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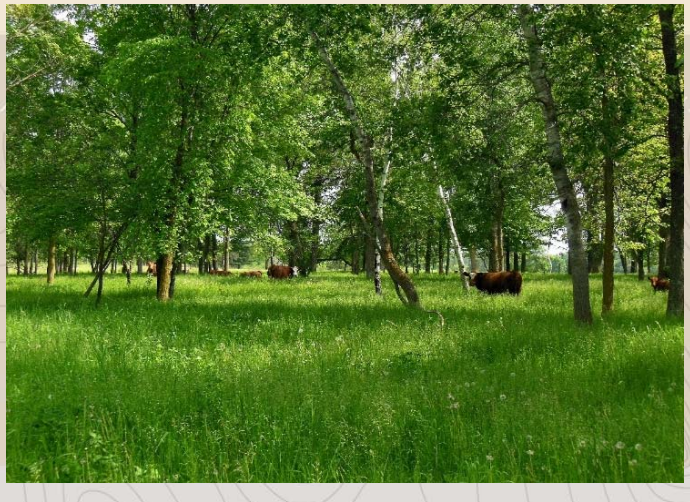
Silvopasture

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

University of Minnesota Extension



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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.

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Jim Chamberlin, Happy Dancing Turtle

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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.

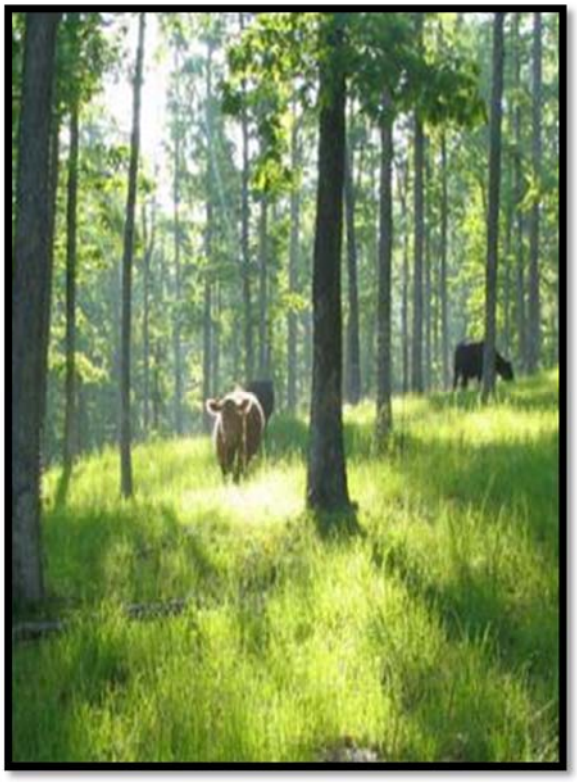
Besides the potential gains from product diversification and improved timber and livestock production, well-managed silvopasture systems can also provide the following benefits:

- 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

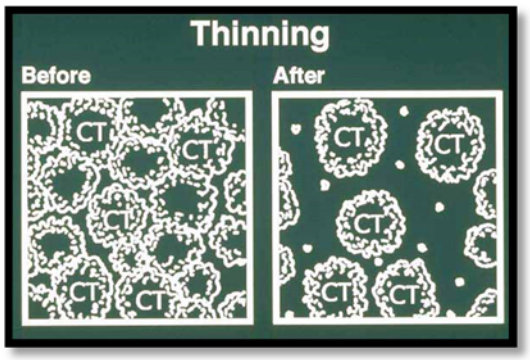
Silvopasture systems can be established in one of two ways:

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

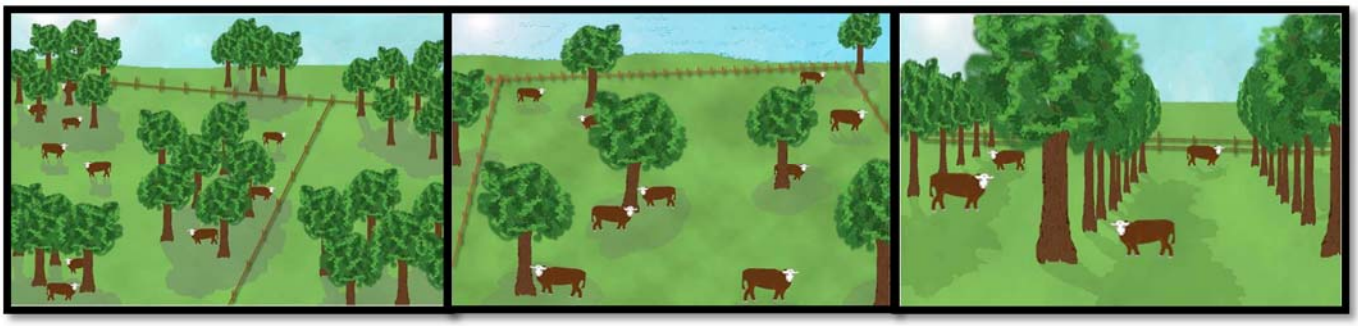
When converting a pasture to silvopasture, tree planting typically occurs in a grid patterns. However, by using different configurations or by establishing tree clusters across a paddock, the time between thinning may be increased and the area available for forage may be maximized.

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.



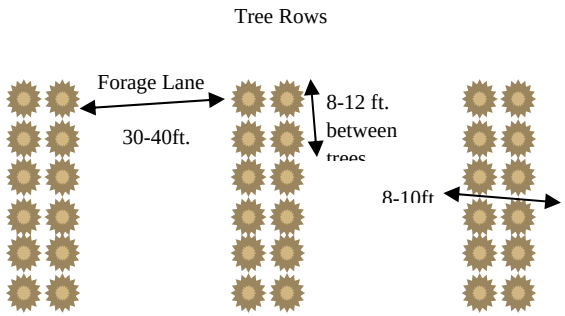
Common Planting Formations: Group plantings, single plantings, and row plantings

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

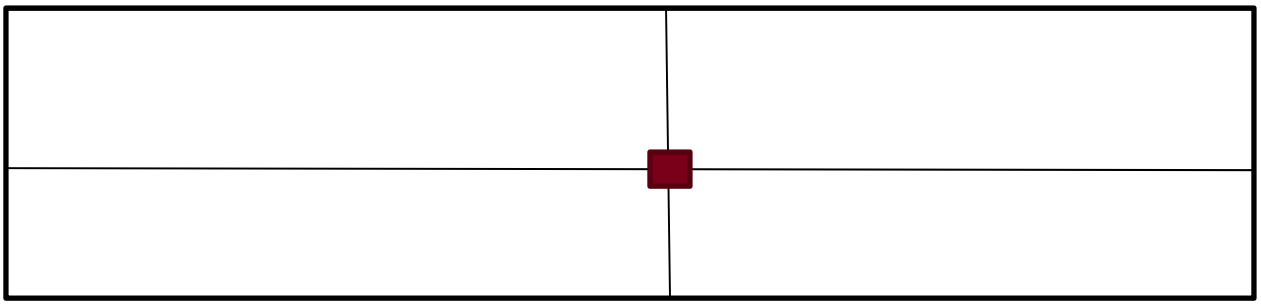
Poor: "Dumping" livestock on an area and leaving for extended periods, causing overgrazing of forages and damage of tree obstacle planting in a row creates a fence that steers animals on pasture pathways between and around tree seedlings

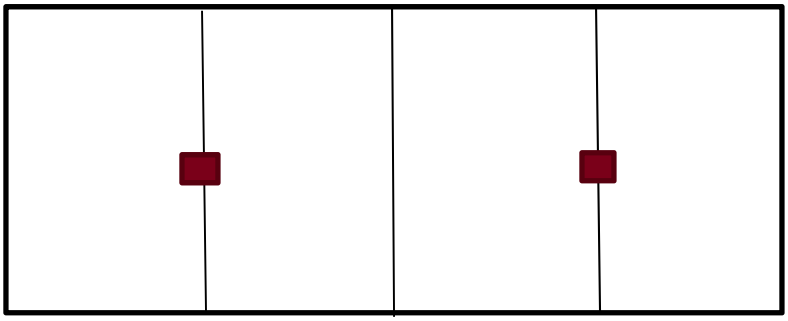
- Grazing periods could range in duration from 1 day to 6 days but should typically be less than 3 days. Establish grazing periods according to the rate of forage regrowth in the paddock rather than following a set of calendar schedule.
- Use higher quality parts of forage plants for grazing (the top 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

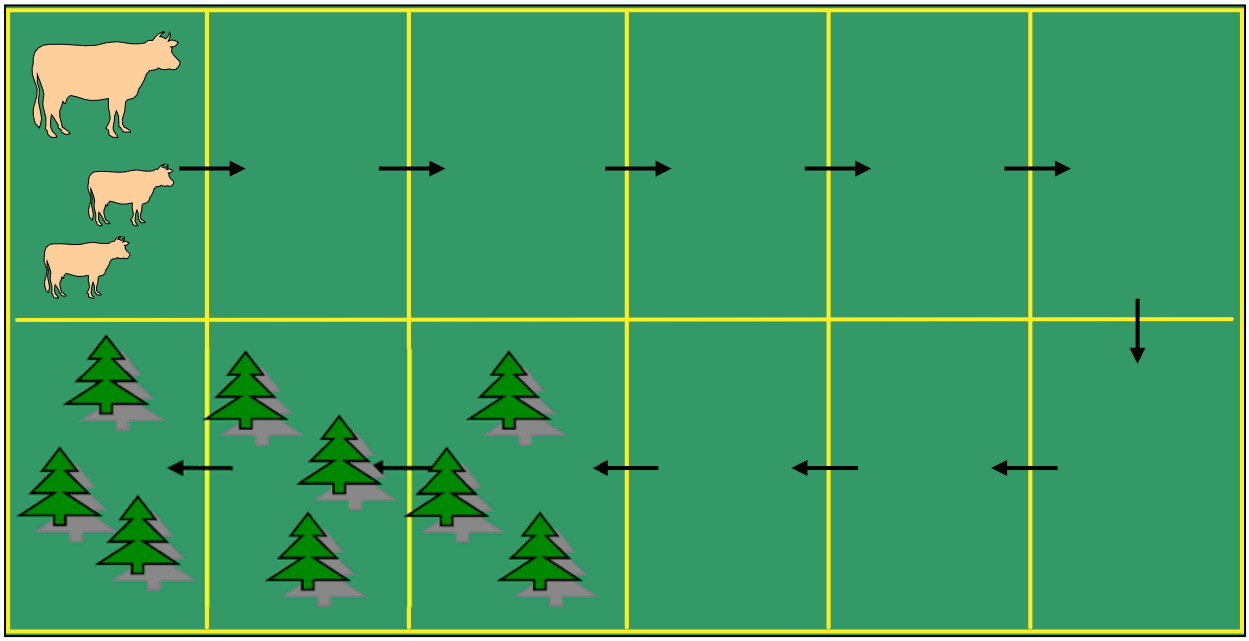
Once forage is established, lay out pastures and fencing for rotational grazing and ensure that each pasture has a sufficient water supply for livestock requirements. Do this before introducing livestock to the system. Proper pasture rotation using a paddock fencing system provides recovery periods for 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.

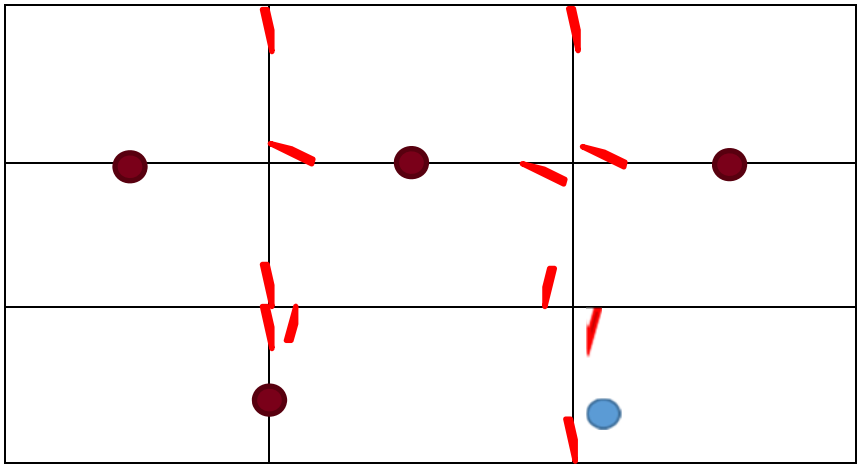


Fencing

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
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Plants Commonly Found in Established Minnesota Horse Pastures

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

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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.