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Evaluating Energy Infrastructure Land Use in the Delaware River Basin

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http://drbproject.org

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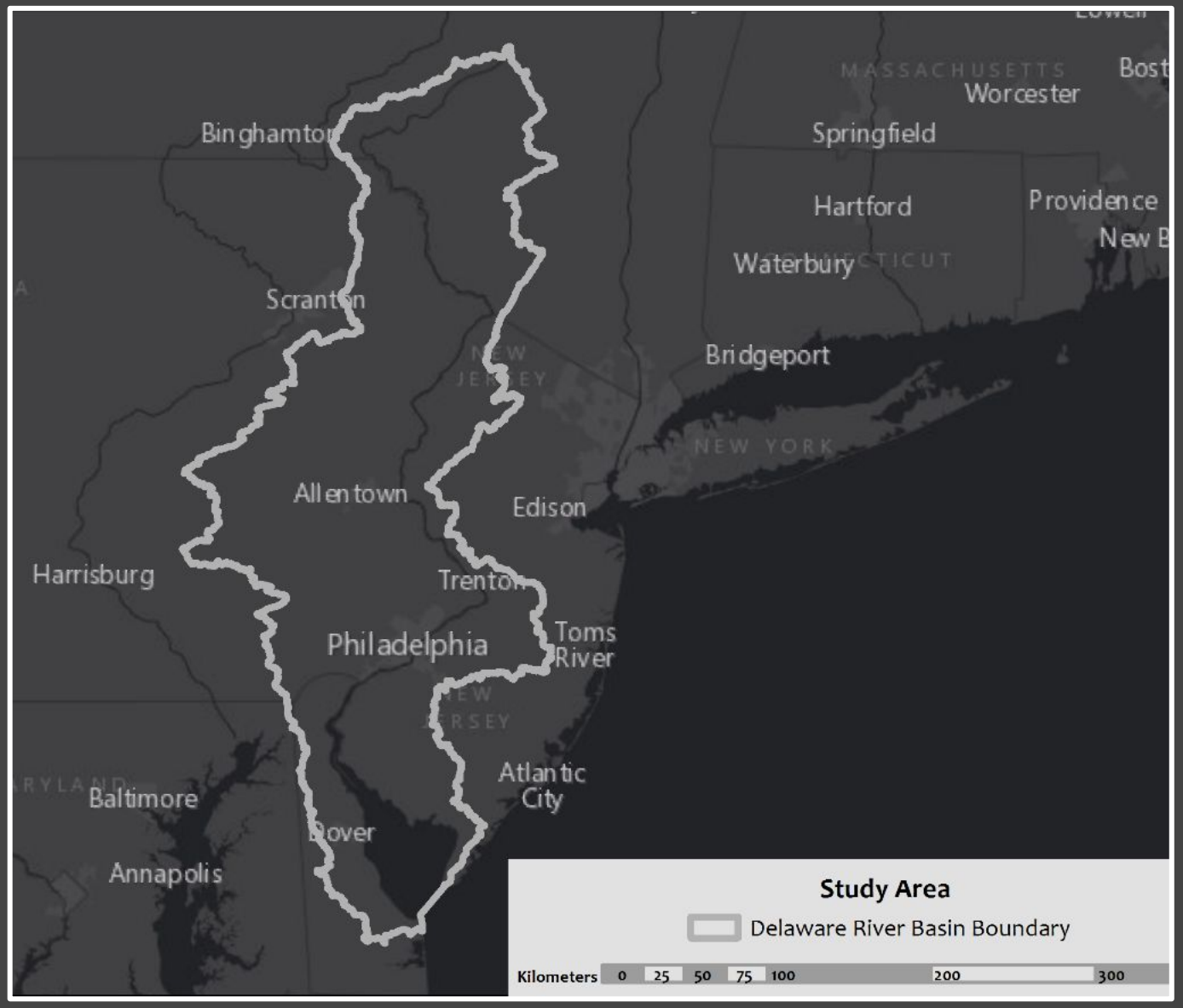
Center for Land Use and Sustainability
SHIPPENSBURG UNIVERSITY

Study Area & Motivation

- 35,000 sq. km (13,500 sq. mi)
- 8.2 million residents
- 3.6 million jobs
- Provides water resources and ecosystem services to more than 15 million people (*5% of U.S. population*)

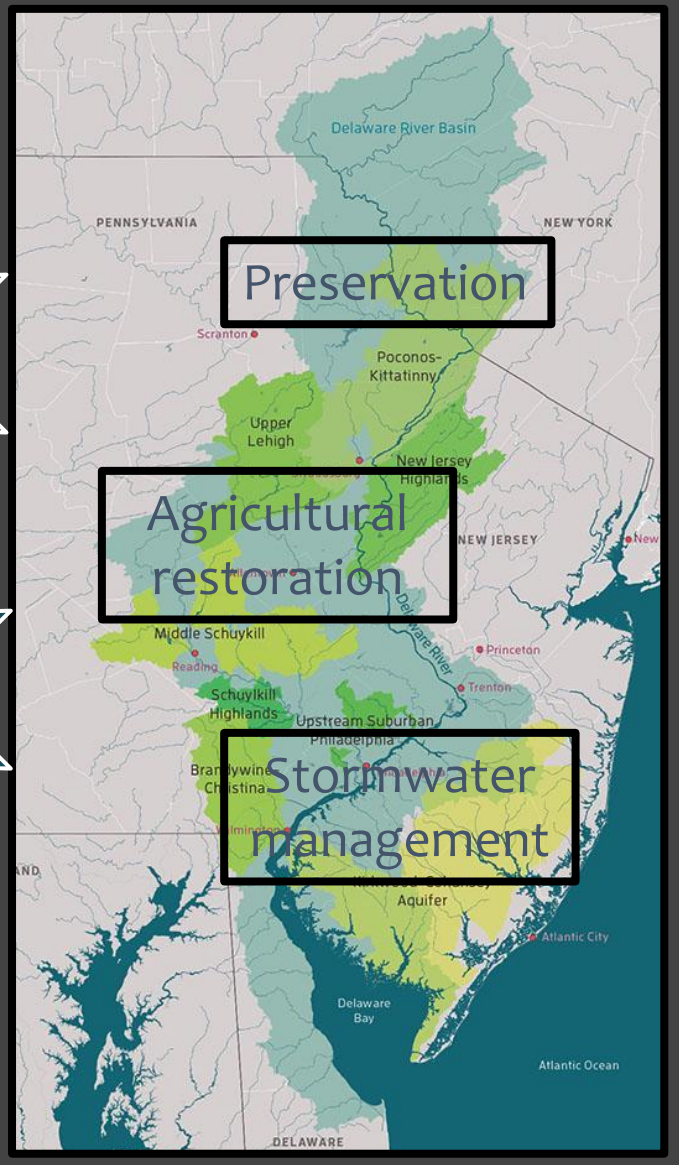


Delaware River Watershed Initiative

WILLIAM PENN FOUNDATION

OPEN SPACE INSTITUTE

NATIONAL FISH AND WILDLIFE FOUNDATION



PLOS ONE

RESEARCH ARTICLE

Energy Sprawl Is the Largest Driver of Land Use Change in United States

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OPEN ACCESS

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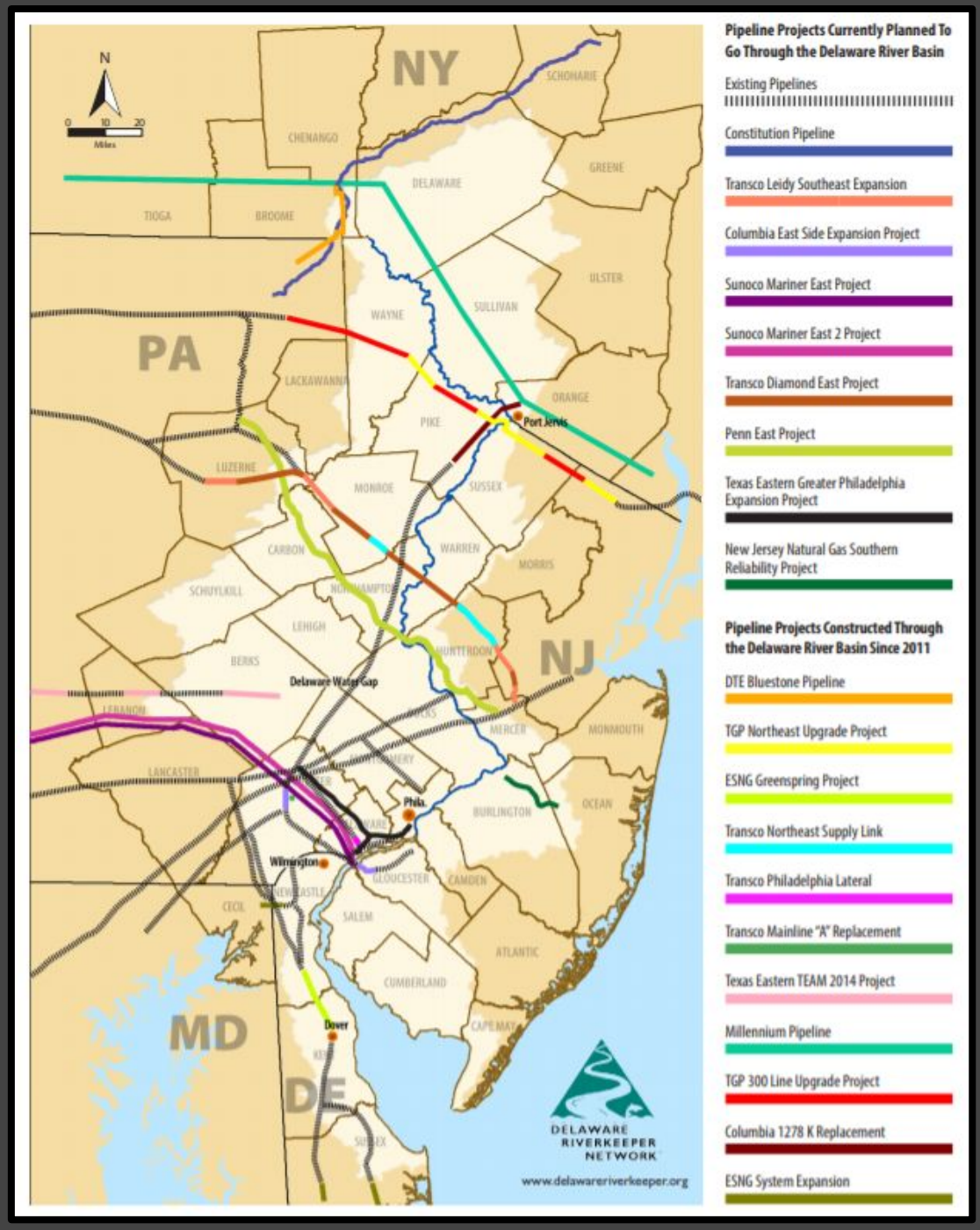
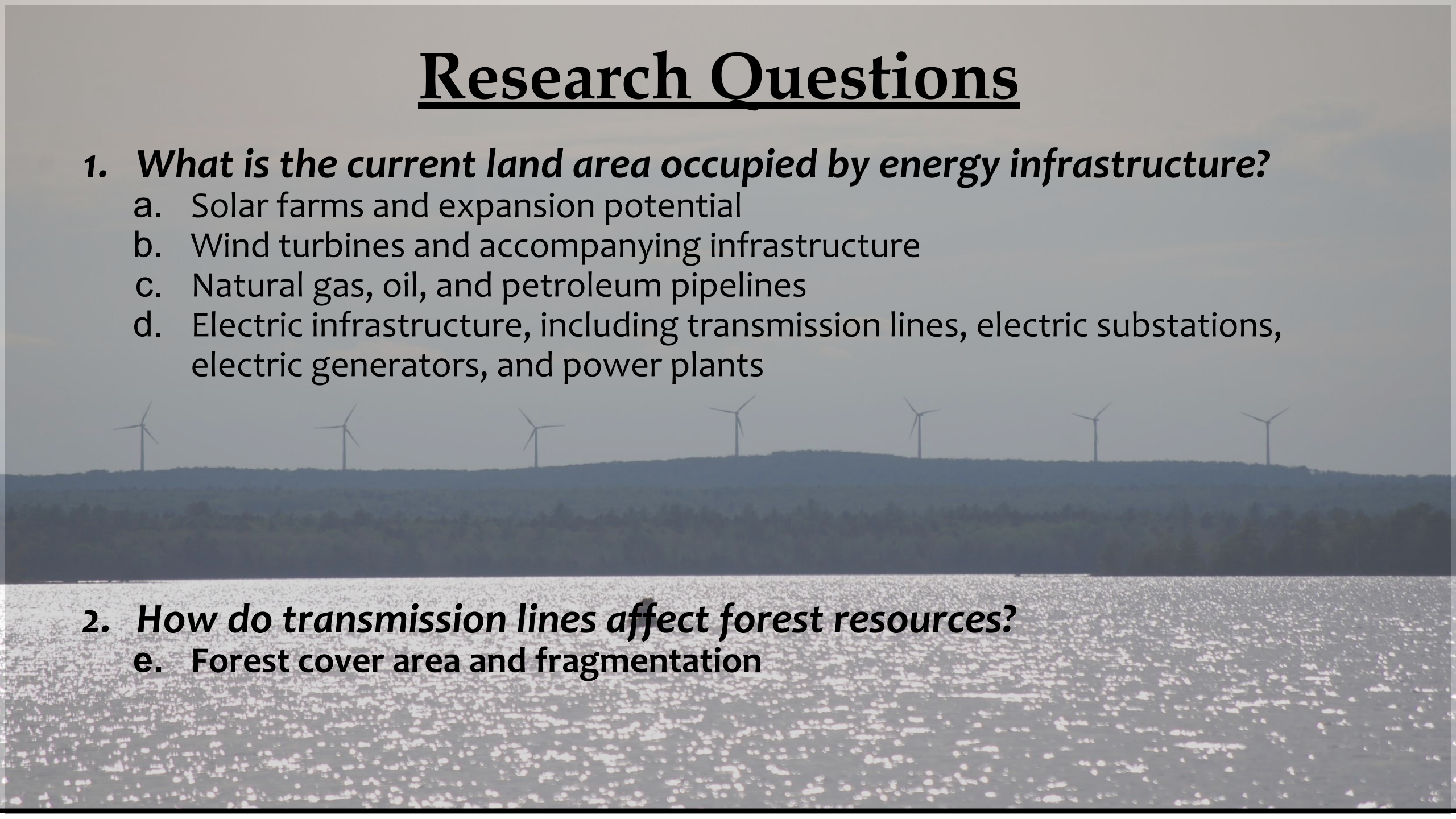
Abstract

Energy production in the United States for domestic use and export is predicted to rise 27% by 2040. We quantify projected energy sprawl (new land required for energy production) in the United States through 2040. Over 200,000 km^2 of additional land area will be directly impacted by energy development. When spacing requirements are included, over 800,000 km^2 of additional land area will be affected by energy development, an area greater than the size of Texas. This pace of development in the United States is more than double the historic rate of urban and residential development, which has been the greatest driver of conversion in the United States since 1970, and is higher than projections for future land use change from residential development or agriculture. New technology now places 1.3 million km^2 that had not previously experienced oil and gas development at risk of development for unconventional oil and gas. Renewable energy production can be sustained indefinitely on the same land base, while extractive energy must continually drill and mine new areas to sustain production. We calculated the number of years required for fossil energy production to expand to cover the same area as renewables, if both were to produce the same amount of energy each year. The land required for coal production would grow to equal or exceed that of wind, solar and geothermal energy within 2–31 years. In contrast, it would take hundreds of years for oil production to have the same energy sprawl as biofuels. Meeting energy demands while conserving nature will require increased energy conservation, in addition to distributed renewable energy and appropriate siting and mitigation.



Research Questions

1. ***What is the current land area occupied by energy infrastructure?***
   a. Solar farms and expansion potential
   b. Wind turbines and accompanying infrastructure
   c. Natural gas, oil, and petroleum pipelines
   d. Electric infrastructure, including transmission lines, electric substations, electric generators, and power plants

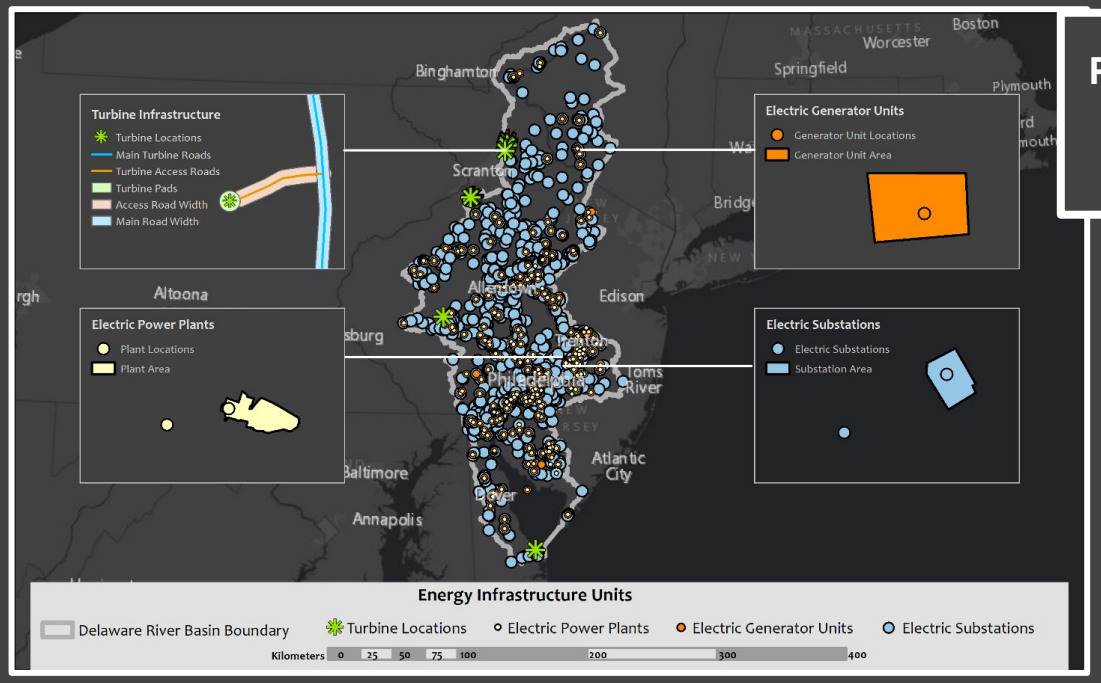


2. ***How do transmission lines affect forest resources?***
   e. Forest cover area and fragmentation

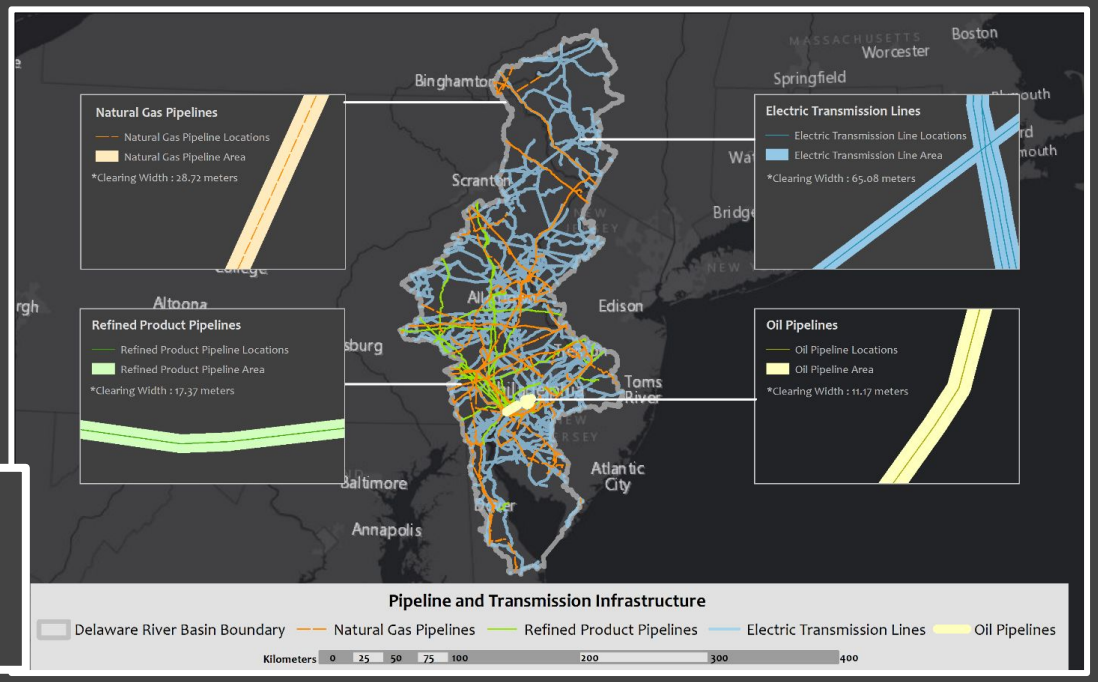
What is the current land area occupied by energy infrastructure?

1. Data collection:

a. S&P Global Platts - electric and pipeline data
b. EIA Database - solar and wind farm data



PLEASE see us for specific methodology!

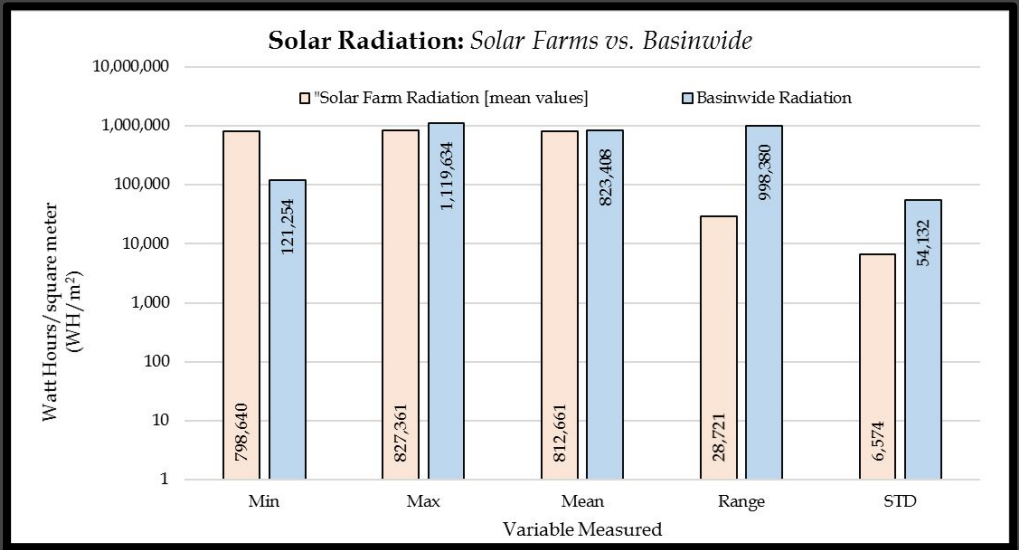


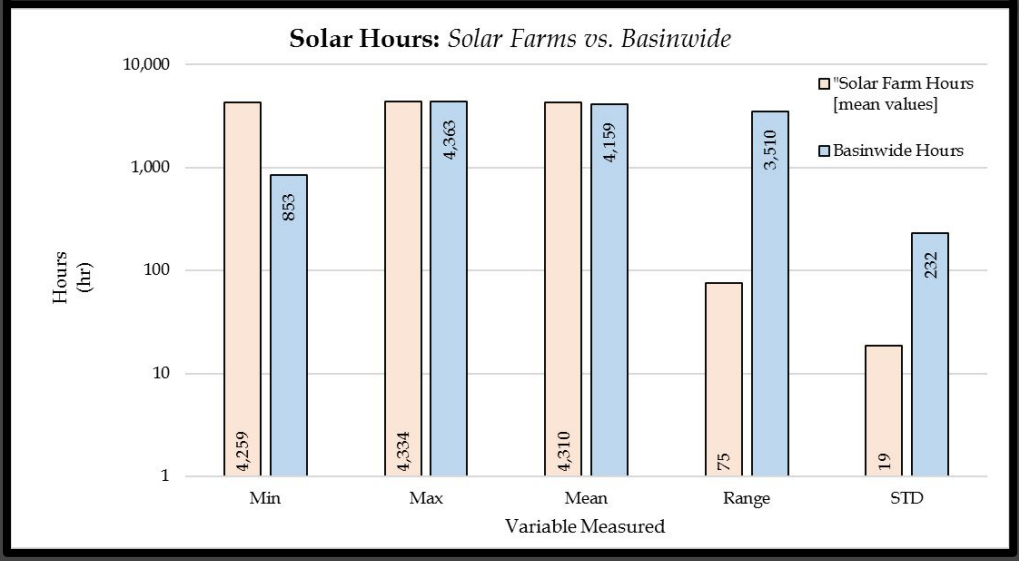
2. Different method for each dataset:

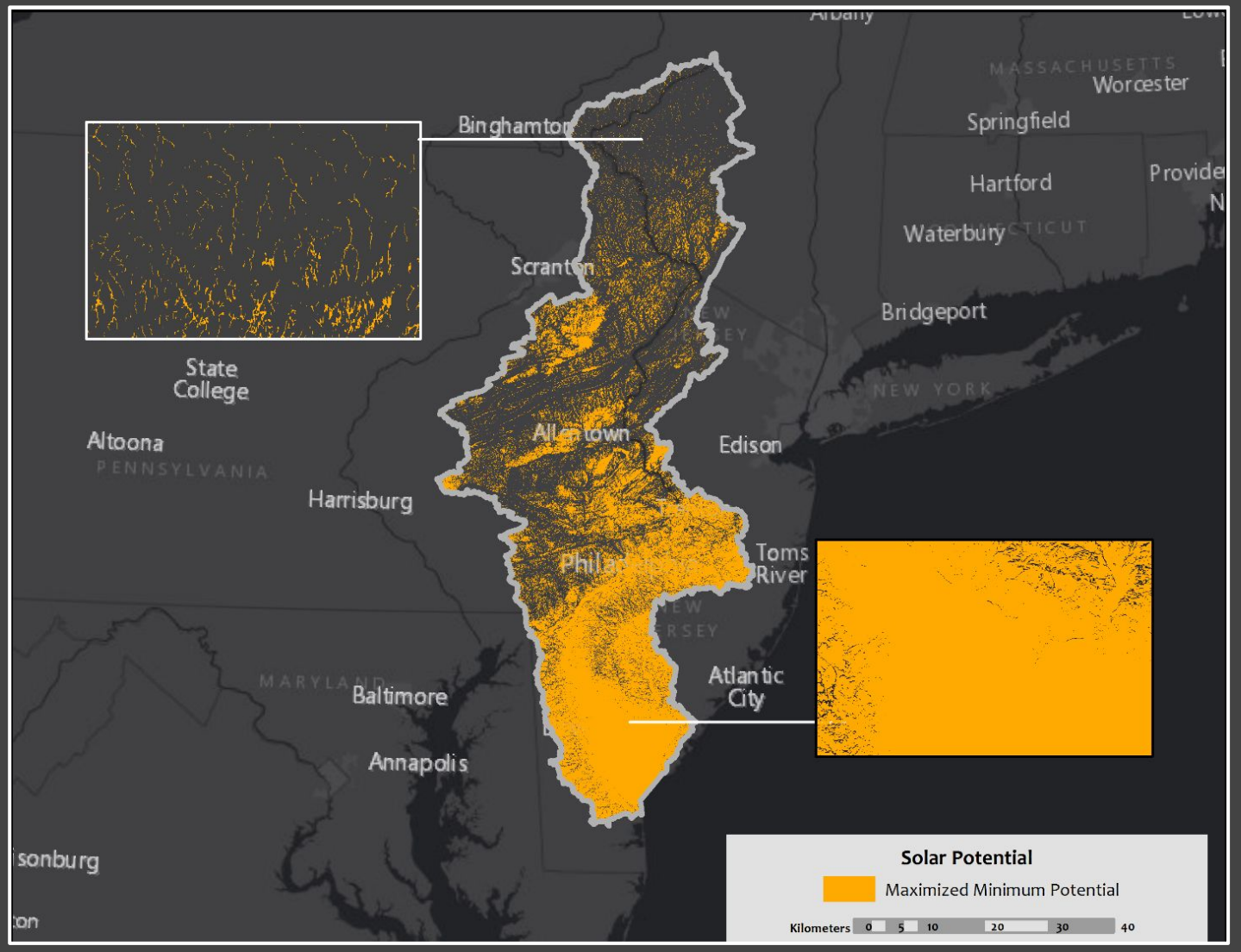
a. Random samples using aerial imagery
b. Various ESRI ArcGIS geoprocessing techniques to represent sample
c. Various area and zonal statistic calculations (ArcToolbox and Excel)

Solar Potential

Total DRB Area (sq. km)	Solar Farm Area (sq. km)	Min Rad Area (sq. km)	Min Hours Area (sq. km)	MaxMin Intersect Area (sq. km)
35252.72	0.08	29073.79	15311.73	14046.45
% Area w/ Potential		**82.47**	**43.43**	**39.85**



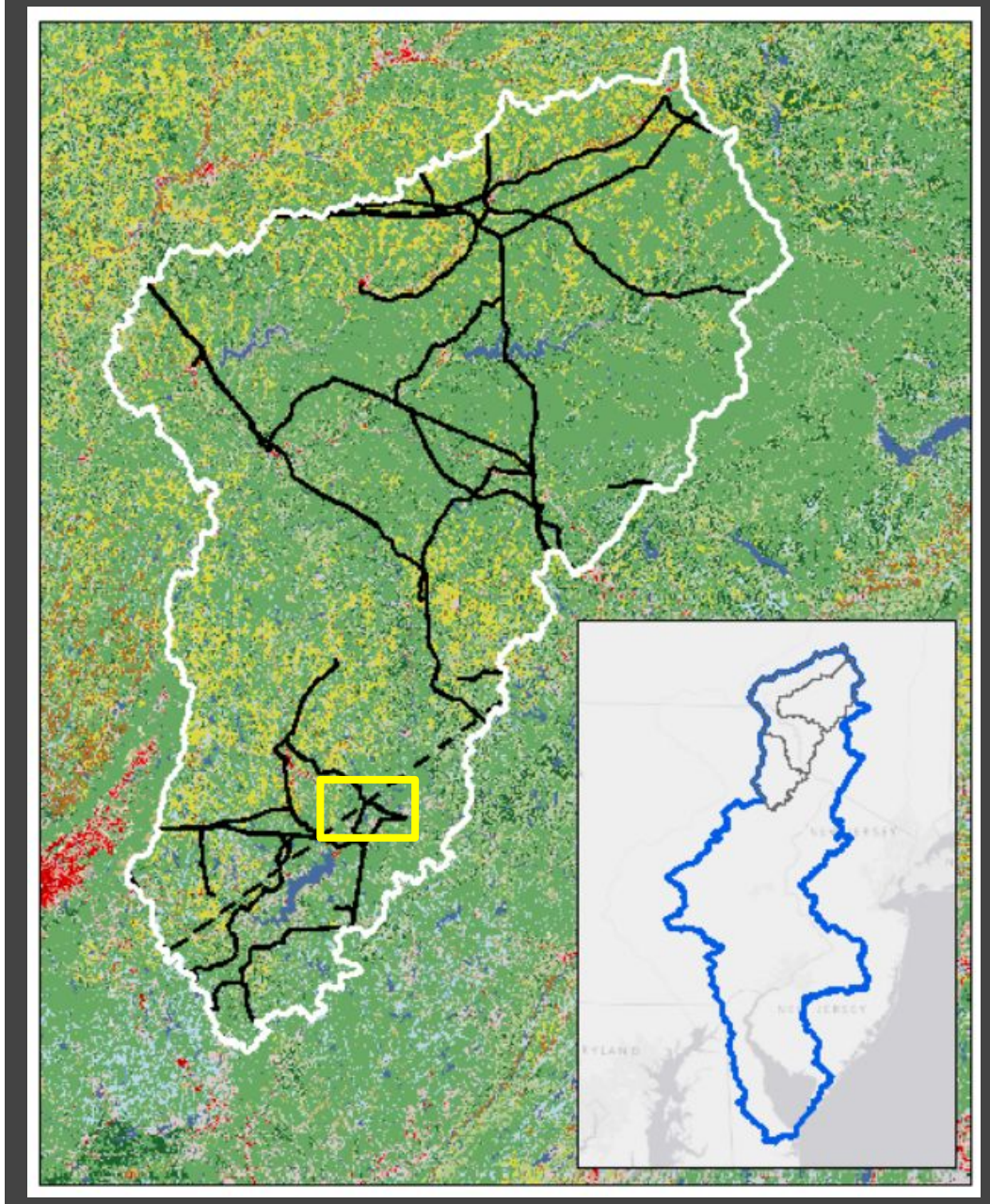


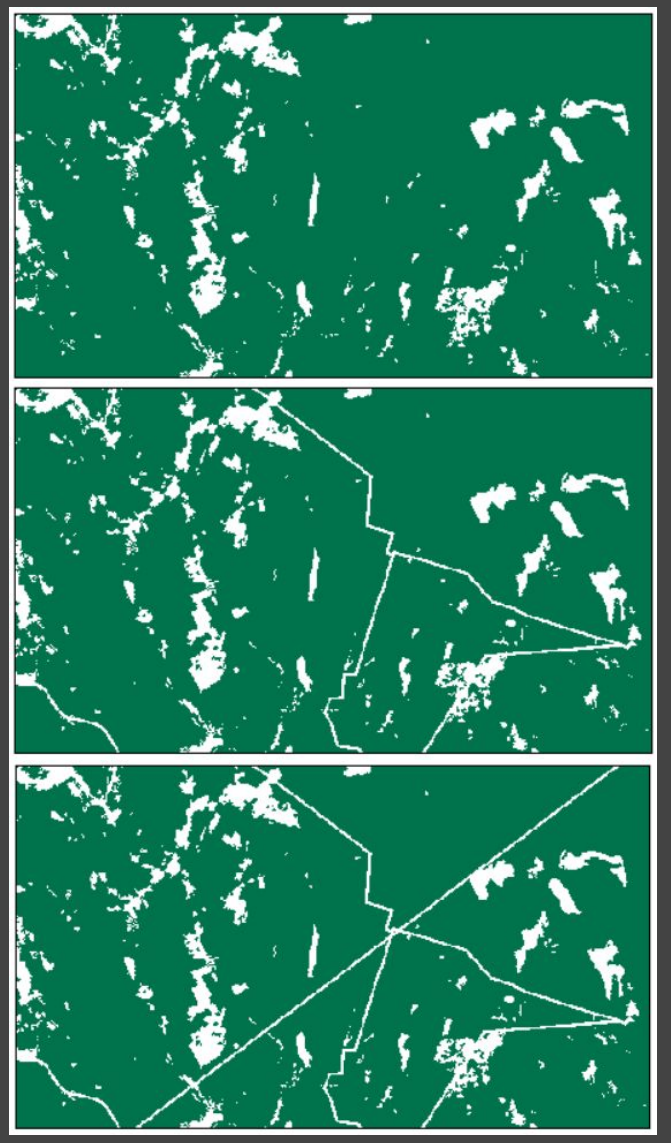


Approximate Land Occupancy

Feature (Buffer Used)		Estimated Area				Lengths	
Data Layers and Totals		sq. km	acres	Standard Dev. (sq. km)	Standard Error (sq. km)	km	miles
Transmission Lines (32.54 m per side_65.08 m)	#1	885.25	218,748.93	0.77	0.20	27,420.87	17,038.54
Electric Generator Units		0.81	199.83	0.004	0.001	N/A	N/A
Electric Power Plants		56.20	13,887.22	0.45	0.08	N/A	N/A
Electric Substations		5.55	1,370.76	0.01	0.001	N/A	N/A
Natural Gas Pipelines (14.26 m per side_28.72 m)	#2	128.19	31,677.36	0.32	0.08	9,036.15	5,614.80
Oil Pipelines (5.585 m per side_11.17 m_MOST UNDERGROUND)		0.29	70.63	0.03	0.01	48.87	30.36
Refined Petroleum Product Pipelines (8.69 m per side_17.37 m)		39.70	9,810.48	0.38	0.10	4,573.30	2,841.72
Solar Farms (Panels Only)		5.00	1,234.33	N/A	N/A	N/A	N/A
Wind Turbines and Associated Impervious Surfaces (Pads, Roads, Lots)		0.08	20.03	N/A	N/A	N/A	N/A
Total Wind Turbine Impervious Surface (Without Transmission or Stations)		0.08	20.03	N/A	N/A	43.71	27.16
Total Pipeline (Without Transmission or Stations)		168.18	41,558.47	N/A	N/A	13,658.32	8,486.88
Total Solar Farms (Without Transmission or Stations)		5.00	1,234.33	N/A	N/A	N/A	N/A
Total Electric Infrastructure (Includes all Transmission and Stations)		947.80	234,206.75	N/A	N/A	27,420.87	17,038.54
Total Energy With All Infrastructure		1,121.06	277,019.58	N/A	N/A	41,079.19	25,525.43

How do transmission lines affect forest resources?



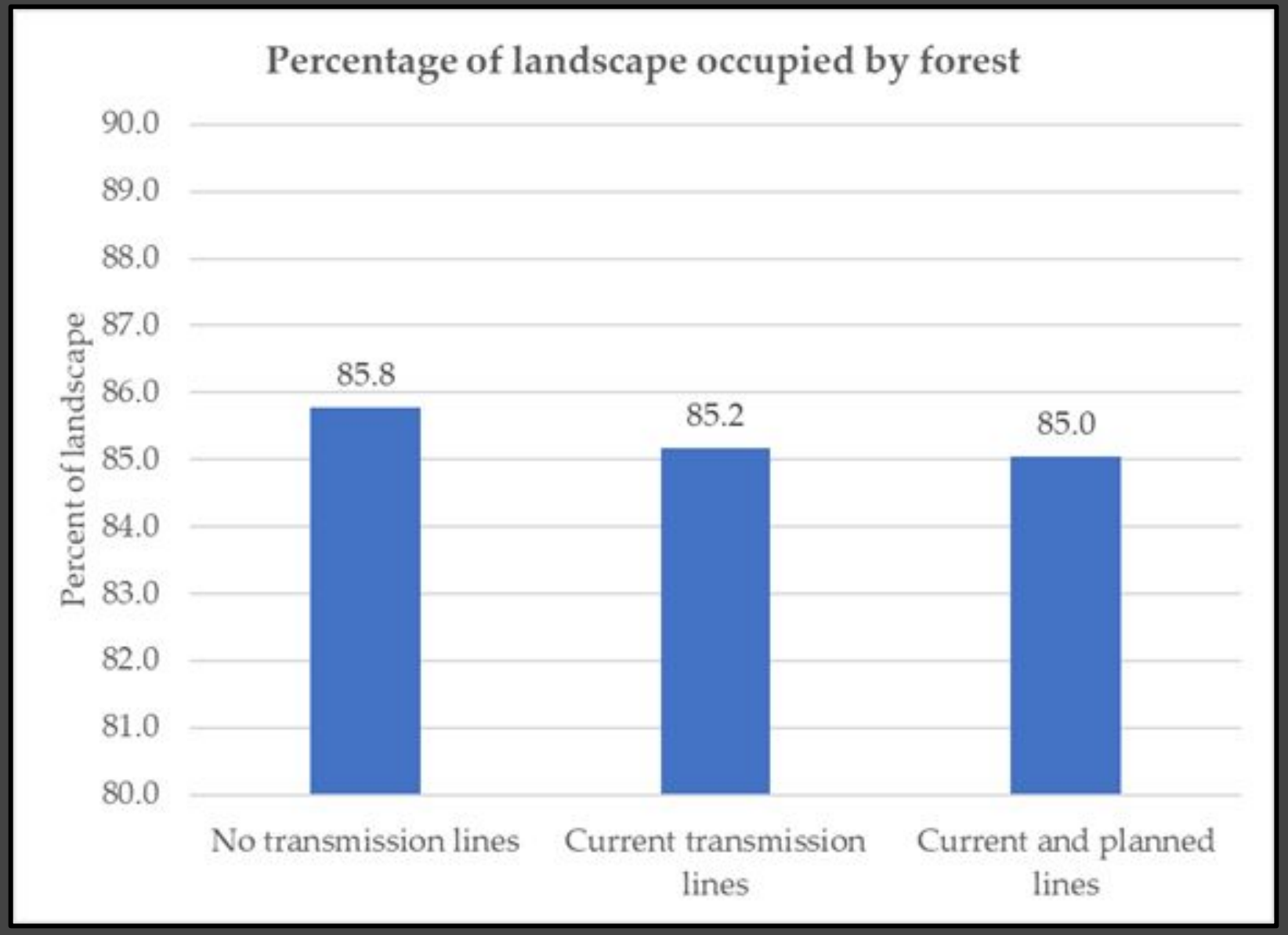


Scenario 1:
No transmission lines

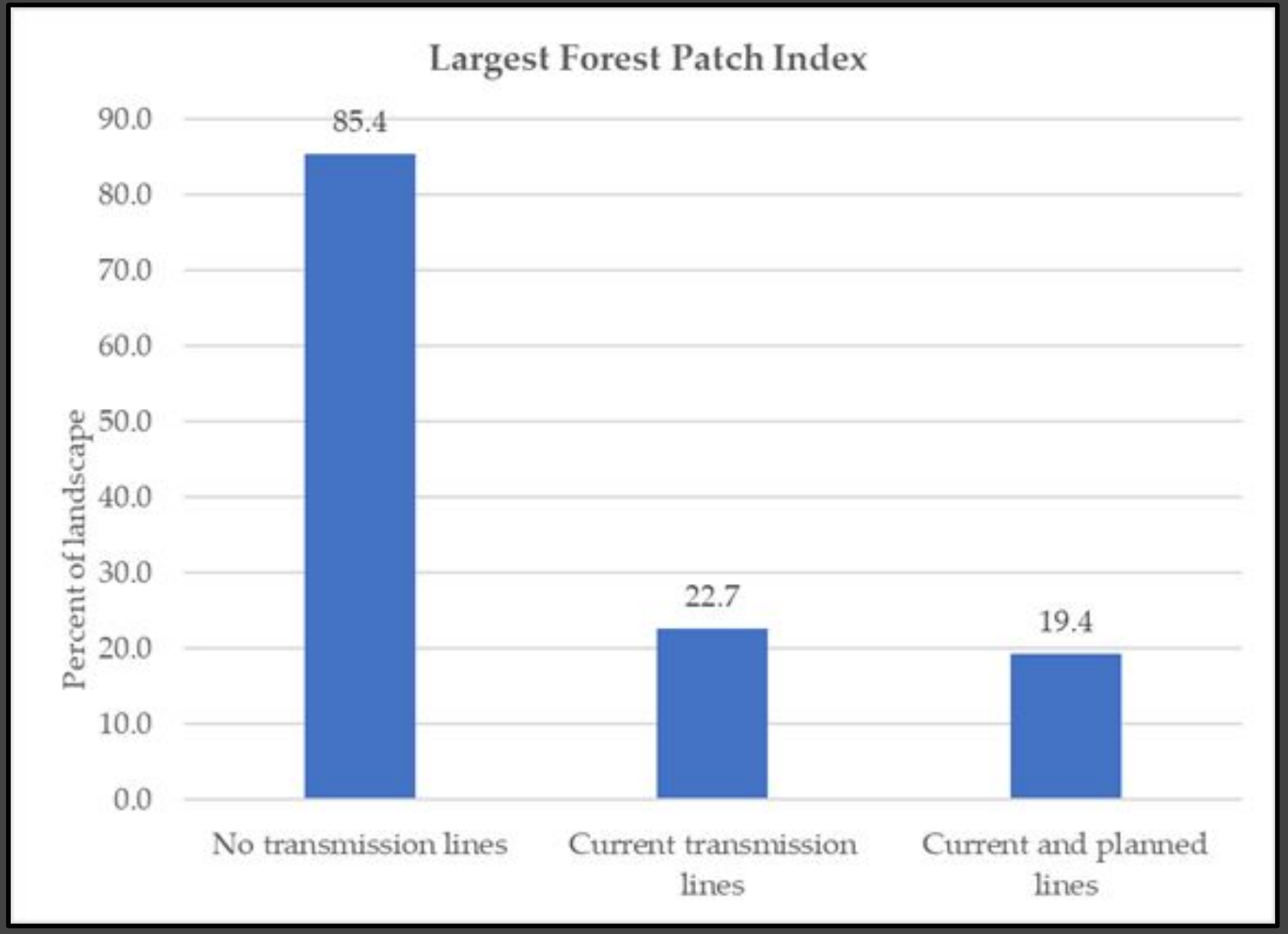
Scenario 2:
Current transmission lines

Scenario 3:
Current & planned transmission lines

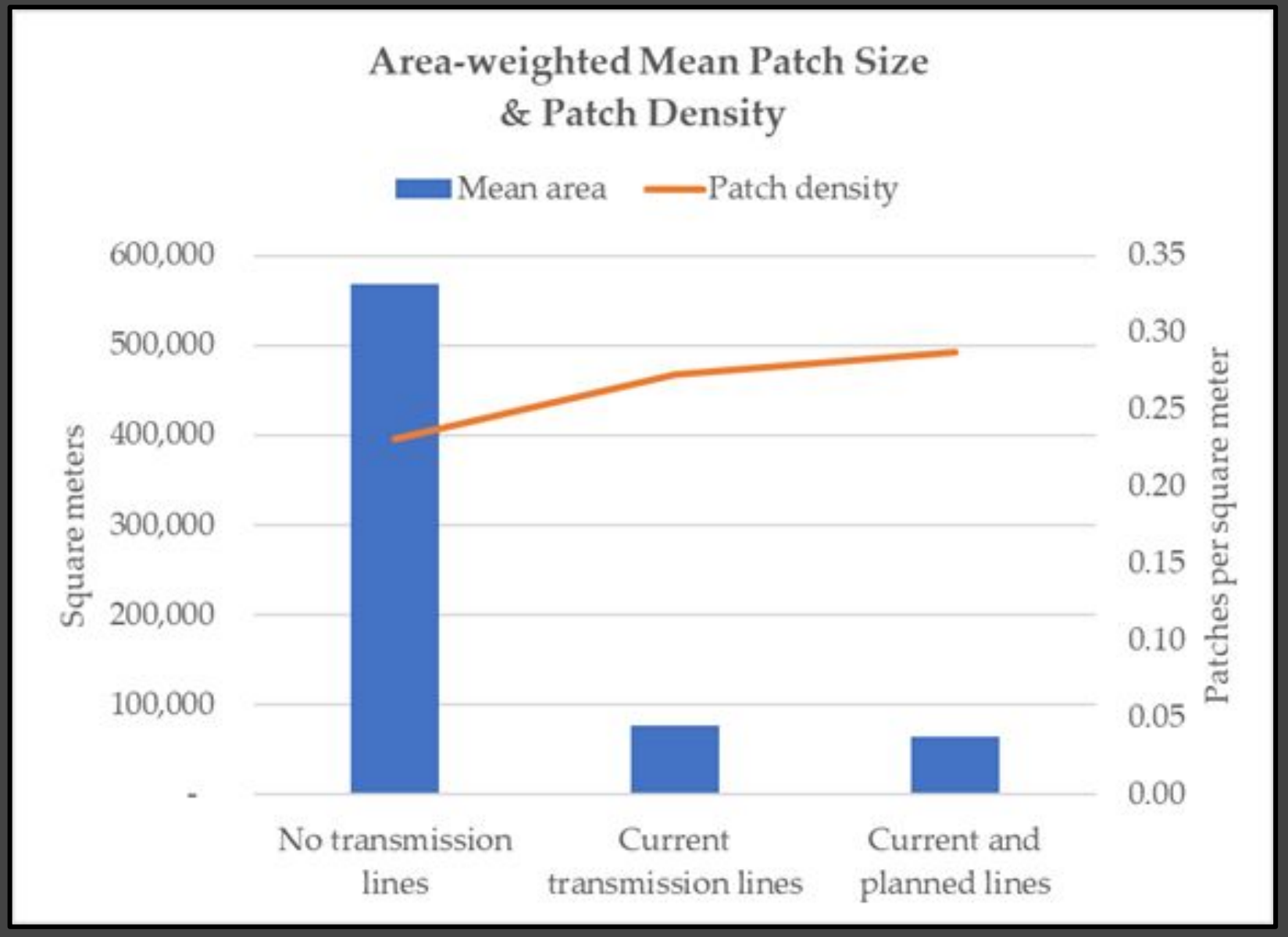
Effect of transmission lines on *overall forest cover* is minimal...



…*but* large forest patches are <u>fragmented</u>



Mean patch size decreases *while* patch density increases.



Conclusions

- ***We estimate…***
  - 1,121 km^2 of land in the DRB (approx. 3%) is occupied by energy infrastructure
  - 79% transmission lines
  - 11% natural gas pipelines
- ***Potential for significant increases***
  - Marcellus shale gas boom
  - Alternative energy sources

- ***Effects on overall forest cover may so far be minimal***
  - **<u>BUT</u> forest patch structure is impacted**
  - **Indicates a need to anticipate and plan for future expansion**

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