Incorporating Bioenergy into Sustainable Landscape Designs

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

Consider bioenergy as an opportunity to add value through integration by applying landscape design

Landscape design supports planning for improved resource management

- Helps stakeholders identify ways to manage for more sustainable provisions of services including renewable energy
- Takes context, trends and current conditions into consideration

Negative impacts of bioenergy can be avoided or reduced by attention to three principles:

1. Conserve priority ecosystem and social services
2. Consider local context
3. Monitor effects of concern and adjust plans to improve performance over time

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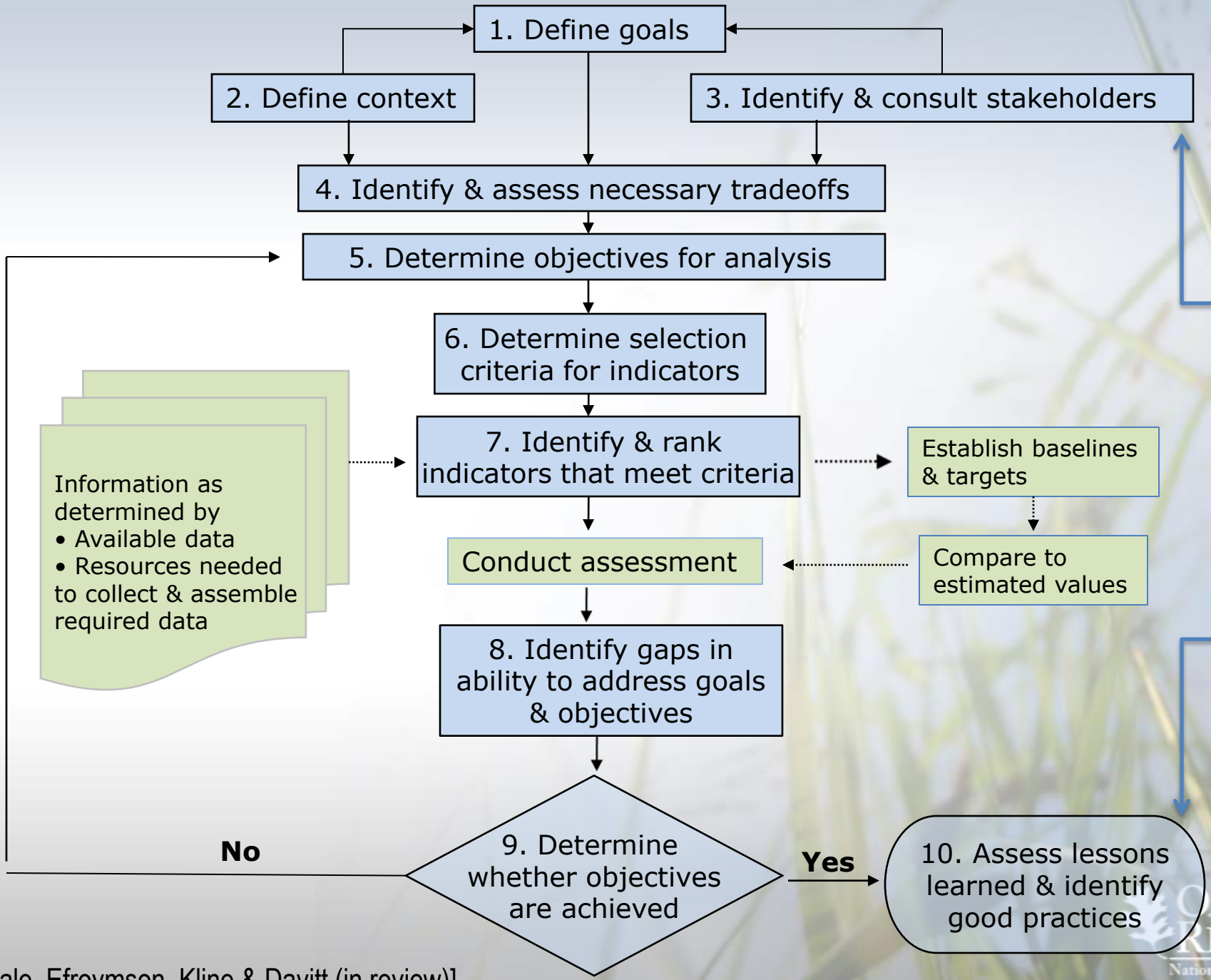
Landscape design approaches for bioenergy are place- and time-specific.

- Set goals
  - Involve key stakeholders
  - Develop consensus approach
- Consider constraints
- Address wastes and other opportunities
- Evaluate and apply solutions
- Monitor to support adaptive management



[Dale, Efroymson, Kline & Davitt (in review)]

Pressures and incentives for landscape design

- Legal demands or regulations
- Customer requirements or specifications
- Stakeholder concerns
- Competitive advantage, Reputation loss
- Environmental and social pressure groups
- Understand interactions at relevant scales
- Enable improved outcomes (provision of multiple services)

[Building from Seuring and Muller (2008) Journal of Cleaner Production 16:1699-1710]

Obstacles to developing and deploying landscape design

- Landowner rights
- Traditional practices
- Up front planning required
- Coordination and outreach, stakeholder engagement
- Complexity/level of effort
- Higher initial costs

[Building from Seuring and Muller (2008) Journal of Cleaner Production 16:1699-1710]

Recommended practices

- Consider management goals and options within the broader context
- Attention to site selection and environmental effects in the
  - location and selection of the feedstock
  - transport of feedstock to the refinery
  - refinery processing
  - final transport and use of bioenergy.
- Monitoring and reporting of key measures of sustainability
- Attention to what is “doable”
- Stakeholder engagement throughout process

McBride et al. (2011) Ecological Indicators 11:1277-1289.
Dale et al. (2013) Ecological Indicators 26:87-102.

U.S. Department of Energy (DOE) Approach to Assessing Bioenergy Sustainability

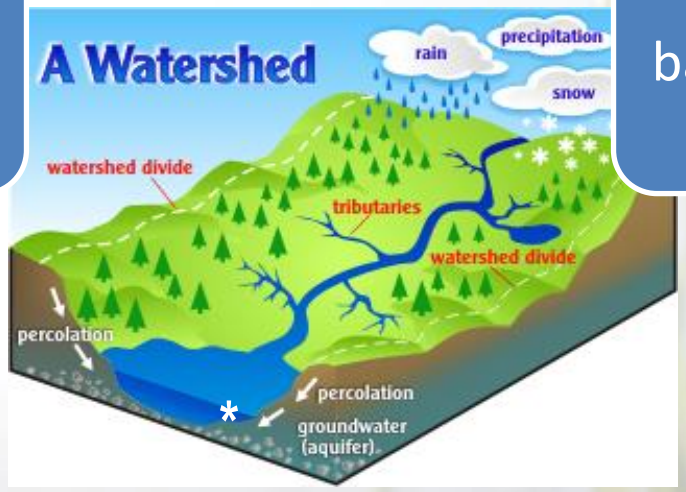
✔ Select Indicators

Establish baselines and targets

Evaluate indicator values

Identify trends and tradeoffs

Develop and test best practices



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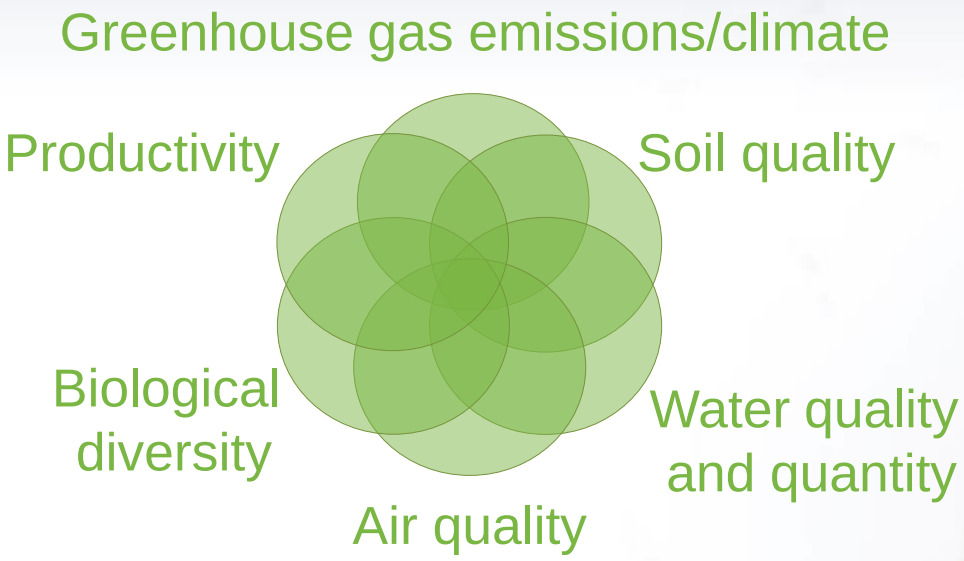
Categories for environmental and socioeconomic sustainability



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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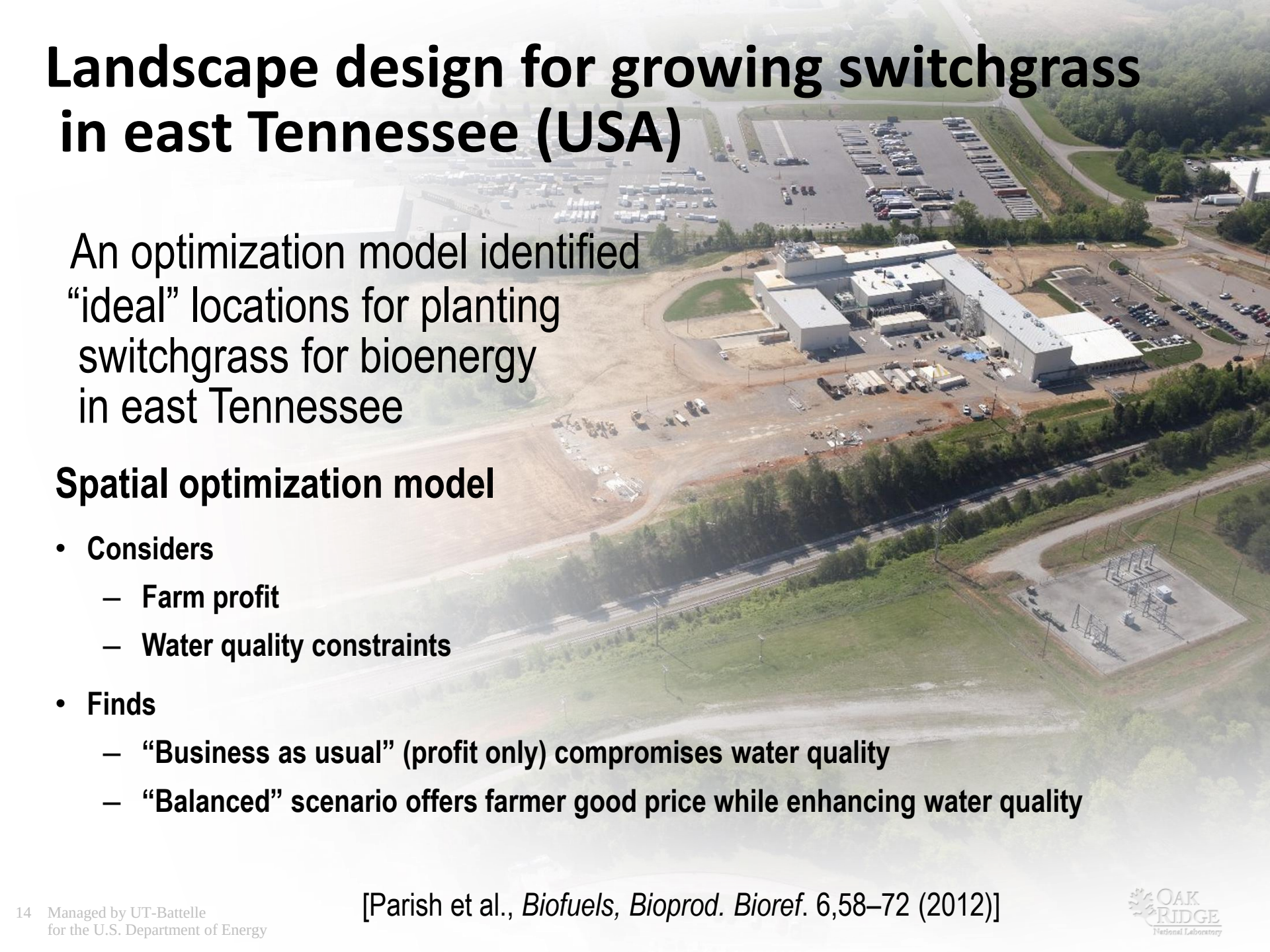
Landscape Design Involves Adapting Indicators to Particular Contexts

- **Indicator set is a starting point for sake of efficiency and standardization**
  - Particular systems may require addition of other indicators
  - Budget may require focus on a smaller set of indicators
  - Some indicators more important for different supply chain steps
- **Protocols must be context-specific**

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

Landscape design for growing switchgrass in east Tennessee (USA)



An optimization model identified "ideal" locations for planting switchgrass for bioenergy in east Tennessee

Spatial optimization model

- **Considers**
  - **Farm profit**
  - **Water quality constraints**
- **Finds**
  - **"Business as usual" (profit only) compromises water quality**
  - **"Balanced" scenario offers farmer good price while enhancing water quality**

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

Data for indicator approach are available to help assess switchgrass for 10 counties, Vonore, TN

IBSS
Southeastern Partnership for
Integrated Biomass Supply Systems

Data available from Vonore for most indicators of socioeconomic sustainability

* Information not currently available for Vonore

not an issue in this context

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)
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.

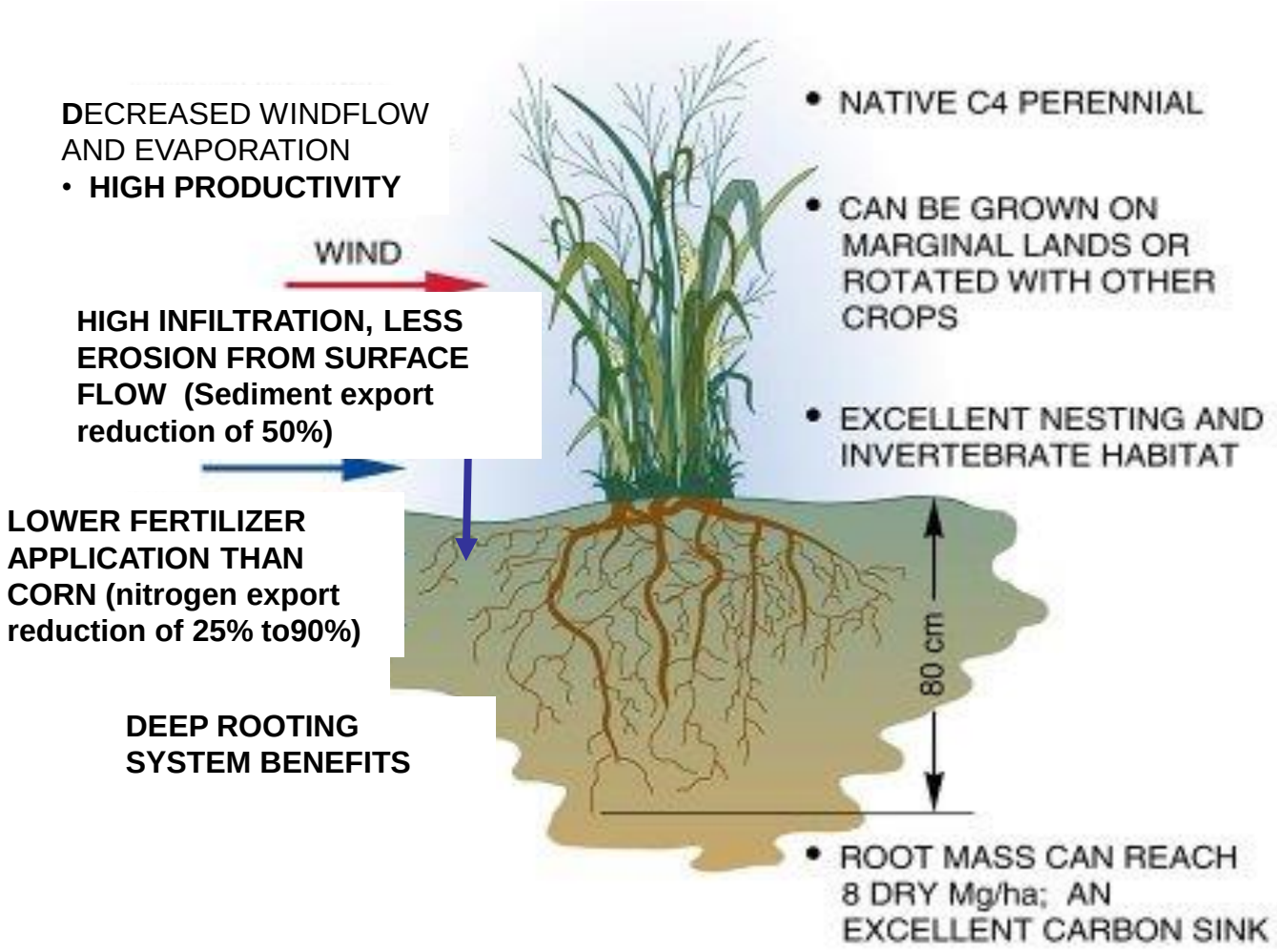
Data available from Vonore for all indicators of environmental sustainability

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

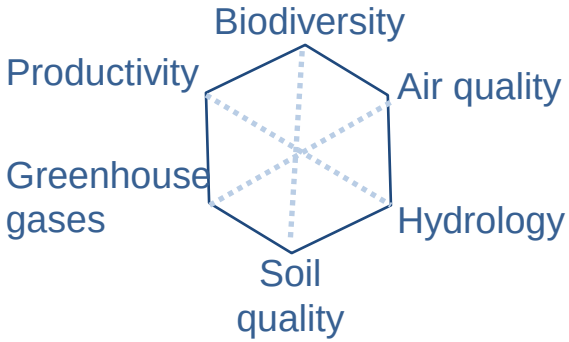
While switchgrass offers environmental benefits in east Tennessee, the low cost of competing fuels and lack of alternate markets translates to little demand

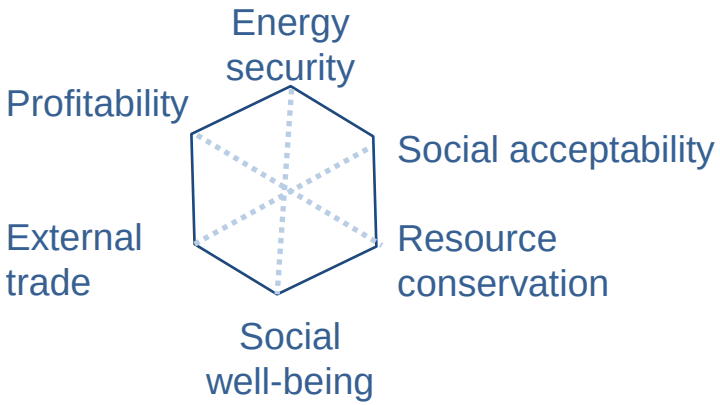


Dale et al. (2011) *Ecological Applications* 21(4):1039-1054.

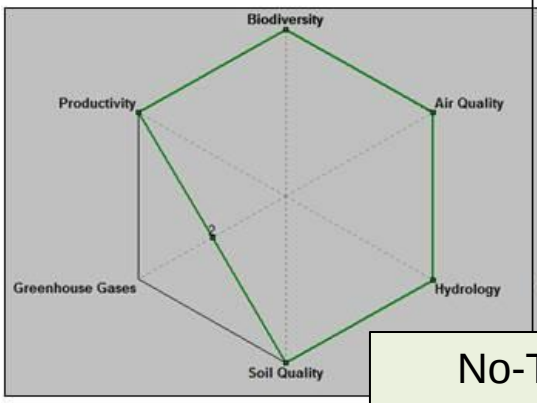
Preliminary ratings of six environmental and six socioeconomic sustainability categories

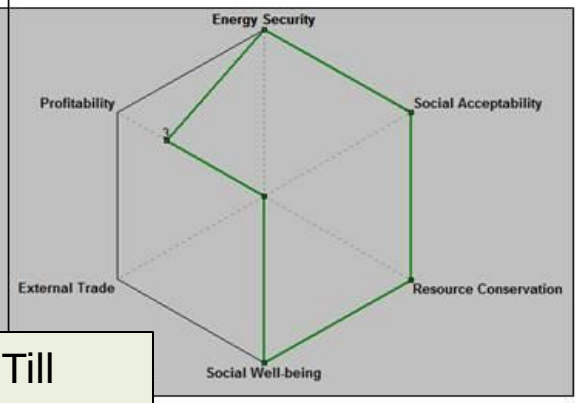
Key to chart



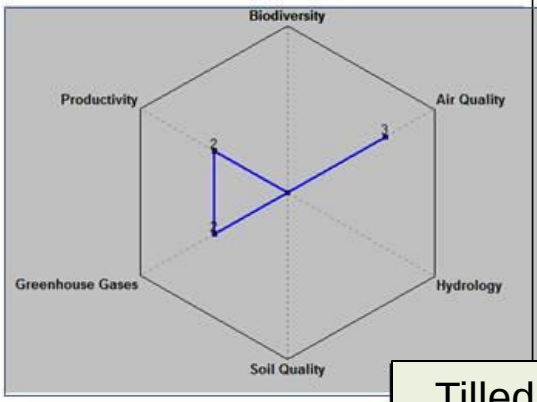


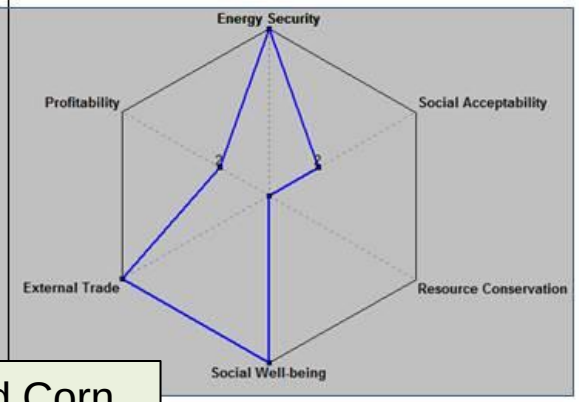
Environmental categories | Socioeconomic categories



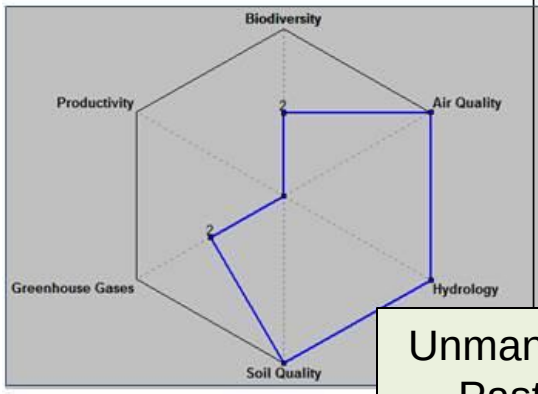


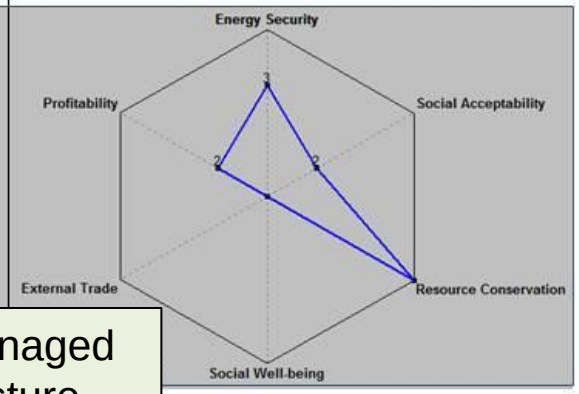
No-Till Switchgrass





Tilled Corn



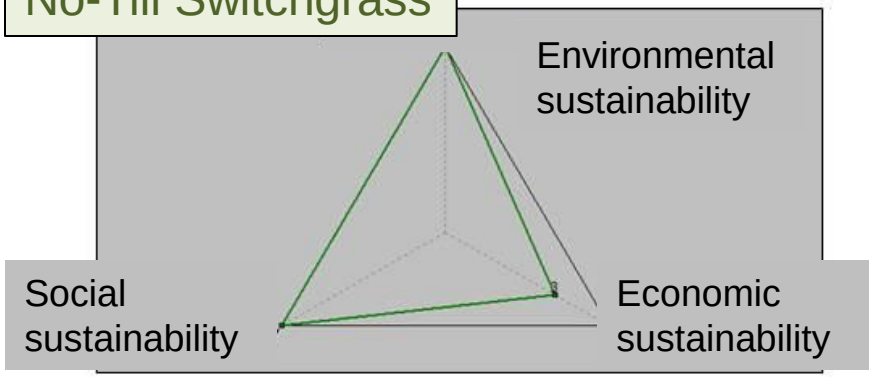


Unmanaged Pasture

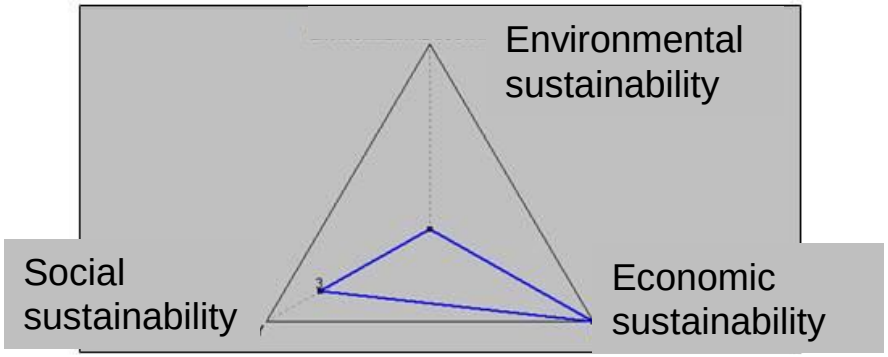
Relative contributions of the three sustainability "pillars" to the overall sustainability

The center point of each triangle represents the lowest possible rating, and the outer edges represent the highest rating.

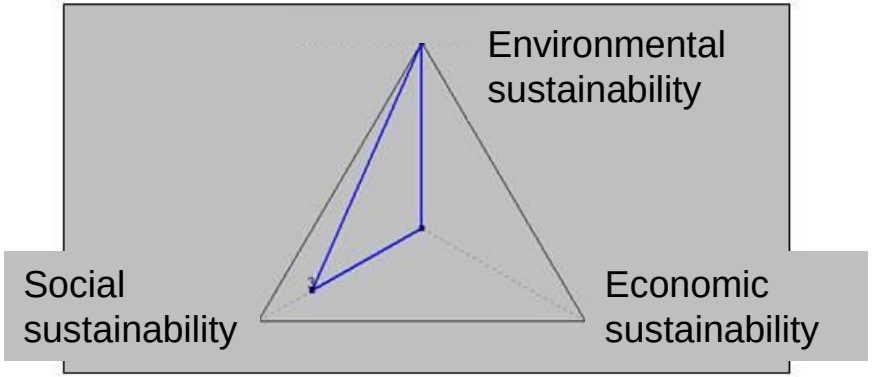
No-Till Switchgrass



Tilled corn



Unmanaged pasture



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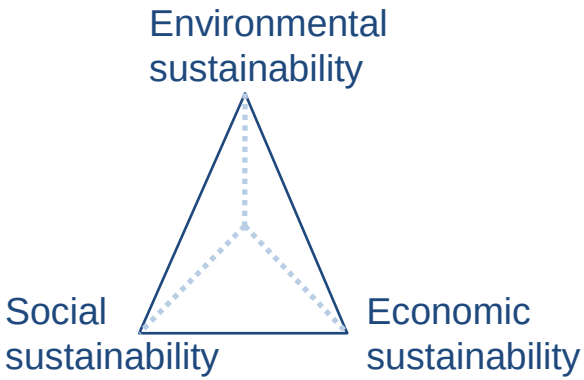
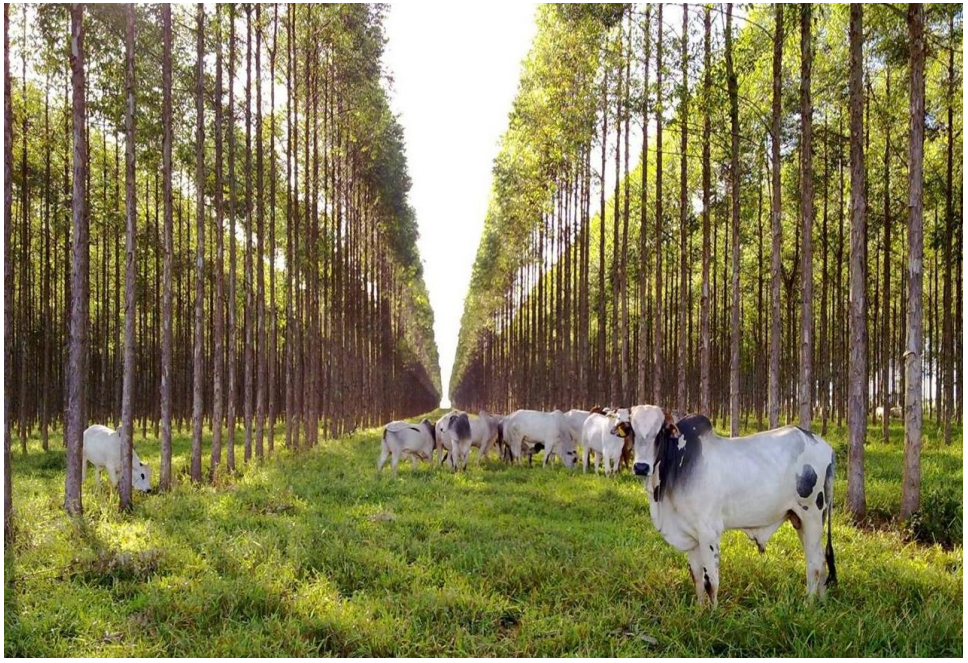


DOE Workshops, Case Study of Eucalyptus in Brazil

Arnaldo Walter and Camila de Oliveira, UNICAMP and CTBE, SP, Brazil

- Legal and regulatory framework
  - Land use regulated by Forestry Code (amended in 2012).
  - “Permanent Preservation Areas” & “Legal Reserve Areas” defined
  - Identified appropriate areas for specific uses (e.g., eucalyptus and pines)
  - Foster good practices to reduce environmental impacts
- Institutional framework
  - Forestry Science and Research Institute (IPEF) calls for
    - “Landscape sustainable practices”
    - “Use of degraded areas”.
  - Annual reports on Forestry Management by the industries highlight
    - Improving yield
    - Preserving water resources
    - Reducing & monitoring impacts on biodiversity
    - Adopting social programs
    - Reducing fragmentations
- Design
  - Integrating livestock into plantations
  - Integrating soy into planted forests.
  - Preserving natural vegetation
- Challenge in using pellets: logistics



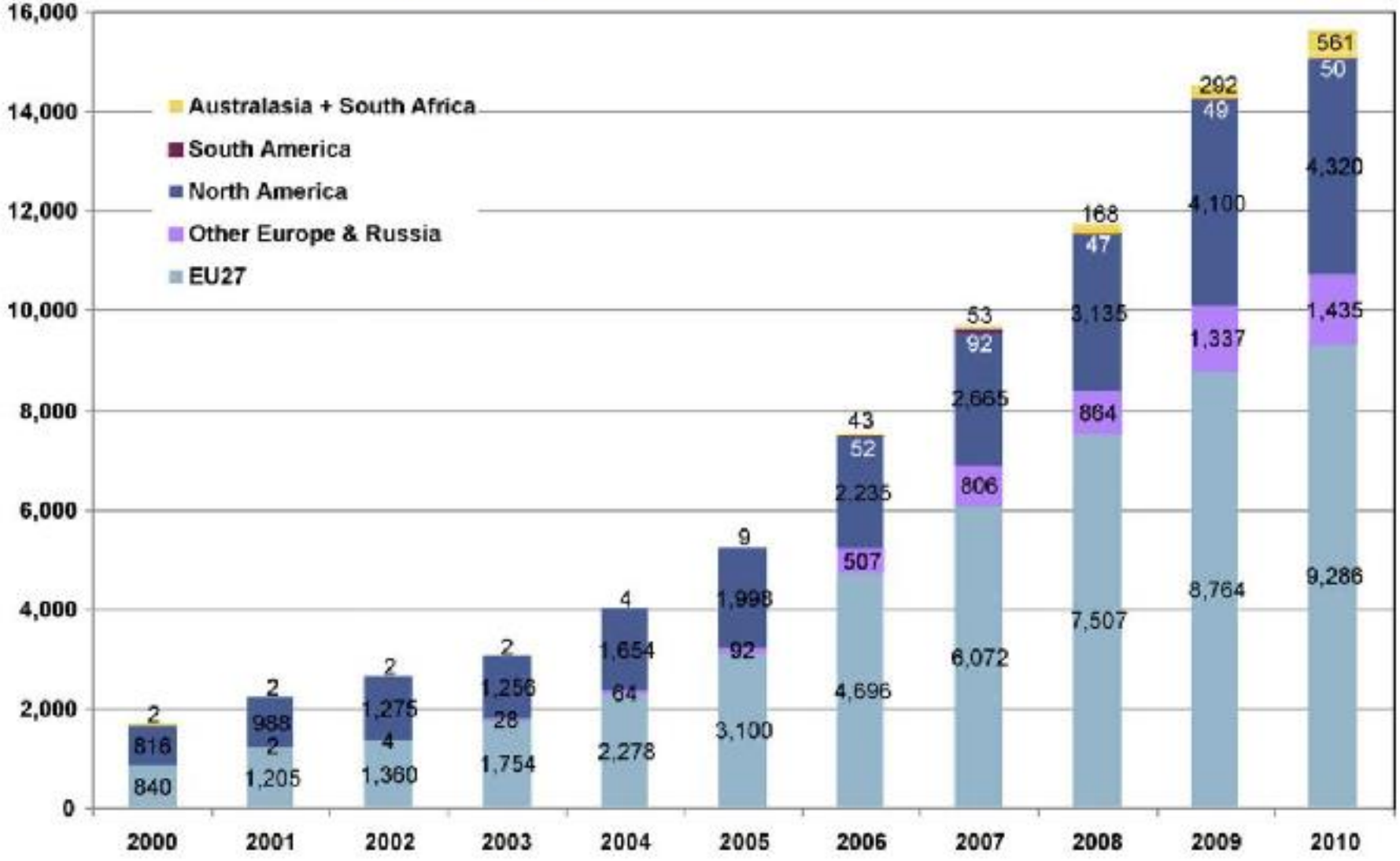
Remediation Case Study: New York

Tim Volk, (SUNY and NEWBio Project)

- Community Drivers: use of former industrial land and provision of renewable energy
  - Growing shrub willows on settling basins as alternative to standard geomembrane cap
  - Environmental monitoring willow fields for soils and water quality
  - Starting assessment of social factors in driving biomass use in the region
- Multifunctional systems
  - Sustainable Reuse Remedy
    - ✓ Use organic waste stream from local brewery to create favorable growing conditions
    - ✓ Manage water to minimize leaching to surface and ground water
    - ✓ Produce biomass
  - Shrub willow in highway rights of way for snow drift control and potential biomass production
  - Willow incorporated into riparian buffers
  - Potential for recreation uses

Southeast U.S. woody biomass case: Mill residues, management thinnings, co–products of tree harvest for saw timber and pulp, now used for bioenergy

Global wood pellet production 2000 - 2010



(Source: Lamers et al. RSER, 16(2012) 3176-3199

Trees are cut and sorted by size, qualities.

- Harvest meets Sustainable Forestry Initiative (SFI) standard
- Protection of places providing unique ecosystem services
- Targeting multiple round-wood markets (4): saw timber; pulp; low-value ‘form wood’ to China; remainders to pellets
- All branches and other residues, remain in forest
- Tagging, weighing systems in field supports “Chain of custody”

IEA Task 43: Biomass feedstocks for energy markets

- **Overall approach**
  - Empirical case studies dealing with environmental, economic and social changes over time*
  - Looking for where can methodology* be coordinated to improve consistency and comparability among the individual case studies (to the extent it is possible and useful)
  - Policy messages: Barriers and opportunities to overcome them
- **Case studies**
  - Mobilization of forest* bioenergy supply chains in boreal and temperate forests (Canada, US and N Europe & Australia)
  - Mobilizing agricultural residues for bioenergy and biorefinieries
  - Regional biogas production from organic residues
  - Cultivation of grasslands and pastures – the sugarcane ethanol case
  - Integration of bioenergy crops into agricultural landscapes*

* ORNL is in discussion with IEA Task 43

Threats and solutions for tropical forests and biodiversity are similar to those for sustainable landscapes and food security: they begin with local governance and institutional capacity…

Solutions involve:

- Rural livelihoods*
- Local governance, participation, capacity, enforcement
- Land tenure and related policies
- Land-use plans, soil management, productive land uses to reduce losses from disturbance, fire*
- Inventory & protect key conservation areas*

***Bioenergy policy could help**

Source: Kline, 2008 California Biomass Collaborative., based on USAID-FAA Sec. 118/119 Reports for 2000-2008.
FAO 2010c. See FAO forest management and conservation best practices: http://www.fao.org/bestpractices/content/05/05_02_en.htm

Strategies for success in promoting more sustainable natural resource management and landscape designs

- Shared vision among all stakeholders (not easy!) including identification of and support to *local champions*
- Sustained *political will* at all relevant levels
- *Long-term commitments* from partners for time and resources needed for success
- Consistent, reliable, on-the-ground *presence* by activity implementers
- Public-Private *Partnerships* to utilize market forces for meeting both short and long-term development and conservation goals.
- Timely *corrective actions* facilitated by information and experience sharing within the region – willingness to adjust course as required to achieve goals.
- Participatory and transparent governance of the resources – *tenure rights*.
  "Activities must empower communities to improve their ownership and responsibility over the sustained stewardship of these valuable resources, upon which so many lives and livelihoods depend." – Alfred Nakatsuma Vaca

Source: Alfred Nakatsuma, USAID Senior Environmental Program Manager and Keith L. Kline, based on >50 years of combined international development experience.

Thank you!

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

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