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Defining Silvopastures: Integrating Tree Production With Forage-Livestock Systems for Economic, Environmental, and Aesthetic Outcomes

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To many Virginia landowners, silvopasture is a somewhat novel term composed of common elements: "silvo," a derivation of the Latin "silva," refers to woods or forest; "pasture" refers to the plants that make up grazing lands — the basis for most ruminant livestock production. While these words are readily recognized individually, there is some confusion about the combined term — "silvopasture." The aim of this publication is to reduce confusion by clearly defining silvopasture, explaining why and how trees might be managed together with forages and livestock, and describing some of the hurdles and opportunities that come with managing these agroforestry systems.

What Is Silvopasture?

To better define silvopasture, it might be helpful to start by stating what it is not. First, silvopasture might appear to be a new practice, but in reality, it's an old practice that scientists and land managers are rediscovering and refining. The photo with cattle grazing under black locusts (fig. 1) is a reasonable representation of practices that were common on eastern farmsteads decades ago. Trees were an essential resource, providing lumber, poles, posts, fuel, and fodder. Black locust trees, which fix nitrogen, were also an important source of this nutrient in a world without industrial fertilizers.

Figure 1. Cattle grazing fescue-based pastures under black locust trees in Blacksburg, Virginia. Photo by John Fike.

Along with its historical place, there are two other misconceptions that need to be addressed to understand silvopasture systems in a management context. First and foremost, silvopasture is NOT turning livestock loose in the woods, NOR is it a single tree standing in a pasture (figs. 2 and 3). In both cases, when livestock have uncontrolled access to trees with little to no management or they depend on one tree for particular benefits, several negative outcomes are likely.

Figure 2. Livestock frequently take advantage of the shade provided in wooded sites, but the lack of tree and forage management means this is NOT silvopasture. Note the bare soil, poorly distributed trees, and invasive vegetation at this site. Photo by John Fike.

Figure 3. Silvopasture is also NOT a single sentry tree in a pasture. Allowing livestock to have unmanaged access can damage trees, and such sites often become nutrient sinks, where nutrients from other parts of the pasture accumulate. In addition, mucky conditions under the trees create an environment that harbors infectious agents. Photo by John Fike.

The Four-“I” Principle of Silvopastures

Silvopastures are **intentional** in that some or all system components (trees, forages, and livestock) can be chosen for use together with potential compatibilities and synergies in mind. These systems are more **intensive** in that they normally require a greater degree of forethought and engagement than traditional timber or forage-livestock production. For instance, developing a rotational grazing system is an important element of silvopasture management. Recognizing the **integrated** nature of silvopasture helps to capitalize on how components of the system change in time and space (e.g., trees that leaf out late and drop leaves early compete less with cool-season forages for sunlight). Component management, in turn, is **interactive** (e.g., shade for forages and livestock and nutrient recycling for forages and trees). Such interactions can be optimized to benefit the whole system.

So if it is not these things, what is silvopasture?

As hinted at, the term silvopasture implies actively managed tree-forage-livestock systems. In this regard, each component is actively managed (fig. 4). Silvopasture systems can be created by planting trees in pastures or by establishing forages under thinned trees. Each of these approaches has unique demands and opportunities, but in both cases, system management follows the “four-‘i’ ”agroforestry principle. That is, silvopasture management at its best is intentional, intensive, integrated, and interactive.

Figure 4. Top, a loblolly pine stand was thinned and forages were established to create a silvopasture in Virginia’s Southern Piedmont. Bottom, these 17-year-old black walnut trees were originally planted 8 feet apart within rows, with rows planted 40 feet apart in Virginia’s Ridge/Valley region. The trees were thinned once before this photo. A final thinning will be made to create a 40-foot by 40-foot spacing. Top photo by Greg Frey, bottom photo by John Fike.

Benefits of Silvopastures

In most silvopastures, trees are grown to provide longer-term economic returns to the farm, while livestock generate annual income. However, tree crops and products can also improve the short-term economic output of the farm system. Fruits, nuts, pods (see table 1), or browse can have value for human or livestock consumption; in the case of pines, baling needles for straw mulch (fig. 5) or tippings for seasonal greenery can provide added farm income. Along with direct production benefits, silvopastures can also improve resource use and conservation outcomes through greater light and nutrient capture, reduced erosion, wildlife food and habitat, and risk reduction (through farm diversification). Whatever the rationale for implementation — and regardless of the implemented system — management is fundamental for success.

Table 1. Nutritional profile of 'Millwood' honeylocust seedpods from studies in Virginia and a comparison with whole-ear corn.[a]

Pod component or corn	Neutral detergent fiber (%)	Acid detergent fiber (%)	Acid detergent lignin (%)	Crude protein (%)	In vitro digestibility (%)
Seed	13.2	7.5	—	20.4	96.3
Husk	27.3	19.3	6.3	6.2	78.7
Whole seedpod	23.5	16.1	6.3	9.9	83.3
Whole-ear corn[b]	28.0	11.0	2.0	9.0	—

[a] *Adapted from Johnson et al. (2013).*

[b] *Source: NRC (1989).*

Figure 5. Pine straw markets are developing in the Southeast where needles of suitable length (longleaf or perhaps loblolly) can be harvested with a minimum of twigs and cones. Photo by John Fike.

Management and Resource Optimization

The role of management in these systems cannot be overstated. Management is needed to mitigate potential negative interactions that can occur when trees and forages compete for system resources, especially light, water, and nutrients. The following sections address some of the resource issues and explain related system functions.

Light

Cool-season forages such as fescue, orchardgrass, and red and white clovers typically are the primary species in Virginia's forage livestock systems. Although their productivity differs in response to shade, all cool-season forages are light-saturated at less than full sun — that is, in full sun they can't use all the light available to them. Thus, pasture production might not be reduced when trees and forages are efficiently integrated into silvopasture systems. In some cases, moderate shading can even increase forage yield. Tree species selection and management play important roles in these dynamics.

Temperature

Reduction of available light to the forage canopy by trees can have other benefits. In spring, forages grown under trees often "green up" sooner because trees buffer the environment by reducing wind speeds and increasing temperatures around the forage canopy. In summer, trees can have energy-sparing effects on forages (e.g., cooling from shade reduces costs of maintenance during periods of excessive heat or during large swings in temperature; fig. 6), and this can reduce the summer production slump effects that are often seen in cool-season pastures. In this way, the effects of lower light can be partly offset by the reduced stress on forage plants. Lower temperatures can have positive effects on forage nutritive value and digestibility.

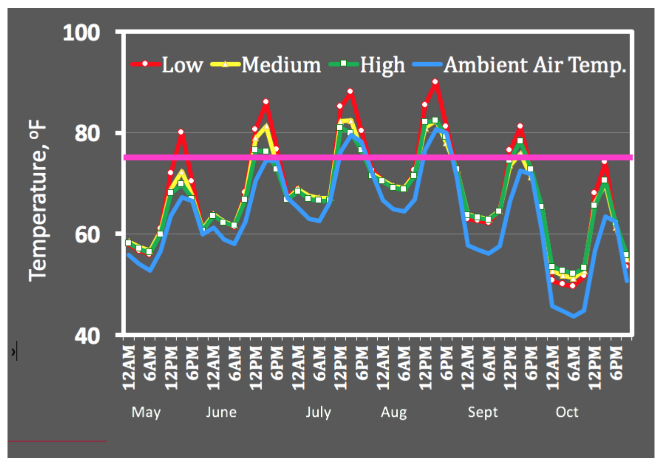

Figure 6. This graph shows average air temperature (blue line) and the average soil temperatures under low (red), moderate (yellow), and high (green) shade conditions in young stands of walnut and honeylocust trees. Temperatures were averaged over 24 hours within months in 2003, a relatively cool year. The pink line at about 75 degrees Fahrenheit (°F) represents the optimal temperature for cool-season grass growth (Sprague 1944). Graph reprinted by permission from Buergler (2004).

Moisture and Nutrients

Tree-forage interactions are often assumed to reduce soil moisture and nutrients for at least one of the plant types. However, the nature of these interactions depends on multiple factors, including tree species, planting density, spatial arrangement, aspect (the direction the slope faces), soil type and depth, tree and forage rooting depths, and tree and forage water and nutrient-use efficiencies.

In many cases, soil moisture is maintained because trees lower soil temperatures and decrease wind speeds, thus reducing evaporation and transpiration losses. Trees can also improve nutrient cycling in pastures by accessing nutrients deep in the soil and moving them to the surface via roots exudates and leaf drop. Trees can also increase the system's nutrient-use efficiency by capturing nutrients such as nitrogen that are readily leached below the forage rooting zone, and this, in turn, supports more rapid tree growth.

Animal Production From Silvopastures

Certainly, most producers consider shelter or heat stress abatement for livestock as one of the most desirable functions of silvopasture management. Many studies have shown that tree shade improves livestock performance (McDaniel and Roark 1956) and behavior (Mitloehner and Laube 2001), but data on animal gain in actual silvopastures with broadly distributed trees are limited in temperate systems with deciduous trees that drop leaves. Animal performance in an early stage, mixed pine-walnut silvopasture system in Missouri was equal to that in open pastures, despite a 20 percent reduction in forage production (Kallenbach, Kerley, and Bishop-Hurley 2006). Similar results were reported in Virginia (Fannon 2012). Increased forage nutritive value and the energy-sparing effects of a more comfortable environment are likely the primary factors supporting comparable rates of gain between systems where forage yield reductions occur.

More recently, Kallenbach (2009) noted that adding trees to about 25 percent of the farm could help even out the forage supply over the growing season by increasing growth early and late in the growing season and reducing the sharp yield peak in midspring (fig. 7). Cows in the silvopasture system also gained more weight and had fewer incidences of dystocia (difficult delivery) when compared to those in open systems.

A Note on Pasture Management

Capturing the benefits of the interactions among trees, forages, and livestock in silvopastures requires greater management than is often used in typical pasture systems. Rotational grazing is an essential tool for silvopasture management because it prevents animals from camping in a few spots and thus compacting soils, damaging trees, and overgrazing the forage understory.

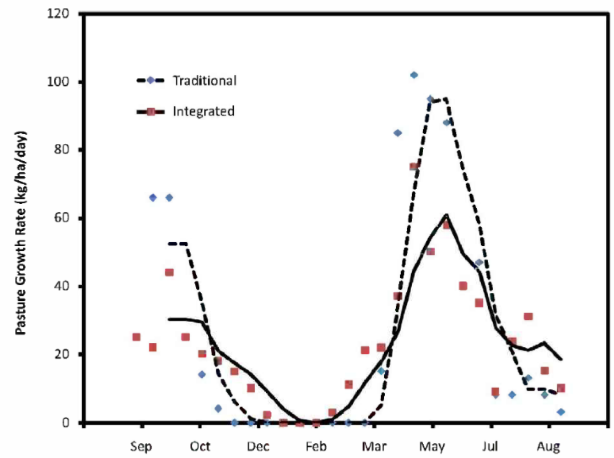

Figure 7. Pasture growth rates in traditional and integrated (25 percent of land base in hardwood silvopasture) land management systems in Missouri (Kallenbach 2009). Data are averaged over two seasons and trend lines are three-week moving averages. Figure reprinted with permission.

Tree Production

Per acre, timber production in silvopastures will typically be lower than in a forest or plantation because tree numbers must be fewer to maintain light for forage growth. With proper management, however, tree growth rates can be greater in silvopastures because of increased nutrient inputs (e.g., fertilizers or legume nitrogen) and returns (animal manure). The value per tree can be increased by pruning limbs from tree trunks to create a high-value log or by collecting marketable products such as nuts, fruits, or needle straw. Creating silvopastures in existing wood lots and timber stands also offers an opportunity to rehabilitate forests that have been degraded from past abuses of high-grading harvest practices ("taking the best and leaving the rest") or unlimited animal access.

Environmental Outcomes

Silvopastures provide opportunity to improve environmental quality, whether by planting trees or thinning stands. In forest settings, timber stand improvement practices can be used to select and manage for preferred species and to remove reservoirs of invasive tree and shrub species. Adding forages to the understory can heal eroded lands scarred from years of unmanaged livestock access. Similarly, planting trees in pastures can help reduce erosion, nutrient leaching, and runoff. Also, the greater comfort afforded livestock can reduce their use and degradation of surface waters. Silvopastures could also be an important management tool for sequestering carbon because trees can capture and store atmospheric carbon.

The System as a Whole

Managing trees, forages, and livestock on the same piece of ground presents both challenges and opportunities beyond those found in traditional forage-livestock or tree plantation systems. As noted previously, even if merging these production systems results in a partial production decline for each component, the overall output of the system can be greater than the systems managed as monocultures. Silvopastures can be strategically integrated into a whole farm system to mitigate stress on livestock, improve environmental outcomes, or increase aesthetic appeal with an eye toward greater profitability over the long term.

Producer Adoption and the Long View

Silvopastures are not for everyone, and a summary of potential advantages and disadvantages is provided in table 2. The ability to capture the advantages of silvopastures will require more skills and greater management inputs than needed for typical forage-livestock systems. They also require a long view. A common first reaction to the idea is, "I'm not going to harvest those trees, so why should I plant (or manage) them?" This can be answered both from economic and land ethic bases. First, the value of a tree can be sold or bequeathed, whether a tree is ready for harvest today or tomorrow. Second, our goal as stewards should be to leave the land better — the woodpile higher — for those who will follow. The integrative, interactive nature of silvopasture systems offers land managers unique opportunities to think and manage both for short- and long-term outcomes while making greater, more efficient use of natural resources.

Table 2. Potential advantages and disadvantages of silvopasture management.

Item	Potential advantages	Potential disadvantages
Livestock/ forage	Reduced heat stress. Less use of streams and surface waters for cooling. Reduced effects of fescue endophyte. Better animal social behaviors: less fighting, aggression. Animals distributed among trees, not congregated around a single tree. Earlier spring green-up and delayed dormancy in fall.	May require less frequent use or less intensive defoliation of forages. Some legumes sensitive to shade. High management intensity, including time, labor requirements. Lower total forage growth. Rotating pastures necessary. Potential loss of pastureland during the tree establishment period.
Forest/ low-density plantings	Increased wood quality by pruning lower limbs (fewer/smaller knots). Opportunity for species selection. Better management of existing forest stand. Increased growth of crop trees through capture of nutrients added for pasture production. Managed trees can have greater market value. Reduced invasive species. Lower risk of forest fire.	Reduced wood quality if animals congregate around a single tree or if access is not controlled. Limited regeneration potential without exclusions or replanting. Planting hardwood trees can be risky, costly, or both. Systems might require management of individual trees. Risk of tree quality reduction (epicormic sprouts) with high rates of initial forest thinning. Soil compaction.a Trees may be lost to windthrow or other damage. Risk of trees falling on fences or animals.
Conservation/ social/ economic services	Carbon sequestration. Reduced soil erosion, water runoff. Greater water infiltration. Greater nutrient (nitrogen and phosphorus) capture. Greater species and market diversity. Improved wildlife and pollinator habitat.b Aesthetically pleasing. Diversification of income sources and time horizons of income sources. Total return on investment equal to or greater than alternatives.c Cost-share incentive opportunities. Stewardship ethic.	Cooler, moister environment can increase bacterial loads on pasture. Added infrastructure investment (e.g., fences, water) to rotationally graze paddocks.

[a] *Bezkorowajnyj et al. (1993); Sharrow (2007).*
[b] *Husak and Grado (2002); Shrestha and Alavalapati (2004).*
[c] *Husak and Grado (2002); Clason (1998).*

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