

Production and Water Use in Pennsylvania's Organic Shales*

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Abstract

Thousands of shale gas and oil wells have been drilled in Pennsylvania since 2004. In addition to the Marcellus Formation, other organic-rich shales are being targeted, including the Upper Devonian Genesee and Burket shales and the Upper Ordovician Utica Shale. Water is used to hydraulically fracture these wells, with a portion of these treatment waters flowing back after stimulation. Formation water is also generated after the well has been turned into production. Shale wells produce hydrocarbons in 35 of Pennsylvania's 67 counties. Most of the production comes from the two 'sweet spots' in the Marcellus play in southwest and northeast Pennsylvania.

This study looks at production and water use in shale wells from 2010 through 2018. Producing formation information is from the Pennsylvania Geological Survey's Exploration and Development Well Information Network (EDWIN). Treatment water volumes are as reported by operators on well completion reports. Production and wastewater data are from PA DEP's database. Information from these sources was compiled for almost 6800 wells that reported production between 2010 and 2018. Different regions were compared to identify patterns of fresh and recycled water use.

More than 75% of the state's hydrocarbon production comes from the two 'sweet spots' of the Marcellus play: Greene and Washington counties in the southwest and Bradford, Lycoming, and Susquehanna counties in the northeast. More than half of the natural gas production comes from the northeastern 'sweet spot' where county-wide average daily gas production per well ranges from 1808 to 3243 MCF/day. County-wide average daily gas production per well in the southwestern 'sweet spot' ranges from 1571 to 2088 MCF/day. The two counties with the highest average daily production per well, Wyoming (4889 MCF/day) and Sullivan (3944 MCF/day), are adjacent to the northeast's 'sweet spot.' Ninety percent of the liquids production (oil plus condensate) comes from Washington County. All the liquids production comes from the western part of the state, but not necessarily from the 'sweet spot.' Liquids production is also significant in Butler and Mercer counties.

The most shale wells have been drilled in Washington County. This county has also used the most hydraulic fracture treatment water and produced the most oil and condensate. Susquehanna County has used the second-largest amount of treatment water and has the highest natural gas production. Most (80 to 95%) of the wastewater from these wells is recycled and reused in other wells.

Production and water use in Pennsylvania's organic shales

Katherine Schmid, P.G.

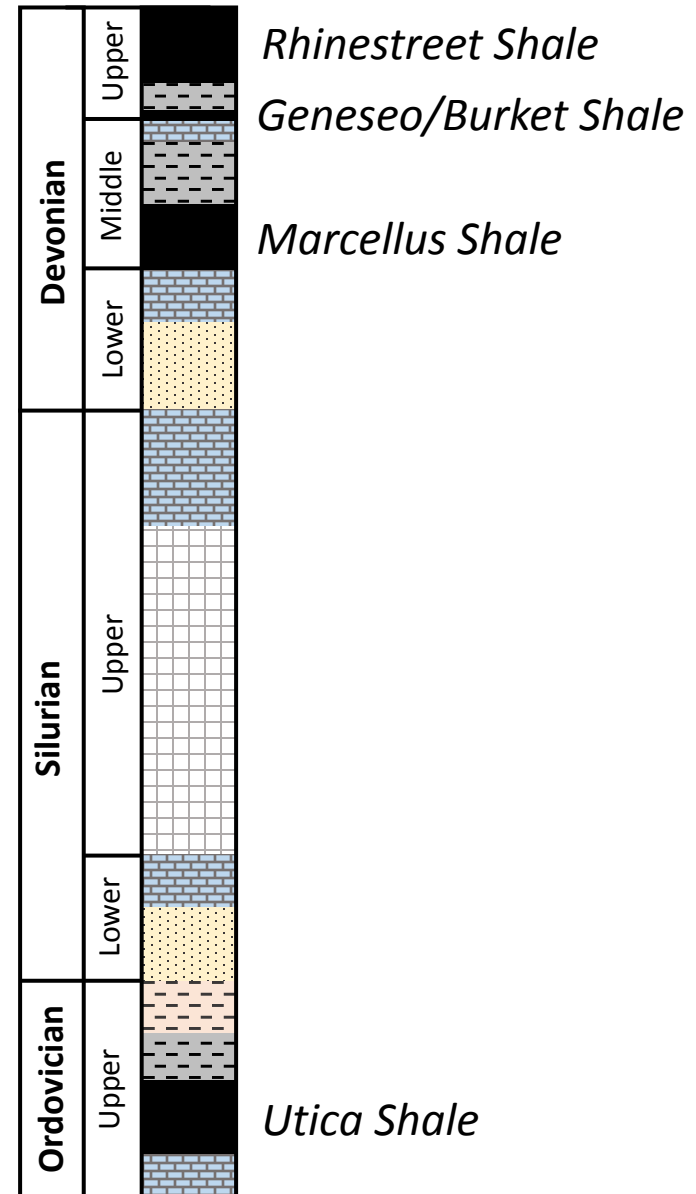
2019 AAPG

Eastern Section Meeting



Introduction

- Since 2004, multiple organic shales have been targeted across Pennsylvania by drillers
- This study examines well production and water use in these shale wells



Outline

- Wells drilled in these organic shales
- Hydrocarbon production from the shales
- Amount of water used to fracture the shales

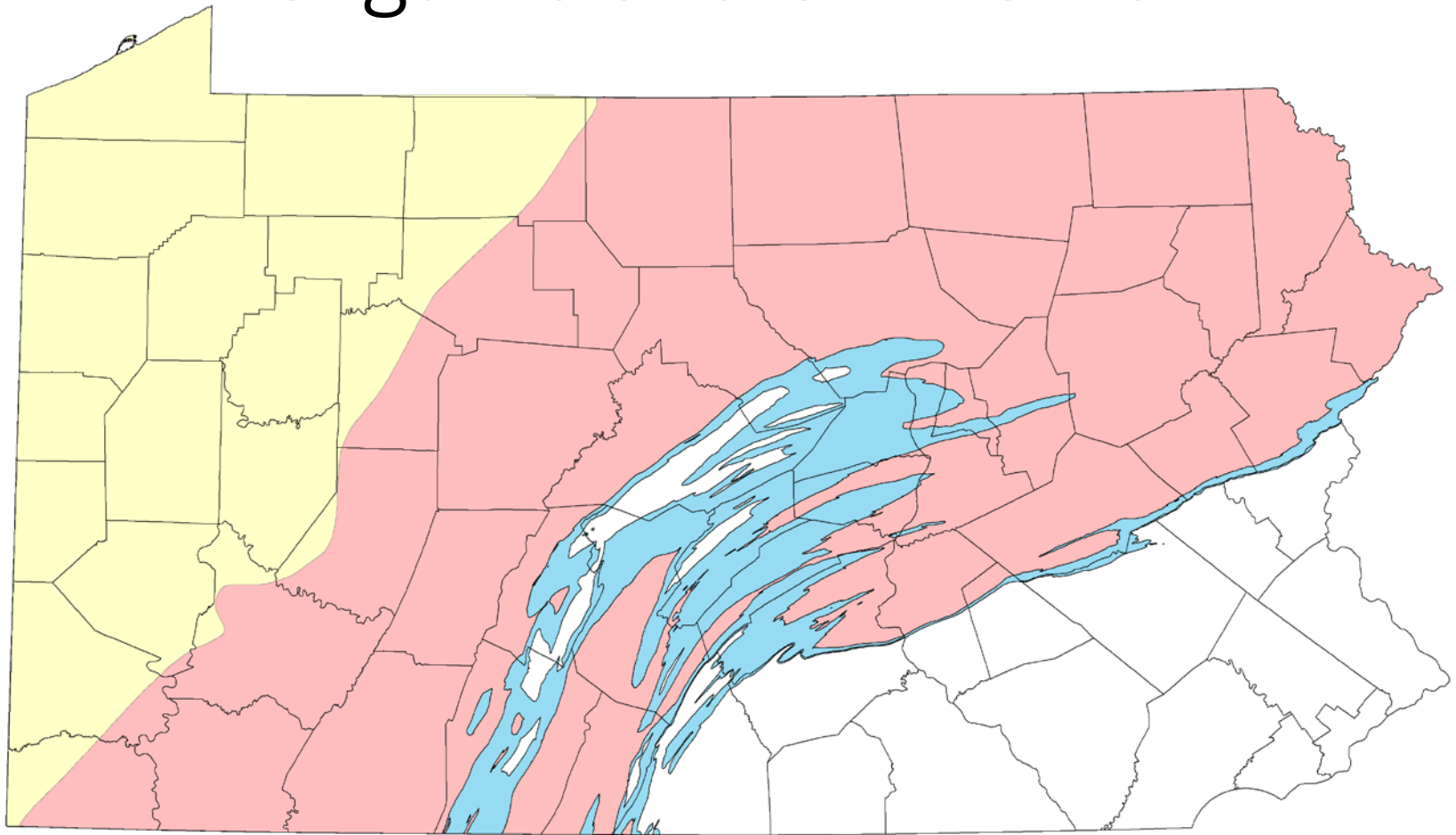


Data Sources

- Well specific production data has been compiled from PA DEP's Oil & Gas Production/Waste Reports (OGRE) Website
- Interpreted producing formation data are from DCNR's EDWIN database
- Amounts of water used to fracture wells are from the well completion reports scanned into EDWIN

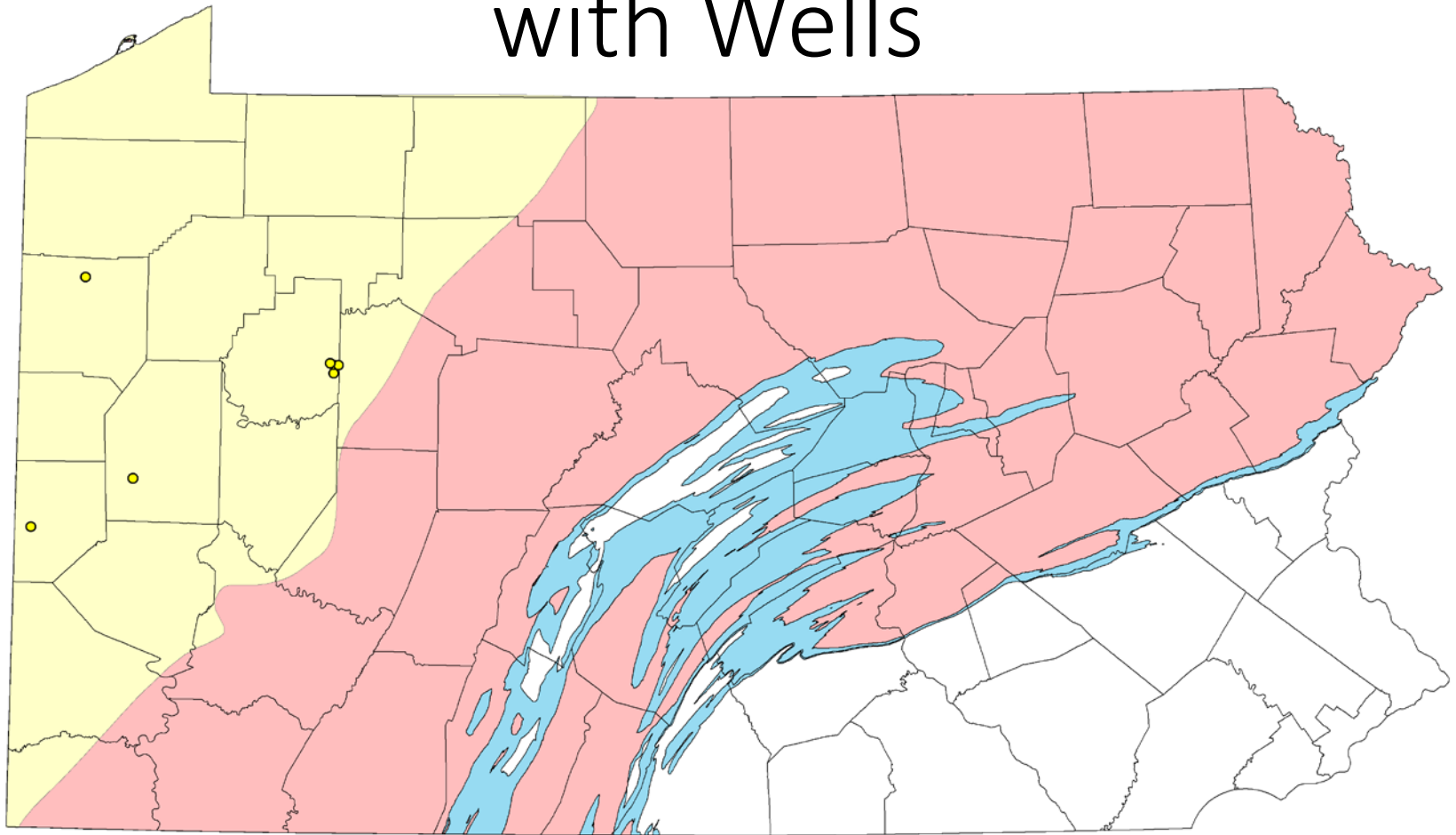


Organic Shale Extents



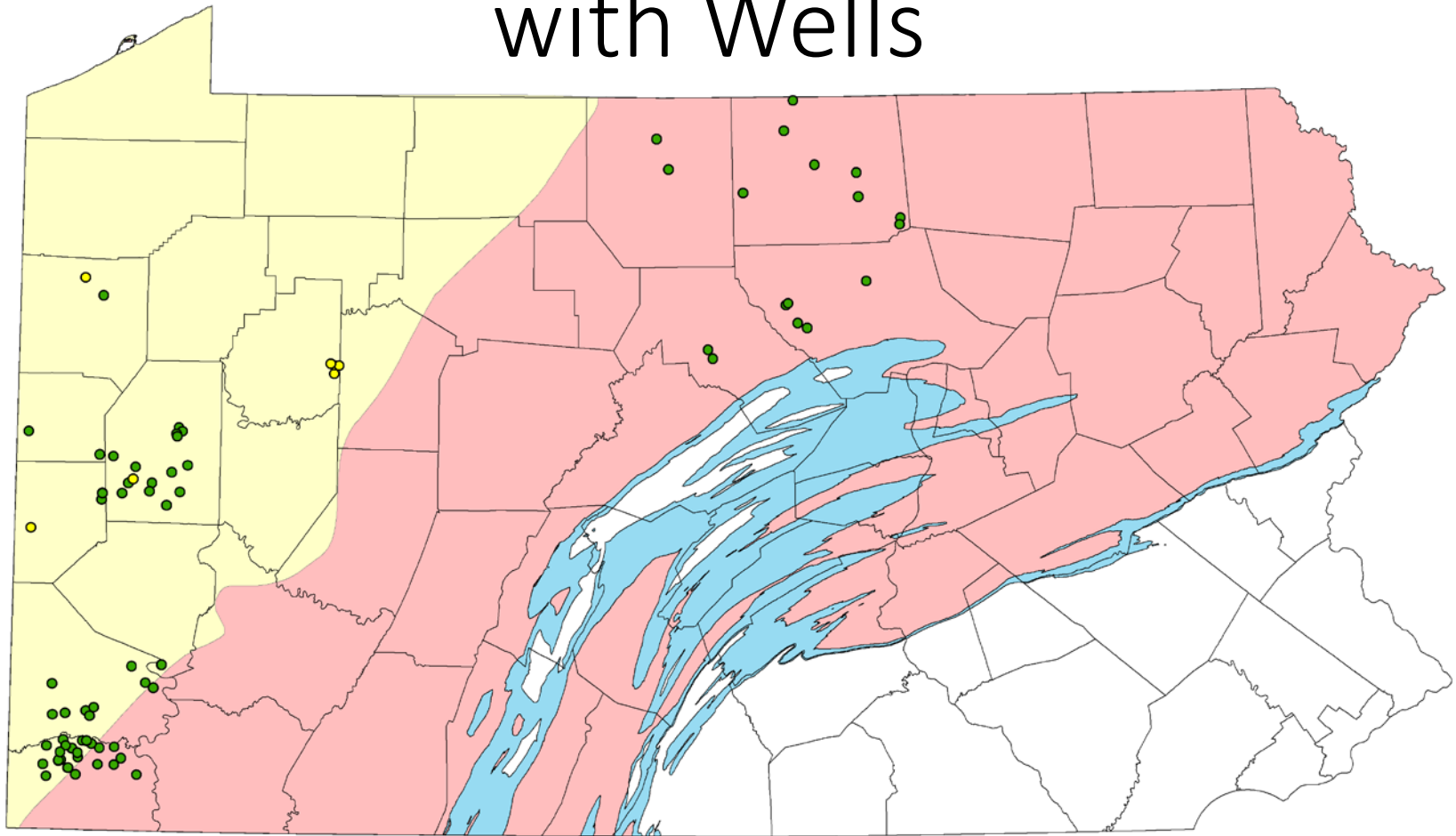
- Utica Shale
- Marcellus Shale
- Rhinestreet Shale

Organic Shale Extents with Wells



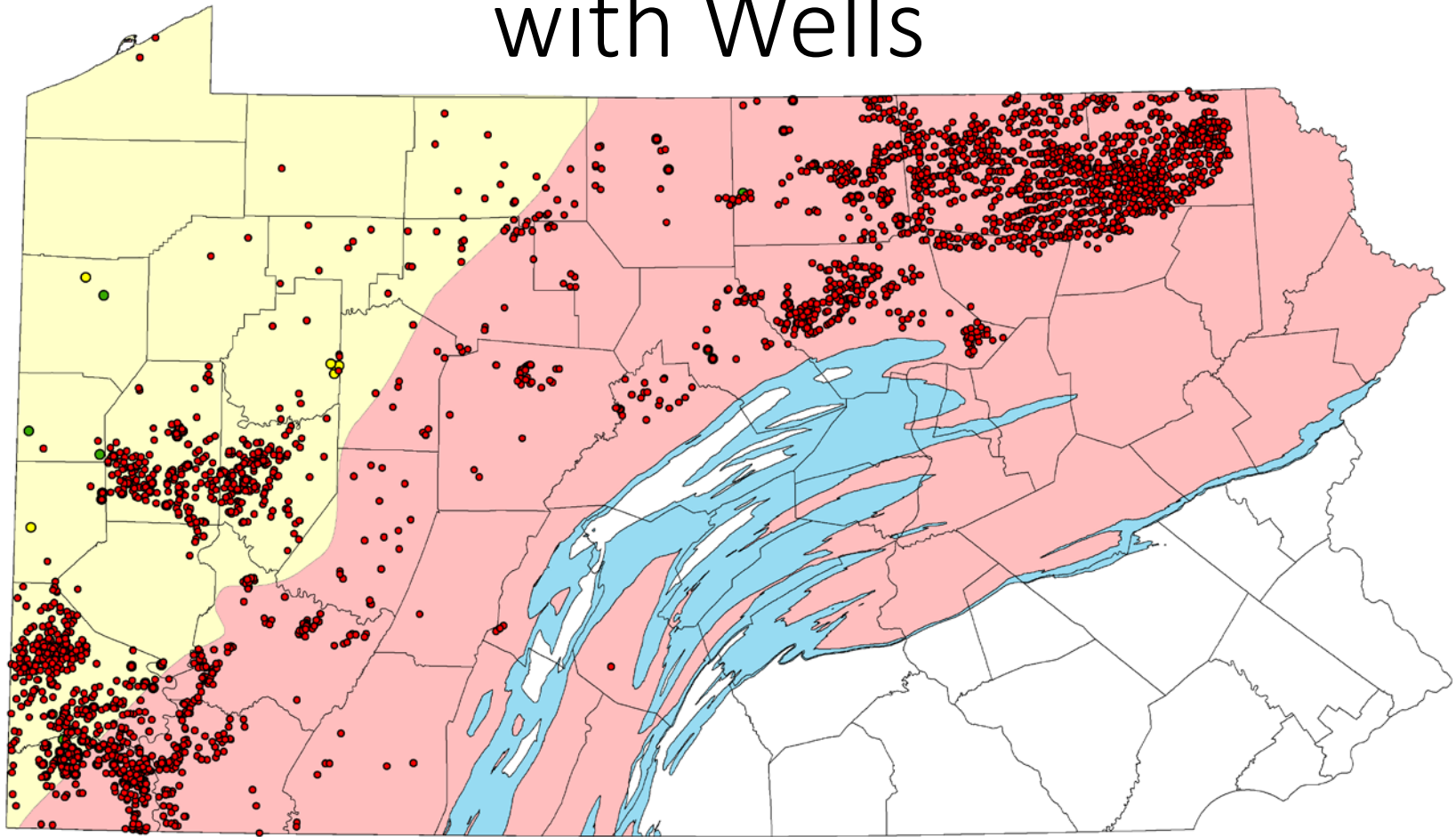
- Utica Shale
- Marcellus Shale
- Rhinestreet Shale
- Rhinestreet Wells

Organic Shale Extents with Wells



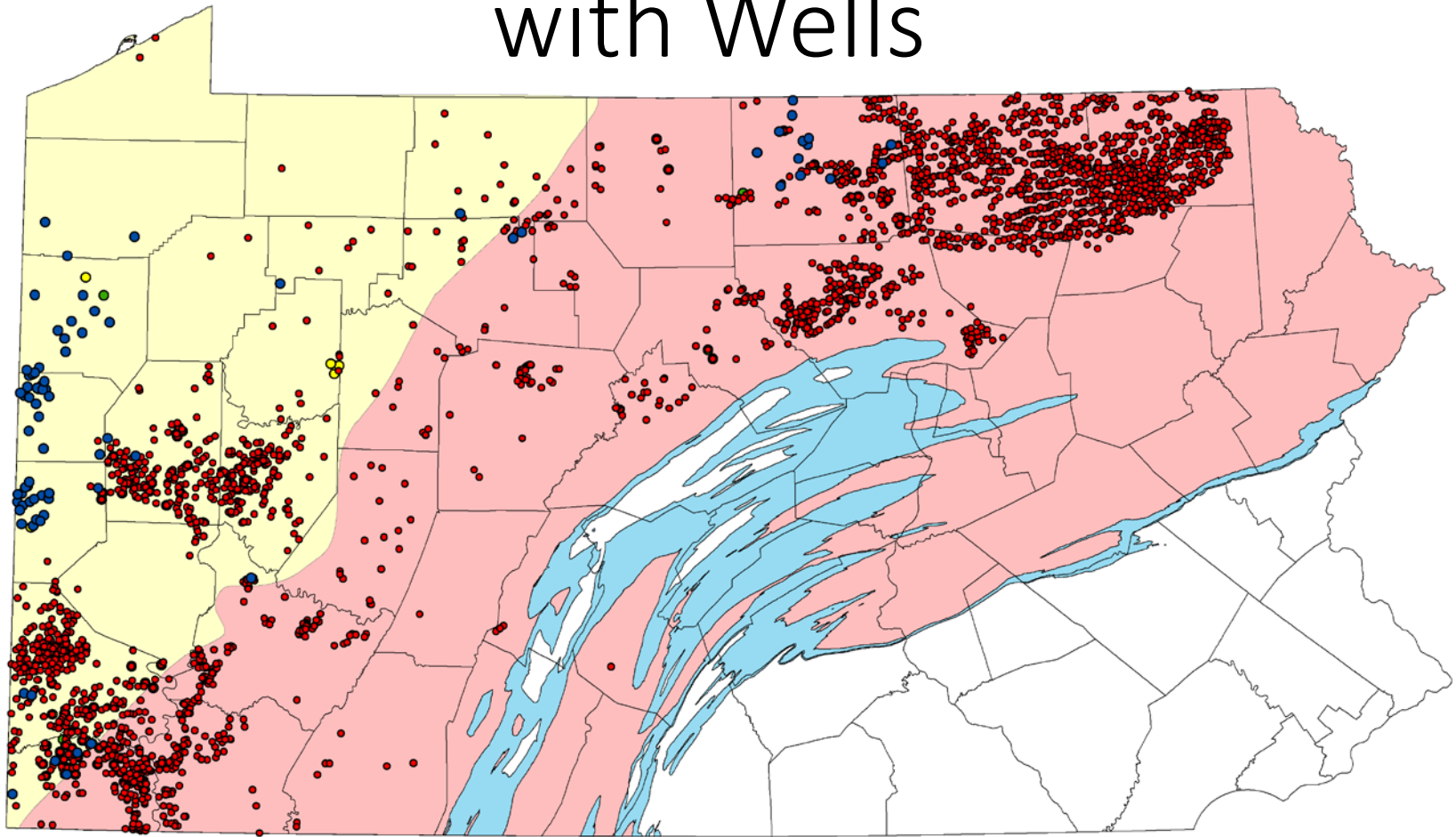
- Utica Shale
- Marcellus Shale
- Rhinestreet Shale
- Rhinestreet Wells
- Genesee/Burket Wells








Organic Shale Extents with Wells



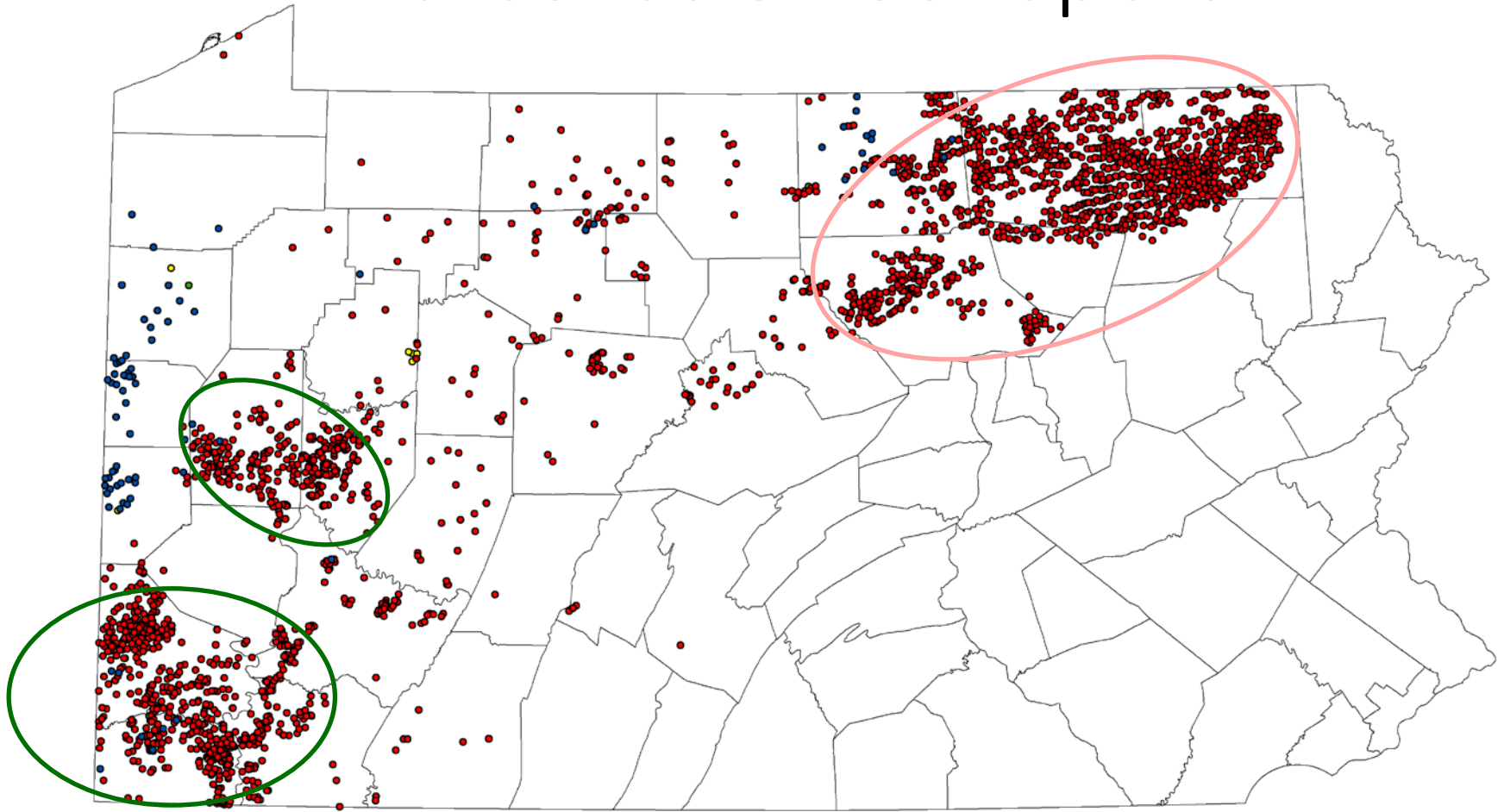
- Utica Shale
- Marcellus Shale
- Rhinestreet Shale
- Rhinestreet Wells
- Genesee/Burket Wells
- Marcellus Wells

Organic Shale Extents with Wells



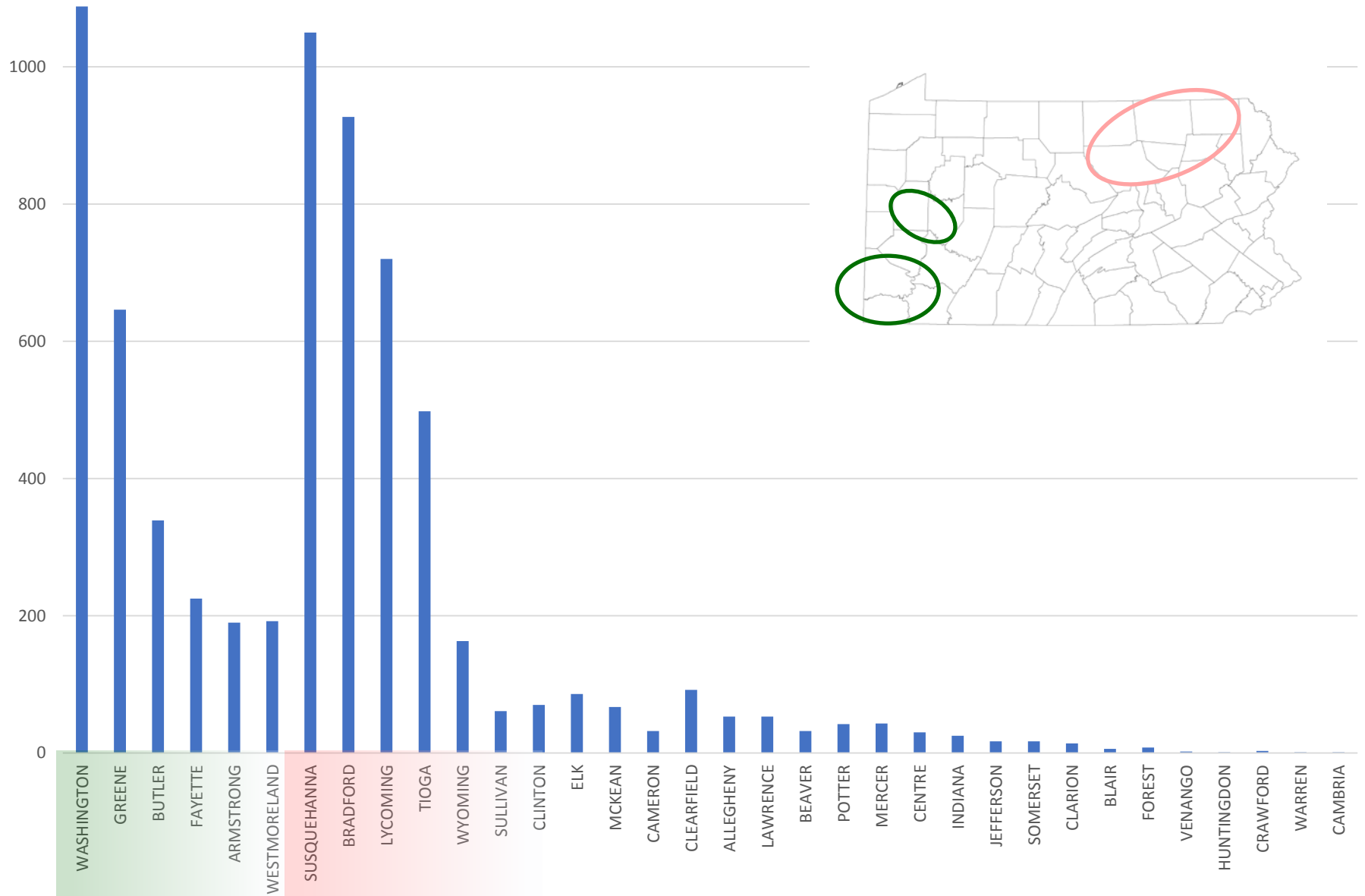
- | | | |
|--|--|---|
|  Utica Shale |  Rhinstreet Wells |  Marcellus Wells |
|  Marcellus Shale |  Geneseo/Burket Wells |  Utica Wells |
|  Rhinstreet Shale | | |

Marcellus Sweet Spots



- Rhinestreet Wells
- Genesee/Burket Wells
- Marcellus Wells
- Utica Wells

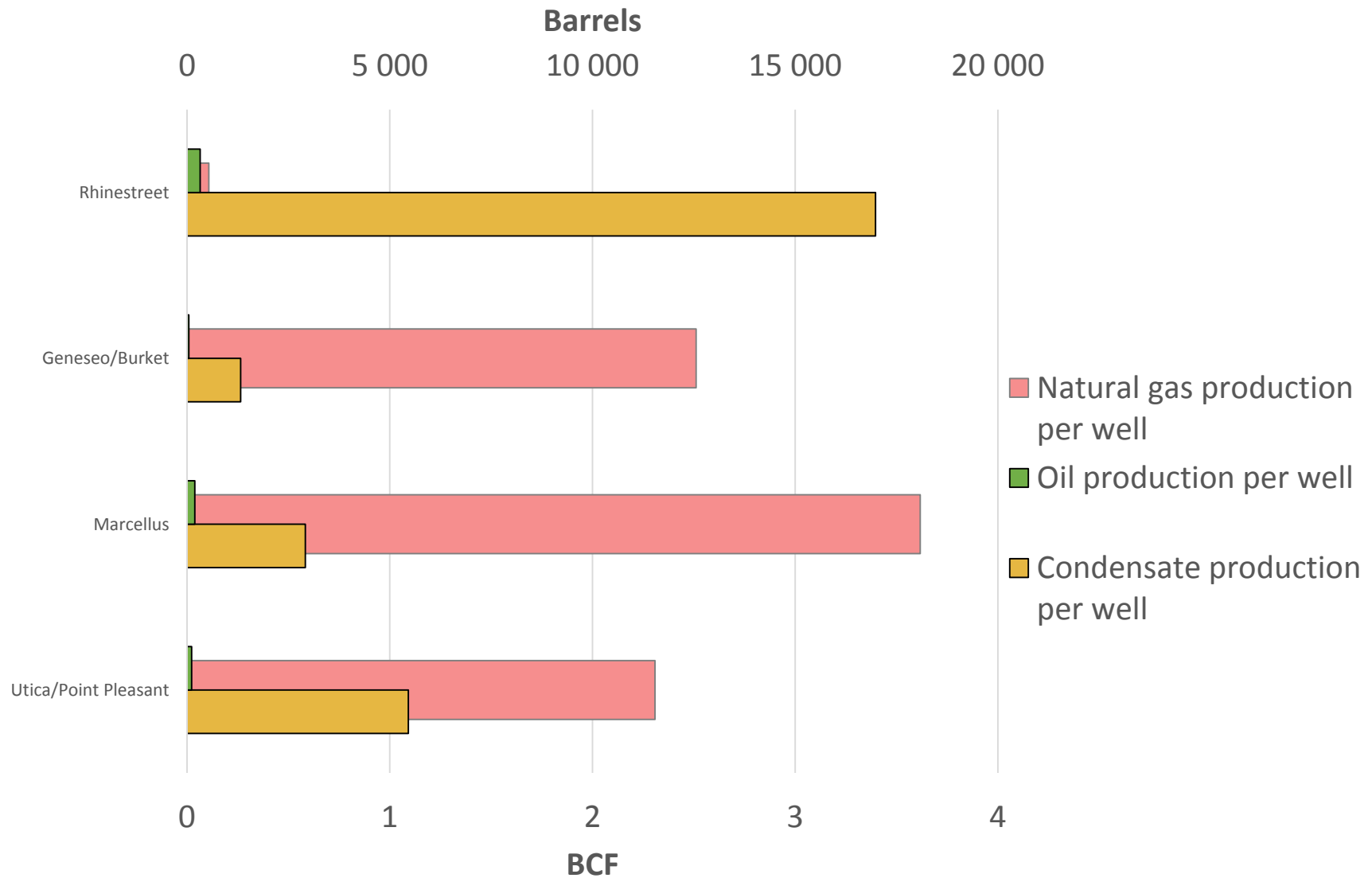
Number of shale wells in each county



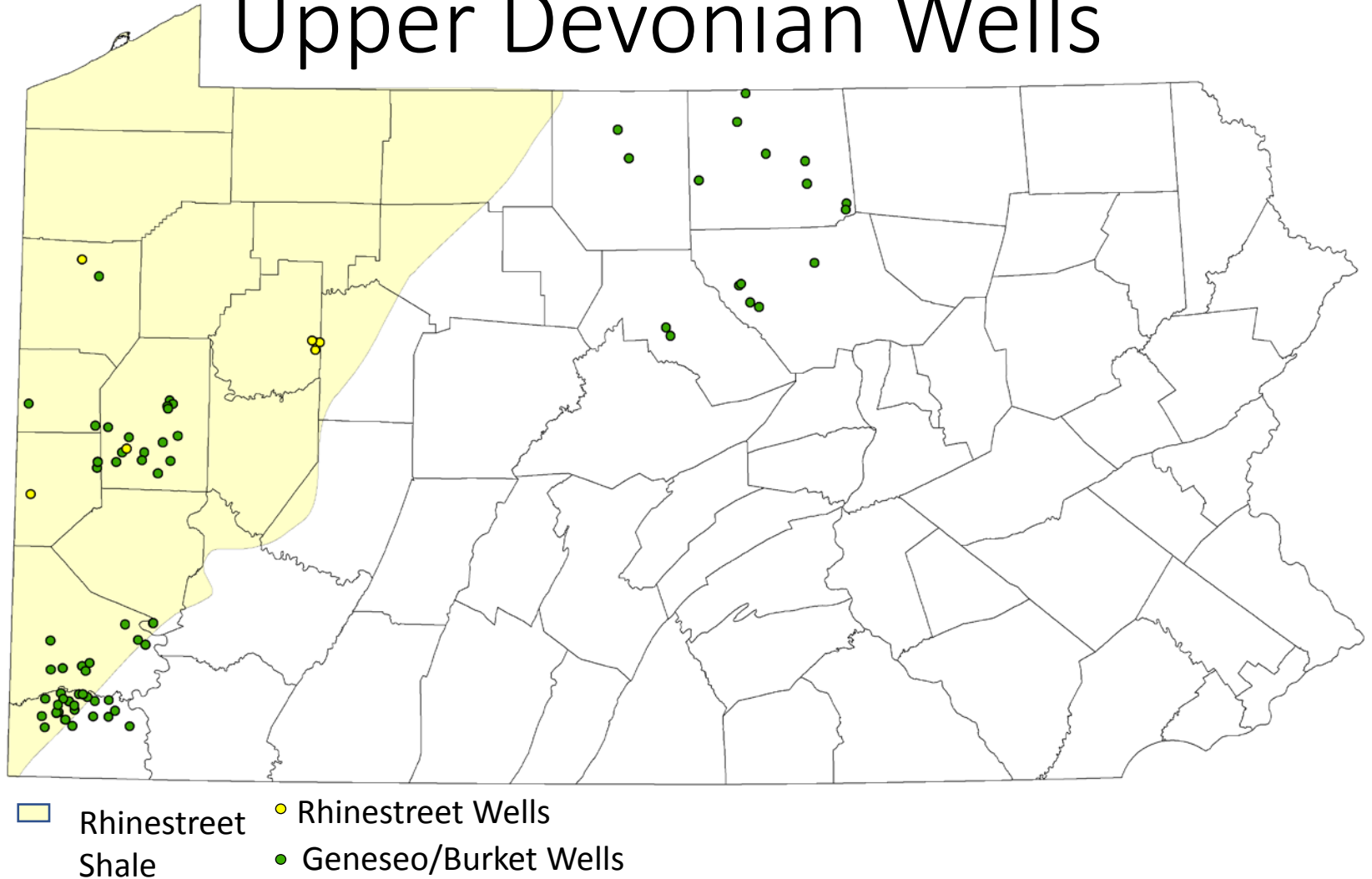
Now to focus on Hydrocarbon Production...



Hydrocarbon production per well in the different shales

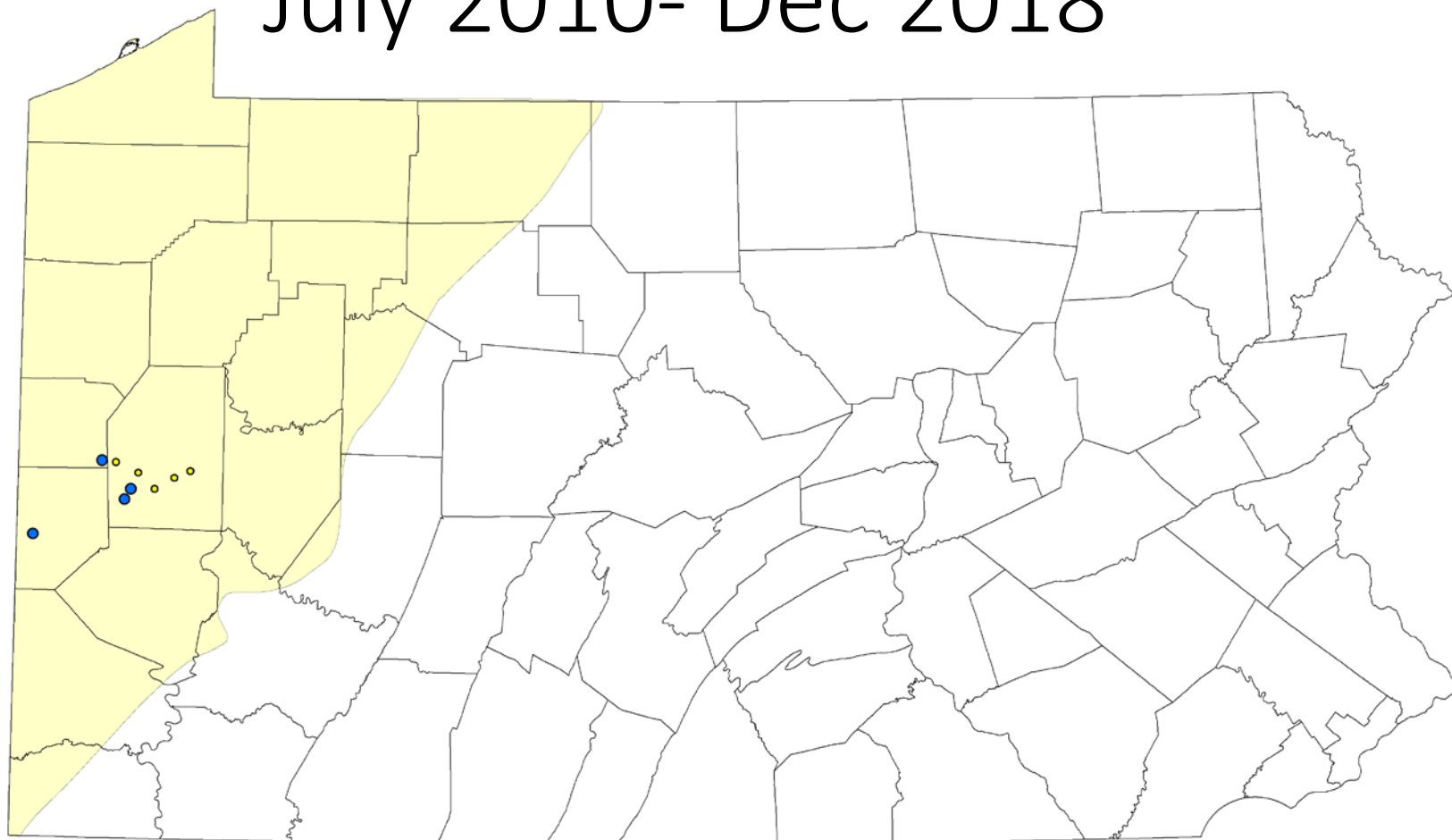


Rhinestreet Shale Extents with Upper Devonian Wells



Upper Devonian Oil Production

July 2010- Dec 2018

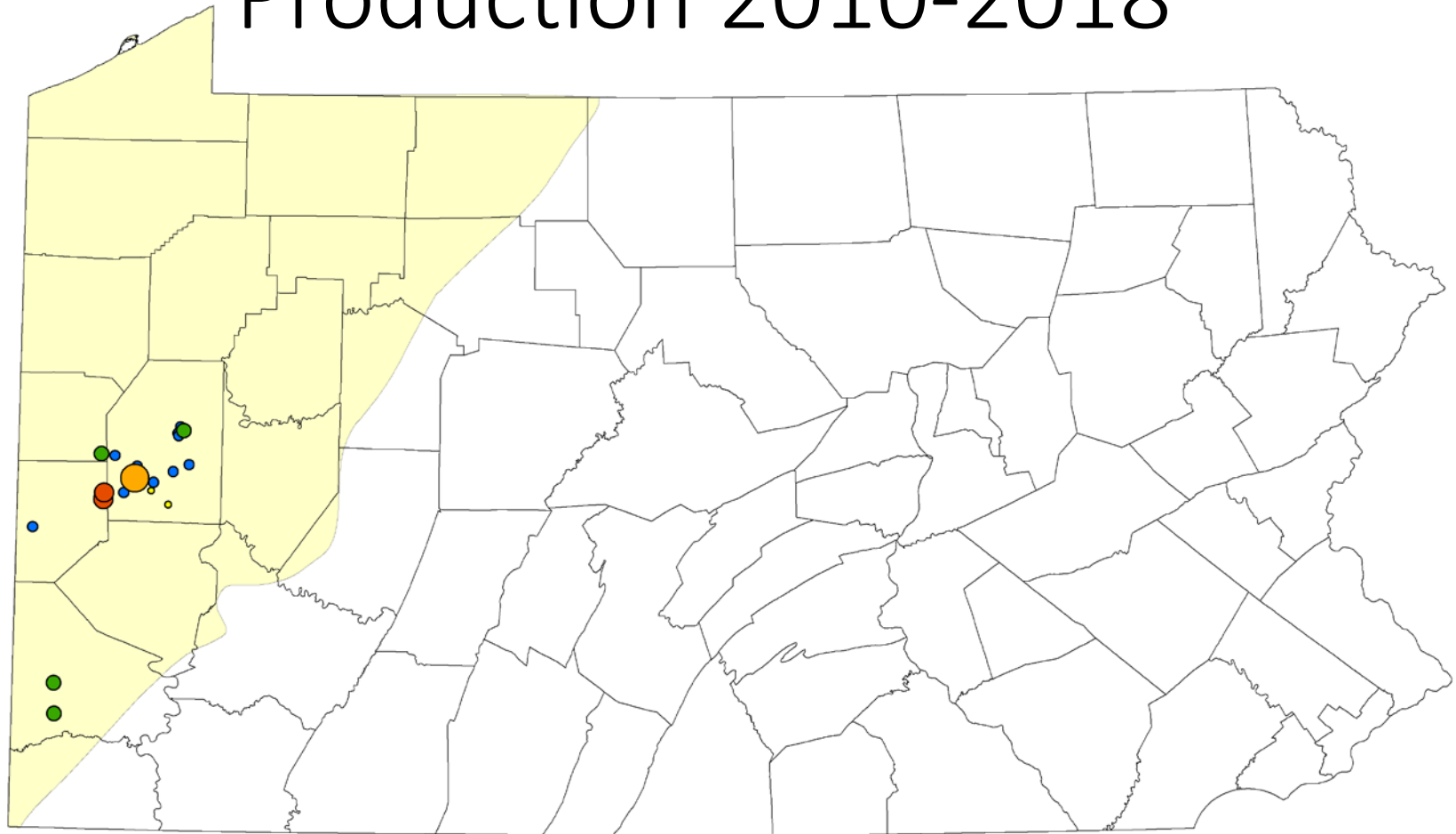


Total oil production (bbls)

- 0 – 500
- 500 – 5,000

 Rhinestreet Shale

Upper Devonian Condensate Production 2010-2018

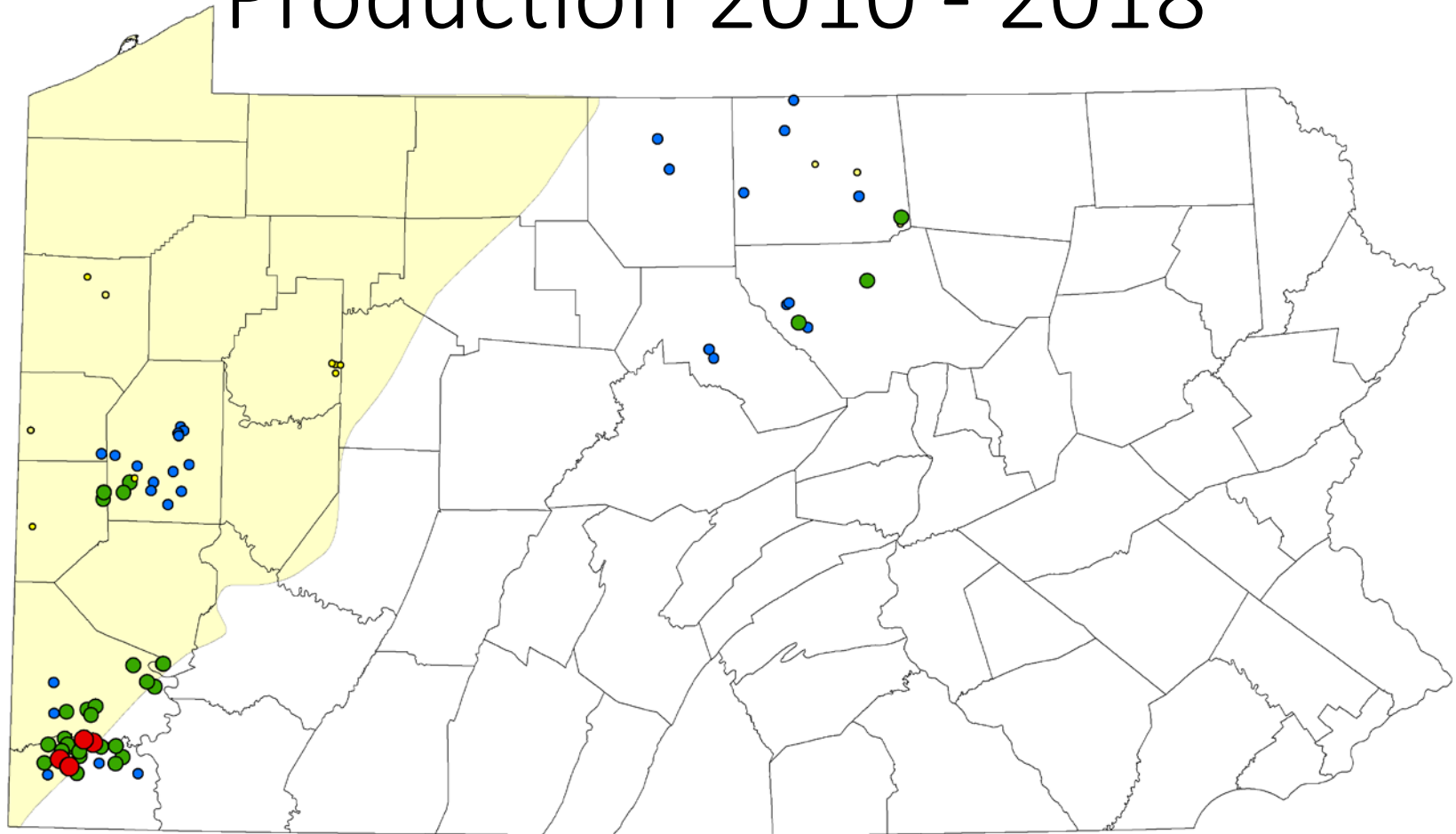


Total condensate production (bbls)

- | | | |
|---------------|-------------------|---------------------|
| • 0 – 500 | • 5,000 – 20,000 | • 50,000 – 100,000 |
| • 500 – 5,000 | • 20,000 – 50,000 | • 100,000 – 150,000 |

 Rhinestreet Shale

Upper Devonian Natural Gas Production 2010 - 2018

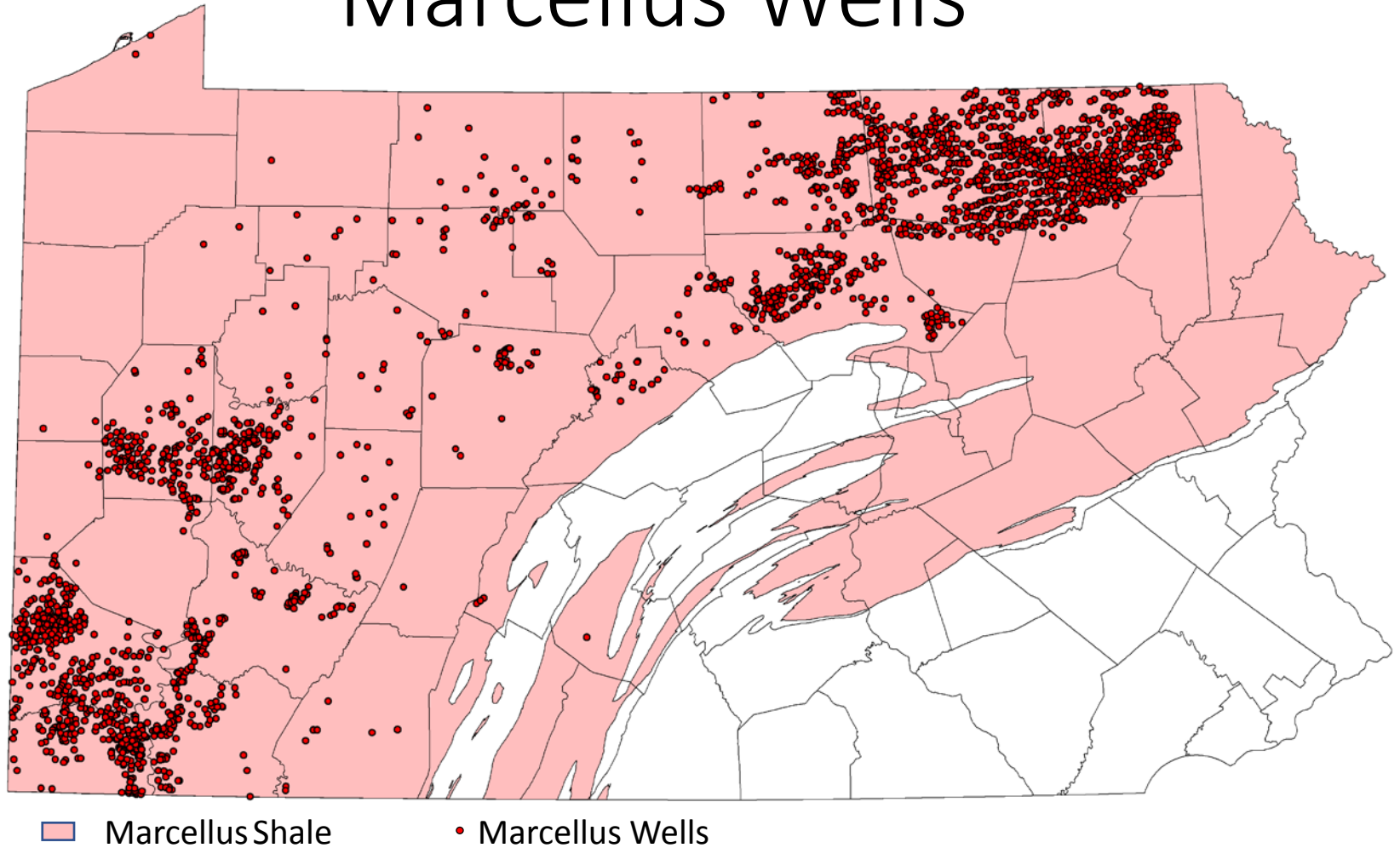


Total gas production (BCF)

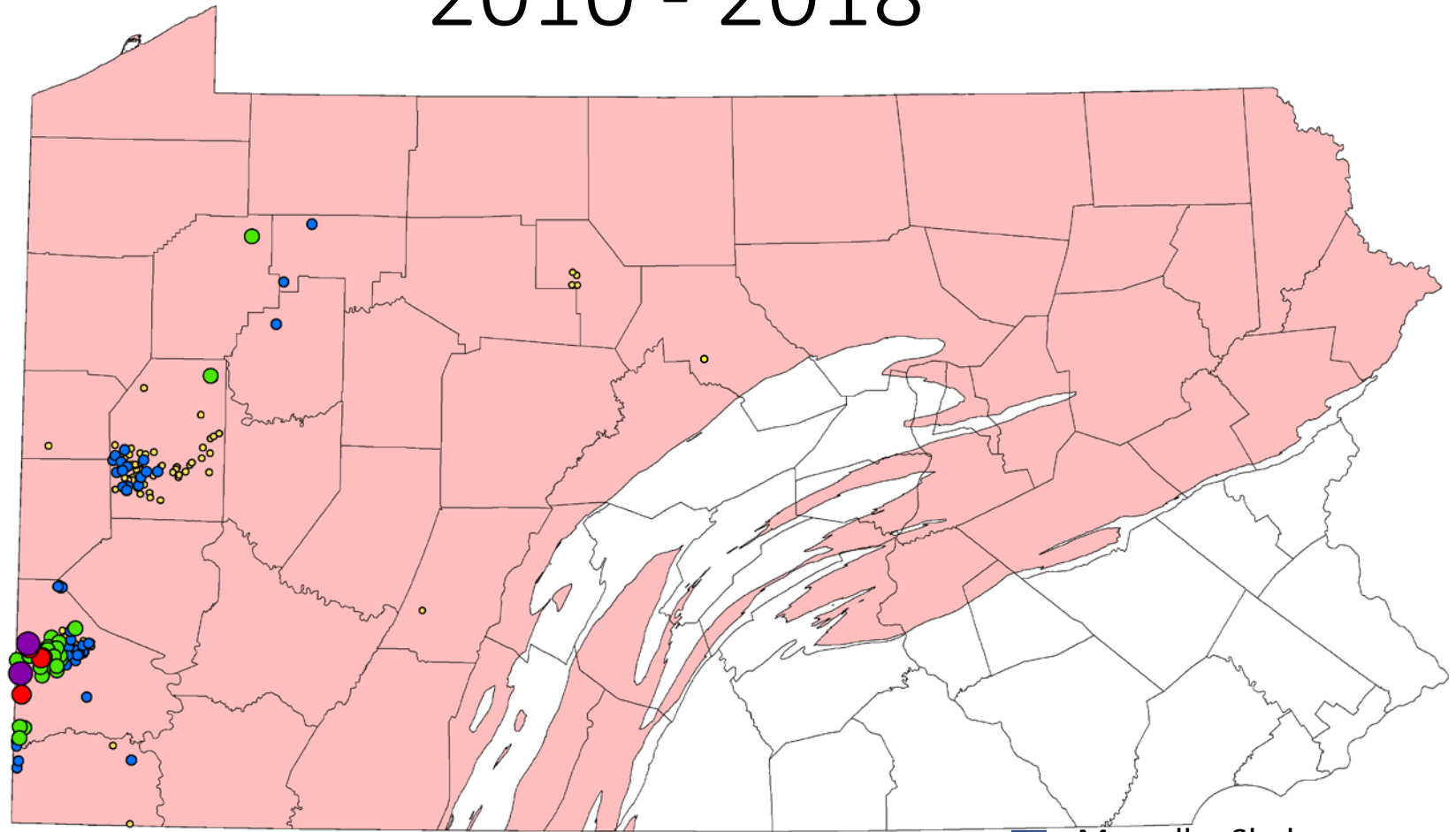
- 0 – 0.5
- 0.5 – 2.5
- 2.5 – 5.0
- 5.0 – 7.5

 Rhinestreet Shale

Marcellus Shale Extents with Marcellus Wells



Marcellus Oil Production 2010 - 2018



Total oil production (bbls)

• 0 – 500

• 500 – 5,000

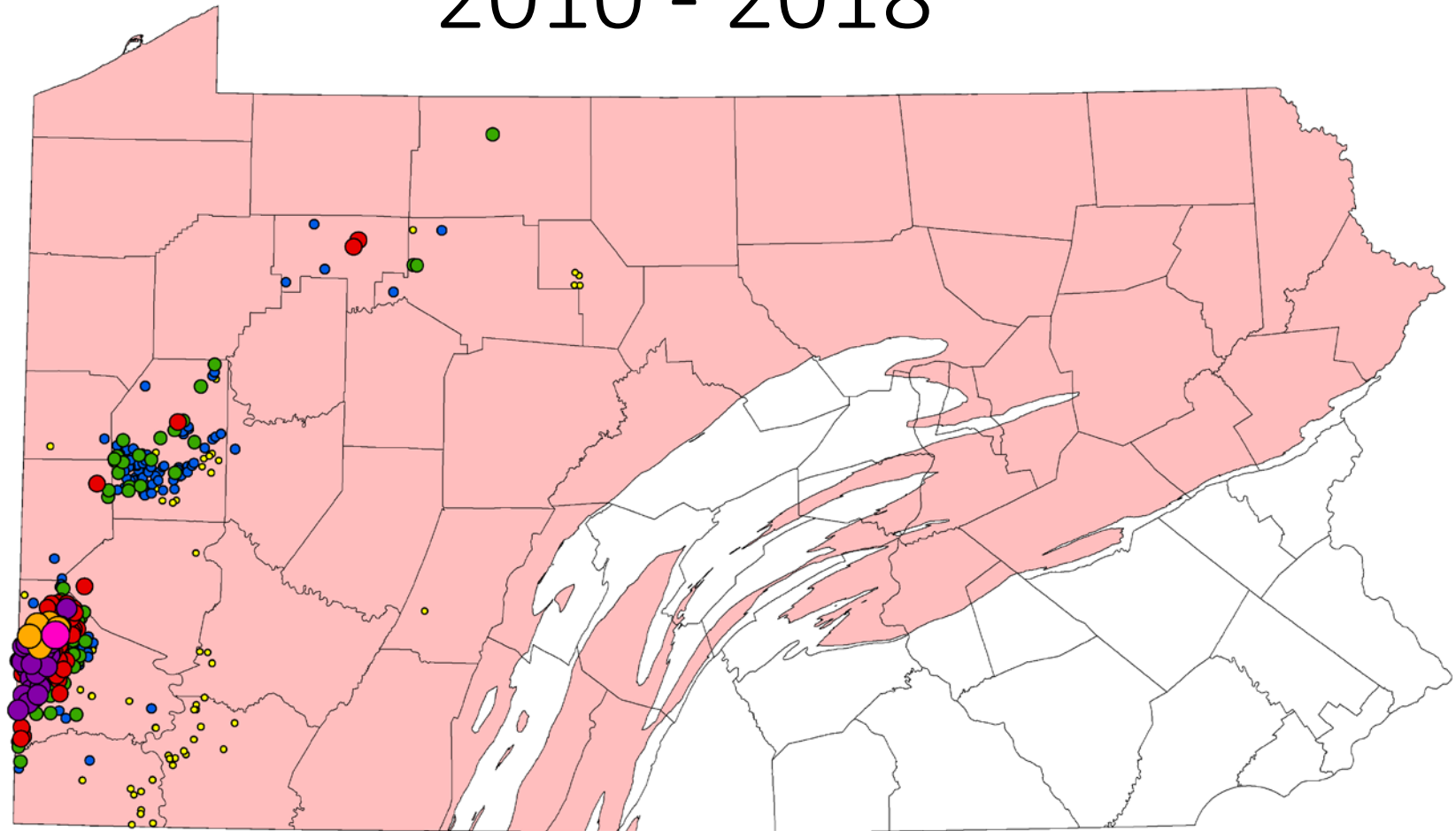
• 5,000 – 20,000

• 20,000 – 50,000

• 50,000 – 100,000

■ Marcellus Shale

Marcellus condensate Production 2010 - 2018

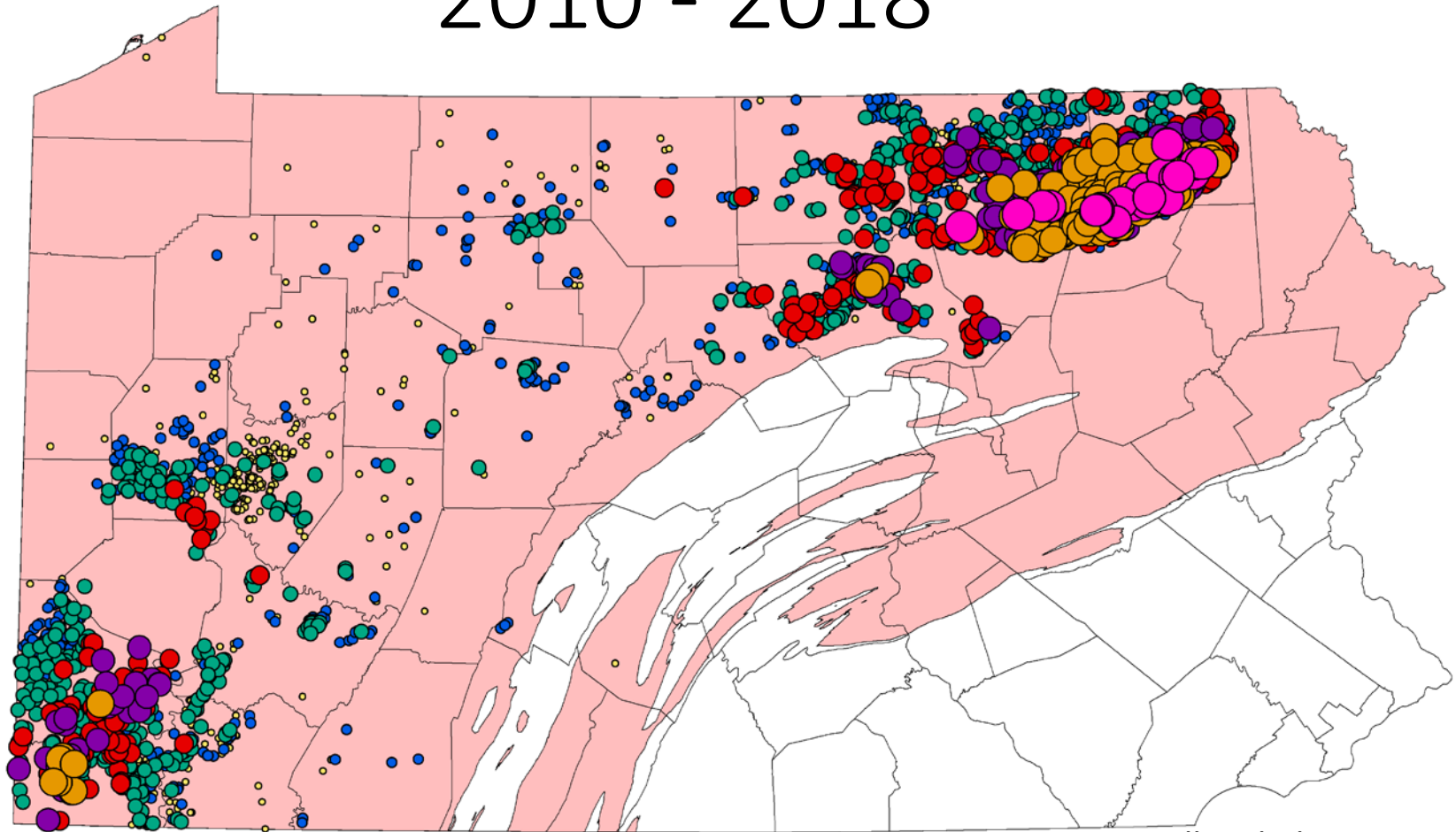


Total condensate production (bbls)



■ Marcellus Shale

Marcellus Natural Gas Production 2010 - 2018

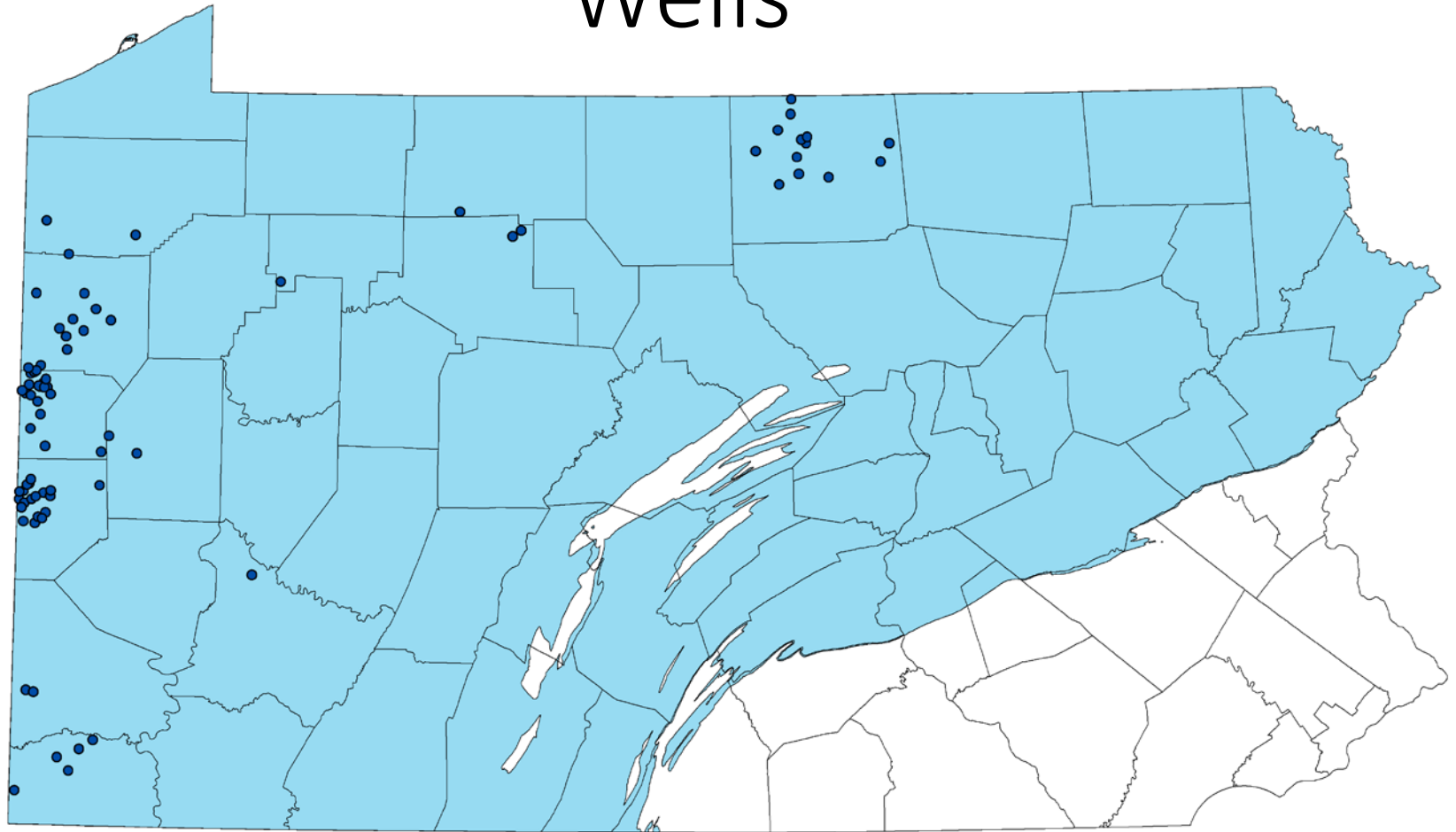


Total gas production (BCF)



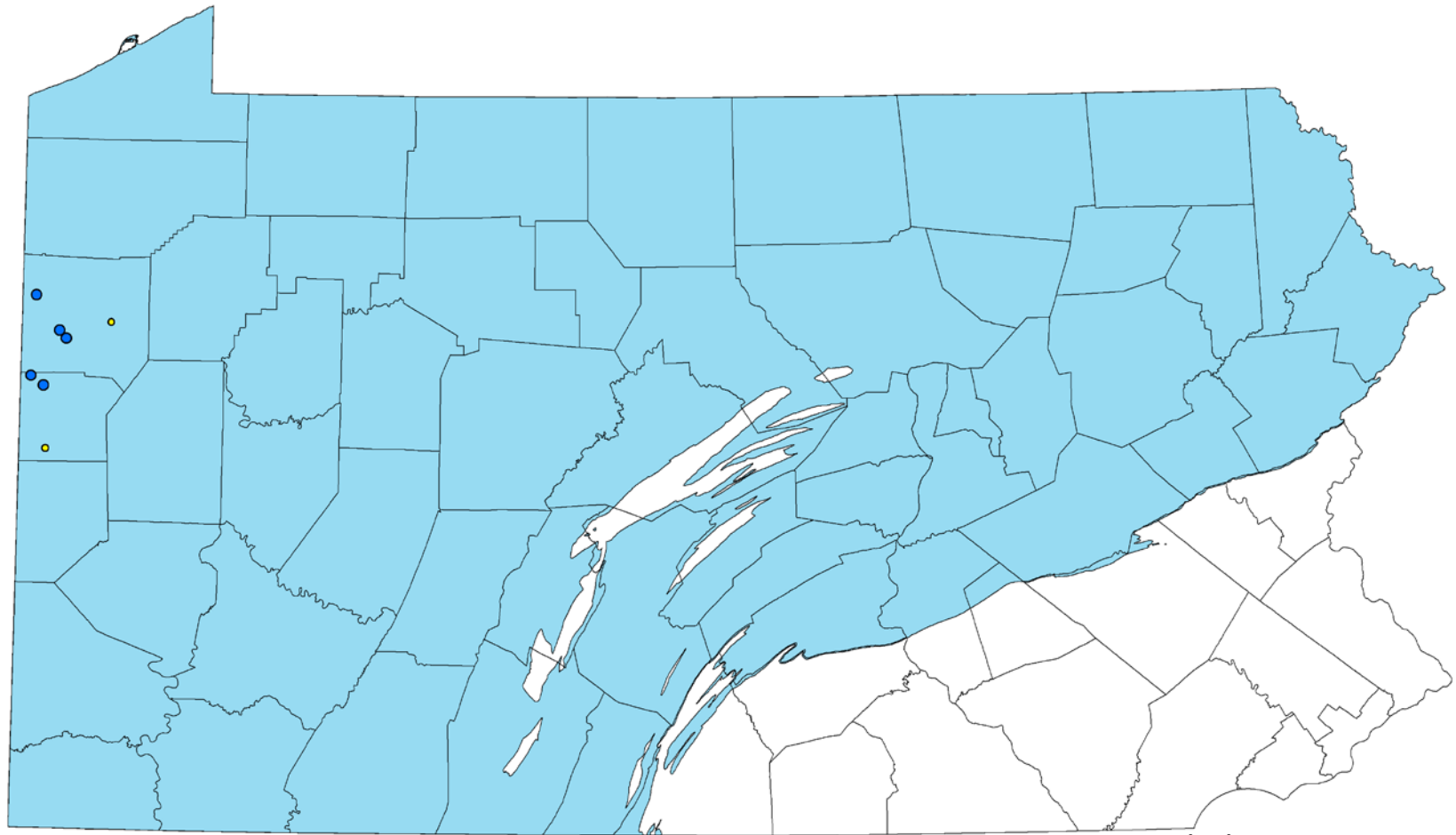
Marcellus Shale

Utica Shale Extents with Utica Wells



■ Utica Shale • Utica Wells

Utica Oil Production



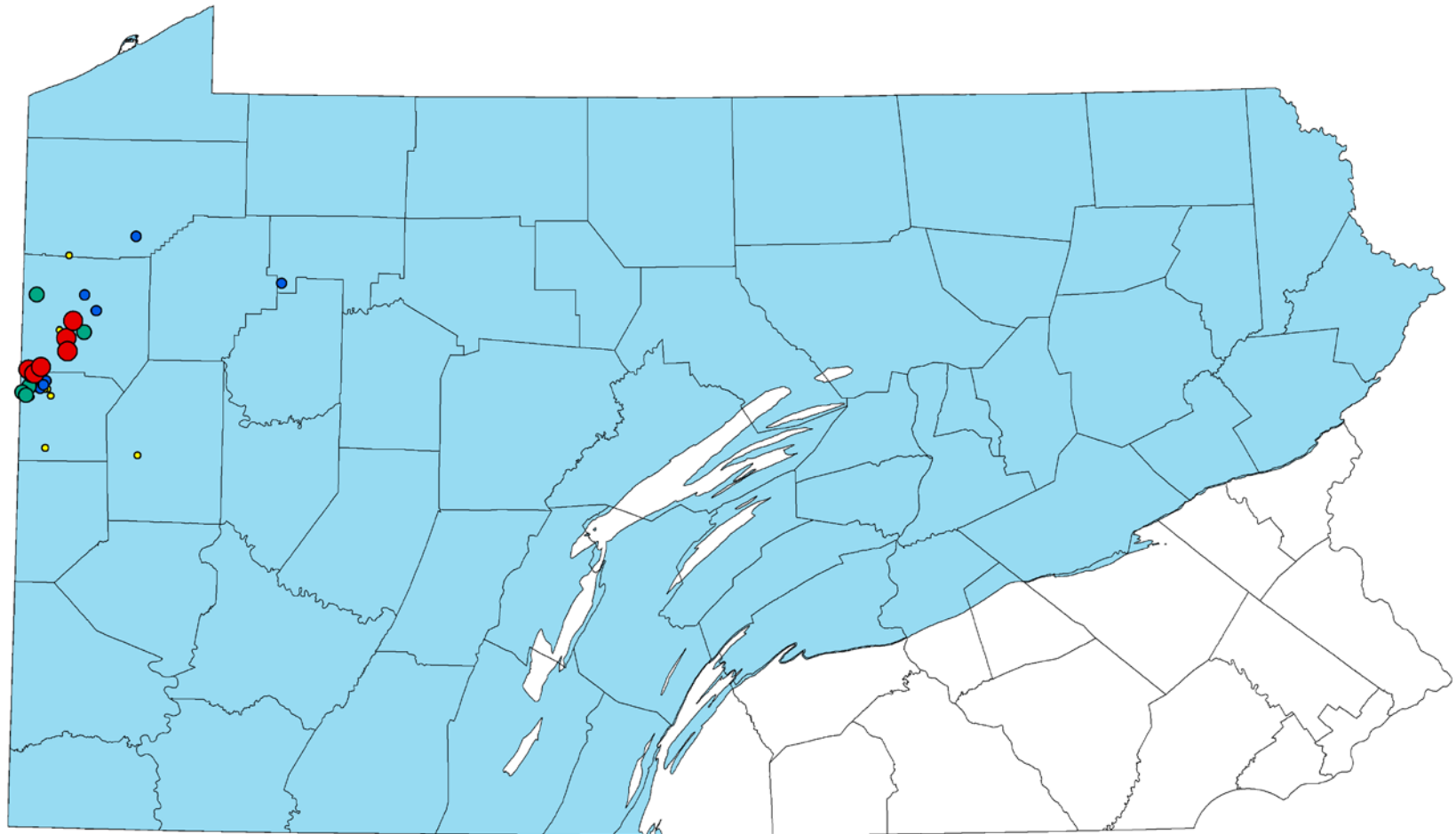
Total oil production (bbls)

0 – 500


500 – 5,000

■ Utica Shale

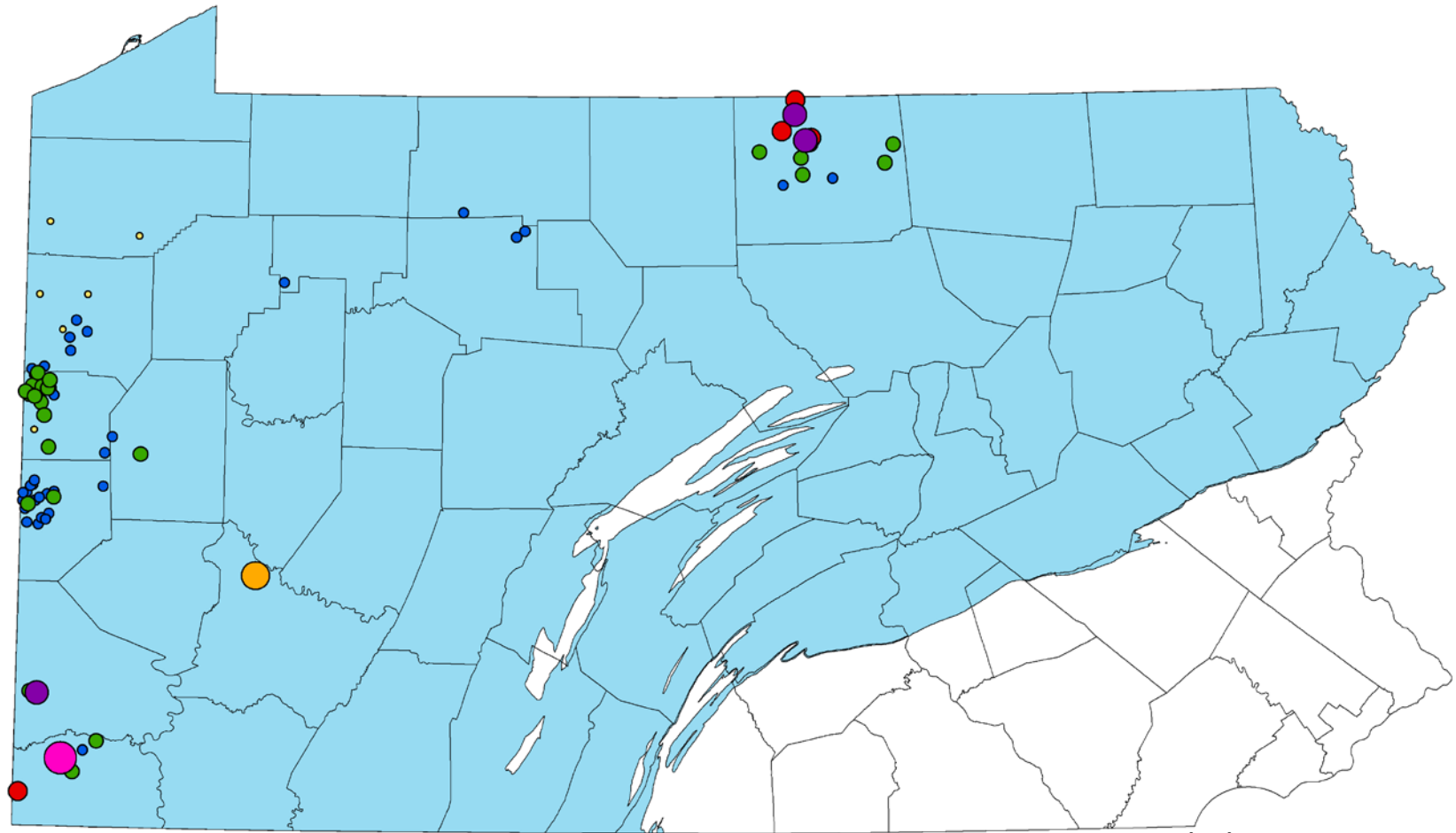
Utica Condensate Production

**Total condensate production (bbls)**

- 0 – 500
- 500 – 5,000
- 5,000 – 20,000
- 20,000 – 50,000

 Utica Shale

Utica Natural Gas Production

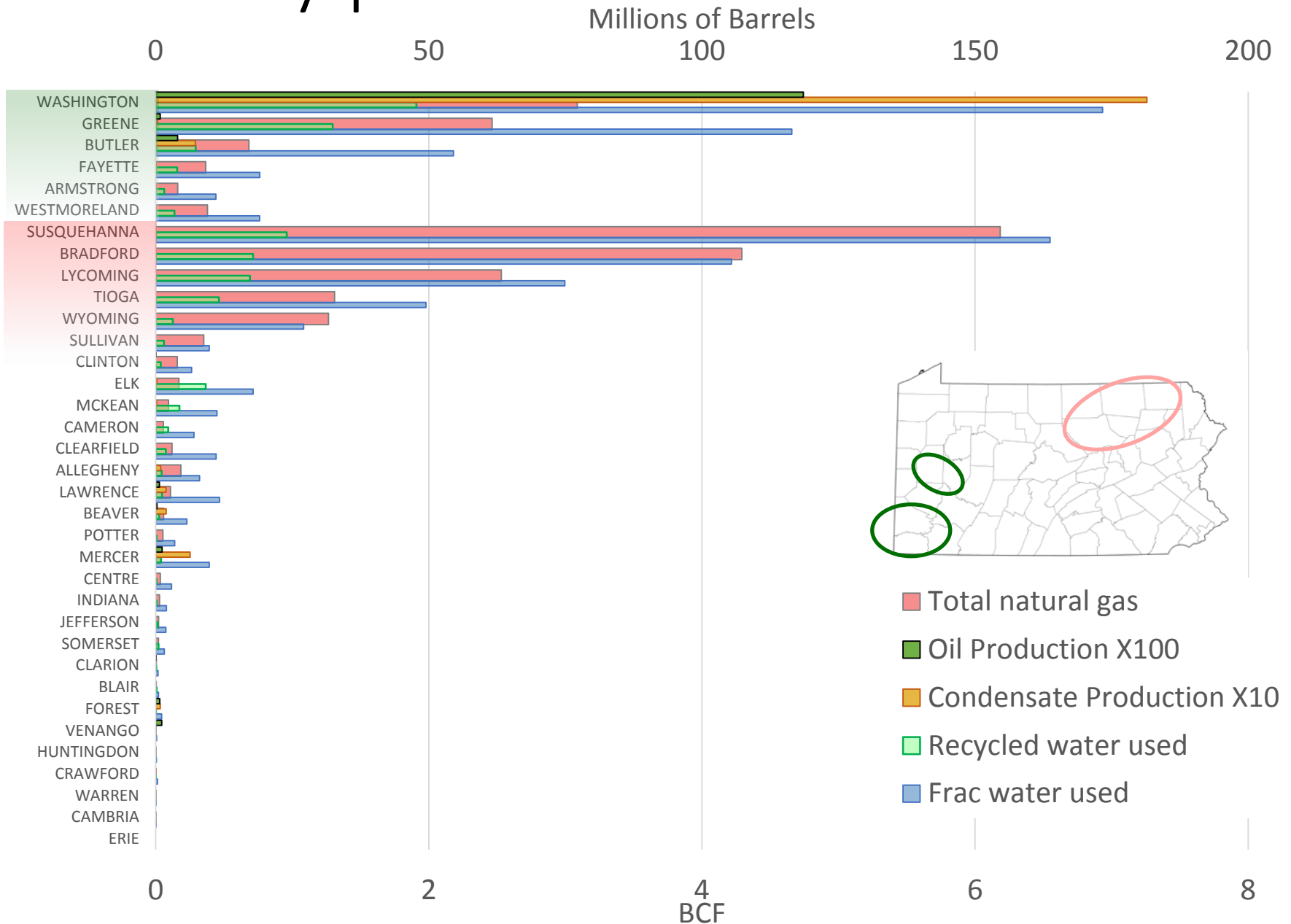


Total gas production (BCF)

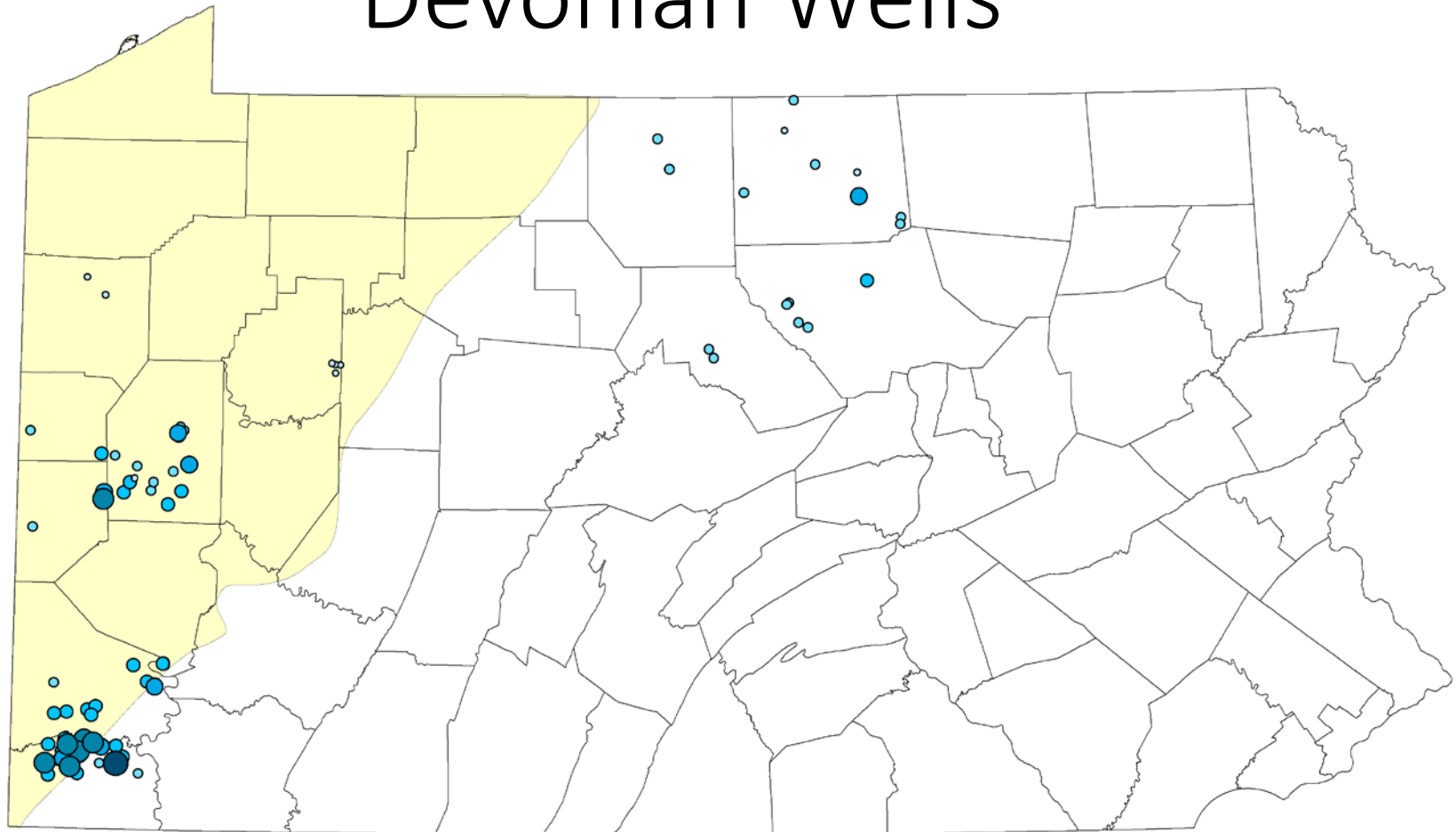


Utica Shale

County production and water use



Water used to Frac Upper Devonian Wells

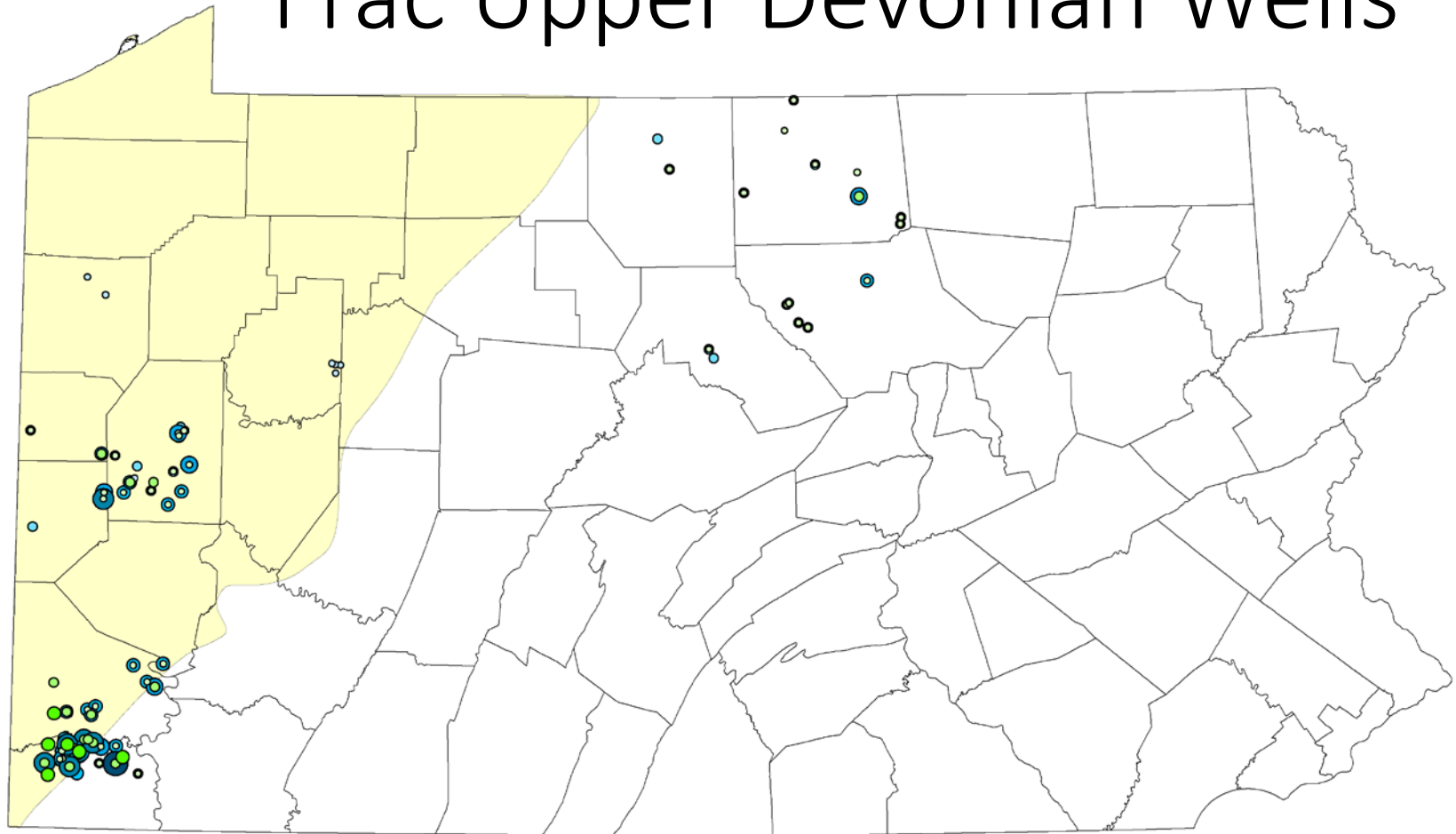


Total frac water (Mgal)

- 0.0 – 2.5
- 2.5 – 6.5
- 6.5 – 10.0
- 10.0 – 12.5
- 12.5 – 15.0
- 15.0 – 25.0

 Rhinestreet Shale

Water and recycled water used to Frac Upper Devonian Wells



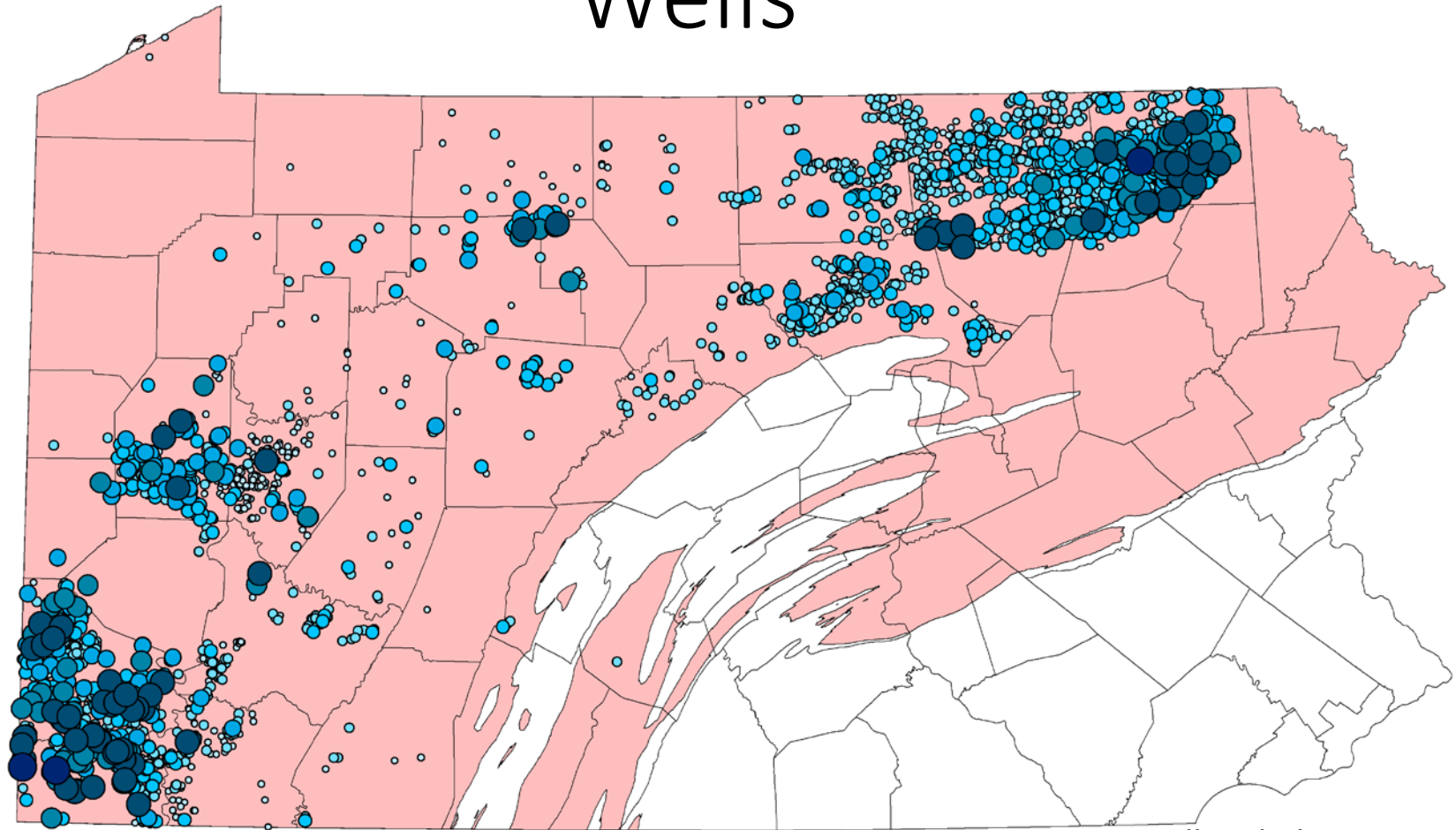
Total frac water (Mgal)

- 0.0 – 2.5
- 2.5 – 6.5
- 6.5 – 10.0
- 10.0 – 12.5
- 12.5 – 15.0
- 15.0 – 25.0

Total recycled water (Mgal)

- 0.0 – 2.5
- 2.5 – 6.5
- 6.5 – 10.0
- 10.0 – 12.5
- 12.5 – 15.0

Water used to Frac Marcellus Wells

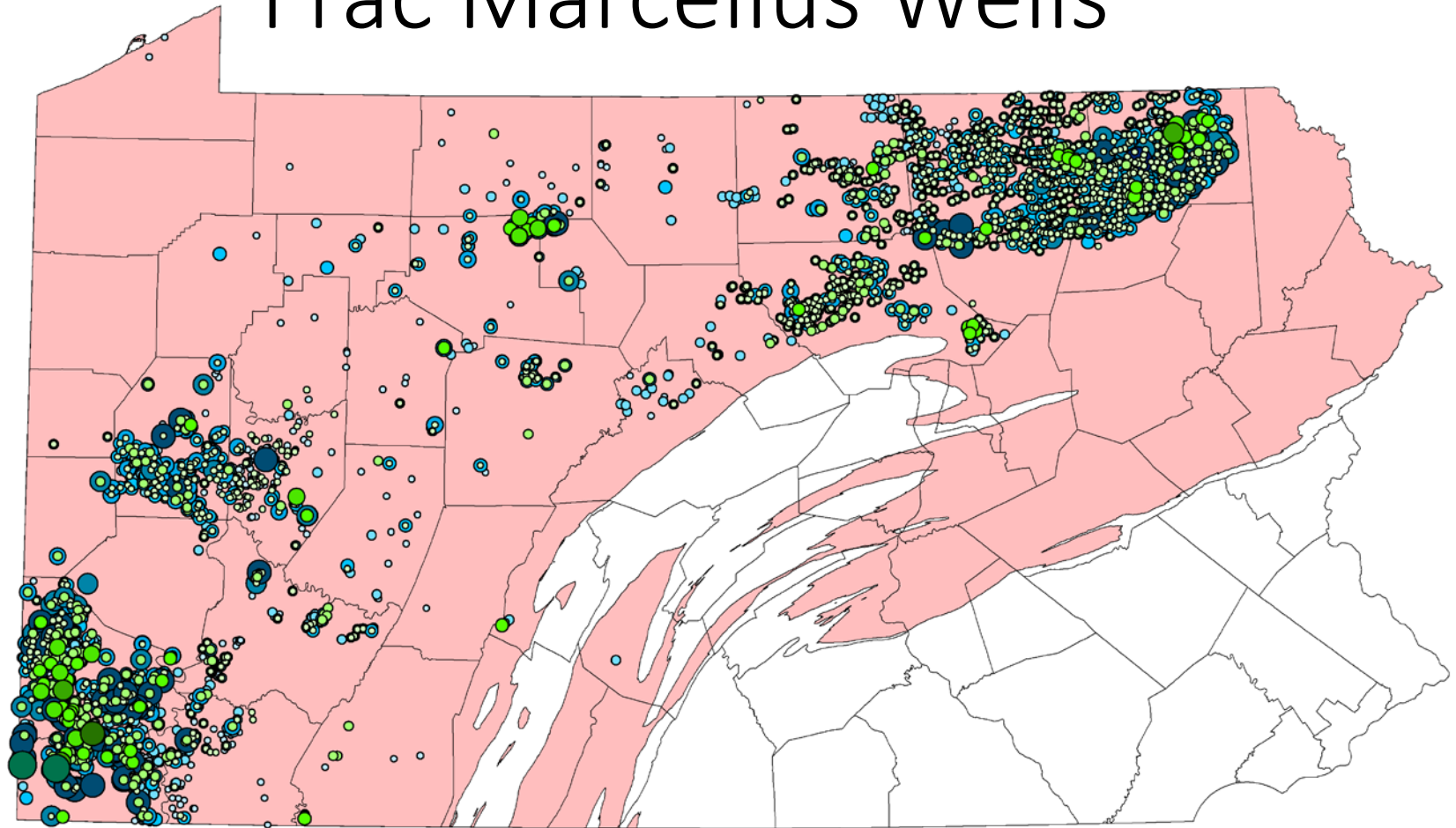


Total frac water (Mgal)

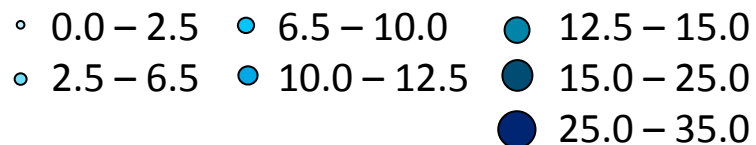
- 0.0 – 2.5
- 2.5 – 6.5
- 6.5 – 10.0
- 10.0 – 12.5
- 12.5 – 15.0
- 15.0 – 25.0
- 25.0 – 35.0

◻ Marcellus Shale

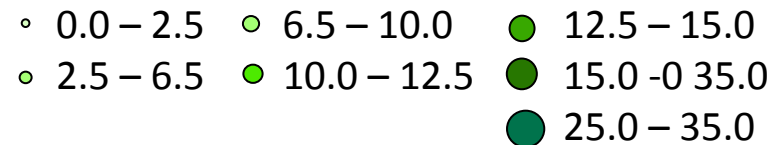
Water and recycled water used to Frac Marcellus Wells



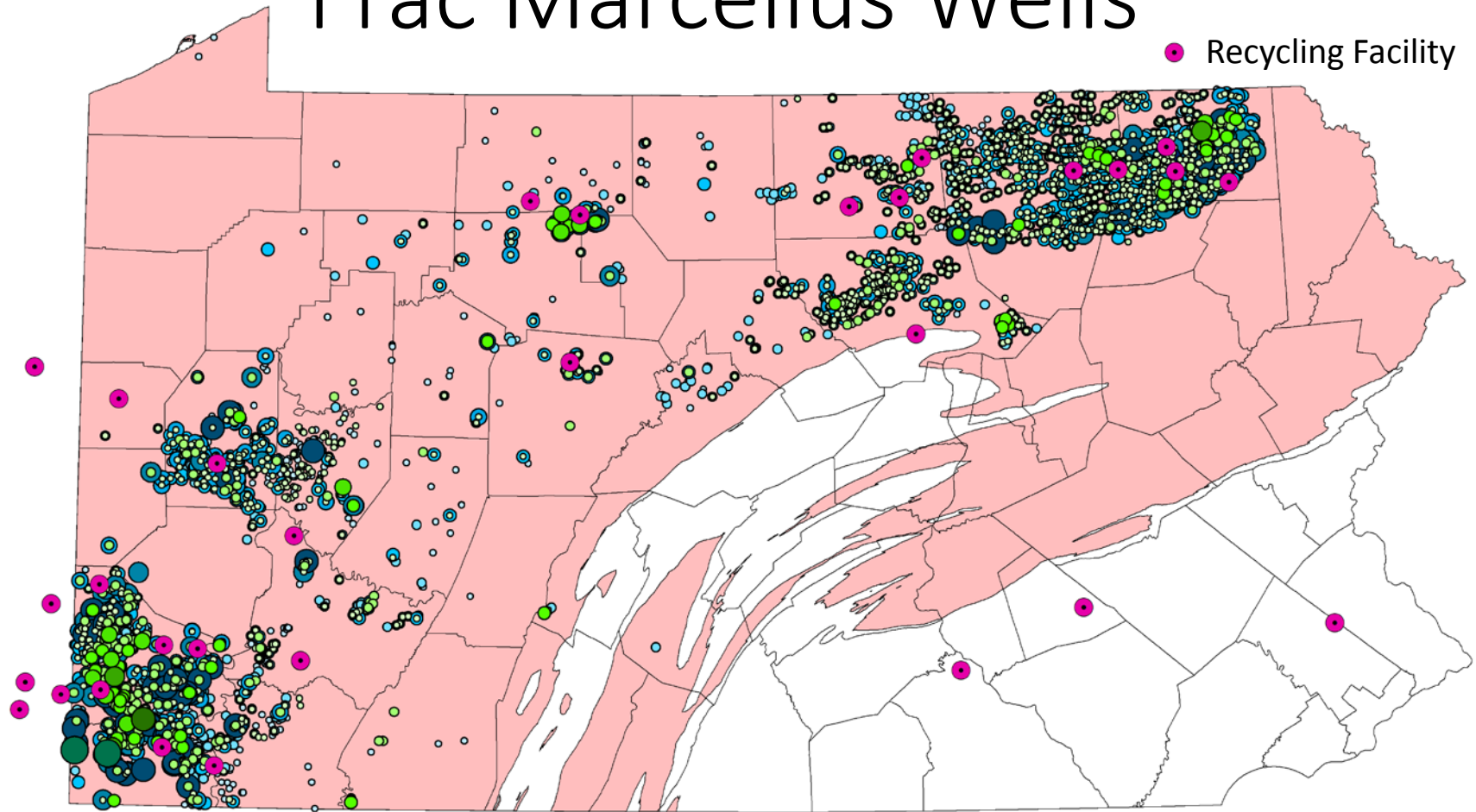
Total frac water (Mgal)



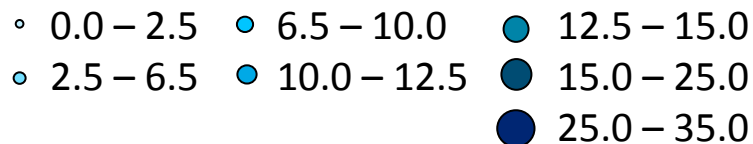
Total recycled water (Mgal)



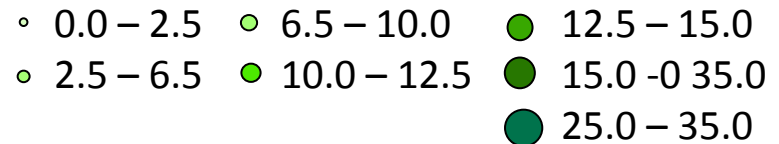
Water and recycled water used to Frac Marcellus Wells



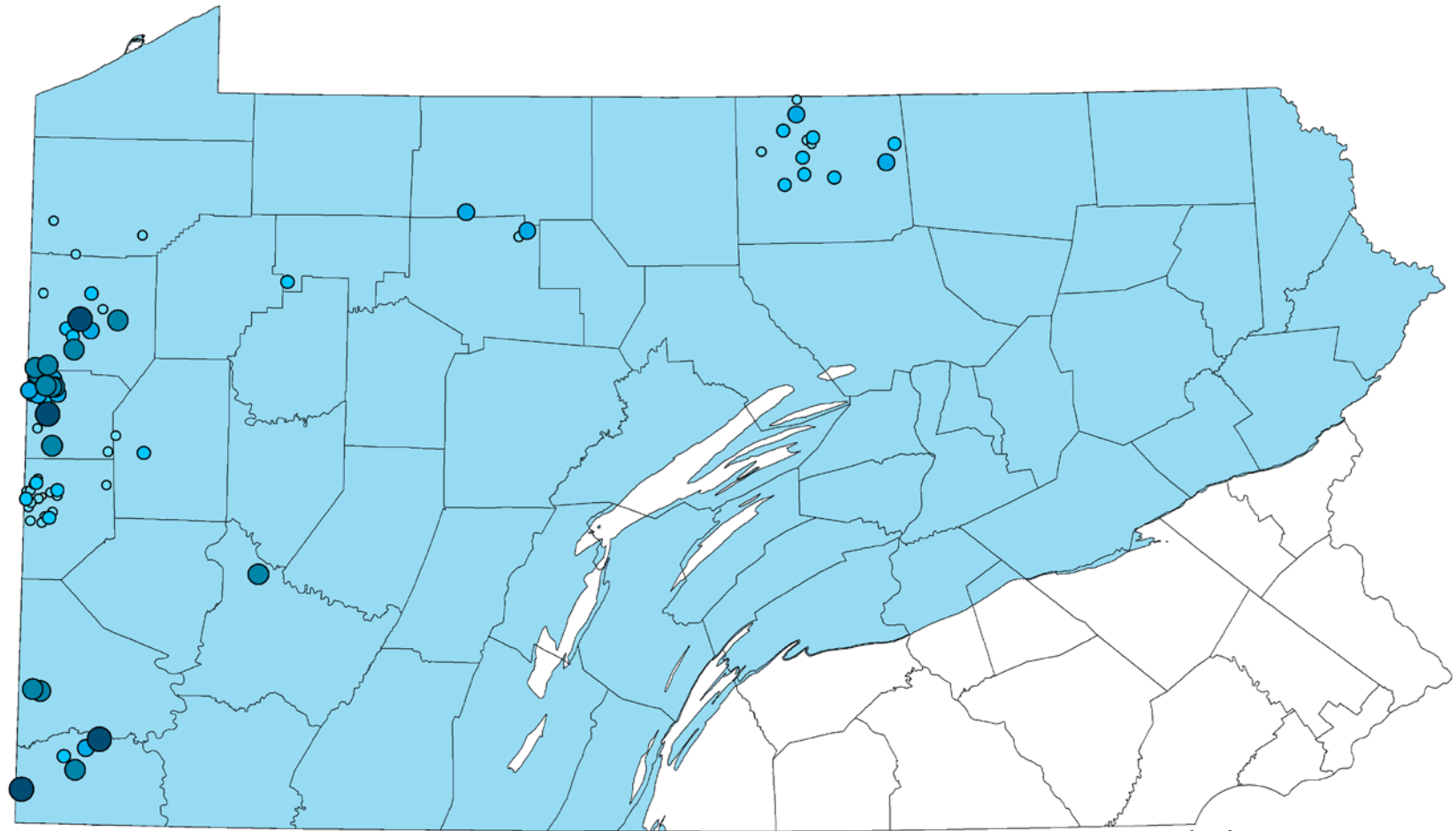
Total frac water (Mgal)



Total recycled water (Mgal)



Water used to Frac Utica Wells

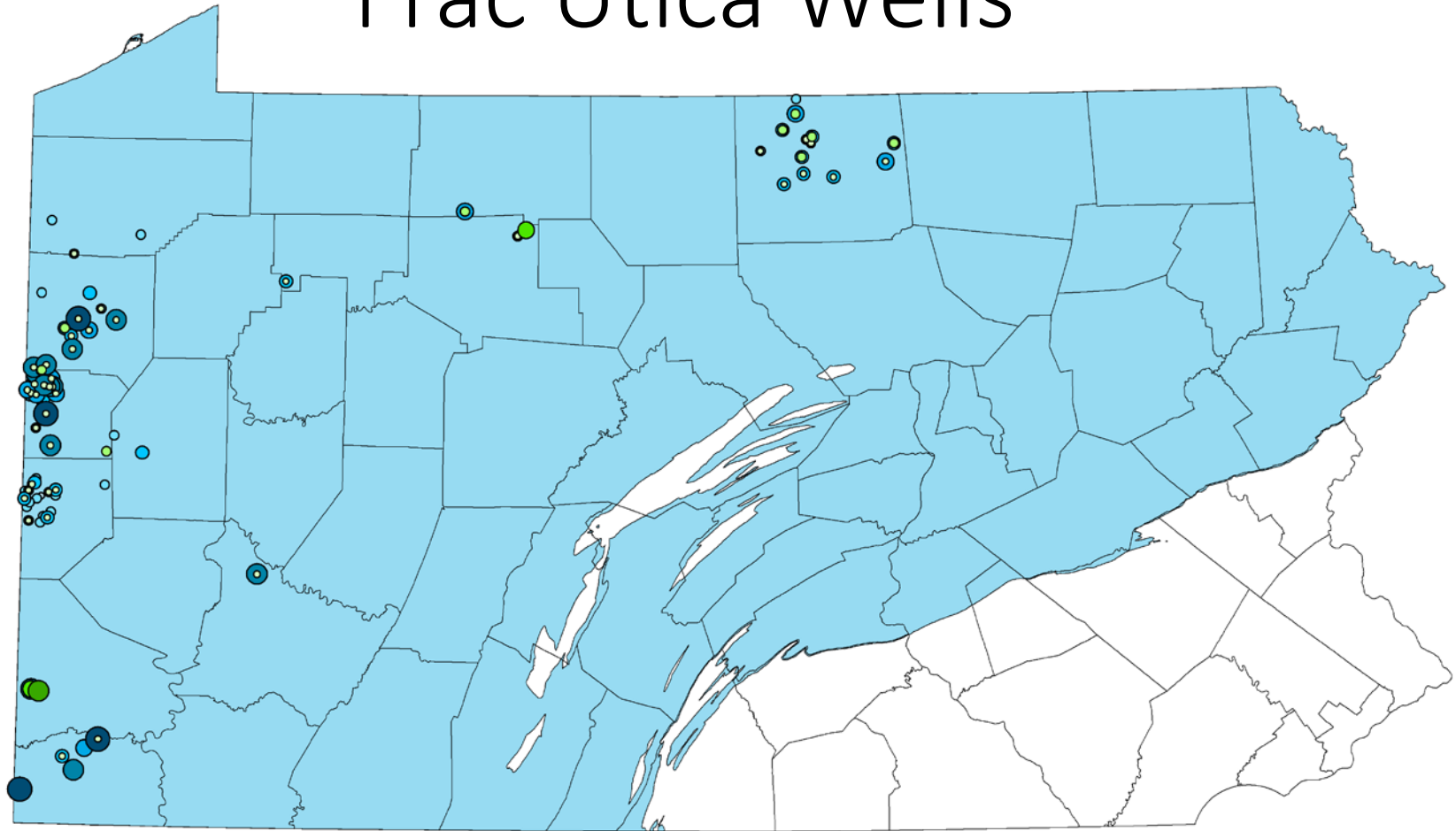


Total frac water (Mgal)

- 0.0 – 2.5
- 2.5 – 6.5
- 6.5 – 10.0
- 10.0 – 12.5
- 12.5 – 15.0
- 15.0 – 25.0

Utica Shale

Water and recycled water used to Frac Utica Wells



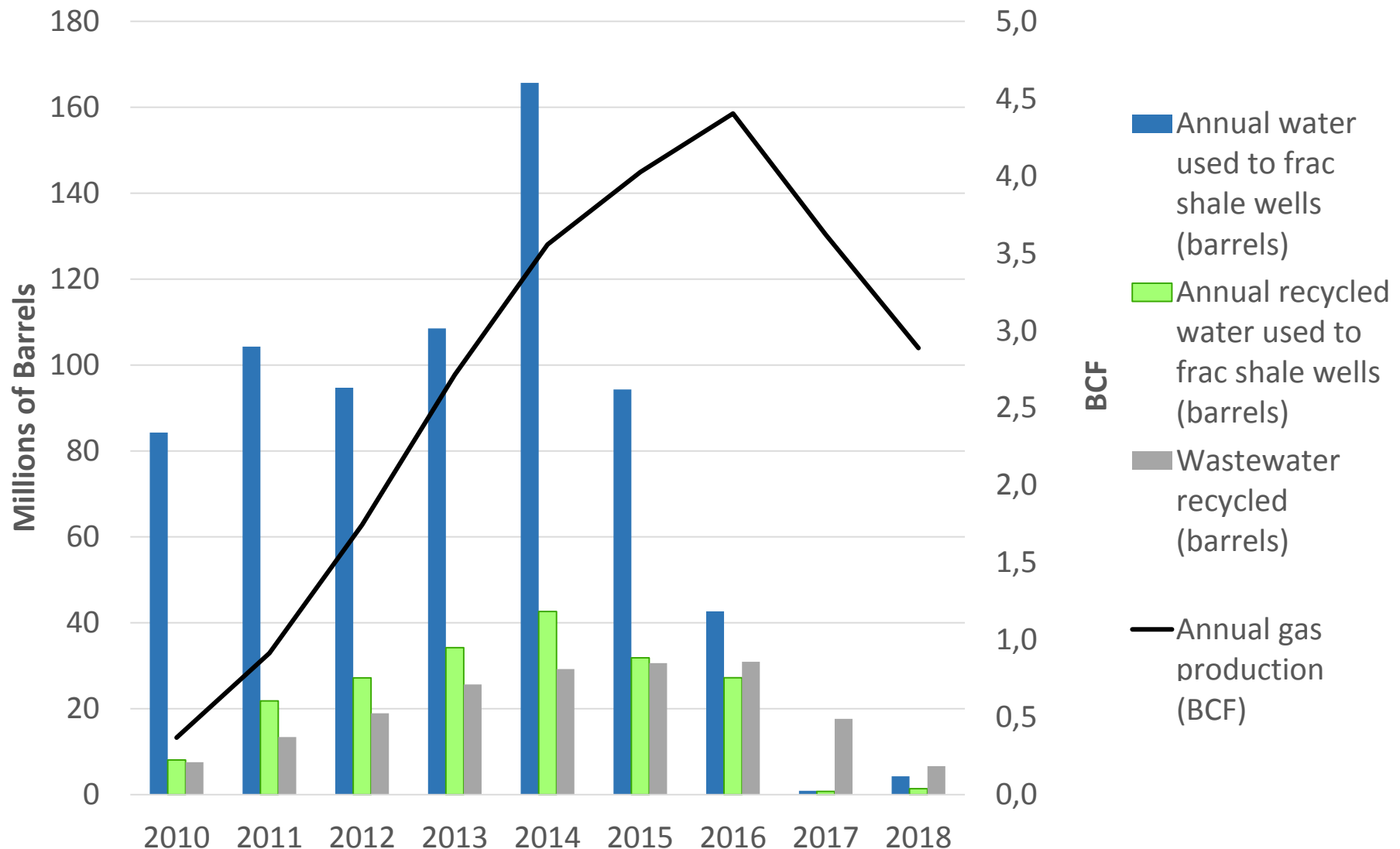
Total frac water (Mgal)

- 0.0 – 2.5
- 2.5 – 6.5
- 6.5 – 10.0
- 10.0 – 12.5
- 12.5 – 15.0
- 15.0 – 25.0

Total recycled water (Mgal)

- 0.0 – 2.5
- 2.5 – 6.5
- 6.5 – 10.0
- 10.0 – 12.5
- 12.5 – 15.0

Annual gas production vs water use



Conclusions

- More than 75% of the state's hydrocarbon production comes from the two 'sweet spots' of the Marcellus shale play
 - Over half the natural gas production comes from the northeastern 'sweet spot'
 - 90% of the liquids production comes from Washington County in the southwestern 'sweet spot'
- Most of the waste water from these wells is recycled and reused in other wells



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