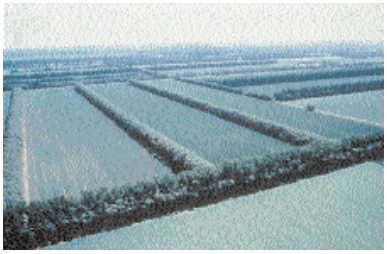
AGROFORESTRY

IN THE UNITED STATES

RESEARCH AND TECHNOLOGY TRANSFER NEEDS FOR THE NEXT MILLENNIUM



AFTA

ASSOCIATION FOR TEMPERATE AGROFORESTRY

Fall 2000

AGROFORESTRY

IN THE UNITED STATES

RESEARCH AND TECHNOLOGY TRANSFER NEEDS FOR THE NEXT MILLENNIUM

THE ASSOCIATION FOR TEMPERATE AGROFORESTRY
COLUMBIA, MISSOURI
FALL 2000

Funding for this project was provided by the USDA National Agroforestry Center.
Photos courtesy of the USDA.

Association for Temperate Agroforestry

Formed in 1991, the Association for Temperate Agroforestry Inc. (AFTA) is a private, non-profit organization. The mission of AFTA is to promote the wider adoption of agroforestry by landowners in temperate regions of North America. Agroforestry practices combine trees and shrubs with crops and/or livestock to increase and diversify farm and forest production while conserving natural resources. AFTA pursues its mission through activities such as networking, information exchange, public education, and policy development. These include 1) the publication of a quarterly newsletter, *The Temperate Agroforester*, 2) co-sponsorship of the biennial North American Agroforestry Conference series (begun in 1989), 3) preparation of reports on agroforestry development and policy, and 4) serving as a liaison with regional agroforestry groups.

This report builds upon the 1997 AFTA report - *The Status, Opportunities, and Needs for Agroforestry in the United States*. The purpose of this report is to identify high priority research questions and technology transfer needs for the five major agroforestry practice areas: 1) alley cropping, 2) forest farming, 3) silvopasture, 4) riparian forest buffers, and 5) windbreaks.

Experts for each practice area drafted sections of this report. The report was then sent to AFTA members for review and comment. The final report reflects a consensus on high priority research questions and technology transfer needs by the AFTA membership.

To request copies of this report or learn more about the Association for Temperate Agroforestry, please write AFTA, 203 ABNR Building, University of Missouri, Columbia, MO 65211, or email *afta@missouri.edu*. Please visit our website at *www.missouri.edu/~afta*.

Agroforestry in the U.S. is defined as:

Intensive land-use management that optimizes the benefits (physical, biological, ecological, economic, and/or social) from biophysical interactions created when trees and/or shrubs are deliberately combined with crops and/or livestock.

Table of Contents

AFTA Strategic Direction

It has happened slowly but surely. Over the last two or three decades dramatic adjustments to farmland management and ownership have changed the face of the American "farmscape." One alarming change is that a significant portion of prime farmland and ranchland is being lost to development (e.g., converted to home sites, factories, roads, and shopping centers). In the U.S. an estimated fifty acres of farmland is now lost every hour of every day to development pressures. Similarly, forest cover in the U.S. has started to decline after remaining essentially constant since the 1920s. As the U.S. population continues to increase by three million each year, forestry and agriculture will both face the problem of meeting an increasing demand for goods, as well as for an expanding array of services, such as clean water, recreation, and wildlife habitat. More importantly, society will have to meet its needs with a fixed or shrinking land base.

Agriculture and forestry share many goals and over the centuries they have provided the strategic foundation for our country. Together they comprise more than 75 percent of the land use in the U.S. Too often there is a tendency to treat agriculture and forestry separately when addressing natural resource concerns. Yet, a high proportion of the watersheds and landscapes in this country are an interwoven mosaic of both uses. Rural communities often depend on both agriculture and forestry to remain economically viable. Solutions are needed that build from a comprehensive, all-lands approach. Otherwise, it is like trying to make a patchwork quilt without bothering to sew the pieces together -- everything comes unraveled.

Technology can provide some productivity gains as improved crops become available through biotechnology and genetic engineering, but the heavy reliance on fertilizers and pesticides already is manifesting its own not-too-subtle impact on the environment. Likewise, consumers and producers are engaged in a lively debate on food safety and environmental issues related to the production and consumption of genetically modified crops. In the future, agriculture may be able to produce sufficient food to meet the world's demand but production costs will rise and so too will the cost of food and the potential for negative impacts to the environment.

Agriculture Needs Agroforestry

When the USDA National Commission on Small Farms Report was issued in January 1998, it listed several recommendations on agroforestry and concluded that.... "USDA extension, conservation, and forestry services should make greater efforts to promote and support agroforestry as part of an economic and ecological strategy for a healthy agriculture."

Today, many farmers and ranchers are struggling to make a livelihood on small acreage farms. They often have limited financial means and are seeking ways to maximize their income per acre, while keeping their requirement for purchased inputs low. Production systems need to become more diverse. New crops and new production methods need to be embraced. Cost-effective alternatives that can meet environmental goals and increase profits need to be available to producers.

A more diversified agricultural sector means producers will need to select from a broad portfolio of management practices; practices that include science-based agroforestry technologies. Most agroforestry practices are designed to be readily integrated into existing farm operations. In many instances, the adoption of one or several agroforestry practices can be the difference between profitability and economic loss.

ULTIMATELY THE CHALLENGE WILL BE TO FIND WAYS TO SUSTAIN THE PROVISION OF GOODS AND SERVICES THAT SOCIETY DERIVES FROM FORESTS AND AGRICULTURE IN WAYS "...*THAT MEET THE NEEDS OF THE PRESENT WITHOUT COMPROMISING THE ABILITY OF FUTURE GENERATIONS TO MEET THEIR OWN NEEDS*."

Forestry Needs Agroforestry

The U.S. made a commitment to sustainable forest management when it signed the Santiago Declaration in 1995. However, there are places in the U.S. that are already experiencing difficulty meeting society's expectations for some forest-derived benefits. For example, in many areas land use fragmentation patterns across the landscape have resulted in the reduction of many plant and animal species that rely on forest habitat. In other regions there are projections of inadequate wood supply. Insufficient water quality and aquatic habitat are issues that now affect most regions.

If society's needs and aspirations for forest-derived goods, services, and amenities truely are to be met, we must find ways of augmenting traditional forestry by gleaning some portion of these benefits from agricultural lands. For example:

- Windbreaks can provide corridors across agricultural lands to connect forest fragments and increase wildlife benefits, while protecting soils, crops, and livestock, conserving energy, and producing commercially valuable products.
- Riparian forest buffers on farms and ranches can protect surface waters from sediments, nutrients, and contaminants, while enhancing aquatic habitats, producing marketable products, and sequestering carbon.
- Fast-growing hybrid poplar trees grown on farmlands can treat agricultural waste and provide income for farmers, while helping to meet the demand for wood fiber and energy.
- Farm woodlots can be used to grow specialty products such as ginseng or mushrooms under a modified forest canopy, thereby encouraging timber stand improvement practices.
- Grazing/timber systems allow farmers to generate an annual income from grazing livestock under thinned forest stands while producing high quality sawlogs.

A COMPREHENSIVE APPROACH IS NEEDED TO INCREASE THE INVESTMENT IN DEVELOPING AND IMPLEMENTING AGROFORESTRY PRACTICES IN THE U.S. THIS NEEDS TO OCCUR THROUGH AN EXPANSION OF EXISTING STATE AND FEDERAL AGENCY PROGRAMS, AN INCREASED USE OF LANDOWNER ASSISTANCE PROGRAMS, AND BY EXPLICITLY INCLUDING AGROFORESTRY IN COMPETITIVE RESEARCH GRANT AND EXTENSION PROGRAMS.

Agroforestry is Relevant to Many Issues

With more than eighty percent of Americans now living in urban or suburban environments, it has become increasingly important that the public understand that much of what it values is derived from agriculture and forestry. People need to understand that clean water does not just happen; that the food and fiber they consume and the wastes they generate have associated consequences and responsibilities.

There is no shortage of issues that agroforestry can help resolve. Although many resource professionals and landowners don't yet understand the full benefits of adding agroforestry practices to their land management portfolio, many are beginning to investigate the possibilities. Most farmers, ranchers, and communities cannot afford to plant trees or shrubs simply because it's the right thing to do. It's hard to be virtuous when you're in a daily struggle to make ends meet. But once a landowner in an area implements an agroforestry practice that successfully solves a problem, agroforestry often begins to "sell itself" to his or her neighbors.

Agroforestry practices are grouped into five categories: 1) alley cropping, 2) forest farming, 3) silvopasture, 4) riparian buffers, and 5) windbreaks. This document describes agroforestry practices within each of these categories and lists associated high priority research questions and technology transfer needs.

Overarching Needs

There are some common needs that apply to all agroforestry practices. More regional workshops and field demonstration projects can help illustrate both the logistics and the economics of an agroforestry practice to resource conservation professionals and landowners. The generation of educational materials, such as videos and “how-to” manuals, that provide specific guidance on how to design, install, and manage agroforestry practices, along with innovative extension/outreach programs, will facilitate more local adoption. The networking and integration among resource agencies at the national, state, and local levels needs to increase.

Since agroforestry is a hybridization of agriculture and forestry conservation and production technologies, landowners need to be able to evaluate the economic performance of an agroforestry practice against traditional forestry and agricultural cropping alternatives. In most instances there remains a need to better characterize the economic cost for establishment and maintenance of an agroforestry practice and its economic return. This must include considerations of financial risk and operational complexity. Region-specific economic analyses are needed that present information in ways that natural resource professionals and landowners can understand. In many areas landowners are seeking advice on how to form cooperatives to harvest and market new products.

Agroforestry practices have been shown to provide benefits in many settings:

- ***Carbon Storage*** -
  Sequesters large amounts of carbon in trees and shrubs across a large landbase.

- ***Pest Management*** -
  Provides habitat for beneficial insects and birds. Presents a physical barrier that interrupts pest cycles.

- ***Soil Conservation*** -
  Reduces loss of soil organic matter, nutrients, and soil particles.

- ***Streams and Lakes*** -
  Protects water quality by intercepting sediments and agricultural chemicals. Reduces streambank erosion and improves aquatic habitat.

- ***Water Conservation*** -
  Reduces evaporation and plant transpiration, beneficially distributes snowmelt, and protects riparian zones from agricultural runoff.

- ***Wildlife Habitat*** -
  Provides food, cover, nesting sites, and travel lanes.

- ***Economic Benefit*** -
  Provides income from trees and their products, while allowing for annual income from crop and livestock production. Improves crop yield and quality.

- ***Livestock*** -
  Protects livestock from harsh climate, improves animal health, and lowers feed costs. Provides annual income from grazing/timber systems. Moderates noise and odor from animal operations.

- ***Aesthetics*** -
  Provides plant diversity, wildlife habitat, and recreational corridors.

- ***Energy Conservation*** -
  Reduces energy costs associated with farm operations.

Alley Cropping

Two incomes in the space of one… Making a living from year to year off an annual crop is fraught with uncertainty. Success depends on weather conditions and favorable markets at harvest. Alley cropping systems provide a way to lower risk by diversifying production. In alley cropping an agricultural crop is grown simultaneously with a long-term tree crop to provide annual income while the tree crop matures. Traditionally, fine quality hardwoods such as walnut, pecan, and oak have been preferred species, as they can be managed to produce high-value lumber or veneer logs. More recently, fast-growing hybrid poplar trees are being grown for sawtimber in 15-20 year rotations. When nut-bearing trees are used, they can provide an intermediate product for sale. In addition to improving annual cash flow, these systems also protect annual crops from wind, reduce soil erosion, and provide wildlife habitat. Most row, grain, and forage crops, as well as specialty crops, such as catnip or St. John's Wort, have been shown to grow well in an alley cropping system.

ALLEY CROPPING - The level of investment in research on alley cropping must increase. More information is needed to provide the scientific basis for designing practices that can meet an expanding set of landowner and societal objectives. AFTA has identified the following high priority research questions:

RESEARCH QUESTIONS

- What crop rotation systems and tree and shrub species are compatible in various regions of the country?
- What is the combined yield of different tree, shrub, and crop combinations, especially conventional crops?
- What are the optimal row spacings for different tree, shrub, and crop combinations?
- How can weeds be controlled, particularly at the interface between tree rows and crops?
- Which insects and diseases are significant problems and can beneficial insects be used in an integrated pest management system?

ALLEY CROPPING - The level of investment in technology transfer on alley cropping must increase. Increased technology transfer efforts should focus on packaging completed, but scattered, research results to facilitate their use by resource professionals and landowners. AFTA has identified the following high priority information needs:

TECHNOLOGY TRANSFER NEEDS

- Region-specific technical information that provides suitability ratings for tree and shrub species and compatible crops.
- Operational guidelines for managing trees, shrubs, and crops in various alley cropping arrangements.
- Guidelines for tree establishment by region.
- Information on cost-share programs for establishment and maintenance.
- Educational information on marketing strategies and how to establish cooperatives.
- Information on different manual and machine-assisted pruning methods.
- Regional economic data on common tree, shrub, and crop combinations.
- Farmer-friendly financial analysis models that compare the costs and benefits of various alley cropping practices over time.
- Information on the availability of plant material.

Forest Farming

Made in the shade… Many farmers who own woodlots are finding they can make money in the shade. Many high-value specialty crops are now being cultivated under the protection of a forest canopy that has been modified to provide the appropriate microclimate and light conditions. Meanwhile, the timber stand improvement activities that are carried out to develop the appropriate understory conditions, like thinning less desirable stems and pruning lower branches on the eventual "crop" trees, can result in the production of clean, knot-free wood of higher value as a long-term economic strategy. Shade tolerant crops such as ginseng, goldenseal, shiitake mushrooms, and decorative ferns are being grown and sold for medicinal, culinary, or ornamental uses.

FOREST FARMING - The level of investment in research on forest farming must increase. More information is needed to provide the scientific basis for designing efficient production practices. AFTA has identified the following high priority research questions:

RESEARCH QUESTIONS

- What stocking levels are appropriate for various tree species to regulate understory shade and microclimate for the production of floral greens, mushrooms, ginseng, and other specialty crops?
- Which non-timber forest products have the economic potential to be grown under a forest canopy, and what are their growth requirements?
- What are the start-up and operating costs for producing various understory crops?
- How compatible are existing forest/woodlot management strategies with the production of understory crops?
- What are the effects of shade levels on valued-properties of understory crops, for example the concentration of chemically active compounds?
- Will different genotypes of understory crop species provide production gains?
- How can woody plants that produce specialty forest products be integrated into other agroforestry practices, like windbreaks and riparian forest buffers?
- How do the economics of forest farming compare to those of traditional forestry?
- What are the characteristics of current and evolving markets for the major specialty forest products?

FOREST FARMING - The level of investment in technology transfer on forest farming must increase. Increased technology transfer efforts should be focused on packaging completed, but scattered, research results to facilitate their use by resource professionals and landowners. AFTA has identified the following high priority information needs:

TECHNOLOGY TRANSFER NEEDS

- Information on region-specific marketing opportunities for understory species at both wholesale and retail levels.
- Information on buyer standards and specifications for understory crops.
- Region-specific production enterprise budgets for common understory crops.
- Understory cropping practices that are compatible with various forest management practices, such as timber stand improvement or shelterwood cuts.
- Handbook on the production, marketing, and sale of specialty forest products with specific information on species and improved cultivars.
- Information on sources of agroforestry plant materials, such as fodder-producing tree varieties, shade-tolerant fruit species, medicinal plants, decorative flowers, bioremediators, and handcrafts.
- Financial analysis models of costs and returns to landowners from various forest farming practices.

Riparian Forest Buffers

Water matters...Many of the waters in the United States are polluted to the extent that they can no longer be safely used to supply drinking water, for swimming and other recreation opportunities, or to provide edible fish. Much of the loss of water quality has been shown to be a result of non-point source pollution from agricultural activities. Practices like cropping and grazing often occur up to the edges of streams, lakes, ponds, and wetlands. The result is a loss of aquatic habitat and high levels of sediment and chemical inputs which lower water quality. Forested riparian buffer practices consisting of grasses, shrubs, and trees have been shown to be an effective strategy for improving water quality by intercepting sediments, filtering excess nutrients, and degrading pesticides. They also can stabilize streambanks, protect floodplains, enhance aquatic and terrestrial habitats, and provide landowners with harvestable products.

Riparian Forest Buffers - The level of investment in research on riparian forest buffers must increase. More information is needed to provide the scientific basis for designing buffers that can meet an expanding set of landowner and societal objectives. AFTA has identified the following high priority research questions:

Research Questions

- What are the above- and below-ground carbon dynamics of riparian buffers?
- How do buffer design criteria, such as width, age, vegetation type, and management, influence their ability to process different contaminants, such as sediments, nutrients, and pesticides?
- How do landscape parameters, such as site characteristics, land uses, hydrology, and topography, influence riparian buffer functions related to water quality, bank stabilization, and flood protection?
- What management is needed to maintain the intended buffer functions over time?
- How can information at the plot/field/farm level be scaled to the watershed level?
- What are the establishment and maintenance costs associated with various buffer designs over time?
- How does the effectiveness of riparian buffers vary with season and different levels of contaminant loading?
- What is the potential of various riparian forest buffers to provide wildlife habitat?
- What tree and shrub species can be incorporated into riparian forest buffers to produce income-generating specialty forest products?

RIPARIAN FOREST BUFFERS - The level of investment in technology transfer on riparian forest buffers must increase. Increased technology transfer efforts should be focused on packaging completed, but scattered, research results to facilitate their use by resource professionals and landowners. AFTA has identified the following high priority information needs:

TECHNOLOGY TRANSFER NEEDS

- Management guidelines for riparian forest buffers that allow for the economic usage or harvest of trees that are not adjacent to the water.
- An expanded USDA Conservation Reserve Program that provides cost-share and land rental payments that include streambank bioengineering and constructed wetlands.
- Educational materials on how to design riparian forest buffers that simultaneously meet conservation objectives along with providing opportunities for commodity production practices.
- Computer simulation models that operate at the regional level to gauge the effectiveness of different buffer designs and placements.
- Tools to identify and predict pollutant pathways in landscapes to identify the most efficient design and placement of riparian buffers in the landscape.
- Decision support tools to help determine on-farm financial performance of riparian forest buffers.
- Listing and sources for tree, shrub, and understory species and cultivars with potential economic value.

Silvopasture

Trees grow old but so do farmers… Many farmers who own conifer woodlots simply wait for the trees to grow bigger and then take whatever price they can get for a once in a lifetime harvest. Unfortunately, the price often is low due to the lack of timber stand improvement activity throughout the rotation. Thinning less desirable stems and pruning lower branches on the eventual "crop" trees could have resulted in the production of clear, knot-free wood of higher value. Fortunately, agroforestry silvopasture practices are conducive to promoting forest management, while generating forage production in the understory that is suitable for livestock grazing.

Recent research has shown that many cool- and warm-season grasses and legumes yield high levels of quality forage when grown under as much as fifty percent shade. This knowledge is being used to design integrated timber/grazing practices in conifer stands that allow high value sawlogs to be grown as a long-term product, while on the same acre, an annual income can be generated from grazing livestock. Silvopasture field studies have shown that the "crop" trees continue to grow well, while the level of forage production is similar to that of an open pasture.

Although it takes longer, it is also possible to establish tree seedlings in an open pasture or crop field. Trees must be protected from grass competition and animal grazing until they reach adequate size. In the meantime, the trees displace very little land from grazing or crop production during the initial years of establishment.

Research has also begun to evaluate the potential for silvopature with hardwood species.

SILVOPASTURE - The level of investment in research on silvopasture practices must increase. More information is needed to provide the scientific basis for designing silvopasture practices that can meet an expanding set of landowner and societal objectives. AFTA has identified the following high priority research questions:

RESEARCH QUESTIONS

- What are the effects of wide spacing, pruning, and fertilization on the production and quality of wood and forage?
- What is the efficiency of multi-row and multi-species tree planting vs. single-row and single-species plantings for converting open areas to silvopastures?
- How do the tree and forage components interact to compete for light, water, and nutrients?
- Can supplemental products be produced in silvopastures, such as pine straw?
- How compatible are other conifer cover types, such as ponderosa pine and Douglas-fir to silvopasture management?
- How compatible is silvopasture with hardwood tree species?
- What are the yield and quality of cool- and warm-season forages as affected by various management regimes under tree shade?
- What are the forage preferences of cattle, goats, and sheep in a silvopasture practice, and what is their compatibility with the trees?
- How do cultural practices such as mowing, herbicide, and cultivation affect the establishment and early growth of tree seedlings planted into existing pasture?
- Can other commercially viable specialty products be produced in silvopasture systems to enhance biological and economic diversity?

SILVOPASTURE - The level of investment in technology transfer on silvopasture must increase. Increased technology transfer efforts should be focused on packaging completed, but scattered, research results to facilitate their use by resource professionals and landowners. AFTA has identified the following high priority information needs:

TECHNOLOGY TRANSFER NEEDS

- Region-specific production and economic budgets for silvopastoral enterprises.
- Guidelines for converting coniferous farm woodlots into silvopastures.
- Guidelines for converting alley cropping enterprises into silvopasture.
- Information on equipment, markets, and economics of on-farm timber processing.
- Information on compatible combinations of tree and forage species.
- Cost-effective methods of protecting newly planted tree seedlings from livestock damage.
- Economic analysis models that are operational at the regional scale (e.g. Agroforestry Estate Model).
- Information on silvopasture benefits for livestock.
- Information on benefits/problems of various types of livestock and tree combinations.

Windbreaks

Wind happens…. In the summer, hot dry winds deplete water resources by increasing surface evaporation and elevating plant transpiration rates. Exposed soil can become subject to wind erosion and unprotected crops can be stressed. Odors associated with livestock can be transported long distances, as can spray drift from the application of agricultural chemicals and dust from farming operations. In the winter, the chilling effects of wind and drifting snow often cause hardships to farm families and their livestock, as well as to rural communities.

The concept behind windbreaks is not new. They are also referred to as "shelterbelts" and have been used extensively in the United States since the "dust bowl" era of the 1930s and now comprise about 1.5 million acres. A windbreak's major function is to reduce wind speed. Therefore, a windbreak can be defined as any barrier that reduces troublesome winds by creating a wind shadow to the leeward (downwind) side. An agroforestry windbreak is one that utilizes single or multiple rows of trees and/or shrubs that are integrated into agricultural systems.

What is new is the expanding array of issues windbreaks are being asked to address. While an extensive body of knowledge and technical guidelines has been developed, past efforts have been concentrated on the use of field windbreaks to prevent soil erosion, protect crops from drying winds, and deflect blowing snow. Today, windbreaks are being used for a wide variety of purposes.

WINDBREAKS - The level of investment in research on agroforestry windbreaks must increase. More information is needed to provide the scientific basis for designing windbreaks that can meet an expanding set of landowner and societal objectives. AFTA has identified the following high priority research questions:

RESEARCH QUESTIONS

- How does porosity relate to the effectiveness of windbreaks for achieving various landowner objectives and how can porosity be conveniently measured.
- How can older, deteriorated field and farmstead windbreaks be renovated in a cost-effective manner?
- How can woody species that produce specialty forest products be incorporated into windbreaks to increase economic returns to landowners?
- What are the benefits of windbreak protection for a large array of crops?
- What is the economic value of reduced soil erosion?
- How do windbreaks affect crop water-use, to include irrigation efficiency and snow management?
- Which design and management options provide the best direct economic return to the landowner?
- What are the benefits of various windbreak designs used for livestock and how effective are they in mitigating odors and reducing dust?
- Can short-rotation woody crops be effectively designed into windbreaks to generate additional income while providing crop and livestock protection?
- How effective are fast growing tree species, such as hybrid poplar, at treating irrigation wastewater and wastes from animal feeding operations on-farm?
- What is the potential of windbreaks to store carbon above- and below-ground at the field level and nationally?

WINDBREAKS - The level of investment in technology transfer on agroforestry windbreaks must increase. Increased technology transfer efforts should be focused on packaging completed, but scattered, research results to facilitate their use by resource professionals and landowners. AFTA has identified the following high priority information needs:

TECHNOLOGY TRANSFER NEEDS

- Economic fact sheets using existing data for crop production in association with windbreak practices.
- Economic data on the influence of windbreaks on feed requirements, mortality rates, and animal health for animal feeding operations.
- Windbreak designs that maximize plant species diversity to reduce the negative impact of insects, diseases, and weed infestations on windbreaks.
- Educational materials to promote proper windbreak management and renovation by the public.
- Learning materials to better educate natural resource professionals and university agricultural science and forestry students on windbreak technologies.
- Informational tools about windbreak practices that optimize the production of marketable specialty forest products to increase income for small farms.
- Management and economic guidelines for harvesting timber or non-timber products while maintaining windbreak functions.