AGROFORESTRY

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AN INTEGRATION OF LAND USE PRACTICES

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University of Missouri Center for Agroforestry

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The University of Missouri Center for Agroforestry (UMCA) is an interdisciplinary research, teaching and technology transfer program that draws on the expertise of university faculty in forestry, fisheries and wildlife, entomology, plant pathology, agronomy, animal science, agricultural economics, rural sociology and horticulture. The Center coordinates agroforestry activities for use in Missouri and adjacent areas of the Midwest. Its mission is to initiate, coordinate and enhance agroforestry activities to meet the environmental, social and economic needs of land management within the state of Missouri, North America and the temperate zone worldwide.

Agroforestry

Agroforestry is a set of integrated land use practices. It combines trees, shrubs, forages, grasses, livestock and crops in innovative, flexible combinations tailored to the landowner's needs. The goal in agroforestry is to optimize production and conservation benefits.

Properly designed and implemented, agroforestry practices can

- **Increase crop production**
- **Diversify products and farm income**
- **Improve soil quality and reduce erosion**
- **Improve water quality and reduce damage due to flooding**
- **Enhance wildlife habitat and improve biodiversity**
- **Reduce pest management inputs**

In the temperate United States, agroforestry consists of five main practices:

(1) Alley Cropping

(2) Silvopasture

(3) Riparian Forest Buffers

(4) Windbreaks and

(5) Forest Farming.

When designing and implementing any of the five practices, it is important to consider the compatibility of the species with the site, the compatibility between species, the farm equipment available and the potential markets. Your local natural resource professionals in agriculture extension, the natural resources conservation service, and your local state forestry office can provide you with design and implementation assistance, as well as information regarding restrictions or requirements for stream-side protection or maintaining wildlife habitat.

Alley Cropping

Alley cropping is the planting of trees and/or shrubs in single or multiple tree rows at relatively wide spacing with a companion crop grown in the alleyways between the tree rows. The benefits realized in alley cropping practices include increased income diversity, biological diversity, improved aesthetics and reduced negative environmental impacts.
Alley cropping practices are designed according to the site characteristics, the tree products desired (e.g., nuts or timber), the growth requirements of the selected tree, the crop being grown in the alleyway, the farm equipment available and the landowner's objectives. For example, alleys can be arranged in

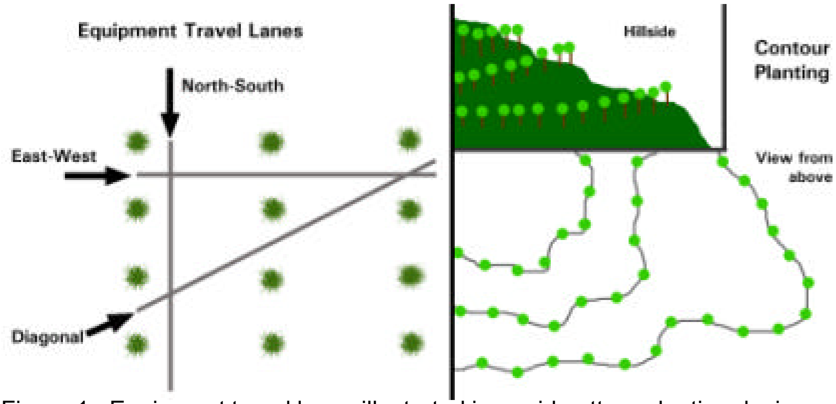

Figure 1 - Equipment travel lanes illustrated in a grid pattern planting design. Tree rows are planted on the contour on sloping sites.

Walnut and corn alley cropping practice.

straight rows and on diagonals to allow equipment to travel in various directions, reducing soil compaction (Figure 1). On sloping land, it may be necessary to plant the rows on the contour creating a terrace to reduce soil erosion due to water runoff.

While designs for an alley cropping practice will vary depending on landowner objectives, there are several basic considerations. Spacing between the trees within the row and between the rows of trees must be considered when designing an alley cropping practice. Distance between the rows is determined by (1) the growth requirements of the companion crop, (2) the width of the available farm equipment, (3) the type of tree(s) grown, (4) the desired product(s), and (5) the duration or length of time the landowner wishes to grow a light demanding crop in the alleyway. Selected trees should be deep rooted, create a light shade and produce one or more products (timber, nuts, fruit, pinestraw). Shrubs or coniferous trees can be used in multiple tree rows (Figure 2) to provide additional products and to train hardwood species to grow straight and tall, producing high value timber products. Growing trees for timber or nuts may require pruning of young trees. Pruning young nut trees to a height of eight (8) feet allows equipment to pass below the branches for mowing and harvesting of nuts while retaining much of the crown area. Greater pruning heights, to reduce defects in the wood caused by low branches, may be required for producing quality timber.

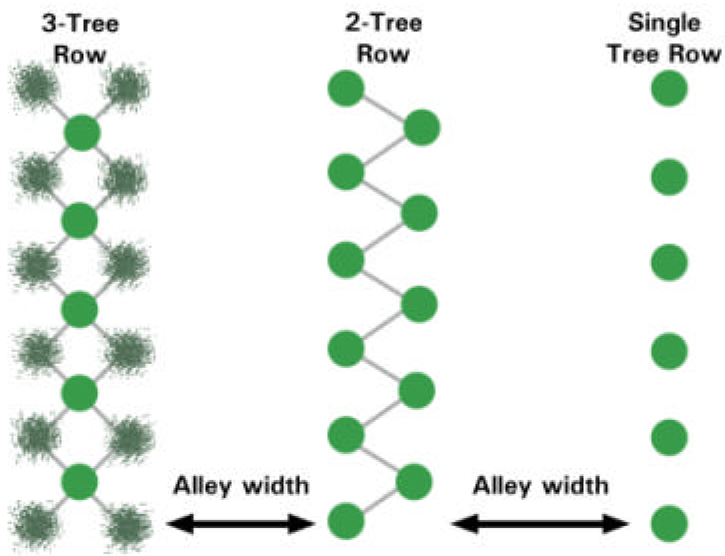

Figure 2 - Tree arrangement in triple (evergreen tree or shrub in the outer rows with a deciduous tree in the middle row), double and single rows.

Harvesting wheat between walnut trees in an alley cropping practice.

Traditional row crops as well as horticultural, medicinal or vegetable crops can be incorporated into an alley cropping practice. As the trees grow and produce more shade in the alleyways, companion crop selections may change. Over time, competition for water can limit the width of the area in the alley that can be cropped. Deep trenching with a ripper, trencher or chisel plow between the tree row and the crop to sever lateral tree roots (known as lateral root pruning) may be necessary to minimize production losses of the alley crops. Wider alleyways will accommodate crops that require full sun such as corn and soybeans. When shade becomes limiting, there will need to be a shift to a more shade tolerant crop such as shade tolerant forages or berry producing shrubs.

Cattle grazing in pecan silvopasture practice.

Silvopasture

Silvopasture deliberately combines trees with forage and livestock production in an *intensively* managed practice. Letting cows graze in a natural woodland area without any type of tree or forage management is **NOT** considered a silvopastoral practice.

Rotationally grazing livestock, planting, pruning and protecting trees and monitoring forage quality are all part of managing a silvopasture practice. Proper design and planning, as well as a working knowledge of the silvopasture components, can reduce the time and labor involved.

Several benefits are realized by implementing a silvopasture practice. Trees protect livestock from temperature extremes by blocking cold wind and snow in winter and providing shade in summer. Livestock benefit from improved forage quality and reduce the need for chemical or mechanical vegetation control. Research at the University of Missouri Center for Agroforestry has shown that many forages, such as red clover and smooth bromegrass, perform better, are more palatable, and produce higher levels of desired nutrients under some shade. Well-chosen and maintained forages control undesirable vegetation and fix nitrogen utilized by the trees.

Silvopasture practice design can be similar to design options for alley cropping with special consideration given to the interactions between trees and livestock (Figure 3). Trees can be planted in rows, individually throughout the pasture or in groups. Existing forest stands can be managed for grazing livestock as part of an ***intentionally*** designed silvopasture practice.

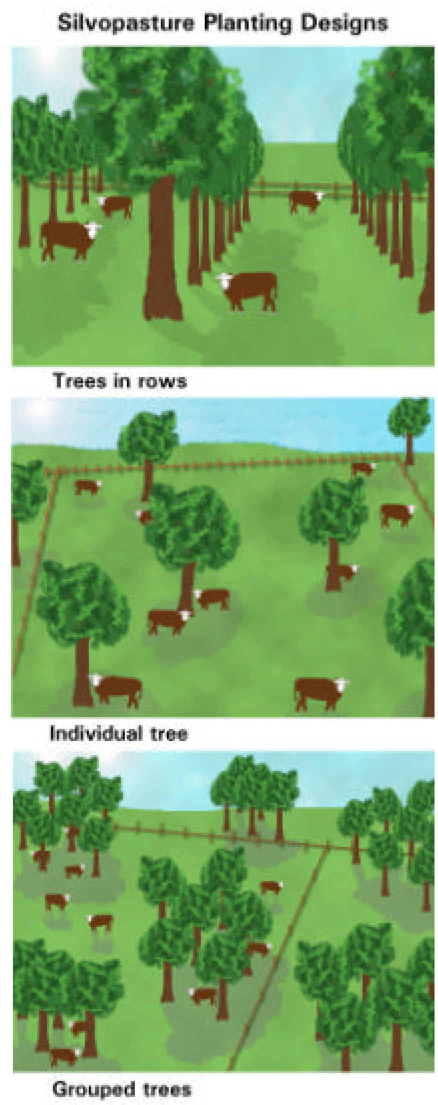

Figure 3 - Planting designs for silvopasture practices.

For optimal performance, select trees, forages and livestock that

1. are compatible with the site and each other,
2. produce marketable products,
3. meet landowner management objectives and,
4. if desired, provide wildlife or environmental benefits.

Sheep grazing in a Christmas tree silvopasture practice.

Trees may produce nuts such as black walnut or pecan or be grown for timber alone. Livestock may include but are not limited to cattle, sheep, goats, horses, ostrich, emu, moose, fallow deer, poultry, bison and elk. During tree establishment stages, livestock should be excluded from the site or protection measures, such as electrified fencing, should be used to prevent damage to young trees. While livestock are excluded, forage can be produced for sale or feed for livestock.

Year 1 - fast-growing riparian species are planted to establish buffer.

Year 2-3 - tree roots begin to stabilize stream banks and herbaceous vegetation grows in naturally.

Established buffer - some marketable trees have been removed and slower growing, higher value species are planted in the understory. Herbaceous vegetation is fully established in the understory.

Riparian Forest Buffers

Riparian forest buffers can have positive impacts on water quality. They are strips of planted or managed trees, shrubs and grasses along the banks of waterways. One popular design consists of three zones: Zone 1, undisturbed forest, is closest to the water; Zone 2, managed forest, is next to the undisturbed forest; and Zone 3, composed of grasses, is farthest from the water (Figure 4).

The roots of the undisturbed vegetation (trees and shrubs) in Zone 1 stabilize streambanks, hold soil in place and prevent channelization of the stream. Shade from the trees helps moderate the temperature of the water, benefiting aquatic life. Roots and woody debris provide food and habitat for aquatic life and slow the velocity of water.

Zone 2, the managed forest, can be planted with fast growing trees and/or shrubs that produce marketable products which can be harvested for profit. In this zone, nutrients in the runoff water are absorbed in the soil and used by trees and shrubs. When flooded,

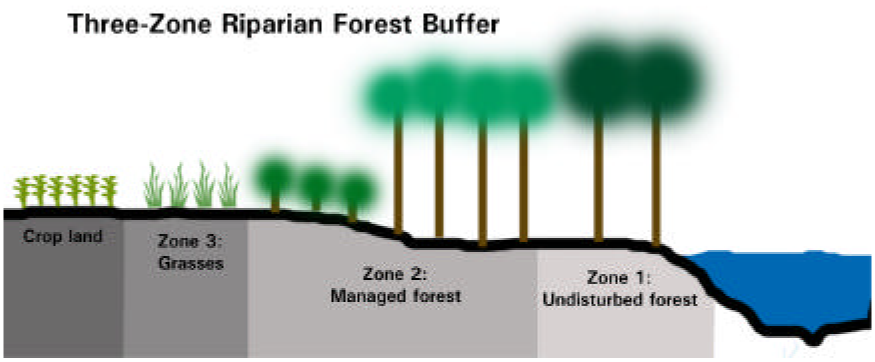

Figure 4 - Diagram of riparian forest buffer zones.

forested zones also serve as recharge areas for ground water aquifers.

Grasses and other herbaceous vegetation in Zone 3 tend to increase soil porosity allowing greater infiltration and water storage potential. Dense grasses slow the flow of surface water and spread the flow more evenly over the landscape. Reducing the velocity of the water flow allows sediment to settle out, allows time for pesticides to degrade and permits increased uptake of excess nutrients. Grasses can potentially be used for forage, hay or other products.

Keep in mind that not all areas will be wide enough to accommodate a three-zone buffer design. The width of the riparian forest buffer depends on the landowner's objectives, the condition of the waterway and the site characteristics (slope, soil type).

Windbreaks


Windbreak adjacent to crop field.

Windbreaks protect crops and livestock from strong winds, reduce wind erosion, improve irrigation efficiency, expand wildlife habitat, improve aesthetics, manage snow and provide marketable products. Protection from cold wind and snow and hot, drying summer winds improves crop quality and yield despite the loss of cropping area due to the windbreak. Windbreaks provide shade and protection from temperature extremes in pastures and around feedlots improving livestock health, feeding efficiency and reproductive success. Increased plant and wildlife diversity have the potential to reduce fertilizer and pesticide inputs by capitalizing on natural pest predators and nutrient cycling.


Cattle sheltered by livestock windbreak.

Multiple row windbreaks allow harvesting of marketable trees and products without reducing the effectiveness of the windbreak. Trees, shrubs and/or herbaceous vegetation, selected for the products they produce (nuts, pulp for paper, botanicals) and their windbreak effectiveness, are planted perpendicular to the prevailing wind at wide spacing.

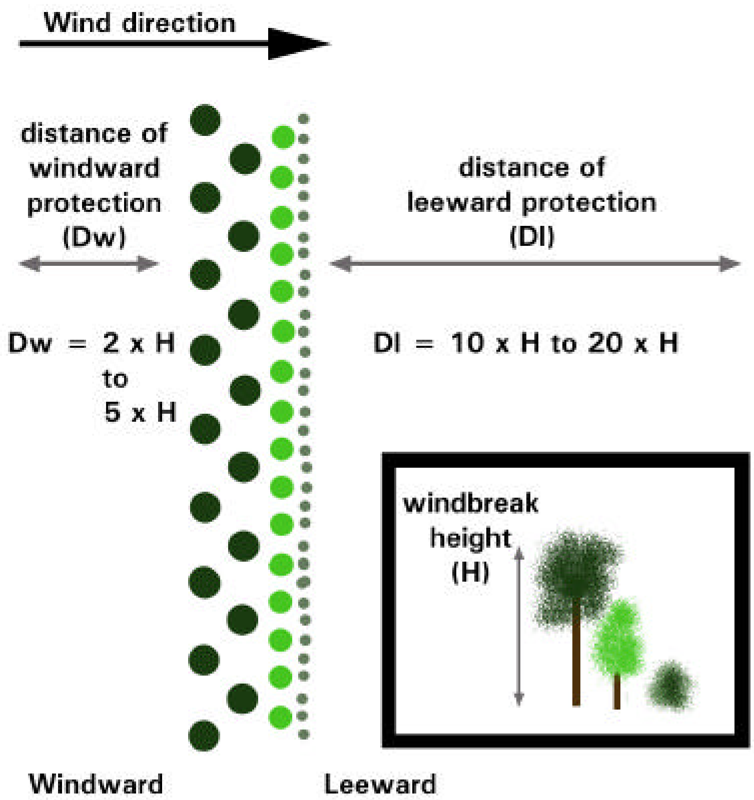

Figure 5. Wind protection diagram with a multi-row windbreak.

The area protected by, and the effectiveness of a windbreak, are determined by:

- Height
- Density
- Width
- Species composition
- Length
- Orientation
- Continuity

Wind speeds are reduced on the windward side of a windbreak to a distance two (2) to five (5) times the height of the tallest row. On the leeward side, wind speeds are reduced for a distance of ten (10) to 20 times the height of the trees (Figure 5). Windbreak density, the ratio of the solid portion to the total area, determines the amount of wind that flows through the windbreak. Densities of 40 to 60 percent provide the greatest leeward area of protection. Livestock windbreaks and crop windbreaks require different densities and orientation for optimal protection during sensitive seasons. Windbreaks are oriented perpendicular to: (1) hot, dry summer winds to protect field crops during the growing season, (2) cold winter winds to protect livestock during calving season or (3) winter and early spring winds to reduce erosion when soil is exposed. The most effective length of a windbreak is ten (10) times the height to reduce the influence of end-turbulence (i.e. turbulent winds at either end). Gaps in the windbreak create areas of high-wind velocity reducing the effectiveness of the windbreak and should be avoided.

Management is the key to an effective windbreak. Gaps resulting from tree harvest, damage or mortality must be replanted. Pruning may be required if producing timber or for the general health of the trees and shrubs.

Ginseng in an intensively managed forest farming practice.

Forest Farming

Forest farming is a unique practice in which existing forest stands are managed to create an appropriate environment for growing potentially high value understory crops. Many medicinal and botanical plants that are currently wild-crafted (harvested from wild sources) from public and private lands are becoming scarce. Forest farming can mitigate over-harvesting by managing for these scarce, high value species.

Shiitake growing on logs in a forest farming practice.

Fruiting goldenseal in a forest farming practice.

When establishing a forest farming practice, the existing forest needs to be managed to open the canopy and create the appropriate light environment for the understory crop. The non-timber component or special forest products can be ginseng, goldenseal and other medicinal plants, floral greenery and/or food products like mushrooms and berries. Several crops can be grown in conjunction. Some existing practices combine growing ginseng, goldenseal and mushrooms as they have similar light requirements.

Anyone interested in undertaking forest farming or producing special forest products should thoroughly research the crop, including the growing requirements and the markets available or the potential for developing markets. Many herb and botanical dealers have certain requirements which must be met before establishing a planting contract with growers. The landowner needs to consider the labor involved and should start with small plots. As many of the crops associated with forest farming are high value, added protection measures may be required to deter theft.

Research in Agroforestry

The University of Missouri Center for Agroforestry (UMCA) conducts research in the five temperate agroforestry practices at the 650-acre University of Missouri Horticulture and Agroforestry Research Center (HARC) in New Franklin, Missouri.

Alley cropping

Pitch pine (*Pinus rigida*)/loblolly pine (*P. taeda*) hybrids and black walnut (*Juglans nigra*) planted in single, double and triple rows are grown to examine the effects of row configuration on these species. Triple row spacing (walnut flanked on both sides with pine) is intended to produce a high quality sawlog by promoting natural pruning of the walnut's lower branches through shading of the trunk. Associated with this project are two progeny testing experiments which look at the suitability of pine hybrids and exotic pines for pine needle mulch production in Missouri.

Single and double-row pine in alley cropping study

Cattle grazing near a row of young trees protected by an electric fence in the silvopasture study.

Silvopasture

Animal science researchers are testing methods to protect seedlings being established in cattle pastures. Two methods being examined are electrical fencing and unpalatable sprays.

Riparian Forest Buffers

For demonstration and water quality protection purposes, a riparian forest buffer has been established along the stream adjacent to the silvopasture experiment. This buffer will serve as an educational demonstration of a three-zone forested riparian buffer and to protect the stream from high nutrient content in the runoff water from the silvopasture practice.

Logs inoculated with mushroom spores in a forest farming setting

Windbreaks

Windbreaks serve to protect crops, livestock and soil from harsh seasonal winds. A recently established windbreak demonstrates windbreak effectiveness and a method of offsetting windbreak segments to minimize the wind tunneling effects of gaps in a windbreak created by roads or access to a field.

Forest Farming

Mushroom production has the potential to add value to an existing forest or riparian forest buffer. Researchers are examining propagation methods for high value mushrooms, such as the European black truffle and shiitake, under the shade of a forest canopy.

Related Research

Root Production Method™, a method of air pruning tree roots as a means of improving growth rate and fruit production, is being compared to traditional bare root seedling growth and fruiting. Researchers are examining eleven species that have potential in agroforestry practices.

Root mass of bare root seedling (left) versus RPM™ seedling (right)

Cottonwood leaf beetle feeding.

Cottonwood and poplar hybrids are fast growing trees with potential for use in agroforestry practices. Several projects are being conducted on poplar to examine clonal variation in growth rate, carbon sequestration potential and susceptibility to insect damage.

Shade houses for shade tolerance evaluation.

A **shade tolerance evaluation** of grasses and other herbaceous plants is the first stage in an assessment of the suitability of these plants for use in agroforestry practices. After being evaluated for their tolerance to 50 percent and 80 percent shade, plants will be tested under various levels of shade in competition with trees for moisture and nutrients.

A recently constructed **flood tolerance** laboratory is used to test plant species and cultivars for tolerance to flooding. The effects of stagnant versus moving water and water depth are being examined.

Living mulches used in agroforestry practices may provide soil erosion protection and supplemental nutrition for trees. Researchers are examining the effectiveness of legumes and grasses as living mulches grown in conjunction with establishing trees.

Linear channels of the flood tolerance laboratory.

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Where can I get more information?

Local Information

Start by contacting natural resource professionals in your area for information specific to your site. This includes university agriculture extension, local or regional forestry professionals and the Natural Resources Conservation Service (NRCS).

General Information

For more general information on agroforestry and the five practices contact:

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