Incorporating Bioenergy into Sustainable Landscape Designs

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Center for BioEnergy Sustainability
Oak Ridge National Laboratory
http://www.ornl.gov/sci/ees/cbes/

U.S. DEPARTMENT OF ENERGY

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Consider bioenergy within system as an opportunity to <u>design landscapes</u> that add value

Landscape design is a plan for resource allocation.

- Suggest a way to manage for more sustainable provisions of bioenergy and other services
- 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

Landscape design approach for bioenergy should be applied to particular contexts

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

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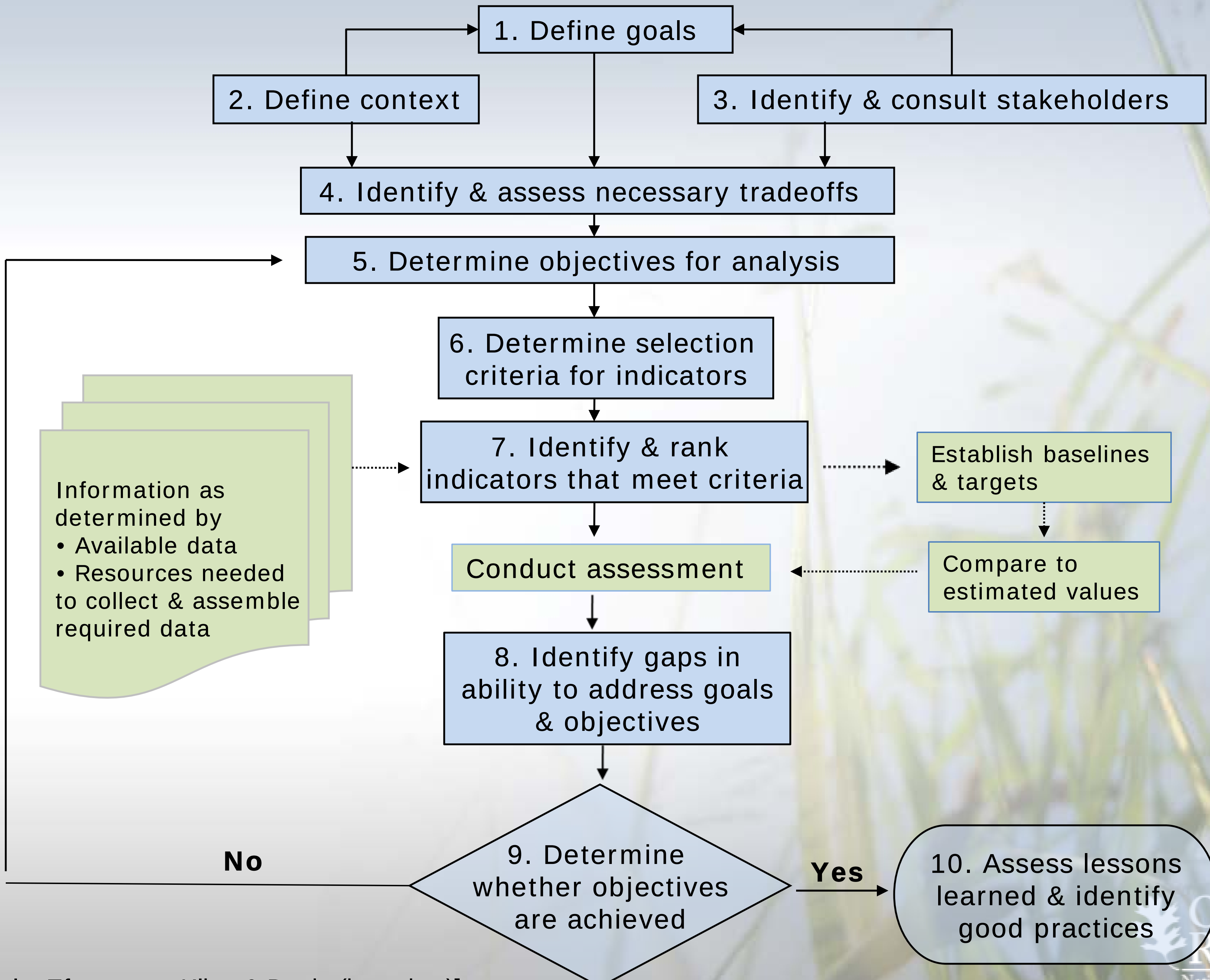

[Dale, Efroymson, Kline & Davitt (in review)]

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Pressures and incentives for landscape design

- Legal demands or regulations
- Customer requirements or specifications
- Stakeholder concerns
- Competitive advantage
- Environmental and social pressure groups
- Reputation loss

[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 complexity/effort
- Higher initial costs

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

Recommended practices

- Stakeholder engagement throughout process
- Consider management 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 dissemination of bioenergy.
- Monitoring and reporting of key measures of sustainability
- Attention to what is “doable”

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DOE Approach to Assessing Bioenergy Sustainability

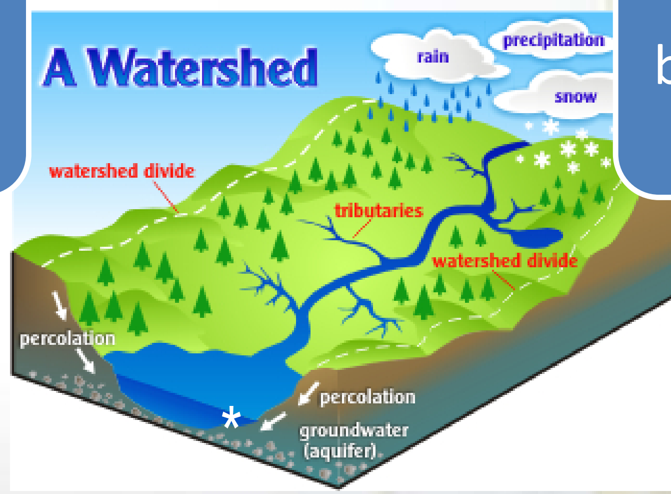
✓ Select Indicators

Establish baselines and targets

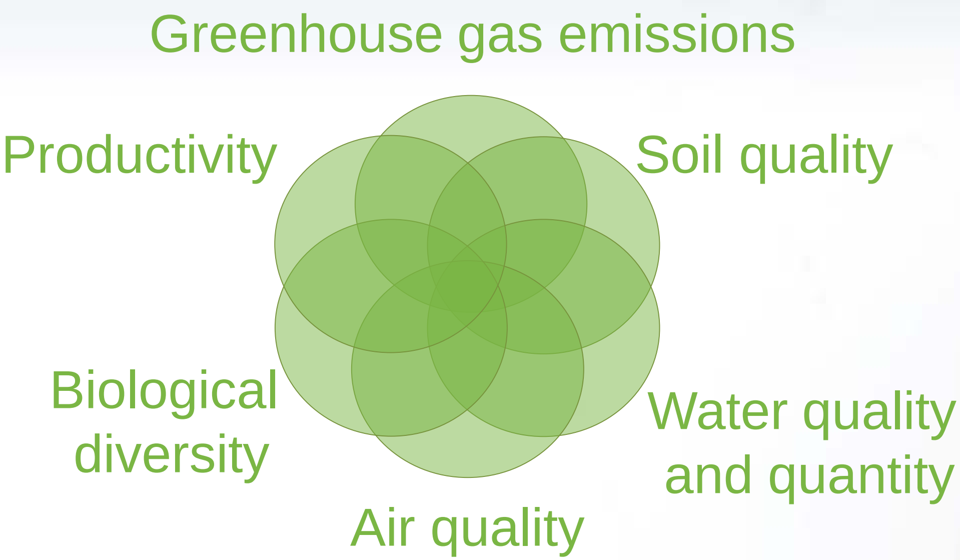
Evaluate indicator values

Identify trends and tradeoffs

Develop and test best practices



Categories for environmental and socioeconomic sustainability



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

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

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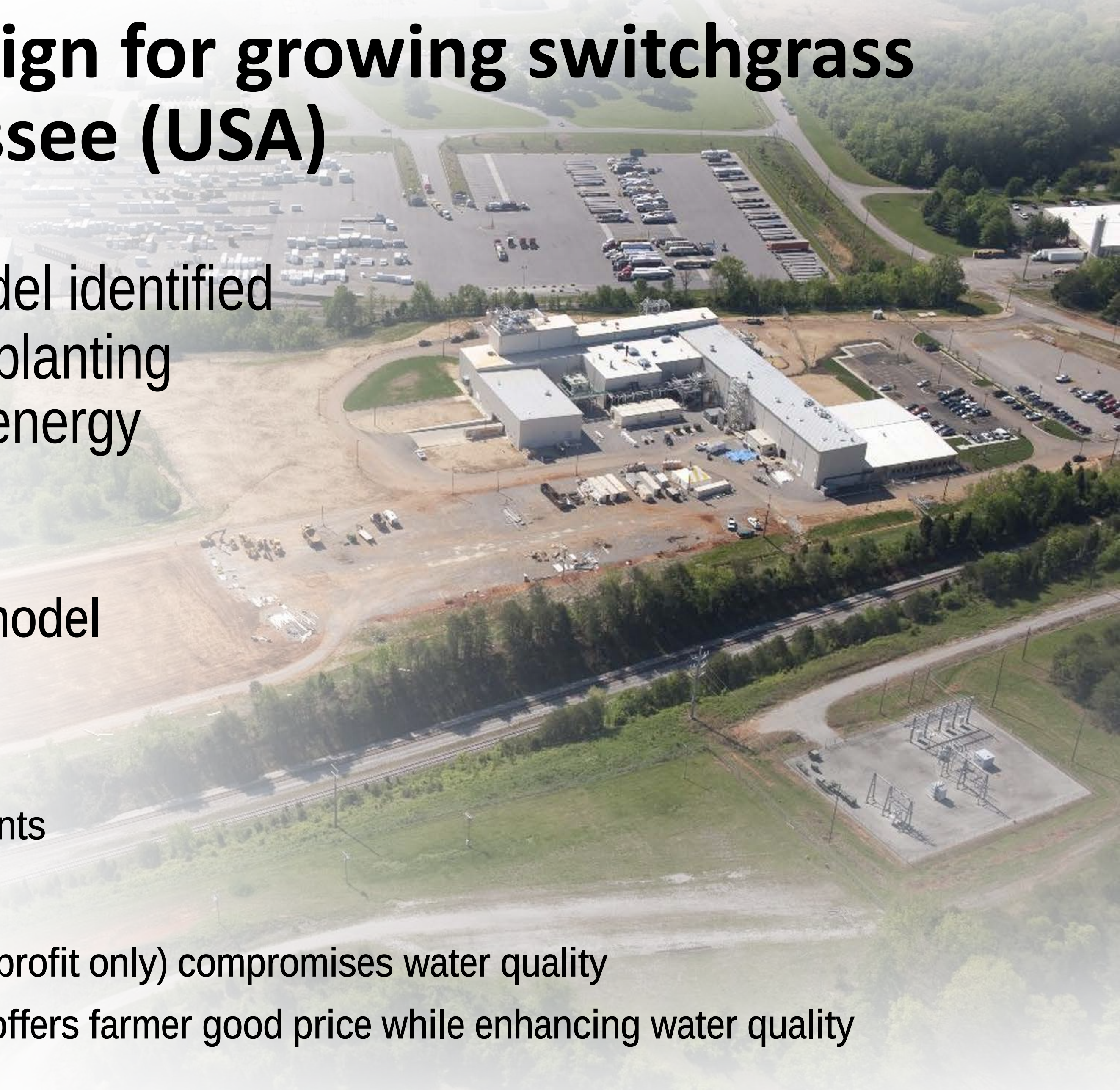
Landscape Design Involves Adapting Indicators to Particular Contexts

- **Indicator set is a starting point for sake of efficiency and standardization**
  - Particular systems may require addition of other indicators
  - Budget may require subtraction of some 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 available from Vonore for most indicators of socioeconomic sustainability

* Information not available from Vonore
# not an issue for switchgrass

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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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

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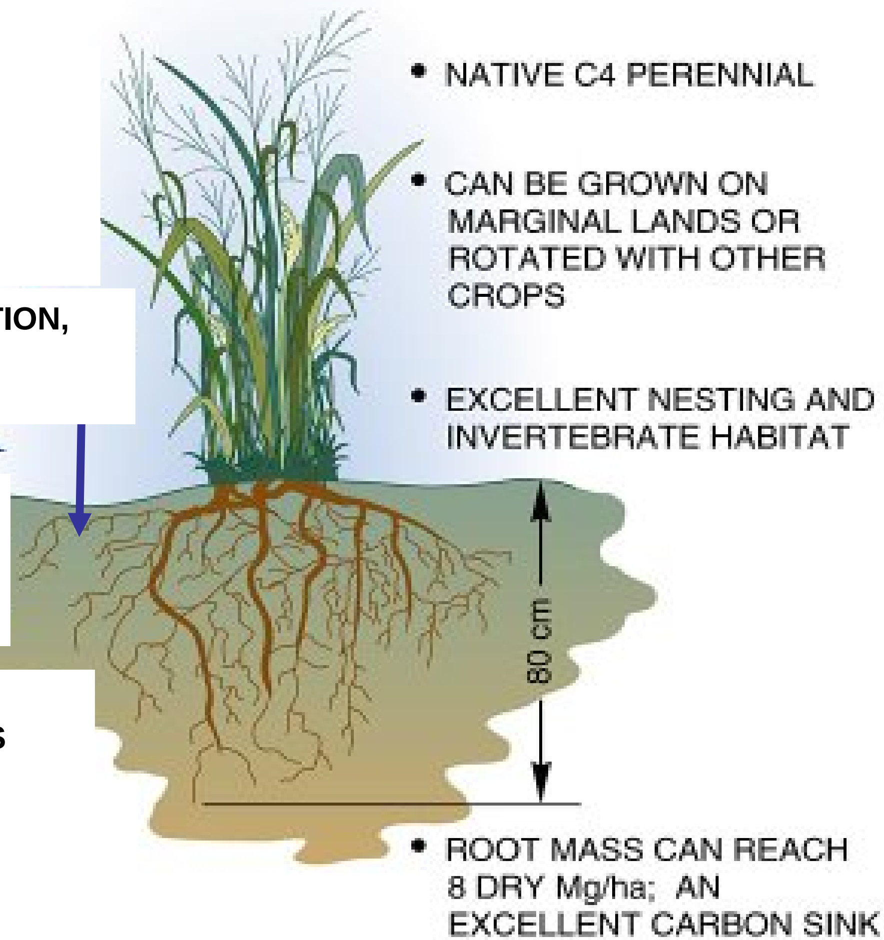
While switchgrass has great sustainability benefits in east Tennessee, the low cost of natural gas translates to little demand for ethanol

- **HIGH PRODUCTIVITY**
- **HIGH INFILTRATION, (Sediment export) reduction of 50%**

LOWER FERTILIZER APPLICATION THAN CORN (nitrogen export reduction of 25% to90%)

DEEP ROOTING SYSTEM BENEFITS



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

Case Study of Eucalyptus in Brazil

Arnaldo Walter and Camila de Oliveira

- 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

- Community Drivers: use of former industrial land and provision of renewable energy
  - o Growing shrub willows on settling basins as alternative to standard geomembrane cap
  - o Environmental monitoring willow fields for soils and water quality
  - o Starting assessment of social factors in driving biomass use in the region
- Multifunctional systems
  - o 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
  - o Shrub willow in highway rights of way for snow drift control and potential biomass production
  - o Willow incorporated into riparian buffers
  - o Potential for recreation uses

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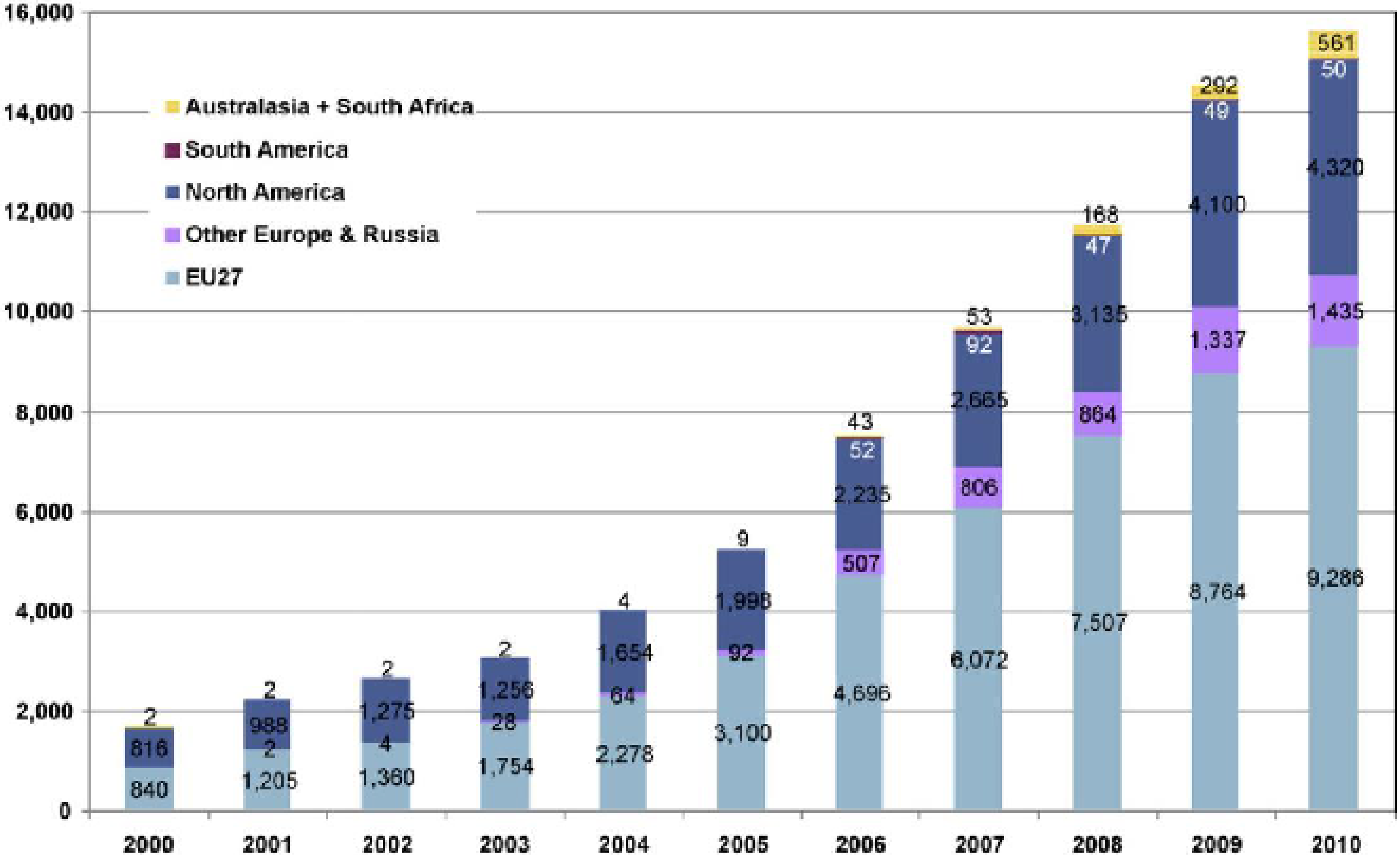
SE woody biomass case: By–products of tree harvest for saw timber and pulp used for bioenergy

Universiteit Utrecht

Global wood pellet production 2000 - 2010



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

Trees are cut and sorted by size.

- Harvest meets standards of Forest Sustainability Initiative (FSI)
- Branches returned to forest
- Protection of places providing unique ecosystem services
- Largest trees shipped to China

Plum Creek
Ticket #
3540124514
LOGISTICS
Logger Name: Southeast Logging Inc
County: Liberty State: GA
Harvest Unit: 110H-CB JONES-2THIN
Front Log Count: 42 Avg. Length: 19.6
Back Log Count: 44 Avg. Length: 13
Created Time: 10:13 AM Created Date: 10/23/13
Product: PST Cut to Length
Destination: East Coast Terminal
Hauler Name: Wall Timber Products Inc
j2799 Truck #: Robbie Finch
Authorization:
Contractor Signature:
Time: 10/24/13 07:45 AM
Location:
Latitude: 31.71831
Longitude: -81.45925
Contract: 350F6502

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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

Thank you!

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