2011
Project Abstract
For the Period Ending June 30, 2014

PROJECT TITLE: **Prairie Management for Wildlife and Bioenergy - Phase II**
PROJECT MANAGER: Clarence Lehman
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2011, First Special Session, Chp. 2, Art.3, Sec. 2, Subd. 03g
APPROPRIATION AMOUNT: $600,000

Overall Project Outcome and Results

Many wildlife areas and conservation lands were formerly marginal agricultural fields that have been converted into rich habitats of grasses and flowering plants. That habitat traditionally required maintenance by prescribed burning. However, mowing can be more feasible and can provide future commodity incentives through a carbon-negative energy source.

Our prevailing question was how grassland areas could be harvested annually without upsetting their ability to support wildlife. We organized over 1000 acres into 60 production-size, 20-acre plots spanning the temperature gradient in western Minnesota. The plots were harvested in prescribed intensities and patterns each fall from 2009-2012 after plants had senesced and migratory wildlife left. Each year, surveys of songbirds, gamebirds, small mammals, reptiles, amphibians, insects, and plants were conducted and bioenergy potential calculated.

Our results showed that bioenergy can be harvested sustainably without harming resident wildlife by following simple protocols developed during the project. Specifically, leaving unharvested refuges of 5-10 acres rotated annually in a 20-acre plot minimized significant impact on wildlife, and we recommend such refuges as best practices. Harvesting without any refuge negatively affected some wildlife, specifically prairie and meadow voles, a shrew, sedge wren, common yellow throat, clay-colored sparrow, swamp sparrow, waterfowl nesting, and potentially native bees. Deer mice, grasshopper sparrows, common grackles, spiders, flies and beetles increased with harvest. Plant cover and biomass did not change significantly during our harvesting tests. We cut and analyzed over 3,000 tons of biomass with yields ranging from 0.6-1.8 tons/acre and projected ethanol yields averaging 108-gallons/ton. Recommendations for best harvesting equipment are low weight-to-tire-width ratio, easily repaired, and readily cleaned between fields.

The broad consensus among wildlife experts is that diverse ecosystems offer habitat that is superior for a spectrum of wildlife, The overall significance of this project is that it

identified and tested better methods for maintaining such habitat on public and private grasslands of Minnesota.

Project Results Use and Dissemination

During this six-year project the Environmental Trust Fund and other substantial federal and local funds have resulted in two graduate theses, 26 publications, posters and presentations, five outreach events and newspaper articles, nine symposia, a website, a publically available dataset carrying the raw data and metadata supporting our conclusions, and a draft Best-Management-Practices document.

That draft document has been formatted professionally for publication, with release scheduled this calendar year. Some managers in the Minnesota DNR have begun using harvesting as a grassland management tool on Wildlife Management Areas and through Cooperative Farm Agreements, and we expect that this can expand and become routine as project results, including the Best-Management-Practices document, are published and disseminated broadly.

Dissemination will be ongoing for some time, with new scientific papers in preparation and continuing presentations at conferences.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2011 Work Plan Final Report

Date of Report: 8/15/2014
Final Report
Date of Work Plan Approval: 6/23/2011
Project Completion Date: 6/30/2014
Is this an amendment request? No

Project Title: Prairie Management for Wildlife and Bioenergy - Phase II

Project Manager: Clarence Lehman
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Location:
Counties Impacted: Statewide
Ecological Section Impacted: Lake Agassiz Aspen Parklands (223N), Minnesota and Northeast Iowa Morainal (222M), North Central Glaciated Plains (251B), Northern Minnesota and Ontario Peatlands (212M), Northern Minnesota Drift and lake Plains (212N), Northern Superior Uplands (212L), Paleozoic Plateau (222L), Red River Valley (251A), Southern Superior Uplands (212J), Western Superior Uplands (212K)

Total ENRTF Project Budget:
ENRTF Appropriation $: 600,000
Amount Spent $: 600,000
Balance $: 0

Legal Citation: M.L. 2011, First Special Session, Chp. 2, Art.3, Sec. 2, Subd. 03g

Appropriation Language:
$300,000 the first year and $300,000 the second year are from the trust fund to the Board of Regents of the University of Minnesota to research and evaluate methods of managing diverse working prairies for wildlife and renewable bioenergy production. This appropriation is available until June 30, 2014, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Prairie management for wildlife and bioenergy: Phase II

II. FINAL PROJECT SUMMARY: This project forms part of a broad effort to sustain Minnesota resources while improving the rural economy and contributing to our energy independence. The project tested best management practices to maintain grassland habitat for wildlife while generating bioenergy. The work continued and completed the monitoring of wildlife responses and other ecological responses to harvesting prairies for bioenergy, as started from a 2008 ENRTF project., allowing sufficient time for the significance of results to be tested. A major objective of the project was to identify biomass harvesting patterns that could maintain wildlife populations by leaving distinct size and shapes of refuges within the grassland, but doing so while harvesting the greatest sustainable amount of biomass from the sites. Over 1000 acres of restored grasslands across western Minnesota were divided into 20-acre plots. The plots were organized in three locations spanning the temperature range of Minnesota---in the region of Windom, Morris and Crookston. Wildlife surveys encompassed birds, small mammals, and insects, with special attention to pollinators. Bioenergy surveys monitored changes in plant communities and differences in bioenergy potential from production-scale harvests. Results are being used to develop guides for landowners and to produce standard protocols for bioenergy and wildlife evaluations. Best management reports are being produced for state land-managing entities to improve management efficiency and potentially reduce costs of habitat management.

III. PROJECT STATUS UPDATES:

Project Status as of *(*January 1, 2012*)*:
This project, which began in July 2008, was selected for continued funding so Phase II began in July 2011. As that was in the middle of field season, surveys continued throughout the remainder of the summer and into Fall 2011. A full harvest and the associated surveys (such as bale cores) occurred in two of the three regions. It was decided to focus efforts and funds on the southwest and west central location and

discontinue harvest in the northwest region. Field season data is being entered into spreadsheets and will be processed further throughout the winter. An upcoming staff and PI meeting will review protocols, interim data, outreach, and future research directions.

Amendment Request (May 24, 2012)**:**
We are requesting the reallocation of funds between the budget categories Travel Expenses and Professional/Technical Contracts. This change would move $25,000 from the latter category into three activities of the travel budget. This is in response to the unexpectedly high cost of travel throughout the field plots for wildlife and biomass surveying, re-projecting costs for future travel, and of paring down harvest. Specifically, we request to move $12,000 into Activity 1 of Travel, $7000 to Activity 2, and $6000 to Activity 3. We do not expect this shift to significantly alter the deliverables of the Activities.

Amendment request approved by LCCMR – 6/11/12.

Project Status as of *(*July 1, 2012*)*:
Field work for summer 2012 is underway. Surveys that have begun include plant flower blooms, songbird, herpetafauna, insect sweepnets, bees and pollinators, and insect pitfalls. Data from the previous field season has been entered into spreadsheets and processed. A meeting was held in January 2012 which included faculty, PIs, and staff. Paper assignments and data for papers were divided and ideas for future studies were exchanged. We continue to review and update protocols; release interim data as appropriate; facilitate outreach, including preparing papers for publication and materials for dissemination; plan future research directions in response to results so far; and apply for supplemental funding.

Project Status as of *(*January 1, 2013*)***:**
Fall harvest was completed in late November, following a summer of drought throughout the region. Bale and harvest data were collected, as in previous years. Wildlife and vegetation surveys continued throughout the summer as well. Project members met in early November to review current project status, discuss available data, identify subprojects, assign members to these subprojects, and discuss ongoing funding options. Twelve distinct subprojects were identified: one has been published, one submitted, and an additional eight are in various stages of completion. Subprojects appear below under the appropriate Activities.

Project Status as of *(*July 1, 2013*)***:** A paper titled “Energy potential of biomass from conservation grasslands in Minnesota, USA” has been published and is open access at *http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0061209*

Songbird surveys were conducted and data are being entered into digital formats. Two papers on these results are nearing completion. Data from 2012 plant and animal surveys has been entered. Data analysis is underway for waterfowl nest success, songbird abundance and diversity, small mammal abundance and diversity, and the effect of biomass harvest on plant composition and diversity. Manuscripts are in preparation. A meeting was held between UMN researchers and DNR staff to report preliminary findings from the study. A paper summarizing the design and intent of the project was published, following a related Sun Grant Conference presentation funded by a supplemental UMN travel grant (Williams et al. 2012, see citation below in Dissemination, Section V).

Project Status as of *(*January 1, 2014*)***:** A manuscript reporting the effects of biomass harvest on pheasant and duck nest survival and density was accepted with revisions by the *American Midland Naturalist* journal. Revisions were made and are now in review by the journal editors. A poster was prepared and presented at the 98th Ecological Society of America (ESA) annual meeting. At the ESA conference, a special Ignite session based on ecosystem complementarity highlighted work from this project. A presentation summarizing the preliminary results was delivered for the UMN Conservation Biology Seminar Series. Two manuscripts from insect surveys are nearing submission. Data from bee surveys is being analyzed and preliminary results have been discussed with the MN DNR to aid in their best management practice development. Specific results are discussed in individual sections below.

Amendment Request (January 21, 2014)**:**
We are requesting a retroactive amendment to reallocate funds between travel, contracts, and personnel. Specifically, we expect to save $8,000 from Activity 4, reducing technical contracts from $75,000 to $67,000. Because complete field surveys were not planned for Summer 2014, we did not need to not apply the full harvest treatment in Fall 2013. This also reduced travel costs in Activity 2 (determining biomass productivity and harvest yields) from $8,000 to $5,215. We are requesting that the $10,785 be transferred to the Personnel category in Activity 5 (analyses, reporting, and publications). Moving funds to this category is for analysis by staff, faculty, and technicians.

Approved by the LCCMR February 24, 2014

Amendment Request (June 13, 2014)**:**
We are requesting two sets of amendments. The first request is for expertise necessary to complete two specific tasks. The second request reflects some redistributions between categories that will help more efficiently complete this study.

Proposed increase 1. We need to contract with an expert in bee identification for the final stages in species identification and to do so need to move $375 to the Contracts section of the budget in Activity 3. We would also like to employ the statistical consulting expertise at the University to assist in insect data analysis. As this is employing internal resources at the University and falls under the Other category, we would like to move $180 to the Other category in Activity 5. This is a proposed increase of $555 for these categories.

Proposed increase 2. The majority of the remaining work includes writing and analysis falling under Activity 5. These tasks require personnel time resulting in a change to the Personnel budget from $58,785 to $65,687. We would also move $46 to the Equipment budget for Activity 3, changing the Equipment budget from $2,900 to $2,946. The $46 would pay for curation supplies to prepare the insect collection for long term storage. This is a proposed increase of $6948 for these two categories.

Proposed reductions. As we have nearly completed (a) Travel for Activities 1, 3, and 4, (b) Equipment needs for Activities 1, 2, and 4, and (c) Other for Activity 3, we propose the balance in other areas to be provided from these three categories. Specifically we propose to reduce budgets for the following categories: Travel: Activity 1 ($19,500 to 16,318), Activity 3 ($6,000 to 3,979), Activity 4 ($1,500 to 978); Equipment: Activity 1 ($4,000 to 3,339), Activity 2 ($100 to 83), Activity 4 ($1,000 to 835); Other: Activity 3 ($2000 to 1065). This amounts to a total reduction of $7503.

In summary, the total Personnel budget would change to $497,687 by adding $6,902, the Contracts budget to $67,375 by adding $375, the Equipment budget to $7,203 by subtracting $797, the Travel budget to $26,490 by subtracting $5,725 and the Other budget to $1,245 by subtracting $755. These changes balance the project through its completion date.

Approved by the LCCMR June 24, 2014

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Wildlife Sampling

Description: Survey crews will sample songbirds, small mammals, and insects. Bird surveys will be conducted in the spring using transect counts. Insects will be sampled at least once during the summer in all plots with sweep nets and potentially pit-fall traps. Small mammal surveys will take place in all plots in the fall of each year using catch-and-release live traps.

Summary Budget Information for Activity 1:	ENRTF Budget:	$ 210,157
	Amount Spent:	$ 210,157
	Balance:	$ 0

Activity Completion Date:

Outcome	Completion Date	Budget
1. Determine relative abundance of small mammals in various harvesting regimes.	Spring 2014	$54,500
2. Determine relative abundance of song birds in various harvesting regimes.	Spring 2014	$54,500
3. Determine biomass of insects of various size classes and functional groups.	Spring 2014	$101,083

Activity Status as of *(*January 1, 2012*)*: Small mammal trapping was performed in Fall 2011 following the protocols of previous years. A total of fifty-nine plots in all three regions were successfully surveyed for four consecutive nights. QuIST insect sampling, which had begun in Summer 2011 during Phase I of the project, was completed in the southwest region. Songbird surveys were completed before July 1, 2011 and so were reported with the previous phase. Data for these surveys has been entered into spreadsheets and will be further formatted this winter.

Activity Status as of *(*July 1, 2012): The wildlife sampling season began in early April. Plot preparation (flagging boundaries and survey points) for the song birds, insect, and small mammal surveys began on April 30, 2012. *Song bird surveys* began on May 5 and finished on June 14. Song bird data entry began in late May and will be further formatted this summer. Preliminary analysis shows that species richness was significantly less in 2011 than in the other three years of study. In both 2011 and 2012, species richness was significantly less in full harvest plots than in controls; this was a decline of 39.8% in 2011 and 23.0% in 2012. Preparation for the August *small mammal surveys* began in mid April and will continue through July. Random *insect* GPS sweep points were generated for all survey periods and plots (March-May). The first round of insect sampling was performed in

the southwest site from May 30th to June15 on all plots and in the west central site between June 18-22 on all plots. Insect pit-fall traps were installed (May 2012) on nine plots in the southwest site and the first round of sampling was performed on June 22-25. Bee bowl sampling posts were installed (April 2012) and surveys were run on April 26-27, May 3-4 with another sampling scheduled for late June or early July. Bloom transects were laid out on nine plots, and quadrat locations flagged on all transects (Early April). Weekly bloom survey began on April 17 2012, data spreadsheet entry began on June 13.

Re-installation of herpetafauna (reptile and amphibian) trap arrays was started on April 3rd and was completed on April 12. Trapping of herpetafauna began on April 12. Data entry into spreadsheets for the summer-long herpetafauna survey started on June 13.

Activity Status as of *(*January 1, 2013*)***:** The wildlife sampling season was completed in early September. Survey markers and equipment, including herpetofauna arrays, insect sampling posts, and small mammals markers, were removed in preparation for harvest. Subprojects that have emerged from Activity 1 include

- *Small mammals*: A preliminary manuscript has been written, covering three years of small mammals survey data. It will be expanded to include 2012 survey results. Preliminary abundance analysis was performed for two small mammals: Microtus (genus-level) abundance declined and short-tailed shrews (*Blarina brevicauda*) abundance did not change. Occupancy analysis (presence/ absence, as opposed to abundance) was performed for seven small mammals: percent harvest affected the presence of both Microtus and masked shrews (*Sorex cinerea*) negatively (i.e. the species/genera was less likely to be found in plots with increasing percent harvest). The magnitude and significance of these changes and subsequent analysis will be discussed in the completed small mammal manuscript.
- *Song birds:* Four years of data are being incorporated into a manuscript. No differences in preliminary analysis were observed in species richness or total number of species, but no abundances increased with harvest. Preliminary results are that four of ten birds surveyed were affected by harvest, including the sedge wren, which is of conservation concern.
- *Game bird nesting:* Daily survival rates were calculated for waterfowl and pheasant nests in harvested and un-harvested areas within the study. Preliminary results suggest that biomass harvest does not change the probability of a nest surviving. The nest density is being compared among harvest and un-harvested regions. Preliminary results show that nest density is higher in the uh-harvested areas, but that this does not translate to fewer nests in harvested areas. Preliminary manuscript is underway.
- *QuIST:* The Quantitative Insect Sampling Technique is a new method for assessing and calibrating standard insect collection methods. Data acquisition is complete and preparation of a manuscript is underway.

- *Herpetofauna*: Reptile and amphibian survey data were identified at a recent project status meeting as being robust and warranting a manuscript. Data is assembled and will be analyzed by project members in spring 2013.

Activity Status as of *(*July 1, 2013*)***:** Insect field survey were complete as of the last field season and the Quist data from those surveys is being analyzed. Two scientific papers are in preparation, one on best management practices for sweep netting and calibrating the resulting data with quantitative exhaustive samples, the other applying those methods.

Activity Status as of *(*January 1, 2014*)***:** Quist data has been analyzed. Two manuscripts related to the Quist method are nearing submission, one on the formula for calculating the volume swept by a net in radial and forward motion, and correcting an erroneous formula that has been in the scientific literature, another on calibrating sweep net data with quantitative exhaustive samples. Manuscripts that result from this quantitative work will show the fraction of each major arthropod group that is captured by sweep netting, which turns out to average only a few percent. Bee and Bloom data has been entered and formatted and data analysis has begun and manuscript has been initiated. A master's thesis by Robert Dunlap on birds and small mammals in the study is nearing completion, with results from that thesis previewed under birds and mammals below.

Birds. We observed a total of 57 bird species in our plots over five years. 11 of which were frequent enough for analysis of abundances. All but two of these were characteristic grassland birds. Red-winged blackbirds and common grackles are not grassland specialists but are generally common in agricultural lands, and are included in the analysis. The common species are Sedge Wren, Common Yellowthroat, Clay-colored Sparrow, Savannah Sparrow, Grasshopper Sparrow, Le Conte's Sparrow, Swamp Sparrow, Dickcissel, Bobolink, Red-winged Blackbird, and Common Grackle. Sedge wren and grasshopper sparrow are designated as Partners in Flight conservation priority species. Le Conte's Sparrow and Dickcissel were only regionally abundant.

Overall, heavier harvesting slightly decreased the number of bird species occupying the sites, but not substantially (Figure 1.1). Individual bird species responded differently, with grasshopper sparrow and common grackle increasing in abundance with heavier harvesting, sedge wren, common yellowthroat, clay-colored sparrow, and swamp sparrow declining with heavier harvesting. and savannah sparrow, Le Contes sparrow, dickcissel, bobolink, and red-winged blackbird remaining unaffected by the intensity of harvesting.

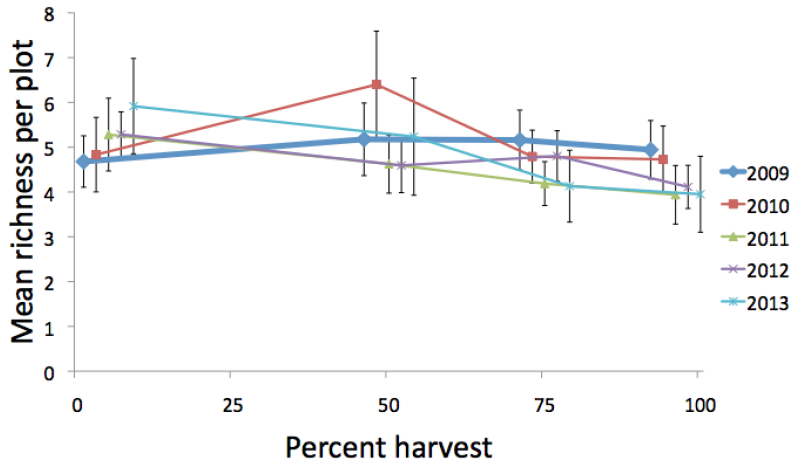


Figure 1.1. The pre-harvest 2009 trend is fairly flat, with slightly more species in harvested plots. This changes somewhat in 2010 with more species present in 50% harvest plots. But for the most part in 2011, 2012, and 2013, the trend was slightly decreasing abundance with greater harvest.

In exploratory models, the amount of grassland and wetland within a quarter kilometer of each plot was important to most species. An interesting discovery from our exploratory models is that harvest pattern (various size blocks and strips) did not seem important to any species in our study, but the number of species was slightly reduced for strip patterns.

Mammals. We observed a total of 11 species/genera of small mammal in our plots over four years of small mammal surveys. Of these, three were common enough to allow analysis of abundance---voles, deer mice, and northern short-tailed shrews. Four other species occurred in lesser numbers---the meadow jumping mouse, thirteen-lined ground-squirrel, short-tailed weasel, and masked shrew. For those we applied presence-absence analyses. Only a few times we observed the northern grasshopper mouse, too infrequently for analysis.

Overall, heavier harvesting does not seem to affect the number of small mammal species occupying the sites (Figure 1.2). Northern short-tailed shrews, meadow jumping mice, thirteen-lined ground-squirrel, and short-tailed weasel were not affected by the intensity of harvest. Voles and masked shrews were reduced and the case was not clear for deer mice, due to low abundance in some years. Population cycles with large fluctuations in abundance are common for many small mammals. No small mammals in our study appeared to be affected by the pattern of harvest.

Voles were most abundant in the northwest region and northern short-tailed shrews were most common in the southwest. However, our species-richness analysis did not identify the region as a significant variable, suggesting that similar communities of small mammals are present throughout the study area.

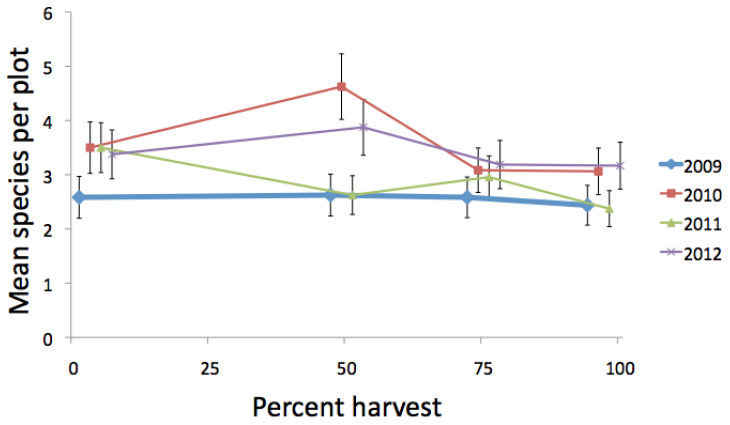


Figure 1.2. The number of species of small mammals is not substantially reduced by increased intensity of harvest.

Final Report Summary: (August 15, 2014):

Small Mammals. Small mammal catch-and-release trapping was performed in Fall 2011 and fall 2012 following the protocols of previous years. A master's thesis by Robert Dunlap on birds and small mammals in the study was completed in 2014 and detailed analysis is presented in there.

In summary, we observed a total of 11 species/genera of small mammal in our plots over four years of small mammal surveys. Of these, three were common enough to allow statistical analysis---voles, deer mice, and northern short-tailed shrews. Four other species occurred in lesser numbers---the meadow jumping mouse, thirteen-lined ground-squirrel, short-tailed weasel, and masked shrew. For those we applied presence-absence analyses. We observed the northern grasshopper mouse a limited number of times, too infrequently for analysis. A note for future researchers is that masked shrews have very high metabolism and catch-and-release traps must be checked frequently to ensure their well-being. Voles were most abundant in the northwest region and northern short-tailed shrews were most common in the southwest. However, our species-richness analysis did not identify the region as a significant variable, suggesting that similar communities of small mammals are present throughout the study area.

Population cycles with large fluctuations in abundance are common for many small mammals, but overall, heavier harvesting did not seem to affect the number of small mammal species occupying the sites (Figure 1.2). Northern short-tailed shrews, meadow jumping mice, thirteen-lined ground-squirrel, and short-tailed weasel were not affected by the intensity of harvest. Voles and masked shrews were reduced as the fraction of the plot harvested increased. The case was not clear for deer mice, due to low abundance in some years. No small mammals in our study appeared to be affected by the shape of harvested area.

These results are significant to grassland management because small mammals occupy a central role in the natural food web, and with appropriate biomass harvesting, such as leaving an unharvested refuge each year within the grassland, that role should not be adversely affected. These results have been incorporated into a best management practices document. Methods used in this portion seem appropriate to questions being asked.

Songbirds. Songbird surveys were conducted in May-June 2012 according to protocols of previous years. A master's thesis by Robert Dunlap on birds and small mammals in the study was completed in 2014 and detailed analysis is presented there.

In summary, we observed a total of 57 bird species in our plots over five years. Eleven species were common enough for analysis of abundances. All but two of these were characteristic grassland birds. Red-winged blackbirds and common grackles are not grassland specialists but are generally common in agricultural lands, and were included in the analysis. The common species are Sedge Wren, Common Yellowthroat, Clay-colored Sparrow, Savannah Sparrow, Grasshopper Sparrow, Le Conte's Sparrow, Swamp Sparrow, Dickcissel, Bobolink, Red-winged Blackbird, and Common Grackle. Sedge wren and grasshopper sparrow are designated as Partners in Flight conservation priority species. Le Conte's Sparrow and Dickcissel were only regionally abundant.

Overall, heavier harvesting slightly decreased the number of bird species occupying the sites, but only by two species or fewer. Individual bird species responded differently, with grasshopper sparrow and common grackle increasing in abundance with heavier harvesting, sedge wren, common yellowthroat, clay-colored sparrow, and swamp sparrow declining with heavier harvesting. And savannah sparrow, Le Conte's sparrow, dickcissel, bobolink, and red-winged blackbird remaining unaffected by the intensity of harvesting.

In statistical models, the amount of grassland and wetland within a quarter kilometer of each plot was important to most species. An interesting result is that harvest pattern

(various size blocks and strips) did not seem important to any species in our study, but the number of species was slightly reduced for strip patterns.

Results have been incorporated into best management practices document which further discusses their implications. Generally, if certain songbirds are targets of management, then their response to harvest in this study should guide management to either leave more or less area as unharvested refuge. Many grassland birds use areas larger than our plot size and this is something to consider in future studies.

Insects. Quist insect sampling, which had begun in Summer 2011 during Phase I of the project, was completed in the southwest region in July and August 2011. Insect sweeps were performed in all sites from May-August 2012. Insect pit-fall traps were run in June July and August 2012 on nine plots (control and full harvest) in the southwest site. Bees were sampled in control and full harvest plots using bee bowls five times between April and August 2012. Bee sampling formed a valuable contribution given the current state of bee decline worldwide.

One manuscript related to the Quist method has been submitted, on the formula for calculating the volume swept by a net in radial and forward motion, and correcting an erroneous formula that had been in the scientific literature. Another on calibrating sweep net data with quantitative exhaustive samples is pending local review and submission. Manuscripts that result from this quantitative work will show the fraction of each major arthropod group that is captured by sweep netting, which turns out to average only a few percent. A calibration table for use with sweep netting is presented in the best management practices document.

June vegetation height (sward height) in unharvested plots appeared to increase through subsequent years as compared to fully harvested plots. This in later months heights appeared equal between treatments. However statistical analysis did not show the June difference to be significant statistically. Therefore sward height simply became a covariate in biomass analysis.

Insect response to harvesting was measured in biomass. Dry weights were taken from each arthropod taxon. Arthropod biomass was affected by harvest, with harvested plots displaying slightly but statistically significantly higher arthropod biomass. Among taxa, this effect is significant for spiders, beetles and flies, but not for true bugs, ants bees and wasps, larvae, or grasshoppers.

Certain functional groups of invertebrates---that is, groups defined by their roles in the ecosystem---are beneficial to humans. Pollinators enable seed and fruit production, and natural enemies (parasites and predators) help control certain crop pests. We counted individuals of these groups from sweep net samples and they showed no degradation due to harvest. Pollinator numbers actually showed a slight statistically significant increase in

the full harvested plots by the last year. (However see next section on bees.) Insects that are natural enemies of other potentially harmful insects showed no significant difference between control and full harvest plots. Study in this area will continue, and continued study by future investigators is suggested. Pitfall data has not been fully analyzed due to time and funding, but will be analysed in future funding. Sometimes grasslands could harbor insect pests or insects that are vectors for plant diseases, but that information is not available from our study.

Bee bowl data has been analyzed and our data do not show that total bee abundance and abundance of small bees and stem nesting bees were not significantly affected by full harvest as compared to control plots. However there is a trend in small stem nesting bees that suggests possible negative impact recommending caution in suggesting that harvest is completely benign. One flaw with this data set is that it did not include the pre-harvest bee community, due to its start date, so we are unable to make that comparison. Bee populations fluctuated greatly during the study, highlighting the benefits of long term monitoring for bee research.

Bee bowls are an efficient way to sample bees. Though other researchers are showing it does not sample the full community, it can still show effects of an experimental treatment. Sweep netting is also efficient but vegetation height turns out to be important. Although valuable and necessary to this project, Quist is time consuming and instead we recommend our calibration table or including vegetation height in sweep net analysis wherever possible. Any research involving insects would benefit from focused goals and significant time or funds allocated to processing samples and identifying insects.

Herpetafauna. Reptiles and amphibians were surveyed from April to August in 2011 and 2012 following the successful methods of previous years. This was continued because survey data were robust and warranting future publications. Data analysis was not within the scope of this project but has begun with other funding, and future results will be distributed. We found the arrays we used to be more effective than lone bucket traps. The following reptiles and amphibians identified in our southwest study area.

Rana pipiens	Northern Leopard Frog	55%
Bufo americanus	American Toad	19%
Thamnophis radix	Plains Garter Snake	11%
Thamnophis sirtalis	Common Garter Snake	6%
Ambystoma tigrinum	Tiger Salamander	4%
Pseudocris triseriata	Western Chorus Frog	3%
Eumeces septentrionalis	Prairie Skink	1%
Bufo cognatus	Great Plains Toad	<1%
Chrysemys picta	Painted Turtle	<1%

Game bird nesting. Game birds surveys were completed during the first phase of this project and analyzed during the current phase. and are incorporated in a publication currently in review.

Biomass harvest can affect nesting biology in at least two ways (1) If harvested areas are less suitable for nesting, nest density would decrease. (2) If harvested areas are less suitable for nesting but waterfowl still nest there, nest predation could increase. We found that the probability of a nest surviving is the same for nests initiated in harvested areas and unharvested areas. Nest predators in the region of this study were not more or less likely to find and consume nests in harvested areas. However, waterfowl preferred to nest in the unharvested regions. Nest density was lower in the harvested regions. It is important to note that there was a similar number of nests initiated prior to the first harvest and following harvest, but that the nests were more concentrated in the unharvested regions.

We found more nests in plots with taller grass and also in those plots that had more abundant wetlands within a 500 meter radius from the plot center (Jungers et al., in review). Waterfowl preferred nesting in upland grassland sites that were near wetlands, and these nests had a better chance at surviving compared to those further from wetlands. Therefore, some regions of upland habitat within conservation grasslands should be left standing if managed for bioenergy, and these unharvested regions should be located near wetlands if possible. This selection strategy should not only help maintain waterfowl populations during harvest, but may also limit harvest inefficiencies due to wet ground.

ACTIVITY 2: Vegetation and soil sampling

Description: Survey crews will measure plant species richness and diversity in all plots. Summer vegetation will be sampled to determine standing biomass stocks. Soil cores will be collected in all plots. Bale cores will be collected in all plots for chemical analysis and dry matter calculations to be used for determining harvest yield. Stubble height will be measured in all plots during harvest.

Summary Budget Information for Activity 2:	**ENRTF Budget:**	**$ 44,199**
	Amount Spent:	**$ 44,199**

	Balance:	**$ 0**

Activity Completion Date:

Outcome	**Completion Date**	**Budget**
Determine biomass productivity and harvest yields.	**Spring 2012-2014**	**$ 44,199**

Activity Status as of *(*January 1, 2012*)*: Vegetation cover surveys were performed in Fall 2011 in all three regions on a total of fifty-eight plots. Biomass samples from approximately twelve points on each of the fifty-eight plots were sampled and weighed. Stubble height was measured at randomized plot locations following harvest in the southwest and west central regions. These data have been entered into spreadsheets and will be further formatted this winter.

Activity Status as of *(*July 1, 2012*)*: Data from the previous biomass samples were analyzed and will be reported in prepared manuscripts (reported under Activity 5). Preparation is underway for 2012 vegetation sampling which will start in late July. Preparation includes generating random sampling points for each of the forty-four plots, training staff, assembling survey equipment, and finalizing data sheets.

Activity Status as of *(*January 1, 2013*)*: Vegetation sampling, including bloom surveys, percent cover, and vegetation transects, were completed in summer 2012, as in previous years. Three subprojects were identified under Activity 2 and will be prepared in separate manuscripts. These include:

- *Bioenergy potential*: This manuscript has been submitted for publication and is currently under peer review. A result of this data is that fall harvest during the first four years of this project had no statistically significant effect on bioenergy potential. That is, four years of harvest did not diminish grassland yield potential.
- *Plant community percent cover*: A preliminary result of this analysis is that no change was observed in composition of plant functional group with harvest. This manuscript is in preparation.
- *Blooms and pollinators*: These data include number and abundance of blooms for 2011 and 2012. Data are assembled and analysis is expected to begin in spring 2013. The working hypothesis for this subproject is that dead litter is cut out (i.e. harvested) leaving space for increased blooms.

Activity Status as of *(*July 1, 2013*)***:** Collection of vegetation data from all years, now completed, were compiled, audited, and analyzed. A publication reporting the effect of biomass harvest on the relative abundance of plant species functional groups and diversity was initiated.

Activity Status as of *(*January 1, 2014*)***:** A publication reporting the effects of biomass harvest on plant composition was completed, to be submitted to the journal Biological Conservation pending co-author approval. This paper describes that biomass yields from conservation grasslands in the south location averaged 4 Mg ha^{-1}, only marginally less than first-year harvest yields from high-diversity mixtures in experimental plots at a nearby agricultural research center. Biomass quality from mixed-species grasslands not managed for bioenergy is similar to dedicated energy feedstocks, in terms of theoretical ethanol conversion efficiency and biomass nitrogen. Almost all of the variation in land ethanol yield was based on biomass yield, and therefore efforts in managed grasslands should be focused on maximizing biomass yield rather than biomass quality, where ethanol yield is a factor. A combination of climate, soil fertility, and plant community factors influence overall bioenergy potential. The effect of forbs and legumes on biomass yield and tissue nitrogen, respectively, were different in the south compared with the central and north locations. A greater proportion of warm-season grasses increased ethanol conversion efficiency. After three continuous years of harvest, with a portion of standing biomass within the harvested area left unharvested, yield did not decrease with number of harvests. Tables and figures below, available in the paper, provide additional detail.

Table 1. Mean biomass yields (Mg ha^{-1}).

Location	2009	2010	2011	2012	Average
South	2.7	2.5	4.0	2.8	3.1
Central	1.6	1.6	2.2	-	1.8
North	1.3	1.6	-	-	1.6

Table 2. Estimated maximal biomass yields (Mg ha^{-1}) from hand-clipped samples.

Location	2009	2010	2011	Average
South	7.1	3.3	4.5	5.2

Central	3.6	2.9	4.0	3.6
North	3.1	2.7	-	2.9

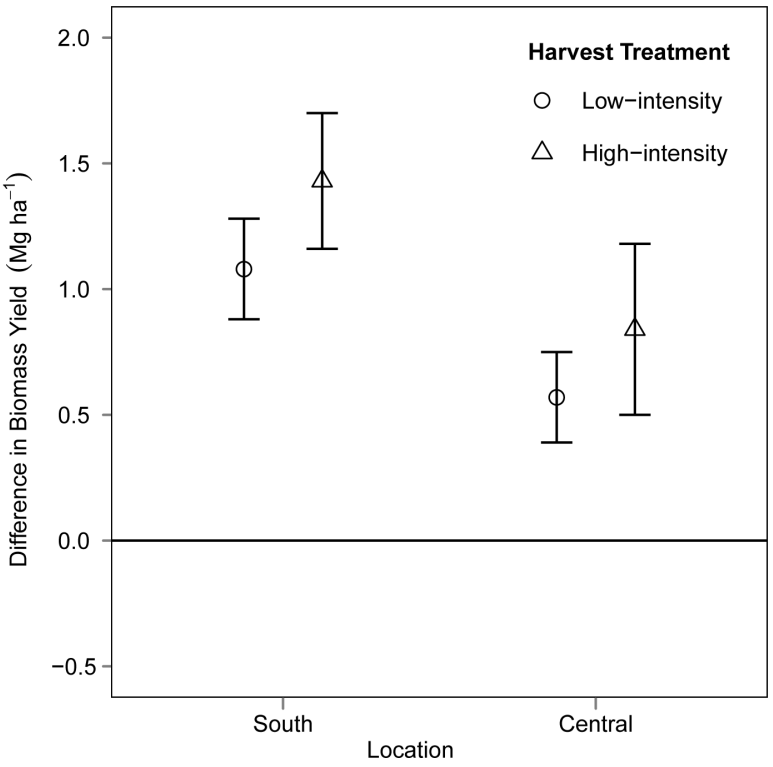


Figure 2.1. Leaving some parts of the field unharvested for wildlife refuges, rotated in different parts of the field each year, does not reduce biomass when those parts are harvested. Fields with refuges of standing biomass (circles) have similar biomass yields through time as those that are completely harvested annually (diamonds). Error bars overlap, indicating no significant differences.

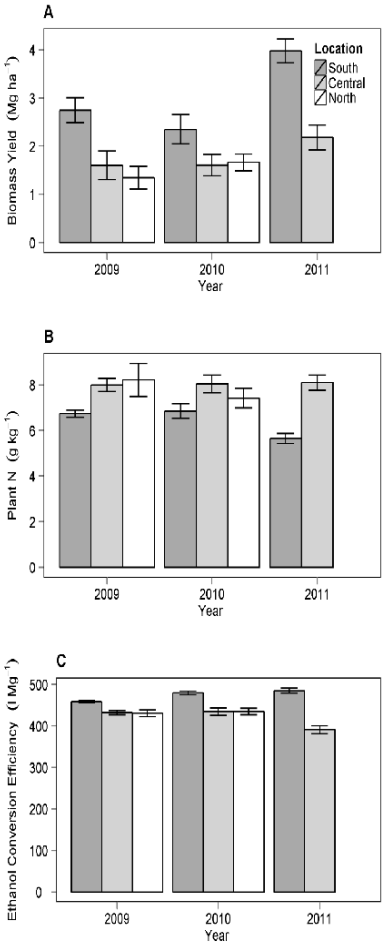


Figure 2.2. Black, gray and white bars are mean values from plots harvested in south, central and north locations respectively. Biomass yield (A) on conservation grasslands is almost double in the south versus the north, plant tissue nitrogen (B) has the opposite trend, and ethanol conversion efficiency (C) does not vary strongly across the region.

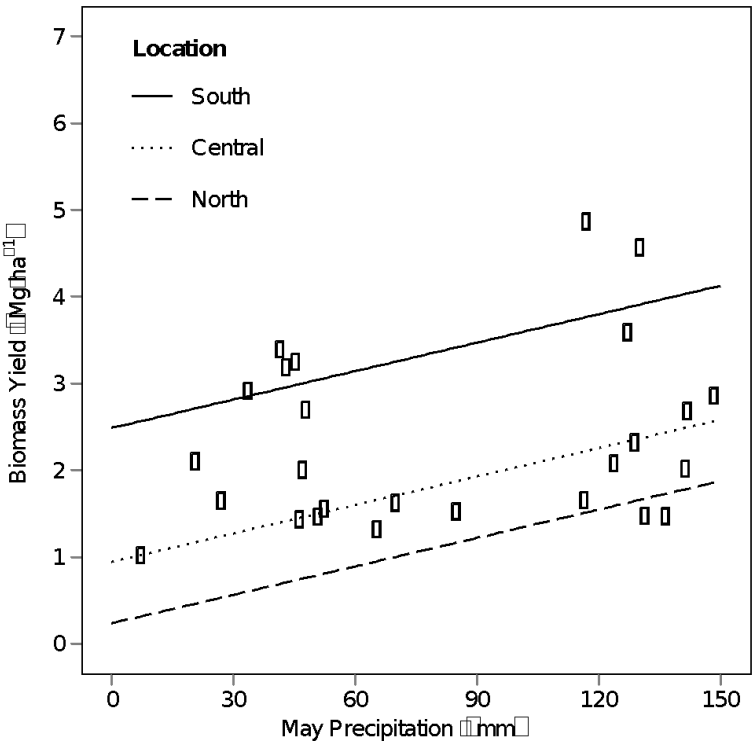


Figure 2.3. May precipitation is an important part of biomass yield. Dots represent average measured biomass yield and May precipitation values. Lines are model estimates for bioenergy yield, with all other things equal at their average values.

Plant community percent cover: It is important to know how biomass harvest will affect the primary objectives of conservation grassland programs, including plant and animal diversity. We have found that late-season biomass harvest did not disturb plant community composition, number of species present, abundance of functional group of plants, or diversity, after four years of harvest. We expect that many habitat and bioenergy characteristics related to plant composition will remain the same where late-season biomass harvest is implemented, as depicted in the figure below.

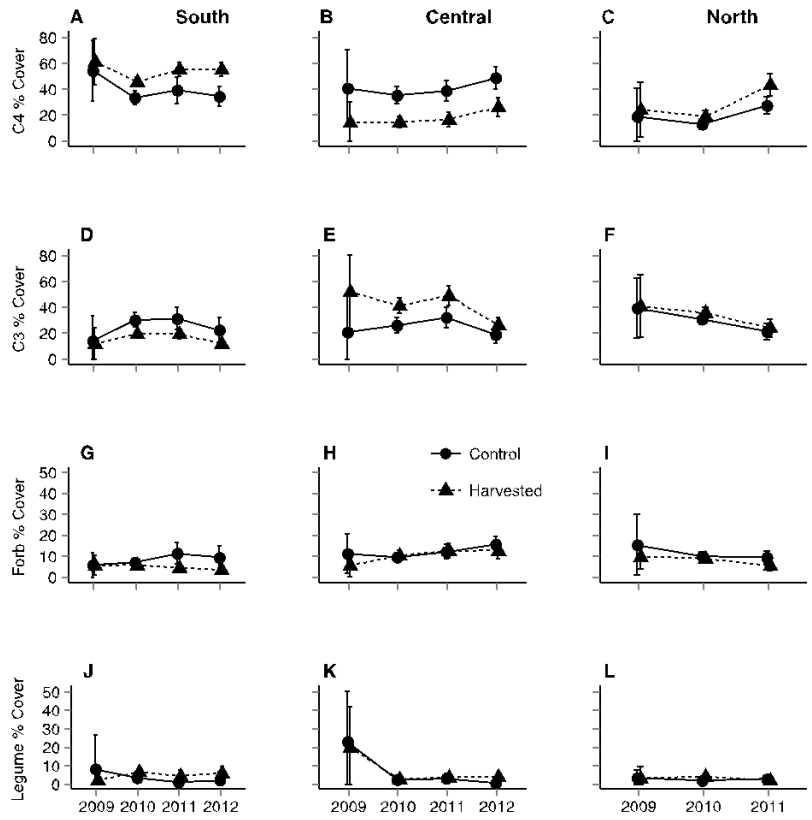


Figure 2.4. Biomass harvest does not significantly affect the composition of conservation plant communities, as shown by the similar trends for harvested (diamonds) and unharvested plots (circles).

Blooms and pollinators: The data include number and abundance of blooms for 2011 and 2012. Data are assembled and analysis is expected to begin in spring 2013. The working hypothesis for this subproject is that dead litter is cut out (i.e. harvested) leaving space for increased blooms.

Final Report Summary (August 15, 2014)**:**

Vegetation cover surveys, biomass samples and stubble height were performed in 2011 and 2012. Soil cores are planned for late summer 2014, using supplemental funding obtained from the University of Minnesota. A new vegetation measure, blooming plant surveys, were conducted once a week during the summers of 2011 and 2012 to correlate with bee abundance data. Transects and quadrats were set up in 9 control and full harvest plots in the southwest region. Species of plants in bloom were counted on transects, and number of blooms per species were counted in quadrats.

A publication reporting on biomass yields and energy potential was completed, Jungers, J. M., J. E. Fargione, C. C. Sheaffer, D. L. Wyse, and C. L. Lehman. (2013). Energy potential of biomass from conservation grasslands in Minnesota, USA. *PLoS One*. 8(4): e 61209. This paper describes that biomass yields from conservation grasslands in the south location averaged 4 Mg ha^{-1}, only marginally less than first-year harvest yields from high-diversity mixtures in experimental plots at a nearby agricultural research center. Biomass quality from mixed-species grasslands not managed for bioenergy is similar to dedicated energy feedstocks, in terms of theoretical ethanol conversion efficiency and biomass nitrogen. Almost all of the variation in land ethanol yield was based on biomass yield, and therefore efforts in managed grasslands should be focused on maximizing biomass yield rather than biomass quality, where ethanol yield is a factor. A combination of climate, soil fertility, and plant community factors influence overall bioenergy potential. The effect of forbs and legumes on biomass yield and tissue nitrogen, respectively, were different in the south compared with the central and north locations. A greater proportion of warm-season grasses increased ethanol conversion efficiency. After three continuous years of harvest, with a portion of standing biomass within the harvested area left unharvested, yield did not decrease with number of harvests. Theoretical ethanol yields suggest that southwesten Minnesota has enough biomass to support a production scale ethanol facility. Tables and figures to this effect are in previous updates and available in the paper.

Plant community percent cover: A paper is in press on this topic, Jungers, J.M., J. E. Fargione, C. C. Sheaffer, D. L. Wyse, and C. L. Lehman. (In Press). Short- term harvesting of bioenergy from conservation grasslands maintains plant biodiversity. *Global Change Biology: Bioenergy*. It is important to know how biomass harvest will affect the primary objectives of conservation grassland programs, including plant and animal diversity. We have found that late-season biomass harvest did not disturb plant community composition, number of species present, abundance of functional group of plants, or diversity, after four years of harvest. We expect that many habitat and bioenergy characteristics related to plant composition will remain the same where late-season biomass harvest is implemented.This is an important result for managers because it means that they can interrupt their normal disturbance schedule to harvest biomass from conservation grasslands without affecting the plant community. Land managers continued some of their usual weed control measures, such as spot spraying thistles, during the study.

Bloom surveys. Data do not show that full harvest significantly reduced or increased bloom abundance or timing. Thus it is likely that fall harvest will have little impact, though harvested

areas did green up sooner in the spring. Full analysis is forthcoming. Bloom survey methods were reasonably practical, though it is difficult to say with present information what quantity of resources for bees various blooming species represent.

ACTIVITY 3: Sample Analysis

Description: Biomass collected from the bale cores will be analyzed for nutrient and sugar concentrations. Sub-samples will be combusted to determine ash and energy content. Soil cores will be analyzed for carbon/nitrogen ratios and other nutrient concentrations. Sweep net and pitfall samples of insects will be sorted to functional group and size, in part to estimate biomass value as food for other wildlife. Insect samples will be sorted by year and collection method.

Summary Budget Information for Activity 3:	**ENRTF Budget:**	**$ 193,465**
	Amount Spent:	**$ 193,465**
	Balance:	**$ 0**

Activity Completion Date:

Outcome	**Completion Date**	**Budget**
1. Determine ethanol, gasification and other energy potential of biomass.	**Spring 2012-2014**	**$6,000**
2. Identify trends in nutrient stocks in soil and biomass to understand ecosystem nutrient sustainability.	**Spring 2012-2014**	**$6,000**
3. Biomass of insects as food source for waterfowl, game-birds, and songbirds.	**Spring 2014**	**$181,465**

Activity Status as of *(*January 1, 2012*)*: Bale cores from all harvest treatments in the west central and southwest region were taken at harvest and analyzed for sugar ratios, macro- and micro-nutrient concentrations. Results from the chemical analyses are being entered into spreadsheets. Insects collected by QuIST and sweepnet methods in Summer 2011

(project Phase I) are being analyzed by project members in labs at the U of M and Cedar Creek.

Activity Status as of *(*July 1, 2012*)*: Biomass samples from 2011 have been analyzed. Data have been processed, grouped, and assigned to project members, and results are being written into project publications. Sorting of 2011 insect samples was completed in January and the data was entered. Analysis and manuscript preparation of insect data from the QuIST absolute sampling method was begun February-March. Data from insect sweepnet, pitfall and bee bowls from 2011 has been entered and prepared for the analysis which will be conducted after the 2012 season. Processing of 2012 insect samples began in June 2012. No new information on trends in insect data are available at this stage. 2012 samples appear comparable to previous years, with perhaps fewer bees captured in 2012. Small mammal data from 2009-2011 was analyzed over the winter and will be written up once 2012 data is collected. Data will continue to be analyzed by project members in labs at the U of M and Cedar Creek.

Activity Status as of *(*January 1, 2013*)*: The emphasis of Activity 3 is determining harvesting effects on *insect biomass*. Insects collected via sweep nets and pitfalls during summer 2012 were classified and tallied by project members and a team of undergraduate researchers at Cedar Creek Ecosystem Science Reserve. Data were incorporated with previous years and analysis and manuscript preparation is underway. Preliminary analysis found insect biomass, as length-weighted counts, increased after one harvest. Also, from zero (control plot) to full harvest there is a statistically significant harvest effect.

Activity Status as of *(*July 1, 2013*)***:** A summary of theoretical ethanol potential based on bale core analysis is published in the peer-reviewed article “Energy potential of biomass from conservation grasslands in Minnesota, USA” published in the open-access journal *PLoS One.*

Activity Status as of *(*January 1, 2014*)***:** No further sample analysis was performed in this time period, pending information from the final field season.

Final Report Summary (August 15, 2014)**:**
Bale cores from all harvest treatments in the west central and southwest region were taken at harvest in 2011 and analyzed for sugar ratios, macro- and micro-nutrient concentrations. A summary of theoretical ethanol potential based on bale core analysis is given in the final report summary of Activity 2 and in published in the peer-reviewed article “Energy potential of biomass from conservation grasslands in Minnesota, USA” published in the open-access journal *PLoSOne.*

Insects were analyzed by project members in labs at the U of M and Cedar Creek. Sorting and processing was completed in January 2013. Insects of each taxa division and length class were dried and weighed and a chart produced in 2013 to calculate insect biomass. In June 2014 an expert in bee identification was contracted to identify more difficult species. Results of this data are discussed in Activity 1.

ACTIVITY 4: Production-scale biomass harvest

Description: Each plot will be harvested using farm-grade harvesting equipment. Each plot will have an assigned harvesting regime, which includes a precise size and shape of refuge. Refuges will be left as 50%, 25%, and 0% of the plot and left as either a block or a set of equally distributed strips. Refuges will rotate annually within the plot. Harvesting will take place after the primary nesting season when plants have senesced, yet before spring green-up. This category covers transportation of the biomass.

Summary Budget Information for Activity 4:	**ENRTF Budget:**	**$ 86,313**
	Amount Spent:	**$ 86,313**
	Balance:	**$ 0**

Activity Completion Date:

Outcome	**Completion Date**	**Budget**
1. *Provides treatment effects for experiment*	**Fall 2014**	**$ 86,313**

Activity Status as of *(*January 1, 2012*)*: Harvest for the southwest and west central regions began at the end of September 2011 in the west central region, and was completed in early November 2011 in the southwest region. All plots in these regions were dry and able to be harvested per their refuge regime. A total of 1537 bales were created in the southwest plots and 479 on the west central plots. No harvesting was done in the northwest region in Fall 2011 due to expense, although ruts from the wet 2010 harvest were repaired.

Activity Status as of *(*July 1, 2012*)*: Land-use contracts between project management and landowners are in development. Negotiations between project management and harvest contractor are in progress, and a contract is expected to be signed by mid-July.

Activity Status as of *(*January 1, 2013*)***:** Harvesting was completed in late fall by the same harvesting contractor, Minnesota Native Landscapes, as in previous years of the project. This lends consistency year to year and reduces the "learning curve" of locating fields and performing the correct harvest pattern. A drought occurred during summer 2012 in Minnesota and throughout the Midwest. Data from bale cores and harvest outcomes are not yet analyzed, though from preliminary observations in the field, less baled biomass is expected. To maximize efficiency in the field, contractors did not harvest fields where little to no biomass could be harvested due to lack of moisture. Harvest was performed only in the southwestern region, though wildlife and vegetative surveys were conducted in both the west-central (Morris, MN area) and southwestern region (Windom, MN area).

Activity Status as of *(*July 1, 2013*)***:** Biomass yield data from all years, now complete, were electronic-ally entered and formatted for analysis and archival storage. A publication on energy potential of biomass from conservation grasslands was prepared for submission. See a summary of results under Activity 2.

Activity Status as of *(*January 1, 2014*)***:** Biomass harvesting for the project was completed in the late fall of 2012. No harvest was planned or performed in 2013 because there will be no subsequent sampling in 2014, due to project completion.

Final Report Summary (August 15, 2014)**:**
The southwest region was harvested in fall 2011 and 2012 and west central region was harvested in 2011. In 2011 plots were generally dry and harvest went according to plan with 1537 bales from southwest plots and 479 on the west central plots. No harvesting was done in the northwest region in Fall 2011 due to difficulties in that region, and due to expense, although ruts from the wet 2010 harvest were repaired. The same harvesting contractor, Minnesota Native Landscapes, was used throughout the project. This lent consistency year to year and reduced the learning curve of locating fields and performing the correct harvest pattern. In 2012 contractors did not harvest fields where little to no biomass could be harvested due to lack of moisture. A publication on energy potential of biomass from conservation grasslands was prepared for submission, see Activity 2. No harvest was planned or performed in 2013 because there will be no subsequent sampling in 2014, due to project completion. Harvest logistics and recommendations can be found in the best management practices document related to this project. Much of project knowledge of harvesting was learned by examination differing methods. Conservations

grasslands are not as uniform as agricultural fields are and require adaptability and ecological knowledge on the part of harvesters.

ACTIVITY 5: Reports and dissemination

Description: Results will be distributed in the form of academic publications, public reports, project web site pages, local newsprint, and other forms of media. Substantial funds are allocated to this activity because multiple publications are needed for a variety of audiences to disseminate the results of this broad study.

Summary Budget Information for Activity 5:	**ENRTF Budget:**	**$ 65,867**
	Amount Spent:	**$ 65,867**
	Balance:	**$ 0**

Activity Completion Date:

Outcome	**Completion Date**	**Budget**
1. Economic and logistic analysis report of harvest feasibility	**Spring 2014**	**$23,000**
2. Final report for DNR explaining ecological impacts of harvesting for BMP	**Spring 2014**	**$23,000**
3. Multiple peer-reviewed publications on impacts of harvesting prairies for energy	**Spring 2014**	**$19,687**

Activity Status as of *(*January 1, 2012*)*: Project investigator, Clarence Lehman, was interviewed by Scott Rall, Worthington (MN) Daily Globe's outdoors columnist for an article published January 6, 2012. The article discusses how this project may benefit hunters and sportsmen in that area. Dr. Lehman was also interviewed by Carol Davit, Missouri Prairie Journal editor about his work on native prairie. The article, titled "Carbon Storage, Ecological Stability, and Epiphany at Bluebird Prairie," can be found in volume 32, numbers 3 & 4 of the journal. In addition, this interview is linked from the project website (http://ww.cbs.umn.edu/wildlife).

Activity Status as of *(*July 1, 2012*)*: Two manuscripts have been prepared and will be submitted for publication this summer. The first is titled "Energy potential of biomass from conservation grasslands in Minnesota," and is intended for a journal like *PLoS One,* and the second is titled "Short-term harvesting of bioenergy from conservation grasslands maintains plant biodiversity," and is intended for a journal like *Biological Conservation*. These papers will be sent to LCCMR staff as soon they are accepted for publication, or earlier upon request. Manuscript preparation for QuIST absolute insect sampling method, small mammal trapping and bird surveys has begun.

A best management practice report has been prepared and will be updated as necessary throughout the project. Additional modes of dissemination are discussed in the section below.

Activity Status as of *(*January 1, 2013*)***:** Three subprojects were identified under Activity 5. One has been published, the second is submitted, and the third will be prepared at the completion of the project:

- *First year summary of harvest:* Jungers J, Lehman C, Sheaffer C, and Wyse D. Characterizing Grassland Biomass for Energy Production and Habitat in Minnesota, *Proceedings of the 22nd North American Prairie Conference*, 2010. 168-171.
- *Summary of methods:* A manuscript was submitted to the proceedings of the *2012 Sun Grant Initiative Conference* under the title "Bioenergy From Reserve Prairies in Minnesota: Methods for Measuring Harvest and Monitoring Wildlife." All project participants are authors.
- *System integration and dynamics:* This planned manuscript will accompany the final report the LCCMR, as a synthesis of project results and analyses.

Activity Status as of *(*July 1, 2013*)***:** A paper titled "Energy potential of biomass from conservation grasslands in Minnesota, USA" has been published in *PLoS One* and is available for free at *http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0061209*

Activity Status as of *(*January 1, 2014*)***:**
A paper titled "Effects of grassland biomass harvest on nesting ducks and pheasants" was submitted and accepted with revisions to the journal *American Midland Naturalist*, and revisions of been submitted.

A poster summarizing the effects of biomass harvest on plant community composition was prepared and presented by Jacob Jungers at the *Ecological Society of America* annual meeting in August 2013.

A summary of the preliminary results from plant, songbird, waterfowl, and small mammal surveys was presented by Jacob Jungers at the UMN Conservation Biology Seminar in December 2013. Data from this presentation are included under Activity 2 status.

Two manuscripts on Quist method are nearing completion and manuscript on bee and bloom data has been initiated.

Preliminary results of bee data have been reviewed with the Minnesota DNR to aid in their development of best management practices.

Final Report Summary (August 15, 2014)**:**

For the Final Report Summary of Activity 5, please see the related Final Report Summary in Section V, Dissemination, immediately below.

V. DISSEMINATION:

Description: The results of this project will be distributed to a wide range of audiences, from industry to academia. Results will be distributed in the form of academic publications, public reports, project web site pages, local newsprint, and other forms of media. Substantial funds are allocated to this activity to disseminate the results of this broad study in multiple publications for a variety of audiences.

Status as of *(*January 1, 2012*)*: Project investigator, Clarence Lehman, was interviewed by Scott Rall, Worthington (MN) Daily Globe's outdoors columnist for an article published January 6, 2012. The article discusses how this project may benefit hunters and sportsmen in that area. Dr. Lehman was also interviewed by Carol Davit, Missouri Prairie Journal editor about his work on native prairie. The article, titled "Carbon Storage, Ecological Stability, and Epiphany at Bluebird Prairie," can be found in volume 32, numbers 3 & 4 of the journal. In addition, this interview is linked from the project website (http://www.cbs.umn.edu/wildlife).

Status as of *(*July 1, 2012*)*: The project website has been continually updated to reflect seasonal information and photos. Data relevant to land managers has been sent to them.

These include the raw data and results of wildlife surveys on their respective properties. Project member Jake Jungers presented information at the Third Crop Producers Meetings in April. Project member Colleen Satyshur presented information on the project to Cedar Creek personnel and interns in June 2012. An abstract to present information on the effects of grassland biomass harvest on nesting waterfowl was accepted for The Wildlife Society 19th Annual Conference.

Status as of *(*January 1, 2013*)***:** Subprojects discussed under Activities 1-5 are summarized here:

Subproject	*Activity*
QuIST: Insect calibration	1
Small mammals	1
Birds	1
Game bird nesting success	1
Herpetofauna	1
Blooms and pollinators	2
Bioenergy potential	2
Plant community percent cover	2
Insect biomass	3
First year synthesis	5
Summary of methods	5
System integration and dynamics	5

The project website continues and photos are added throughout the year. The survey and harvest data will be publicly shared on the website as reports and papers are published. Project participants actively seek additional funding and recently secured an Institute on the Environment mini-grant which will be used to share and coordinate prairie and wetland research currently being done at the UMN. In addition, project participants continue to coordinate with Minnesotan and outstate groups that are interested in pursuing grassland biomass as a renewable bioenergy.

A poster summarizing project methods was presented at the 2012 Sun Grant Initiative Conference held in New Orleans, LA. The poster shared a title with the submitted paper: “Bioenergy From Reserve Prairies in Minnesota: Methods for Measuring Harvest and Monitoring Wildlife.”

Preliminary results from the waterfowl and pheasant nest surveys was presented in the form of a poster at The Wildlife Society Annual Conference in October 2012. The title of the poster was “Managing conservation grasslands for bioenergy and wildlife: Measuring the effects of biomass harvest on waterfowl and pheasants”. Copies of the posters are available on the project website.

Status as of *(*July 1, 2013*)***:**

Project design and logistics were presented by S. Williams in a poster at the Minnesota Society for Conservation Biology annual meeting on March 16 at Dodge Nature Center in West Saint Paul, MN.

Project status was presented at a special DNR meeting for the purpose on March 26 in Hutchinson MN, titled “Grassland Biomass Harvest Wildlife Impacts, Project Update.” Presented by C. Lehman, J. Jungers, C. Satyshur, and S. Williams.

A project overview was given to participants at the DNR Prairie Partnership meeting on June 26 in Spicer, MN. Presented by C. Lehman and S. Williams. Travel paid by a supplemental UMN IonE mini-grant.

A project overview paper was published in the Sun Grant proceedings, S. Williams, J. Jungers, K. Johnson, C, Satyshur, M. DonCarlos, R. Dunlap, T. Mielke, J. Schaffer, D. Tilman, D. Wyse, R. Moon, T. Arnold, and C. Lehman, 2012. “*Bioenergy from reserve prairies in Minnesota: Measuring harvest and monitoring wildlife*.” Proceedings from Sun Grant National Conference: Science for Biomass Feedstock Production and Utilization, Volume 2, Chapter 5, New Orleans. Online at http://sungrant.tennessee.edu/NR/rdonlyres/78D6D6DF-1610-4A79-A04C-A9278C860C0D/3742/Williams_Shelby.pdf).

A data management paper relevant to the project was published in the computing literature, C. Lehman and A. Keen, *“Using the Centinel Data Format to Decouple Data Creation from Data Processing in Scientific Programs.”* International Conference on Scientific Computing, Proceedings, CSC'13. Journal link

http://world-comp.org/p2013/CSC.html , article link
http://world-comp.org/p2013/CSC7282.pdf .
This paper and one other it references describes the data archival system we developed for this and other projects, and used for this project. Publication funded by other sources.

Status as of *(*January 1, 2014*)*:
Project concepts were presented by J. Jungers at the August 4-9 national meeting of the Ecological Society of America (ESA) at an Ignite session organized by S. Williams. Funded by a supplemental UMN EEB travel grant.

Wildlife and biomass aspects of the project were presented by S. Williams at the national ESA meeting in a special biomass session. Funded by a supplemental UMN EEB travel grant.

Design and status of the duck and pheasant nesting aspects of the project were presented by J. Jungers in a poster at the National ESA meeting. Funded by a supplemental UMN ConsBio student grant.

Results from the project are guiding a new effort, the Midwest Conservation Biomass Alliance (MBCA), combining government, academia, industry, and other organizations. C. Lehman and J. Jungers presented and participated at MCBA meetings in Wisconsin, Missouri, and Iowa, funded by supplemental UMN and external resources. In additional, a UMN IonE mini-grant has been secured for the spring meeting of this group in St. Paul, which will further highlight, promote, and perpetuate the goals of this project.

A second UMN IonE mini-grant has been secured to fund an initiative to connect UMN interests with DNR, TNC, USFWS, and other agencies concerning the broader goals of this project. A preliminary meeting at DNR Headquarters in Saint Paul on July 15, with C. Lehman, J. Jungers, and S. Williams kicked this off.

An overview of the entire project and specific data management practices used in the project were presented to the USGS at the Northern Prairie Wildlife Research Center in North Dakota on October 28 by C. Lehman. They may be interested in adopting or adapting this project's data management practices for broader use. Funded by supplemental UMN grants.

A summary of the preliminary results from plant, songbird, waterfowl, and small mammal surveys was presented by J. Jungers at the UMN Conservation Biology Seminar in December 2013. Attended by LCCMR staff.

A project paper summarizing theoretical ethanol potential based on bale core analysis, J. Jungers, J. Fargione, C. Sheaffer, D. Wyse, and C. Lehman, “Energy potential of biomass from conservation grasslands in Minnesota, USA” was published in the open-access journal *PLoS One.*

A project paper on game birds and biofuel harvest, J. Jungers, T. Arnold, C. Lehman, “*Effects of grassland biomass harvest on nesting ducks and pheasants*” was submitted and accepted by the *American Midland Naturalist* journal, pending revisions that have been submitted.

Final Report Summary (August 15, 2014):

Dissemination of results was maintained throughout the project and continues after its completion. In summary of what is detailed elsewhere in this report, project results were communicated through (1) nine presentations to groups such as UMN, USGS, and MN DNR, (2) two presentation to participating state land managers, (3) two press interviews, (4) three posters at the national conferences, (5) a session of six presentations at the Ecological Society of America's annual meeting, (6) one masters and one doctoral thesis completed, (7) six scientific papers published, in press, or in revision, with others in preparation, (8) contributions to two new emerging organizations, (9) project data communicated and reviewed with the Minnesota DNR to help in their development of best management practices for pollinators, (10) a report of best management practices for managing grasslands for wildlife under harvest being formatted for general publication, and (11) an ongoing project website,

In particular, supporting the above summary, (1) J. Jungers presented information at the Third Crop Producers Meetings in April 2012. (2) C. Satyshur presented information on the project to Cedar Creek personnel and interns in June 2012. (3) Project status was presented at a special DNR meeting for the purpose on March 26 2013 in Hutchinson MN, entitled Grassland Biomass Harvest Wildlife Impacts, Project Update. Presented by C. Lehman, J. Jungers, C. Satyshur, and S. Williams. (4) A project overview was given to participants at the DNR Prairie meeting on June 26, 2013 in Spicer, MN. Presented by C. Lehman and S. Williams. Travel paid by a supplemental UMN IonE mini-grant. (5) Project concepts were presented by J. Jungers at the August 4-9 national meeting of the Ecological Society of America (ESA) at an Ignite session of eight speakers organized by S. Williams. Funded by a supplemental UMN travel grant. (6) Wildlife and biomass aspects of the project were presented by S. Williams at the national ESA meeting in a special

biomass session in 2013. Funded by a supplemental UMN travel grant. (7) Design and status of the duck and pheasant nesting aspects of the project were presented by J. Jungers in a poster at the National ESA meeting in 2013. Funded by a supplemental UMN ConsBio student grant. (8) An overview of the entire project and specific data management practices used in the project were presented to the USGS at the Northern Prairie Wildlife Research Center in North Dakota on October 28 2013 by C. Lehman. They may be interested in adopting or adapting this projects data management practices for broader use. Funded by supplemental UMN grants. (9) A summary of the preliminary results from plant, songbird, waterfowl, and small mammal surveys was presented by J. Jungers at the UMN Conservation Biology Seminar in December 2013. Attended by LCCMR staff. (10) A poster summarizing project methods was presented at the 2012 Sun Grant Initiative Conference held in New Orleans, LA. The poster shared a title with the submitted paper: Bioenergy From Reserve Prairies in Minnesota: Methods for Measuring Harvest and Monitoring Wildlife. Funded by a supplemental UMN travel grant. (11) The waterfowl and pheasant nest surveys was presented in the form of a poster at The Wildlife Society Annual Conference in October 2012. The title of the poster was Managing conservation grasslands for bioenergy and wildlife: Measuring the effects of biomass harvest on waterfowl and pheasants. Copies of the posters are available on the project website. (12) Project design and logistics were presented by S. Williams in a poster at the Minnesota Society for Conservation Biology annual meeting on March 16 2013 at Dodge Nature Center in West Saint Paul, MN. (13) A project overview paper was published in the Sun Grant proceedings, S. Williams, J. Jungers, K. Johnson, C, Satyshur, M. DonCarlos, R. Dunlap, T. Mielke, J. Schaffer, D. Tilman, D. Wyse, R. Moon, T. Arnold, and C. Lehman, 2012. Bioenergy from reserve prairies in Minnesota: Measuring harvest and monitoring wildlife. Proceedings from Sun Grant National Conference: Science for Biomass Feedstock Production and Utilization, Volume 2, Chapter 5, New Orleans. (14) Two data management papers relevant to the project were published in the computing literature by C. Lehman, S. Williams and A. Keen, Adrienne in 2012 and 2013. These papers describe the Centinel data archival system we developed for this and other projects, and used for this project. (15) A project paper summarizing theoretical ethanol potential based on bale core analysis, J. Jungers, J. Fargione, C. Sheaffer, D. Wyse, and C. Lehman, Energy potential of biomass from conservation grasslands in Minnesota, USA was published in the open-access journal PLoS One in 2013 (16) A project paper on game birds and biofuel harvest, J. Jungers, T. Arnold, C. Lehman, Effects of grassland biomass harvest on nesting ducks and pheasants was submitted in 2013 and accepted by the American Midland Naturalist journal, pending revisions that have been submitted. (17) A project paper on calibration of sweep netting results by C. Lehman and C. Satyshur was submitted and is in revision. (18) Two papers describing the archival database system used in the project by C. Lehman, S. Williams, and A. Keen are published in the computing literature. (19) A

masters thesis by R. Dunlap was completed in 2014, entitled "Responses of Songbirds and Small Mammals to Harvests of Native Grasslands for Biofuels in Western Minnesota," T. Arnold advising. (20) A doctoral thesis by J. Jungers was completed in 2014, entitled "Managing Conservation Grasslands for Bioenergy and Wildlife," C. Lehman advising. (21) Project participants continue to coordinate with Minnesotan and outstate groups that are interested in pursuing grassland biomass as a renewable bioenergy. (22) Results from the project are guiding a new effort, the Midwest Conservation Biomass Alliance (MBCA), combining government, academia, industry, and other organizations. C. Lehman and J. Jungers presented and participated at MCBA meetings in Wisconsin, Missouri, Iowa, and Minnesota, funded by supplemental UMN and external resources. In additional, a UMN IonE mini-grant has been secured for the spring meeting of this group in St. Paul, which will further highlight, promote, and perpetuate the goals of this project. (23) Project participants secured an Institute on the Environment (IonE) mini-grant in 2013 being used to share and coordinate prairie and wetland research currently being done at the UMN with DNR, TNC, USFWS, and other agencies concerning the broader goals of the University and of of this project. Meetings within the University and at DNR Headquarters in Saint Paul have been conducted, with S. Williams organizing. (24) A second IonE mini-grant has been secured that funded a regional meeting of the MCBA in Minnesota, with J. Jungers organizing. (25) A third IonE mini-grant has been secured that will fund a training session for biological staff of University and agencies to learn identification of bees, in connection with ongoing pollinator aspects related to this project, with C. Satyshur organizing.

VI. Project Budget SUMMARY:

Funds will employ 9.3 FTE technicians, managers, students and interns to survey and analyze results of wildlife and bioenergy potential from harvested grasslands.

A. ENRTF Budget:

Budget Category	**$ Amount**	**Explanation**
Personnel:	**$ 497,687**	Two full-time research coordinators (3 FTE), project manager (0.2 FTE), 60 months of intern work (5.1 FTE), and a graduate student (1 FTE).
Professional/Technical Contracts:	**$ 67,390**	Contract to harvest experimental plots: MN Native Landscapes Inc.(Selected after competitive evaluation before a panel of forage experts. This company has proved reliable and will continue to be contracted, if quality persists,

		at equal or less cost to maintain consistency in treatments)
Equipment/Tools/Supplies:	**$ 7,188**	Field equipment: Replacement bamboo poles: $75/fifty, flagging tape, replacement small mammal traps: $15 each, microscope parts, bale coring supplies (drill battery: $60, parts for corer: $25, ATV maintenance), sorting supplies, materials for disposable insect pit-fall traps, blades for clippers: $132/six, sample bags: $0.10/bag, cleaning chemicals/tools for small mammal traps, safety equipment for field interns (gloves: $12/pair, hip-boots: $30/pair, safety glasses: $9/pair)
Travel Expenses in MN:	**$ 26,490**	Travel and lodging between St. Paul, Windom, and Morris MN-Based on standard University compensation rates. About 6500 miles/year at $0.51 / mile standard UM reimbursement rate.
Other:	**$ 1,245**	Chemical Analysis: Biomass-150 samples: Mineral analysis ($14/sample), Carbon/Nitrogen ($3/sample) and sugar analysis ($15/ sample). Soil- 195 samples: Carbon/Nitrogen ($4/sample), p.H. Organics, N,P,K ($20/sample)
TOTAL ENRTF BUDGET:	**$ 600,000**	

Explanation of Use of Classified Staff: NA

Explanation of Capital Expenditures Greater Than $3,500: NA

Number of Full-time Equivalent (FTE) funded with this ENRTF appropriation: 9.3

VII. PROJECT STRATEGY:

A. Project Partners: Minnesota DNR, USDA-NRCS, Minnesota citizens.

B. Project Impact and Long-term Strategy: Bioenergy production in Minnesota and around the globe has the potential to improve conditions for wildlife species, but if not properly done, could make conditions markedly worse. The broad consensus among wildlife experts is that diverse ecosystems, such as prairie grasslands or diverse woodlands, offer habitat that is superior for a wide spectrum of wildlife, in comparison with simplified habitats like cornfields or brome grass (Fargione et al., 2009). The present project focuses on such habitats of high biodiversity that can be useful for bioenergy and beneficial to wildlife. It is well understood that biodiversity is good for wildlife, and this project provides information of how management methods can best provide bioenergy production, wildlife protection, and other services to society. Practical question such as how much refuge in a bioenergy system must be maintained as wildlife cover have been part of the experimental examination, necessary biomass industries ramp up to a large scale.

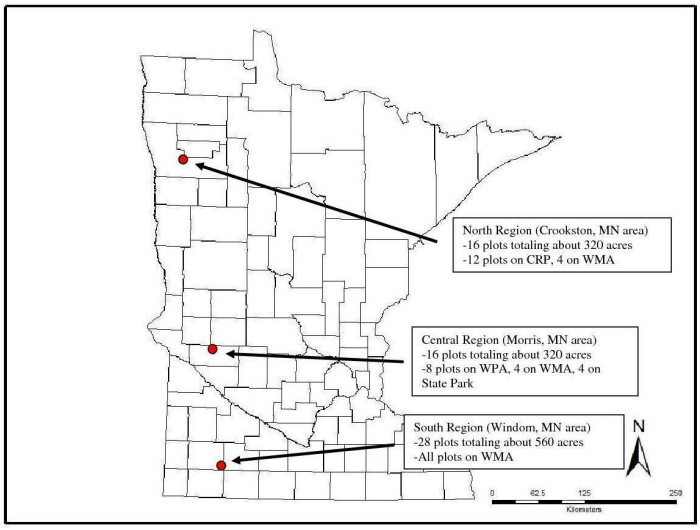
C. Spending History:

Funding Source	*M.L. 2008 or FY 2009*	*M.L. 2009 or FY 2010*	*M.L. 2010 or FY 2011*	*M.L 2011 or FY 2012*	*M.L. 2012 or FY 2013*
ENRTF subd. 3(q)	$750,000				
National Fish and Wildlife Foundation 2009-2011	$300,000				
USDA-Conservation Innovation Grant 2009-2011		$500,000			
UMN-College of Biological Sciences 2010		$60,000			
UMN-Institute on the Environment PWP, SW					$2,000
UMN-Institute on the Environment MCBA, JJ					$2,000

UMN-Institute on the Environment Training, CS					$3,000
UMN-Office of Vice President of Research					$30,000

VIII. ACQUISITION/RESTORATION LIST:NA

IX. MAP(S):



X. RESEARCH ADDENDUM:

XI. REPORTING REQUIREMENTS:

Periodic work plan status update reports will be submitted not later than Jan 1, 2012, July 1, 2012, Jan 1, 2013, July 1, 2013, Jan 1, 2014. A final report and associated products will be submitted between June 30 and August 15, 2014 as requested by the LCCMR.

Attachment A: Budget Detail for M.L. 2011 (FY 2012-13) Environment and Natural Resources Trust Fund Projects

Project Title: Prairie management for wildlife and bioenergy: Phase II
Legal Citation: M.L. 2008, Chap. 367, Sec.[2], Subd. 3(q)
Project Manager: Clarence Lehman
M.L. 2011 (FY 2012-13) ENRTF Appropriation: $ 600,000
Project Length and Completion Date: June 31, 2014
Date of Update: Aug 15, 2014

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Balance	Activity 2 Budget	Amount Spent	Balance	Activity 3 Budget	Amount Spent	Balance	Activity 4 Budget	Amount Spent	Balance	Activity 5 Budget	Amount Spent	Balance	Total Budget	Total Balance
BUDGET ITEM																	
Personnel (Wages and Benefits)																	
Field Coordinator 1: 2 FTE. Organize and manage field sampling of birds, mammals, and vegetation. Oversee vegetative sampling and harvest operation. Help with data for reports. Field Coordinator 2: 1 FTE. Organize and manage field sampling of insects. Organize and manage lab sorting of insects, voucher collection, and data. Project Manager: 0.2 FTE to manage expenses, work programs, and field coordinators. Interns: 4 seasonal interns for 15 months to collect data. 5.1 FTE Graduate Student: 1 FTE. Manage data sets. Design floral surveys and harvest collection protocols. Author manuscripts of vegetation and harvest data.	190,500	190,500	0	38,900	38,900	0	185,100	185,100	0	17,500	17,500	0	65,687	65,687	0	497,687	0
Professional/Technical Contracts Contract for bee identification with an expert in the field, $1.50/specimen identified. Contract to harvest experimental plots: MN Native Landscapes Inc.(Selected after competitive evaluation before a panel of forage experts. This company has proved reliable and will continue to be contracted, if quality persists, at equal or less cost to maintain consistency in treatments)	0	0	0	0	0	0	390	390	0	67,000	67,000	0	0	0	0	67,390	0
Equipment/Tools/Supplies Field equipment: Replacement bamboo poles: $75/fifty, flagging tape, replacement small mammal traps: $15 each, microscope parts, bale coring supplies (drill battery: $60, parts for corer: $25, ATV maintenance), sorting supplies, materials for disposable insect pit-fall traps, blades for clippers: $132/six, sample bags: $0.10/bag, cleaning chemicals/tools for small mammal traps, safety equipment for field interns (gloves: $12/pair, hip-boots: $30/pair, safety glasses: $9/pair)	3,339	3,339	0	83	83	0	2,931	2,931	0	835	835	0	0	0	0	7,188	0
Travel expenses in Minnesota Travel and lodging between St. Paul, Windom, and Morris MN-Based on standard University compensation rates. About 6500 miles/year at $0.51 / mile standard UM reimbursement rate.	16,318	16,318	0	5,215	5,215	0	3,979	3,979	0	978	978	0	0	0	0	26,490	0
Other Statistical consulting at the University of Minnesota, $90/hour, for 2 hours. Chemical Analysis: Biomass-150 samples: Mineral analysis ($14/sample), Carbon/Nitrogen ($3/sample) and sugar analysis ($15/ sample). Soil- 195 samples: Carbon/Nitrogen ($4/sample), p.H. Organics, N,P,K ($20/sample)	0	0	0	0	0	0	1,065	1,065	0	0	0	0	180	180	0	1,245	0
COLUMN TOTAL	**$210,157**	**$210,157**	**$0**	**$44,199**	**$44,199**	**$0**	**$193,450**	**$193,450**	**$0**	**$86,313**	**$86,313**	**$0**	**$65,867**	**$65,867**	0	600,000	**$0**