Fourth Annual Conference on Carbon Capture & Sequestration

Developing Potential Paths Forward Based on the Knowledge, Science and Experience to Date

Advanced Concepts: Biomass Offsets

Co-Firing Biomass Fuels with Coal and the Potential Impact on Terrestrial Sequestration

John Kadyszewski, Sean Grimland and Nick Martin

May 2-5, 2005, Hilton Alexandria Mark Center, Alexandria Virginia

Summary

- Co-firing biomass with coal produces multiple environmental benefit streams
- Potential benefits from terrestrial sequestration exceed costs of retrofit to enable use of biomass fuels
- Examples from SSEB identification of potential pilot projects

Environmental Benefits

- Carbon benefits
  - Displace coal -- annual benefit
  - Stimulate changes in land use that result in higher average carbon stocks
- Can reduce NOx emissions
- Biomass usually has no sulfur or mercury
- Low ash and less particulates

Options for Cofiring Biomass

- Blend biomass with coal on the conveyor belt and feed through the pulverizer– estimated cost $100-200/kw
  - Limited to < 3% heat from biomass except with cyclone boilers that could blend up to 10%
- Retrofit to add biomass-only injection point – estimated cost $200-300/kw

Examples from Southern States Energy Board (SSEB) Regional Carbon Sequestration Partnership

Prepared in partnership with the Electric Power Research Institute (EPRI)

Overall Methodology

- Quantify carbon benefits from fuel displacement
  - Determine how much biomass fuel is required
- Identify potential biomass fuel sources
  - Identify potential sources of biomass fuels
  - Identify and quantify competing demands
  - Classify land around coal plant
  - Develop carbon production numbers for potential land use changes that increase carbon stocks

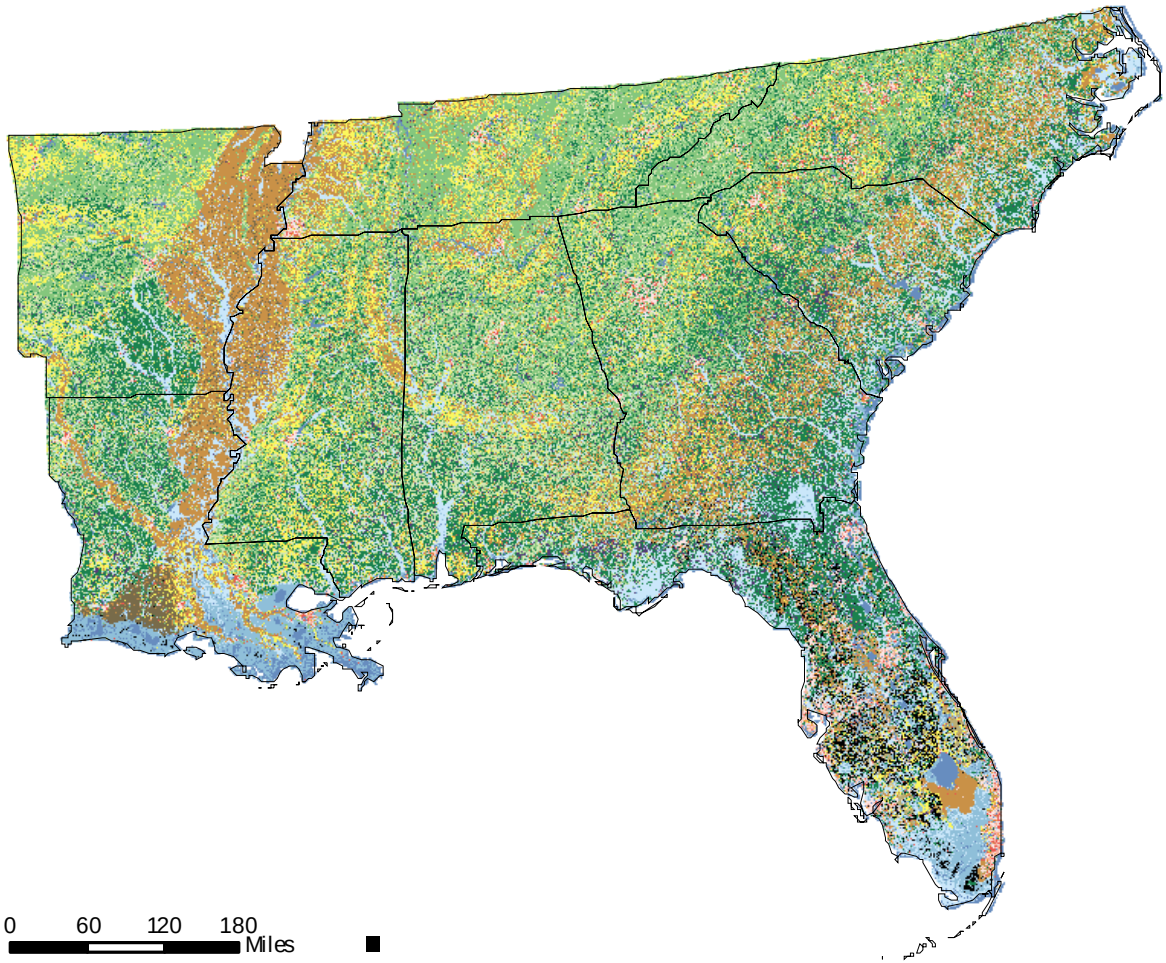
Fuel Requirements

-- Assuming Heat Rate 11,000 BTU/kWh

-- Capacity Factor 80%

Power Output	Biomass Fuel Required	Land Required
30 MW	212,000 MT	42,000 acres
50 MW	353,000 MT	70,600 acres
80 MW	565,000 MT	113,000 acres

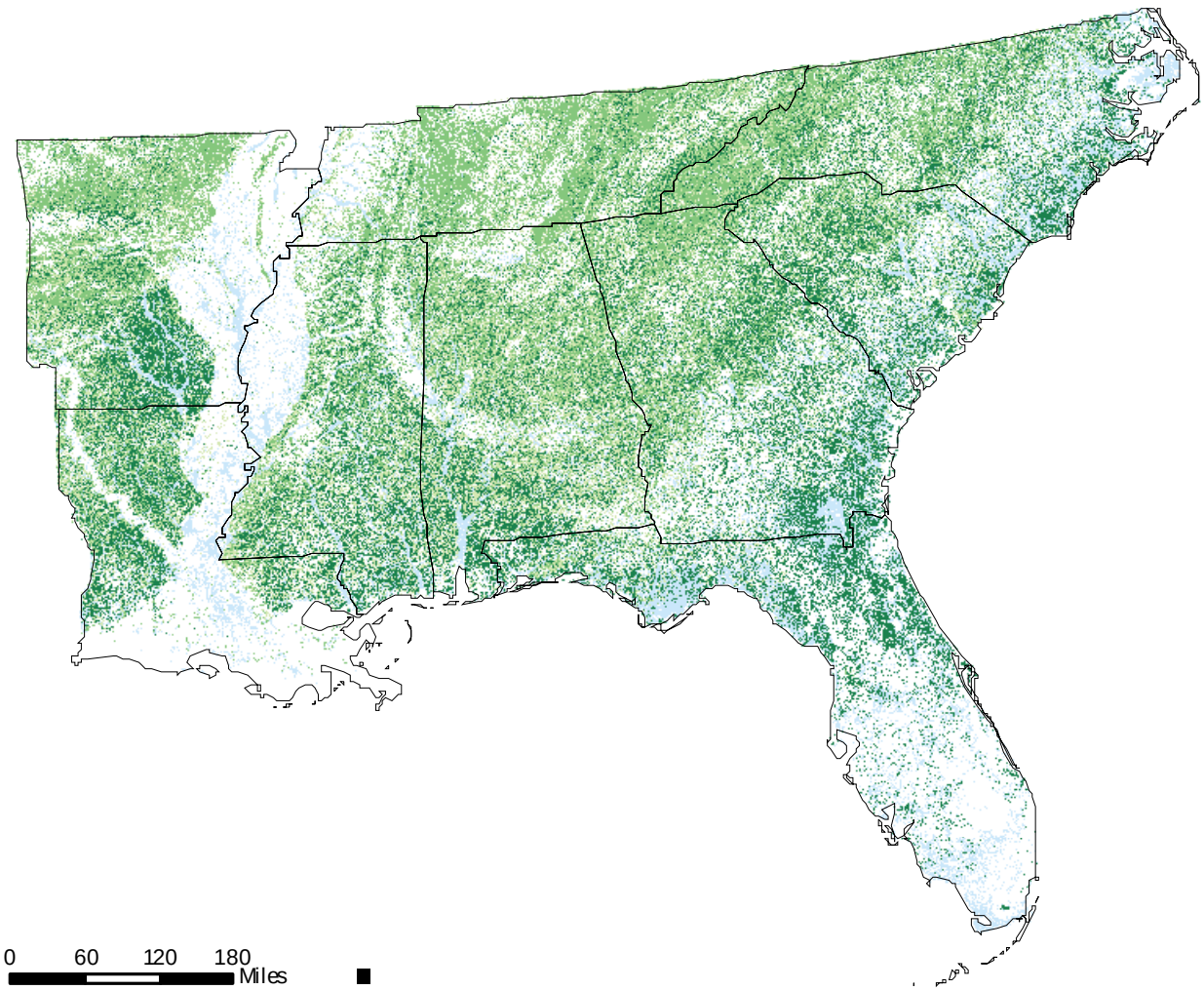
Look at Current Land Use Patterns to Determine Existing Carbon Stocks and Potential for Change



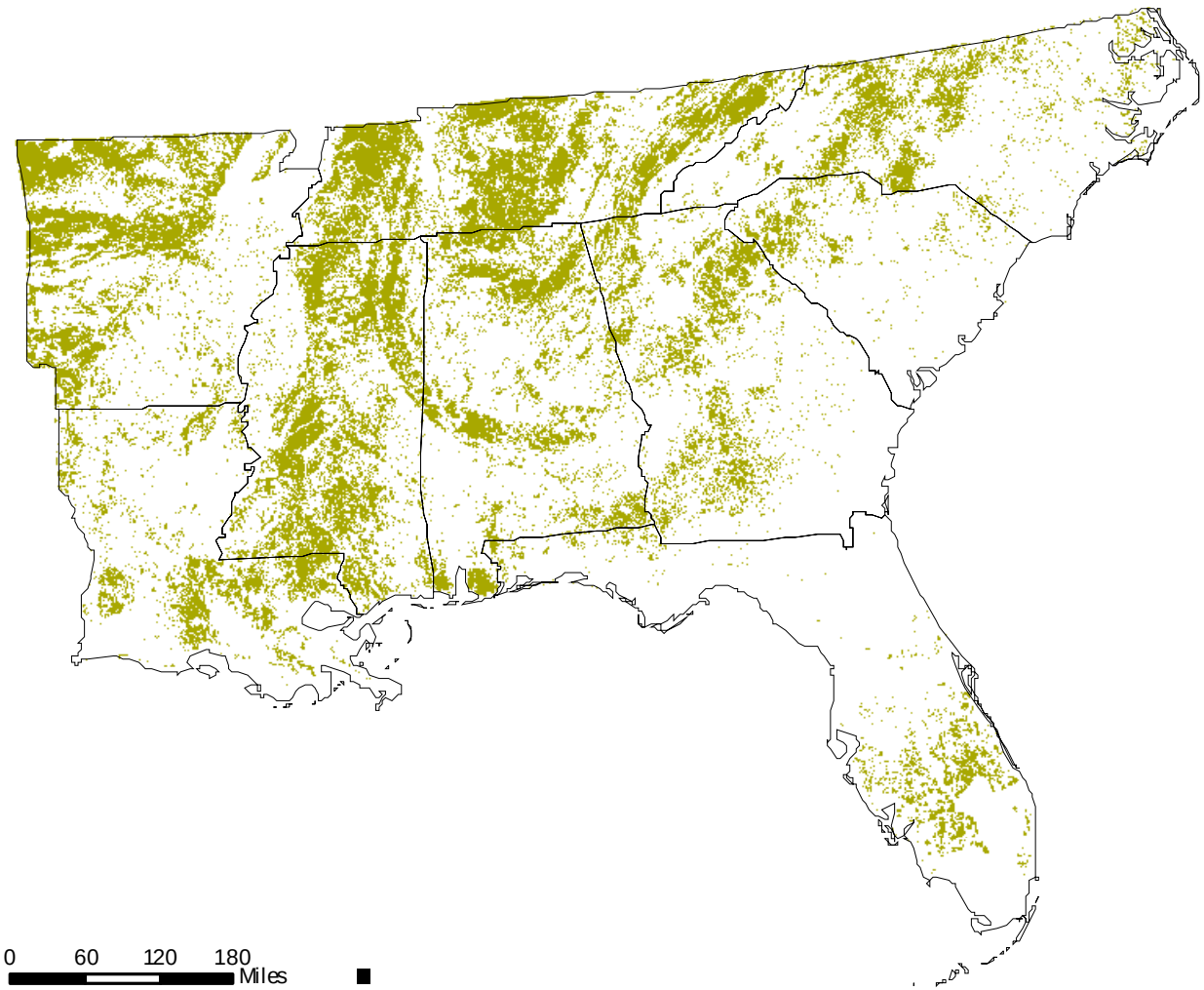
USGS NLCD

- Open Water
- Perennial Ice/Snow
- Low Intensity Residential
- High Intensity Residential
- Commercial/Industrial/Transportation
- Bare Rock/Sand/Clay
- Quarries/Strip Mines, Gravel Pits
- Transitional
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrubland
- Orchards/Vineyards
- Grasslands/Herbaceous
- Pasture/Hay
- Row Crops
- Small Grains
- Fallow
- Urban/Recreational Grasses
- Woody Wetlands
- Emergent Herbaceous Wetlands

Forest Lands

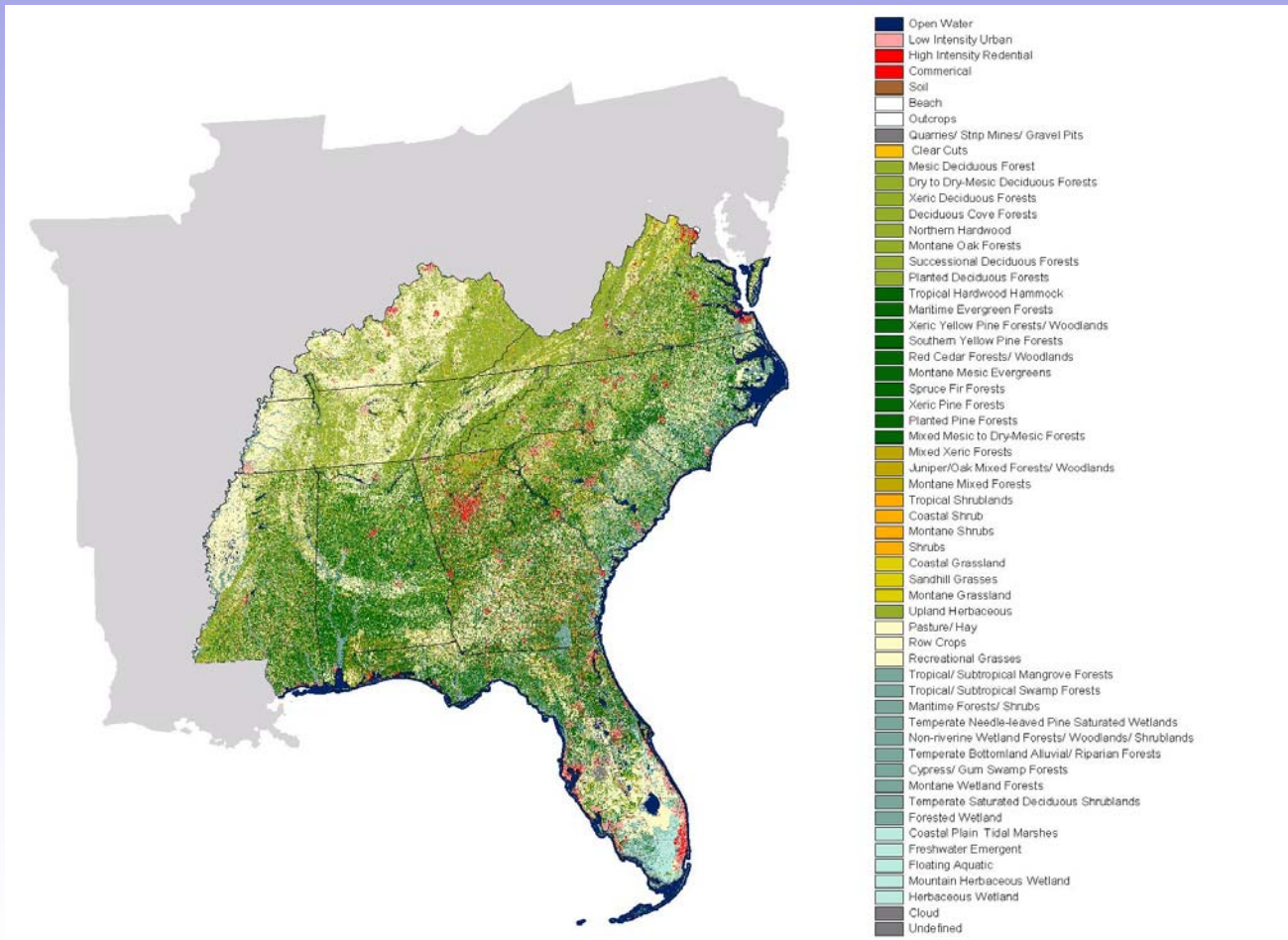


Grazing Lands

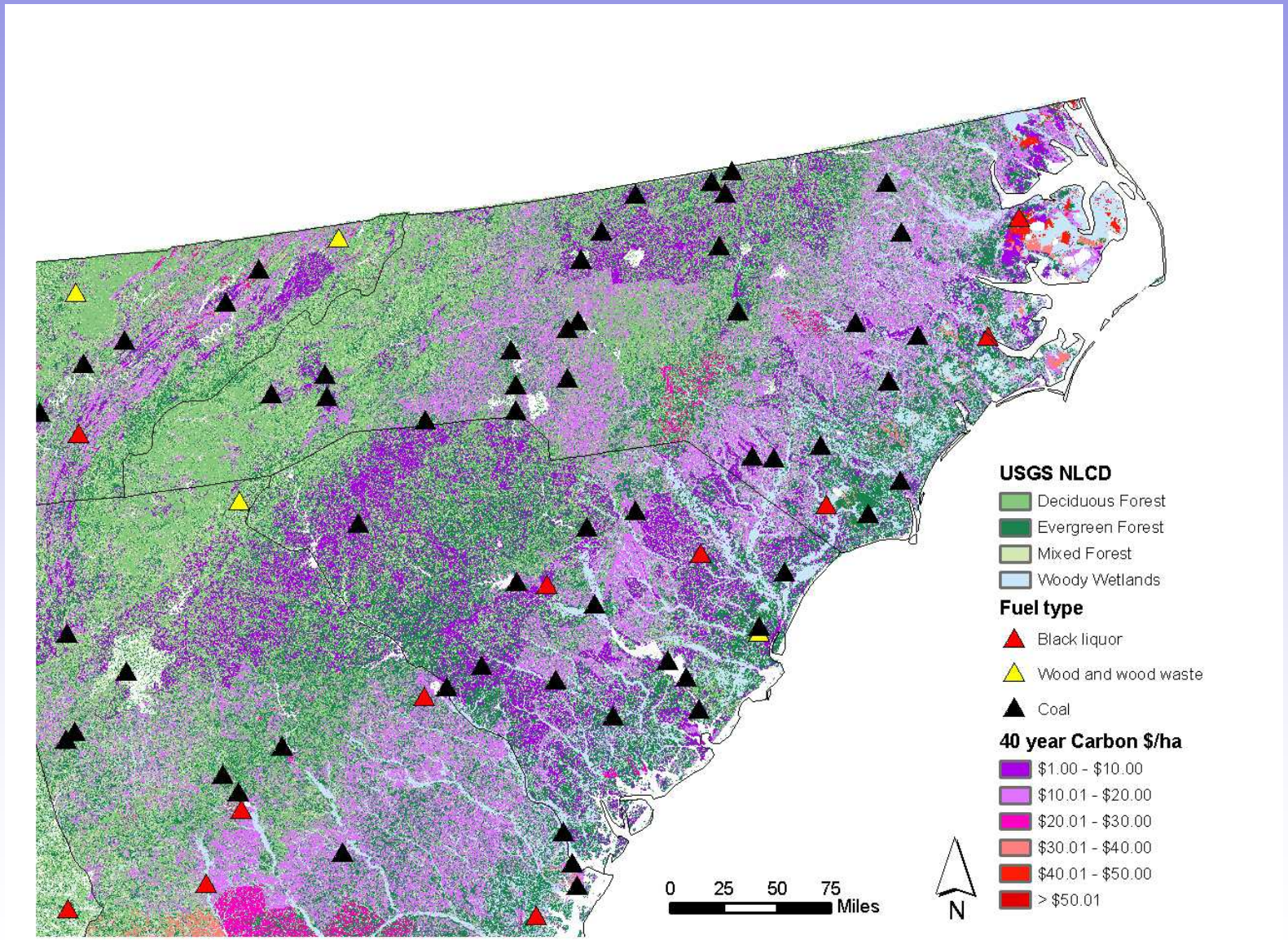


Examine Land Ownership and Restrictions

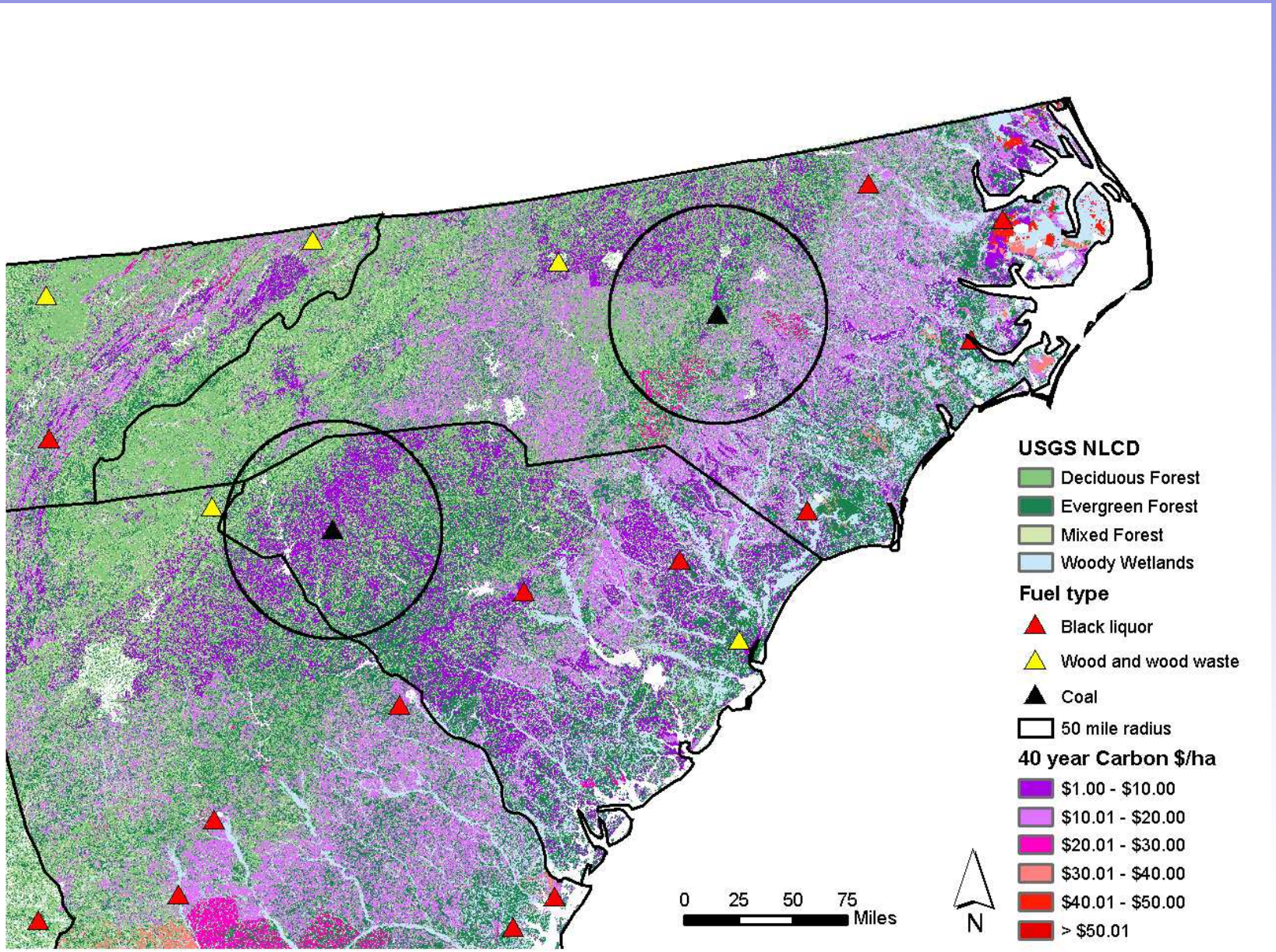
- Permanent protection from conversion with mandated management
- Permanent protection from conversion with extractive use
- No restrictions



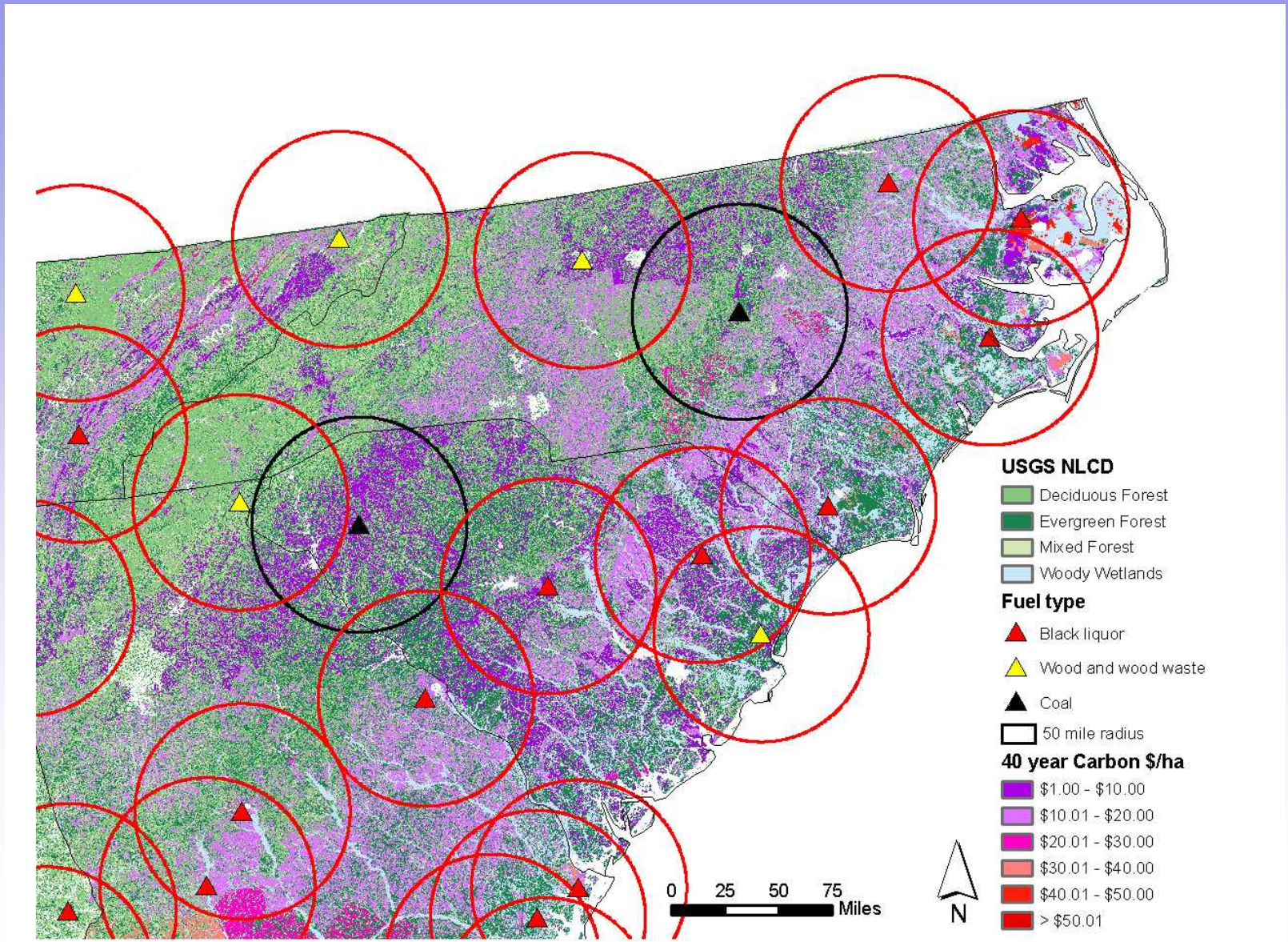
Power Generation in the Carolinas



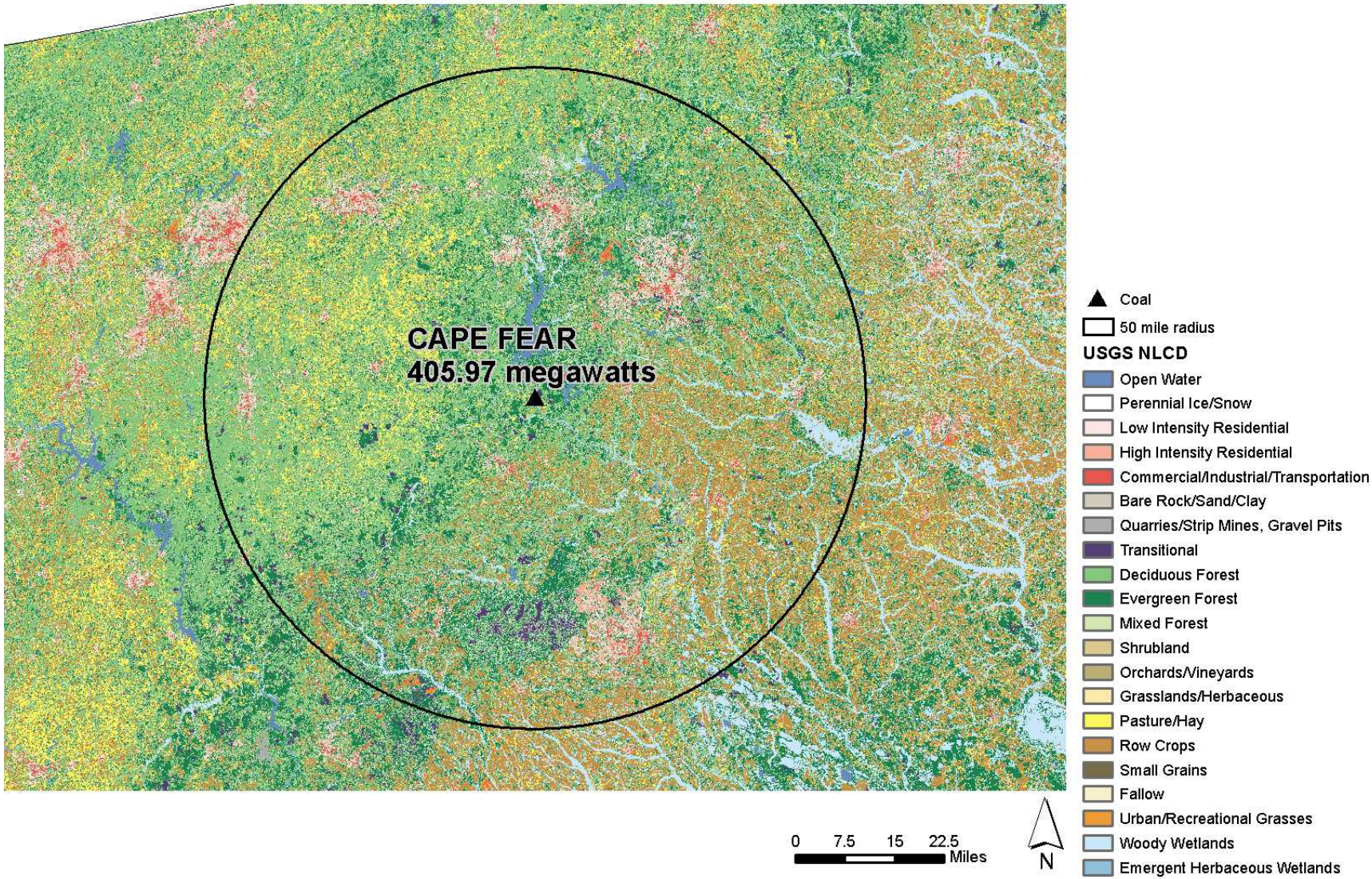
Select Two Coal-Fired Power Plants



Competing Demands for Biomass Fuel

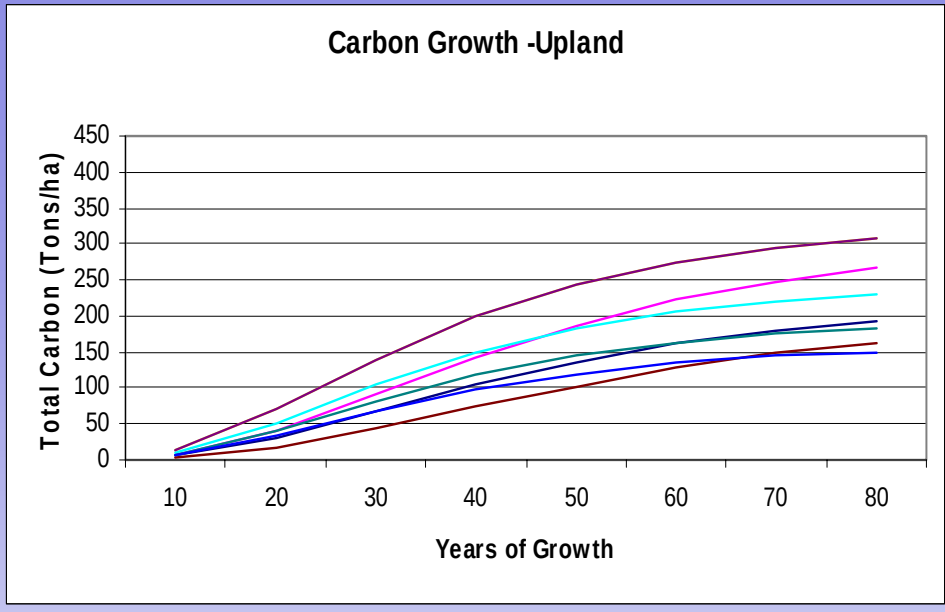


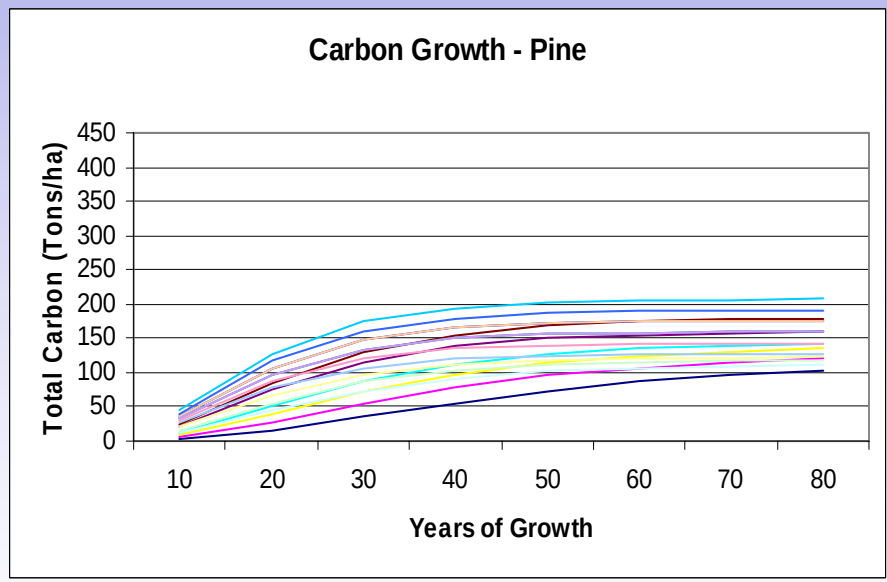
Duke Power: Cape Fear -- NLCD Land Cover

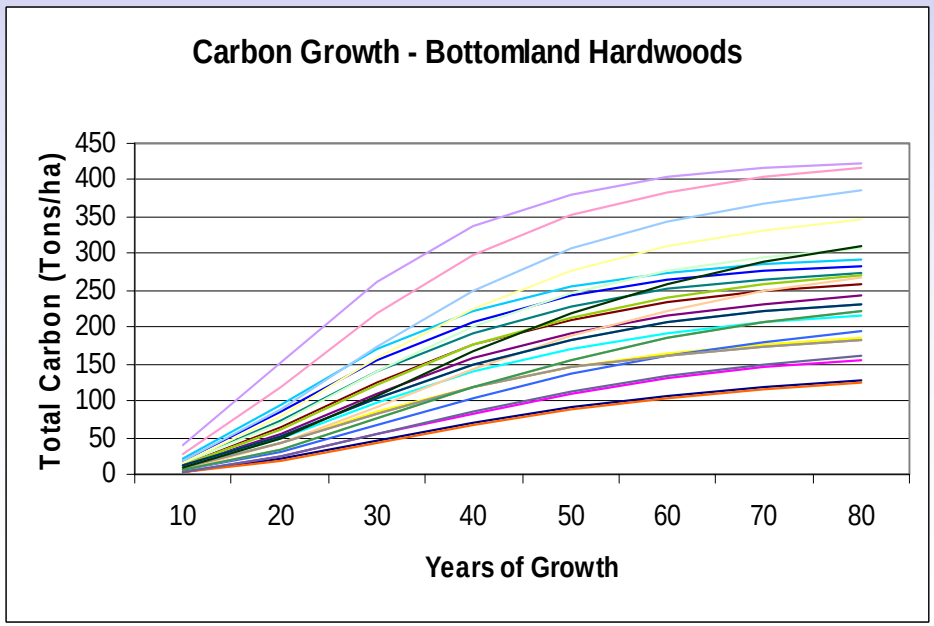


Growth Curves

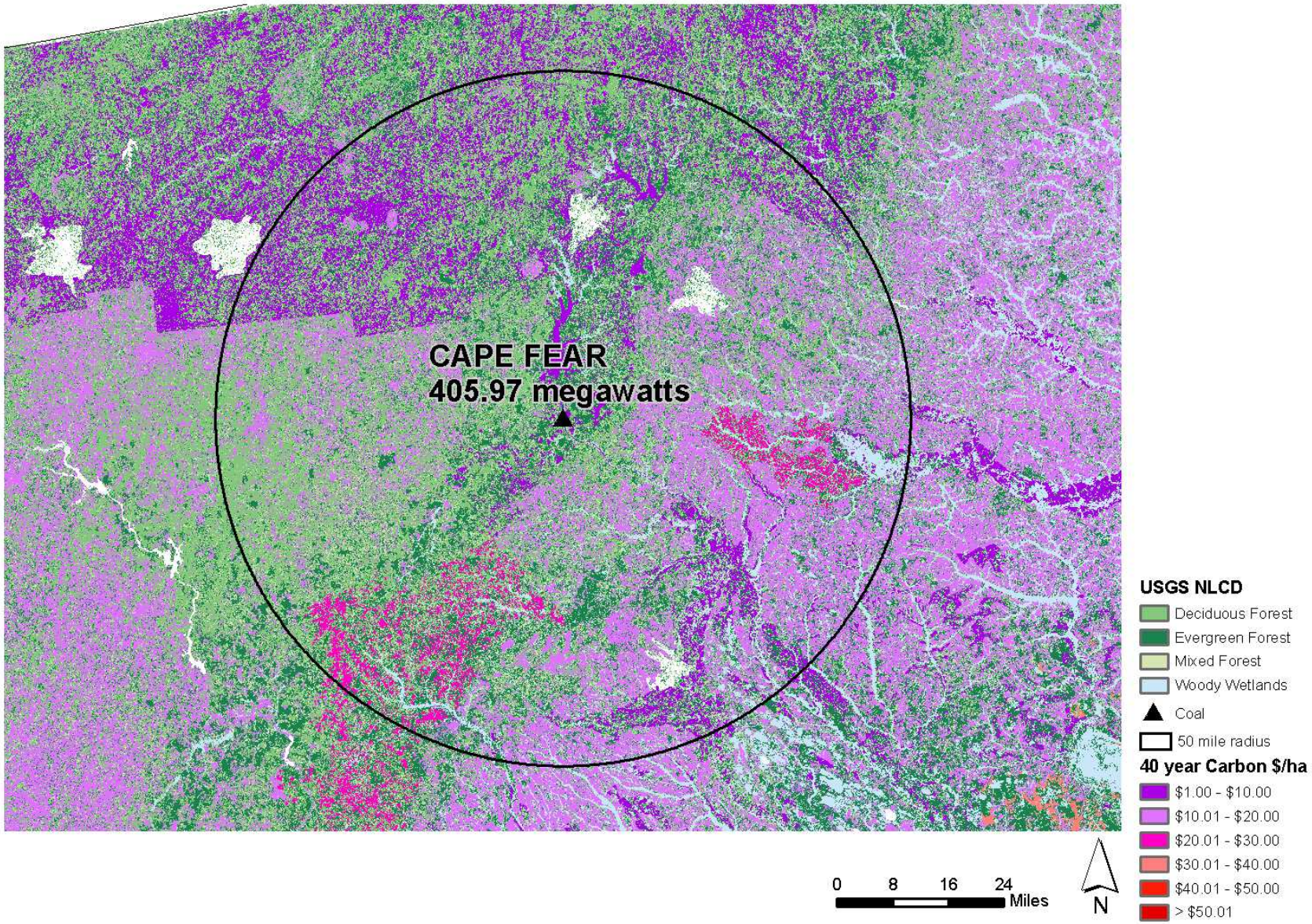
- STATSGO
- Forest inventory (FIA)
- Growth curves by species



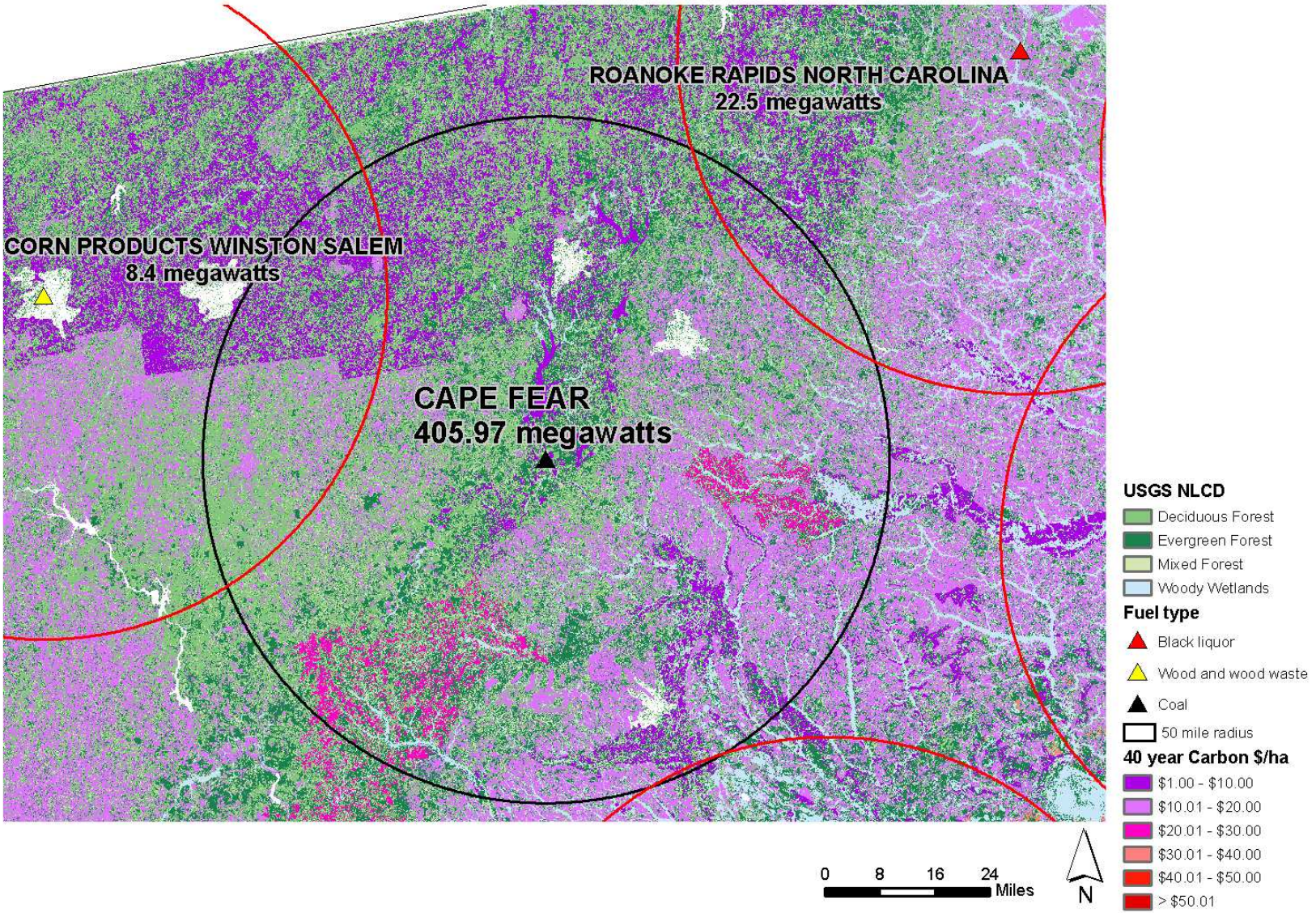




Carbon Price: Dollars per Hectare -- 40 Years



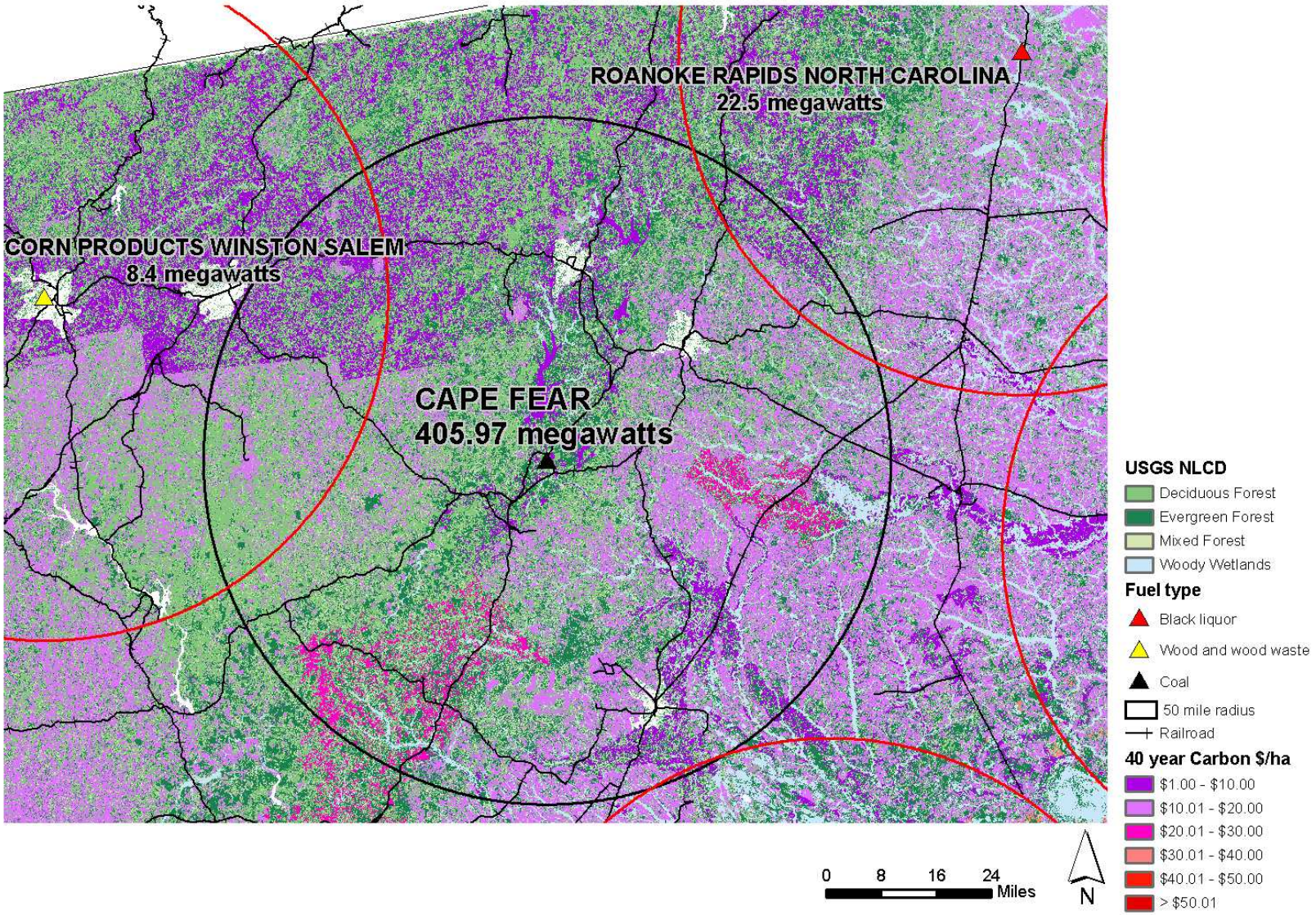
Two Competing Demands Within 50 Miles



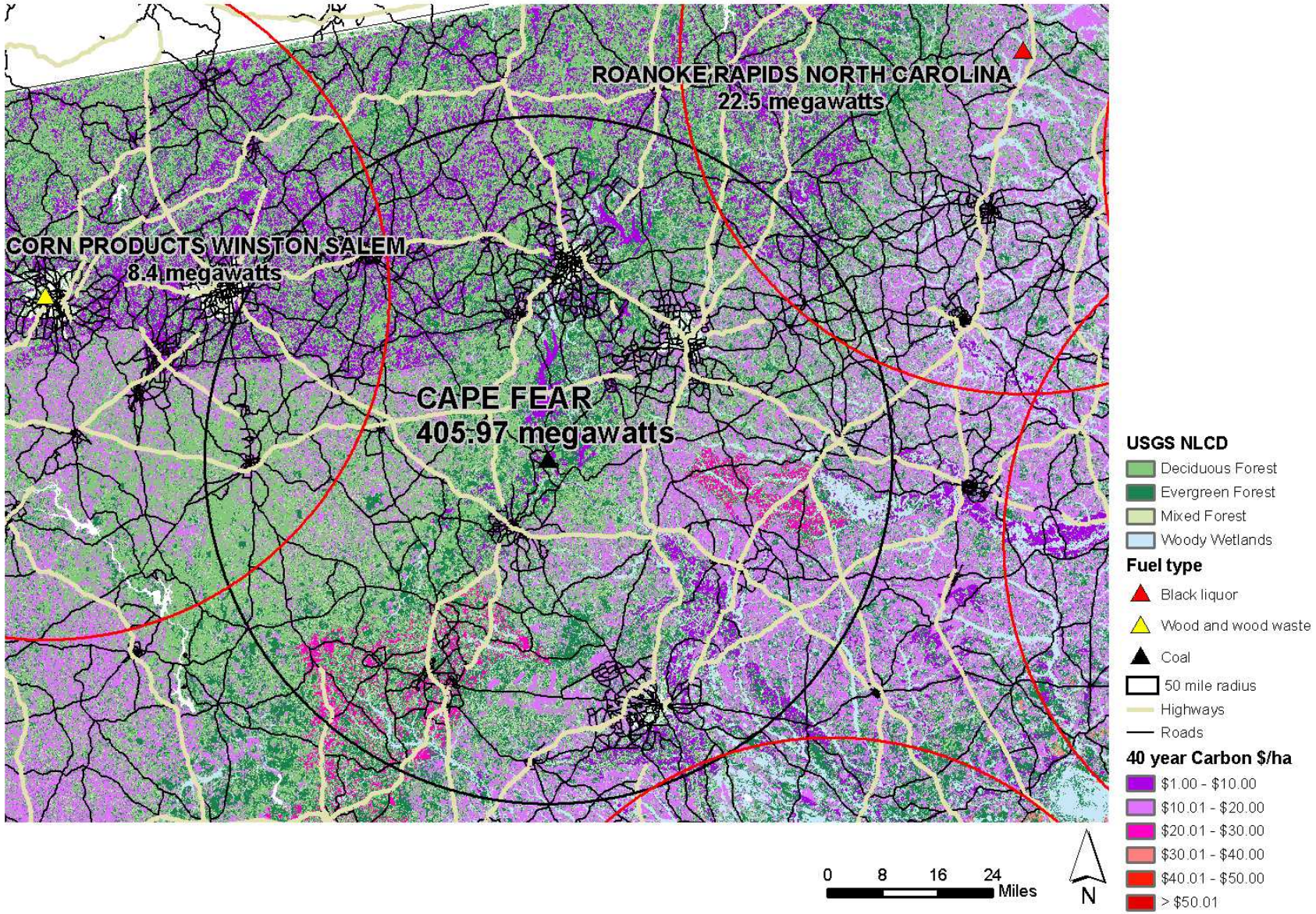
Transport and Storage Costs

- Moving thinnings and logging residues from forest to road
  - Costs depend on slopes and site access
  - On-site chipping vs centralized chipping
  - Damage to residual stand
- Deliver to plant
  - Depends on distance
- Inspection, unloading and storage

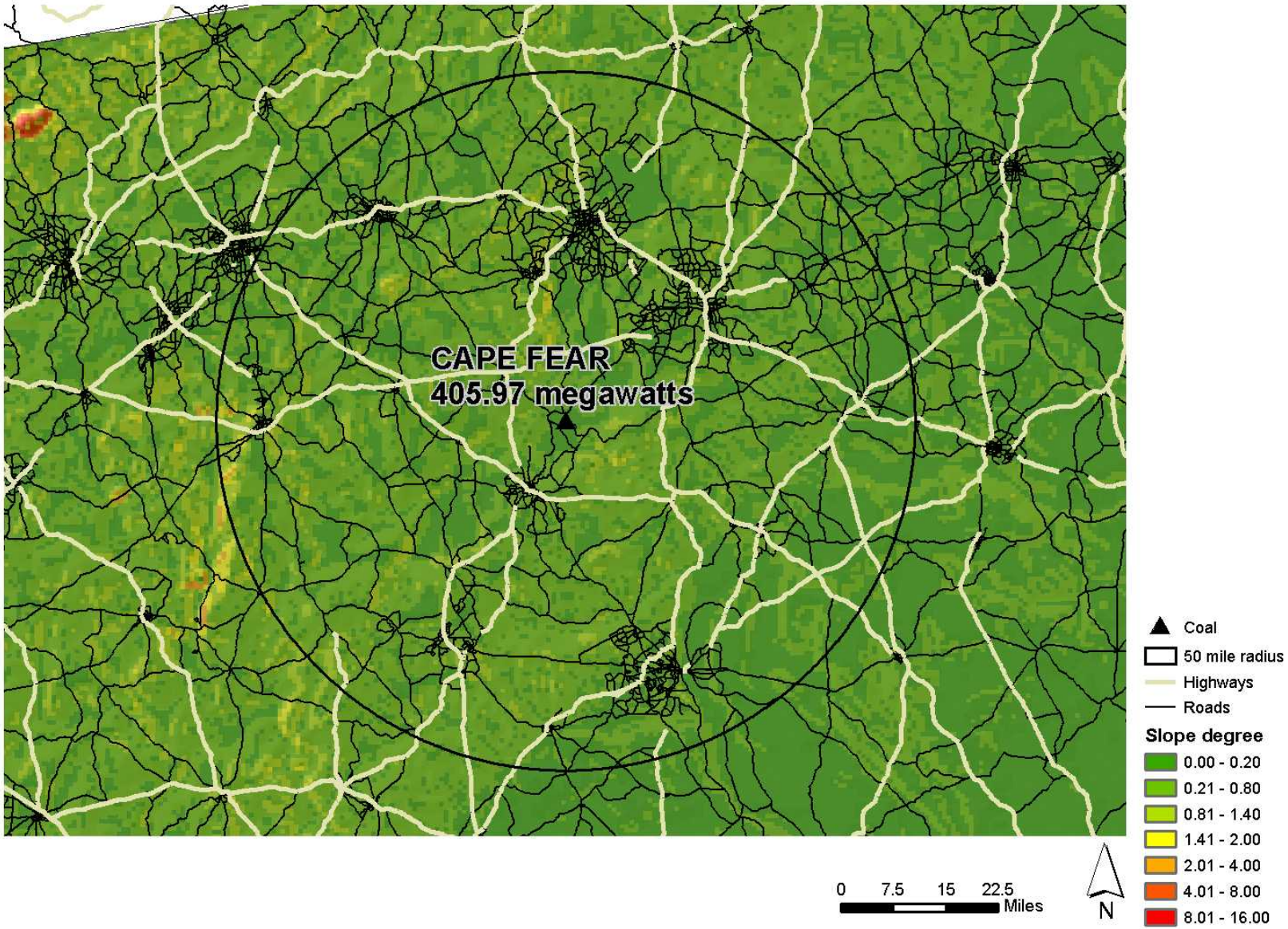
Railroads


ROANOKE RAPIDS NORTH CAROLINA
22.5 megawatts
CORN PRODUCTS WINSTON SALEM
8.4 megawatts
CAPE FEAR
405.97 megawatts
0 8 16 24
Miles
N
USGS NLCD
Deciduous Forest
Evergreen Forest
Mixed Forest
Woody Wetlands
Fuel type
Black liquor
Wood and wood waste
Coal
50 mile radius
Railroad
40 year Carbon $/ha
$1.00 - $10.00
$10.01 - $20.00
$20.01 - $30.00
$30.01 - $40.00
$40.01 - $50.00
> $50.01

Highways and Secondary Roads



Slope in Degrees



Potential Terrestrial Sequestration

-- Assuming conversion to forest with 20 or 40 year rotations

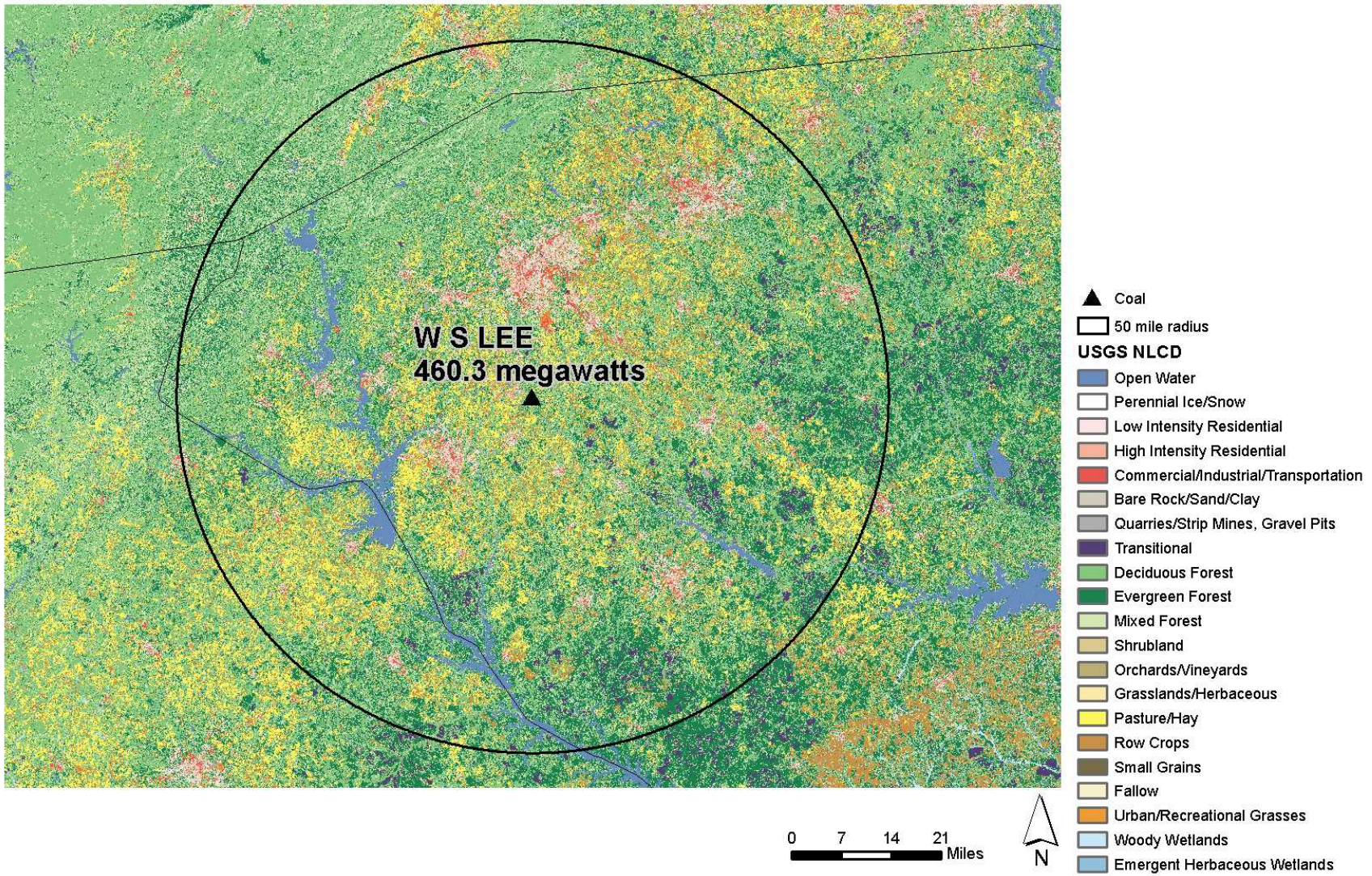
Power Output	Biomass Fuel Required	Land Required	Change in Carbon Stocks
30 MW	212,000 MT	42,000 acres	20 yrs – 2.1 M tons 40 yrs – 6.3 M tons
50 MW	353,000 MT	70,600 acres	20 yrs – 3.5 M tons 40 yrs – 10.5 M tons
80 MW	565,000 MT	113,000 acres	20 yrs – 5.7 M tons 40 yrs – 17.0 M tons

Land Requirements

-- 5 Million Acres within 50 miles

Land Required	Percentage	Carbon Sequestration Value at \$2/MT CO_2
42,000 acres	< 1 %	20 yrs – \$15.4 Million 40 yrs – \$46.2 Million
70,600 acres	~1.4%	20 yrs – \$25.7 Million 40 yrs – \$77.0 Million
113,000 acres	~2.3%	20 yrs – \$41.8 Million 40 yrs – \$124.7Million

Carolina Power & Light: WS Lee – NLCD



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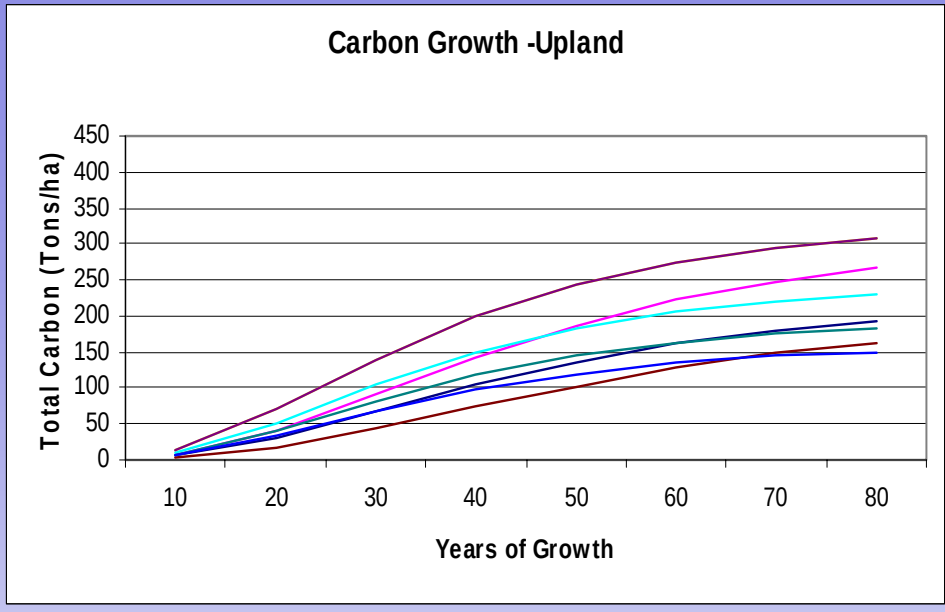

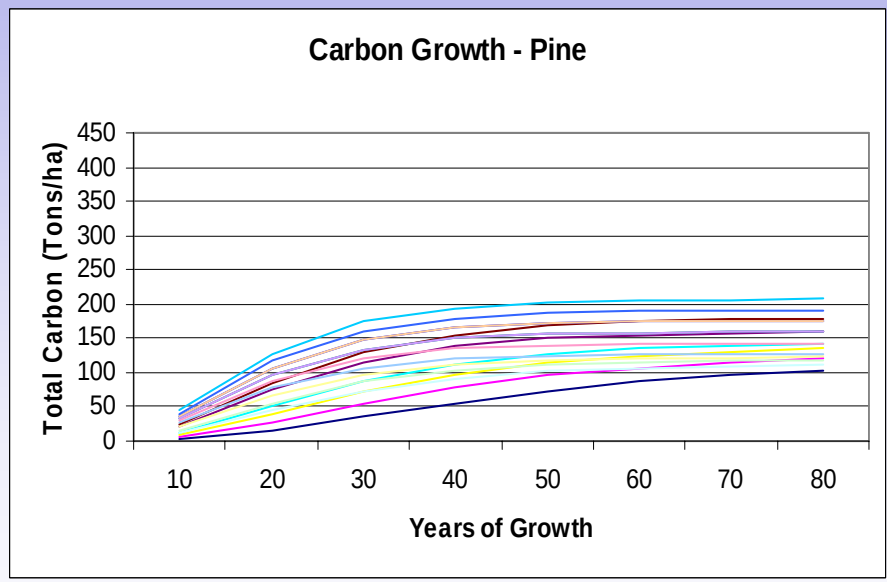

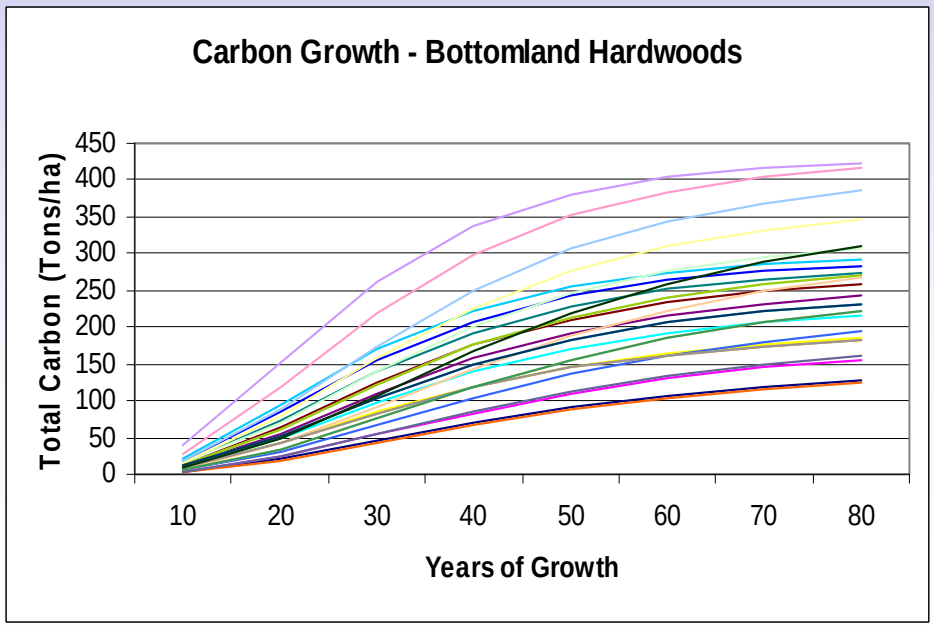

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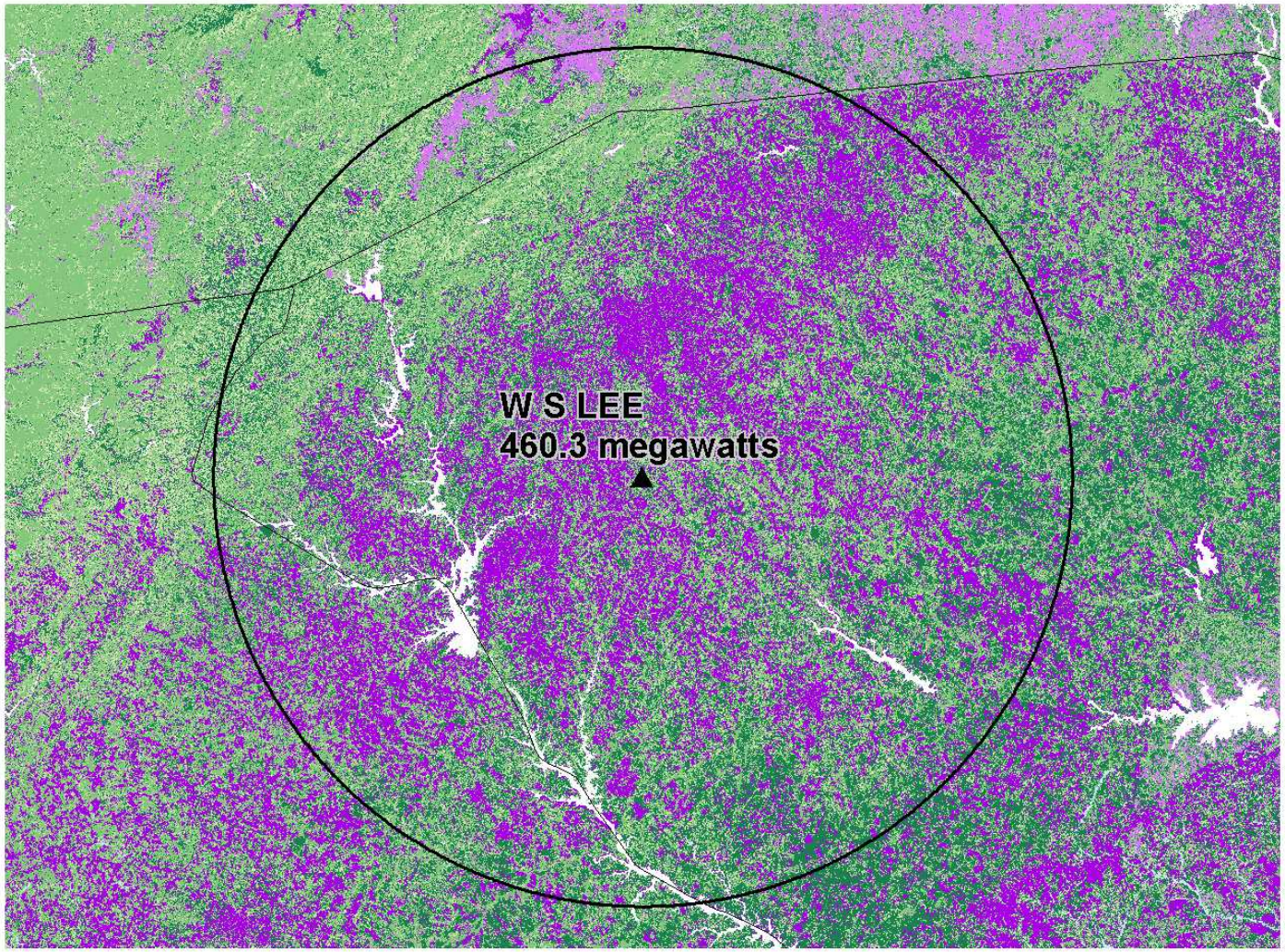

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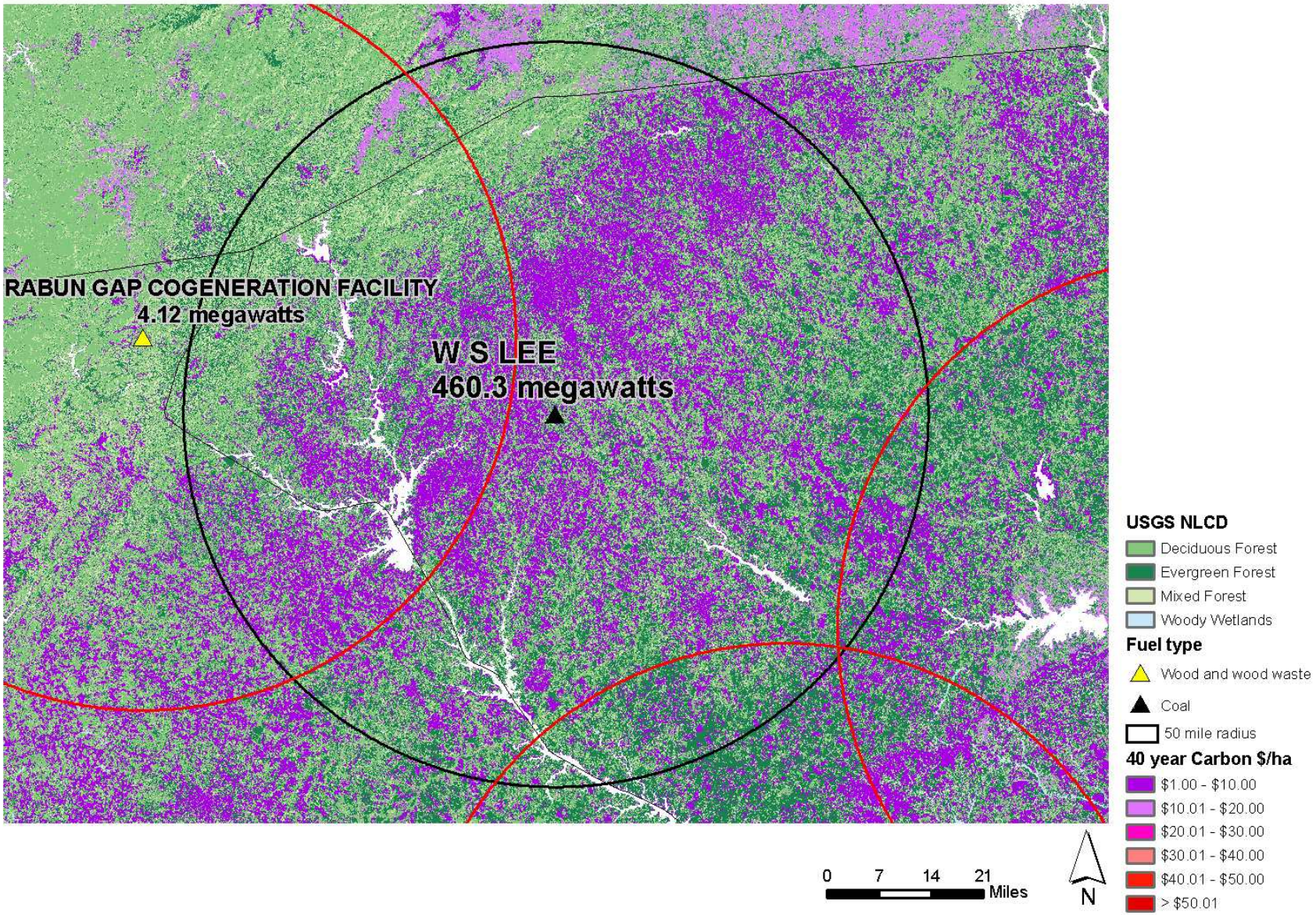
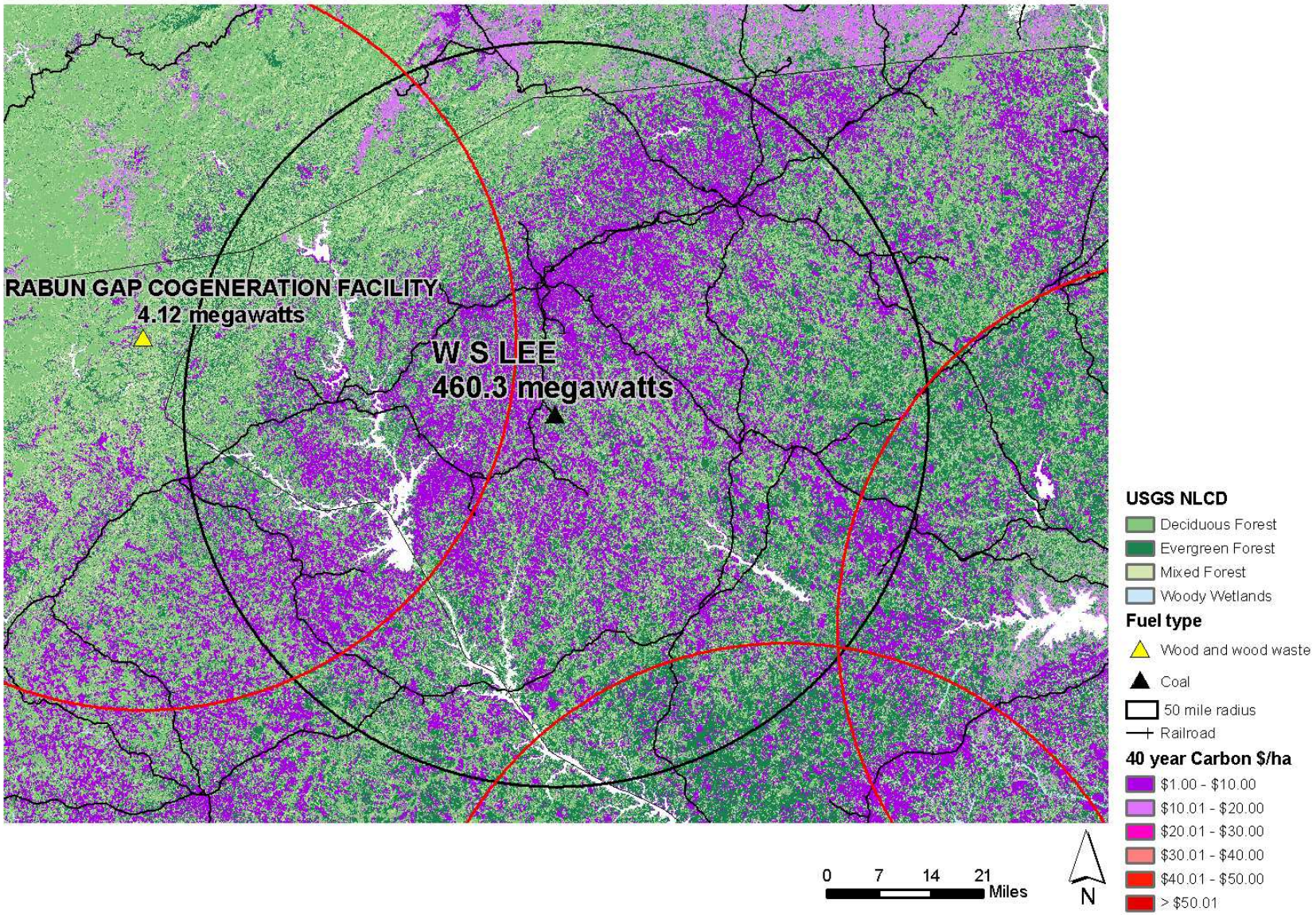


Railroads


RABUN GAP COGENERATION FACILITY
4.12 megawatts
W S LEE
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Deciduous Forest
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Fuel type
Wood and wood waste
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50 mile radius
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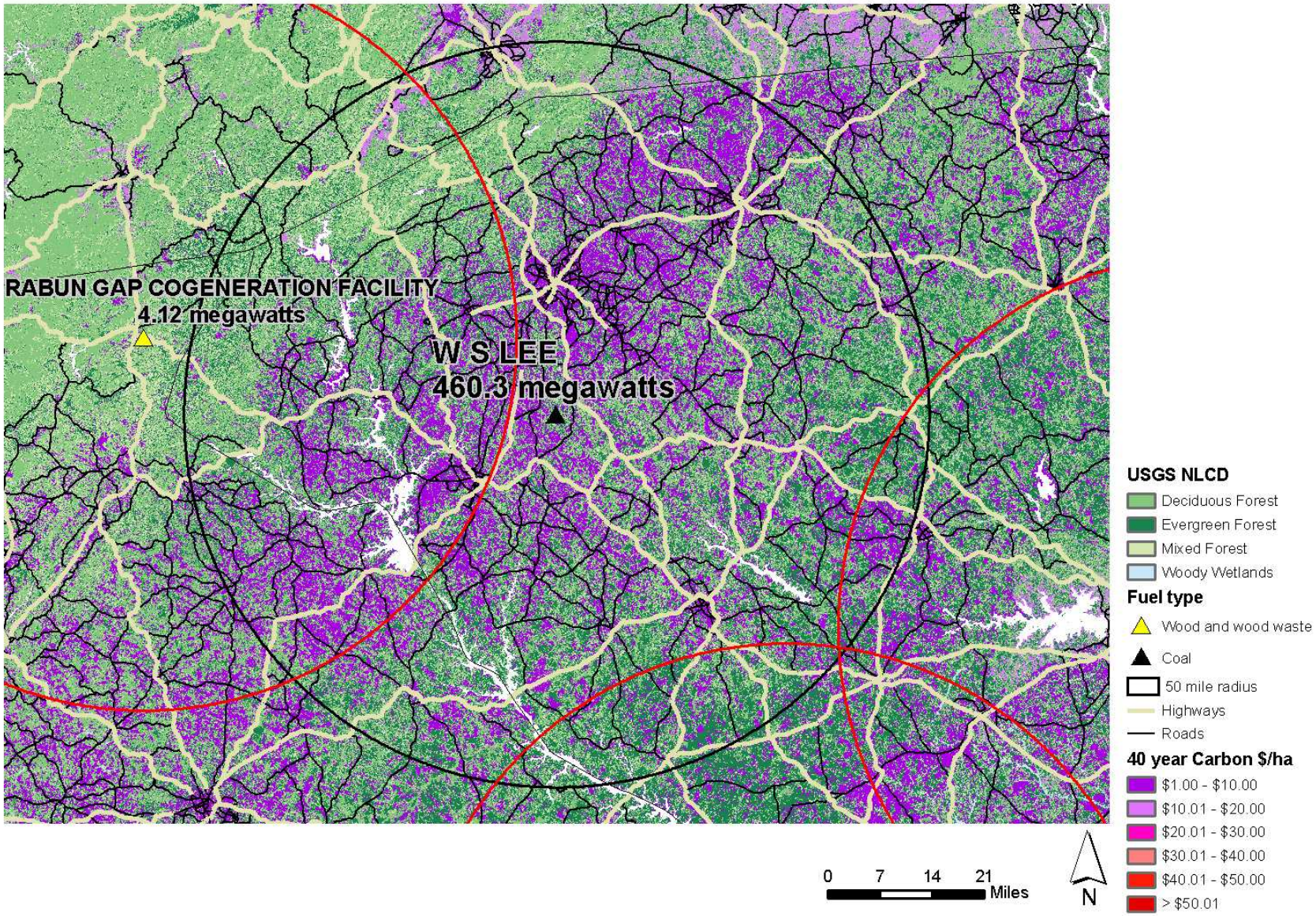
$40.01 - $50.00
> $50.01
0 7 14 21
Miles
N

Highways and Secondary Roads



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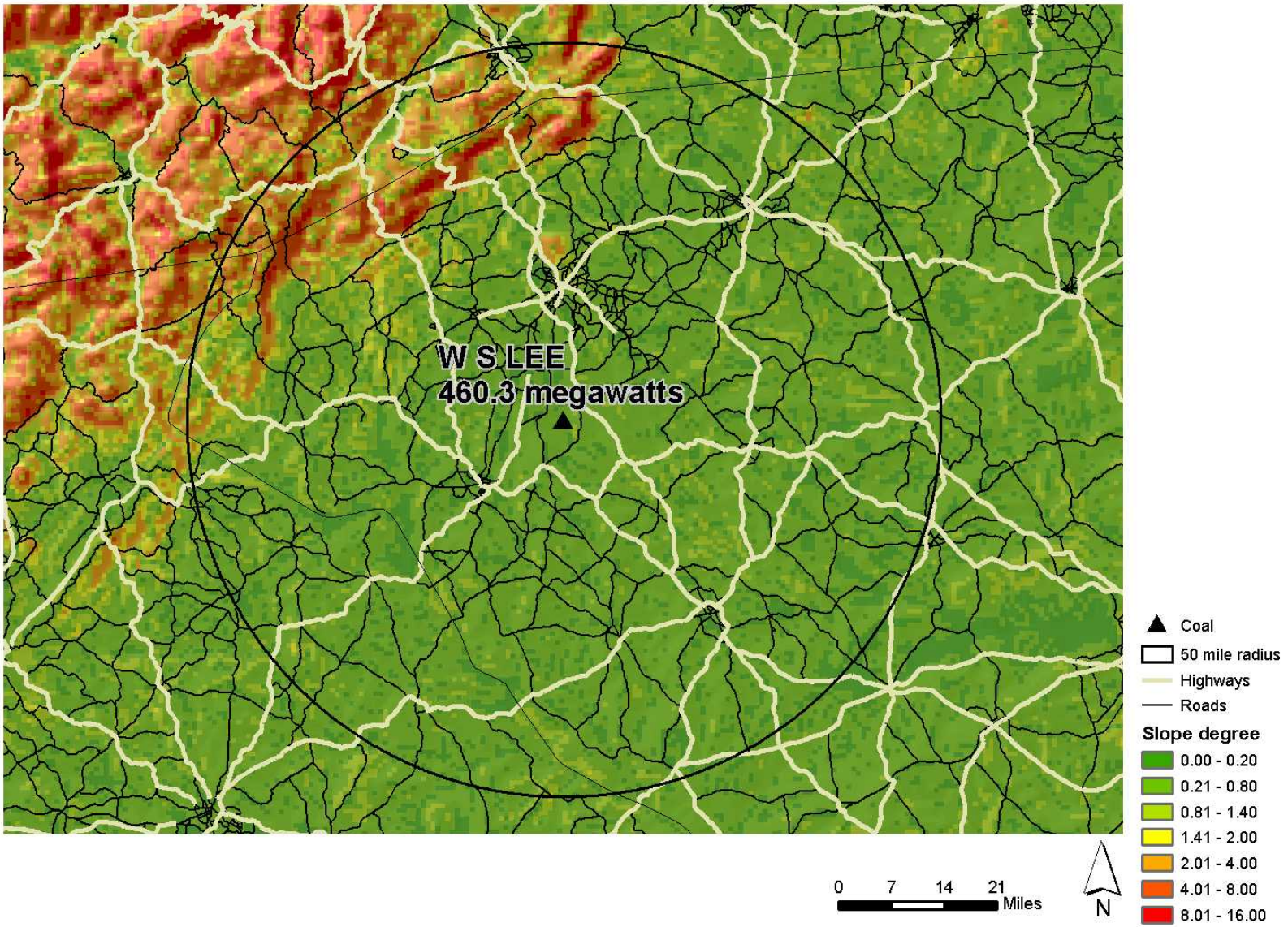
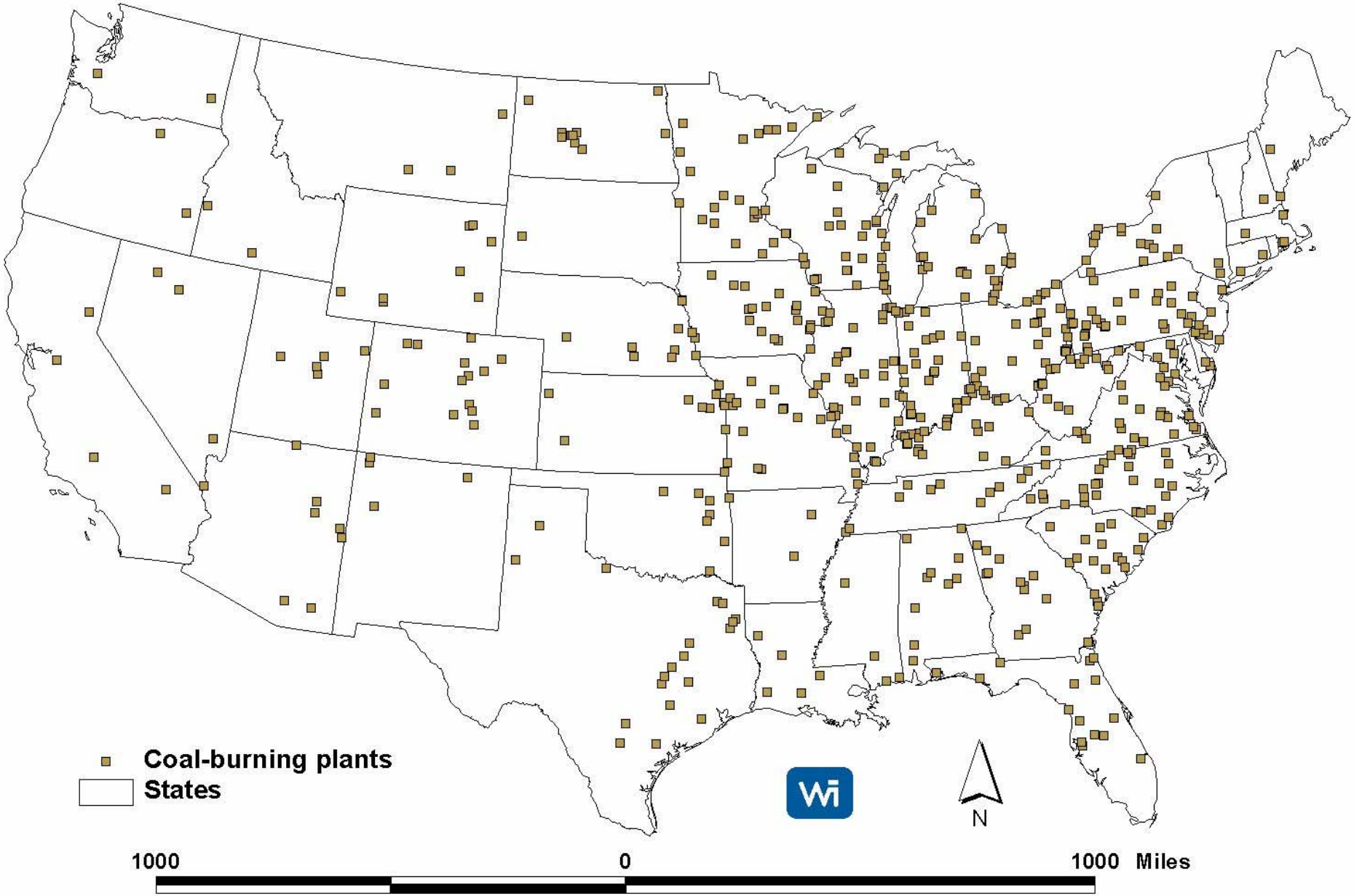
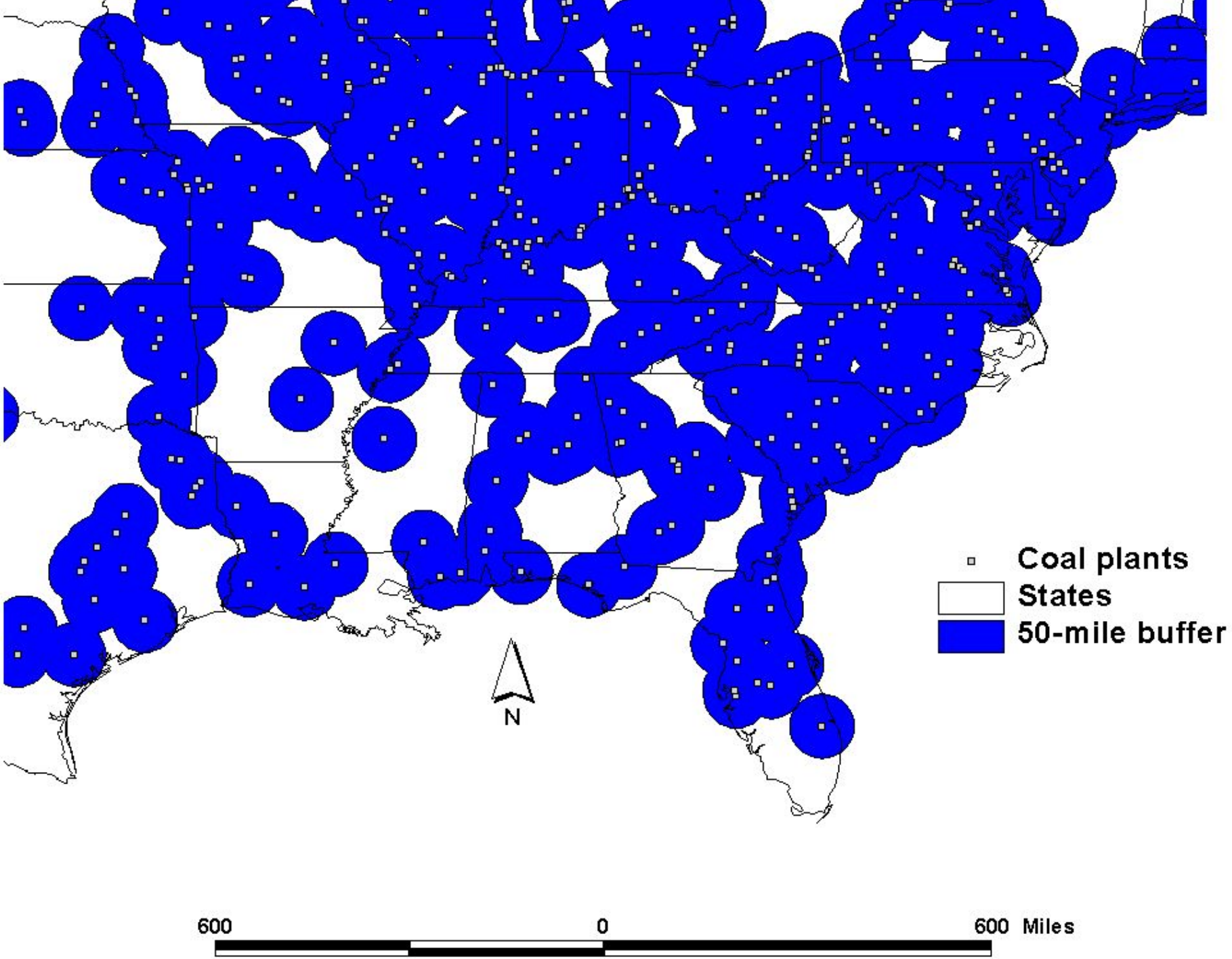
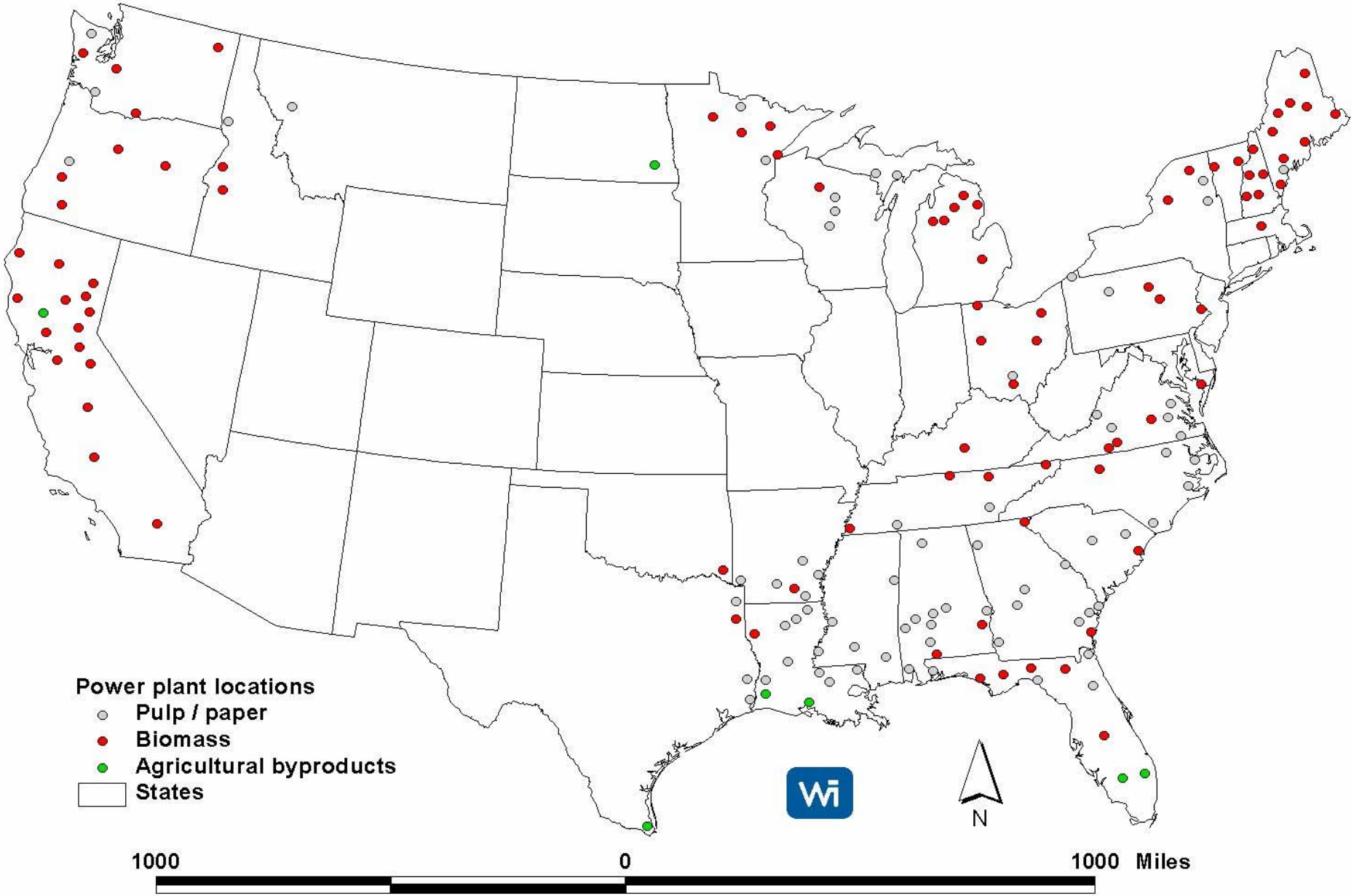



Coal-burning plants
States
N
1000
0
1000 Miles


Coal plants
States
50-mile buffer
N
600
0
600 Miles


Coal-burning plants
States
80-mile radii from coal plants
N
250
0
250 Miles


Power plant locations
Pulp / paper
Biomass
Agricultural byproducts
States
N
1000
0
1000 Miles

Fuel Use at Biomass Energy Plants

Plant	Capacity Factor %	MW	GWh /yr	BTU/ kWh	Estimated Tons/yr
Shasta-CA	96	50	418	17,200	846,000
Stratton-MA	90	45	353	13,500	561,000
Kettle Falls-WA	82	46	327	14,100	542,000
Grayling-MI	63	36	200	13,600	320,000
McNeil-VT	35	50	155	14,000	255,000
Bay Front-WI	82	30	164	13,000	251,000
Multitrade-VA	19	79	133	14,000	219,000
Camas –WA	65	17	97	17,000	194,000
El Nido*-CA	60	10	53	20,000	125,000

Source -- Morris, G (2000) “Biomass Energy Production in California: The Case for a Biomass Policy Initiative”, NREL/SR-570-28805.

Fuel Requirements

-- Assuming Heat Rate 11,000 BTU/kWh

-- Capacity Factor 80%

Power Output	Biomass Fuel Required	Land Required
30 MW	212,000 MT	42,000 acres
50 MW	353,000 MT	70,600 acres
80 MW	565,000 MT	113,000 acres

How to Choose a Site

- Identify coal-fired power plants with most attractive terrestrial carbon sequestration opportunities
  - Plant life extension
  - Cost of biomass fuel
  - Cost of carbon credits
  - Potential co-benefits
  - Corporate branding
- Design equipment for co-burning biomass with coal
- Cooperate with forest products industry
- Link biomass fuel purchase with terrestrial sequestration opportunity

Project Benefits

- Immediate contribution to reduced GHG concentrations in the atmosphere
- Potential new source of revenue for local landowners and forest products industry
- Outreach to local communities
  - Raise awareness of cost-effective options to reduce emissions
  - Build public support for long term program objectives