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CONSERVING OUR SOILS, FARMS, AND ENVIRONMENT
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Summary

This report, addressing silvopastures, is one of a set of seven describing practices supported by the Grasslands Partnership project. Incorporation of trees into pasture can improve soil organic carbon, provide shade for livestock, and provide alternative income sources for the farm. Guidance is provided for selecting sites, trees species, and establishment methods for those trees for creating silvopasture within currently non-forested sites. Attention to tree species, spacing, protection, and competition control are all critical to successful implementation.

CLIMATE SMART PRACTICES – SILVOPASTURE PRACTICE INTRODUCTION AND IMPLEMENTATION GUIDE SHEET

Silvopasture, a sustainable agroforestry practice, involves the intentional integration of forage, trees, and livestock. Silvopastures offer potential for numerous environmental, economic, and social benefits, including improved soil health, increased biodiversity, enhanced livestock responses, and diversified income streams for farmers. Silvopastures are considered one of the best agronomic approaches to carbon drawdown and may provide livestock producers and landowners with direct access to carbon markets.

Silvopastures may be created both by thinning existing timber stands and by planting trees. Under this program, we will only offer financial support for efforts to establish silvopastures by planting trees into a) existing pastures and b) for crop fields transitioning to silvopasture.

Successful silvopastures can be created both by planting hardwood and softwood tree species. Choice of specific tree, forage and livestock used in these systems should consider local topography and climate, soil conditions, available resources, and prioritization of expected outcomes from the system. A list of preferred trees follows in the tree selection section.

Implementation Basics

1. *Site Selection:* This project is only supporting tree planting into new fields or existing pastures. Suitable sites for establishing silvopastures should be determined based on criteria such as topography, soil type, drainage, and level of management needed. Consider the availability of sunlight, water, and other resources required for tree and forage growth, as well as accessibility for livestock and equipment.

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2. *Forage Crop Establishment:* Prepare the land by removing any existing vegetation and debris. Conduct a soil test to determine nutrient levels and pH, and apply lime and/or fertilizers as needed based on the results (consult your local Extension resources). Where forages must be established as part of the implementation process, regionally suitable forage species should be established following recommended seeding rates and planting methods for the region. *Because this project is centered in the fescue belt, preference should be given to tall fescue where viable.* Implement proper weed control measures, such as mowing or herbicide application, to establish a healthy and productive forage stand.

3. *Tree Establishment:* Select tree species that are compatible with the local climate, soil conditions, and desired silvopasture objectives. Control competition from existing vegetation around trees (with herbicide, mulching or gravel or a combination of these). Bare root seedling trees are most commonly planted; larger planting stock (e.g., whips, saplings) can be successful but require more care/attention during establishment. Follow recommended tree planting guidelines, including proper tree spacing and planting depth, and watering where practical (or essential). Trees can be planted in rows or clusters. When planning for the silvopasture's final configuration, provide enough space between final crop trees to accommodate their expected mature size as well as the understory's light needs and general logistics requirements (e.g., for moving farm equipment and livestock through the site). Silvopastures also can be planted at a higher density than intended for the final stand with the expectation that some trees will be removed over time. This may support better tree development and provide opportunity to select trees of better form. In some cases, extra trees (e.g., rows of pines) may serve as trainer trees for the leave trees and can be a source of harvestable pulpwood.

4. *Tree Protection:* Consider using tree shelters or tree guards to protect young hardwood trees from browsing animals (both livestock and wildlife). Such protection may also be needed to prevent small rodents from girdling hardwood seedlings. Gravel "mulch" may be more effective than organic mulch in this regard because rodents can more easily burrow under wood chips, leaf litter or other organic mulches. Fencing may be sufficient protection for softwood trees which generally need more protection from trampling than from browsing. Electric fence or netting for livestock and 3-D fencing for wildlife can be part of the protection plan. In some cases, fencing systems and tree protections can be integrated.

5. *Competition Management:* Some tree species are less affected by competition than others. Reduce forage competition with new trees, particularly for sensitive species, by killing the sod where the trees will be planted. Tillage or herbicide both can be effective, but herbicides must be compatible with (i.e., should not damage) new tree seedlings. Keeping a 2-3' radius around hardwood trees for the first couple of years will hasten height and diameter growth of the seedling. Mulch can be used but may provide habitat for rodents. Gravel around the tree base may also be effective at suppressing vegetation without harboring rodents.

6. *Livestock Integration*: Introduce livestock, such as cattle, sheep or goats, into the silvopasture system once the forage crops and trees are well established. If the trees are still in the establishing phase but the forage component is ready to be grazed by livestock, then trees need to be well-

protected (e.g., using fencing) from potential defoliation by the grazing livestock. Prevent overgrazing and promote uniform forage utilization by monitoring and adjusting livestock stocking rates and areas where forages may be weaker. Temporary (electric) fencing is a tool that can help to achieve uniform utilization of the forage resource and facilitate movement and management of livestock.

7. *Maintenance and Management*: Post-plant "aftercare" is an important component of establishment success, particularly for hardwood trees in tubes. The following checklist (developed by a commercial planter) can serve as a guide for maintenance and would be advisable to add to the contract for farmers who hire commercial operators to plant trees.

- ☐ Determine if the trees are alive
- ☐ If dead, mark the tube with an X using a thick marker or grease pen
- ☐ Remove weeds inside the tube
- ☐ Prune as necessary
- ☐ Reset stake and tube as needed
- ☐ Cut the top of the tubes if needed to reduce rubbing damage
- ☐ Apply vole deterrent (in fall)
- ☐ Reapply mulch (year 2) as original breaks down

Regular maintenance - mowing, weed control, tube repair, fencing - will aid tree growth. Conduct regular inspections of fencing and repair as needed. As trees age, lower limbs may be pruned to allow in light or to keep alleys open, or both.

Trees per-Acre (year-2 live tree minimums) and Spacing and Configuration Considerations

Tree size and form generally dictate numbers of trees per acre. Minimum trees-per-acre guidelines here are based on general differences in form and resource use between hardwood and softwood trees as well as considerations of establishment costs. Softwood trees generally are less expensive and require fewer resource inputs to establish than hardwood trees. They also typically have tighter canopies and close planting supports self-pruning. Closer (higher density) planting can benefit hardwood tree form from a timber perspective, but this must be weighed against the costs of establishment, protection and management and their future value.

For this project, farmers planting hardwood trees are expected to develop a silvopasture stand with a minimum of 30 live trees per acre two years post-establishment. Research-based recommendations for planting hardwood silvopastures are limited, but a good rule of thumb for a mature system would be 25-35 trees per acre, with the final tree stocking rate dependent on mature tree size. With cool-season forages underneath trees, sufficient spacing that maintains at least 60% light in the understory will keep forage production comparable to open field production, and this will be a feature of canopy size and density, which can vary by species as well as by site conditions (Figure 1).

Figure 1. *An aerial view from Google Earth showing walnut (large) and honeylocust (small) trees on an experimental research site in Virginia, June 2022. Trees were planted in 1995 at 8' x 40' spacing and thinned over time to approximately 40' x 40'. Walnut trees are substantially larger than honeylocusts and over time forage production in the walnut system is about 30% less than in open pasture. At this site, forage production under honeylocusts has generally equaled or been greater than in the open pasture systems.*

Tree configurations for hardwood plantings should account for final tree size, form, and canopy characteristics. Tree number per acre will decline slightly when trees are planted in repeating rows across a field. Wider alleys with tighter spacing within tree rows can be helpful in accommodating equipment and herd movement. This likely will alter canopy characteristics as trees compete with each other within rows. A square acre (208 feet on a side) with trees about 40 feet apart both within and between rows would result in 39 trees on the first acre, but the number of trees/acre will decrease as trees are "shared" across acres.

For this project, farmers planting softwood trees are expected to develop a silvopasture stand that will have a minimum of 120 live trees per acre two years after establishment. Recommended tree stocking rates specifically for pine-based silvopasture systems also are limited but typically have been informed by plantation production approaches. Tree stands with a 10' x 10' spatial arrangement would leave a stocking rate of about 450 trees per acre and this rate might be adjusted based on site conditions and timing of thinning events during the timber rotation. In a silvopasture, softwood planting configuration may be similar approach but would incorporate broad alleys to support forage production (Figure 2).

Each layout in Figure 2, based on double row configurations, provides tree and alley spacing and the corresponding tree stocking density. Field widths are adjusted to accommodate alley-row width configurations and the corresponding acres are given. Spacing examples provided here can be adjusted as desired but should be made based on site conditions, infrastructure and logistics needs, and producer preference. The assumption here is that producers may want to manage with large alleyways, but other configurations – e.g., multiple clusters or aggregated trees at lower densities can also be functional and desirable.

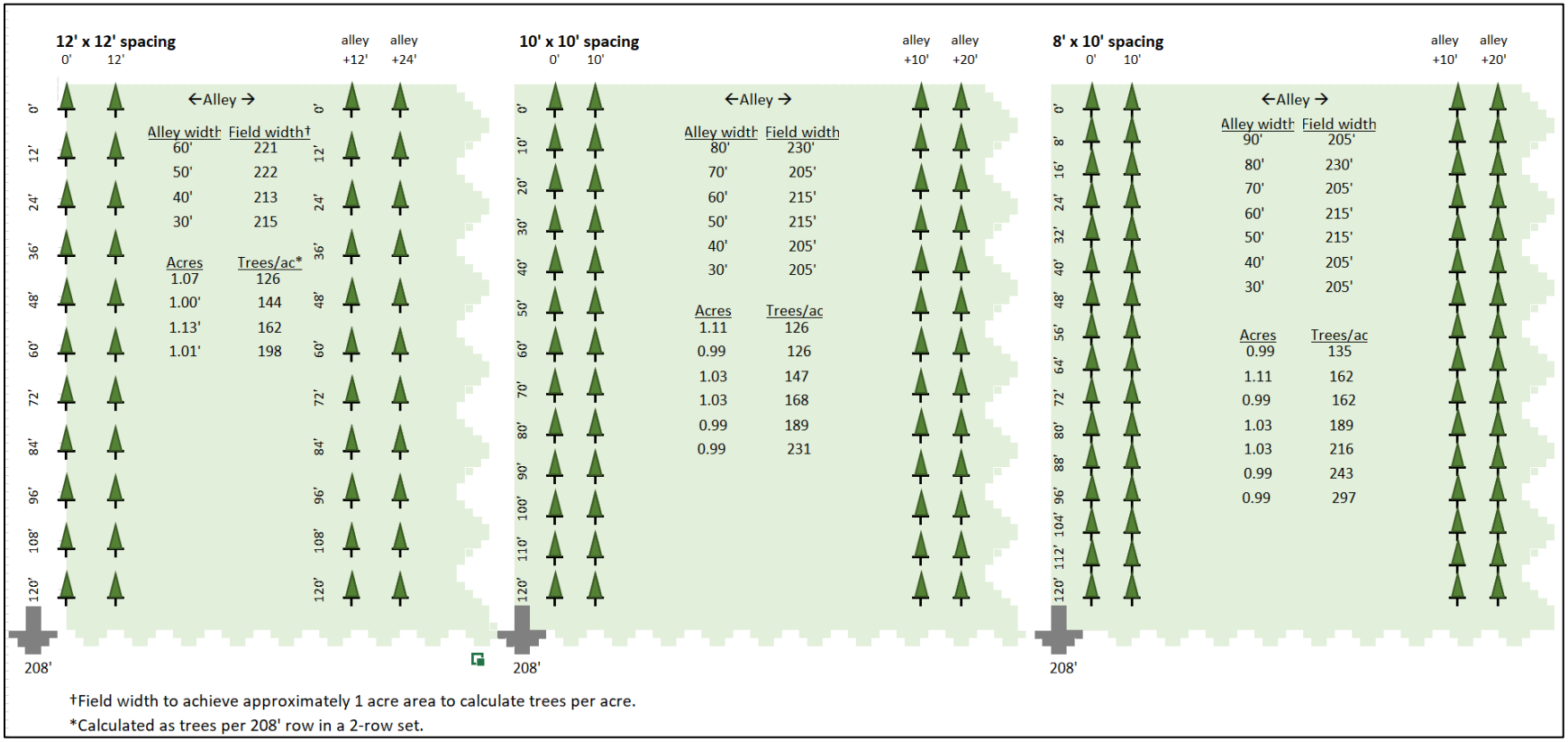

Figure 2. *Common softwood layouts with row and alley spacings to reach 120 tree/acre minimums.*

At the latitudes for this project, a north-south orientation is preferable where rows of trees are to be planted. This generally is considered better for forage production given the potential for greater sunlight to reach the forages. However, overriding factors such as topography, aspect, and existing or future infrastructure needs should get first consideration. Inter-row and alley-width spacing may in turn be adjusted where tree layout presents challenges.

Protection Systems

Producers can take any number of approaches to tree protection as described in section 4 of *Implementation Basics*, above. Sites with heavy wildlife depredation potential will need greater investment, whether in tubes, mulch, or fence or some combination. Where deer are an issue, simple, low-cost 3-D fencing can be effective (Figure 3) but this will need continuous maintenance, particularly in seasons when plants are desired for browsing or rubbed (to remove velvet from antlers). Tubes are particularly useful when tree species are palatable to wildlife and livestock, but they add significant cost in material, labor, and maintenance. Tubes should be ventilated to provide air to the tree for growth and to limit the potential for disease development. Our personal observations are that systems with stakes that are flexible can be easier to maintain than stakes that easily break or shatter after a couple of years in the field. This is a greater issue when slower-growing trees are planted. In some cases, producers are integrating their temporary (polywire) fencing with non-conductive stake and tube systems. This both helps with tree protection and creates fencing systems that support rotational grazing. For yellow pines and other trees that need little protection from browsing, fencing is more important to deter cows trampling the young seedlings. As such, a hot line above or on either side of the seedlings may provide sufficient protection. Protection also must be considered in the context of the livestock as mature cows may be disinterested in trees, whereas calves may pull up seedlings for fun and bulls will walk over a tree for a belly rub. As well, cows may be less inclined to strip tree bark than small ruminants.

Figure 3. *The tree in the foreground is protected up to the top of the tube but can be browsed. Simple three-dimensional fencing can be an effective way to keep deer from browsing (as with trees in the background). Photo: John Fike*

Forages

Cool-season forages generally will be preferred in the upper South given that their light and temperature requirements for optimum growth are better suited to both the cooler conditions of the

region and the shaded environments created by silvopastures. Warm-season perennial forages (native or non-native) will generally be preferred in the lower South given the climate and generally greater light and temperature needs. In either case, alley widths should be wide enough to provide sufficient light and heat units through the summer growing season. Silvopastures implemented with wider alleys will require closer inter- or intra-row tree spacing to meet per-acre planting minimums.

Tree Selection Guidance and Guides

Tree species selection should be based on farm needs (e.g., for shade, browse, or utility lumber) and for available markets for timber, nuts or other tree products. Often there are tradeoffs to consider in species selection. E.g., better-adapted species for a site may also be slower growing, or rapidly growing trees may only be suited to specific sites. In all cases, selected tree species should be adapted to site conditions to support more rapid growth and disease resistance. Additional selection guidance follows:

- Natives are preferred: Generally, it will be best to obtain adapted trees from local sources to better match your site conditions, but this may not be possible in all cases.

- Rapid growth: Getting trees established quickly and reducing the time required to protect trees provides greater flexibility for the system and its management. Rapid growth also supports faster opportunity for income diversification and also supports the project objective of rapidly capturing carbon.

- Form and phenology. Trees that have tight canopies or heavy leaves can produce significant shade. (Thus, species such as maple are not encouraged except in low density plantings.) In the same way, phenology (the timing of development) can affect resources to the pasture, and trees that leaf out early and drop leaves late can add significant shade to the system. Leaf structure, particularly for hardwoods, also is a consideration; compound leaves (that allow more light penetration through the canopy) and which degrade more easily after they fall to the ground are generally more desirable. However, all of these issues can be addressed by spatial arrangement and management inputs. Preferred species are more deeply rooted and put out fewer lateral roots which create more competition for nutrients and water and which are subject to damage from compaction. As with aboveground management, such issues can be addressed by rotational grazing and timing animal access to silvopastures when soils are not readily compacted.

- Low input needs: Trees that require less work may generally be better suited to extensive farm operations, but approaches to tree management will differ by producers and their interest. Pruning, thinning or both may be needed for many hardwood species and is common management for producing high quality pine timber. Such inputs can be reduced somewhat by tight spacing (thus trees self-prune). On the other hand, less pruning may be desired where larger crown is desired for production of additional products.

- Additional products: Fodder, nuts, fruits and pine straw are among the many tree products that may be harvested from silvopasture trees. Materials used for human consumption must meet

safe food handing guidelines. In some cases, producers may choose to plant more trees than desired for the final silvopasture, with the intention of harvesting some trees for fuelwood or pulpwood.

- Available markets: As noted, a number of products can be derived from trees, but whether markets for the products are available or can be accessed should be considered. (e.g., is the mill close enough for economic timber harvest)

Preferred hardwoods for this project include: black walnut; black locust; white, red and other regionally-adapted oak species; pecan, yellow poplar; apple; and persimmon, among others.

Preferred softwoods include yellow pines such as slash, longleaf, shortleaf, loblolly, pitch and pitch-lob hybrids; white pines; and other conifers such as bald cypress.

Other tree species may be used for your silvopasture, and there are several candidates with desirable features but which have limitations such as potential to spread or shallow rooting and thus greater susceptibility to trampling damage. These can be used successfully, but producers should be aware of potential management needs.

Additional Resources

Defining silvopastures: https://www.pubs.ext.vt.edu/CSES/CSES-146/CSES-146.html

Creating silvopastures when planting trees: https://www.pubs.ext.vt.edu/CSES/CSES-185P/CSES-185.html

Producers engaged with silvopastures (video series)
https://www.youtube.com/playlist?list=PLsPrMF2hUwAZvIp87cm-UNEtzkJIBJJ2i

Considerations for establishing and managing silvopastures
https://ext.vt.edu/content/dam/ext_vt_edu/topics/agriculture/silvopasture/files/silvopastures-considerations.pdf

Tree selection guide for mid-Atlantic silvopastures – our first 2- trees
https://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/spes/spes-476/SPES-476.pdf