A landscape design approach for sustainability of woody biomass production

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September 22, 2015

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

U.S. DEPARTMENT OF ENERGY

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Dirtier than coal?

Why Government plans to subsidise burning trees are bad news for the planet

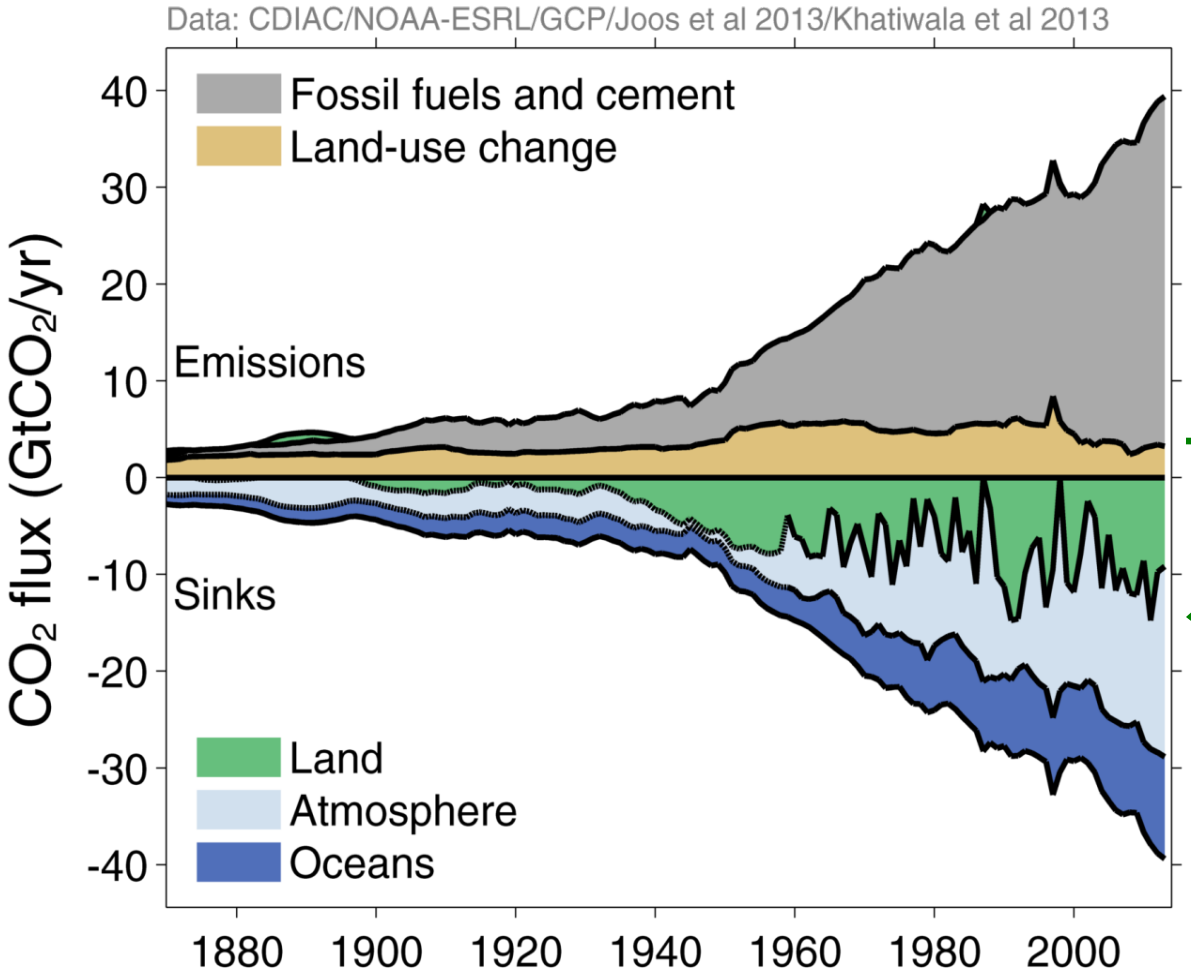
RSPB

friends of the earth
see things differently

GREENPEACE

Why consider biomass for energy?

Emissions are partitioned between the atmosphere, land, and ocean



Source: CDIAC; NOAA-ESRL; Houghton et al 2012; Giglio et al 2013; Joos et al 2013; Khatiwala et al 2013; Le Quéré et al 2014; Global Carbon Budget 2014

1. Incentives to better manage terrestrial sinks are essential; represent an IPCC 'low-cost/low-risk' option
2. "LUC" emission ***estimates weak***
3. Land system is important sink (goal: expand net sink capacity)

Atwood M (July'15): "Oil does not have to come out of the ground… Carbon has been recycled ever since plant life emerged on earth"

Bioenergy Sustainability Research

- Advance common definitions of environmental & socioeconomic costs and benefits of bioenergy systems
- Quantify opportunities, risks, & tradeoffs associated with sustainable bioenergy production in specific contexts

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ORNL's goals support US Department of Energy objective:

Enable long-term supply of sustainable feedstock and clean, domestic bioenergy

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

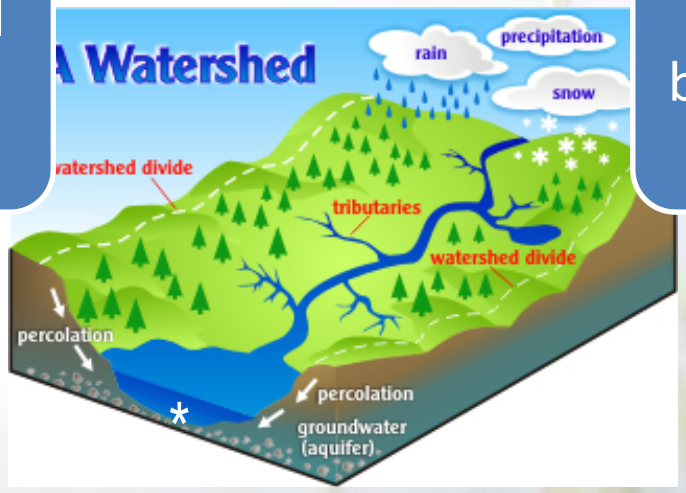
Select Indicators

Establish baselines and targets

Evaluate indicator values

Identify trends and tradeoffs

Develop and test best practices



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By–products of tree harvest for saw timber and pulp in Southeast Region (SE) of USA are increasingly used for bioenergy

U.S. Wood Pellet Trade

US (KTonnes)

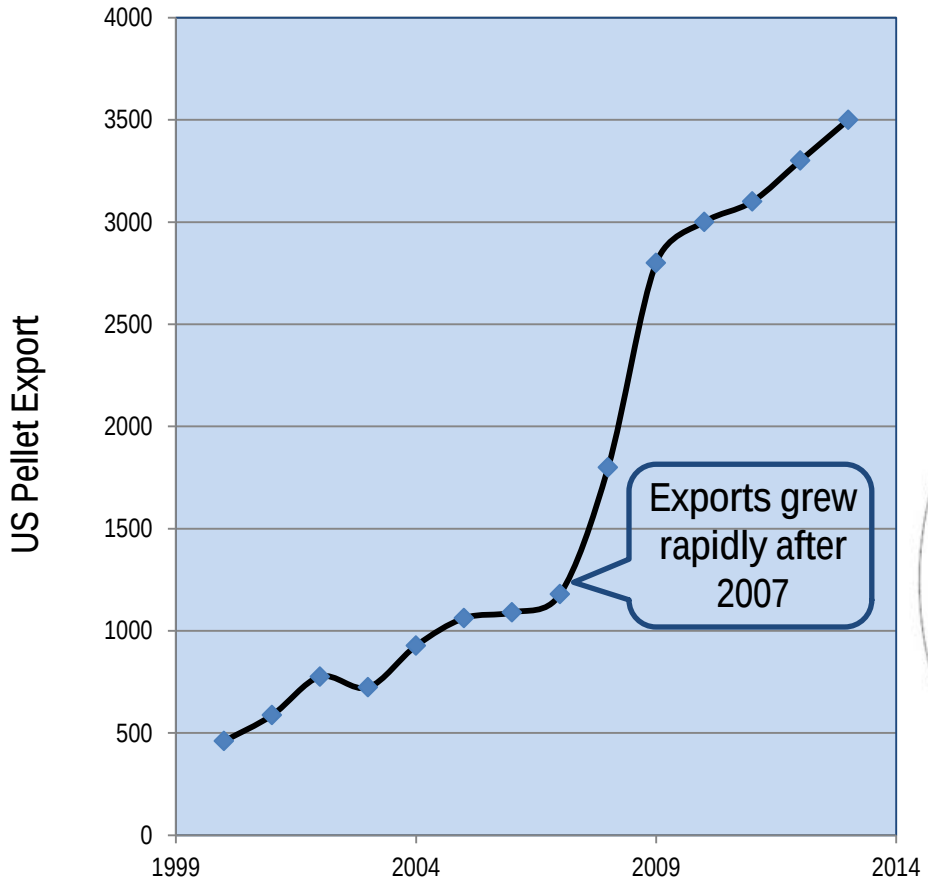
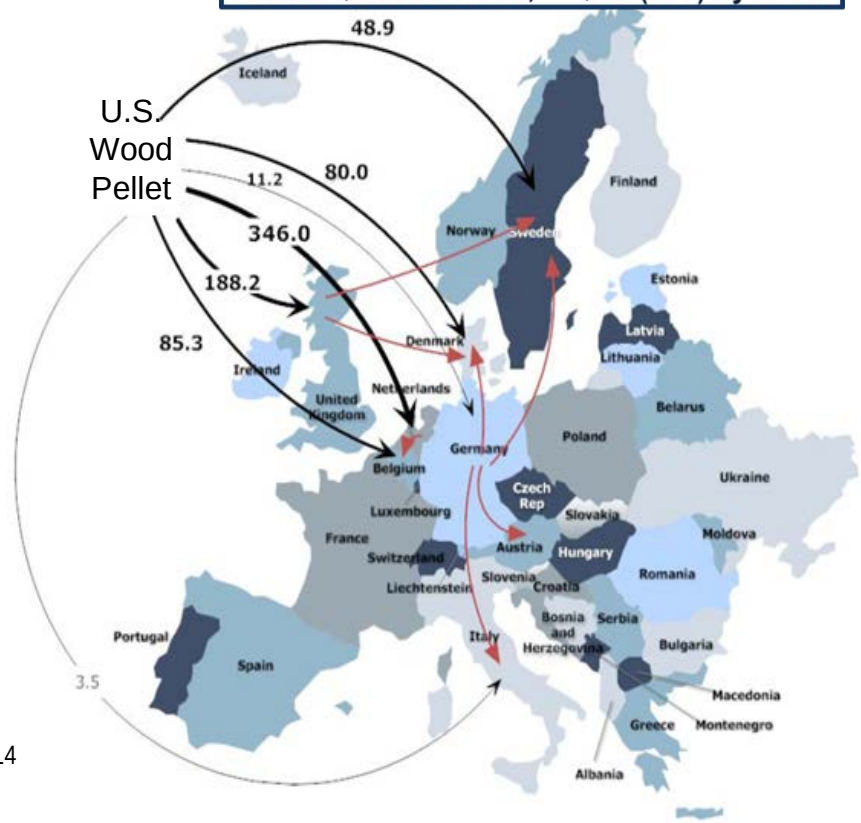


Figure: U.S. Pellet Export (US EIA, 2014)

Exports to EU are projected to continue to 2030.

Example: exports at risk, US pellet exports Valued $650M in 2013, > $1B (est.) by 2016



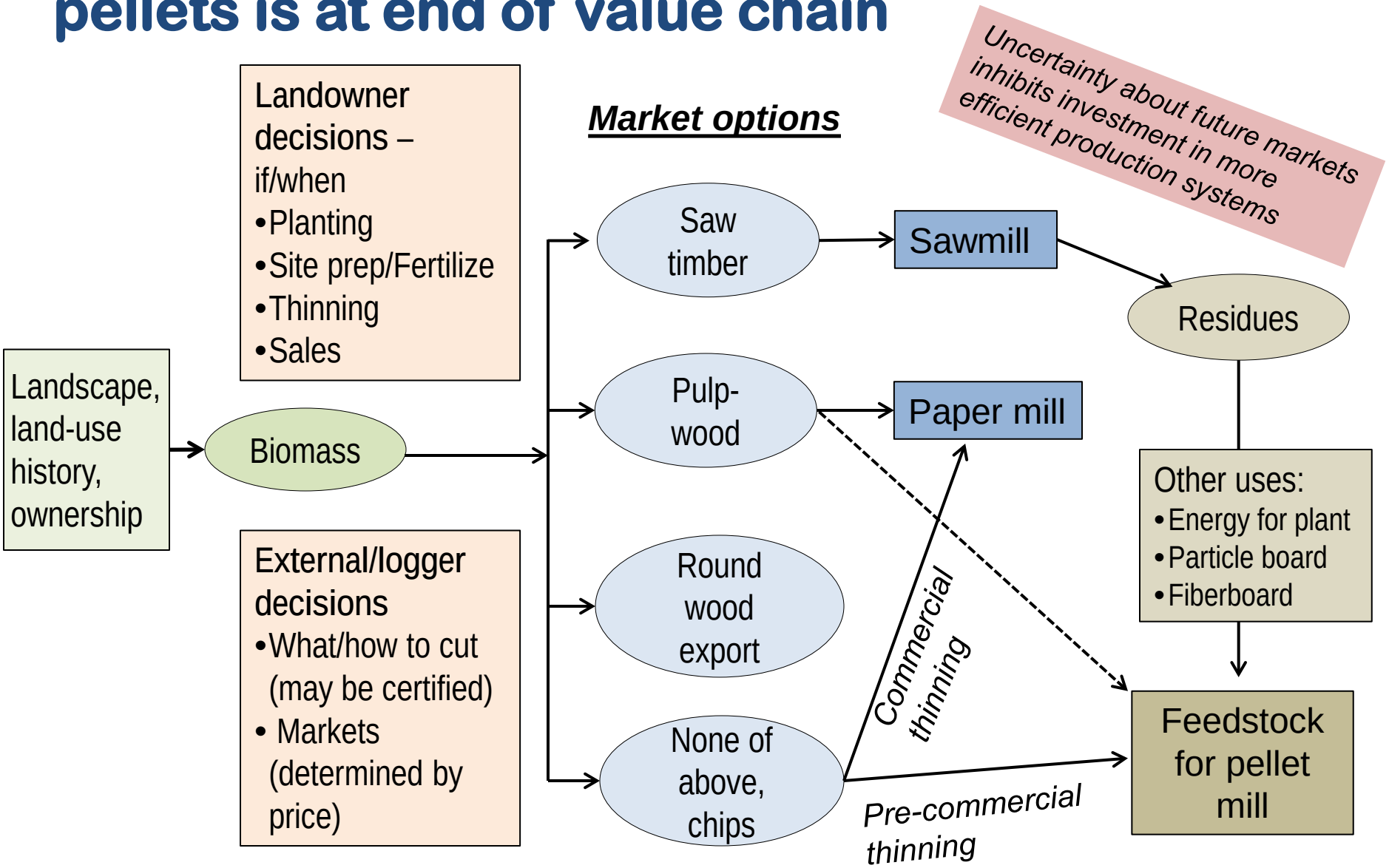
2010 Wood Pellet Trade flow from US to major EU markets and from Net exporters within EU , in 1000 MT

Data source: Lamers et al., 2013 and Eurostat, 2012

Key Research Questions

- How does SE US pellet production to meet export demand differ from a business-as-usual case (pre-2007 trend)?
  - Under what conditions does the pellet industry compete with pulpwood use?
  - Will pellet industry lead to more land staying in forests?
- Are there significant changes to key indicators?
  - Biodiversity
  - Land use changes
  - Greenhouse gas emissions
- Does pellet industry provide benefits?
  - Jobs
  - Water quality improvement
  - Preserving land as forest
  - *Other benefits?*

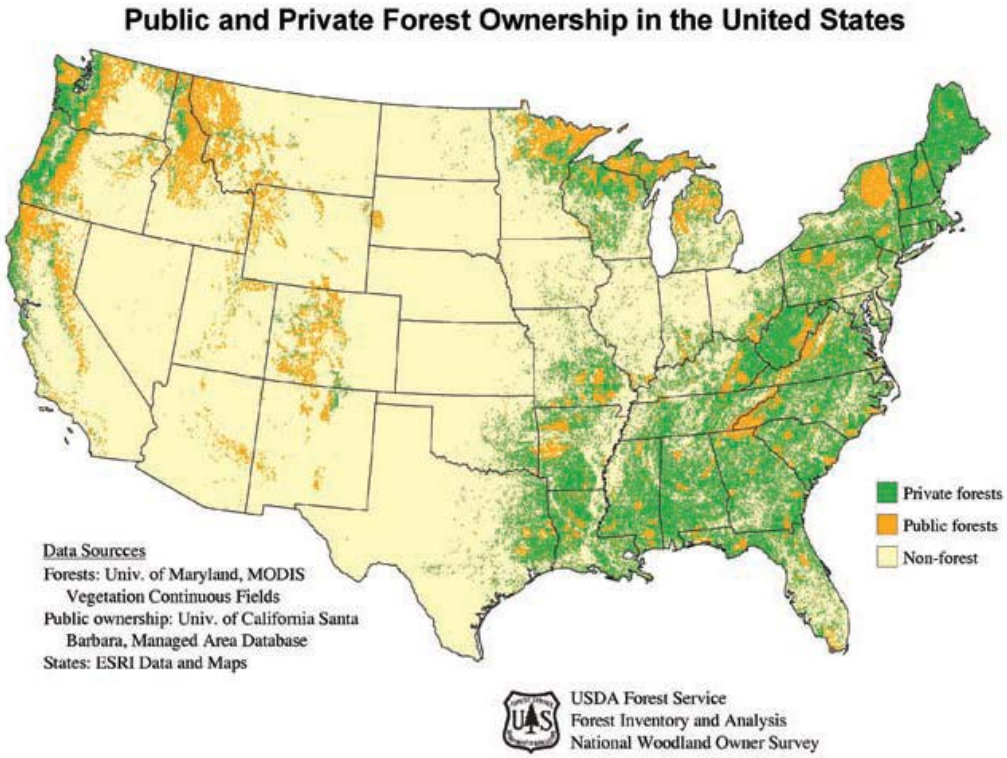
Factors to consider: woody biomass for pellets is at end of value chain

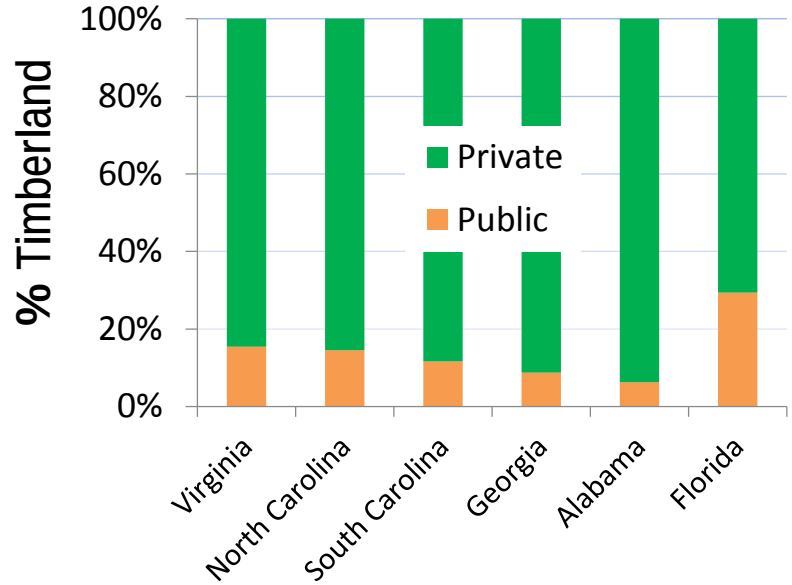


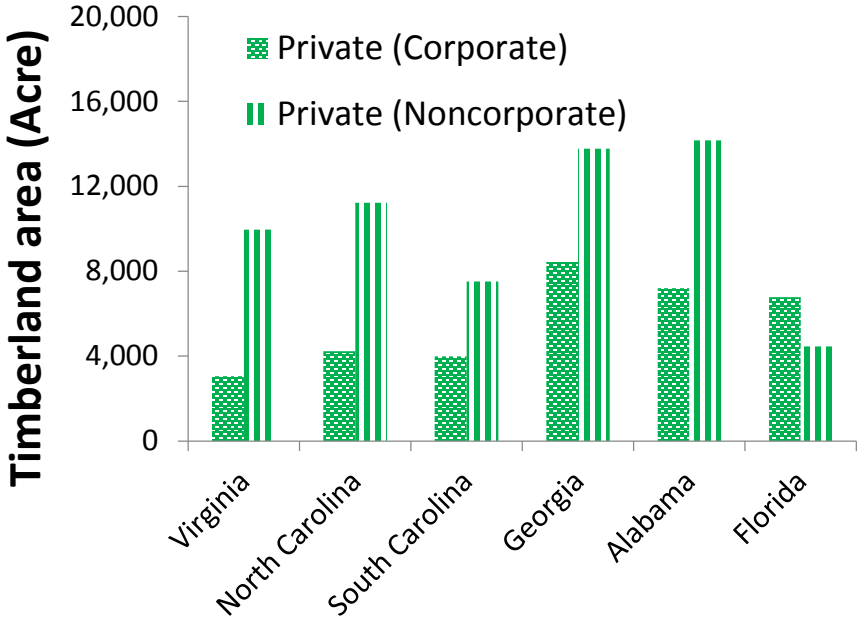
Trees are cut and sorted by size

- Size and quality determine market options
- Harvest meets standards
  - Corporate forest lands - for example,
    - ✓ Forest Sustainability Initiative (FSI)
    - ✓ Forest Stewardship Council (FSC)
  - Non-corporate lands
    - ✓ Trained ‘master loggers’
- Follow best practices
  - Branches returned to forest
  - Land-use plans protect places providing ecosystem services

Most US timberland is in SE, under private, non-corporate ownership



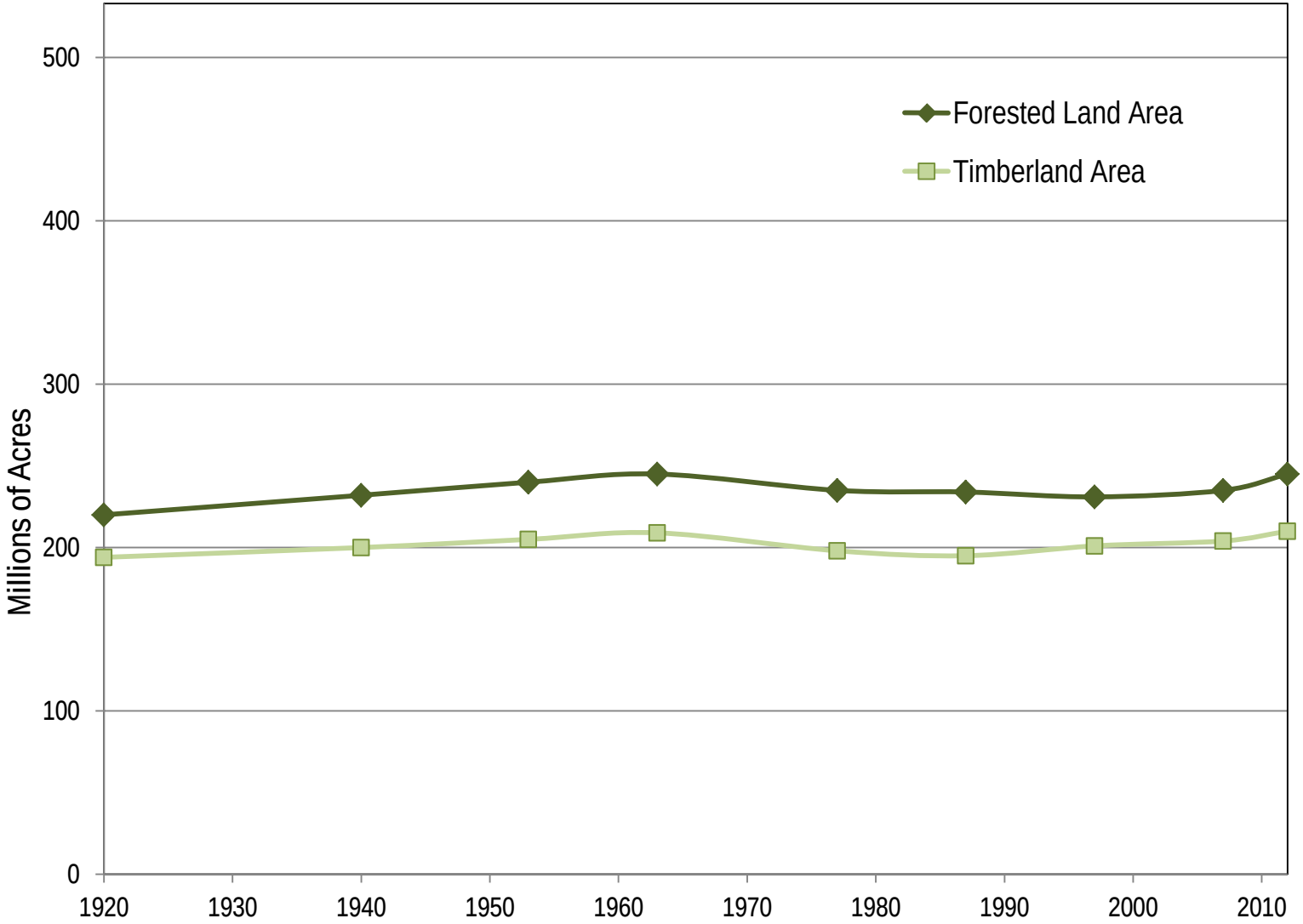




Source: FIA RPA 2012; Timberland: forestland capable of >20cft/acre-year of industrial wood

Forest Area Trends for U.S. South* *(533 million acres)*

Source: Aug 2014 USFS Data from FS-1035



*** USFS "South" includes states of VA, NC, SC, GA, FL, KY, TN, AL, MS, AK, LA, OK, and TX**

Application of landscape design approach

Two major export ports for energy pellets in SE USA:

- Savannah: mostly intensively managed pine plantations
- Chesapeake: both pine and mixed hardwoods

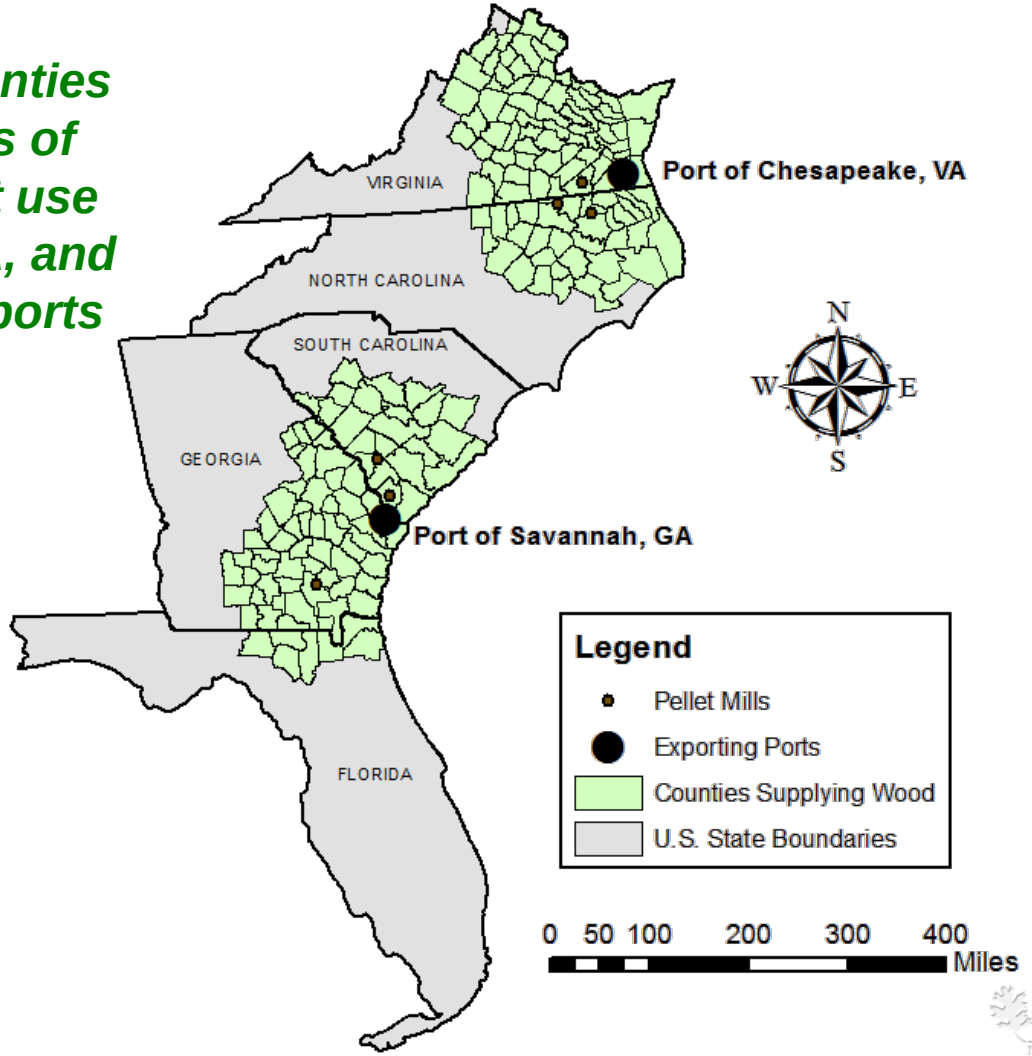
***Fuelsheds*: Counties within 75 miles of pellet mills that use Chesapeake, VA, and Savannah, GA ports**

Advisory team:

- NCASI
- Weyerhaeuser
- Plum Creek

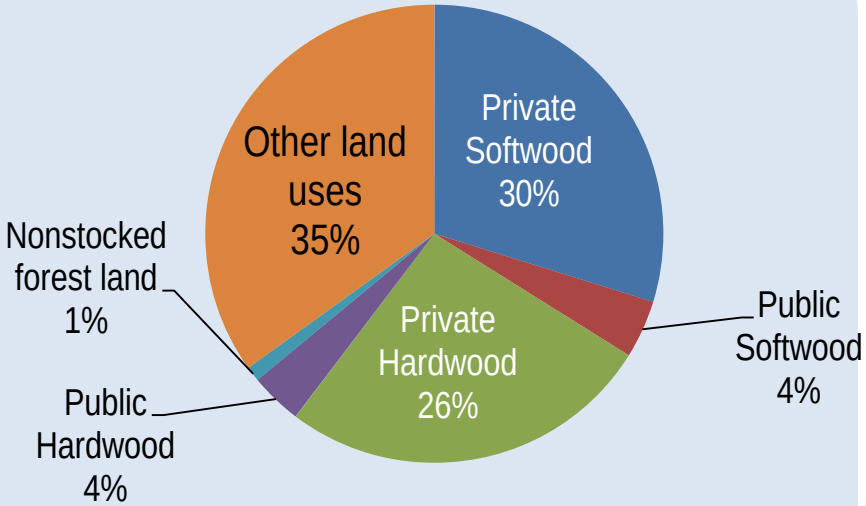
Collaborators:

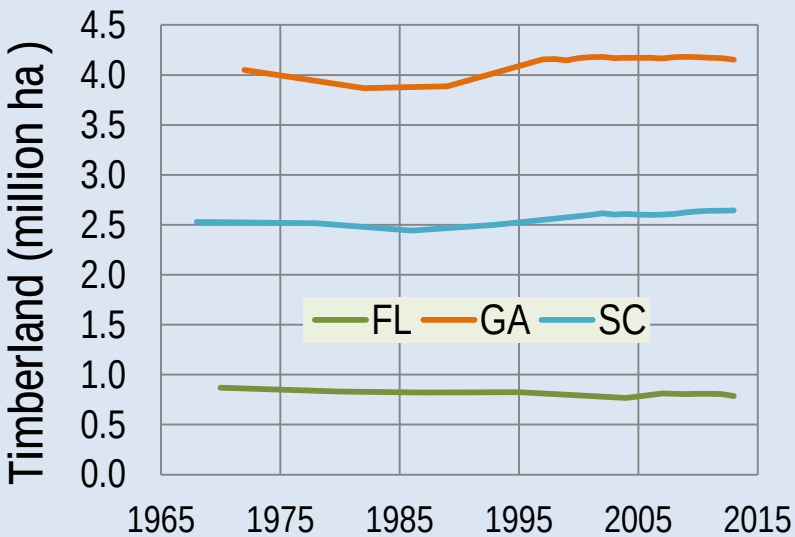
- NCSU: Bob Abt
- USDA: Karen Abt
- Utrecht University: Floor Van der Hilst, Anna Duden, Steef Hanssen



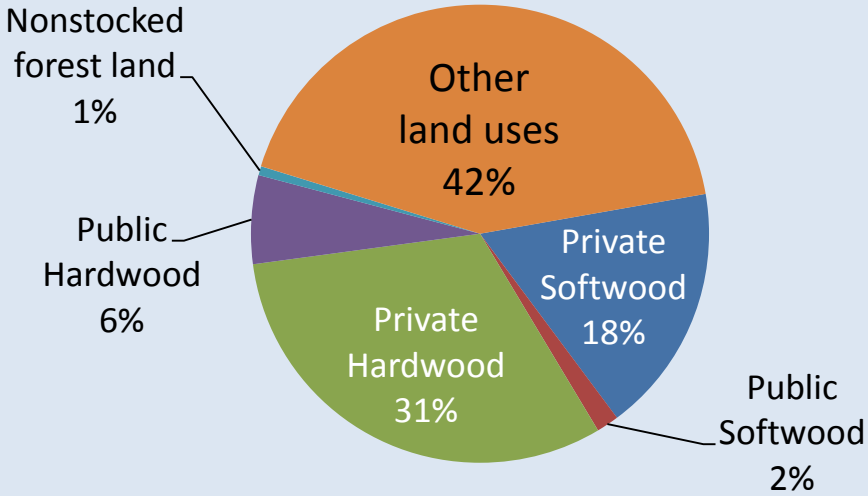
Forest Inventory Analysis (FIA) data for fuelsheds

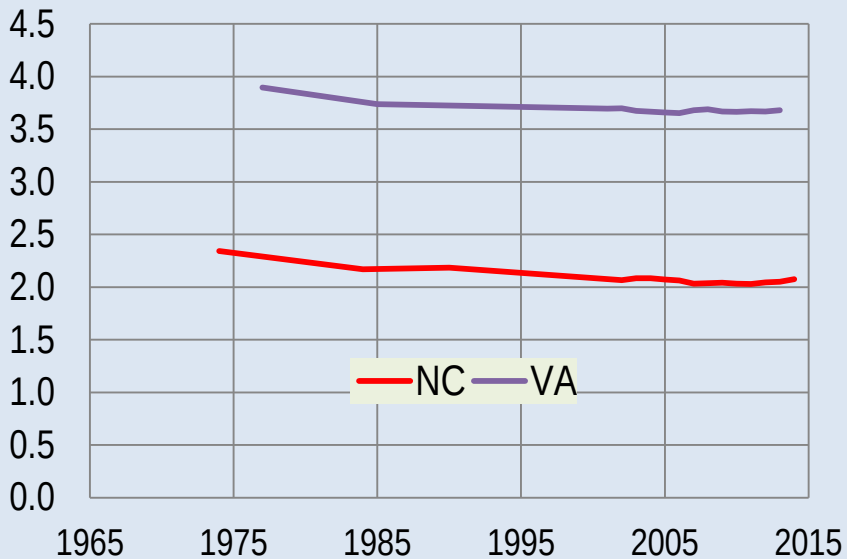
Savannah fuelshed 2013





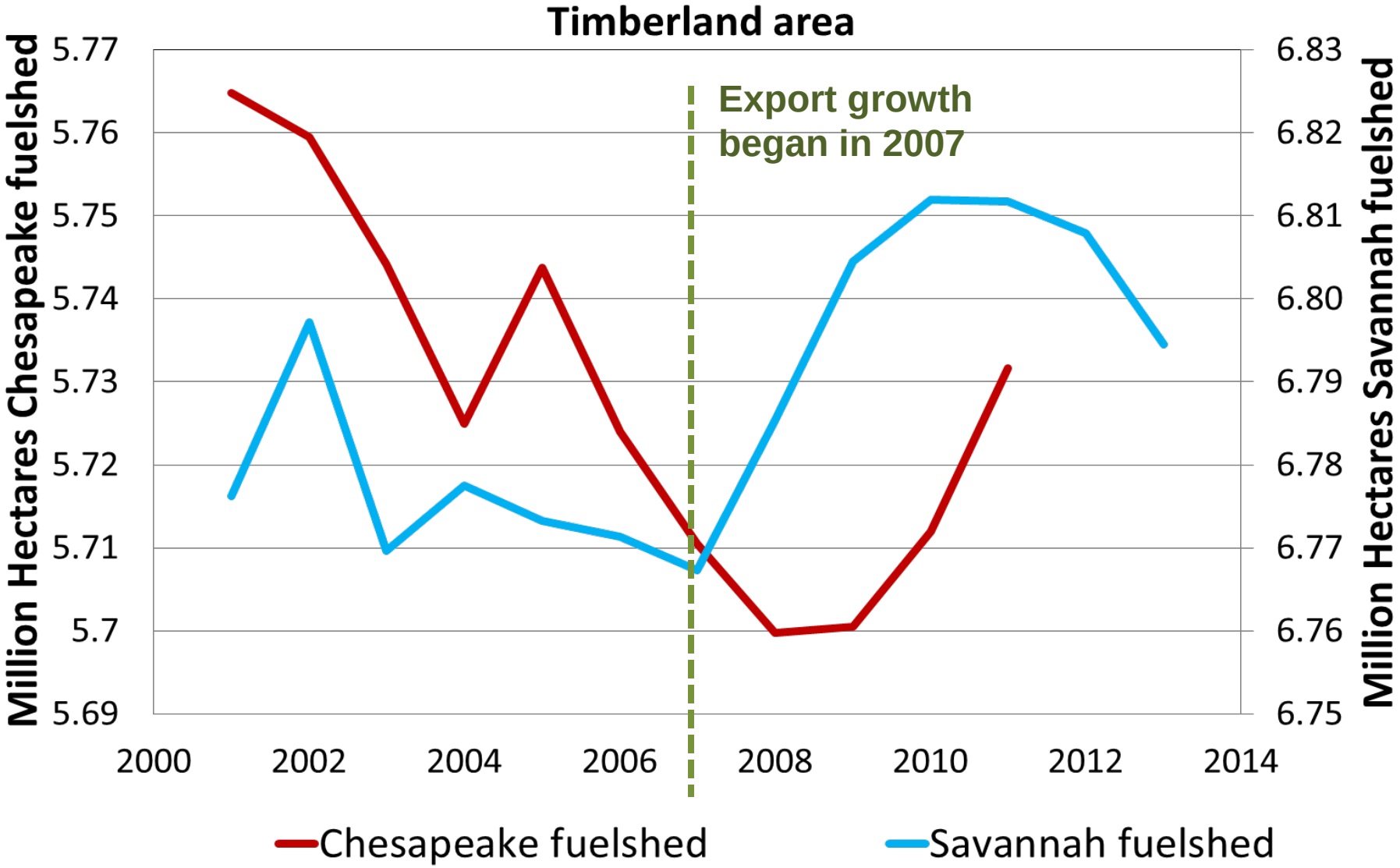
Chesapeake fuelshed 2013





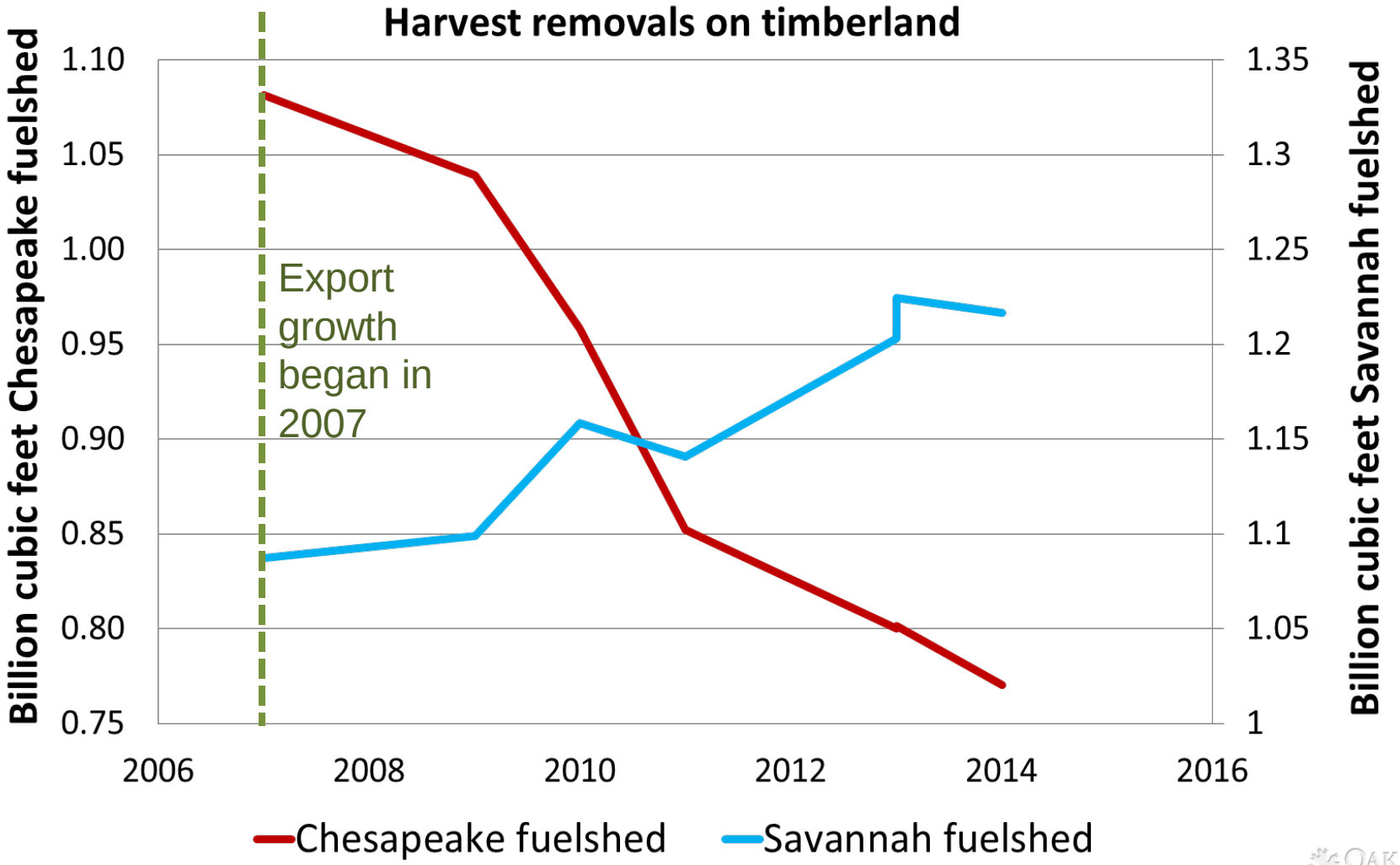
Data description: FIA RPA 2012; Timberland: forestland capable of >20cft/acre-year of industrial wood

Timberland area increased by >20,000 Ha since 2007 in both pellet exporting fuel-sheds



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

Timber harvests in Chesapeake fuelshed decreased ~28% and in the Savannah fuelshed increased ~25% (2007-2014)

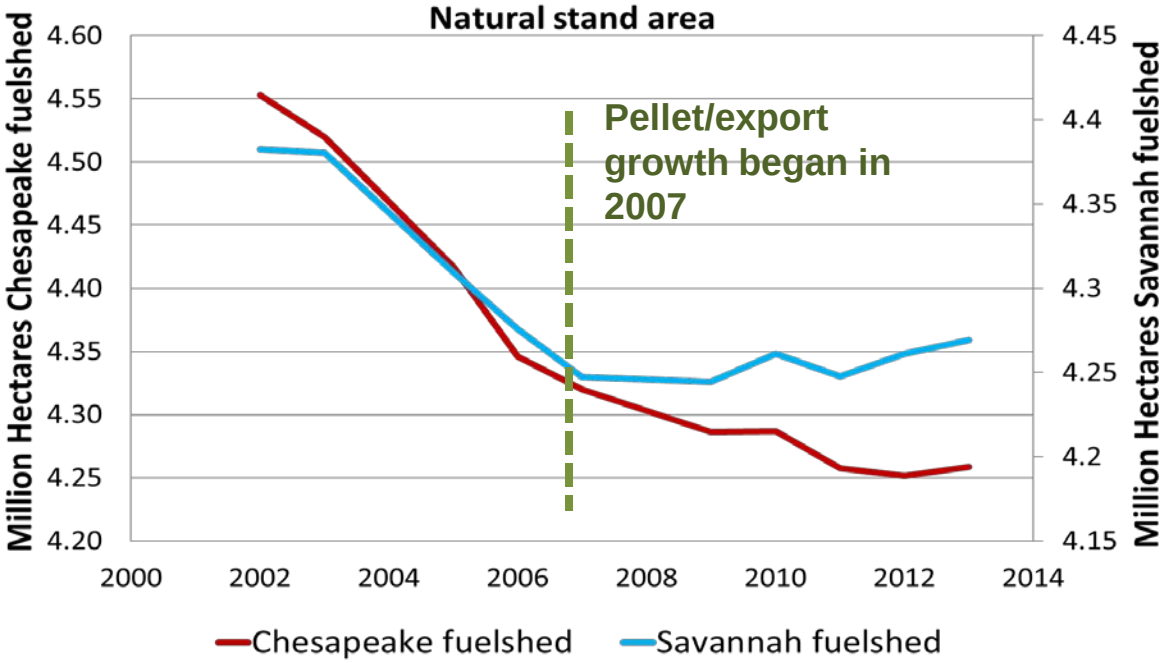


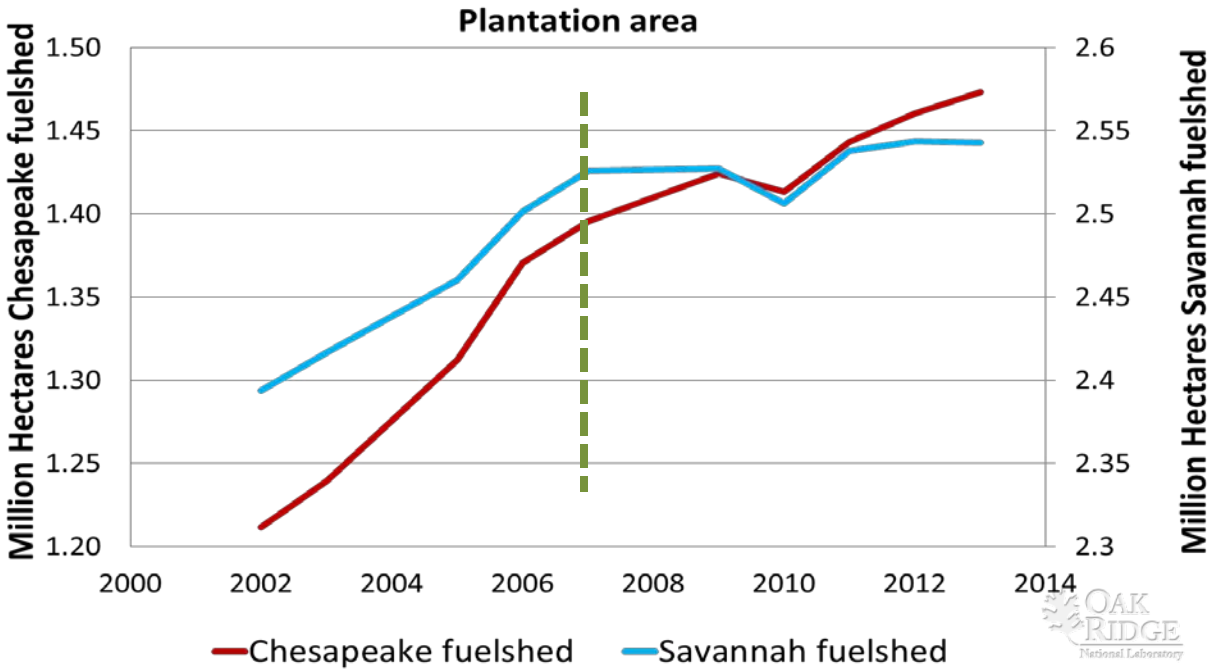
Data description: FIA RPA 2012

Natural forest stands have been displaced by:

- Agriculture
- Development
- Plantations

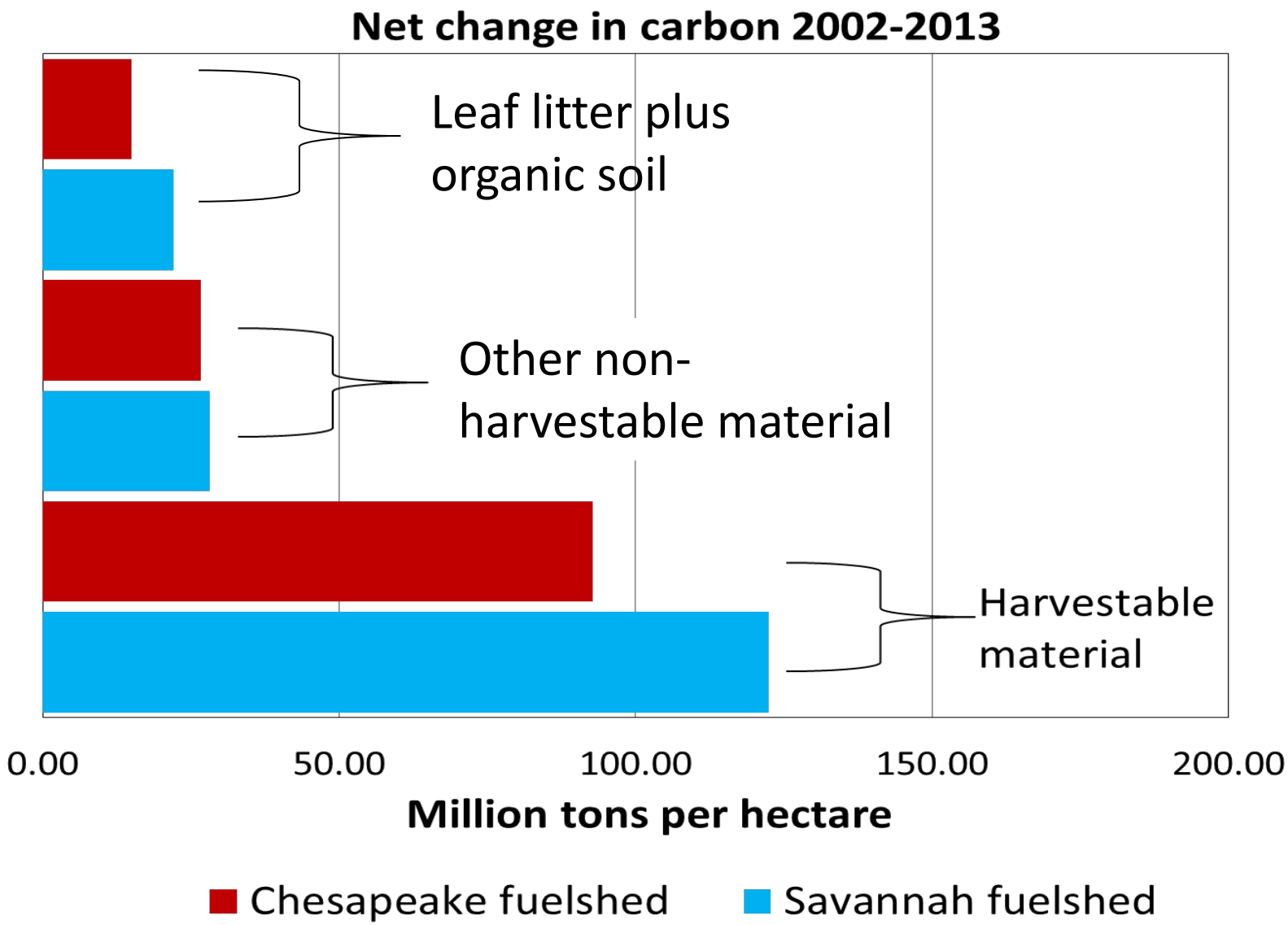
- Expanding plantations displace natural forests in both fuelsheds,
- In the Savannah fuelshed, both natural stand area and plantation area increased slightly since 2007.





Data description: FIA RPA 2012

Net carbon in fuelsheds appears to be increasing



Data description: FIA RPA 2012

Conclusions (preliminary)

- Increased wood pellet production from two major fuelsheds in the SE US did not affect
  - Soil carbon
  - Above-ground biomass
  - Forest area
  - Timberland area
  - Large tree class stand area

- Savannah and Chesapeake fuelsheds have increased timberland area since 2007, when pellet production expanded

- Sustainability aspects to be assessed:
  - Socio-economic effects for local communities
  - Effects on ecosystem services
    - Biodiversity
    - Wetland forest areas
    - Forest transitions to agriculture and vice-versa
    - Transitions of mixed hardwoods and native pines to more intensive pine plantations
    - Urban expansion into forest areas – primary threat to forests in the SE

Discussion

- Pellets industry is expanding but is not a major driver of forest sector activity
- Forest harvest is primarily driven by demand for lumber
- Sustainability concerns
  - Biodiversity
  - Changes in land use or management
  - GHG and climate forcing effect estimates
    - Reference conditions
    - Time and space (scales)
  - Opportunities
    - Jobs
    - Water quality improvement
    - Preserving land as forests
    - Continual improvement in practices = increasing sustainability
  - Need stakeholder engagements
    - Communications
    - Science-based reviews

Response to ESA on wood-derived bioenergy policy

Dale VH, Kline KL, Marland G, Miner RA. 2015. **Ecological objectives can be achie ved with wood-derived bioenergy**. *Frontiers in Ecol and Enviro* 13(6): 297-299.

- EPA's Clean Power Plan proposal recognizes the complexity and importance of system boundaries in time and space.
- With increasing demand for forest products, forest area in the US typically expands
- Managed forests benefit neighboring landscapes by
  - ✓ limiting intrusion of disturbances
  - ✓ enhancing ecosystem services
- Net benefits from bioenergy can accrue immediately or within a few years with sustainable forest management practices

Wood remaining on the ground after a clear- cut harvest at the Oak Ridge Forest (University of Tennessee – Forest Resources AgResearch and Education Center)

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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

Next steps

- **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 – will test landscape design
  - Other feedstocks in other regions - testing indicator approach for cellulosic crops in Midwest project led by Antares http://energy.gov/eere/articles/energy-department-announces-9-million-

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.

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Categories of socioeconomic sustainability indicators

Ten minimum practical measures

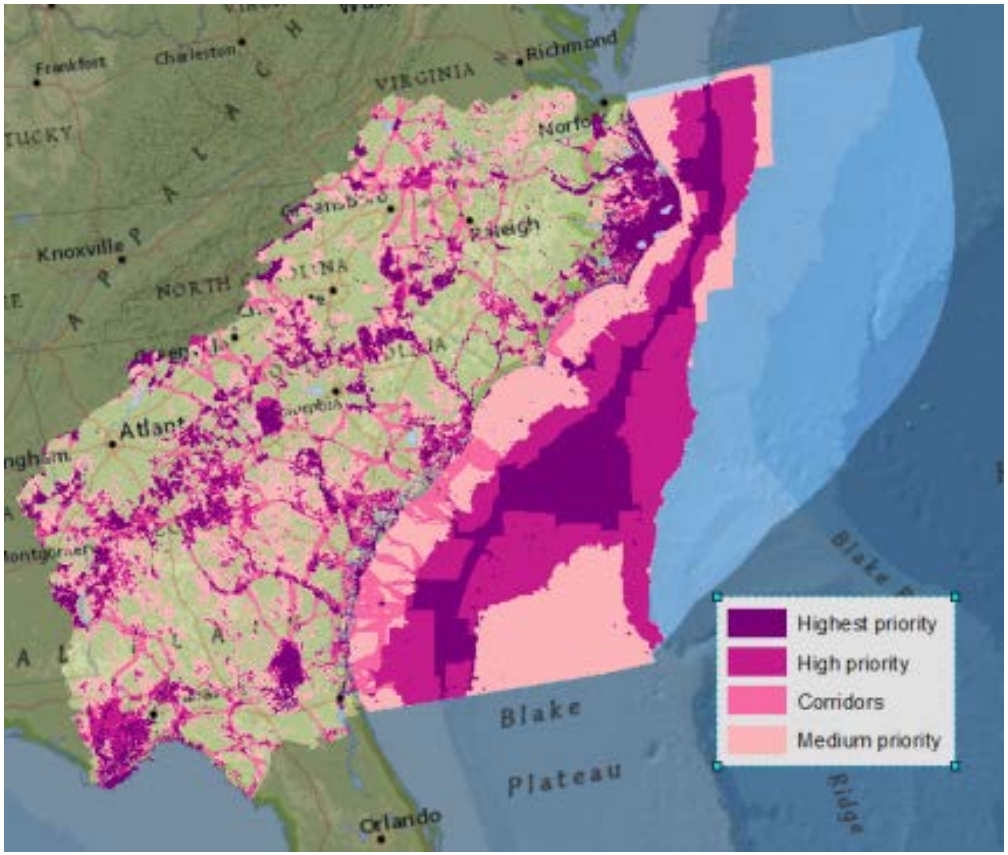
Category	Indicator	Units
Social well-being	Employment	Number of full time equivalent (FTE) jobs
	Household income	Dollars per day
	Work days lost due to injury	Average number of work days lost per worker per year
	Food security	Percent change in food price volatility
Energy security	Energy security premium	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 catastrophe event

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

We hope to build form the work of the South Atlantic Landscape Conservation Cooperative

- The SA LCC has created a shared blueprint for landscape conservation actions that sustain natural and cultural resources

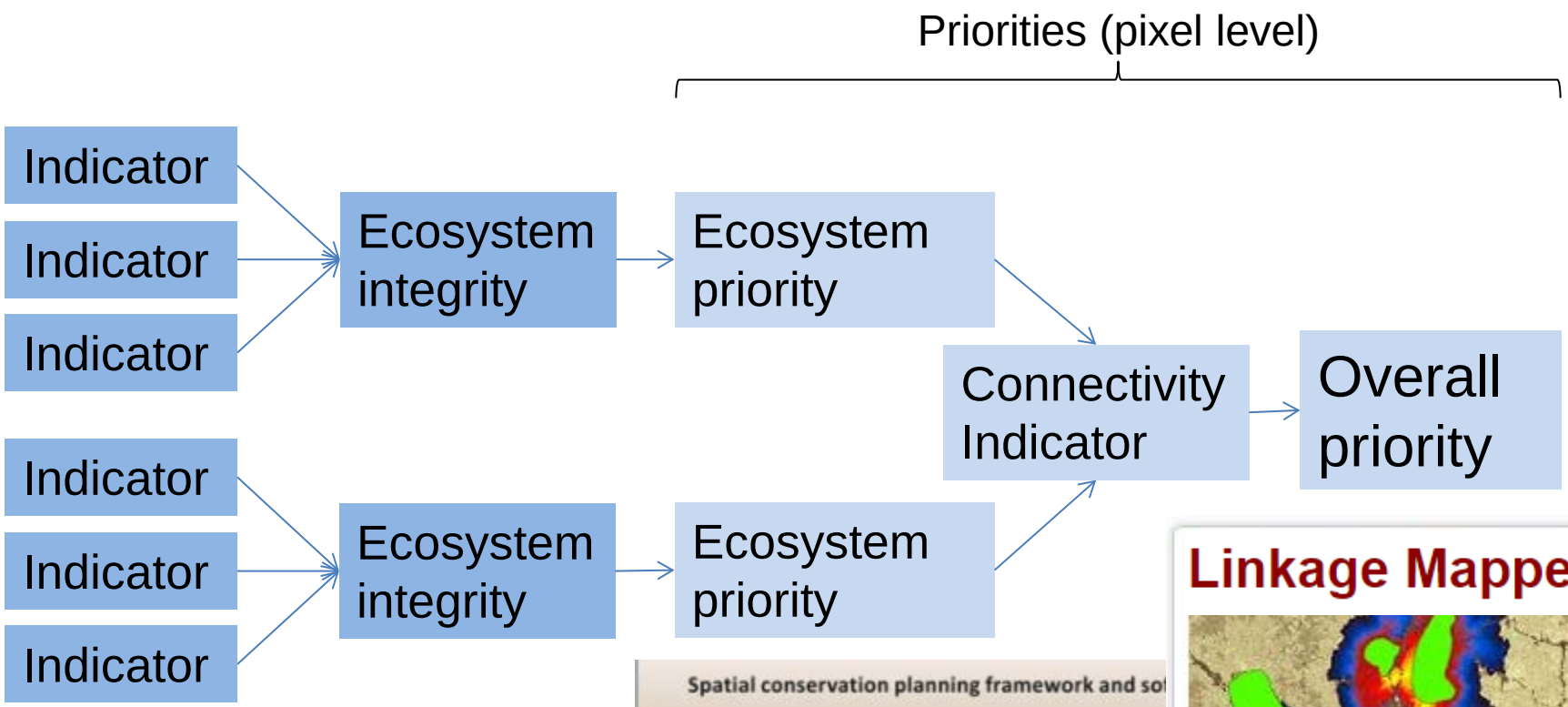


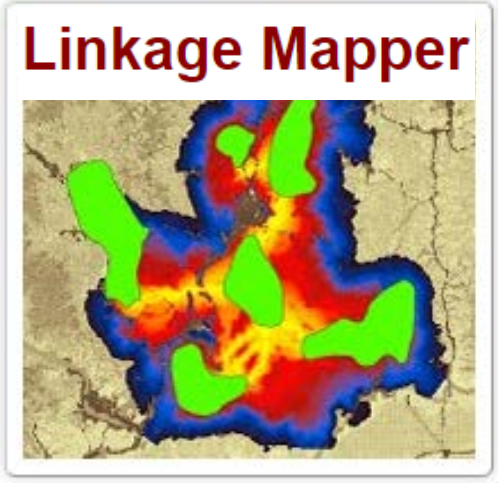
Indicators

Selection Criteria

- **Ecological** (How well it represents a variety of other organisms/ecological attributes and responds to landscape change),
- **Practical** (Can it be monitored and modeled based on current programs and resources)
- **Social** (How well do they resonate with a variety of audiences).

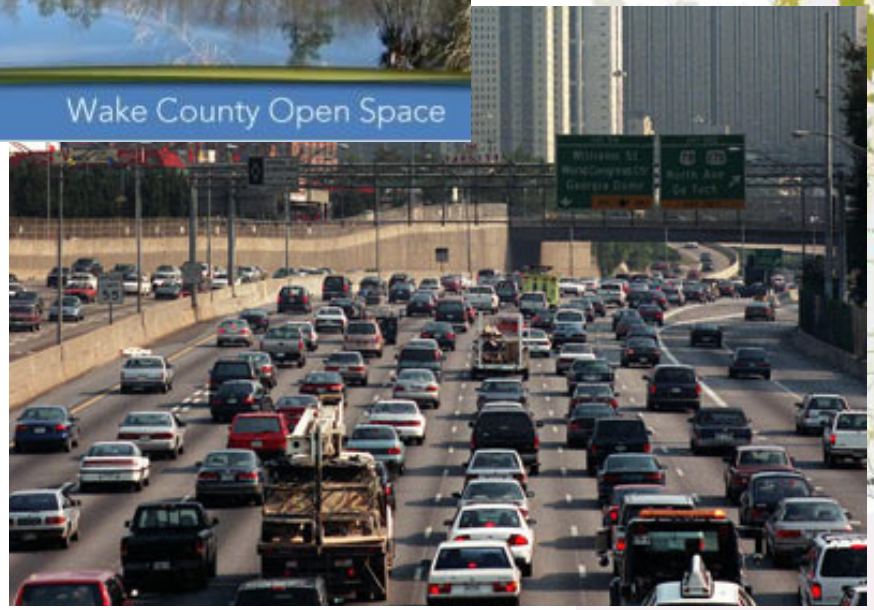
Blueprint 2.0

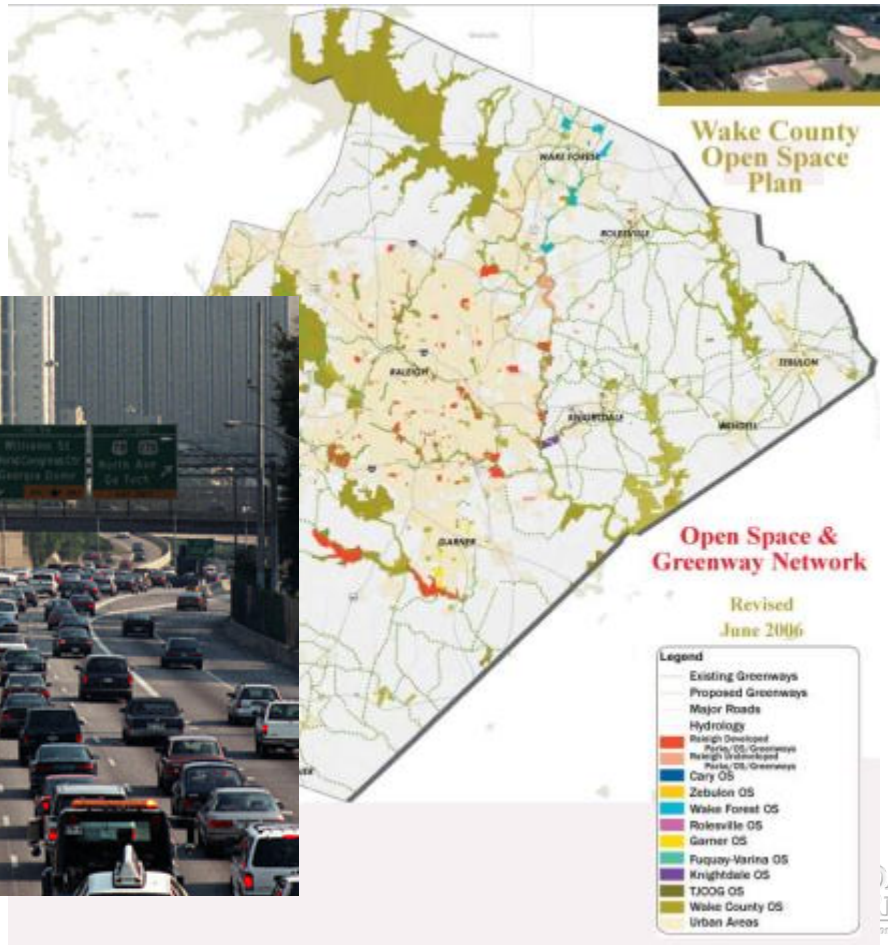




How can the Blueprint be used?

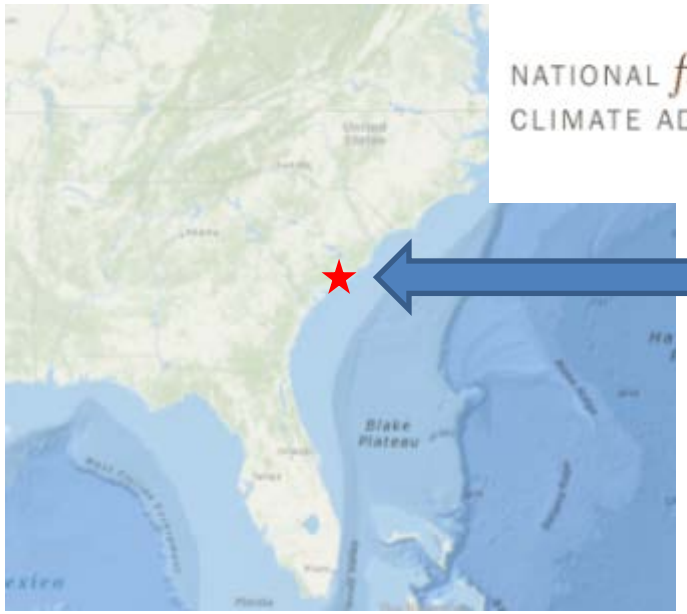
- Case A: guiding infrastructure development



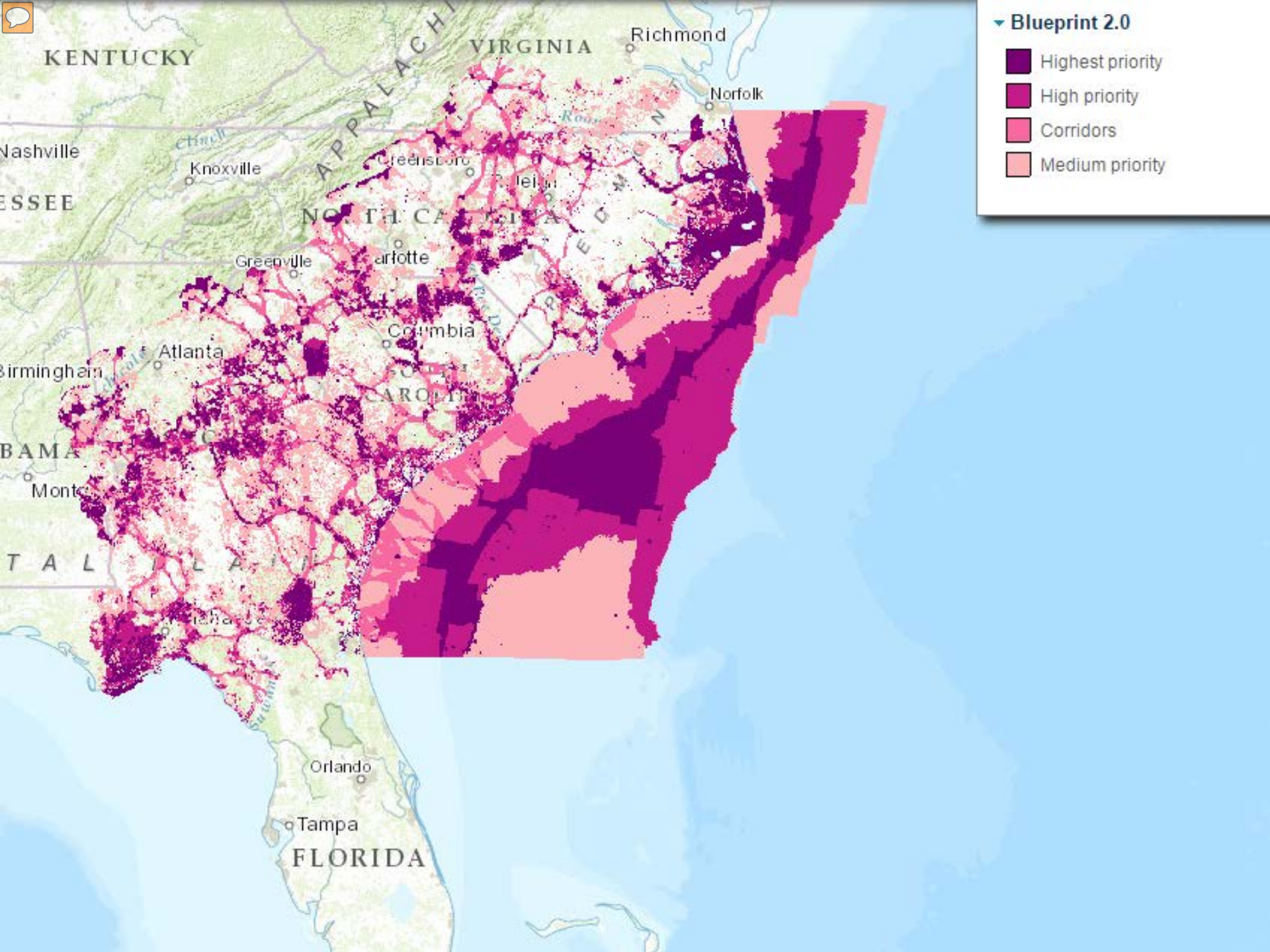


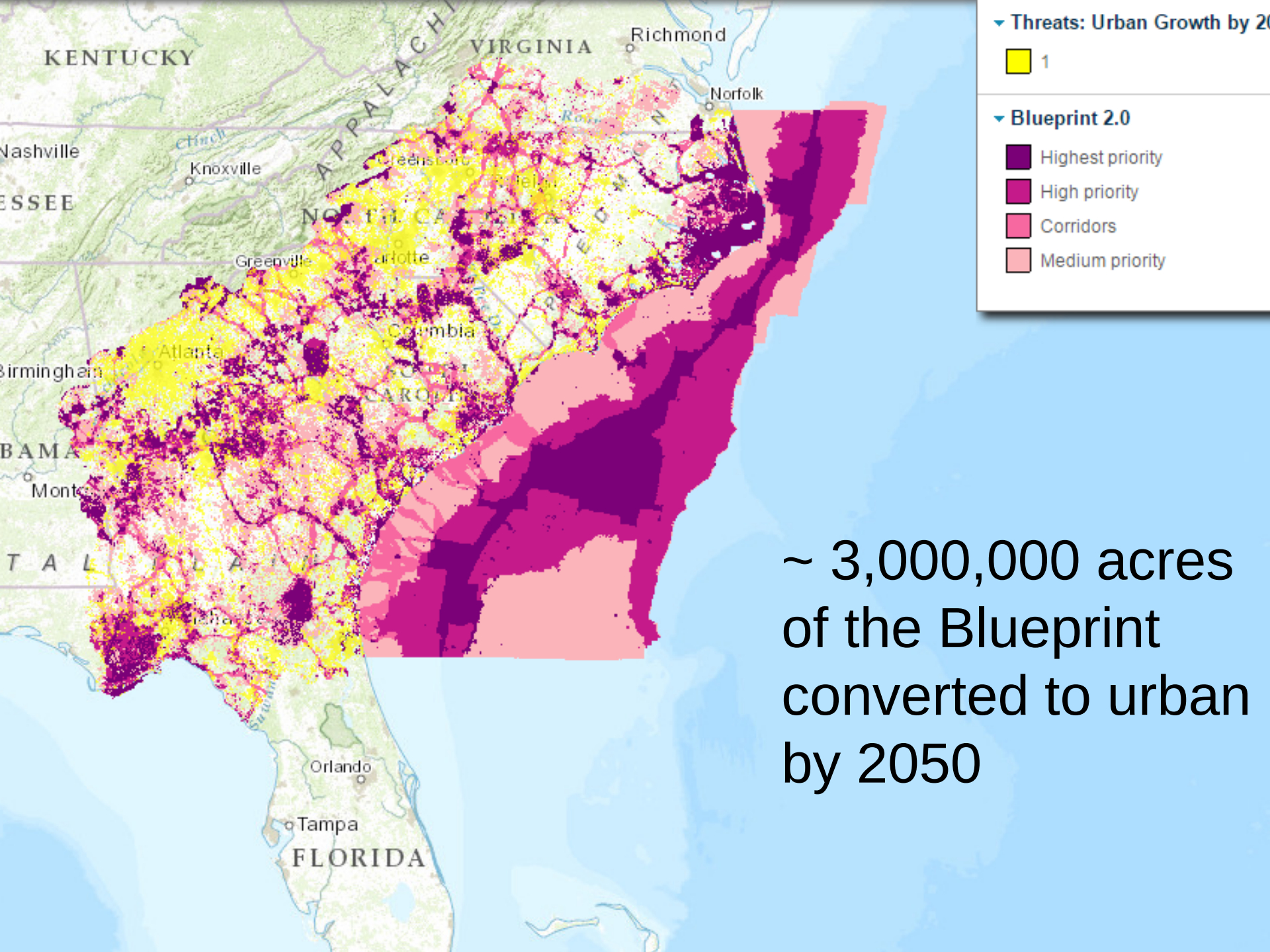
How can the Blueprint be used?

- Case B: Bringing in landscape perspectives to local adaptation (how do I fit in?)



NATIONAL *fish, wildlife & plants*
CLIMATE ADAPTATION STRATEGY


Blueprint 2.0
Highest priority
High priority
Corridors
Medium priority
KENTUCKY
VIRGINIA
Richmond
Norfolk
Nashville
Knoxville
Greenville
Atlanta
Orlando
Tampa
FLORIDA



~ 3,000,000 acres of the Blueprint converted to urban by 2050

Thank you

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- Forums on current topics
- Recent publications

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

This research is supported by the U.S. Department of Energy (DOE) Bio-Energy Technologies Office and performed at Oak Ridge National Laboratory (ORNL). Oak Ridge National Laboratory is managed by the UT-Battelle, LLC, for DOE under contract DE-AC05-00OR22725.

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