CFAES

Silvopasture Systems

Roger A. Williams, Associate Professor, School of Environment and Natural Resources

Introduction

What exactly is silvopasture? It is a term that is sometimes thrown around in the agricultural world, but some, or many may not know what it really is. In a nutshell, silvopasture is the integration of growing trees and grazing livestock operations on the same land. Silvopasture systems are managed for both forest products and forage for livestock, and thereby providing both short- and long-term income sources. The annual grazing income can provide the cash flow for the tree operation while the tree crop matures. When the tree crop is mature and ready to be harvested, easy access to the trees are available due to the set-up of the silvopasture system. While there may be a number of management activities that are required for a successful system, the benefits of silvopasture can make it worthwhile. It becomes a means to maximize the land potential in providing a resource to society and income to the landowner.

The two main products of the system are livestock (short-term) and marketable trees (long-term). Or, it may be nuts or fruit if not harvesting merchantable trees. Silvopasture systems can reduce economic risk by providing multiple products from the forest and livestock.

One of the key elements in silvopasture is rotational grazing in order to minimize damage to crop trees. This includes long-term planning for tree regeneration, the future forest. Another key element in a silvopasture system is the protection of soil, which is the foundation of forage and tree productivity.

In a well-designed silvopasture system, the trees you want to consider should be marketable, fast growing and high quality and should eventually provide an income for the landowner in some form. The forage chosen should be palatable, site specific, tolerant to the reduced amount of sunlight it might receive and be responsive to intensive management. Some native grasses that are a good choice are big bluestem, switch grass, Indian grass and Timothy, but the selection will depend upon the region of silvopasture location.

Another advantage of a silvopasture system is that it provides shade and protection from wind. Research has shown that providing shade for livestock and protecting them from wind can increase livestock production and performance. This is a result of reducing the stressful environments in which livestock are raised.

Silvopasture systems are created by either introducing livestock forage into a woodlot or tree plantation, or by introducing (planting) trees into a pasture. Both of these approaches will be discussed briefly.

Establishing Forages within Woodlots

Before establishing forages within a woodlot, the first question that needs to be asked is whether a site is suitable for silvopasture. Keep in mind that sometimes woodlots are woodlots because the area is unsuitable for agriculture. The site, including the soil and topography, may not be able to adequately produce the necessary forage.

It is very likely that trees will have to be removed to provide foraging space, and to provide sunlight for forage growth. This will require a lot of work to prepare the ground suitable for forage production. But critical questions will be what trees should I remove, and what trees should I leave behind? What spacing should there be between trees?

Since one of the goals of a silvopasture system is to provide income from tree harvests, the trees to be left behind should be marketable species, of good form and quality. Spacing will be determined by the tree species left behind, the amount of foraging space desired/required, and the amount of sunlight needed for forage production. Tree species that are tolerant of shade can withstand higher forest densities than those that cannot tolerate much shade (Table 1). While trees that are tolerant of shade can perform well in higher densities, they can perform better if the density is not too high.

Table 1. Shade tolerance ratings for select tree species growing in Ohio.

SHADE TOLERANT		**INTERMEDIATE SHADE TOLERANT**	
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Acer negundo	Boxelder	*Betula alleghaniensis*	Yellow birch
Acer saccharum	Sugar maple	*Betula lenta*	Sweet birch
Acer rubrum	Red maple	*Celtis occidentalis*	Hackberry
Acer saccharinum	Silver maple	*Fraxinus americana*	White ash
Aesculus spp.	Buckeyes	*Fraxinus pennsylvanica*	Green ash
Carpinus caroliniana	American hornbeam	*Quercus alba*	White oak
Carya laciniosa	Shellbark hickory	*Quercus macrocarpa*	Bur oak
Diospyros spp.	Persimmon	*Quercus rubra*	Northern red oak
Fagus grandifolia	American beech	*Quercus velutina*	Black oak
Morus rubra	Red mulberry	*Quercus montana*	Chestnut oak
Nyssa sylvatica	Blackgum	*Pinus strobus*	Eastern white pine
Ostrya virginiana	Eastern hophornbeam	*Ulmus americana*	American elm
Tilia americana	Basswood	*Carya spp.*	Hickories (except for Shellbark)
Tsuga canadensis	Eastern hemlock		
Ulmus rubra	Slippery elm		

SHADE INTOLERANT	
Scientific Name	**Common Name**
Carya illinoinensis	Pecan
Gymnocladus dioicus	Kentucky coffee tree
Juglans cinerea	Butternut
Juglans nigra	Black walnut
Juniperus virginiana	Eastern red cedar
Liriodendron tulipifera	Yellow poplar
Northern catalpa	Catalpa speciosa
Populus deltoides	Eastern cottonwood
Populus grandidentata	Big-tooth aspen
Populus tremuloides	Quaking aspen
Prunus pensylvanica	Pin cherry
Prunus serotina	Black cherry
Robinia pseudoacacia	Black locust
Salix nigra	Black willow
Sassafras albidum	Sassafras

When harvesting the trees off the site there will be logging slash produced, which will need to be removed. The slash removal can be worked up in a logging contract, or it can be piled and burned. You may want to have stump height specs written into a logging contract, and you may need to have stumps ground or dug out. Stumps can create a tripping hazard for some livestock. Prescribed burning is a good method to eliminate forest litter as it creates good, nutrient-rich seed beds for seeding in new foraging plants.

The spacing of trees left behind will be determined by where the selected trees are located in the woodlot, their original juxtaposition in the woodlot, the amount of sunlight the forage grasses need and possibly the type of livestock to be grazed. Trees can be spaced uniformly, irregularly or left in patches. If one is dealing with a plantation the same patterns can apply or tree rows can be removed.

The more space a tree has to grow, the more sunlight that can be exposed to the crown of a tree, creating better growth and health. Trees that have relatively small crowns should not be chosen as your future silvopasture crop tree; you want trees with more fully-developed crowns. A rule of thumb is to select trees that have at least a live crown ratio (LCR) of 1/3 or more. The LCR is the ratio of the length of a tree's live crown to the total height of the tree. Trees with an LCR of less than 1/3 are less likely to respond to thinning with increased growth.

It is also important to note that in general hardwood tree species need more room to grow than softwood species. Most hardwood trees species have a decurrent growth pattern while most softwood species have an excurrent growth pattern. Decurrent growth means that trees tend to fork and branch out while excurrent growth means a single main bole is produced with many lateral branches that extend out at approximately 90 degrees. Accordingly, we find that softwood forests, on average, develop into higher densities than hardwood forests. Thus maximum stand densities will be higher for softwood forests than for hardwood forests.

When thinning out your woodlot to create a silvopasture system, one thing you will need to pay attention to is the possibility of epicormic branching developing on the bole of your residual trees. Epicormic branches are small shoots or branchlets that sprout from adventitious or dormant buds on stems or branches of woody plants. It is believed that these occur as a result of sunlight exposed onto the sides of tree boles that were previously shaded. Epicormic branches are considered defects on tree boles because they result in undesirable knots on trees, reducing the monetary value of logs and lumber. These should be pruned off as soon as they are discovered since one of the goals in a silvopasture system is to produce income from quality timber.

Another obvious key to a successful silvopasture system will be forage production. Factors influencing the forage production include that there is sufficient sunlight necessary for forage growth and response to grazing, and proper rotational grazing to minimize possible overgrazing. The soil nutrition may have to be adjusted to enhance forage development, and the amount of necessary sunlight will need to be created by reducing the tree density in the woodlot and managing tree spacing to get the proper sunlight for forage production. When planning the thinning of the woodlot you will need to make sure there will be enough area to grow forage that will support your livestock. This includes not only that actual physical area but also enough sunlight is introduced to grow the forage you plan to produce.

Establish Trees into Existing Pasture

One of the disadvantages of establishing a silvopasture system through this approach is the length of time necessary to produce commercially viable trees. Of course the length of time can be shortened somewhat by selecting fast-growing tree species, or those that produce desirable fruits early if fruit production is a goal.

Selecting the tree species you will plant requires some consideration; not all species are created equal. Species will exhibit different growth rates, and different species will have different commercial value. And more importantly, you also need to evaluate the soil to determine current soil conditions and soil type so you can select the proper tree species to plant. Not every soil is ideal for every species. Different species

have different soil nutrient, soil moisture and rooting depth requirements, and accordingly perform best when those needs are met. It is important to match the tree species with the type and condition of soil you are working with.

Planting rates from 100 to 400 trees per acre are typically recommended for planting a silvopasture system. Of course these can be planted in groups, as individual trees evenly spaced, or in rows. If in rows they may be planted in single, double or triple rows or sets (Figure 1). And within these different row arrangements there are different options you can exercise (Table 2).

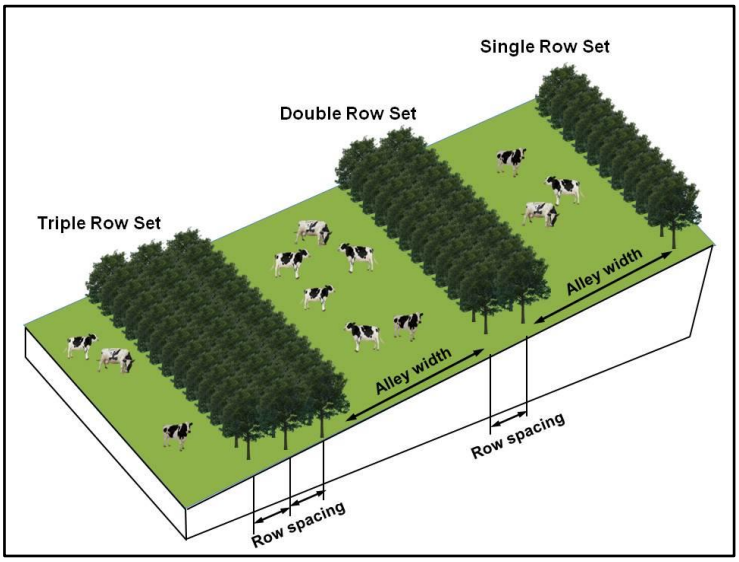

Figure 1. An example layout of a silvopasture system showing alley width, row spacing, and tree sets for establishing a silvopasture system in existing pasture (adapted from *USDA National Agroforestry Center 2000*).

Table 1. Silvopasture planting options and trees per acre[1] (adapted from *USDA National Agroforestry Center 2000*)

Alley Width	Single-Row Set				Double-Row Set				Triple-Row Set			
	Row Spacing	Tree-to-tree in row spacing			Row Spacing	Tree-to-tree in row spacing			Row Spacing	Tree-to-tree in row spacing		
		6 foot	8 foot	10 foot		6 foot	8 foot	10 foot		6 foot	8 foot	10 foot
15 feet	Row spacing and alley width are the same for single-row sets	484	363	290	6 foot	***691***	***518***	***414***	6 foot	***807***	***607***	***484***
					8 foot	***631***	***473***	378	8 foot	***703***	***528***	***422***
					10 foot	***580***	***435***	348	10 foot	***622***	***468***	374
					12 foot	***537***	***403***	322	12 foot	***558***	***418***	335
20 feet		363	272	218	6 foot	***558***	***418***	335	6 foot	***680***	***512***	***409***
					8 foot	***518***	388	311	8 foot	***605***	***455***	363
					10 foot	***484***	363	290	10 foot	***545***	***409***	327
					12 foot	***454***	340	272	12 foot	***495***	372	297
30 feet		242	182	145	6 foot	***403***	303	242	6 foot	***512***	390	311
					8 foot	382	287	229	8 foot	***473***	356	284
					10 foot	363	272	218	10 foot	***435***	328	262
					12 foot	345	259	207	12 foot	***403***	303	242
40 feet		182	136	109	6 foot	315	237	189	6 foot	***419***	315	252
					8 foot	303	227	182	8 foot	389	292	234
					10 foot	290	218	174	10 foot	363	273	218
					12 foot	279	209	167	12 foot	340	256	204

[1] Field shape and planting design may cause some variation in trees per acre. Bold figures are outside of recommended planting rates for silvopasture.

Generally, the ideal soil is not compacted, moist but well-drained, lots of nutrients, typically a loam to clay-loam soil. This would be a good soil for most species considered. However, different tree species can tolerate different levels of not-so-ideal soils, and species need to be matched with soil to maximize the tree growth potential.

When establishing trees in a pasture to create a silvopasture system, the primary factors that affect tree planting success are:

- Soil drainage: excessively drained or poorly drained
- Existing competing vegetation: grasses, weeds, and invasive plants
- Exposure/aspect: wind, sun, and shade
- Wildlife: deer, bear, voles, and other small mammals

Both softwood and hardwood species are suitable for silvopastures, and a multitude of trees and configurations can be utilized. Trees such as locusts, walnuts and members of the hickory family leaf out after the initial flush of cool-season forage growth, thus reducing competition with forages in spring and buffering forages and livestock from high temperatures in summer. Leaves from these tree species also degrade more readily than heavier leaves of oaks or maples, thus not “suffocating” forage grasses. However, one must consider the particular objectives of silvopasture in terms of what tree species may have the higher commercial value.

In reality many tree species are suitable for silvopasture systems. Species selection will depend upon not only the site conditions, but also the landowner goals. Other aspects the landowner may want to consider when choosing what tree species to plant are:

- Fast-growing and open-crowned species to allow good for-age production
- Deep-rooted species to avoid competition with forage for moisture
- Drought-tolerant species
- Genetically improved seedlings able to resist pests and diseases
- Species that are capable of providing high-quality timber
- Nut- and fruit-producing marketable hardwood species, such as pecan and walnut if fruit or nut production is an objective of the silvopasture system
- Species such as black locust, which is a legume that fixes nitrogen in the soil, and makes good, durable fence posts
- The potential market/stumpage value of a particular species
- Softwood species are more suited to close-spaced plantings than hardwood species

Young trees will need to be protected until the tree crown gets above browsing height. The use of tree guards or fencing will need to be put into place around newly planted trees.

Pruning of older trees may be necessary to prevent browsing of lower branches, and reduce the attraction of trees to livestock. This will help to reduce or eliminate damage to trees, plus increase the value of trees by reducing the amount of knots in the wood of the tree. It is critical to monitor damage to trees by livestock, as damage can reduce the growth and wood quality, and potentially expose the tree to a variety of pathogens.

Soil Protection

Soil is one of the more critical components of the system, as it plays a major role in the production of forage and the growth of trees. The soil should have regular testing to determine if and when additional fertilizer or lime is needed to support desirable forage production. Areas of high livestock concentration will need to be monitored for soil compaction and invasive weeds. Controlled grazing may be necessary to reduce soil compaction in particular areas by the use of paddocks and strategically placed salt or mineral licks. The idea would be to encourage more uniform livestock distribution. Soil compaction becomes more of an issue with shallow-rooted tree species, and create issues related to moisture reaching tree roots.

This means monitoring the soil periodically for:

- Proper fertility
- Proper pH (softwood species tend to make the soil more acidic; manure tends to raise the soil pH) Caution: Too much manure can increase nitrogen levels to a point where roots are "burned" (another reason to try to keep herds dispersed)
- Proper texture/structure (as related to soil compaction)
- Soil moisture

It is also important to note if establishing forages in existing woodlots, soils that formed under hardwood forests can be very fertile and productive agricultural lands because of the decomposing leaves and forest litter at the soil surface. However, soils formed under pine forests are can be more acidic and possibly sandier, and may be less suited for growing crops.

Silvopasture and Carbon

Silvopasture systems that establish trees into pastures can possibly qualify as a carbon offset project. As forests grow, the trees absorb CO_2 from the atmosphere through photosynthesis and store it within their growing biomass (trunk, branches, leaves and root systems). A "forest carbon offset," is a metric ton of carbon dioxide equivalent (CO_2e)—the emission of which is avoided or newly stored—that is purchased by greenhouse gas emitters to compensate for emissions occurring elsewhere (Figure 2).

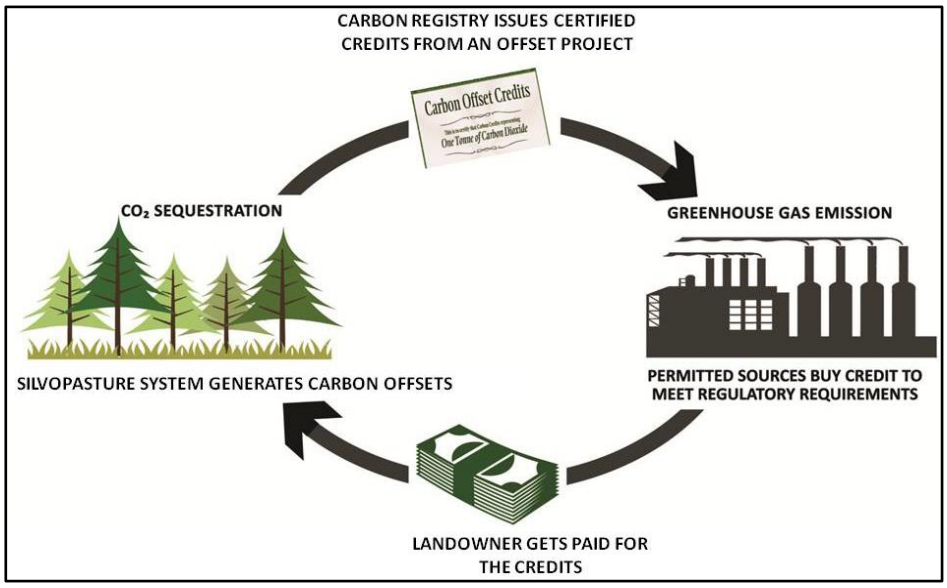

Figure 2. Silvopasture systems sequester carbon out of the atmosphere, and the sequestered carbon can be bought and sold through registries to entities that emit carbon

Carbon offsets established through projects that sequester carbon or the use of carbon neutral alternatives are a means to mitigate climate change. Project Drawdown, a nonprofit organization that seeks to help the world reach "Drawdown"— the future point in time when levels of greenhouse gases in the atmosphere stop climbing and start to steadily decline – have identified silvopasture as a means in which to accomplish this. Out of 82 potential methods of establishing carbon offsets silvopasture ranks 9th in terms of mitigating greenhouse gas emissions. This accounts for not only the carbon that is captured out of the atmosphere but also the carbon that is emitted in these systems.

Offsets may be developed under voluntary market standards or compliance market standards, each of which has specific carbon accounting and eligibility rules. In either case, a landowner can be paid for every metric ton their forests/trees sequester. Common types of forest-related activities that can qualify for registered carbon offset projects include:

- Improved Forest Management: better, sustainable forest management increases carbon in the forest and in durable, harvested wood products.
- Avoided Conversion: forests with a demonstrably high likelihood of tree and carbon loss (usually from conversion to agriculture or development) commit to retain forest as forest, and the avoided carbon dioxide emissions through this conservation effort yield offsets.
- Afforestation/Reforestation: carbon is sequestered and offsets generated through the creation or re-establishment of forests.

Silvopasture systems can possibly qualify under the third activity- afforestation/reforestation. Whether the system qualifies will depend upon the number of trees planted per acre and the amount of land involved. There are minimum requirements that need to be met for a carbon project to be registered. While these minimums will vary depending on the carbon registry/certification you will follow, but some of the more common minimums include:

- Typically a minimum of 40 acres of forested land.
- Forested acres typically must have a minimum of 10% canopy cover.
- All forestland must be enrolled.
- Commercial harvests have not occurred on the property within a certain number of years prior to the enrollment date
- Landowners must be willing to forgo harvesting for a period of years into the contract period.
- Landowners must be up-to-date on their property taxes.

Not all silvopasture systems will qualify as a carbon offset project. The process of creating a forest carbon project can vary, but in general, the process includes:

1. Assess project feasibility
2. Complete a carbon inventory of the forest based on the chosen carbon registry protocols
3. Develop a project area management plan explaining management goals and practices to be employed
4. Prepare and submit project plan and documentation to chosen carbon registry
5. After project plan is accepted and registered, a third-party project verifier will be hired

6. Submit project verification to registry and, after reviewed and approved, receive carbon offsets verified
7. Market and sell carbon offsets
8. Ongoing monitoring and verification, as well as periodic re-inventory of the project, required as per the carbon standard requirements, throughout project life

There are many things one will need to consider if wanting to place a silvopasture system into the carbon markets through a carbon offset project. There will be minimum commitment periods that a landowner will have to commit to, and a need to consider how this fits in with other management goals. There will be a cost of developing a project and managing its obligations throughout the full project life, and balance that with the offset volumes the silvopasture project produces and the carbon price trends and potential. Many registries will guarantee you a price for your carbon in a contract up through certain periods of time.

The number of offsets your silvopasture project produces will depend in part upon the methodology chosen, specific management practices implemented, and many other factors. It is important to note that timber stocks are not equal to carbon stocks, since carbon stocks may also include dead wood, harvested timber, and other carbon pools. Also, carbon stocks are not equal to carbon offsets, since offsets are calculated as the difference between the project and a modeled baseline scenario of carbon stocks in the project absence. Baseline definition and modeling differ from registry standard to registry standard and are a critical component of carbon offsets because the baseline establishes the reference condition against which the project activity is compared.

Summary

The key to the success of a silvopasture system is active management. It is a form of intensive management, and if it is not managed it won't function properly. This system provides shade and protection from wind which can increase livestock production and performance. It can reduce economic risk by providing multiple products from the forest and livestock. The production costs are reduced and marketing flexibility is enhanced by distributing management costs between the tree, forage, and livestock components. Depending on the tree species used in the system, a variety of products – from sawtimber to firewood, from nuts or fruit to greenery and carbon– can be extracted from the silvopasture system. Silvopastures can create a more attractive landscape, higher biodiversity than a normal pasture system, and produce a better image of land stewardship.

References

USDA National Agroforestry Center. 2000. From A Pasture to A Silvopasture System. Agroforestry Notes. AF-Note 22. 4p.