Science-based approaches to improve understanding of LUC and guide decisions toward positive outcomes

BETO Analysis & Sustainability Webinar

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DOE Bioenergy Technologies Office
Virginia H. Dale and ORNL CBES team

http://www.ornl.gov/sci/ees/cbes/
This presentation is based on:

07 June 2016 presentation in the Workshop: The world needs more land-use change

24th European Biomass Conference and Exhibit (EUBCE 2016)

http://www.eubce.com/parallel-events/workshops/the-world-needs-more-land-use-change.html
Toward positive LUC outcomes: How to get there from here?

- Science-based information to guide decisions
  - Indicators
  - Causal analysis
  - Standards
- Process of monitoring, analysis & continual improvement
- Discussion & examples
  - Natural climate mitigation
  - Food, fuel and other services
  - Guatemala
  - Climate-smart soils
  - Are food prices increasing?

Photo by Kline: LUC near Atlanta, GA
Science-based analysis to guide decisions

Science: systematic methodology based on evidence and observation

- Start with clear definition of problem
- Ask right questions
- Test hypotheses
- Conduct critical analysis
- Determine cause and effect
- Document verifiable, replicable results
- Build on experience and learn from others

- Confounding data and terminology
  - Land cover versus land uses (multiple) and management
  - Crop price and trade versus total production and actual uses, losses
  - Correlation versus causation

- Science evolves as new data and understanding become available
- Targeted data collection
Environmental indicators for bioenergy sustainability & associated ecosystem services

<table>
<thead>
<tr>
<th>Category</th>
<th>Ecosystem service: type</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil quality</td>
<td>Supporting and regulating service: soil quality</td>
<td>Total organic carbon (TOC)</td>
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<td>Total nitrogen (N)</td>
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<td>Extractable phosphorus (P)</td>
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<td>Bulk density</td>
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<td>Water quality and quantity</td>
<td>Regulating service: drinking water; Cultural service: recreation</td>
<td>Nitrate concentration in streams</td>
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<td>Total phosphorus (P) concentration in streams</td>
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<td>Suspended sediment concentration in streams</td>
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<td>Herbicide concentration in streams</td>
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<td>Peak storm flow</td>
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<td>Minimum base flow</td>
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<td>Consumptive water use (incorporates base flow)</td>
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</tbody>
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| Greenhouse gases       | Regulating services: carbon sequestration and climate regulation                       | CO₂ equivalent emissions (CO₂ and N₂O) |
| Bio-diversity          | Regulating services: biodiversity, pollination, seed dispersal, pest mitigation; Supporting service: habitat | Presence of taxa of special concern |
| Air quality            | Supporting and regulating service: air quality                                         | Habitat area of taxa of special concern |
| Productivity           | Production services: food, feed, fiber and fuel                                       | Yield                              |

McBride et al. (2013) & Dale et al. (submitted 2016)
## Socioeconomic indicators for bioenergy sustainability & associated ecosystem service

<table>
<thead>
<tr>
<th>Category</th>
<th>Ecosystem service: type</th>
<th>Indicator</th>
<th>Profitability</th>
<th>Provisioning services:</th>
<th>Resource conservation</th>
<th>Social acceptability</th>
<th>External trade</th>
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</thead>
<tbody>
<tr>
<td>Social well-being</td>
<td>Cultural services:</td>
<td>Employment</td>
<td>Profitability</td>
<td>Provisioning services:</td>
<td>Resource conservation</td>
<td>Social acceptability</td>
<td>External trade</td>
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<td>jobs and family income; Provisioning service: food</td>
<td>Household income</td>
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<td>services: food, feed, fuel and fiber</td>
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<td>Food, feed, fuel and fiber</td>
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<td>Energy security</td>
<td>Provisioning service:</td>
<td>Work days lost due to injury</td>
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<td>Provisioning services:</td>
<td>Depletion of non- renewable energy resources</td>
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<td></td>
<td>energy</td>
<td>Food security</td>
<td></td>
<td>services: fuel, chemicals, plastics</td>
<td>Fossil Energy Return on Investment (fossil EROI)</td>
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<td>External trade</td>
<td>Provisioning services:</td>
<td>Terms of trade</td>
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<td>Provisioning services:</td>
<td>Public opinion</td>
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<td></td>
<td>food, feed, fuel and fiber</td>
<td>Trade volume</td>
<td>Return on investment (ROI)</td>
<td>services: food, feed, fuel and fiber</td>
<td>Transparency</td>
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<td>Net present value (NPV)</td>
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Dale et al. (2015; and submitted 2016)
Causal Analysis

(Efroymson et al. Accepted 2016 in Land Use Policy)

Generate pathway diagrams for potential causes

Generate hypotheses for causes of specified change

Analyze strength of evidence to determine probable causes
- Mechanistically plausible cause
- Complete pathway
- Spatial co-occurrence
- Time order
- Analogous agents
- Simulation model results
- Agent-response relationships

Allocate proportional causation

State problem

Characterize historic trends

Determine data sufficiency
Policies to Boost Solid Biomass (IRENA)

• **Accelerate improvement of crop yields:**
  – How to promote higher yields with low commodity prices to growers and 40% waste in food systems?

• **Collect comprehensive data on land** that could be used for sustainable **wood and grass crops**, including likely yields.
  – Where is land the constraint? [not globally; see 2015 SCOPE report]
  – Do we understand how land management can accelerate carbon storage **AND** productivity, and strengthen terrestrial sinks? (e.g., Woodall et al. 2015)

• **Research practices for cultivating rapidly growing trees and grasses on pastureland…** – grown for what markets?
  – Millions of hectares of pasture burn each year to eliminate encroaching vegetation

• **Institute more secure land tenure and better governance** to provide incentives for more intensive land management. – **YES!**

• **Provide Incentives to plant trees on degraded lands.**
  – *What incentives work best? Who benefits?*
  – *Can markets provide the right signals?*
  – *Is certification the answer?*

IEA Bioenergy Joint Task Meeting Question: “Can certification ensure sustainability?”

“No” because –

1. Nothing can ensure sustainability.
2. There are many opportunities for substitution in biomass markets
3. Transaction costs for certification, monitoring and verification are high relative to the value of the product (biomass)
4. Uncertainties about sustaining political will and market premiums
5. Even well-designed schemes can be “gamed,” and a few well-publicized cases undermine credibility.
Can policies applying standards and certification *facilitate* the transition toward sustainability?"

“*Yes, if*” it

1. Is *developed with users* as a cost-effective tool that meets their needs
2. Provides feedback to guide production toward *continual improvement* from users’ perspectives
3. Is designed to *adapt* to changing contexts and priorities
4. Is *inclusive*
5. Is *supported* by government, civil society, and financial incentives
ASTM Standard Practice for Assessing Relative Sustainability (2016 draft, Committee E48)

• Guidance on process for assessments:
  – relevance to local needs
  – information necessary to support continual improvement
  – replicable, measurable and verifiable indicators are not predetermined, and
  – support fair comparisons and informed choices.

• Certification schemes can differentiate products but
  – Are outcomes – documents and labels – what society really wants?
  – Who benefits?

See: https://www.astm.org/COMMITTEE/E48.htm
Framework to Support More Sustainable Outcomes

1. Determine selection criteria, list options
2. Identify & rank options that meet criteria
3. Conduct assessment
4. Identify gaps in ability to address goals & objectives
5. Determine whether objectives are being achieved
6. If no, define sub-objectives, timeline
7. If yes, determine baselines & targets
8. Compare to goals and values for indicators
9. Assess lessons learned & identify good practices

- Monitoring and feedback support continual improvement

- Information as determined by:
  - Available data
  - Resources needed to collect & assemble required data

- Training and tech resources support:
  - Data collection, portfolio of options, assessments

Sustainable bioeconomy contributes to SDGs addressing 

1 poverty, 2 food security and nutrition, 3 health, 5 gender, 6 water and sanitation, 7 affordable and clean energy, 8 jobs, 12 sustainable consumption/production, 13 climate change, 14 oceans, seas and marine resources, 15 terrestrial eco-systems, forests, land degradation and biodiversity, and 16 strengthened institutions.

Souza et al. 2015

[Link](http://sd.iisd.org/news/iaeg-sdgs-sets-workplan-for-finalizing-indicators/)
Challenge: As long as hunger continues around the world, concerns about food security will persist.
Food security

*International workshop set forth key issues*

• Identify synergies – for example
  – Flex crops can be used for food or fuel
  – Rural infrastructure supports food & fuel
  – Sustainable resource management

• Frame the problem:
  Ask the questions that matter

• Use clear terminology
  – Workshop report and publication in GCB-Bioenergy (Kline et al 2016)

http://www.ifpri.org/event/workshop-biofuels-and-food-security-interactions
The nexus between biofuel sustainability and food security invokes a focus on resource management.

(Kline et al. 2016)
Attributes of the nexus

- Good governance
- Infrastructure & technology
- Integrated crop management
- Ecosystem services
- Social services
- Resilience to extreme events

(Kline et al. 2016)
At the nexus of food security and sustainable bioenergy:

- Address rural poverty
- Diversify crops and sources of income
- Improve productivity
Challenge: As long as deforestation continues, concerns about LUC will persist. Maya Biosphere Reserve, Guatemala: Habitat loss, contamination of water and soil, and new settlements are legacies of oil, not agriculture.
Climate-smart soils

Markets for biomass and a bioeconomy support additional “yes” responses. And

a. Outreach & awareness
b. Practices that increase
   • Productivity
   • Soil carbon
c. Long-term rotation of trees with annuals to store more carbon, deeper, in more stable forms, than what would occur without ‘LUC’
d. Understanding that it’s not generic “LUC” that matters, but how matter changes that matters

Chart from Paustian et al. (2016) *Nature*
Steps to encourage beneficial LUC

- Give biomass value! Reduce losses
  - Fires and other disturbances
  - Wastes
- Legal and financial motivations to invest in and adopt better management practices
- Pathways to “natural climate mitigation”
  - Better management of occupied lands
  - Conserve remaining forests (no new roads!)
  - Restore and replant former forest lands
  - Create value-added jobs and services that reduce pressure on isolated forest frontiers (reduced deforestation) in LDCs
- Accelerate shifts to ever higher performing urban and integrated agro-silvo-pastoral systems
- Increase scrutiny, awareness and enforcement to end illicit land-management activities
- Apply same performance criteria to all sources of energy and all land management (food, feed, fiber, energy...
Conclusion: Plenty of biomass, inadequate rewards for good management

We need to
• Learn from experiences
• Build local partnerships
• Develop and apply a suite of metrics that reflect local stakeholder priorities for “sustainability”

Interesting discussion ensued with audience incl. JRC research staff on ILUC and food prices

Q&A and discussion illustrated:

• Disparate concepts of what ILUC represents
• Lack of agreement on
  ➢ Definitions
  ➢ Facts

Source: Kline notes on discussion following EUBCE Workshop June 2016. Some argued prices are declining, others that prices are increasing. This USDA price index used 1978 as ref. point.

Indexes based on identical source data sets can tell many different stories, depending on what reference point is chosen as the initial point of comparison and how interest rates are handled.
Interesting discussion ensued with JRC research staff on ILUC and food prices

Are food prices increasing?

FAO global Food Price Index (FPI) based on commodities versus the FAO global food Consumer Price Index (CPI), 2000-2015 (FAOStat, 2015). % change is relative to the 2002-2004 average for FPI and year 2000 for CPI. The food CPI increased at an average annual rate of 6% over 2000-2015, while the average annual global FPI varied sharply and was negative in 7 of the 15 years.

Source: Kline et al. 2016 Fig. 1 “Food security – bioenergy interactions"
Interesting discussion ensued
Are food prices increasing?
Define food. What are the right questions to ask?

Source: Kline et al. 2016 Fig. 1 “Food security – bioenergy interactions"
Interesting discussion ensued

Are food prices increasing?
Why do we care? Assumed relationships?

Source: Kline et al. 2016 Fig. 1 “Food security – bioenergy interactions
Figure Global food commodity price indices (1866-2008 per Sumner 2009) and Famine Index based on the average famine deaths reported by decade, (average for 1900-2010 = 100; index calculated based on Roser 2015) Chart prepared by Kline for draft MS on Food Security-Bioenergy interactions
Thank you

Center for Bioenergy Sustainability
http://www.ornl.gov/sci/ees/cbes/

See CBES website for
• Reports
• Forums on current topics
• Recent publications


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The views in this presentation are those of the author/presenter who is responsible for any errors or omissions.
“memorable” musical introduction from EUBCE:

What the world needs now is land-use change  
Not what you were thinking of, but the kind we all can love

What the world needs now is land-use change  
Growing more crops and trees, can provide for many needs

What our lands need now is more science-based love  
That’s the only thing that there’s just too little of

To the tune of, “What the world needs now is love,” with apologies to Jackie Deshannon, author of original lyrics (below). Note: the original lyrics are great, and fit the thoughts above. Indeed, these were on my mind when we conceptualized this workshop last November. -KLK

What the world needs now is love, sweet love,  It’s the only thing that there’s just too little of
What the world needs now is love, sweet love,  No, not just for some but for everyone…

Lord, we don't need another meadow  
There are cornfields and wheat fields enough to grow  
There are sunbeams and moonbeams enough to shine  
Oh, listen, lord, if you want to know

What the world needs now is love, sweet love  
It's the only thing that there's just too little of  
What the world needs now is love, sweet love  
No, not just for some, oh, but just for ever, every, everyone
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BOOSTING BIOFUELS
Sustainable Paths to Greater Energy Security

- Close yield gaps
- Better use and management of pasture, marginal land
- Reduce food chain losses
- Forestry
BETO Bioenergy research at ORNL-CBES

- Advance common definitions of environmental & socioeconomic costs & benefits of bioenergy systems
- Quantify opportunities, risks, & tradeoffs associated with bioenergy production in specific contexts
- Support efforts to improve stainability assessment via agreements on definitions, criteria, baseline & targets & a manageable set of relevant indicators
- Support improved standards, recognizing that certification ≠ sustainability

Enable long-term supply of renewable biomass for clean, domestic bioenergy