Agroforestry Notes
USDA Forest Service, Rocky Mountain Research Station • USDA Natural Resources Conservation Service

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The Biology of Silvopastoralism

Introduction

Forestry and livestock grazing are common competing uses for non-irrigated lands around the world. Forest grazing is a traditional practice in most of North America. Approximately 25 percent of all US forest land is grazed by livestock. Young forests and mature open-canopied forests can provide considerable amounts of forage for livestock. Prescription grazing makes beneficial use of ground vegetation that would otherwise compete with trees for soil moisture and nutrients, harbor gnawing rodents, and pose a fire hazard. Pasture grasses and legumes are sometimes seeded into newly harvested forest areas to reduce erosion, to provide high-quality food for deer and elk, and to decrease establishment of unwanted trees and brush. Such seedings provide a forage base, which may not persist without livestock grazing. Older, closed canopy stands of trees are frequently thinned to increase tree and forage growth. Pastures may contain a few scattered large trees or small groves of trees that were left when the land was cleared. Together, these traditional practices form a base of experience from which current, more intensely managed, silvopastoral systems have evolved.

Agroforestry Concepts

Agroforests are planned, managed agroecosystems. Agroforestry differs from traditional forestry and agriculture by its focus on the interactions among components rather than on the individual components themselves. Success of agroforestry is, therefore, largely determined by the extent to which individual forest and agricultural components can be integrated to help rather than hinder each other. Each component is judged by its capacity to produce desired products, and its ability to assist other components. For instance, trees can produce saleable wood fiber, forage for livestock, and fruits or nuts, while increasing pasture and livestock production by breaking the wind and providing shade. Pasture plants provide forage for livestock and serve as a living mulch to help suppress weeds and to reduce soil erosion. Livestock provide income, consume weeds, and are a major tool by which grass/legume, and tree/forage competition is controlled. Grazing may also reduce fertilizer needs by increasing the effectiveness of soil nutrients through recycling (in dung and urine) of elements such as nitrogen, phosphorous, potassium, and sulphur which are stored in pasture forage. Just as a well-designed system is better than the sum of its individual parts, the combined tree plus forage productivity of silvopastures may substantially exceed that of pastures or forests grown alone. For example, one acre of grass-legume/Douglas-fir silvopasture in Western Oregon has been observed to produce as much forage and timber as 1.6 acres of similar forest and pasture grown alone.

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Tree Component

Tree pattern is as important as the number of trees planted per acre in governing agroforest effects upon tree and pasture production. For a given pattern, the number of trees planted per acre is determined by the number of trees desired in the final forest, number of trees to be sold as commercial thinnings, and the expected proportion of trees lost to mortality or thinned for poor form or growth. In commercial conifer forests, four to six times the number of trees desired in the mature forest are generally planted. However, agroforests are usually planted at lower tree densities than forests so that forage can be grown longer into the timber rotation. As one might expect, tree pattern has a greater impact upon forage production for faster growing trees and at higher tree densities. The traditional forestry practice of planting trees an equal distance apart in a grid-like pattern maximizes the occupancy of the site by trees but limits pasture production. Forage production under tree grids falls off rapidly once trees exceed about 35 percent canopy cover. Grouping trees together into rows, or clusters concentrates their shade and root effects, provides larger open spaces for pasture production, and facilitates mowing, grazing, and other management operations with little sacrifice in tree growth. Trees planted in rows often perform poorly if they do not have at least one side in full sun. Therefore, single or double rows are generally preferred over triple rows of trees. Grouping of trees is especially helpful under very low tree densities where single, free standing trees may blow over in strong winds or have poor growth and form from being exposed to the weather.

Trees planted eight feet apart in single rows provides 23-foot wide forage alleys for sheep grazing a five-year-old Douglas-fir/perennial ryegrass silvopasture in western Oregon.

The ability of plants to withdraw soil moisture and nutrients is strongly associated with the amount of fine roots that they have. Ground vegetation that quickly establishes a dense, shallow, fibrous root system, such as many perennial grasses, competes severely with newly planted trees. Young, establishing trees may be killed by drought stress in thick stands of ground vegetation, but substantial reduction in tree growth is more common than actual mortality. Dense stands of brush may reduce the growth of even established trees. Young trees often benefit from two to three years of vegetation control after planting. Herbaceous plants and many brush species may be effectively suppressed by prescrption grazing, mechanical treatment, or chemical application. A commonly used approach when planting trees into established pastures is to spray a strip or circle around trees to provide a four to six foot diameter competition-free zone around each tree. Once trees overtop and establish deep roots beneath the rooting zone of competing ground vegetation, competition for moisture and light is largely one-sided, with trees reducing understory production, but understory having little effect upon overstory trees.

Lower densities of trees and planting patterns in which trees have one or more sides in the open, typically used in agroforests, promotes rapid growth of trees. However, these more open-grown trees may have greater taper and more large branches than trees growing in closed canopy forests. Pruning of lower branches up to a height of at least one log length has proven to be a profitable solution to log quality where processors are willing to pay a premium for large, knot free logs. Pruning also raises the tree canopy so that more light can reach the ground, thus maintaining higher pasture production for a longer portion of the tree rotation and producing an open park-like forest which is visually pleasing to

Pasture Component

neighbors.

Southern pines provide a shady, park-like setting for cattle grazing in Louisiana.

Clovers or other pasture legumes are often seeded into pastures to provide highly nutritious food for livestock and to convert atmospheric nitrogen into an organic form which plants and animals can use. Nitrogen fixation is actually accomplished by bacteria living in the roots of host legumes. The bacteria/host partnership is quite specific with each bacterial strain associating successfully with only a limited group of plant hosts, called their "cross inoculation group." The usual practice is to directly apply bacterial inoculum to seeds just prior to planting rather than gamble that sufficient amounts of appropriate bacteria already exist in the soil. Nitrogen fixing trees such as alders, black locust, or mesquites also form bacterial associations which make them useful as sources of nitrogen for other plants and animals in silvopastures.

Competition between trees and pasture is reduced by selecting pasture plants which either grow at a different time of year, or are more shallowly rooted than trees. For example, cool season grasses (such as annual ryegrass) and legumes (such as crimson or subterranean clover) can be seeded into southeastern pine stands with little detrimental impact upon growth of either trees or subsequent warm season pasture plants. In the Pacific Northwest, shallowly rooted subterranean clover-ryegrass pastures actually reduce summer moisture stress in trees compared to ungrazed naturalized grasses which are more deeply rooted and grow longer into the dry season. Trees reduce forage production by competing for soil moisture, nutrients, and light. The major factor reducing forage production in open canopy forests, such as young timber stands, is probably soil resources rather than light. Forage plants which grow primarily during the rainy season, and those with high drought tolerance are most likely to compete successfully with trees in established young agroforests. As tree canopies begin to coalesce into a closed canopy, tolerance of low light conditions becomes important in selecting forage species.

Livestock Component

Trees in pasture provide shelter for livestock during periods of inclement weather. This can significantly improve animal performance during particularly hot or cold times of the year. Specifically designed tree plantings called "livestock havens" are sometimes planted solely for livestock protection. Forage growing under the shady, low wind environment near trees tends to mature more slowly and, therefore, be lower in fiber and more digestible than that growing out in the open. Young agroforests may be grazed by cattle or sheep with little browsing damage to trees provided that other, attractive forage is present. However, this can be tricky to do in practice, particularly with hardwood trees, which seem to be inherently more attractive to livestock than are conifers. Conifers, although not really palatable to livestock, are most likely to be browsed after spring bud break when foliage is still light green in color. Livestock like variety in their diet. They will often consume a small amount of tree foliage each day. This small amount of browsing may accumulate to unacceptable levels when animals are in the sil-

vopasture for prolonged periods. Age and experience of animals is probably more important than breed in predicting the willingness of livestock to browse or debark trees. Young animals and those with a past experience of eating tree foliage are much more likely to browse trees. Browsing damage can sometimes be eliminated by removing a few problem animals. Browsing by livestock is unlikely to kill young trees unless it is both severe and repeated several times. Removing the top bud of conifer trees, or of over half of the current year's foliage, however, will reduce tree growth that year. Trampling of very young seedlings and livestock rubbing on tree saplings may be a problem, particularly with cattle. Where livestock damage must be avoided, young agroforests may be hayed, or trees protected from livestock by chemical repellents, electric fences, individual tree shelters, or rigid mesh tubes. Once the top branches of trees grow above the reach of livestock and a thick layer of bark has developed, potential for tree damage by livestock browsing is minimal and agroforests may be managed similar to pastures.

Additional Information

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