

Tight Oil: A Solution to U.S. Import Dependence?

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Post Carbon Institute**

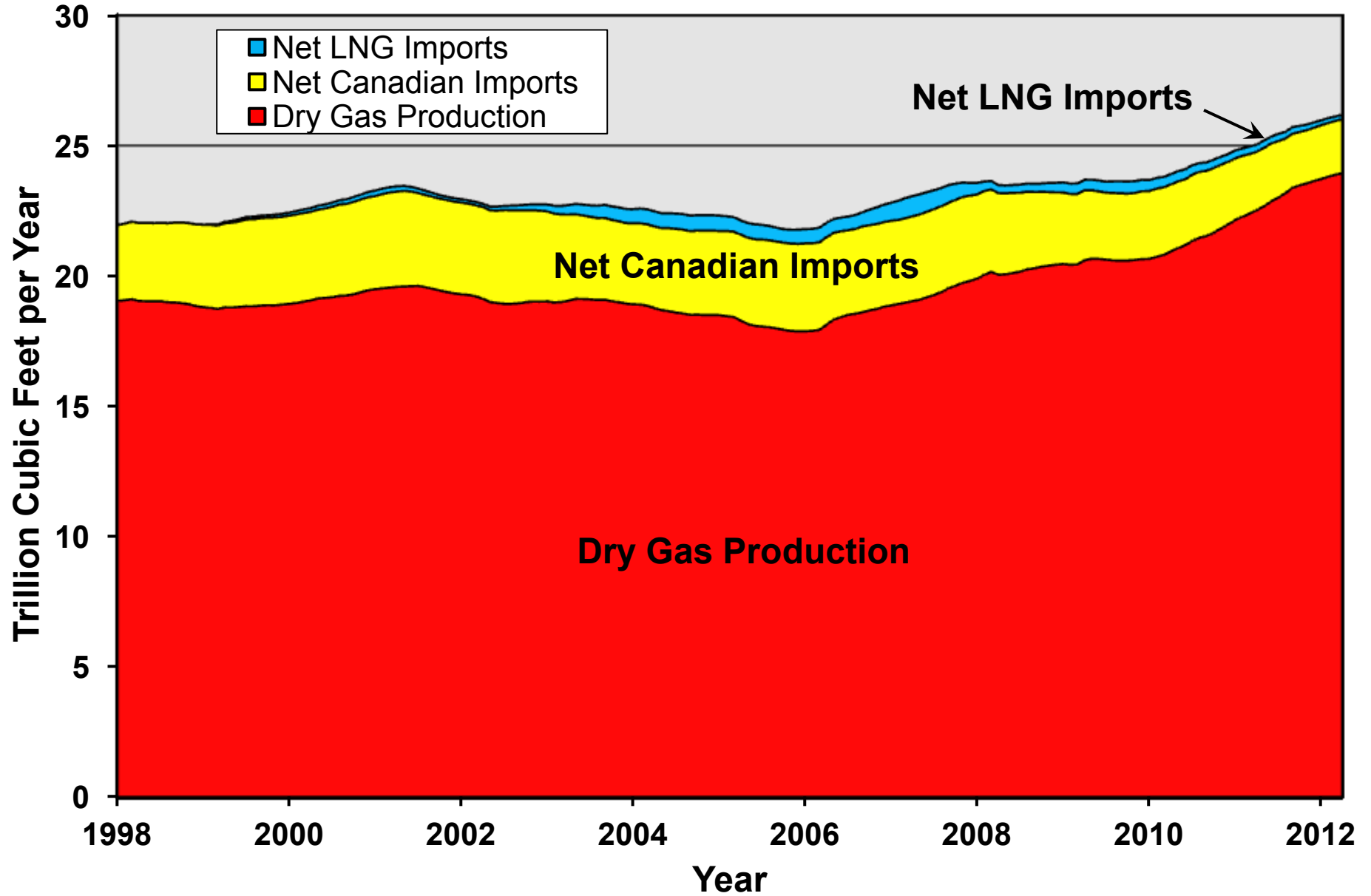
The Shale Revolution

- Began with the application of high-volume, multi-stage, hydraulic-fracturing of shale for gas in the Barnett Field of eastern Texas.
- Now accounts for 40% of U.S. gas production.
- The technology was first applied to oil extraction in the Bakken Field of Montana and North Dakota.
- Allowed a 50% increase in U.S. oil production reversing the long standing decline from peak U.S. production in 1970.
- Nearly 35% of upstream investment in lower 48 exploration and development will be applied to the Bakken and Eagle tight oil plays in 2013.

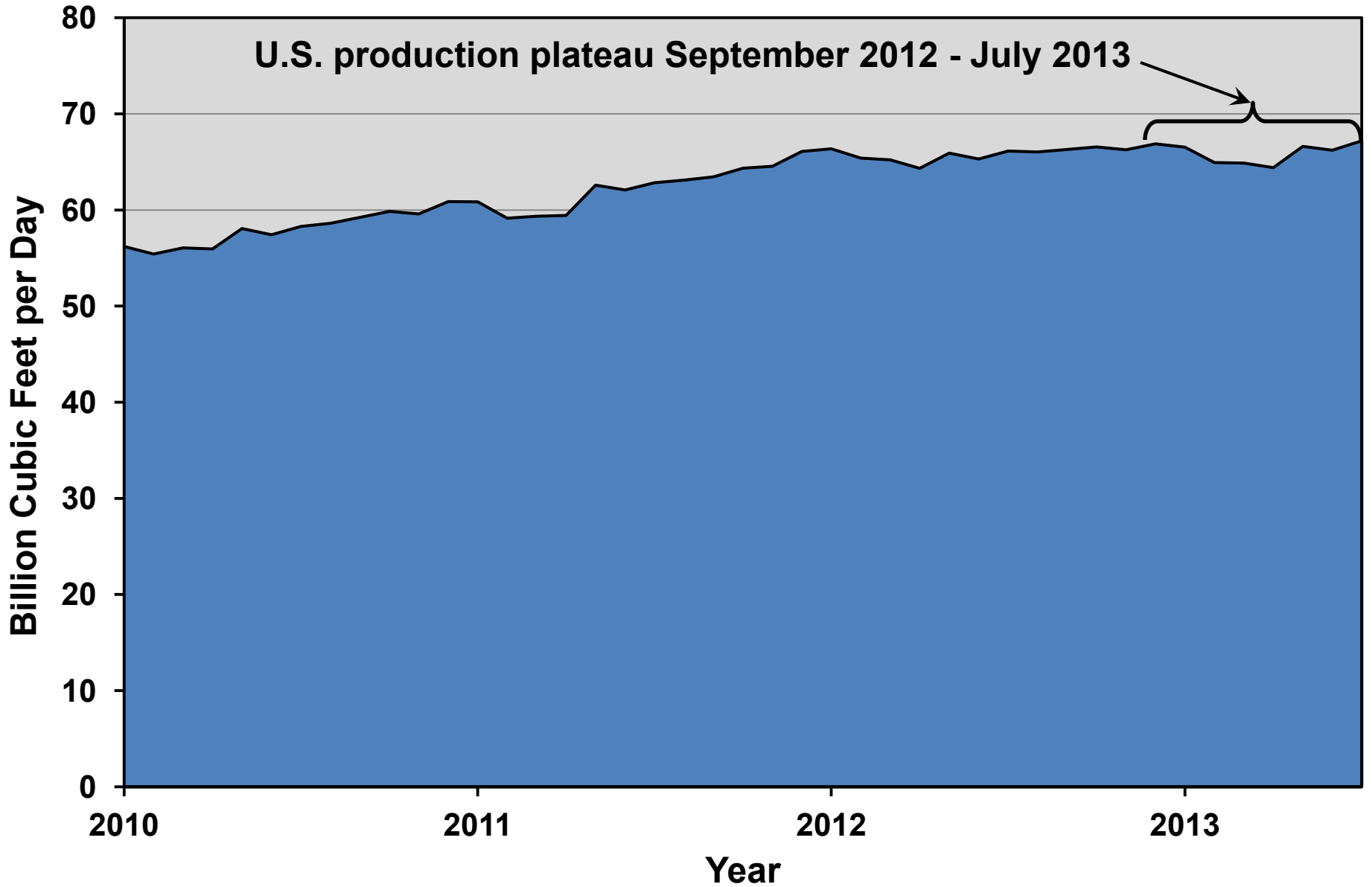
Conventional Wisdom

- The United States is on the verge of Energy Independence thanks to the “SHALE REVOLUTION”.
- Shale Gas production will continue to grow for the foreseeable future (2040 at least) and prices will remain below \$4.50/mcf for the next 10 years and below \$6.00/mcf for the next 20 years.
- Shale Gas can replace very substantial amounts of oil for transport and coal for electricity generation.
- The way is clear for U.S. LNG exports to monetize the shale bounty.
- Tight Oil will allow U.S. production to exceed that of Saudi Arabia and U.S. imports will shrink to zero.

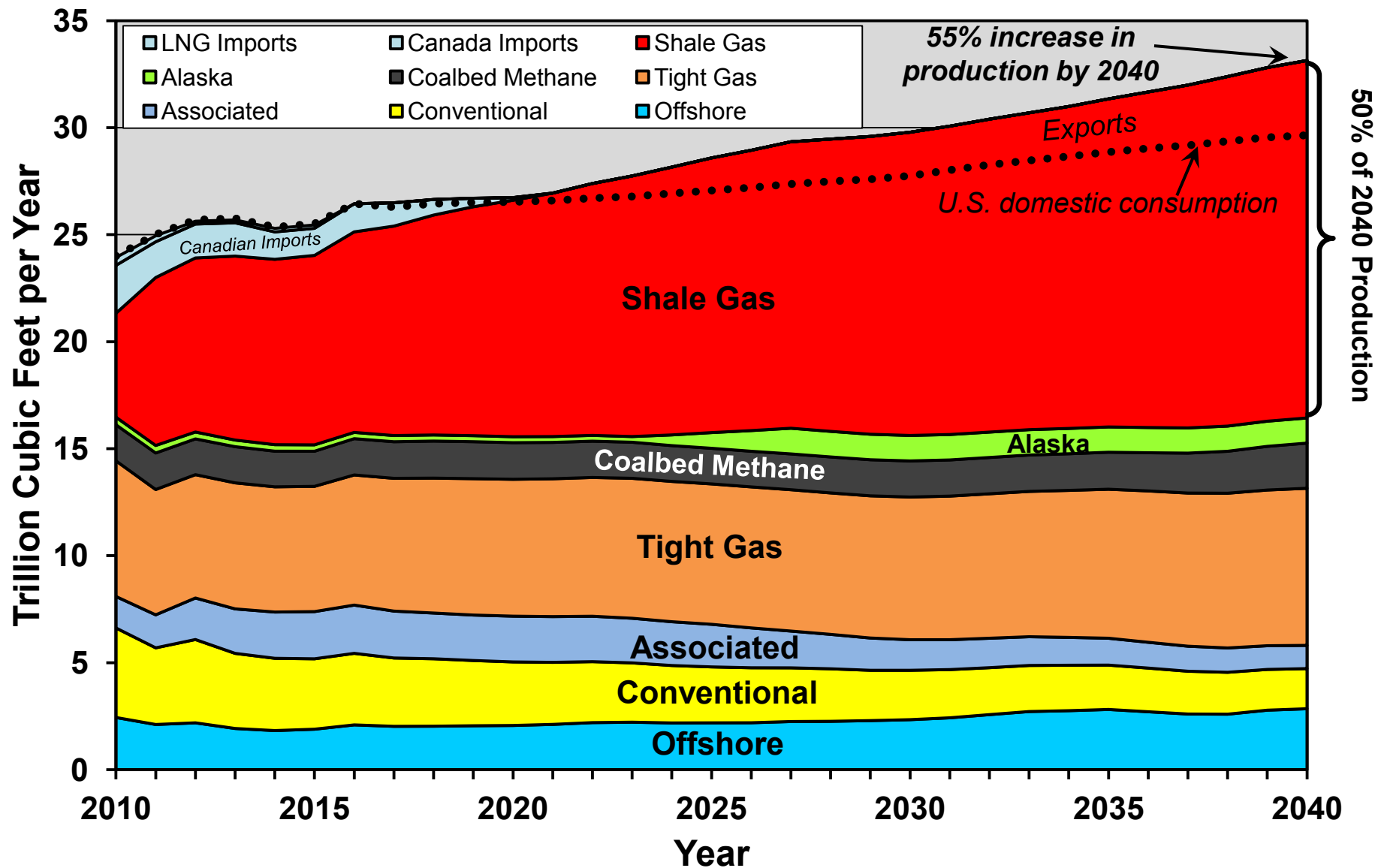
U.S. Gas Production and Imports, 1998-2012



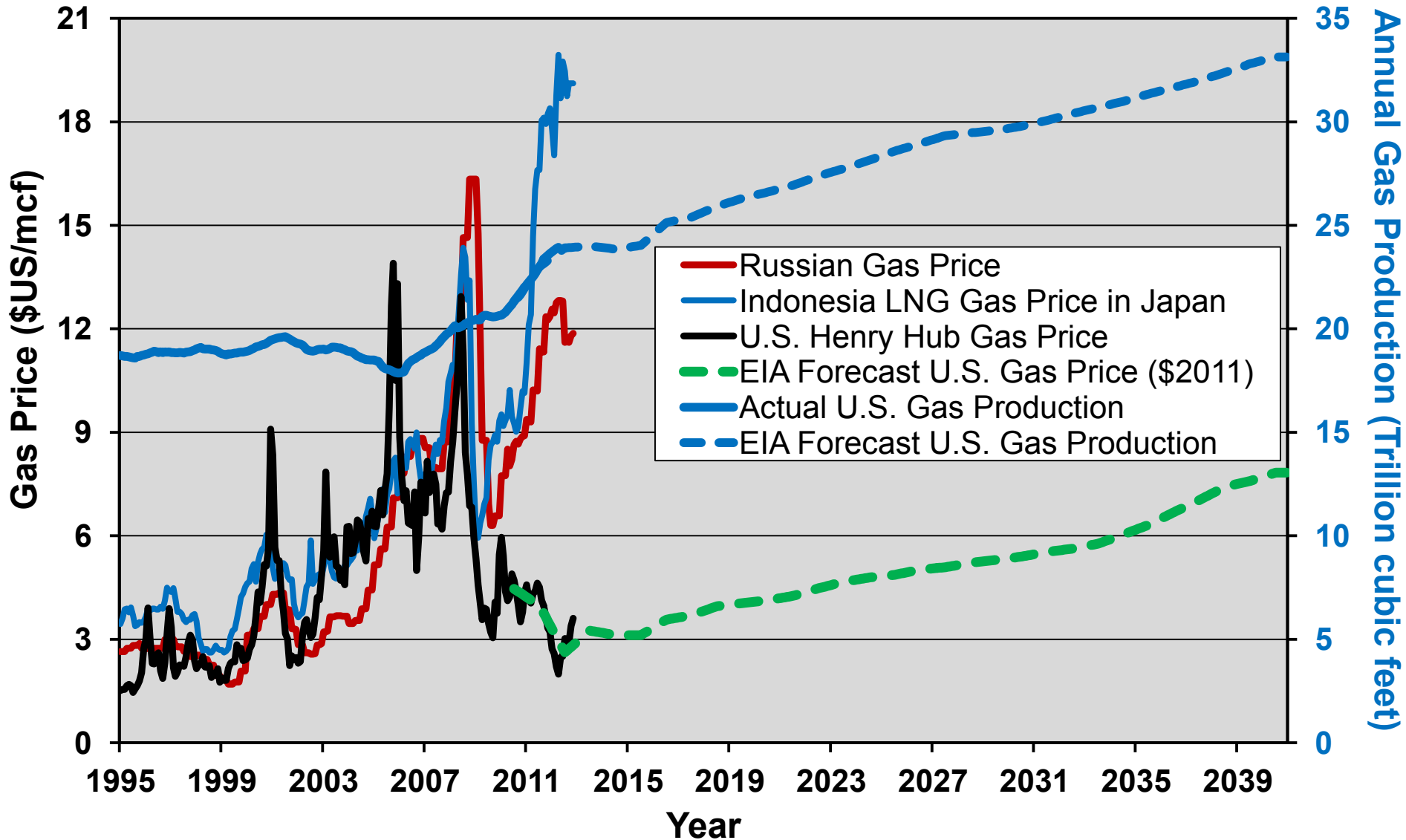
U.S. Dry Gas Production, 2010-2013



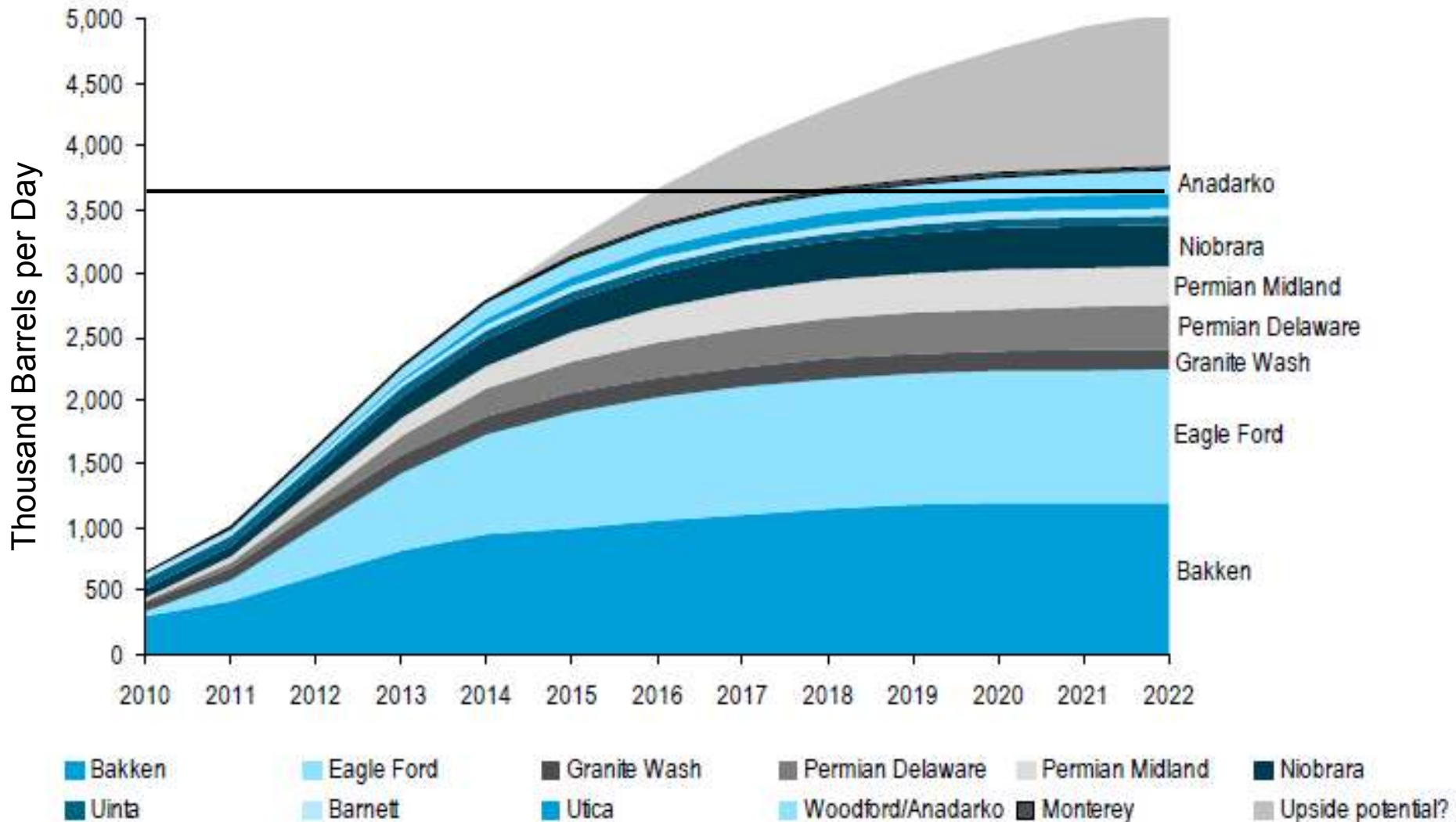
U.S. Natural Gas Supply Projection by Source, 2010-2040, EIA Reference Case 2013



EIA Projections of Gas Price and U.S. Production Compared to History, 1995-2040

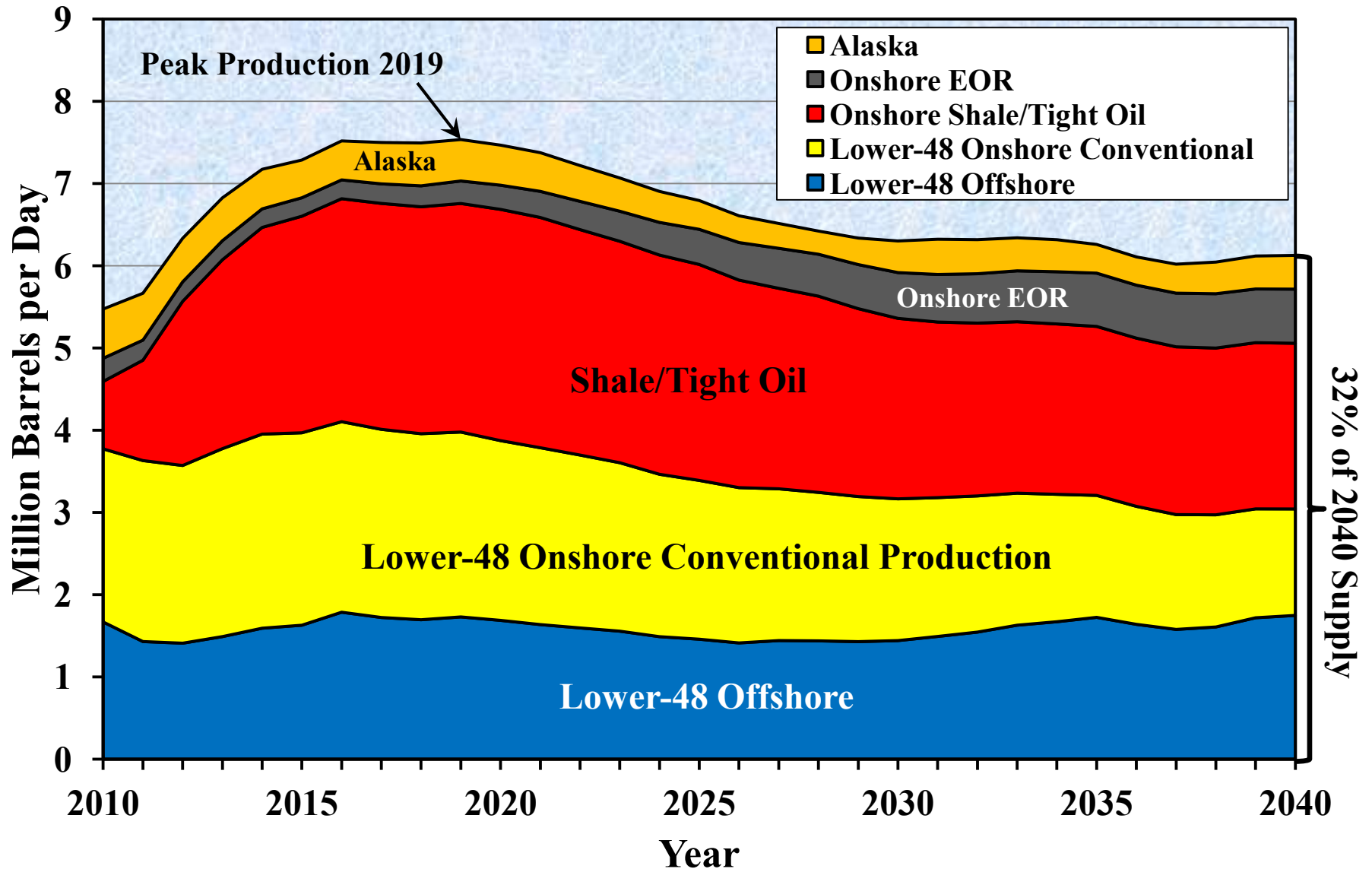


Citigroup 2012 Projection of U.S. Shale Oil, 2010-2022

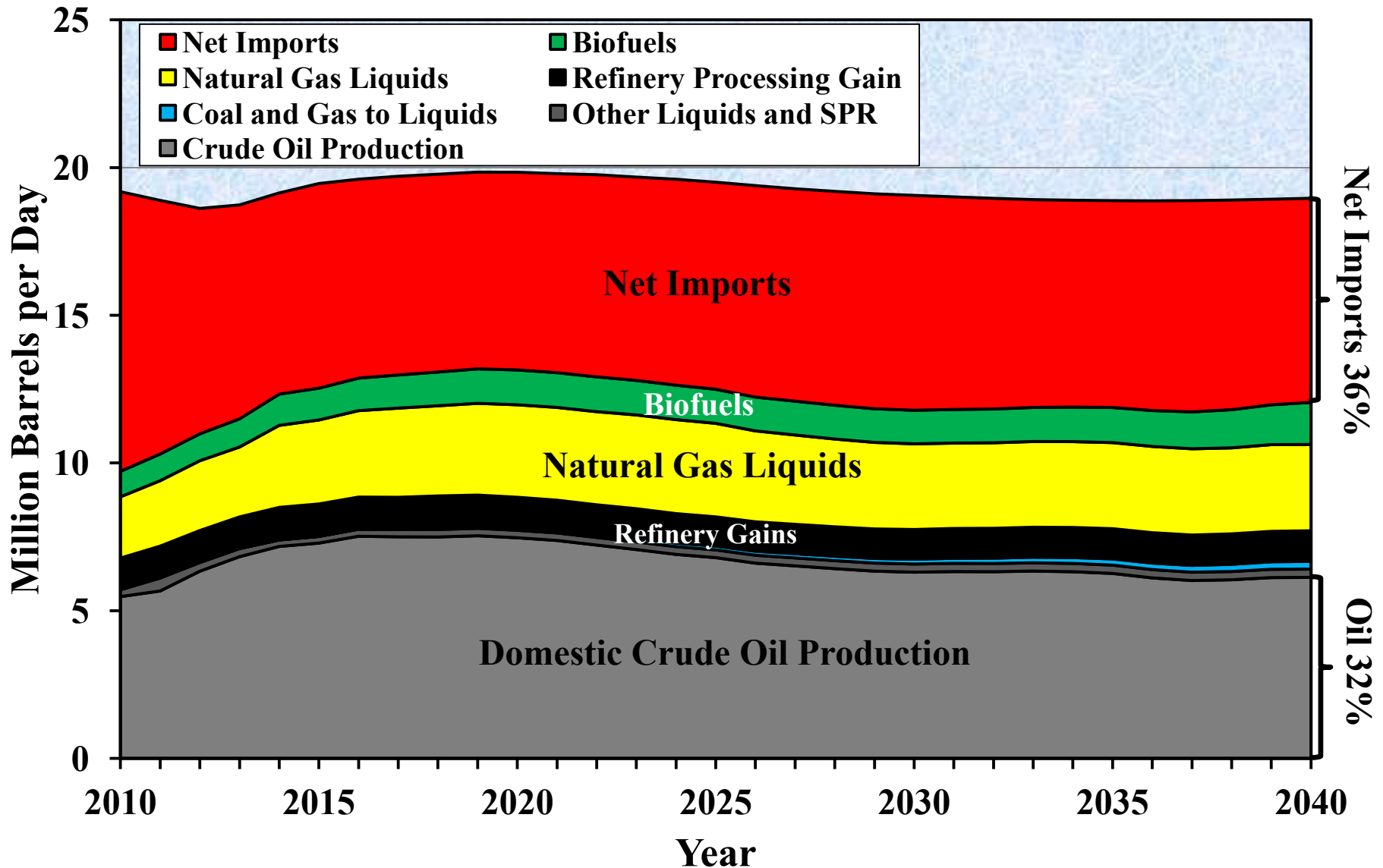


Source: Citi Investment Research and Analysis

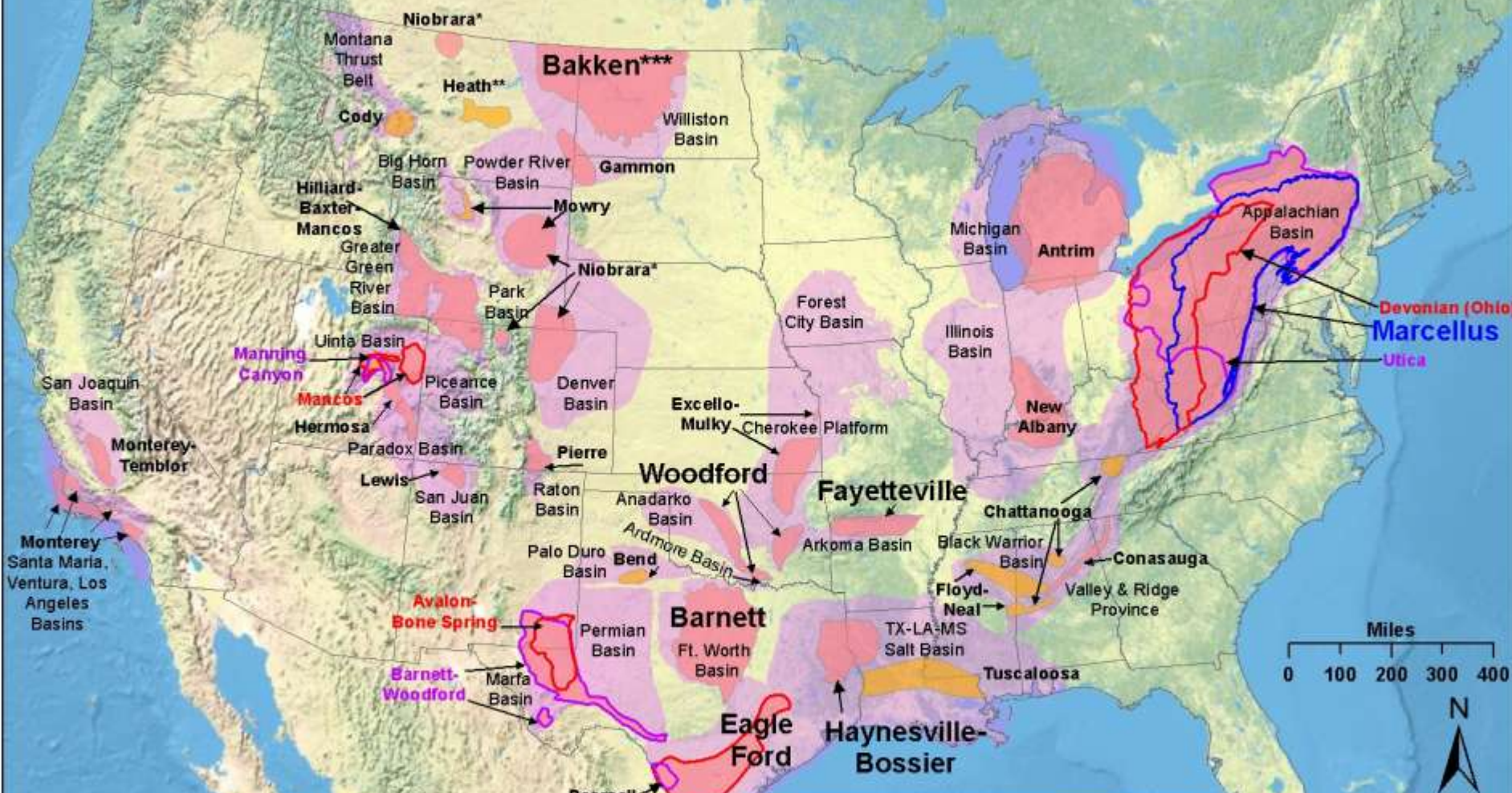
U.S. Crude Oil Production Projection by Source and Region 2010-2040 (EIA 2013 Reference Case)



U.S. Petroleum Liquids Supply by Source 2010-2040 (EIA 2013 Reference Case)



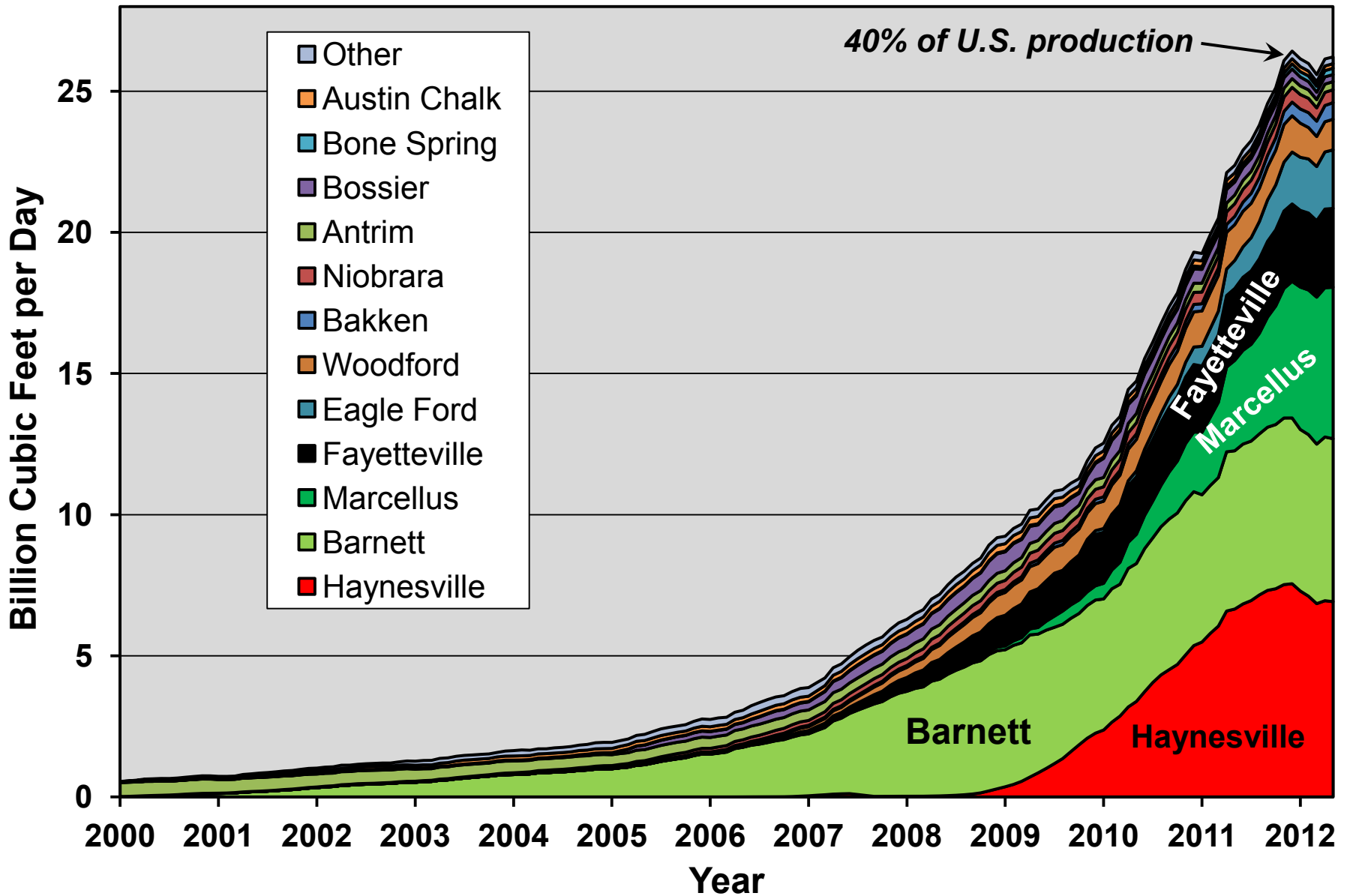
Lower 48 states shale plays



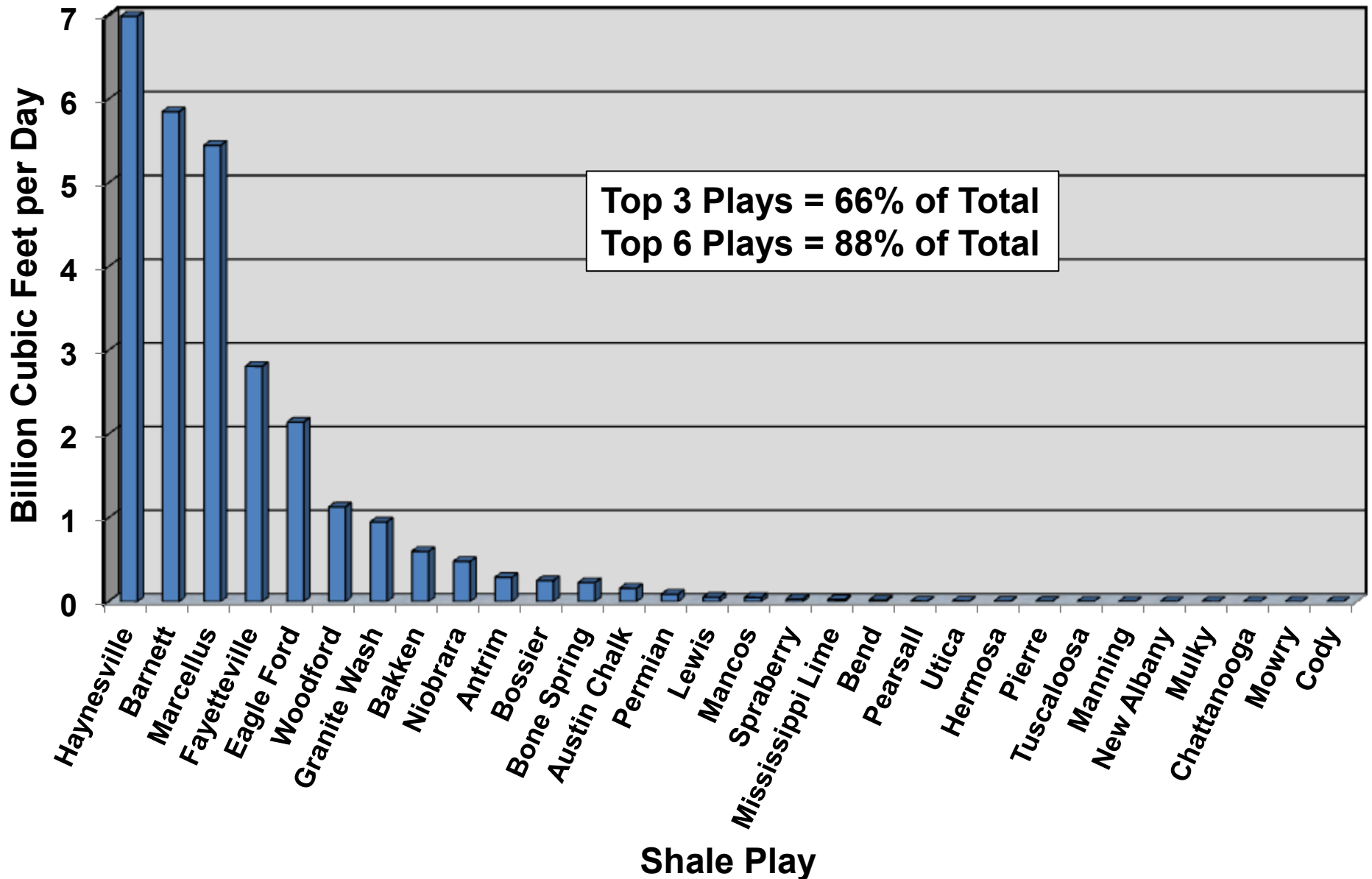
Shale plays	Basins
■ Current plays	* Mixed shale & chalk play
■ Prospective plays	** Mixed shale & limestone play
Stacked plays	*** Mixed shale & tight dolostone-siltstone-sandstone
▬ Shallowest/ youngest	
▬ Intermediate depth/ age	
▬ Deepest/ oldest	



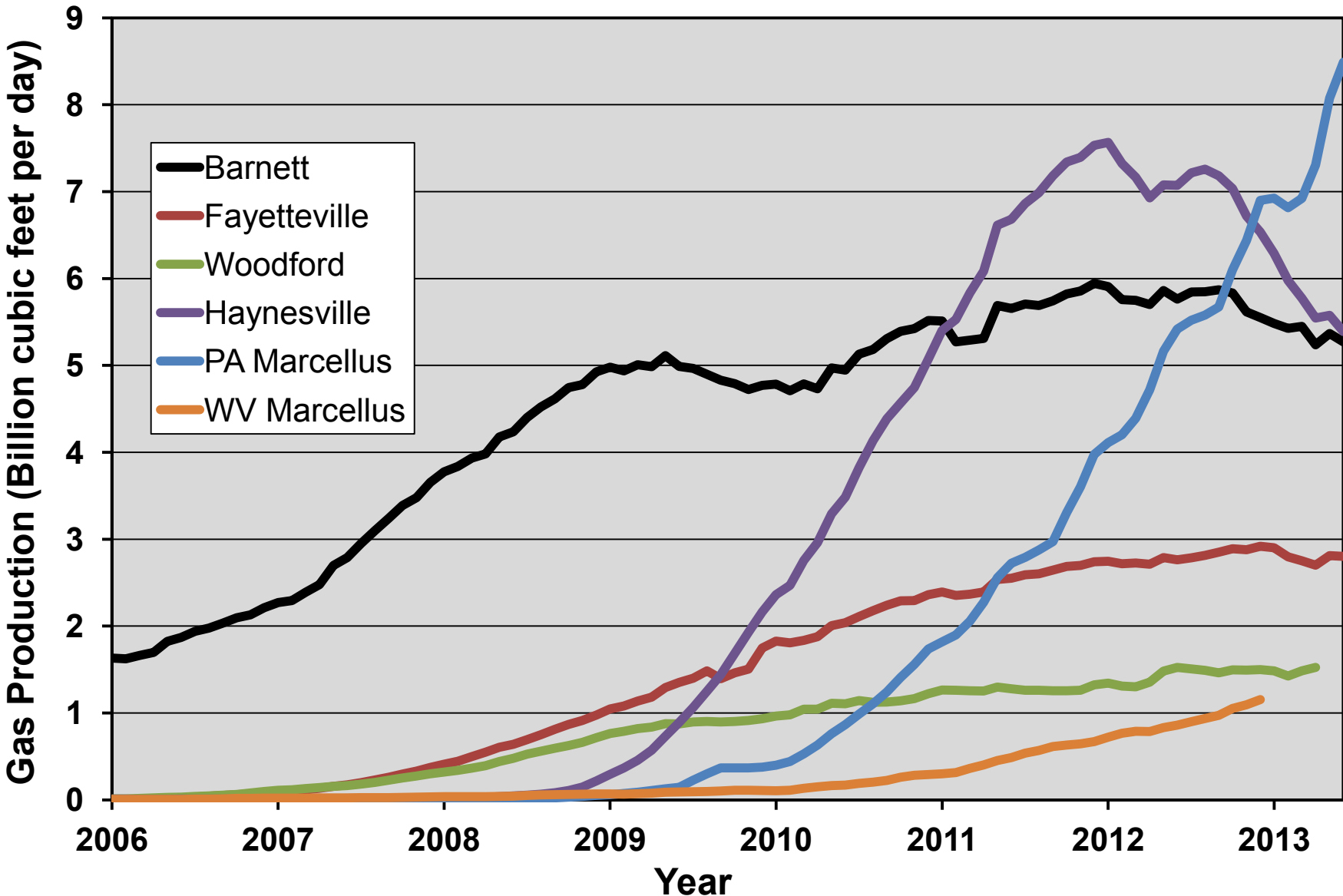
Shale Gas Production by Play, 2000-2012



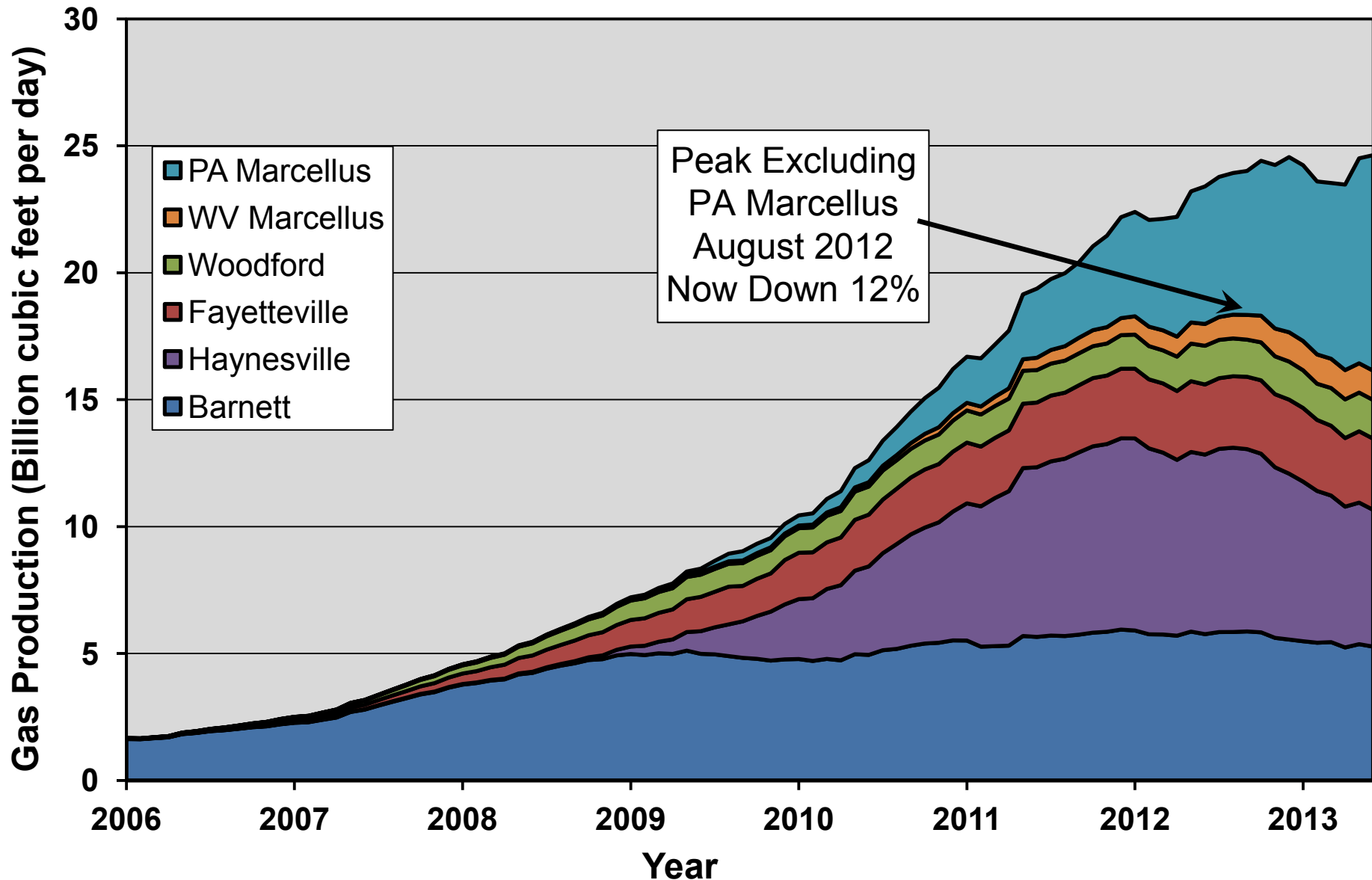
Shale Gas Production by Play – mid 2012



Shale Gas Production from Top Five Plays Comprising 80% of U.S. shale gas production, 2006 - 2013

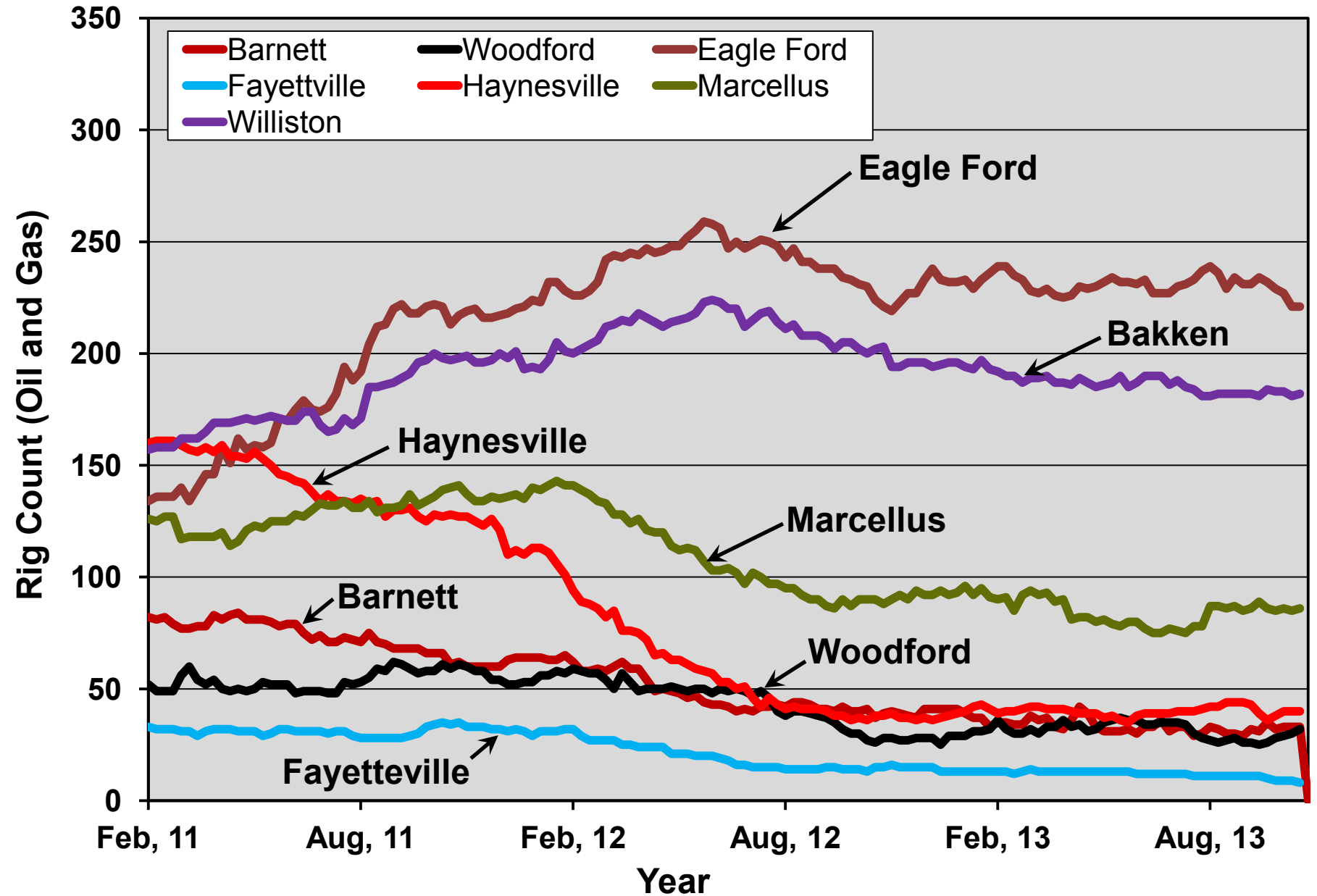


Shale Gas Production from Top Five Shale Gas Plays, 2006-June, 2013

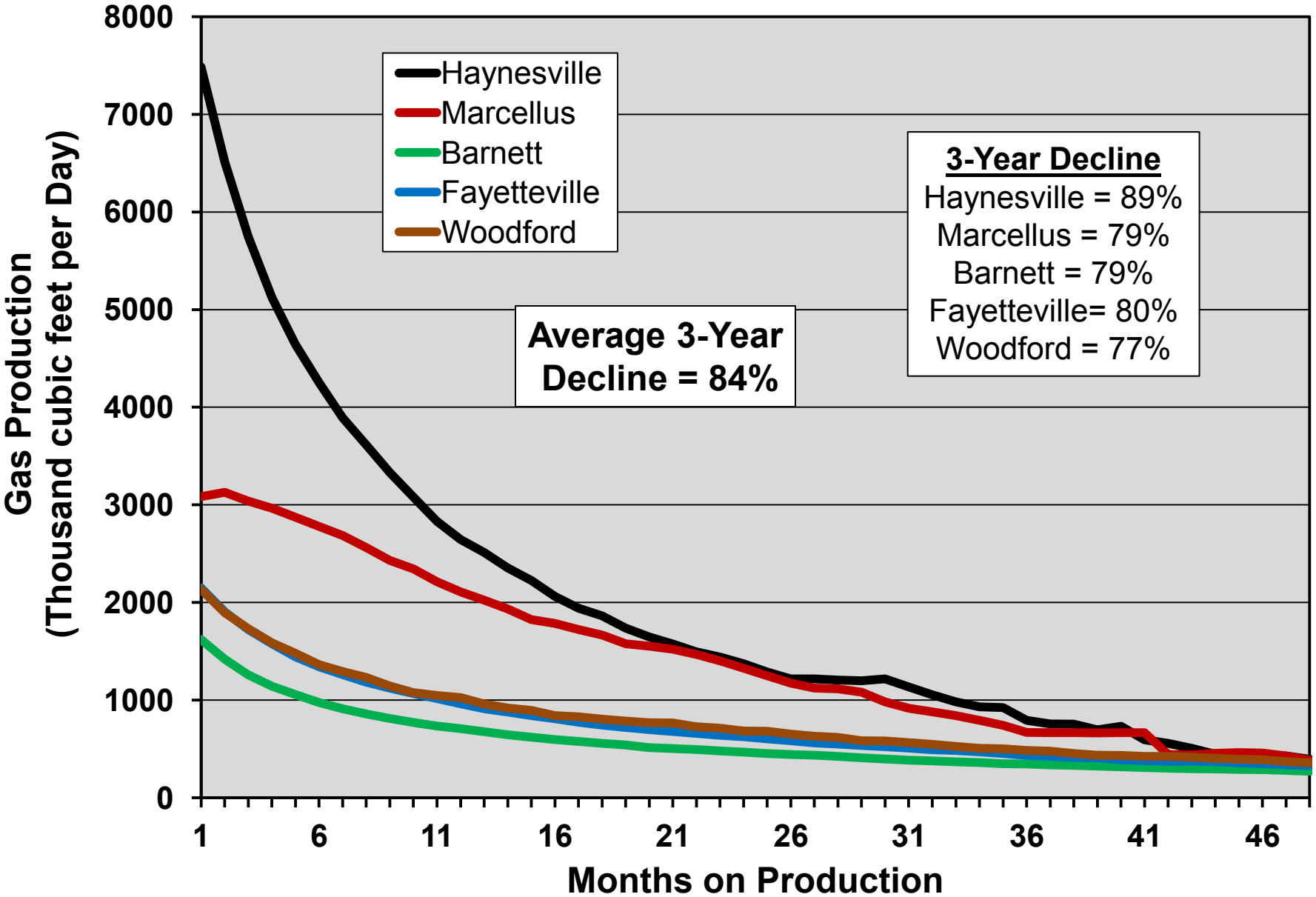


Peak Excluding
PA Marcellus
August 2012
Now Down 12%

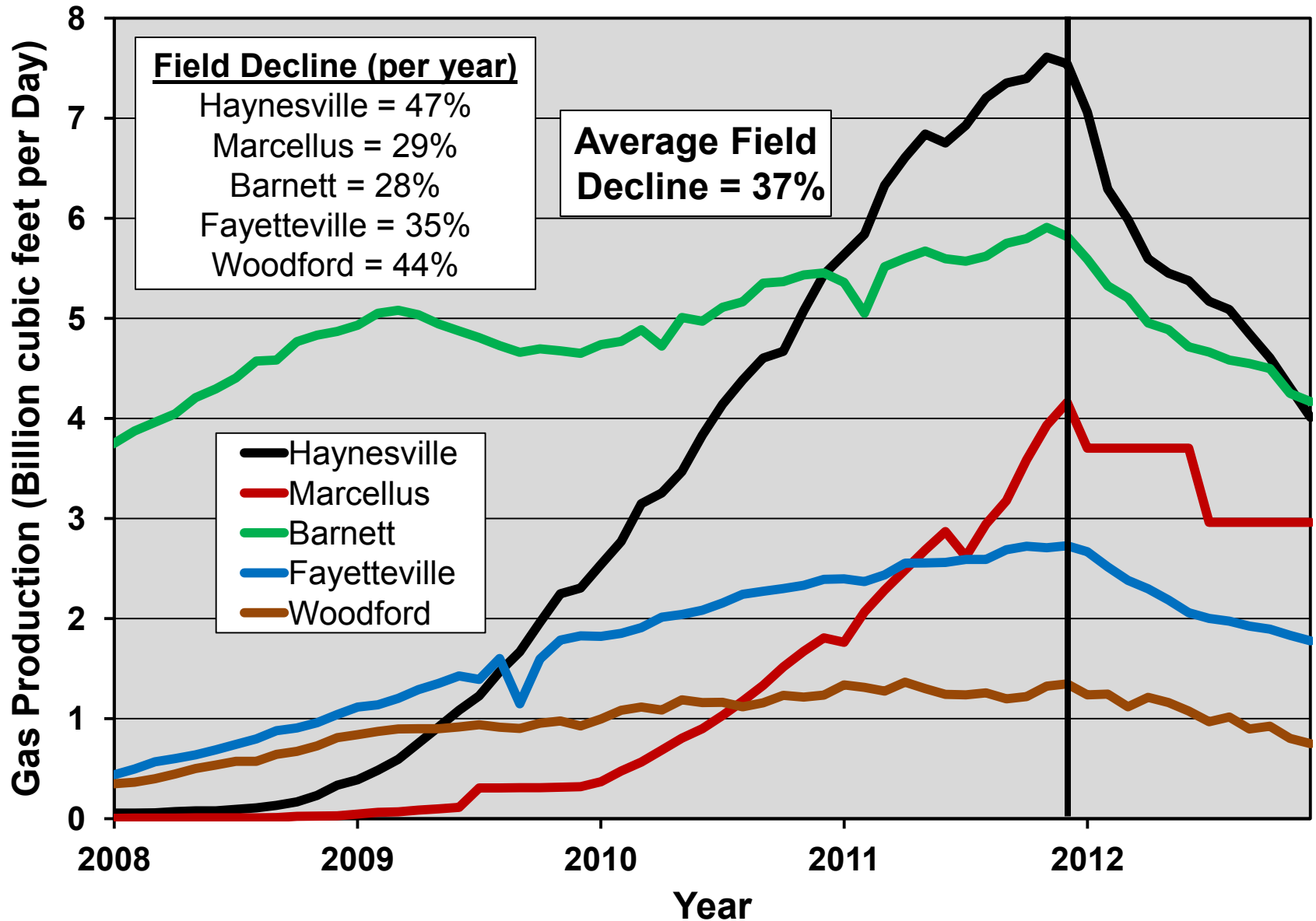
Rig Count for Selected Shale Plays, 2011-2013



Type Gas Well Decline Curves for Top Five Shale Gas Plays Constituting 80% of Shale Gas Production

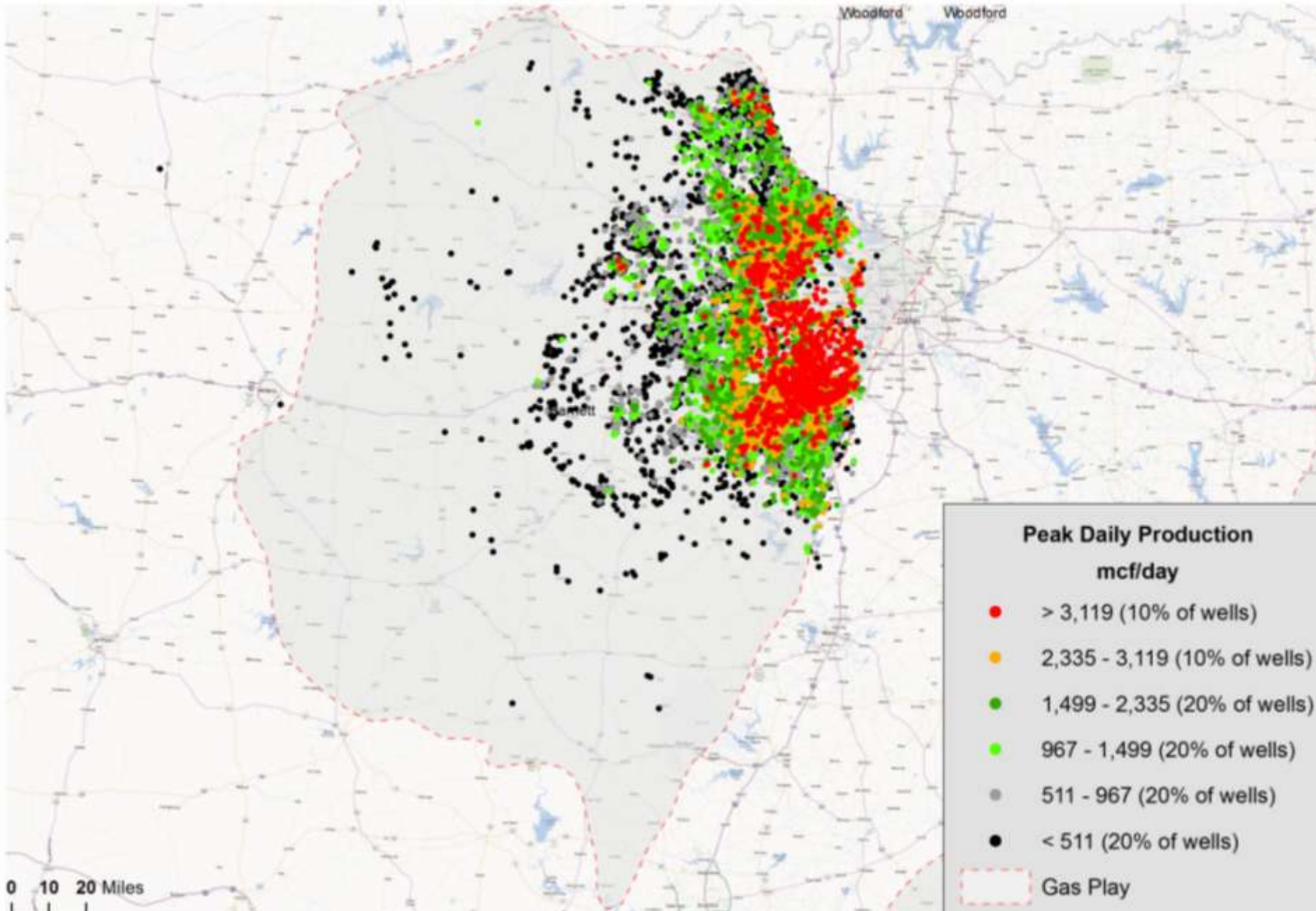


Overall Field Decline for Top Five Shale Gas Plays based on Production Decline from pre-2012 Wells



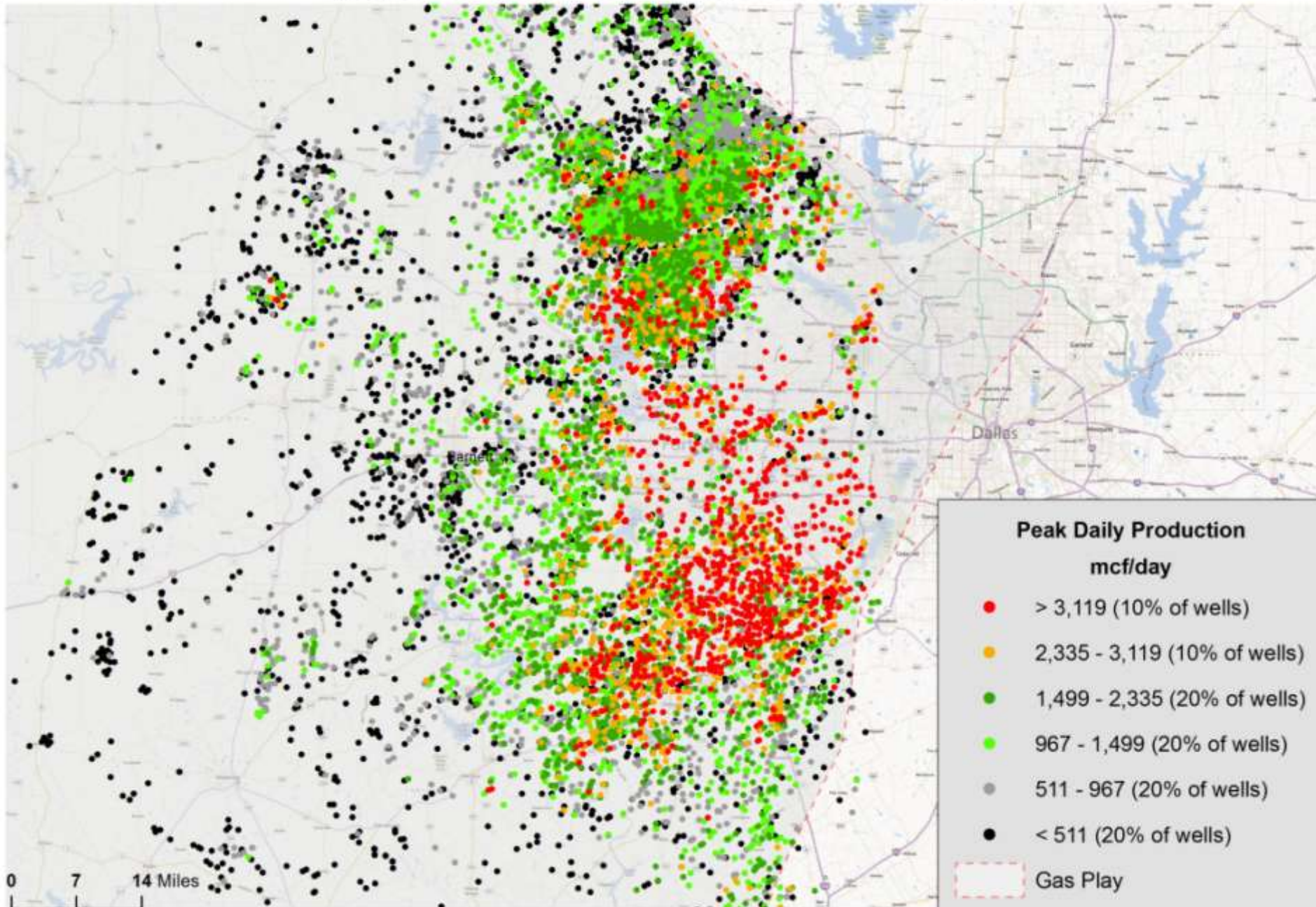
Barnett Well Quality

Spatial Distribution of Peak Gas Production



Barnett Well Quality

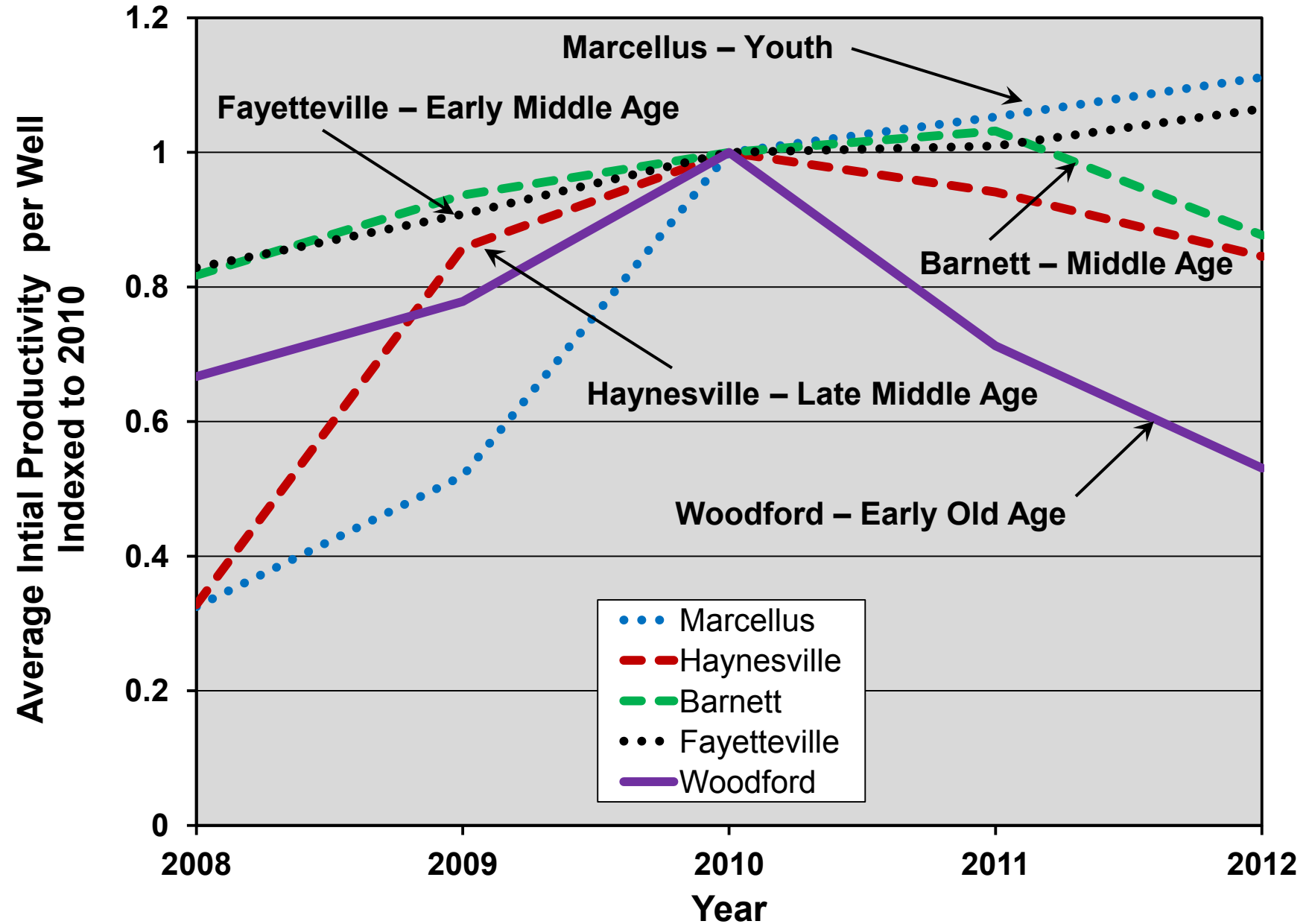
Spatial Distribution of Peak Gas Production



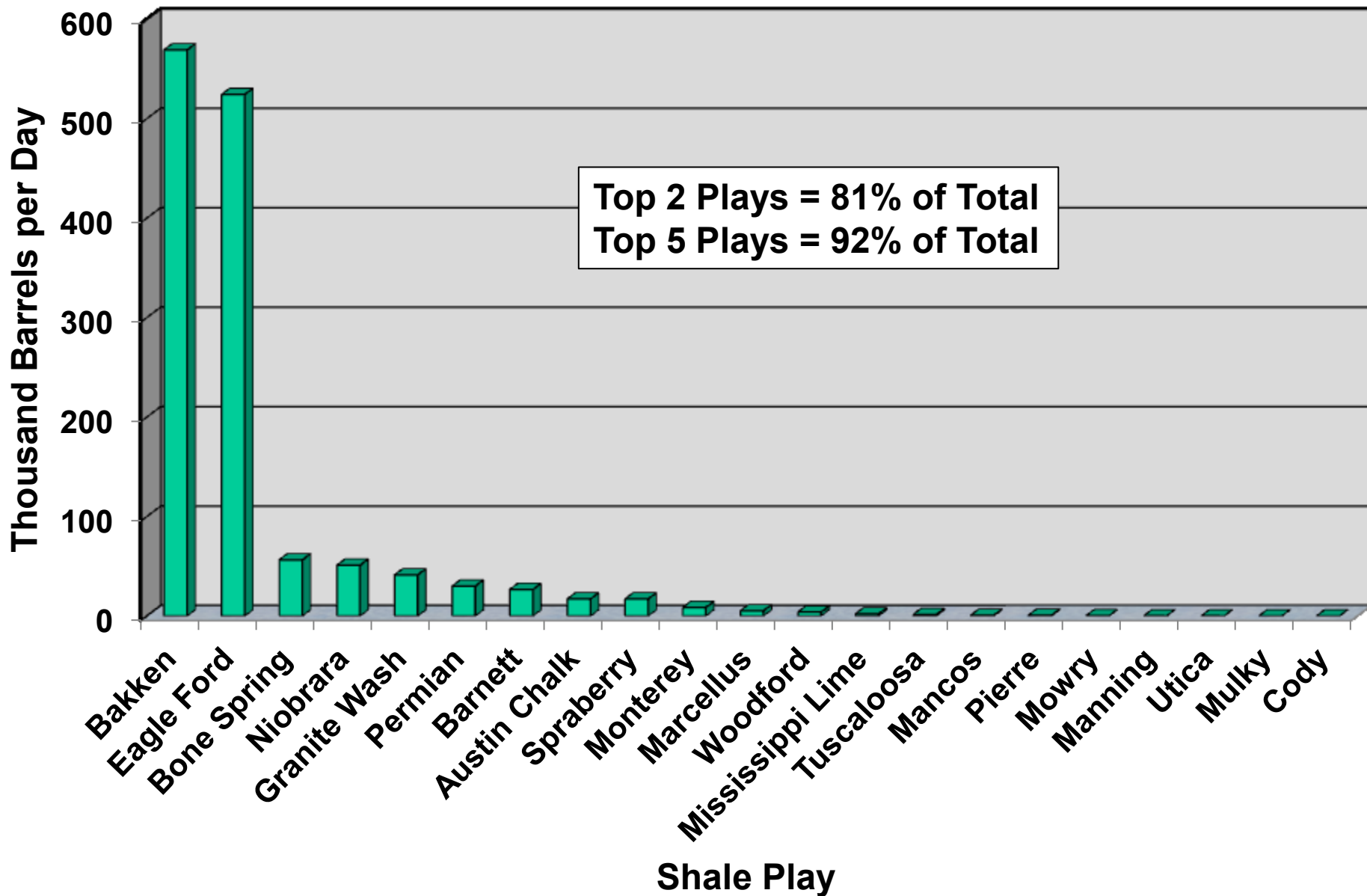
The Shale Play Life Cycle

- Discovery followed by leasing frenzy.
- Drilling boom follows to meet “held-by-production” lease requirements.
- Sweet spots identified, targeted and drilled off.
- Gas production rises rapidly and is maintained for cash-flow despite potentially uneconomic full-cycle costs.
- Sweet spots become saturated and well quality and field production decline.
- Plays like the Haynesville become middle aged after just five years.

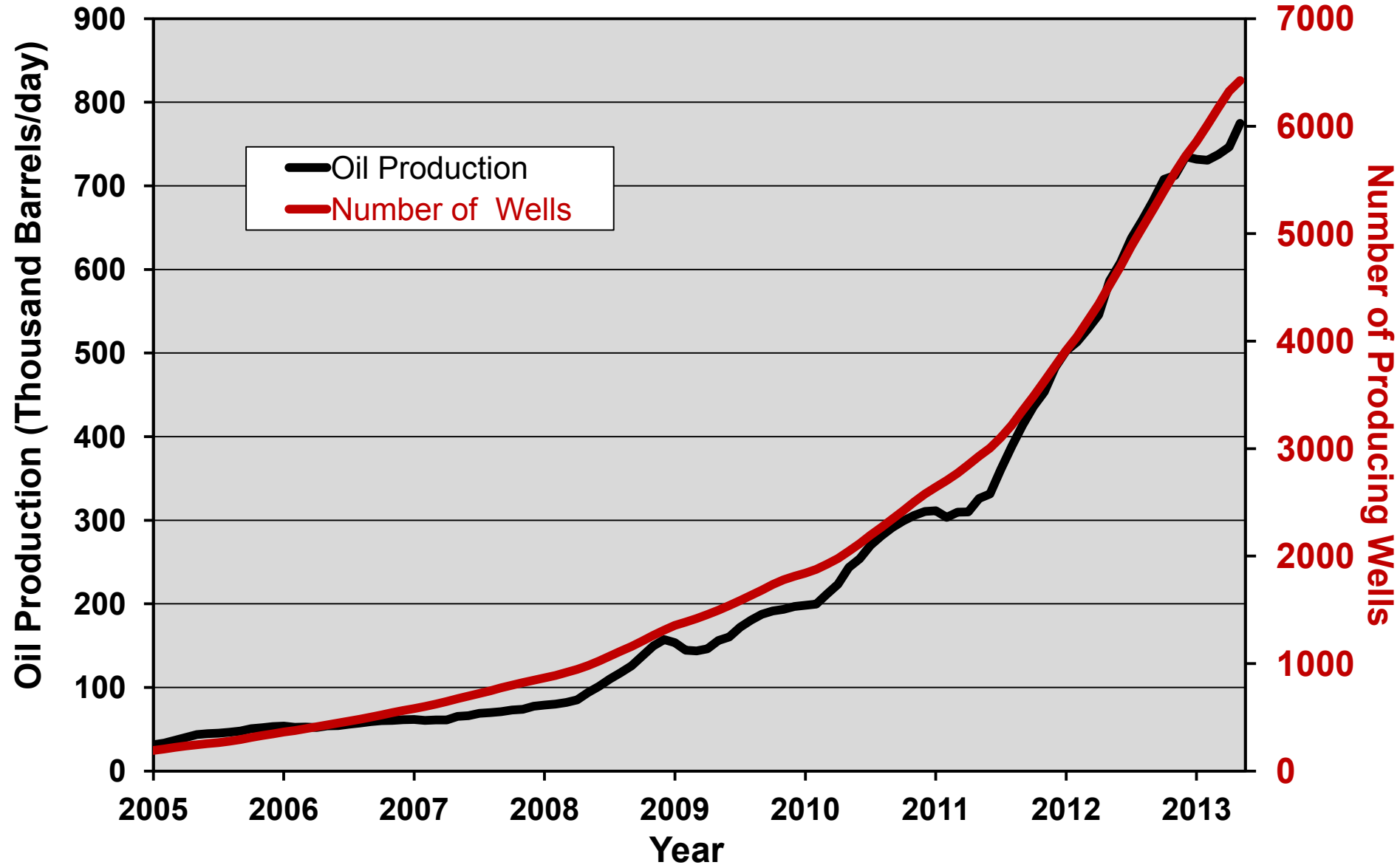
Horizontal Well Quality Trends – Top Five Shale Gas Plays



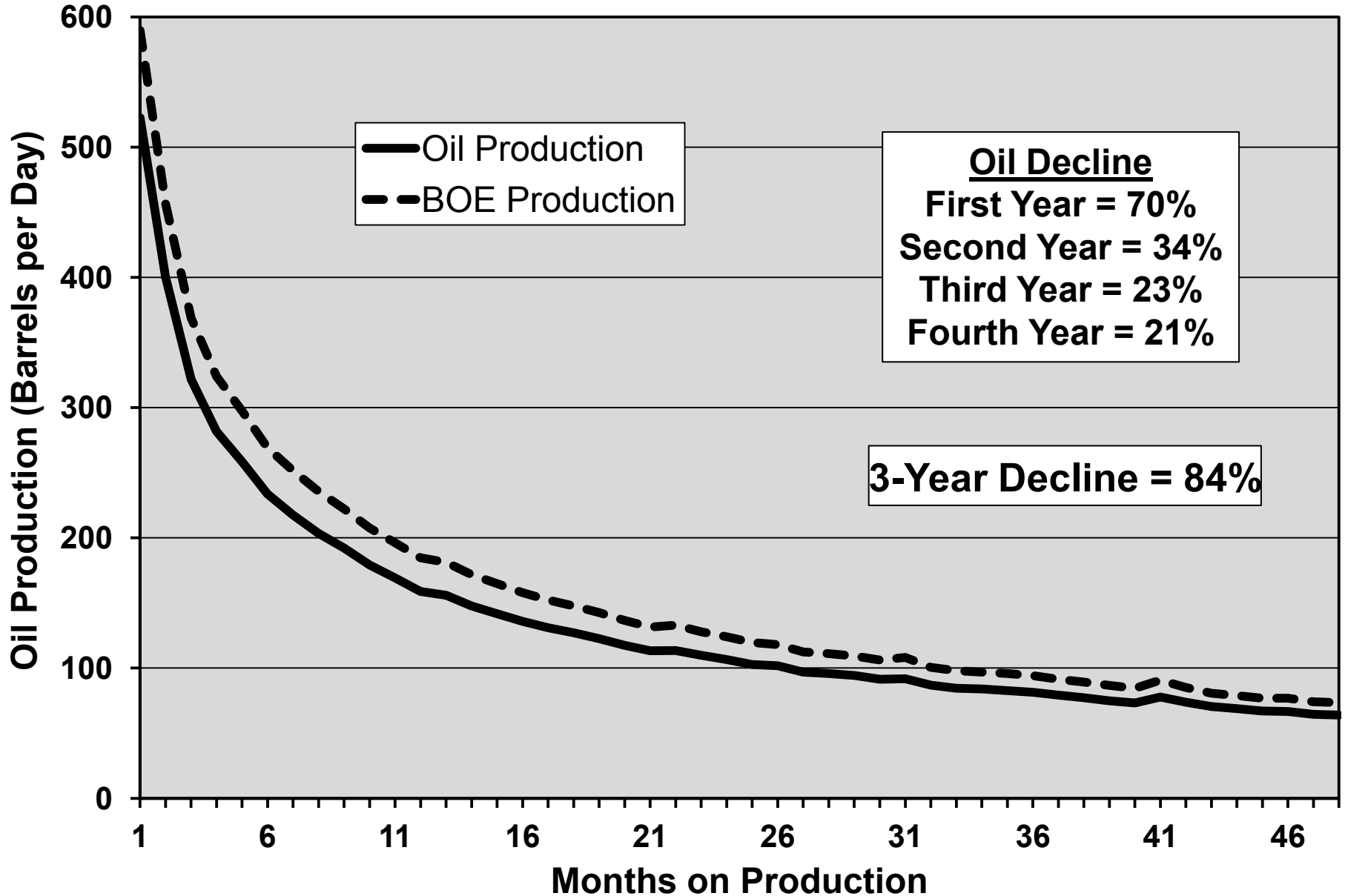
Crude Oil and Other Liquids Production by Shale Play – mid 2012



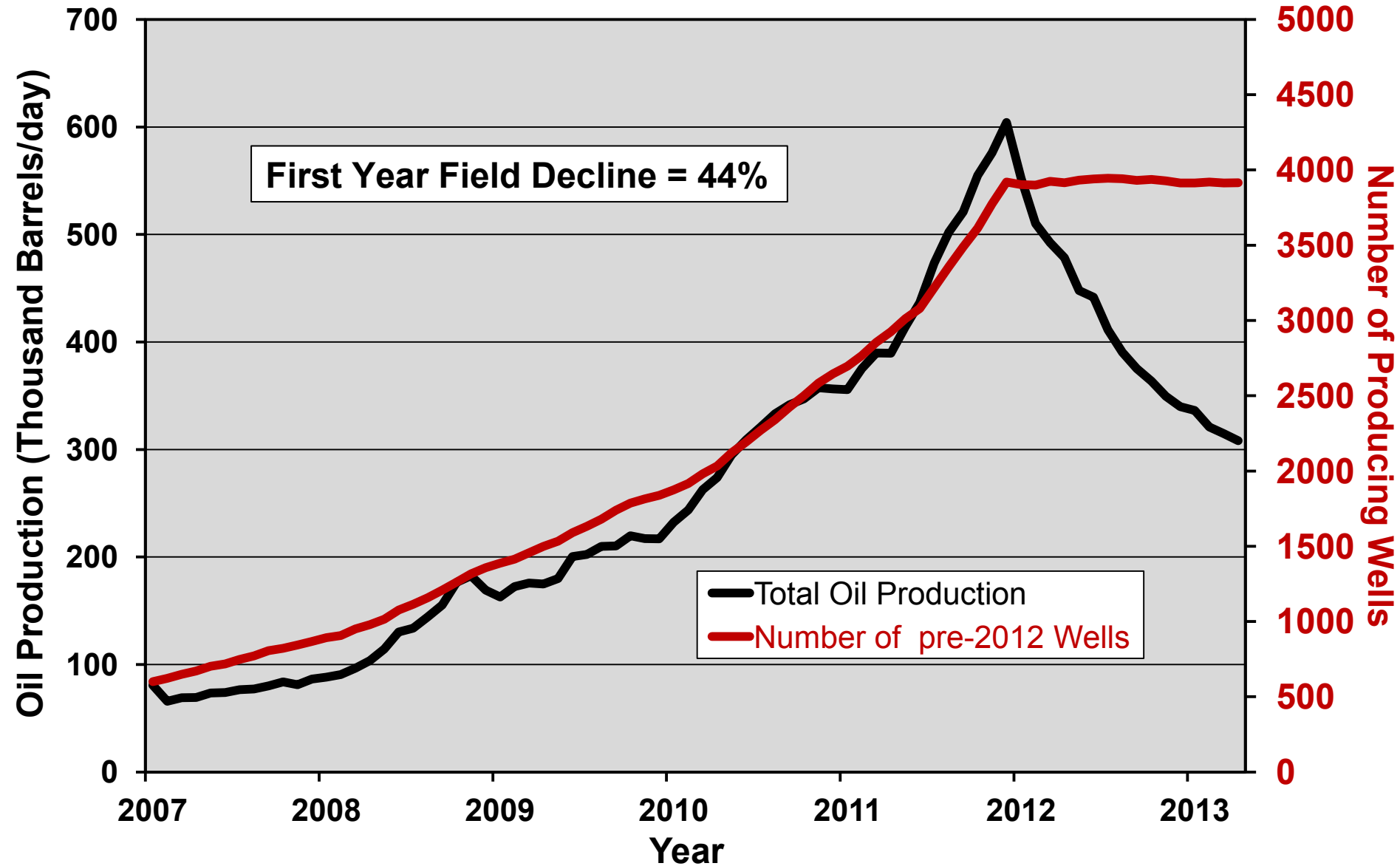
Bakken/Three Forks Oil Production and Number of Operating Wells, 2005-2013



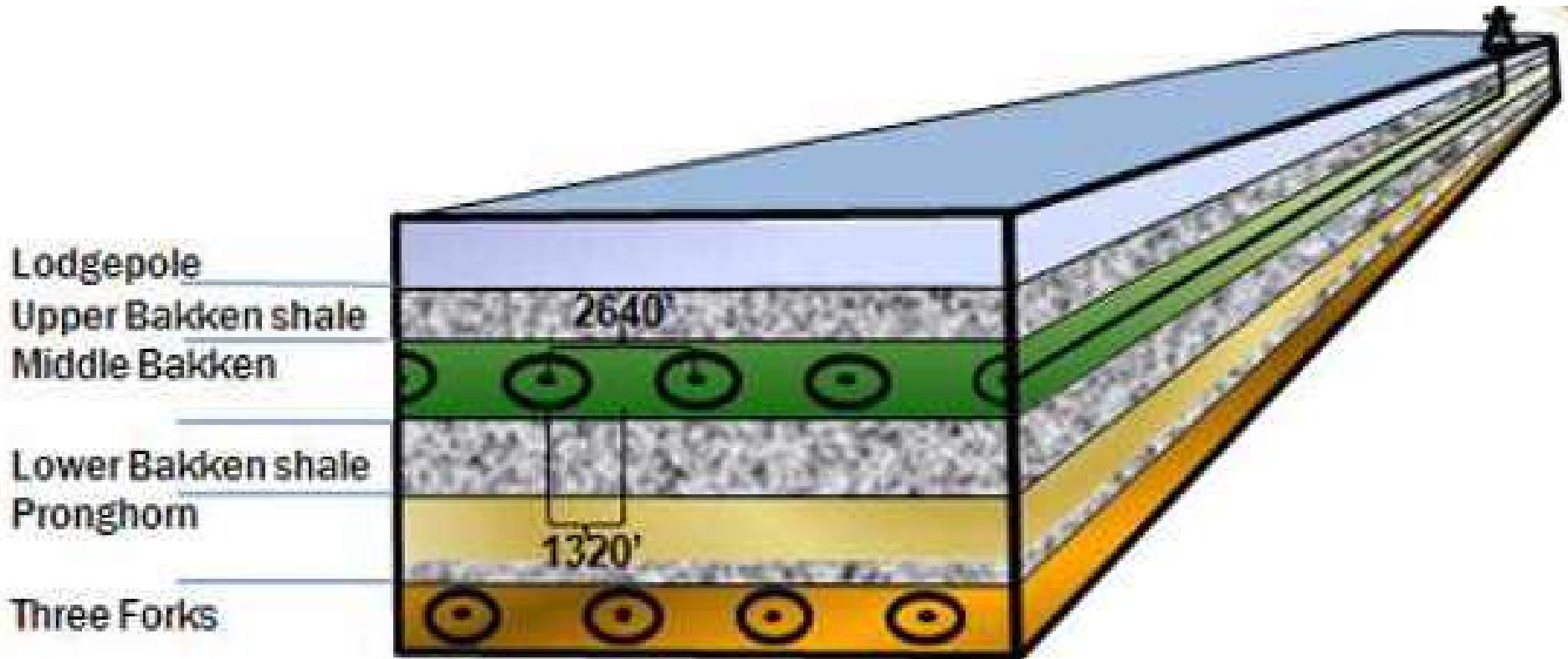
Bakken/Three Forks Type Oil and Barrels of Oil Equivalent Well Decline Curves Including Montana and North Dakota



Bakken Field Production Decline – Oil Production from all Wells Drilled Prior to 2012

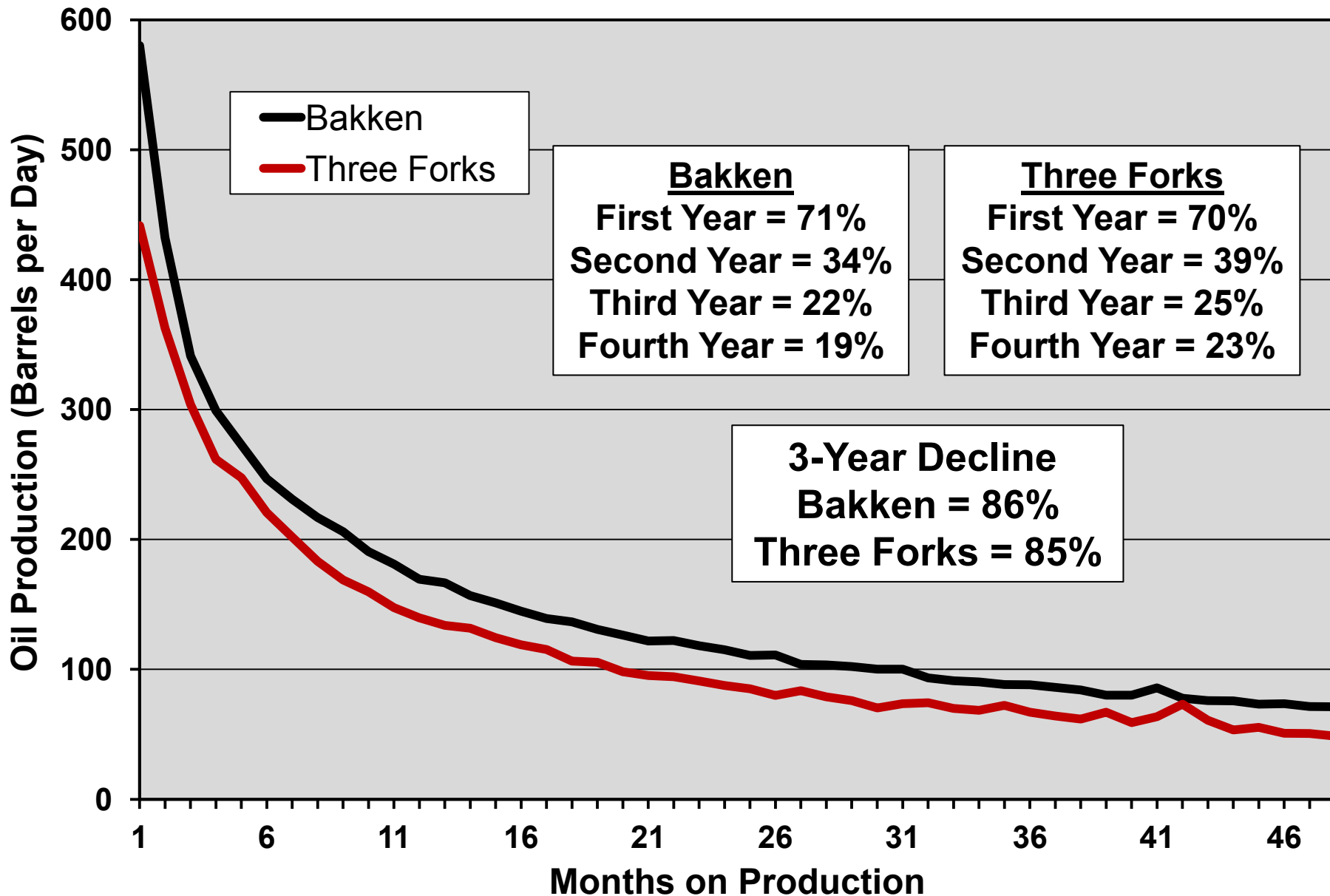


Bakken/Three Forks Stratigraphy

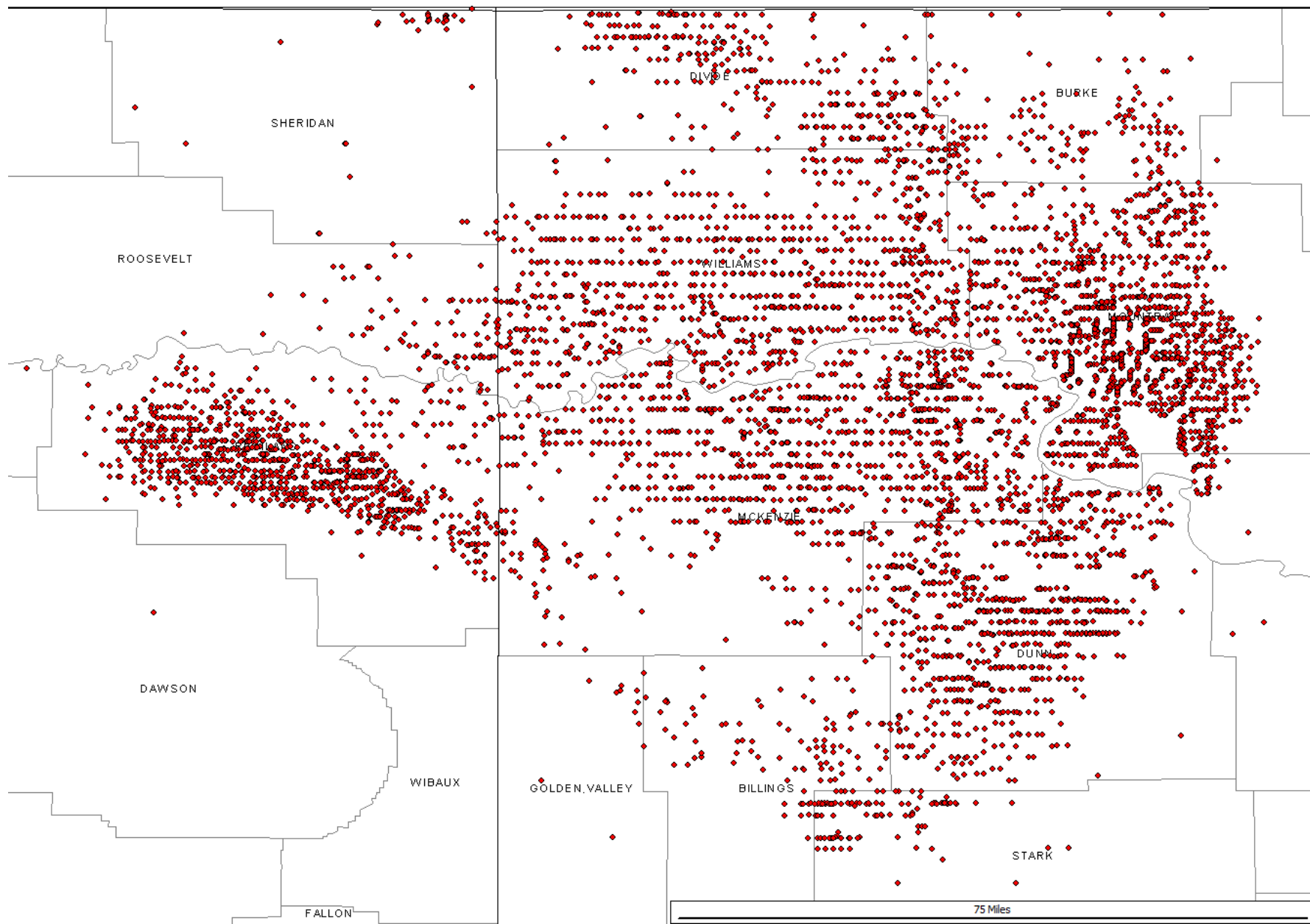


Bakken and Three Forks

Type Oil Well Decline Curves in North Dakota

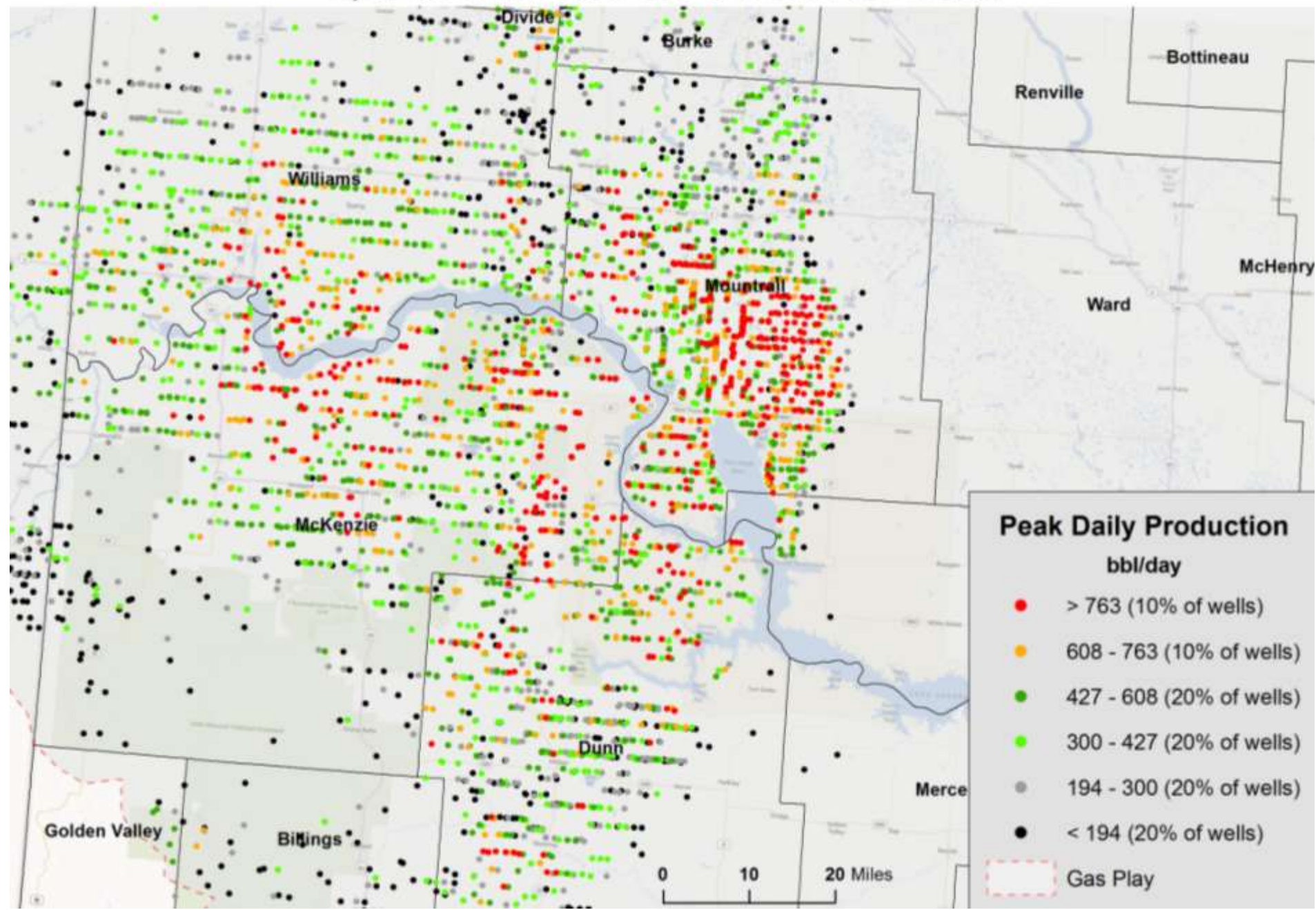


Bakken/Three Forks Well Distribution through mid-2013

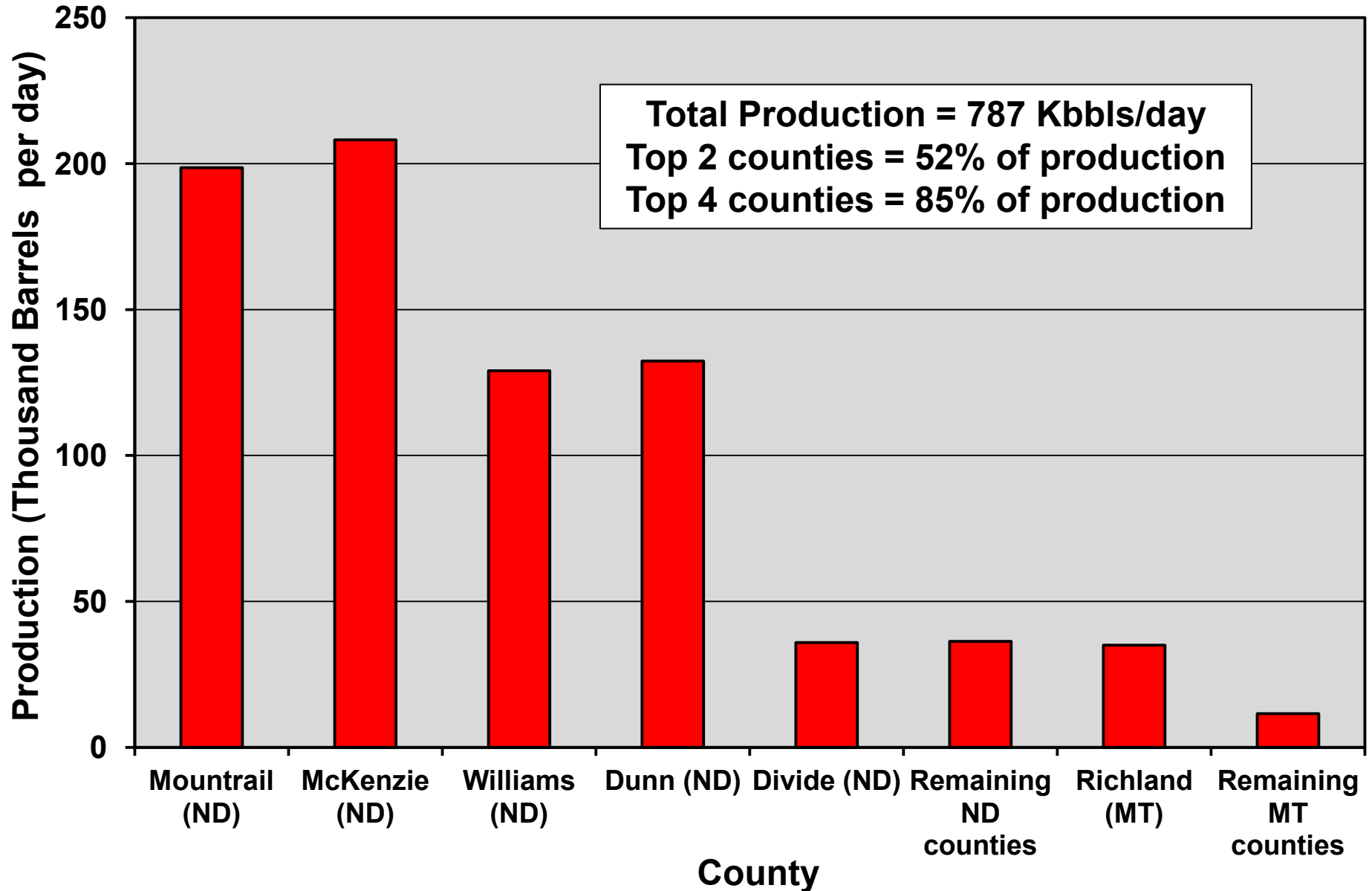


Bakken Well Quality

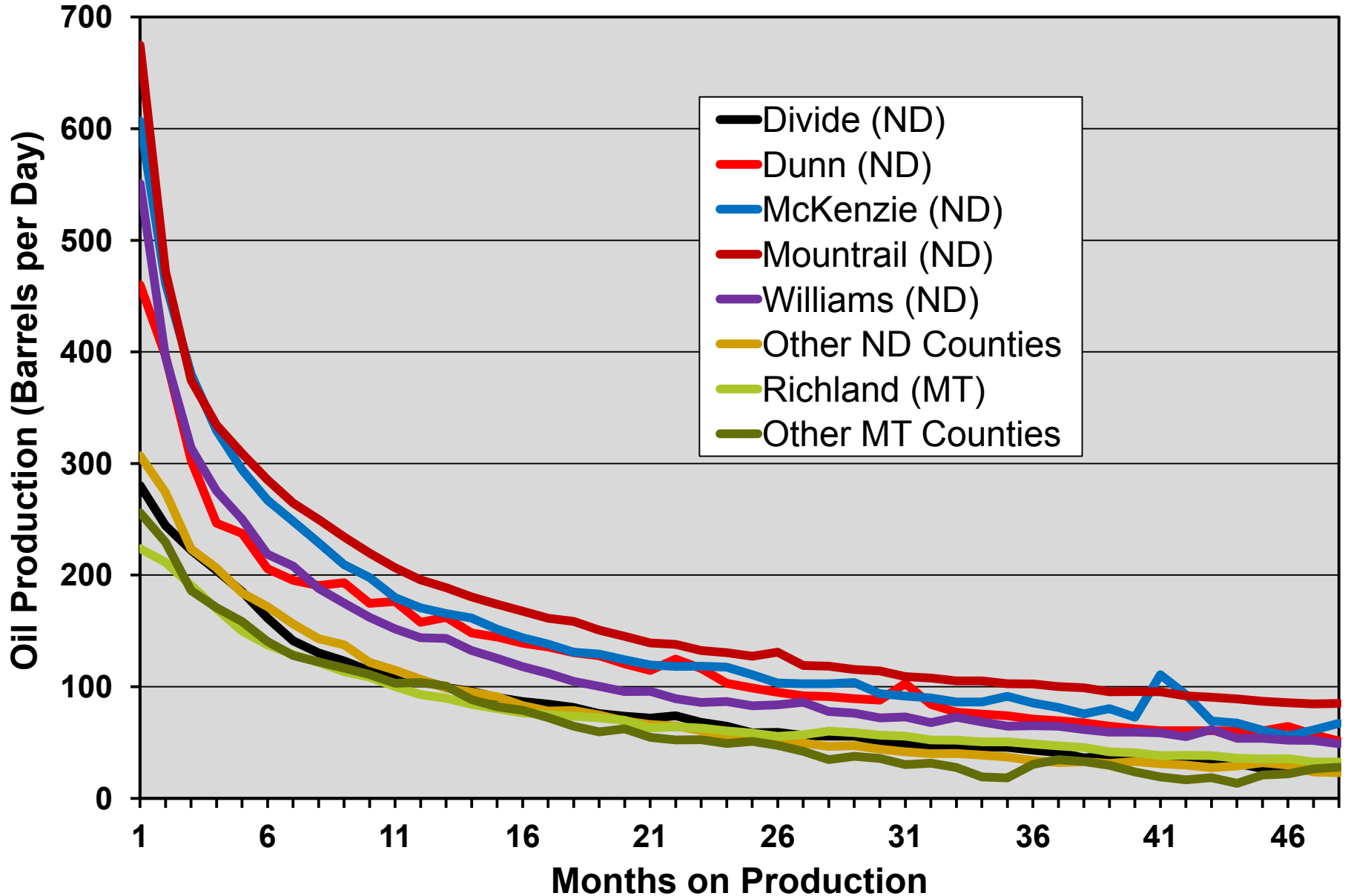
Spatial Distribution of Peak Oil Production



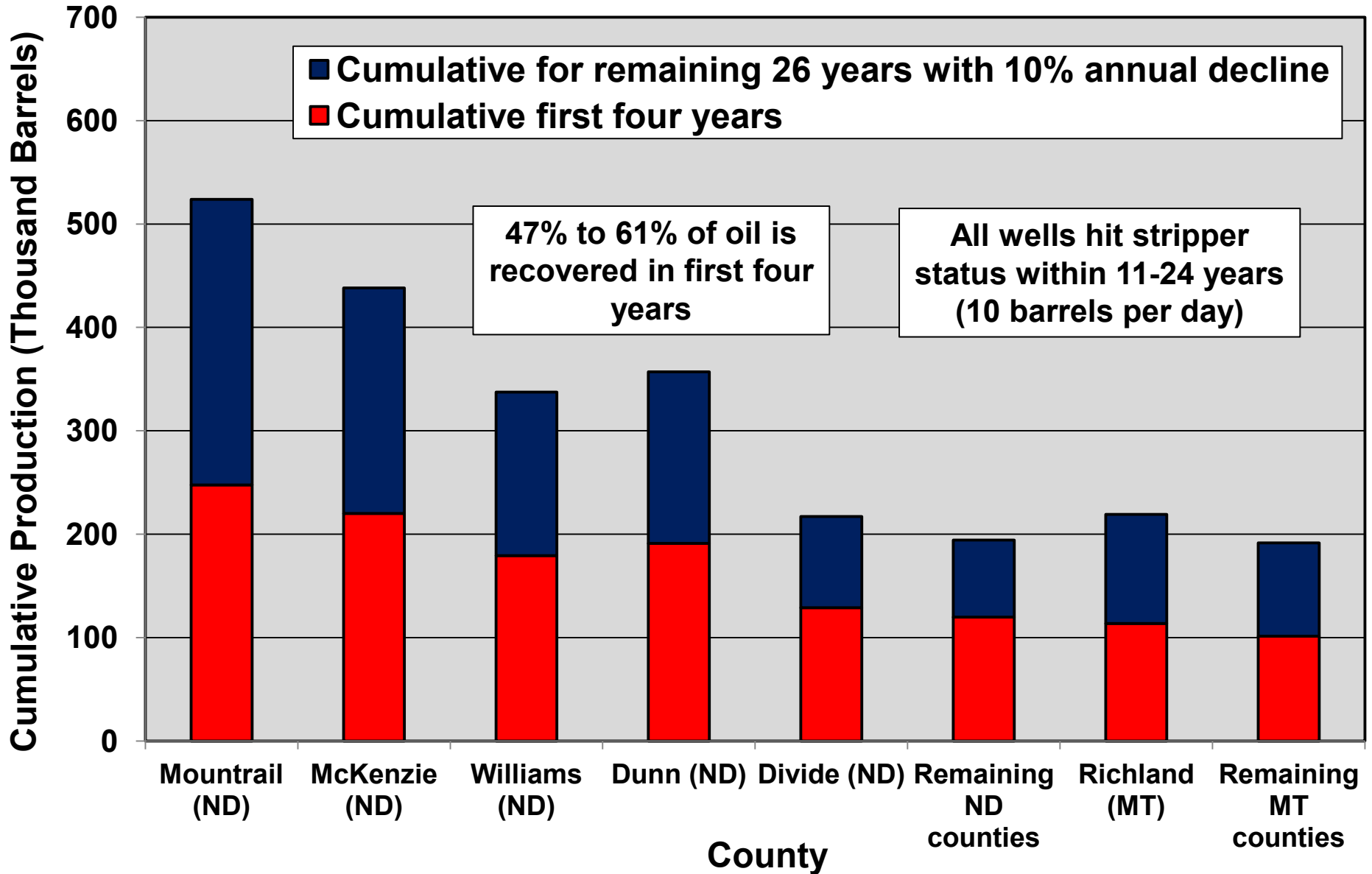
Bakken/Three Forks Production By County, North Dakota and Montana, June, 2013



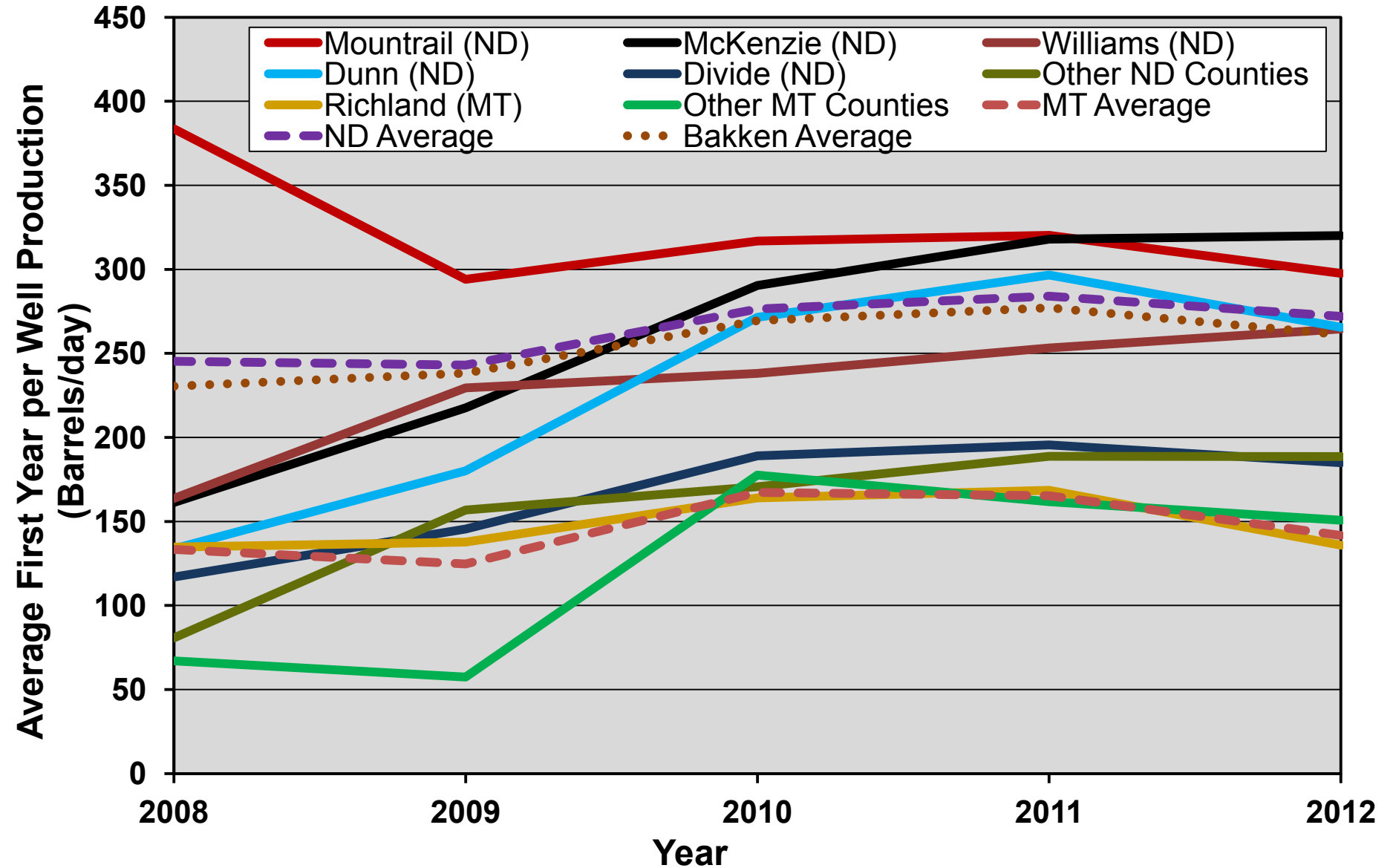
Bakken/Three Forks Type Oil Well Decline Curves by County and Region



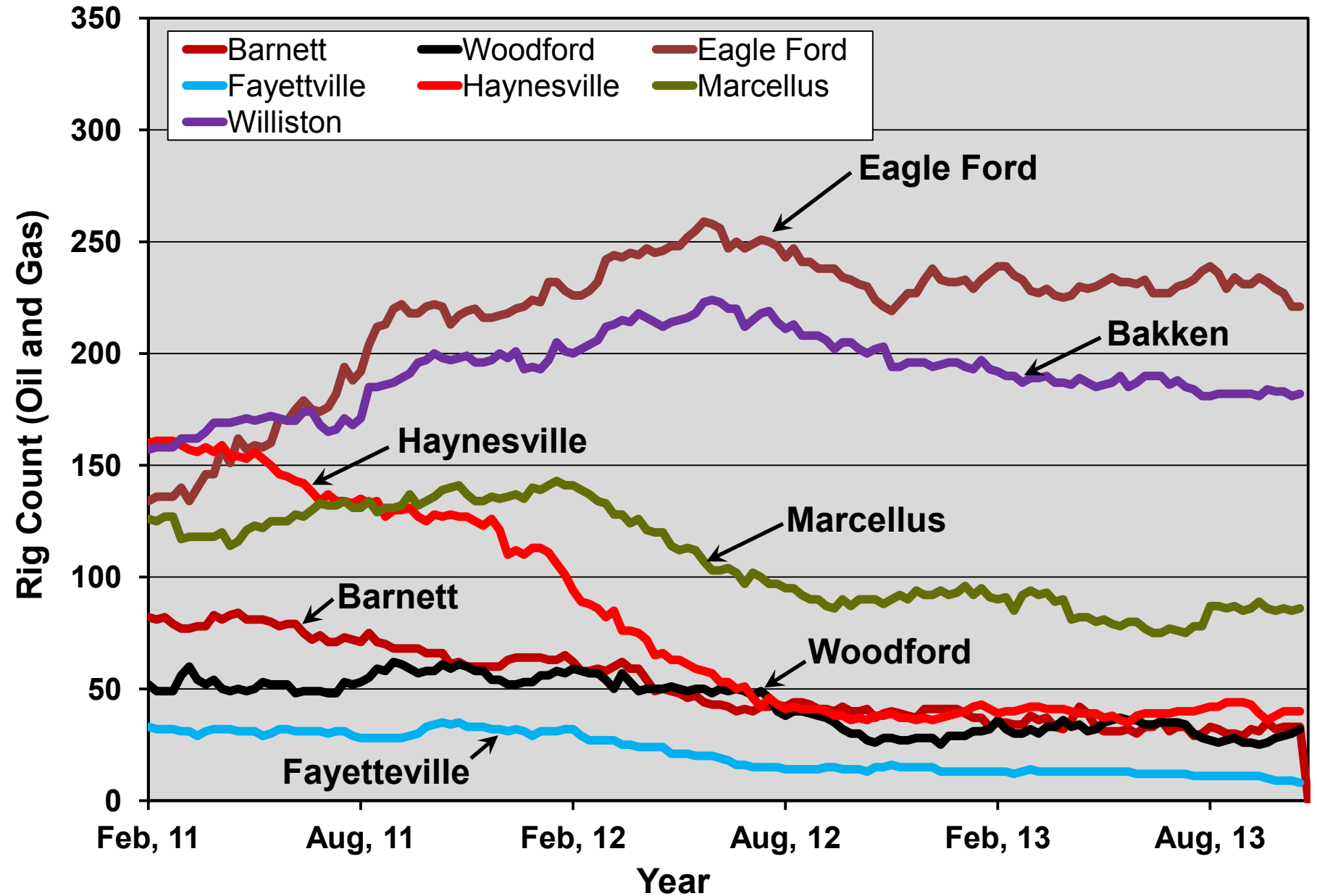
Bakken/Three Forks Estimated Ultimate Recovery per Well By County, North Dakota and Montana (over 30-year life)



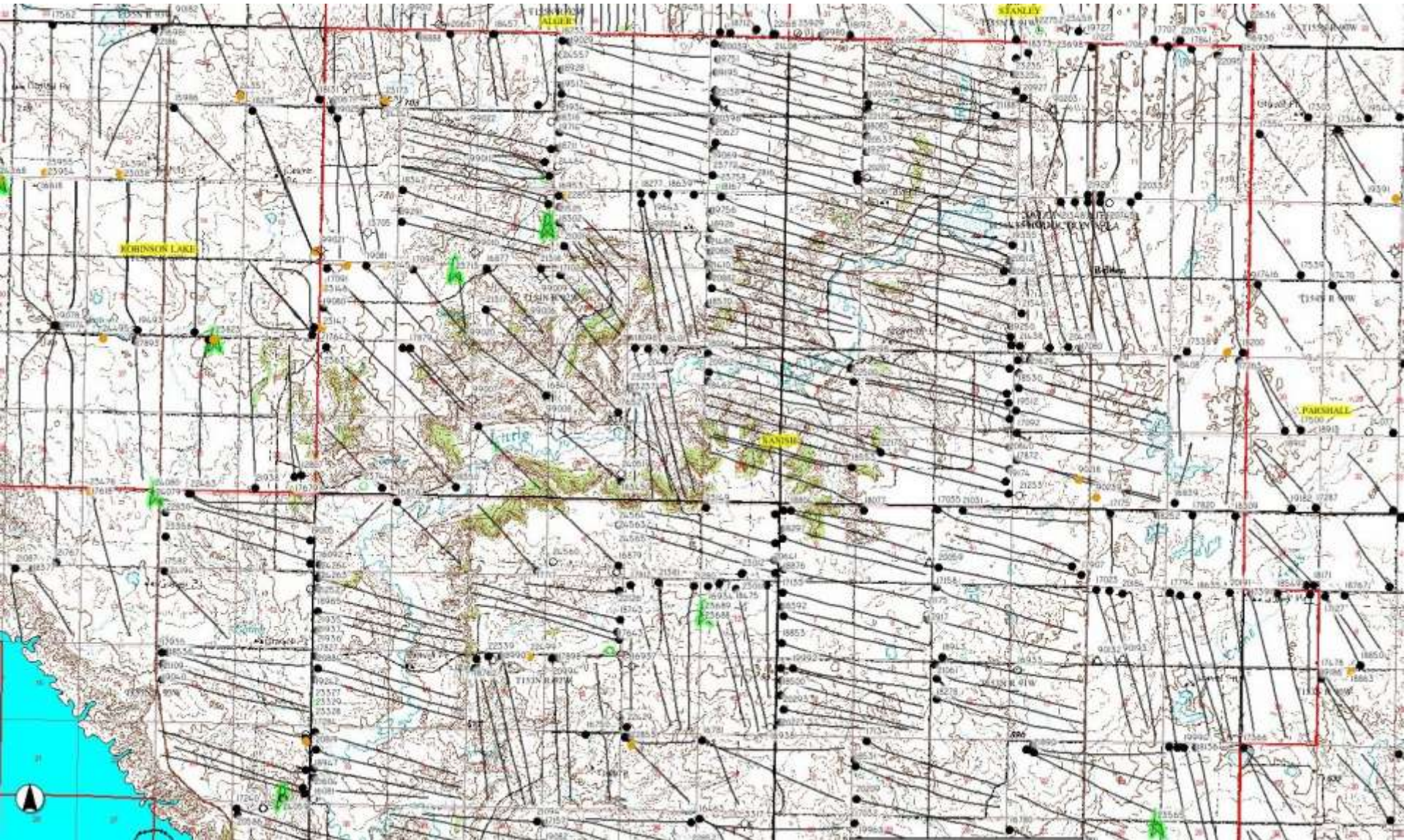
Bakken Average First Year Well Production by County and Region, 2008-2012



Rig Count for Selected Shale Plays, 2011-2013

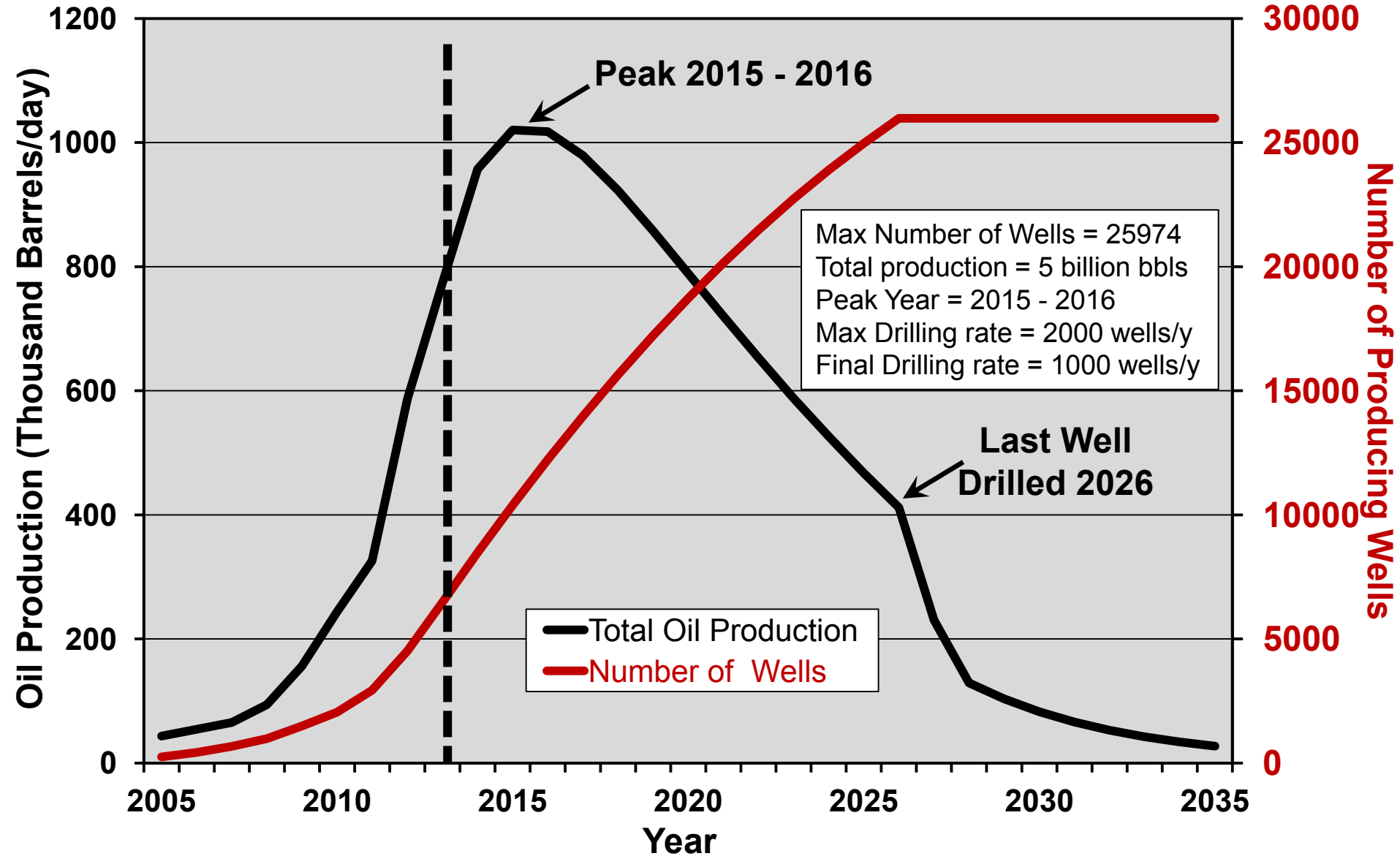


Horizontal Well Development in the Parshall Area Sweet Spot of the Bakken

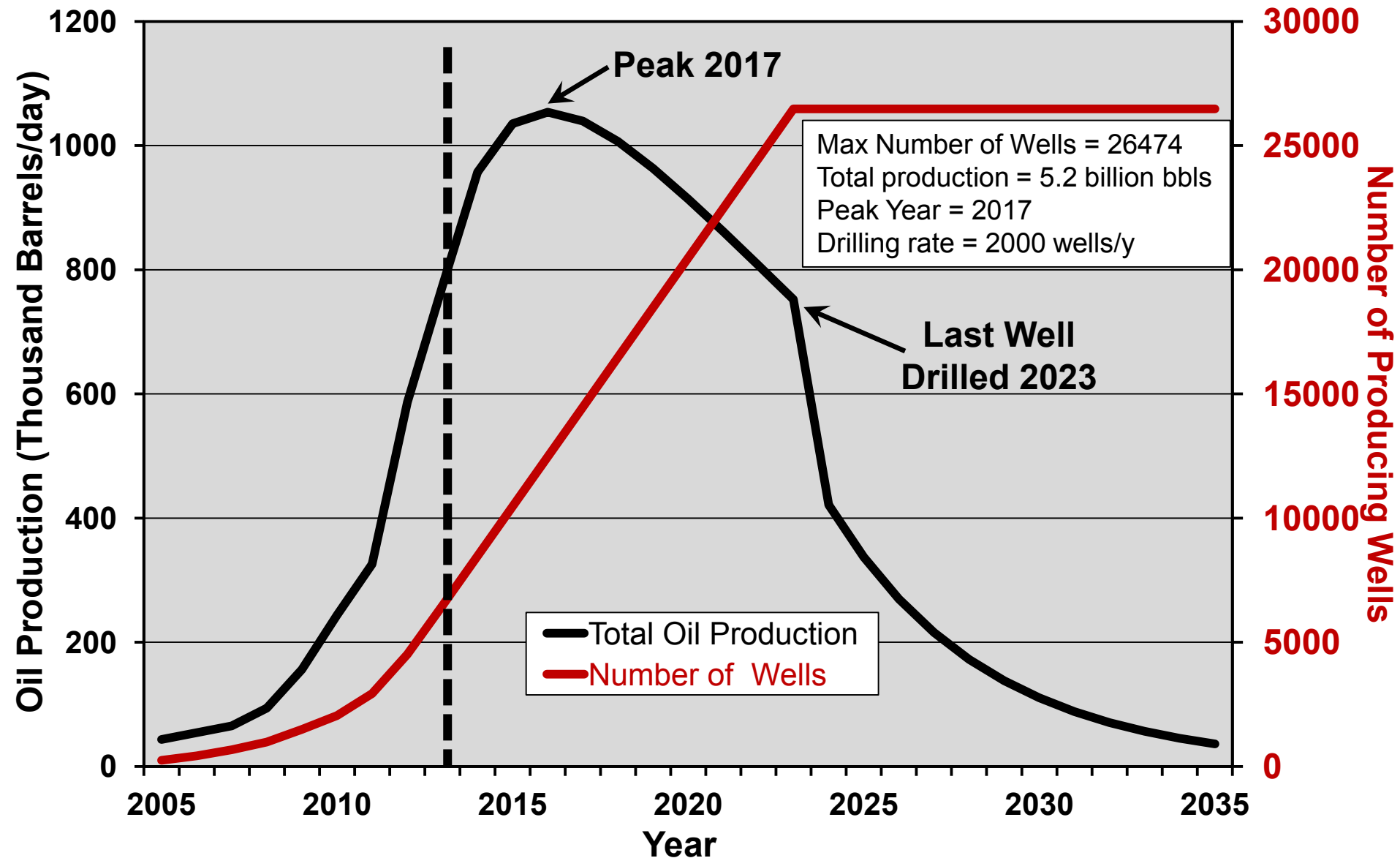


3 Miles

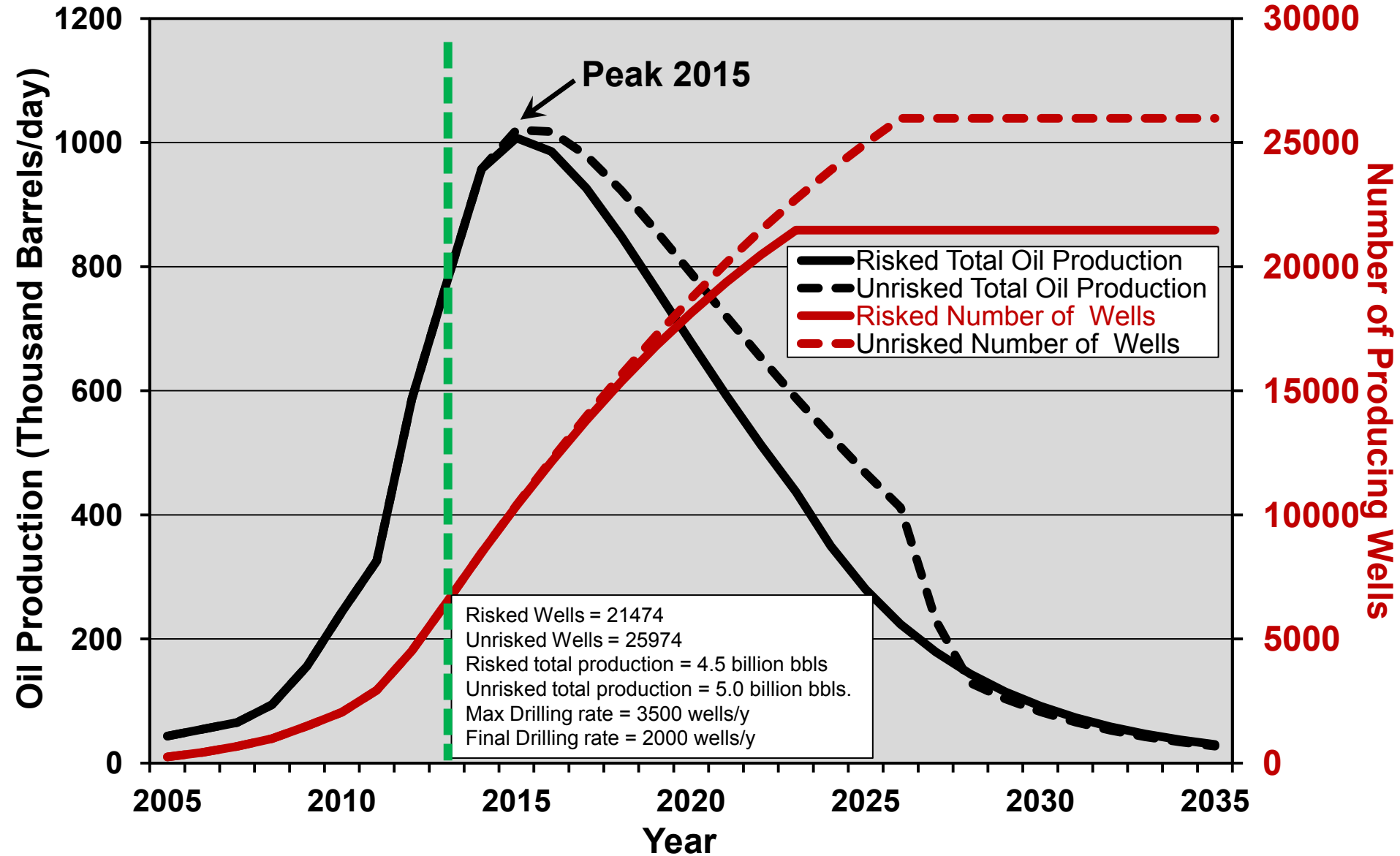
Bakken Oil Production - Declining Drilling Rate Scenario, (2000 wells/year declining to 1000 wells/year), 2005-2035



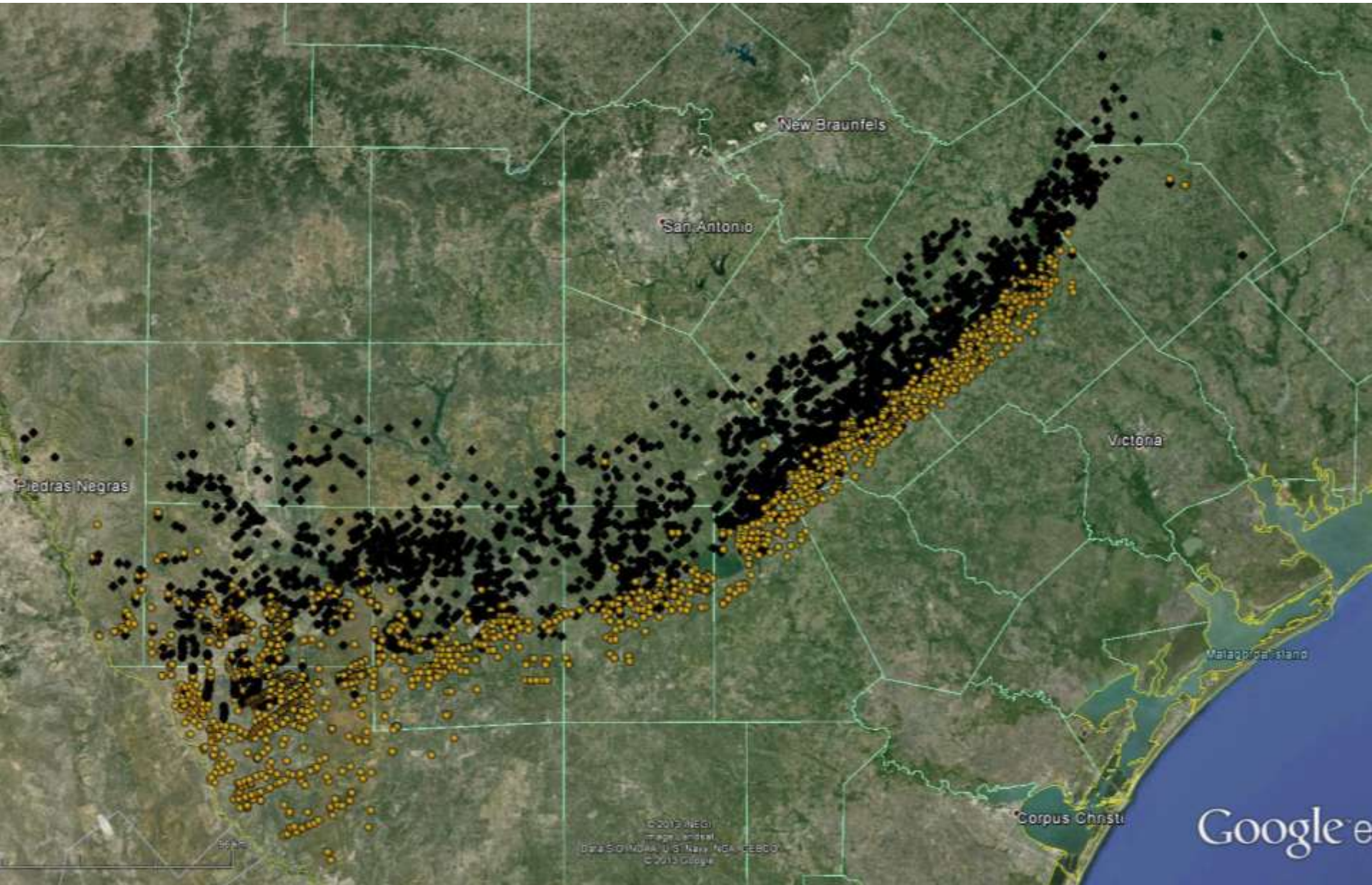
Bakken Oil Production - Constant Drilling Rate Scenario, (2000 wells/year), 2005-2035



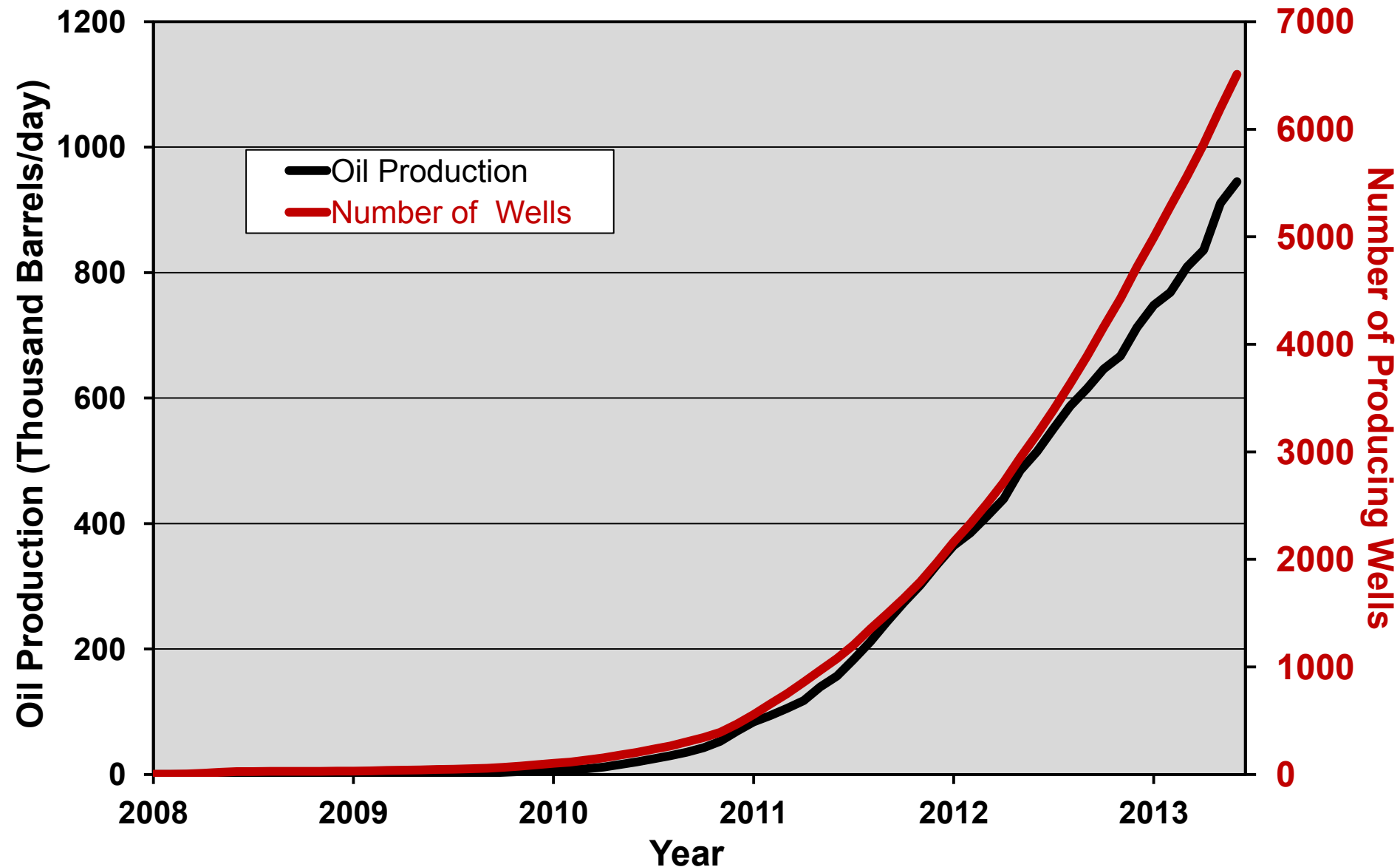
Bakken Oil Production - Declining Drilling Rate Scenario, Risked at 80% for locations versus Unrisked, 2005-2035



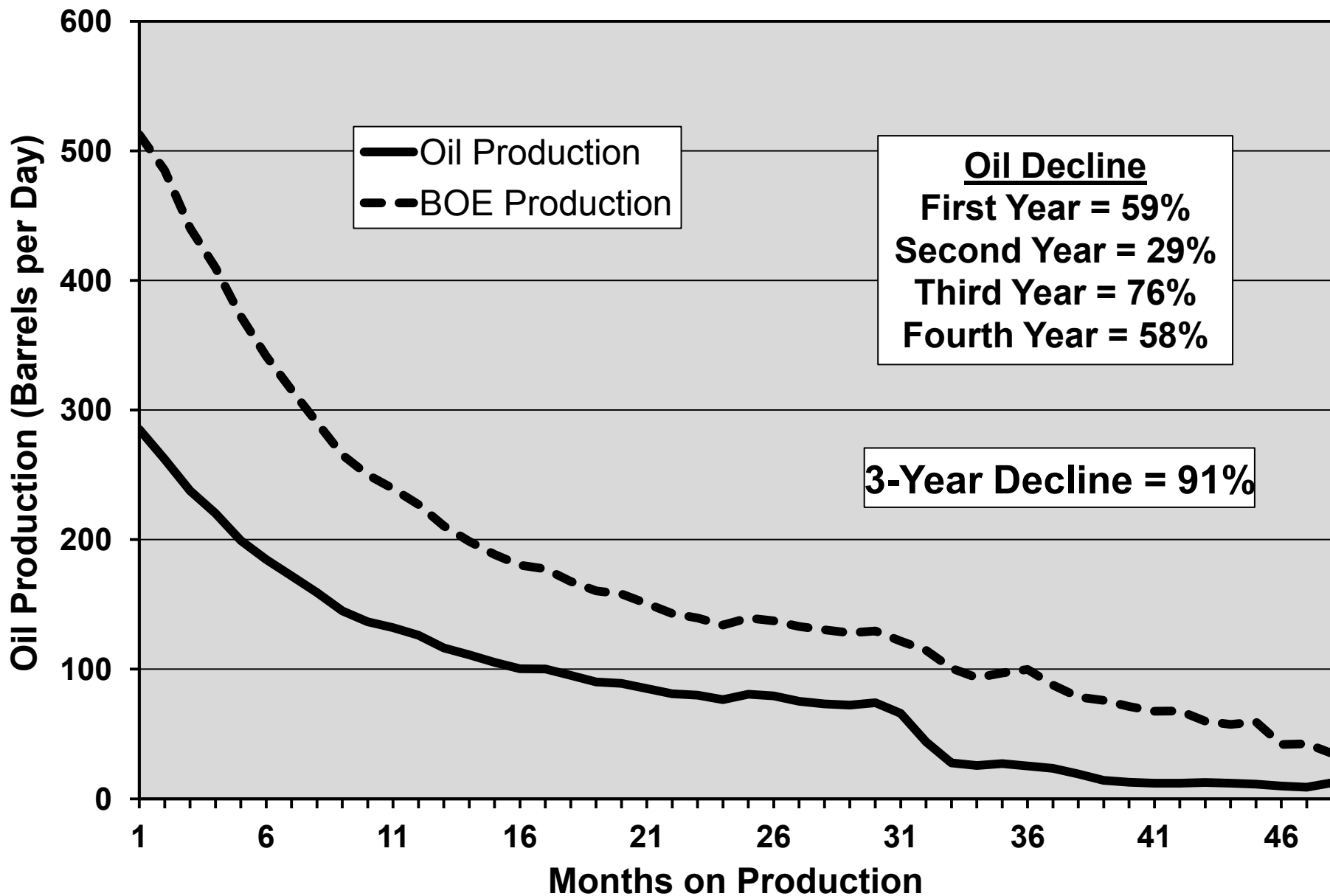
Eagle Ford Gas and Oil Well Distribution through mid-2013



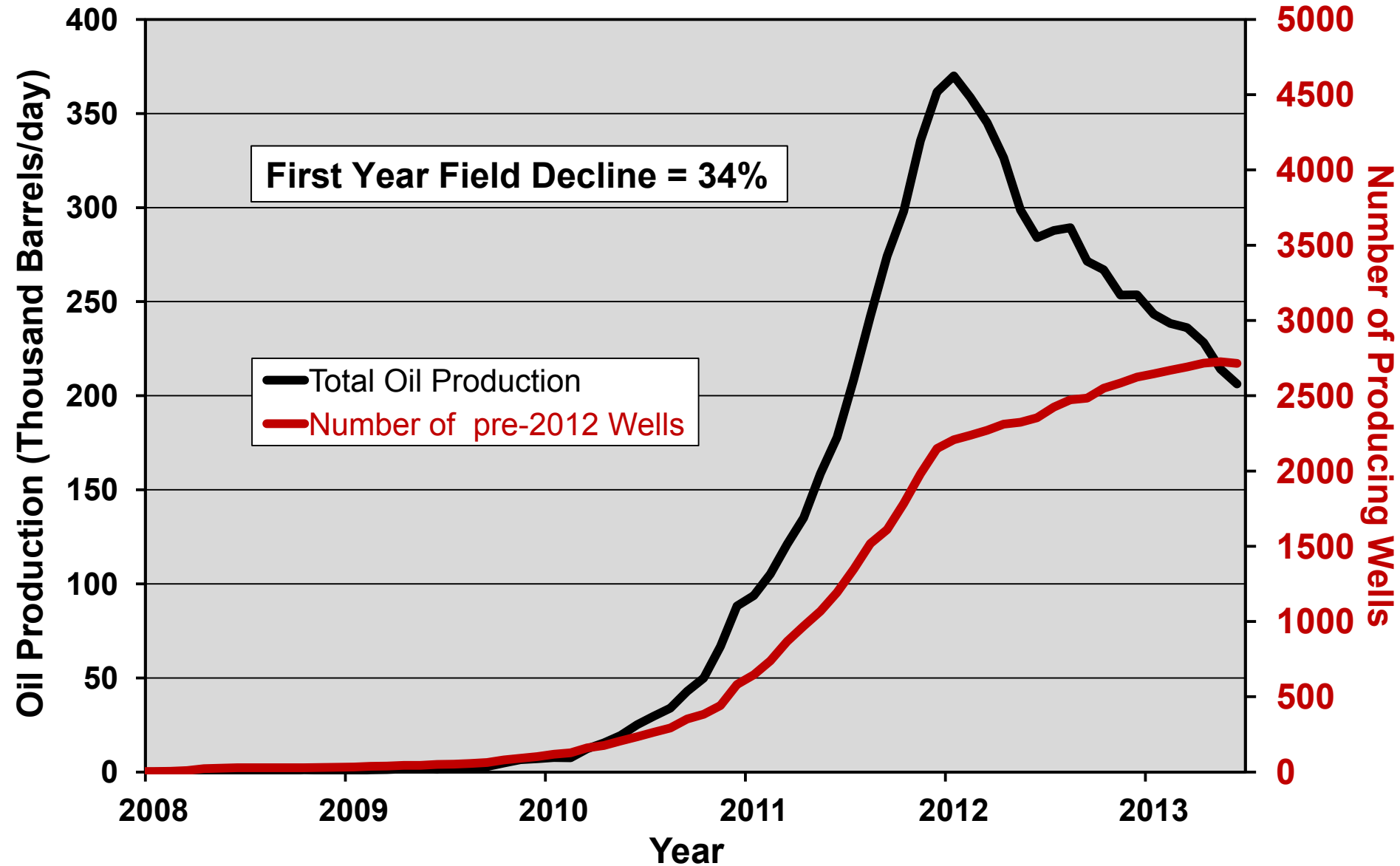
Eagle Ford Oil plus NGL Production and Number of Operating Wells, 2005-2013



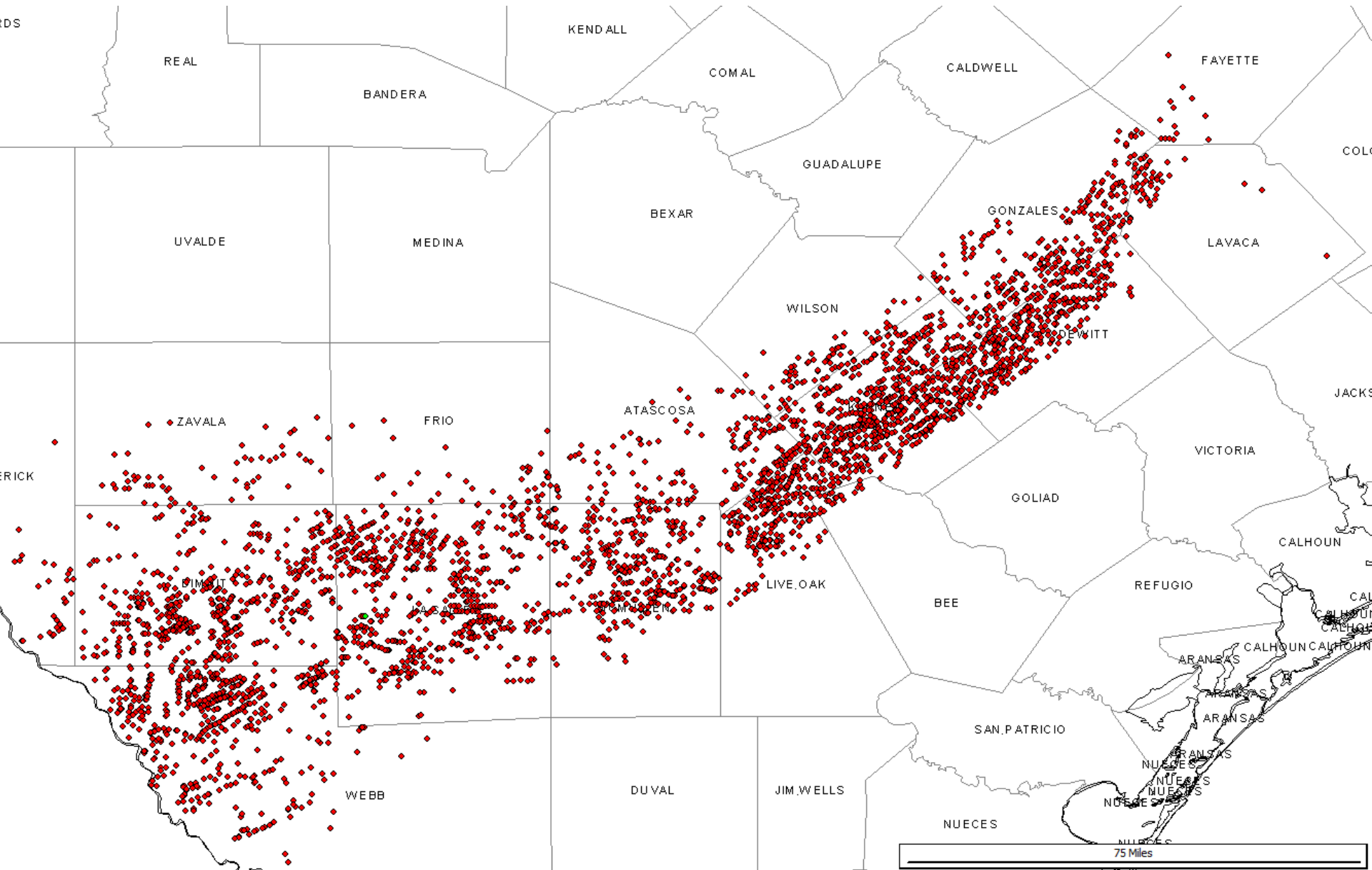
Eagle Ford Type Oil and Barrels of Oil Equivalent Well Decline Curves



Eagle Ford Field Production Decline – Oil Production from all Wells Drilled Prior to 2012

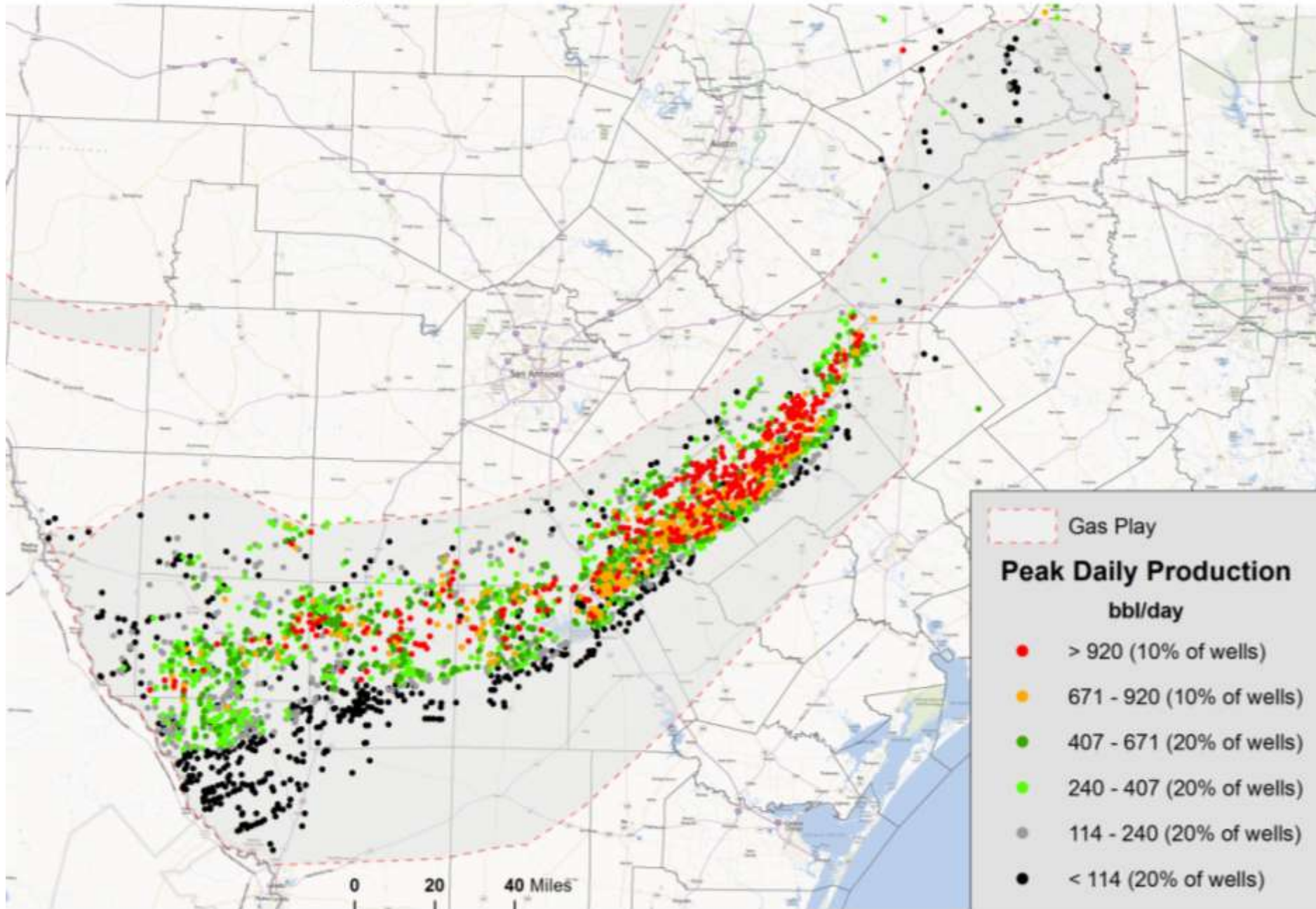


Eagle Ford Well Distribution through mid-2013

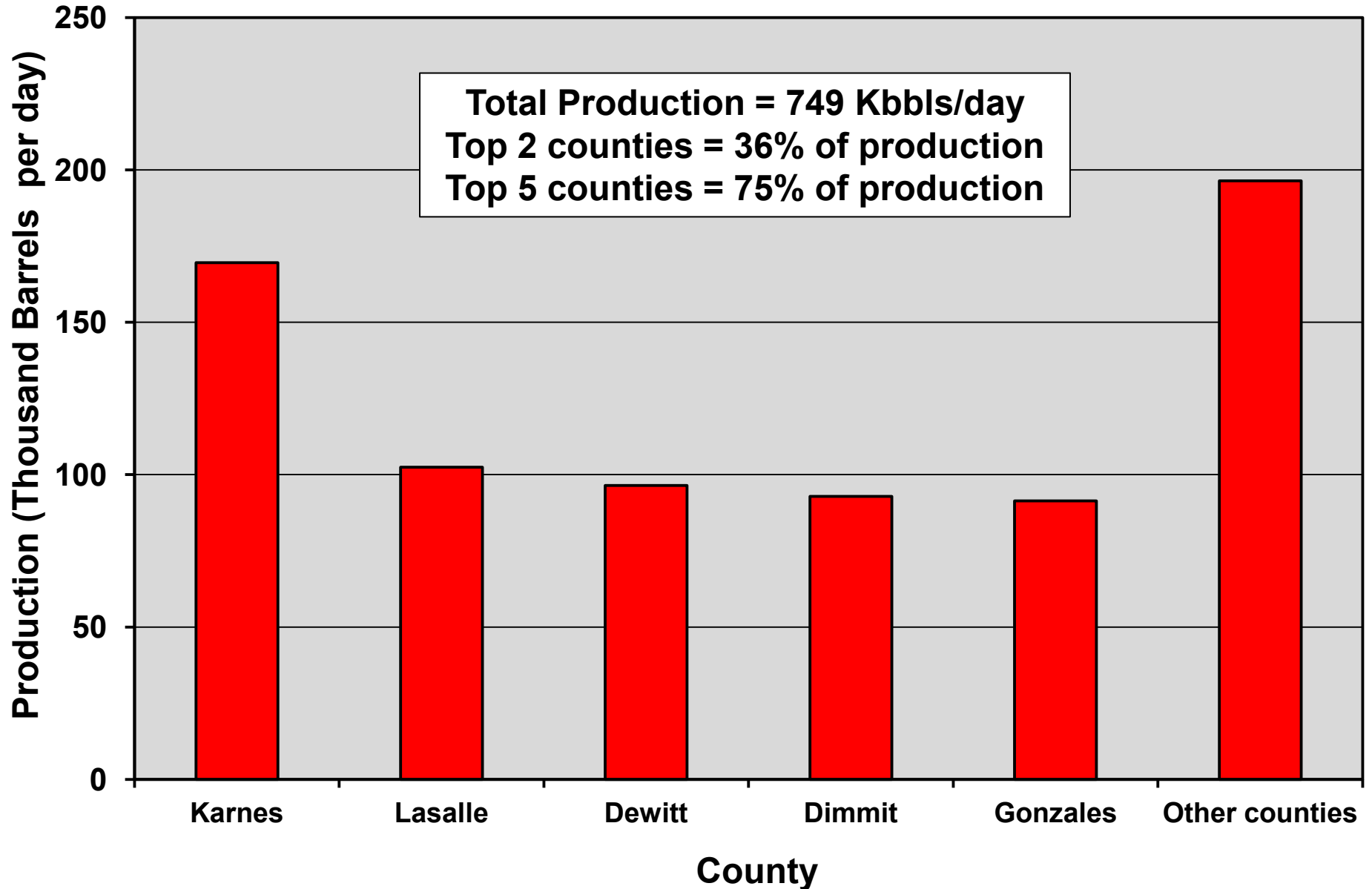


Eagle Ford Well Quality

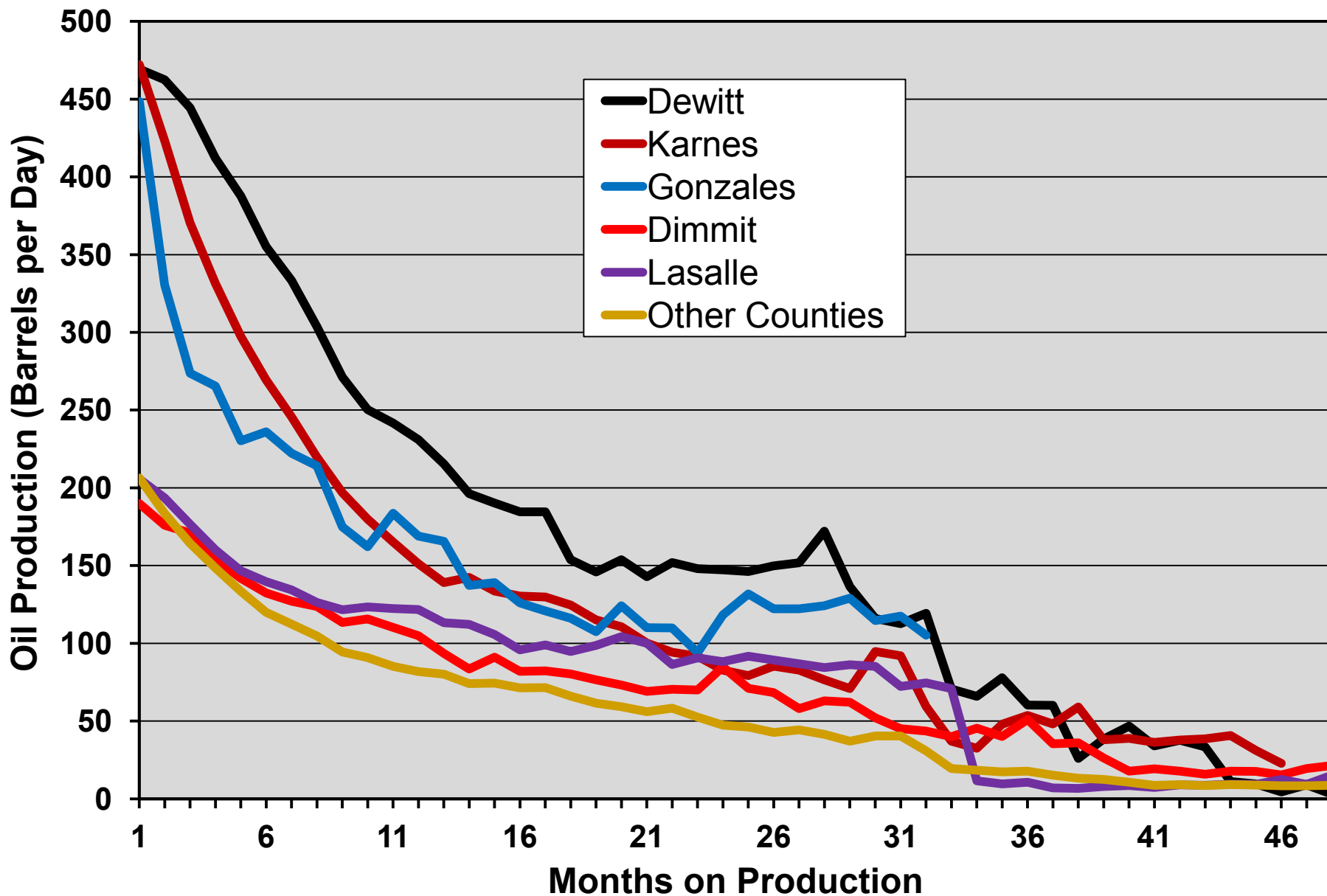
Spatial Distribution of Peak Oil Production



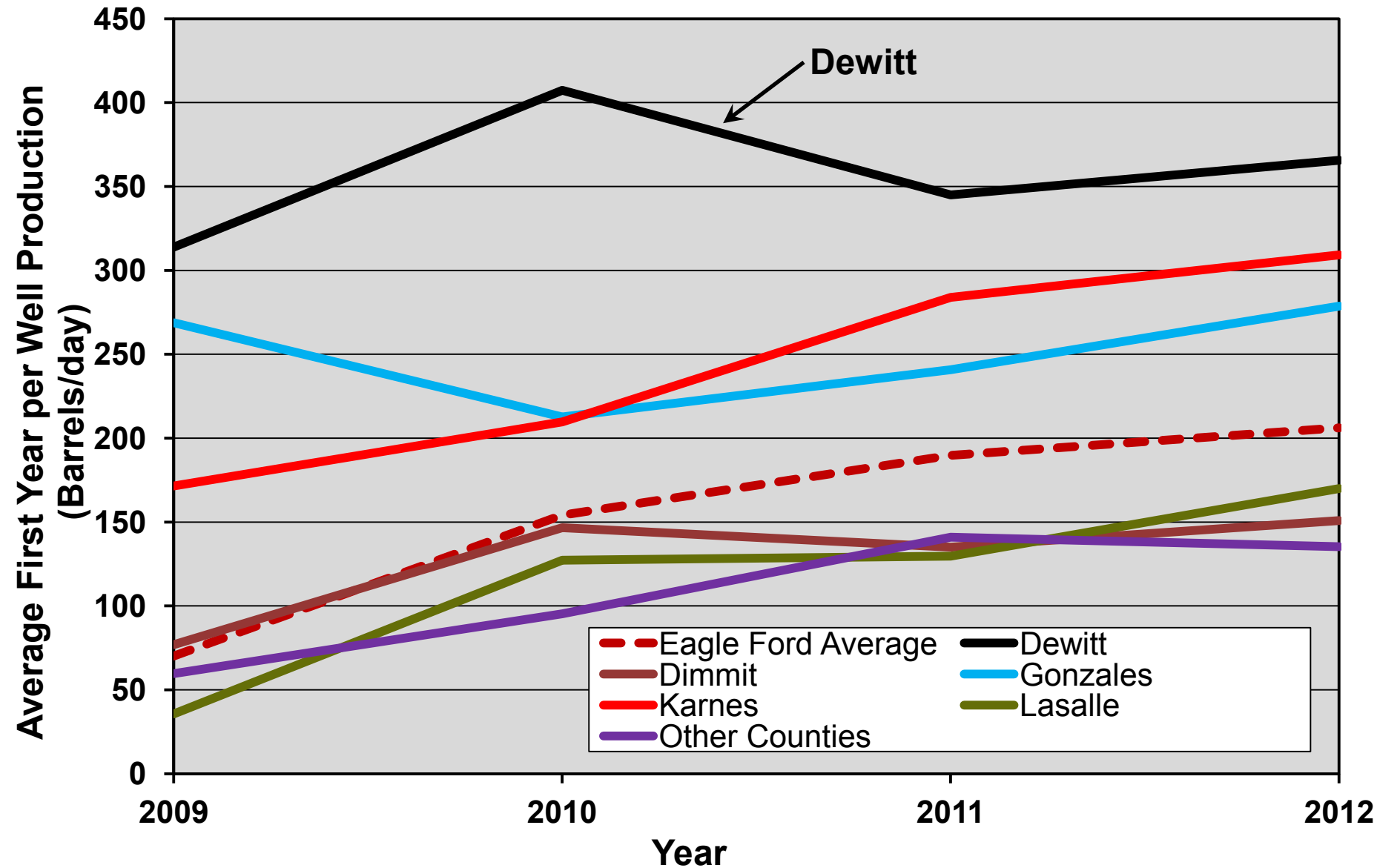
Eagle Ford Oil Production By County, June, 2013



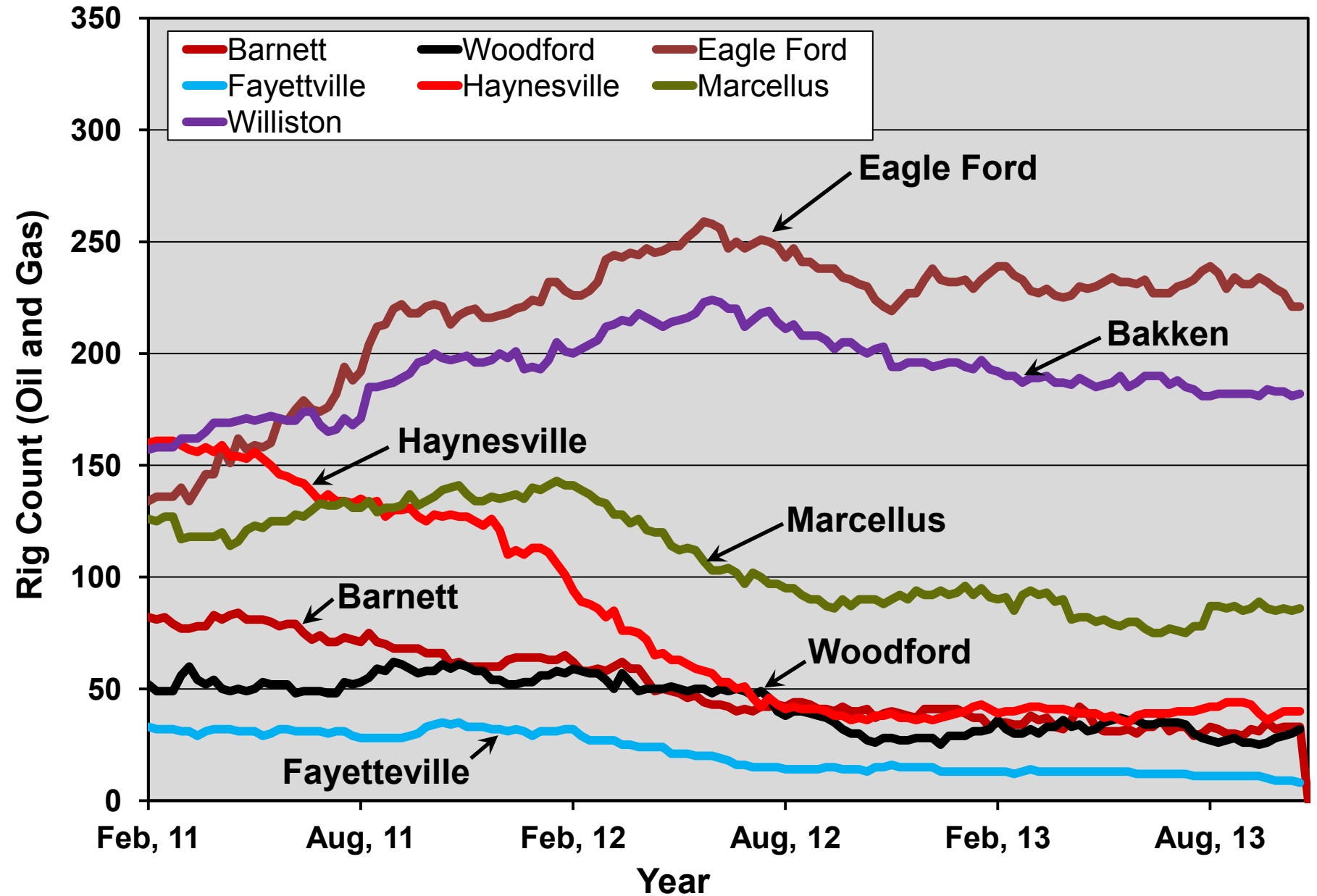
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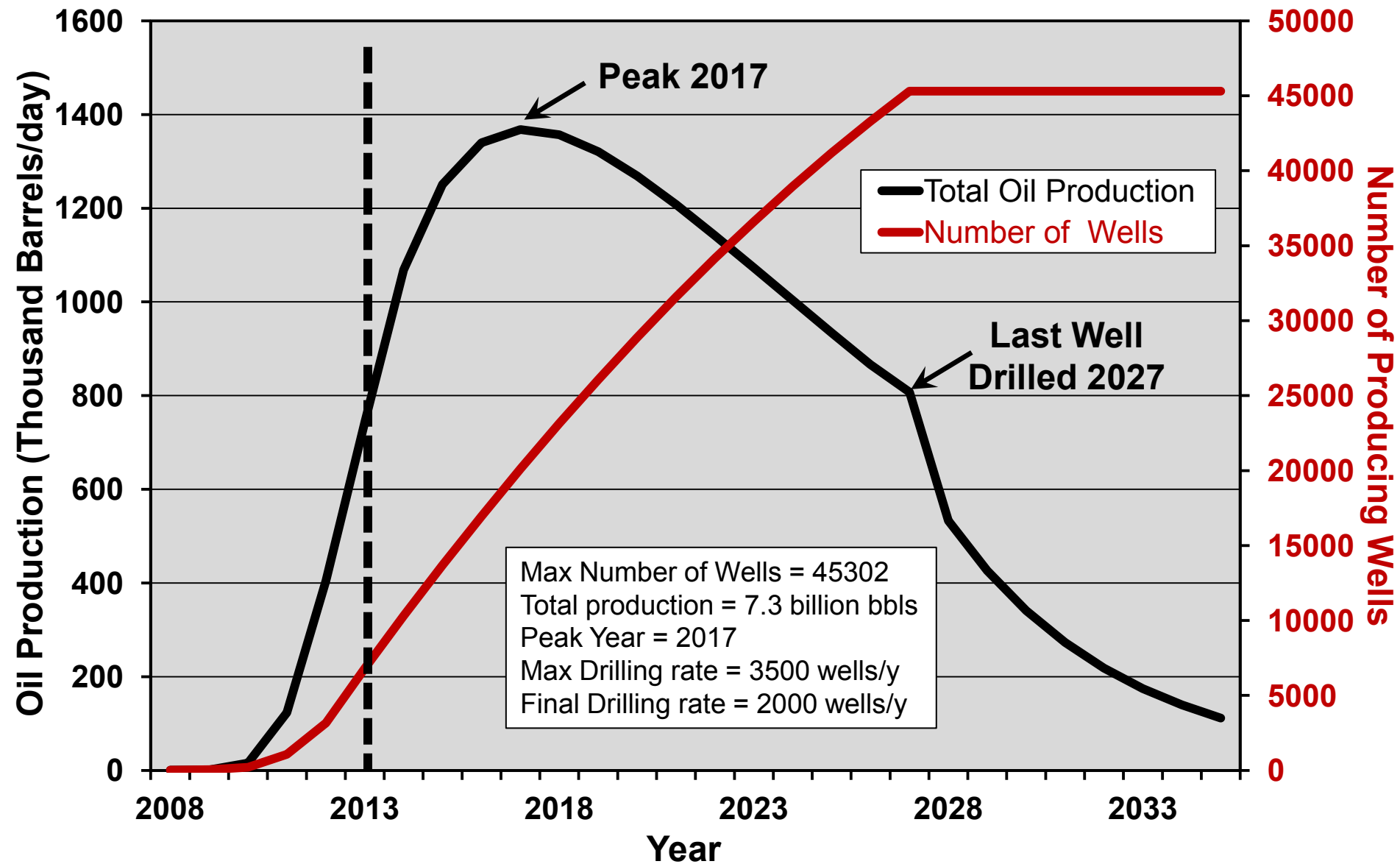
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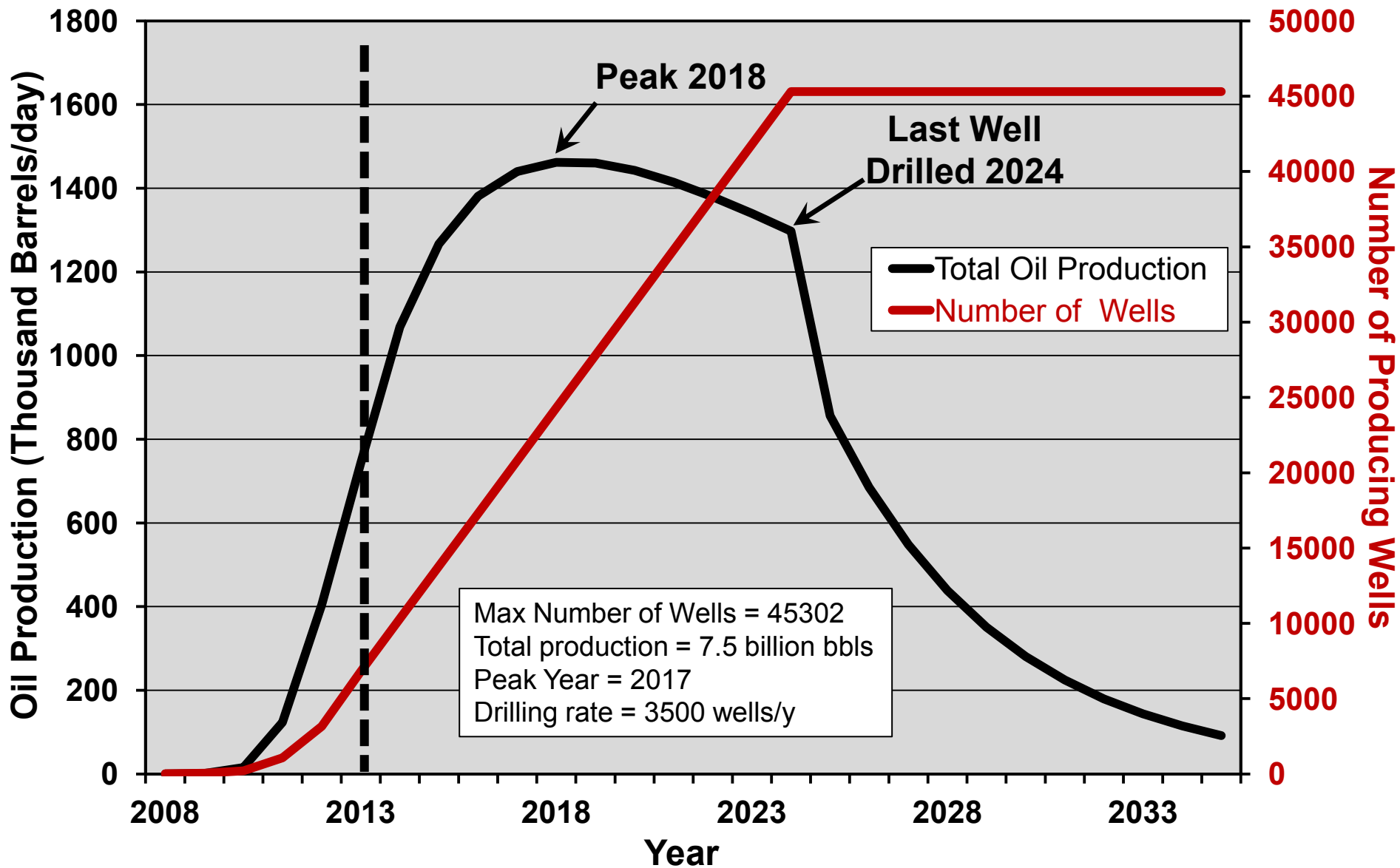
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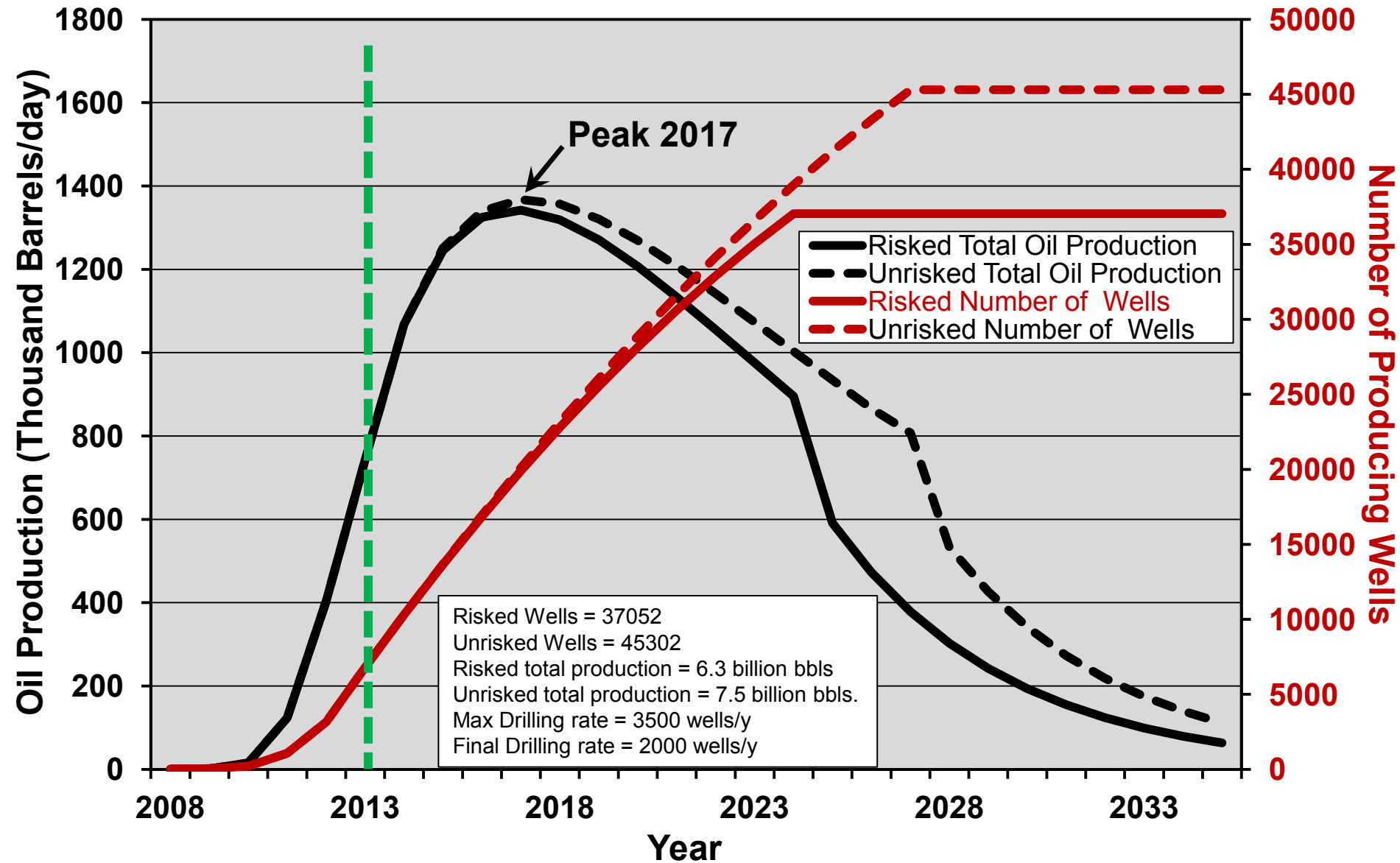
Eagle Ford Oil Production - Declining Drilling Rate Scenario, (3500 wells/year declining to 2000 wells/year), 2008-2035



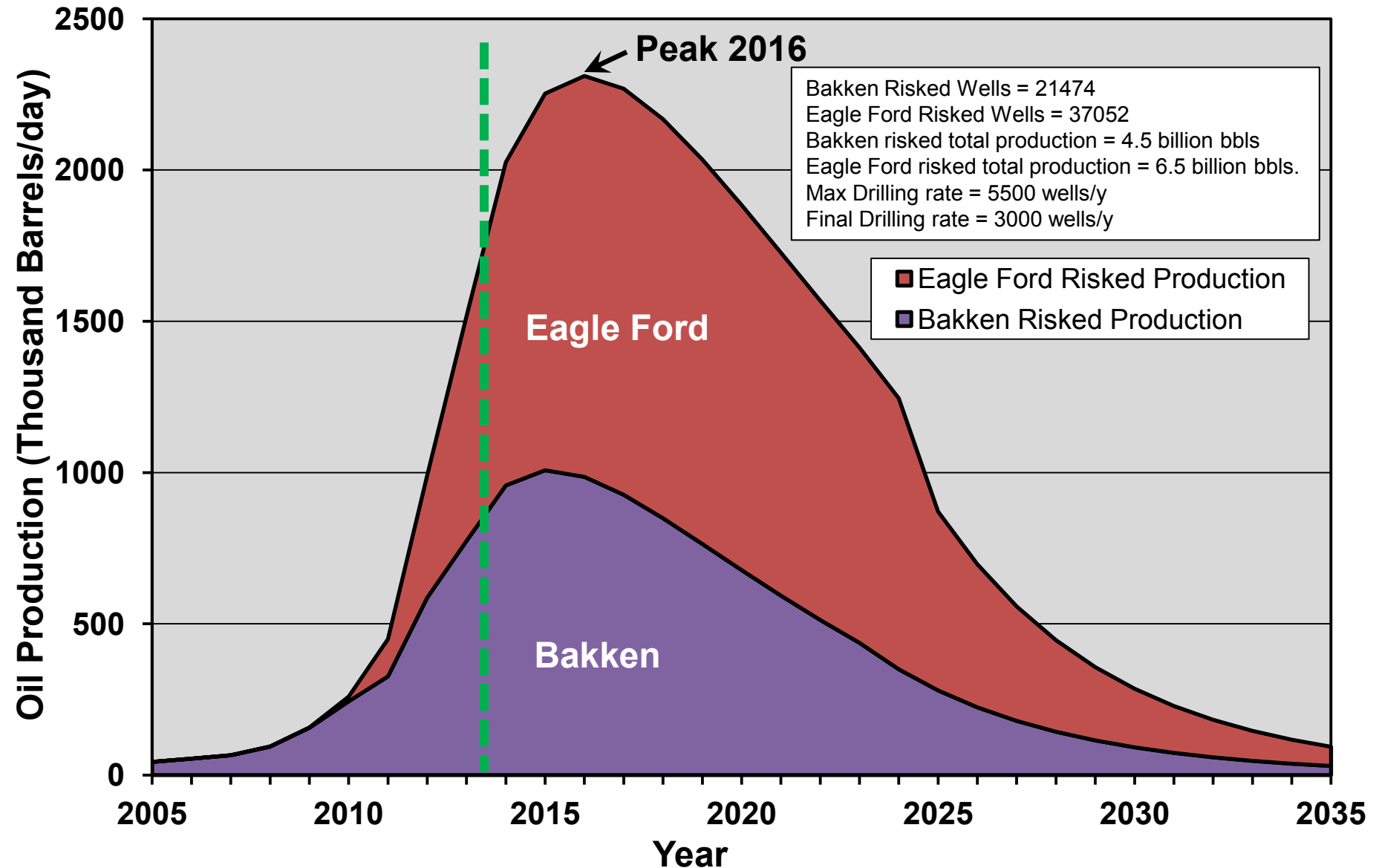
Eagle Ford Oil Production - Constant Drilling Rate Scenario, (3500 wells/year), 2008-2035



Eagle Ford Oil Production - Declining Drilling Rate Scenario, Risked at 80% for locations versus Unrisked, 2008-2035



Bakken and Eagle Ford Oil Production – Declining Drilling Rate Risked at 80% for locations, 2005-2035



There is no such thing as a *FREE LUNCH*

There has been a great deal of pushback by many in the general public – and in State and National governments – to environmental issues surrounding hydraulic fracturing.

(eg. Global Frackdown held October 19, 2013, involving 250 protests in 26 countries)

There is no such thing as a *FREE LUNCH*

- High levels of water consumption
- Methane contamination of groundwater
- Disposal of produced fracture fluid potentially contaminating groundwater and inducing earthquakes
- Industrial footprint – truck traffic, air emissions etc.
- Full cycle greenhouse gas emissions which may be worse than coal

A Reality Check?

"We are all losing our shirts today.

We're making no money. It's all in the red."

(Rex Tillerson, CEO of Exxon Mobil, *Wall Street Journal*, June 2012)

The United States oil and gas industry has "over fracked and over drilled"

(Mattihus Bichsel, projects and technology director, Royal Dutch Shell Plc.,
October 17, 2013)

Shell writes down \$2.2 billion in shale assets and puts Eagle Ford properties up for sale

(Reuters September 30, 2013)

Tight Oil Takeaways

- Tight oil production from the top two plays is likely to peak in 2016-2017 timeframe.
- High field decline rates mandate sustained high levels of drilling to maintain production.
- Increasing drilling rates over current levels in the Bakken and Eagle Ford, which account for one third of U.S. E&P investment, would only increase peak production slightly and move it forward by perhaps a few months.
- Increases in the number of available drilling locations will increase ultimate recovery but will not change the timing of peak production at current drilling rates.
- High quality shale plays are not ubiquitous:
 - *88% of shale gas production comes from 6 of 30 plays.*
 - *70% of tight oil production comes from 2 of 21 plays.*

Implications for the U.S.

- The “Shale Revolution” has been a “game-changer” in that it has temporarily reversed a terminal decline in supplies from conventional sources. Long-term sustainability is highly questionable and environmental impacts are a major concern.
- Almost all eggs are in the shale basket as a hope in meeting U.S. energy supply growth projections from oil and gas.
- US “Energy Independence” and freedom from oil imports with the forecast energy consumption trajectory is highly unlikely, barring a radical reduction in consumption.
- The “Shale Revolution” has provided a temporary respite from declining oil and gas production, but should not be viewed as a panacea for increasing energy consumption – and exporting the bounty. Rather, it should be used as an opportunity to create the infrastructure needed for a lower energy throughput and alternative energy sources.