

BUILDING BIGGER BETTER BUFFERS FOR BIOENERGY

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BIOFUEL PRODUCTION: THE BEST OF TIMES ... THE WORST OF TIMES

In response to the President's call for reducing America's dependence on foreign oil, the rising petroleum prices, and the need for more climate change-friendly ways of doing business, the race to develop bioenergy production systems has begun. Biofuels production, primarily corn-based ethanol, has grown from less than 2 billion gallons per year (GPY) to more than 7 billion GPY between 2002 and 2007. The good news is - corn is around \$3-5 per bushel and agricultural land prices have risen tremendously! The bad news is - corn is around \$3-5 per bushel and agricultural land prices have risen tremendously!

While short-term economic benefits of biofuel production may be evident, some groups argue that increased fossil fuel demand (for inputs) and impacts on soil, water, and wildlife resources will exceed these short-term benefits (Marshall, 2007; National Research Council, 2007). There is concern that prior gains from natural resource investments will be rapidly lost as lands under conservation programs, such as the Conservation Reserve Program, are pulled out of enrollment and converted back into crop production - either for biofuel crops or as a replacement for displaced food crop production. Higher nutrient loadings from expanded corn production will likely increase hypoxic conditions in our nation's coastal waters, such as in the Gulf of Mexico and Chesapeake Bay (Marshall, 2007; Simpson *et al.*, 2007).

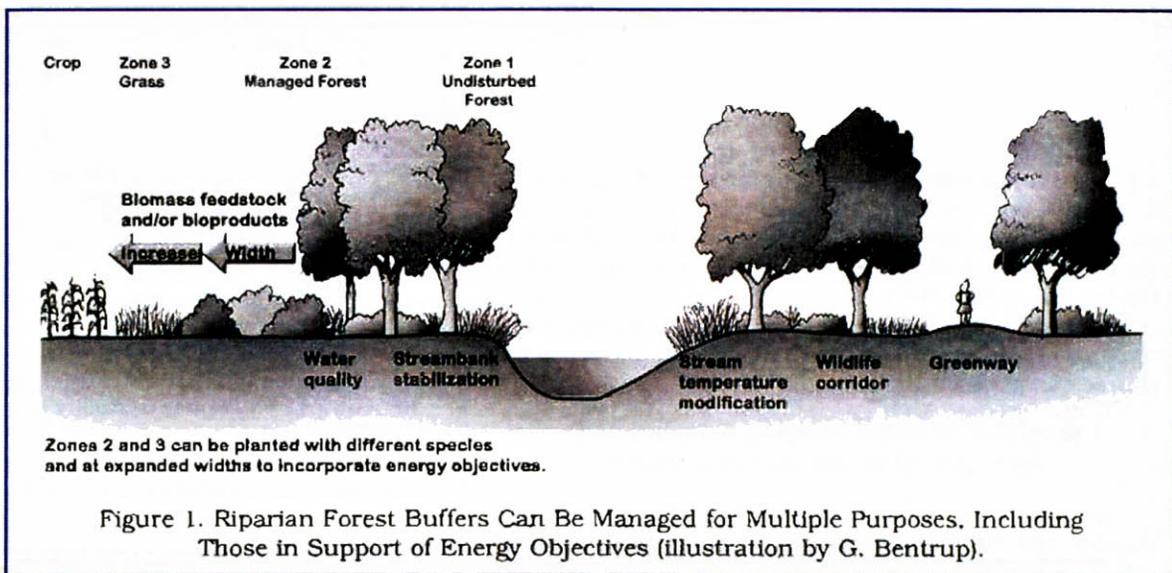
Economic fallout of biofuel production on food, feed, and fuel markets, as well as determining the real environmental footprint of its production cycle, are also areas of much concern and discussion. Doornbosch and Steenblik (2007) have concluded that the "potential of the current technology of choice - ethanol and biodiesel - to deliver a major contribution to the energy demands of the transport sector without compromising food prices and the environment is very limited." Even cellulosic-based bioenergy systems, while possibly more sustainable, have related concerns and are now being scrutinized in terms of environmental "greenness" and broader issues of sustainability.

Despite these potential problems, agriculture can be and will need to be a part of the energy solution. Since bioenergy production from agricultural lands cannot be implemented as a one-dimensional program without having serious repercussions on other resources, these programs must be formulated in a way that the other agricultural land services are not compromised. We need to go further and proactively create management practices and strategies that connect energy, food production, and natural resources objectives on agricultural lands. Riparian forest buffers (RFBs) by their very location, composition, and impacts on the landscape provide a beginning step in this direction - an opportunity to augment services on agricultural lands that will be required for sustainable bioenergy production.

Shifts in farm policy, programs, and markets will be necessary to make adoption of RFBs more attractive to landowners, especially as the value of bioenergy crops and land prices continue to escalate

RIPARIAN BUFFERS: LINKING ENERGY/FOOD PRODUCTION/NATURAL RESOURCE OBJECTIVES

RFBs already provide numerous services, including water quality protection, wildlife habitat, carbon sequestration and recreational, and income-generating opportunities (Figure 1). With proper design, placement, and management, they may provide many of these services while also contributing to energy objectives in a number of important ways (see Box 1). Just by supplying greater levels of water, soil and wildlife conservation on the landscape, RFBs can become an integral component of bioenergy crop production strategies, especially those involving monocultures and/or annual crops. In this direction, Marshall (2007) recommended increased Farm Bill fund-



ing for the Conservation Security Program and the Environmental Quality Incentives Program to provide support for RFB establishment, including a new U.S. Department of Agriculture program specifically encouraging riparian buffers to address water quality concerns related to corn-based ethanol systems.

BOX 1. Working Trees for Energy: The Many Roles Riparian Forest Buffers Can Play in Support of Energy Objectives.

- **CONSERVATION SERVICES:** RFBs may mitigate adverse ecological impacts created by bioenergy production, especially in regard to water quality.
- **FIRING/CO-FIRING TO REPLACE NATURAL GAS:** Plant materials in RFBs may be a source of feedstock used to replace the natural gas currently used in many corn-based ethanol plants.
- **BIOENERGY PRODUCTS:** Many plants suitable for use in RFBs, especially in Zone 2, produce fruits and nuts that have high yields and bio-oil properties (e.g., hazelnut, Osage orange, Chinese tallow, *Jatropha*).
- **BIOMASS FEEDSTOCK:** The biomass components of RFBs may serve as sources of feedstock to augment commercial ethanol production.
- **ON-SITE/LOCAL HEATING POWER PRODUCTION:** As the technology for small (5-50kW) generators (i.e., BioMax BioEnergy Platform) that can utilize a variety of forest and agricultural residues becomes more available and affordable, RFBs can serve as the source of residues for meeting on-site heating and power needs.

Advantages of RFBs in bioenergy production are listed in Box 2. By modifying RFB design these buffers can "assume additional duties" in support of energy objectives. These RFBs can be part of a "combined food and energy" (CFE) system on the farm (Kuemmel *et al.*, 1997). This more multi-purpose approach is gaining interest and support, especially in Europe. To this end, potential management options being examined include integrating annual crops with mixed perennial plantings, such as willow and *Miscanthus*, as a means to generate biofuel materials, environmental services, and a livable income for farmers. The riparian environment is actually ideal for realizing the good growth of short rotation woody crop species (SRWC). There are substantial environmentally sensitive land areas, such as the Upper Mississippi and Lower Mississippi Alluvial Valley (LMAV) that need to be taken out of agricultural production that would be highly suitable for incorporating feedstock production at commercial-production levels. Stanturf *et al.* (2003) reported on four management possibilities for biofuel production, along with other services, in the LMAV that include these massive riparian areas. By providing these multiple services, which include those that support energy - while leaving the bulk of the land open for agricultural production, RFBs could be both a viable and an appealing piece to connect the energy, food production, and natural resource concerns on these lands.

RIPARIAN BUFFER SPECIES: ATTRIBUTES AND NEW SPECIES COMBINATIONS

Including energy objectives within RFB designs will require new RFB guidelines and standards. Establish-

ment, management, and harvesting protocols for RFBs that include a bioenergy component will be very important so that production and harvest of materials do not compromise the RFB site and functions for other services. Further, RFB management will need to be a workable part within the whole-farm management plan.

Realizing the potential of riparian plantings to provide multiple benefits requires rethinking the species and combinations that might best provide a complementary mix of productive, income generating, and environmental benefits. Current species combinations/systems have been designed primarily for the purposes of improving water quality and enhancing wildlife values. New planting designs will need to take advantage of emerging carbon markets and other ecosystem service markets while providing a marketable biomass product. Other considerations include stress and pest resilience by the RFB plants themselves and species/combination selections that promote greater natural enemy populations for pests of adjacent crops.

While we have begun to get a handle on the bioenergy properties of many herbaceous species, more work needs to be conducted on the yield and sustainability of short rotation woody species production under different site conditions and management practices. Performance of SRWCs (e.g., poplar, willow, and black locust) need evaluation for growth on marginal lands and in creating positive interactions with nearby crops, and in terms of wood qualities for biofuel use. We already have a pretty solid foundation for using willows for applications ranging from bioenergy, living snow fences, phytoremediation, and riparian buffers, while others are adding to our understanding about the potential of poplars to "farm the runoff," providing both phytoremediation and biomass.

The potential for many of these woody species used in RFBs for producing high value bio-oil and other

BOX 2. Advantages of Using Riparian Forest Buffers in Support of Energy Objectives.

- RFBs are located on lands that are marginal/sensitive to most agricultural operations but which are suitable for many perennial herbaceous and woody crops.
- The use of perennial herbaceous and woody plants in multi-species RFBs do not require the high level of inputs of annual crops and can farm the excess nutrients from adjacent fields; resulting in both water protection and production of biomass.
- Reduction in annual soil disturbance, along with year-around plant cover provides greater soil and water quality protection and wildlife habitat.
- Herbaceous and woody species that can and have been utilized in Zones 2 and 3 have more favorable net energy conversion ratios than corn, with many of the woodies (e.g. willow, hybrid poplar and cottonwood) having ratios of ~1:11, co-firing with coal, and ~1:16 through gasification.
- The woody component in a bioenergy-modified RFB offers greater flexibility in harvest times, easier storage (e.g. 'on-the-stump') and greater flexibility in end-use, all which contribute to reducing farmer risk.
- The multipurpose, diversified nature of a bioenergy-RFB provides added resilience against climate change variability and extremes.

bioproducts needs more study. Hazelnut, a shrub-like tree already utilized in conservation practices, has been found to have higher yields of bio-oils and better thermal qualities than soybeans (Scott Josiah, personal communication, September 8, 2006, Nebraska State Forester, formerly University of Nebraska Extension Forester, Lincoln, Nebraska). Osage orange, a species once extensively planted in hedgerows, can yield significantly large amounts of latex and other potentially high value compounds important for energy, chemotherapy, insecticidal, and other uses (Alan Gravett, personal communication, 2007, Midwest Forestry and Biofuels, Bloomfield, Iowa). Other species, such as Chinese tallow and *Jatropha*, are being investigated for their production potential of bioenergy bioproducts.

Using new species and species combinations, however, releases another scourge from Pandora's box. A big consideration will be the potential for "weediness" or invasiveness. In RFB plantings, the emphasis has been to use native plant materials where possible, recognizing that ecosystems can generally keep native plants in check. Unfortunately, many of the high value bioenergy species have the potential to become invasive, especially some of the nonnative grasses (e.g., *Miscanthus*) and species being genetically bred for attributes such as greater water use efficiency (e.g., switchgrass). Similarly, these plantings could also then harbor and promote populations of pests. The better we can design for multiple purposes initially, the less investment we will need to make applying "bandaids" on the landscape as each problem crops up.

BIGGER, BETTER, AND BIOENERGY BUFFERS: GETTING THEM ON THE GROUND

We are rapidly building the technological basis for achieving bioenergy objectives within RFBs. However, without a similar investment to build our understanding of the socio-economic and political factors that will determine acceptance and adoption of the practice, we will be left with a technology with no place to go. Market uncertainty for cellulosic feedstocks is a big barrier right now. Investments for commercial production using cellulose are based on having a secured base of feedstock availability. With corn-based ethanol production, this was simply a matter of switching end-use of a crop already in place. With cellulosic feedstock crops, we are faced with the problem of getting the feedstock in the ground years before the market investment is there. Farmers are reluctant to lose control of their land by putting it under perennial operations, especially as it requires a longer-term investment before they would realize a return. We need to develop the infrastructure needed to transition to a cellulosic-based biofuel future. One possibility may be to develop ecosystem service markets which pay farmers for services provided from conservation practices. Unfortunately, ecological benefits of perennial crops, especially derived from diversified plantings, are hard to quantify, and even then, may be less real to the farmer than the price per bushel of biofuel crop.

Shifts in farm policy, programs and markets will be necessary to make adoption of RFBs more attractive to landowners, especially as the value of bioenergy crops and land prices continue to escalate. First, conservation programs in the Farm Bill need to have incentives and flexibility to promote CFE-like operations and not just piece-meal actions. Incentives should provide farmers with a reasonable level of support for offsetting upfront establishment costs and reducing their investment risks. Switching crop subsidies to conservation payments for more carbon-neutral biofuels may be one alternative, a situation that has already occurred in the EU. One proposed idea is called the *Biomass Reserve Program* akin to the Conservation Reserve Program, for meeting feedstock production needs. Additionally, a *Biomass Innovation Grant*, based on the Conservation Innovation Grants program has also been proposed (Simpson *et al.*, 2007). We could even be looking at a model similar to that in New Zealand where the dairy industry, in the interest of green certification on its milk products, worked in partnership with the many governing entities and landowners and enacted the Dairy Accord, which included the fencing off of all riparian areas.

Education will also be imperative, not only to landowners but also those people involved in policy and programs formulation and delivery. A survey of Tennessee farmers found that few were aware of the potential of growing switchgrass for bioenergy, and an even smaller proportion was willing to consider it (Jensen *et al.*, 2007). Growing biofuel crops, other than corn, will require a major paradigm shift for farmers. Developing and managing combined food and energy farms will be an even bigger step. Again, RFBs put out on the sensitive edges of the farm, may be a way to ease into this transition. Tools will be needed that facilitate the discussion and formulation of shared agendas among landowners, resource professionals, and the energy industry. Something as simple as visualization software, such as *CanVIs* developed by the National Agroforestry Center, that can help the landowners see these perennial systems as they would appear in different arrangements and over time on their lands, may be key to overcoming some of the barriers.

Those of us working in the riparian buffer arena need to be looking at and better connect with the many other issues surrounding our agricultural lands. The potential for designing "bigger, better, and bioenergy riparian buffers" is there. Yet, this potential will need to be better conceptualized and developed, better communicated to those responsible for developing program and policies; and better communicated to landowners and future landowners; and, most importantly, to the resource professionals that will be delivering a "brave, new" energy vision for our agricultural lands. Experience, going back to the Dust Bowl days, tells us that to develop more sustainable CFE systems, especially under the uncertain economic and climate world we live in, the interests of the farmer, the conservationists, and the energy industry will need to be brought together - sooner than later - so that community-readiness is in place when the cellulosic-bioenergy industry comes knocking on our doors.

Building Bigger Better Buffers for Bioenergy . . . cont'd.

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RIPARIAN ECOSYSTEMS AND BUFFERS

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Riparian ecosystems are complex, unique landscapes linked to the flow and quality of water through our streams and floodplains, and affecting their ability to sustain agriculture, industry, recreation, and the quality of our lives. Riparian areas are also being put to work as buffers, one of the most common best management practices being used today. Protection, restoration, and management of riparian areas remain some of the preeminent aspects of watershed science. In searching for solutions from streams and floodplains down to coastal shores.

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Describes the *active river area* as a dynamic and useful framework for managing critical river and riparian ecosystems

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