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Creating Silvopastures: Some Considerations When Planting Trees in Pastures

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Silvopastures — integrated tree-forage-livestock production systems — have the potential to boost farm resource use and income. These systems take advantage of the beneficial interactions among system components, add biodiversity, and increase animal comfort. The intentional and careful combining of trees and livestock in time and space can yield both short-and long-term returns and have positive environmental outcomes. In well-managed silvopasture systems, trees can reduce livestock stress by protecting them from inclement weather or by reducing ambient temperatures and radiation. They can provide marketable timber and nontimber products and improve environmental quality by reducing water runoff and capturing nutrients and by reducing animal use of surface waters.

Additional information on the benefits of silvopastures and some "hows" and "whys" of these systems can be found in Virginia Cooperative Extension publication CSES-146P, "Defining Silvopastures: Integrating Tree Production with Forage-Livestock Systems for Economic, Environmental, and Aesthetic Outcomes." Those interested in creating silvopastures by thinning existing tree stands are directed to VCE publication CSES-155P, "Creating Silvopastures: Some Considerations When Thinning Existing Timber Stands." The aim of this publication is to describe how silvopastures can be created by planting trees in established pastures.

Planning for Silvopastures

Because planning and managing a silvopasture system require diverse skill sets, it is helpful to build an advisory team with the various types of expertise needed. Seeking guidance from those who have implemented silvopastures; working with experts in trees, forages, and livestock; and getting feedback from those who contribute to the farm's operations (e.g., custom applicators) can save time and money and minimize future frustrations. For many livestock producers, getting assistance with tree selection and establishment decisions will be essential. Careful consideration must be given to layout, compatibility with forage species, appropriate protection from livestock and equipment, and long-term management needs.

Tree Selection and Layout

Tree selection is critical. As one Virginia forester says, "You can grow almost any tree almost anywhere for a period of time, but not necessarily well." In addition to species and site compatibility, trees should be chosen to complement, not compete with, the farm operation.

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Typical attributes for tree selection include (1) marketable timber or nontimber products (e.g., nuts, fodder, pine straw); (2) growth pattern and rate; (3) deep-rooted morphology, with preference for deep-rooted species to reduce competition with forages; (4) open canopy to allow more light to the forage understory; (5) late leaf out and early leaf drop dates; (6) drought tolerance; and (7) environmental conservation services provided. Other important considerations include cost, labor requirements, site suitability, resources required for establishment and management, and land tenure constraints.

Because no tree species will meet all of these criteria, selection should best match the producer's goals, resources, and site characteristics (fig. 1). For many managers, trees will first and foremost be part of an animal comfort strategy — to relieve heat stress in summer or to provide windbreaks/shelter in winter. Some tree species also provide secondary feed resources, such as valuable fodders or browse for livestock.

When grown strictly for timber, trees are a long-term investment. Well-managed trees can add diversity to the landowner's financial portfolio and could have higher rates of return than livestock over time. When considering growing trees for future timber, landowners must be aware that tree plantations often require a minimum size to be economical. This is particularly true for commodity products, including pulpwood and southern pine sawtimber, or for low-value timber for railroad ties and pallets. Specialty or high-value timber products, such as good-quality black walnut timber or veneer logs, might be feasible at smaller scales. However, markets are more limited and might not be available in some areas; thus, market access is an important consideration. Alternatively, producers could opt to plant species they can process themselves for products, such as firewood or posts for sale or for use on the farm.

Trees can also provide medium-term returns with nontimber products, whether marketed as commodities (e.g., pine straw or greenery, nuts or fruits) or as value-added goods (e.g., wreaths, ciders, or acorn-fattened hogs). Creating wildlife habitat for hunting leases and improving the aesthetic appeal of the land are other common goals. Of course, these aims are only attainable if on-the-ground resources, such as soils or climate, are suitable for the producer's trees of interest.

Although planting a single tree species can simplify management, combining different species offers other — and often multiple — benefits. For

Figure 1. Both soft- and hardwood species are suitable for silvopastures, and a multitude of trees, combinations, and configurations can be used. Top, Warm-season trees, such as locusts, walnuts, and members of the hickory family, leaf out after the initial flush of cool-season forage growth. Such tree growth patterns reduce competition for light in spring and fall and buffer forages and livestock from high temperatures in summer. The leaves from such trees also degrade faster than the heavy leaves of oaks or maples. Trees are 17 years old in the photo and were thinned to half this density the following spring. (Photo by John Fike.) Conifers are well-suited to high-density plantings with wide alleys. Bottom right, At this site, fescue or switchgrass plus lespedeza are grown in the alleys. The warm-season mix provides excellent habitat for quail and other wildlife. Pines were planted on an 8-foot by 8-foot by 60-foot spacing (i.e., the trees were planted at 8 feet within rows, 8 feet between rows, and with 60-foot alleys). Trees often grow more rapidly in well-managed silvopastures than in plantations because they have greater fertility, water, and light resources. (Photo by John Fike.) Bottom left, These 11-year-old loblolly pines are about 15 feet tall. (Photo by Gabriel Pent.)

example, planting rows of conifers on either side of hardwood timber trees can provide a windbreak and simultaneously "train" hardwoods to grow upward like a forest-grown tree, rather than outward like a yard tree. This co-planting strategy and training of the hardwood species can reduce branching on the trunk and increase the value of timber. Conifers can also provide additional revenue when marketed as pulpwood or biomass, even when harvested as small-diameter trees. Because of the shorter production cycle for softwoods, a multispecies planting might also provide earlier returns than those typical of a hardwood-based system.

Mixed plantings could also be useful where trees have complementary or offsetting features. For example, black walnut (*Juglans nigra*) timber is highly prized, but the trees have long rotation times and might release compounds that possibly inhibit the growth of forage legumes, such as clovers and alfalfa. In contrast, black locust (*Robinia pseudoacacia*) trees fix nitrogen and have fairly rapid growth rates, but they can sometimes be difficult to manage because of thorns and excessive sprouting. Planting these trees in combination could help maintain the nitrogen supply while limiting the harmful effects of chemicals released to the forage understory. This mixed planting could require more oversight (e.g., to prevent thicket growth) but likely would produce some marketable timber in a shorter period of time than would be possible with walnut trees alone.

Along with species selection, it is important to carefully plan the silvopasture layout (fig. 2). Tree planting density and spatial arrangements will vary based on the amount of shade a tree species casts or the water it requires. Prevailing winds, animal movement, infrastructural needs for water or fencing, and aesthetic appeal are all management considerations. Clustered planting arrangements can be visually appealing and beneficial for some tree species, but most plantings are laid out in rows to facilitate management. Row orientation is an important factor for optimizing light to the forage understory, with north-south oriented rows preferred at Virginia's latitudes.

Rotational stocking is essential for good silvopasture management, and placement of feeders and waterers is an important consideration in the silvopasture layout. To avoid serious headaches, designs must leave

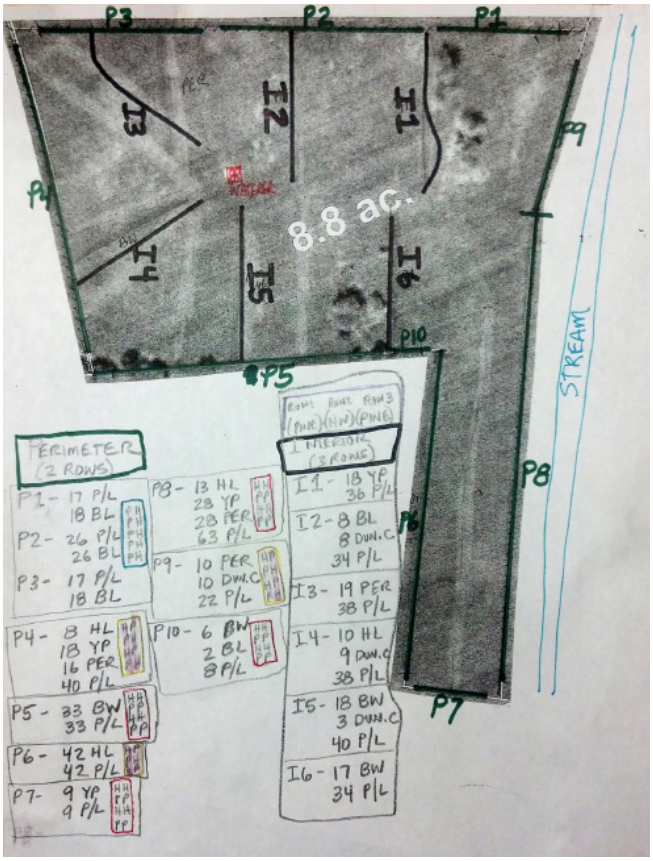

Figure 2. A good map of the farm or targeted fields can greatly aid silvopasture planning. Knowing soils and boundary dimensions will be helpful for tree selection and placement. GPS systems can be useful for the layout, but in this case, the farmer used photocopies of an aerial photo to draw multiple layout possibilities before finalizing the plan. The farmer's choice for species and numbers of trees for perimeter (P) and interior (I) row sections are written underneath the picture of the field. In the field, fences placed alongside the tree rows for protection also facilitate livestock rotations, making grazing management easier. (Figure courtesy of Buck Holsinger.)

room to move equipment, such as mowers, fertilizer spreaders, and boom sprayers, or turn it around in the field — both at planting and after years of tree growth.

Site Preparation and Vegetation Control

Field work begins after the design phase. Controlling existing vegetation, either chemically or mechanically, is an essential step for tree establishment (fig. 3). Herbicides generally have better results and are more cost-effective both in pre- and post-plant applications. However, one must take care to ensure

Figure 3. Good vegetation control is essential for successful tree establishment. Top, Herbicide applications and tillage are the primary methods used to reduce vegetative competition for new tree plantings. (Photo courtesy of Todd Groh, Virginia Department of Forestry.) Herbicides can kill existing vegetation without soil disturbance. Tillage or other mechanical disturbance can be used to break up or remove sod before trees are planted. Middle, A scalper is used to remove the sod layer, facilitating planting. (Photo courtesy of Todd Groh.) Such methods can be preferred for organic production systems, although in all cases care should be made to avoid tillage on sites conducive to soil erosion. Bottom left, Planting trees in pastures without reducing competition can slow tree growth. (Photo by John Fike). Bottom right, Disturbance can also result in significant weed pressure by exposing bare soil and stimulating dormant weed seeds. In this case, scalping also limited the ability to use mowing for post-plant vegetation control because sod deposited on top of the ground left the soil surface uneven and difficult to drive over. (Photo by John Fike.) Not all weeds are bad, however; some weed cover can obscure seedling trees from wildlife reducing browsing and scraping.

that the herbicides used are compatible with the type of trees planted and the stage of budding, or that the trees are protected from any chemical application. Also, the cost-effectiveness of vegetation control is somewhat species-dependent. For example, loblolly and pitch loblolly hybrid pines are fairly robust and could survive plantings where existing vegetation is not controlled well; shortleaf and white pine are less robust. Even with tolerant tree species, however, reducing the competition from other vegetation will speed tree growth.

Mechanical options for removing competition include tillage/scalping, mowing, weed mats/mulch, and intense grazing pressure. Tilling or scalping the vegetation physically removes the current sod cover at establishment. This soil disturbance can create good habitat for weeds and, depending on implementation, could make the ground uneven in and around the planting area, which can make mowing difficult. Intense grazing pressure can also be used to weaken existing forage stands before planting and reduce competition after planting if the trees can be protected. Other nonherbicidal post-planting weed suppression or competition reduction strategies include mats, mulches, or judicious mowing, although these can be counterproductive in some cases.

Along with controlling competing vegetation, deep ripping (subsoiling) can be useful for site preparation. This is most beneficial in sites where soils have a hard pan or are subject to compaction. Ripping can break this compacted layer, allowing tree roots to penetrate deeper into the soil profile.

Tree Planting

Tree planting is generally regarded as a fairly straightforward endeavor, but poor planting technique is a common problem that can significantly increase costs. Poorly planted trees (e.g., too shallow, too deep, roots improperly placed underground or in compacted soil) have higher mortality and reduced long-term vigor, which leaves trees more susceptible to disease and insect damage. It is prudent to explore planting options and ensure that each tree seedling is correctly planted.

While trees can be planted from seed, germination is often low, and sourcing seed can be difficult. The traditional approach is to plant either bare-root

seedlings or trees with a root ball (grown in a plastic container or dug up and "balled and burlapped"). For large plantings of multiple trees on multiple acres, bare-root seedlings are far and away the best planting option. Bare-root seedlings are the most affordable and easiest to handle, and they grow rapidly given appropriate planting and adequate soil moisture. Bare-root seedlings are generally 1 year old, having spent the first growing season in a crop field bed. The trees are harvested by lifting them from the growing bed, and they are packaged for sale/shipment in late winter/early spring. Seedlings can range in size from 1 foot to several feet tall (including root and shoot), depending on species and growing conditions.

Although both fall and spring are good times of the year to plant trees, most bare-root seedlings are planted in early spring because that is when they are prepared by commercial and state nurseries. It is best to get trees in the ground before they break dormancy and begin to bud. In Virginia, this is any time from February through April, depending on local climate. Native plants are the best indicators of optimal planting time. If the soil is not frozen and the buds on some of the earliest blooming species, such as redbud and red maple, have not started to swell, it is a good time to plant.

Prepare everything necessary for getting trees into the ground before they arrive. The less time there is between their arrival and planting, the better. If some delay is unavoidable, store trees in a refrigerator or other cool, damp place that won't be subjected to freezing temperatures. It is essential to keep the root system moist during storage.

Several tools can be used to make planting easier and faster (fig. 4). Hoedads and dibble bars are simple hand-held tools used to create a slot in the earth for the roots and to close the planting hole after inserting a tree. These tools might be available for loan from the local Virginia Department of Forestry office. A simple shovel technique involves pushing the blade into the ground from opposing directions to create a wedge of soil. The wedge should be cut deep enough to accommodate the seedling's root system. Remove this wedge, place the tree in the hole at the right depth, and replace the wedge with some gentle downward pressure to ensure good root-to-soil contact with no air gaps in the soil.

These planting methods work well for small seedlings and with species such as conifers that have more fibrous root systems. However, large, coarse, woody roots typically do not bend well and can be a challenge to fit into a slot in the earth. In these cases, a hole typically needs to be prepared and the extracted soil loosened for backfilling. In many cases, using a shovel instead of a posthole digger will be preferable for maintaining tree health. Posthole diggers and augers can glaze and compact the soil on the side of the hole, especially in clay-rich soils. These smooth, compacted surfaces reduce root penetration and thus limit root expansion.

Furthermore, it is easy to go deeper than needed with these tools, which can lead to planting too deep as well as excessive settling of the planting and potential damage to the root collar. While this is a general rule of thumb for bare-root seedlings, in cases where larger trees with root balls are being planted, use of augers could be the most practical way to efficiently plant a large number of trees.

Professional tree planter crews can be employed to plant any kind of tree (fig. 5). Depending on the site and size of the job, they could use a tractor and tree planter for pine plantings, but otherwise they will use the same hand tools described previously. Additional tree planting resources can be found on the Virginia Department of Forestry website at www.dof.virginia.gov/tree/care/how-to-plant-seedling.htm.

The root of the matter — when it comes to planting trees — is in fact the roots. Roots should be moist when received and kept moist, even while planting. Roots of planted trees should be below ground, but not too deep (the top-most root should be just barely below the soil surface). Root tips should be pointed down or out (perpendicular from the tree). Avoid the "J-root" planting style, where roots are pointed upward. All roots should be in contact with soil — there should be no air pockets below ground. Following these basic guidelines will keep tree root systems healthy, in turn supporting better above ground growth.

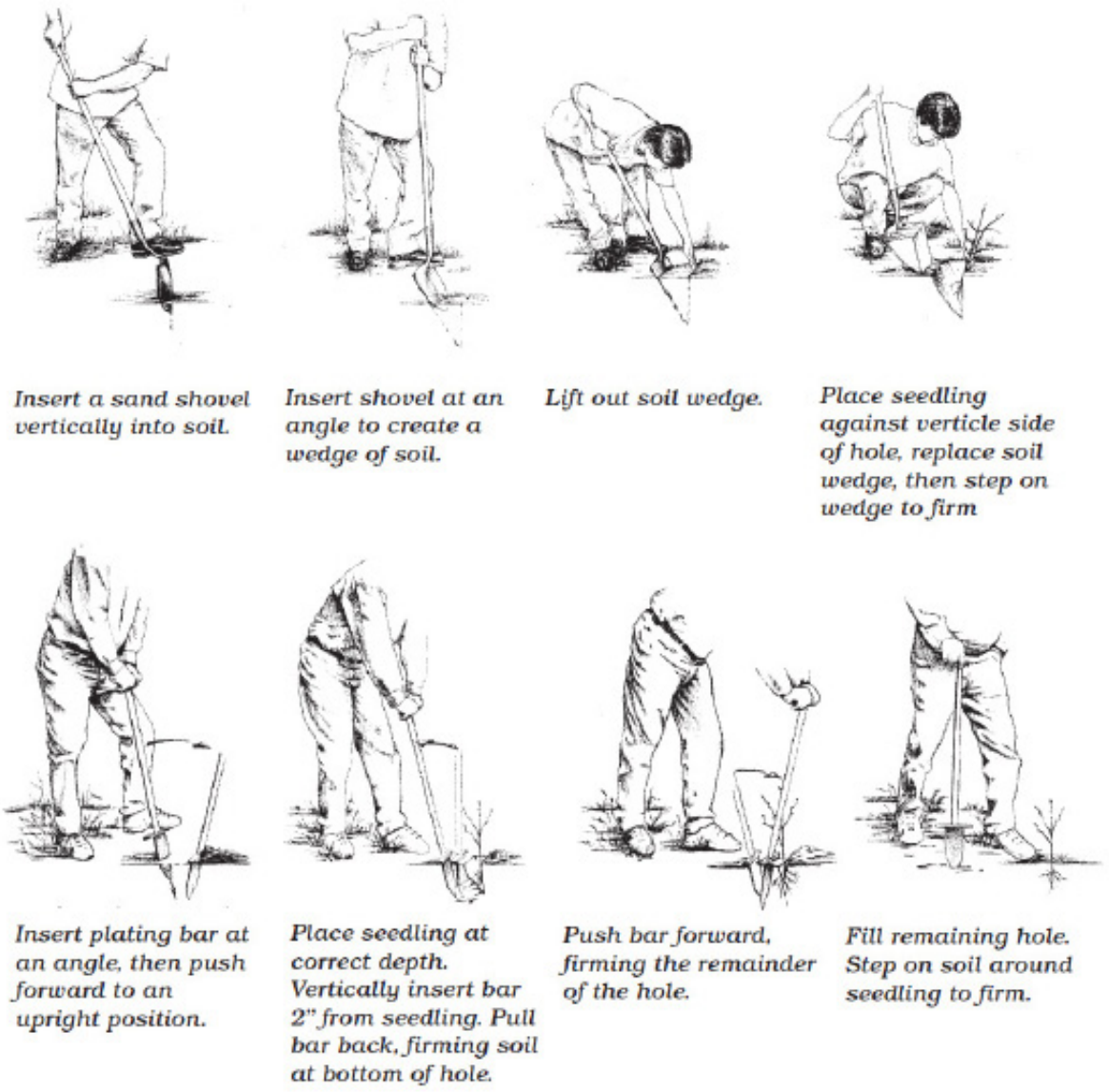

Figure 4. Small-scale plantings can be accomplished with shovels (top row) or dibble bars (bottom row), which might be available to borrow from the state department of forestry. Planting into moist soil in late winter or early spring before seedlings break dormancy gives the young trees time to adapt to their new environment. (Figure courtesy of Nita Upchurch and the Iowa Department of Natural Resources.)

Tree Protection and Management

Along with reducing vegetative competition, trees often need protection from herbivores, such as rodents (especially voles), deer, and livestock. Suitable protection is also critical for tree survival, particularly when planting trees into pasture and at a low planting density (versus a reforestation planting).

Protective tree tubes are often used to shield hardwood trees from deer and rodents. A variety of tube types and sizes is available, and it is important to match tree needs with the correct type of tube. For example, American chestnuts are best planted in short (2-foot) tubes, but they can still be subject to browsing without further protection. Also, it is important that tubes are able to break away from the tree as the trunk fills the tube; a tube permanently fixed to a tree can girdle the trunk and cause considerable tree damage.

Although there is some evidence that applying chemical products can deter deer and livestock on a small scale, there is little data on the value of these types of treatments, especially when planting on a scale

Figure 5. Several methods can be used to plant trees. Left, Large-scale plantings that require protective tubes can be done by hand with commercial crews at relatively low cost. For mixed plantings of different hardwood species, flagging can be used to indicate which and how many trees go in a row. Right, A mechanical tree planter may be best for establishing long rows of conifers at high density. Note: The vegetation in the left picture was sprayed just prior to planting. The planting in the right picture took place out of season to demonstrate the tree planter. (Photos by John Fike.)

greater than a few trees. Typical recommendations call for spraying these products on a monthly basis in season, which is often impractical. There are also new "biomimetic" protection systems on the market (fig. 6). These cages have barbs that are designed to mimic the physical deterrence of thorn bushes. While this makes sense intuitively, there is little research on this method of protection. In some cases, three-dimensional fencing (both electrified and non-electrified) has proven adequate for keeping deer at bay.

Unlike with hardwoods, tubes are rarely used to protect conifer seedlings. Given the lower costs of the seedlings, the larger number of trees planted per acre, and the lower levels of predation, using tubes for conifers is usually not cost-effective. However, some protection likely will be required in the early stages of silvopasture implementation. Consider livestock class, age, and condition as well as tree types when making protection decisions. Deer and livestock could find conifers, such as white pine, to be tasty, while cattle might avoid some species of pine if they have adequate alternative forage sources. Because conifer seedlings are generally inexpensive, losses from animal damage can be mitigated by planting at higher densities, and they can be further offset by the cash retained from not protecting the trees. However, young steers have been observed making a game of pulling newly planted pine seedlings from the ground, and

Figure 6. Top left, A tube may be insufficient for protecting a tree. Deer routinely browsed this oak tree as it grew out of the tube, and livestock often push tubes over for fun or to scratch an itch. (Photo by John Fike.) Top right, A biomimetic fence (top right) surrounds a seedling in a short tree tube. (Photo courtesy Greg Ormsby Mori, University of Missouri.) Cattle grazed the pasture during the summer, and the tree was not damaged. Some producers have had success making similar cages with barbed wired. Bottom left, Three-dimensional fencing, constructed with two interior and one exterior line of electrified fencing, is also effective for deterring deer. (Photo courtesy Premier1 Fence.) Such systems can be relatively inexpensive and effective, although the requirements vary depending on the size of the site to be protected. Lower right, The benefit of three-dimensional fencing is clear in this photo where a browsed red oak outside the fence (foreground) stands in contrast to an unbrowsed oak in the background. (Photo by John Fike.)

older animals — especially bulls — can "walk down" sizeable pine trees to get a belly rub (fig. 7).

Some producers opt to avoid grazing new silvopasture plantings until the trees are large enough to tolerate some pressure from livestock. However, this option is not always feasible, and some producers might need to graze pasture even during the establishment phase. To minimize the loss of grazing area, a single hot wire can often be positioned about 3 feet from the tree row. This allows cows to graze near the tree but prevents their browsing on the tree itself (fig. 8).

Fence lines can also be set high enough that calves or small ruminants can graze the area around tubed trees, which both minimizes loss of grazing area and provides vegetation management and reduced competition for the young trees. If fencing is not an option due to cost or operational barriers, it might be best to make hay in the alleys until the trees are an adequate size for the integration of livestock.

Figure 7. Livestock can damage pine trees by rubbing (left), tromping, or even walking down trees for a belly rub (right). In pine stands such as these, some damage can be sustained without economic consequence, but it is important to match the management with the objectives. (Photo courtesy of George Rheinhardt, USDA-NRCS, Arkansas.)

Some Additional Considerations

It is important to remember that silvopastures are dynamic systems that change (and will require management input) over time. Maintaining adequate light to the forage understory could require thinning or pruning — but this can have other benefits. Trees with clean boles, for example, can have substantially greater timber values when premiums are available for high-quality logs. Pruning and thinning require proper technique; removing small limbs for best

Figure 8. Portable or permanent fencing or a combination of the two can be used to keep livestock off new trees. A single hot strand can allow animals access to the forages around the tree, helping to reduce competition during establishment. (Photo courtesy of Buck Holsinger.)

timber quality can be good off-season work. Although economic analyses are limited, one generally can expect greater returns from silvopasture systems that incorporate routine tree maintenance into the management plan.

Given the status of timber markets, producers looking to make revenue from growing a couple of acres of average quality timber trees might be disappointed. Small plantings are generally less attractive to loggers, although easy access (in pastures) to high-value trees (e.g., black walnut or red oak) could enhance the attractiveness of smaller acreages. Regardless, even small plantings offer an opportunity to improve animal comfort and performance, protect environmental resources, create more appealing landscapes, and diversify farm resources and income streams. Many landowners can perceive the benefits of these systems; the big challenge for implementation, then, is to manage the complexity of a silvopasture system on a time scale that is much longer than traditional crop and livestock enterprises.