

2013 DOE Bioenergy Technologies Office (BETO) Project Peer Review

Defining Sustainability

Date: May 22, 2013

Technology Area Review: Analysis
and Sustainability

Principal Investigator: Virginia Dale

Organization: Oak Ridge National
Laboratory



Goal Statement

- Goal: To ensure long term supply of sustainable feedstock and bioenergy by determining
 - How bioenergy production can affect sustainability
 - How those effects can be measured.
- Relates to these BETO objectives
 - Establish performance metrics for bioenergy sustainability
 - Build consensus on specific definitions and ways to quantitatively measure bioenergy sustainability
 - Provide a consistent and evidence based message on meaning of bioenergy sustainability
 - Build methodology to measure and assess sustainability



Quad Chart Overview

Timeline

- Project start date: FY09
- Project end date: FY17
- Percent complete: 55%

Barriers

- St-A. Scientific Consensus on Bioenergy Sustainability
- St-B. Consistent and Evidenced-Based Message on Bioenergy Sustainability
- St-D. Implementing indicators and Methodology for Evaluating and Improving Sustainability

Budget

- Funding for FY11:\$1000k (DOE)
- Funding for FY12: \$684k (DOE)
- Funding for FY13: \$700k (DOE)
- Years the project has been funded: 5
- Average annual funding: \$637k

Partners

- Stakeholder groups: Council on Sustainable Biomass Production (CSBP), Global BioEnergy Partnership (GBEP), Roundtable for Sustainable Bioenergy (RSB), National Council on Air and Stream Improvement (NCASI)
- Other DOE Labs : NREL, Argonne, INL, PNNL, Savannah River
- Other agencies: USDA, EPA, FAO (Food and Agriculture Organization)
- Universities: Univ. Tennessee, NC State, Texas A&M, Great Lakes Bioenergy Research Center (GLBRC)
- Industry: Arborgen, Ceres, Dupont, Genera, Institute for Forest Biotechnology, Weyerhaeuser, Noble Foundation

Project Overview (1)

- History of project 11.1.1.5
 - FY09: Initiated as Office of the Biomass Program (OBP) project 1.7.1.2 with three parts:
 - **Sustainability = Task A of 11.1.1.5**
 - 11.2.3.1 Global feedstock supply, modeling and land use – Reported by Debo Oladosu
 - Quantifying watershed sustainability indicators – subsequently split into
 - 11.1.1.8: Short-rotation woody biomass sustainability (reported by Natalie Griffiths)
 - **Test of indicators in east Tennessee = Task B of 11.1.1.5**
 - FY12: Sustainability Tasks A and B (above) became OBP Sustainability Project 11.1.1.5

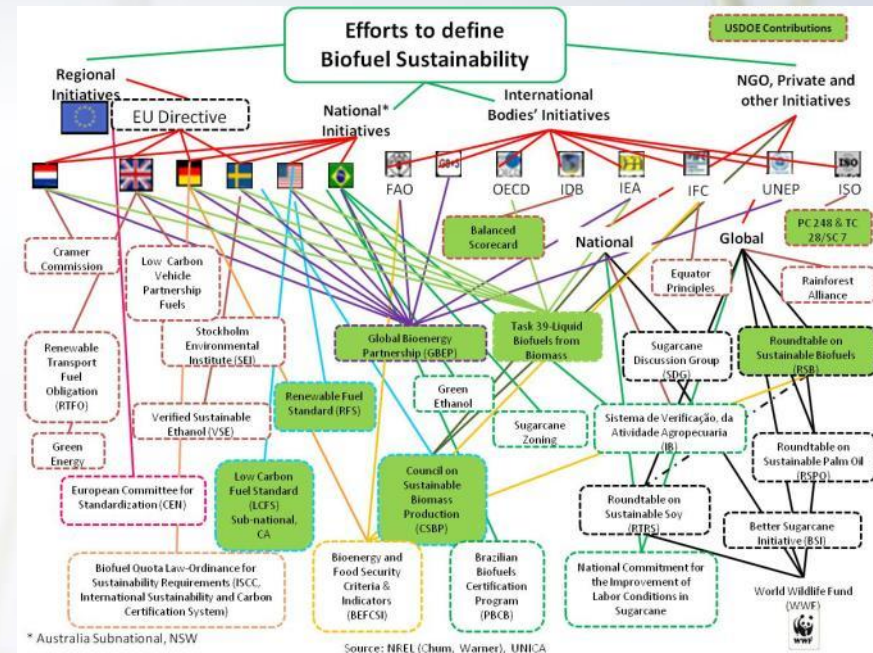


- Objectives
 - Review and define sustainability indicators
 - Assist BETO in its role of defining sustainability for bioenergy and determining indicators for use at the national scale
 - Implement and evaluate sustainability indicators for bioenergy decisions

Project Overview (2)

Context: Many initiatives are exploring indicators for sustainability – e.g. for bioenergy...

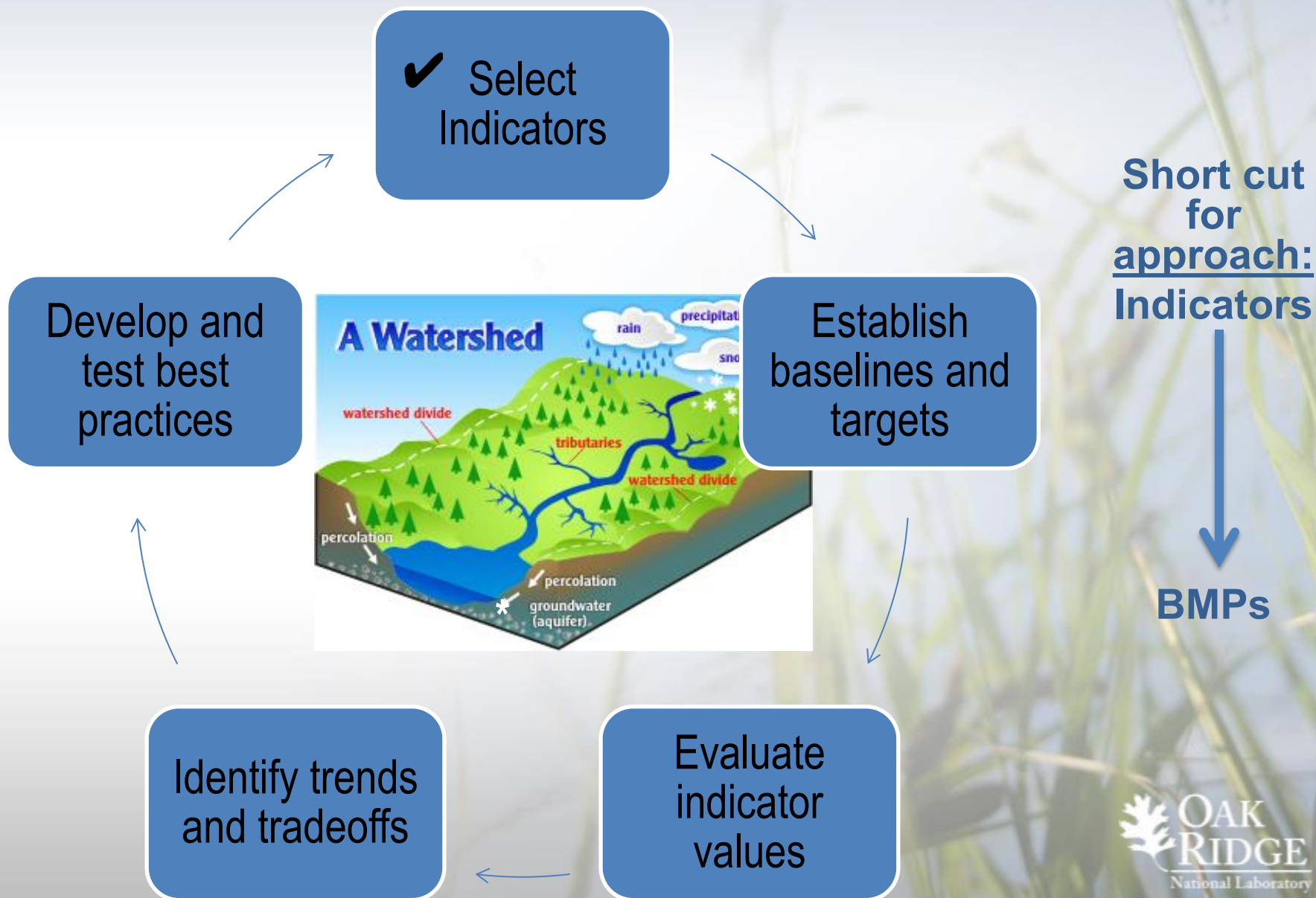
- ISO (International Organization for Standardization)
- GBEP (Global Bioenergy Partnership)
- RSB (Roundtable on Sustainable Biofuels)
- Many more



BUT

- Some indicators focus on management practices although knowledge is limited about which practices are “sustainable”
- Implementation is limited by indicators being too
 - ✓ Numerous
 - ✓ Broad
 - ✓ Costly
 - ✓ Difficult to measure

Approach (1) Defining and Quantifying Bioenergy Sustainability (11.1.1.5)



Approach (2)

A. *Advance common definitions of environmental and socioeconomic costs and benefits of bioenergy systems*

- Assist BETO in its role of defining sustainability for bioenergy and determining indicators for use at the national scale
- Work with other groups who are defining and establishing concepts of bioenergy sustainability

B. *Quantify opportunities, risks and tradeoffs associated with sustainable bioenergy production in specific contexts*

- Implement and evaluate sustainability indicators considering
 - Switchgrass in east Tennessee
 - Other feedstocks in other regions
- Explore analyses tools to assess several indicators of bioenergy sustainability



Approach (3) – Consider indicators within entire system as an opportunity to design landscapes for sustainability bioenergy production



Approach:
Indicators



BMPs

Project Management Approach (1)

– *Team:*

- Virginia Dale, landscape ecologist (principal investigator)
- Latha Baskaran, watershed modeling
- Rebecca Efroymsen, risk assessment
- Keith Kline, energy specialist and international issues
- Esther Parish, geographer

– *Supplemental team*

- Other ORNL staff
- Other DOE Labs
- University partners
- Other agencies: USDA, EPA, FAO
- Private partners: industry and NGOs

– *Review of progress*

- Workshops that foster discussion
- Peer review process
- Presentation of rough ideas at conferences



Project Management Approach (2)

Key milestones for monitoring progress

- 2011 (3rd and 4th quarter)
 - Proposed environmental indicators for sustainable bioenergy
 - Analyzed key concerns about bioenergy sustainability systems
 - Spatial optimization of bioenergy system developed and deployed
- 2012
 - Developed approach for validating projected watershed sustainability for bioenergy system in Vonore, TN
 - Proposed set of socioeconomic indicators for sustainable bioenergy
- 2013
 - Assessment of spatially explicit multivariate tools to evaluate indicators of bioenergy sustainability that are part of BMPs
 - Identification of potential collaborators to help characterize the robustness and variability of proposed indicators of bioenergy sustainability
 - Description of aquatic macroinvertebrate habitat model as linked to the Soil Water Assessment Tool (SWAT) used to assess bioenergy choices on both water and biodiversity
 - Evaluation of targets and baseline conditions as part of establishing Best Management Practices(BMPs) for specific bioenergy pathways

Approach:
Indicators



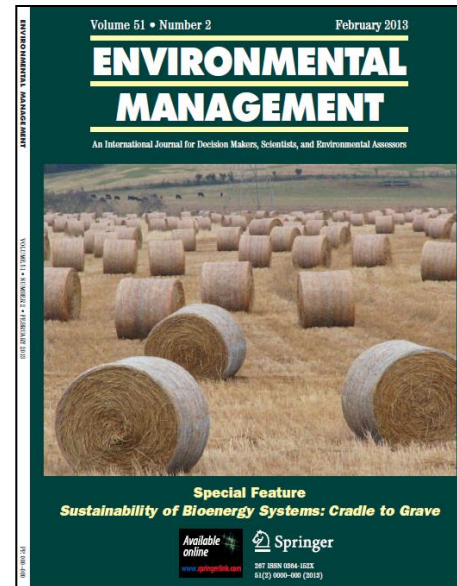
BMPs

2 - Technical Accomplishments/ Progress/Results

Task A. Advance common definitions of environmental and socioeconomic costs and benefits of bioenergy systems

- Assisted BETO by providing reviews and analysis when requested - for example
 - GBEP (Global Bioenergy Partnership)
 - RSB (Roundtable on Sustainable Biofuels)
 - FAO (Food and Agriculture Organization)

[ORNL's engagement with international partners presented by Keith Kline & Helena Chum]
- Worked with Council on Sustainable Biomass Production (CSBP) to establish basis for certification: June 2012: CSBP released agriculture standard (<http://www.csbp.org/CSBPStandard.aspx>)
- Participated in National Academy of Sciences (NAS) reports
 - Dale - Committee on Economic and Environmental Impacts of Increasing Biofuel Production
 - Efroymsen - Committee on Sustainable Development of Algal Biofuels
- Worked with others (<http://www.ornl.gov/sci/ees/cbes/Collaborations.shtml>)
 - for example
 - National Council for Air and Stream Improvement (NCASI) workshop on eucalyptus
 - National Science Foundation Research Collaboration Network on Bioenergy Sustainability
 - Great Lakes Bioenergy Research Center workshops
 - Research Coordination Network on Pan American Biofuels and Bioenergy Sustainability
 - ORNL workshops: (<http://www.ornl.gov/sci/ees/cbes/>)
 - Billion Ton Study: What can be Learned about Bioenergy Sustainability?
 - Bioenergy Sustainability: Cradle to Grave [Special feature in Feb 2013 issue of *Environmental Management*]



Sustainability Indicators

A measurement that provides information about the effects of human activities on the environment, society or economy.

Indicators should be

- **Useful**
 - Policymakers
 - Producers
 - Managers
- **Technically effective**
 - Sensitive to stresses on system
 - Anticipatory: signify impending change
 - Have known variability in response
- **Practical**
 - Easily measured
 - Consider context of measure
 - Broadly applicable
 - Predict changes that can be averted by management actions



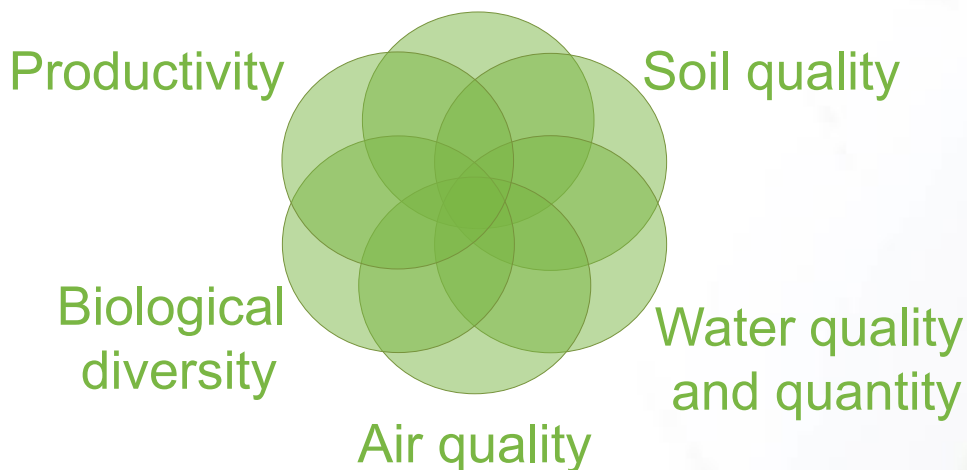
Dale and Beyeler (2001) Challenges in the development and use of ecological indicators. *Ecological Indicators* 1: 3-10.

2 - Technical Accomplishments/ Progress/Results

(page 2 of 2)

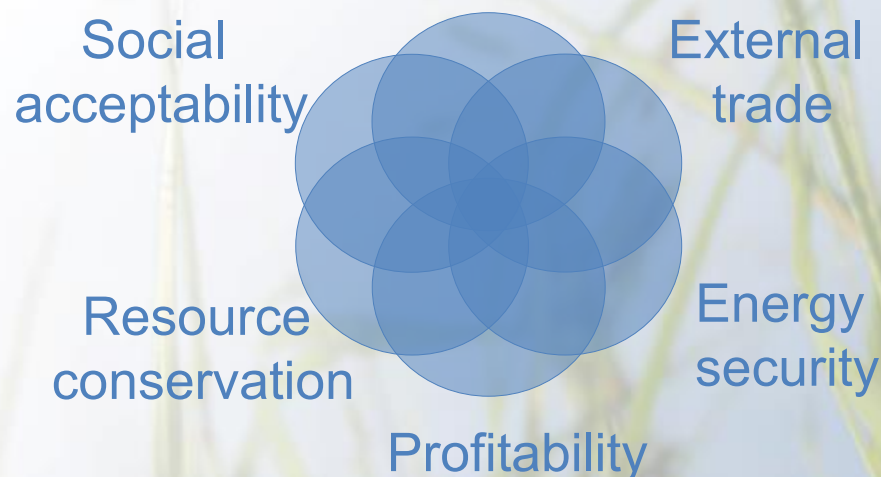
Task A. Advance common definitions of environmental and socioeconomic costs and benefits of bioenergy systems

Greenhouse gas emissions



McBride et al. (2011) *Ecological Indicators* 11:1277-1289.

Social well being



Dale et al. (2013) *Ecological Indicators* 26:87-102.

Recognize that measures and interpretations are context specific

Efroymson et al. (2013) *Environmental Management* 51:291-306.

Milestone: Identified 35 sustainability indicators for bioenergy

Categories of environmental sustainability indicators

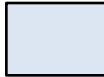
Environment	Indicator	Units
Soil quality	1. Total organic carbon (TOC)	Mg/ha
	2. Total nitrogen (N)	Mg/ha
	3. Extractable phosphorus (P)	Mg/ha
	4. Bulk density	g/cm ³
Water quality and quantity	5. Nitrate concentration in streams (and export)	concentration: mg/L; export: kg/ha/yr
	6. Total phosphorus (P) concentration in streams (and export)	concentration: mg/L; export: kg/ha/yr
	7. Suspended sediment concentration in streams (and export)	concentration: mg/L; export: kg/ha/yr
	8. Herbicide concentration in streams (and export)	concentration: mg/L; export: kg/ha/yr
	9. storm flow	L/s
	10. Minimum base flow	L/s
	11. Consumptive water use (incorporates base flow)	feedstock production: m ³ /ha/day; biorefinery: m ³ /day

Environment	Indicator	Units
Greenhouse gases	12. CO ₂ equivalent emissions (CO ₂ and N ₂ O)	kgC _{eq} /GJ
Biodiversity	13. Presence of taxa of special concern	Presence
	14. Habitat area of taxa of special concern	ha
Air quality	15. Tropospheric ozone	ppb
	16. Carbon monoxide	ppm
	17. Total particulate matter less than 2.5µm diameter (PM _{2.5})	µg/m ³
	18. Total particulate matter less than 10µm diameter (PM ₁₀)	µg/m ³
Productivity	19. Aboveground net primary productivity (ANPP) / Yield	gC/m ² /year



McBride et al. (2011) *Ecological Indicators* 11:1277-1289.

Categories of socioeconomic sustainability indicators

 *Ten minimum practical measures*

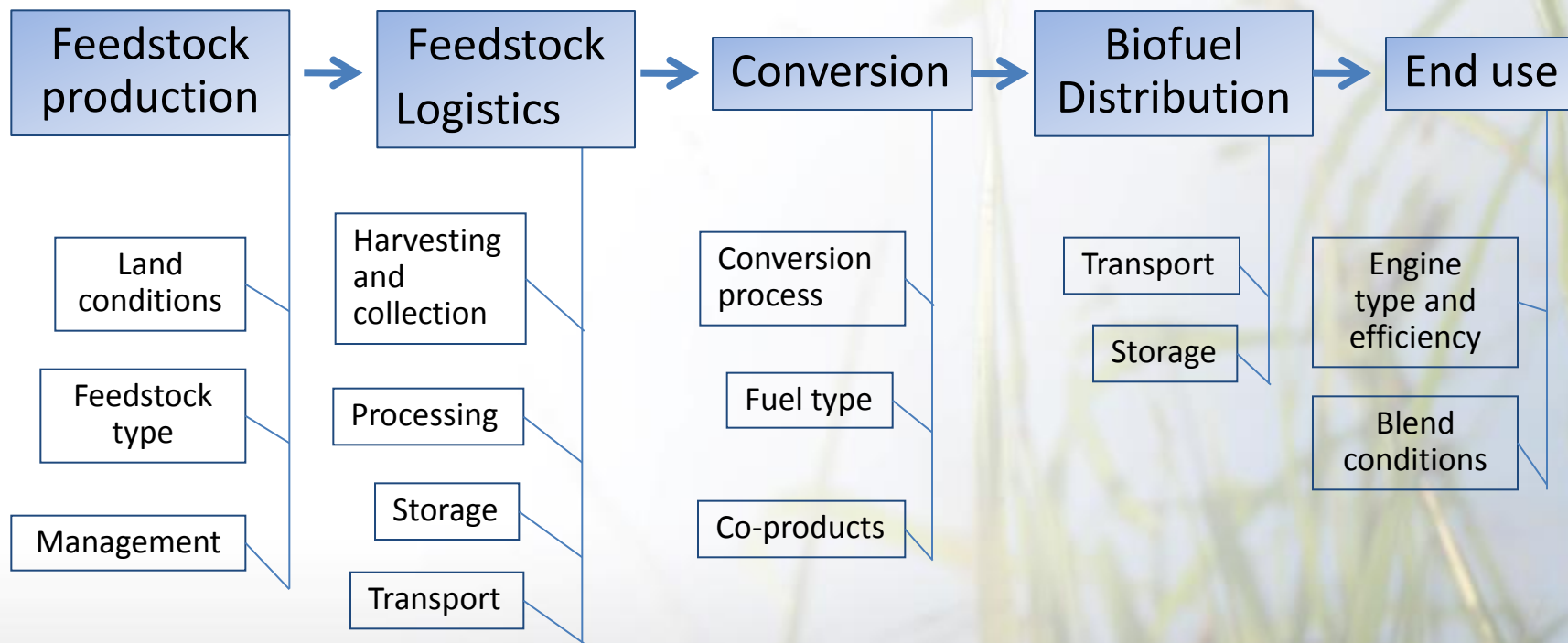
Category	Indicator	Units
Social well-being	Employment	Number of full time equivalent (FTE) jobs
	Household income	Dollars per day
	Work days lost due to injury	Average number of work days lost per worker per year
	Food security	Percent change in food price volatility
Energy security	Energy security premium	Dollars /gallon biofuel premium
	Fuel price volatility	Standard deviation of monthly percentage price changes over one year
External trade	Terms of trade	Ratio (price of exports/price of imports)
	Trade volume	Dollars (net exports or balance of payments)
Profitability	Return on investment (ROI)	Percent (net investment/initial investment)
	Net present value (NPV) ²	Dollars (present value of benefits minus present value of costs)

Category	Indicator	Units
Resource conservation	Depletion of non-renewable energy resources	MT (amount of petroleum extracted per year)
	Fossil Energy Return on Investment (fossil EROI)	MJ (ratio of amount of fossil energy inputs to amount of useful energy output)
Social acceptability	Public opinion	Percent favorable opinion
	Transparency	Percent of indicators for which timely and relevant performance data are reported
	Effective stakeholder participation	Number of documented responses to stakeholder concerns and suggestions reported on an annual basis
	Risk of catastrophe	Annual probability of catastrophic event

Dale et al. (2013) *Ecological Indicators* 26:87-102.

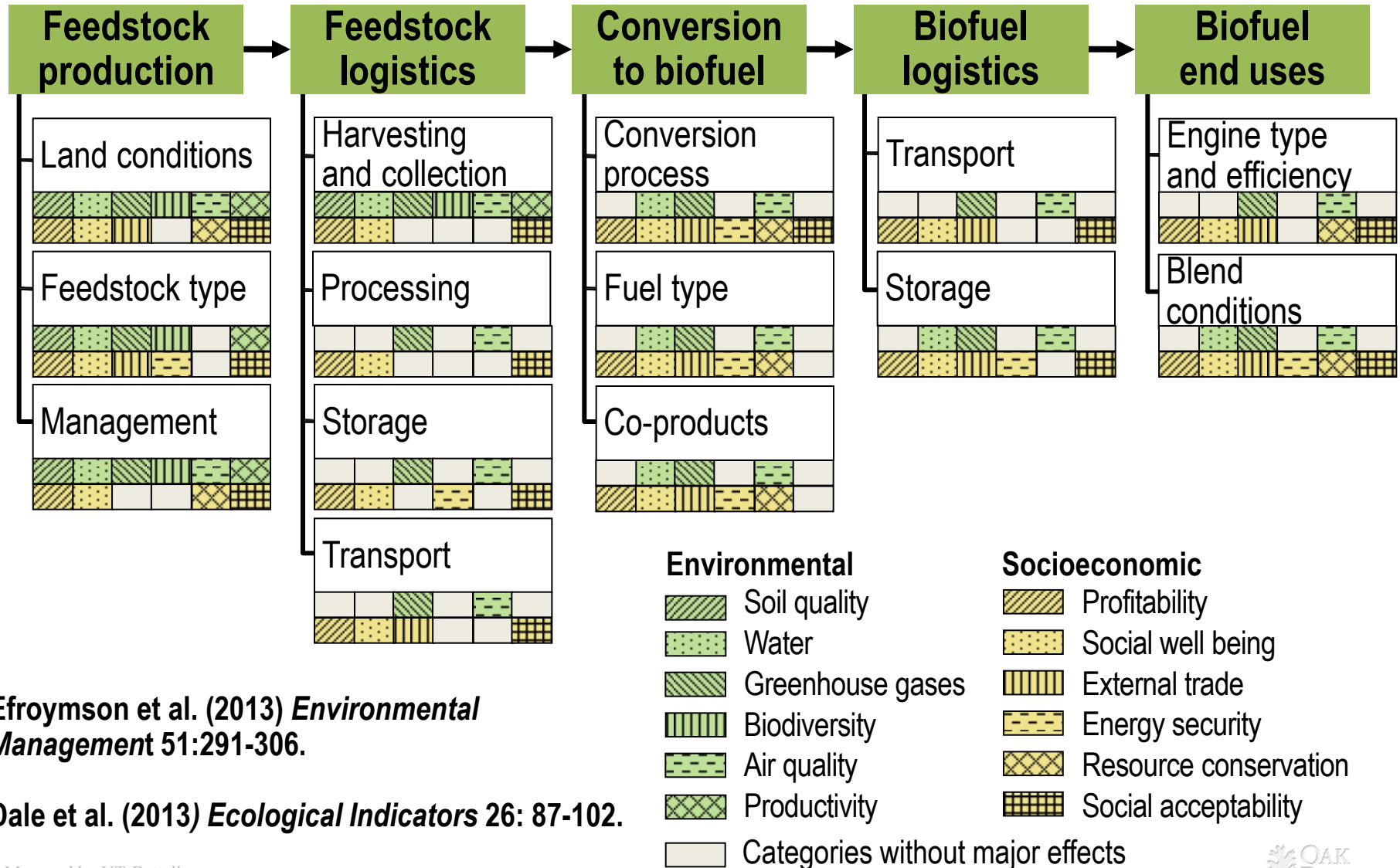
Sustainability Should Apply to

- Entire supply chain
- Diverse feedstocks
- All conversion pathways



(Example shown is biofuel, but concepts are applicable to bioenergy as well)

Consider biofuel supply chain in terms of sustainability indicators

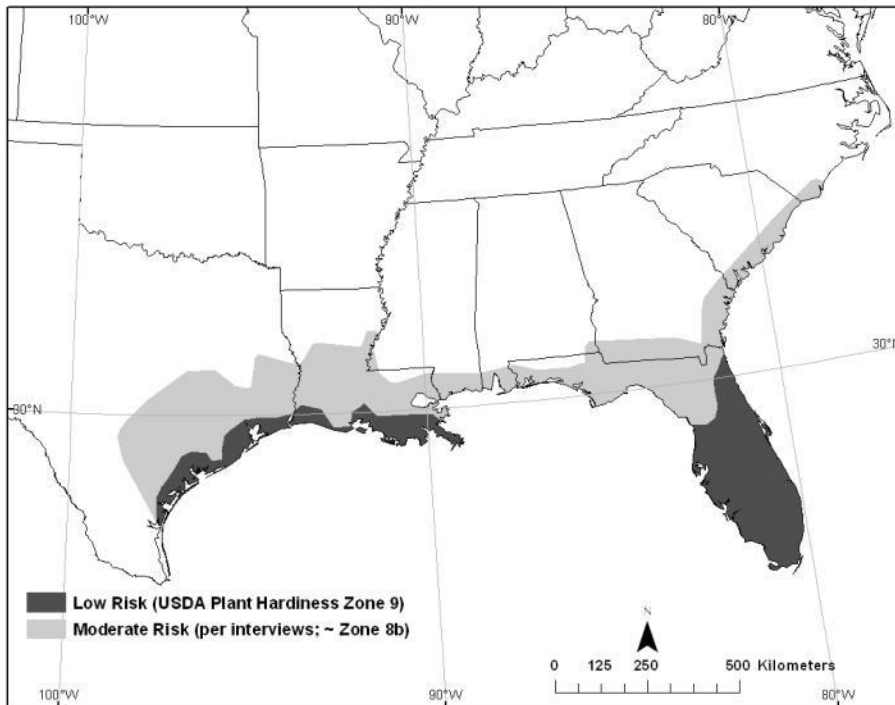


Efroymsen et al. (2013) *Environmental Management* 51:291-306.

Dale et al. (2013) *Ecological Indicators* 26: 87-102.

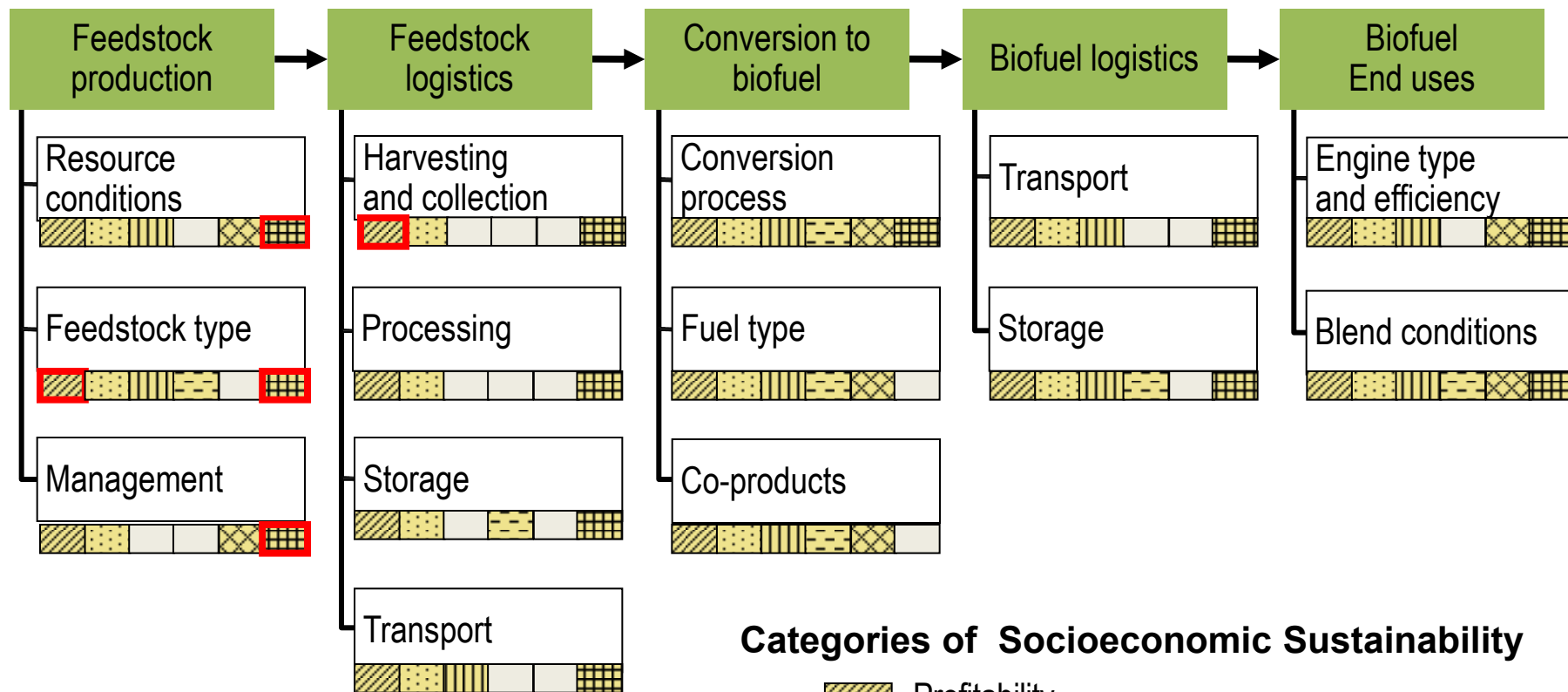
Sustainability indicators apply uniquely to specific contexts

For example, *Eucalyptus* is being considered for planting in the southeastern US.



Kline and Coleman (2010) *Biomass and Bioenergy* 34(12):1655-1666.

Major effects within the biofuel supply chain for *Eucalyptus* grown for bioenergy in southeastern US



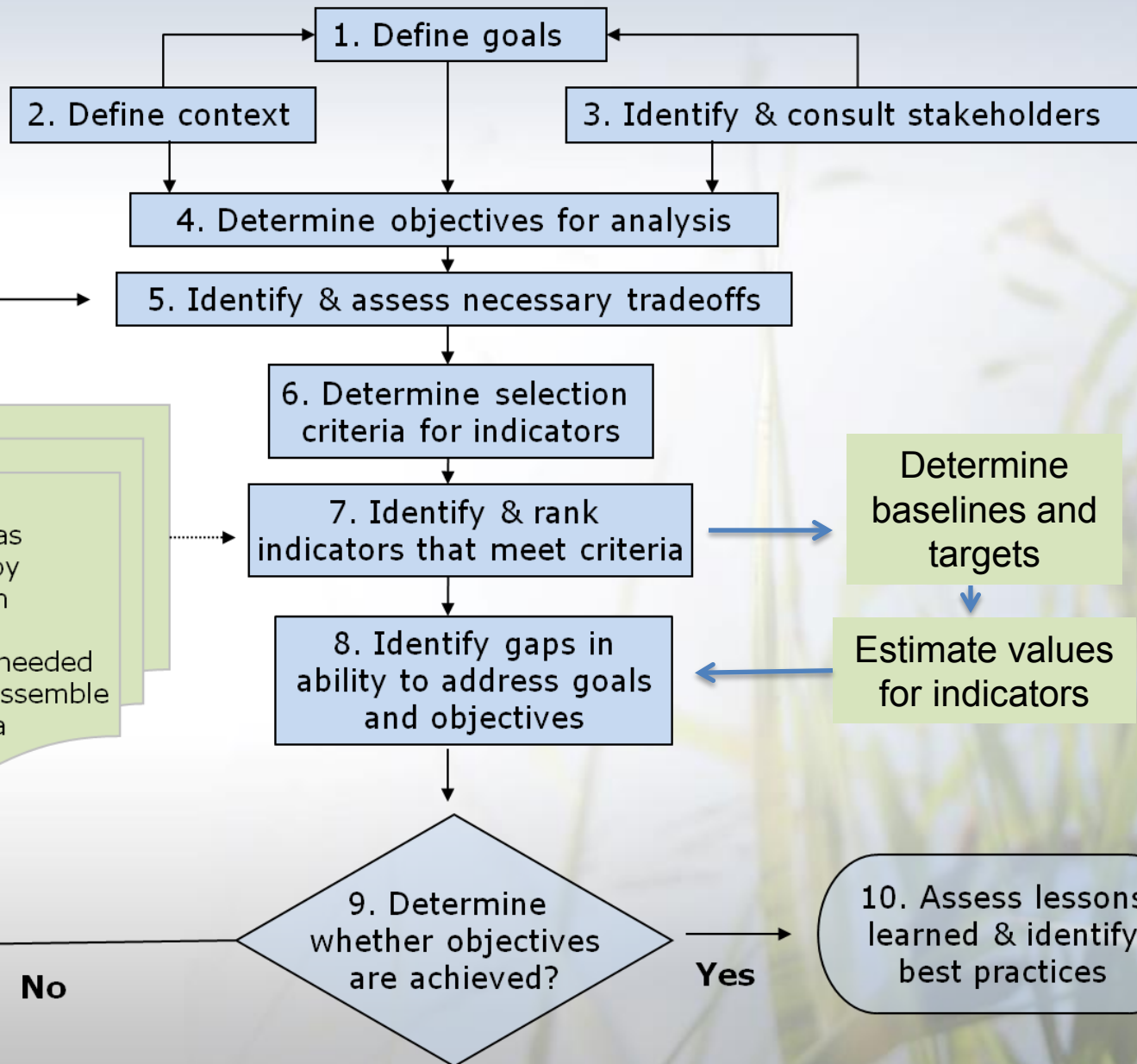
Categories of Socioeconomic Sustainability

-  Profitability
-  Social well being
-  External trade
-  Energy security
-  Resource conservation
-  Social acceptability
-  Categories without major effects

Based on Dale et al. (2013) *International Journal of Forestry Research*, vol. 2013, Article ID 215276.

Are considering algal-based biofuels under separate algae project: WBS 9.6.1.9

Framework for Using Indicators to Assess Issues



The context of assessments of bioenergy sustainability

- Indicator set is a starting point for sake of efficiency and standardization
 - Particular systems may require addition of other indicators
 - Budget may require subtraction of some indicators
- Protocols and interpretations must be context-specific

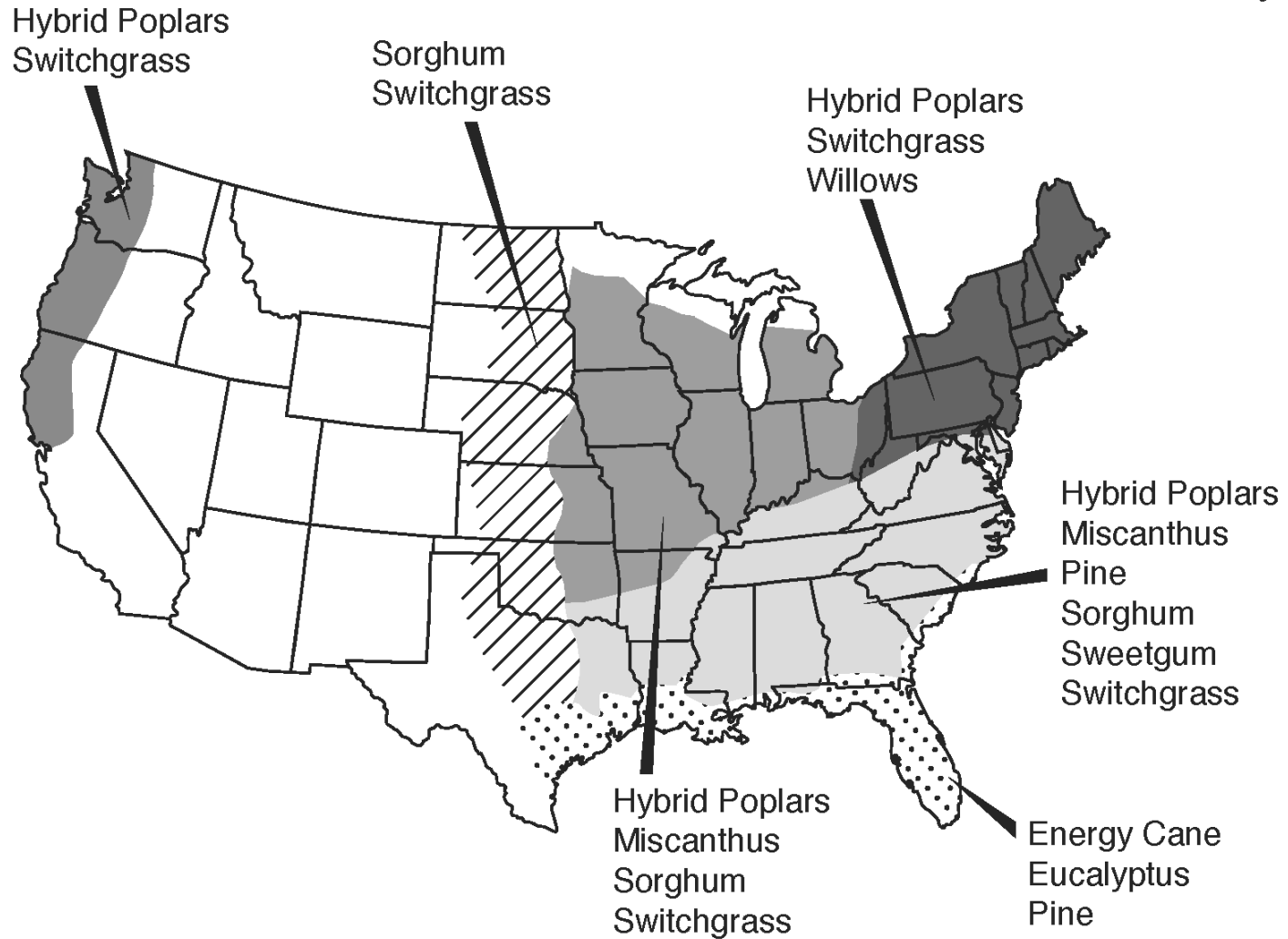


Context considers:

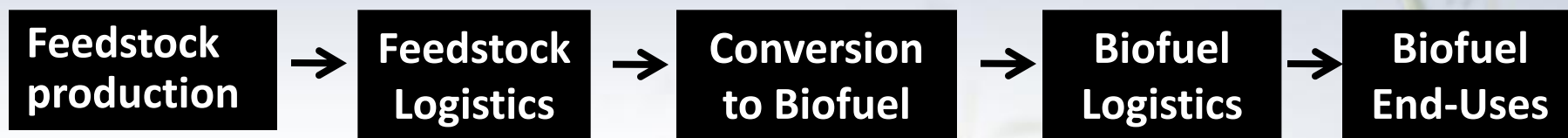
- Baseline and reference conditions
- Biofuel system
 - Feedstock
 - Supply chain
 - Feedstock management
- Decisions framework
 - Policy
 - Certification
 - Comparison with alternatives
- Purpose of assessment
 - Assessment of current condition
 - Monitoring trends
 - Providing early warning signal
 - Diagnosing cause
- Spatial and temporal extent
 - Location
 - Time
 - Scale
- Stakeholder values

Recommended Biofuel Feedstock Plantings in Regions of the U.S.

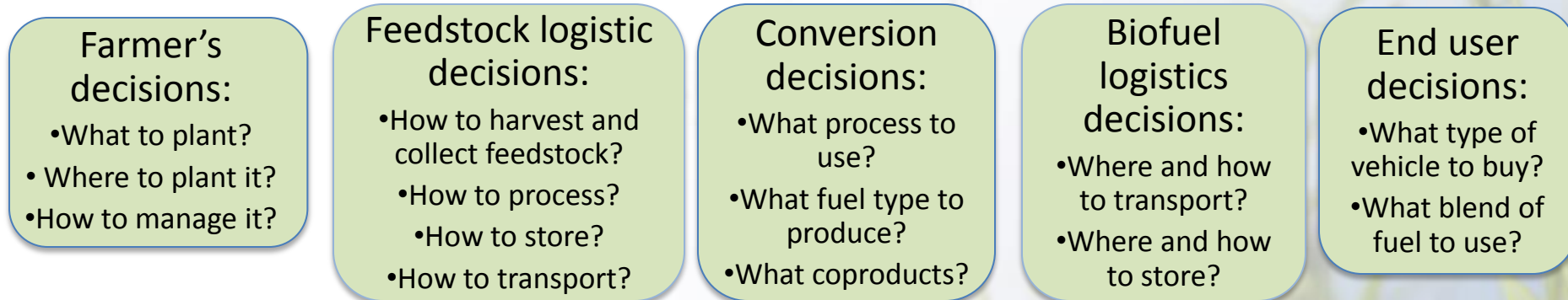
ORNL 2009-G01231/dgc



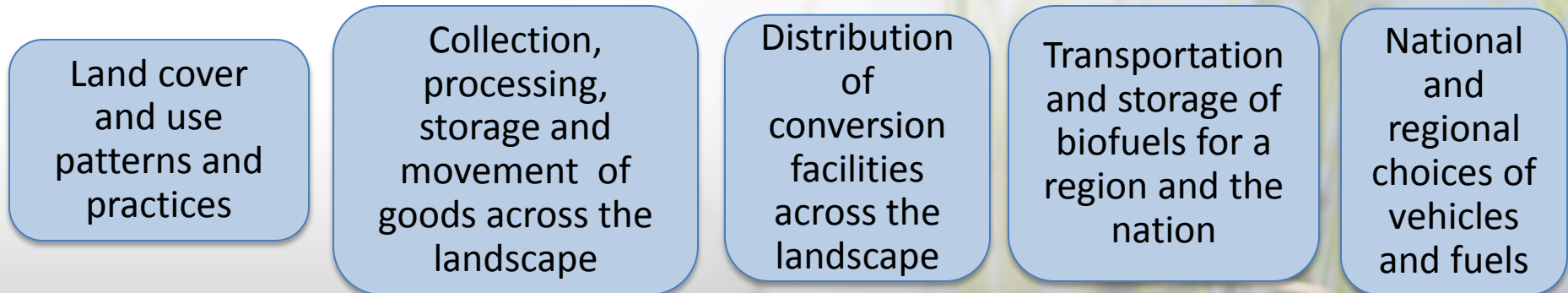
Bioenergy system decisions occur at all points along supply chain and at different scales. Information about sustainability indicators can be used to inform those decisions.



Individual perspective:



Cumulative perspective:



Assessing multiple effects of bioenergy choices

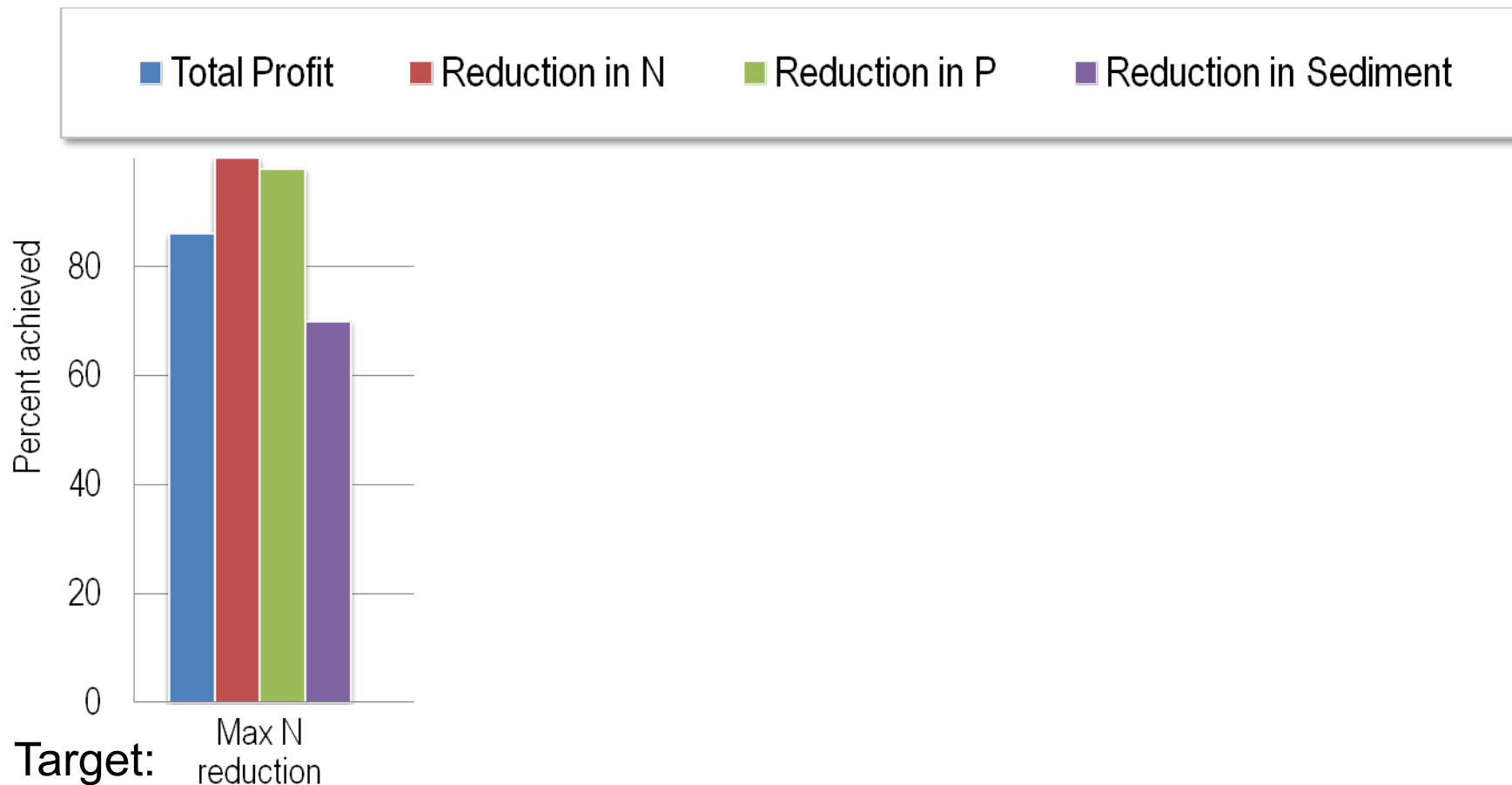
An optimization model identifies “ideal” sustainability conditions for using switchgrass for bioenergy in east Tennessee

Spatial optimization model

- Identifies where to locate plantings of bioenergy crops given feedstock needs for Vonore refinery
- Considering
 - Farm profit
 - Water quality constraints

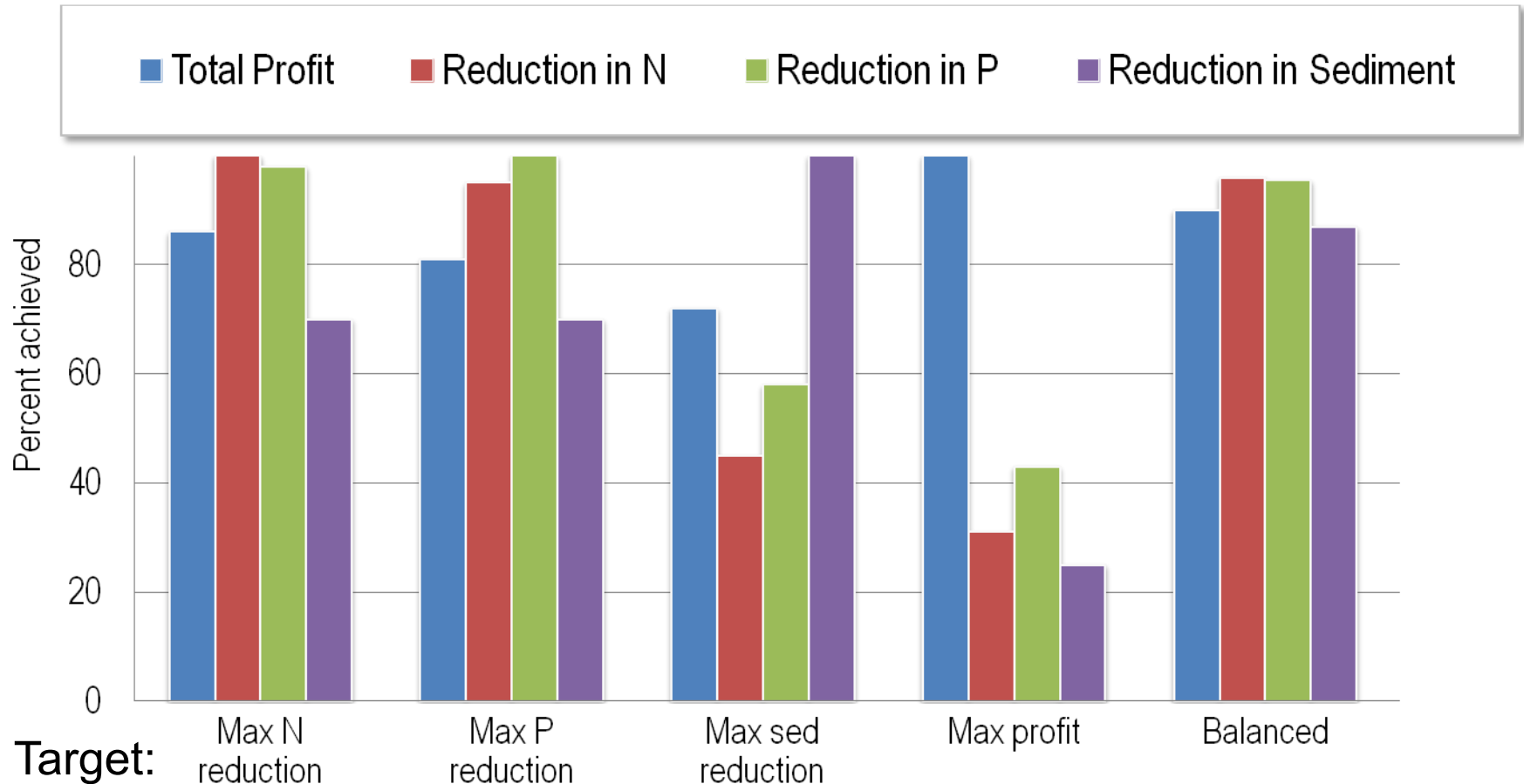
Balancing objectives:

Design of cellulosic bioenergy crop plantings may both improve water quality and increase profits while achieving a feedstock-production goal



Balancing objectives:

Design of cellulosic bioenergy crop plantings may both improve water quality and increase profits while achieving a feedstock-production goal



Land area recommended for switchgrass in this watershed:

1.3% of the total area (3,546 ha of 272,750 ha) for the production goal of 65,000 tons of switchgrass per year from that watershed.

Integrated Biomass Supply System (IBSS) Partnership: Project on Bioenergy Crop Sustainability: Water Quality Model Verification and Watershed Indicator Development

Partners

Principal Investigators:

Tim Rials and John Schwartz (Univ. Tennessee)

ORNL: Dale, Parish, and Baskaran

R&D Objectives

- Measure effects of bioenergy crops on hydrology and water quality at catchment and watershed scales.
- Provide field data to verify the Soil and Water Assessment Tool (SWAT) model for energy crops in east Tennessee.
- Support development of environmental sustainability indicators and landscape design criteria for bioenergy crop production.

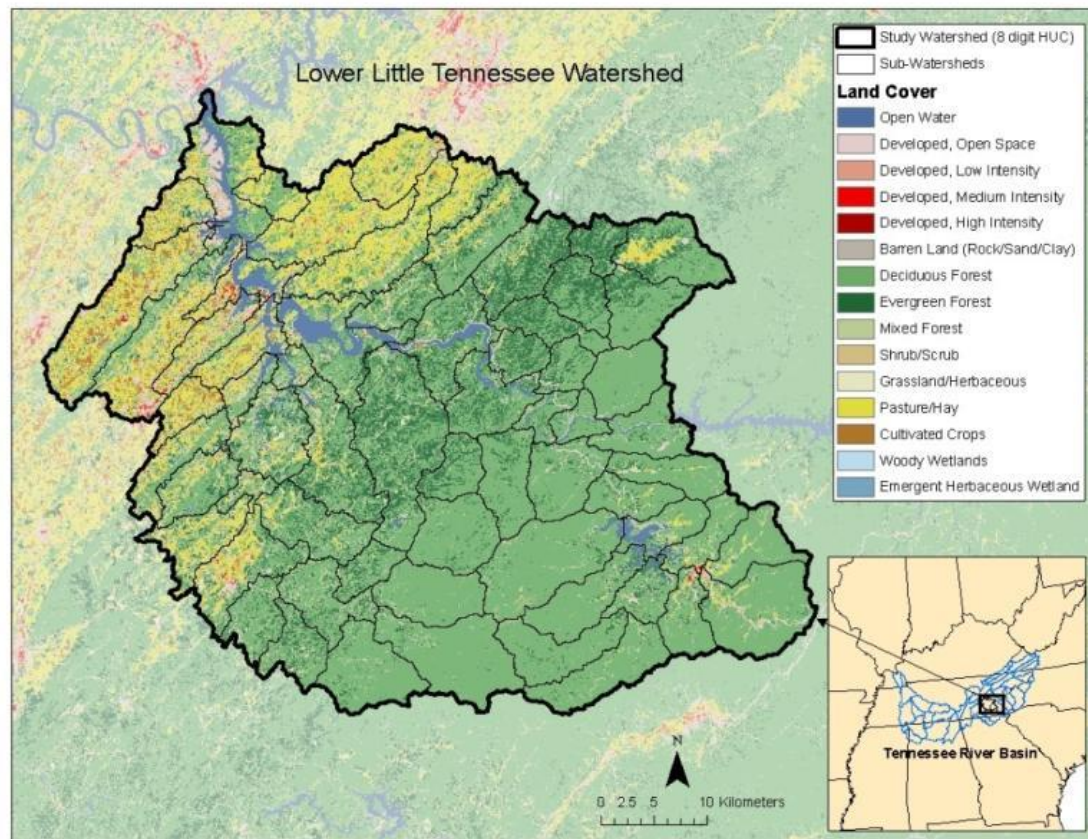
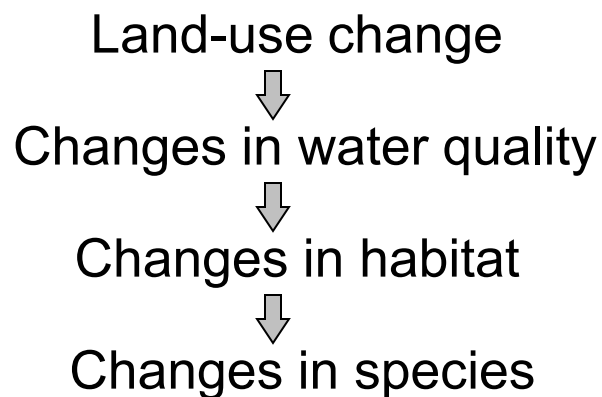


Status

1. Select catchment and watershed sites: March 2012
2. Install field monitoring equipment: July 2012
3. Monitor water quality at study sites: Ongoing
4. Move to woody production sites: Future

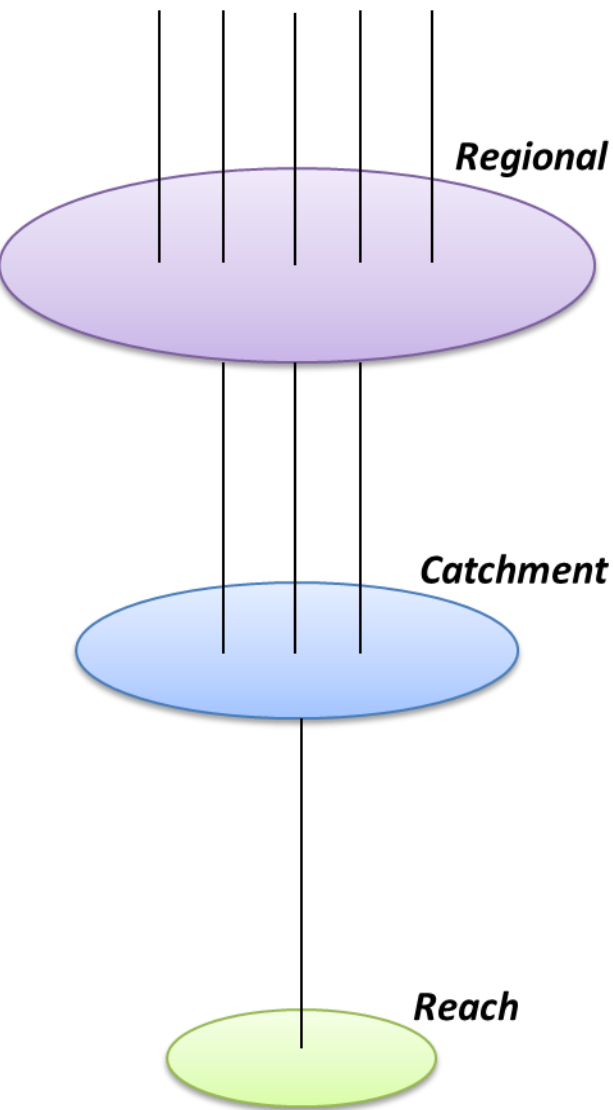
Assessing multiple effects of land change associated with bioenergy

Consider multiple effects:



EPT richness = number of distinct taxa in the insect orders

- Ephemeroptera (mayflies)
- Plecoptera (stoneflies)
- Trichoptera (caddisflies)



Landscape/ stream features	Related factors that affect macroinvertebrates
Geomorphology	Flow regime, substrate, ion concentration
Climate	Stream flow, temperature
Stream Order	Channel characteristics, food resources
Land Cover and management	Land disturbance, increased impervious surface area, altered hydrology, transport of non-point source pollutants (e.g. sediment, nutrients) to streams, input of organic matter in the stream
Stream flow	Flow volume, channel dynamics, erosion, floods and low flows
Sediments and Substrate	Turbidity, scouring and abrasion, substrate composition, in-filling interstitial habitat, stream depth heterogeneity
Nutrients	Nutrient enrichment, dissolved oxygen, changes to assemblage composition
pH	pH sensitivity, toxicity

Adapted from Poff (1997)

Effects of planting switchgrass: watershed scale

Land management

- Tillage
- Harvest
- Fertilizer application

Land-based processes

- Soil erosion
- Nutrient runoff

Stream-based processes

- Sediment load
- Nutrient concentration

In-stream stress

- Channel instability
- Instream sediment load (turbidity)
- Primary production

Macro-invertebrate processes affected

- Habitat alteration
- Biotic interactions
- Food source

SWAT (Soil Water Assessment Tool)

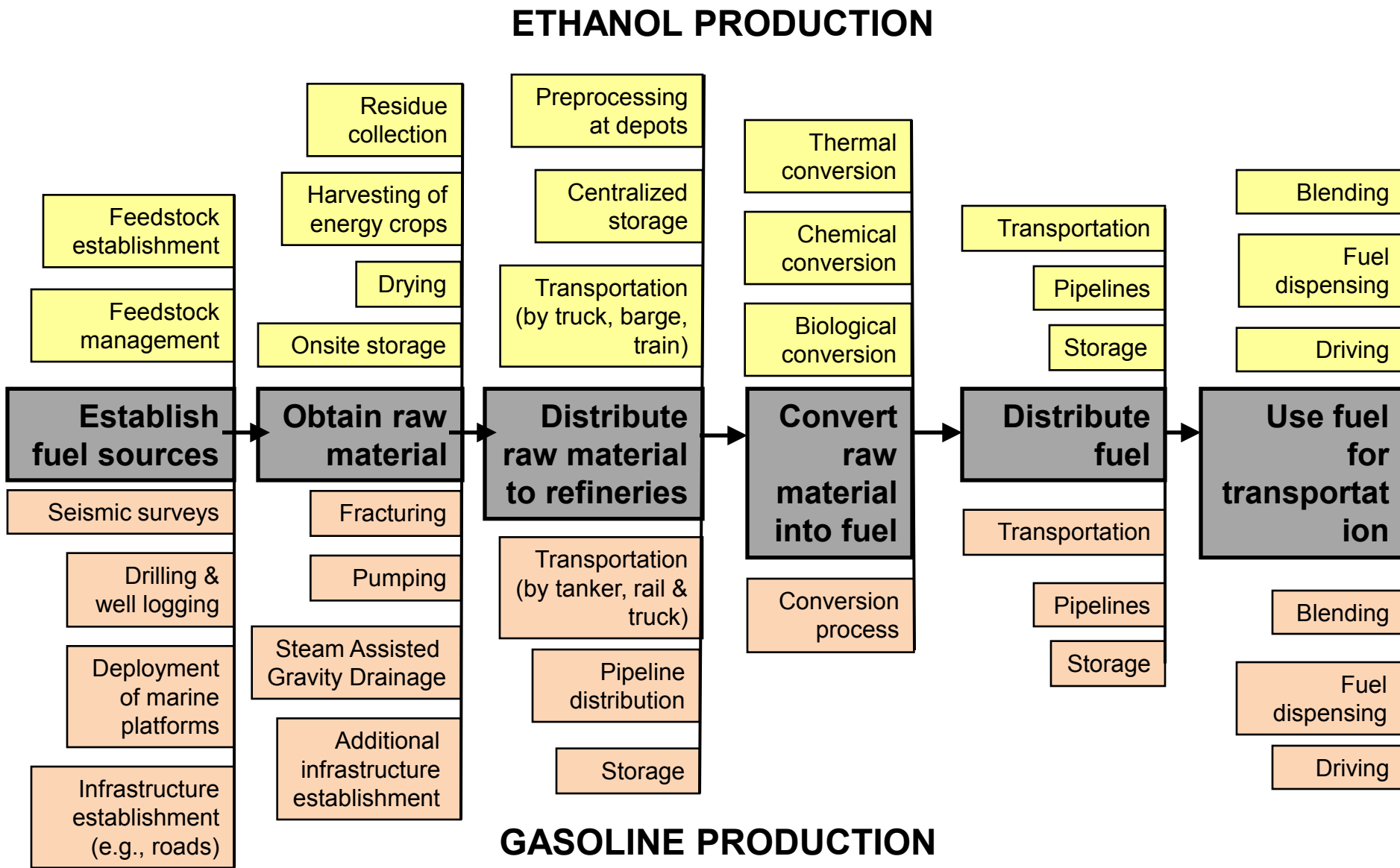
- Sediment concentration
- Total N concentration
- Total P concentration

Habitat model

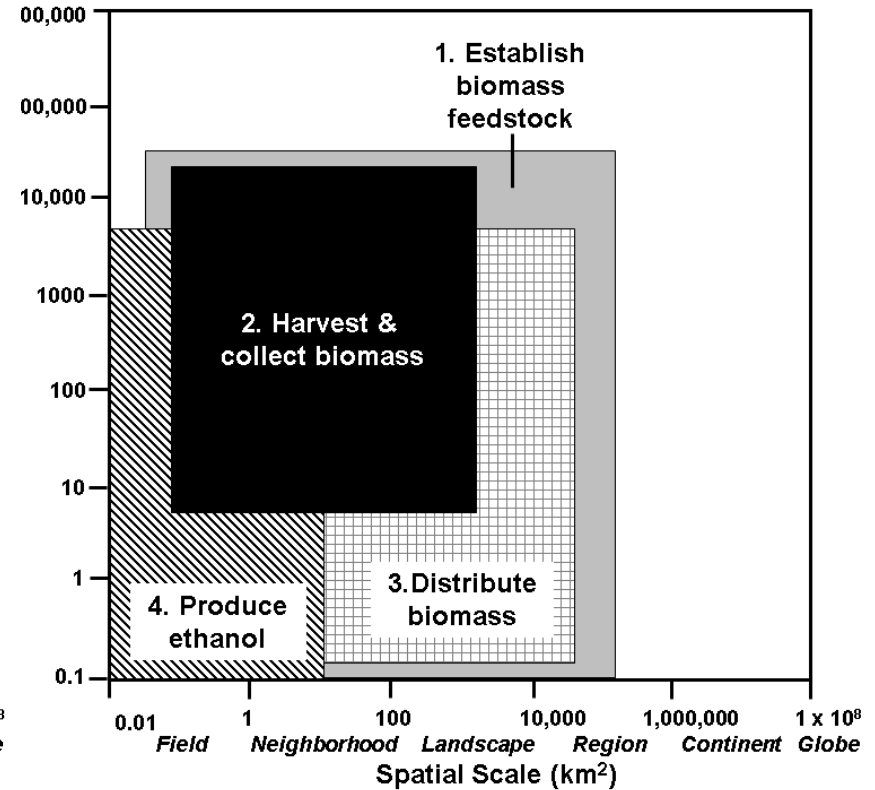
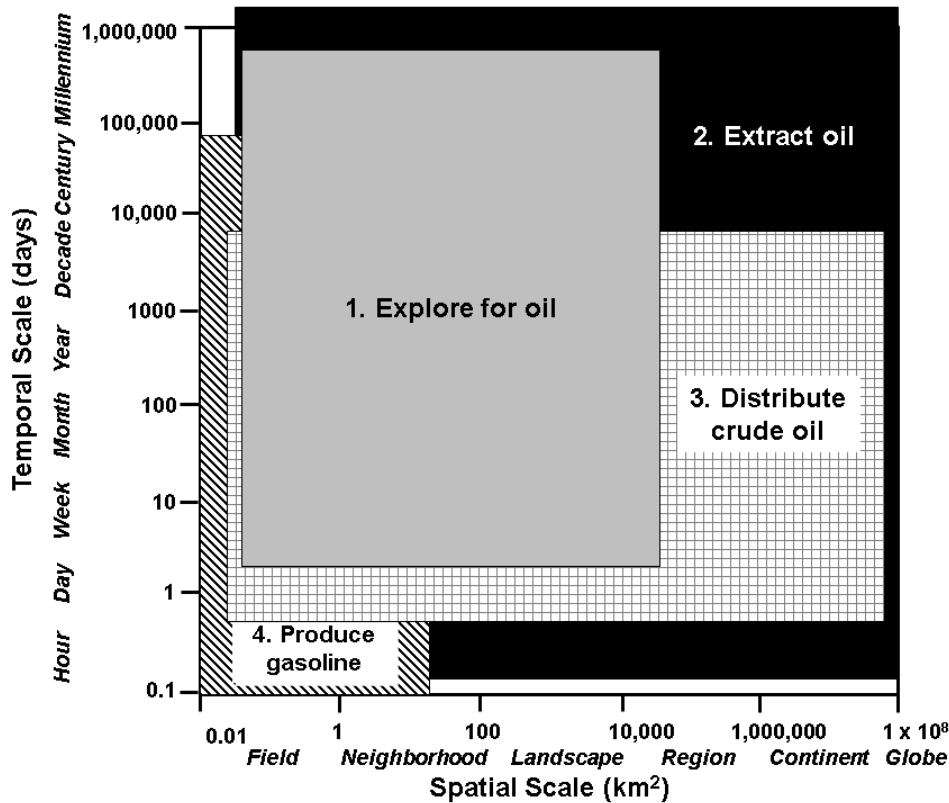
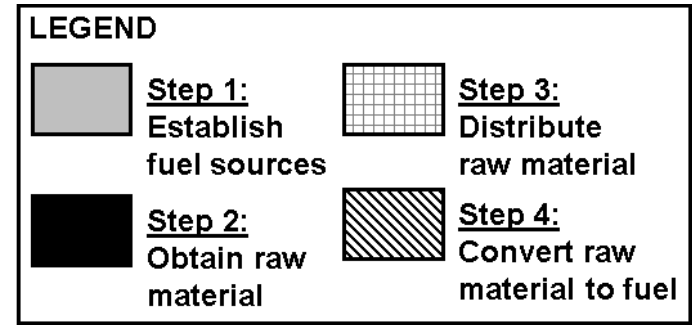
Macroinvertebrate taxa richness

BMPs

Comparing Ethanol to Gasoline across Supply Chain



Stommel Diagram comparison of scale of environmental effects from gasoline and ethanol production across supply chain



Conclusions of ethanol to gasoline comparison

- Scale matters -- not just extent & duration, but also intensity, reversibility...
 - Insufficient to solely compare processes using analyses that do not consider space/time differences
- Ethanol ramp-up may lead to land-use change, but gasoline production
 - Alters landscapes more than realized
 - Might lead to permanent loss of resource
- Ethanol expansion has the potential to reduce environmental impacts of liquid transportation fuel production
 - Research, monitoring & enforcement are needed (quickly!) to guide choices toward more sustainable management



3 - Relevance

- Accomplishments contribute to goals and objectives of the technology area and overall BETO sustainability goals
 - Evaluating sustainability and identifying best practices for biofuels produced from cellulosic feedstocks ... considering environmental, social, and economic indicators across the supply chain.
 - Implementing and promoting best practices for all sustainability categories for an integrated biomass-to-bioenergy process from cellulosic feedstocks.
- Project considers applications of the expected outputs.
 - Indicators are selected that
 - Build from indicators proposed by others engaged in bioenergy sustainability
 - Are useful, practical, and technically effective
 - Evolving framework is being designed to focus on application, assessment, and development of BMPs

**Approach:
Environmental
&
socioeconomic
Indicators**



BMPs

4 - Critical Success Factors

- Environmental and socioeconomic aspects of sustainability seen as critical to commercially viable and sustainable bioenergy industry
- Bioenergy sustainability is recognized as being context specific
- Assessment of sustainability of bioenergy systems is deployed across the industry
- BMPs for sustainable bioenergy production are based on targets, baselines, trends and environmental and socioeconomic sustainability of bioenergy systems
- Potential interactions and trade-offs for different bioenergy scenarios are considered
- Landscape designs are used in deployment of sustainable bioenergy systems



5. Future Work (1)

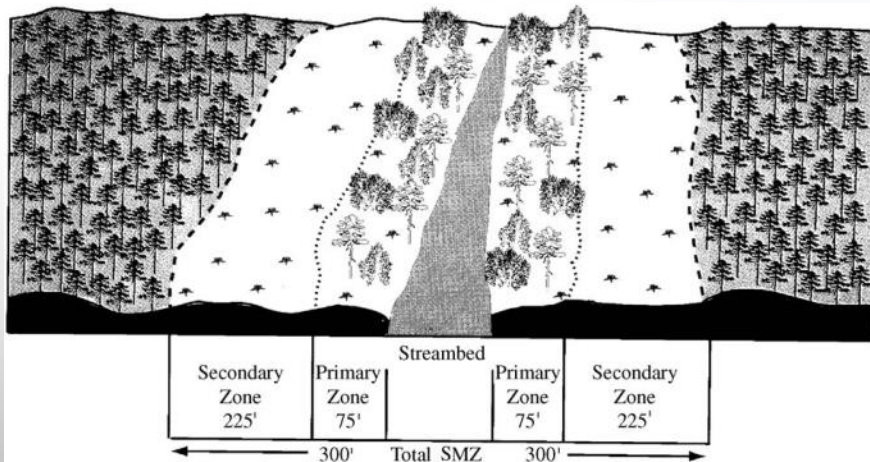
Moving toward BMPs for bioenergy pathways via targets and baseline conditions

Review of BMPs for bioenergy

- General BMPs for bioenergy/biofuel (e.g., many states)
- BMPs for dedicated biofuel crops
- Sustainable harvest of forest biomass

Types of environmental BMPs

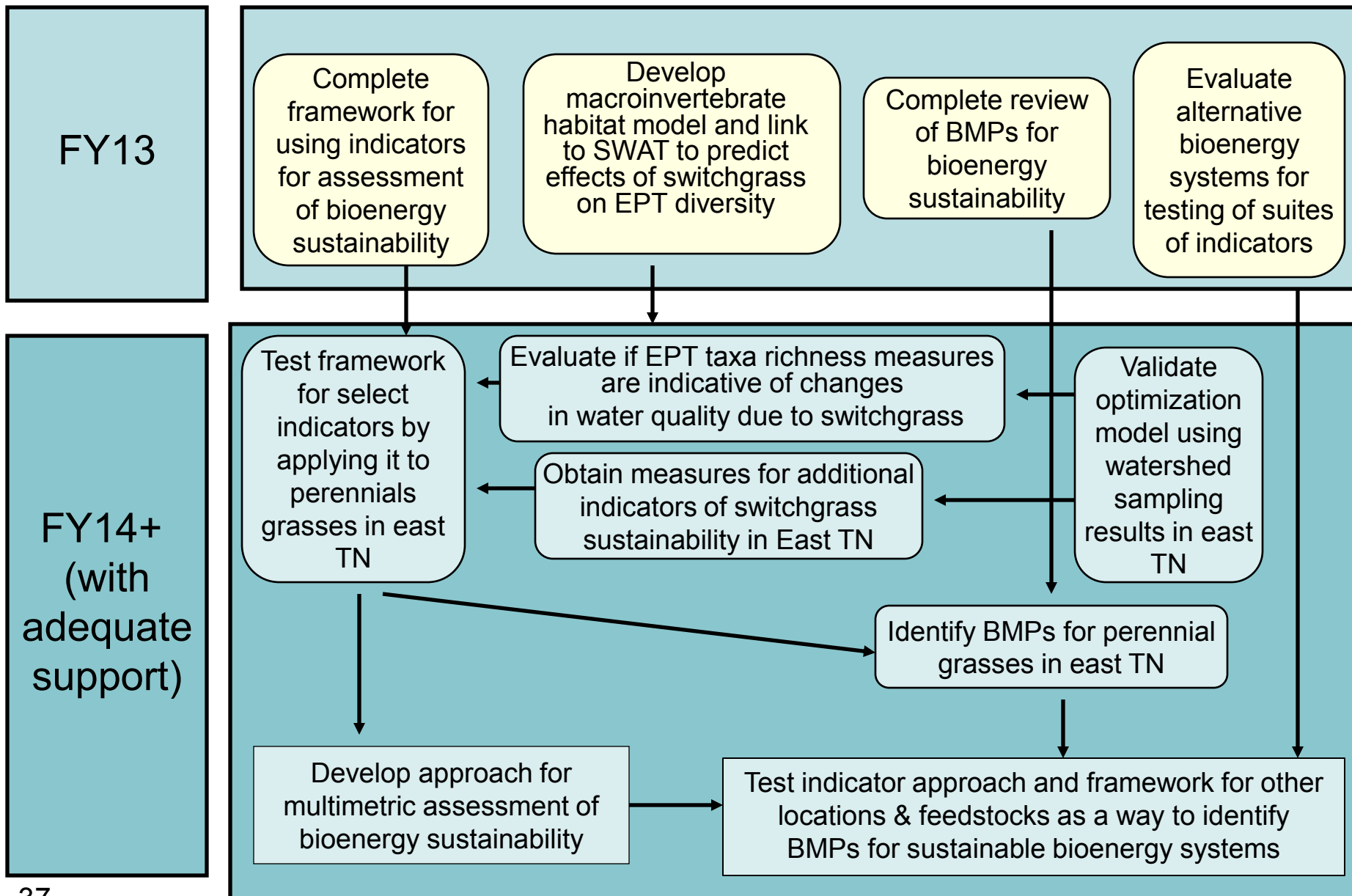
- Crop selection
- Rotation
- Tilling regimes
- Cropping intensity
- Water use efficiency
- Use of marginal/degraded lands
- Control of potential invasion
- Buffer strips
- Streamside management zones
- Harvest management regimes



Florida Forest Service—Perennial Stream Management

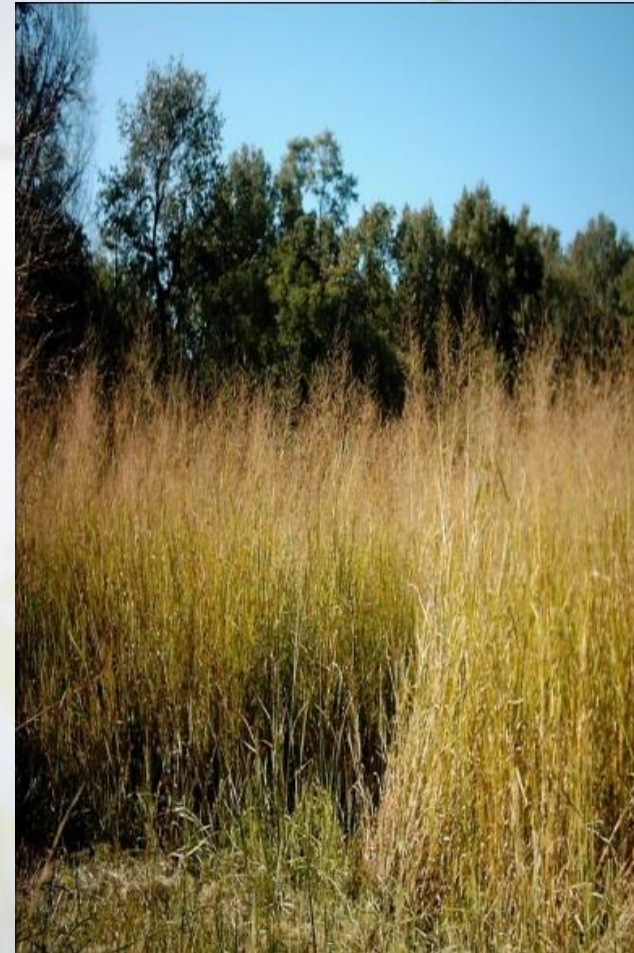


5. Future Work (2)



5. Future work (3)

- **Upcoming key milestones**
 - Evaluation of targets and baseline conditions as part of establishing Best Management (BMPs) for specific bioenergy pathways
 - Description of aquatic macroinvertebrate habitat model as linked to the Soil Water Assessment Tool (SWAT) used to assess bioenergy choices on both water and biodiversity
 - Update on validation of SWAT/BLOSM (Biomass Location for Optimal Sustainability Model)
- **Decision point**
 - Identification of alternative bioenergy system and collaborators to help us characterize both the robustness and variability of proposed indicators of bioenergy sustainability
 - Successful validation of SWAT/BLOSM



Summary (1)

- Approach
 - From indicators to baseline and targets to evaluation to trends and tradeoffs to BMPs
 - Spatially explicit multi-metric analyses tools
- Technical accomplishments
 - ✓ Identified limited set of environmental and socioeconomic indicators of bioenergy sustainability
 - ✓ Developed understanding of how to assess bioenergy sustainability in particular contexts
 - ✓ Spatial optimization model (BLOSM) developed and deployed and is being validated via plantings in paired watersheds around Vonore
- Relevance
 - Focus on cellulosic bioenergy across supply chain
 - Considering environmental and socioeconomic aspects of sustainability
- Critical Success factors and challenges
 - Establishment of a baseline for environmental sustainability of feedstock supply (i.e., production, harvest/collection, and processing)
 - Obtaining sustainability data across the supply chain
 - Defining best practices for sustainable bioenergy production
 - Considering potential interactions and trade-offs among different goals (environmental protection and profit) and (eventually) different bioenergy scenarios

Approach:
Indicators



BMPs

Summary (2)

- Future Work
 - Complete and test framework for sustainability assessment for full set of indicator categories
 - Determine BMPs for bioenergy sustainability
- Technology transfer
 - Inclusion of information and data in KDF allows for archival and sharing
 - Dissemination of results via 15 publications in past two years
 - Many presentations and exchanges with colleagues from other federal agencies, universities, and nongovernmental organizations
 - Provided ideas and material
 - Presented by others (e.g., Kristen Johnson, Helena Chum, Keith Kline)
 - To national and international meetings and certifications efforts (e.g., RSB, GBEP, ISO, CSBP)



Additional Slides

Progress Since 2011 Review of 11.1.1.5

Results of 2011 Review

Evaluation Criteria	Sustainability Platform Mean	Project Mean
Relevance	8.3	9.6
Approach	7.9	8.9
Progress	8.0	9.1
Benefits		9.0
Overall		9.1
Percentile rank		100%

- Strengths – (select quotes from 2011 review)
 - “Project is very relevant to goals of Sustainability Platform”
 - “Project has been active in interfacing with other groups working on developing indicators”
 - “Progress has been substantial”
 - “The project is well focused and founded. It simply could not be more relevant.”
 - “This was the best presentation and best project reviewed all week.”
- Weaknesses (select quotes from 2011 review)
 - “The project is trying to use empirical model and not rely so much on modeling, however modeling may not be so easily avoided.”
 - Response: While we prefer empirical measures, we recognize they are not always available and use models that are validated for the system of concern and appropriately documented (our ideas for how to do this are in Dale and Kline (2013) Modeling for integrating science and management. Pages 209-240 In D.G. Brown, D. T. Robinson, N. H. F. French, and B.C. Reed (editors), *Land Use and the Carbon Cycle: Advances in Integrated Science, Management, and Policy*, Cambridge University Press.
 - “It would be important to apply all of these indicators back to the fossil energy baselines in a variety of bioenergy systems.”
 - Response: We agree and have made some progress in that analysis – see Parish et al. (2013).
 - “The upcoming socioeconomic indicators will be especially challenging.”
 - Response: They were! That is why we asked many groups to comment on our preliminary selection.
 - “The demonstration of functional systems is an important next step and may require some iteration thinking accomplished to date.”
 - Response: We are working on a demonstration with switchgrass and other feedstock systems.
 - “I hope the results of his study are presented in the KDF”
 - 2013 – Information is entered on the KDF as soon as it is available.

Progress Since 2011 Review of 1.7.1.2

- Strengths – (select quotes from 2011 review)
 - “Project is a well-conceived integration of modeling and field study, and approach is clearly described. ”
 - “Very inclusive and engaging lots of partners.”
 - “Good progress has been made. The workshop brought together a broad swath of stakeholders to help define the parameters of a useful tool.”
 - “Responds to need for an integrated and interdisciplinary approach. “

Results of 2011 Review		
Evaluation Criteria	Sustainability Platform Mean	Project Mean
Overall score	7.66	8.78
Percentile rank		100%

- Weaknesses (select quotes from 2011 review)
 - What is the unique value proposition of BLOSM?” –
 - Response: Our indicator approach is designed to lead to BMPs and is designed to identify decisions that support certain ecosystem services.
 - “The team has held workshops, continued collaborations with other researchers and is awaiting final word by USDA on a key proposal, which is complementary to this effort. ”
 - Response: The USDA IBIS project was funded in the summer of 2011, and data being collected under IBIS are being used to validate the BLOSM model.
 - “I am not sure if this model will take into account all the implications of large scale production (harvesting equipment, storage, pre-processing, transportation and infrastructure).”
 - Response: The model does not take into all of those aspects of the biorefinery. It considers issues that are affected by the key question being asked - “where is it to plant switchgrass given certain goals and constraints ”
 - Installing the monitoring system will be a challenge?”
 - Response – The most difficult part of installing the monitoring system was selecting the monitoring locations. We wanted paired sites that were similar except for density of switchgrass plantings, accessible, and had year round flow.

Journal Publications (2011-2013)

- Papers in Special Feature of *Environmental Management* (February 2013) “Sustainability of Bioenergy Systems: Cradle to Grave.” Editor of special feature: Jie Zhuang, University of Tennessee, Knoxville, Tennessee, USA
 - Dale VH, KL Kline, D Perla, A Lucier. 2013. Communicating about bioenergy sustainability. *Environmental Management* 51(2): 279-290. DOI: 10.1007/s00267-012-0014-4
 - Efroymsen, RA, VH Dale, KL Kline, AC McBride, JM Bielicki, RL Smith, ES Parish, PE Schweizer, DM Shaw. 2013. Environmental indicators of biofuel sustainability: What about context? *Environmental Management* 51(2): 291-306 DOI: 10.1007/s00267-012-9983-6
 - Parish ES, KL Kline, VH Dale, RA Efroymsen, AC McBride, TL Johnson, MR Hilliard, JM Bielicki, 2013. A multi-scale comparison of environmental effects from gasoline and ethanol production. *Environmental Management* 51(2): 307-338. DOI: 10.1007/s00267-012-9983-6
 - Johnson TL, JM Bielicki, RS Dodder, MR Hilliard, PO Kaplan, CA Miller. 2013. Stakeholder decision making along the bioenergy supply chain: Sustainability considerations and research needs. *Environmental Management* 51(2): 339-353.
- Dale VH, Efroymsen RA and Kline KA. 2011. The land use-climate change-energy nexus. *Landscape Ecology* 26(6):755-773.
- Dale, VH, KL Kline, L Wright, R Perlack, M Downing, RL Graham. 2011. Interactions Between Bioenergy Feedstock Choices and Landscape Dynamics and Land Use. *Ecological Applications* 21(4):1039-1054.
- Dale, V. H. and K. L. Kline. 2013. Modeling for integrating science and management. Pages 209-240 In D.G. Brown, D. T. Robinson, N. H. F. French, and B.C. Reed (editors), *Land Use and the Carbon Cycle: Advances in Integrated Science, Management, and Policy*, Cambridge University Press.
- Dale VH and KL Kline. 2013. Issues in using landscape indicators to assess land changes. *Ecological Indicators* 28:91-99.
- Dale, VH, MH Langholtz, BM Wesh, and LM Eaton. 2013. Environmental and socioeconomic indicators for bioenergy sustainability as applied to Eucalyptus. *International Journal of Forestry Research*. vol. 2013, Article ID 215276, 10 pages, 2013. doi:10.1155/2013/215276
- Dale VH, RA Efroymsen, KL Kline, M H Langholtz, PN Leiby, GA Oladosu, MR Davis, ME Downing, MR Hilliard. 2013. Indicators for assessing socioeconomic sustainability of bioenergy systems: A short list of practical measures. *Ecological Indicators* 26: 87-102.
- Dale VH, Kline KL, Kaffka SR, and Langeveld JWA. 2013. A landscape perspective on sustainability of agricultural systems. *Landscape Ecology*. (DOI) 10.1007/s10980-012-9814-4 <http://www.springerlink.com/openurl.asp?genre=article&id=doi:10.1007/s10980-012-9814-4>
- Kline KL, GA Oladosu, VH Dale, and AC McBride. 2011. Scientific analysis is essential to assess biofuel policy effects: In response to the paper by Kim and Dale on “Indirect land use change for biofuels: Testing predictions and improving analytical methodologies.” *Biomass and Bioenergy* 35:4488-4491.
- McBride, A, VH Dale, L Baskaran, M Downing, L Eaton, RA Efroymsen, C Garten, KL Kline, H Jager, P Mulholland, E Parish, P Schweizer, and J Storey. 2011. Indicators to support environmental sustainability of bioenergy systems. *Ecological Indicators* 11(5) 1277-1289.
- Parish, ES, Hilliard M, LM Baskaran, VH Dale, NA Griffiths, PJ Mulholland, A Sorokine, ME Downing, R Middleton, NA Thomas. 2012. Multimetric Spatial Optimization of Switchgrass Plantings Across a Watershed. *Biofuels, Bioprod. Bioref.* 6(1):58-72.
- Parish ES, Kodra E, Steinhäuser K, Ganguly AR (2012) Estimating future global per capita water availability based on changes in climate and population. *Computers & Geosciences*. Available online 18 February 2012 at <http://dx.doi.org/10.1016/j.cageo.2012.01.019>

Book Chapters (2011-2013)

- Dale, V. H. and K. L. Kline. 2013. Modeling for integrating science and management. Pages 209-240 *In* D.G. Brown, D. T. Robinson, N. H. F. French, and B.C. Reed (editors), *Land Use and the Carbon Cycle: Advances in Integrated Science, Management, and Policy*, Cambridge University Press.
- Patton-Mallory M, KE Skog, VH Dale. 2013. Integrated forest biorefineries: Sustainability considerations for forest biomass feedstocks. *In* (L. Christopher, ed.) *Integrated Forest Biorefineries*. Royal Society of Chemistry, London, England, pp. 38-55.
- Dale, V.H. 2011. The role of disturbance in seasonally dry tropical forest landscapes. Pages 75-97 *In* W. McShea, J. S. Davies, N. Bhumpakphan (Editors) *The Ecology and Conservation of Seasonally Dry Forests in Asia*. Washington, DC: Smithsonian Institution Scholarly Press.

Workshop Organized

- September 28-30, 2011 – A workshop on “The Billion Ton Study: What can be Learned about Bioenergy Sustainability?” was held at Oak Ridge National Laboratory (ORNL). An all day field trip on the 28th featured demonstration of forest residue collection, the National Transportation Research Center, switchgrass fields, and the Genera Energy LLC Biomass Innovation Park. See <http://www.ornl.gov/sci/ees/cbes/workshop.shtml>
- Virginia Dale served on the Steering Committee/Programming Committee for the SunGrant National Conference on “Science for Biomass Feedstock Production and Utilization” held in October 2-5, 2012, in New Orleans.

Reports

- Efroymson RA, VH Dale, Y Jager, KL Kline, ES Parish, L Baskaran. (2012) Targets for Sustainability Indicators for Biofuels: A report developed to help the DOE national laboratories make progress on the Joule 4 Milestone.
- March 1, 2012: Anthony Turhollow, Allen McBride, Tim Theiss, and Keith Kline -Comments on DOE's review of a draft by the International Energy Agency of their forthcoming Technology Roadmap *Bioenergy for Heat and Power*.
- Jan 20, 2012 - Virginia Dale - Comments on the National Research Council on their report *Advancing Strategic Science: A Spatial Data Infrastructure Roadmap for the U.S. Geological Survey* from National Research Council's Board on Earth Sciences and Resources.
- December 20, 2011 - The final report was distributed for "The Billion Ton Study: What can be Learned about Bioenergy Sustainability?" workshop which was held September 28-30. Full report can be found at <http://www.ornl.gov/sci/ees/cbes/workshop.shtml>.
- National Research Council (Lave LB, Burke IC, Tyner WE, Dale VH, Halvorsen KE, Hill JD, Kaffka SR, Klasing KC, McGovern SJ, Miranowski JA, Patrinos A, Schnoor JL, Schweikhardt DB, Selfa TL, Sohngen BL and Soria JA), 2011. *Renewable Fuel Standard: Potential Economic and Environmental Effects of U.S. Biofuel Policy*. National Academy Press, Washington, D.C.
- 2011 -Debo Oladosu and Keith Kline provided comments to DOE Office of the Biomass Program on the economic indicators proposed by the Global Bioenergy Partnership (GBEP). ORNL recommendations addressed indicators for "Change in Income," "Gross Value Added" and "Net Economic Contribution."
- June 7, 2011 - ORNL submitted comments on GBEP Capacity Building to support an Office of the Biomass Program (OBP) proposal submitted to the State Department.
- Roundtable on Sustainable Biofuels (RSB): 2011 – Keith Kline participated in the RSB Indirect Impacts Expert Group (IIEG) <http://rsb.epfl.ch/lang/en/iieg>
- Virginia Dale contributed to forest chapter of the National Assessment of Climate Change.
- Esther Parish and Virginia Dale contributed information on switchgrass and woody biomass to a report entitled "Sustaining Tennessee in the Face of Climate Change: Grand Challenges and Great Opportunities." Researchers from across the State of Tennessee contributed information to this 72-page report led by ORNL's Climate Change Science Institute (CCSI). The report will be presented to the Mayor of Nashville and other Tennessee leaders in business, government, and nongovernmental organizations at a conference planned for September 11, 2012.

Awards

- April 16, 2013 - Virginia Dale named “Distinguished Landscape Ecologist” by the U.S. Regional Association of the International Association for Landscape Ecology. The award notes that “in her current role as Director of the Center for BioEnergy Sustainability, [Virginia] is focused on land use impacts of biofuel production and the identification of ecological indicators to produce biofuels sustainably. ”
- Feb 8, 2012 - Keith Kline and Virginia Dale received a research Innovation Award from the National Biodiesel Conference: “In this age of skepticism and competition for resources, it behooves us to quantify the environmental benefits in methodical and scientific ways. Keith Kline and Virginia Dale are leaders in scientific thought and published research on the true environmental impact of biodiesel and renewable fuels...”
<http://blog.biodieselconference.org/?p=905>
- The Jason Project won the Best Science or Health Curriculum category at the CODiEs for *Operation: Tectonic Fury* to which ORNL staff contributed. This project was led by Virginia Dale with expert advice provided by Esther Parish. Amy Johnson and Sam Jackson from the University of Tennessee helped engage the middle school students and teacher in sampling soils under switchgrass in fields near Vonore, Tennessee. The soils were analyzed under the guidance of Deanne Brice and Charles Garten. Mike Hilliard and Alex Sorokine shared model results about the sustainability implications of energy crops via the Everest display. Bobby Whitten showed the students how ORNL’s supercomputers are used to expand knowledge. The module *Operation: Tectonic Fury* provides a way for middle school students to use basic science skills to understand how geologic and human forces shape the earth. Because of ORNL’s contributions, farming practices and planting of energy crops are included as influences. The true reward, of course, is knowing that this excellent teaching module will help science come alive in middle schools across the country for many years to come.

Presentations (1)

- May 13, 2013 – Virginia was a keynote speaker at the University of Georgia's Bioenergy Systems Research Institute (BSRI) retreat on "Sustainability and Bioenergy Systems."
- April 14-18, 2013 – Esther Parish and Virginia Dale attended the annual symposium of the US chapter of the International Association of Landscape Ecologists in Austin, TX. Esther presented "Comparing Scales of Environmental Effects from Gasoline and Ethanol Production across Different Ecosystems." Virginia presented "Selecting and Deploying Indicators for Sustainability of Bioenergy Systems."
- April 9-13, 2013 – Latha Baskaran presented "Cross-Scale Analysis of Factors Affecting Aquatic Macroinvertebrate Distribution in Tennessee" at the Association of American Geographers (AAG) annual meeting in Los Angeles, CA.
- April 2-4, 2013 – Virginia Dale was a plenary speaker at the 2013 Conference on Invasion Biology, Ecology and Management Conference in Lexington, KY
- March 18-22, 2013 - Virginia Dale was an invited plenary speaker at the Ecological Society of Mexico annual meeting in Villahermosa, Mexico. At the meeting she
 - Gave plenary lecture on "Developing and Distributing Knowledge Appropriate for Decision Making"
 - Was interviewed by two newspapers: The Herald out of Villahermosa and *La Jornada* out of Mexico City
 - Gave an invited lecture on "Sustainable Bioenergy Challenges and Perspectives" at the Colegio de Postgraduados at the Campus Tabasco in Cardenas, Tabasco, Mexico
 - Lead a Cafés Científicos discussion on "Bioenergy Opportunities in Mexico"
- February 13, 2013 - Virginia Dale presented, "From Disturbance to Sustainability" to the Department of Forestry, Wildlife and Fisheries at the University of Tennessee, Knoxville, TN.
- January 16-17, 2013 – Keith Kline gave a presentation on "Bioenergy Sustainability: Addressing the Science and the Need" at the University of Queensland and then led a workshop on this topic.
- November 5-8, 2012 – At the 9th Biennial Short Rotation Woody Crops Operations Working Group met in Oak Ridge and Knoxville, TN, Virginia Dale gave a presentation on "Environmental and Socioeconomic Indicators for Bioenergy Sustainability as Applied to Short Rotation Woody Crops"
- November 29-Dec 1, 2012: Virginia Dale was a presenter and panelist for the Bioenergy Futures: Technical Feasibility Meets Social Sustainability Workshop, at Michigan State University.
- Sept 18, 2012 -- Rebecca Efrogmson presented "Sustainability Indicators for Bioenergy Systems and Applicability to Genetically Modified Organisms (GMOs)" at the 12th International Symposium on Biosafety of Genetically Modified Organisms in St Louis, MO.
- July 23-24, 2012 - Esther Parish presented a poster on "Designing Bioenergy Cropping Systems to Maximize Sustainability Objectives" at a 60-person workshop on "Visualization Technologies to Support Research on Environment Interactions" held in Annapolis, Maryland by the new National Socio-Environmental Synthesis Center (SESYNC).

Presentations (2)

- July 19, 2012 - Virginia Dale was the keynote speaker at the ORNL Celebration of Women in Science, and her talk was on “From Disturbance to Sustainability: Following Interesting Questions and Fun Opportunities.” Esther Parish presented a poster on “Designing Bioenergy Cropping Systems to Maximize Sustainability Objectives.”
- Aug 5-10, 2012 – Several ORNL participated in the 2012 Ecological Society of America (ESA) Annual Meeting in Portland, Oregon.
 - A Special Session, "A Debate on the Sustainability of Biomass Production for Energy", focused on the proposition “Producing bioenergy can be sustainable for habitat availability and biodiversity, and can eschew the risk of new invaders.” H. Jager was the organizer and R. Efroymson represented the “for” position.
 - Virginia Dale spoke in the Symposium "Bioenergy and Biodiversity: Oxymoron or Opportunity?" on “Environmental and socioeconomic indicators of bioenergy sustainability.”
- July 2, 2012 – Virginia Dale and Keith Kline gave presentations on “Bioenergy Sustainability: Addressing the Science and the Need” for the DOE Biomass Program Staff meeting.
- Aug 24, 2012 – Latha Baskaran presented a talk “Effects of switchgrass related land-use changes on aquatic macroinvertebrates” at the Fishheads seminar series in ORNL.
- May 14-15, 2012: Keith Kline gave a presentation entitled “Indicators to support sustainability assessment of energy systems and biodiversity” at the World Renewable Energy Forum in Denver, Colorado (www.ases.org/conference/).
- May 29-31, 2012: Keith Kline and Virginia Dale attended the National Science Foundation Pan American Research Coordination Network for Biofuels and Bioenergy Sustainability, Merida, Mexico. Keith presented on land-use change analysis and indicators for sustainability. Virginia presented on the sustainability indicators work. Keith and Virginia displayed six posters at the meeting.
- June 20, 2012 - Keith Kline presented “Sustainability, Certification and Opportunities to Level the Playing Field” as invited speaker/panelist at the BIO 2012 International Convention in Boston, MA (<http://convention.bio.org/>).
- June 26, 2012 - Virginia Dale gave a presentation on “Indicators to support assessment of environmental and socioeconomic sustainability of bioenergy systems” to scientists from the University of Arizona who are interested in collaboration opportunities.
- April 24 , 2012 – Virginia Dale and Paul Leiby presented “Indicators to support assessment of socioeconomic sustainability of bioenergy system” to the DOE workshop in Washington, DC on Social Aspects of Bioenergy Sustainability. The presentation was based on the paper developed by VH Dale, RA Efroymson, KL Kline, MH Langholtz, PN Leiby, GA Oladosu, MR Davis, ME Downing, and MR Hilliard. Rebecca Efroymson, Keith Kline and Debo Oladosu also participated in the workshop.

Presentations (3)

- May 8 2012 - In a webinar organized by OBP about the U.S. Department of Energy Biomass Program's recent workshop on the social aspects of bioenergy sustainability in Washington, D.C., Virginia Dale gave a presentation on "Indicators to support assessment of socioeconomic sustainability of bioenergy systems." Rebecca Efroymsen presented summaries regarding knowledge gaps, implementation challenges, and recommendations of one of April 24 Workshop breakout sessions.
- February 22-24, 2012 – Virginia Dale and Matt Langholtz presented a talk on "Environmental and socioeconomic indicators for bioenergy sustainability as applied to Eucalyptus" at symposium on "Assessment and Management of Environmental Issues Related to Eucalyptus Culture in the Southern United States" in Charleston, SC.
- January 30, 2012 – Virginia Dale gave a presentation on "The Potential for Sustainable Deployment of Biofuels Under EISA" at the American Chemical Society (ACS) Science and the Congress briefing on Cellulosic biofuels on Capitol Hill in Washington, DC.
- March 13, 2012 – Rebecca Efroymsen presented "Measuring environmental effects of biofuel production at the BioEnergy Symposium 2012--Transportation Biofuels. Infrastructure, Design, Environment and Sustainability (IDEAS) center at UNC Charlotte
- March 13, 2012 – Rebecca Efroymsen served as a panelist in "A Round-Robin Snapshot: Eight Strong Voices Shape our Biofuels Future," a lunchtime panel at BioEnergy Symposium 2012—Transportation Biofuels. Infrastructure, Design, Environment and Sustainability (IDEAS) Center at UNC Charlotte.
- March 28, 2012—Esther Parish presented "Projecting Continental U.S. Water Stress Based on Global Datasets" at the American Water Resources Association (AWRA) 2012 Spring Specialty Conference on GIS and Water Resources VII, "Managing Climate Change Impacts on Water Resources: Adaptation Issues, Options and Strategies" in New Orleans, LA.
- December 5-9, 2011 – Virginia Dale gave a presentation on the "Land use, energy and climate change nexus" at the American Geophysical Union (AGU) Fall meeting in San Francisco, CA.
- November 17, 2011 – Virginia Dale gave a plenary talk on "Steps towards Bioenergy Sustainability" at the National Science Foundation Emerging Frontiers in Research Innovation, Resilient and Sustainable Infrastructures Program (NSF-EFRI RESIN) Workshop in Champaign, IL. <http://ict.illinois.edu/conferences/RESINworkshop2011/>
- November 10-11, 2011 – Virginia Dale visited Michigan Technological University as a Distinguished Ecologist lecturer in the School of Forest Resources and Environmental Science and gave a lecture on "Steps towards Bioenergy Sustainability."

Presentations (4)

- September 19-21, 2011 - Presentations at the International Energy Agency (IEA) Joint Task 38/40/43 Workshop on "Quantifying and managing land use impacts of bioenergy" in Campinas, Brazil.
 - Keith Kline presented "Top Ten Steps to Improve Quantification of Land-Use Change Effects of Bioenergy Systems"
 - Virginia Dale presented "Indicators to Support Environmental Sustainability of Bioenergy"
 - Maggie Stevens presented a paper by Debo Oladosu and colleagues titled "Empirical Analysis of the Sources of Corn Used for Ethanol Production in the United States: 2001-2009"
 - Keith Kline presented "Moving Forward: Policies to Improve Land Use & Address Social Concerns" and a plenary comment summarizing "Challenges to Certifying Sustainable Bioenergy Production" September 9, 2011 – Keith Kline presented a review of opportunities and synergies between food security and reduced GHG emissions for the workshop on "The Role of Commodity Roundtables & Avoided Forest Conversion in Subnational REDD+" in San Diego, California.
- August 14-18, 2011 – Keith Kline presented "Indicators to support environmental sustainability of agricultural production and bioenergy crops" at the Brazilian Bio-Energy Science and Technology (BBEST) Conference in São Paulo, Brazil
- August 21-25, 2011 – Virginia Dale presented "Integrating climate change with land-use change" at the 4th World Conference on Ecological Restoration of the Society for Ecological Restoration (SER) in Mérida, Mexico.
- May 24, 2011: Keith Kline presented "Bioenergy, Land-Use Change and Food Security" underscoring the opportunities for bioenergy to address multiple development goals in a webinar sponsored by the National Biodiesel Board (www.biodieselsustainability.org).
- June 24, 2011 – Virginia Dale gave a presentation titled "Pathways toward Sustainable Bioenergy" in Howard Baker Center's Energy and Environment speaker series at the University of Tennessee.
- June 14, 2011 – Virginia Dale presented "Environmental Effects of Large-Scale Algal Fuel Production" to the National Research Council Committee on Sustainable Development of Algal Biofuels
- May 2-5, 2011: At the 33rd Symposium on "Biotechnology for Fuels and Chemicals," Seattle, WA. Robin Graham gave a presentation titled "Indicators to Support Environmental Sustainability of Bioenergy Systems."
- May 17-18, 2011: Latha Baskaran attended the Frontiers in Bioenergy conference at Purdue University and gave a presentation on "Evaluating bioenergy sustainability using indicators and a watershed-scale optimization model."

Education and Outreach Presentations

- November 18 , 2012 – Rebecca Efroymson presented on “Environmental Scientists: Who We Are and What We Do” to 3rd, 4th, 5th graders at Haw Creek Elementary School, Asheville, NC.
- October 24-25, 2012 – Virginia Dale was a guest speaker at the University of Tennessee 2012 From Grow to Go: A Biomass Field Day in Vonore, TN.
- Sept 27, 2012 - Virginia Dale gave a presentation to students and teachers from the L&N STEM Academy on “Indicators to support sustainability assessment of energy systems.”
- June 20, 2012 - Virginia Dale gave a presentation on “Indicators to support assessment of sustainability assessment of energy systems” to more than 200 interns at ORNL.
- June 1, 2011 – Virginia Dale gave a presentation to 500 5th-8th grade students and teachers at the Glenville State College, WV on behalf of The Jason Project. <http://www.jason.org>
- October 25, 2011 - Virginia Dale gave a presentation on “Environmental Stewardship” for bioenergy crop production during the Biomass Production Field Day in Vonore, TN, sponsored by the University of Tennessee, the US Dept. of Energy, Genera Energy, Ceres Inc., and DuPont Danisco Cellulosic Ethanol - <http://www.biomassfieldday.com>
- Several webinars and conference calls with high school classrooms

ORNL CBES Forums (1)

(<http://www.ornl.gov/sci/ees/cbes/forums.shtml>)/

- May 8, 2013 – Danny Inman (NREL) - “Land Use Change Modeling using System Dynamics”
- April 18, 2013 – Latha Baskaran "Studying the potential of aquatic macroinvertebrates as indicators of bioenergy-related land-use changes"
- Feb 20, 2013 – Rachel Burton, Senior Associate at MARC-IV presented “Enzyme Catalysis for Biomass Based diesel Fuels”.
- Feb 14, 2013: Carlos Cerri of University of Sao Paulo presented “Measuring environmental sustainability indicators in land use change for sugarcane ethanol production in Brazil”
- October 18, 2102 – Robert Fletcher from the University of presented “Bioenergy expansion: A Wildlife perspective.”
- November 8, 2012 – Lynn Wright from Wright LinkConsulting presented “Energy Crop Resource and Technology Development: A Historical Perspective 1978-2012.
- December 20, 2102 – Rebecca Efroymson presented “Sustainable Development of Algal Biofuels”.
- September 20, 2012 – Xuesong Zhang from Pacific Northwest National Laboratory (PNNL) presented “Balancing Human Needs and Ecosystem Services to Develop a Sustainable Biofuels Industry: A Modeling Systems Approach.”
- Aug 16, 2012 – Mike Jostrom, Director of Renewable Resources for Plum Creek Timber Company presented “Vested in Carbon: Perspectives of a Large US Forest Owner.”
- July 26, 2012 – Danny Inman from the National Renewable Energy Laboratory (NREL) presented “Biofuel Sustainability Analysis.”.
- July 16, 2012 – Siwa Msangi, Senior Research Fellow from the International Food Policy Research Institute, Washington D.C., presented “Biofuels, Agriculture and Food Security: Key Connections and Challenges” at a special CBES forum.
- June 7, 2012: Ariel Uribe Rodriguez and Edgar Castillo from the Colombian Petroleum Institute will present "Energy Diversification Program at ECOPETROL" Topics that will be discussed: Advanced Biofuels, Heat and Power generation from Biomass and Renewables (Proposal) and Energy Efficiency in upstream operations".
- June 21, 2012: Natalie Griffiths (ORNL) and Matt Langholtz (ORNL) "Examining the effects of short-rotation pine for bioenergy on water quality and quantity using a watershed-scale experiment"
- May 21, 2012: Marcelo Moreira from the Institute for International Trade Negotiations, Brazil will present "Coupling GIS and economic data into land use models: The Brazilian Land Use Model experience"

ORNL CBES Forums (2)

(<http://www.ornl.gov/sci/ees/cbes/forums.shtml>)

- May 17, 2012: Charles Kwit, "Gene flow matters in switchgrass (*Panicum virgatum* L.), a potential widespread biofuel feedstock"
- May 10, 2012: Bobby Grisso "Outreach Delivery as Part of Bioenergy Education".
- April 19, 2012: John Schwartz (UT) and Zachariah Seiden (UT), "Study Design for Water Quality Monitoring from Switchgrass Fields near Vonore, Tennessee: Support for SWAT and BLOSM Models"
- March 15, 2012 – James Szybist from National Transportation Research Center (NTRC) presented “Impacts of Emerging Engine and Fuel Technologies on the Efficiency of Future Engines.” .
- February 16, 2012 – Brian Davison from BESC presented on behalf of Paul Gilna “How BESC relates to Sustainability.”
- January 19, 2012 – Scott Curran from NTRC presented “Performance of Advanced Combustion Modes with Alternative Fuels: Reactivity Controlled compression Ignition Case Study.
- December 15, 2011 – “Southeastern Partnership for Integrated Biomass Supply Systems” presented by Tim Rials, Director of the Center for Renewable Carbon, University of Tennessee.
- November 17, 2011 – Four 5-10 minute panel presentations on “Sustainability Considerations for the Oak Ridge National Laboratory Biomass Steam Plant Feedstock Supply” was presented by ORNL staff; Elliott Barnett, Mark Downing, Matt Langholtz and Erin Webb.
- October 20, 2011 – Jacob LaRiviere, Assistant Professor of Economics at the University of Tennessee presented “The Effect of Ethanol on Fuel Price Behavior and the Viability of Cellulosic Biofuels”.
- June 16, 2011: Jody Endres from the Law and Regulation Program at the Energy Biosciences Institute at the University of Illinois presented “A legal typology of sustainable biomass definitions in U.S. law, and other theoretical perspectives.”
- May 19, 2011: Ken Goddard, University of Tennessee’s Extension Biofuels Specialist, presented “Growing and Harvesting Switchgrass for Ethanol Production in Tennessee”
- May 12, 2011: Luis A.B. Cortez, of University of Campinas, Brazil discussed the potential for bioenergy expansion in Latin America and Africa (the LACAF Project).
- April 21, 2011: Elena Berger, a postdoctoral fellow at the Georgia Tech School of Public Policy, doing research at the Technology Policy Assessment Center (TPAC) presented “Dynamics of Innovation of Biofuel Ethanol: Three decades of experience in the U.S. and in Brazil”