THE POTENTIAL FOR UNDERGROUND COAL GASIFICATION IN INDIANA

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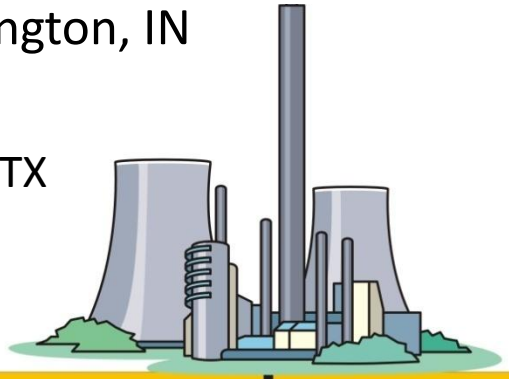


CCTR Advisory Panel Meeting, March 5, 2009

The Concept of UCG

- Injection and production wells are drilled and linked together in a coal seam.
- Air or oxygen is injected and the coal is ignited.
- Water or steam is utilized.
- The gasification process produces primarily H_2, CO, CH_4 and CO_2.
- The produced gases flow to the surface where they are processed and utilized.

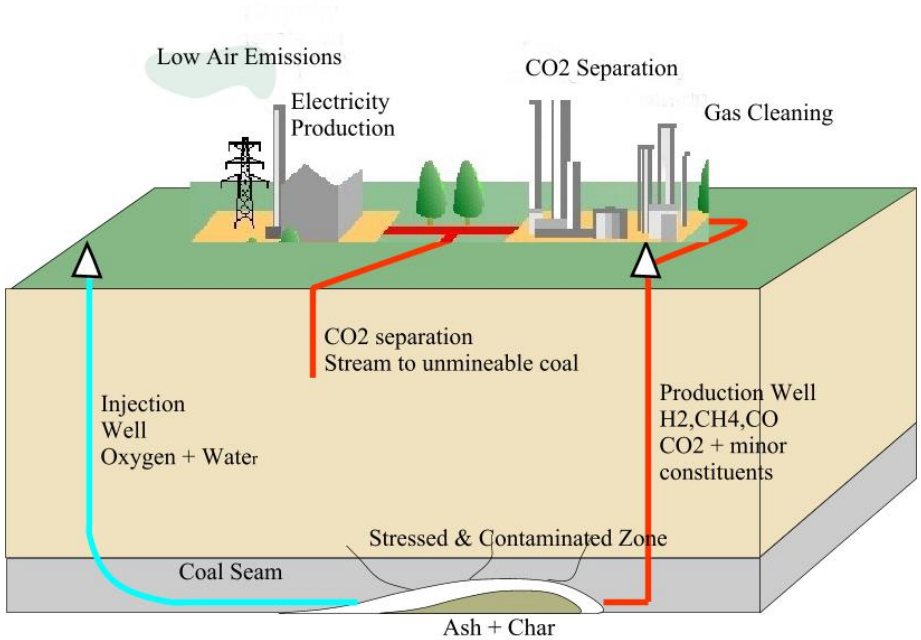


Image: UCG Engineering, Ltd., http://www.coal-ucg.com

Advantages of UCG

- As compared with conventional underground mining and surface gasification, UCG has several important advantages:
  - Lower capital costs
  - No labor underground
  - Minimal underground technology
  - Simpler surface technologies
  - Increased coal resource utilization
  - No coal or solid wastes at the surface
  - No coal transportation costs

Feasibility assessment of UCG potential in Indiana

Purdue University and Indiana Geological Survey collaborated to complete:

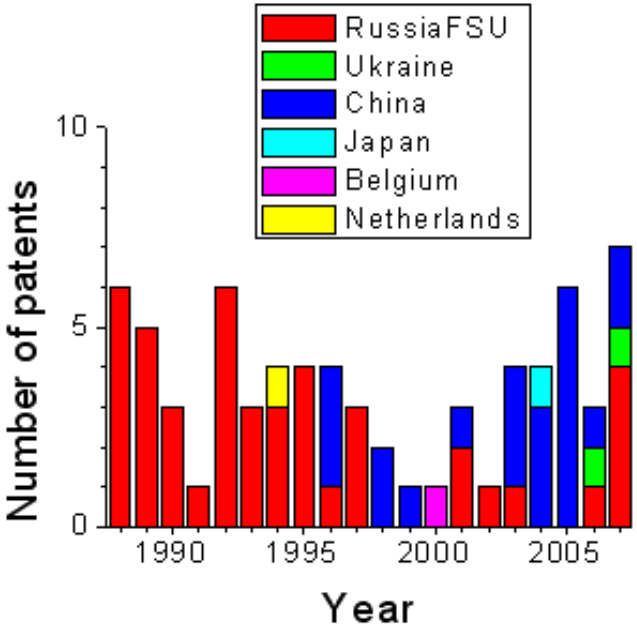
- Phase 1 (completed August 31, 2008)
  - Analysis of UCG current state of the science and technology (globally) and determination of criteria for selecting UCG locations in Indiana
  - Primary Responsibility: Purdue
- Phase 2 (completed November 29, 2008)
  - Analysis of geospatial information and determination of potential UCG locations in Indiana
  - Primary Responsibility: IGS
- Phase 3 (completed March 1, 2009)
  - Screening of the most promising UCG locations
  - Recommendations for future work
  - Primary Responsibility: Purdue and IGS

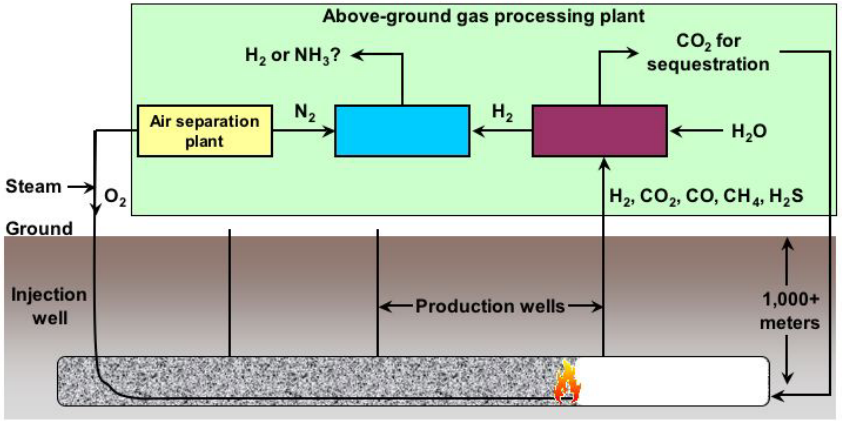
Analysis of Current Status of UCG

- Important milestones:
  - Development of UCG in the Former Soviet Union (five UCG plants in operation in 1960s)
  - UCG trials, modeling, and development of CRIP technique in the United States (1980s)
  - Trials and modeling in Western Europe (deep coals, 1990s)
  - Experiments in China (abandoned mines, 1980s - present)
  - Chinchilla experiment in Australia (ErgoExergy, 1999-2003)
  - Numerous current UCG activities throughout the world

Analysis of Current Status of UCG

- Analysis of the patent literature:
  - 1998-2008: Russia and China are the most active countries in UCG development
- The main challenge in UCG is related to the methods for linking injection and production wells:
  - Hydraulic fracturing and reverse combustion
  - Directional drilling and CRIP
- Selection of the best UCG technology is a complex process, and the properties of the UCG site must be taken into consideration.





CRIP process. Image: LLNL

Determination of Screening Criteria for Feasibility Assessment

- Various factors such as
  - Thickness of coal seam
  - Depth of coal seam
  - Coal rank and other properties
  - Dip of coal seam
  - Water availability
  - Amount of coal
  - Land-use restrictions

  were analyzed and two were identified as the most important criteria for determining the possibility of using the UCG process in Indiana.

Criterion #1: Thickness

Thickness	Suitability
> 2.0 m	high
1.5 – 2.0 m	medium
1.0 – 1.5 m	low
< 1.0 m	unacceptable

- Of the seven major coal seams present in Indiana, the Seelyville and Springfield Coals have the largest quantity of sufficiently thick sites (>1.5 m).

Criterion #2: Depth

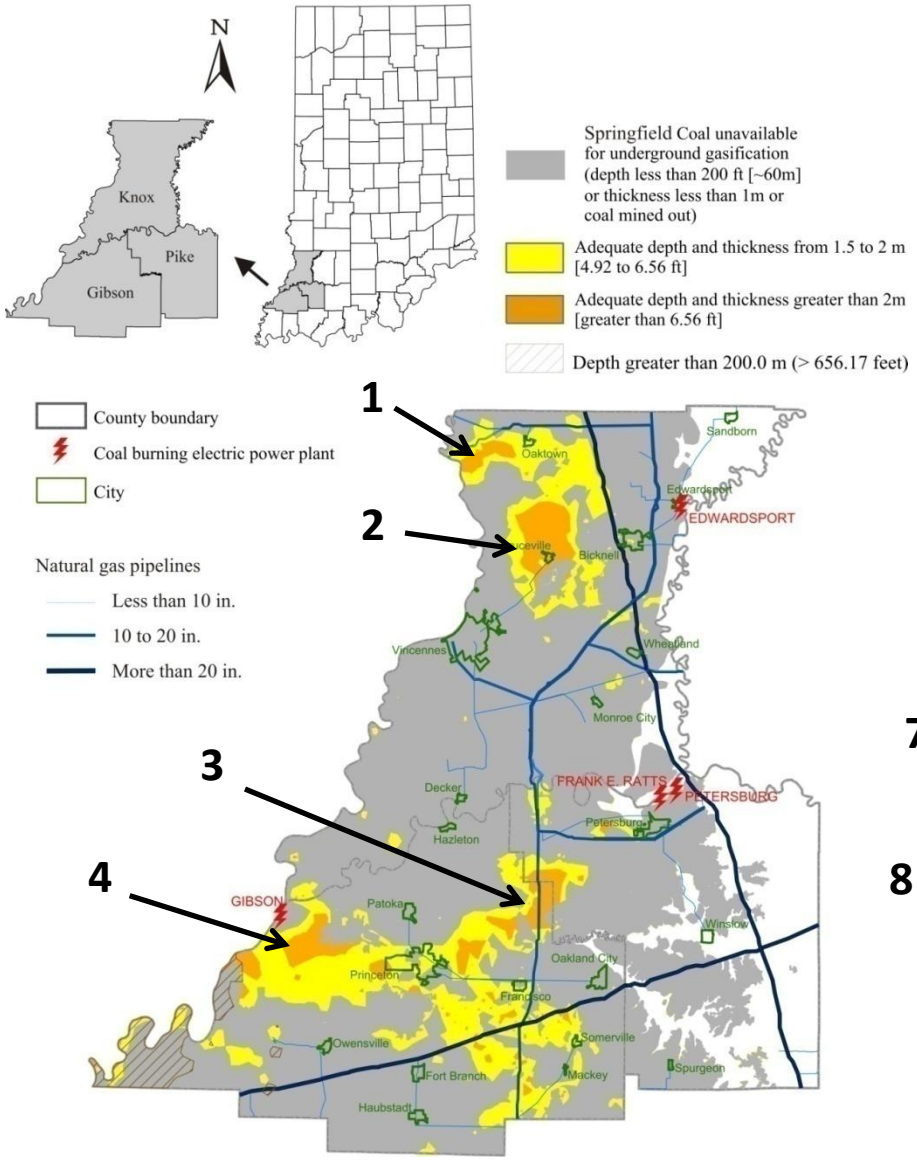
Depth	Suitability
> 200 m	high
60 - 200 m	adequate
< 60 m	unacceptable

Other Geospatial Information Used in the Feasibility Analysis

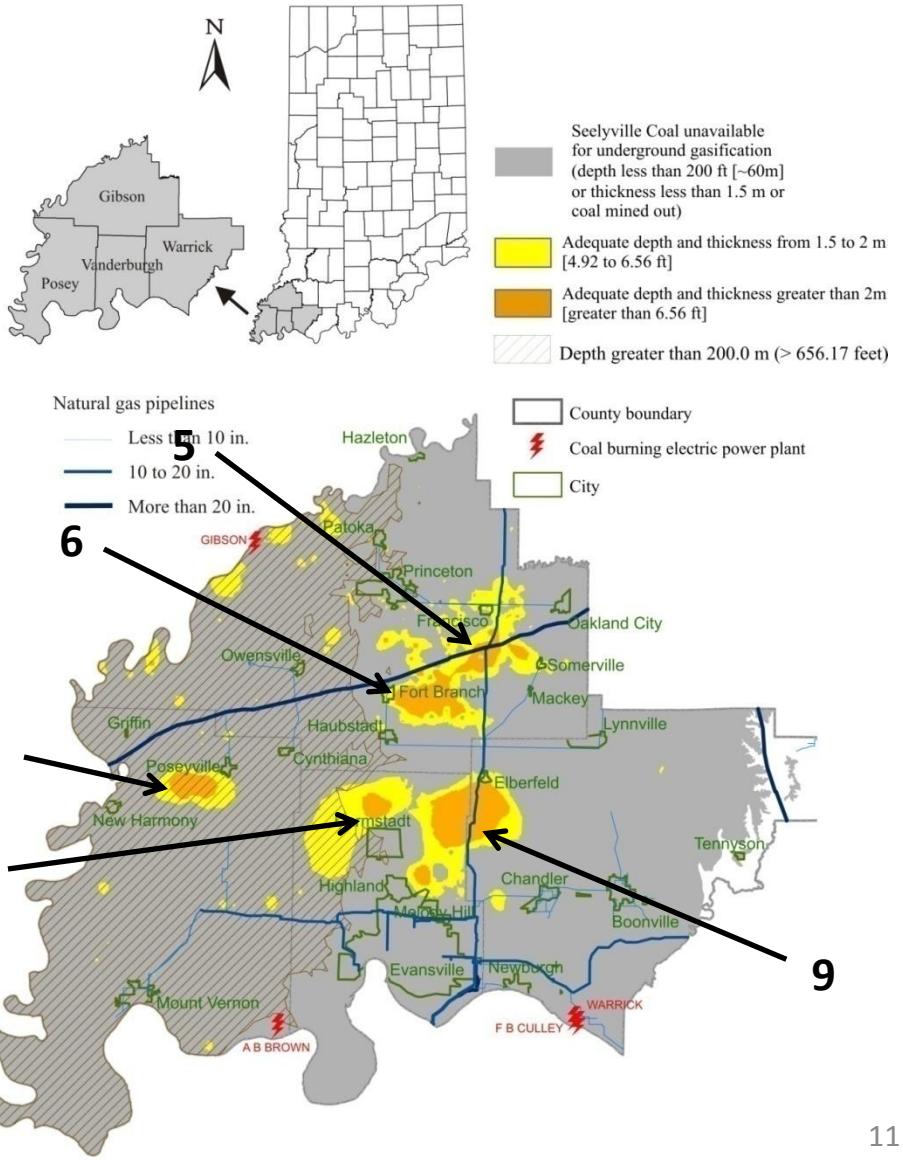
- Infrastructure proximity
  - Coal-burning power plants
  - Natural gas pipelines
  - Cities
  - Highways
  - Railroads
- Coal Availability (Surface and Underground)
  - Technical restrictions to mining
  - Cultural restrictions to mining
- Coal Properties
  - Heating value
  - Moisture content

Criteria: Thickness, Depth and Infrastructure

Springfield Coal Member



Seelyville Coal Member



Characteristics of Selected Zones

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Mass [10^6 short tons]	27.7	103.2	53.1	32.4	35.8	75.5	46.2	23.6	182.9
Thickness range [ft]	6.6-7.9	6.6-8.6	6.6-10.3	6.6-7.9	6.6-9.4	6.6-9.2	6.6-11.4	6.6-9.4	6.6-11.3
Depth range [ft]	200-660	200-660	200-660	200-660	200-660	200-660	> 660	200-660	200-660
Moisture range [ar,%]	5-10	5-10	5-7.5	7.5-12.5	< 7.5	5-7.5	5-7.5	7.5-10	7.5-10
Ash range [dry, %]	7.5-12.5	10-15	10-15	5-10	10-15	10-15	7.5-12.5	12.5-15	12.5-20
Sulfur [total, dry, %]	3-4	2-4	3-5	1-3	3-5	2-4	3-4	3-4	2-4
Heating value [dry, 10^3 Btu/lb]	12.5-13.0	12.0-13.0	11.5-12.5	13.0-14.0	11.5-12.0	11.5-12.0	12.0-13.0	11.5-12.5	11.5-12.0
Distance to nearest power plant [miles]	14	9.5	10	3	18	17	18	17	17
Distance to nearest pipeline [miles]	1	0	0	7	0	2	3	5	0
Distance to nearest town [miles]	3	0	6.7	5.5	3	2.5	2.2	1.6	2.5

Project Summary

- Analysis of UCG current status shows that this technology has the potential to grow and replace/complement traditional methods for coal mining and gasification.
- Screening criteria for selecting areas where UCG could potentially function in Indiana have been formulated.
- Geospatial analysis of these data derived nine potential localities for potential UCG operations in southwestern Indiana.
- Detailed characterization (geological, chemical and engineering) of these localities must be undertaken to determine the most promising sites for UCG in Indiana.

Recommendations for Future Work

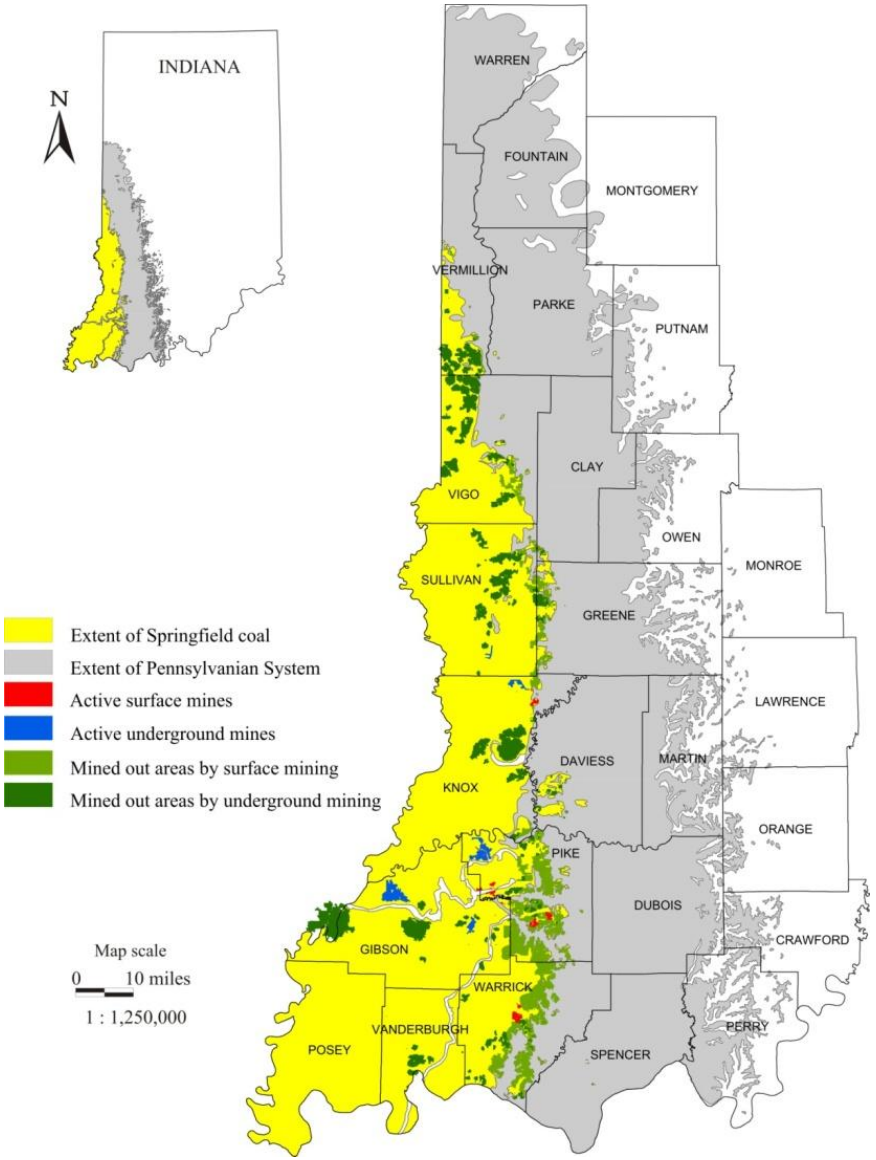
- Follow-up detailed characterization and evaluation of the selected localities, including:
  - Evaluation of the hydrology of the coals and surrounding rocks (both potable and non-potable aquifers).
  - Determination of the geomechnical properties of the overlying rock (risk of subsidence).
  - Studies on the influence of the petrophysical characteristics of the coals on the kinetics of the UCG process.
  - Site-specific modeling of the UCG process with a focus on the environmental aspects (groundwater contamination).
  - Investigation of the possibility to couple UCG operations with CO_2 capture and sequestration.
  - Economic analysis, including capital, operational and environmental costs.
- Concurrently, organize cooperative agreements with Lawrence Livermore National Laboratory (LLNL); Ergo Exergy and/or Linc Energy – for site characterization for a future pilot project.

Appendix

Detailed Springfield and Seelyville Coal Bed Maps for individual criteria, important for UCG operations

Coal Seam Extent

Springfield Coal Member



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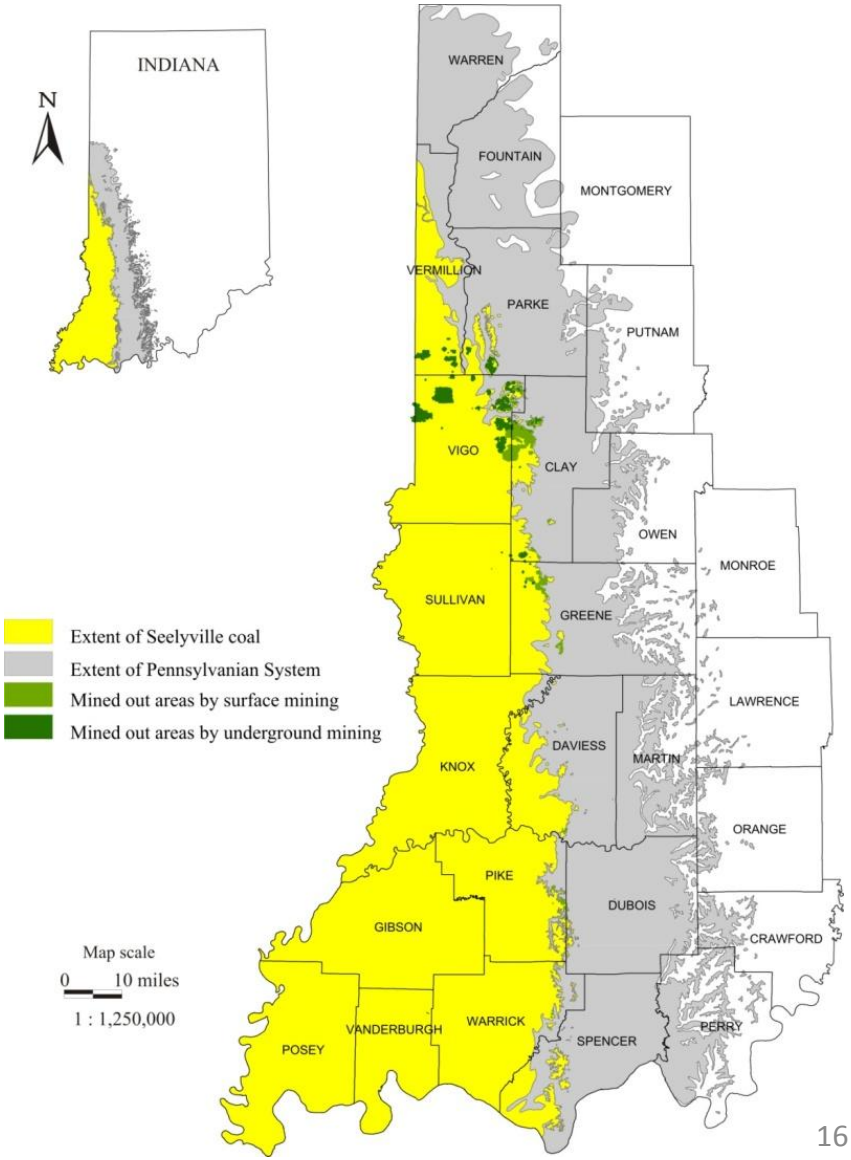
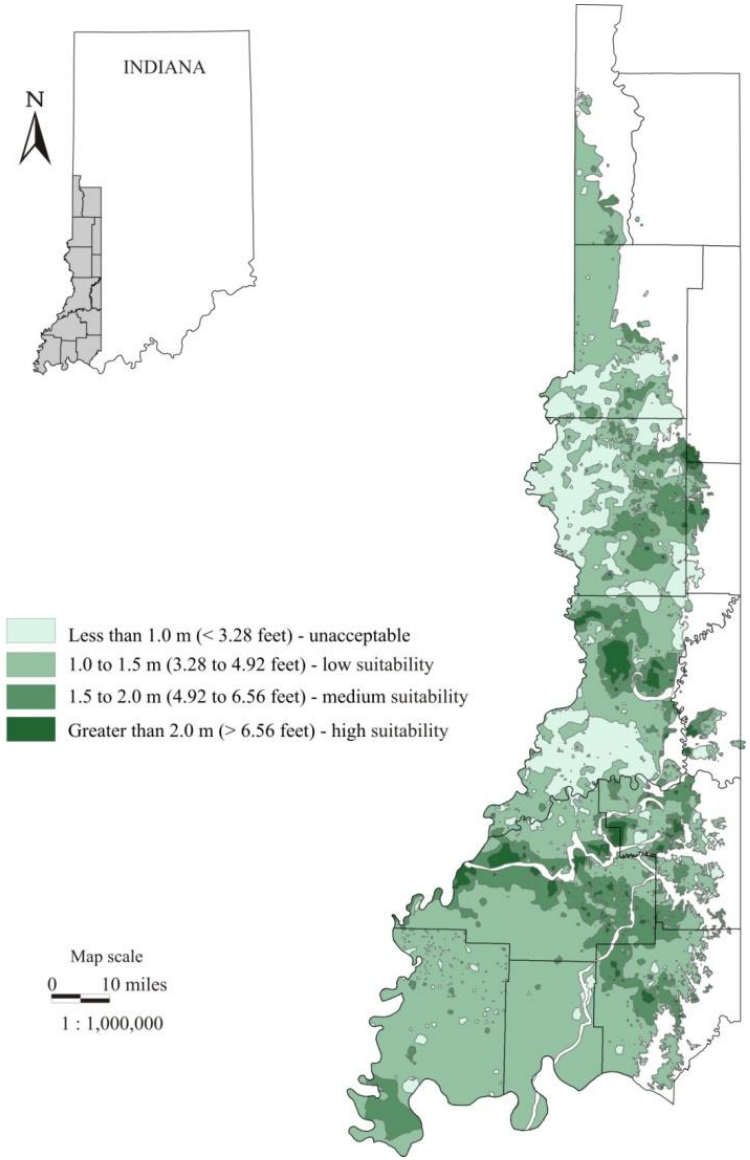


Criterion: Thickness

Springfield Coal Member



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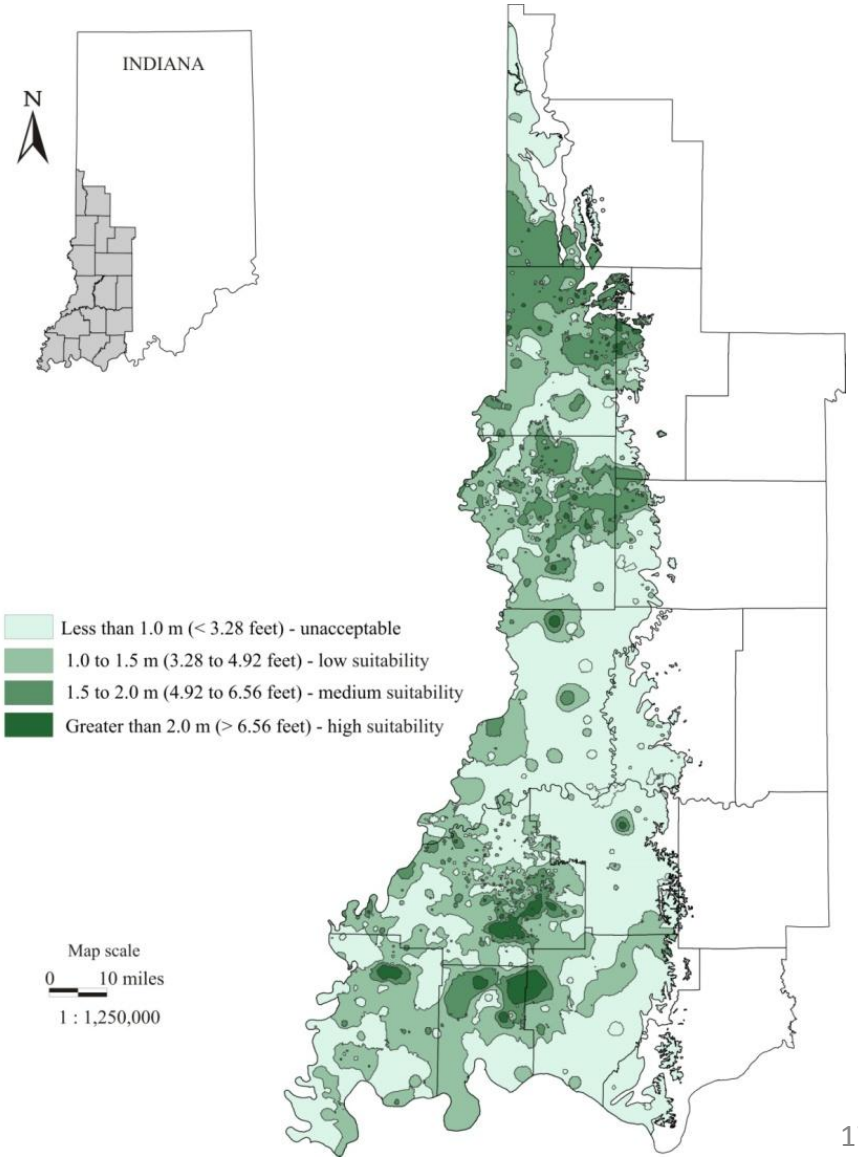
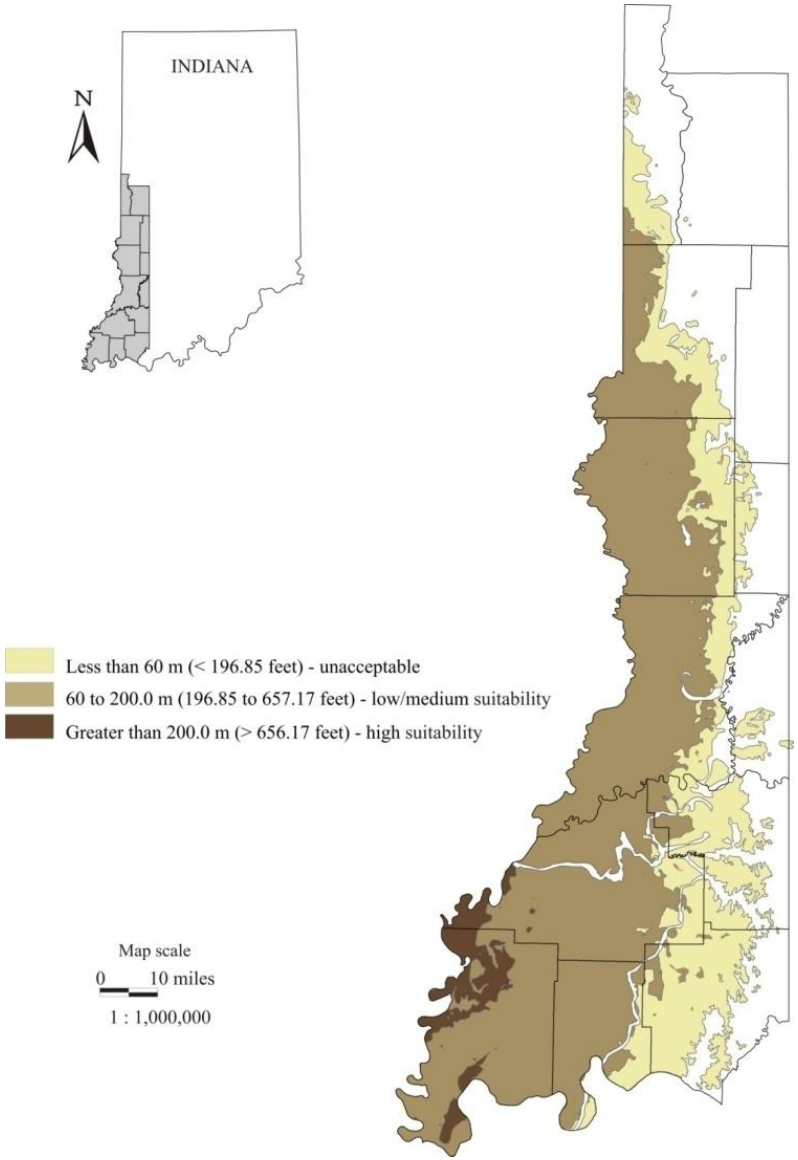


Criterion: Depth

Springfield Coal Member



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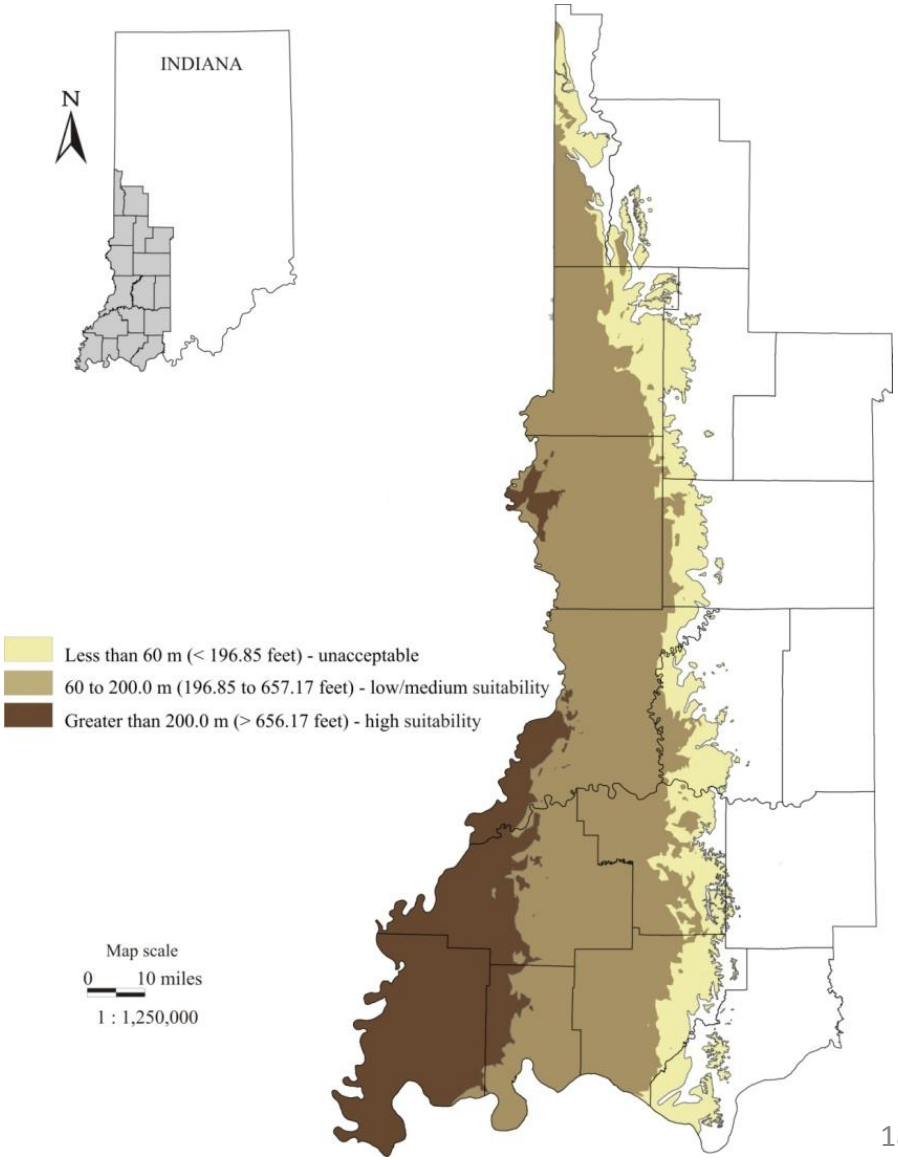
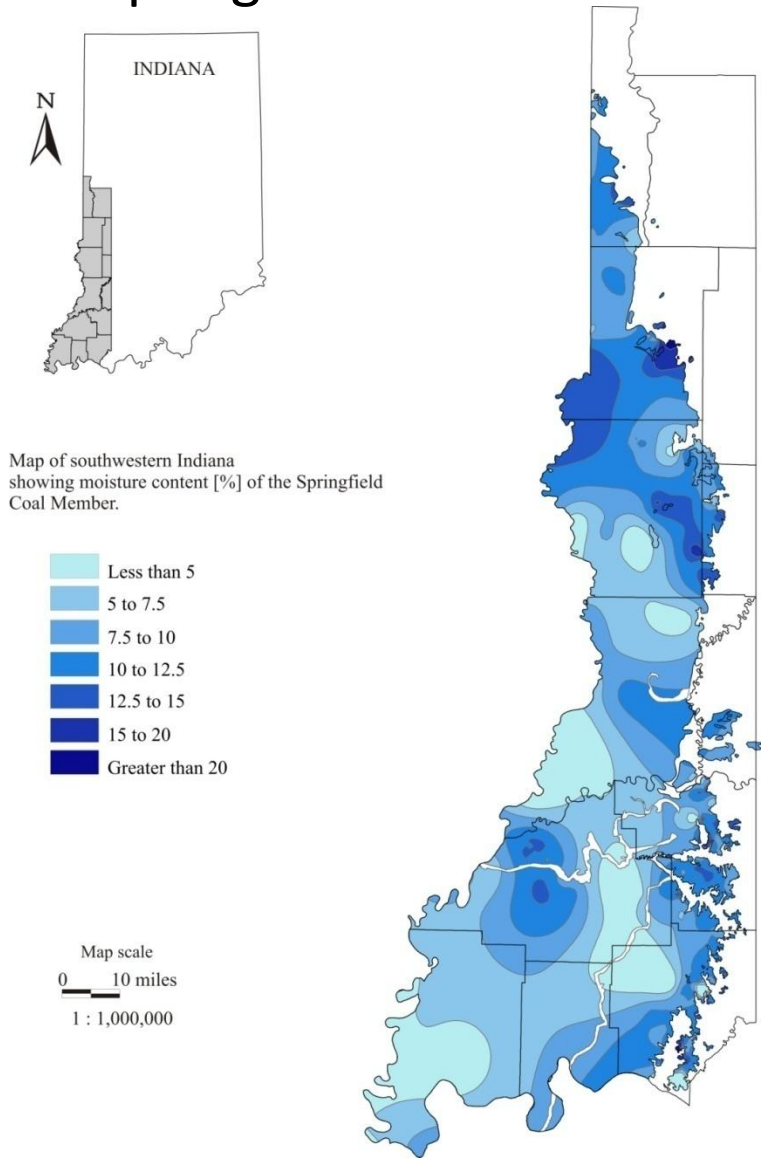


Criterion: Moisture

Springfield Coal Member



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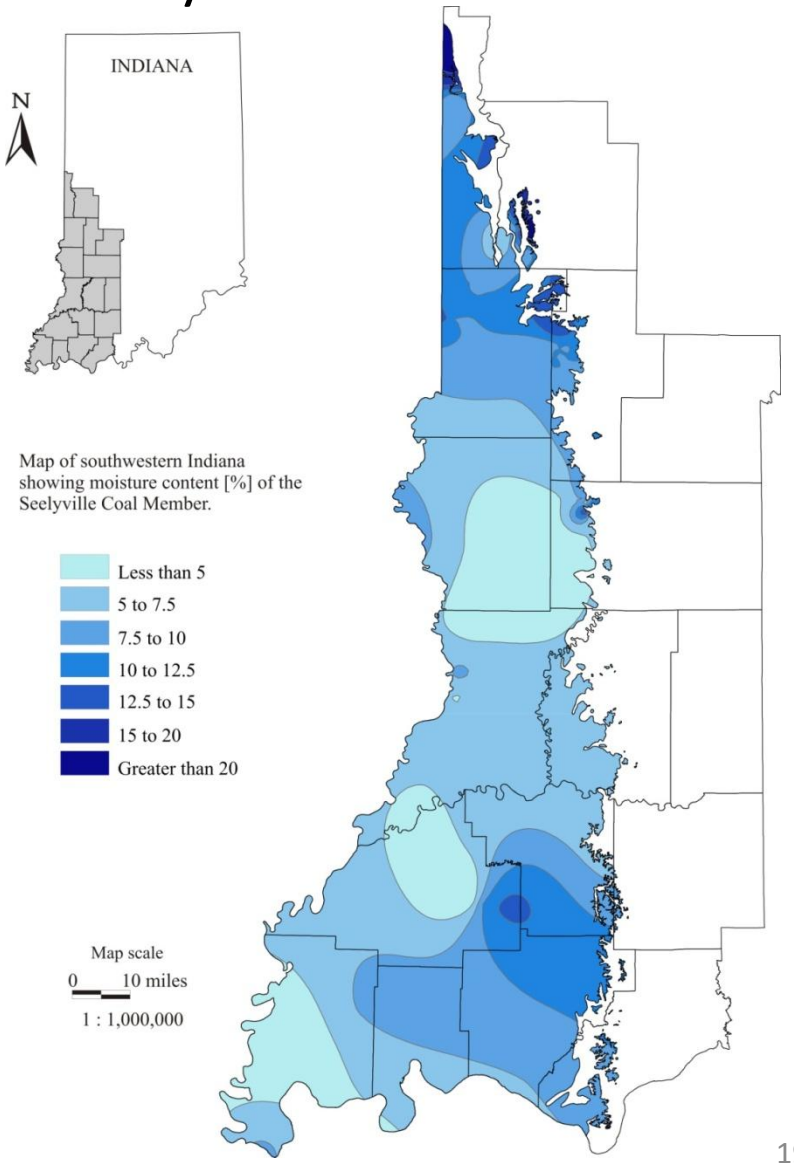
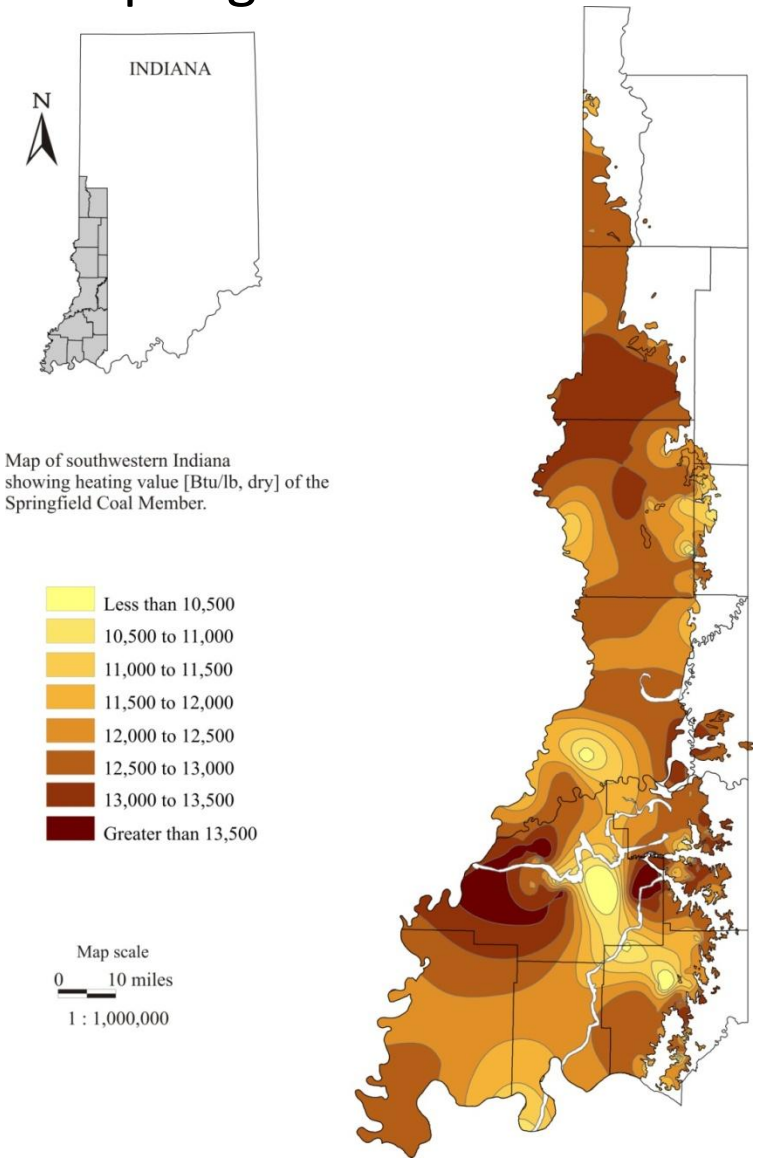


Criterion: Heating Value

Springfield Coal Member



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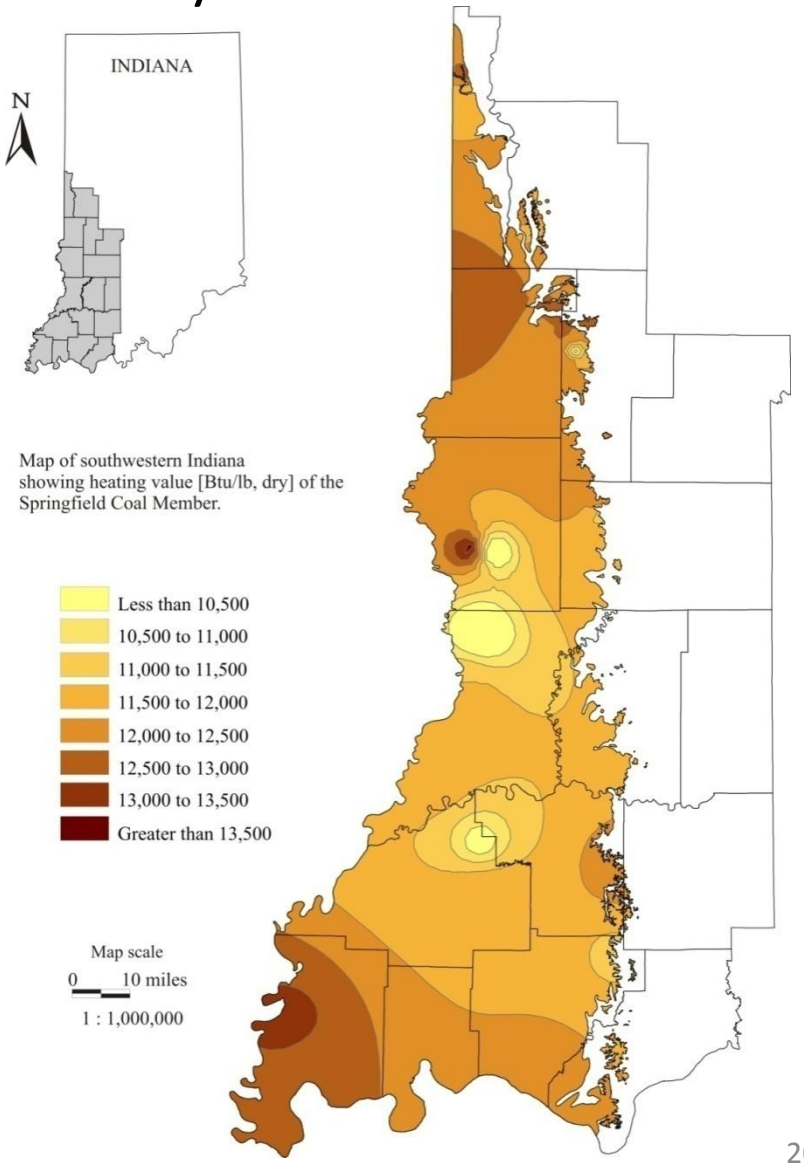
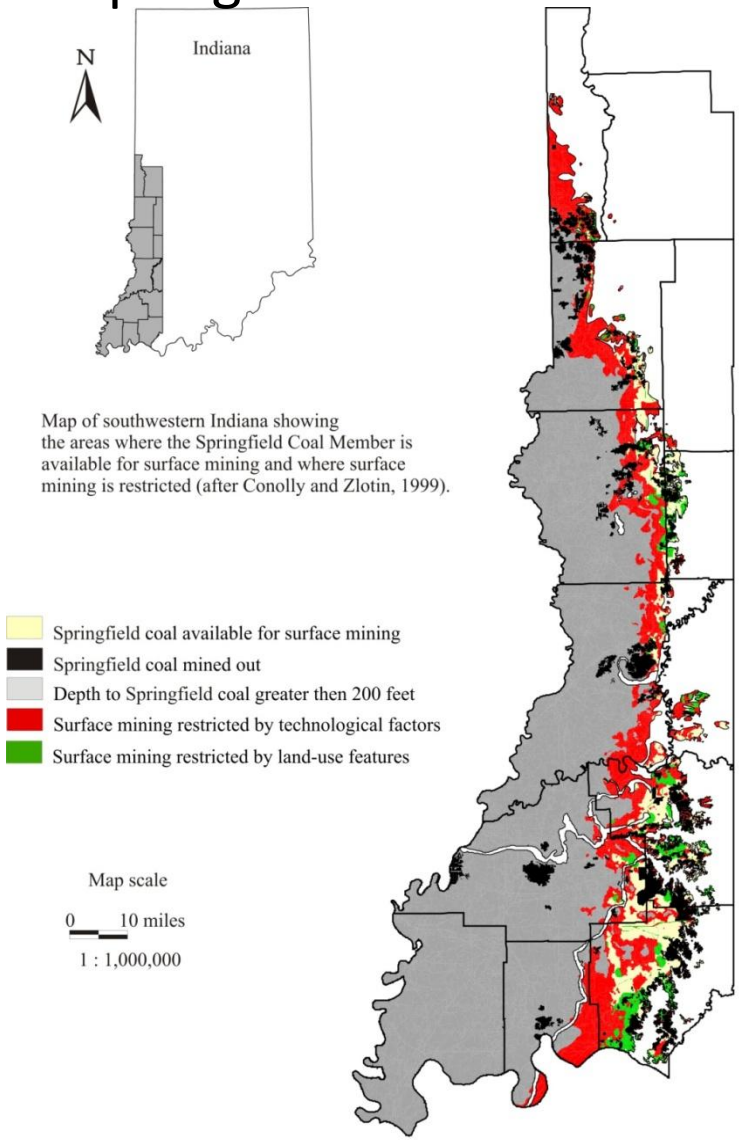


Criterion: Restrictions for Surface Mining

Springfield Coal Member



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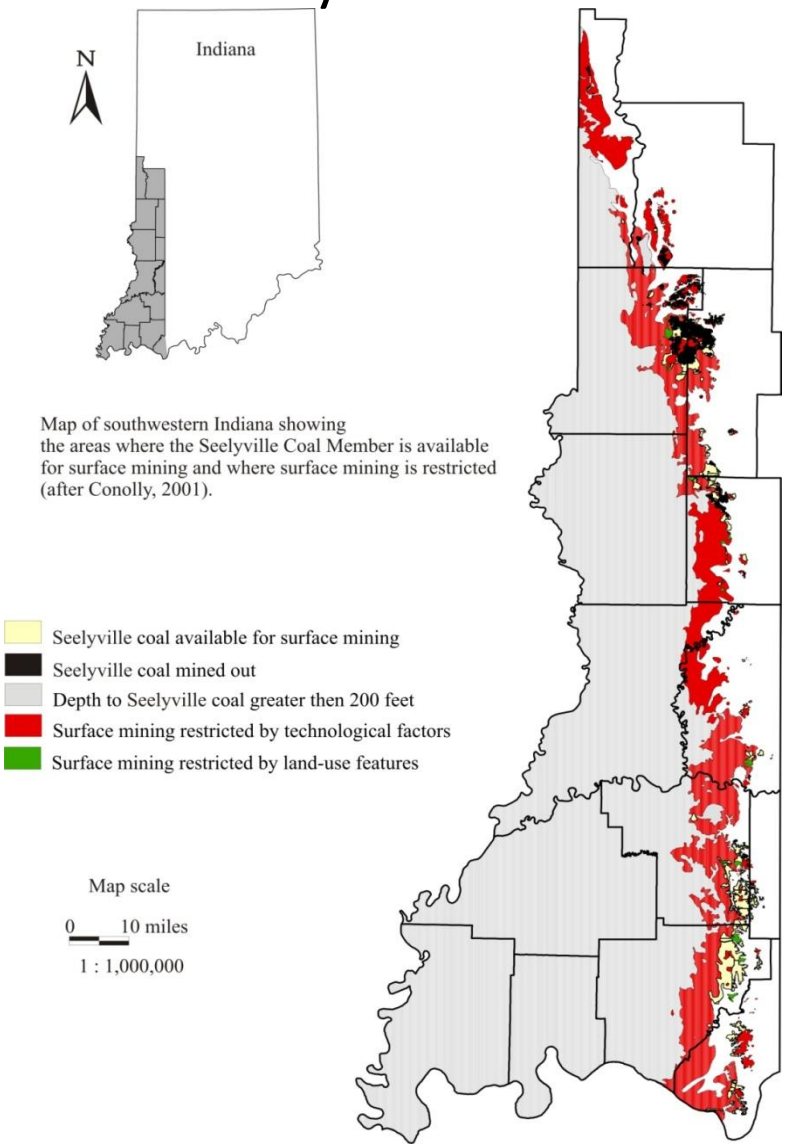
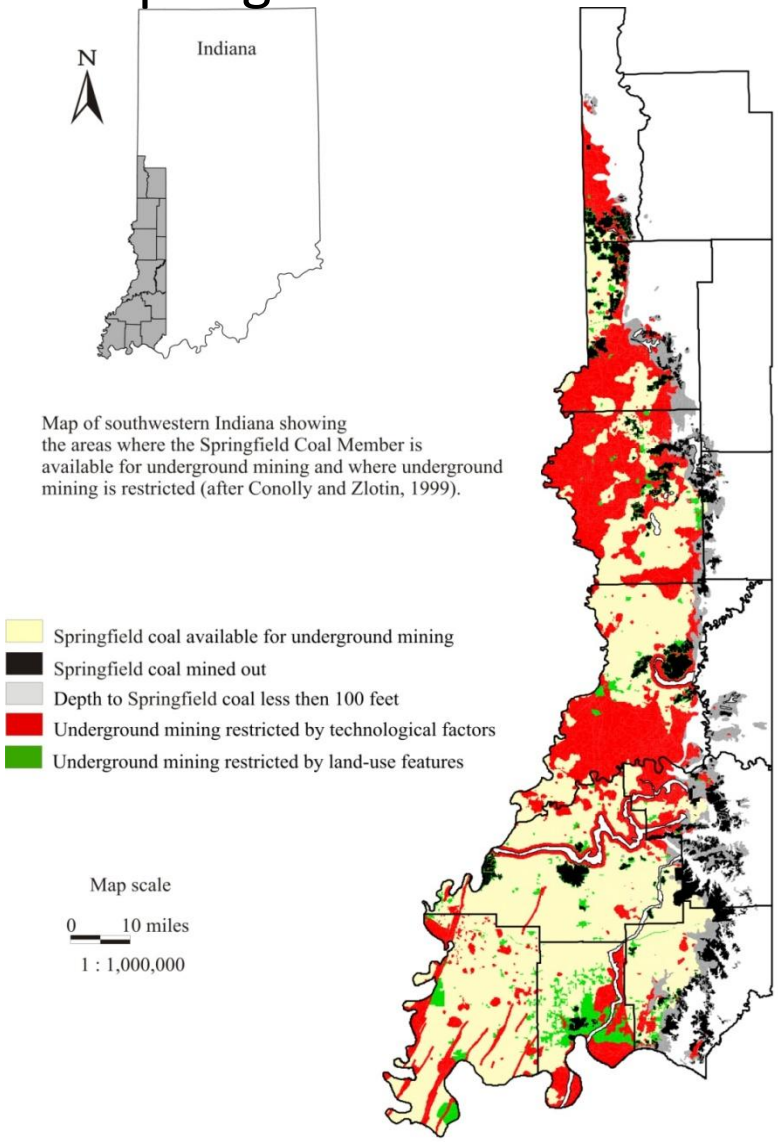


Criterion: Restrictions for Underground Mining

Springfield Coal Member



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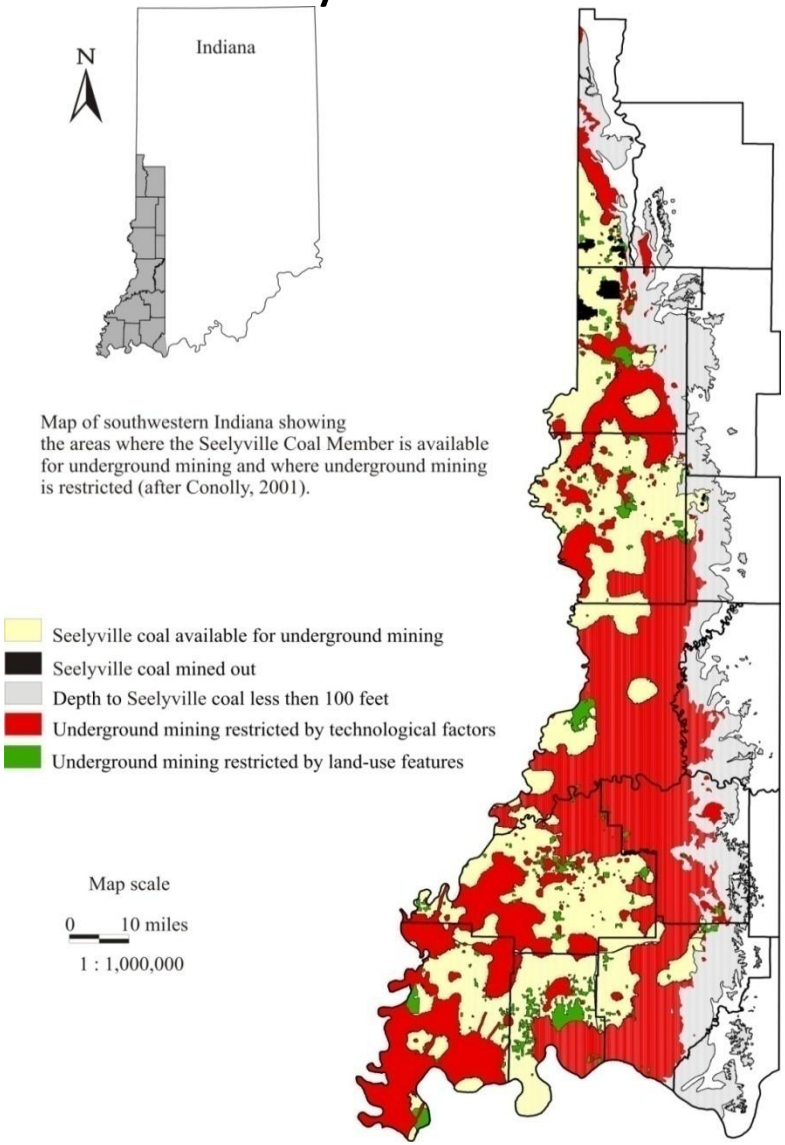

Criteria: Thickness, Depth and Infrastructure

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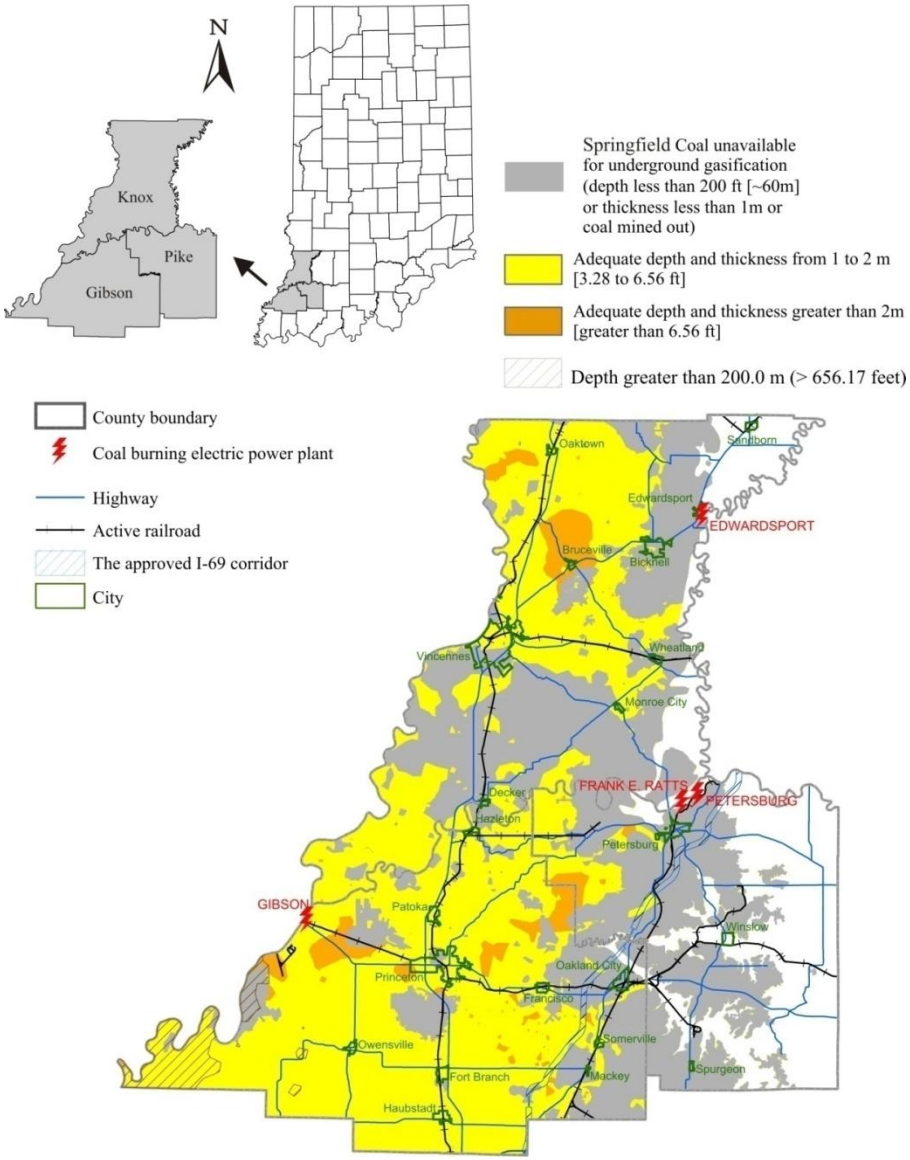

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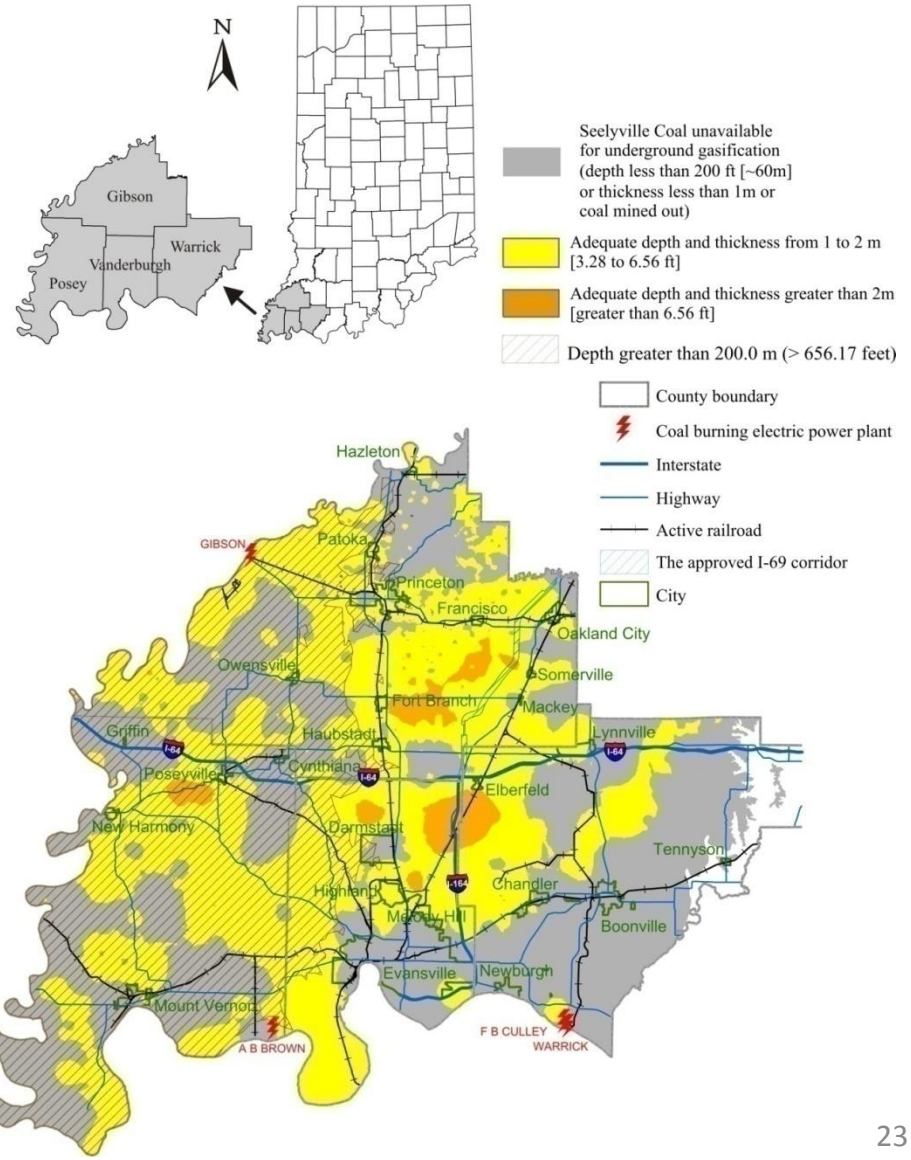

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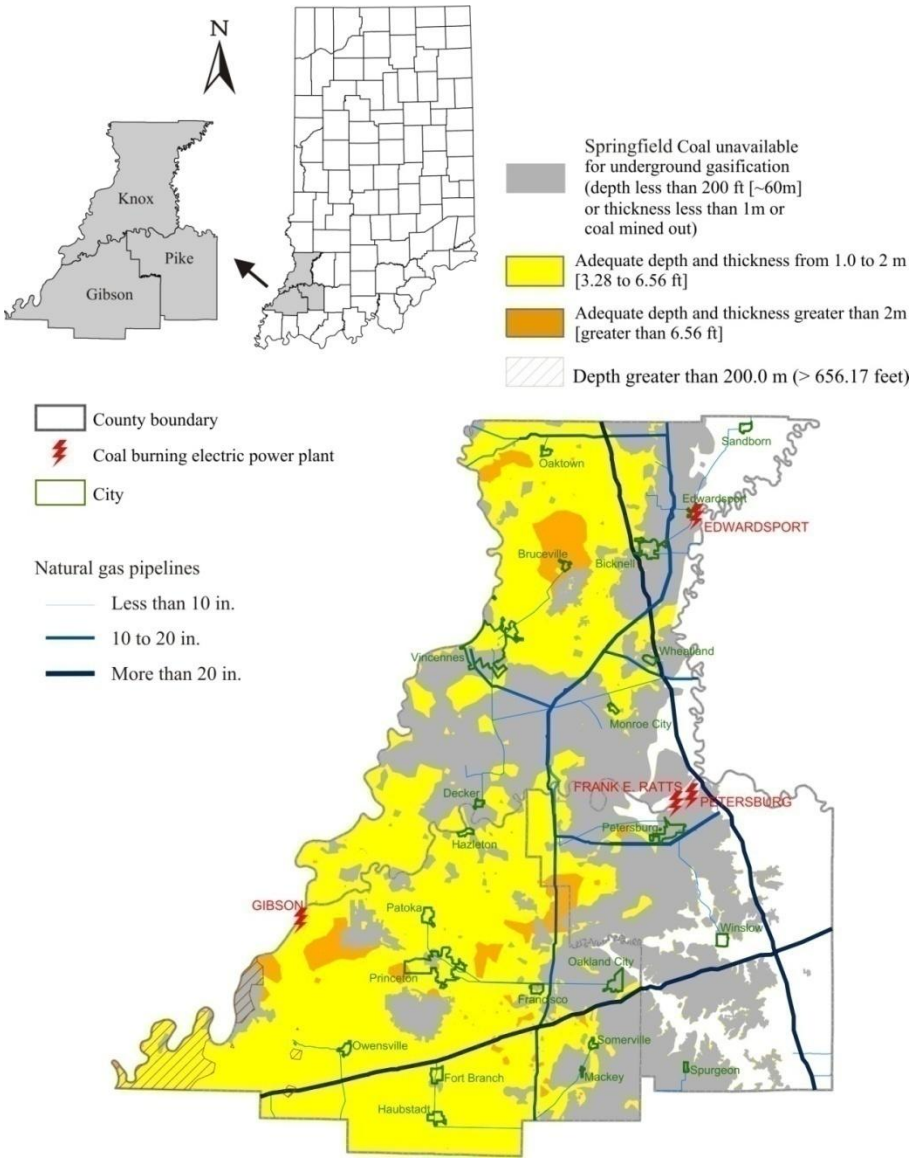

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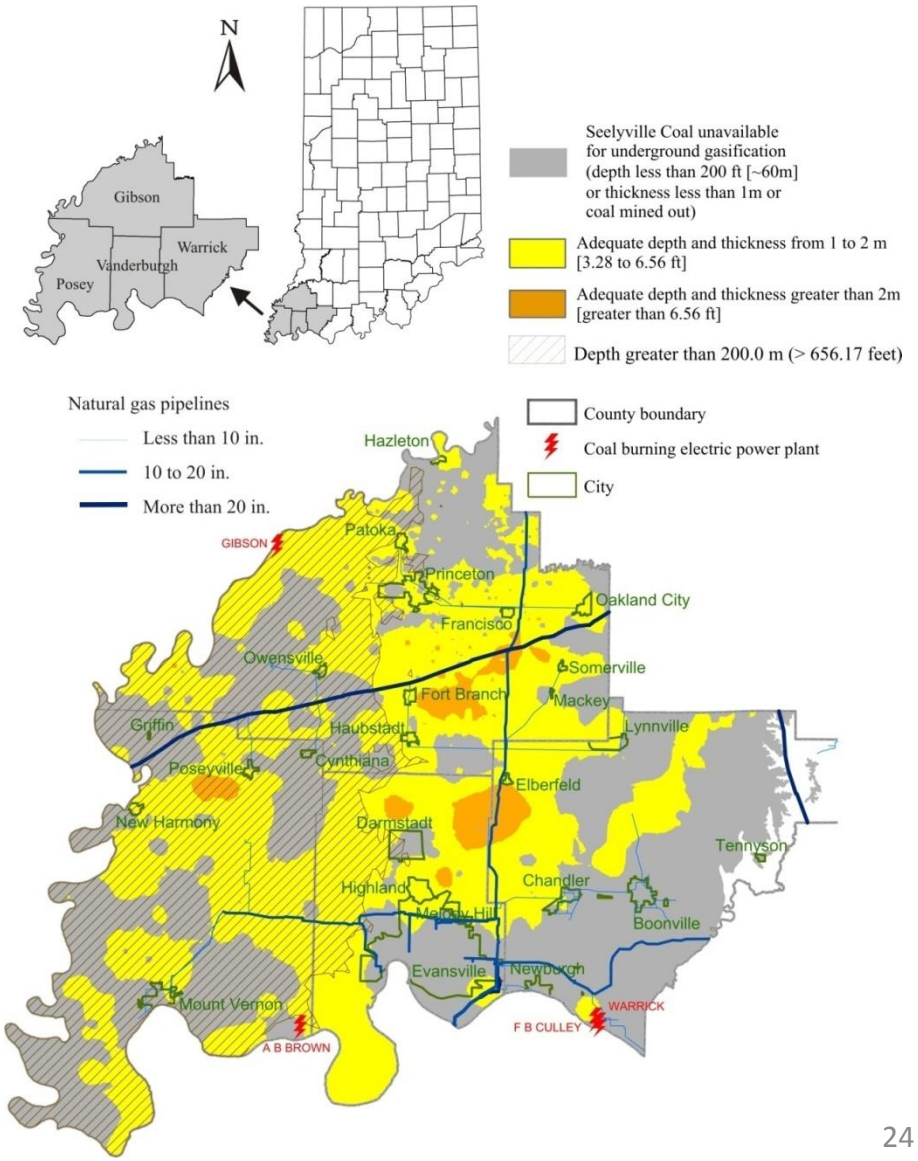

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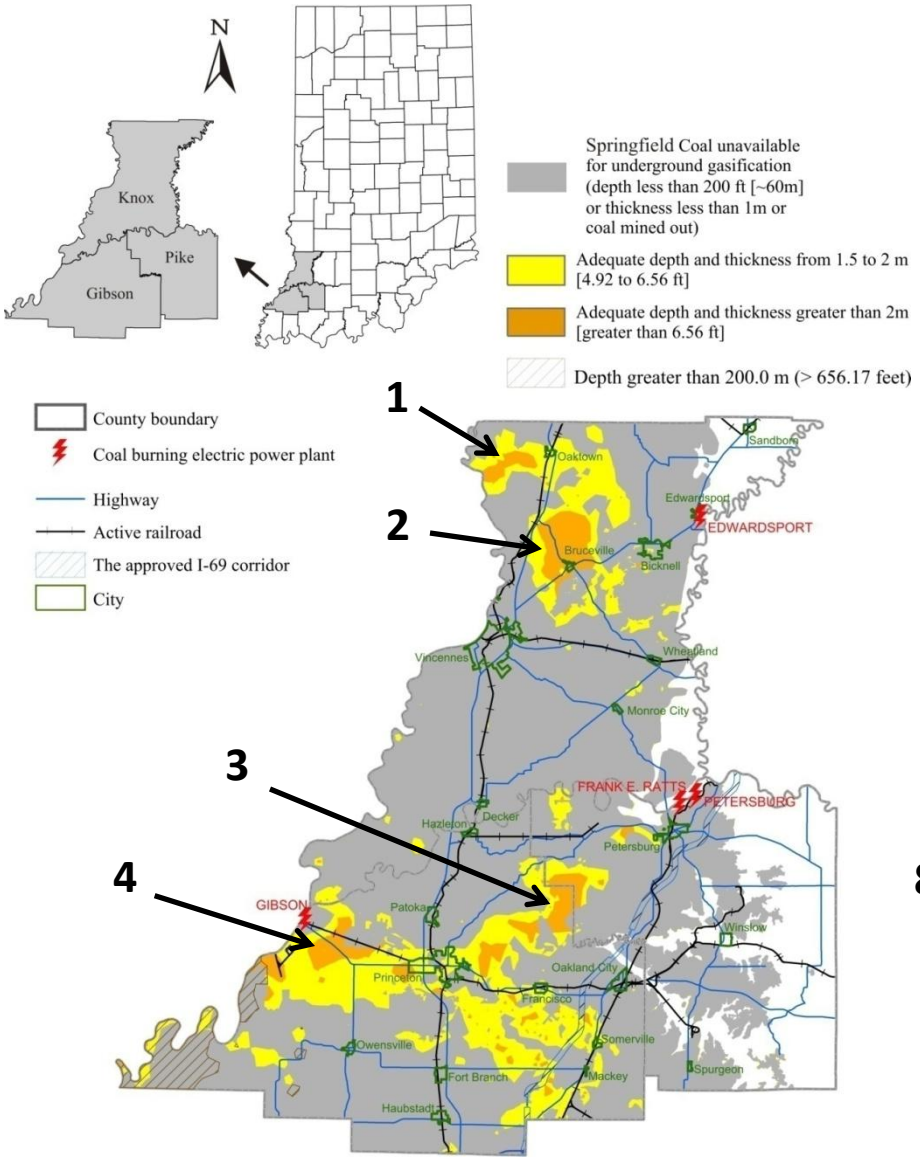

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