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ATTRA
Appropriate Technology Transfer for Rural Areas
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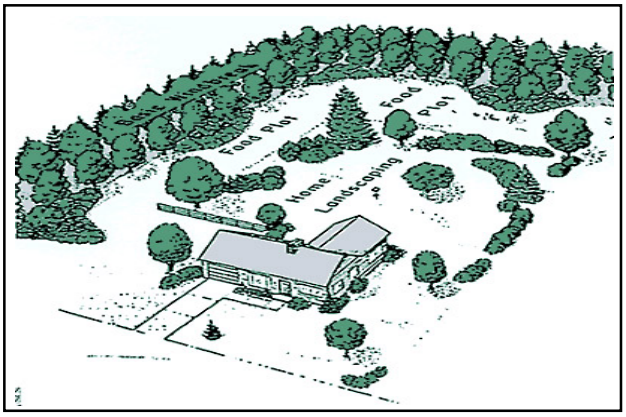
AGROFORESTRY OVERVIEW

HORTICULTURE SYSTEMS GUIDE

Abstract: *Integrating trees and shrubs with the other enterprises on a farm can create additional sources of income, spread farm labor throughout the year, and increase the productivity of the other enterprises, while protecting soil, water, and wildlife. Agroforestry systems include alleycropping, silvopasture, windbreaks, riparian buffer strips, and forest farming for non-timber forest products. While they clearly offer economic and ecological advantages, these systems also involve complex interactions, which complicate their management. When designing an agroforestry enterprise, one should research the marketing possibilities and include the agroforestry system in the complete business plan for the farm. This publication presents the principles of agroforestry, an overview of common practices, marketing considerations, several case studies, and an extensive list of further resources.*

By Alice Beetz
NCAT Agriculture Specialist
June 2002



Trees add beauty and serve as a windbreak.

INTRODUCTION

Agroforestry is a farming system that integrates crops and/or livestock with trees and shrubs. The resulting biological interactions provide multiple benefits, including diversified income sources, increased biological production, better water quality, and improved habitat for both humans and wildlife. Farmers adopt agroforestry practices for two reasons. They want to increase their economic stability and they want to improve the management of natural resources under their care.

A traditional tree farm or nut plantation managed as a single-purpose monocrop is not an agroforestry system. Neither is a woodlot when it's managed for wood products only. Agroforestry involves combining a tree planting with another enterprise—such as grazing animals or producing mushrooms—or managing a woodlot for a diversity of special forest products. For example, an agroforestry system might produce firewood, biomass feedstocks, pine-straw mulch, fodder for grazing animals, and other traditional forestry products. At the same time, the trees are sheltering livestock from wind or sun, providing wildlife habitat, controlling soil erosion, and—in the case of most leguminous species—fixing nitrogen to improve soil fertility.

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NCAT

Agroforestry practices in use in the United States include alleycropping, silvopasture, windbreaks and shelterbelts, riparian buffer strips, and forest farming (special forest products). An overview of each of these major systems is presented below.

Agroforestry Practices

1. Alleycropping

Alleycropping involves growing crops (grains, forages, vegetables, etc.) between trees planted in rows. The spacing between the rows is designed to accommodate the mature size of the trees while leaving room for the planned alley crops. When sun-loving plants like corn or some herbs will be alleycropped, the alleyways need to be wide enough to let in plenty of light even

While trees mature, crops provide income.

when the trees have matured. Alternatively, the cropping sequence can be planned to change as the trees' growth decreases the available light. For example, soybeans or corn could be grown when the trees are very small; then, as the tree canopy closes, forages could be harvested for hay; finally, when the trees are fully grown and the ground is more shaded, grazing livestock or shade-tolerant crops like mushrooms or ornamental ferns could occupy the alleyways.

Like all integrated systems, alleycropping requires skillful management and careful planning. Both the crop and the trees have requirements that sometimes necessitate trade-offs between them. The design must allow sufficient room for the equipment needed to service each enterprise. If either crop requires chemical herbicides or insecticides, the other must be tolerant of these treatments. In the case of livestock, there may be periods during and after chemical use when animals must be withdrawn from the area. Livestock can cause damage, even when the trees are fully grown; roots injured by livestock hooves are susceptible to disease. Soil compaction is a danger in wet weather. These examples indicate how crucial planning is to the ultimate success of an agroforestry system.

In most alleycropping systems, trees are planted in straight rows, sometimes with no regard for

Bob Carruthers, a crop farmer in Morrilton, Arkansas, faced the choices of getting bigger, getting out of commodity crop farming, or waiting to be pushed out. He decided to plant pecans on his laser-leveled fields and to continue cropping in the alleys while the trees grow. He chose several pecan varieties that are in demand on the market and have an extended ripening season. He planted them 35 feet apart with 60-foot alleyways, installed micro-sprinklers for irrigation, and fertilized, based on soil and leaf-tissue tests, for several years. Four years after establishment, he is already harvesting a few pecans and selling them retail for $1.50 per pound. He plans to buy a mechanical sheller so that he can add more value to his product and continue to sell direct without depending on a wholesaler.

In the 60-foot alleys, Carruthers plants no-till wheat and soybeans, with a 17% reduction in yield as compared to his former monocropped fields. He has planned for the change in light availability as the trees mature; when sunlight limits soybean production, he will grow only wheat in the alleys. At year 22 or thereabouts, he will take out every other tree in the row, leaving a 60-foot by 70-foot spacing. Having originally estimated that he would regain the establishment costs in 13 years, he now expects to do so in 10 or 11 years. Meanwhile, the cropping system contributes cash flow in these early years when tree revenue is minimal.

slope or contour. There are, however, advantages to planting the trees in curves or on the contour. These include the slowing of surface-water movement and the reduction of soil erosion. The trees can be planted in single rows or in blocks of multiple rows between alleys. The first row in a block is planted on the contour line; subsequent rows are planted below the original line according to the slope of the land. The final row of trees in one block is planted parallel to the contour line on which the next block of trees will begin. The width of the tree blocks varies, but the cropping alleyways between them have parallel edges. This design avoids creating point rows within the alleys, thus simplifying crop equipment maneuvers. The width of the alleys is determined by the size of this equipment.

If planting on the contour is impractical, another option is to plant trees in curved zigzags so that water running downhill is captured or at least slowed. Islands of trees can offer some of the same advantages if they don't interfere with cropping operations.

In large plantings, fast-growing hardwoods or pines are interplanted as trainers to ensure that the crop trees develop upright, unbranched trunks. Alternatively, the crop trees can be planted close together in the rows, to be thinned and pruned several times as they grow. Although these early-harvested trees may have little market value, their presence during the first years of growth has increased the main crop's value. The goal is to produce long, straight sawlogs with few lower branches, for maximum profit at final harvest. Whatever the planting design, trees on the outside edge of a group will grow more side branches, or even a lopsided trunk, resulting in lower-value sawlogs.

2. Silvopasture

Tree and pasture combinations are called *silvopastoral agroforestry*. Hardwoods (sometimes nut trees) and/or pines are planted in single or multiple rows, and livestock graze between them. Although both the trees and the livestock must be managed for production, some systems emphasize one over the other. Usually, in the early years of establishment, crops or hay are harvested from the planting. Grazing generally begins after two or three years, when the trees are large enough that the livestock can't damage them. In other instances, tree tubes and electric fencing protect the young trees, and grazing begins immediately.

Tom Frantzen and his family are innovative farmers in northeastern Iowa. In 1992, they began an intercropping experiment by planting double rows of hybrid cottonwood trees at even spacings across one of their fields, with alternating strips of corn and oats in the alleys. The oats are underseeded with red clover, and every third alley strip is a second-year stand of red clover. From a distance the field has an attractive striped pattern. Each year the oats are combined and the straw is baled. The red clover underseeded in the oats is lightly grazed as a new seeding, and then used as pasture in the second year.

Every year, a farrowing hut is placed on each second-year clover strip. Bred gilts graze on clover (or alfalfa) while the adjacent crops and trees are protected from damage with two strands of portable electric wire. Six pounds of ground corn and minerals per gilt supplement the pasture to ensure proper nutrition prior to farrowing. In the fall, the growing pigs and lactating sows harvest the corn strips. Grazing both the corn and the red clover keeps harvest costs to a minimum. The corn and trees separate the groups of sows and pigs, provide a windbreak, and offer shade in the heat (1).

Grazing livestock on silvopasture eliminates some of the costs of tree maintenance. With good grazing management, for example, herbicides and mowing may become unnecessary. Grazing also enhances nutrient cycling and reduces commercial fertilizer costs; the animals remove few nutrients, and their waste is a valuable input for the trees. Well-managed grazing will increase organic matter and improve soil conditions. However, controlling the number of animals per acre, limiting the number of days those animals remain on each site, and avoiding compaction are critical for a successful silvopasture system.

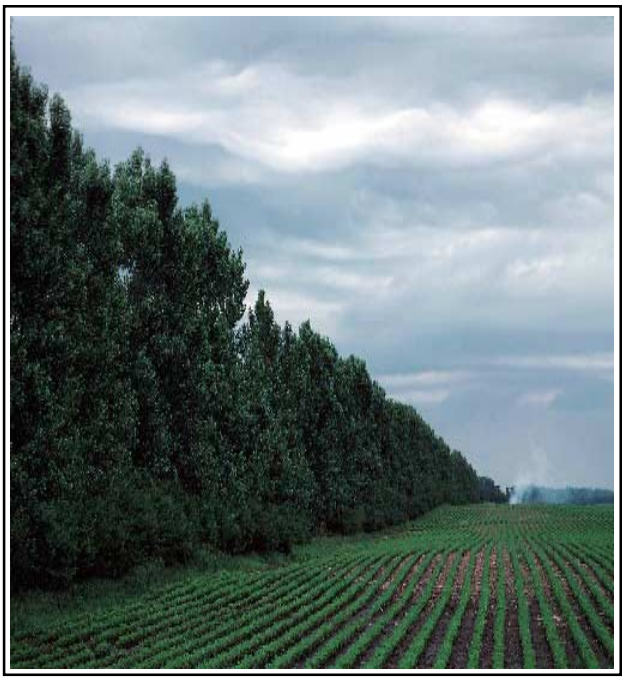
Competition for water between the pasture and the trees may be a concern. In a silvopasture with nut trees, for example, seasonal water shortages during late summer can negatively affect nutfill and the production of fruit buds for next year's harvest. Irrigation is justified in such a situation if the trees are being managed for nut production. Water competition may not be as critical for *timber* silvopastures.

Further information about silvopastoral systems is available from the National Agroforestry Center and other resources listed at the end of this publication.

Grazing sheep replace the mower in Christmas trees.

3. Windbreaks or Shelterbelts

Extensive research on windbreaks, also called *shelterbelts,* has been carried out in the U.S. Trees are planted in single or multiple rows along the edge of a field to reduce wind effects on crops or livestock. Windbreaks have been shown to reduce wind impact over a horizontal distance equalling at least ten times the height of the trees. Wind and water erosion are reduced, creating a moist, more favorable microclimate for the crop. In the winter the windbreak traps snow, and any winter crops or livestock are protected from chilling winds. Beneficial insects find permanent habitat in windbreaks, enhancing crop protection.



A windbreak protects Iowa crops.

Although the trees compete for available water along the edges between the windbreak and the crop rows, potentially reducing crop yield near the windbreak, the net effect on productivity is positive. In fact, even on land that's well suited for high-value crops, a windbreak can increase the crop yield of the entire downwind field by as much as 20%, even when the windbreak area is included in the acreage total (2).

Windbreaks can be designed specifically for sheltering livestock. Studies have shown the economic advantages of providing protection from windchill, a major stress on animals that live outside in the winter. Reduced feed bills, increases in milk production, and improved calving success have resulted from the use of windbreaks. The National Agroforestry Center (see **Further Resources**) offers a series of booklets on windbreak technology as well as a publication entitled *Outdoor Living Barns*. Another resource, focused specifically on incorporating trees into family farms, is *Shelter and Shade* by John and Bunny Mortimer (3).

Besides providing protection to crops and livestock, windbreaks offer other advantages. They

benefit wildlife, especially by serving as continuous corridors along which animals can safely move. Farmers can even develop windbreaks into additional profit centers for the farm—hunting leases, selective timber harvests, firewood sales, and special forest products are some of the possibilities (these marketing options are discussed below).

Any tree species can be used in a windbreak. However, deciduous species, even in multiple rows, will lose effectiveness when they lose their leaves. For year-round use, some of the species selected should be evergreen. Fast-growing trees should be included; it's best to plant deep-rooted, non-competitive species along the edges. Regular deep chisel-plowing along the edges will keep roots from spreading into the crop rows. If some of the trees are harvested periodically, replacements can be planted, establishing a long-term rotation within the windbreak.

Farmers in the upper Midwest are investing in hybrid hazelnut or poplar plantings as part of their crop and livestock systems. They are integrating them into the farm to provide benefits such as windbreaks, terraces, or riparian buffers. Using livestock wastes as a part of the fertility program is being investigated.

The newly introduced hybrid hazelnut takes the form of a bush (most hazelnuts have been raised as small trees in the northwestern U.S.). These plants are resistant or tolerant to eastern filbert blight, which is a serious threat to the industry in the Northwest. The demand for the nut is large and established. Midwestern farmers are exploring cooperative marketing options. Harvesting equipment appropriate for these plantings is being developed.

4. Riparian Buffer Strips

Trees, grasses, and/or shrubs planted in areas along streams or rivers are called *riparian buffers* or *filter strips*. These plantings are designed to catch soil, excess nutrients, and chemical pesticides moving over the land's surface before they enter waterways. Such plantings also physically

Buffers protect water quality.

stabilize streambanks. On cropland that is tiled to improve drainage, polluted water can flow directly into streams; constructed wetlands installed in the buffers can capture and clean this drainage water before it enters the stream.

Forested areas along streams fulfill other needs of the community at large by storing water and by helping to prevent streambank erosion, which in turn decreases sedimentation downstream. These areas protect and enhance the aquatic environment as well. Shading the water keeps it cooler, an essential condition for many desirable aquatic species. Buffer strips also provide wildlife habitat and can be managed for special forest products.

Crop and livestock farmers, as well as local communities, have become aware of the threat that agricultural practices can pose to pure drinking water. Consequently, there are federal, state, and local government programs to assist in the design and planting of riparian buffer strips. The federal Continuous Conservation Reserve Program can be used for this purpose. The local Farm Services Administration office can advise on this program and other options. Conservation organizations are another potential resource. Some offer conserva-

tion easements or trusts when land is permanently withdrawn from agricultural production.

5. Forest Farming and Special Forest Products

When a natural forested area is managed for both wood products and an additional enterprise, it becomes an agroforestry system. For help with the management of timber, county Extension agents can refer farmers to Extension forestry specialists. These specialists are qualified to give advice on thinning, pruning, and harvesting practices, as well as on marketing options. They may or may not be able to visit the farm for on-site consultation. The Association of Consulting Foresters of America (See **Further Resources** below) can refer you to private forestry consultants in your area.

Besides producing saw timber and pulpwood, woodlands can generate income from many other products. Established forests offer many non-timber "special forest products" that contribute to cash flow without requiring the one-time harvest of old trees. For example, landowners can manage established woods to encourage naturally occurring patches of berries or bittersweet. Or they might plant understory crops adapted to the forest type and climate. Growing mushrooms on logs is another, more labor-intensive, possibility; a canopy of either hardwoods or pine will provide the shade needed to maintain moisture for fruiting. See the ATTRA publication *Mushroom Cultivation and Marketing* for more information.

The number of products that a woodland can contribute is limited only by the owners' imaginations and their ability to identify and exploit a profitable market. Here are a few examples:

- fruits, nuts, berries
- honey and other hive products
- mushrooms
- herbs and medicinal plants
- materials for basket-making or chair-caning
- pine straw, boughs, pinecones
- plant materials as dried or fresh ornamentals
- bamboo
- aromatics
- fenceposts, firewood, smokewood
- decorative or odd wood, e.g. burls
- dye materials
- tree and shrub seeds, seedlings, and cuttings
- charcoal

Ginseng thrives under mature forest.

Berries and vines for crafts or basketry are examples of products that can be harvested and marketed without any costs of establishment; on the production end, they may require only that the canopy be managed for optimal light conditions. Some other examples of non-timber forest products are listed in the box on this page. For more information on special forest products, request the new ATTRA publication *Woodlot Enterprises*, and visit the Web sites listed below under **Further Resources**.

The Business of Agroforestry

1. Establishment Costs and Interim Income

Effort spent at the beginning of an agroforestry project on properly preparing the site and following the recommended planting procedures will pay off well later on. Depending on the type of project, establishment costs can be considerable. For an alleycropping system—or even a windbreak—destruction of existing vegetation and deep chiseling or ripping of the soil are mini-

mal requirements. A season of growing a cover crop before planting the trees, and use of mulch or landscape cloth to reduce early competition for water and nutrients, will increase the chances of quick, healthy growth. Lending institutions will likely require a good business plan in order to fund such a project, especially for a beginner. However, government support programs such as the continuous CRP (Conservation Reserve Program) or other program payments will help to defray these costs in some areas of the country. Consult with your local Farm Services Agency about whether such programs would apply to your acreage.

Raspberries between young pecan trees.

The delay until the income from a new planting begins to pay back these initial costs is a key consideration for most landowners. Alley crops and silvopastures provide income from the area between tree rows in this early stage. In addition, as a stand of same-age trees matures, some trees will be harvested in order to reduce competition as the trees begin to require more space. Although the early thinnings are not likely to be worth very much, the later ones may have some market value. It pays to investigate all the options, including marketing value-added products directly. Hardwood chips could be sold to a landscaping firm, for instance, or firewood may have nearby customers. Consider some of the "special forest products" mentioned above.

Nut trees produce income from the nuts long before the timber can be harvested. In fact, over the life of the planting, the value of the nut harvest of improved varieties is liable to surpass the value of the wood at final harvest. Black walnut is a valuable timber and nut tree, but it requires a good site and takes a long time (often eighty years) before timber harvest can begin. Early training and pruning, as well as managing fer-

Short-rotation Woody Crops

Several of the agroforestry practices described here can incorporate fast-growing trees such as poplar and willow. Called short-rotation woody crops, they are used in riparian buffers, windbreaks, or alleycrops. Harvested for biomass, fiber, or other products, such trees can produce a marketable crop in as few as ten years when managed intensively. Rapid initial growth requires a prepared site, adequate fertility and water, and competition controls (e.g., mulch, herbicide, weed barriers).

In some systems, after a tree is cut, one of the sprouts that grows from the stump is chosen as the replacement stem. After it has grown for several years, it is harvested and the process is repeated. This practice of repeatedly cutting and re-sprouting trees from an established root system is called coppicing. Alternatively, trees are simply harvested once, and new trees planted as replacements. Since new hybrids are continually being developed for use as short-rotation woody crops, producers might choose to completely re-plant in order to take advantage of newer genetic lines.

Short-rotation woody crops are of increasing interest to the energy and fiber industries. For example, in Minnesota, as native aspen forests are exhausted, the pulp industry has turned to hybrid poplars. They are being monocropped in plantations or included in farm agroforestry systems. In this case, the demand is established and so is the infrastructure to harvest and process the crop. These fast-growing trees are often planted in rotation for regular income. However, an all-in, all-out system can also be successful.

tility and pests, will maximize the value of both crops. Pecans, either native or improved varieties, have some of the same advantages and disadvantages. However, pecan trees are seldom harvested for timber while they are still producing because of the high value of the nut.

In the case of pines, boughs for the ornamental market and pine needles for landscaping mulch provide early income potential. Again, the total value of these products over the life of the stand can be more than that of the timber. The advantage of providing income while trees grow to maturity, however, can be critical to the cash-flow situation of the farm. In every system, the amount and type of management and labor required for interim and final products must be carefully weighed during the design stage.

Larry Godsey at the University of Missouri's Center for Agroforestry wrote an excellent publication on developing a budget that combines multiple enterprise budgets over the life of an agroforestry planting. *Economic Budgeting for Agroforestry Practices* is available from The Missouri Agroforestry Center (See **Further Resources** below). An on-line version can be downloaded from the Center's website.

2. Marketing

Thorough research into the markets available for each type of tree product is absolutely essential before committing to any forestry enterprise. For most forestry products, the buyer must be relatively close to the site. Otherwise, the transportation costs will eat up potential profits. Although short-rotation woody crops are a relatively new type of forestry without established markets, it is likely that regional markets will develop over time where there are customers such as ethanol producers, electric power producers, and the fiber industry.

Regions where forestry is a longstanding tradition are likely to have markets for all types of wood products (e.g., saw timber, chip and saw, pulpwood). Without such a forestry infrastructure already in place, it is risky to commit to an agroforestry system. However, because private lands are becoming a more important source of tree products, new markets will develop in other regions. It is, of course, difficult to predict where, especially when planning for harvests twenty years or more in the future.

Careful consideration must be given not only to the marketing plan, but to the harvest plan as well. The planting design must accommodate harvest equipment and leave room for maintenance operations. Young trees are easily wounded, and these wounds provide entrance to pest organisms.

Thinning and pruning may generate sales if wisely marketed. This part of the planning process requires the advice of a forestry professional, whether a government agent or a private consultant. Remember that loggers and timber buyers are likely to have their own best interests in mind.

Landowners who want to add value to their forest products have some choices. One way is to certify that the forest and its harvest have been managed according to specified ecological standards. There are currently several "eco-label" certification programs. Eco-labeling has caught on in Europe where consumer recognition is high, but has not consistently earned premium prices in the U.S. Contact ATTRA for more information about forest certification programs.

In some cases, landowners can add value themselves, for example by cutting and selling firewood. Access to a portable sawmill can enable landowners to saw their own logs into lumber, air dry it, and sell it directly to specialty woodworkers. Other options, like selling pine thinnings as Christmas decorations, require imagination and marketing know-how. Fee hunting or wildlife photography, possibly combined with camping or bed-and-breakfast facilities, might also be considered.

3. Evaluating Agroforestry Options

Agroforestry systems are much more complex than single-purpose farm or forestry enterprises. Each component of the system—the trees as well as the crops or livestock—must undergo a series of evaluation procedures: testing against the

farm or family goals, evaluating resources, investigating promising options from a longer list of possibilities, making the choice, planning, and then implementing the plan and monitoring progress.

Evaluation of an agroforestry system requires collecting the following information (4):

- *Farm Accounts*—Income and expenditures for existing enterprises and potential ones, including fixed and variable costs.
- *Planting and Felling Areas*—The program of harvest and planting for each year of the project.
- *Labor and Materials*—Includes the costs of seedlings, fertilizer, herbicides, and insurance, as well as planting, pruning, and thinning expenses.
- *Wood Yields*—Predicted wood-product values by log grade, including cost of harvest and transport.
- *Understory Profiles*—Crop or livestock products, including harvested tree products (nuts, pinestraw), and how production will change through the tree rotation; effects of canopy closure and windbreak benefits.
- *Environmental Impacts*—Water yield, erosion reduction, carbon sequestration, wildlife.
- *Social Effects*—Family and farm goals, support of the rural community, improved visual aesthetics.

Since agroforestry systems in temperate climates have not been studied through several complete rotations, landowners will work with incomplete data during the evaluation process. Yield data from same-age tree plantations must be adjusted for an agroforestry system. Understory competition for water and nutrients, as well as light effects on both understory and tree edges, should be taken into account when projecting yields and expected market values.

The Missouri Agroforestry Center's excellent publication *Economic Budgeting for Agroforestry Practices* (5) offers step-by-step guidelines for developing multiple enterprise budgets and then combining them into a cash flow plan (see **Further Resources** below). In addition, the more generic ATTRA publication *Evaluating a Rural Enterprise* can be accessed on the Web at <http://www.attra.org> or obtained in print form by calling ATTRA.

Integrating several enterprises necessarily involves multiple interactions. How will each component affect the other—for better or worse? How can all operations be managed without damage to other parts of the system? Despite every effort to predict, there will be unforeseen consequences. Advantages and disadvantages will become apparent. It is therefore more critical than usual to continually observe what's happening on the site. If, during planning, certain indicators can be identified as early warning signs, better monitoring will result. An alert manager can avoid losses by quickly noticing problems as they occur.

Cattle profits offset walnut establishment costs.

Agroforestry systems, especially for temperate climates, have not traditionally received much attention from either the agricultural or the forestry research communities. Nevertheless, implementing designs using trees and bushes to enhance crop or livestock production, waste management, and natural resource protection is a step toward a permanent, stable agriculture. Farmers have pioneered many of these systems. Each requires a careful initial design adapted to the site and the farm operation, continuous observation, and a commitment to a long timeline. The resulting farmscape will be beautiful as well

as productive, and can be a source of pride for the family and the community.

Where to Look for More Information

There are a growing number of information resources on agroforestry in temperate climates, easily available to anyone who seeks them.

The Association for Temperate Agroforestry (AFTA) (See the **Further Resources** section below) is the professional organization devoted to agroforestry research, demonstration, and information dissemination in North America. Its quarterly newsletter, *The Temperate Agroforester*, is included as a benefit of paying annual membership dues. In addition, many books on temperate agroforestry are available to members at a discount. AFTA sponsors a biennial international conference where researchers and practitioners gather to learn what is happening in temperate agroforestry throughout North America. The Proceedings from these conferences provide an excellent overview of the field. Proceedings from many of the past conferences are still available. (See AFTA's website or contact AFTA about availability for purchase.) The seventh conference was held in Regina, Saskatchewan, Canada, in August of 2001. When proceedings become available, ordering information will be posted on the AFTA website.

Based in Lincoln, Nebraska, the National Agroforestry Center (NAC) is an interagency venture of the Natural Resources Conservation Service and the USDA Forest Service. The partnership combines the resources of both agencies to develop and apply agroforestry technologies in appropriate conservation and/or production systems for farms, ranches, and communities. NAC publishes *Inside Agroforestry*, a quarterly periodical containing news from the Center as well as information about developments in agroforestry in the U.S. They also offer a number of practical publications, many of which are free. See **Further Resources** below.

ATTRA distributed a recent USDA publication entitled *Building Better Rural Places: Federal Programs for Sustainable Agriculture, Forestry, Conservation and Community Development*. It identifies numerous agencies and programs, some of which can help plan and fund new agroforestry projects. Although hard copies are no longer available, it is posted on ATTRA's website: <http://www.attra.org/guide>. An update of the electronic version is planned.

Several excellent reference books—both classics and recent publications—are listed below under **Further Resources**, along with many electronic sources of forestry or agroforestry information.

References

1) Richards, Keith. 1997. Planning for a positive future: This family seeds enterprises that fit their farm vision. Planting Your Farm's Future Series, National Center for Appropriate Technology, Fayetteville, AR. 2 p. <http://www.attra.org/pub/leaflets/planningrs.html>.

2) Conservation Trees For Your Farm, Family & Future. No date. The National Arbor Day Foundation. Nebraska City, NE. 10 p.

3) Mortimer, John and Bunny Mortimer. 1996. Shelter & Shade: Creating a Healthy andProfitable Environment for Our Livestock with Trees. Green Park Press, Jackson, MS. 161 p.

4) Knowles, Leith and Phillip Middlemiss. 1999. Evaluating Agroforestry Options. A Continuing Professional Development course held at Hot Springs, AR, June 12, 1999. June. p. 6.

5) Godsey, Larry D. 2000. Economic Budgeting for Agroforestry Practices. Publication UMCA–3–2000. University of Missouri Agroforestry, Columbia, MO. 20 p.

Further Resources

Agroforestry-related organizations:

Association for Temperate Agroforestry (AFTA)
School of Natural Resources
1-30 Agriculture Bldg.
University of Missouri
Columbia, MO 65211

The $25/year membership fee includes a subscription to The Temperate Agroforester, a quarterly newsletter, as well as discounts on association events and on many agroforestry books ordered through the association.

The National Agroforestry Center
Rocky Mountain Forestry and Range Extension Station
Univ. of Nebraska East Campus
Lincoln, NE 68583-0822
http://www.unl.edu/nac

Offers a free quarterly newsletter, Inside Agroforestry, to anyone who requests it, and manypublications on agroforestry practices andproducts, all at low or no cost.

Association of Consulting Foresters of America
732 N. Washington St., Suite 4-A
Alexandria, VA 22314
(703) 548-0990
http://acf-foresters.com/

Forest Landowners Assn.
P.O. Box 450209
Atlanta, GA 31145
(800) 325-2954
http://www.forestland.org/

Members receive Forest Landowner Magazine bimonthly and a Forest Landowner Manual; announcements of the Southern Forestry Conference and other relevant seminars; discount rates on hunt lease liability insurance; access to student scholarships; and tax and policy updates.

National Woodland Owners Assn.
374 Maple East, Suite 310
Vienna, VA 22180
(800) GRO-TREE
e-mail: info@woodlandowners.org
http://www.woodlandowners.org

Members receive a quarterly newsletter, National Woodlands, with information on managing woodland, legislative and tax issues, as well as other intermittent publications; a complimentary visit from a certified forester; and access to videos and other publications.

Books:

Agroforestry for Soil Management, 2nd ed. 1997. By Anthony Young. CAB International, New York, NY. 320 p.

Describes benefits of trees in controlling soil erosion, increasing soil fertility, and maintaining soil structure on marginal lands; offers support for agroforestry practices that improve the soil.

Agroforestry for Sustainable Land-Use. 1999. Edited by Daniel Auclair and Christian Dupraz. Kluwer Academic Publishers. 266 p.

Examines the environmental and social conditions that affect the roles and performance of trees in field- and forest-based agricultural production systems.

Agroforestry: Science, Policy and Practice. 1995. Edited by Fergus L. Sinclair. Kluwer Academic Publishers. 296 p.

An attempt to use the results of process-oriented research toward the goal of developing a policy framework to encourage adoption of agroforestry as a sustainable land-use practice.

Design Principles for Farm Forestry. 1997. Anon. RIRDC/LWRRDC/FWPRDC Joint Venture Agroforestry Program. <http://www.mtg.unimelb.edu.au/designbook.htm>. Pub no 97/48. 102 p.

A guide to help farmers create their own agroforestry design. Written around seven basic reasons for planting trees, each chapter provides basic design principles to achieve that objective; each chapter also provides hints at how to adapt a design to capture multiple benefits. Available for downloading at the website, or in hard copy for $16 from:
RIRDC
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Enhancing Wildlife Habitats: A Practical Guide for Forest Landowners. 1993. By Scott S. Hobson, John S. Barclay, and Stephen H. Broderick. NRAES-64. Northeast Regional Agricultural Engineering Service, Ithaca, NY. 172 p.

Available for $25 plus $4 shipping from:
Northeast Regional Agricultural Engineering Service
152 Riley-Robb Hall
Ithaca, NY 14853-5701.
(607) 255-7654

Forest Farming. 1985. By James Sholto Douglas and Robert A. de J. Hart. 1985. Intermediate Technology Publications, New York, NY. 207 p.

Food production using tree and other forest resources. Out of print. See your librarian or a used bookseller.

Forest Gardening: Cultivating an Edible Landscape. 1996. By Robert Hart. Chelsea Green, White River Junction, VT. 234 p.

Describes how to transform even a small cottage garden into a diverse hospitable habitat for song birds, butterflies, and other wildlife using a wide variety of useful plants, including fruit and nut trees, perennial herbs, and vegetables.

An Introduction to Agroforestry. 1993. By P.K. Ramachandran Nair. Kluwer Academic Publishers (in cooperation with ICRAF). 496 p.

Describes the development, ecological foundations, and status of agroforestry today. Covers technical aspects of the five major agroforestry practices and evaluates each. Socioeconomic factors and the future of agroforestry are also included.

Nontimber Forest Products in the United States. 2002. Edited by Eric Jones, Rebecca McLain, and James Weigand.

Describes the range of products being produced in woodlands, including traditional uses and users of the forest – both commercial and noncommercial; discussion of sustainable manage ment; also policy, economics, and future research needs.

North American Agroforestry: An Integrated Science and Practice. 2000. Edited by H. E. Garrett, W. J. Rietveld, and R.F. Fisher.

Temperate Agroforestry Systems. 1997. Edited by Andrew M. Gordon and Steven M. Newman. CAB International, New York, NY. 288 p.

Design and practice of agroforestry systems based on ecological theory.

Restoration Forestry: An International Guide to Sustainable Forestry Practices. 1997. Edited by Michael Pilarski. 1994. Kivaki Press, Durango, CO. 525 p.

An encyclopedia of sustainable forestry with international scope, including temperate and tropical applications; an important reference book.

The Silvicultural Basis for Agroforestry Systems. 1999. Edited by Mark S. Ashton and Florencia Montagnini. CRC Press. 296 p.

This college-level textbook summarizes the state of current knowledge in the rapidly expanding field of agroforestry.

The Status, Opportunities & Needs for Agroforestry in the United States: A National Report. 1997. Edited by Miles L. Merwin. Association for Temperate Agroforestry. 41 p.

Available for $6 from AFTA (See contact information listed above).

Temperate Agroforestry Systems. 1997. Edited by Andrew M. Gordon and Steven M. Newman. CAB International, New York, NY. 269 p.

Explores the development of temperate agroforestry systems, concentrating on temperate-zone areas where the greatest advances, adoptions, and modifications have taken place: North and South America, China, Australia, New Zealand, the United Kingdom, and Continental Europe.

Timber Management for Small Woodlands. Katherine M. Layer. Information Bulletin 180. Revised edition. Cornell Cooperative Extension Service, Ithaca, NY. 57 p.

The Theory and Practice of Agroforestry Design. 1998. By Paul A. Wojtkowski. Science Publishers, Inc., Enfield, NH. 282 p.

Focuses on the theory of agroforestry design; not a manual for practitioners.

Tree-Crop Interactions: A Physiological Approach. 1996. Edited by Chin K. Ong and P.A. Huxley. CAB International, New York, NY. 416 p.

Uses quantitative physiological evidence to support the potential role and benefits of agroforestry in sustainable agriculture, showing how the principles of crop physiology can be applied to the un derstanding of tree-crop interactions.

Tree Crops: A Permanent Agriculture. 1987. By J. Russell Smith. Island Press, Covelo, CA. 408 p.

Visionary classic describing use of temperate-zone trees to produce food for people and livestock without the erosion associated with annual cropping systems.

A Tree for All Reasons: Introduction and Evaluation of Multipurpose Trees for Agroforestry. 1991. By P.J. Wood and J. Burley. ICRAF, Nairobi, Kenya. ISBN: 92 9059 075 0.

Includes chapters on species selection, planning and design, assessment, and areas of research work.

The Woodland Steward, 2nd Ed. 1994. By James R. Fazio. The Woodland Press, Moscow, ID. 211 p.

Woodland management, including inventory and planning; harvesting and improving the woodlot; chapters on Christmas trees, hollies as a business, and maple sugaring.

Woodland Stewardship: A Practical Guide for Midwestern Landowners. 1993. By Melvin J. Baughman, Alvin A. Alm, A. Scott Reed, Thomas G. Eiber, and Charles R. Blinn. Minnesota Extension Service, University of Minnesota, St. Paul, MN. 195 p.

How to take care of woodlands, including inventory, improvement, and protection; harvesting and marketing; managing for wildlife; and tax and financial investment analysis; excellent supporting appendices.

Proceedings:

Proceedings of Past North American Agroforestry Conferences (AFTA)

The biennial North American Agroforestry Conference series, initiated in 1989, has been a forum for researchers, teachers, extensionists, and practitioners to share up-to-date information about temperate agroforestry. The papers and poster abstracts presented at the meeting are collected in a printed proceedings published by the hosting institution. These proceedings provide a wealth of information on a wide range of topics related to agroforestry.

- **Exploring the Opportunities for Agroforestry in Changing Rural Landscapes**. Proceedings of the Fifth North American Agroforestry Conference, August 1997, Ithaca, NY. Edited by Louise Buck and James P. Lassoie. Published in 1997.

  Includes an update on institutional and extension developments, the latest research on temperate agroforestry practices, modeling efforts, and multipurpose trees. Available for $20 (ppd. USA); check payable to Cornell University from:
  Dr. Louise Buck
  Natural Resources Dept.
  Fernow Hall
  Cornell University
  Ithaca, NY 14853

- **Building a Sustainable Future**. Proceedings of the 4th North American Agroforestry Conference, July 1995, Boise, ID. Edited by John H. Ehrenreich, Dixie L. Ehrenreich, and Harry W. Lee. University of Idaho, Moscow, ID. 200 p. Published in 1996.

  Topics covered include: agroforestry potential, biology, and economics of temperate agroforestry systems, and updates on research of agroforestry practices. Available for $30 to AFTA members; $35 for nonmembers (ppd., checks payable to College of Forestry, University of Idaho) from:
  Dr. John Ehrenreich
  College of Forestry, Wildlife, and Range Stations

University of Idaho
Moscow, ID 83844-1135
(208) 885-7600
(208) 885-5878
e-mail: dixie@uidaho.edu

- **Opportunities for Agroforestry in the Temperate Zone Worldwide**. Proceedings of the Third North American Temperate Agroforestry Conference, August 1993, Ames, IA. Edited by Richard C. Schultz and Joe P. Colletti. Published in 1994.

  Includes papers presented on agroforestry systems design, biology, and socio-economics. For purchase information, contact:
  Richard Schultz
  Department of Forestry
  249 Bessey Hall
  Iowa State University
  Ames, IA 50011-1021
  (515) 294-7602

- **Proceedings of the Second Conference on Agroforestry in North America**. August 1991, Springfield, MO. Edited By H. E. 'Gene' Garrett. The School of Natural Resources, University of Missouri, Columbia, MO. Published in 1992.

  Papers on general biology, wildlife, systems design, pest management, water quality, and social/economic aspects of agroforestry systems. OUT OF PRINT - check your nearest university library.

- **Agroforestry in North America**. Proceedings of the First Conference on Agroforestry in North America, August 1989, Guelph, Ontario. Edited by Peter Williams. Department of Environmental Biology, Ontario Agricultural College, University of Guelph, Guelph, Ontario, Canada.

  Covers a wide range of topics on temperate agroforestry applications. Available for $25 CDN (AFTA members) and $30 CDN (non-members), checks payable to the University of Guelph, from:
  Andrew Gordon
  Dept. Of Environmental Biology
  University of Guelph
  Guelph, Ontario N1G 2W1
  Canada
  (519) 824-4120, ext. 2415
  (519) 837-0442 (Fax)

Other Proceedings of Interest:

Proceedings of the North American Conference on Enterprise Development Through Agroforestry: Farming the Agroforest for Specialty Products. October 1998. Edited by Scott J. Josiah. The Center for Integrated Natural Resources and Agriculture Management, University of Minnesota, St. Paul, MN. 243 p. Published in 1999.

Includes sections on marketing; medicinals and botanicals; handicrafts, specialty woods, and decorative florals; forest-based food products; unique challenges of specialty forest products; and emerging issues in forest farming. Contact CINRAM for ordering information:
The Center for Integrated Natural Resources and Agricultural Management
(CINRAM)
University of Minnesota
115 Green Hall
1530 Cleveland Ave. North
Saint Paul, MN 55108
(612) 624-4299 / 7418 / 4296
(612) 625-5212 FAX
e-mail: CINRAM@umn.edu
http://www.cnr.umn.edu/FR/CINRAM/home/index.htm

Agroforestry and Sustainable Systems: Symposium Proceedings. Held in August 1994 in Fort Collins, CO, 1995. Edited by W. J. Rietveld. General Technical Report RM-GTR-261. USDA-Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 276 p.

Topics include: the use of dormant woody planting for slope protection, living snowfences, agroforestry and wildlife, agroforestry-enhanced biodiversity, conservation trees , and a report on the status of agroforestry in five agroclimatic regions of the U.S. Organized and sponsored by the USDA. Out of print. See your librarian for help in obtaining.

Agroforestry in Sustainable Agricultural Systems. 1998. Edited by Louise E. Buck and James P. Lassoie. Lewis Publishers, Inc., Boca Ratan, FL. 400 p. ISBN: 1-56670-294-1.

A selection of papers from a June 1997 workshop in Montpelier, France, including what is understood about underlying processes in agroforestry, an exploration of relevant modeling approaches, and descriptions of temperate and Mediterranean systems – both traditional and innovative.

Journals/Periodicals:

Agroforestry Abstracts
Available on the Internet with a fully-searchable 13-year archive of worldwide agroforestry information with weekly updates. Subscription: $150 regular; $80 for AFTA members. Free 30-day trial of the on-line version is available.

Agroforestry Systems
International scientific journal that publishes results of original research, critical reviews and short communications on any aspect of agroforestry, including biophysical and socioeconomic aspects. Subscription: $427 regular; $60 for AFTA members.

Websites related to agroforestry:

These websites are continually in flux. If they can't be found at the addresses listed, a Web search will assist you in finding their current locations.

National Agroforestry Center's home page
http://www.unl.edu/nac/
NAC homepage with links to publications and other excellent materials, including a Specialty Forest Products series.

University of Missouri Center for Agroforestry
http://agebb.missouri.edu/umca/
General agroforestry information, publication on budgeting agroforestry practices, and videos on various practices; describes the Center and its staff, provides abstracts of research; excellent links to many related sites.

Forest Landowners Guide to Internet Resources
http://www.na.fs.fed.us/pubs/misc/ir/index.htm
Index of on-line publications covering a wide range of topics related to owning and managing woodlands, pubs on special forest products, riparian buffers and windbreaks, forest tourism, and much more; includes direct on-line links.

The Australia Master Tree Grower Program
http://www.mtg.unimelb.edu.au
Resources for practitioners including an on-line publication for farmers, Design Principles for Farm Forestry; spreadsheets and links to other sites.

Farm, Community, and Tree Network (FACT Net)
http://www.winrock.org/forestry/factnet.htm
Fact sheets on many nitrogen-fixing trees – many of them tropical. Research reports and past publications are also available.

Forestry and Agroforestry in NRCS (Natural Resources Conservation Service)
http://www.nhq.nrcs.usda.gov/BCS/forest/agforest.html
Directory of state and national agroforestry professionals in NRCS; links to other related government agencies and resources; links to forestry professionals; access to videos and slide shows on various woodland management issues.

Resources for Tropical Forestry and Agroforestry
http://www.agroforester.com/index.html
Source of The Overstory, a free e-mail journal; although the focus is on tropical regions, there is considerable information relevant to temperate zone agroforestry.

Poplar and Willow home page
http://poplar2.cfr.washington.edu
Covers topics related to newly developing short–rotation woody production for energy and other uses.

Websites related to special forest products:

USDA Forest Service—Special Forest Products
http://www.srs4702.forprod.vt.edu/pubsubj/sfp.htm
Contains several articles about non-timber forest products.

University of Minnesota site
http://www.cnr.umn.edu/FR/CINRAM/home/
Site to order the Proceedings from the 1998 Specialty Forest Products/Forest Farming Conference and a publication on marketing Special Forest

Forestry with Steve Nix
http://forestry.miningco.com/cs/alternativeforest
Several articles about forest products, including charcoal, tree seeds, botanicals, and pine straw.

Institute for Culture and Ecology's U.S. Non-timber Forest Product Database
http://ifcae.org/ntfp/
Database lists commercial and non-commercial NTFP species – for identification, development and conservation; can be searched by scientific or common name, product use, parts used, state range, and distribution; also has a searchable bibliographic and Internet links database.

WoodWeb
http://www.woodweb.com/Home.html
Woodworking industry homepage with information on lumber sales, funiture and cabinet-making, business, and many other topics related to this industry.

By Alice Beetz
NCAT Agriculture Specialist

Edited by Richard Earles
Formatted by Cynthia Arnold

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The electronic version of **Agroforestry Overview** is located at:
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