extent of the Marcellus Shale fairway generally lies within West Virginia, and in a short period of time, Marcellus drilling activity has transformed the economic landscape and outlook of natural resources in West Virginia. Since 2005, over 2100 Marcellus wells but use of the technical combination of horizontal drilling and hydraulic fracturing of wells created a rapid escalation of shale gas drilling in the Appalachian basin. Approximately 650 of those gas production in West Virginia has increased from approximately 0.8 Tcf in 2005 to over 3 Tcf in 2012. Though some of these well have commingled production from other producing zones, the gas". Multiple-stage completions in excess of 40 stages and measured depths of over 15,000 ft are observed. The lateral legs are often drilled perpendicular to naturally occurring structures to increased steadily from 2005 to 2012. While the present focus is natural gas would again lead to an expanded geographical interest of the dry gas regions of the Marcellus Shale in West Virginia. Regardless, projections for future production continue to increase. The West Virginia Geological and Economic Survey(WVGES) continuously updates a database for all oil and gas activity in West Virginia while conducting geological research Current research includes the examination of the geological controls on the Marcellus Shale as well as a volumetric resource assessment of Marcellus potential in the State.



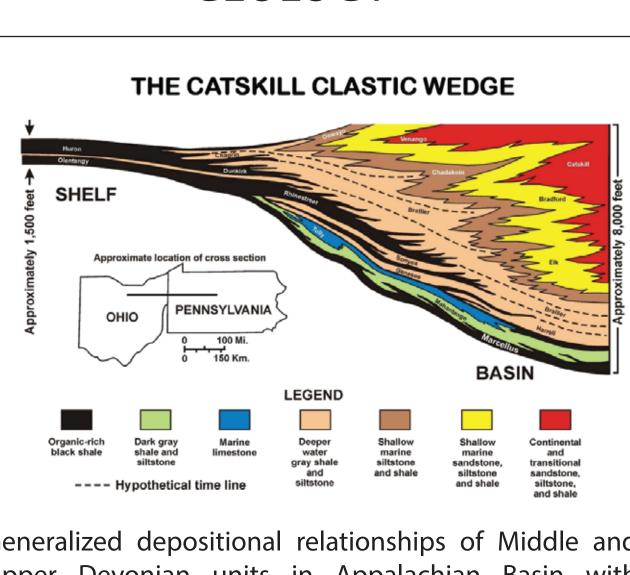




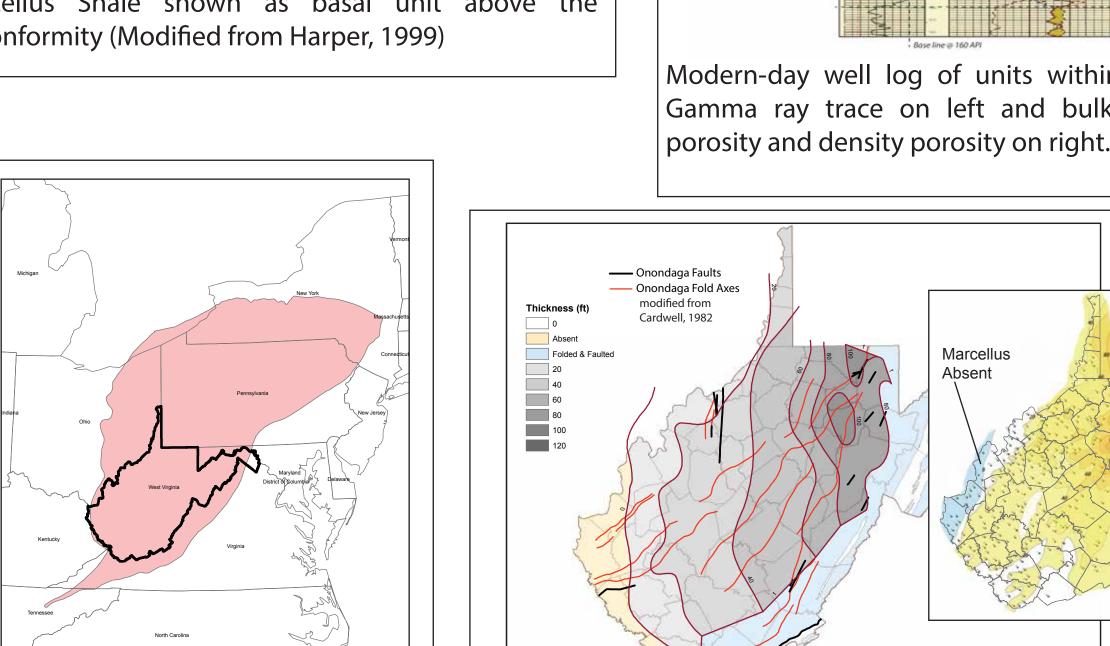
showing stratigraphic position of Middle

Devonian Marcellus Shale.

# West Virginia Geological & Economic Survey, 1 Mont Chateau Rd, Morgantown, WV, 26508, pdinterman@geosrv.wvnet.edu GEOLOGY



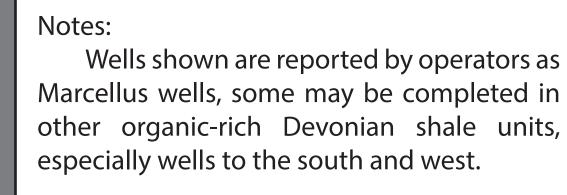
unconformity (Modified from Harper, 1999)



Maps showing thickness of organic-rich shale with high gamma ray readings within the Hamilton Group as described by Schwietering (1980) on left and updated work by Pool (2013) on right. Also, with location of West Virginia shown are Onondaga age mapped faults and fold axes. Thickness does not constitute entire Marcellus Shale thickness, but only the highly radioactive subset of it. Exact location of westernmost extent of Marcellus Shale is estimated.

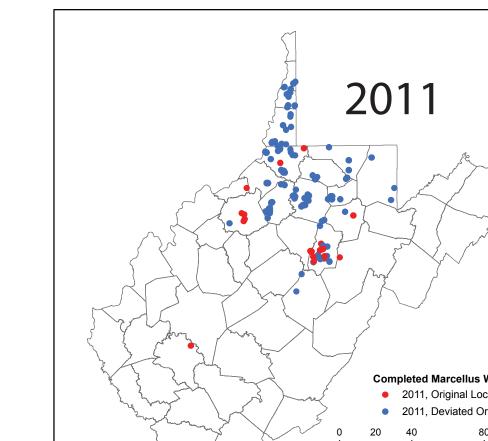
### YEAR BY YEAR LOCATIONS OF COMPLETED MARCELLUS WELLS

2. Concentration of activity from a wider area to mostly north-central and northern West Virginia.



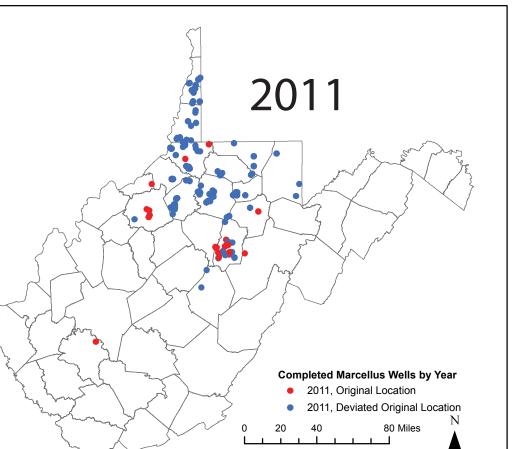
data current through

A lag time exists from when wells are drilled and reported to the WVGES. Therefore wells, especially for wells completed in 2013.



The Shifting Landscape of Marcellus Shale Development in West Virginia

Philip A Dinterman, Susan E. Pool, Jessica Pierson Moore, J. Eric Lewis, Jennifer L. Luczko

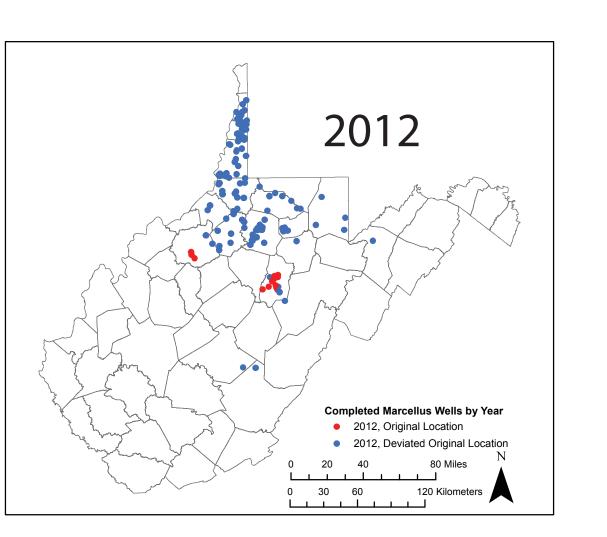


Completed Marcellus Wells by Yea

2005, Original Location

2008, Original Location

2008, Deviated Original Locatio



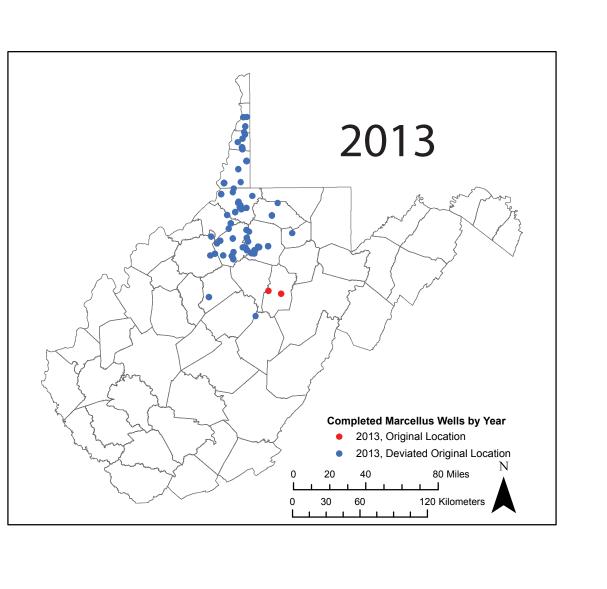
Completed Marcellus Wells by Year

2006, Original Location

Completed Marcellus Wells by Year

2009, Deviated Original Location

2009, Original Location



2007, Original Location

0 20 40 80 Miles 0 30 60 120 Kilometers

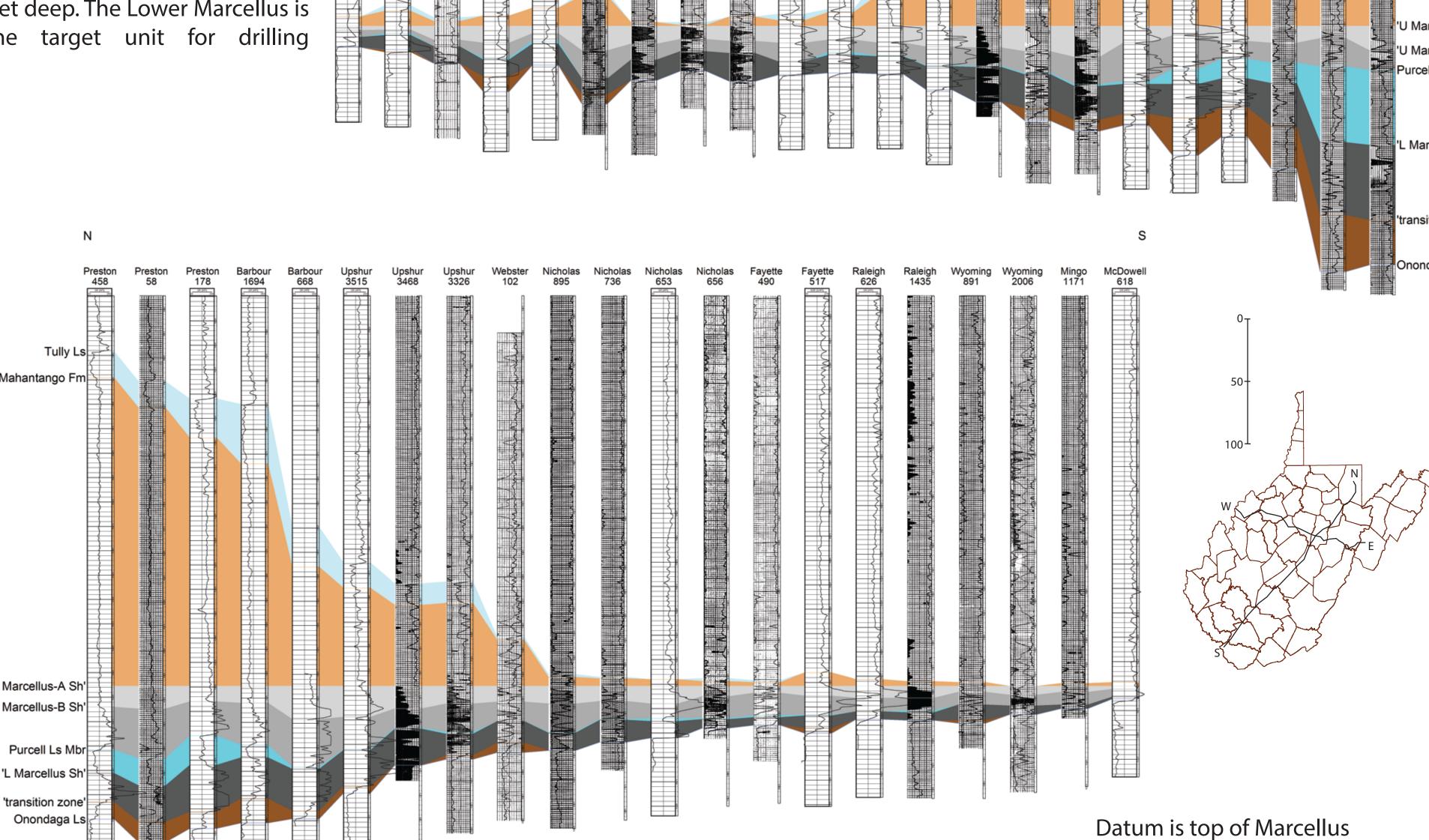
Completed Marcellus Wells by Year

2010, Deviated Original Location

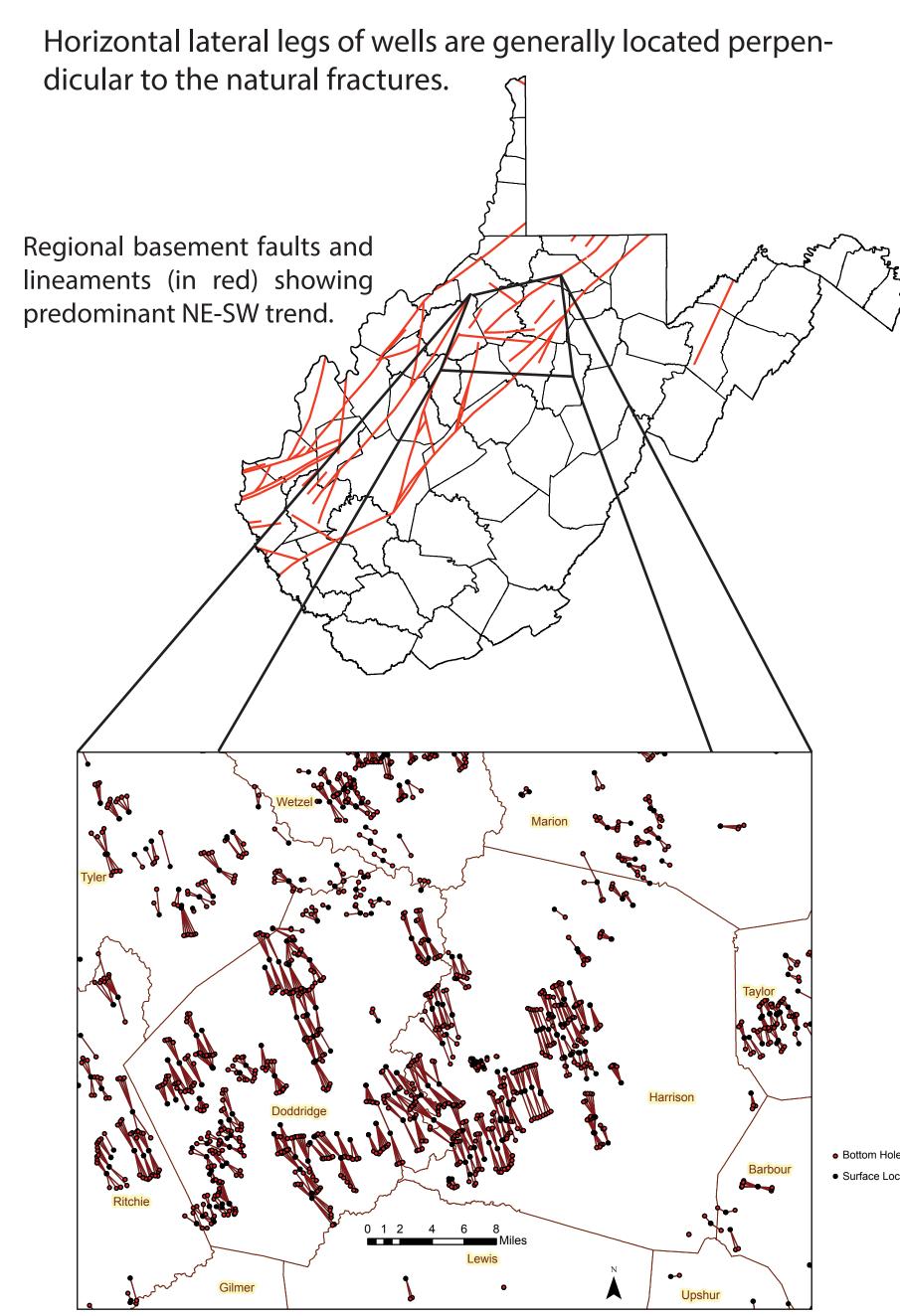
2010, Original Location

### **GEOLOGIC CROSS SECTIONS**

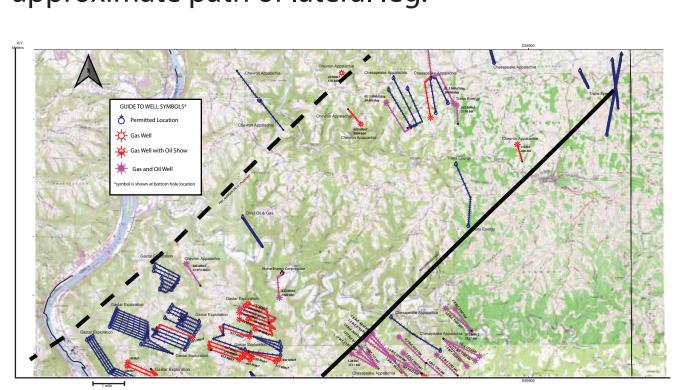
Marcellus thins to south and west and is exposed at the surface in eastern West Virginia. In West Virginia, the Marcellus is 5000-8000 feet deep. The Lower Marcellus is generally the target unit for drilling



### FRACTURE NETWORK

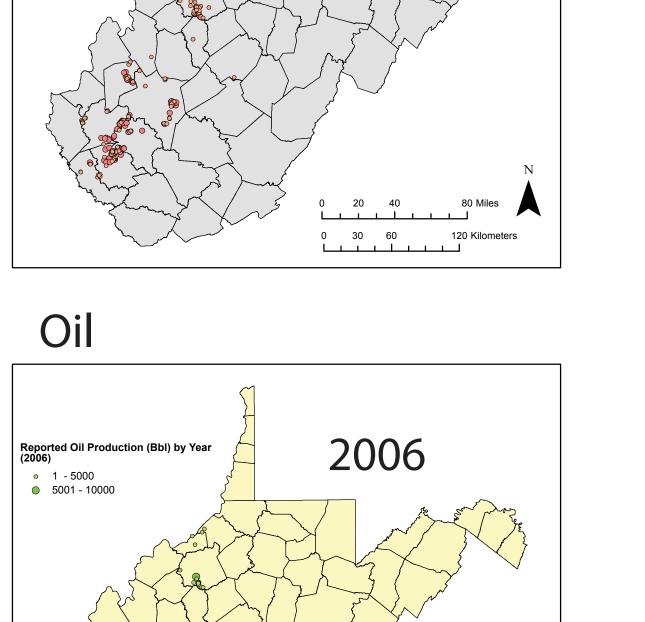


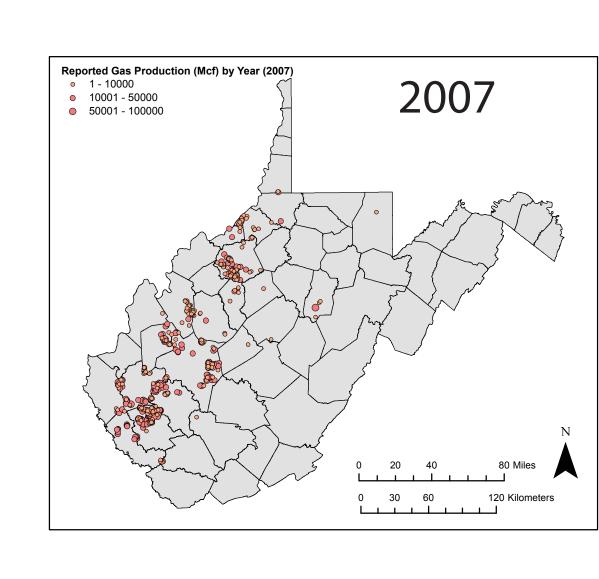
Marcellus surface and bottom hole locations connected by approximate path of lateral leg.

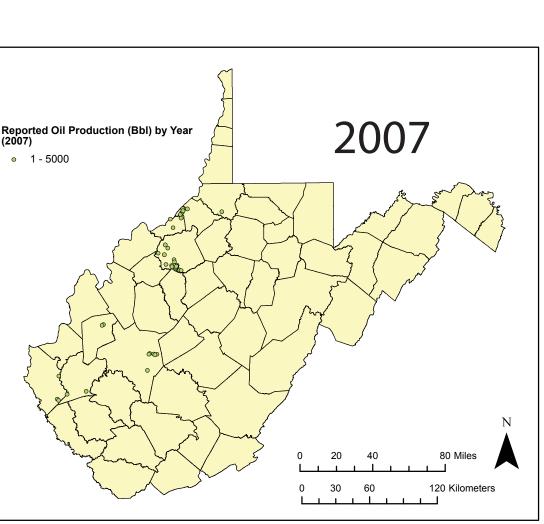


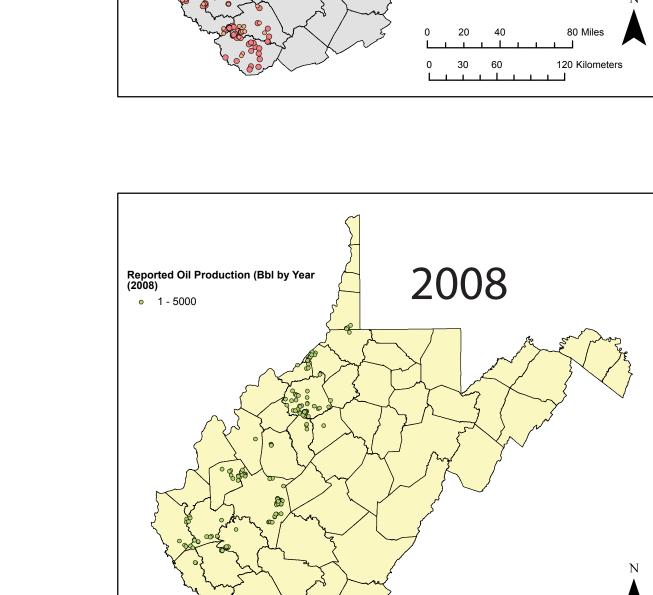
Detailed map of several horizontal wells showing horizontal leg and geometry of multiple laterals off of same well pad.

### REPORTED MARCELLUS SHALE PRODUCTION IN WEST VIRGINIA

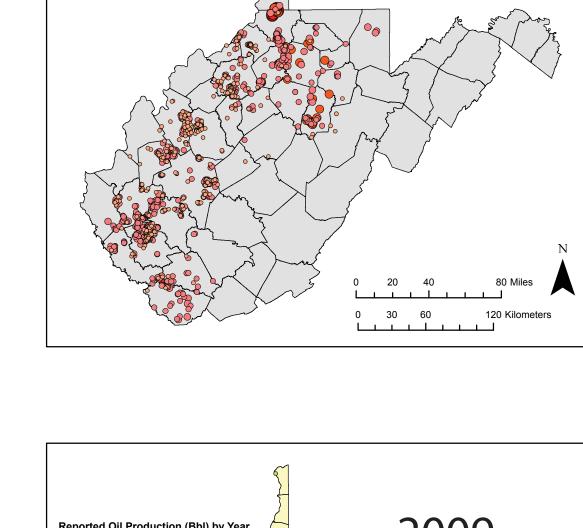


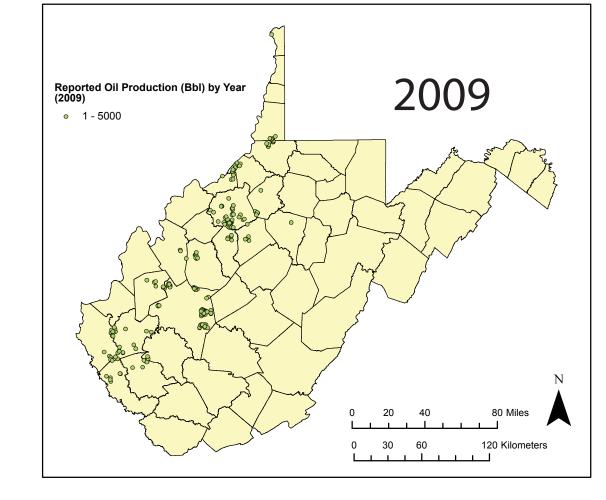


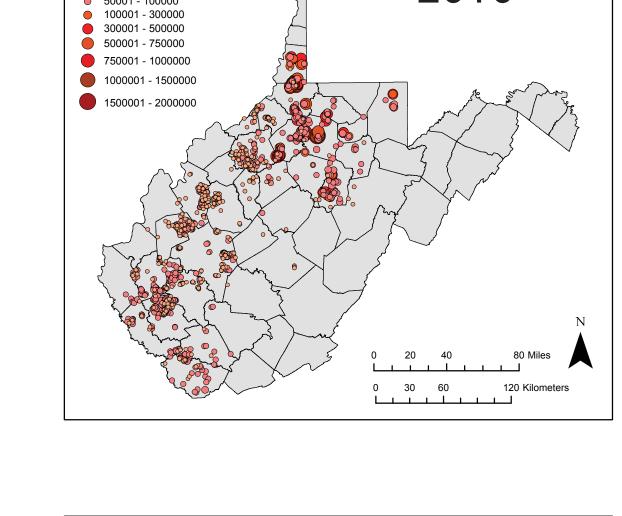


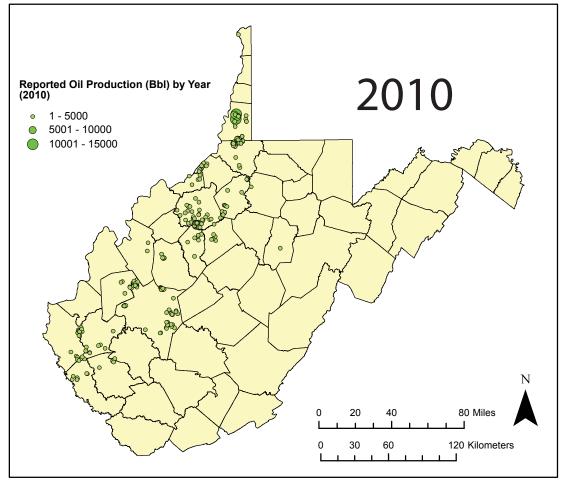


500001 - 750000 750001 - 1000000









1. Wetzel (283,421 bbl)

4. Marshall (94,411 bbl)

6. Ritchie (30,728 bbl)

3. Doddridge (112,143 bbl)

2. Ohio (145,120 bbl)

5. Tyler (35,201 bbl)

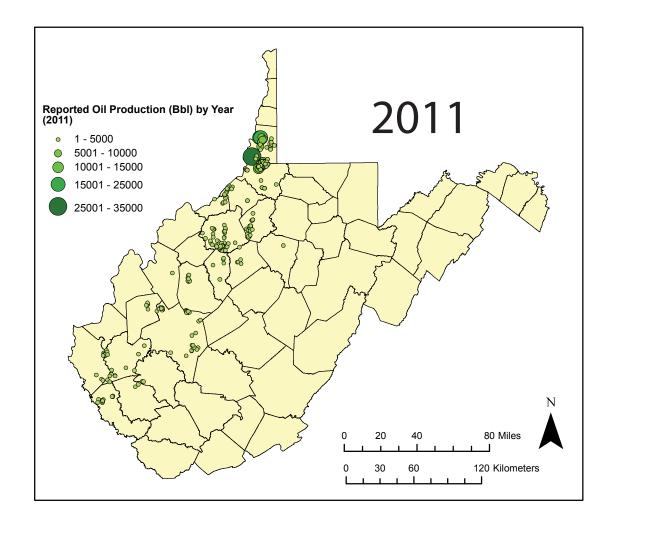
1. Harrison (104.5 Bcf)

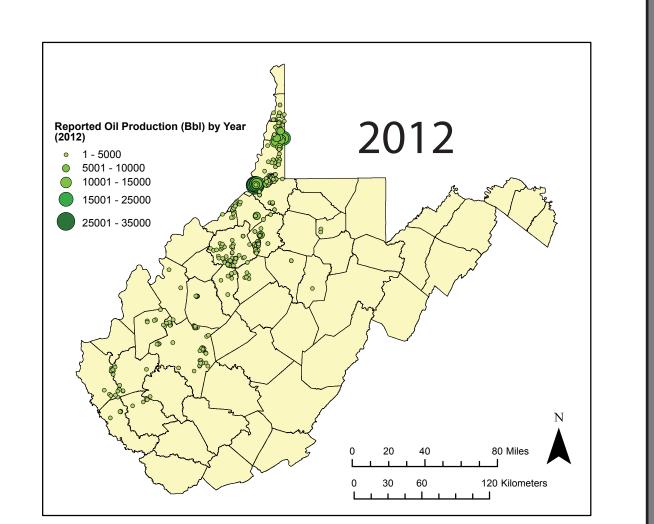
5. Upshur (15.8 Bcf)

7. Marion (11.5 Bcf)

9. Monongalia (3.3 Bcf)

8. Tyler (6.8 Bcf)





the Marcellus. Oil numbers may be affected because many of the comingled wells also

2006-2012 production is shown. 2005 reported production is not shown due to

irregularities in those data and 2013 production has not yet been reported to the

produce oil from horizons such as the Berea Sandstone and Big Injun sandstone.

Beginning in 2013 Natural Gas Liquids will be reported separately from oil & gas.

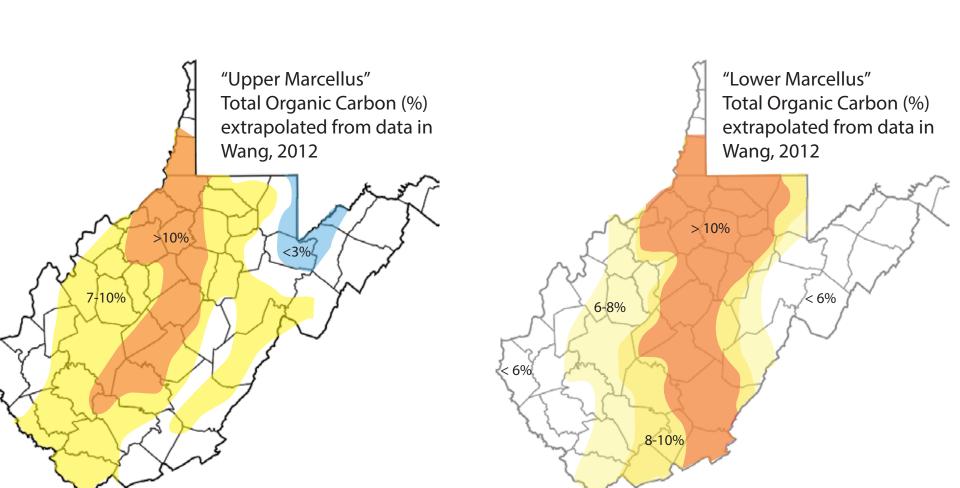
'Upper Marcellus", especially on the eastern & western edges of the state. Clay content in the "Lower Marcellus" decreases to the east (Pool, 2013).

(http://www.wvgs.wvnet.edu/www/datastat/devshales.htm)

and 1/2014 for permitted wells.

Shapefiles for Marcellus thickness, outcrops, and Onondaga structure, faults, and

## MARCELLUS RESOURCE ASSESSMENT

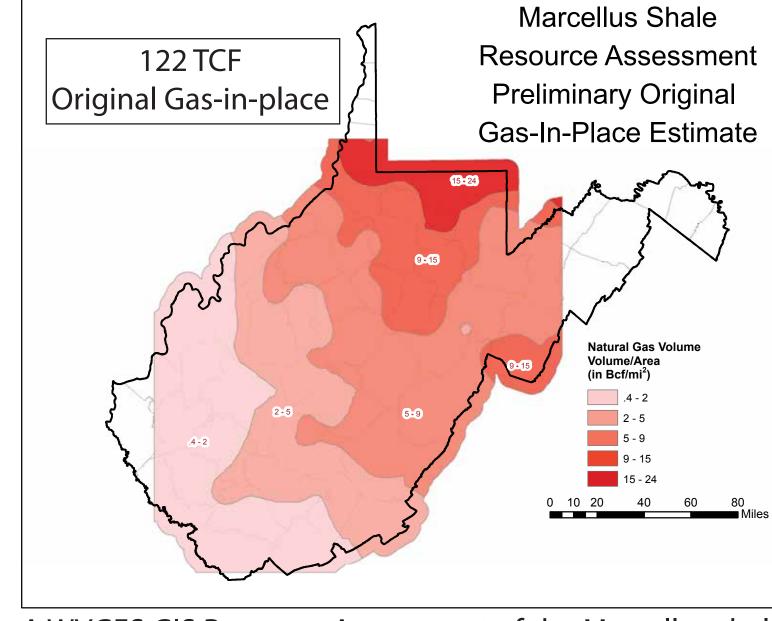


centrated toward the west and east (Pool, 2013).



Completed, Permitted, & Cancelled Marcellus Wells in West Virginia (Updated 3/14).

Production data through 2012. Data current through 2/2014 for completed wells



Cross sections modified from Pool (2013)

gas-in-place in West Virginia. This does not represent recoverable gas.

### REFERENCES

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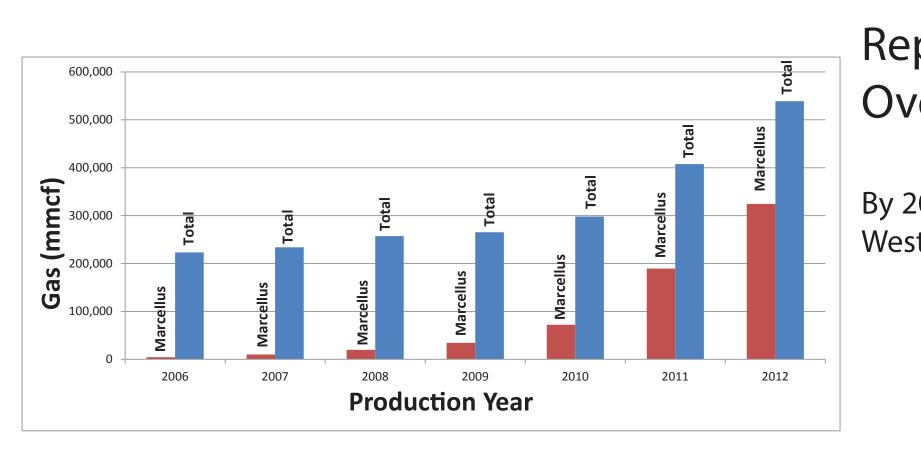
Shale for West Virginia using Basic Geologic Data and GIS. Master of Geographic Information Systems, University Park, PA: The Pennsylvania State University.

Equivalents in West Virginia. Morgantown, West Virginia: West Virginia Geological and Economic Survey Open File Report OF-8608.

JSGS Marcellus Shale Assessment Team, 2011, Information relevant to the U.S. Geological Survey assessment of the Middle Devonian Shale of the Appalachian Basin Province, 2011: U.S. Geological Survey Open-File Report 2011–1298, 22 p.

Wang, G. 2012. Black Shale Lithofacies Prediction and Distribution Pattern Analysis

of Middle Devonian Marcellus Shale in the Appalachian Basin, Northeastern U.S.A. Doctoral dissertation, Morgantown, WV: West Virginia University.



Reported Marcellus Production Compared to Overall Production in West Virginia

By 2012 the Marcellus accounts for 60% of reported produced gas in West Virginia.

