Incorporating Bioenergy into Sustainable Landscape Designs

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U.S. DEPARTMENT OF ENERGY
OAK RIDGE NATIONAL LABORATORY
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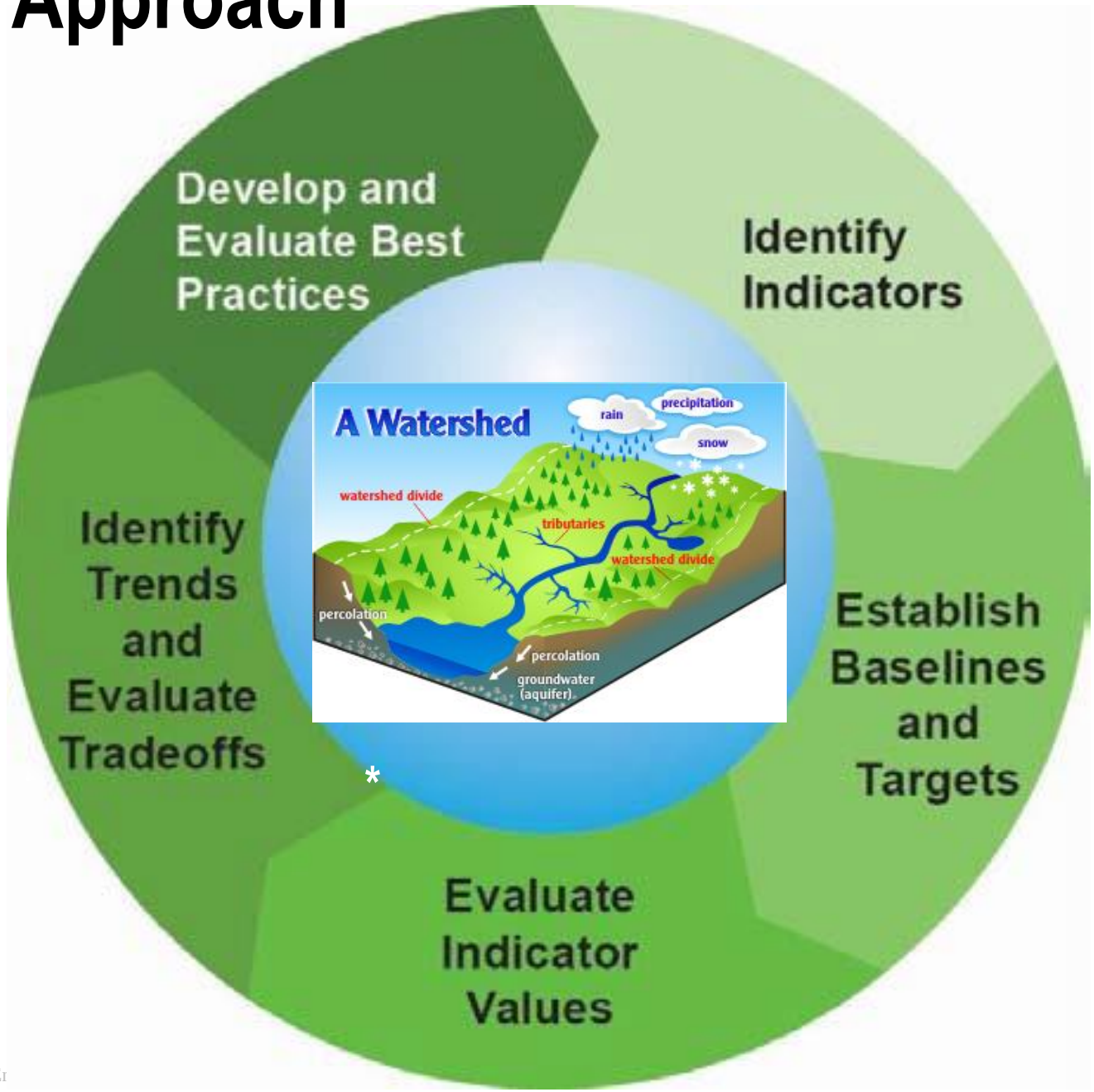
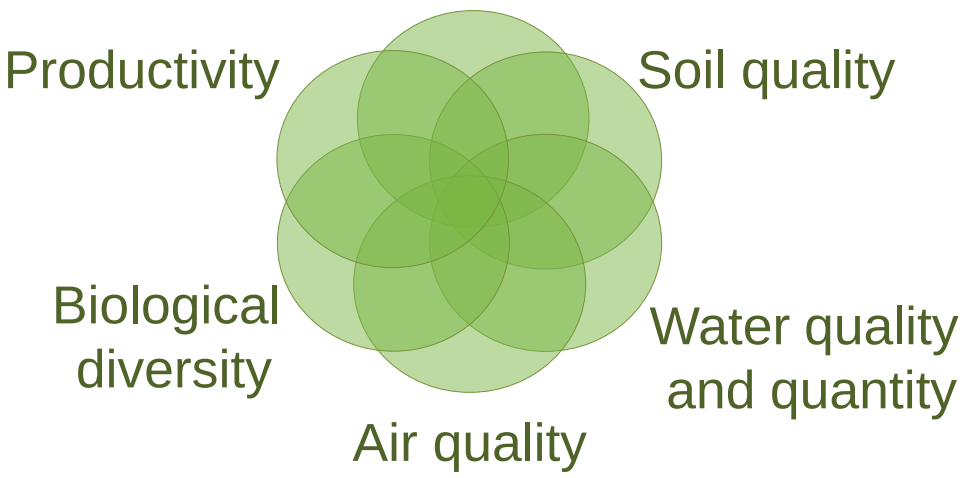
Sustainability brings together disparate perspectives

Overall Approach



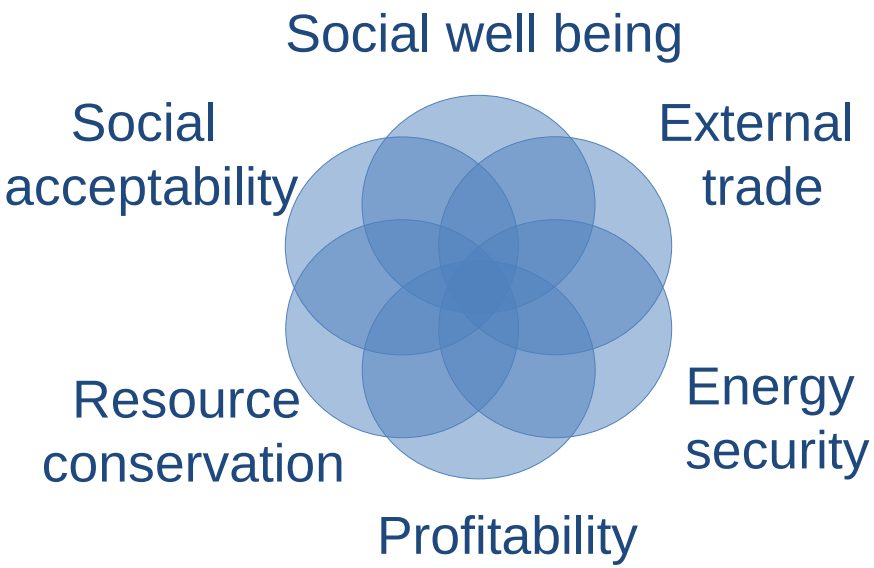
Categories of indicators of progress toward sustainability

Environmental



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

Socioeconomic



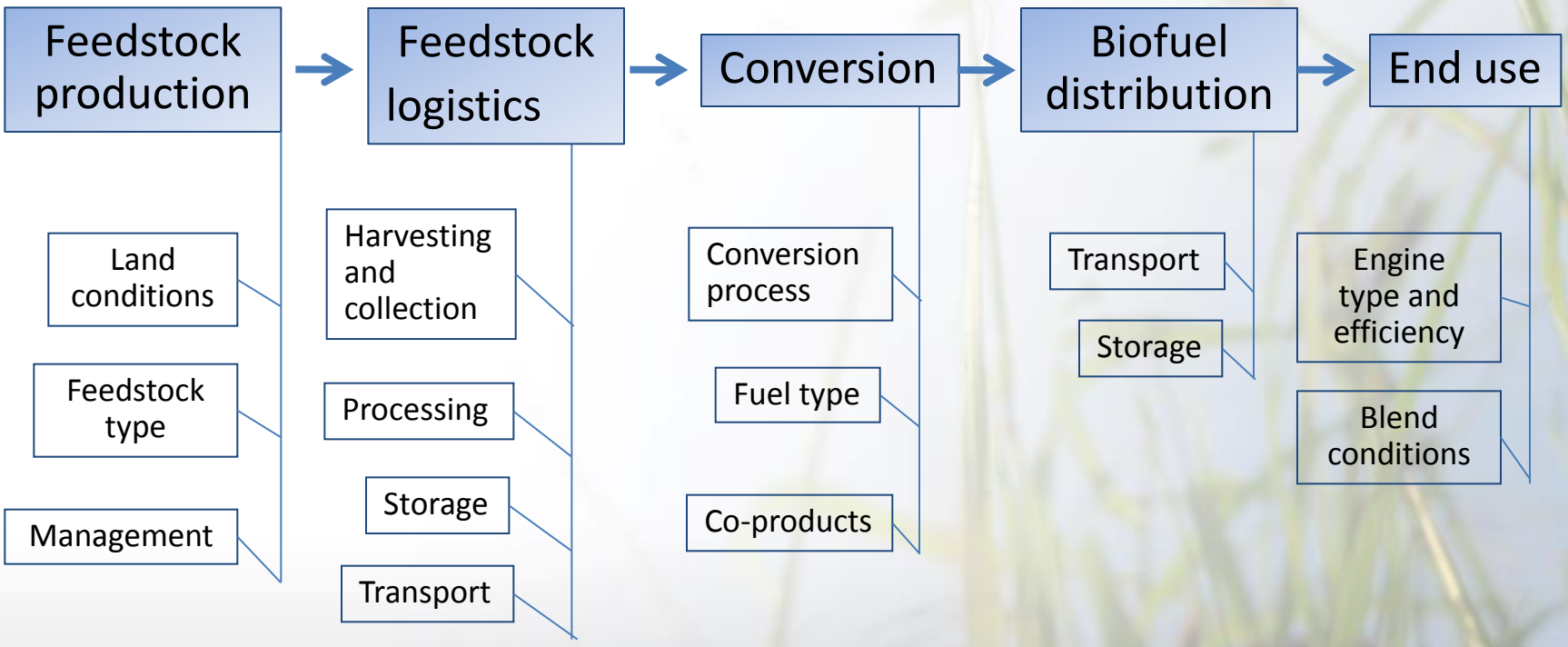
Dale et al. (2013) *Ecological Indicators 26:87-102.*

Metrics & interpretations are <u>context</u> specific

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

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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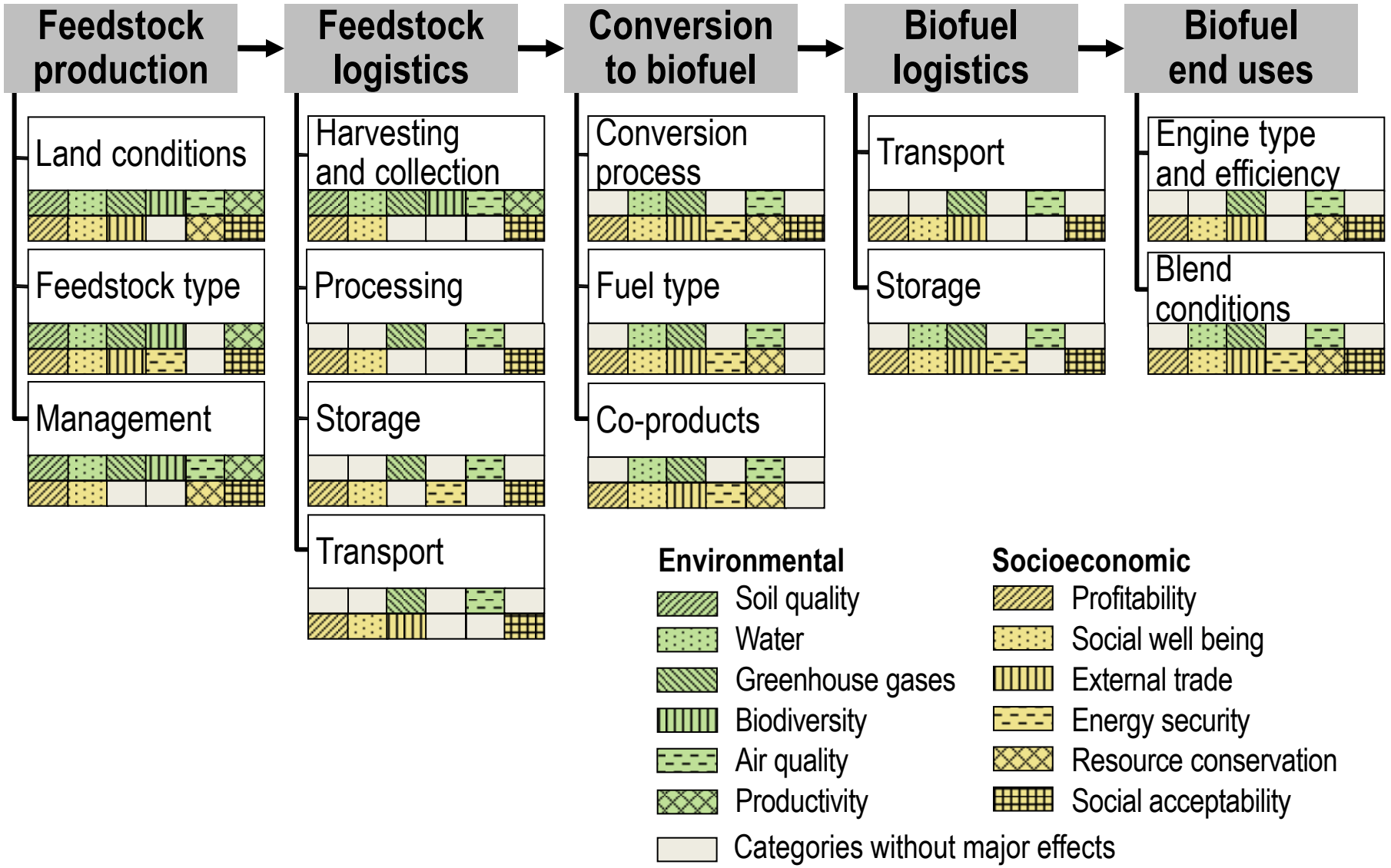
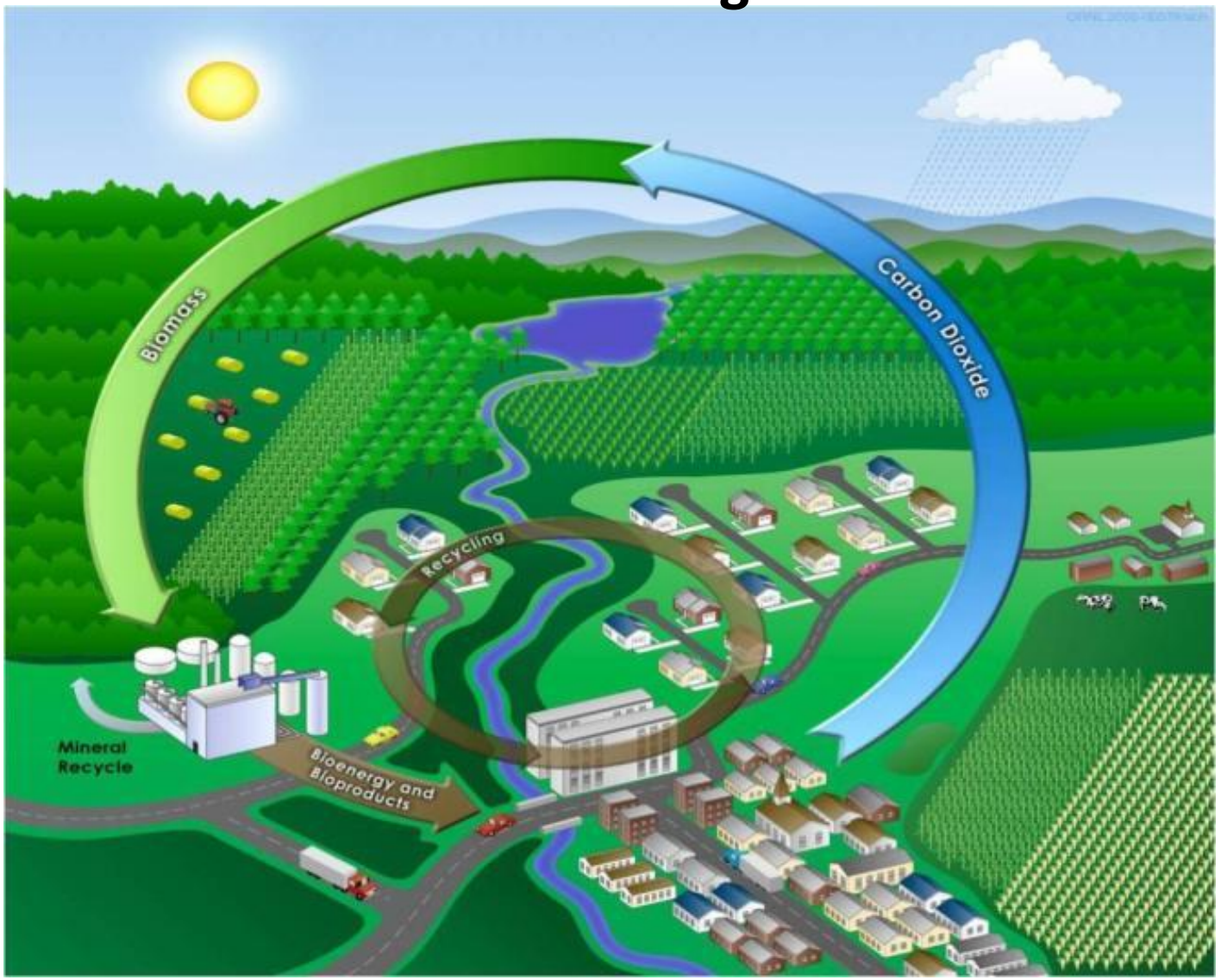
Biofuel Supply Chain in View of Indicators

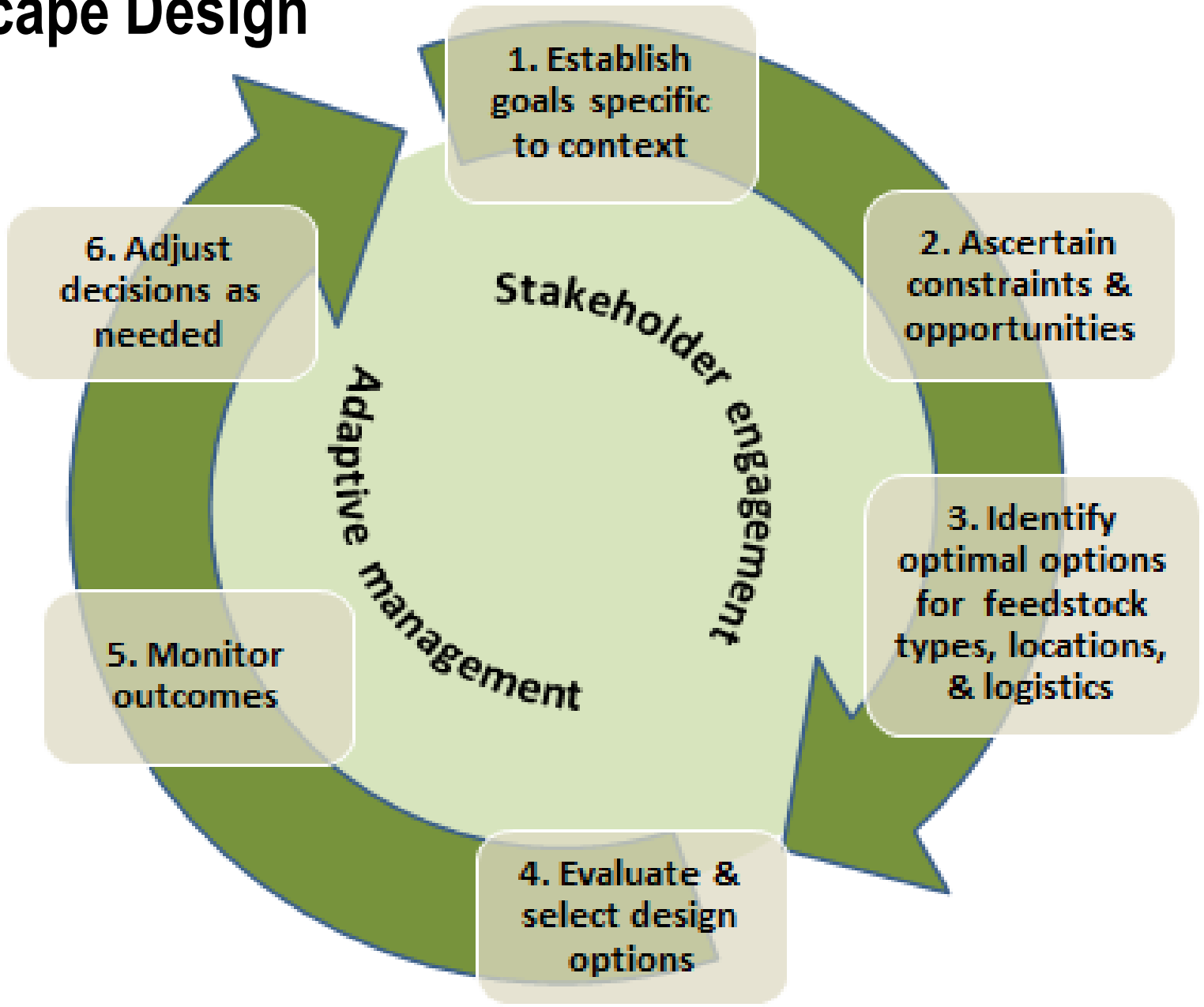


Integrating Bioenergy via Landscape Design Improves Resource Management



Dale et al. (2016). *Renewable & Sustainable Energy Reviews* 56:1158-1171.

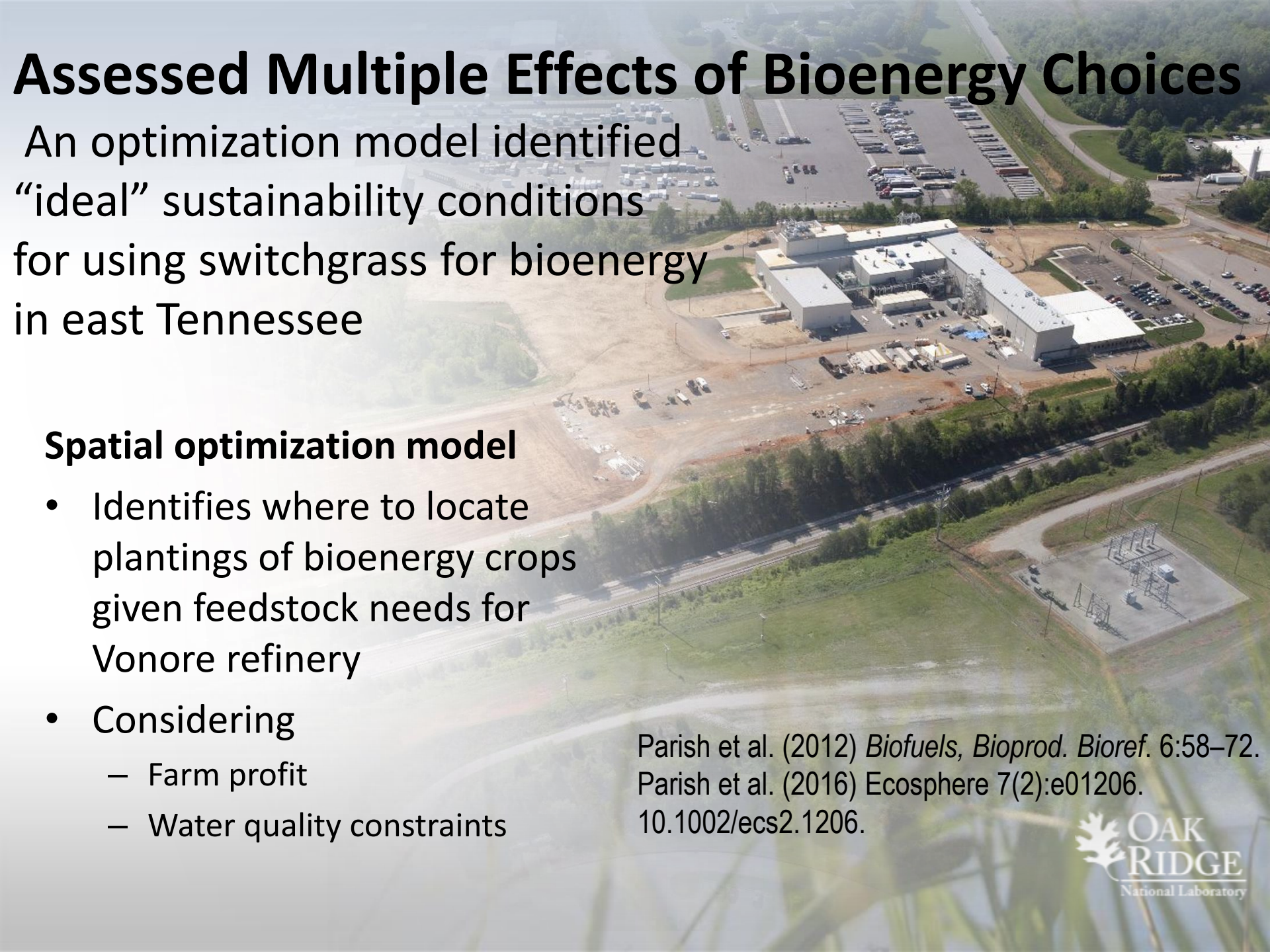
Landscape Design



Dale et al. (2016)

Assessed Multiple Effects of Bioenergy Choices

An optimization model identified "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.
Parish et al. (2016) Ecosphere 7(2):e01206. 10.1002/ecs2.1206.

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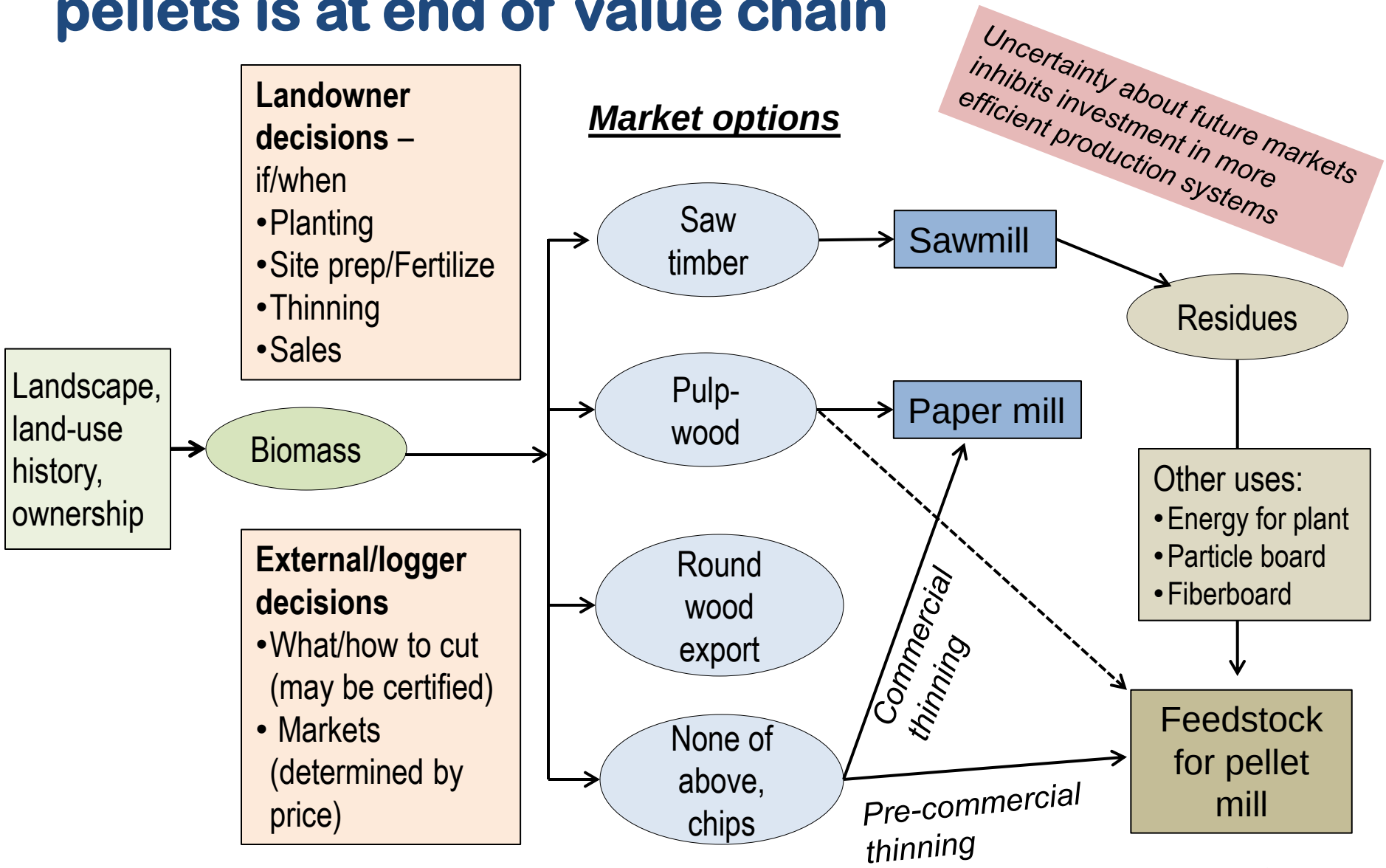
Lacking markets, woody debris after timber harvests is left to decay; often burns; and can contribute to risk, frequency and intensity of wildfires

Key Research Questions

- How does SE US pellet production for export to EU *(now through 2030)* differ from business-as-usual case of no pellet production?
  - Under what conditions does the pellet industry complement or compete with pulpwood use?
  - Will pellet industry alter amount of land staying in forests?
- Are there significant changes to key indicators?
  - Biodiversity
  - Land-use changes
  - Greenhouse gas emissions
- Does pellet industry provide costs or benefits?
  - Jobs
  - Water quality improvement
  - Preserving land as forest
  - *Other benefits?*

Factors to consider: woody biomass for pellets is at end of value chain



ORNL analysis uses Forest Inventory Analysis (FIA) data collected by USDA

Long-term survey of the forests in the US provides information on status and trends in

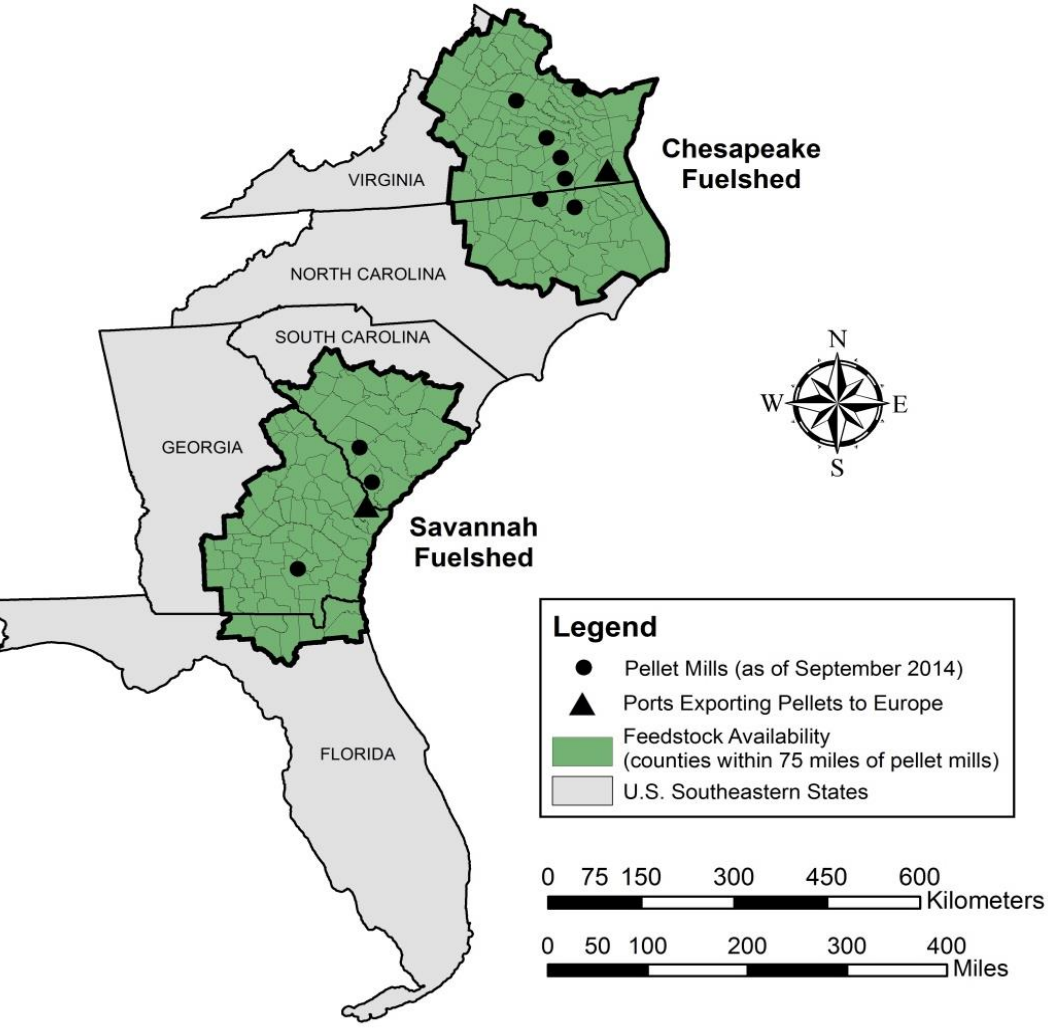
- **Forest area and location**
- **Species, size, and health of trees**
- **Total tree growth, mortality, and removals by harvest**
- **Wood production and utilization rates by various products**
- **Forest land ownership**

http://www.fia.fs.fed.us/tools-data/

Prior analysis by USDA shows that most US timberland is in SE, under private, non-corporate ownership

Source: FIA RPA 2012; Timberland: forestland capable of >20cft/acre-year of industrial wood

Effects on forests of wood-based pellet production in fuelsheds of the SE US



Increased wood pellet production from two major fuelsheds in the SE US did <u>not</u> affect

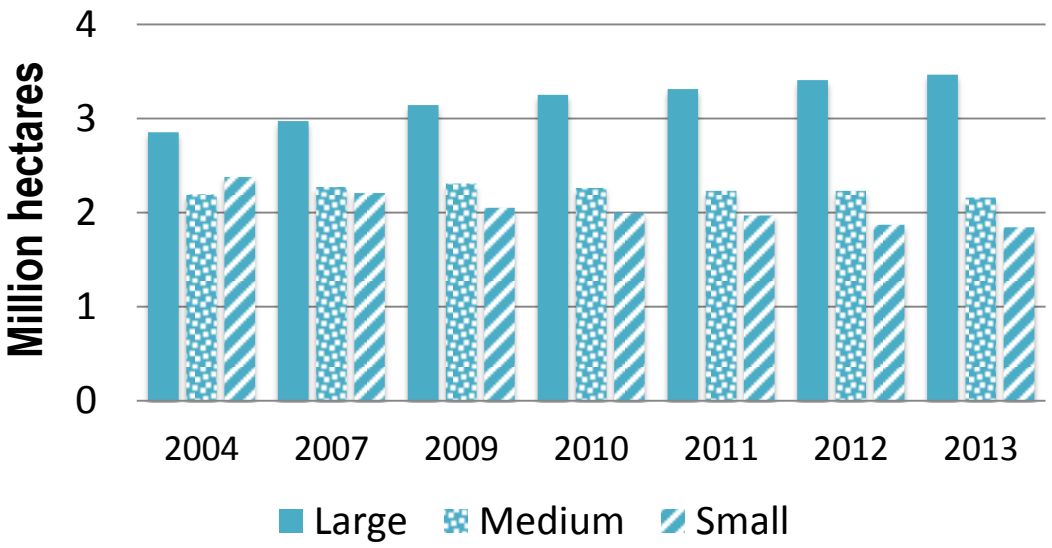
- Carbon in
  - Litter and soil
  - Other nonharvestable material
  - Harvestable material
- Above-ground biomass
- Forest area
- Timberland area
- Large tree class stand area
- Standing dead

Consistent size distribution reflects healthy stand

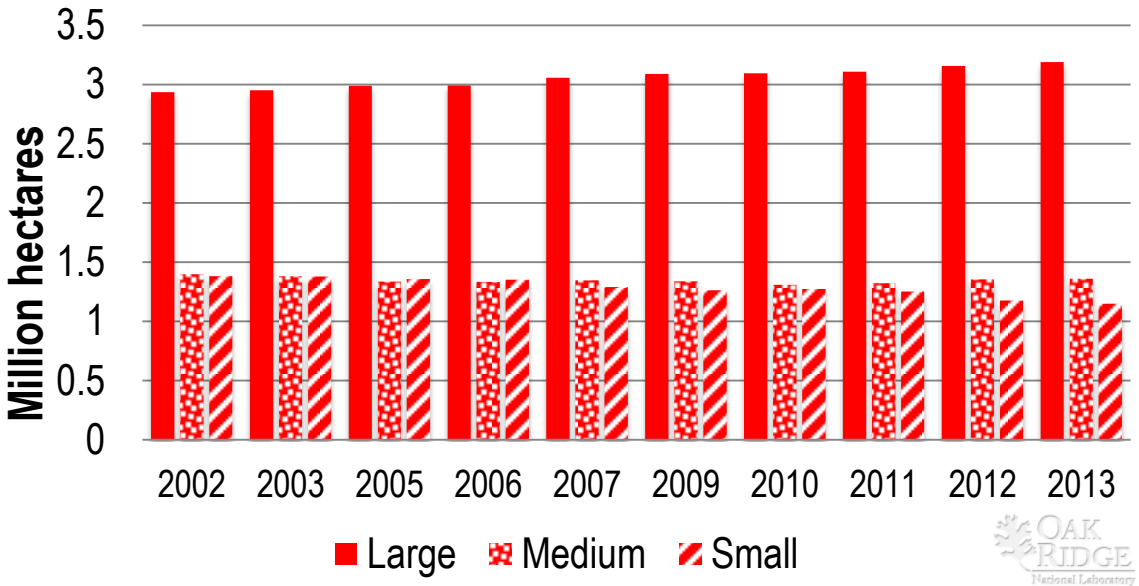
Major stand diameter categories

Category	Hard-wood	Soft-wood	Stocking
Large	>11"	>9"	>50% in medium or large trees
Medium	5-11"	5-9"	>50% in medium or large trees & more medium than large trees
Small	<5"	<5"	At least 50% small diameter trees

Savannah fuelshed stand size



Chesapeake fuelshed stand size



Next steps

- **Evaluate projections for future pellet exports using Bob Abt's economic model**
- **Continue to develop and test tools for assessment of progress toward bioenergy sustainability**
  - Focus on particularly challenging indicators
    - ✓ Biodiversity
    - ✓ Reference case for carbon accounting
    - ✓ Water quality

- **Case studies of evaluating progress toward sustainability**
  - Pellet production in SE US – survey of private landowners (building on National Woodland Owner Survey)
  - Cellulosic crops in midwestern US (project led by Antares Group Inc.) http://energy.gov/eere/articles/energy-department-announces-9-million-

Next step: Tool to Visualize Progress toward Sustainability

- **Objective: Develop and test visualization tool (starting with a demonstration)**
  - Displays information about progress being made toward bioenergy sustainability
    - In a particular context as defined by the user.
    - As characterized by a suite of environmental, social and economic indicators
  - Enhances understanding of tradeoffs and communicates relative importance of different components
- **Audience: Diversity of stakeholders: individuals, groups, businesses, organizations**
- **Identify relevant properties of bioenergy sustainability indicators for aggregation**
  - How can information from multiple distributions for indicators be aggregated in a way that reduces complexity and maintains the most information?
  - Use statistical and probabilistic approaches and properties of specific aggregation functions
  - Quantifying uncertainty using the geometric mean as the aggregation function has yielded positive results
- **Develop "dashboard" = collection of linked components that can affect each other**
  - Aggregate correctly
  - Provide clear interpretation of results
  - Engage user in exploring alternatives
- **Process – Design a flexible platform via several case studies**

Opportunities Bioenergy Offers to more Sustainable Systems

- **Better management of renewable resources**
  - Reducing wastes and inefficiencies
  - Existing infrastructure, know-how and technologies
  - Retaining land in agriculture or forest
- **Improve environmental conditions**
  - Soils & water
  - Biodiversity
  - Carbon and GHG
- **Enhance food & energy security**
  - Conserving fossil energy resources
  - Reducing risk of catastrophes
- **Increase rates and stability of employment**

Dale and Kline (in review)

Barriers to more Sustainable Systems

- **Public perception**
  - Unmet expectations
  - Uncertainty about future demand & prices
- **Economics**
  - Unstable policy
  - Up-front costs & risks of new energy systems
  - Uneven playing field
    - Subsidies
    - Lack of Infrastructure for new systems
    - Easy access to inexpensive fossil fuels
- **Sustainability concerns**
  - Food security
  - Biodiversity
  - Ambitious requirements

Dale and Kline (in review)

Paths Bioenergy Provides to more Sustainable Systems

- **Use wastes and residues**
- **Be context specific**
  - Build on existing infrastructure and knowhow
  - Communicate costs and benefits
- **Promote better management**
  - Integrated agriculture
  - Landscape design

Dale and Kline (in review)

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Thank you!

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