Summary of the June 2009 Forum
of the Center for BioEnergy Sustainability (CEBS)
"Landscape Design for Bioenergy Sustainability"

The June 2009 CBES Forum featured four speakers: Mark Downing of Oak Ridge National Laboratory (ORNL)'s Environmental Sciences Division, Tim Rials of the University of Tennessee at Knoxville (UTK), Pat Mulholland of ORNL's Environmental Sciences Division, and Esther Parish of ORNL's Computational Sciences and Engineering Division.

Mark Downing had to attend a funeral and was unable to give his keynote presentation on landscape design for bioenergy. Virginia Dale gave a précis of it in his absence.

Landscape design for bioenergy has to deal with

- Social choices
- Farm choices leading to products and co-benefits
- Landscape design
- Hydrology and water quality
- Environmental conditions

To address these issues, the land manager must ask: What is to be maximized? For what purpose is the land to be used? Are there multiple benefits? What are the baseline measures? Are the amenities positive or negative, and of what magnitude are they? Quantification may assist us in valuation from a monetary sense, although this action is controversial.

Environmental amenities (e.g., rainfall) change over time, as do the benefits. The question must be asked whether one amenity is being sacrificed for another at a given time of year.

- Is this really a system of dynamic tradeoffs?
- Should we be disturbed about low production numbers in January and December?
- Which amenity interacts and contributes to the increase in another amenity?
- Do the monetary values matter, or is it the sum of environmental amenities that really matters?
- Are there any real indicators, or are what we assume to be indicators just the ***result*** of some action that should or should not have been taken?

These are the types of things that one needs to think about in developing a landscape design.

Tim Rials said that at UTK, they have adopted the philosophy that biofuels are all about the feedstock and success hinges on that feedstock's sustainability. In partnership with Genera Energy and Dupont Danisco Cellulosic Ethanol, the University is developing a demonstration biorefinery and establishing a dedicated feedstock of choice. The pilot plant is located in the Niles Ferry Industrial Park in Vonore, Tenn., and is almost complete.

The University is contracting with farmers to plant 6000 acres of switchgrass to feed the refinery. The 6000 acres would produce 5,000,000 gallons of ethanol. Switchgrass is well-suited to the southeast and is native to the region. It is drought tolerant. It requires only common farm equipment to cultivate it.

A major hurdle for the bioenergy industry is sustainable feed stock supply. In addition, the production system has R&D needs.

The project has established a farmer incentive program. A total of 723 acres were planted in 2008, which produced from 0.5 to 5.0 tons per acre of switchgrass. This project ***is*** the market for switchgrass now. There is a lot of interest in growing switchgrass shown by the farming community. The project is paying $450 per acre per year plus providing the seed.

There were lots of landscape-design factors that had to be considered during the first year of the project: farmer experience, location, soils, and previous field condition (particularly the degree of weed control). The land-use changes induced by the program were

- Hay/pasture: 73 acres
- Native grasses: 52 acres
- Roundup-ready crops: 522 acres
- Wheat: 74 acres

The ecological impacts under study include water quality, soil stabilization, nutrient cycling, carbon cycling, and wildlife habitat. The project is investigating all of these issues. Switchgrass has a good reputation (in comparison to corn) on most of these issues. This year, 2000 acres were added, and more landscape-design research questions are being factored in. Next year, the project will approach a commercial mode.

Pat Mulholland pointed out that water quality is a landscape-design issue because of eutrophication from the runoff of fertilizes. Nitrogen export will likely be increased by increases in corn ethanol production. Feedstocks such as switchgrass and woody vegetation may lead to fewer hydrology and water quality concerns; however, there are few available field data, although nitrogen and phosphorus export may still be a concern if fertilizers are used. Herbicide export is also a concern. Switchgrass, in particular, may reduce problems relating to flashy stream hydrology and high rates of erosion often found with row crop agriculture. However, there are no data on switchgrass, just model results that show that surface runoff is 55% less than with corn, sediment yield is 99% less, edge-of-field erosion is 99% less, and nitrogen export is 16 to 65% less. These data indicate a substantial improvement over corn and soybean production.

At an experimental station in Milan, Tenn., The University of Tennessee is collecting information on soil nitrate leaching; leaching is apparently higher and more variable with switchgrass. But these data come from small-plot studies. We would want to study 10- to 50-ha catchments with at least 25% of the area in switchgrass.

Effects of biofuels crops can be studied empirically with (1) a BACI (before-after-control-intervention) design and treatment catchments (which would require multi-year pre-treatment data) or (2) multiple control and treatment catchments (five or six of them) with no pre-measurements needed.

Plot-scale measurements that should be taken include: soil moisture; soil carbon, nitrogen, and phosphorus content; and soil solution chemistry. At the watershed scale, needed measurements include: water balance (precipitation and discharge) and sediment and nutrient export (stream profile concentrations of suspended sediment, inorganic and organic forms of nitrogen and phosphorus, and pesticides). Ideally, the precipitation data would be hourly and the sediment and nutrient export measurements would be available

both seasonally and during storm events. These are the data that are needed to best understand the landscape effects of switchgrass planting.

Richard Middleton and other colleagues at ORNL are integrating a hydrologic model of Vonore landscape based on the Soil and Water Assessment Tool (SWAT) with an optimization framework so that they can consider the costs and benefits of having economic and environmental impacts (i.e., water quality) of planting switchgrass in different locations within watersheds at various scales.

Esther Parish said that ORNL has developed a geographic information system (GIS) tool in collaboration with UTK to incorporate environmental considerations into the current switchgrass siting decisions at Vonore. The GIS tool incorporates slope (since flat land and steep land should both be excluded from consideration), current land cover, the percentage of impervious cover within the watershed (with areas above 20% impervious cover being considered poor candidates for measuring changes to water quality), proximity to waterways (including impaired streams), proximity to existing switchgrass fields, and proximity to existing USGS and TDEC stream gauges. The GIS covers a 50-mile radius around the biorefinery in Vonore. With this tool, one can select land with the best potential for acquiring water quality data. Thus far, the ability to quantify the effects of planting switchgrass on watershed health has been hampered by the lack of before and after chemical stream gage data in the immediate vicinity of the switchgrass plots

During the **discussion period**, it was pointed out that

- A great majority of switchgrass plots will be over dolomite and will not have drainage systems that can be sampled. However, the water will eventually come out of the karst system, and a water-quality study could be planned on such a catchment with a little more difficulty.
- The U.S. Geological Survey has benchmark sites, but they are not numerous in agricultural regions.
- The crop models are generally not designed for perennial crops.
- Other studies that have been carried out include one on water quality with switchgrass in South Carolina and crop-selection studies in China.
- Switchgrass has a high evapotranspiration rate and decreases runoff, which could affect the potable water supply. But these are not single-issue (i.e., water quality or profit) decisions but are affected by all the issues highlighted by Mark Downing.
- An analysis of the need for irrigation may need to be considered when this approach is applied to other regions.
- The question arises of the relative profits associated with the different uses of the land, and that issue can be seriously affected by the price of energy.

There are a lot of alternative management strategies to be considered, such as multiple cropping of switchgrass fields for forage and then for ethanol, switchgrass mixed in with pine, and other crops being mixed in (especially grasses).

Presentation Slides