

# An Intermodal Network Model of Coal Shipments in the U.S.

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# Presentation Overview

- Integrated Freight Network Model
- Application of model for coal shipments
- Coal shipments at the national level
- Coal and the Ohio River Basin

How does the movement of coal to, from or within the Ohio River basin fit into the larger national picture of coal production and consumption?

# Integrated Freight Network Model

- Incorporates three modes of travel
  - Roadways
  - Railways
  - Waterways
- Intermodal Points
  - Ports
  - Intermodal facilities
  - Rail switchyards
- Network attributes (impedances) enable model to optimize routing for shippers across all three modes

# What is not yet included?

- Capacity constraints on corridors and nodes
- Speed
- Travel time
- Weight or cargo restrictions
- Characteristics of haul
  - Railcar/barge/truck types
  - Unit train? Backhaul possibilities?

# Shipping Rates

- Detailed shipping rates not available
- A number of possibilities to estimate or model shipping rates for different modes
- Order of magnitude used to supply generic rate information
  - Barge = 1 x distance
  - Rail = 3 x distance
  - Truck = 6 x distance

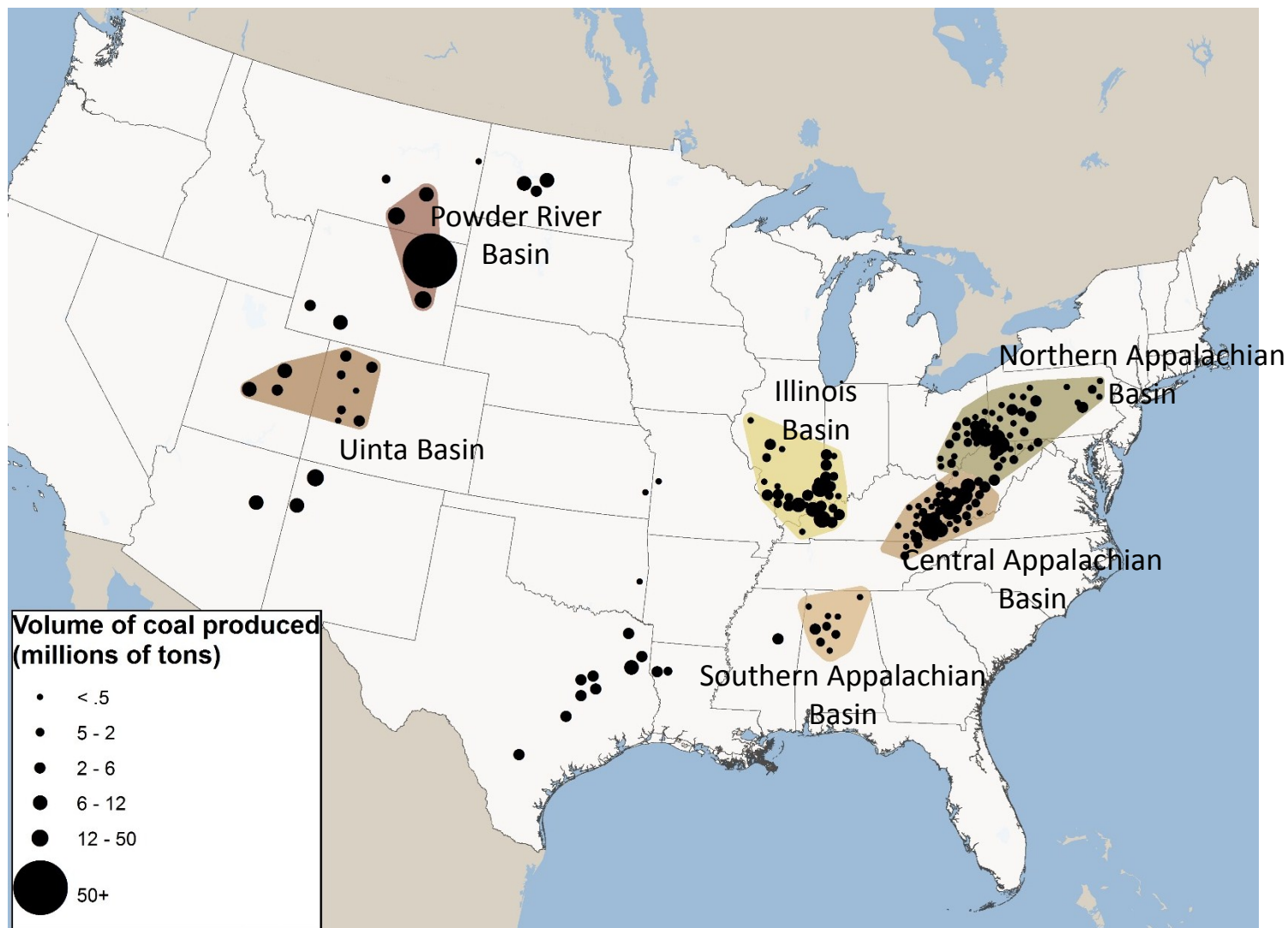
# Modeling freight data: Coal

- Energy Information Administration ([www.eia.gov](http://www.eia.gov))
  - Publishes annual data on movement of energy sources domestically in the US (coal, petroleum, natural gas)
- For coal, data includes
  - Origin (mine)
  - Destination (power plant)
  - Mode (rail, water, road, conveyor)
  - Volume
- Network models optimal routing of coal from origin (generalized to county centroids) to destination (power plants), as described by the EIA data
- Coal volumes aggregated along network segments for analysis

# Coal, statistically

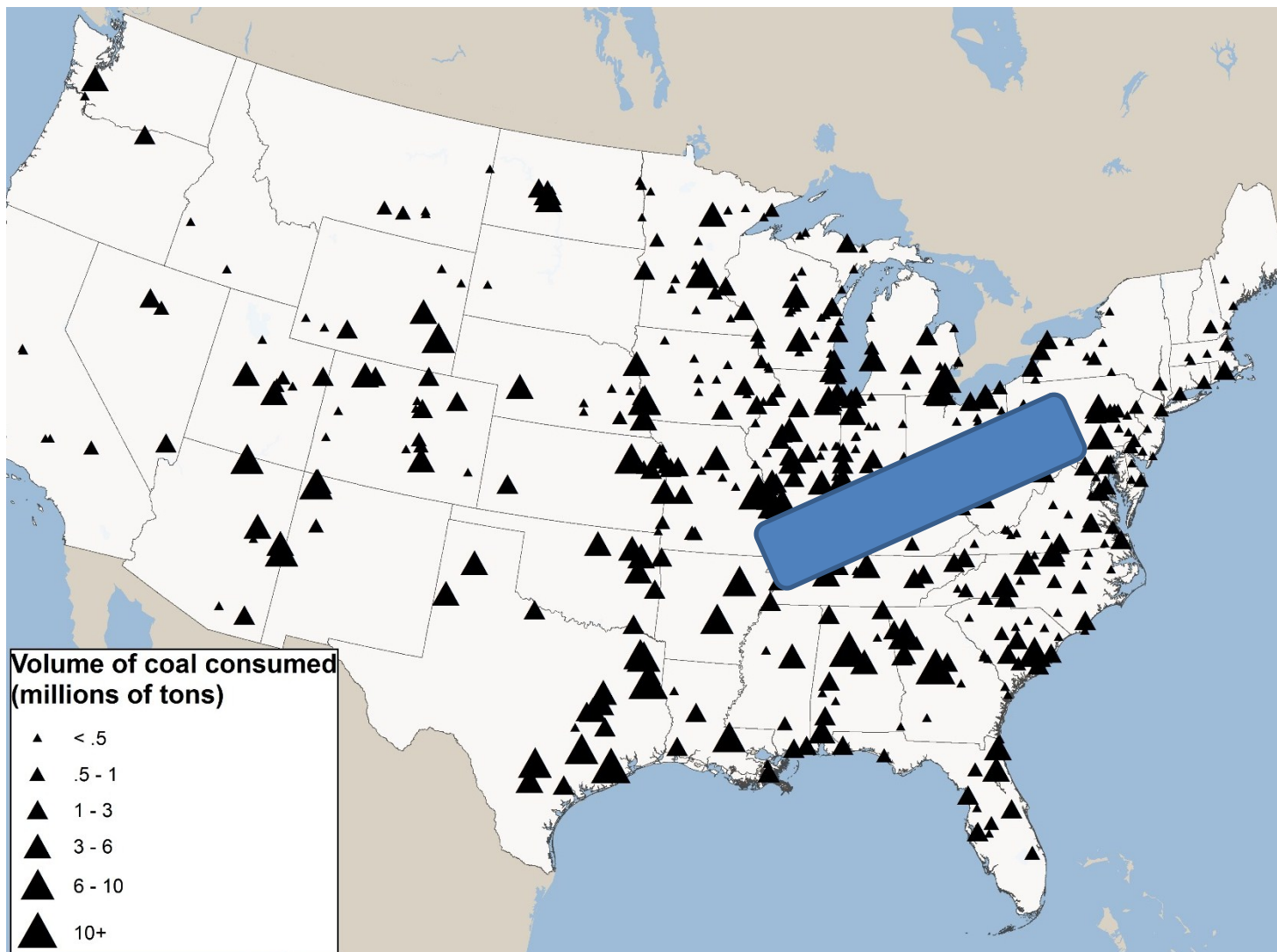
- In 2011, 1.1 billion tons of coal were produced in the U.S.
- 88,000 employees, 1,300 coal mines, 24 states
- Total value of coal production at \$45 billion
- 90% of coal produced in the US is consumed domestically (electricity, industry), 10% exported
- 10 million tons of coal also imported (about 1% of total US consumption)
- Coal is the leading fuel source for generation of electricity in the US, accounting for over 40% of total grid

# Coal production in the US, 2010





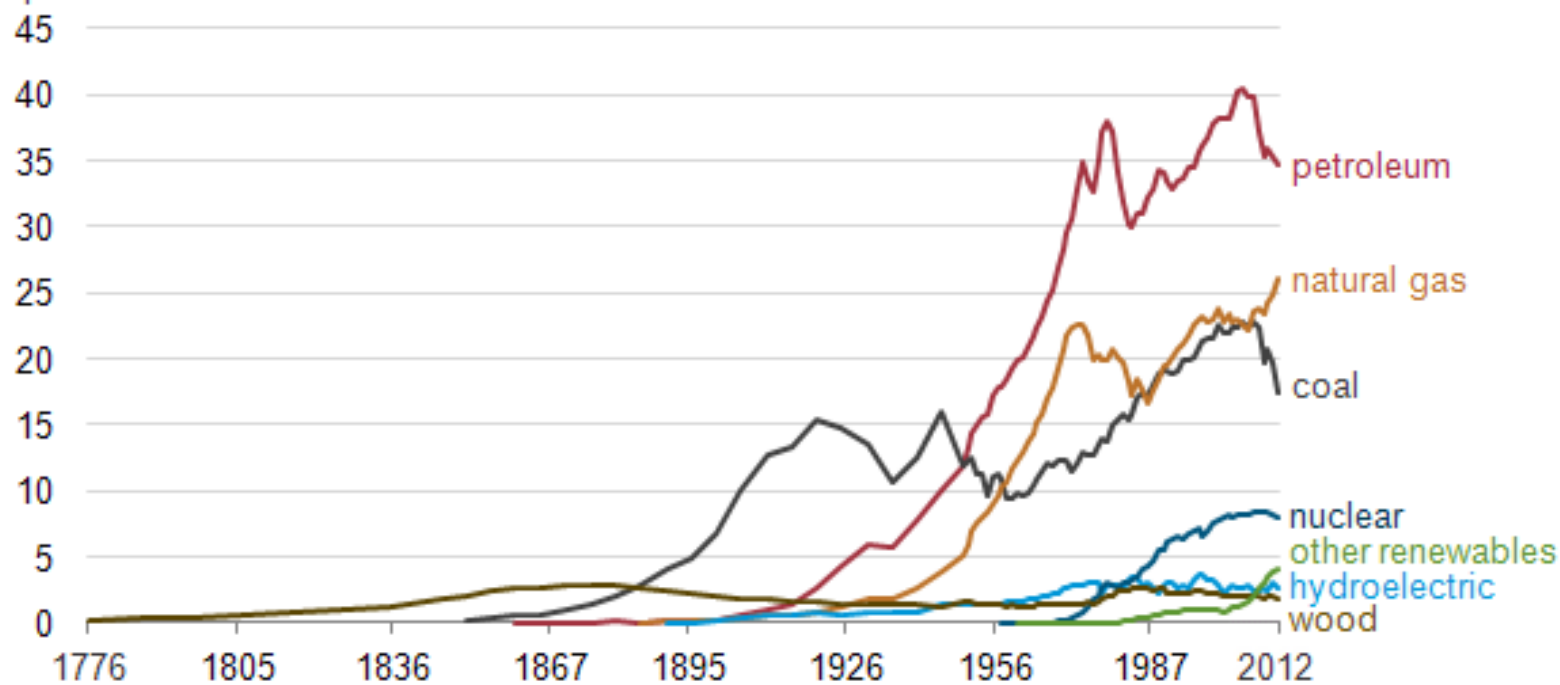
# Coal consumption in the US, 2010



# Energy consumption by fuel type, all sectors

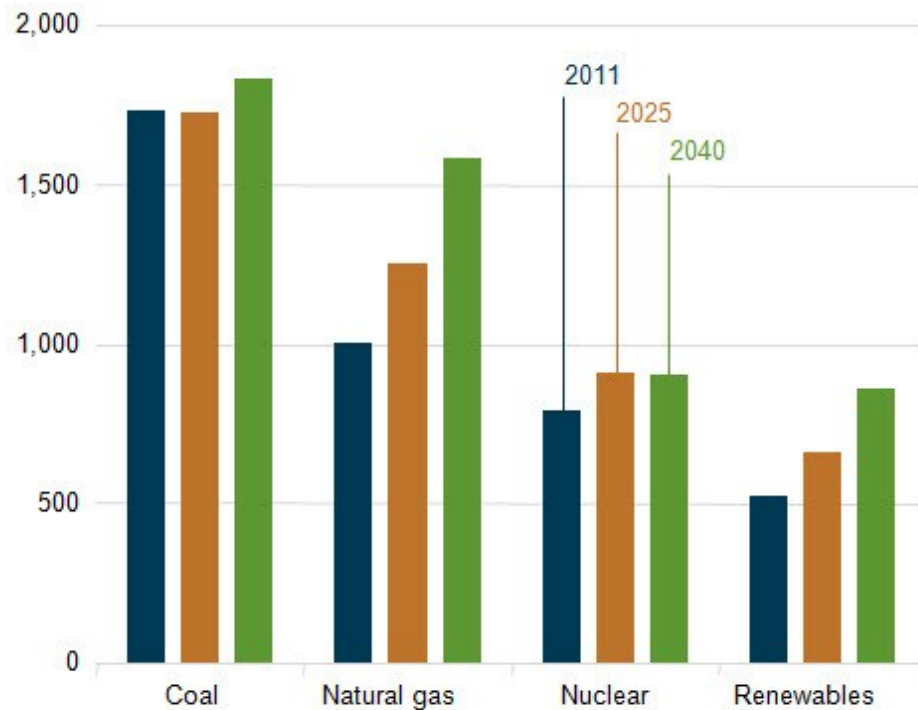
History of energy consumption in the United States (1776-2012)

quadrillion Btu



# Forecasted fuel consumption for electricity

Figure 76. Electricity generation by fuel, 2011, 2025, and 2040 (billion kilowatthours)

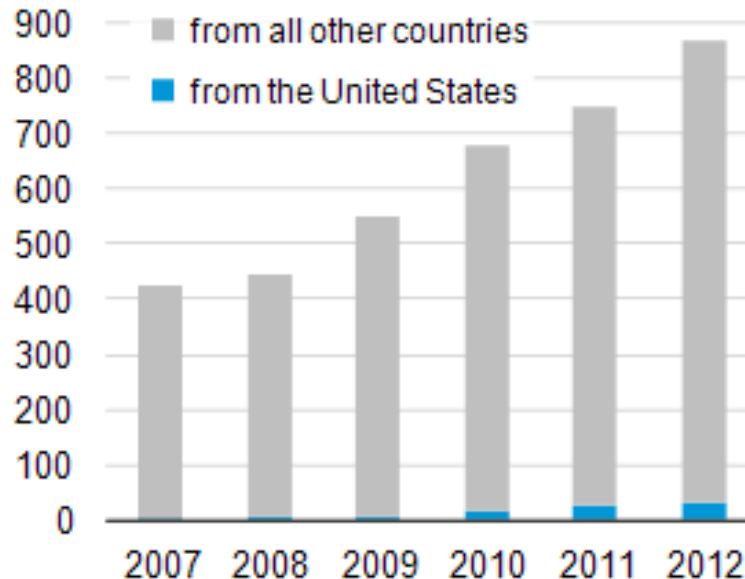


# Coal exports

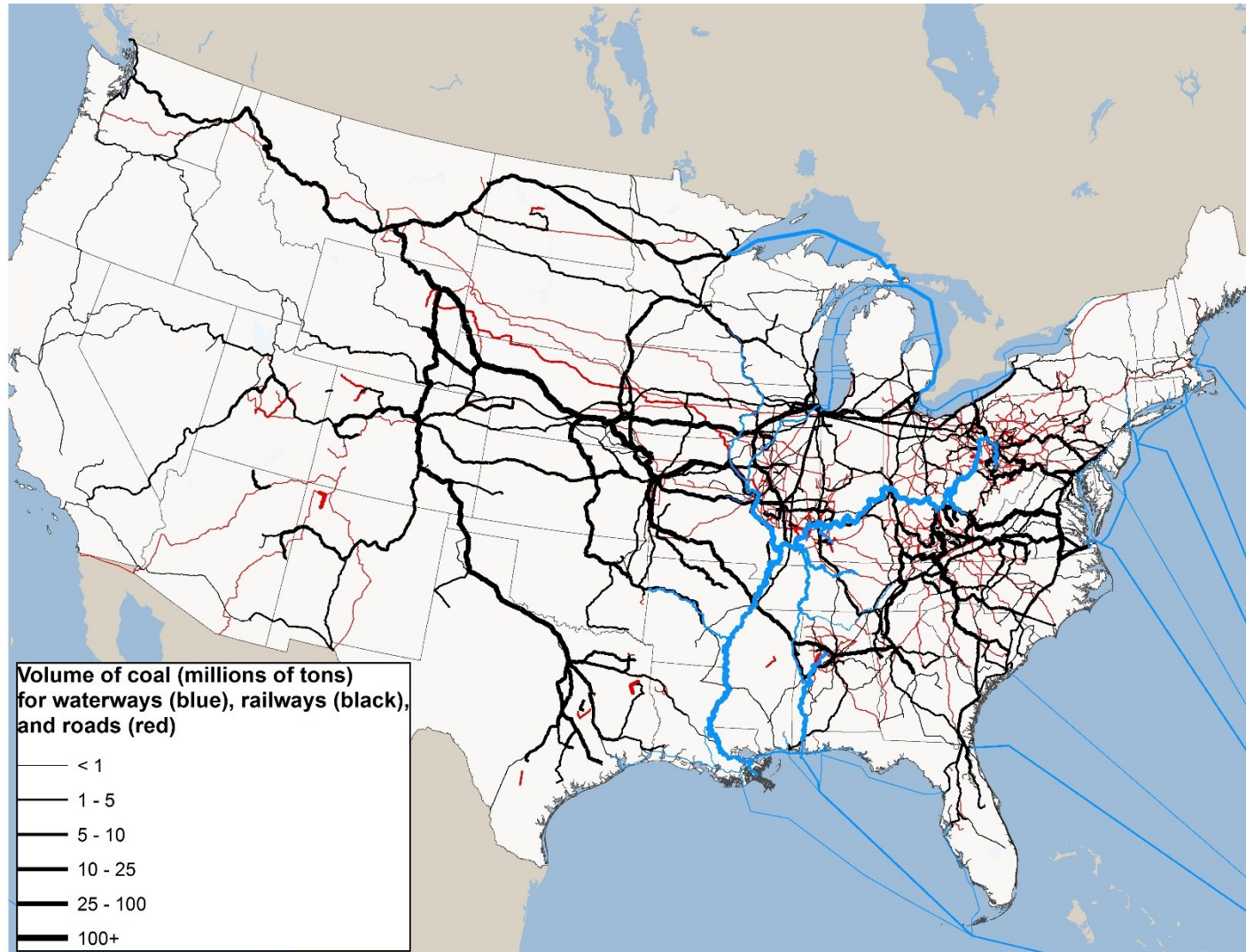
**U.S. coal exports by destination country**  
(2007-12)  
million short tons



**China, South Korea, India, and Japan coal imports by country of origin**  
(2007-12)  
million short tons



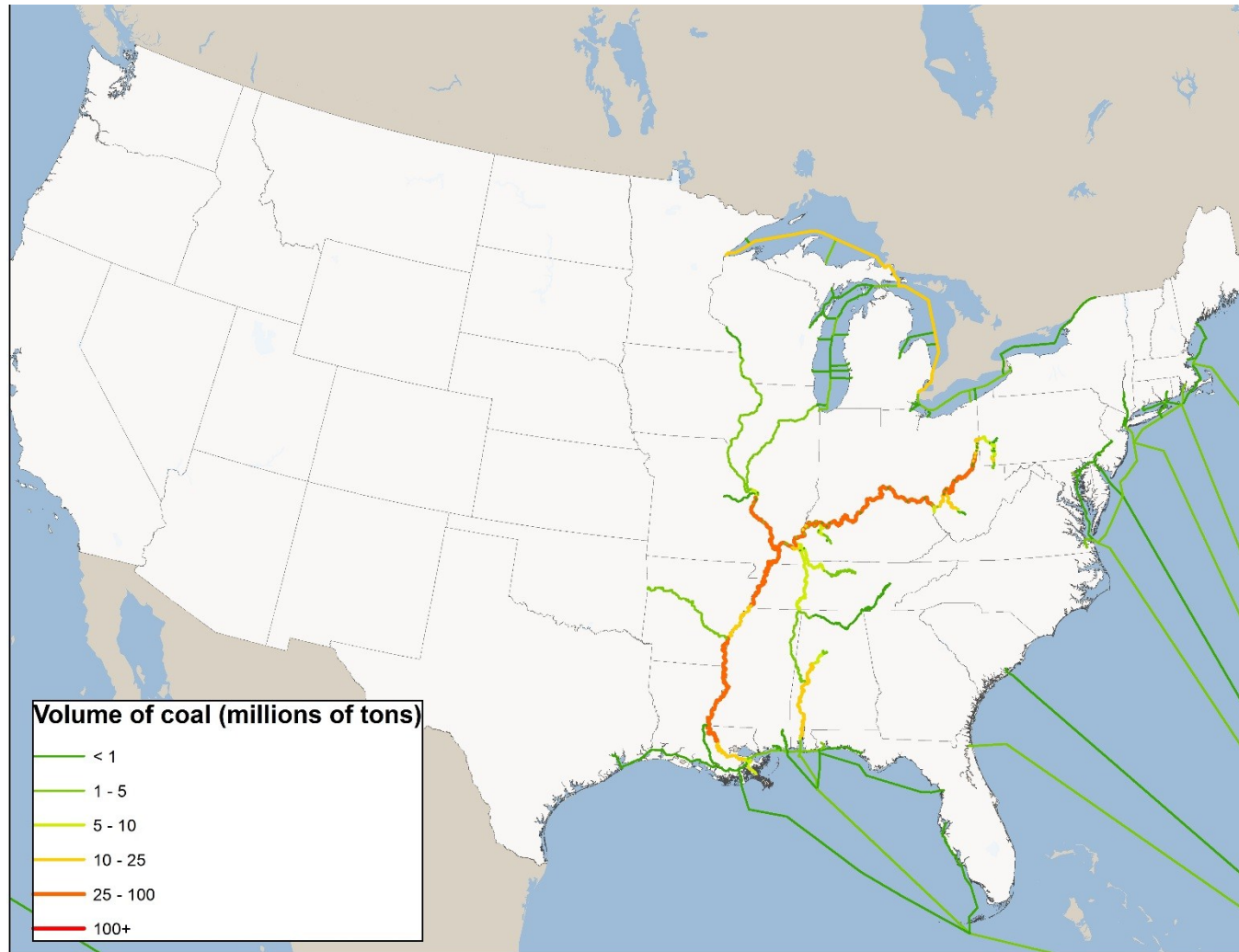
# Coal modeled across all modes



# Coal transportation: Waterways

- Coal is 2<sup>nd</sup> leading ton-mile commodity (just behind petroleum) for the barge industry
- In 2009, coal accounted for 24% (volume) of all commodities shipped on the inland waterways
- Of domestic coal shipments, 11% were at least partly on inland waterways
  - Share of coal shipments is larger when including imports and exports

# Modeled coal movements on waterways

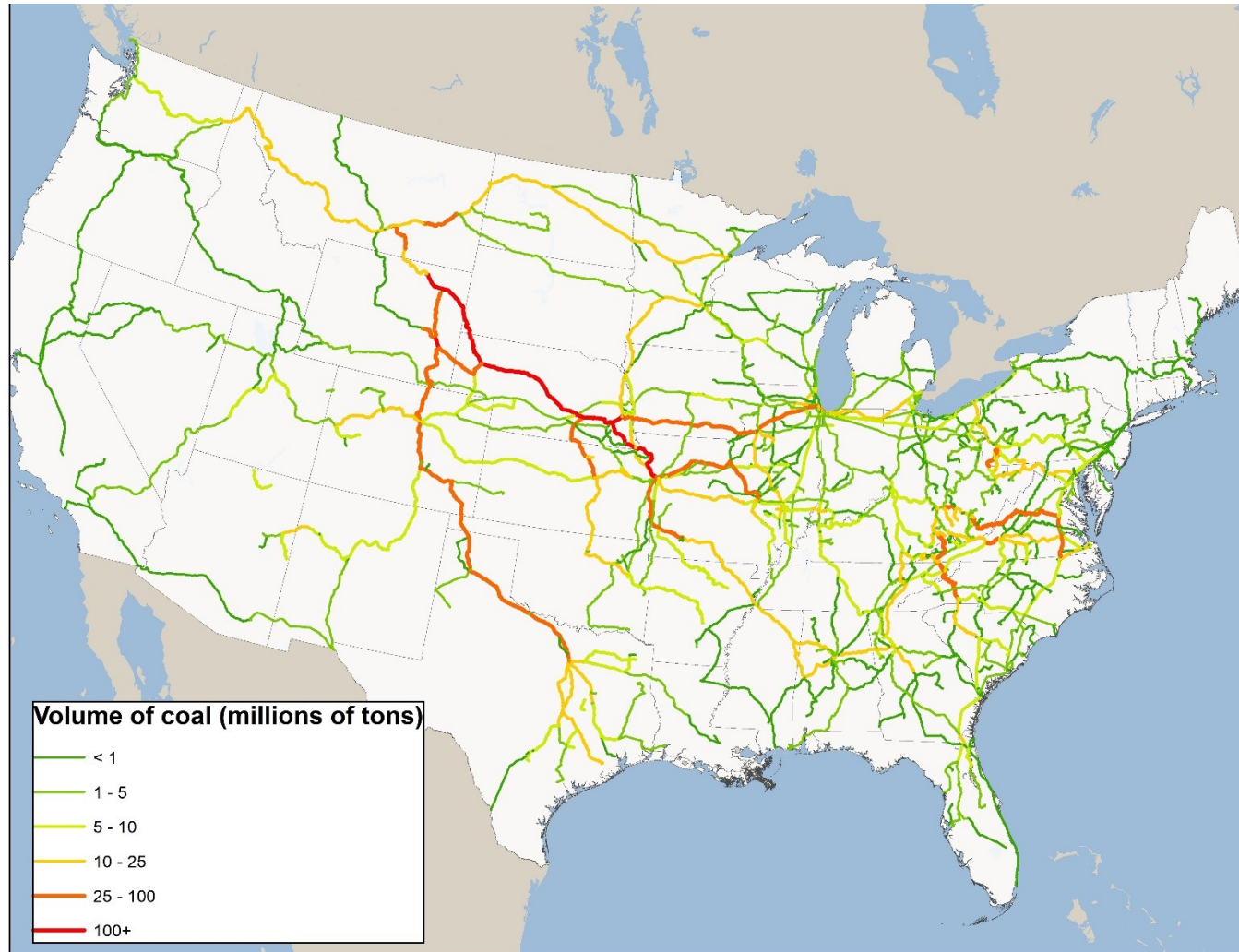


# Coal transportation: Railways

- For the rail industry, coal is the single largest ton-mile commodity
  - 43% of total rail tonnage
  - 25% of gross revenue
- In 2010, 771 million tons of coal, or 74% of total production, went by rail for at least part of its route
- Primary mode of transport for coal out of the Powder River Basin of Wyoming



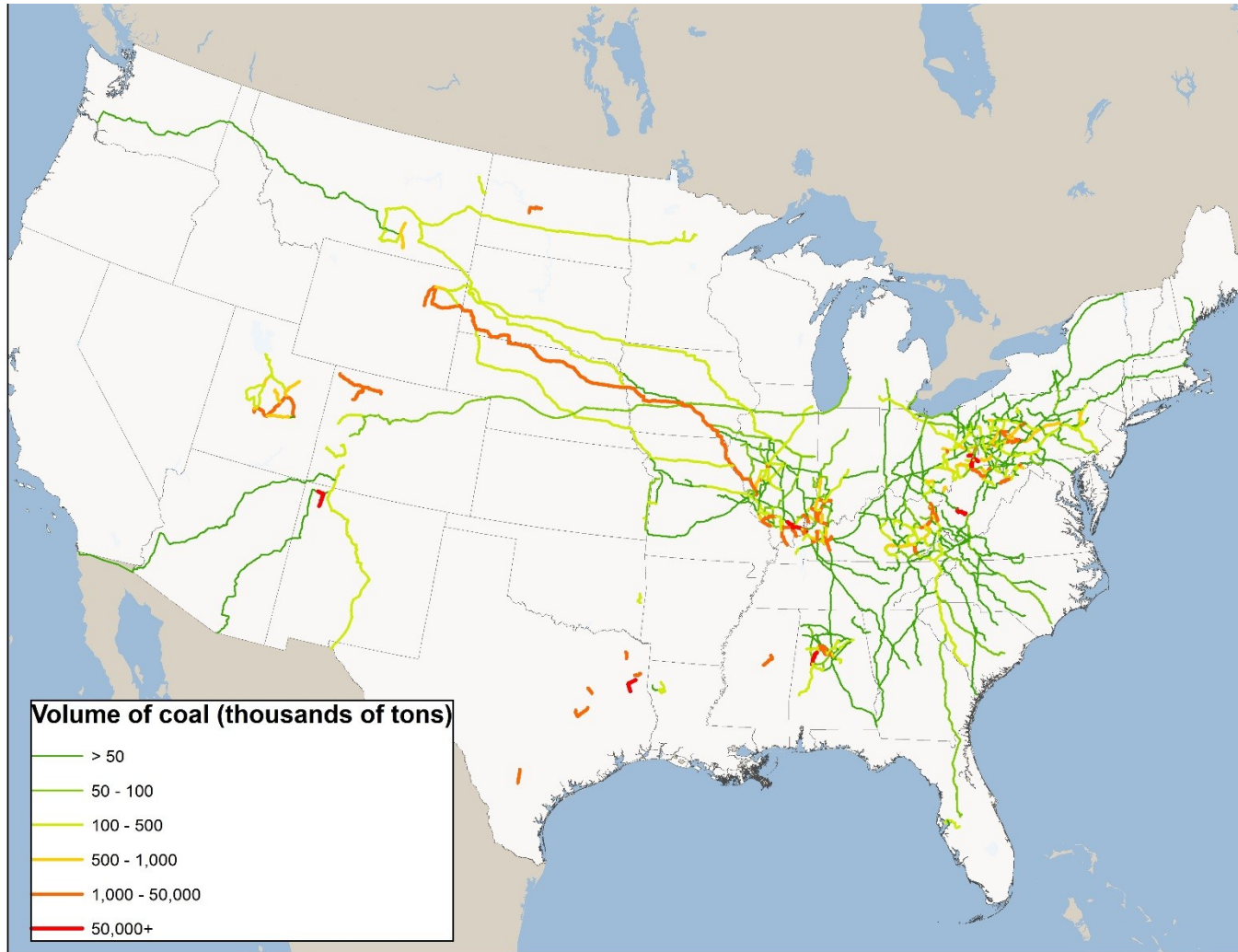
# Modeled coal movements on railways



# Coal transportation: Roadways

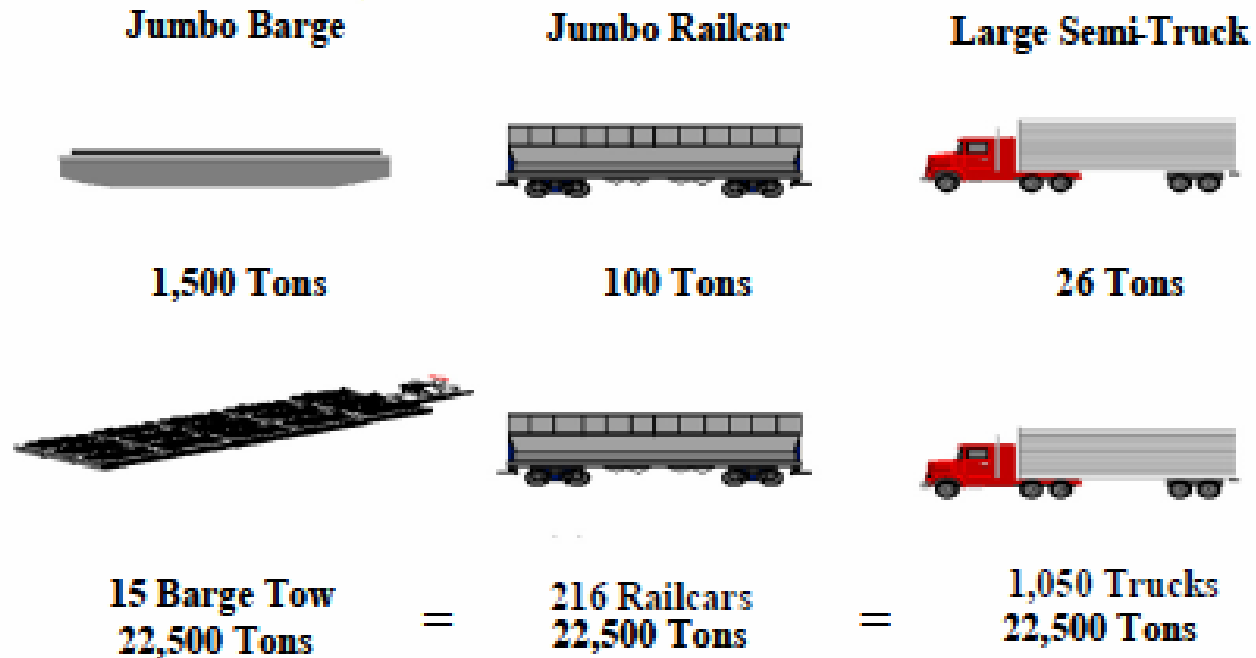
- In 2010, 197 million tons of coal, or 19% of total production, went at least a part of its shipment route by truck. Of this,
  - 107 million tons solely by truck
  - 89 million tons only part of way by truck
- Mostly shorter distance hauls
- More common east of the Mississippi R.

# Modeled coal movements on roadways

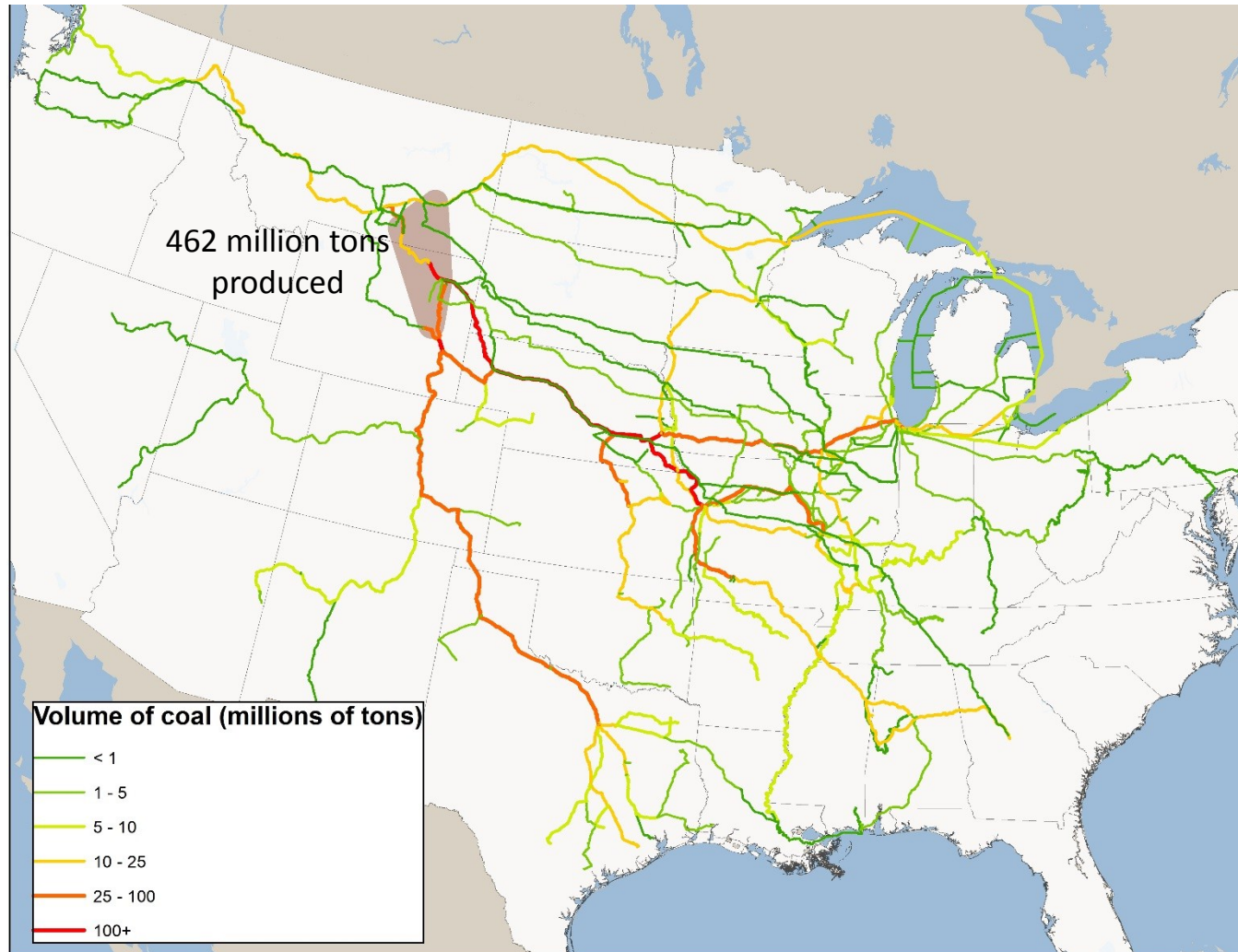


# Modal comparison for hauling coal

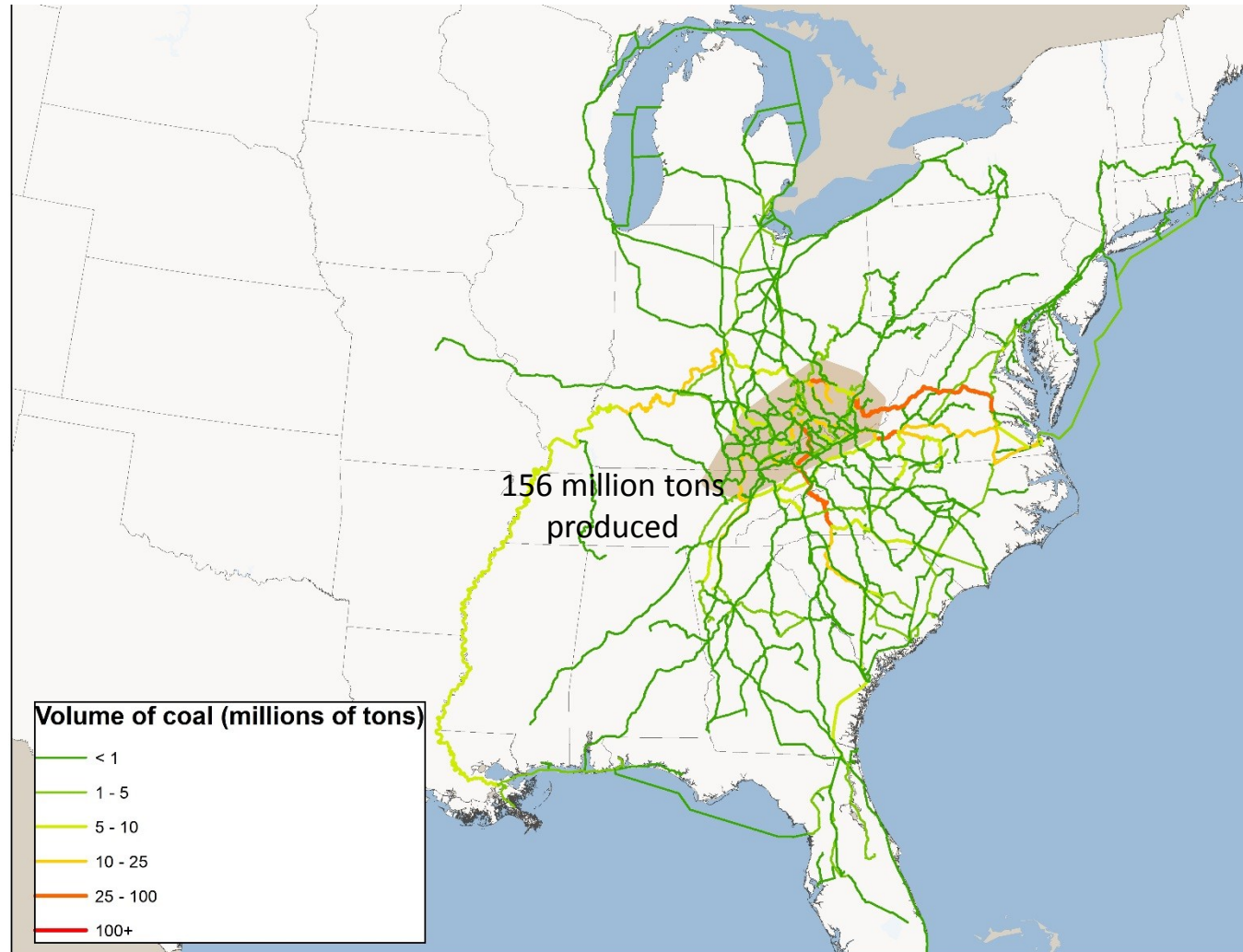
## Modal Carrying Capacity



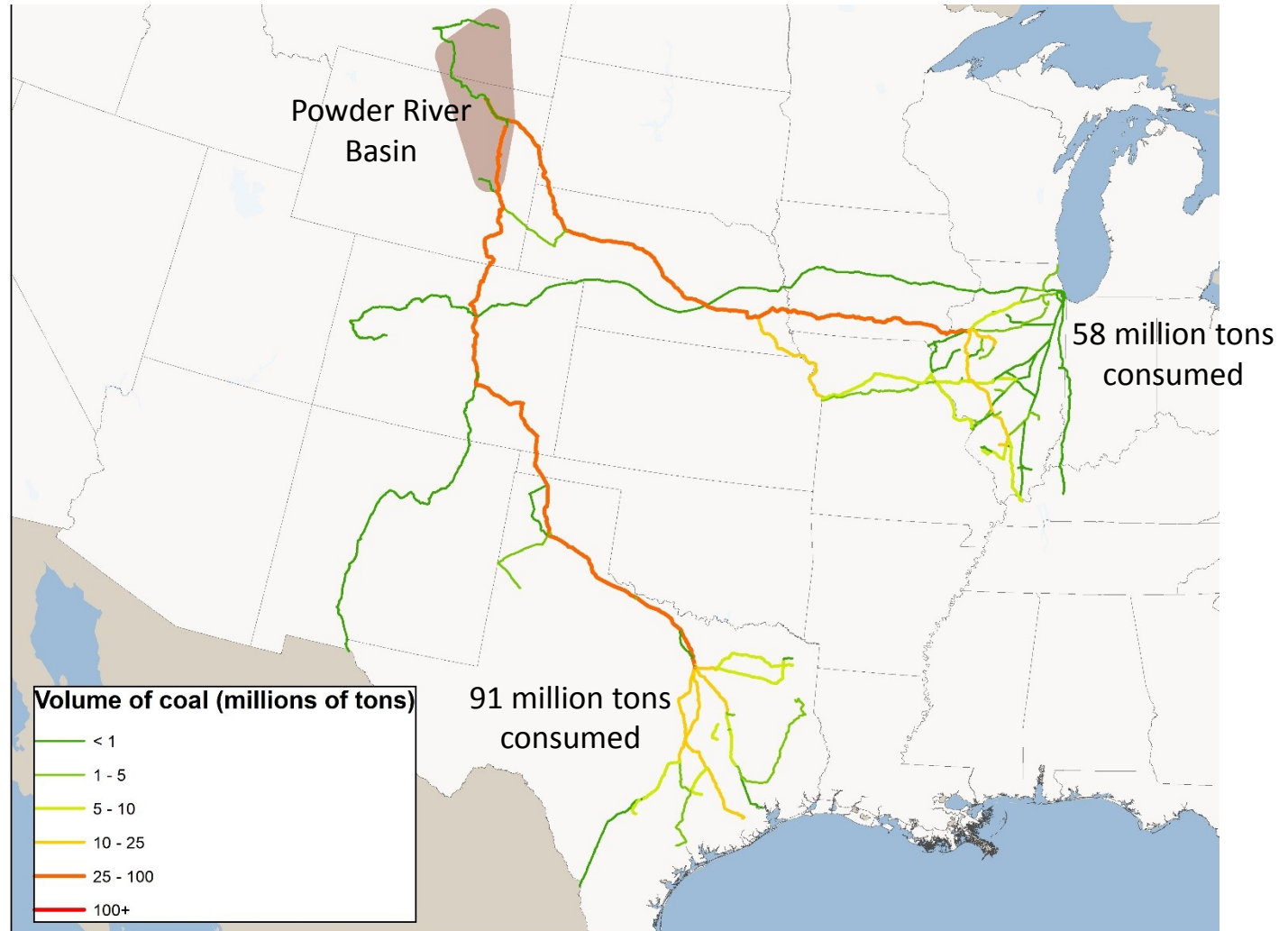
# Modeled coal movements from the Powder River Basin



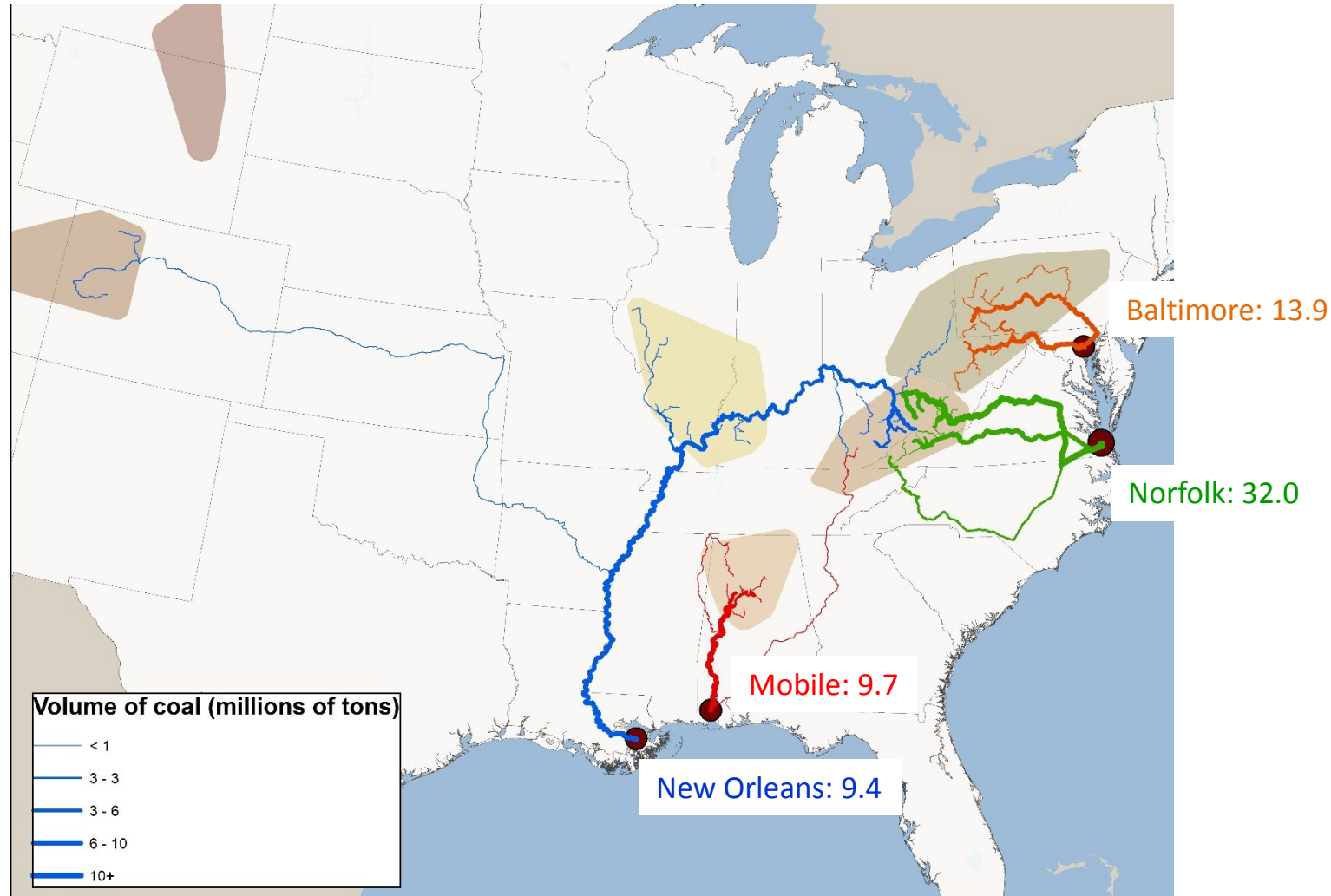
# Modeled coal movements from the Central Appalachian Basin



# Modeled coal movements to Texas and Illinois

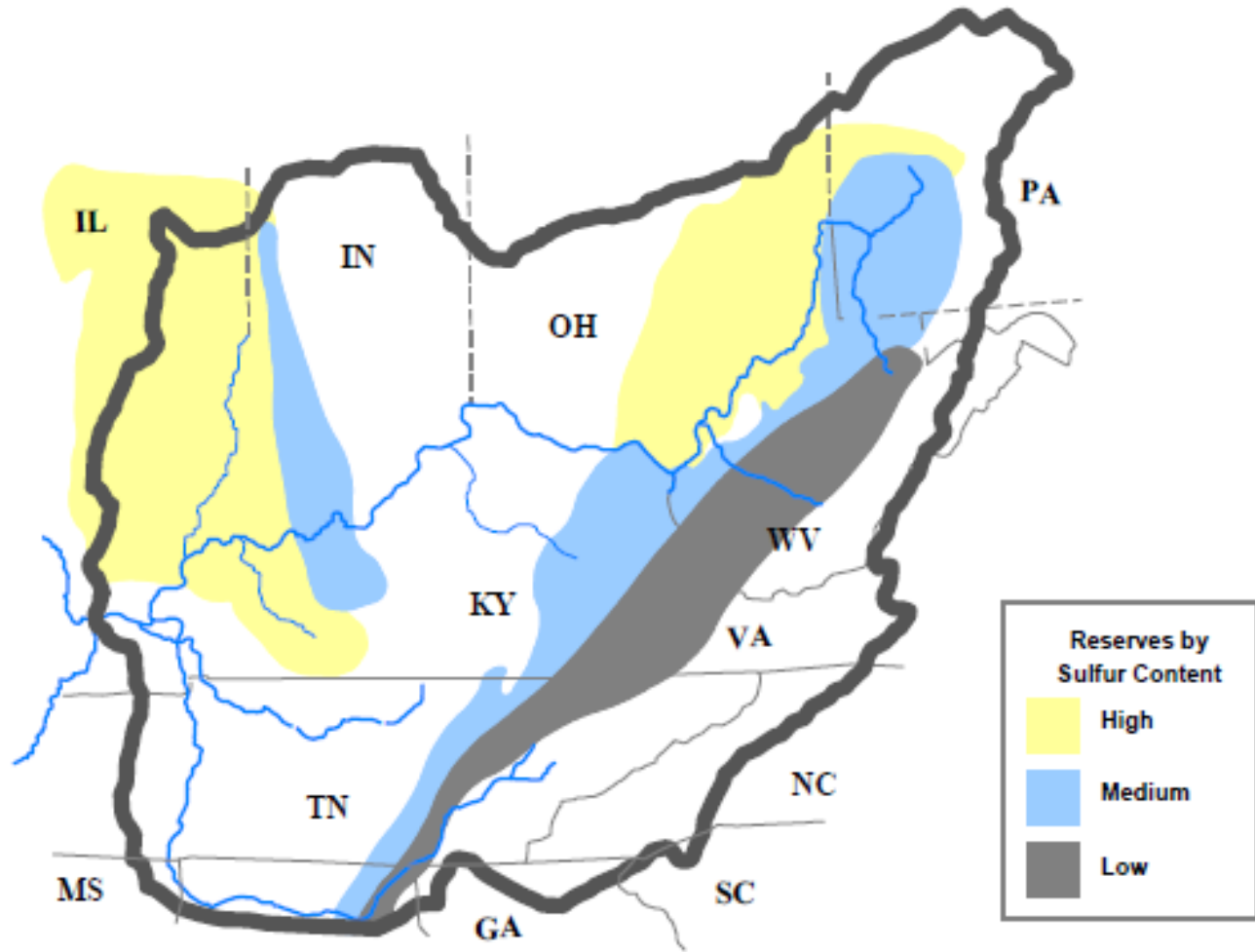


# Modeled coal exports (millions of tons)

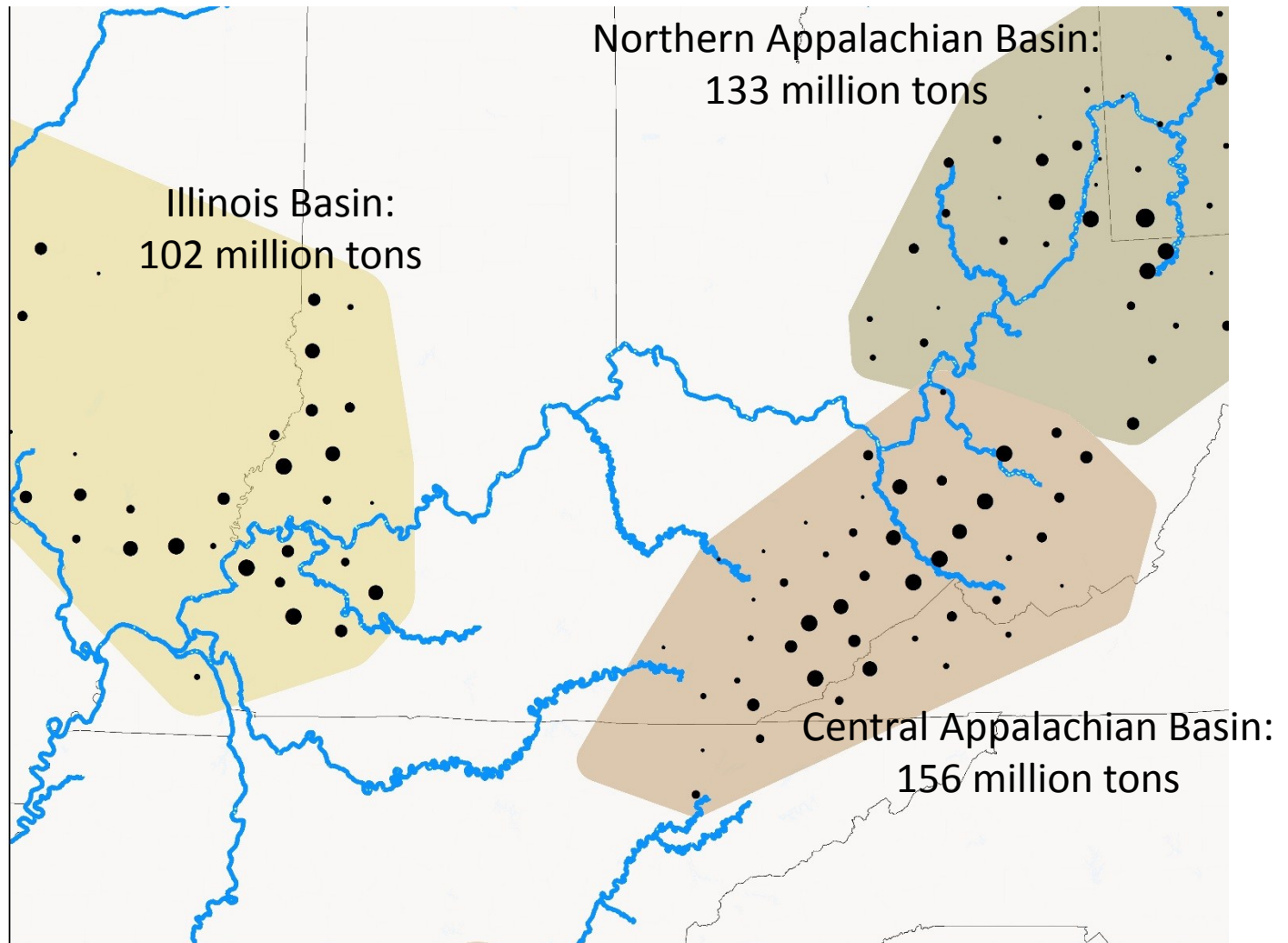




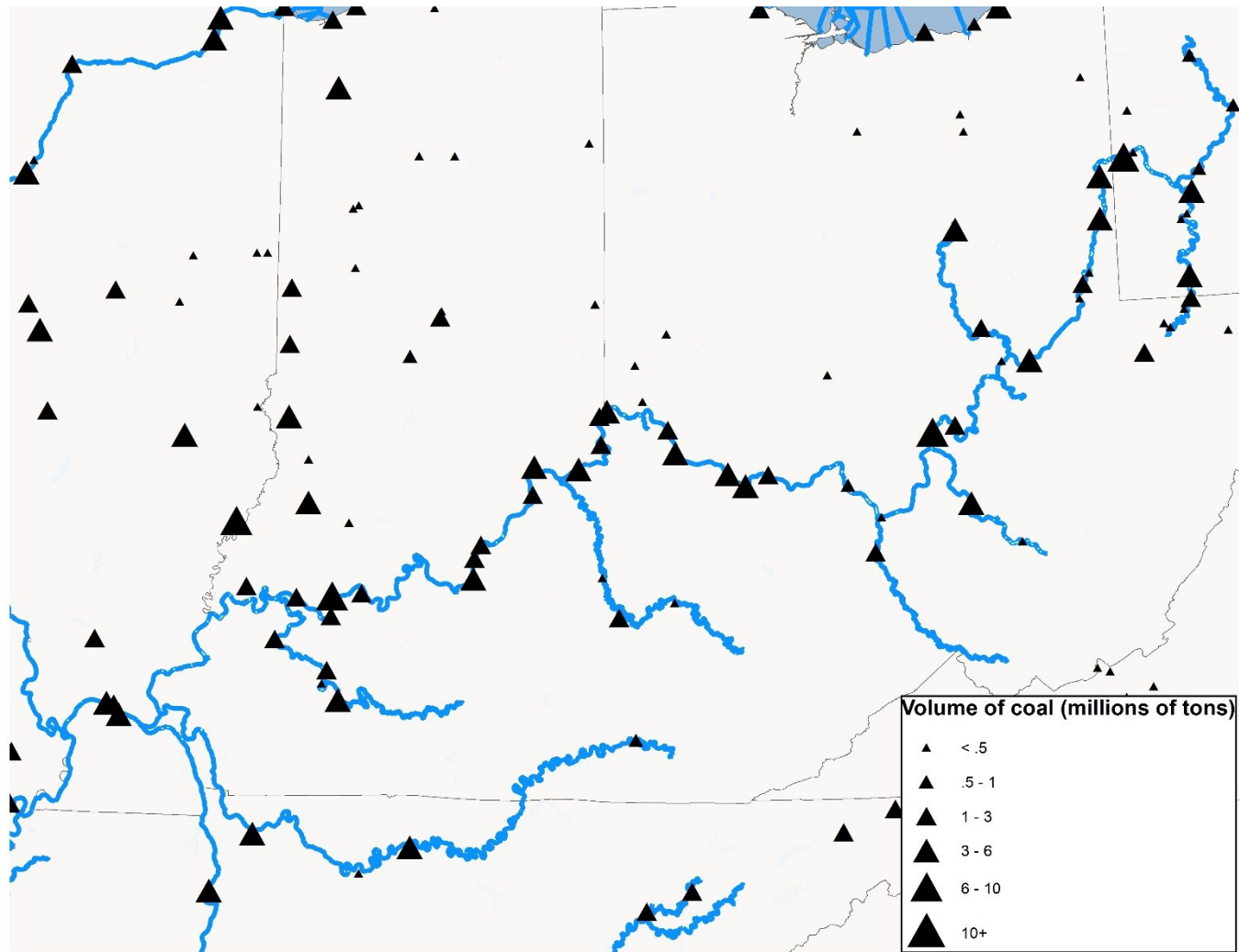
# Coal in Ohio River Basin



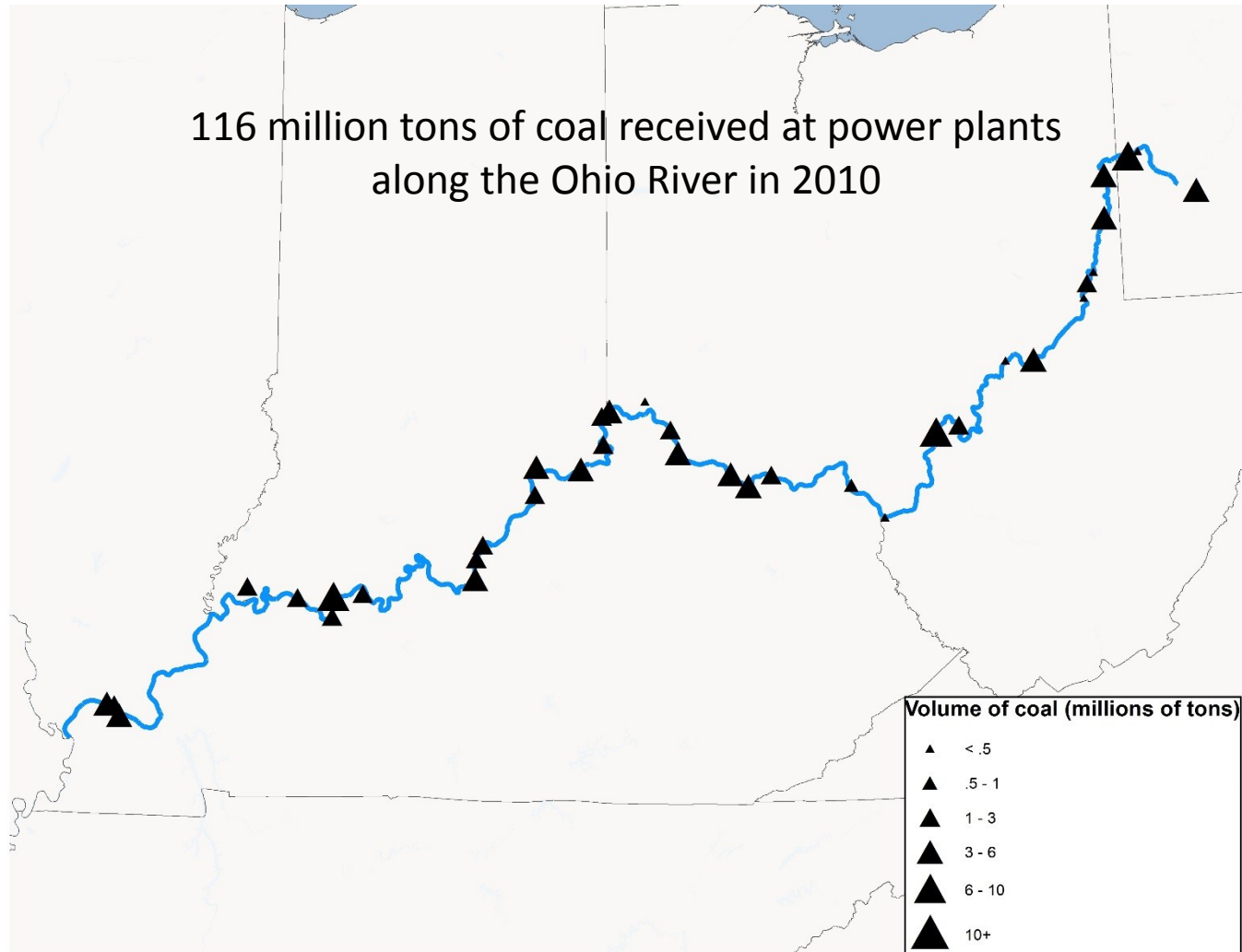
# Coal production around the Ohio River in 2010



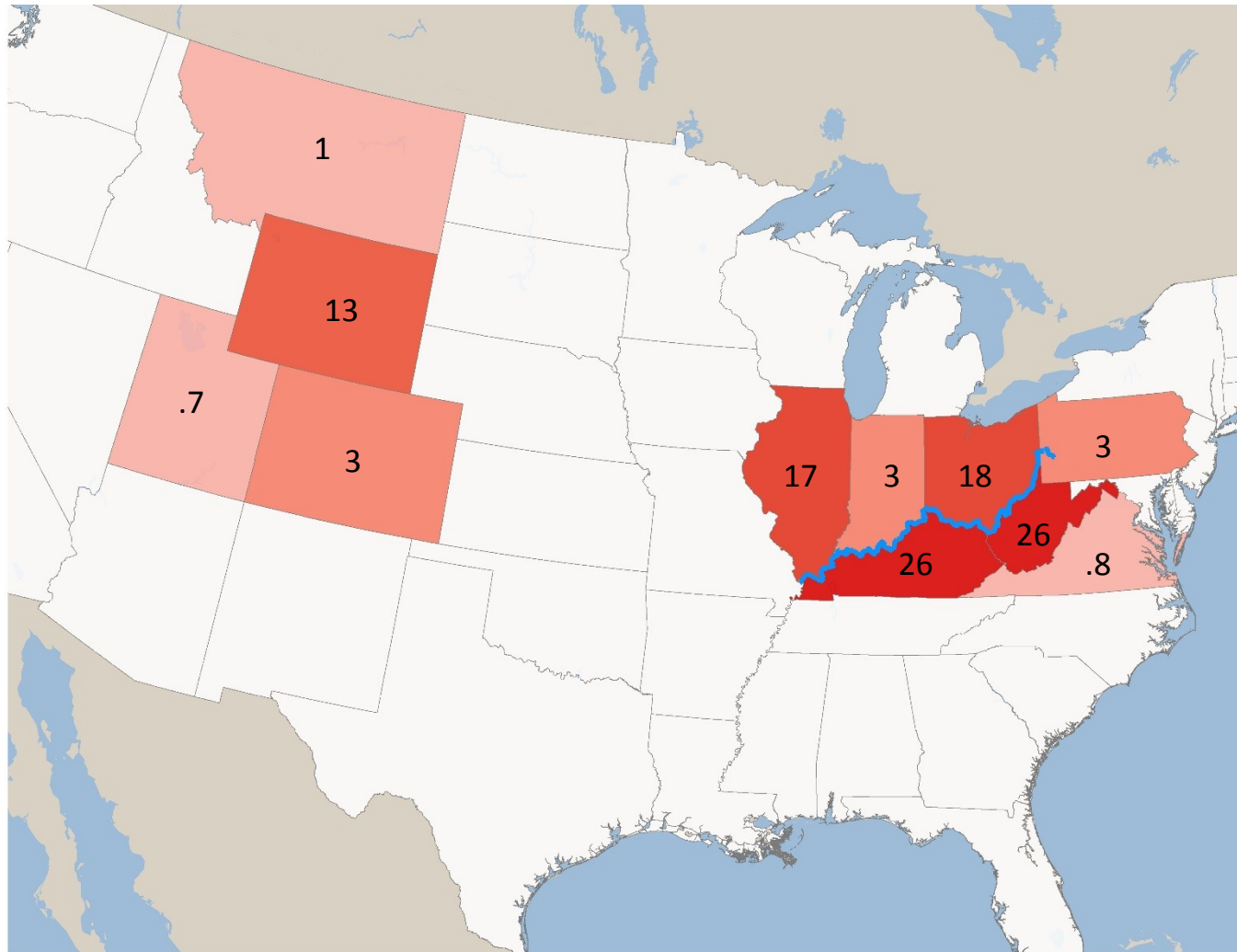
# Coal consumption around the Ohio River



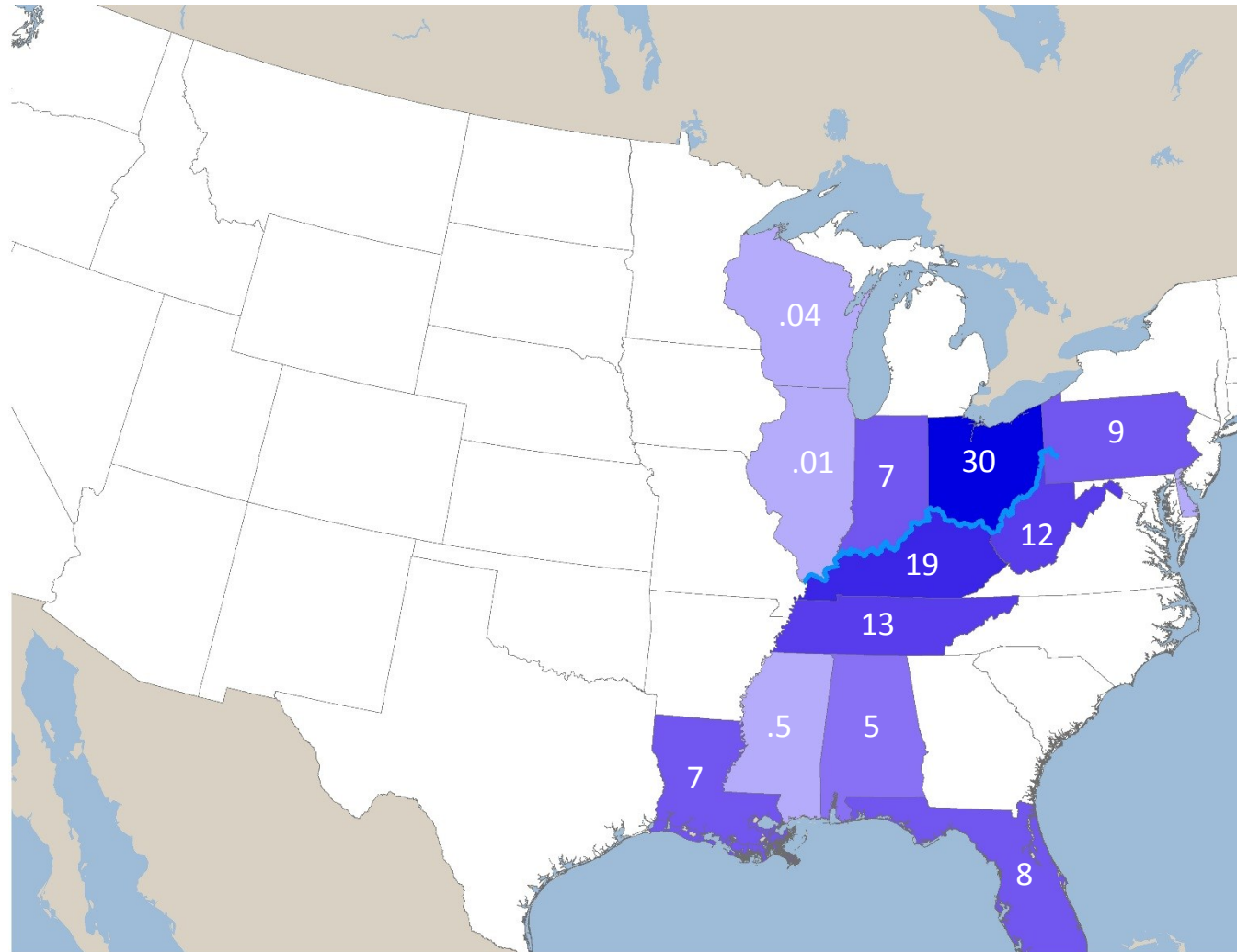
# Coal consumption around the Ohio River



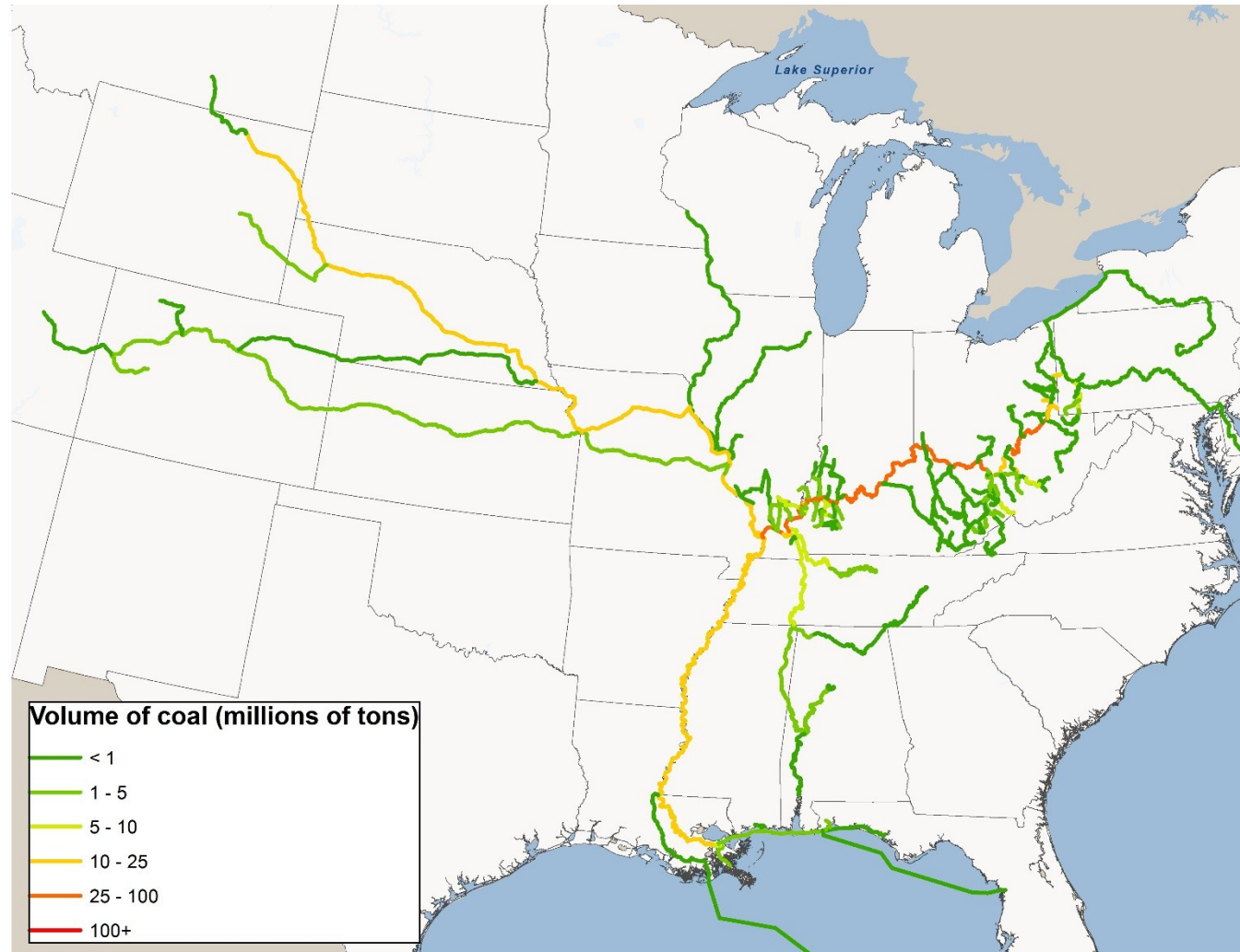
# State origins of coal that ships on the Ohio River (millions of tons)



# State destinations of coal that ships on the Ohio River (millions of tons)



# Full intermodal routes of coal that ships on the Ohio River



# Future directions

- Modeling all energy movements on an annual basis
  - Coal, petroleum, natural gas
- Diversion studies
  - What happens if a segment of the network is closed
- Incorporation of more robust shipping rate data
  - Modeling and estimation of all types of commodities across the three modes