EM 8989-E • October 2009

Silvopasture: An Agroforestry Practice

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What Is Silvopasture?

Silvopasture is defined as the intensive management and growing of perennial grasses or grass-legume mixes in a forest stand for livestock pasture. It is one of the most applicable agroforestry management practices that could be used in most regions of Oregon. Agroforestry is a set of practices geared to optimize productivity and conservation benefits within a set of integrated land use practices. It is important to note that allowing livestock to graze in a natural woodland area without any type of tree or forage management is not considered agroforestry. The expected outcome is that silvopastoral practices will be employed that improve the productivity of the grazing animal, improve the quality and diversity of forage available to the grazing animal and wildlife, and effectively interpose timber-stand improvement across a wide array of forested land. Silvopasture can be accomplished in two ways: trees can be introduced into an already established pasture system, or forages can be introduced into a thinned forest system. The correct choice of tree species must conform to specific site soil conditions, while desirable forages must withstand varying degrees of shade under a well-managed rotational grazing system.

Silvopasture Economics

Silvopasture systems reduce economic risk by producing multiple products. The production costs are reduced and marketing flexibility is enhanced by distributing management costs among the tree, forage, and livestock components. Grazing animals control competition for moisture, nutrients, and sunlight, thereby enhancing tree growth. Studies have shown that in cold weather, livestock protected by trees exhibit improvements in weight gain by as much as 10% and require up to 50% less feed. Milk production has been shown to increase by 8% to 20%. Windbreaks can greatly reduce or eliminate disastrous losses of newborn lambs and calves from blizzards. Trees also help reduce evapotranspiration from forage, thereby lengthening the feed production cycle.

Should All Pastures Be Converted to Silvopasture?

Converting all of a pasture system to silvopastures is unlikely on a wide scale. One should choose pastures where tree growth could be ideal and mix with compatible forages. Use the silvopastures strategically to complement the grazing system. Use tools such as management-intensive grazing (MiG) to help divide the farm into management units or grids. These grazing grids or paddock systems provide recovery periods for forages and reduce soil compaction, hence allowing greater root development to occur for both trees and forages. Converting pastures to silvopasture has added advantages, such as allowing harvest of forage (pasture and hay) and wood products from the same parcel; added productivity from increased nitrogen fixation of pasture legumes, which benefit both forage and tree systems; and improved wildlife habitats. However, as in any integrated system, there may be some increased costs such as fencing, equipment outlay, and investments in MiG.

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Which Should Come First, the Trees or the Pasture?

Either planting forages into tree stands (fig. 1) or planting trees into pasture (fig. 2) can work, depending on one's current situation, goals, and type of climate. If planting trees into existing pasture, vegetation control is critical, especially where grass roots are dense and might compete vigorously with the trees. In dry summer climates, conifer seedlings grow fastest when all competing vegetation is removed around the seedlings for the first 3 years. In these areas, at least 20% to 30% of the planting area should be weed free (an area about 4 to 6 feet wide around each seedling). Herbicides, vegetation control mats, or mechanical treatments can be used to keep this zone free of vegetation. The alternative is to plant forage into thinned forest stands (see "Trees," below).

Figure 1. Plantation to silvopasture. Reproduced by permission of the National Agroforestry Center.

Figure 2. Pasture to silvopasture. Reproduced by permission of the National Agroforestry Center.

Components of a Silvopasture Practice

Silvopasture practices require management of a three-way interaction among livestock, trees, and forages. However, there are four variables in a silvopastoral practice that require independent management: livestock maintenance, tree species, tree density, and forage species. Successfully integrating and managing these dependent and independent components requires good understanding of the biology and dynamics of the components alone and in combination. Let us look at each component separately.

Forages

It is essential to choose forages that do well in the level of shade produced by the tree cover and that meet the nutritional needs of the chosen livestock. Both tree size and tree density influence understory forage production. General guidelines allow for a total combined canopy cover of about 35% before forage production is significantly impacted. Luckily, many cool-season forages recommended for silvopasture in Oregon, such as perennial ryegrass, orchardgrass, and tall fescue (with a mix of subterranean clover and white clover), can perform well under 50% shade depending on soil conditions and aspect. The clovers serve as biological sources of plant-available nitrogen for use by both the grass and trees. By matching tree and forage selections, one will have more palatable forage, more efficient grazing, and more vegetation removal.

Shallow-rooted, summer-dormant forages such as subterranean clover and perennial ryegrass are a good choice for dry sites, to maximize late spring/early summer forage growth. One should seed forage at lower rates and have the livestock graze it before the forage becomes competitive. Tall fescue and white clover will grow as long as soil moisture is available, making them suitable for deeper soils where they compete with trees for dry-season moisture. As time progresses, the forage composition of silvopasture systems will change as trees grow and modify the environment. Orchard grass and subterranean clover seem to tolerate the environment under trees better than perennial ryegrass. Although tall fescue also does well under trees, it has the lowest quality and highest degree of competition among the recommended forages.

It is important to plan before establishing forages. Site preparation is essential if one wants to introduce the forage into thinned forest stands. This helps suppress native vegetation from smothering the forages. Fall seeding is preferable, as it allows the seedlings to germinate and take advantage of early fall and spring weather to grow before being influenced by fresh flush of added canopy from the trees. For rotational grazing to be successful, fencing plans have to be determined and appropriate grids established depending on whether electric or stationary fencing will be used. Finally, install a water supply to accommodate livestock stocking rate and MiG.

Most silvopastoral systems are established with cool-season grasses (fig. 3), as they provide longer periods of potential grazing compared with warm-season forages. Cool-season forages have their peak production in the spring when temperatures are cool. They are less competitive for water in the summer months, when moisture may be limiting to tree growth, and many perform reasonably well under partial shade. When grown under 50% shade, cool-season forages have quality and digestibility equal to or better than those of forages grown out in the open. This is because the modified climate and change in light levels cause the grasses and legumes to increase growth (because of modified climate and moisture) and have less lignin in their leaves (improved quality). Cool-season forages should be grazed no shorter than 3 inches and should be left at 6 inches in height at the end of the growing season.

However, if warm-season forages are used, they should be grazed no shorter than 8 inches during the growing season and during the last grazing rotation left at 10 inches in height. Warm-season forages achieve most of their growth in the summer months, do not perform well under partial shade, and are more competitive for water during the summer months when moisture availability is limited.

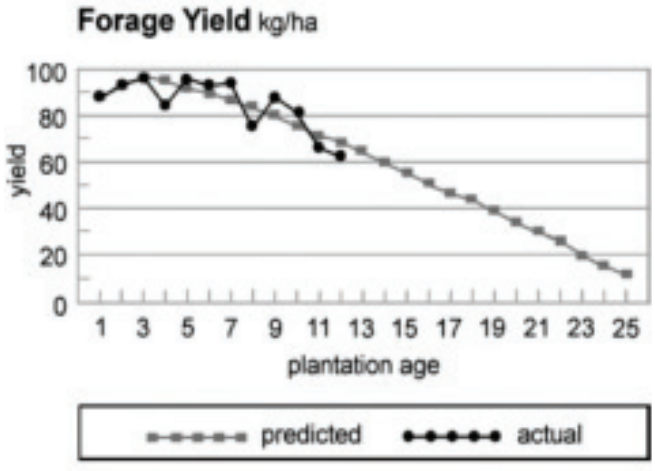

Figure 3. Percentage yield of cool-season forages over time for a subterranean clover/perennial rye Douglas-fir silvopasture system in western Oregon. Reproduced with permission from Sharrow and Fletcher (2003).

Livestock

Cattle and sheep are the primary animals used in silvopastoral practices. Animal performance can be improved with reduction of heat stress and improved forage availability and nutritional quality. Shade has been shown to improve animal performance, with primary emphasis placed on heat-stress amelioration. Research with cattle has shown that, compared with unshaded or sparsely shaded pasture, uniformly distributed shade results in maximum grazing time. Stress due to heat and cold has been shown to adversely affect cattle performance, thereby reducing average daily gain. Properly positioned trees and shrubs can provide much-needed protection for pastures, feedlots, and calving areas. Reducing wind speed lowers animal stress, improves animal health, and increases feeding efficiency. It takes careful management to ensure that livestock do not damage young trees, especially in situations where trees are introduced to established pastures.

Water is an important element in silvopastoral systems. Consider using portable water tanks (with tank covers) or permanent tanks. Portable tanks have the advantage of being able to be removed during tree management or harvesting operations. Water sources should be within 600 to 800 feet of travel distance for the animals. At this distance, water consumption by livestock can be up to 15% less compared with distances over 800 feet. When water is located close to the forage resource, animals will drink more frequently. This tends to keep the herd dispersed throughout the paddock and results in a greater portion of time spent grazing.

Seasonal changes affect watering habits. Animals acquire water through drinking and from the moisture in the forage they eat. As air temperature increases, water requirements also increase. Water requirements vary by the kind, size, age, and

breed of livestock. For example, dairy breeds need significantly more water than beef breeds. A simple rule of thumb used by livestock managers is 1 gallon of water per day per 100 pounds of body weight. Water use also varies considerably depending on the animal's health, air temperature, water temperature, lactation, and other environmental factors. Water-supply options for silvopasture should include wells, creeks, ponds, spring developments, and municipal or rural water systems.

Fencing is critical to the overall success of silvopastoral systems, as it enables intensive grazing and proper pasture rotation utilizing "pasture recovery periods." An energized fence is primarily a psychological barrier and can only be effective if the fence carries enough charge to deliver a "deterrent" shock. Low-impedance alternating-current (AC) or battery-powered systems with solar recharge are available from local stores. In a silvopasture practice, the potential for malfunction increases with the risk of falling branches or trees damaging the system. To ensure effective operation, the energized fence should have the following:

- *A properly sized energizer.* Generally, an output of 1 joule per mile of fence is sufficient.
- *Proper grounding.* Use a minimum of 3 feet of ground rod per joule of output.
- *Lightning protection.* Install a surge protector at the power source, a lightning choke at the fence, and an additional ground rod every 3,000 feet of fence.
- *High tensile strength.* Such wire is recommended when using energized fences for border areas and is also used for cross-fencing. The number of strands depends on the type of livestock being grazed. Generally, a minimum of four to six strands is recommended for border fencing and one to three strands for cross-fencing cattle. Other types of livestock often require special considerations, such as distance above the ground of the bottom wire and distance between wires for smaller livestock such as goats and sheep.

Polywire or polytape can be used for temporary or portable cross-fencing to create smaller paddocks for intensive grazing or to allocate stockpiled pastures for winter grazing, thereby enhancing forage recovery periods.

Trees

Douglas-fir and ponderosa pine are the two dominant timber species in the Pacific Northwest. However, other locally adapted conifers or hardwoods may be used, either alone or in mixed-species stands. For example, red alder has been grown as a quick-rotation sawlog between longer rotation Douglas-fir clusters in silvopasture systems. Shading from the conifers encourages tall, straight alder logs that can be cut and sold when the growing Douglas-firs require additional space. Others may include black walnut, KMX hybrid pine (*Pinus radiata* × *P. attenuata*), black locust, maple, cherry, and poplar. For any tree used, it is generally worth the extra cost to purchase large, healthy seedlings grown from a locally adapted seed source. Such seedlings are not only quicker to establish and grow but also more tolerant of browsing and other damages.

In most of the western region of Oregon, reforestation generally requires densities of up to 500 trees per acre, depending on species; therefore, silvopasture is largely infeasible during this stage. These trees may take 40 to 60 years to mature, but commercial thinning at 10 to 20 years of age will open up the canopy and reduce densities to about 200–250 trees per acre. Under the trees, the space created by thinning allows desirable forages for livestock to thrive. These can be invigorated by applying nitrogen in early spring to produce enough forage for livestock.

Grazing in the Shelter of a Tree

- Shade produced by the canopy can reduce stress on cattle during summer months.
- Cattle that graze in shaded conditions have been shown to have improved weight gains.
- Shade is also beneficial in husbandry of dairy cattle, where milk production and reproductive efficiency need to be maintained.
- Trees can provide protection from wind and winter weather.
- Trees and shrubs can reduce the effect of windchill and help manage blowing snow, both of which may be a concern for winter/spring calving operations.
- Research has shown that cattle on winter ranges require a 20% increase in food energy to offset the effects of exposure.

In other regions of Oregon, conventional planting in a silvopastoral pattern may be desirable. Different configurations, such as planting at 8-foot intervals between trees with 18 feet between rows, or establishing tree clusters across a paddock, may increase the time between required thinnings and maximize the area available for forage growth. Much wider spacing between tree rows is feasible and depends on the landowner's objectives. In all but the most widely spaced initial plantings, such as 40 feet by 40 feet (fig. 4), thinnings will at some point be necessary to maintain sufficient light levels for forage production.

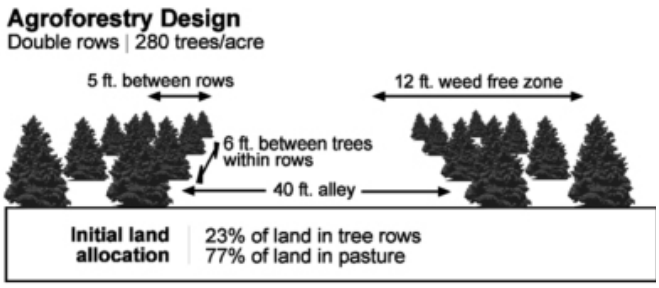

Figure 4. One example of a recommended agroforestry design. Reproduced with permission from Sharrow and Fletcher (2003).

Some Desirable Characteristics of an Agroforestry Tree Species in a Silvopastoral System

- Marketability, including both the wood itself and other products such as nuts or fruit, which would provide another source of income
- Compatibility with the companion crops or forage that are chosen (some trees produce growth-inhibiting chemicals, which may affect what can be grown)
- High quality
- Fast growth, or such high value that a species of medium growth rate is acceptable
- Deep roots, so the trees do not compete with the crops or forage for moisture
- Rapidly decomposing foliage
- Proper matching to the site, either wet or dry
- Leaves that produce a light rather than a heavy shade (this will be especially important as the trees mature and the canopy closes; the lighter the shade that is produced, the longer one can grow forages)

Tree Arrangement on the Land

The proper design plan for any silvopasture practice should consider the spacing between trees, both within and between tree rows (fig. 4). Tree arrangement, either during tree establishment in pastures or as a result of thinning trees within managed forested stands, can vary greatly among trees in single, double, or multiple rows, individual widely spaced trees, and clustered or grouped trees. Silvopastures are often planted at lower initial tree densities, 200 to 300 trees per acre, and more attention is devoted to the care of each tree. A traditional grid pattern spreads the trees out, minimizing competition between trees while maximizing the competition between trees and ground vegetation.

Planting trees into single rows, multiple rows, or clusters provides wide, open alleys for forage production and easy access for livestock grazing, hay harvesting, fertilizer spreading, spraying, and other agricultural practices. The width of the alley between tree rows is often dictated by the size of farm equipment (fig. 5). For example, a 20-foot alley provides full and easy access for cutting hay with a 16-foot swather. Trees that grow best at higher densities are often used for silvopastures. Grouping them into rows or clusters may promote tree growth by providing a "forest effect." Single rows and double rows are often used in silvopastures because they greatly reduce competition between trees and pasture.

Figure 5. Width of the alley between tree rows is often determined by the size of the farm equipment. Reproduced by permission of the National Agroforestry Center.

Different results can be expected from each arrangement. Landowner objectives will determine the best arrangement of trees and the forages to be used. There are several key factors to keep in mind when establishing the practice on a given site and determining the width of the alley between rows of trees. These include equipment size, forage, changes through time, thinning, and pruning.

For planned silvopasture where both trees and forage are started at the same time, timely thinning can be used to maintain semi-open crown conditions. Thinning also serves to increase the resources (light, water, and nutrients) available to the remaining, higher value trees. Proper pruning of the lower branches, to develop a high-value butt log, can increase log value and increase the space available for operating equipment and can increase the sunlight available to the forage.

Common Silvopasture Questions

Is "Pasture in the Forest" a Proven Silvopasture Practice?

A research study in Lincoln County, Oregon, on forage production (fig. 6) under thinned Douglas-fir forests has shown that if woodland owners adopted silvopastoral systems like the one in the study, new animal stocking rates of 4 and 6.5 acres per cow/calf unit could be adopted under 25- and 55-year-old thinned trees, respectively. However, this is a result of only one study on one site; for example, it might be expected that the stocking rate would be lower on a site located on a north-facing slope.

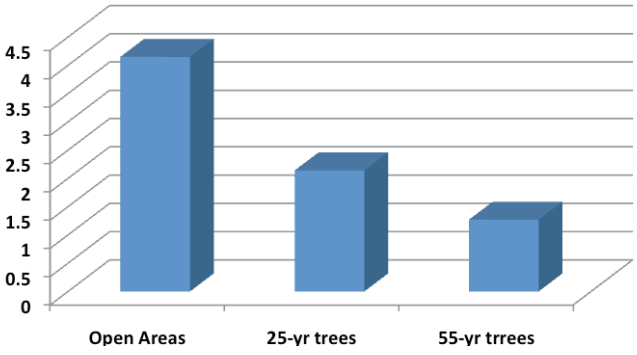

Figure 6. Tons of dry matter per acre of forage hay produced under a silvopasture system as compared with open areas in Harlan, Oregon, using thinned Douglas-fir forests. The two systems were managed under 25- and 55-year-old trees. Forages were fertilized once in April with nitrogen at a rate of 75 pounds per acre. Reproduced with permission from Angima (2009).

Is the Silvopasture Practice Sustainable?

Sustainability refers to the long-term potential of a practice to continue through multiple harvests. And, yes, the silvopasture practice is sustainable. However, it becomes sustainable only through proper planning and management. Planning should include activity schedules that predict when certain management practices will need to take place. During the early years, when trees are small, forage productivity is potentially the same as that of open pasture. In practice, 15% to 30% of the potential productivity during the first 2 to 3 years is lost in the vegetation control strips around trees. The actual point at which trees begin to reduce forage production will depend on forage species and site characteristics. Once this point is reached, forage production will decline rapidly, although significant forage production may continue well into midrotation. Use of the soil-survey forest site index can help with the timing for judging tree height development over time, depending on initial tree planting density.

Does the Silvopasture Practice Have any Long-Term Effects on Soil Compaction?

Soil compaction can have a negative influence on forage and tree productivity. While it may be more challenging to see the effects of compaction on tree growth, it is easily visible in forage productivity. One of the best ways to gauge whether or not the soil is being overly compacted is by the stand of forage being produced. If a forage stand is thin and does not grow back following removal of the livestock, then compaction may be a problem (this assumes that drought or lack of nutrients is not the factor limiting production). Always strive to not overuse pasture. Sound management, such as MiG and occasional aeration of the soil, may help limit compaction. If the forage in a silvopasture practice is maintaining growth and productivity, then compaction is not likely a problem.

Summary

Farm productivity and product quality can be increased substantially when silvopasture practices are utilized. Always use managed-grazing principles with the silvopasture practice. As a part of grazing

considerations, do not forget to supply adequate water for the livestock, and keep livestock within 600 to 800 feet of water. Silvopasture offers many opportunities to enhance livestock productivity, through both the modified climate created and improved forage quality. Silvopastoral grazing of understory vegetation may reduce water stress on trees during dry periods through reduced transpiration of water by the forage plants, and nitrogen-fixing vegetation combined with grazing increases nitrogen uptake of the associated trees.

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For More Information

Other Publications

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Online Resources

ATTRA

http://attra.ncat.org/attra-pub/PDF/grazingcontracts.pdf.

http://attra.ncat.org/attra-pub/PDF/grazingnetworks.pdf.

http://www.attra.org/attra-pub/PDF/managedgraze.pdf.

http://www.attra.org/attra-pub/PDF/multispecies.pdf.

University of Florida

http://edis.ifas.ufl.edu/pdffiles/FR/FR13900.pdf.

University of Missouri Extension (Grazing and Watering)

http://muextension.missouri.edu/explorepdf/envqual/eq0379.pdf. http://muextension.missouri.edu/explorepdf/envqual/eq0380.pdf.

Published October 2009.