US Department of Energy webinar

Biofuels for the Environment and Communities

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Earth Day
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http://www.ornl.gov/sci/ees/cbes/

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U.S. DEPARTMENT OF ENERGY

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Discussion Topics

- Assessment of sustainability costs and benefits requires
  - Common understanding of "sustainability"
  - Measurable indicators
- Landscape design for sustainable bioenergy is a path forward that
  - Engages stakeholders
  - Uses adaptive management

William Bruce Cameron:
"Not everything that can be counted counts, and not everything than can be counted should be counted."

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Overall Approach

Code for checks	
✔	Completed
✔	Tested in East TN
✔	Reviewed

From the Multi-Year Program Plan DOE's Bioenergy Technologies Office

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Focusing on Bioenergy Sustainability Brings Together Disparate Perspectives

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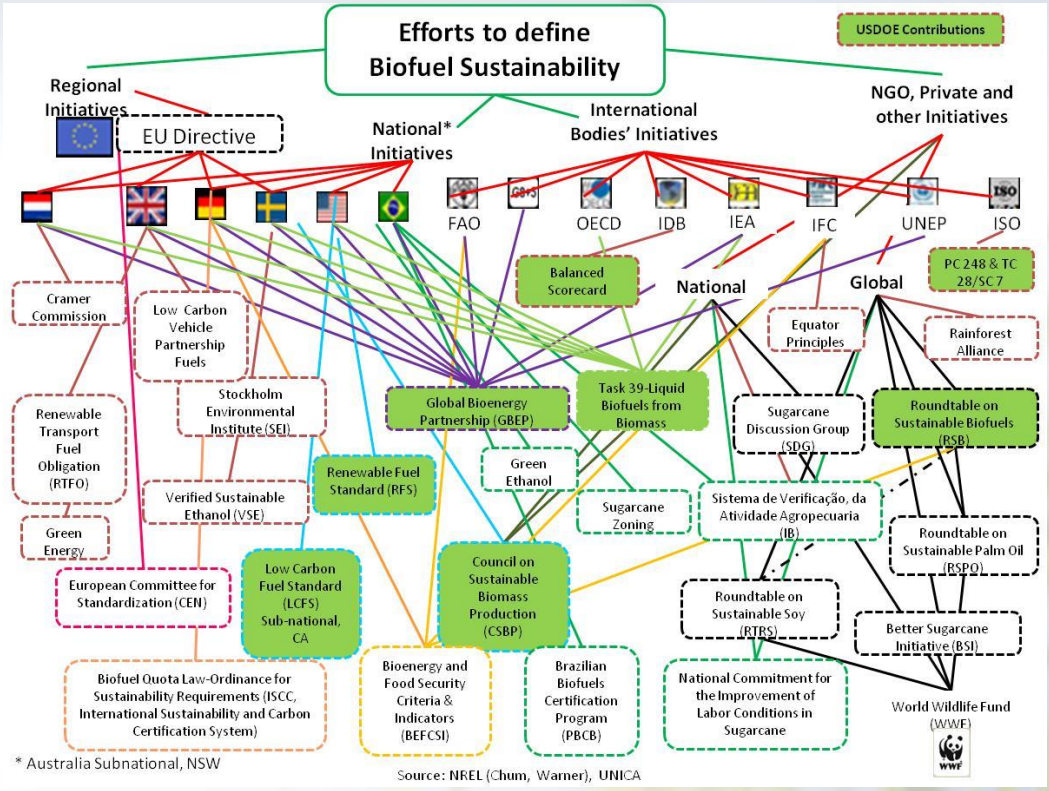
Many Initiatives are Exploring Indicators for Assessing Sustainability of Bioenergy



BUT

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

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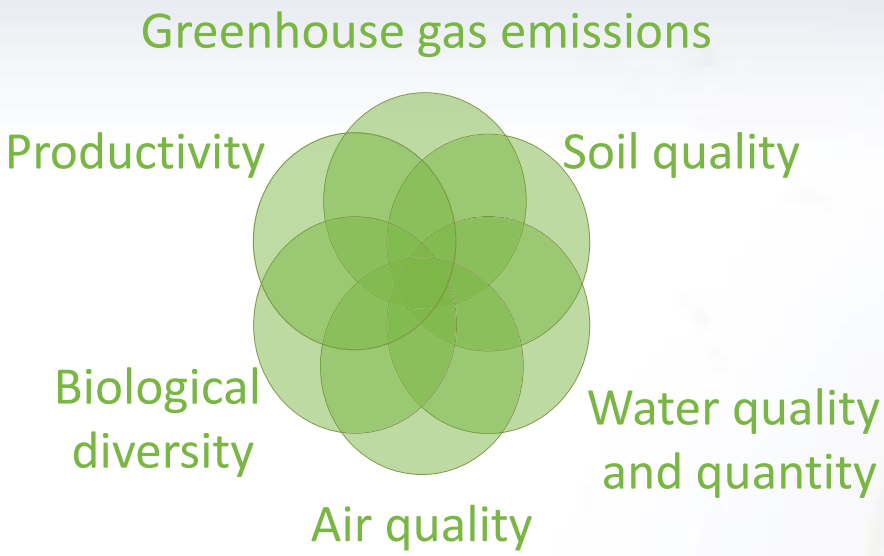
Categories for Indicators of Environmental and Socioeconomic Sustainability



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

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

Recognize that measures and interpretations are <u>context</u> specific

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

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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_2O)	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 ($PM_{2.5}$)	$\mu g/m^3$
	18. Total particulate matter less than 10µm diameter (PM_{10})	$\mu g/m^3$
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
	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 outputt
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.

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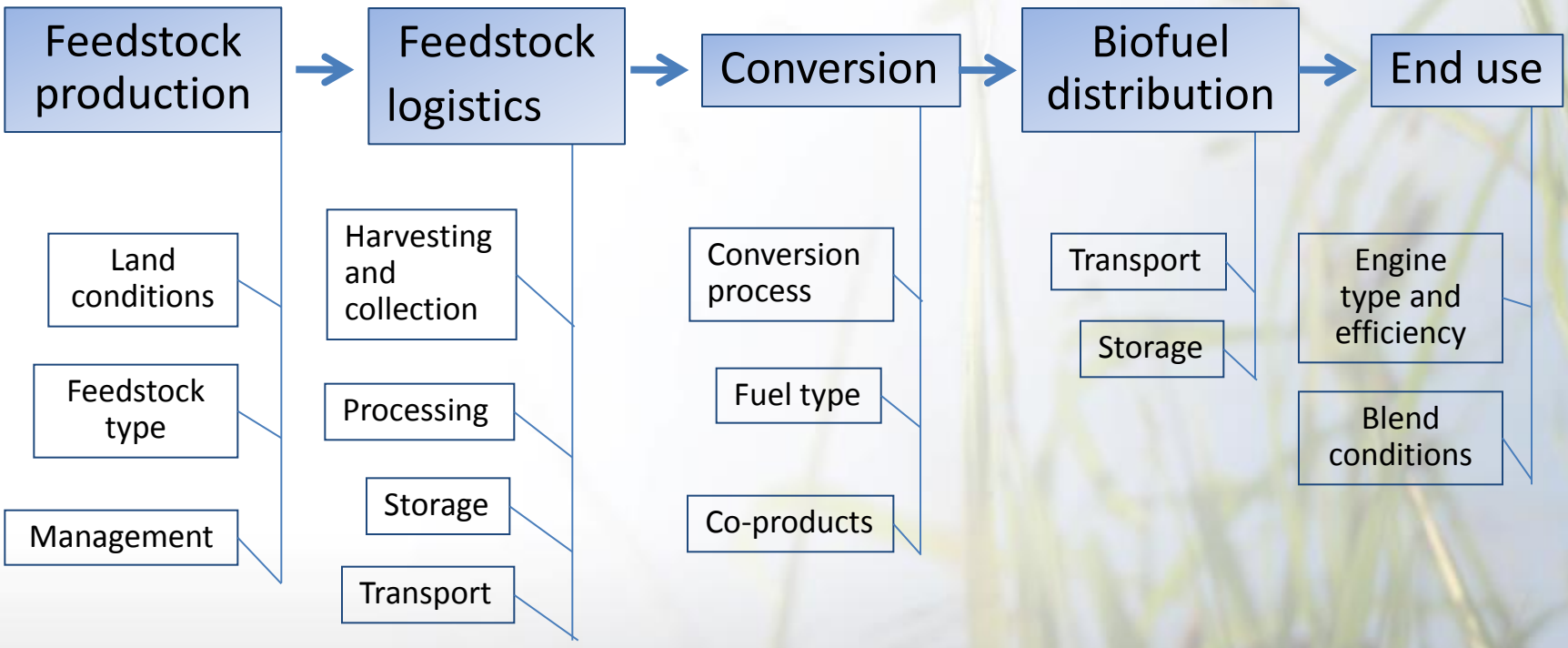
Sustainability Should Apply to

- Entire supply chain
- Diverse feedstocks
- All conversion pathways



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

Dale et al. (2013) *Environmental Management* 51: 279-290.

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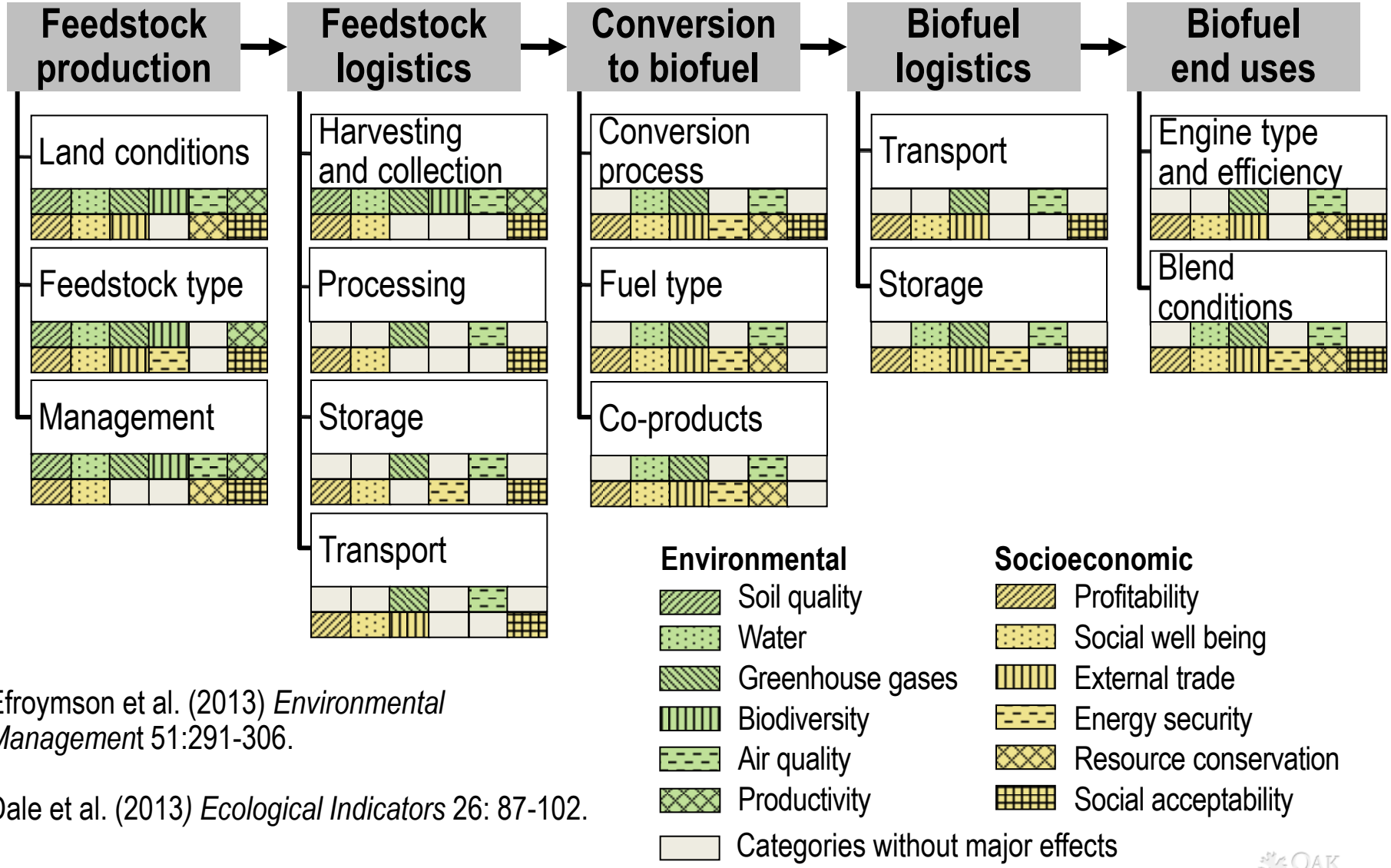
Biofuel Supply Chain in View of Indicators



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

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

Adapting Suite to Particular Contexts

- **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
  - Some indicators more important for different supply chain steps
- **Protocols must be context-specific**

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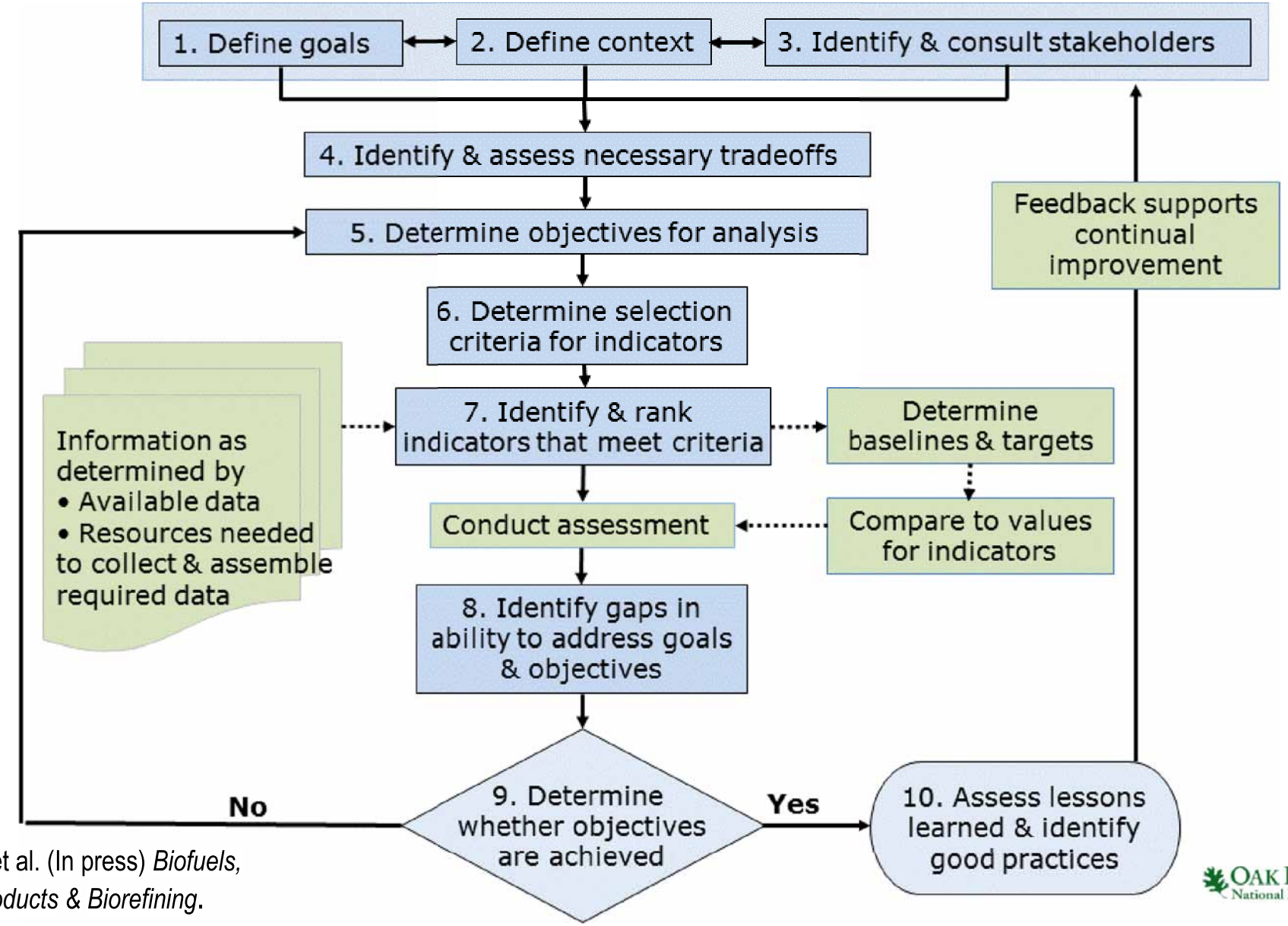
Framework for Selecting Indicators



Dale et al. (In press) *Biofuels, Bioproducts & Biorefining*.

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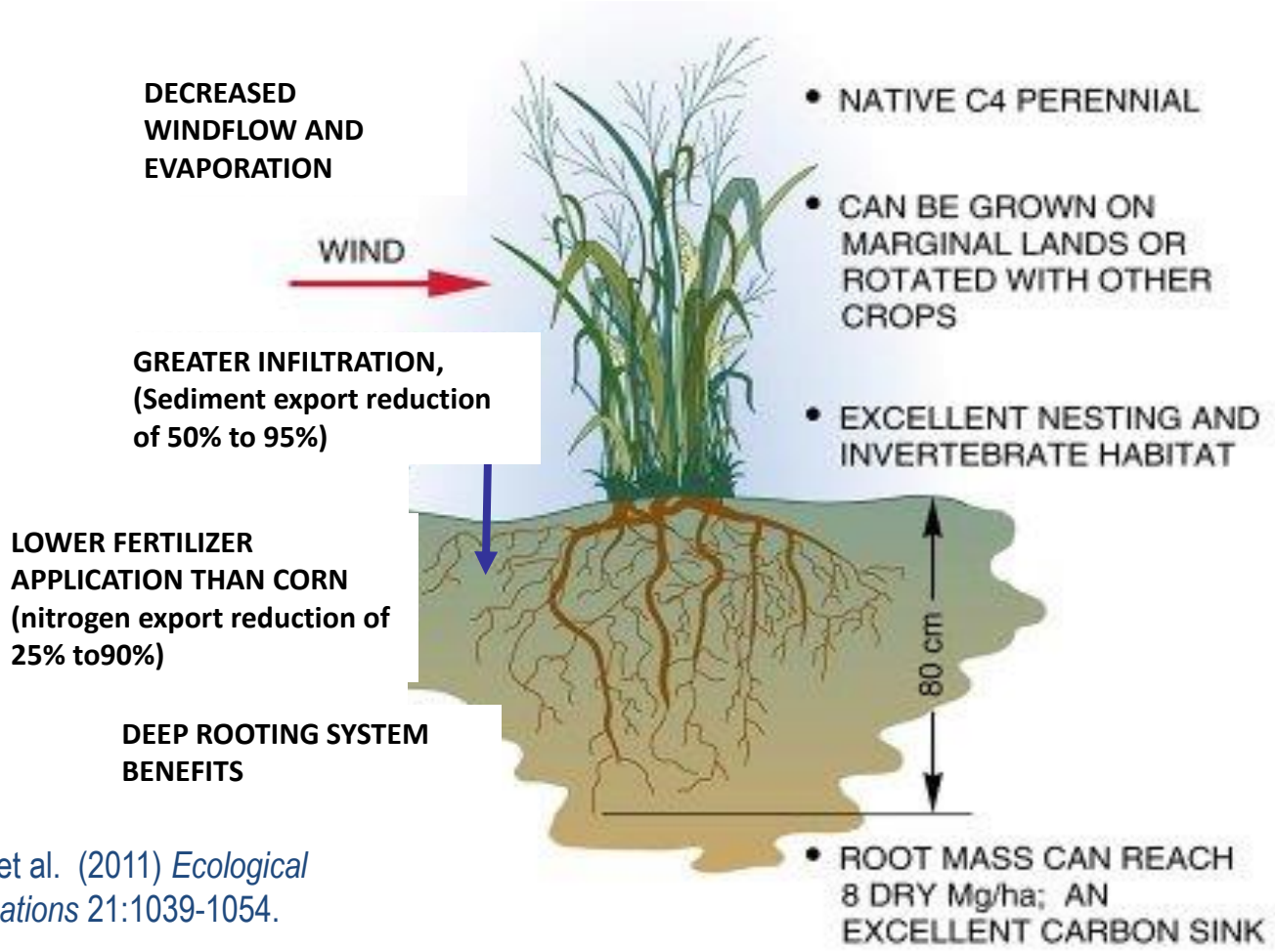
Sustainability benefits of switchgrass (a "model" perennial crop)

Note: Specific crops are appropriate for different conditions



Dale et al. (2011) *Ecological Applications* 21:1039-1054.

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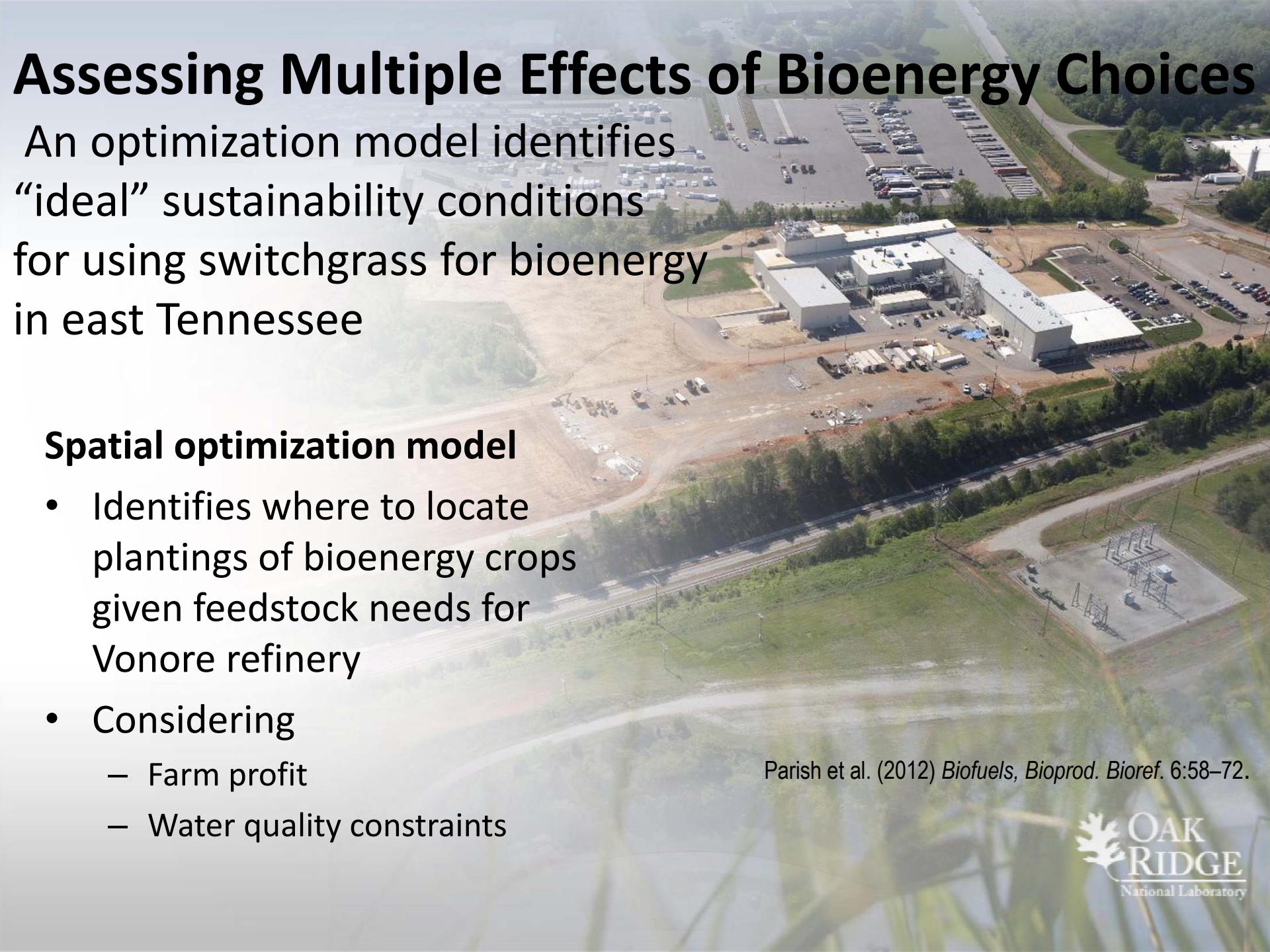
Assessing Multiple Effects of Bioenergy Choices

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

Parish et al. (2012) *Biofuels, Bioprod. Bioref*. 6:58–72.

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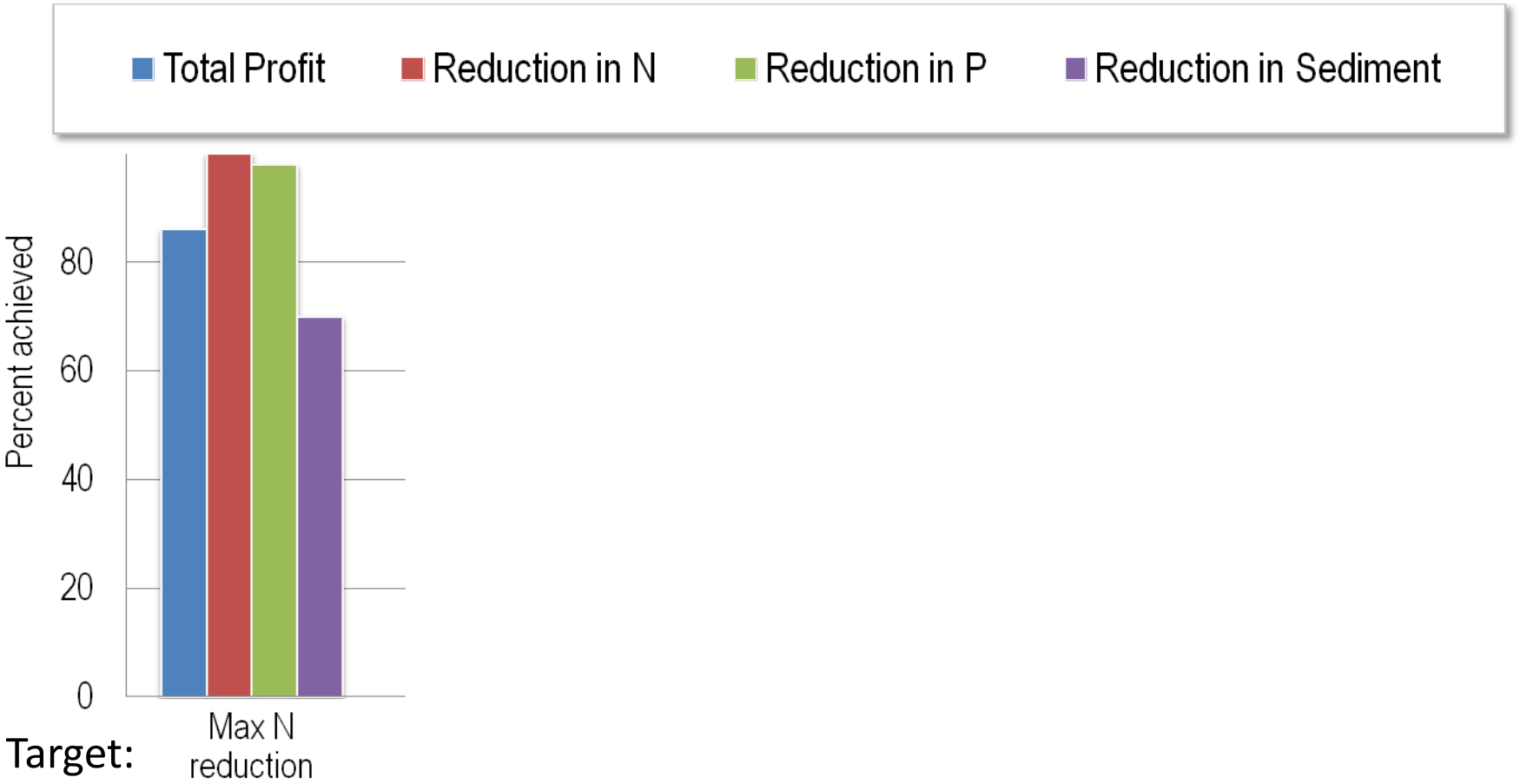
Balancing Objectives: Location of plantings may improve water quality & increase profits while achieving feedstock-production goal



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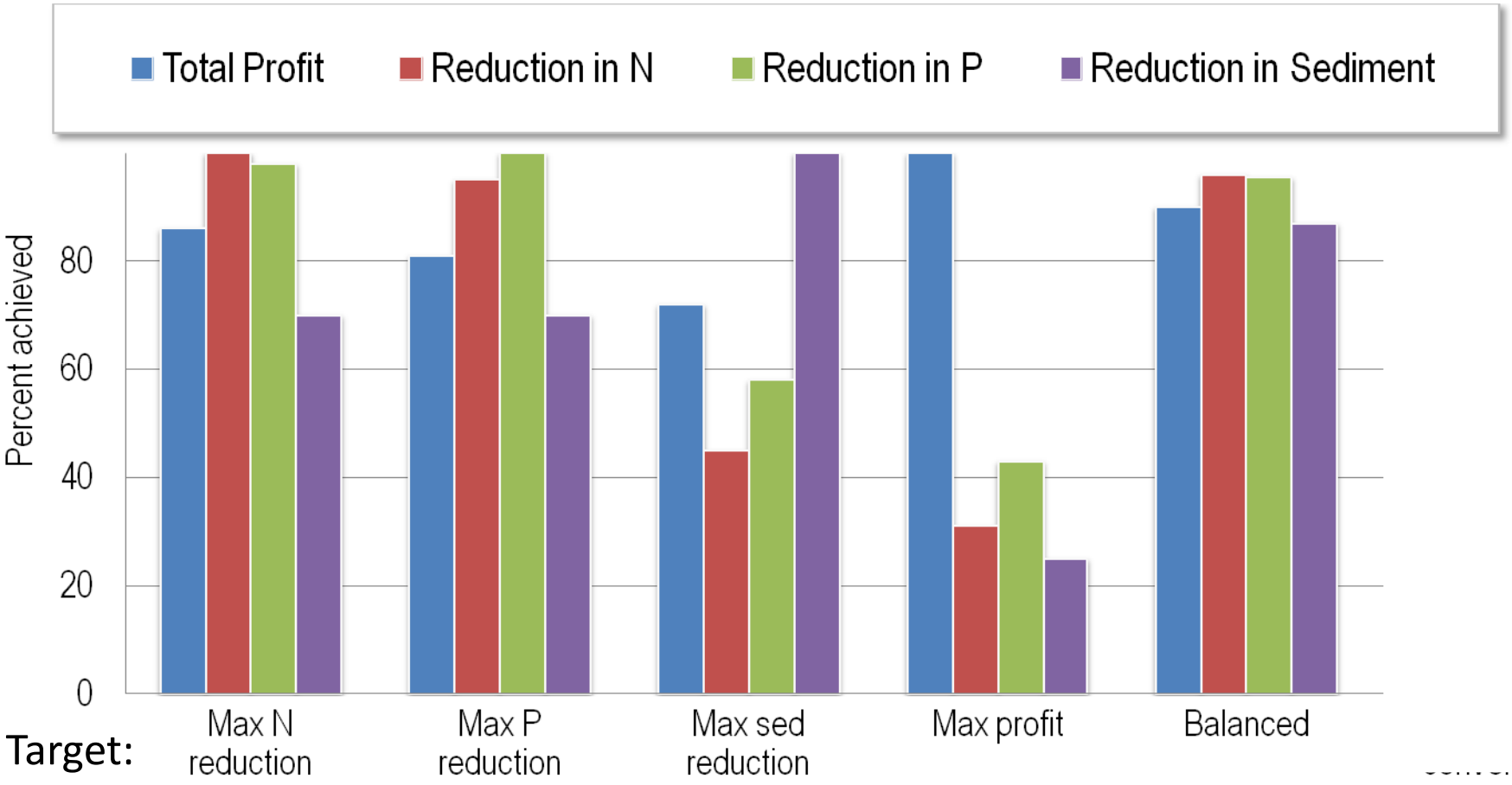

Land area recommended for switchgrass in this watershed:
1.3% of the total area (3,546 ha of 272,750 ha)

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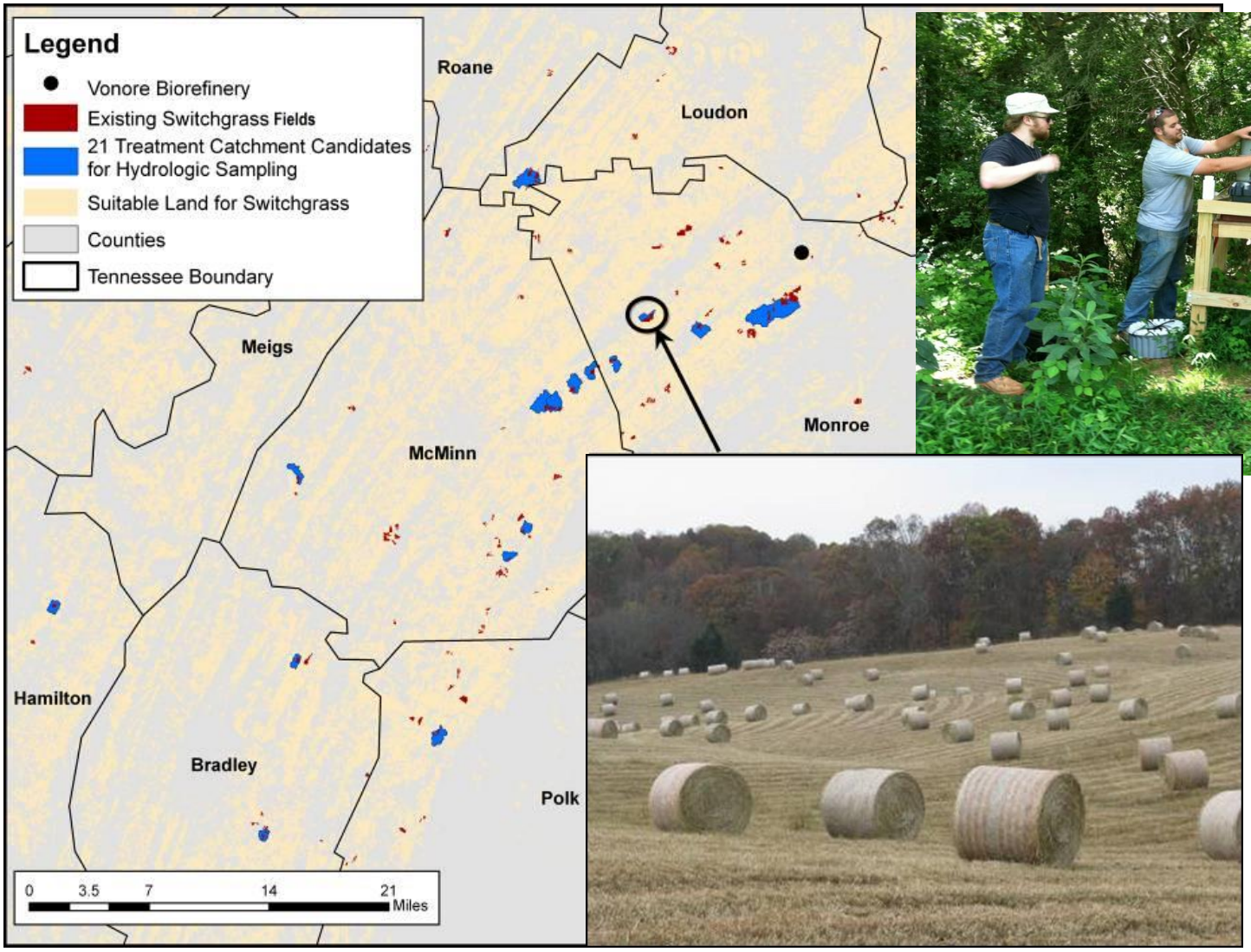
Using Multi-Attribute Decision Support System (MADSS): to compare sustainability of 3 scenarios in east Tennessee

Leverages data from SE Partnership for Integrated Biomass Supply Systems (IBSS)



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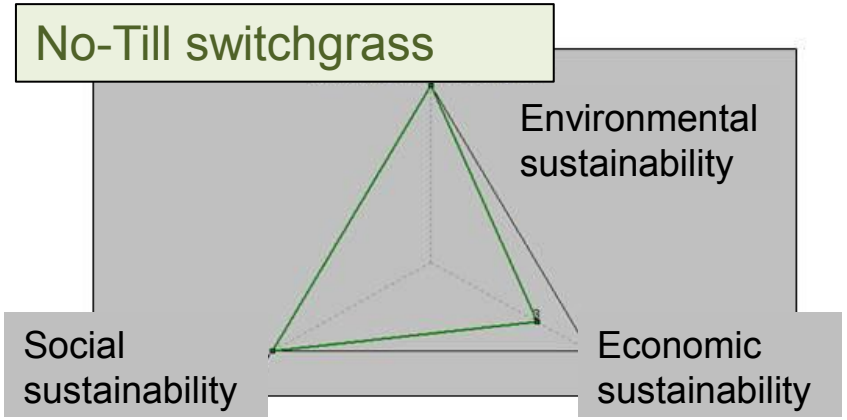
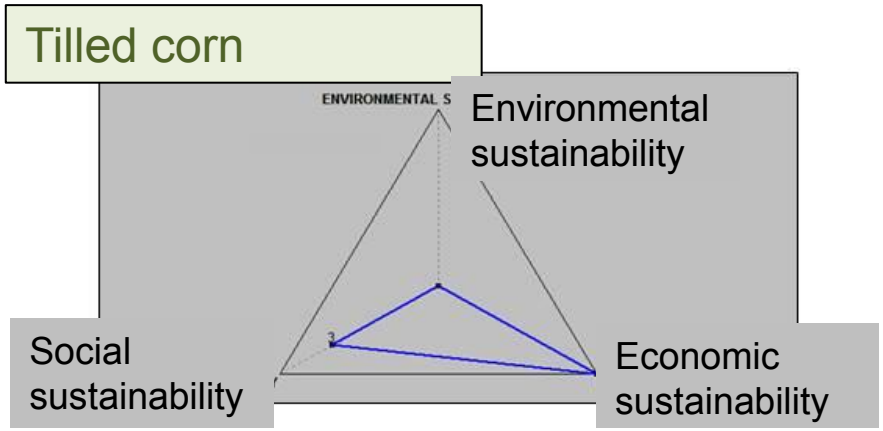
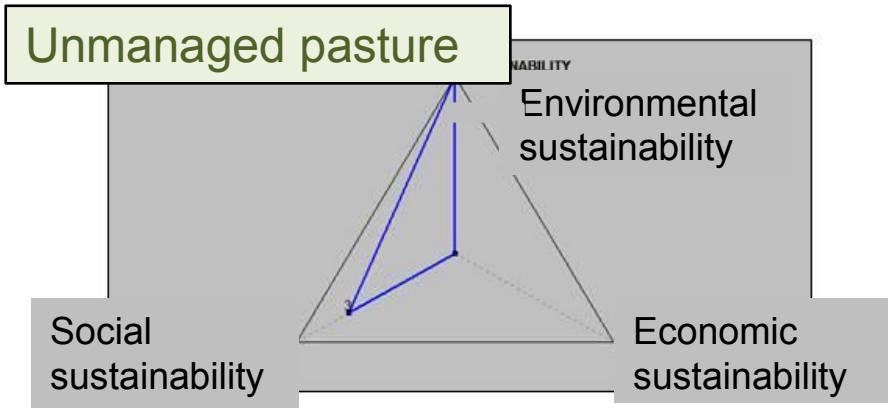
Case Study of MADSS Applied to East TN:

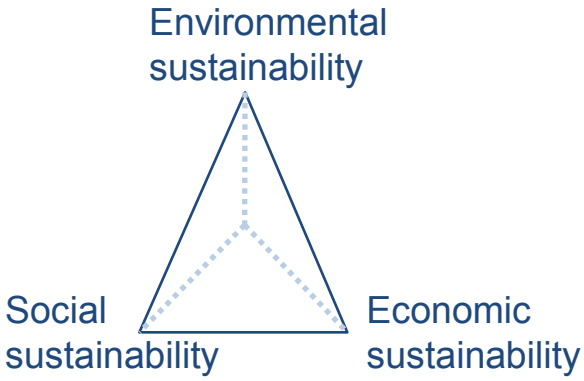
Determines relative contributions of three "pillars" to overall sustainability







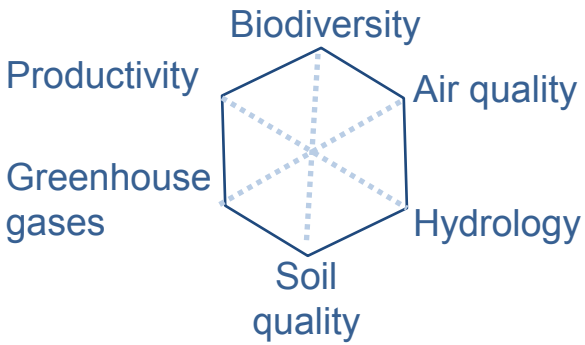
Key to chart

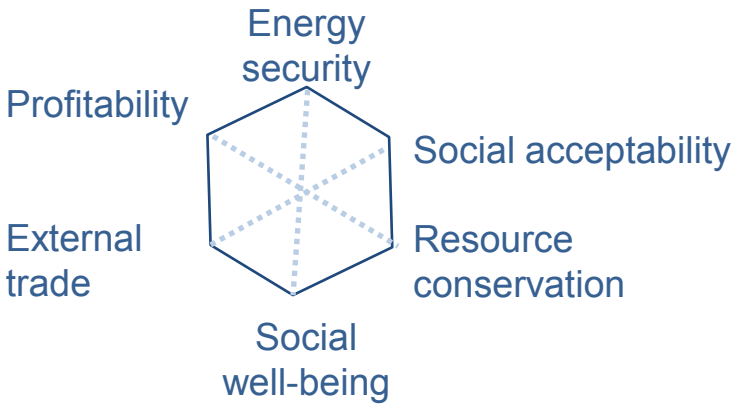


Parish et al. (In review) Ecosphere.

Case Study in East TN:
Rates environmental & socioeconomic sustainability

Key to chart





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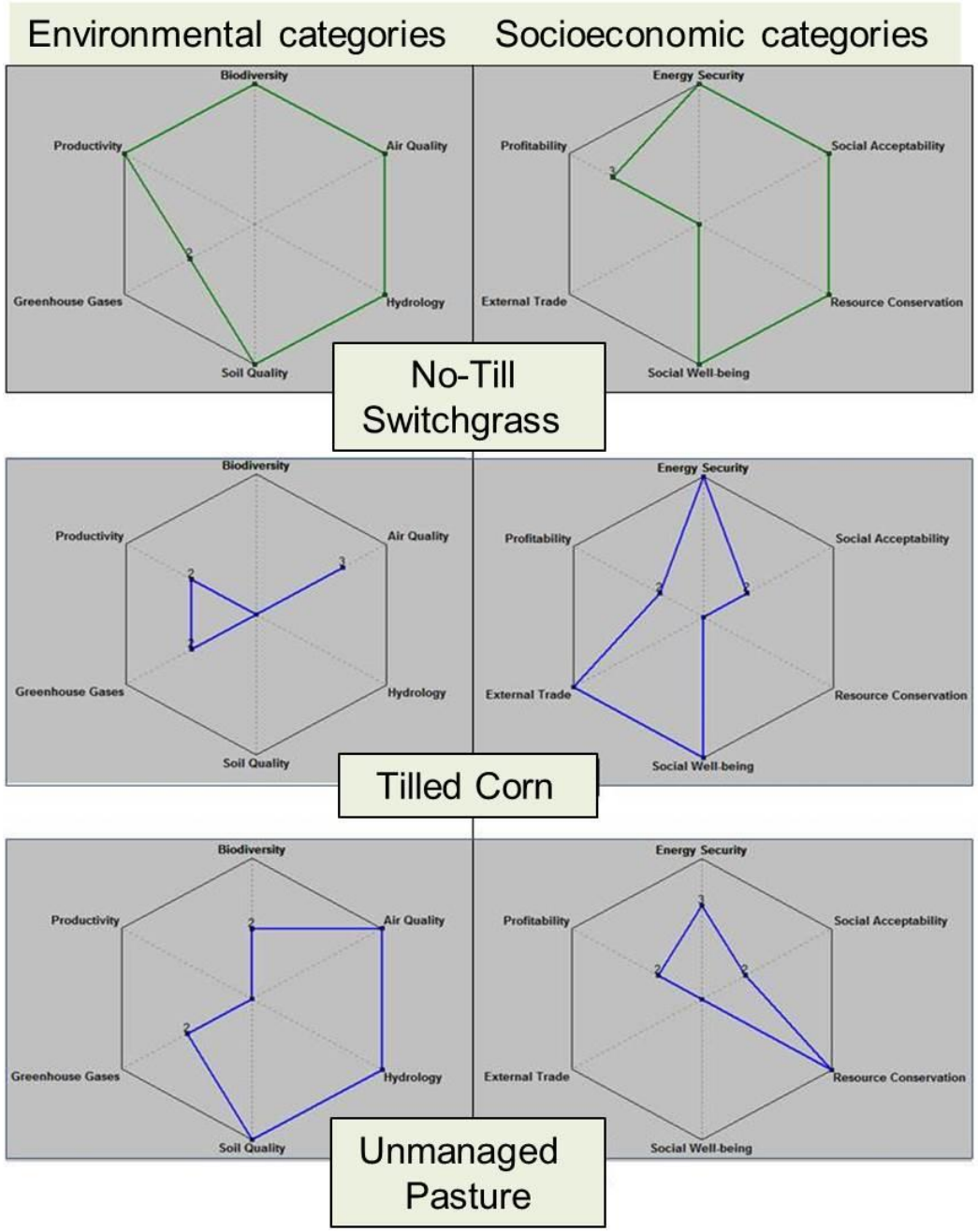

Consider Indicators within System as an Opportunity to Design Landscapes that add Value

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Landscape Design Approach

Dale et al. (In review) *Renewable & Sustainable Energy Reviews*

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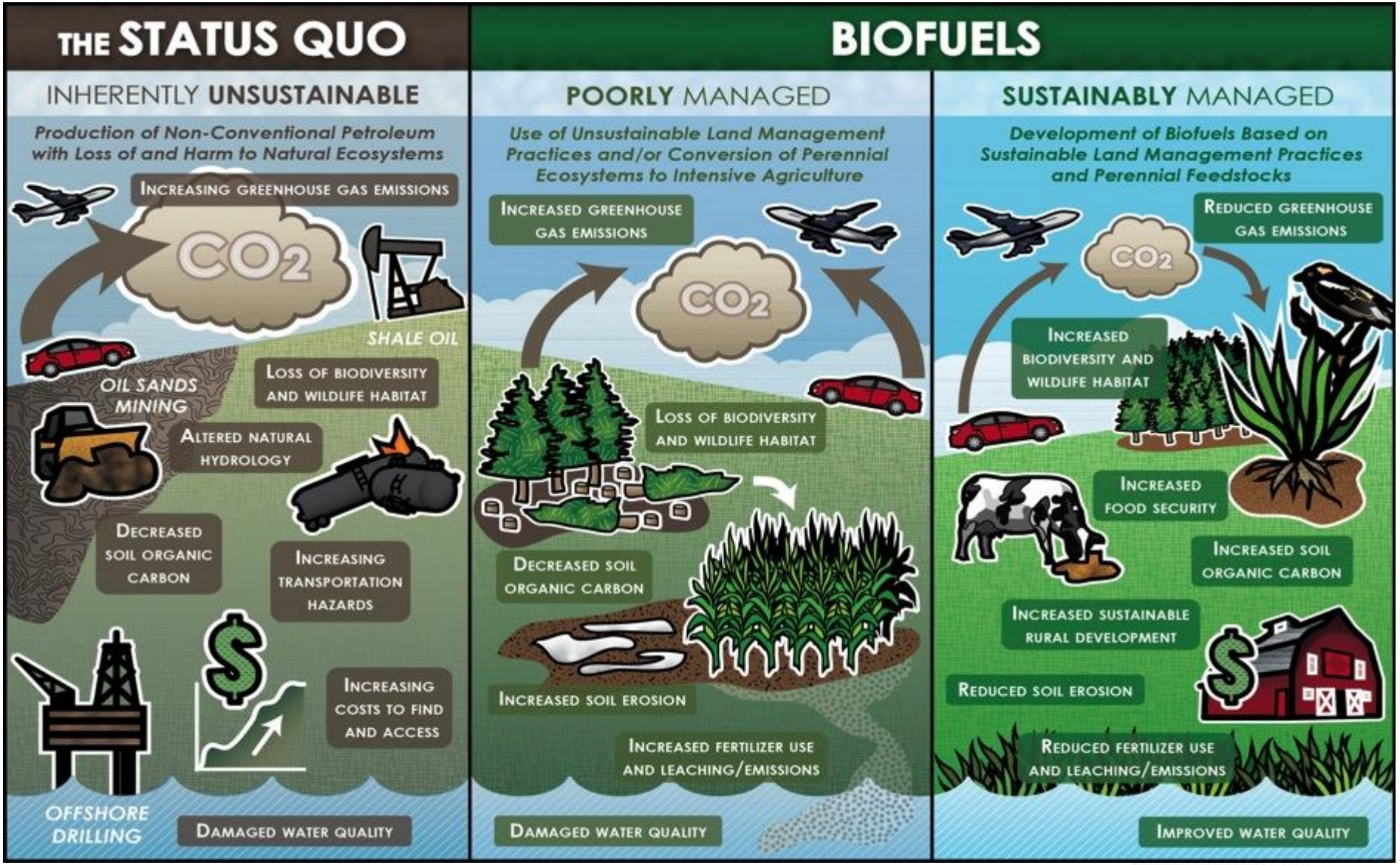
Management of Biofuels can Support Goals



Dale Bruce et al. (2014) *Environmental Science & Technology* 48: 7200-7203.

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Recommended Practices

- **Avoid negative effects**
  - Identify & conserve priority biodiversity areas
  - Apply location-specific management of biofuel feedstock production systems.
- **Attend to site selection and environmental effects in the**
  - Selection and location of the feedstock
  - Transport of feedstock to the refinery
  - Refinery processing
  - Final transport and dissemination of bioenergy.
- **Monitor, assess & report on key measures of sustainability**
- **Attend to what is "doable"**
- **Communicate opportunities and concerns to the stakeholders and get their feedback**
- **Employ adaptive management**

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Thank you!

CBES

Center for BioEnergy Sustainability

http://www.ornl.gov/sci/ees/cbes/

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