnesota Sharp-tailed Grouse Society will assist in these field studies on a volunteer basis.

Data will be analyzed to characterize 1) songbird communities associated with brushlands where sharp-tailed grouse are present, compared to areas where they are absent, 2) relationships between songbird abundance or community composition and the same landscape-level features addressed with respect to sharp-tailed grouse, and 3) habitat-level features associated with presence of grouse and openlands songbird species.

B.2.c. Materials: Materials and equipment to be purchased for implementing this activity include binoculars, data forms, field maps, permanent markers for sampling points, and a broadcast playback unit (estimated cost $1,500).

B.2.d. Budget: $68,000
Balance: $0

B.2.e. Timeline:	7/95	1/96	6/96	1/97	6/97	11/97
Identify and mark sampling points	*************					
Inventories and habitat characterization		********		*******		
Data entry and annual summary			********	*******		
Final analysis and summary				*************		

The deliverables for this and other activities have been discussed with DNR personnel. These will consist of semiannual progress/technical reports submitted to DNR; the timing of delivery of these reports will coincide with semiannual reports to LCMR. The technical reports will be more detailed, including data summaries (graphical, tabular, maps), results of statistical analyses, and tentative conclusions. For this activity, the report in 1/96 will include discussion of selection of sampling points and supporting field studies; no additional deliverable will be incorporated into the 6/96 report because it will not be possible to analyses results of spring bird surveys before that date; report in 1/97 will include results and preliminary analyses for spring/summer 1996 field season, including results of bird surveys and characterization of vegetation at sampling points; the 6/97 report will not report any new data but will discuss progress and additional analyses; the final report in 11/97 will include full analysis characterizing songbird communities and sharptailed grouse abundance in different brushland habitats, data transfer.

B.2.f. Workprogram Update:

Our work under this objective was modified to focus on songbirds, without a significant component of surveying sharptailed grouse. Grouse surveys were continued by DNR wildlife biologists during the course of this project; our efforts to survey them as well would have duplicated that work, and entailed extensive field work at an additional time of year (grouse best surveyed on the dancing grounds during late March - mid May; songbirds May and June). During 1996, we surveyed songbirds on active and defunct grouse dancing grounds and on managed and unmanaged brushlands. We observed little difference in bird communities on active and defunct dancing grounds. Those results confirmed the view that broader-scale, landscape properties have been more influential in determining changes in dancing-ground habitat quality than changes in vegetation on the dancing grounds themselves. Songbird communities on dancing grounds were composed primarily of species associated with open-field and agricultural habitats. We observed some differences in bird communities on managed and unmanaged brush, including some species such as golden-winged warbler and gray catbird that may be affected negatively by brush harvesting.

In 1997, our songbird surveys focused more specifically on brushland sites with different management histories, to better understand the possible responses of songbirds to changes similar to those that would occur following brush harvesting. We compared songbird communities on unmanaged sites with those on sites that had been managed by mechanical treatment of brush, both with and without subsequent burning, and with different durations since management. Unmanaged sites had more songbird species and more individuals than managed sites, with abundance of 12 of 20 individual species differing between groups. Bird species composition was relatively insensitive to management type (shearing only compared to shearing plus burning) and time since management. We used classified satellite imagery (describe above for sharptailed grouse habitat analyses) to understand landscape relationships of songbirds on managed and unmanaged sites. Unmanaged sites were surrounded by more forest (both upland and lowland), whereas managed sites were in landscapes dominated by brush and bog forests. This difference undoubtedly was a component in the observation that bird species associated with more open areas were more abundant on managed sites, and species that require shrubs were more abundant on unmanaged sites. Thus, the effect of large-scale brush management or removal on songbirds will depend in part on the surrounding landscape.

As brush management proceeds, perhaps including initiation of large-scale commercial brush harvesting, efforts should be made to create and maintain large patches of open area but leave large areas of brush habitat required by brush-dependent species. Further information is needed on the relationship between habitat size requirements and configuration for individual bird species, similar to the results we described above for sharptailed grouse.

B.3. Activity: Identification of new sharp-tailed grouse dancing grounds

B.3.a. Context within the project: DNR biologists know the locations of a large number of sharp-tailed grouse dancing grounds in the state. It is likely that additional, previously unidentified, sites exist. Knowledge of additional sites, their locations relative to known dancing grounds, and their possible need for habitat management will contribute to effective management of sharp-tailed grouse and brushland habitats.

B.3.b. Methods: Landscape classification studies and GIS analyses (conducted during the first year of the project) are intended to refine understanding of landscape characteristics of sharp-tailed grouse dancing grounds. This information, along with ground surveys and consultation with DNR wildlife biologists, will be used to identify sites in lowland brush complexes 1) that have landscape compositions and configurations similar to those of known dancing grounds but that 2) are not currently mapped as known dancing grounds. In conjunction with other field studies conducted during spring and early summer 1997, sounds of dancing male sharp-tailed grouse will be broadcast from points near sites that are candidates for "new" dancing grounds. An observer will listen for responses by sharp-tailed grouse for a 15-20 minute period following each playback. An on-site visit will be made to any previously unknown dancing grounds to assess habitat condition and possible need for brush management. If characterization of landscape features is sufficiently advanced during winter 1995-1996, these methods also will be employed during the spring/early summer 1996 field season. Members of the Minnesota Sharp-tailed Grouse Society will assist in these field studies on a volunteer basis.

B.3.c. Materials: To allow efficient use of field time, an additional broadcast unit (estimated cost $1,500) and tapes will be purchased for this activity.

B.3.d. Budget: $10,000
Balance: $0

B.3.e. Timeline:	7/95	1/96	6/96	1/97	6/97
Map identification of candidate sites		******************			
Field surveys of grouse presence	*******		*******		
Habitat assessment of new sites		*******		*******	

The deliverables for this and other activities have been discussed with DNR personnel. These will consist of semiannual progress/technical reports submitted to DNR; the timing of delivery of these reports will coincide with semiannual reports to LCMR. The technical reports will be more detailed, including data summaries (graphical, tabular, maps), results of statistical analyses, and tentative conclusions. Because this activity builds on results of B.1, the 1/96 report will focus only on discussion of progress in landscape classification as it relates to determining criteria for selecting potential, previously unmapped dancing grounds; the 6/96 will include summary reports of spring 96 field studies aimed at locating new dancing grounds; the 1/97 report will include expanded description of results of spring 96 studies and further progress on selecting additional sites; the 6/97 and final (11/97) will include preliminary and final description of landscape criteria, their application in locating new dancing grounds, and maps of dancing ground locations; data transfer.

B.3.f. Workprogram Update:

Efforts to identify sharp-tailed grouse dancing grounds that are not currently mapped were unsuccessful. It had been the intent to use playbacks of sounds of dancing male sharptails to elicit audible responses from birds on unknown grounds. Although the playbacks produce the desired response (vocalization, increased activity) in birds on known dancing grounds, it has proved infeasible to use this approach for locating new grounds.

We pursued a different alternative to learning the locations of dancing grounds that may not be known to DNR biologists and area managers. A press release, explaining the objectives of the project and requesting information on dancing ground sites was mailed to about 40 local newspapers in northern Minnesota, including both the east-central and northwest sharptail ranges. This release generated only three (3) responses. Two of these were rambling discourses on predator control and the state's shortcomings in habitat management. One contained reasonably detailed information on a dancing ground locality, ut based on 10-year-old observations. We conclude that the only reasonable way to identify more dancing ground localities is through direct observation by biologists and others who are in the field during the spring dancing season conducting grouse surveys or other work. However, it is likely that there are not large numbers of unknown dancing grounds in the state.

C. Title of Objective: Develop educational information and planning/management approaches

C.1. Activity: Design and execution of demonstration programs for habitat enhancement via biomass harvesting.

C.1.a. Context within the project: In this activity, we will build on the information and approaches developed in addressing objectives A and B to accomplish focused management on several parcels of land in brushland complexes. The intent of this activity is to 1) apply the knowledge and principles developed through other aspects of this study, 2) demonstrate on a limited scale the feasibility of harvesting brush for biomass, 3) develop models for enlisting landowner cooperation, 4) create demonstration projects for educational activities on brushland management, and 5) create study sites, to be used in conjunction with other study areas to be identified in this activity, for future investigation of some possible ecological effects of brush removal.

C.1.b. Methods: We will identify several parcels of brushland in the east-central sharptail range for which management via treatment of brush would be expected to produce especially major benefits for habitat improvement. Selection of these areas will be based largely on principles and results developed from the landscape- and habitat-level analyses conducted in fulfilling Objective B. Specifically, we will seek to locate areas in brushland complexes that have the landscape configuration characteristic of persistent dancing grounds, but in need of brush treatment to achieve appropriate habitat composition. This selection will be refined through consultation with DNR wildlife biologists. Management of these parcels would be accomplished through experimental brush harvesting. We will attempt to select sites where treatment of relatively limited areas of brush (likely 5-15 acre parcels) would complete the appropriate configuration and habitat composition to enhance habitat quality for sharp-tailed grouse. Depending on the acreage of brush that needs to be removed from each site, we would attempt to create 3-5 demonstration projects in different portions of the east-central range of sharp-tailed grouse. Depending on availability, we will select at least one site in a complex of mixed land ownership (private/state, or private/county/state) to gain experience and produce a further case study in soliciting landowner cooperation in planning integrated resource management of brushland landscapes.

In consultation with DNR wildlife biologists, we will identify other brushland sites in nearby brushland complexes 1) from which brush will not be harvested and 2) that have been managed recently by prescribed burning. The unharvested areas are intended to serve as control sites for use in future studies of ecological effects of brush removal, and the burned areas for use in future studies comparing ecological effects of brush removal and prescribed burning. As noted in section VII (below), many important biological responses to brush harvesting may not be detectable within a short time of this habitat manipulation. Thus, it is not possible in this project to monitor the ecological effects of brush harvesting using studies on these identified sites. It is not our intent to study ecological patterns on these sites in detail, except to document comparability of the sites to the extent possible. Instead, these sites are being identified in the present study solely for the purpose of formalizing the selection of suitable sites for comparative research to be conducted in future projects, should the results of the current project indicate that further study of brushland harvesting is warranted.

Several factors will be considered in selecting the unharvested control and the burned study sites. To the extent possible, sites will be selected that are in reasonable proximity and of similar acreage to the harvested sites. We will choose unharvested control sites that have comparable brush biomass and species composition to the sites identified for demonstration harvesting, and for which management is not envisioned in the near future. We will consult with DNR wildlife biologists to select sites recently managed by prescribed burning that had pre-burning brush configuration similar to the demonstration sites; such information, at least qualitative, is available. To the extent possible, all of these sites will be in similar landscape contexts, but it is not known at present how well we will be able to match sites in this respect. When appropriate, sites selected for this purpose will be among those on which we measured biomass availability and characterized avian communities. For each of the 3-5 demonstration harvest plots, we will select at least one (two if possible) each unharvested control and burned sites.

Brush removal will be conducted in close cooperation with DNR area wildlife managers with extensive experience with brushland management. Brush will be cut using a combination of 1) STS (Sentence to Serve) crews under the direction of experienced crew leaders, who will hand-cut brush for subsequent mechanical removal and 2) mechanical shearing (estimated cost $60/acre) with subsequent removal by mechanical means with STS assistance (e. g., loading). Brush will be removed from the site or to the perimeter of the site for burning. The actual approaches used for brush cutting and removal will be selected on the basis of site size and configuration and snow/frost conditions when brush is to be removed.

Season of harvesting undoubtedly has major effects on the subsequent regeneration responses of shrubs, as well as on other ecological factors such as nutrients. It is beyond the scope of this project to examine effects of harvesting at different seasons. Furthermore, the potential commercial harvesting of brush being addressed in this project would occur mostly or entirely during winter, or perhaps late fall or early spring when the ground is frozen. Access to lowland brush sites is most feasible at this time of year, and risk of impacts on soil or water table are least when the ground is frozen. Most mechanized management activities in brushland (shearing, hydroaxing, etc.) conducted by DNR have been during winter. Thus, all aspects of our work, including harvesting and removal of brush from these demonstration plots, will be in the context of winter harvest. Access to **upland** brush sites may be more feasible at other seasons, but harvesting of brush from upland sites is not a significant component of the brushland harvest envisioned in this project. Harvesting brush from uplands would need to take into account concern about conversion of sites that otherwise might mature into productive forested habitat. However, it is possible that habitat management objectives at some sites would be facilitated by harvesting brush from small, brushy upland "inclusions" in otherwise lowland brush complexes; this harvest potentially could occur during the frost-free season, depending on the site. Except for such circumstances, we do not envision substantial non-winter harvesting of brush.

Creation of demonstration sites is not intended to test any equipment that might be used in future, large-scale commercial harvest of brush. Similarly, use of STS personnel clearly is not intended to provide a model for future commercial harvest. Instead, the objective is to achieve a small-scale simulation of mechanical harvesting without investing major financial resources into equipment development. The sites on which harvesting is simulated are intended solely for the indicated demonstration and education purposes, and to provide suitable sites for future ecological study.

Brush height and density on sites selected for brush removal will be measured, and extensive sets of "before" and "after" photographs of these sites will be made. This information and photographs will be used for subsequent educational and outreach efforts.

C.1.c. Materials: Equipment to be used in cutting and removal of brush will be rented or leased rather than purchased.

C.1.d. Budget: $25,500
Balance: $0

C.1.e. Timeline:	7/95	1/96	6/96	1/97	6/97
Identification of sites	****************				
Brush removal			*********		

The deliverables for this and other activities have been discussed with DNR personnel. These will consist of semiannual progress/technical reports submitted to DNR; the timing of delivery of these reports will coincide with semiannual reports to LCMR. The technical reports will be more detailed, including data summaries (graphical, tabular, maps), results of statistical analyses, and tentative conclusions. Much of this activity will be completed later in the project. The actual creation of the demonstration sites is a product to be delivered 6/97. It is not anticipated that there will be a real product to be delivered in 1/96. In 6/96, the report will include preliminary information on selection of sites to be harvested, prescribed-burn comparison plots, and unharvested control plots, including criteria employed in selecting sites; songbirds will have been surveyed on these plots in May-June 1996. The 1/97 report will include analysis of biological properties (brush composition, avian communities) of sites selected for harvest and their comparison plots, detailed plans and schedule for harvesting brush during winter 1996-97, and progress made on harvesting up to the time of the report. The 6/97 report will include final analysis and assessment of the activity of creating demonstration plots, photographic comparisons (before and after, and among plots) and results of public relations activities conducted on these sites during spring 1997.

C.1.f. Workprogram Update:

During winter 1997, three demonstration brush removal projects were conducted according to the protocol outlined in previous project updates. Specifically, we bulldozed brush to the perimeter of a sheared area to create two adjacent blocks of 4 acres each, resulting in an effective 8-acre block that would simulate the ecological conditions remaining after a brush moval operation. These were located in larger areas of sheared brush, adjacent to areas of untreated brush.

These projects were located in varied ecological and management settings. One (Eveleth DNR work area) was adjacent to a large DNR brush shearing project conducted also during winter 1997. The demonstration project (20 acres total) was placed to increase the landscape connectivity between the DNR shearing project and a nearby open grass/brush area. The second project (Cloquet DNR work area; 110 acres total) was a regenerating aspen stand on private land; the landowner, a beef cattle farmer, was interested in converting this stand for management as open pasture. This stand is adjacent to an area of willow brush, open fields, and lowland conifer, and its center contained a prominent knoll that showed promise to be a future dancing ground sites. Sharptailed grouse have been observed in the fields and brush adjacent to this site. This project resulted in a much more open landscape, with the brush-removal area centered on the knoll. Although results of our landscape analyses were not known to us at the time that this site was selected for study, those analyses showed that dancing grounds have less upland brush and less regenerating hardwood than defunct dancing grounds and random points in the landscape, out to a distance of at least 1000 m from the dancing ground site. Thus, treatment of this site in the manner described was fully consistent with results of our landscape analyses.

The third project (Cloquet DNR work area; 40 acres total) was in lowland willow brush bordered on one edge by pasture and another by open aspen forest. Sharptails have been observed in the brush and pasture at this site, and an active dancing ground is present within several hundred meters. Shearing and brush removal focused on dense-brush portions of this stand, effectively increasing the size of the grassland area. Poor frost conditions in the northwestern part of the state prevented our completing a demonstration project there.

Some of the anticipated details of this objective proved unworkable. It was not possible for us to overlay the logistics of avian census routes, the complexity of ownership of brushland areas suitable for shearing, and DNR management plans so that we could link the bird census areas with the demonstration brush removal areas. However, the areas that we selected for demonstration sites are portions of larger, homogeneous blocks of brush habitat. The comparability of the removal and control areas is probably as great as can be achieved, given the variety of constraints on locating these areas.

C.2 Activity: Develop outreach and educational information on brushland ecology and management.

C.2.a. Context within the project: There is an apparent lack of sensitivity and awareness of brushland habitat management issues in Minnesota, and of options and opportunities for managing brushlands. Because a concerted outreach and educational effort is needed to assure that management needs are addressed, these activities represent a substantial component of this overall project.

C.2.b. Methods: Preliminary educational information on brushland management needs and opportunities will be synthesized early in the project. One component of the educational package will be an effort to integrate Trygg and Marschner maps to better depict pre-settlement brushland vegetation in the state. We will pursue public relations and media coverage of brushland management issues and of our specific project, to be based in part on this information. This package will be employed in establishing key landowner contacts in our major work areas (Cromwell and Meadowlands), as well as in other areas that include extensive brushland complexes. We will solicit cooperation of DNR wildlife biologists and area wildlife and forestry managers in establishing these contacts. The network of landowner contacts will be maintained throughout our project, and will form a primary basis for 1) providing outreach to communicate major findings of our research and 2) identifying potential sites for demonstration projects. To maximize the educational and outreach value of the demonstration projects, we will hold public meetings or other venues (to include landowners) prior to actual brush removal, to communicate the rationale and objectives for removing brush to manage habitats, the basis for selection of particular sites, the possible economic incentives, and the anticipated schedule for completion of the project. On-site tours of the treated sites will be conducted in the spring following brush removal. It is anticipated that members of the Minnesota Sharp-tailed Grouse Society will conduct public tours on these sites and in other ways assist with publicizing this part of the project. In addition, it is anticipated that these demonstration sites will be valuable to DNR biologists or area managers in their continuing contacts with landowners. To the extent possible, project staff, working in conjunction with DNR staff, will provide on-site assistance for landowners interested in developing brushland management plans.

As the overall project progresses and new information becomes available, we will continue media coverage and other activities to disseminate information to outdoor-user groups, the environmental community, land managers, and the general public. By the end of the project, we will develop a comprehensive set of information for use in public and landowner education, although it is not our intent to print this information on a large scale. Minnesota Sharp-tailed Grouse Society members will contribute to this overall activity.

C.2.c. Materials: No major items of equipment are to be purchased to implement this activity. Major materials costs will include printing and mailing.

C.2.d. Budget: $13,000
Balance: $0,000

C.2.e. Timeline:	7/95	1/96	6/96	1/97	6/97
Establish landowner contacts	********	********	********		
Produce and disseminate information	********	********	********	********	

The deliverables for this and other activities have been discussed with DNR personnel. These will consist of semiannual progress/technical reports submitted to DNR; the timing of delivery of these reports will coincide with semiannual reports to LCMR. The technical reports will be more detailed, including data summaries (graphical, tabular, maps), results of statistical analyses, and tentative conclusions. For this activity, each semiannual report will represent a synthesis of information and understanding developed to date on the project, organized in a way that facilitates information transfer to landowners, land managers, and members of the public. Throughout the course of the project, important deliverables will include information dissemination of a variety of forms (press releases, interviews, presentations, etc.); these will be catalogued in each semiannual report. It is anticipated that these activities will occur at a relatively small scale in the first six months of the project but expand as our information base builds. We will begin working to establish landowner contacts at the beginning of the project; these efforts will be described in the first and all subsequent reports. The final report will include a comprehensive set of information about ecology of brushland landscapes, sharptailed grouse and other faunal elements, management needs and opportunities, and possibilities for biomass harvest. It is not our intent to produce a publication-quality version of this information, but merely to establish the necessary information base. Depending on funding requirements to accomplish other aspects of this activity, it may be possible to organize and host a symposium on brushland management in the state.

C.2.f. Workprogram Update:

A variety of activities and accomplishments took place to educate members of the public and land managers about brushland management and sharptailed grouse ecology. D. Christian and DNR wildlife researcher W. E. Berg made a presentation on the project and its objectives at the annual meeting of the Prairie Grouse Technical Council in August 1995. An interview by D. Christian was broadcast on KUMD public radio in Duluth during March 1996; this interview included discussion of sharptailed grouse ecology, population trends, and brushland management. D. Christian contributed information about the brushland ecology and harvesting project for inclusion in an article by Sam Cook in the Duluth News-Tribune in spring 1996. This article focused on dancing behavior and trends in population and habitat; W. Berg contributed extensively to this article. Information also was provided to reporters for several other newspaper articles. D. Christian gave a formal presentation at a DNR workshop (joint Forestry and Wildlife) on brushland ecology and management at Camp Ripley during February 1997, as well as formal seminars on sharptailed grouse ecology and management at the University of Minnesota in September 1996 and July 1997.

As noted above a press release was sent to about 40 local papers in the northern part of the state, soliciting information on dancing ground localities and providing additional exposure to brushland management issues. Christian and other project staff spoke extensively with landowners and others during the course of field work in the sharptail range of Minnesota throughout the project. These discussions focused on the objectives of the project, the status of sharptailed grouse, and possibilities for landowner cooperation. A form letter was distributed to all landowners contacted. In the course of gaining landowner permission to survey birds, Mark Nelson (the technician who conducted the work), discussed the project and its objectives with another group of landowners. We will be preparing at least three manuscripts describing the results of the project for submission to journals such as the Journal of Wildlife Management, Biomass and Bioenergy, and others.

One specific initiative under this objective is to integrate the Trygg and Marschner maps to gain a better understanding of the prevalence of openland, potential sharptail, habitats in the pre-European landscape in forested portions of Minnesota. We completed analysis comparing the Trygg and Marschner maps, although these analyses failed to provide useful insight into landscape differences, in part because of different notations and land-use classification on the two maps. We completed an analysis of bearing-tree maps to characterize the pre-European landscape in areas (sections) which sharptailed grouse currently occur. These analyses focused on identifying whether areas where sharptails have occurred in the past several decades (generally open areas) were also more open at the time of the original land survey. The results showed that for some areas this is the case. That is, these areas were, at the time of the land survey, more open than the surrounding landscape. For others, this is not true, but likely for complex reasons. For example, in the Sandstone area, sections where sharptails occur now were as likely to be forested at the time of the land survey as the surrounding area, consistent with the view that sharptails in that part of the state occupy areas that were cleared by humans. In some parts of the northwest, sections where sharptails occur have landscape composition similar to the overall landscape, but those are extremely open landscapes. On the prairie fringe, sections containing sharptails may be more forested than the surrounding landscape, reflecting the fact that this species requires mixed landscapes, not open prairie. Thus, interpretation of the results of these analyses is complex. However, this approach provides a useful basis which could be refined to delineate areas of the state that should receive priority for management as openlands habitats, and in educating the public and land managers about managing for openlands habitats within the forested part of the state. Proper refinement of these approaches will depend on having bearing-tree data available in electronic form. Analyzing data extracted from paper bearing-tree maps was extremely cumbersome, and hindered efforts to answer questions about the proper scale at which such analyses should be conducted.

D. Additional Information

D.1. Quality Control and Assurance in the Data Collection:

D.1.a. All aspects of the project: Original field data sheets and logs of field personnel will be retained. Data will be checked for entry errors in two separate steps, including by an individual other than the person who originally entered the data. Statistical properties of data sets will be determined before analysis; for example, both statistical and graphical means will be used to detect outliers, and individual data points are re-checked against laboratory and field data sheets. Individuals experienced with data management will be in charge of the analyses. Extensive ground truthing of locations and land-type classifications will be made in the course of our numerous activities at the field sites.

D.1.b. Soil and Biomass Analyses: The sampling design incorporates five replications of each sample collected in the field with a sufficient amount of material collected to allow multiple analysis should the event arise. Samples are bagged in polyethylene in the field and kept frozen before being prepared for chemical analysis. Prior to submission of soil and vegetation samples to the laboratory, these samples are split and re-labeled to allow repeated analysis of samples identified as possible outliers through post-hoc statistical analysis. Both reference blanks and replicates of samples are inserted into each laboratory batch to ensure that the instrument readings are consistent and accurate.

D.1.c. Bird inventorying: Individuals employed to conduct bird surveys will be qualified observers. During screening, qualified applicants will be tested in their ability to identify birds by sight and sound; procedures to conduct these tests have been developed at NRRI. The demands of censusing openlands and brushlands birds are less stringent than for forest songbirds. Protocol proposed for sampling birds is representative of accepted methods for surveying these animals in openlands habitats.

D.2. Data Management procedures: All data will be entered into MS-DOS compatible database (Paradox™ database) and spreadsheet (Lotus 123™) software and stored onto floppy disks. Data files will include complete descriptions of the variables measured, units of measurement, and how the data were collected. Disks will be archived at two separate locations to minimize risk of loss or damage. Data archives will include a central repository for NRRI; these archives, including explanatory information, will be available upon request through the library as Paradox, ASCI, or dBase files. We will work closely with DNR to facilitate transfer of data and information to that agency in formats that are suitable for their needs. We will work to assure that GIS information developed and analyzed on the project is in a format to facilitate transfer to GIS systems in use by DNR.

VI. Evaluation: This program can be evaluated by its ability to: 1) provide an assessment of biological capacity of brushlands to sustain harvesting brush as a biomass source and an evaluation of currently available harvesting technology; 2) identify habitat and landscape features and avian community characteristics associated with dancing grounds of sharp-tailed grouse; 3) produce successful demonstration-scale projects of brushland management; and 4) produce and disseminate educational and outreach information on brushland management problems and opportunities. Overall, the project should be evaluated by its ability to enhance development and implementation of integrated management approaches to brushland landscapes in Minnesota.

VII. Context within field: In Minnesota, there has been and continues to be major loss of open and early-succession brushland habitats, primarily as a result of absence of fire or other disturbance that has allowed maturation and senescence of vast areas of brushlands. This ecological change represents a serious conservation issue, with concern about maintaining these habitats and viable populations of species dependent on or closely associated with young, open grass-brush habitats. Unfortunately, brushlands, have been studied far less extensively or intensively than other major habitat types in Minnesota, such as forests, wetlands, prairies, or bogs. We know relatively little about brushland fauna, and about patterns of habitat use or distribution for most species that occur in brushlands. However, it has been amply documented that many species that occur in open grass-brush habitats are declining in the state and the region. The sharp-tailed grouse, once probably the most abundant grouse species in Minnesota and an important indicator species of the open grass-brush landscape, is highly indicative of this trend. Extensive brush landscapes, on which the sharp-tailed grouse is highly dependent, have probably experienced the most severe degradation through fragmentation. Effective management of brushland landscapes requires further knowledge of the importance of brushlands as wildlife habitat for a variety of species including sharp-tailed grouse.

Brushlands historically were maintained in younger successional stages by naturally occurring fire. Most lowland brush areas will not succeed to productive forest if left undisturbed, but will progress to "offsite," unmerchantable lowland forest or decadent brushland. Prescribed burning has been the method of choice for managing brushlands, and substantial state funding is allocated for burning and management of brushland. However, financial and human resources have not been sufficient to accomplish desired goals for brushland management, and additional approaches to brushland management are needed. This project will address this habitat issue through a combination of the development of an economic incentive to manage brushlands, enhanced understanding of biological resources and management approaches for brushland landscapes, and increased awareness of brushland management issues and opportunities.

There is a serious initiative (involving research, discussion, planning, and recent scale-up projects) to increase reliance on woody biomass as a source of energy for generating electrical power. This initiative coincides with increasing demand for wood or paper fiber derived from forest products. These demands will be met primarily by use of products 1) from forest harvest and 2) short-rotation woody or herbaceous energy crops grown in plantations. It is likely that economic development related to use of these products will be limited by supply, in concert with environmental constraints. This project would develop an alternative source of woody biomass that likely would not compete with existing fiber supplies, and that would not entail the establishment and cultivation costs of dedicated biomass crops.

Harvesting brush as a biomass resource is fully compatible with management objectives for lowland brush habitats, as an approach to maintaining these habitats in an open, grassy condition (with greater habitat value for many wildlife species) rather than allowing them to succeed to tall, dense brush (with lower habitat value). One of the possible limitations on brushland harvesting is the availability of biomass in brushland habitats. Limited studies (W. Berguson, unpubl. data) have shown biomass in some lowland brush habitats to be as high as 12 - 17 dry tons/acre, but biomass availability in brushlands is not well understood and more information is needed.

Many brushlands in Minnesota currently are overmature, and seem to contain substantial biomass. Indeed, the state of overmaturity of some stands is such that they have succeeded to poor-quality, unmerchantable forest. Such habitats would provide substantial biomass in the short term, and need to be managed by harvesting or burning or they will be lost as openlands habitats.

We do not necessarily expect that brushland biomass will prove to be high enough that brushland harvesting would, by itself, be able to sustain large power plants. However, there likely is sufficient biomass in brushlands to serve as an important supplement to biomass derived from dedicated energy plantations, such as those presently being developed in Minnesota. Consideration of the economic value of brushland biomass must be in the context of the substantial state funding used for brushland management (primarily shearing and prescribed burning), and the inadequacy of that funding to accomplish fully all desired habitat management. Thus, funding targeted for brushland habitat management could be used to subsidize, in part, brushland biomass harvesting; an alternative view is that revenues generated from brushland biomass may help support habitat management activities. Therefore, it is not necessary that brushland biomass harvesting fully "pay its own way" to represent an economic benefit to the state.

Thus, this program would establish an information base for commercial harvesting of brushlands that would provide woody biomass and, in the same process, enhance critical habitat as a site-specific alternative to costly prescribed burning. This initiative would be pursued in the context of a multifaceted approach to brushland management in the state.

Several issues related to ecological effects of brushland harvesting are central to the long-term sustainability of this approach as a component of brushland management strategies. One important issue is whether brushland harvesting represents a serious drain on site-level nutrient availability. It needs to be recognized that soils in lowland brush sites typically are organically rich; nutrients probably tend to accumulate in these sites rather than moving offsite through leaching or runoff. It is likely that nutrient depletion through brushland harvest is a less serious issue than that resulting from forest harvest or in agricultural situations. Nonetheless, this problem reflects a potentially important environmental issue. It is possible to address this problem in a meaningful way during a relatively short study period, and our workplan incorporates activities that begin to address possible nutrient depletion.

In addition, there are real concerns about the ecological equivalency of brush harvesting and other management approaches (e. g., prescribed burning). It is likely that removing brush by harvesting does not fully simulate the effects of prescribed burning in terms of nutrient cycling and perhaps in terms of microhabitats. However, any lack of equivalency of brush harvesting and prescribed burning needs to be interpreted in the context of the likelihood that prescribed burning, especially on sites that have been protected from fire for many years, does not fully simulate the effects of the natural fires that occurred frequently in openland habitats of Minnesota in pre-European times. Thus, it is possible that any management approach applied to brushland landscapes does not fully simulate natural forces that maintained these habitats. Observations of managed brushlands in Minnesota indicate that sites managed in various ways (prescribed burning, shearing, hydroaxing, handcutting, and chemicals, either alone or in combination) tend to look very similar 4-6 years post-treatment and seem to be inhabited by similar fauna. Nonetheless, it is important to develop an understanding of the comparative effects of burning and brush removal on brush regeneration, habitat structure, and other ecological properties before brush harvesting is applied on a large scale.

Because of the time lag of many important biological responses to habitat change, it is not possible to address these issues in a meaningful way during the same two-year study period in which brushland harvesting is first applied. The workplan of this project includes the establishment of sites for long-term study (including harvested, recently burned, and comparable unburned sites) of this problem in a future project.

VIII. Budget context: No other funds from any source are being spent on activities in this project either for the period ending June 30, 1995, or the two-year period beginning July 1, 1995.

IX. Dissemination: Results of this project will be presented to peers in the respective fields at state, regional, and national scientific meetings. Additionally, results will be communicated in various formats to resource managers, planners, and landowners who will use the information. In addition to presentation of results to these groups, they will be published in the peer-reviewed literature in national journals in appropriate fields. Objective C of the project focuses specifically on activities to disseminate findings of this project. Various phases of the work will be conducted in close collaboration with staff in the DNR Section of Wildlife and Division of Forestry. Results and findings of this project will be made readily available to DNR staff, and project staff will work to expedite information transfer to the DNR.

X. Time: The most opportune time to sample song birds and sharp-tailed grouse is during spring (March - June). A project starting date of July 1, 1995 effectively precludes sampling birds during the first summer of the project. In the proposed work plan for this portion of the project, we will conduct extensive analysis during the first part of the project of satellite imagery (using GIS) and DNR Wildlife data on known sharp-tailed grouse dancing grounds and other brushland sites. These analyses will be directed toward understanding associations of sharp-tailed grouse with site- and landscape-level habitat features. This information will be used to guide field studies of sharp-tailed grouse and songbird abundance in brushlands during spring and early summer 1996. We propose also to conduct these studies during the same time span in 1997 (including at least part of June). However, this will delay completion of all aspects of the work until November 1, 1997, allowing sufficient time to analyze data from the 1997 field season, integrate these data with information collected earlier in the project, and prepare final written reports. Data collection, analysis, and report writing for other aspects of the project will be completed by

June 30, 1997, although the last season's field results may necessitate refinements in proposed management approaches and educational information.

XI. Cooperation:

1. William E. Berguson
   Senior Scientist, Center for Applied Research and Technology Development
   Natural Resources Research Institute, University of Minnesota, Duluth

A forest scientist with extensive expertise and experience in forest economic analysis and the measurement of forest growth and productivity, William Berguson's primary role will be to conduct economic analyses and biomass studies (i.e., Objective A).

2. JoAnn M. Hanowski
   Research Fellow, Center for Water and the Environment
   Natural Resources Research Institute, University of Minnesota, Duluth

An avian ecologist with extensive experience studying birds in northern Minnesota, JoAnn Hanowski will play a primary role in completing activities under objective B, and will contribute to objective C.

3. James W. Slade
   Minnesota Sharp-tailed Grouse Society

James Slade will coordinate and facilitate volunteer activities by membership of the Sharp-tailed Grouse Society, and will serve as a primary contact for communication between project staff and the society.

4. William E. Berg
   Wildlife Research Biologist
   Minnesota Department of Natural Resources, Section of Wildlife
   Forest Wildlife Populations and Research Group

William Berg will spearhead the DNR Section of Wildlife's collaboration on the project, including facilitating data and information transfer, providing substantive input on several portions of the project, and facilitating cooperation and contact between project staff and area managers and wildlife biologists.

5. Jeff Lightfoot
   Rich Staffon
   Minnesota Department of Natural Resources, Section of Wildlife

Jeff Lightfoot (Area Wildlife Manager, Eveleth Area) and Rich Staffon (Area Wildlife Manager, Cloquet Area) will work closely with project staff in locating study sites, implementing demonstration management programs, and other aspects of the project.

The Program Manager, Donald P. Christian, will spend 5% of his time on overall project administration (i. e., budget administration, report preparation, and coordination among cooperators) and another 5% on Objectives B and C.

XII. Reporting Requirements: Semiannual six-month workprogram update reports will be submitted not later than January 1, 1996, July 1, 1996, January 1, 1997, June 30, 1997, and a final report not later than November 1, 1997.

XIII. REQUIRED ATTACHMENT: See attached CVs of:

Donald Christian
William Berguson
JoAnn Hanowski

Attachment: Qualifications of Investigators

The Program Manager (Donald Christian) and major collaborators (William E. Berguson and JoAnn M. Hanowski) are all affiliated with the University of Minnesota, Duluth, Christian at the Department of Biology and Berguson and Hanowski at the Natural Resources Research Institute. All three have had extensive experience working on collaborative, funded projects dealing with natural resources issues and research. All three also have been engaged in ongoing research on different aspects of woody biomass energy (hybrid poplar) development in Minnesota, an initiative that shares similar directions with this proposal.

Berguson has over 15 years of experience in soil productivity research related to forestry, short-rotation culture of hybrid poplars, and management of native aspen stands. He holds a B.S. in Soil Science and an M.S. in Forest Resources from the University of Minnesota. Current projects involve analysis of yield of hybrid poplar plantations, testing of hybrid poplar genotypes throughout the state, analysis of environmental impacts of hybrid poplar management (chemical fate) as well as description of soil resources related to a large scale hybrid poplar implementation project supported by the Department of Energy-Biomass Feedstock Development Program. Berguson is principal investigator on studies of strip thinning of aspen to increase growth as well as studies to determine growth rates of regenerating aspen stands. This experience relates directly to field sampling and analysis in biomass and nutrient analyses. He has numerous publications in the field of soil productivity and management of hybrid poplar plantations..

Christian holds a B.S. in Wildlife Biology and M.S. and Ph.D. degrees in Zoology. Hanowski holds B.S. and M.S. degrees in Biology. Christian and Hanowski have had considerable experience studying ecological problems in Minnesota, including habitat relationships and forest-management issues. Both were on the Wildlife and Biodiversity Study Team of the Forest Management Generic Environmental Impact Statement (GEIS) project, and Christian has served on the GEIS implementation roundtable. Christian's and Hanowski's involvement with hybrid poplar research has stressed assessment of effects on wildlife habitat and biodiversity, both at site-specific and landscape levels. Hanowski has had extensive experience with study and analysis of bird populations and communities in northern Minnesota, including on the LCMR-sponsored Forest Bird Diversity Initiative and earlier work on birds in peatland habitats, including shrublands. Through the forest bird diversity project and a number of other avian ecology research efforts, she has had contact and experience with GIS and related analyses. Christian has had experience with GIS through research projects of students he has advised. Both Hanowski and Christian have had experience dealing with landscape-level considerations in their research on environmental effects of hybrid poplar plantation establishment. Both have numerous publications on ecological problems. In the GIS and image-analysis activities on this project, they will work closely with trained, experienced staff at the GIS Laboratory at NRRI; these staff have worked on a large number of GIS research projects.

Volunteer participation on aspects of the project by members of the Minnesota Sharp-tailed Grouse Society (MSGS) will be coordinated by MSGS leaders James Slade and Roche Lally, under the supervision of Christian and Hanowski.