Indicators to support assessment of sustainability of bioenergy systems

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Indicators are needed to assess both socioeconomic and environmental sustainability of bioenergy systems. Effective indicators can help to identify and quantify the sustainability attributes of bioenergy options. We identify 19 measurable indicators for soil quality, water quality and quantity, greenhouse gases, biodiversity, air quality, and productivity, building on existing knowledge and on national and international programs that are seeking ways to assess sustainable bioenergy. We also identify 16 socioeconomic indicators that fall into the categories of social well-being, energy security, trade, profitability, resource conservation, and social acceptability. Indicators were selected to be practical, sensitive to stresses, unambiguous, anticipatory, predictive, calibrated with known variability, and sufficient when considered collectively.

The utility of each indicator, methods for its measurement, and applications appropriate for the context of particular bioenergy systems are described along with future research needs. Together, this suite of indicators is hypothesized to reflect major socioeconomic effects of the full supply chain for bioenergy, including feedstock production and logistics, conversion to biofuels, biofuel logistics and biofuel end uses. We envision that this indicator suite can serve as a basis for the practical evaluation of sustainability in a variety of bioenergy systems. In addition, we created a Biomass Location for Optimal Sustainability Model (BLOSM) to test the hypothesis that landscape design of cellulosic bioenergy crop plantings may simultaneously improve water quality (i.e., decrease concentrations of sediment, total phosphorus, and total nitrogen) and increase profits for farmer-producers while achieving a feedstock-production goal. BLOSM was run using six scenarios to identify potential switchgrass (Panicum virgatum) planting locations in the Lower Little Tennessee watershed to supply a planned, nearby commercial-scale biorefinery. BLOSM results indicate that a combined economic and environmental optimization approach can achieve multiple objectives simultaneously when a small proportion (1.3%) of the Lower Little Tennessee watershed is planted with perennial switchgrass.