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 grazig.. 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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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 ft^2/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 $14,971from 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 infiltrations 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.

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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 silvopastur; 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%).

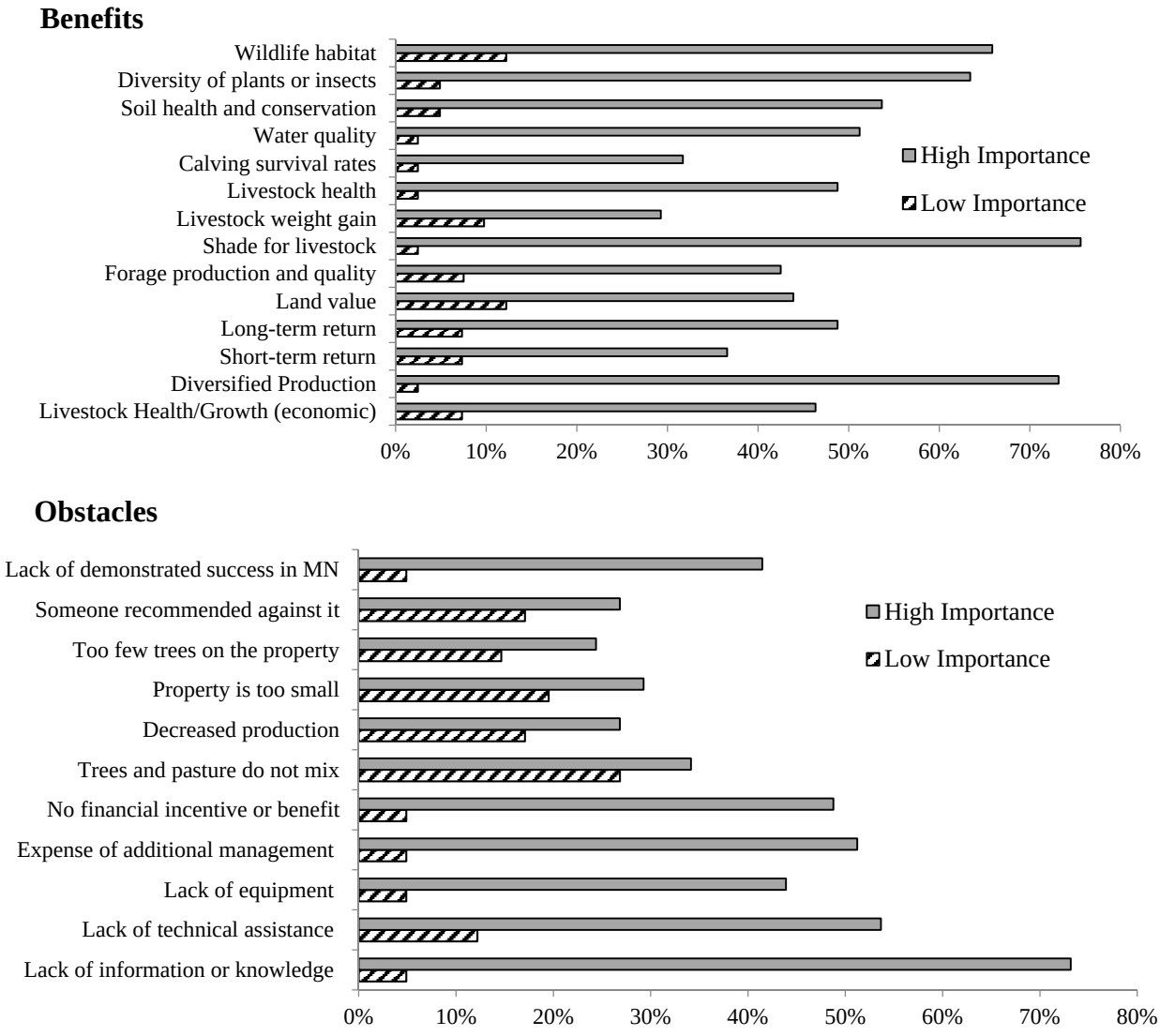


Figure 1.1 Benefits and obstacles of silvopasture as ranked by Natural Resource Professionals.

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 t0 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

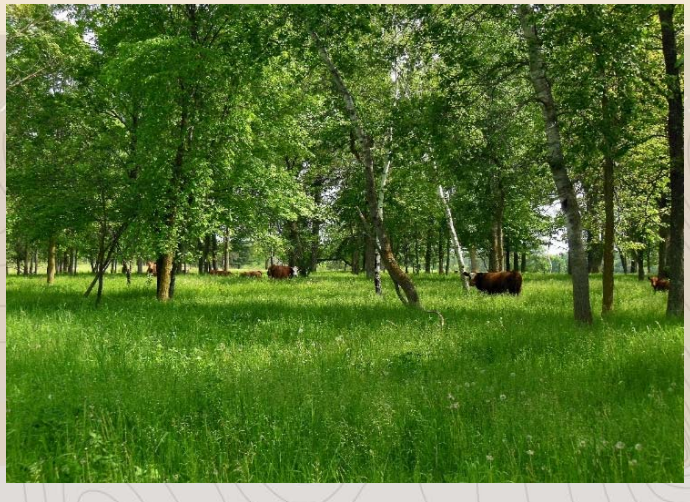
Farmer Cooperators Fee @ $500/farmer x 3 farmers x 3 ~~2~~ years covering cost of time involved in hosting field days (setting-up tent, renting portable potty, chairs and tables during field days) and time off from work to help project team set-up the project including the use of machineries and farm 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**

UNIVERSITY OF MINNESOTA | EXTENSION

Silvopasture

ESTABLISHMENT AND MANAGEMENT PRINCIPLES FOR NORTHERN HARDWOOD FORESTS IN MINNESOTA AND THE NORTH CENTRAL UNITED STATES

University of Minnesota Extension



Silvopasture

ESTABLISHMENT AND MANAGEMENT PRINCIPLES FOR NORTHERN HARDWOOD FORESTS IN MINNESOTA AND THE NORTH CENTRAL UNITED STATES

This guidebook was created with the hope of increasing the adoption of silvopasture in Minnesota and in other parts of the north-central region. It will serve as a concise field companion when planning future silvopasture.

Acknowledgements

This guidebook was developed as a component of the Legislative-Citizen Commission on Minnesota Resources (LCCMR) funded project "Enhancing Environmental and Economic Benefits of Woodland Grazing" Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 03j.. Funding was also provided by the Central Region Sustainable Development Partnership (CRSDP) – University of Minnesota Extension.

Many individuals generously contributed to the development of this guidebook through original research, review of content, design and editing.

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INTRODUCTION

Silvopasture is an agroforestry practice that intentionally integrates livestock, forage production, and trees into an intensively managed system. In a silvopastoral system, the forage, trees, and livestock complement one another to increase the overall productivity of the land. The practice of silvopasture provides annual income from livestock sales while fostering long-term economic benefits from high value timber products.

Components of Silvopastoral Systems:

In a silvopasture system, management of trees through thinning and pruning helps provide high value timber and ensures that sufficient light is available for forage while grazing animals control competition for moisture, nutrients and sunlight enhancing tree growth. Trees also provide shade for livestock and create a microclimate that improves forage quality. Livestock also promote nutrient cycling and nitrogen fixing forage crops benefit trees.

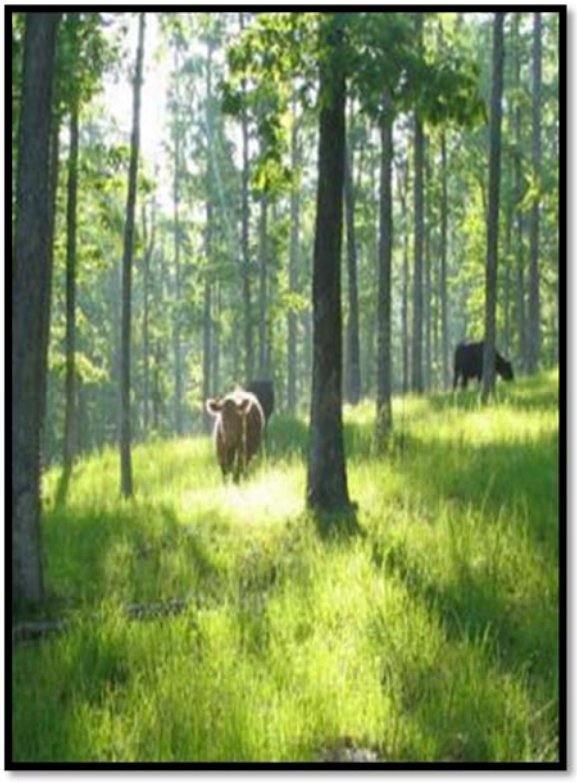
Besides the potential gains from product diversification and improved timber and livestock production, well-managed silvopasture systems can also provide the following benefits:

- Reduced economic risk through product diversification
- Reduced harvesting costs and better access to timber
- Erosion control
- Improved nutrient cycling
- Wildlife habitat
- Improved air quality
- Flood and drought control
- Recreation opportunities
- Improved aesthetics and property values
- Carbon sequestration
- Reduced nutrient runoff and improved water quality
- Reduced fire hazard
- Economic control of weeds
- Reduced habitat for gnawing rodents
- Improved pollinator forage

Due to these benefits, silvopasture is a means of encouraging good forest stewardship while positively influencing productivity and financial gain.

POTENTIAL OF SILVOPASTURE IN MINNESOTA

Silvopasture has great potential as an agroforestry system in Minnesota. The practice has demonstrated success with rotationally grazed cool season forages grown in intensively managed upland oak hardwood forests.



Minnesota has over 650,000 acres of farm woodlands grazed by livestock without the benefit of the application of a silvopasture system. Allowing livestock to graze a natural woodland area without active livestock grazing/forage and tree management is detrimental to the forest and produces very limited forage for cattle. Unmanaged woodland grazing can result in soil compaction or erosion, loss of biodiversity, water contamination, tree damage and reduced timber and livestock yields. Converting unmanaged grazed woodlands to silvopasture can help generate both ecological and financial benefits.

In Minnesota, silvopasture systems can be established in two ways: 1) by thinning existing grazed woodland or 2) planting trees on existing marginal pasture areas. The former allows thinning of trees to a level that supports forages or by removing trees in designated areas to create corridors. Silvopasture systems can be established on existing pastureland by planting single or double rows of trees with forage corridors between them or in groups or blocks (non-linear plantings).

IS SILVOPASTURE RIGHT FOR YOU?

Silvopasture is a management option by which landowners can realize diverse income-generating possibilities and increase productivity from the same acreage of land.

It is possible to establish Silvopasture systems on any land that is capable of simultaneously supporting trees and forage systems. However, the conversion to a silvopasture system typically requires a well thought-out transition and active engagement in the management of the trees, livestock and forage components of the system. When considering whether silvopasture is right for you, consider the following points:

- The transition to silvopasture requires a significant investment in fencing, water distribution, tree establishment or removal, forage establishment and even temporary pastures.
- Silvopasture systems typically require a large land base in order to sustain both continual timber and livestock production.
- The rotational grazing systems necessitated by silvopasture require more labor and regular monitoring as well as more fencing and water facilities compared to continuous stocking.
- Conversion to silvopasture may temporarily interrupt established cattle production cycles.
- Grazing unmanaged woodlands is not a silvopasture practice.

If you are unable to contribute the time and infrastructure necessary to actively and intensively manage the system, then silvopasture may not be the right practice for you.

Silvopasture is not a plant it and leave it system. *Silvopasture does not involve allowing livestock to graze unmanaged woodlands and requires more than one or two trees in a pasture.*

Key Considerations

Cost-share program and tax regulation considerations:

- Many state Natural Resource Conservation Service (NRCS) offices also list silvopasture as a practice that provides program payment for eligible producers.
- In Minnesota, landowners that participate in sustainable forest management can also receive a property tax rebate through the Rural Property Tax Program[1].

Environmental considerations:

- Silvopasture trees and forage species must be well adapted to the site and compatible with the planned livestock management system.
- Adequate soil fertility, pH, and structure provide the foundation for the silvopasture system. Monitor the system for soil compaction and regular soil testing to assess whether additional soil amendments is necessary.
- Protect any streams or water resources on the land. Unmanaged livestock grazing can alter a stream's morphology by causing the deterioration of weakened stream banks, and acting as a nonpoint source of pollution by contributing excess phosphorous, nitrogen, and sediment loads to the water body.

[1] For more information visit: http://www.revenue.state.mn.us/propertytax/factsheets/factsheet_15.pdf

Economic considerations:

Integrating trees, forage and livestock creates a land management system that produces marketable products while maintaining long-term productivity. This system reduces economic risk by producing multiple products with established markets. Production costs are also reduced and marketing flexibility is improved because management costs are distributed between timber and livestock components. Due to these benefits, silvopasture often has a higher internal rate of return compared to other management options. Landowners practicing silvopasture may also be able to generate additional income by:

- Offering recreational activities such as bird watching, wildlife viewing, or hunting on their property.
- Producing fruits, nuts, and materials for crafts, ornamental plants, maple syrup, mushrooms, organic mulch, and other secondary products.

In the future, there may also be opportunities for landowners engaged in silvopasture to earn additional income through payment for ecosystem service programs.

Costs Involved in Silvopasture

Prior to deciding to implement a silvopasture system on your land, consider the following economic costs related to silvopasture establishment, long-term management, or planning and establishment.

Initial Establishment Costs	*Long Term Economic Considerations*

• Site Preparation
  o Costs involved in thinning trees or clearing the area for seedlings (either mechanically or with herbicide) on a pasture (including cost of equipment, labor and cost of herbicide)
  o Tilling or plowing rows for tree planting
  o Soil sampling & fertilizer amendments (as needed)
• Seedling/forage seed costs
• Labor costs associated with planting
• Fencing costs (permanent or temporary, electric or portable polywire, solar or traditional)
	• Tax value classification of the system (do you qualify for tax breaks?)
	• Yearly cost for annual crop/forage establishment (seeds, herbicide, labor, equipment etc.)
	• Fence maintenance
	• Livestock management expenses
	• Watering facilities/structures for livestock
	• Fertilizer amendments (for forage and/or trees)
	• Labor costs for pruning and thinning, and other forest stand management activities.

TREES IN A SILVOPASTURE SYSTEM

Benefits

- Provision of income from the production of high quality timber as well as other products and services.
- Shelter provided by trees decreases livestock stress, improves animal health, increases feeding efficiency and promotes uniform grazing within a pasture.
- Forage growing in a shady, low wind environment near trees is more protein rich, lower in fiber and more digestible for livestock compared to forage growing in open pasture.

Establishment

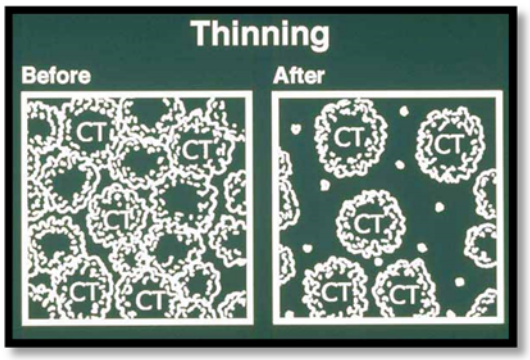
Silvopasture systems can be established in one of two ways:

1. By thinning existing (grazed) forest stands

or

2. By planting hardwood or pine seedlings on existing pasture

From Existing Grazed Forest to Silvopasture



Site Preparation: Thin the stand to reduce its canopy density to establish forage. The canopy density should be thinned by 50%. The goal is to increase the light levels to 30-50% that of open pasture but this can vary depending upon the shade tolerance of the forage species selected. When thinning, select the highest quality trees to maintain as crop trees.

After thinning, clean existing debris and remove unwanted weedy vegetation from the area, with a prescribed burn (if necessary). Prepare the site for seeding as soon as possible after thinning or harvesting so herbaceous vegetation does not have a chance to respond to canopy removal and invade the site.

Forage Establishment: Once the site is prepared, seed immediately to give forage seed an advantage over herbaceous competitors. Establish forage using standard grass establishment techniques. In systems that have been converted from forest to silvopasture systems, it is likely that there will be undesirable understory vegetation besides the desired forage grasses. Manage understory vegetation to facilitate the establishment of the desired forage crop. This can be accomplished through browsing, mechanical treatment or herbicide application. If thistles or other perennial weeds (noxious or invasive species) are in the woodland, control is recommended. Use of systematic herbicide maybe necessary. It is also recommended to seed annual or perennial ryegrass, which will provide cover and will act as a nurse crop for desirable grasses. A fall or dormant seeding before ground freezes, has been successful in many pastures.

Key Message

On converting existing wooded pasture into silvopasture, thinning is necessary to:

1) Improve timber quality of remaining crop trees

2) Allow sufficient amount of light to penetrate into the ground for forage growth

From Pasture to Silvopasture

Site Preparation

- Prepare the site by tilling, mowing or using herbicides to remove competition and establish rows for planting tree seedlings with a non-selective herbicide.

- Spray a strip or circle to provide a 4 to 6 foot diameter "competition free" zone around each tree seedling to avoid competition between forage and trees. Apply prescribed burning or herbicide treatment if necessary in other areas. Do this in fall to control rodents prior to planting.

- Sub-soiling is highly recommended when planting into pasture due to the potential compaction caused by grazing. Sub-soiling must be done along the contour to prevent erosion.

    - Disk the soil if necessary to help break up the sod and incorporate herbicides.

Key Message

Establishing a silvopasture in existing pasture may require intensive seedling management. Seedlings will need protection from grazing and weed/forage suppression and competition control (through subsoiling, herbicides, tillage and/or mulch) may be necessary.

Tree Planting

Purchase seedlings through state-operated or commercial nurseries[2]. When selecting seedlings:

- Use genetically improved tree seedlings when possible.
- Plant large seedlings to help guarantee establishment and early fast growth.
- Select seedlings with well-established root systems. Planting bare root trees in the spring offers the best success and economic value.
- Connect with your Soil and Water Conservation Districts (SWCD) as they sell bare root trees and they may also plant your trees with a tree planter, which is much faster than by hands.

Planting rates are typically from 200 to 400 trees per acre. When planting trees, refer to the following guidelines: http://www.dnr.state.mn.us/treecare/index.html

[2] Refer to the following list of nurseries in Minnesota: http://www.nurserytrees.com/States/state%20Minnesota.htm

Seedling Protection

- Maintain a “competition free” zone around the seedlings for several years until the trees are established.
- Protect new plantings from livestock to prevent browse and trampling. Livestock browsing can damage or kill the tree seedlings. Trampling damage can also cause deformation and weakening of the stem and can provide an entry point for pests and diseases.

- Protect seedlings with either electric or wire fencing. A single strand of electric wire works.
- Seedlings should be protected from livestock until they grow several feet beyond the browse line. In addition, protect trees by rotating cattle frequently and try to keep cattle far from trees when they are transitioning from their winter to summer coat and rubbing is most frequent.
- During the years while the trees are establishing, the area between the rows can be hayed, grazed with a fence protecting the trees, or cropped. Make sure that row spacing is planned to fit the haying equipment that will be used.
- Periodic applications of nutrients may also be necessary to establish and maintain plants.

Herbicides

If herbicides are used to establish or maintain the silvopasture system, it is important to pay special attention to all environmental hazards and site-specific application criteria listed on herbicide labels or in extension or crop consultant recommendations. Consult with your Extension Agent for appropriate herbicide application. Always read and follow label directions.

Species Selection

The right choice of tree crop allows you to carry on a profitable livestock operation while creating a long-term investment in timber and/or forest products. Tree species selection should be done based upon local soil types, site characteristics and limitations, landowner objectives, projected or existing canopy characteristics, and forage, sunlight, marketable value of trees, and moisture requirements.

Trees that can be used for silvopasture in Minnesota include:

- **Black Walnut (*Juglans nigra)*** (Concern: Thousand Cancer Disease)
- **Bitternut Hickory (*Carya cordiformis)***
- **Northern Red Oak (*Quercus rubra*)**
- **White Oak (*Quercus alba*)**
- **Burr Oak (Quercus macrocarpa)**
- **Black maple *(Acer nigrum)***
- **Silver maple (Acer saccharinum)**
- **Sugar maple (Acer saccharum)**
- **Paper Birch (Betula papyrifera)**
- **Green Ash (Fraxinus pennsylvanica)** (Concern: Emerald Ash Borer)
- **Red Pine (Pinus resinosa)**

Consult your County's local forester for appropriate tree species to plant in your site.

Burr Oak Silvopasture in the North Central United States

DESIRABLE SILVOPASTURE TREE CHARACTERISTICS

- Marketability of the wood itself as well as secondary products such as fruits or nuts
- Compatibility with the chosen forage crop and livestock
- High quality
- Fast growing or of such high value that a species of medium growth rate is acceptable
- Deep roots so that trees do not compete with forage for moisture and nutrients
- Rapidly decomposing foliage
- Compatible with local climate, soil type, and moisture
- Canopy produces light enough shade so that forage can be established
- Capable of producing the products you desire

TREE ARRANGEMENT AND DESIGN

Tree Pattern

Trees should be planted or thinned so that they are spaced to optimize growing space and light penetration for high-quality timber and forage. Key factors to keep in mind when establishing a silvopasture design include:

- **Equipment size:** The alley between tree rows should be wide enough to allow the passage of equipment.
- **Forage:** Most forages need a minimum of 50% light. Plan to manage canopy density to produce adequate light for forage growth.
- **Changes through time:** Increased shading occurs as trees mature increasing the need for pruning/thinning.
- **Thinning and pruning:** Timely thinning and proper pruning can increase log value and maintain sufficient sunlight for forage.

Common Planting Arrangements

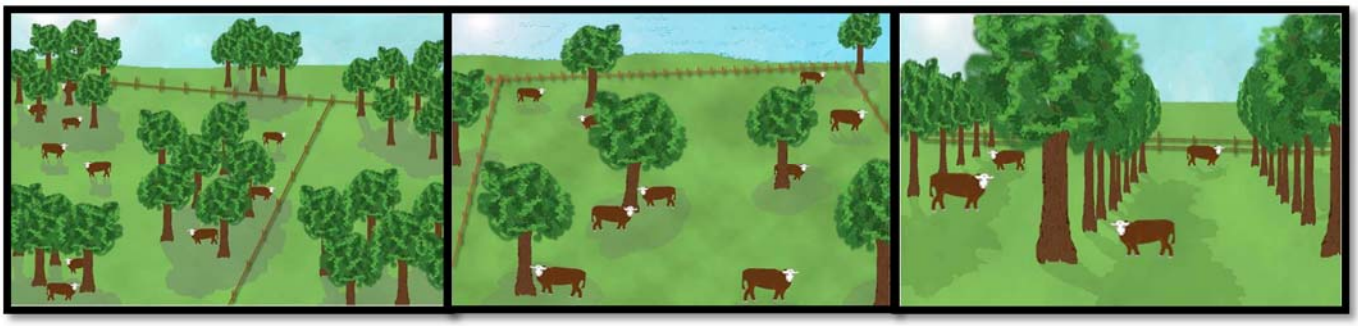
When converting a pasture to silvopasture, tree planting typically occurs in a grid patterns. However, by using different configurations or by establishing tree clusters across a paddock, the time between thinning may be increased and the area available for forage may be maximized.

Single Row Plantings: Trees are spaced about 8 to 12 feet within the row and at least 50 feet between rows, depending on the equipment to manage the forage. Single row configuration depends on your objectives such as better crown space for nut production (if it is the primary objective), simplified maintenance (such as mowing), a diversified landscape, and enhanced farm production.

Double-Row plantings: Staggered tree rows with 8 to 10 feet between trees and rows. Once established, both forage and trees co-exist and can contribute to a highly productive silvopasture system.

Multiple-Row Plantings: Rows of trees at close spacing (8 x 10 feet or 10 x 10 feet) with an alleyway at least 50 feet between sets of tree rows for forage production. Multiple row plantings provide enhanced erosion control, better growth of trees for timber, improved wildlife value, and greater diversification of farm products.

Block Plantings: Evenly distributed tress in block plantings optimize growing space and light for trees and forage. Trees grouped in rows or clusters concentrate shade and root effects, and provide open spaces for pasture production. Thin the plantings routinely to maintain forage production.



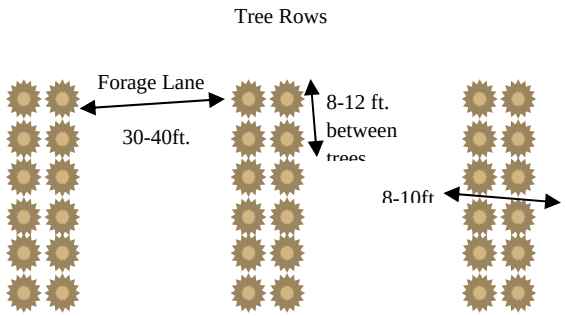
Common Planting Formations: Group plantings, single plantings, and row plantings

Protecting Young Trees from Livestock

Young trees can be protected from livestock by separating livestock from the trees mainly by fencing. This could be in the form of block cages around individual trees or strips of portable fencing appearing like alley cropping."

Spacing and Stand Density

The number of trees per acre will affect the number of thinnings that will need to occur and the types of products that will be produced (i.e. poles, chip and saw lumber, saw timber). In general, lower density stands that are more open tend to favor forage production, accelerate tree diameter growth due to reduced competition, provide easy access for harvest and reduce harvesting costs.



Much wider spacing between tree rows are also feasible depending upon landowner objectives.

Other things to consider while planning tree spacing include:

Within a Row

- Federal/State subsidy program requirements
- Production vs. conservation benefits
- Wood production vs. other tree benefits
- Grafted vs. seedling planted stock
- Markets for small-diameter material

South facing slopes could have a higher tree density because they have more sunlight.

Between a Row

- Production vs. conservation objectives
- Wood production vs. other tree products
- Forage light requirements
- Width of farm equipment

Tree density also has an important effect on cattle distribution within a pasture. When shade is isolated in only a few areas of a paddock, cattle can begin to concentrate in shaded areas, which can damage trees and decrease the overall productivity of the paddock.

Long-Term Tree Management

Once the silvopasture system is established, careful management is necessary to ensure that the timber-forage-livestock system is well balanced. The goal of timber production in a silvopasture system is to produce high-quality timber products.

Canopy Management

Manage the tree canopy between 40 and 60 percent canopy density. Once canopy cover begins to exceed 50-60%, the amount of light reaching the ground will decrease enough that the quality of the forage crop will deteriorate and the system's productivity will decline. Conduct regular thinning and pruning to keep the amount of light necessary for the forages and forbes.

Thinning

Thin trees as needed. The timing of thinning will depend greatly on both tree growth and initial stocking. Remove enough trees at each thinning to maintain sufficient sunlight for forage.

Pruning

Pruning helps ensure that sufficient light is available for forage crops and that the silvopasture system is producing high quality, knot-free wood. Factors to consider include:

- **Trunk diameter:** Once trees are large enough to shade forage, begin pruning to maintain canopy density at around 50%. . Maintain a live crown of no less than 1/3 of tree height.
- **Branch diameter**: Try to remove branches before they exceed four inches in diameter to reduce susceptibility to pests and increase wood quality/growth.
- **Season of year:** The best time to prune living branches is in the dormant season or in late winter or early spring before active growth begins.
- **Refer to** http://www.extension.umn.edu/garden/yard-garden/trees-shrubs/pruning-trees-shrubs/ for proper pruning of branches.

Hardwood trees can develop epicormic branches. Epicormic scars can result in lower log values. From likelihood from likely to less likely it is white oak, black cherry, red oak, chestnut oak, hickory, yellow poplar, red maple, and sugar maple. Image Source: www.agriculture.purdue.edu

LIVESTOCK

Common livestock used include cattle, sheep, goats, horses, turkeys, chicken and hogs. Livestock in silvopastoral systems:

- Provide immediate income
- Help manage weeds and tree/forage competition in silvopasture systems.
- Reduce fertilizer needs by recycling soil nutrients.

Key Messages

1). Carefully monitor the timing and duration of grazing, stocking rates, and carrying capacity of the pasture in order to maintain the quality of the site and ensure tree survival. Insufficient attention to managing livestock by allowing them to roam the system freely without monitoring or managed rotational grazing can result in overgrazing, soil compaction, water contamination, damage to trees and declines in the overall productivity of the system.

2). Develop a comprehensive rotational grazing management plan that includes fencing, rotational grazing schedule, fertilization, placement of watering and supplemental feeding areas.

3.) Monitor trees for browsing, trampling or rubbing and protect them if needed.

4.) Monitor soil for compaction. If the forage stand is thin and does not grow back following removal of livestock, then soil compaction may be a problem (assuming that drought or lack of nutrients is not a factor limiting production).

5.) Remove livestock from the silvopasture area during excessively wet periods to avoid soil compaction and tree damage

Rotational Grazing Systems

A rotational grazing system is a main consideration for livestock management in silvopasture systems. Continuous stocking (maintaining animals in a single pasture during the entire grazing season) is not recommended for silvopasture systems.

A rotational grazing system will help encourage uniform distribution of cattle on the system. Strategically place shade, watering areas, and supplemental feeding areas to encourage uniform livestock distribution within a pasture.

Rotational grazing uses a system of grazing and recovery periods by rotating animals among different cells, paddocks or pastures. Rotational grazing schedules include:

Levels of Management for Livestock

OPTIMAL: Timing livestock access to the area to maximize positive interactions with the forages and minimize negative interactions with tree seedlings. Frequent rotation to optimize forage health

Improved: Moving livestock when forage supply is starting to decline and seedling trees have minimal damage

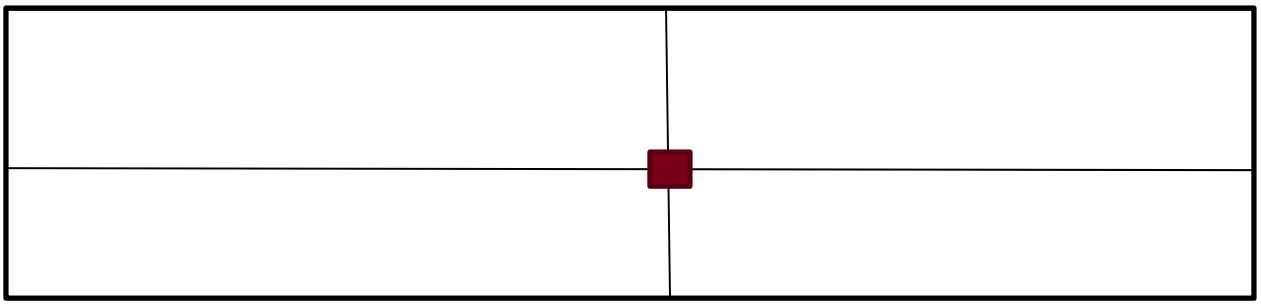
Poor: "Dumping" livestock on an area and leaving for extended periods, causing overgrazing of forages and damage of tree obstacle planting in a row creates a fence that steers animals on pasture pathways between and around tree seedlings

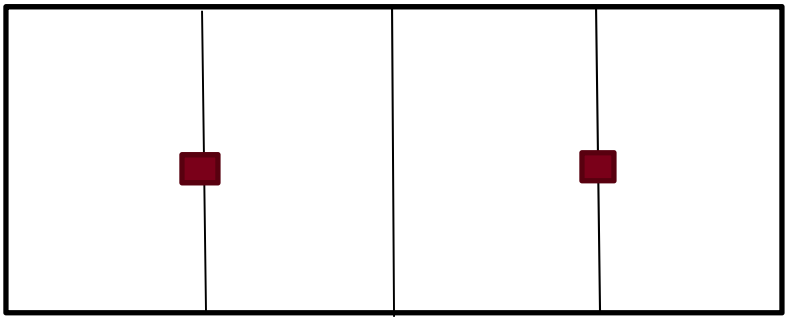
- Grazing periods could range in duration from 1 day to 6 days but should typically be less than 3 days. Establish grazing periods according to the rate of forage regrowth in the paddock rather than following a set of calendar schedule.
- Use higher quality parts of forage plants for grazing (the top third of the leaf) and rotate out the pasture before the animals begin eating the lower quality parts of the plants.
- Rotate paddocks once forage is grazed down 3-4 inches for cool season grasses to prevent effects on forage's root system ability to conduct photosynthesis and ultimately health, vigor and regrowth rate.
- The forage regrowth rate varies based upon several factors including forage species, climate, precipitation, shade, soil nutrients, and time of year. Recovery periods should last between 20-45 days or longer depending upon forage growth rates.
- Plan for management rotation around forage growth to take full advantage of forage quality when it peaks.
- Adjust livestock numbers up and down based upon forage production to manage available forage.

Paddocks

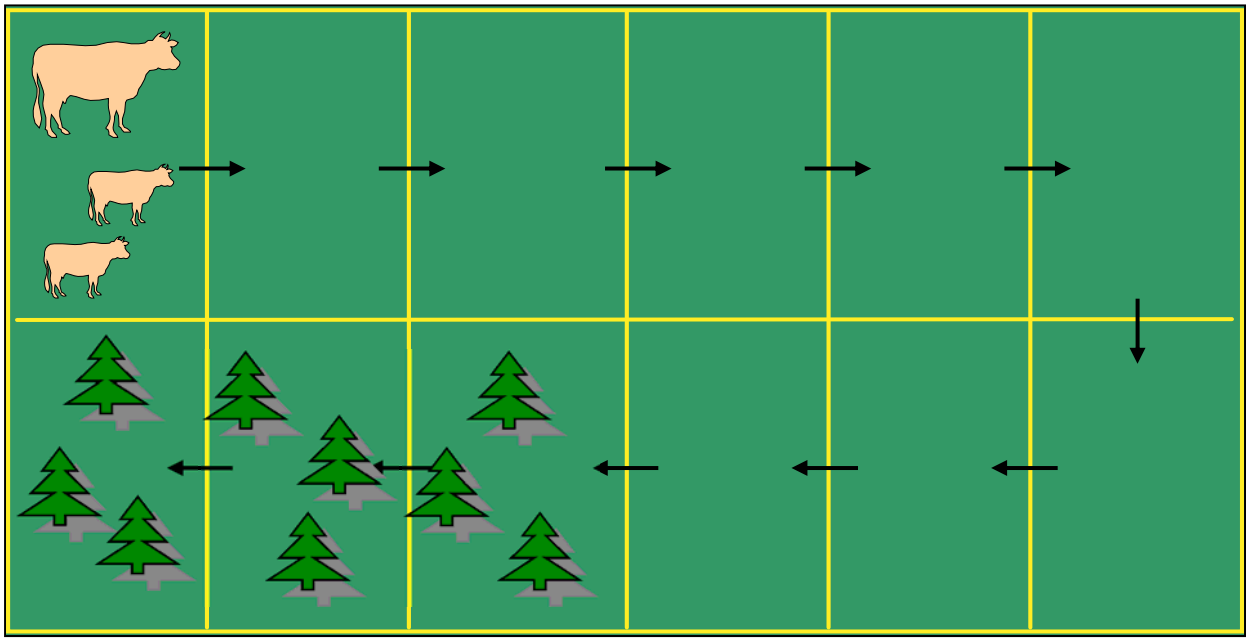
Once forage is established, lay out pastures and fencing for rotational grazing and ensure that each pasture has a sufficient water supply for livestock requirements. Do this before introducing livestock to the system. Proper pasture rotation using a paddock fencing system provides recovery periods for grazed forage, minimizes soil compaction and protects trees. The optimum number of paddocks in a silvopasture system will vary depending upon individual circumstances, resources, goals for the system, environmental conditions and the desired level of animal production.

Where land allows, uniform sized paddocks with parallel sides are desirable to facilitate better grazing distribution. The diagrams below show options for dividing grazing areas into paddocks. The red squares indicate water sources and lines indicate fencing.





For beef cattle, grazing 5-10 paddocks with each paddock grazed 3-6 days and rested 25-35 days may be enough. Provide adequate feeding management to increase the economic efficiency of the livestock production system. Silvopasture can be part of the whole rotational grazing plan.

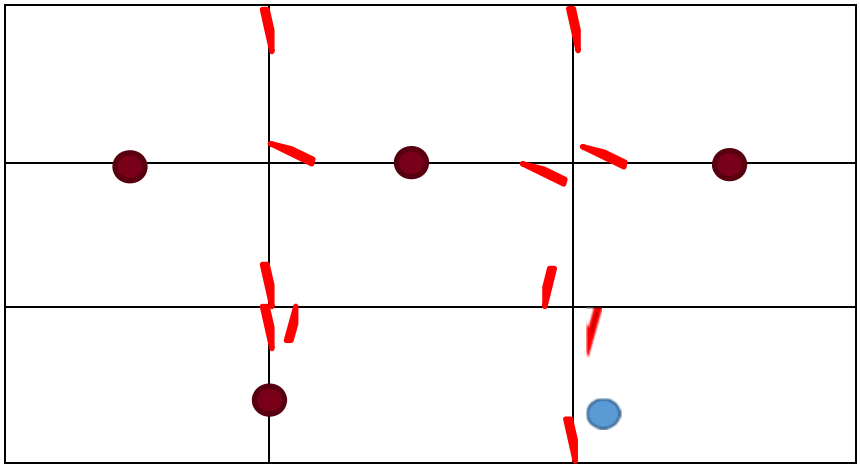


Fencing

Fencing helps control and restrict animal movement within the rotational grazing system. Fence plans should be flexible and not limit grazing options. Common types of fencing include perimeter fences, permanent subdivisions, and temporary/portable fences. Electric fences using battery or solar power are commonly used to contain livestock in paddocks. High tensile wire is recommended when using energized fences.

Gates and Access

The location of gates in the rotational system is important to facilitate movement of livestock through the paddocks and the alignment of temporary lanes and alleyways.



Watering

All grazing animals need to drink water regularly. Water requirements vary for the type, size, age and breed of livestock (see table) and can vary considerably depending upon the animals' health, air temperature, water temperature, stage of lactation and other environmental factors.

Refer to the following guidelines:

- Each paddock should have access to an adequate water supply. A rule of thumb is one gallon of water per day per 100 pounds of body weight per animal.
- Water is especially critical as air temperatures exceed 77 F (or temperature-humidity index of 72 F).

Water intake

Daily Needs in Gallons per Head

	50 F	90 F
Beef Animals		
400lb Calf	4	10
800lb Feeder	7	15
1000lb Feeder	8	17
Cows and Bulls	8	20
Dairy Animals		
Cows	15	30
Calves	2	12
Replacement Heifers	6	15
Bulls	8	20
Horses and Mules	8	12
Sheep or Goats	1.5	3.5

Source: D.M. Ball, C.S. Hoveland, and G.D. Lacefield. 2000. Southern Forages and the Foundation for Agronomic Research. Norcross, Georgia.

- Ensure that water is accessible within 600 feet of the herd. If watering facilities are over 600 feet away, cattle will begin to congregate and form use lanes and alleyways to get to the water source. This can result in mud, trampling of the water source and a less uniform grazing pattern in the paddock.
- Place one water source in a way so that it serves more than one paddock by placing watering tanks in the fence lines toward the center of the paddocks. This allows a wider area of access and keeps compaction and animal concentrations to a minimum.
- When possible, use portable water facilities. These facilities allow the tank location as needed.

FORAGE

The level of forage production in a silvopasture system depends upon:

- The established rotational grazing system
- The tree species, spacing and age
- Forage species and shade tolerance

The tree canopy density must allow sufficient light to reach the understory in order for forage crop to flourish. Light availability is a function of tree spacing, tree crown diameter and tree crown density. Reducing tree density, managing tree spacing and pruning can adjust light.

Major Factors Influencing Forage Production

- TREE SPECIES
- TREE SPACING
- TREE AGE
- FORAGE SHADE TOLERANCE
- FORAGE SELECTION

Forage Species Selection

The forage crop in a silvopasture system must:

- Be suitable for livestock grazing and be able to meet the nutritional needs of the chosen livestock.
- Be compatible with site. Grazing objectives and forage species selected for the silvopasture system.
- Be productive under partial shade. It is important to choose forage that will do well in the level of shade produced by the tree cover.
- Be resilient to moisture stress and responsive to intensive management.
- Be well adapted to local climate and site conditions.
- Have a high net forage production.
- Use warm season grasses if site is appropriate for these species.

The following table lists cool season grasses, forbs and legumes recommended for Minnesota.[3]

Cool season grasses, forbs and legumes recommended for Minnesota	
Wingstem *(Actinomeris alternifolia)*	Prairie Smoke *(Geum triflorum)*
Anise Hyssop *(Agastache foeniculum)*	Sneezeweed *(Helenium autumnale)*
Purple Giant Hyssop *(Agastache scropulariaefolia)*	Tall Sunflower *(Helianthus giganteus)*
Crested Wheatgrass *(Agropyron desertorum)*	Maximillian's Sunflower *(Helianthus maximilliani)*
Big bluestem *(Andropogon gerardi)*	Early Sunflower *(Heliopsis helianthoides)*
Thimbleweed *(Anemone cylindrica)*	Round-Headed Bush Clover *(Lespedeza capitata)*
Swamp Milkweed *(Asclepias incarnata)*	Button Blazing Star *(Liatris aspera)*
Common Milkweed *(Asclepias syriaca)*	Meadow Blazing Star (Liatris ligulistylis)
Butterfly Weed *(Asclepias tuberosa)*	Dotted Blazing Star (Liatris punctata)
Whorled Milkweed *(Asclepias verticillata)*	Prairie Blazing Star *(Liatris pycnostachya)*
Heath Aster *(Aster ericoides)*	Great Blue Lobelia *(Lobelia siphilitica)*
Smooth Blue Aster *(Aster laevis)*	Perennial Rye *(Lolium perenne)*
New England Aster *(Aster novae-angliae)*	Wild Lupine *(Lupinus perennis)*
Panicled Aster *(Aster simplex)*	Wild Bergamot *(Monarda fistulosa)*
Silky Aster *(Aster sericeus)*	Spotted Bee Balm *(Monarda punctata)*
Canadian Milk Vetch *(Astragalus canadensis)*	Common Evening Primrose *(Oenothera biennis)*
White Wild Indigo *(Baptisia leucantha)*	Foxglove Beardtongue *(Penstemon digitalis)*
Fringed Brome *(Bromus ciliatus)*	Large-Flowered Beardtongue *(Penstemon grandiflorus)*
Smooth Bromegrass *(Bromus inermis)*	Timothy (*Phleum pretense)*
Kalm's Brome *(Bromus kalmia)*	Prairie Phlox *(Phlox pilosa)*
Partridge Pea *(Cassia fasciculata)*	Fowl Bluegrass *(Poa palustris)*
Prairie Coreoposis *(Coreopsis palmata)*	Kentucky Bluegrass *(Poa pratensis)*
Orchardgrass *(Dactylis glomerata)*	Prairie Cinquefoil *(Potentilla arguta)*
White Prairie Clover *(Dalea candida)*	Mountain Mint *(Pycnanthemum virginianum)*
Purple Prairie Clover *(Dalea purpurea)*	Long-headed Coneflower *(Ratibida columnifera)*
Poverty Oat Grass *(Danthonia spicata)*	Yellow Coneflower *(Ratibida pinnata)*
Illinois Bundleflower *(Desmanthus illinoensis)*	Black-eyed Susan *(Rudbeckia hirta)*
Showy Tick Trefoil *(Desmodium canadense)*	Little Bluestem *(Schizachyrium scoparium)*
Narrow-leaved Coneflower *(Echinacea angustifolia)*	Compass Plant *(Silphium laciniatum)*
Purple Coneflower *(Echinacea purpurea)*	Cup Plant *(Silphium perfoliatum)*
Canada Wildrye *(Elymus canadensis)*	Stiff Goldenrod *(Solidago rigida)*
Bottlebrush Grass *(Elymus hystrix)*	Showy Goldenrod *(Solidago speciosa)*
Slender Wheat Grass *(Elymus trachycaulus)*	Indiangrass *(Sorghastrum nutans L)*
Virginia Wild Rye *(Elymus virginicus)*	Red Clover *(Trifolum pretense)*
Rattlesnake Master *(Eryngium yuccifolium)*	White Clover *(Trifolium repense)*
Joe Pye Weed *(Eupatorium maculatum)*	Blue Vervain *(Verbena hastate)*
Boneset *(Eupatorium perfoliatum)*	Hoary Vervain *(Verbena stricta)*
Tall Fescue (*Festuca arundinacea)*	Common Ironweed *(Vernonia fasciculata)*
Nodding Fescue *(Festuca subverticillata)*	Culver's Root *(Veronicastrum virginicum)*
Bottle Gentain *(Gentiana andrewsii)*	Heart-leaf Golden Alexander *(Zizia aptera)*
Cream Gentain *(Gentiana flavida)*	Golden Alexanders *(Zizia aurea)*

[3] Check NRCS website (http://plants.usda.gov/java/) for information of each of these species. Each forage species will have a different growth period. Check with your local forage specialist for the appropriate forage to plant.

Forage Establishment

- Plant only viable, high quality and well-adapted planting stock and seeds in the silvopasture system. Follow the same procedure of establishing forages in silvopastoral system as that of the traditional pasture.
- When using soil amendments and fertilizer, account for the requirements and limitations of both forage and tree components of the silvopasture systems.
- Control all perennial weeds that are not desirable or are noxious or invasives.

Forage Management

- Control animal movement within the silvopastoral system to prevent overgrazing.
- Rotate the livestock when the forage has been grazed to a height between 3 inches to 4 inches. Forages should be grazed no shorter than three inches and should be six inches in height at the end of the growing season.
- Time to fallow period to allow adequate regrowth and carbohydrate storage prior to a killing frost.
- The number of grazing units ultimately depends upon plant recovery time, the livestock species being allowed to graze, and the final goal of livestock production (milk vs. meat).

Additional Considerations

Low growing plants like common Bermuda grass, white clover etc. can withstand close late-season grazing because they hold some leaf area close to the ground and have carbohydrate reserves in their stems and rhizomes. Other species such as orchardgrass and many native grasses have less leaf area after close grazing and contain most of their carbohydrate reserves in their stem bases

It is important to recognize that forage species respond differently to grazing pressure.

Recommended Grazing Height and Recovery Periods			
Forage Height	Target Height (Inches)		Usual Days Rest for Recovery of Leaf Area
	Begin Grazing	End Grazing	
Alfalfa	10-16	2-3	15-30
Bermudagrass	4-8	1-2	10-20
Clover, white and sub	6-8	1-3	7-15
Dallisgrass	6-8	3-4	7-15
Tall Fescue	4-8	2-3	15-30
Johnsongrass	16-20	8-12	30-40
Orchardgrass	8-12	3-6	15-30
Ryegrass	6-12	3-4	7-15
Small grains	8-12	4	7-15

Invasive Species and Noxious Weeds

Producers need to be aware of the laws regarding invasive species and noxious weeds. Each state has agencies designated to monitor and provide educational information about management and control. Some laws mandate the landowner to control specific weeds. In Minnesota, the Minnesota Department of Natural Resources (DNR) is the lead agency for invasive species (both terrestrial and aquatic) and the Minnesota Department of Agriculture (MDA) is the lead agency for noxious weeds. To learn more about these laws and terrestrial species you should be aware of, look on the following web sites.

Minnesota Invasive Species (MN DNR)
www.dnr.state.mn.us/invasives/index.html

Minnesota Noxious Weed Law (MDA)
www.mda.state.mn.us/plants/pestmanagement/weedcontrol/noxiouslist.aspx

Plants Commonly Found in Established Minnesota Horse Pastures
www.extension.umn.edu/agriculture/horse/order/docs/DI8646.pdf

Plants Poisonous to Livestock

There are plants in the Midwest that can be toxic or poison to livestock. Producers need to be aware of these plants in their pastures and control them when necessary. To learn more about these plants, look at the web sites below:

Plants Poisonous to Livestock
http://poisonousplants.ansci.cornell.edu/comlist.html

Poisonous Plants
www.extension.umn.edu/agriculture/horse/pasture/poisonous-plants/

Plants Poisonous or Harmful to Horses in the North Central United States
http://pss.uvm.edu/pdpforage/Materials/AnimalDisorders/PlantsPoisonousHorses_Un_Minn.pdf

RESOURCES

Online Resources

USDA National Agroforestry Center (NAC) http://www.unl.edu/nac/silvopasture.htm

Auburn University https://etd.auburn.edu/handle/10415/3347

The University of Missouri Center for Agroforestry http://www.centerforagroforestry.org/practices/sp.asp

Association for Temperate Agroforestry (AFTA) http://www.aftaweb.org/entserv1.php?page=2

TreeSearch http://www.treesearch.fs.fed.us/

Dale Bumpers Small Farm Research Center –USDA Agricultural Research Service
http://www.ars.usda.gov/research/projects/projects.htm?accn_no=412583

University of Minnesota "My Minnesota Woods"
http://www.myminnesotawoods.umn.edu/2009/01/silvopasture/

University of Minnesota Extension
http://www.extension.umn.edu/environment/agroforestry/silvopasture/silvopasture.html

Discovering profits in unlikely places: agroforestry opportunities for added income
http://www.extension.umn.edu/environment/agroforestry/discovering-profits-in-unlikely-places/

Pastures for Profit: A Guide to Rotational Grazing
www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1097378.pdf

University of Minnesota Extension - Agroforestry
www.extension.umn.edu/environment/agroforestry/

Plants Poisonous to Livestock
http://poisonousplants.ansci.cornell.edu/comlist.html

Poisonous Plants
www.extension.umn.edu/agriculture/horse/pasture/poisonous-plants/

Plants Poisonous or Harmful to Horses in the North Central United States
http://pss.uvm.edu/pdpforage/Materials/AnimalDisorders/PlantsPoisonousHorses_Un_Minn.pdf
Minnesota Invasive Species (MN DNR)
www.dnr.state.mn.us/invasives/index.html

Minnesota Noxious Weed Law (MDA)
www.mda.state.mn.us/plants/pestmanagement/weedcontrol/noxiouslist.aspx

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www.extension.umn.edu/agriculture/horse/order/docs/DI8646.pdf

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Brantly, S. 2005. Silvopasture Water and Fencing Systems for Cattle. USDA National Agroforestry Center.

Garrett, H.E.; Kerley, M.S.; Ladyman, K.P.; Walter, W.D.; Godsey, L.D.; Van Sambeeck, J.W.; Brauer D.K. 2004. Hardwood Silvopasture Management in North America. Agroforestry Systems. 61: 21-33.

Raising Cattle and Timber for Profit: Making Informed Decisions about Woodland Grazing. 2004. University of Minnesota Extension.

Silvopasture Establishment and Management Principles For Pine Forests In the Southeastern United States. 2008. USDA National Agroforestry Center.

Training Manual for Applied Agroforestry Practices. 2013. University of Missouri Center for Agroforestry.

Glossary

Agroforestry — The intentional combination of agriculture and forestry to create an integrated and sustainable land use system. Agroforestry takes advantage of the interactive benefits of combining trees and shrubs with crops and/or livestock.

Carrying capacity — The stocking rate that provides a target level of performance while maintaining the integrity of the resource base.

Densiometer — A device used to measure the amount of canopy closure.

Endophyte Free Fescue — Fescue that is not infected with the endophyte fungus that has been associated with poor weight gains and lowered conception rates of cattle, reproductive problems in horses, and poor milk production in dairy animals. Established fescue can be tested to determine the presence of the fungus and it is recommended that infected areas be treated and replanted with endophyte-free fescue to improve herd quality.

Epicormic branches — Shoots arising from adventitious or dormant buds on the stem or branch of a woody plant, often following exposure to increased light levels or fire

Forage — Vegetation browsed or grazed by livestock.

Forage Allocation — The process of dividing forage resources among livestock for different dietary needs. Forage allocation depends on the type of forage available, the carrying capacity of the site, and the seasonal needs of the type of livestock using the site. Forage allocation for calves will be different than for non-lactating cows.

Herd Effect — The impact of a concentrated herd of livestock on soil, water and vegetation resources on a site. Dense herds often lead to soil compaction, erosion and other undesirable effects on a site.

Joule	The actual quantity of energy that passes through an animal in an energized fencing system.
Paddock	A fenced area used to confine livestock to a particular area.
Pruning	The removal of side branches and/or multiple leaders from trees. Pruning is carried out to improve the market value of the final wood product by producing knot-free wood for the improvement of timber quality.
Ripping	The practice of sub-soiling using a specialized blade or "ripper" to break up and aerate compacted soils.
Stocking rate	The number of animals or animal live weight assigned to a grazing unit on a seasonal basis. Stocking rate has an effect on intake and availability.
Thinning	Selective removal of trees, primarily undertaken to improve the growth rate or health of the remaining trees.
Voltage	In considering the voltage necessary to deter livestock, a minimum level of voltage is required to overcome the resistance of the animal's skin, fence, wire and soil. Voltage delivered can be reduced by energy "leakage" through dew, grass etc. Thus, an animal's nose is more sensitive than its hide, as there is less resistance. It is important to consult an energized fencing supplier or livestock specialist in designing and implementing an energized fencing system.