

# ORNL-Industry Partnerships Shape Sustainable Bioeconomy

## Sustainable Bioenergy Production Can be Defined and Measured

ORNL's Center for Bioenergy Sustainability ([web.ornl.gov/sci/ees/cbes/](http://web.ornl.gov/sci/ees/cbes/)) identified 35 indicators to measure environmental, social, and economic dimensions of sustainability. These indicators meet the criteria of being easy to measure, useful to decision makers, and science based. Collecting information on these context-specific indicators helps industry partners to assess progress toward sustainability over time for alternative biofuel production pathways.

ORNL has worked with industry to apply and deploy the science of sustainability at a demonstration-scale switchgrass-to-ethanol production system in East Tennessee. Sustainability indicators were measured for feedstock production and logistic portions of the supply chain. Trajectories of social, economic and environmental indicators were quantified under three future scenarios.

In addition, ORNL is partnering with industry to evaluate sustainability indicators for algal production and develop ecology-based strategies to grow stable, productive algal crops.

## Bioenergy Crops and Sustainable Practices Can Enhance Water Quality, Benefit Fish and Wildlife

ORNL research seeks to understand conditions under which bioenergy production can provide environmental benefits, including improved water quality and biodiversity. Using sustainability indicators developed at ORNL, changes in water quality and biodiversity associated with growing energy feedstocks and harvesting forest and agricultural residues have been measured at the field scale and projected at the regional scale.

- ORNL is leading an effort to assess changes in biodiversity and water quality/quantity for future economic projections as part of the "Billion Ton 2016 Report, Sustainability Volume." ORNL research compares sustainability indicators (nutrient and sediment loadings, water yield) and feedstock production under different conservation management practices and future projections with different price



*Two-year-old loblolly pine managed for bioenergy as part of the watershed-scale experiment at the Savannah River Site. Photo credit: Kevin Fouts, U. Georgia, Aug 2015.*

assumptions. Resource projections will be provided through ORNL's Knowledge Discovery Framework <https://bioenergykdf.net/>.

- ORNL is leading a team of scientists from the USDA-Forest Service and four Universities in a long-term watershed study. The study compares one reference and two treatment watersheds growing intensive short-rotation loblolly pine for bioenergy at the DOE's Savannah River Site. Monitoring data for several indicators of environmental sustainability (water quality, water quantity, soil quality, and productivity) are being used to calibrate a distributed watershed model. This study will also determine whether current forestry best management practices are adequate to protect water and soil resources in the Southeastern US.
- ORNL helped the US Environmental Protection Agency Science Advisory Board (SAB) convene an independent panel to evaluate the state of the science regarding nutrient mitigation and control options in the Mississippi-Atchafalaya River basins (MARB) needed to reduce hypoxia in the Northern Gulf of Mexico. The SAB called for research and technologies to increase cellulosic-based bioenergy yields and protect downstream water quality.
- ORNL is partnering with other national labs to project changes in the hypoxic 'Dead Zone' associated with economically plausible future bioenergy scenarios developed by ORNL's Resource Assessment team. ORNL modeling found reduced median sediment and nutrient loadings for two large river basins in the MARB.

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## Participatory Design of Bioenergy Landscapes Ensures Public Acceptance

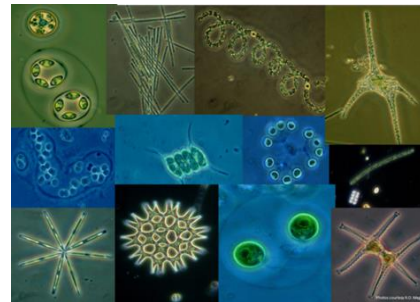
ORNL is working with industry to develop sustainable management practices for lands used to produce feedstocks. ORNL's vision for the design process combines advanced logistic optimization that integrates ecological knowledge with an adaptive, stakeholder-driven process that engages producers. This will ensure that designs are logistically and economically feasible. Hence, it requires clear communication of environmental and socioeconomic opportunities and concerns.

- ORNL convened a workshop in North Carolina that engaged industry, universities, agencies and other national labs in determining how landscape design might integrate bioenergy production systems into the environmental and socioeconomic system. Landscape design can guide decisions toward sustainable provision of bioenergy by monitoring and reporting measures of sustainability along the bioenergy supply chain.
- The landscape design approach is being tested by a project led by Antares Group and the Department of Energy that involves DuPont Industries, Iowa Ag Biofibers, national laboratories, universities, the Iowa Dept. of Agriculture, US Geological Survey, and Monsanto. The goal is to assess and optimize land use for biocrops. Farmers, refineries and consumers will benefit from improved farm-to-gas-tank processes that incorporate principles of sustainable land management.
- ORNL created spatial optimization tools to design landscapes including cellulosic crops that simultaneously improve water quality and increase profits for farmer-producers. One such tool is the Biomass Location for Optimal Sustainability Model, which is being extended to include multiple objectives and to allow stakeholders to decide what combinations of sustainability thresholds are meaningful in a particular context.

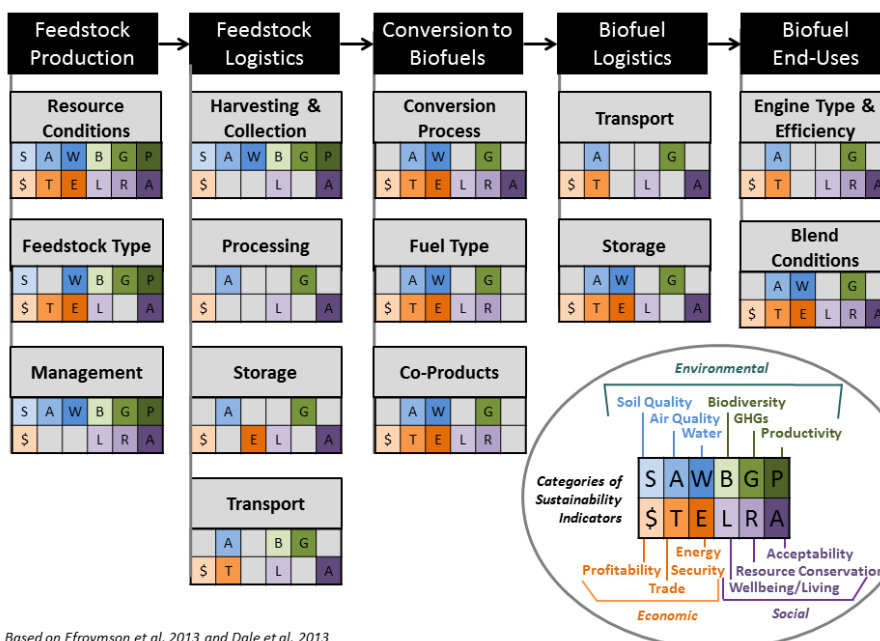
## Sustainability Standards Facilitate International Trade

ORNL is working with industry partners to develop consistent guidance that will enable bio-based industries to access international markets. International standards facilitate trade by providing consensus-based ways to address sustainability concerns.

- ORNL contributed to the development of International Organization for Standardization (ISO) "Sustainability Criteria for Bioenergy" by providing expertise related to greenhouse gas emissions, energy efficiency, and bioenergy production.
- ORNL was a leading contributor to Standard Practice Guide for sustainability assessment by the American Society for Testing and Materials International Technical Committee on "Bioenergy and Industrial Chemicals from Biomass," which will facilitate trade in clean, biomass-based products and provide clear incentives for improved practices.
- ORNL contributed to an International workshop on Biofuels and Food Security to address concerns by agencies about food versus fuel and to demonstrate how biofuels can help avoid or mitigate food crises.



Tapestry of algae.  
Photo credit:  
Val Smith



Context-specific indicators reflect major environmental and socioeconomic effects across the full supply chain for regions and systems. Based on Dale et al. 2013. Ecological Indicators 26: 87.

Based on Efromyson et al. 2013 and Dale et al. 2013

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