

Anticipating Forest Impacts from Shale Gas Development

Nels Johnson
Forest Health Group Monitoring Workshop
Tucson, AZ April 17, 2012

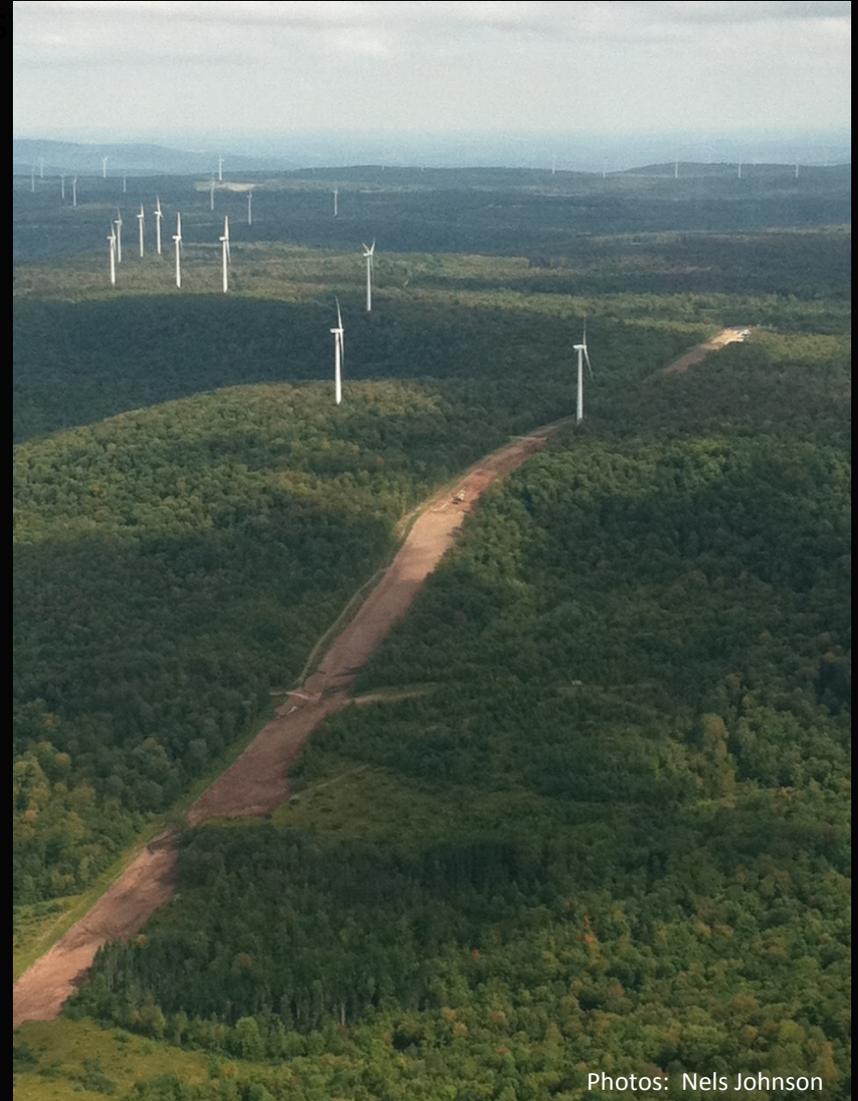


Central Appalachian Forests

Central Appalachian forests have largely recovered from the industrial logging and agricultural clearing of over a century ago...

Central Appalachian Forests

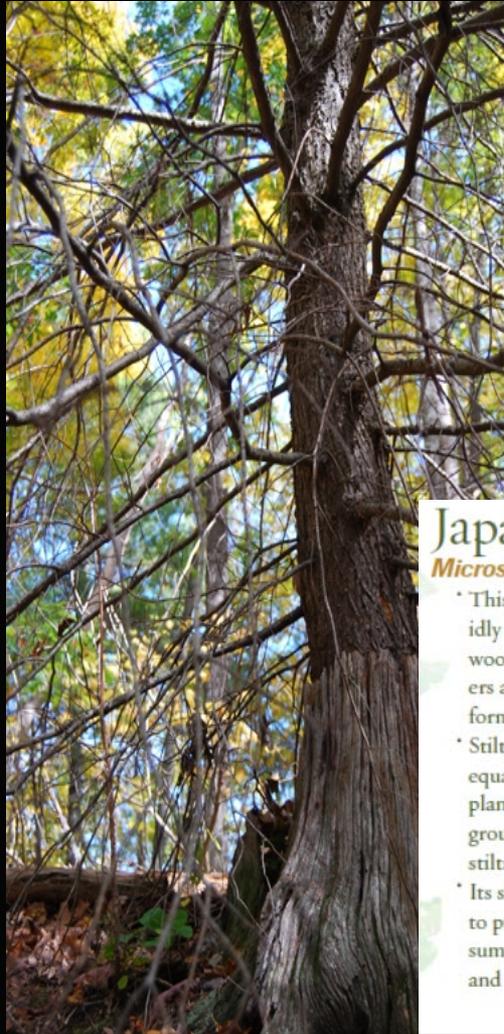
...but new energy development is clearing and fragmenting those valuable forests...



Photos: Nels Johnson

Shale Gas and Forest Health

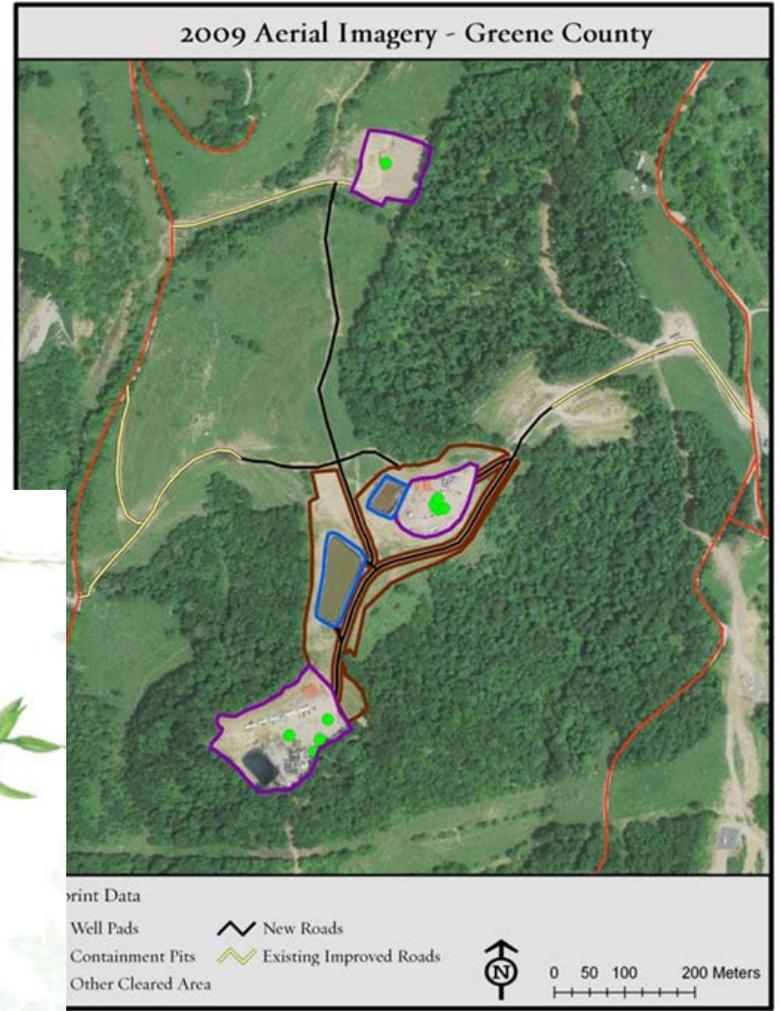
...and exacerbating existing threats to forest health.



Japanese Stiltgrass

Microstegium vimineum

- * This annual grass shows up in the summer and rapidly forms a dense monoculture along roads, woods and streams, choking out groundcovers and tree seedlings. Each plant can form 1,000 seeds.
- * Stiltgrass leaves are divided into unequal halves by a silvery line. The plant gets its name by the above-ground roots that hold it up, like stilts on a boardwalk.
- * Its shallow roots make stiltgrass easy to pull up. Remove several times each summer to encourage new seeds to grow and thus exhaust the seed supply.



Shale Gas and Forest Health



- **Project Goal**: Develop projections of how new energy development could impact natural habitats in Pennsylvania to shape strategies that avoid or minimize those impacts
- **Energy Types**: Focused on energy types that have the most potential for land use change during the next twenty years in Pennsylvania:
 - ***Marcellus Shale natural gas***
 - ***Gas pipelines***
 - ***Wind***
 - ***Wood biomass***
 - ***Electric transmission lines***
- **Analytical Team**: Staff from The Nature Conservancy, Western Pennsylvania Conservancy and Audubon Pennsylvania



Assessment Steps

- What is the **SPATIAL FOOTPRINT** of existing energy development?

 - **PROJECTIONS:**
 - **HOW MUCH** energy infrastructure might be developed by 2030?
 - **WHERE** is energy development more and less likely to occur?

 - **CONSERVATION IMPACTS:**
 - How could future energy development affect forest habitats?
-

Spatial Footprint

2006 Aerial Imagery - Greene County



Reference Data

- Marcellus Shale Active Permitted Wells
- All Other Active Permitted Wells
- Existing Public Roads



2009 Aerial Imagery - Greene County



Footprint Data

- Well Pads
- Containment Pits
- Other Cleared Area
- New Roads
- Existing Improved Roads



Forest Habitat Impacts

Average Spatial Disturbance for Marcellus Shale Well Pads in Forested Context (acres)

Forest cleared for Marcellus Shale well pad	3.1	8.8
Forest cleared for associated infrastructure (roads, pipelines, containment pits, etc.)	5.7	
Indirect forest impact from new edges	21.2	
TOTAL DIRECT AND INDIRECT IMPACTS	30	

Marcellus Projections

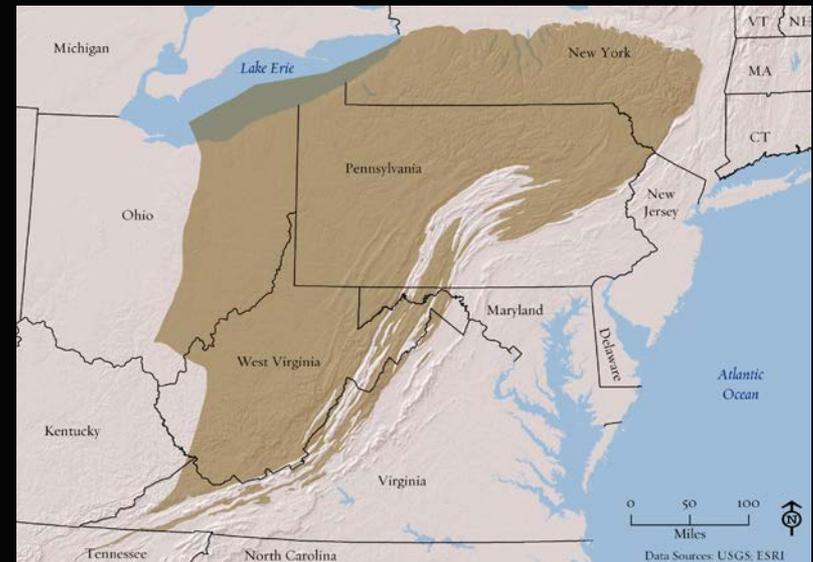
- **Quantity:** How many wells and pads?
- **Geographic Pattern:** Where are they more or less likely?

Assumptions:

- Stable and sufficient prices and capital investment for steady growth
- Continued recent trends and patterns of energy development
- 20-year time period

Data Constraints:

- No proprietary geologic data
- No lease hold data



How Many Marcellus Wells?



Photo: Tamara Gagnolet

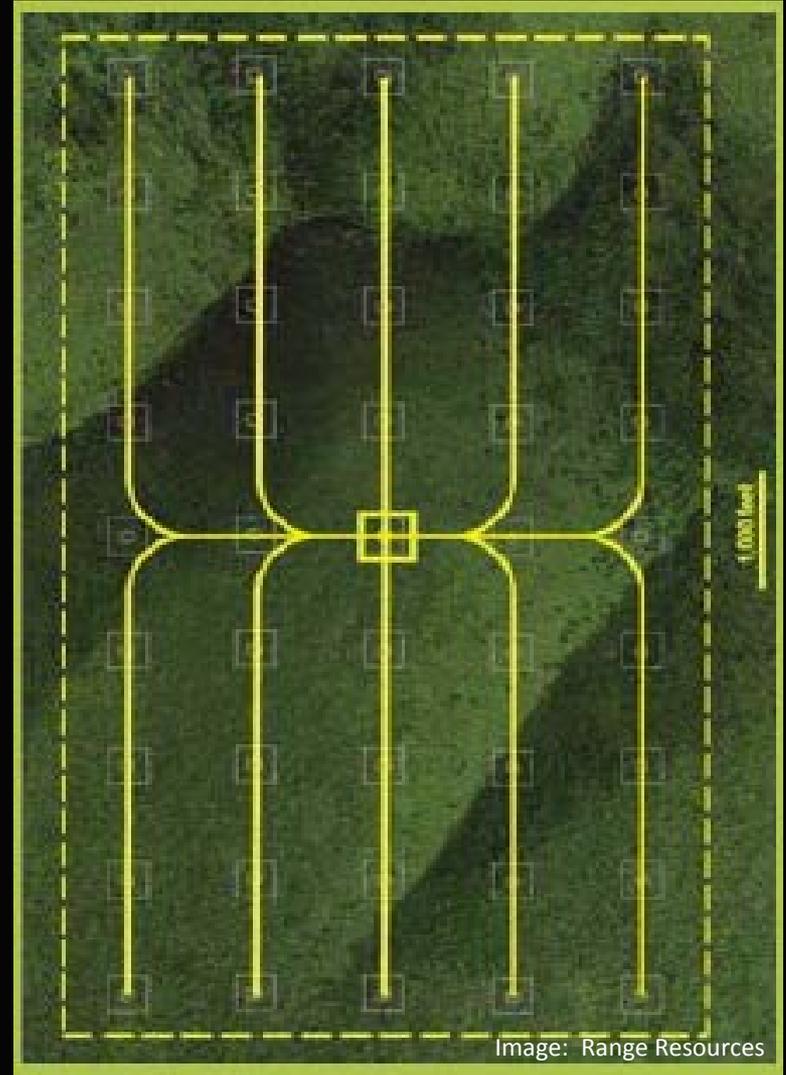
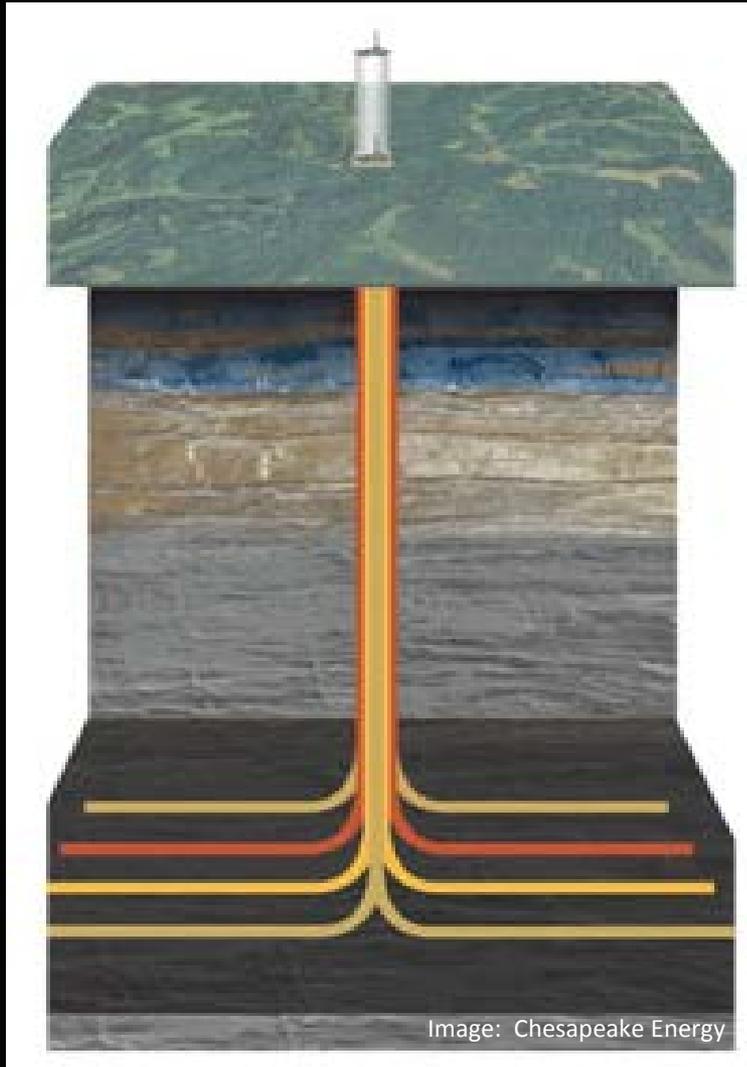
250 horizontal drill rigs

x 1 well drilled per month (or 12/yr)

x 20 years

= **60,000 new wells** drilled by 2030

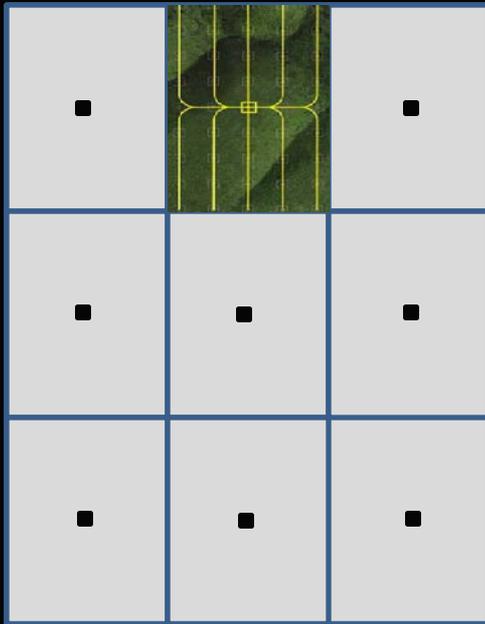
Shale Gas Development



How Many Well Pads?

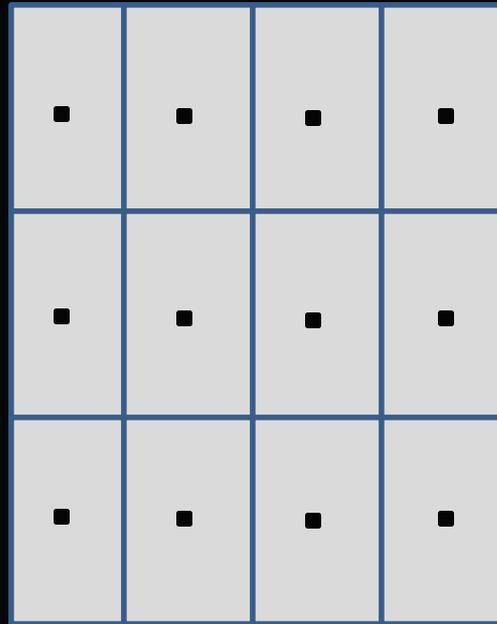
60,000 projected Marcellus wells distributed differently across the landscape

6,000 new pads



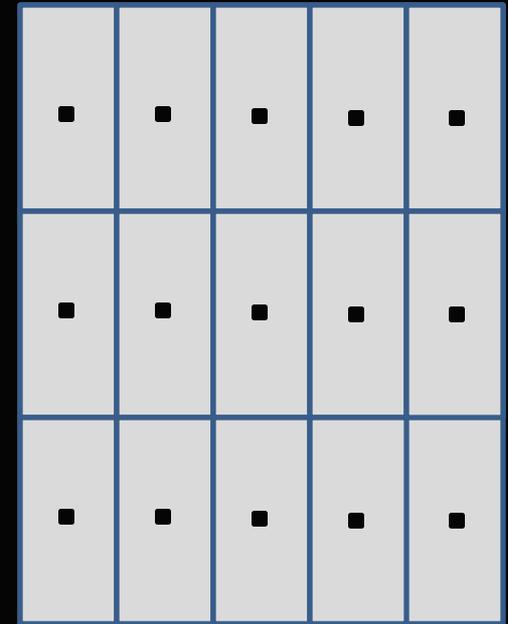
Low Scenario
10 wells per pad

10,000 new pads



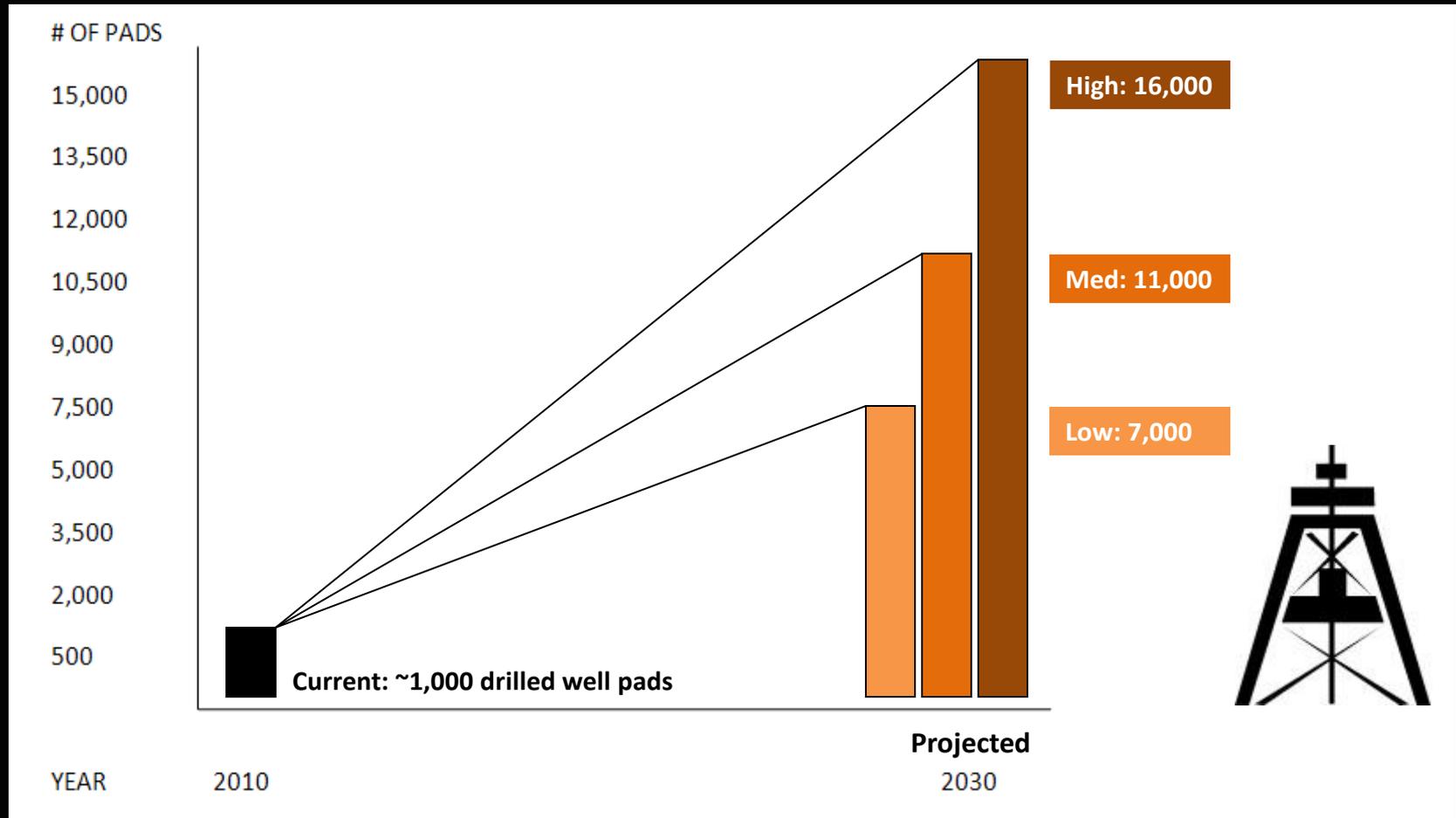
Medium Scenario
6 wells per pad

15,000 new pads



High Scenario
4 wells per pad

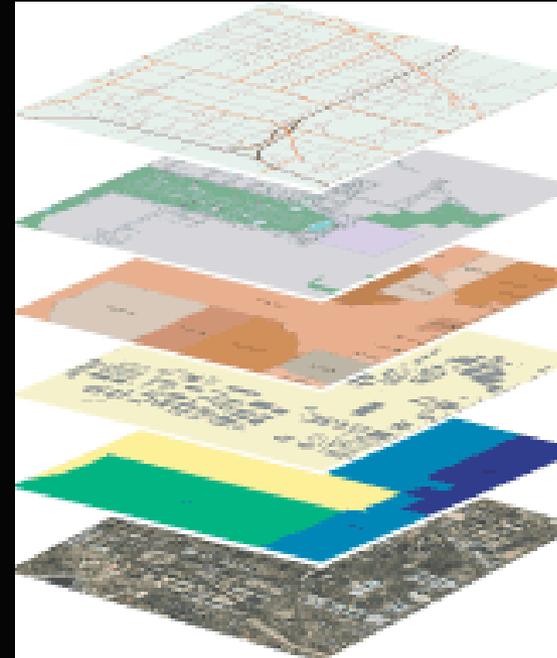
How Many Marcellus Well Pads?



Modeled the relationship between:

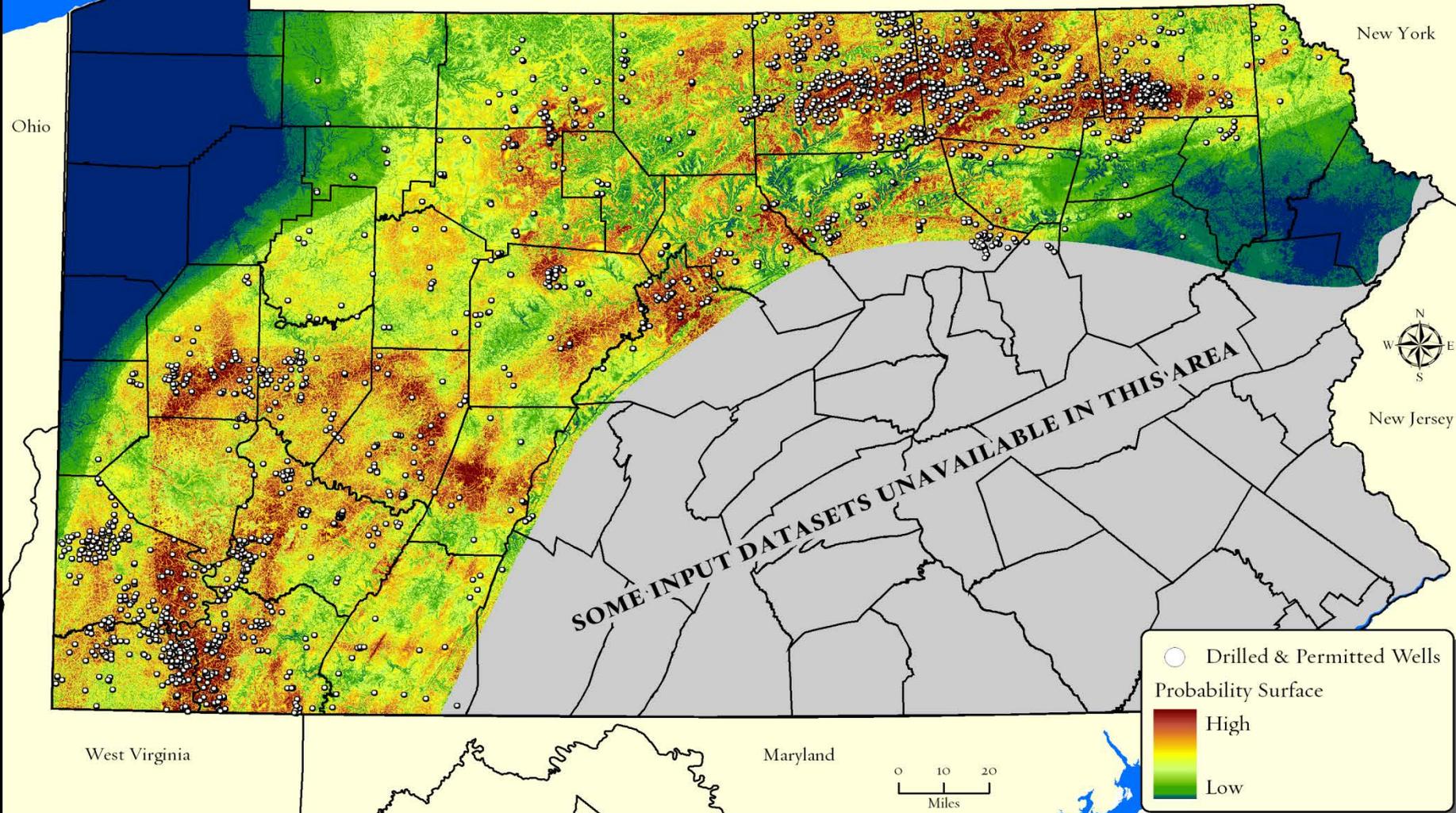
- Drilled and permitted Marcellus wells (from PA-DEP data), and
- Spatial variables related to geology and infrastructure:

- Thermal Maturity
- Shale Depth
- Shale Thickness
- Percent Slope
- Distance to Roads
- Distance to Pipelines



Where Is Marcellus Development Most Likely?

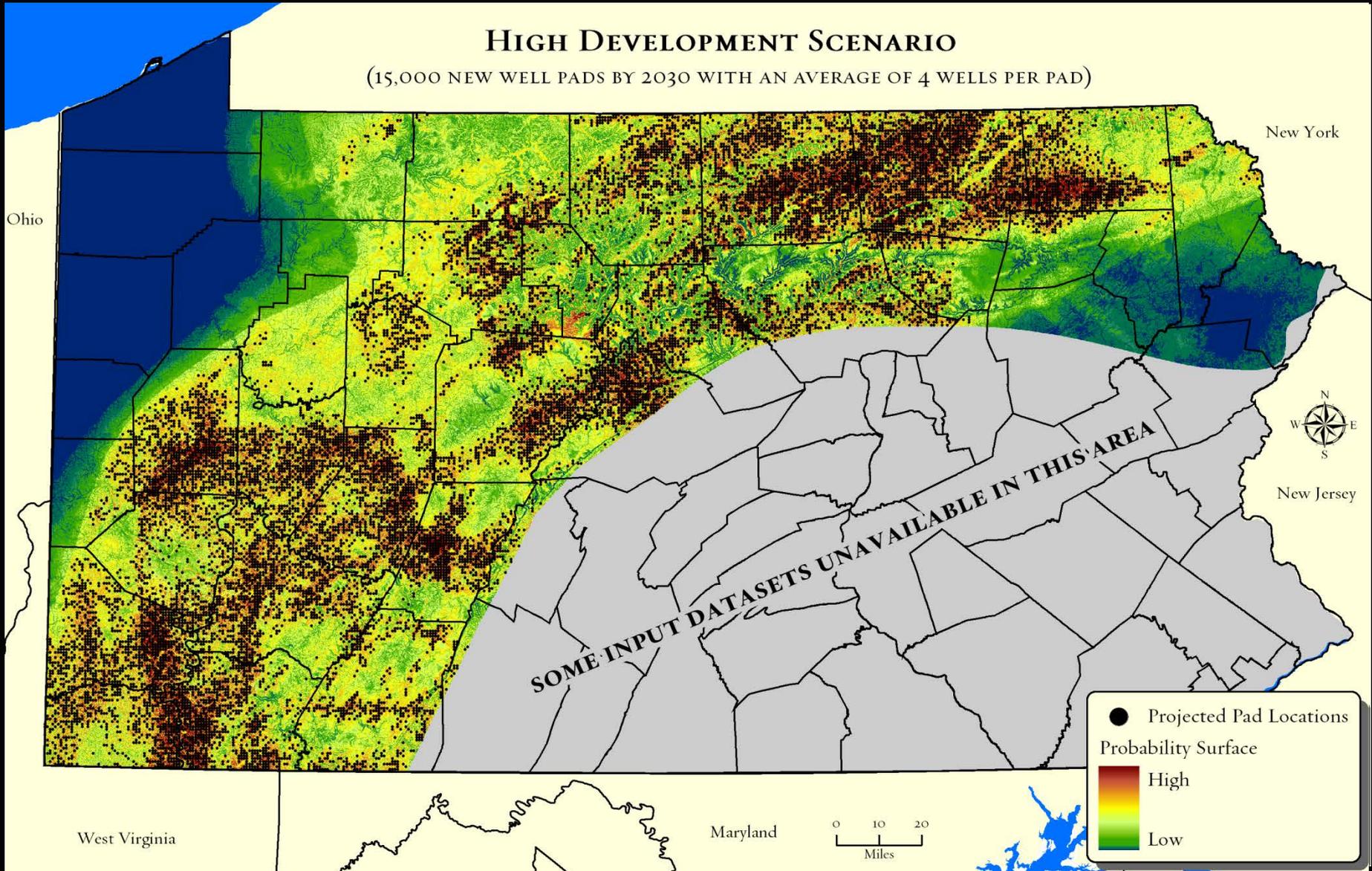
(4,446 DRILLED AND CURRENTLY PERMITTED WELLS AS OF SEPTEMBER 3, 2010)



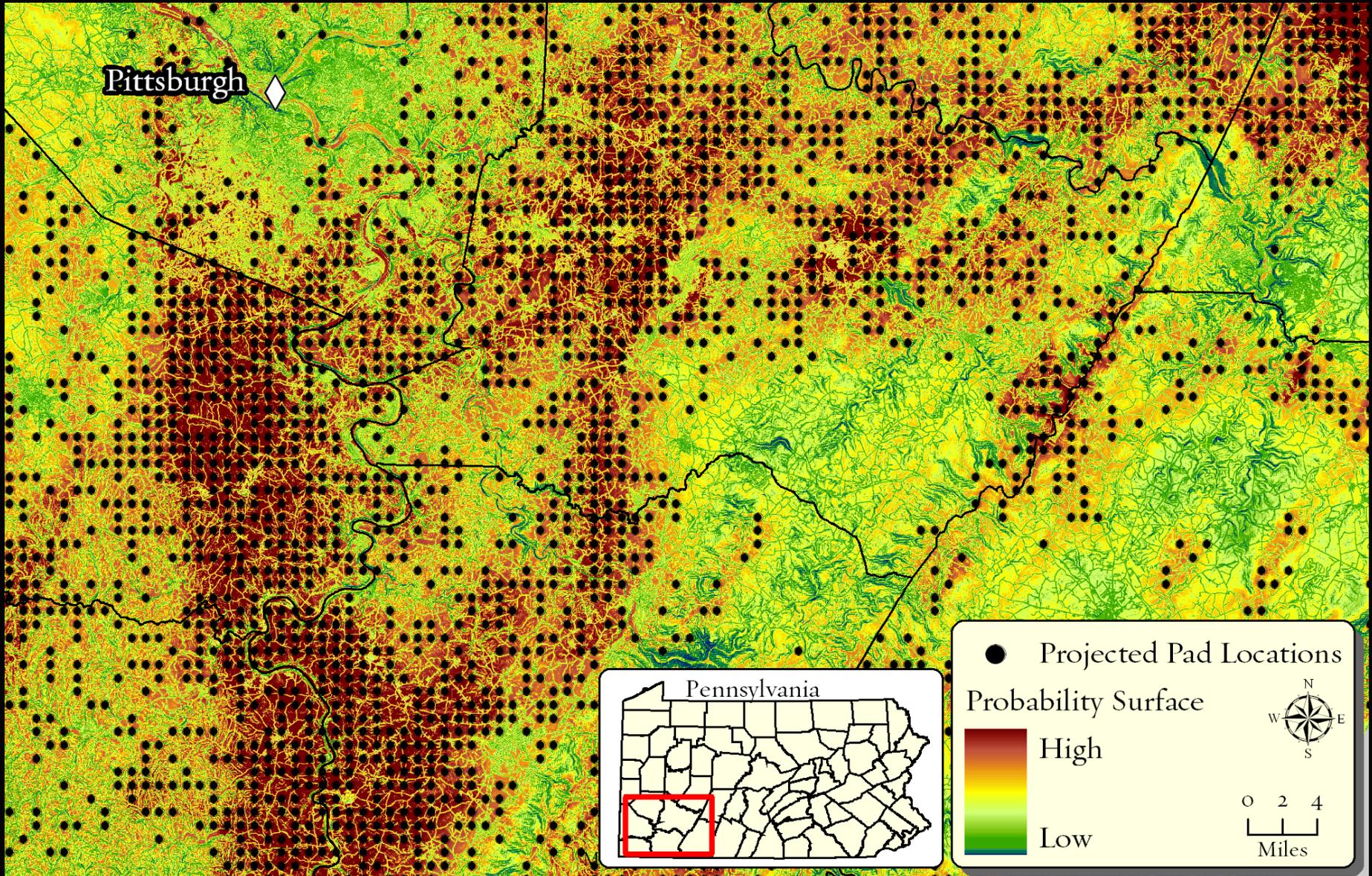
Where Is Marcellus Development Most Likely?

HIGH DEVELOPMENT SCENARIO

(15,000 NEW WELL PADS BY 2030 WITH AN AVERAGE OF 4 WELLS PER PAD)

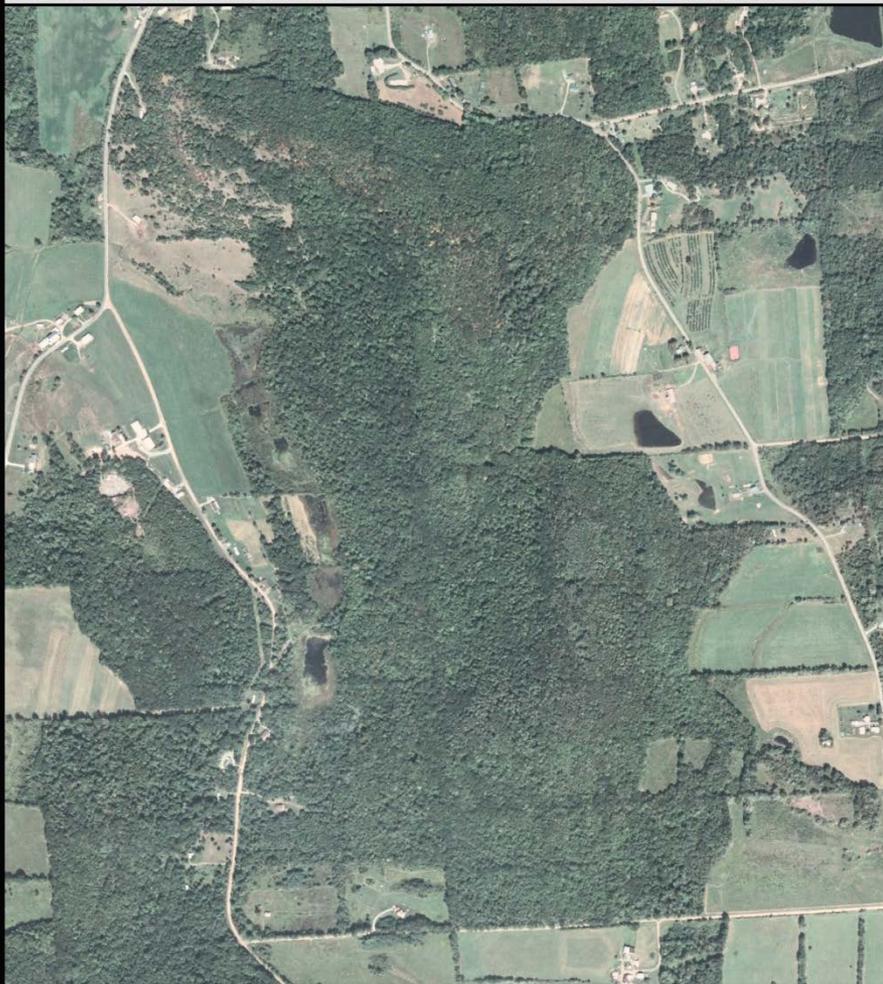


Where Is Marcellus Development Most Likely?



How Many New Gas Pipelines?

2008 Aerial Imagery - Bradford County



0 125 250 500 Meters

Aerial Imagery from NAIP

2010 Aerial Imagery - Bradford County

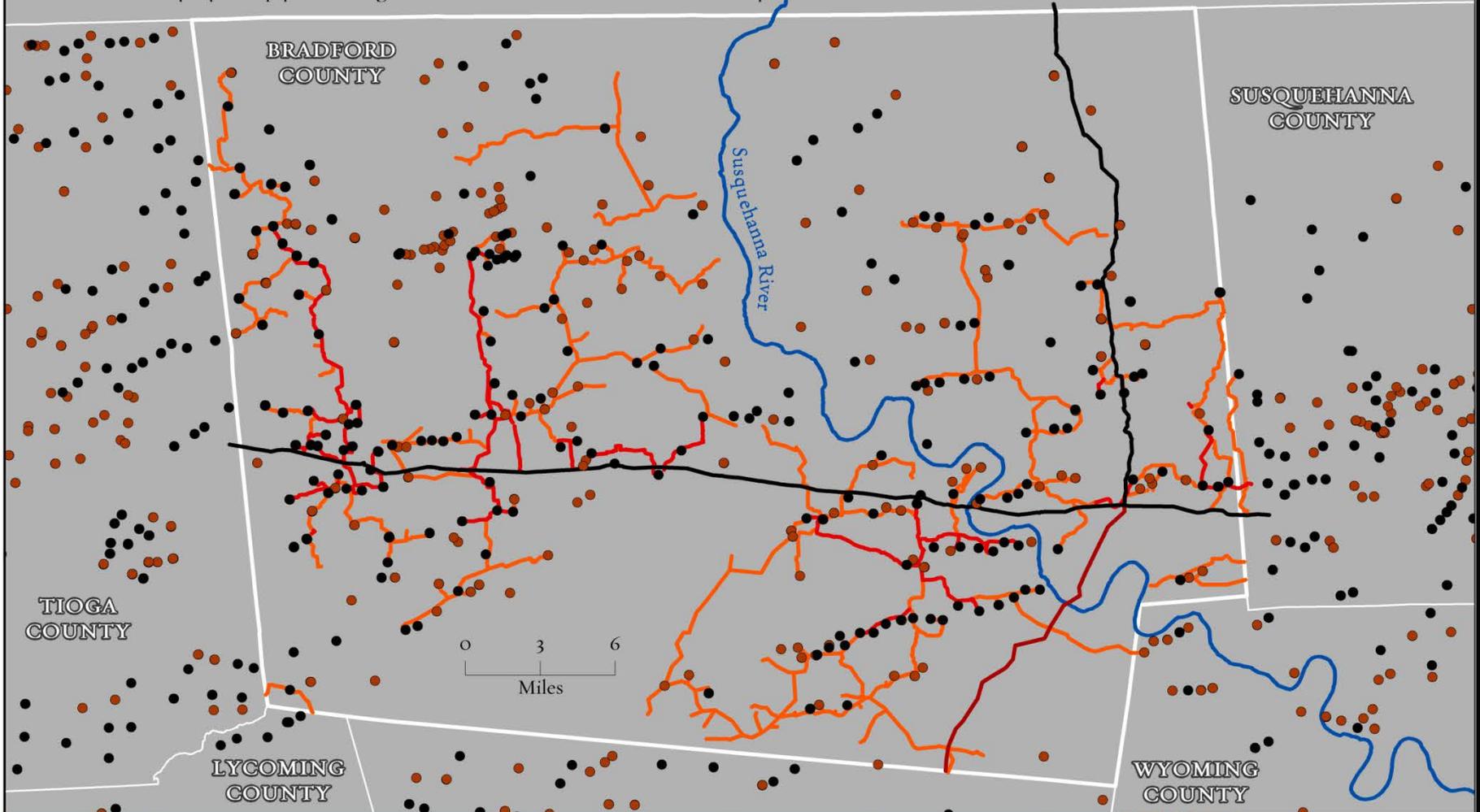


0 125 250 500 Meters

Aerial Imagery from NAIP

MARCELLUS SHALE GAS DEVELOPMENT IN BRADFORD COUNTY

Note: Built versus proposed pipeline designations are based on assessments of aerial photos from summer 2010.



-  Built Transport Lines
-  Proposed Transport Lines
-  Built Gathering Lines
-  Proposed Gathering Lines

-  Drilled Marcellus Gas Wells *
-  Permitted Marcellus Gas Wells *

* According to permit data from PA DEP, as of Dec 31, 2010.

"This map was created using County of Bradford Geographic Information Systems digital data, but this is a secondary product and has not been verified and is not authorized by the County of Bradford."



How Many New Gas Pipelines?



- Based on our assessment of gas pipelines in Bradford County, PA:
 - Right-of-way clearings are ~100 feet wide, ranging from 30 ft to 150 ft
 - Gathering pipelines stretch an average of **1.65 miles per well pad.**

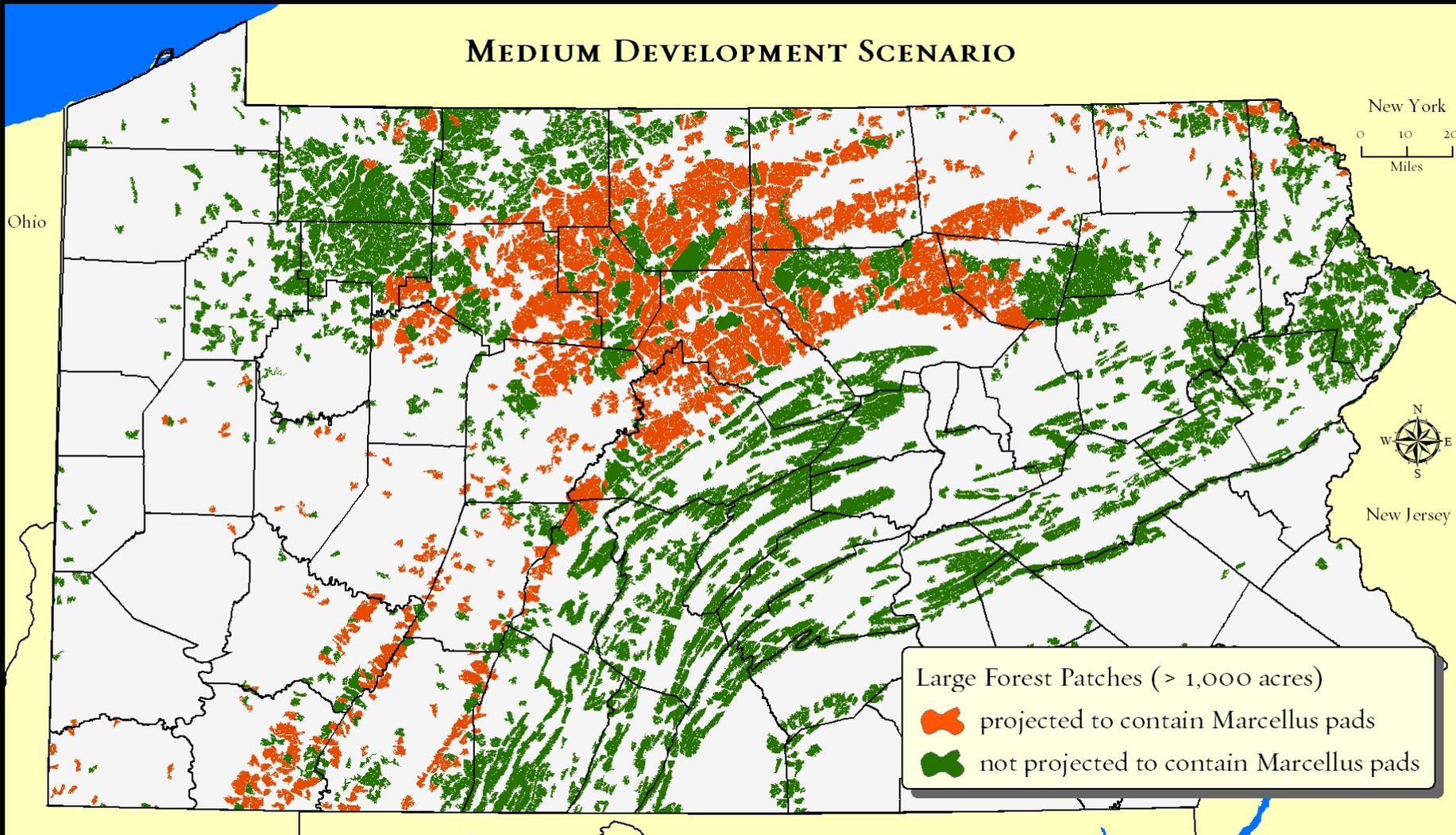
- Based on our Marcellus pad projections:
 - **10,000 and 25,000** miles of new gathering pipelines in PA by 2030
 - Direct forest clearing: **60,000 to 150,000 acres**
 - Forest edge effect: **300,000 to 900,000 acres**

How Many New Gas Pipelines?



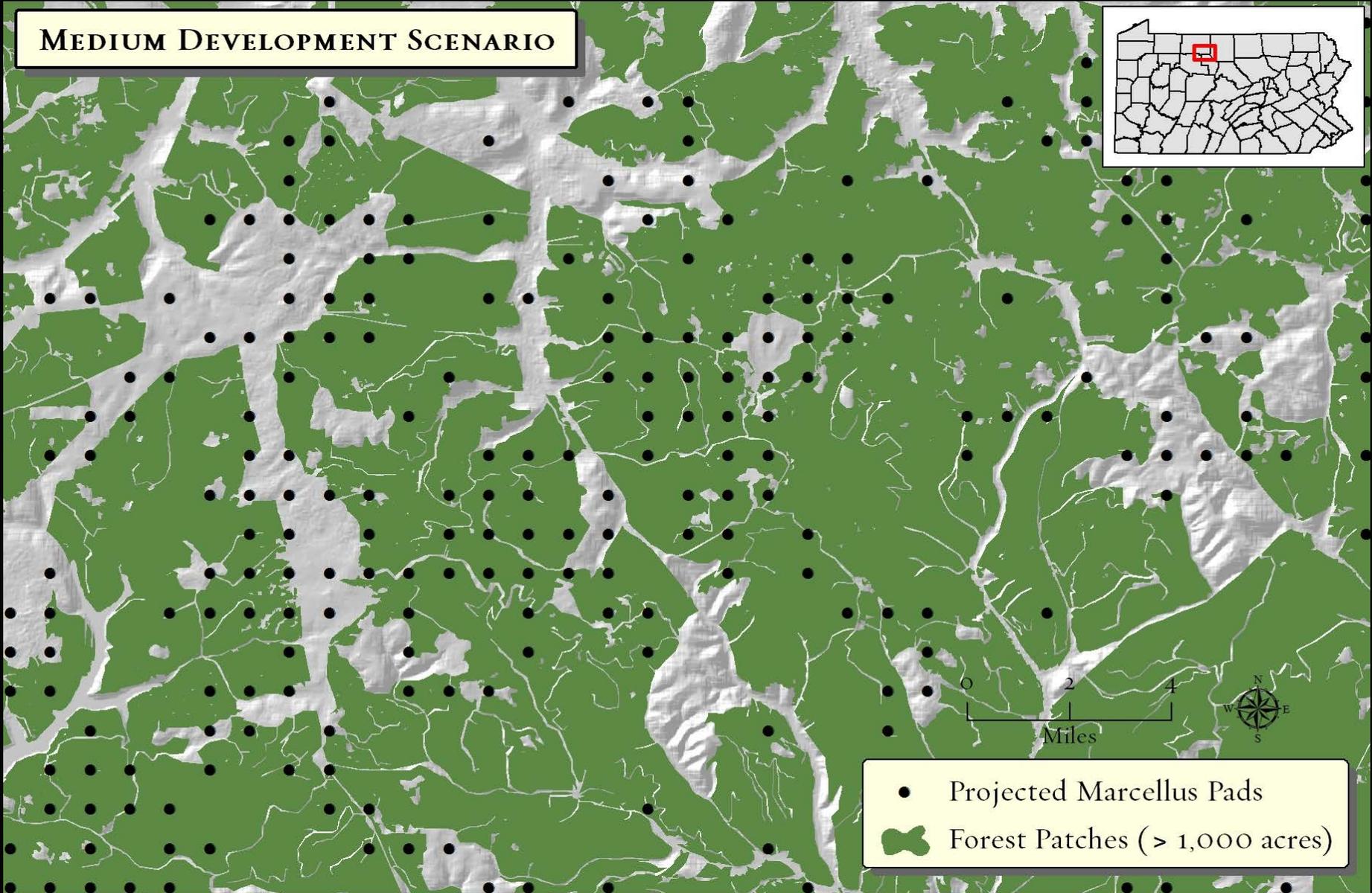
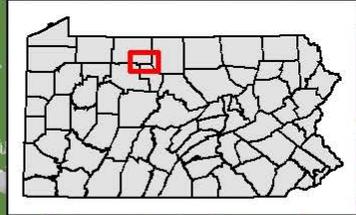
- Pipeline mileage in PA will at least double and possible even quadruple by 2030.
- The pipeline footprint alone is larger than the cumulative area impacted by all other Marcellus gas infrastructure combined.

How Could Forests Be Affected?



Projected Marcellus Well Pads

MEDIUM DEVELOPMENT SCENARIO



Total Forest Impacts

- Based on our spatial footprint assessment and development projections, **100,000 – 240,000** acres of forest cover could be cleared by Marcellus gas development in Pennsylvania by 2030.

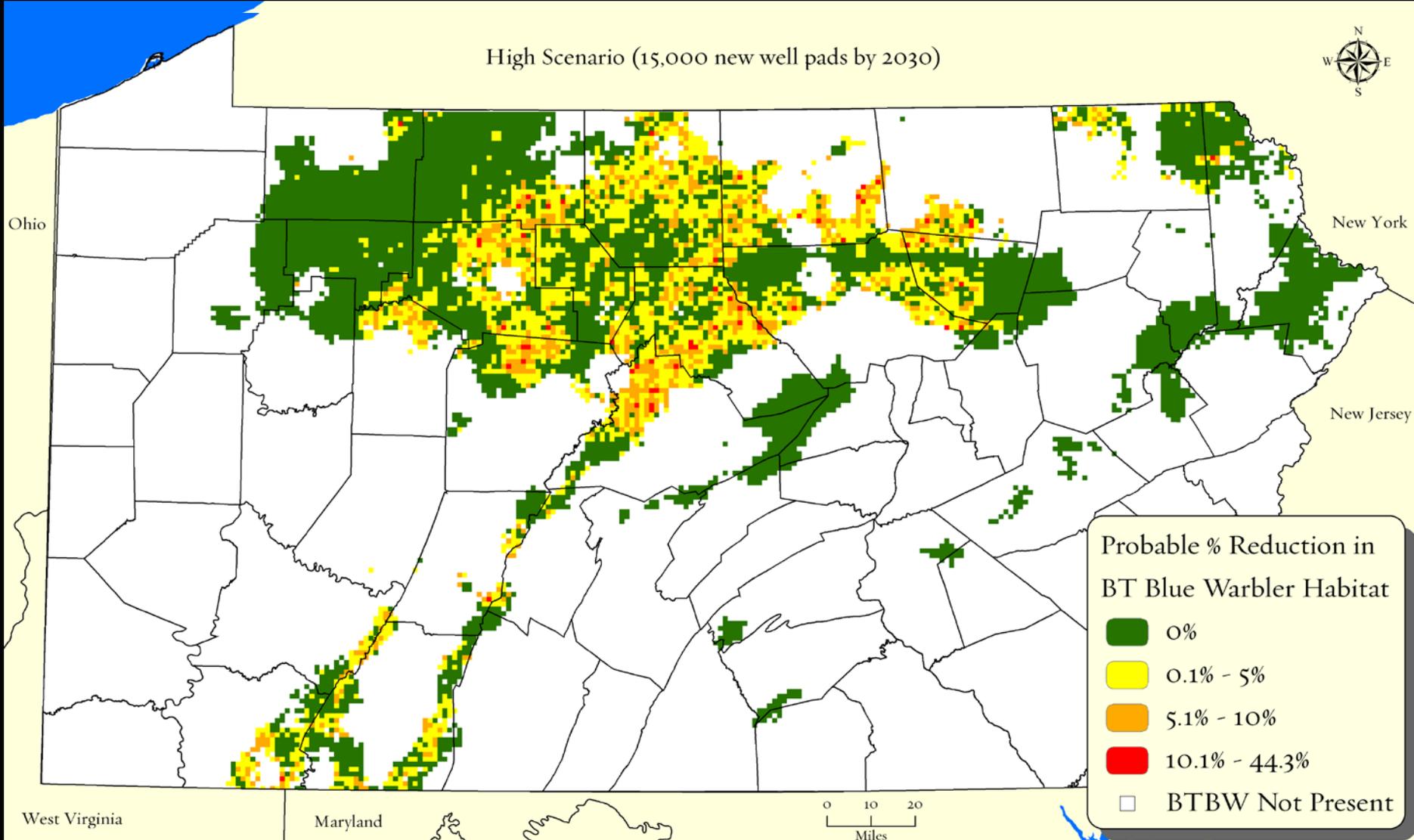


- Such clearings would create new forest edges where predation, changes in light and humidity levels, and expanded presence of invasive species could threaten forest interior species in an additional **470,000 – 1.1 million** forest acres adjacent to Marcellus development.
- Other forest health forest health impacts will also occur due to spread of invasive species, changes in soil and surface hydrology, and air emissions

How Could Bird Species Be Affected?

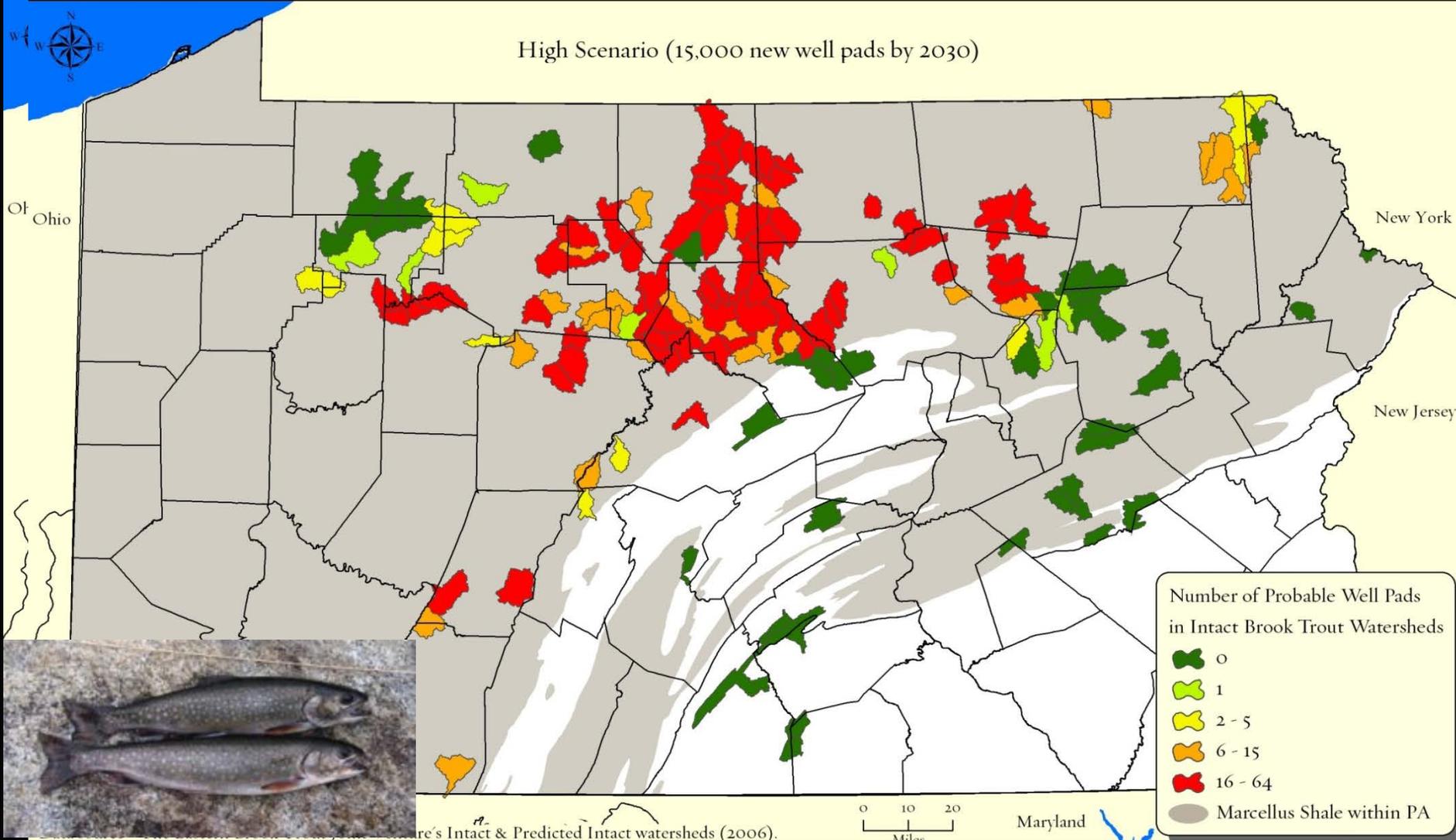


Black-Throated Blue Warbler



How Could Brook Trout Be Affected?

PROBABLE MARCELLUS SHALE WELL PAD DEVELOPMENT WITHIN BROOK TROUT WATERSHEDS



- 1. Invasive Species** – “spider-web” of disturbance creates ideal conditions for spread of invasive species
 - 2. Soil and Hydrology Changes** – gas infrastructure can cause major changes in surface drainage and soils
 - 3. Air Emissions** – ground level ozone may reach damaging levels in some areas
-

1. **Decision Support Tool** to optimize between energy development and habitat conservation
 2. Consolidate and strengthen **science-based Best Management Practices** to minimize habitat impacts
 3. **Field-based Evaluation** of Decision Support Tool and BMPs in Laurel Highlands and North Central PA
-

www.nature.org/paenergy

Nels Johnson
njohnson@tnc.org