

2013 Project Abstract

For the Period Ending June 30, 2015

PROJECT TITLE: Enhancing Environmental and Economic Benefits of Woodland Grazing

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FUNDING SOURCE: Environment and Natural Resources Trust Fund

LEGAL CITATION: M.L. 2013, Chp. 52, Sec. 2, Subd. 03j

APPROPRIATION AMOUNT: \$ 190,000

Overall Project Outcomes and Results

Unmanaged woodland grazing is suboptimal for forage growth and grazing animals, degrades potentially productive trees, and increases soil erosion resulting in reduced water quality. Woodland grazing, without proper management, is estimated to occur on 439,332 acres of Minnesota woodlands. As a beneficial alternative to unmanaged woodland grazing, silvopasture, an agroforestry practice, can be employed, which intentionally manages trees, forage, and livestock as a single management unit to increase forage, maintain tree and livestock health, while improving and protecting the environment. To assess the adoptability and merits of silvopasture, three demonstration sites were established in central Minnesota to demonstrate the impacts of silvopasture on water quality as influenced by infiltration rate, plant species diversity, forage production and quality, and livestock weight gain. These parameters were compared among three established systems in each site: 1) OPEN (conventional open pasture), 2) WOODLAND (traditional unmanaged woodland grazing), and 3) SILVOPASTURE. A survey was also administered to natural resource professionals and landowners to determine current use of silvopasture as well as perceptions including perceived benefits and barriers to adoption.

Environmentally, we found that silvopasture is a beneficial alternative land use system on marginal soils and landscapes where no livestock grazing management is practiced, such as those in traditional woodland grazing. In Central Minnesota where soil texture is generally characterized as sandy loam, with predominantly fine and very fine sand, silvopasture can help inhibit vertical subsurface nutrient transport; thereby reducing the risk of water pollution associated with traditional grazing. As such silvopasture can be implemented and integrated into these traditional and marginal grazing systems to minimize impacts on water quality. Species diversity is of great concern in grazing systems. Although, we recorded higher species diversity in the woodland system due to lack of management, we expect that these dynamics might be different over time, with silvopasture exhibiting higher diversity due to management of the system that included thinning (opening gaps), seeding, and fertilization.

Economically, we found that forage production was significantly higher in silvopasture systems than woodland systems (34% higher in 2014 and 52% higher in 2015) that can translate positively to livestock weight gain. Silvopasture systems take advantage of microclimate modifications and forage availability compared to traditional woodland grazing to enhance production. Livestock weight gain in silvopasture did not vary significantly with open pasture, although the performance of livestock in the former system shows promise for greater production once the system is fully established. Economic assessments show that silvopasture costs between 150 and 1,000 US dollars per acre to establish from previously existing farm woodlands, and result in an increased gain of 16 US dollars per acre in calf sales compared to woodland grazing. With the addition of tax breaks and cost share programs silvopasture can be a feasible way to expand a landowners' productive pasture acreage while enhancing environmental protection.

Project Results Use and Dissemination

Various educational opportunities have allowed for the information in this study to be disseminated. These have included two summer field tours, and four indoor workshops in partnership with local partners such as the Crow Wing River Forage Council, and Central Region Sustainable and Development Partnership. These educational events reached over 660 natural resource professionals, and farmers/producers on silvopasture. The field tour included an indoor session with general information about silvopasture, the requirements for establishment, and field visits to project sites to show first-hand the physical differences between silvopasture, open pasture and woodland systems, and to discuss and present project results. The project sites were featured in the agroforestry institute held in June 2015 where 20 natural resource professionals learned about all types of agroforestry including silvopasture, and specifically how these systems can be employed in Minnesota. Project farmer cooperators have seen positive results and are interested in establishing further silvopastoral systems on their land. Natural Resource Professionals who attended the field tours indicated confidence to include silvopasture as a prescription in their forest management development plan for landowners practicing grazing operation. Additionally, the results from this study have been used to develop a Best Management Practices (BMP) handbook in Minnesota to educate landowners and natural resource professionals about silvopasture, starting with planning to maintenance and management activities of the various components of the practice. This handbook will be available online through the University of Minnesota Extension, and printed copies of the handbook will be distributed to local Natural Resource Conservation Services (NRCS), and Soil and Water Conservation Districts (SWCD) offices. The study results and the BMP handbook are now being used by NRCS to develop a silvopasture standard in Minnesota to increase adoption of the practice. Two manuscripts are in the final stages of editing and will be submitted to journals this fall for publication



Environment and Natural Resources Trust Fund (ENRTF) M.L. 2013 Work Plan Final Report

Date of Status Update Report: September 8, 2016

Final Report

Date of Work Plan Approval: June 11, 2013

Project Completion Date: June 30, 2016

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Project Manager: Diomy Zamora, PhD

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Location: Central and North-Central Minnesota (Beltrami, Benton, Carver, Cass, Crow Wing, Itasca, Kandiyohi, Koochiching, Lake of the Woods, McLeod, Meeker, Morrison, Renville, Scott, Sherburne, Sibley, Stearns, Todd, Wadena, and Wright)

Total ENRTF Project Budget:

ENRTF Appropriation: \$190,000

Amount Spent: \$186,581

Balance: \$3,419

Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 03j

Appropriation Language:

\$190,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to evaluate management options for woodlands used for grazing to improve ecological and economic benefits. This appropriation is available until June 30, 2016, by which time the project must be completed and final products delivered.

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I. PROJECT TITLE

Enhancing Environmental and Economic Benefits of Woodland Grazing

II. PROJECT STATEMENT

Over 527,000 acres of unmanaged woodlands are being used for livestock grazing throughout Minnesota. Of that area, 40% (210,800 acres) is located in central and north-central regions representing more than 11,600 farms. Managing these grazed woodlands based on the use of best management practices will provide environmental and economic opportunities. Silvopasture, the practice of intentionally combining and managing trees, forage (grasses), and livestock (i.e., cattle) as one integrated practice, can enhance woodland grazing for environmental protection/conservation and production benefits. Managing the trees, forage and livestock together as a whole can improve functionality and health of the watershed, resulting in an improved water quality in streams, rivers and lakes due to reduced soil erosion and minimization of nitrate leaching.

Nitrogen applied in excess of what the plant uses results in inefficient use by the forage and contributes to nitrogen leaching below the effective rooting zone and therefore moves into the surface, subsurface drainage and groundwater. The complex root systems under silvopasture can mitigate the effects of nitrate leaching into the groundwater as they occupy different soil depths resulting in improved efficiency of nitrogen uptake, reducing nitrogen losses from soil compared with monoculture agronomic crop and tree plantations (Allen et al., 2004; Bambo et al., 2009). Silvopasture also enhances species (plant and animals) diversity. The timber stand improvement in silvopasture allows light to penetrate to the ground prompting seeds stored in the seedbank to germinate and grow for livestock grazing.

Economically, silvopasture maximizes forage production in wooded pastures while building long-term capital in high quality timber. Silvopasture helps avoid economic losses from reduced timber value and low quality of forage that could translate to decreased animal productivity due to inadequate nutrition. Shade from trees may translate to greater forage production, nutritive value, digestibility of pasture grasses grown under trees relative to open sites and mitigation of stress to animals, hence more livestock weight gain.

Because it utilizes best management practices, silvopasture would create a healthier working agricultural landscape. Silvopasture exhibits potential to enhance environmental and economic benefits within Minnesota's hardwood transition zone where livestock production is practiced. Compared to other parts of the US where silvopasture (e.g., Pine-based system) is a common practice, barriers exist in adopting silvopasture in MN because of lack of knowledge of how trees, forage, and cattle can be managed as one integrated system for environmental and economic benefits.

The goal of the study is to assess, monitor and demonstrate the effectiveness of silvopasture as a tool for enhancing woodland grazing particularly for improving water quality, reducing soil erosion, and enhancing plant species diversity while improving economic productivity of livestock producers in central and north-central Minnesota. Based on educational events that we will offer in conjunction with the Leader Lions Forage Council's educational events, approximately 4% of the 11,600 farmers in these regions will adopt some of the demonstrated silvopasture best practices at the end of the project resulting in reduced soil erosion rate, improved water quality, enhanced plant diversity and a healthier forest and agricultural landscape.

III. PROJECT STATUS UPDATES

Project Status as of December 2013

As planned, starting in July 2013 the first field season was focused on site selection and preparation. At each of three locations, three five-acre paddocks were identified, one for open pasture, one for silvopasture, and one for traditional woodland grazing. All 9 paddocks have access to fresh water. A tree inventory was performed in the silvopasture paddocks and trees were marked and removed to achieve a basal area of 40-45 ft²/acre. Downed debris was removed to minimize impediment to forage production. Soil samples were taken in all the plots to analyze nutrients needs. A mix of red clover and timothy were applied broadcast in the first frost in the autumn.

A mix of 2.5 lbs. timothy and 6 lbs. red clover were applied per acre at all open pasture and silvopasture paddocks in late November and early December. Fencing of all paddocks was completed using a two-line electric fence. Fences are currently not activated. Some initial data collection was conducted as well including a vegetation survey but was not completed due to complexity of the process and the time involved to do it. Initial infiltration measurements were also taken using a modified Philip-Dunne falling head infiltrometer to understand geomorphology of the study site. A survey to understand barrier of adopting silvopasture is being developed for landowners and natural resource professionals. A first draft will be completed by the end of the year. The survey will be distributed February after IRB approval. We are also currently working on finalizing methods for the remainder of the project.

AMENDMENT REQUEST February 10, 2014

Approved by the LCCMR February 17, 2013

U of M Extension is requesting a reallocation of \$1,500 into the Professional/Technical/Professional Service Contracts, Farmer Cooperator Fees line item of Activity 1, to cover farmer cooperators fee for the first year of the project, as this expense was inaccurately calculated for two years (years 2 and 3 only) instead of three years during the project budget development process. This request is consistent with the provision in Section 4 as follows and with the verbal agreement made with the farmer cooperators: "Three farmer cooperators have committed the use of their land for land use and cooperative fees to demonstrate, monitor and assess the potential of silvopasture." The \$1,500 annual total is broken down as follows: \$500/year/farmer cooperator x 3 farmer cooperators. This \$500/year cooperator fee was offered by U of M Extension and agreed to by the farmer cooperators in good faith. During the Year 1 project implementation, farmer cooperators provided significant amount of time and efforts in helping the project team set-up the whole experimental design including site preparation that required them to take some time off from their normal work schedule, and the use of their personal farm machineries and equipment; hence they were promised a minimal cooperator fee. The \$1500 will be reallocated from the Professional/Technical/Professional Service Contracts section of Activity 2; specifically \$750 for private forester; and a reduction of the logger fees from \$5550 to \$4800 for a total reallocation of \$1500 from Activity 2 to Activity 1. The project secured a free service from a Professional Forester from the Minnesota Department of Natural Resources (MNDNR) to do the inventory and marking of trees for the study. Further, the Project negotiated a reduced professional fee service with a Logger contractor to cut down some trees in the silvopasture treatment of the study; hence a saving was generated.

AMENDMENT REQUEST September 23, 2014

Approved by LCCMR 9-23-14

U of M Extension is requesting a reallocation of \$14,971 from the Graduate Student salary and fringe category into the Hourly Labor and Site Prep Contractor line items of Activity 2, to offset overdraft on these categories. During the proposal development, the project team never anticipated that the project will cost more to establish the experiment that also required spending more hourly labor costs. The \$14,971 represents savings for one semester from a graduate student salary and fringe category. The graduate student we hired during the first year project implementation resigned due to a change in priority and decided to quit school; hence the savings.

Project Status as of June 2014

The second field season started in June 2014 and was focused on continued site maintenance, livestock introduction and data collection. This included burning brush piles left from logging, seeding and fertilizing the pasture and silvopasture paddocks, conducting soil infiltration tests, collecting vegetative biomass samples, identifying vegetation species, installing vadose zone access tubes, installing rain gauges, conducting fence maintenance, and sorting, weighing and introducing the cows to assigned paddocks. Overall, we now have a functional experiment set up that will evaluate and compare the impacts of managed and unmanaged grazing on water quality, soil erosion, species diversity, livestock performance and tree vigor.

Particularly, on March and April 2014, additional site preparation was continued; primarily what had not been able to be accomplished the previous field season. This included burning brush piles with left over trees and brush from the study site. Also, the silvopasture and open pasture paddocks (treatments) at all three sites were fertilized

with urea 46-00-00 and potash 00-00-60 in early April based on recommendations of the soil analysis (approved by project expert) to address nutrient deficiencies so that we would be able to create a suitable pasture. Half of these paddocks (2.5 acres) were seeded with native grasses: slender wheatgrass (*Agropyron trachycaulum*), fringed brome (*Bromus ciliates*), and Virginia wild rye (*Elymus virginicus*) based on application recommendation rates by BWSR.

Prior to introducing the cows to the assigned paddocks (treatments), soil infiltration tests were employed using the modified Philip-Dunne falling head infiltrometers used during October and November of 2013. These tests were conducted at five sites across each paddock. The locations were chosen randomly, but subjectively, to encompass a representative of the paddock's landscape by choosing different elevations and slope locations. The test sites were marked by GPS and the data was collected and submitted into excel to be further analyzed. These infiltration tests will be conducted again in fall 2014, spring 2015, and fall 2015 in order to compare how vegetation management influences water transport. Three vadose zone access tubes were installed in each of the paddocks. The wells were dug to reach two feet into the water table. Initial values were collected and recorded for temperature, pH, conductivity, and dissolved oxygen and will be monitored throughout the study.

Four cow-calf pairs were introduced to each of the traditional forest, the silvopasture, and the open pasture paddocks in June 2014; totaling 12 cow-calf pairs per site. Prior to their introduction, the cows (no calves) were weighed and the weight recorded.

For the forage assessment, each paddock was split into five separate grids "squares". From each of these grid "squares", one biomass samples was collected at random and one 100-foot long transect was assessed, totaling five biomass samples and five transects per paddock. This was done at every paddock, at all of the sites before the livestock were introduced and again after they were removed. The biomass samples consisted of one square meter cutouts where all the vegetation was harvested with hand shears. The biomass was dried, weighed and recorded. The dried biomass samples will be sent to a lab to be further analyzed for crude protein, acid detergent fiber (ADF, neutral detergent fiber (NDF), total digestive nutrients (TDN), net energy (NE, and relative feed value (RFV). Transects were ran for 100 feet and at every five feet, forage height and species present were recorded. The locations of the starting point of each transect was recorded and marked in order to return to the same area at further dates.

Surveys to aid in understanding barriers and constraints of silvopasture adoption in Minnesota were developed for natural resource professionals and landowners; both were IRB approved. The natural resource professional survey was sent to all natural resource professionals in Minnesota on April 11, 2014, with response rate of 10.5%. We will increase the response rate by re-sending the survey. The landowner survey was tailored for landowners that currently have livestock and woodlands in the designated 20 counties in central and north-central Minnesota (Beltrami, Benton, Carver, Cass, Crow Wing, Itasca, Kandiyohi, Koochiching, Lake of the Woods, McLeod, Meeker, Morrison, Renville, Scott, Sherburne, Sibley, Stearns, Todd, Wadena, and Wright). The survey will be sent via mail, but there have been many obstacles with obtaining landowner addresses.

Project Status as of December 2014

The second year implementation of the project that began in July 2014 focused on collecting data, site maintenance and coordination to ensure that the project runs smoothly. We collected water samples to assess water quality, collected soil erosion data based on assessing infiltration rate potential of the treatments/paddocks, established transects to assess species richness in all treatments/paddocks, collected biomass, assessed forage quality, and assessed livestock health. We also continued to administer the survey to understand the barriers of adopting silvopasture among landowners and natural resource professionals in Minnesota.

Four cow-calf pairs were introduced to each paddock (3 paddocks of 5 acre each thus 9 paddocks overall), representing project treatments as follows: silvopasture, traditional woodland grazing, and open pasture. These cow-calf pairs were introduced at each site at different days due to forage availability. Biomass, species diversity, infiltration rates, water quality, animal health were assessed before and after introducing the cows in the paddocks.

Soil infiltration tests were conducted during the Fall 2013, Spring 2014 and Fall 2014 using the modified Philip-Dunne falling head infiltrometers. These tests were conducted at five site locations across each paddock per research site. The locations were chosen randomly, but subjectively, to encompass a representative of the paddock's landscape by choosing different elevations and slope locations. Each test started with 30 cm of water and ran for 30 minutes or when the water had infiltrated through, whichever was completed first. The purpose of the infiltration tests was to compare and understand how vegetation management and geology influence water transport. Infiltration tests conducted in fall 2013 were intended to measure the base infiltration rates before seeding was completed in the silvopasture and open pasture paddocks. In spring 2014, the infiltration rates were intended to measure any changes in the infiltration rates after seeding. We expected to see an overall increase in infiltration rates due to increased vegetative cover. The last data collection in fall 2014 was intended to monitor any changes due to the introduction of livestock to the paddocks.

After some analysis of the infiltration data, it appears that overall infiltration rates increased in open pasture and silvopasture paddocks in the spring 2014 (after seeding) and then declined in fall 2014 (after cows had been removed). However, there do not seem to be any significant trends at this time. Infiltration rates in the traditional forest paddocks, which were not seeded, differed across project sites. Initial results seem to indicate that cattle compaction, not vegetation management, influenced infiltration rates in the traditional woodland grazing paddocks. Further analysis still needs to be conducted on the relationships between geology and soil types, landscape (elevation and slope), vegetative cover and how they relate to infiltration rates, which will be done in year 3 (2015 growing season).

The second year implementation of the project went through not without any challenges. Forage availability in each site and in each treatment was among the many challenges we experienced in year 2 and was beyond our control. The number of grazing period allowed in each site, which serves as replicates of the study, was based on forage availability. As such we were only able to introduce the cows twice in 2014 growing season, as opposed to original plan of introducing the cows to the paddocks three times during the growing season. Drought that occurred during the middle of the growing season, among others, caused low forage production in our study. Furthermore, logistical needs of our project were and are very challenging. We've experienced several long days of data collection in year 2. Student workers needed to get up very early to pick-up weighing scales in Grand Rapids, MN to weigh the cows for the economic component of the study. Such scale needed to be brought back to Grand Rapids the same day for use by other researchers in the area; thus we spent so much time driving back and forth on a particular data collection day.

Nevertheless, data collected in 2014 growing season, which represents year 2 project data, are now being analyzed and will be used to enhance project implementation for year 3 of the project which will begin in 2015 growing season.

Project Status as of June 2015

We conducted preliminary analysis of data collected in 2014 growing season including soil erosion potential, water quality impacts of woodland grazing, plant species diversity, and livestock weight gain as influenced by forage quality and quantity were analyzed. Initial results indicate that the soil erosion rate potential of managed woodland grazing (silvopasture) is lower, compared to traditional woodland pasture (no management is in place) and in open pasture. Hoof compaction in traditional woodland pasture has increased its soil erosion rate, which could potentially impact water quality. Data on water quality is still being analyzed in the lab. Species richness and diversity also varied among treatments, with Silvopasture systems showing higher species diversity compared to open pasture and traditional woodland grazing. Preliminary analysis also showed greater livestock gain in Silvopastoral compared to traditional woodland pasture but comparable with open pasture. These findings are being validated in 2015 growing season.

The 2015 field season started in 3rd week of May, 2015, with fencer setup and maintenance, species assessment in transects as per previous year protocol and biomass collection in all paddocks at all sites. Height was also recorded in each transect to create a regression function based on dried biomass weights. Biomass samples were dried and weighed. Consistent with data from 2014 growing season, biomass collected from the open pasture was higher followed by silvopasture and then traditional woodland grazing. Species diversity and richness were

calculated based on first data collection in 2015. Silvopasture showed greater species richness, and the open pasture has the lowest. Cow-calf pairs were introduced to each paddock the second week of June and removed the first week of July based on forage availability. Cows and calves were individually weighed before and after introduction to the paddocks. Overall, calves gained weight in all treatments. Each site varied for which treatment showed the largest calf gain, but traditional forest was consistently lower. Pasture height was assessed immediately after cattle removal to estimate forage growth until the next introduction of cattle. Height measurements were taken in 20 locations in each paddock and will be correlated to lbs/acre using a regression function. Soil erosion rate potentials and water quality impacts of our treatments are continuously being monitored for 2015 growing season. One water sampling well at each paddock was extended deeper to accommodate dry periods. Samples were taken from all wells (3 per paddock) the third week of June and will be tested for presence to estimate infiltration rates.

In February, 2015 surveys were sent out to landowners in designated counties (Beltrami, Benton, Carver, Cass, Crow Wing, Itasca, Kandiyohi, Koochiching, Lake of the Woods, McLeod, Meeker, Morrison, Renville, Scott, Sherburne, Sibley, Stearns, Todd, Wadena, and Wright) through snail mail. Reminder postcards were sent out one month after surveys were sent out to those that had not yet responded. Surveys are currently in the process of being entered into spreadsheets and will be analyzed thereafter. Natural Resource Professionals surveys were conducted online through Qualtrics and have undergone initial analysis. There were 45 surveys returned for the Natural Resource Professionals Survey, which was a 30% response rate. Initial findings include that there are very few (2%) of Natural Resource Professionals know a lot about silvopasture. Lack of information and knowledge and lack of technical assistance were identified as major barriers to silvopasture adoption. Expenses to the landowner and lack of financial incentive were also important barriers to adoption. Additional analysis using statistical method will be done to determine and compare perceptions between landowners and professionals about silvopasture.

AMENDMENT REQUEST August 10, 2015, 2015

U of M Extension is requesting a reallocation of \$7,384 to the Graduate Student salary and fringe category from the following budget line items: 1) Logger to cut down and remove trees (\$1,984), 2) Sample Analysis Costs (\$3,000), and 3) Maintenance of University of Minnesota's Chute Scale (\$2,400) to cover continuation of the Graduate Student's work on the project such as analyzing data, developing reports and assisting the conduct of outreach activities during the 3rd year implementation of the project. The amounts under these respective line item budgets represent project savings, thus we are reallocating them to pay for graduate student continued work in the project. Also, U of M Extension is requesting reallocation of \$1,412 from the Collaborator's travel (University of Missouri – Dusty Walter) to Supplies category to offset the overdraft expense under this category. It is expected that supplies will be needed as we continue to implement the project forward. Dr. Dusty Walter came to Minnesota and performed his responsibilities of the project without charging the project fund.

Project Status as of December 2015

The 2015 field season continued through September 2015. In July the mid-season forage diversity assessments were completed. Cow-calf pairs were introduced again in August for 2 weeks at each site. Cow-calf pairs were weighed before and after introduction and forage height measurements were taken before and after the introduction. Forage samples were taken for quality analysis and biomass weighing directly before the cows were introduced and once again at the end of the season in late September. At the end of August infiltration studies were completed at all sites. Soil samples were taken in late September and send to the lab for analysis to be compared with pre-study soil tests. The forage samples were also sent to the Stearns DHIA lab in November to be analyzed for nutritional quality. Biodiversity surveys were conducted three times throughout the season (early, mid and late) to estimate biodiversity across the seasons at all sites.

Data entry and analysis took place September –December. Final findings are in the process of being compiled and written into a final manuscript. So far, forage trends are that biomass samples weighed the most in open pasture, then silvopasture followed by unmanaged woodland treatments. Biodiversity findings show that biodiversity varied greatly by site, but generally was higher in the woodland the silvopasture than the open pasture. Cattle weights also varied greatly by site and introduction times, but overall trends show that open

pasture and silvopasture generally had the highest weight gain often followed by silvopasture, but not always. Infiltration, water quality and soil quality data are still in the process of being analyzed.

Overall Project Outcomes and Results

Unmanaged woodland grazing is suboptimal for forage growth and grazing animals, degrades potentially productive trees, and increases soil erosion resulting in reduced water quality. Woodland grazing, without proper management, is estimated to occur on 439,332 acres of Minnesota woodlands. As a beneficial alternative to unmanaged woodland grazing, silvopasture, an agroforestry practice, can be employed, which intentionally manages trees, forage, and livestock as a single management unit to increase forage, maintain tree and livestock health, while improving and protecting the environment. To assess the adoptability and merits of silvopasture, three demonstration sites were established in central Minnesota to demonstrate the impacts of silvopasture on water quality as influenced by infiltration rate, plant species diversity, forage production and quality, and livestock weight gain. These parameters were compared among three established systems in each site: 1) OPEN (conventional open pasture), 2) WOODLAND (traditional unmanaged woodland grazing), and 3) SILVOPASTURE. A survey was also administered to natural resource professionals and landowners to determine current use of silvopasture as well as perceptions including perceived benefits and barriers to adoption.

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Project Results Use and Dissemination

Various educational opportunities have allowed for the information in this study to be disseminated. These have included two summer field tours, and four indoor workshops in partnership with local partners such as the Crow Wing River Forage Council, and Central Region Sustainable and Development Partnership. These educational events reached over 660 natural resource professionals, and farmers/producers on silvopasture. The field tour included an indoor session with general information about silvopasture, the requirements for establishment, and field visits to project sites to show first-hand the physical differences between silvopasture, open pasture and woodland systems, and to discuss and present project results. The project sites were featured in the agroforestry institute held in June 2015 where 20 natural resource professionals learned about all types of agroforestry including silvopasture, and specifically how these systems can be employed in Minnesota. Project farmer cooperators have seen positive results and are interested in establishing further silvopastoral systems on their land. Natural Resource Professionals who attended the field tours indicated confidence to include silvopasture as a prescription in their forest management development plan for landowners practicing grazing operation. Additionally, the results from this study have been used to develop a Best Management Practices (BMP) handbook in Minnesota to educate landowners and natural resource professionals about silvopasture, starting with

planning to maintenance and management activities of the various components of the practice. This handbook will be available online through the University of Minnesota Extension, and printed copies of the handbook will be distributed to local Natural Resource Conservation Services (NRCS), and Soil and Water Conservation Districts (SWCD) offices. The study results and the BMP handbook are now being used by NRCS to develop a silvopasture standard in Minnesota to increase adoption of the practice. Two manuscripts are in the final stages of editing and will be submitted to journals this fall for publication

IV. PROJECT ACTIVITIES AND OUTCOMES

Three farmer cooperators have committed the use of their land for land use and cooperative fees to demonstrate, monitor and assess the potential of silvopasture. We will establish and evaluate three systems serving as treatments in each cooperator's farm: 1) conventional (traditional) open pasture, 2) unmanaged (traditional) woodland grazing, 3) silvopasture (managed woodland grazing with trees, livestock and forage together). Effects on water quality, erosion rate, and plant species diversity for each of these systems will be monitored and assessed. Forage quality and nutritional value, and cattle weight gain will also be assessed. An assessment of the overall economic benefits of silvopasture will also be conducted. Field days will be hosted in partnership with the Leader Lions Forage Council to educate livestock producers about silvopasture.

ACTIVITY 1: Conduct needs assessment and educational programs.

Description

An online-survey using survey monkey will be designed and conducted to help us better understand barriers pasture owners with woodlands may have to adopting silvopasture within the target counties in central and north-central Minnesota (Beltrami, Benton, Carver, Cass, Crow Wing, Itasca, Kandiyohi, Koochiching, Lake of the Woods, McLeod, Meeker, Morrison, Renville, Scott, Sherburne, Sibley, Stearns, Todd, Wadena, and Wright). The survey would implement strategies described by Dillman et al. (2009). Prior to initiating the online survey, the target audience will be contacted via postcard containing information about the purpose and intent of the survey. The survey protocol (e.g., survey instrument, correspondence to be sent to individuals) will be developed by the Project Team with the assistance of the University of Minnesota Extension Evaluation Specialist, in cooperation with one or more nongovernmental organizations (NGOs) (e.g., MN Cattleman's Association, Minnesota Milk Producers Association, and the Leader Lions Forage Council) who have knowledge of our target audience. Questions will be developed around 1) demographics (respondent age, farm size, woodlot size, herd size, water and fencing resources), 2) satisfaction with current grazing practices, 3) current use(s) of their woodlands, 4) use of woodlands for grazing (prior use for this purpose, perceptions about its use in the future), 5) prior knowledge about and perceptions of silvopasture, and 6) how they prefer to learn (e.g., face-to-face workshops, field day visits to plots, printed content, digital text, webinars).

Survey data will be entered into Excel and analyzed using descriptive and regression techniques to identify factors which contribute most significantly to implementing silvopasture approaches as well as to help us determine the "best" approaches for creating effective educational offerings to increase adoption of silvopasture.

Educational programs will be conducted on cooperators' farms reaching at least 110 livestock producers, woodland owners and natural resource managers in central & north-central Minnesota in years 2 and 3 of the project. To create more impact and to minimize cost, field days and workshop will be offered in partnership and conjunction with the Leader Lions Forage Council's summer tour (field tour) and winter workshop for livestock producers in the region.

Summary Budget Information for Activity 1

ENRTF Budget: **\$12,740**
 Amount Spent: **\$10,893**
 Balance: **\$1,847**

Activity Completion Date:

Outcome	Completion Date	Budget
1. Survey questionnaires approved by UMN Institutional Review Board (IRB), beta-tested, and sent-out online;	December 2013	\$ 1,000
2. Survey data collection completed.	March 2014	\$ 0
3. Survey data analysis completed and recommendations provided for creating educational programs; a framework for education program developed.	May 2014	\$ 0
4. One in-door workshop offered each year for years two and three targeting at least 50 producers per year. Funds will be used to cover promotional materials for the workshop @ \$500/workshop x 2 workshops during the entire project	Winter 2014 and winter 2015	\$1,000
5. One field day conducted each year during years two and three reaching at least 60 producers per year. Cost will include bus rental, promotional materials, and one travel each year to arrange logistics for the tour.	Summer 2014 and summer 2015	\$2,000
6. Land rental fee to the landowner @ \$30/ac x 12 acres/landowner x 3 landowners x 3 years where the research activity is conducted and for allowing to set-up demonstration of silvopasture in their sites for 3 years. The rate is based on NRCS rate. Farmer cooperators assume all liability for the use of their cattle for the study and for people attending the field tours.	July 2013 to June 2016	\$3,240
7. Farmer Cooperator Fee @ \$500/year x 3 years x 3 farmer cooperators- The farmer cooperator's fee will cover cost incurred by farmers (such farmers' time in preparing and hosting field days causing them to take time off from their normal work/field operations. Preparation includes setting-up tent, rent portable potty, chairs and tables necessary during field tour), and helping project to set-up the experiment that involves taking time off from regular work and use of personal farm machineries and equipment.	Fall 2013 Summer 2014 and summer 2015	\$4,500
6. Post survey conducted to asses changes in practices and behavior of livestock producers, woodland owners and natural resource managers	January 2016	\$1,000
7. Extension materials (i.e., fact sheet and bulletin series) developed including best management practices (BMP) manual of raising livestock in woodlands will be made available online at (http://www.extension.umn.edu/agroforestry/)	January 2016	\$0

Activity Status as of December 2013

A survey to understand barrier of adopting silvopasture is being developed for landowners and natural resource professionals. A first draft will be completed by the end of 2013. The survey will be distributed in February after Institutional Review Board University of Minnesota approval in early January 2014.

No budget has been spent yet at this time for this activity. A portion of the graduate student's was set aside to develop the survey but the graduate student's salary is paid by the project overall. A portion of the budget for activity 2 will be spent during printing and mailing of the survey questionnaires.

Activity Status as of June 2014

Surveys to aid in understanding barriers and constraints of silvopasture adoption in Minnesota were already developed for natural resource professionals and landowners, and these surveys were already approved by the Institutional Review Board (IRB) of the University of Minnesota. The natural resource professional survey was sent to all natural resource professionals in Minnesota on April 11, 2014. It was sent to 496 individuals via the University of Minnesota's Qualtrics survey software. The survey was opened by 86 (17.3%) natural resource professionals and completed by 52 (10.5%). In addition, seven individuals responded via email expressing their opinions on the subject matter. Due to a very low response rate, we will resend the survey to natural resource professionals during Summer 2014. Data will then be analyzed after the second round of sending the survey.

The landowner survey was tailored for landowners that currently have livestock and woodlands in the designated 20 counties in central and north-central Minnesota (Beltrami, Benton, Carver, Cass, Crow Wing, Itasca, Kandiyohi, Koochiching, Lake of the Woods, McLeod, Meeker, Morrison, Renville, Scott, Sherburne, Sibley, Stearns, Todd, Wadena, and Wright). The survey will be sent via mail, but there have been many obstacles with obtaining landowner addresses. We requested with USDA NRCS and FSA offices' assistance to get addresses of these landowners in these counties but they don't have a database that could query the parameters we set forth for survey. To address the challenges of obtaining landowners addresses in these counties, we will work with county assessors' office to get this information in Summer 2014. Once obtained, the survey will be sent to Landowners.

Three educational programs have been offered to landowners and natural resource professionals about the project through the Winter Educational Program of the Leader Lions Forage Council and through the University of Minnesota Agroforestry Extension Programming held in March and April 2014. At least 150 farmers and natural resource professionals and landowners learned about the project that made them excited to see it on the field through field tours, which will be done next summer 2015.

Activity Status as of December 2014

In March 2014, the Institutional Review Board (IRB) approved two separate surveys involving natural resource professionals and landowners. We sent the natural resource professionals survey online in April 2014 to more than 300 natural resource professionals in Minnesota. However, the survey came back with a very low response rate (10.5%), which prompted us to resend the survey for a second time. The survey was sent out a second time in December 2014 via Qualtrics, an online survey program run through the University of Minnesota. The survey is still tailored for Natural Resource Professionals throughout the entire state from NRCS, SWCD, FSA, and approved MN Stewardship Plan Preparers. The goal is to increase the response rate from the previous survey sent out in April of this year. We are optimistic that response rate will increase at this time around. Nevertheless, we used initial results of the survey to tailor our Silvopasture education through this project among livestock producers and landowners in Summer and Fall 2014.

Getting addresses of landowners practicing grazing in the woods in the 20 counties covered by the study remains a challenge. These counties are Beltrami, Benton, Carver, Cass, Crow Wing, Itasca, Kandiyohi, Koochiching, Lake of the Woods, McLeod, Meeker, Morrison, Renville, Scott, Sherburne, Sibley, Stearns, Todd, Wadena, and Wright. FSA, NRCS and these counties do not have databases of landowners practicing woodland grazing. Utilizing databases of the Minnesota Cattlemen's Association, the Leader Lions Forage Council, and the Beef program of the University of Minnesota Extension, the paper-based landowner's survey will be sent out to respondents on January 15, 2015. The survey aims to understand the barriers of adopting silvopasture among producers.

Two educational events related to the project were offered in Summer and Fall 2014 to landowners and natural resource professionals, reaching 120 individuals. Landowners, producers, and natural resource professionals expressed interest about the project and are hoping to learn more about it during the Summer 2015 field tours that we are going to hold.

Extension materials such as factsheets are also currently being developed based on initial results of the study.

Activity Status as of June 2015

In February surveys were sent out to landowners in designated counties (Beltrami, Benton, Carver, Cass, Crow Wing, Itasca, Kandiyohi, Koochiching, Lake of the Woods, McLeod, Meeker, Morrison, Renville, Scott, Sherburne, Sibley, Stearns, Todd, Wadena, and Wright) through paper mail. Reminder postcards were sent out one month after surveys were sent out to those that had not yet responded. Surveys are currently in the process of being entered into spreadsheets and will be analyzed thereafter. Natural Resource Professionals surveys were conducted online through Qualtrics and have undergone initial analysis. There were 45 surveys returned for the Natural Resource Professionals Survey, which was a 30% response rate. Initial findings include that there are very few (2%) of NR Professionals know a lot about silvopasture. Lack of information and knowledge and lack of technical assistance were identified as major barriers to silvopasture adoption. Expenses to the landowner and lack of financial incentive were also important barriers to adoption. While legal barriers was the least important barrier to adoption, natural resource professionals generally agreed that managing trees on the edges of pastures was identified as the most feasible method for establishment of silvopasture. Additional analysis will be done to determine statistical significance as well as differences between landowners and professionals' responses.

Three extension events were held from January 2015- to June 2015. On February 20, 2015, initial results of the study were shared during the Crow Wing River Forage Council winter event that attended by 80 natural resource professionals, producers and landowners. On June 23, 2015, the Crow Wing River Basin Forage Council's annual summer tour focused on silvopasture and included project sites visit. Informational materials such as pamphlets regarding silvopasture and agroforestry practices were made available to participants during the tour. Fifty natural resource professionals and producers attended the tour. On June 25, 2015, 28 natural resource professionals visited the project sites during the Minnesota Agroforestry Institute. Overall, we reached 158 Natural Resource Professionals, farmers and producers about the project in 2015. One of the notable impacts of the project extension activities is the immediate plan to develop a Minnesota NRCS Silvopasture Standards to aid natural resource professionals in discussing and promoting Silvopasture as a best management practice in woodland grazing.

Activity Status as of December 2015

A poster of the project was presented at the SWCD conference on December 7 to communicate our findings so far. Survey data was entered throughout the summer (June-August) and is currently being analyzed. A literature review was conducted throughout the summer (June-August) and will be used to help compile best management practices (along with data from the study itself). We are currently preparing for a presentation at the Crow Wing River Basin Forage Council winter conference in February.

Final Report Summary

Needs Assessment Surveys

Surveys were developed for two different groups – landowners, and natural resource professionals - to help us better understand perceptions of silvopasture including barriers to adoption. The survey targeted landowners in the following counties in central and north-central Minnesota: Beltrami, Benton, Carver, Cass, Crow Wing, Itasca, Kandiyohi, Koochiching, Lake of the Woods, McLeod, Meeker, Morrison, Renville, Scott, Sherburne, Sibley, Stearns, Todd, Wadena, and Wright. The natural resource professionals' survey was targeted towards all natural resource professionals in Minnesota. The surveys were developed and implemented using strategies described by Dillman et al. (2009). Surveys were developed by the project team with the assistance of the University of Minnesota Extension Evaluation Specialist, in inputs and cooperation with the Crow Wing River Basin Forage Council, who have knowledge of the target audience. Questions were developed around 1) demographics (respondent age, farm size, woodlot size, herd size), 2) satisfaction with current grazing practices, 3) current use(s) of their woodlands, 4) use of woodlands for grazing (prior use for this purpose, perceptions about its use in the future), 5) prior knowledge about and perceptions of silvopasture, and 6) how they prefer to learn (e.g., face-to-face workshops, field day visits to plots, printed content, digital text, webinars). Surveys were approved by the Institutional Review Board (IRB) of the University of Minnesota.

The natural resource professionals' survey was emailed to Natural Resource Conservation Districts (NRCS), Soil and Water Conservation Districts (SWCD), Farm Service Agency (FSA) natural resource professionals and approved MN Stewardship Plan Preparers in all of Minnesota. The survey was sent on April 11, 2014 to 496 individuals via the University of Minnesota's Qualtrics survey software. The survey was opened by 86 (17.3%) natural resource professionals and completed by 52 (10.5%). In addition, seven individuals responded via email expressing their opinions on the subject matter. Due to a very low response rate the survey was re-sent in February 2015. For this second round, the survey was sent to 431 individuals; 56 surveys were opened and 42 were completed, resulting in a 9.7% response rate.

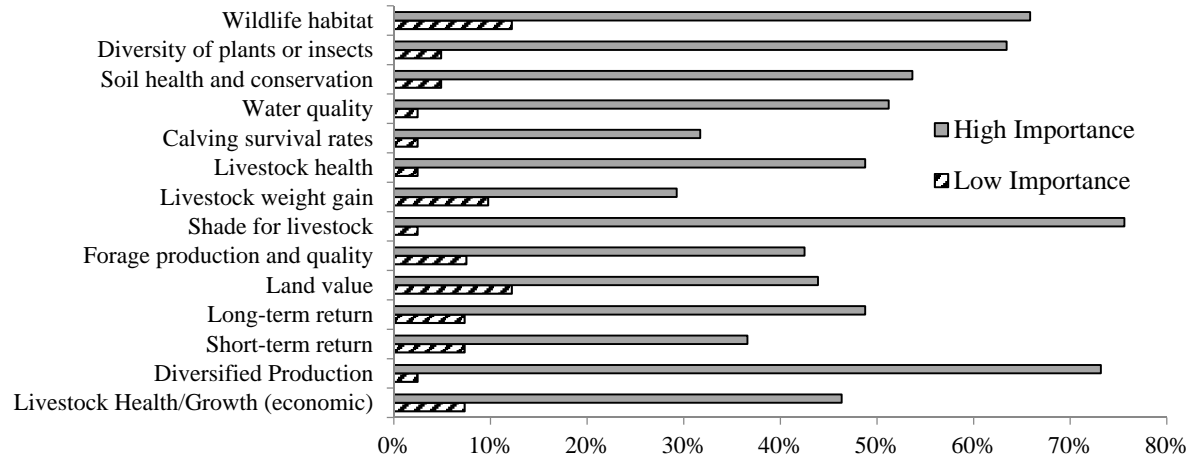
Findings from the survey show that of those who responded to the natural resource professionals (NRPs) survey, 39% were female and 61% were male, and ages ranged from 18 to 69 years with 27% between 18 and 34; 41% between 33 and 54; and 32% between 44 and 69. The majority (93%) of respondents identified their ethnicity as white. Of those who responded, 54% of the individuals work for SWCD, and 32% worked for the NRCS. The remaining 14% is split evenly between those who work for the FSA, and those who are private consultants. More than two thirds of the individuals have been working as a natural resource professional for 6-15 years and 30% of individuals have been working for 21-30 years. The highest number of respondents (37%) reported that crop production is the most common agricultural practice that they help landowners manage followed by pasture with no trees (34%) and pasture with trees (32%). Twenty-seven percent of professionals reported that they use silvopasture as a management tool, mostly between 1 and 25 acres (22%) while 73% of respondents didn't respond indicating lack of use of silvopasture.

Natural resource professional (NRP) respondents indicated increased shade for livestock (mean=4.06: scale of 1 to 5, where 1 is the lowest) and diversified production (mean=3.94) as the most important benefits of silvopasture. Shade for livestock was also the most agreed with benefit of silvopasture based on the landowner respondents. The next two most agreed with benefits for professionals were increased diversity of plants/insects and wildlife habitat (both with mean=3.88) (**Figure 1.1**). NRP respondents indicated lack of information/knowledge as the most substantial obstacle to silvopasture adoption (mean=3.91), which was also the most substantial obstacle for landowner respondents. The next most substantial obstacle was identified as expense of additional management followed by lack of financial incentive (means=3.64. 3.63) (**Figure 1.1**)

Most natural resource professional respondents know at least a little about silvopasture with only 15% reporting they know nothing about it. However, only 2% know a lot about silvopasture. NRP respondents are likely to consider recommending silvopasture (53%), but 7.5% respondents aren't as keen on starting to recommend it. On average NRP respondents were interested in learning more about different aspects of silvopasture; however, NRPs were generally less interested in learning more about these topics than landowners, with an average mean across all categories of 2.55 compared to 3.75 for landowners. NRPs, however, are most interested in learning about tree management (mean 2.7) compared to the other categories.

NRP respondents reported trade journals and neighbors/other farmers (mentioned by 43 and 34 percent NRPs, respectively) as the top sources for forage information. The top rankings for information regarding forestry were professional consultants and trade journals (both 32%). The top rankings for agriculture were trade journals (59%), extension educators (56%), neighbors/other farmers (56%), and professional consultants (56%). Overall, extensions educators (70%) were the most frequently used sources of information regarding any of the three subjects (agriculture, forage and forestry) followed by neighbors/other farmers (58%), professional consultants (63%) and trade journals/magazines (63%).

Benefits



Obstacles

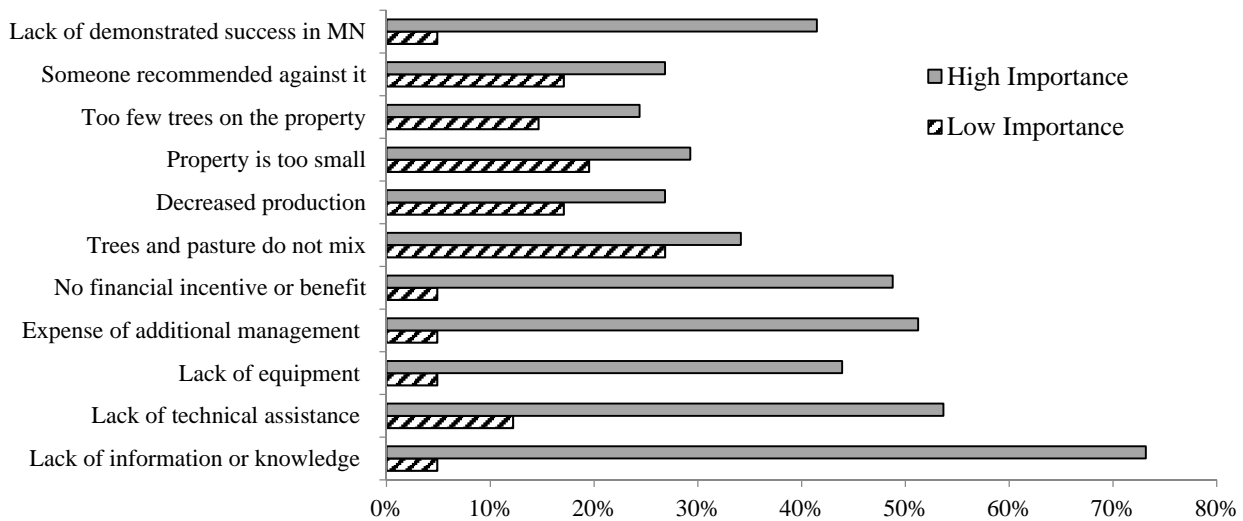


Figure 1.1 Benefits and obstacles of silvopasture as ranked by Natural Resource Professionals.

FINAL Attachment A: Budget Detail for M.L. 2013 Environment and Natural Resources Trust Fund Projects

Project Title: Enhancing Environmental and Economic Benefits of Woodland Grazing

Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 03j

Project Manager: Diomy Zamora

M.L. 2013 ENRTF Appropriation: \$ 190,000

Project Length and Completion Date: July 1, 2013 to June 30, 2016; 3 Years

Date of Update: December, 2013, June 2014, December 2014, June 2015, December 2015, June 2016

PLEASE NOTE: UofM Sponsored Financial Reporting (SFR) will submit separate Official invoices on behalf of Uof M.

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Revised Activity 1 Budget Request (1-25-16)	Amount Spent as of 6.30.16	Balance	Revised Activity 2 Budget Requet (1-25-16)	Amount Spent as of 6.30.16	Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM								
Personnel (Wages and Benefits) - Overall				117,336	117,336	0	117,336	0
1 Graduate Assistant: \$111,423 (54% salary, 46% fringe benefits): 50% FTE								
UMN-CINRAM Economist: \$4,500 (75% salary, 25% Fringe benefits): 3% FTE								
UMN Hyrdologist (\$12,000) 3.9% FTE								
Professional/Technical/Service Contracts								
Private Forester to conduct inventory and mark trees					0	0	0	0
Site Prep Contractor to do site preparation				8,436	8,436	0	8,436	0
Logger to cut down and remove woods				2,816	2,816	0	2,816	0
Hourly Labor as needed for project				23,135	22,819	316	23,135	316
Land Rental fee to Landowner (Farmer) @ \$30/ac x 12 acres/farmer x 3 farmers x 3 years where the research activity is conducted at their farms and for for allowing establishment of silvopasture demonstration site in their farms; Cost also involved cooperators assuming liability for people attending field	4,050	4,050	0				4,050	0

Farmer Cooperators Fee @ \$500/farmer x 3 farmers x 3 2 years covering cost of time involved in hosting field days (setting-up tent, renting portable potty, chairs and tables during field days) and time off from work to help project team set-up the project including the use of machineries and farm equipment.	4,500	4,500	0				4,500	0
Equipment/Tools - Overall				860	756	104	860	104
Water Quality and Soil erosion rate monitoring devices - \$1,060								
Rain Guage and Data Logger - \$500								
1 rectal thermometer - \$300								
Supplies								
Lab and field supplies (seeds, fertilizer, vials, ziploc)				3912	3,879	33	3,912	33
Printing for postcards for survey	1,190	1,130	60	0		0	1,190	60
Travel Expenses in Minnesota						0		
Project Team Travel to project site to implement project (mileage, and lodging, and meals) and offer field tours				18,345	17,838	507	18,345	507
Collaborator 's travel (University of Missouri - Dr. Dusty Walter) to help set-up project				0	0	0	0	0
Other Expenses					0	0	0	0
Sample Analysis costs - overall				2,420	1,808	612	2,420	612
Soil samples analysis - \$1,080						0		
Water Quality samples analysis - \$860						0		
Forage Mineral samples analysis - \$1,620						0		
Forage Samples analysis - \$4,860						0		
Outreach activities to prepare and host 2 field days and 2 workshops (cost includes bus rental, promotional materials)	3,000	1,213	1,787	0		0	3,000	1,787
Maintenance of University of Minnesota's Chute and Scale to be taken at each farm 6 times a year				0	0	0	0	0
COLUMN TOTAL	\$12,740	\$10,893	\$1,847	\$177,260	\$175,688	1,572	190,000	3,419