Sustainable Harvest for Food and Fuel

Raymond R. Grosshans, Kevin M. Kostelnik, Jacob J. Jacobson

Idaho National Laboratory, Center for Advanced Energy Studies, PO Box 1625,

Idaho Falls, Idaho

Abstract

The DOE Biomass Program recently implemented the Biofuels Initiative, or 30x30 program, with the dual goal of reducing U.S. dependence on foreign oil by making cellulosic ethanol cost competitive with gasoline by 2012 and by replacing 30 percent of gasoline consumption with biofuels by 2030.

Experience to date with increasing ethanol production suggests that it distorts agricultural markets and therefore raises concerns about the sustainability of the DOE 30x30 effort: Can the U.S. agricultural system produce sufficient feedstocks for biofuel production and meet the food price and availability expectations of American consumers without causing environmental degradation that would curtail the production of both food and fuel?

Efforts are underway to develop computer-based modeling tools that address this concern and support the DOE 30x30 goals. Beyond technical agronomic and economic concerns, however, such models must account for the publics' growing interest in the reduction of greenhouse gas emissions and sustainable agriculture, the ability to meet present needs without compromising the ability to meet future needs. . This paper discusses ongoing work at the Center for Advanced Energy Studies that investigates the potential consequences and long-term sustainability of projected biomass harvests by identifying and incorporating "sustainable harvest indicators" in a computer modeling strategy.

Introduction

The Center for Advanced Energy Studies (CAES) Sustainable Harvest for Food and Fuel Project supports the Idaho National Laboratory (INL) Biomass Program. For this project, the INL Biomass program leverages key multidisciplinary INL capabilities, including CAES, to enable the cost-effective utilization of biomass. The INL *whole crop utilization* vision focuses on the use of the entire crop, including both the grain and plant biomass to produce food, feed, fiber, energy, and value-added products while maintaining soil health and productivity.

Food vs. Fuel

To promote economic growth, energy security, and to protect the environment, the U.S. is pursuing a national strategy of energy independence and climatic protection in which domestic renewable carbon-neutral biofuels displace 30 percent of U.S. oil consumption by 2030[1]. Such fuels, including ethanol and biodiesel, will be produced from biological feed stocks (biomass).

The availability of this biomass – projected at the billion-ton-per-year mark – will hinge on the application of modern scientific and engineering tools to create a highly-integrated biofuel production system. Efforts are underway to identify and develop energy crops, ranging from agricultural residues to genetically engineered perennials [2, 3, 4]; to develop biology-based processing methods [5]; and, to develop large-scale biorefineries to economically convert biomass into fuels [6].

In addition to advancing the biomass-to-biofuel research and development agenda, policy makers are concurrently defining the correct mix of governmental supports and regulations. Given the volumes of biomass and fuels required to successfully enact a national biomass strategy, policies must encourage large-scale markets to form and expand around a tightly integrated system of farmers, fuel producers and transporters, and markets over the course of decades.

DOE PROGRAM GOALS

The Energy Policy Act of 2005[7] revised U.S. energy objectives and goals. This legislation also reauthorized the Agricultural Biomass Research and Development Program and amendments to the Biomass Research and Development Act of 2000.[8] Specific goals of this legislation include:

- Increase the energy security of the United States,
- Create jobs and promote rural economic development,
- Enhance the environment and public health, and
- Diversify markets for raw agricultural and forestry products.

Consequently, the DOE Office of Energy Efficiency and Renewable Energy's Office of the Biomass Program has implemented the Biofuels Initiative which includes these policy goals:

1. Make cellulosic ethanol (or ethanol from non-grain biomass resources) cost competitive with gasoline by 2012.[9]
2. Replace 30 percent of current levels of gasoline consumption with biofuels by 2030 (30x30), which equals 60 billion gallons of ethanol annually.[2, 10]

The resource pyramid shown in Figure 1 illustrates that of the 1.3 billion tons identified only 190 million (M) tons of biomass are recovered. Of this total, as shown in the pyramid, the “estimated recoverable reserve” (340 M tons) may be harvested under current economic conditions. However, as the harvested amount of biomass increases (i.e., moving down the pyramid), sustainability questions will emerge.

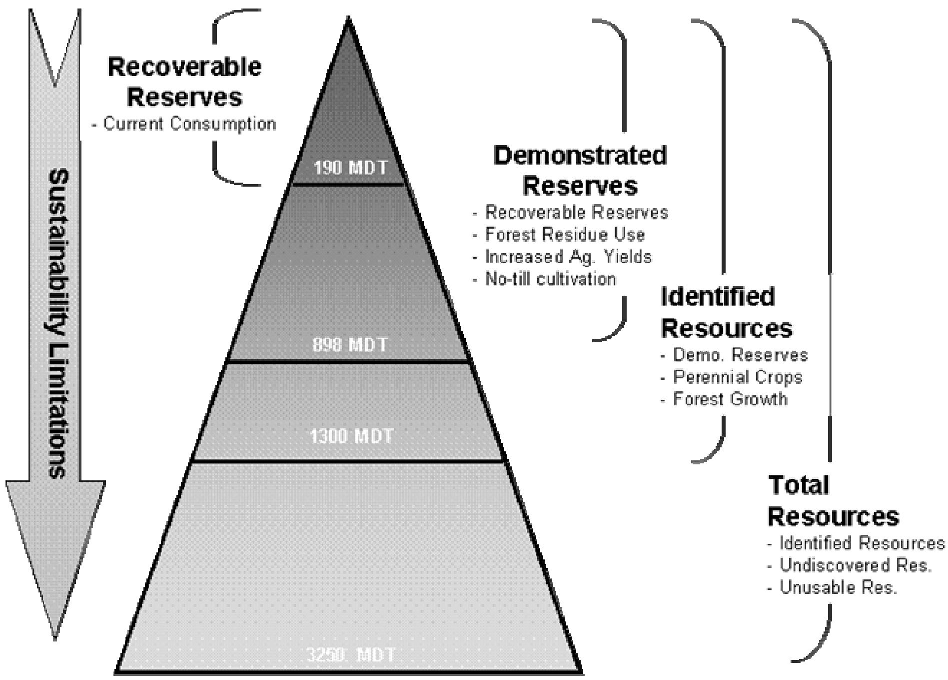

Figure 1: 2005 total U.S. biomass resource summary. This pyramid portrays the resources necessary to reach the 30x30 goals. [2]

The concern, of course, is to rapidly expand biomass production and conversion without negatively impacting the economy or the environment. Policy makers will tangle with the complex interactions of social, technical, economic, and environmental factors that bound energy production and use.

Food supply concerns, part of the social and economic issue, are a particularly contentious issue. Due to its scale and complexity, the biomass strategy will trigger such hot-button political issues as farm-price supports, petroleum industry tax credits, and the role of food in export markets and as an instrument of financial aid to developing nations, to name a few. Moreover, Americans are accustomed to plentiful and affordable supplies of both food and fuel. From a policy perspective, without a reliable means of assessing, communicating, and mitigating food supply issues, the billion-ton biomass strategy could be unattainable.

Providing the estimated billion dry tons of biomass per year will force structural shifts in forestry and agriculture production and markets ─ no matter how careful the planning. For example, some farmers will race to adopt energy crops and adapt to new farm methods while others resist; transport accessibility and price differentials will constrict biomass flows; and, new mixes of crop rotation, chemical application and land-use patterns will produce unforeseen environmental effects. In each case, potential food supply consequences abound.

A recent Wall Street Journal headline tells the tale: “Crop Prices Soar, Pushing up Cost of Food Globally: New Demand for Biofuels Feeds Inflation Pressure; China, India Feel Pinch.” Likewise, according to the International Margarine Association, “Food Needs, EU Biofuels Goal Can't Both Be Met;” the European Environment Agency reports “Once a Dream Fuel, Palm Oil May Be an Eco-Nightmare” as Indonesia quickly becomes the world’s third-leading producer of carbon; and, in some parts of Mexico, tortilla prices have tripled or quadrupled in response to international commodity markets where corn prices are reaching historical highs.[11]

The Sustainable Harvest Approach

The CAES Sustainable Harvest project is investigating the potential impacts and the long-term sustainability of projected biomass harvests as they relate to both food and fuel applications. “Sustainability” refers to an interdisciplinary process that integrates economic development, social values, and environmental health considerations. Sustainability strives to meet the needs of the present without compromising the ability of future generations to meet their own needs.[12] Key to the sustainability concept is acknowledging that human beings, and their associated influences, are inextricably linked to the natural environment. The Sustainable Harvest Approach tries to maximize the resource use without impacting long-term soil health. This is reflected in a optimal combination of percent stover removal, fertilizer use, tilling practice, crop rotation and other farming practices.

The prudent use of valuable natural resources is required to achieve a sustainable biomass harvest that supports both food and fuel goals. Balancing these future demands requires a data-driven approach to the integration of agricultural and forestry systems with both food and fuel production processes and consumer markets. Step one in the Sustainable Harvest Approach is to apply the “principles of sustainability”[13] to understand the projected harvests of biomass for food and fuel and to develop a set of “sustainable harvest indicators”. These sustainable harvest indicators will delineate potential consequences as the biomass strategy unfolds in terms of agricultural/forestry profitability, environmental quality, food and fuel sufficiency, and community viability, see Table 1.

Table 1. List of Preliminary Sustainable Harvest Indicators

Sustainability Issues & Externalities	Major Considerations & Influences	Potential Indicators
Market Size	Population Growth	Census data

	Fuel Demand ETOH % Consumption Export/Imports FFV availability Substitutions for other petrochemicals	Consumption rates Rate of fuel switching
	Energy Demand Growth	Consumption projections
Conversion Technology	Technological Advancements	Conversion Efficiency Rate of energy crop utilization
	Energy Potential	BTUs biofuel vs. oil # of integrated refineries
Natural Resources	Water Demands Water for food demand	Water use/ BTU produced
	Land Resources	Land-use rates Rate of agricultural land conversion Quality of land used
	Nutrients, Soil Health	Soil Balance (generation vs. depletion) Nutrient loading (external fertilizer)
Socio-political concerns	Rural economic development	Return on Investment Employment growth (jobs in energy sector) Farm wage vs. other CRP vs. bio-cropping
	Stakeholder concerns: -Economic security -Incentives equity -Energy security -Conservation -Climate change	Market penetration (Biofuel, FFV) Degree of industrial consolidation Other bio-product acceptance vs. cost Conservation rates NIMBY/downwinder pushback
	Taxes/Tax Credits	Production Tax credit permanence Investment Tax Credit permanence Carbon Tax, when and how much Bio-incentives
	National Security	Imports/Exports Negative consequences of US market on developing countries
Financial Investment	Rate of biofuel R&D	Investor responsiveness Oil prices
	Capital Investment	Investor response
Feedstock production Food commodity production	Market demand Policy incentives Return on Investment (ROI)	ROI/acre Agricultural input cost: -Land, Chemicals, Energy, Equipment Commodity prices and market volatility
Biomass supply logistics	Feedstock assembly Field to bio-refinery Field to vehicle	Transportation distance

Environmental Impacts	Waste Management	Waste/by-products per unit of production Off-site pollutants released
Climate Change	CO2 Emissions	Emission rates Atmospheric CO2 levels
	Ecological Impacts	Wildlife impacts Invasive Plants

Step two is to develop a series of causal loop diagrams (CLD) that portray important and the complex interactions of producers and consumers in U.S. biofuel markets. Data sources include the INL Feedstock Assembly model, the National Renewable Energy Laboratory Biomass Scenario Model, and emergent data from the biomass industry. The CLD shown in Figure 2 shows the master Sustainable Harvest CLD which includes a biofuels loop along with resource loops, a feedstock loop, a food product loop, a petroleum loop, and a byproduct loop.

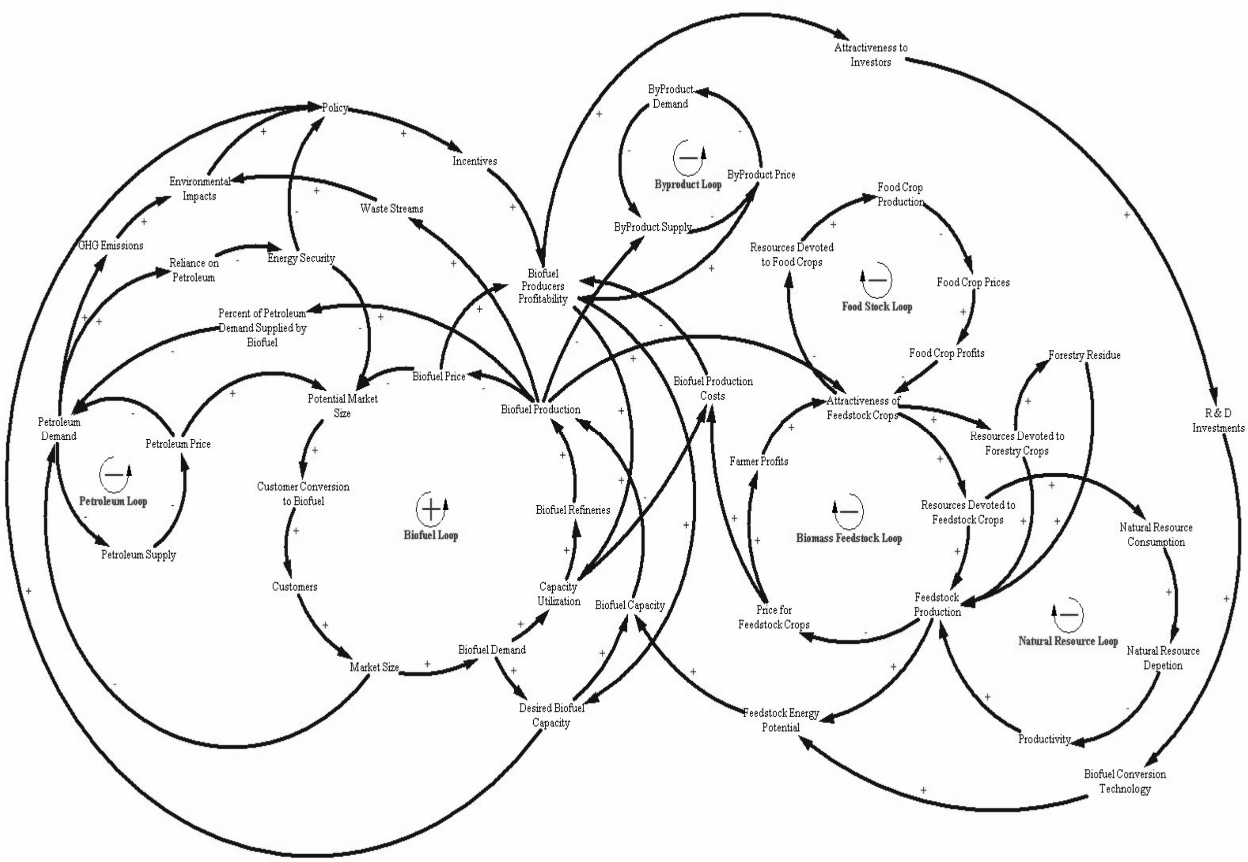

Figure 2: Sustainable Harvest Causal Loop Diagram. This diagram illustrates many of the high level relationships in the biofuel system.

Conclusion

The CAES "Sustainable Harvest for Food and Fuel Project" supports the DOE Office of the Biomass Program goals by investigating the potential impacts and the long-term sustainability of projected biomass harvests as they relate to both food and fuel applications.

This project will identify the potential consequences associated with the national biomass strategy in terms of agricultural/forestry economics, environmental quality, food and fuel sufficiency, and community viability. The principles of sustainability will be applied to provide a validated sustainable harvest indicators model that informs policy in support of the U.S. biomass strategy. At the national level, sustainability indicators will delineate potential consequences as the biomass strategy unfolds in terms of agricultural/forestry profitability, environmental quality, food and fuel sufficiency, and community viability. In turn, these sustainability indicators will guide best management practices at the regional and local levels.

To date, this project has developed a preliminary CLD that maps out the influences of the various components in the biomass system and how they interact. In addition, the project has identified a set of sustainable harvest indicators, along with potential impacts and influences. Future work will further advance these features and will incorporate these concepts into a dynamic model that could be used to develop strategies for developing a sustainable biomass production in support of the 30x30 program.

By helping to ensure that the biomass harvest remains sustainable both in terms of food and fuel, the proposed sustainable harvest indicators model helps sustain regional economic growth, the long-term protection of our environmental and natural resources, and also safeguards the safety, health, and the quality of life for current and future generations.

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