

Working Trees for Energy

Using proven agroforestry practices, *Working Trees for Energy* can help farms, ranches and communities reduce energy use, diversify sources of income and provide environmental benefits.



Wood is one of the oldest sources of renewable energy, and woody crops are part of the solution to America's growing energy needs.

As our nation's energy supply continues to emerge as a key 21st-century issue, the use of woody crops for biofuels, bioenergy and bioproducts is becoming a necessity.

Agroforestry systems can support agriculture and rural economies by reducing en-

ergy consumption, creating a potential source of renewable energy and generating an energy product to be sold to diversify and increase income.

In addition, *Working Trees for Energy* sequester carbon, which helps to mitigate the effects of climate change and greenhouse gases.

The right tree in the right place provides wind protection, shade and cool air, while adding beauty, privacy, income and

wildlife habitat to the landscape.

Working Trees for Energy can be incorporated into windbreaks, silvopasture, alley cropping, forest farming and riparian forest buffers.

Working Trees for Energy explains how trees and shrubs can simultaneously provide an energy source, an income stream for farms, woodlands, ranches and nearby communities, as well as environmental benefits.

Agroforestry Practices for Energy



A Windbreaks

Windbreaks are rows of vegetation used to reduce and redirect wind. Windbreaks can be designed to provide energy savings for a small residential lot, a farmstead or an entire housing development.

A well-designed windbreak can reduce the amount of energy needed to heat and cool a home or dwelling, reducing energy costs as much as 20 to 40 percent.

Field windbreaks improve crop yields, reduce energy inputs, increase water-use efficiency and reduce wind erosion. Most crops produce higher yields and better quality products when protected from the negative effects of winds.

Living snow fences keep roads clear of drifting snow, increase driving safety and reduce road maintenance costs. By reducing or eliminating the need for snow removal, significant energy savings are realized.

A multi-row windbreak planting can be designed to function as both a windbreak and a source of woody biomass for energy needs and products. In this case, additional rows need to be incorporated into the design to allow rotational harvesting while maintaining the design integrity of the windbreak.



B Riparian Forest Buffers

Riparian forest buffers protect water quality by intercepting and filtering pollution from agricultural runoff. In addition, these buffers stabilize streambanks while providing a source of supplemental income.

A riparian forest buffer typically requires rows of trees and shrubs along the water body. Usually three to five rows of trees are established. In order for a riparian forest buffer system to be effective for both biomass production and environmental protection, a minimum of seven woody rows may be necessary. If biomass harvesting is planned, the basic design integrity of the buffer must be maintained.

Therefore, as one or more rows are harvested for biomass or fuelwood, the remaining rows would be left in place as a riparian buffer until the previously harvested row(s) have regrown and are tall enough to be effective as a buffer.

Another benefit of harvesting some trees is the removal of trapped nutrients from the floodplain so they cannot be reintroduced into the stream. More growing time may be necessary to ensure adequate tree height and size.



C Forest Farming

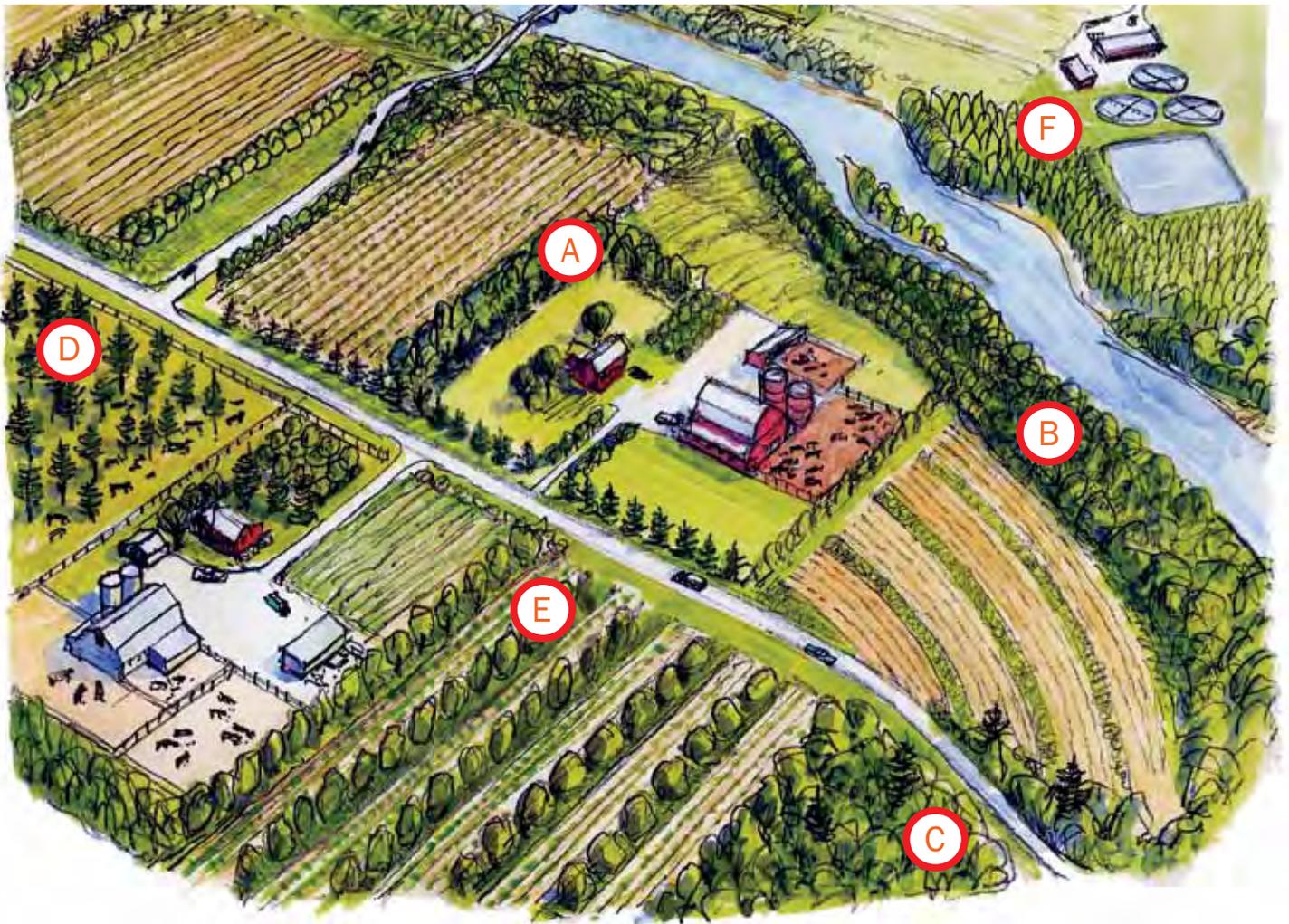
In forest farming, high-value specialty crops are cultivated under the protection of a forest canopy that has been modified to provide a desired amount of shade. Forest farming provides an added income while trees are being grown for wood products and energy use.

Properly managed, forests can be improved to provide not only quality timber and wildlife benefits but also fuelwood. With the growing popularity and economic benefits of using wood as a partial or total energy source, harvesting and gathering fuelwood has become a way of life and a source of income for many. Estimates indicate that an average woodlot in the Midwest contains approximately six cords of hardwood fuelwood per acre that can be harvested while improving the overall forest health.

Trees, like other crops, need room to grow. Too many trees on an acre of land will cause reduced growth rates due to competition for sunlight, nutrients and water. Periodic thinning (selective removal of trees) of these stands will create more space for the better formed, more desirable trees and improve stand growth. Thinning also will increase the supply of fuelwood for use in the home or to be marketed and sold as forest products.



Agroforestry: Making a Difference



Want more information?

Forest Products Lab/USDA Forest Service — Primer for Woody Biomass

http://www.fpl.fs.fed.us/products/publications/pubs_specified_topic.php?groupings_id=56&sort_criteria=title

National Association of Conservation Districts' Biomass Desk Guide

<http://www.nacdnet.org/resources/guides/biomass/>

Department of Energy Biomass Program Resources

<http://www1.eere.energy.gov/biomass/index.html>

eXtension Woody Biomass Community of Practice

<http://www.extension.org/pages/26594/wood-energy-community-of-practice>

Forest Products Fuel Value Calculator

<http://www.fpl.fs.fed.us/documnts/techline/fuel-value-calculator.pdf>

Local Assistance from USDA, use the USDA Service Center Locator

<http://offices.sc.egov.usda.gov/locator/app>

Find Your State Forester

http://www.stateforesters.org/about_nasf

Agroforestry Practices for Energy



D Silvopasture

Silvopasture systems combine trees, forage and livestock production. Trees are managed for long-term, high-value timber and the understory is managed for forage production to support livestock grazing.

Silvopasture systems could be established with multiple rows that would allow periodic harvests for shorter rotation biomass or for energy, while keeping the integrity of the system by retaining specific rows or trees for longer rotation forest products and shade.

Using the silvopasture alleyways between the tree rows for energy production can be another energy option when a viable local biomass market is available. Planting productive forages like switchgrass can add flexibility to a silvopasture. When biomass prices are high or livestock prices are low, grazing can be stopped and the forage could be managed for biomass production for a few years.



E Alley Cropping

In an alley cropping system, an agricultural crop is grown in the alleys between widely spaced rows of trees. The agricultural crop provides for an annual income and the trees can produce a long-term or supplemental income. When planted in alley cropping systems, woody perennial biomass crops can provide feedstocks that support the development of alternative energy industries or on-farm uses, while providing ecosystem services and creating sustainable farming systems.

Recently, there has been interest in using alley cropping for short-rotation, woody species such as willow. The same impacts on microclimate found with windbreaks and annual crops are at work with shrub and tree crops. Results indicate that hardwood alley cropping is a viable alternative to a single species, short-rotation block planting.



F Special Applications

Working Trees for Energy can be used to help deal with both current and future resource challenges such as bioenergy feedstock needed for renewable energy enterprises. Fast growing trees, known as “short-rotation, woody crops,” can be intensively managed for energy biomass production in multiple rows or large blocks or incorporated into agroforestry practices as an added use and benefit.

Producing direct revenues or incorporating the woody bio-feedstock into on-farm uses reduces overall financial risk due to fluctuating prices of fossil-based fuels. The sale of biomass feedstocks is best suited for areas where there are strong markets for feedstocks.

Very small plantings of 10 acres or less may not be financially attractive to contractors or buyers if they are located more than 50 miles from the utilization source. On-farm or on-ranch uses would not have this restriction.



Energy Conservation

Working Trees for Energy can reduce energy consumption on the farm, on the ranch and in communities. *Working Trees for Energy* absorb water through their roots and release moisture through the leaf surfaces by a process called evapotranspiration, which cools the air in much the same way our skin cools us through sweating, saving energy in several ways.

Carefully positioned trees can save up to 25 percent of a household's energy needs for heating and cooling. Trees can block cold winter winds that can enter buildings through small openings and carry heat away from outer surfaces of

buildings. Shade from trees reduces air conditioning needs and makes non-air conditioned homes more comfortable. An air conditioner's efficiency can be increased by as much as 10 percent when shaded by trees.

Communities with unshaded paved streets and parking lots are sometimes referred to as "heat islands," which are much warmer than the surrounding areas. Trees that shade paved areas like driveways and parking lots will greatly decrease surface heat, saving energy and money. Tree leaves also absorb light energy, thereby reducing reflected heat.

Energy Source

Working Trees for Energy can be a source of energy for on-farm operations or personal use. Growing trees for fuel is one option to supplement energy needs in the years ahead. Local utilization of fuelwood limits the risk of spreading invasive pests. Growing woody plants for commercial energy supplies also has merit, as does providing an alternative fuel for small-scale heating applications on-site or in community facilities. The advent of efficient wood

burning stoves and boilers makes wood energy an attractive alternative energy source.

Although *Working Trees for Energy* are often viewed in the landscape as just a conservation practice, they are much more. They are productive conservation. All agroforestry practices can be designed and utilized for periodic harvesting of a portion of the trees and shrubs for energy.

Energy Products

Working Trees for Energy can be sold as raw material for energy conversion. Wood fuel products include firewood, charcoal, chips, pellets and sawdust. The particular form used depends upon source, quantity, quality and application. The use and demand for plant biomass will continue to grow as both domestic and global populations seek renewable energy stocks that support local jobs and rural economies. Agroforestry practices have the potential to provide large quantities of biofuel feedstock, while provid-

ing valuable ecosystem services and helping to build the vitality of rural economies. The amount of biofuel that can be sustainably produced each year is potentially very large. Woody biomass can be used for electrical power and heat generation. Combined heat and power units are a more efficient use of fuel than a single purpose power application.

In addition, *Working Trees for Energy* are well suited for the future of biorefining that creates liquid fuels such as bio-oils, ethanol, methanol and other bioproducts.



Glossary of common bioenergy terms

Bioenergy — Useful, renewable energy produced from organic matter — the conversion of the complex carbohydrates in organic matter to energy. Organic matter may either be used directly as a fuel, processed into liquids and gases or be a residual of processing and conversion.

Biogas — A gas produced from biomass, usually combustible.

Biomass — Organic matter available on a renewable basis. Biomass includes forest and mill residues, agricultural crops and wastes, wood and wood wastes, animal wastes, livestock operation residues, aquatic plants, fast-growing trees and plants, and municipal and industrial wastes.

Biorefinery — A facility that processes and converts biomass into multiple value-added products. These products can range from biomaterials to fuels such as ethanol or important feedstocks for the production of chemicals and other materials. Biorefineries can be based on a number of processing platforms using mechanical, thermal, chemical and biochemical processes.

British thermal unit (BTU) — A standard unit of energy equal to the heat required to increase the temperature of 1 lb (0.45 kg) of water 1°F (0.56°C).

Carbon sequestration — Carbon sequestration is the process by which atmospheric carbon dioxide is absorbed by trees and other plants through photosynthesis and stored as carbon in biomass (trunks, branches, foliage and roots), soil and wood products. Adopting certain agricultural and forestry activities can reduce greenhouse gas (GHG) emissions to the atmosphere and sequester additional carbon.

Char — Carbon-rich combustible solids that result from pyrolysis of wood in the early stages of combustion. Char can be converted to combustible gases under certain conditions or burned directly.

Cofiring — Utilization of bioenergy feedstocks as a supplementary energy source in high-efficiency boilers.

Cogeneration — Combined heat and power (CHP).

Combined heat and power (CHP) — The waste heat from producing power is used for thermal needs.

Ecosystem services — Benefits people obtain from ecosystems. These include provisioning services such as food, water, timber and fiber; regulating services that affect climate, floods, disease, wastes and water quality; cultural services that provide recreational, aesthetic and spiritual benefits; and supporting services such as soil formation, photosynthesis and nutrient cycling.

Energy conservation — Efforts made to reduce energy waste. Energy conservation can be achieved through increased efficient energy use, in conjunction with decreased energy consumption, which can result in increased financial savings, environmental quality and human comfort.

Energy conversion — Converting one type of energy into another. Changing the energy stored in wood into heat by burning it is one example. A wind turbine changing wind energy to electrical energy is another.

Feedstock — Any biomass resource destined for conversion to energy, or to another form such as fuel or bioproducts. For example, corn is a feedstock for ethanol production. Soybean oil may be a feedstock for biodiesel or for bioproducts such as inks, paints, coatings and other bioproducts. Cellulosic biomass has potential to be a significant feedstock source for biofuels, biopower and bioproducts.

Pyrolysis — A process of reduction at oxygen-starved conditions, involving the physical and chemical decomposition of solid organic matter by the action of heat into liquids, gases and a carbon char residue.

Short-rotation woody crops — Fast, growing tree crops that are grown primarily for their fuel value.

Woody biomass — Trees and woody plants, including limbs, tops, needles, leaves and other woody parts, grown in a forest, woodland or rangeland environment that are the byproducts of management.

Wood gasification — The process of heating wood in an oxygen-starved chamber until volatile pyrolysis gases (e.g., CO, H₂, O₂) are released from the wood. The gases emitted are low- or medium-energy-content gases that can be combusted or used to produce chemicals.

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A partnership of



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The USDA National Agroforestry Center (NAC) is a partnership of the Forest Service (Research & Development and State & Private Forestry) and the Natural Resources Conservation Service. NAC's staffs are located at the University of Nebraska, Lincoln, NE and in Blacksburg, VA. NAC's purpose is to accelerate the development and application of agroforestry technologies to attain more economically, environmentally, and socially sustainable land use systems by working with a national network of partners and cooperators to conduct research develop technologies and tools, establish demonstrations, and provide useful information to natural resource professionals.

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