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

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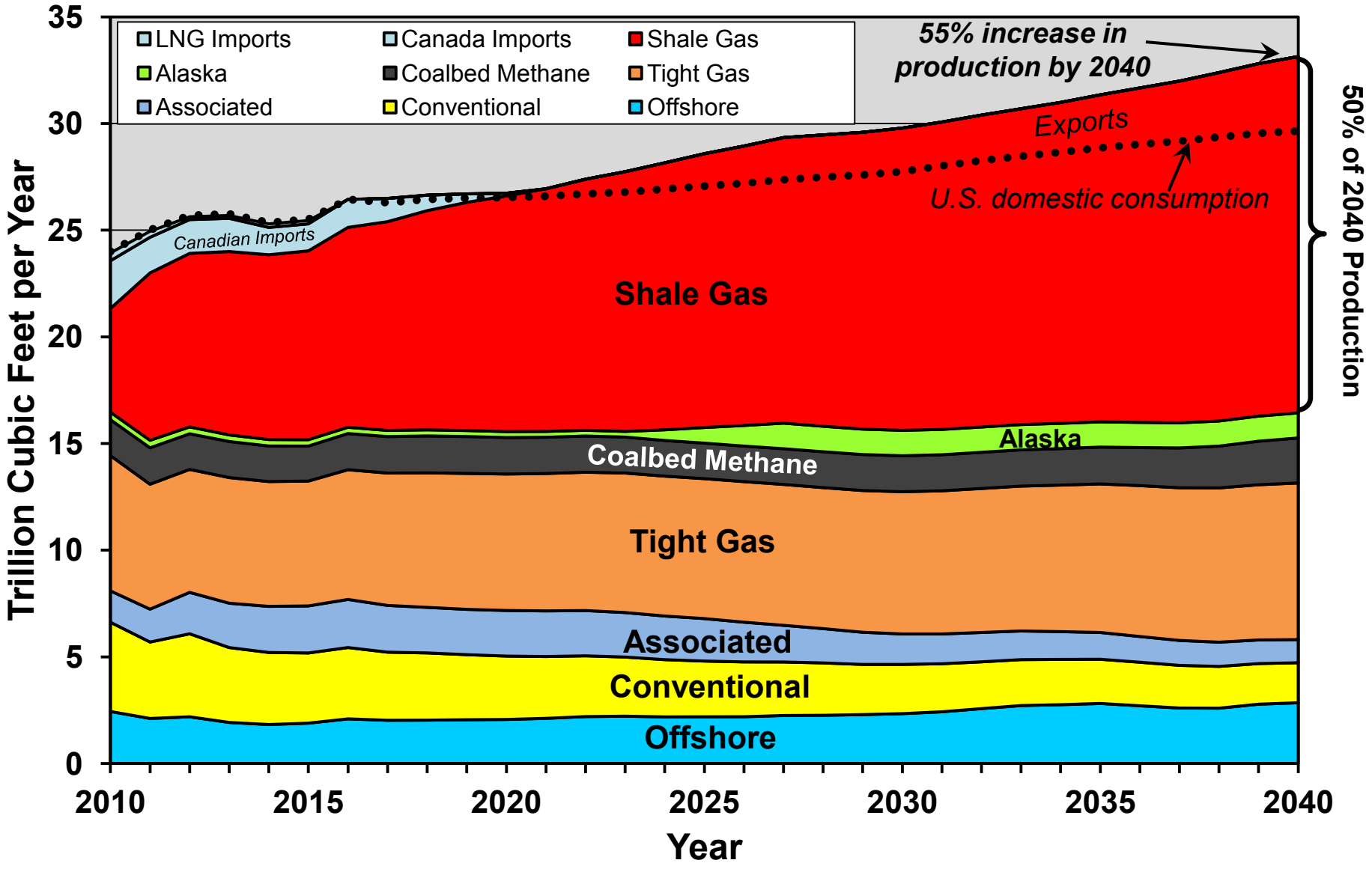
The Shale Revolution

- 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

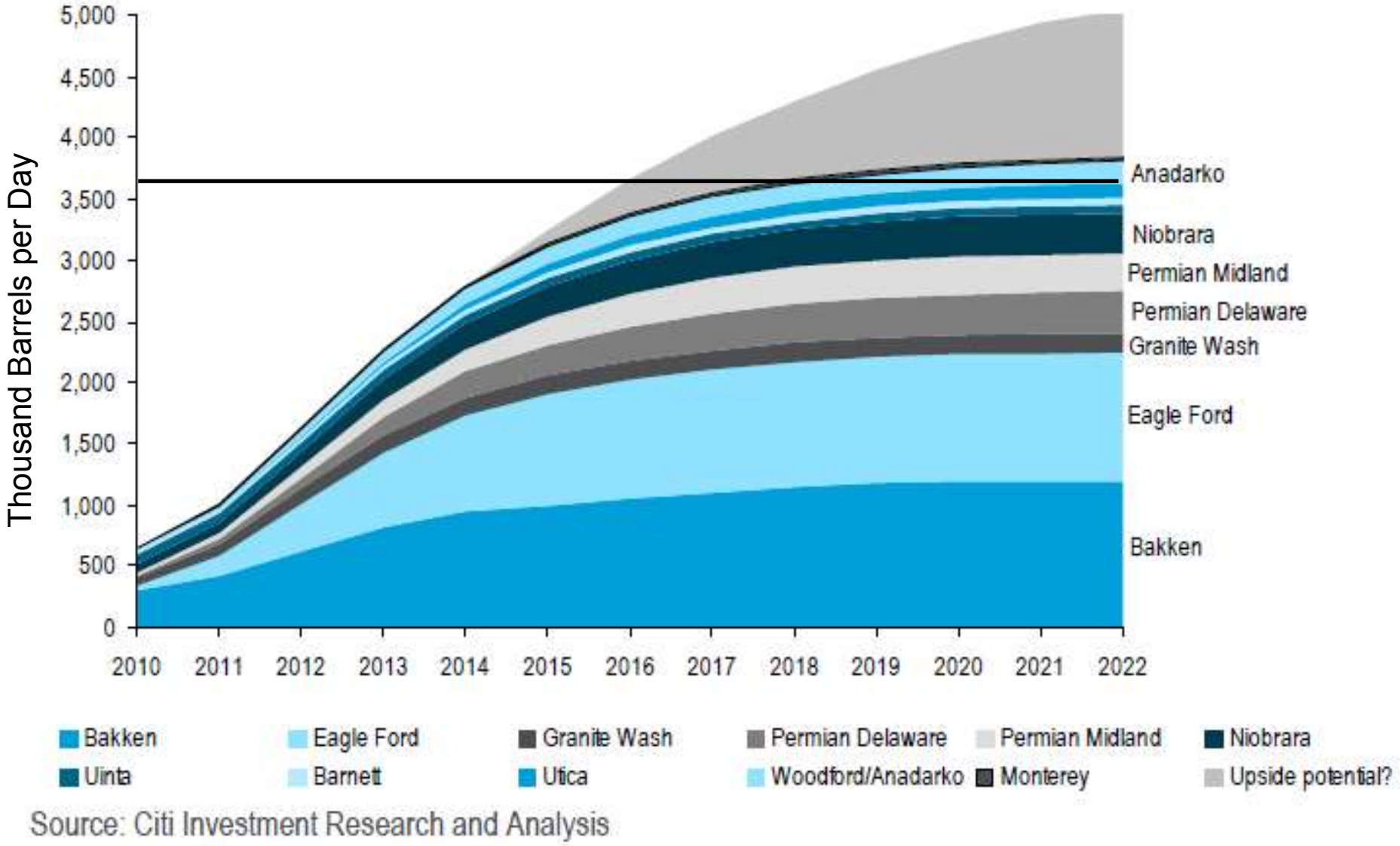
- The United States is on the verge of Energy Independence thanks to the “SHALE REVOLUTION”.
- Shale Gas production will continue to grow for the foreseeable future (2040 at least) and prices will remain below $4.50/mcf for the next 10 years and below $6.00/mcf for the next 20 years.
- Shale Gas can 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. Natural Gas Supply Projection by Source, 2010-2040, EIA Reference Case 2013



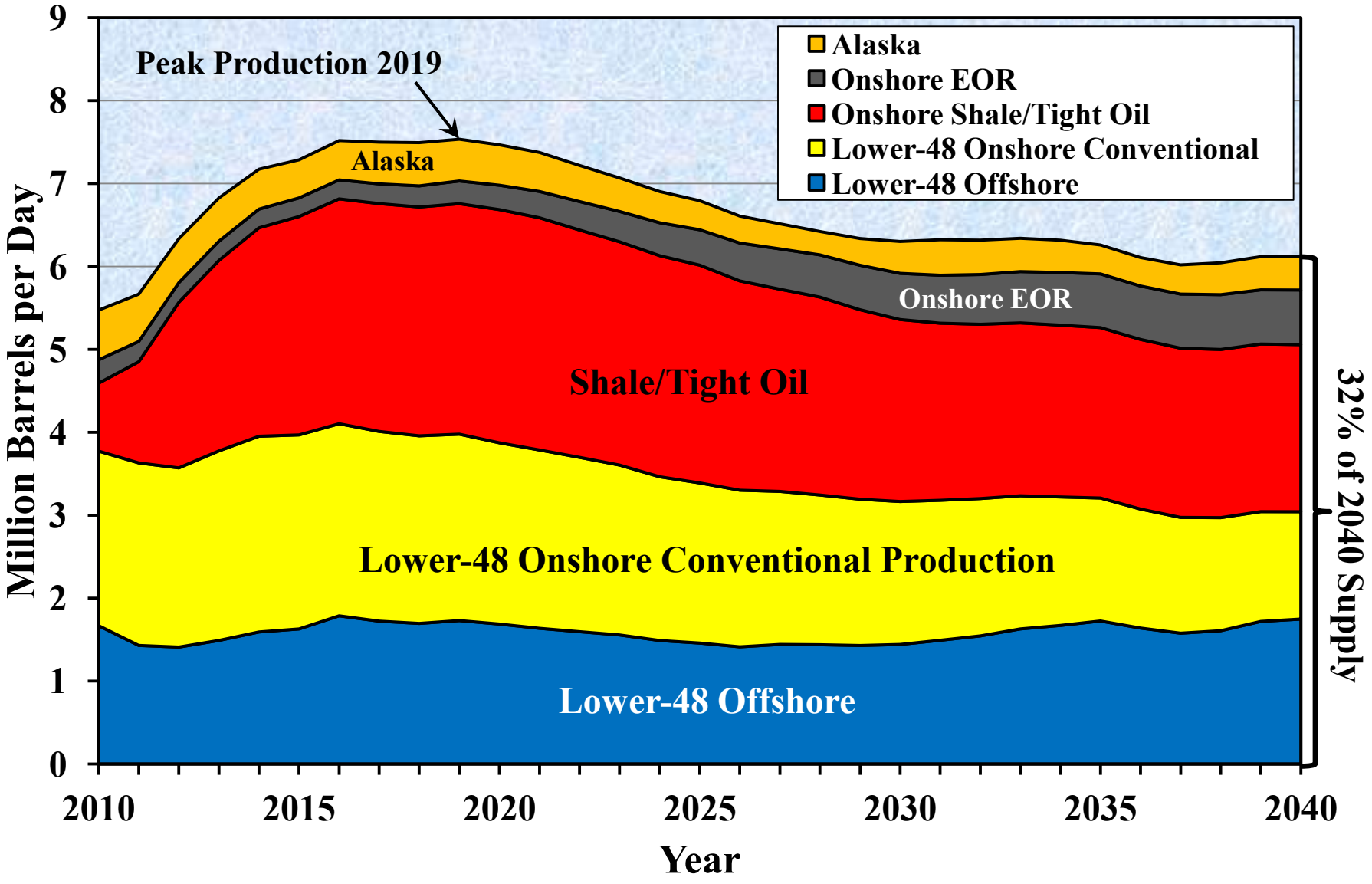
(data from EIA Annual Energy Outlook 2013, Tables 13 and 14, http://www.eia.gov/forecasts/aeo/er/excel/yearbyyear.xlsx)

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



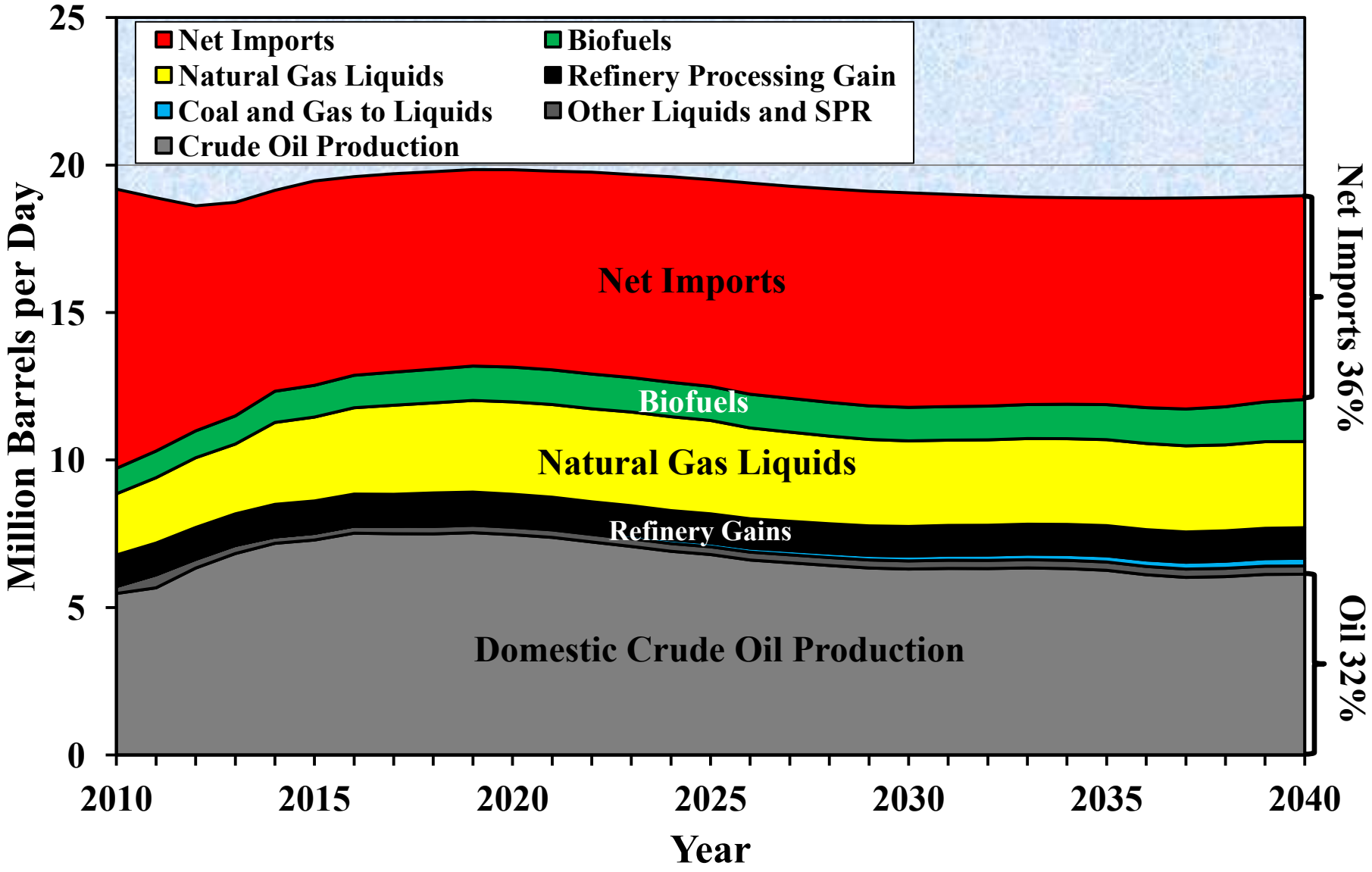
Source: Citi Investment Research and Analysis

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



(data from EIA Annual Energy Outlook 2013, EIA, 2012; International Monetary Fund)

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



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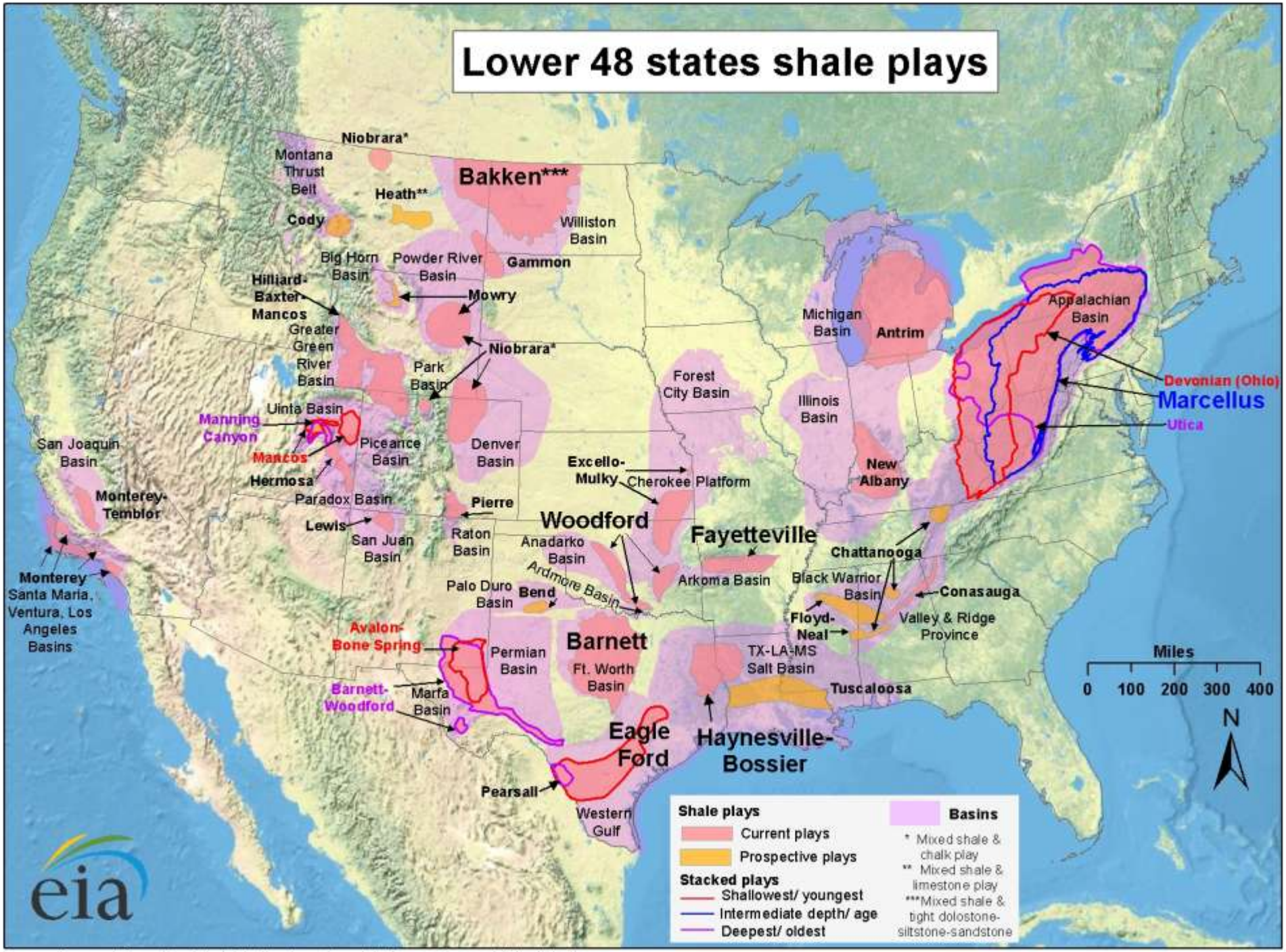
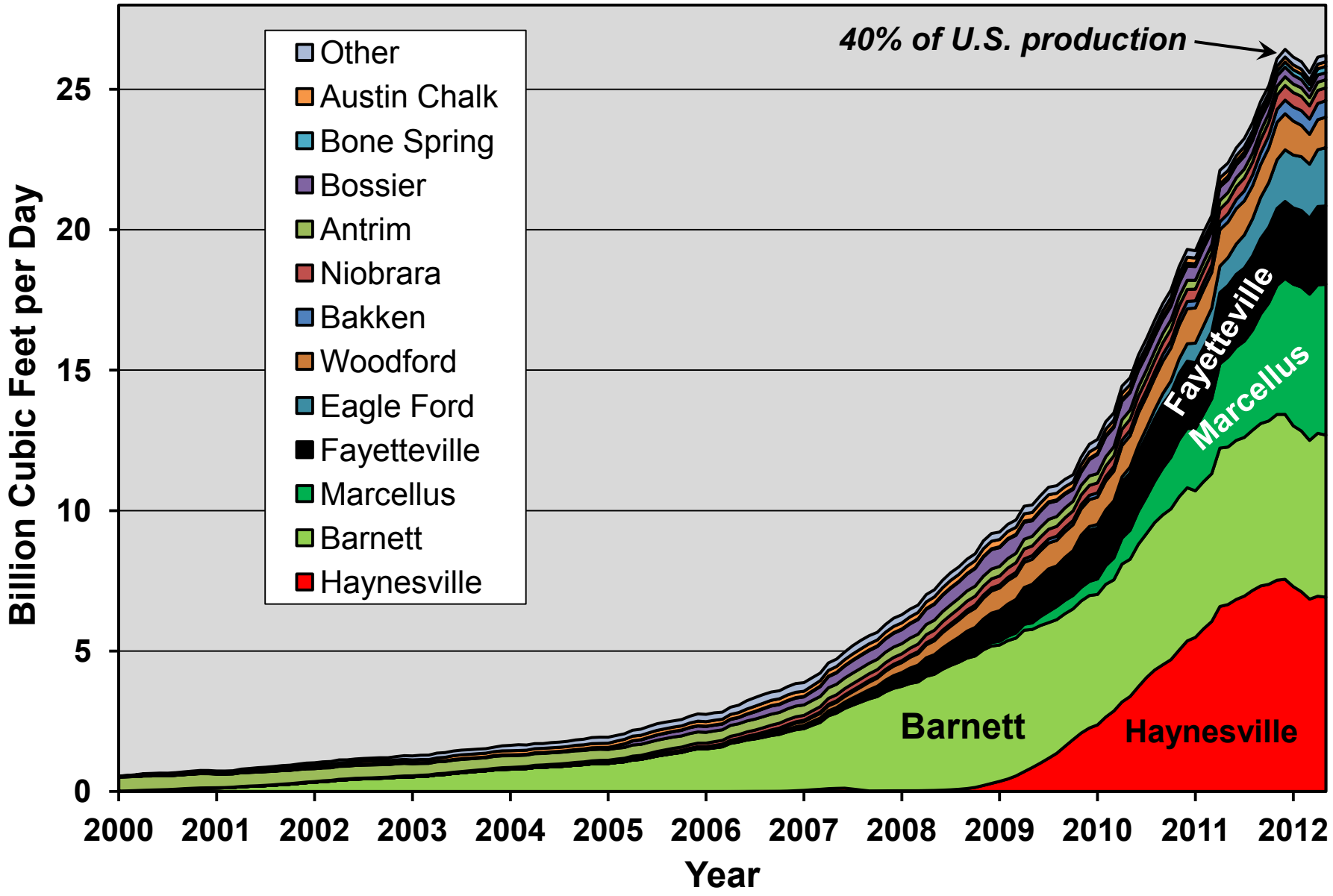
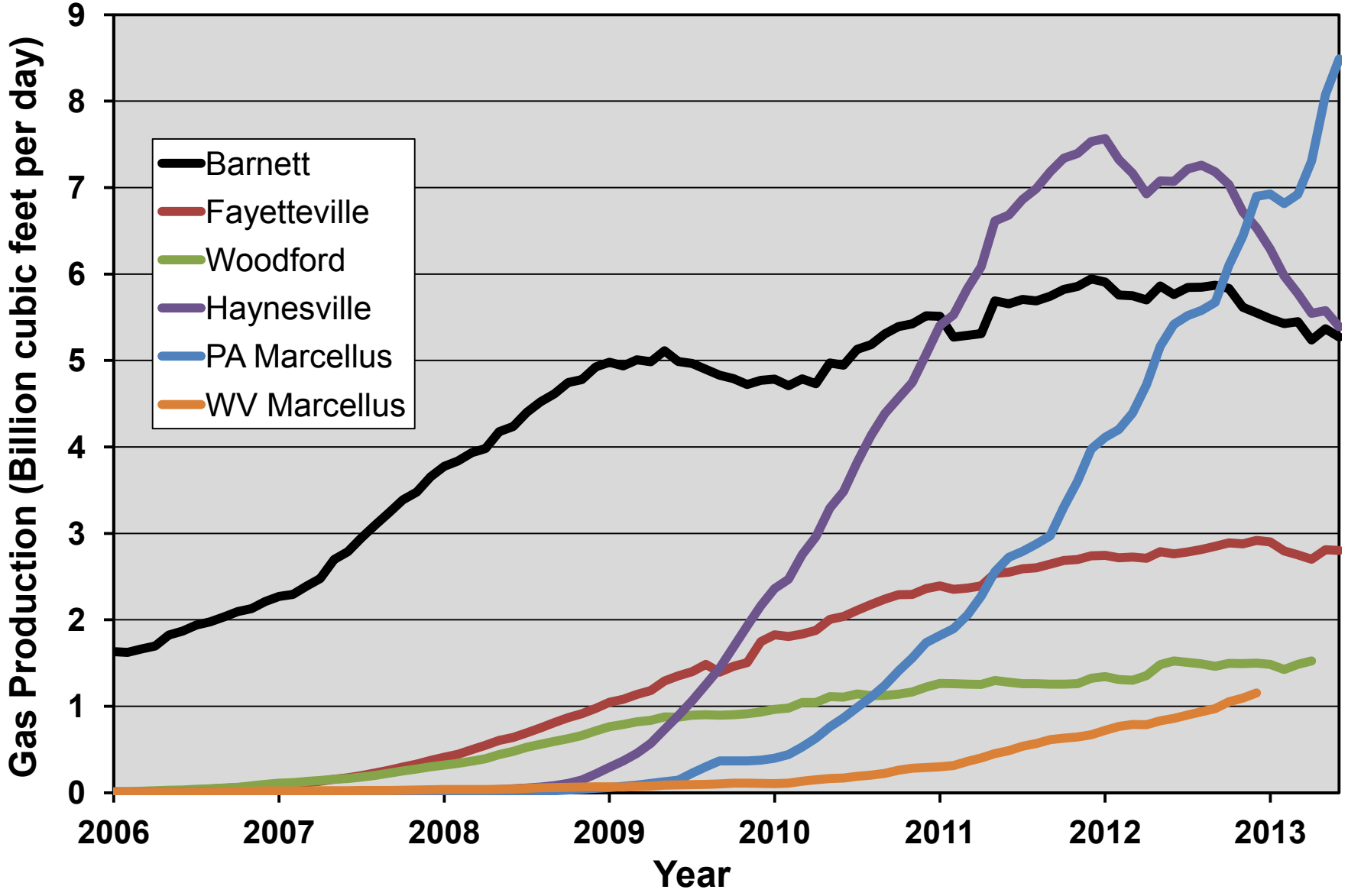

Lower 48 states shale plays
Niobrara*
Montana Thrust Belt
Heath**
Bakken***
Cody
Williston Basin
Big Horn Basin
Powder River Basin
Gammon
Hilliard-Baxter-Mancos
Mowry
Greater Green River Basin
Niobrara*
Park Basin
Forest City Basin
Michigan Basin
Antrim
Appalachian Basin
Devonian (Ohio)
Marcellus
Utica
Illinois Basin
Uinta Basin
Manning Canyon
Mancos
Hermosa
Piceance Basin
Denver Basin
San Joaquin Basin
Paradox Basin
Excello-Mulky
Cherokee Platform
New Albany
Monterey-Temblor
Pierre
Lewis
San Juan Basin
Raton Basin
Woodford
Anadarko Basin
Fayetteville
Chattanooga
Arkoma Basin
Ardmore Basin
Black Warrior Basin
Conasauga
Monterey Santa Maria, Ventura, Los Angeles Basins
Palo Duro Basin
Bend
Floyd-Neal
Valley & Ridge Province
Avalon-Bone Spring
Permian Basin
Barnett
Ft. Worth Basin
TX-LA-MS Salt Basin
Barnett-Woodford
Marfa Basin
Tuscaloosa
Eagle Ford
Haynesville-Bossier
Pearsall
Western Gulf
Miles
0 100 200 300 400
N
Shale plays
Current plays
Prospective plays
Stacked plays
Shallowest/ youngest
Intermediate depth/ age
Deepest/ oldest
Basins
* Mixed shale & chalk play
** Mixed shale & limestone play
***Mixed shale & tight dolostone-siltstone-sandstone
eia

Shale Gas Production by Play, 2000-2012



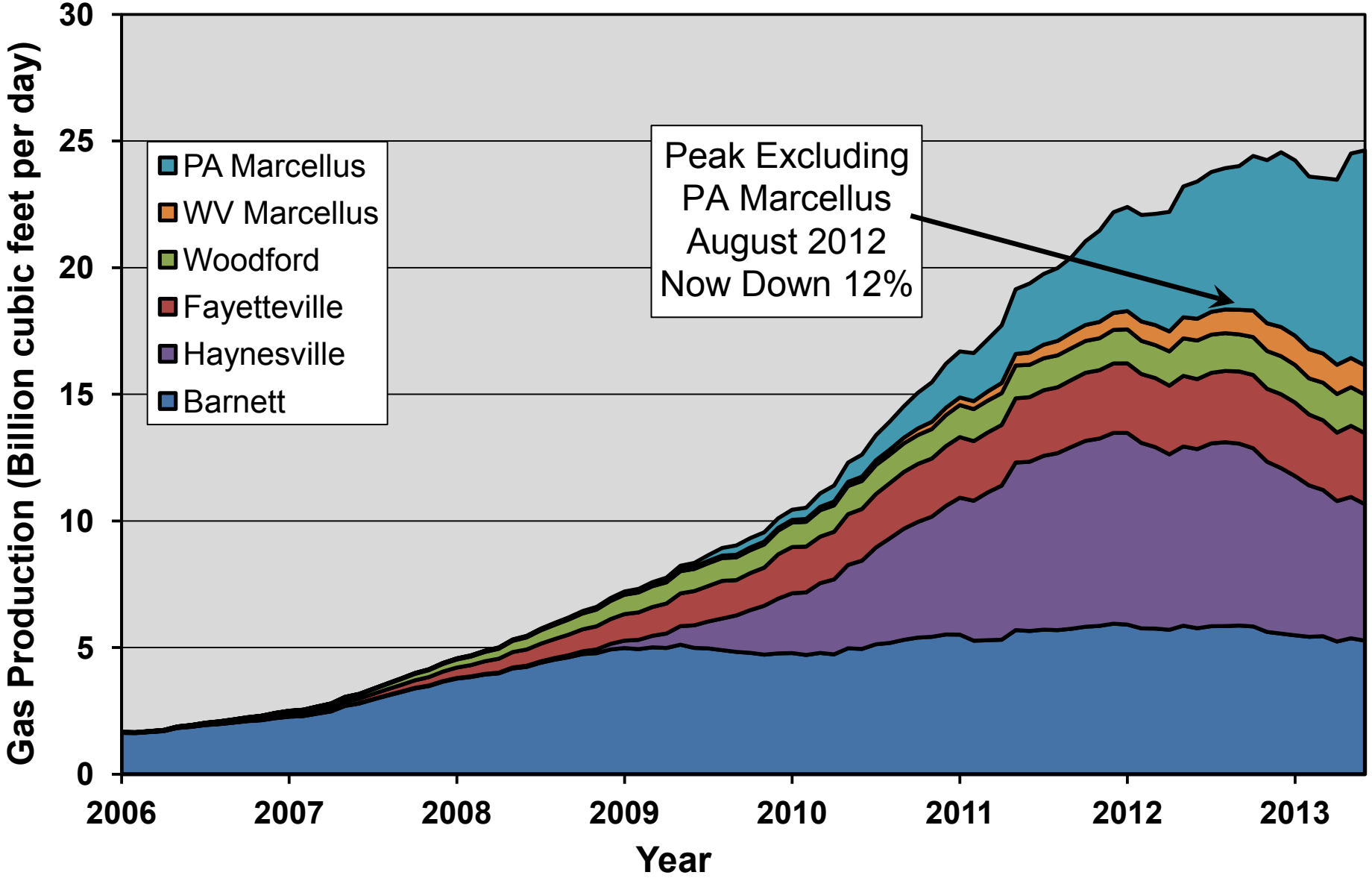
(data from Drillinginfo, September, 2012, fitted with 3 month centered moving average including data up to June, 2012)

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



(data from Drillinginfo, July, 2013, three month trailing moving average)

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



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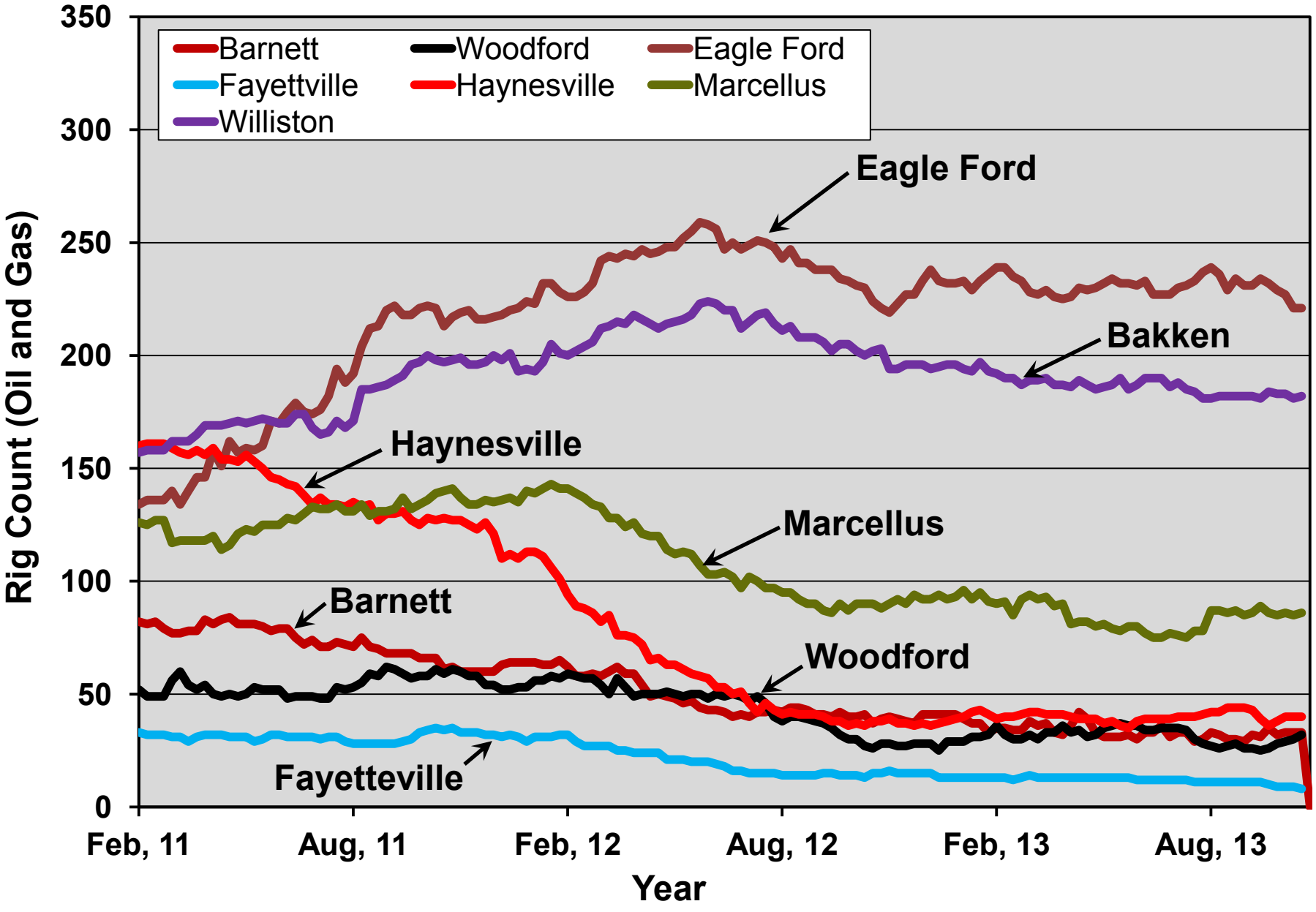
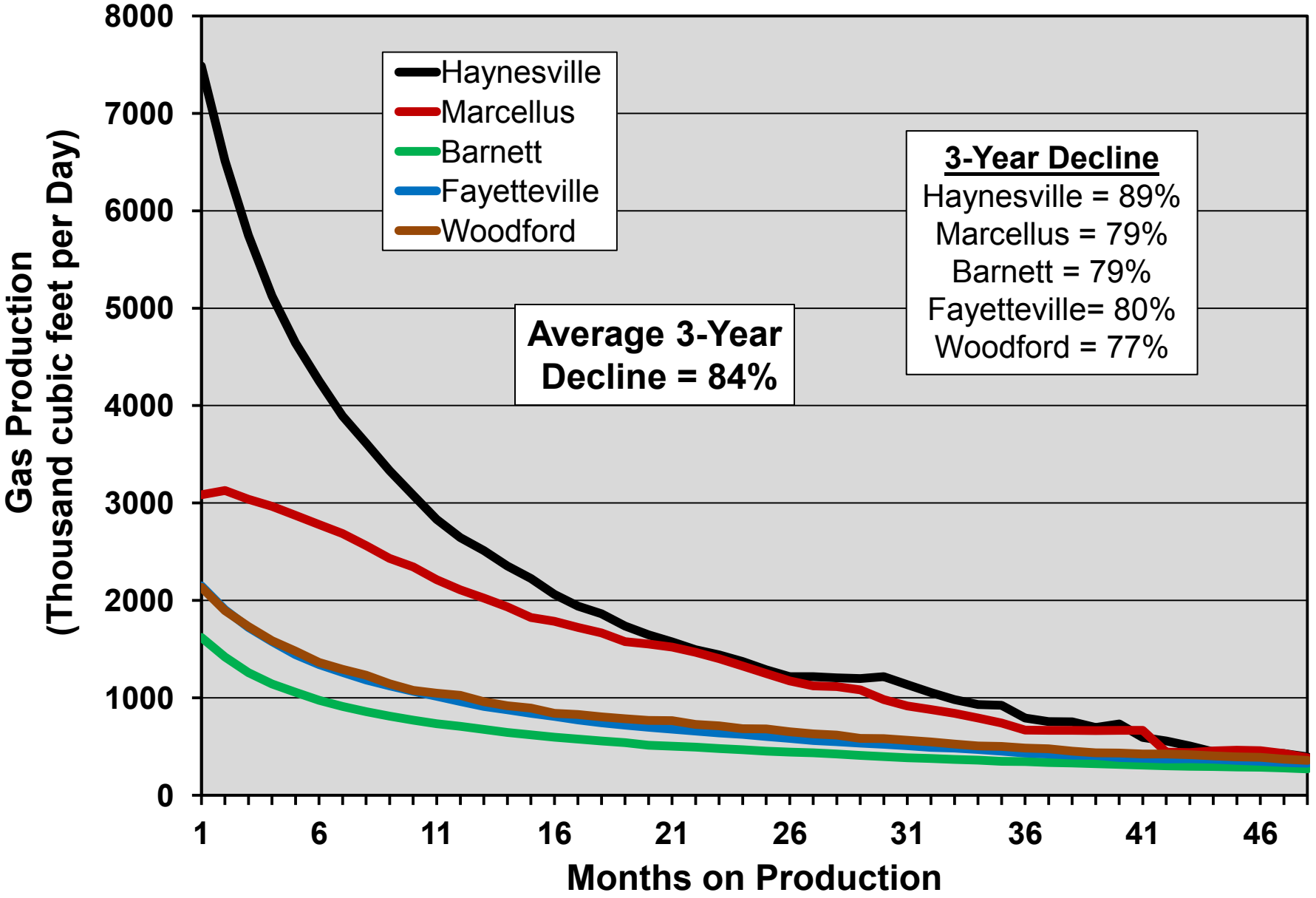
Rig Count for Selected Shale Plays, 2011-2013



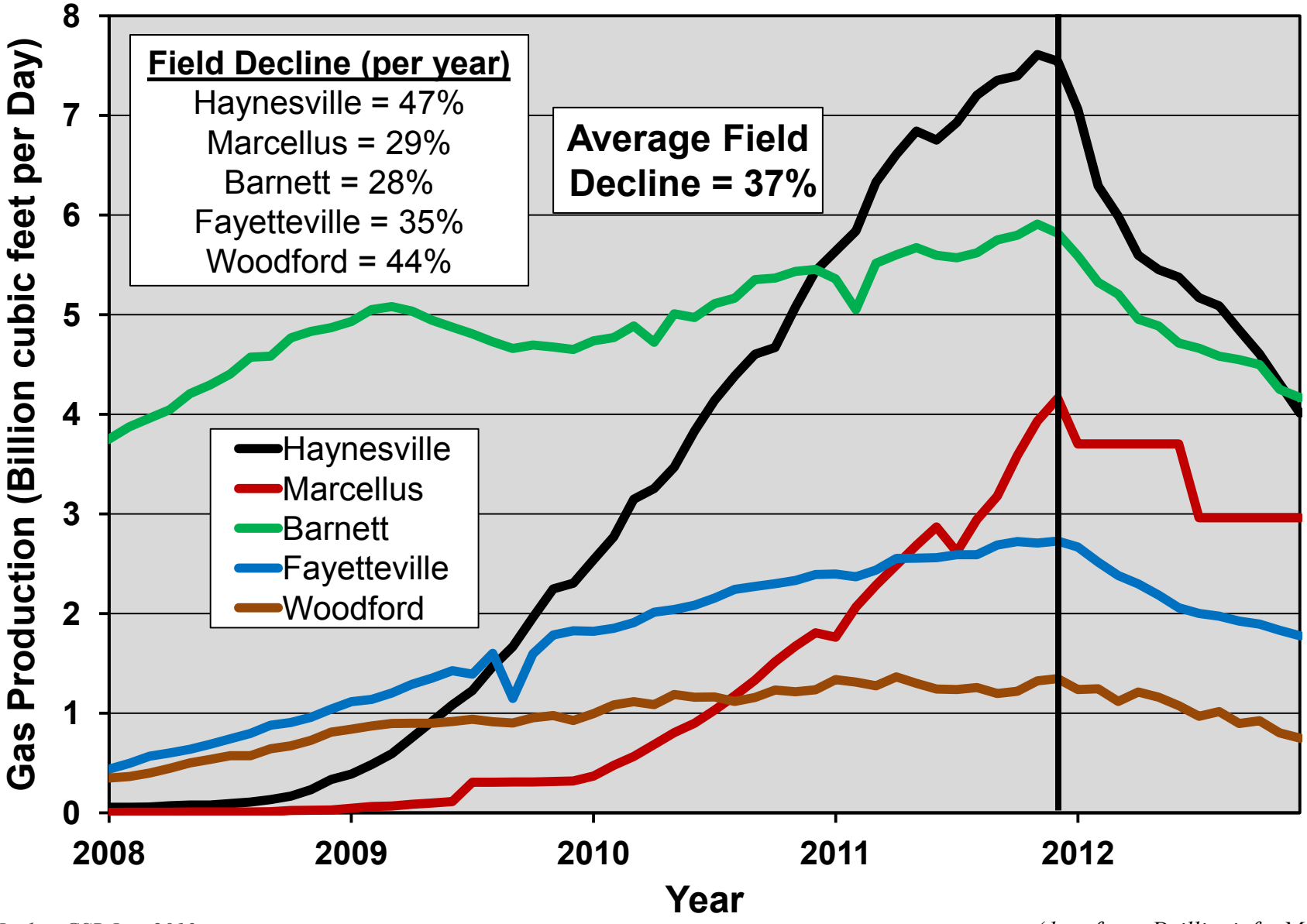
(data from Baker-Hughes, October, 2013)

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



(data from Drillinginfo, March, 2013)

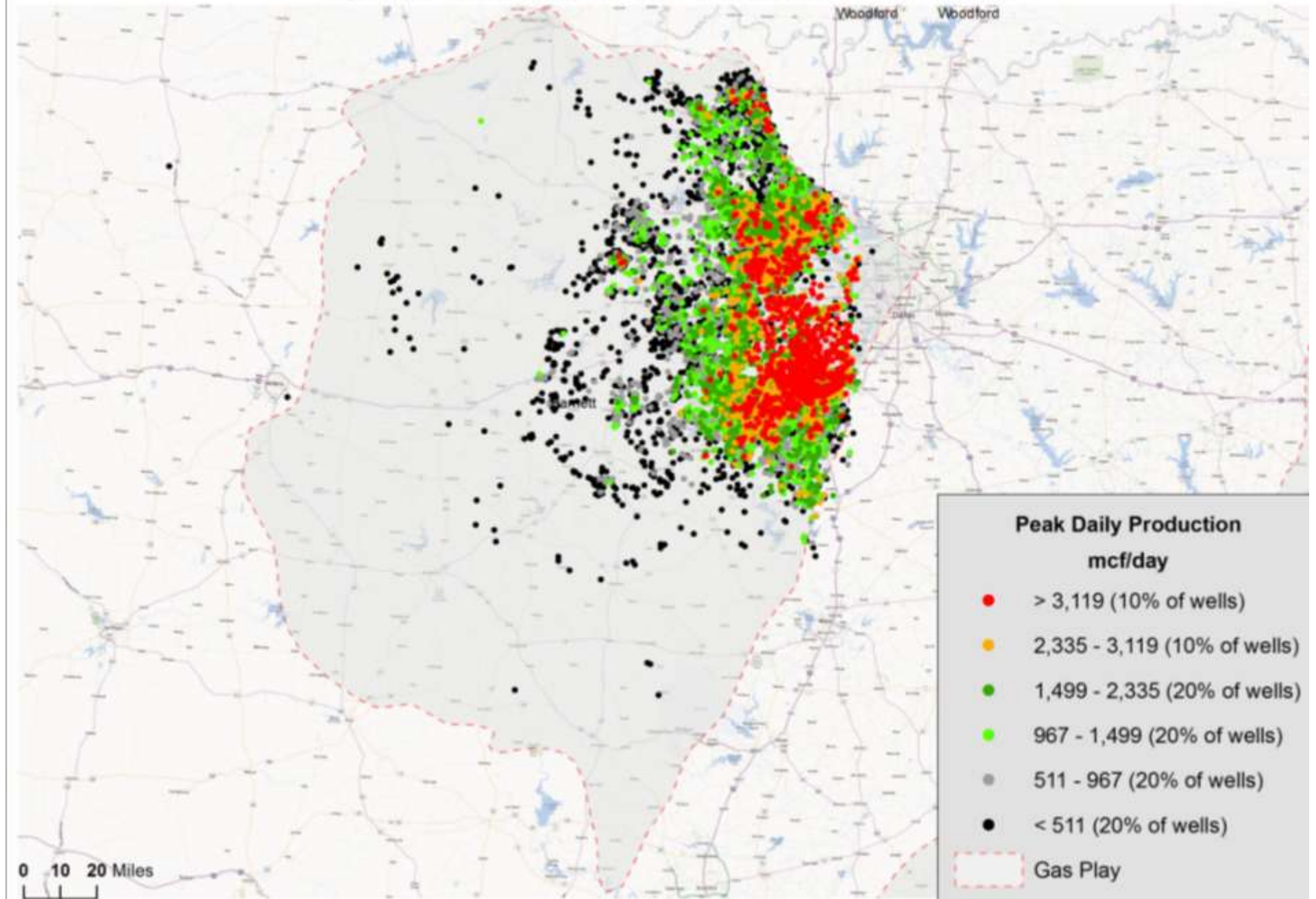
Overall Field Decline for Top Five Shale Gas Plays based on Production Decline from pre-2012 Wells



(data from Drillinginfo, March, 2013)

Barnett Well Quality

Spatial Distribution of Peak Gas Production



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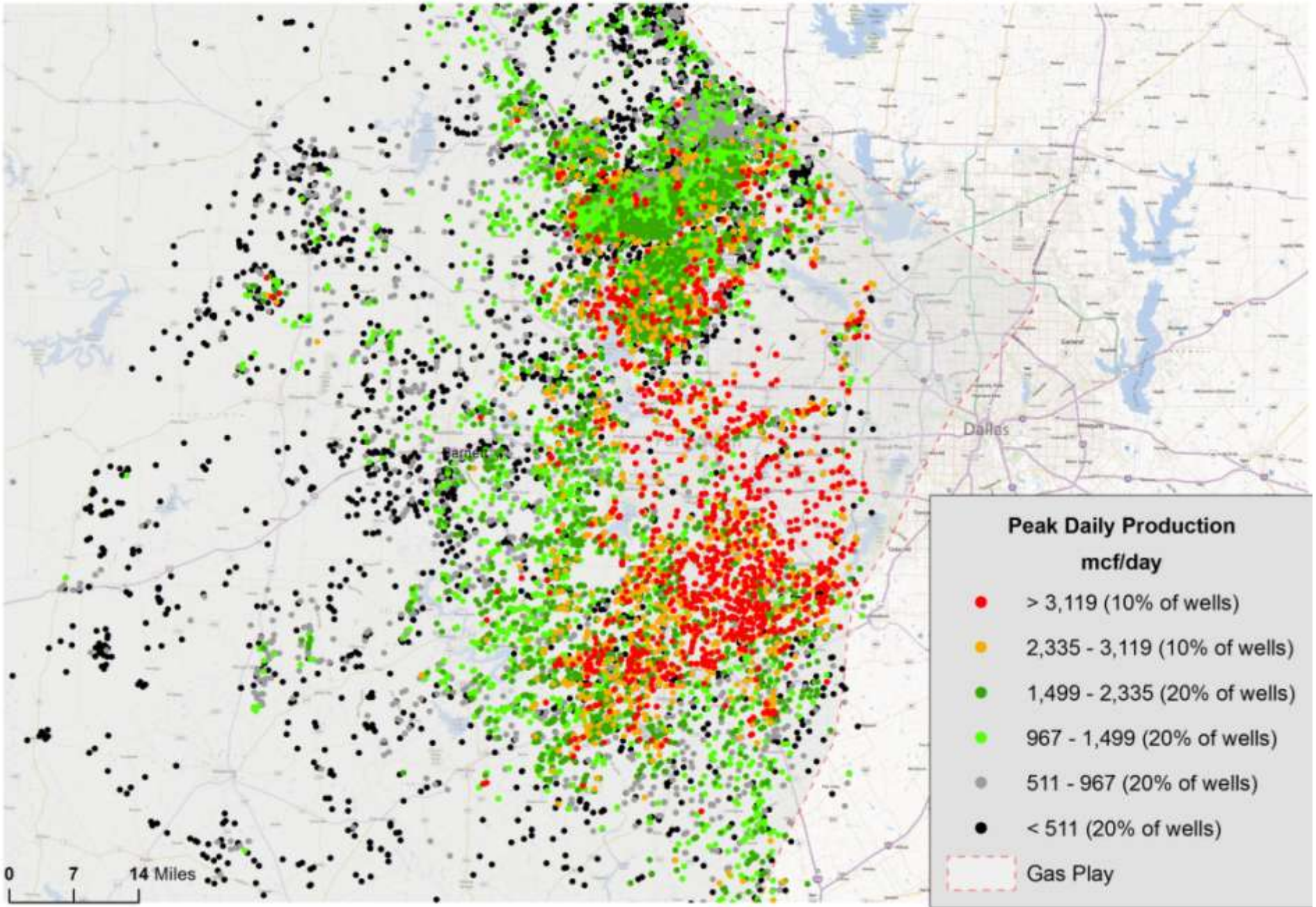
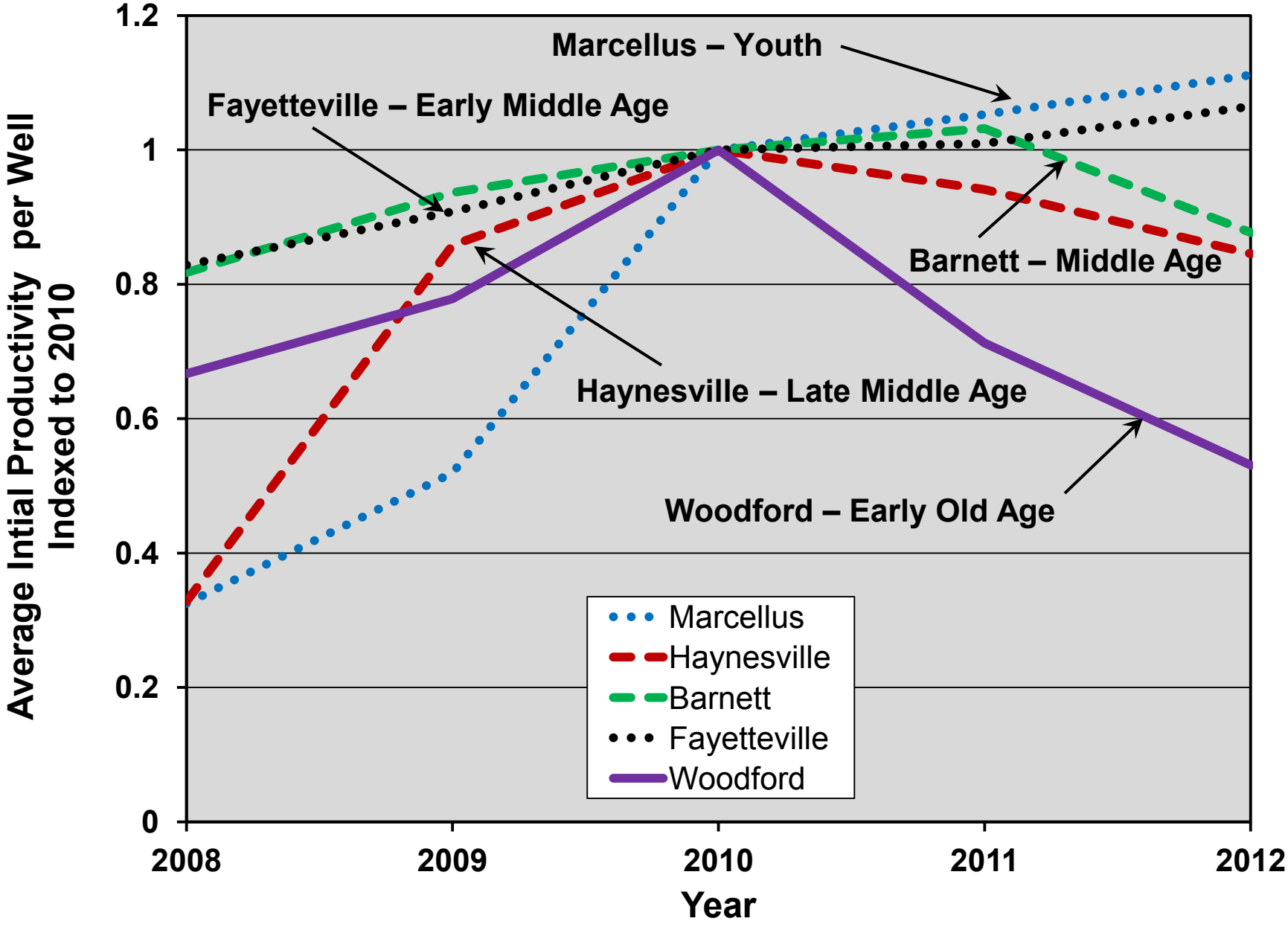


The Shale Play Life Cycle

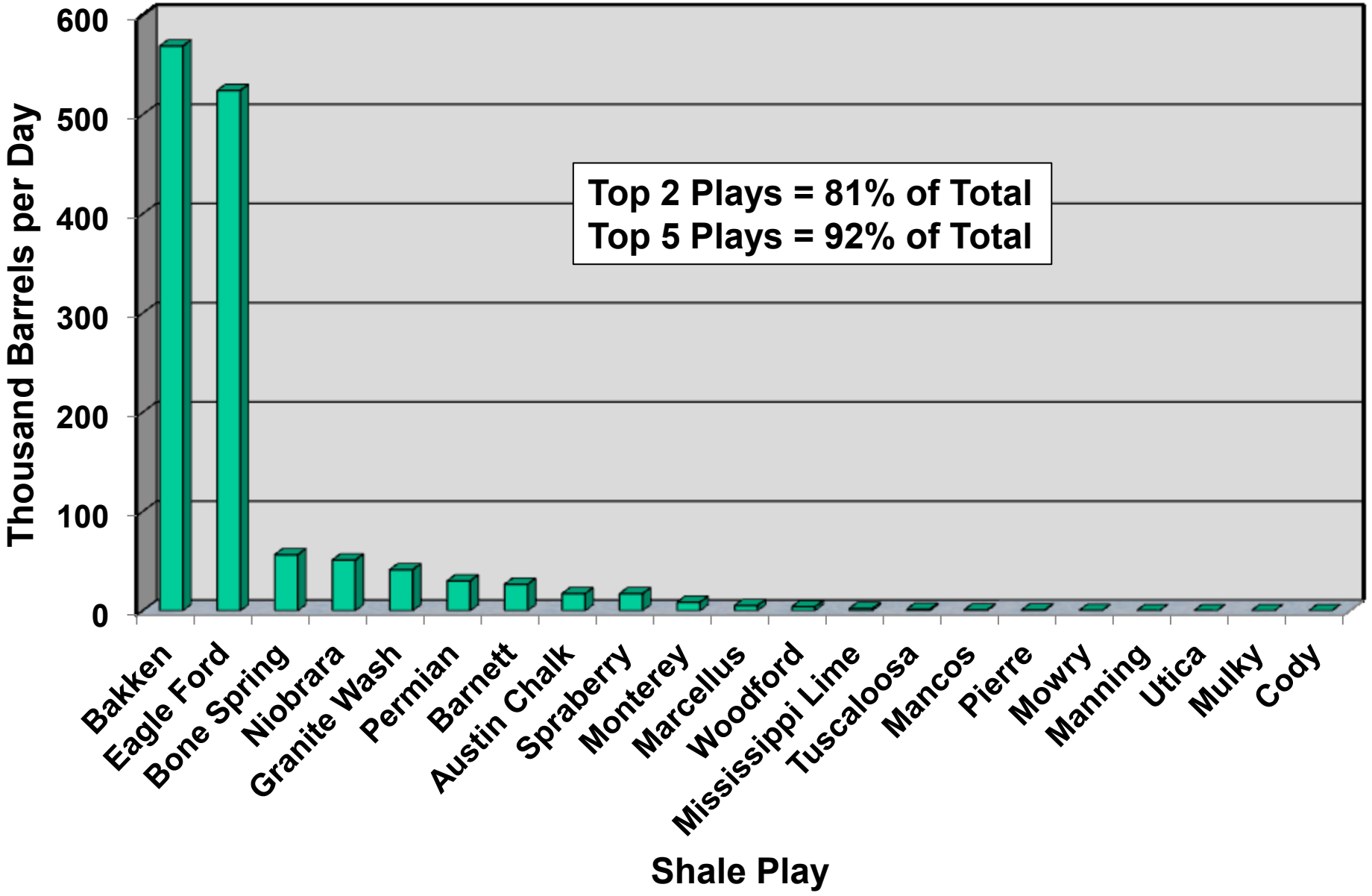
- Discovery followed by leasing frenzy.
- Drilling boom follows to meet “held-by-production” lease requirements.
- Sweet spots identified, targeted and drilled off.
- Gas production rises rapidly and is maintained for cash-flow despite potentially uneconomic full-cycle costs.
- Sweet spots become saturated 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



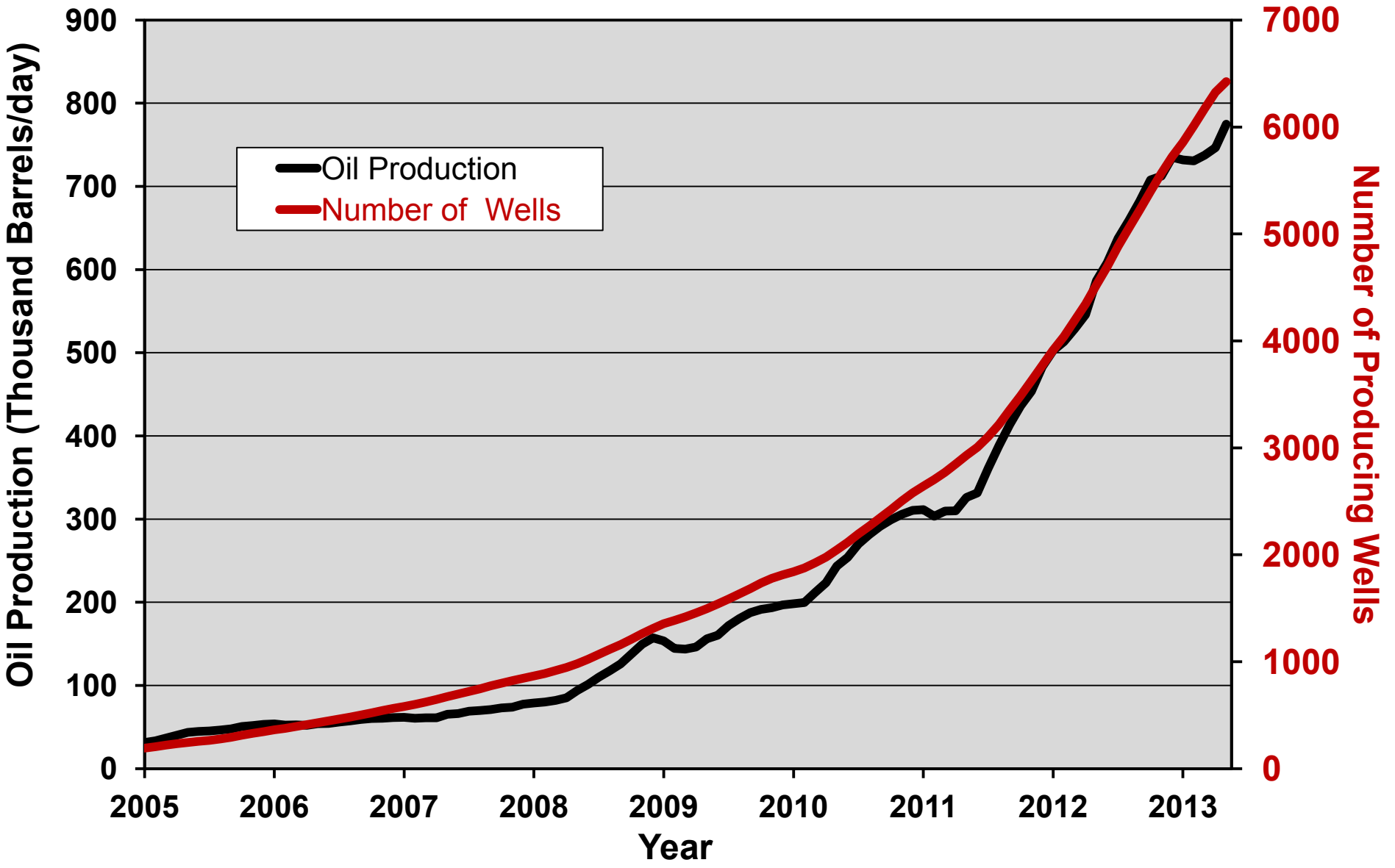
(data from Drillinginfo, March, 2013)

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



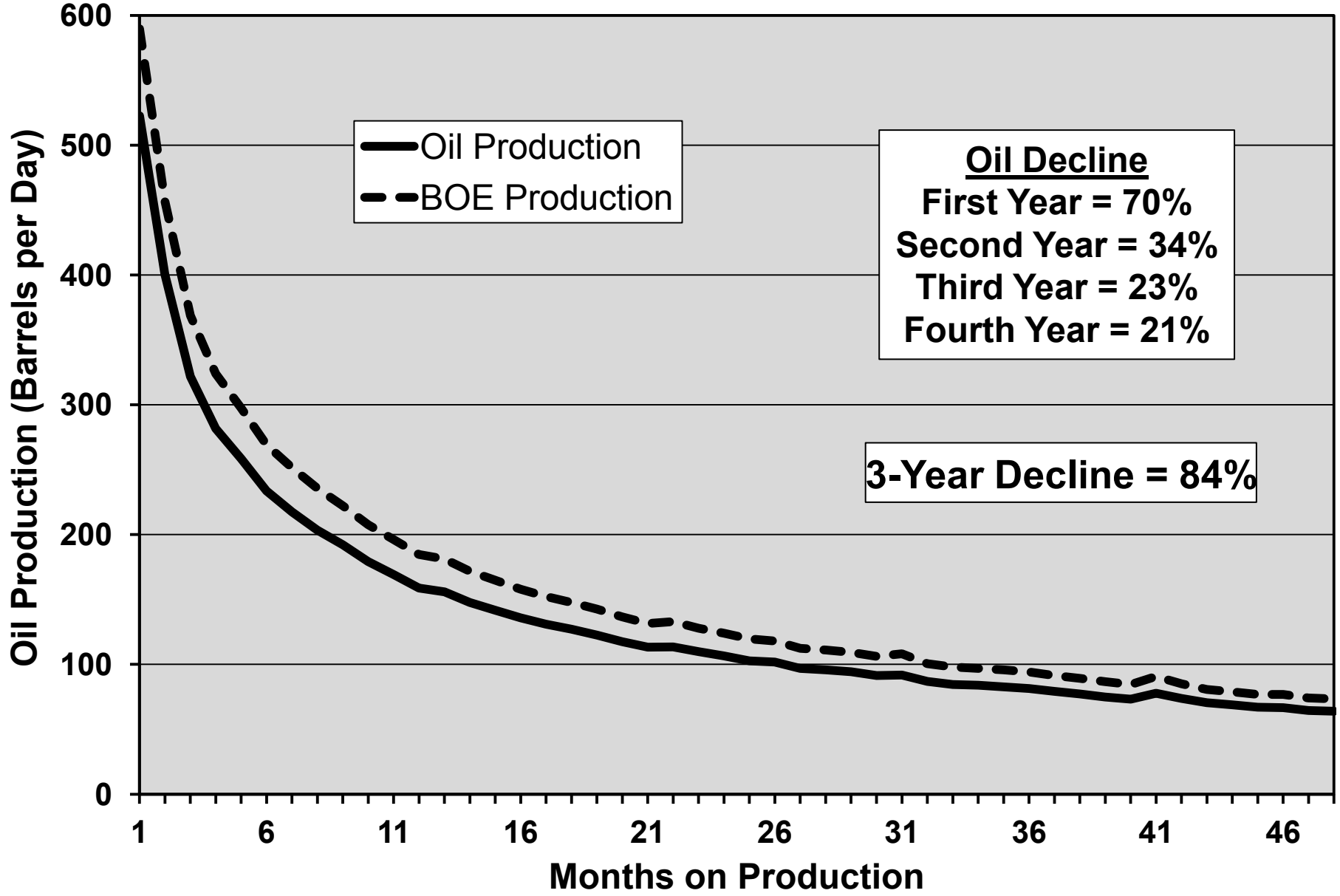
(data from HPDI, September, 2012, for production in most cases through May-June, 2012)

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



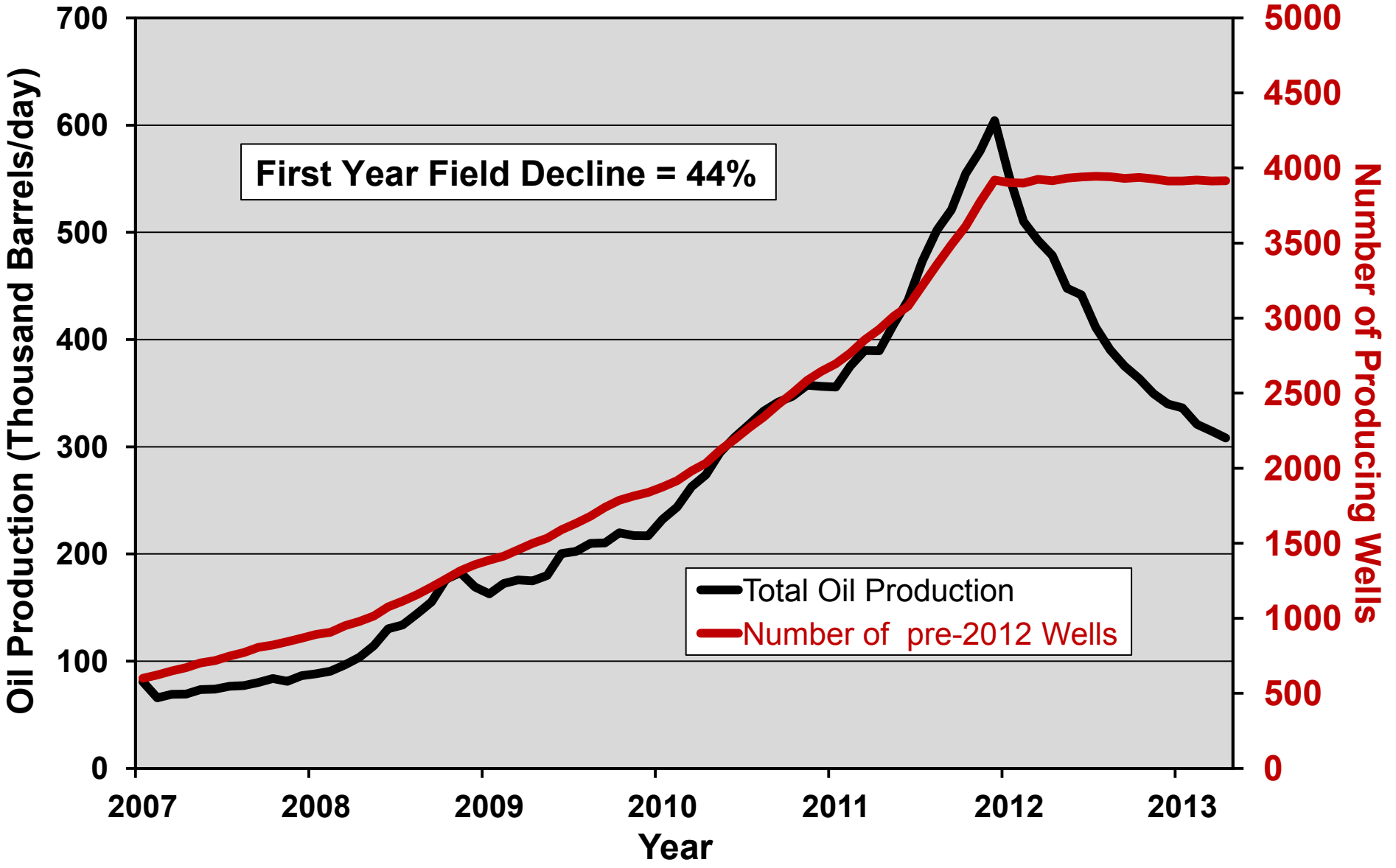
(data from Drillinginfo, October, 2013, three month trailing moving average)

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



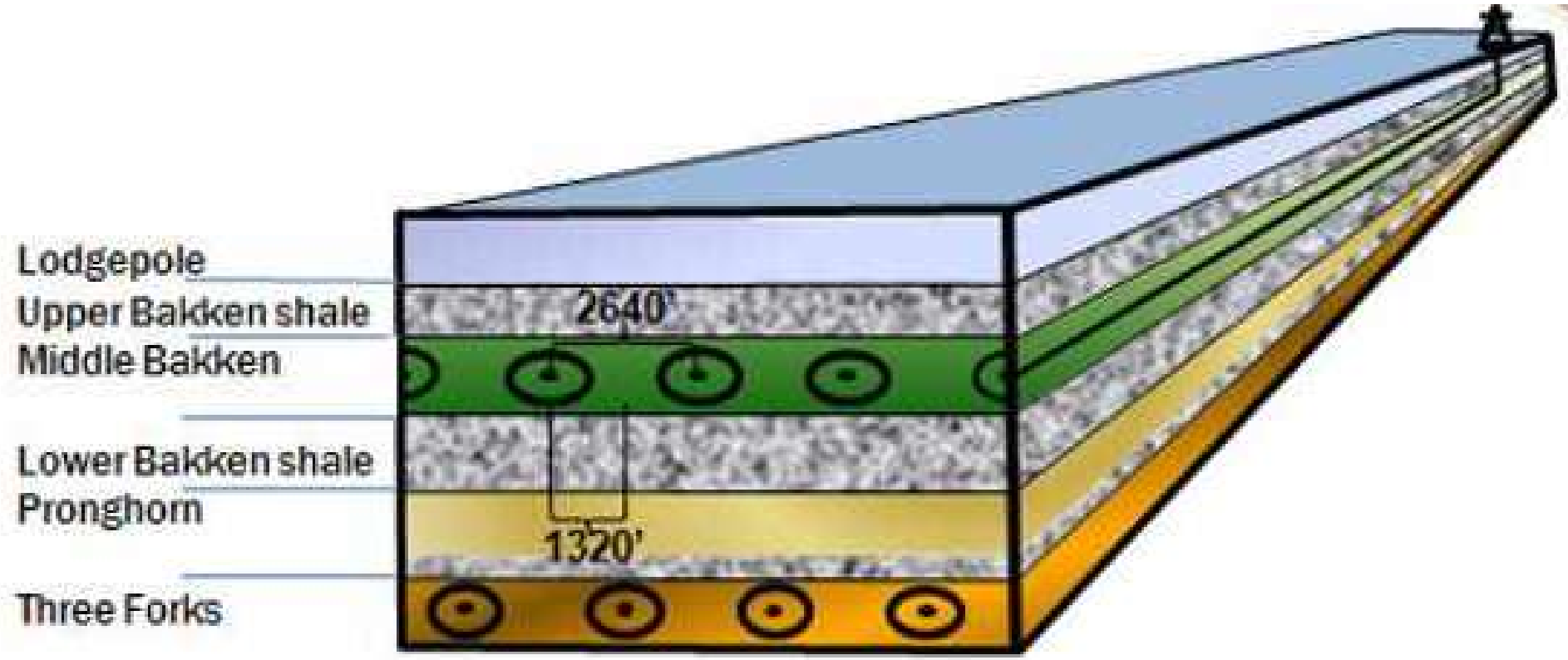
(data from Drillinginfo, October, 2013)

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



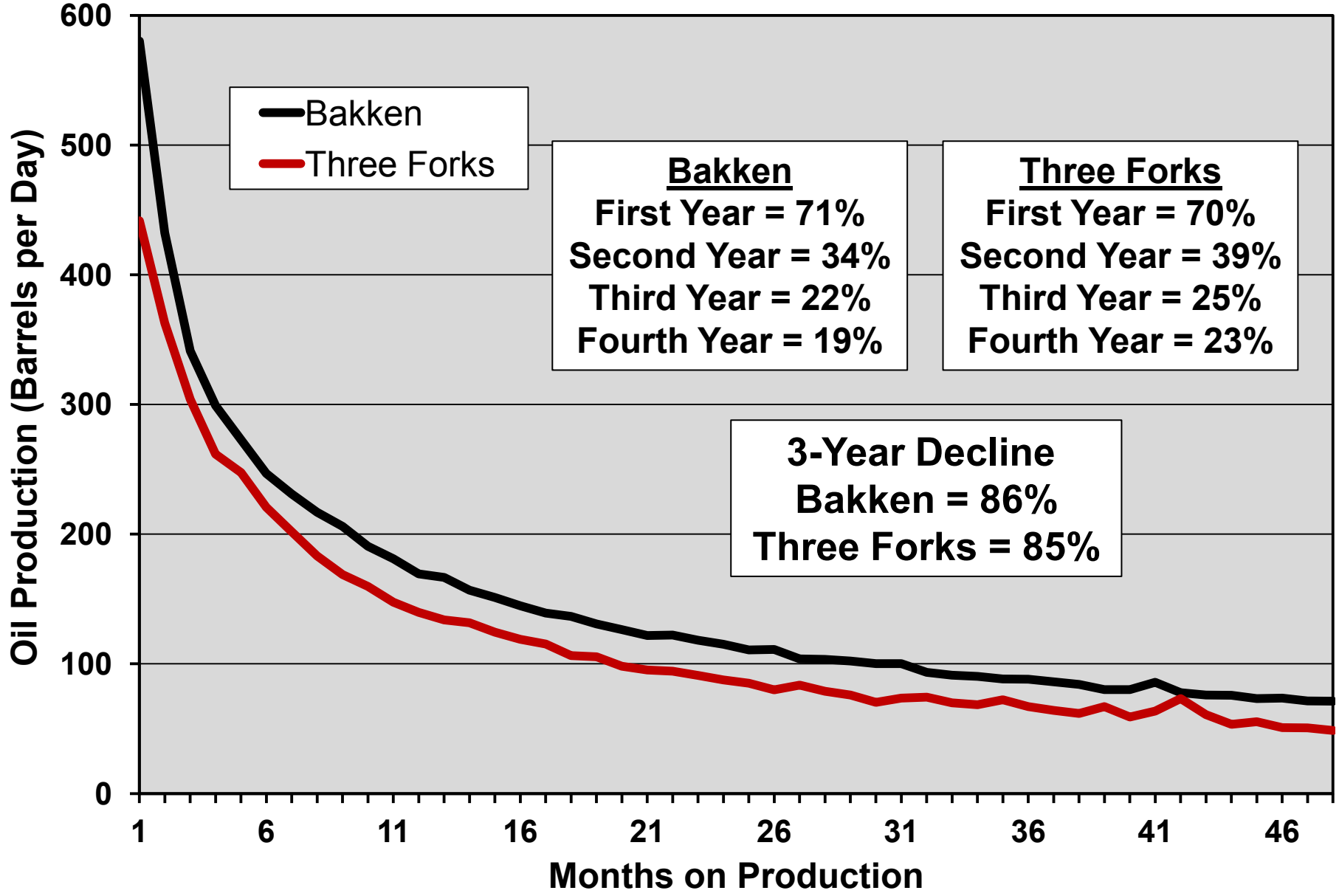
(data from Drillinginfo, October, 2013)

Bakken/Three Forks Stratigraphy



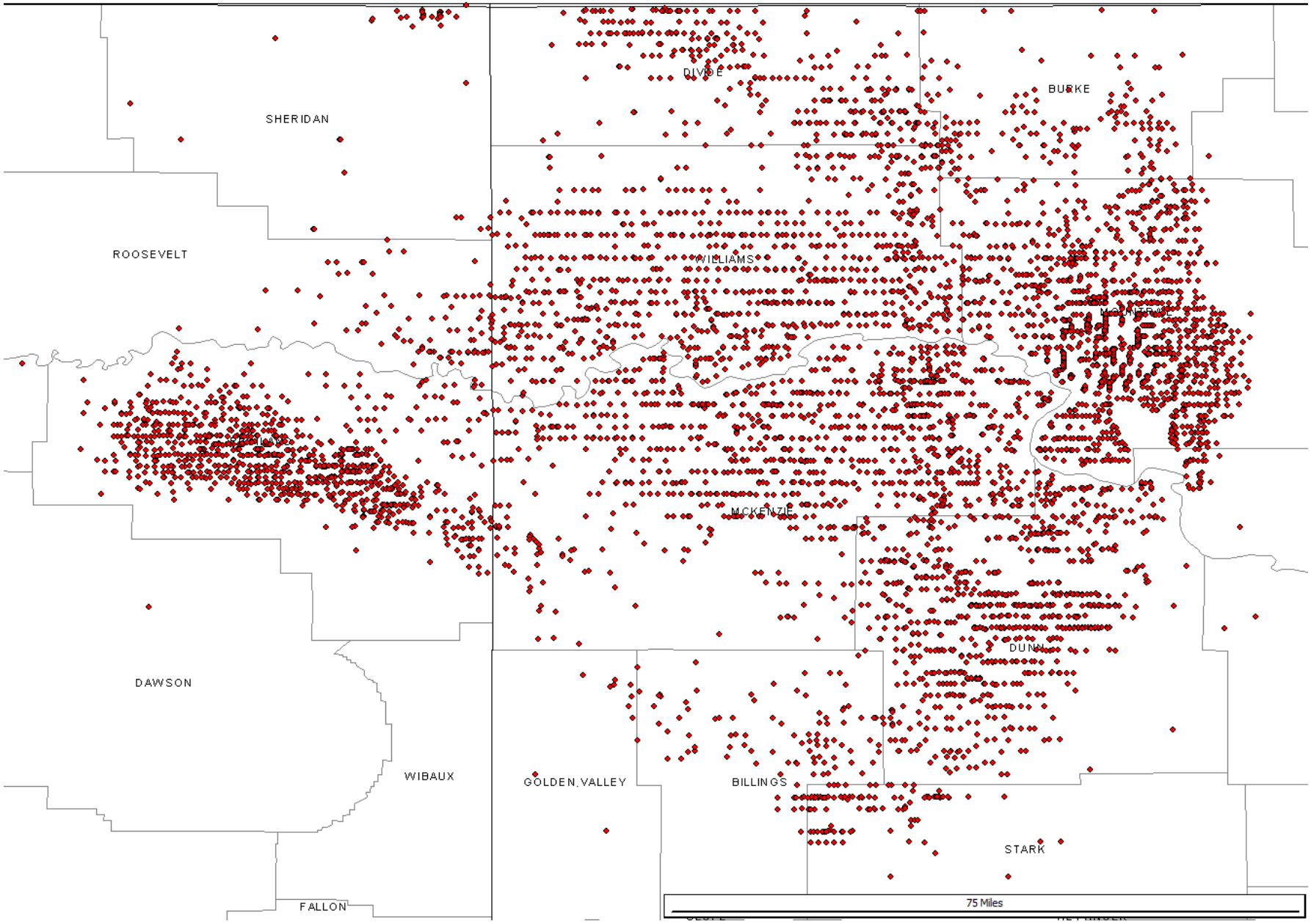
(Image from Samson Oil and Gas)

Bakken and Three Forks
Type Oil Well Decline Curves in North Dakota



(data from Drillinginfo, October, 2013)

Bakken/Three Forks Well Distribution through mid-2013



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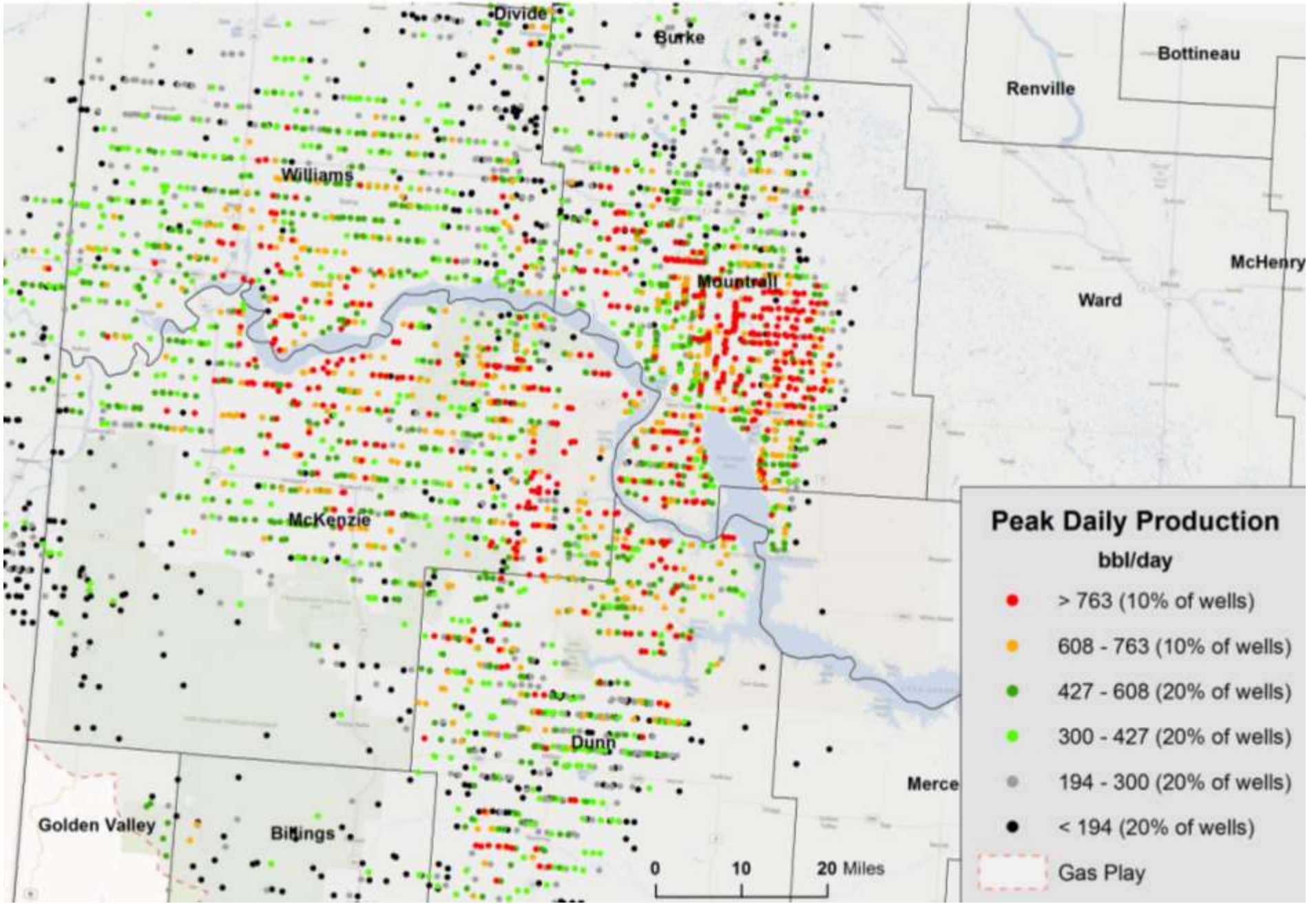
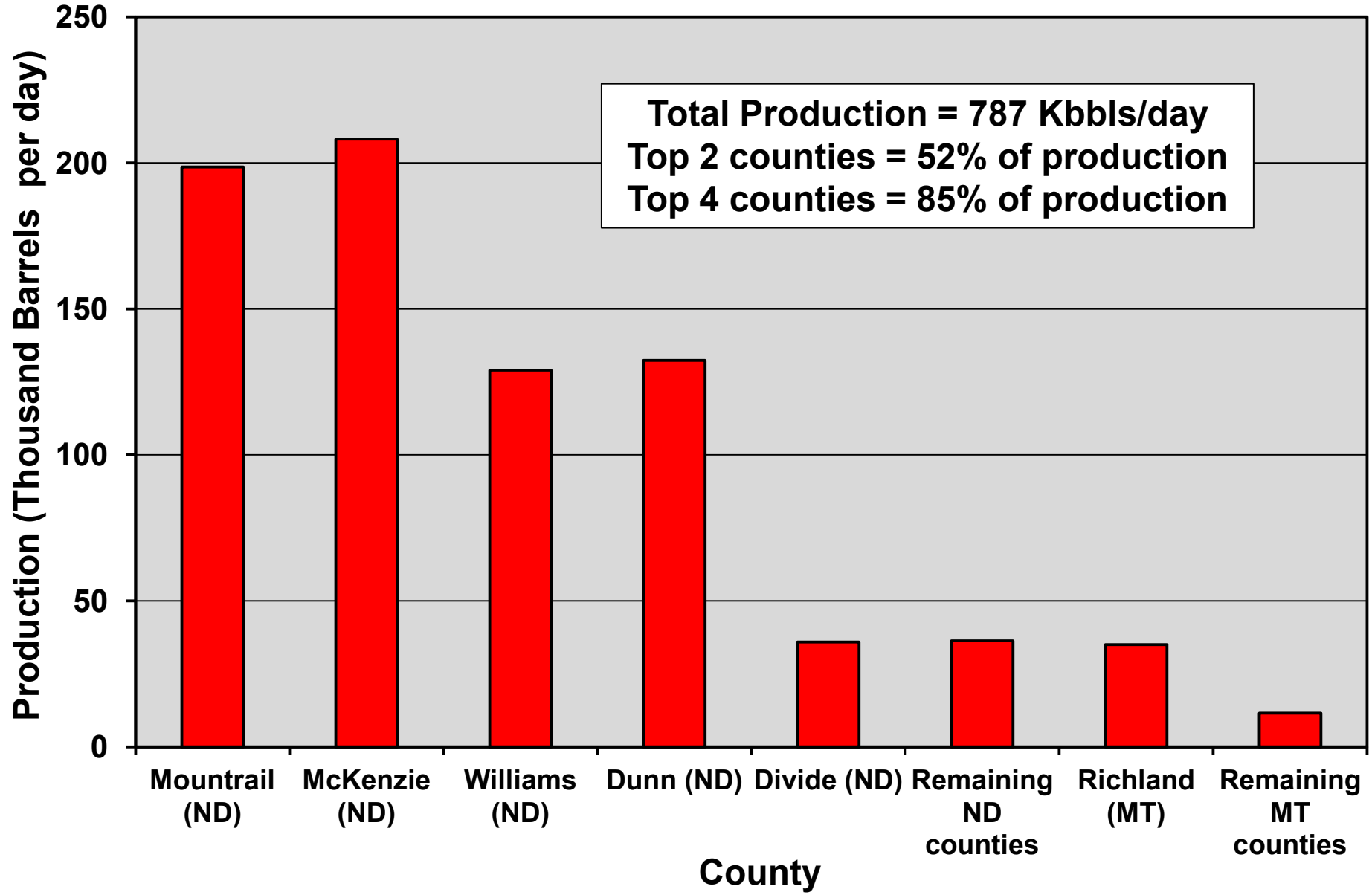
Bakken Well Quality

Spatial Distribution of Peak Oil Production



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



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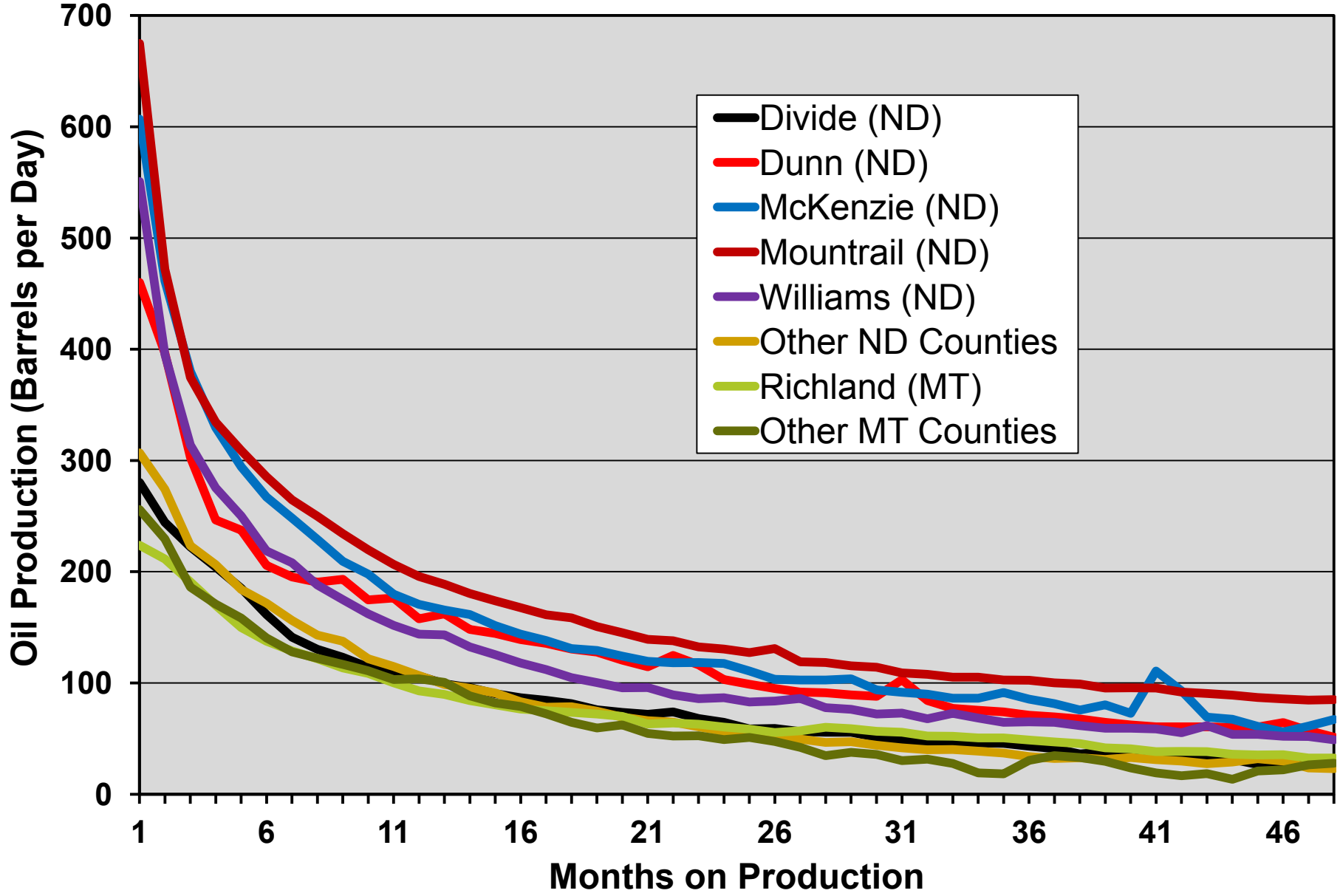
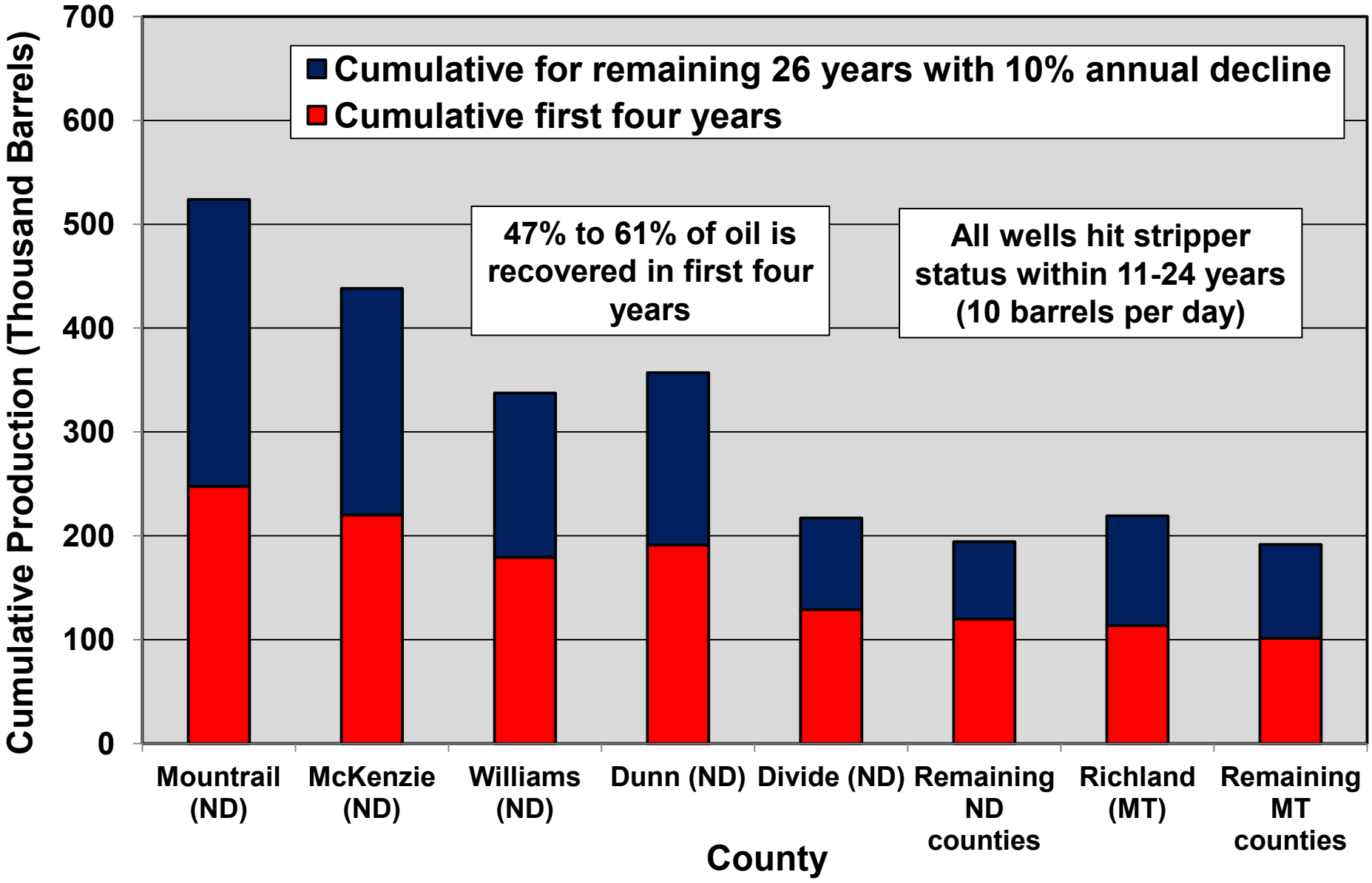
Bakken/Three Forks Type Oil Well Decline Curves by County and Region



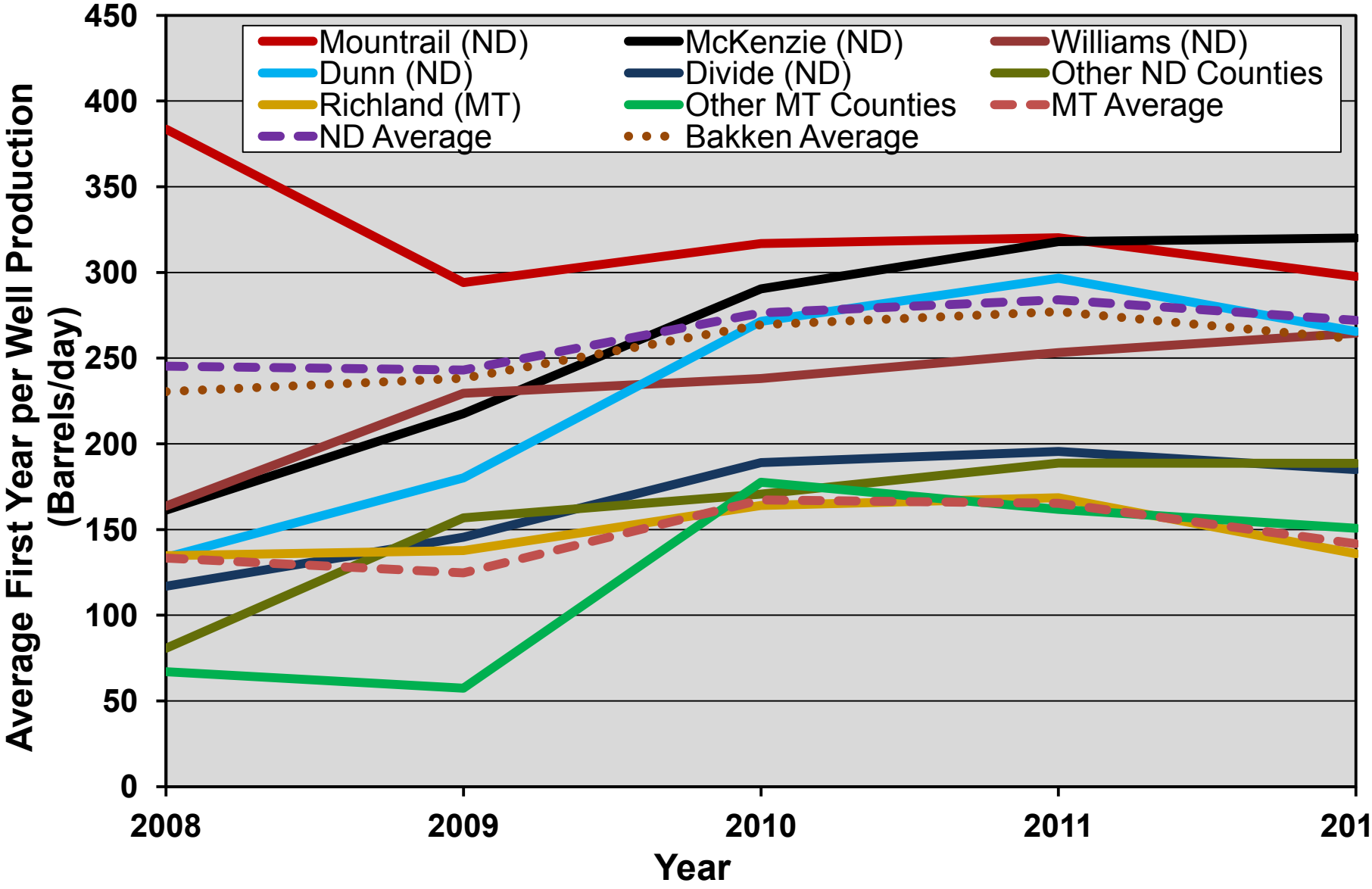
(data from Drillinginfo, October, 2013)

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



(data from Drillinginfo, October, 2013)

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



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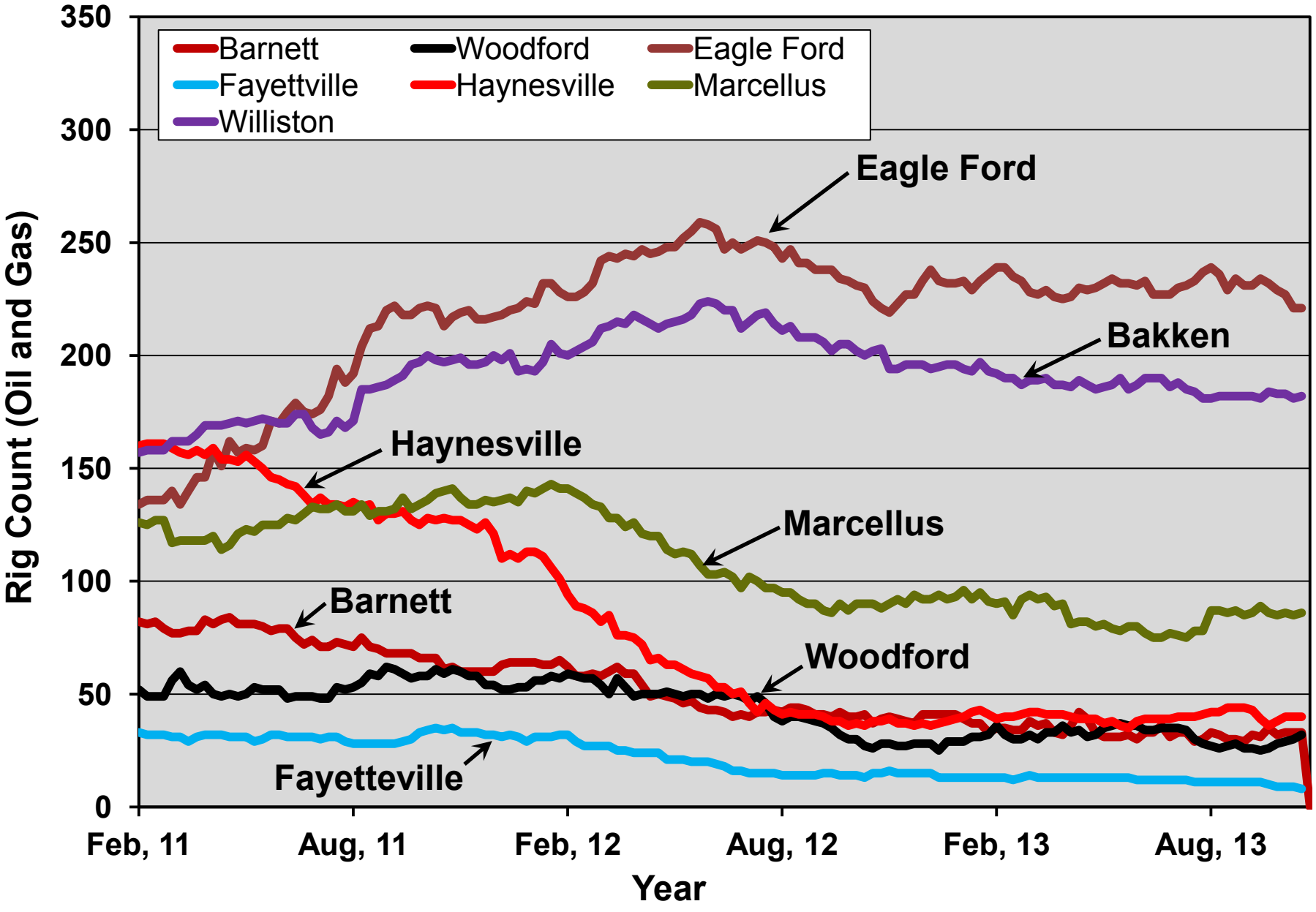
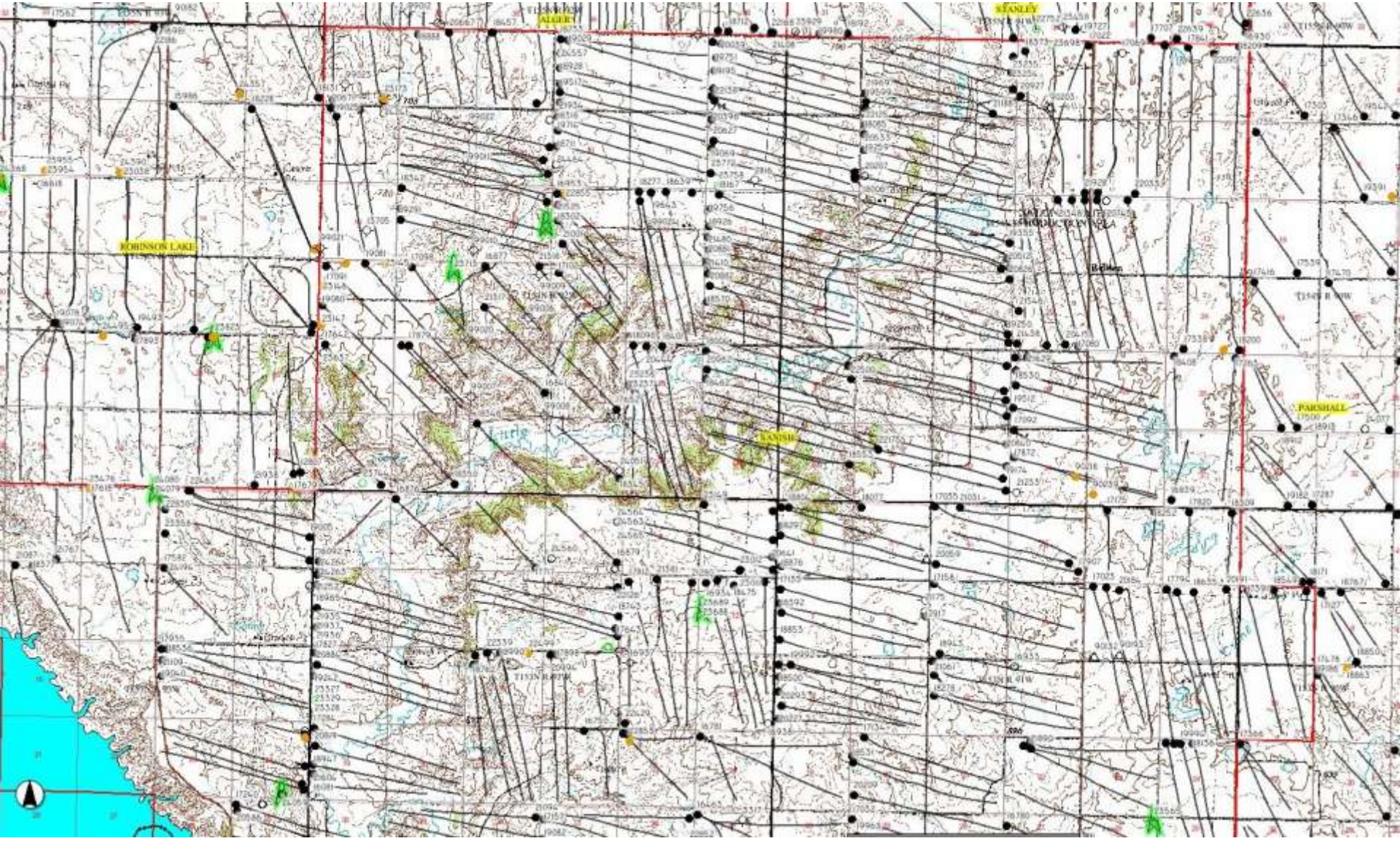
Rig Count for Selected Shale Plays, 2011-2013



(data from Baker-Hughes, October, 2013)

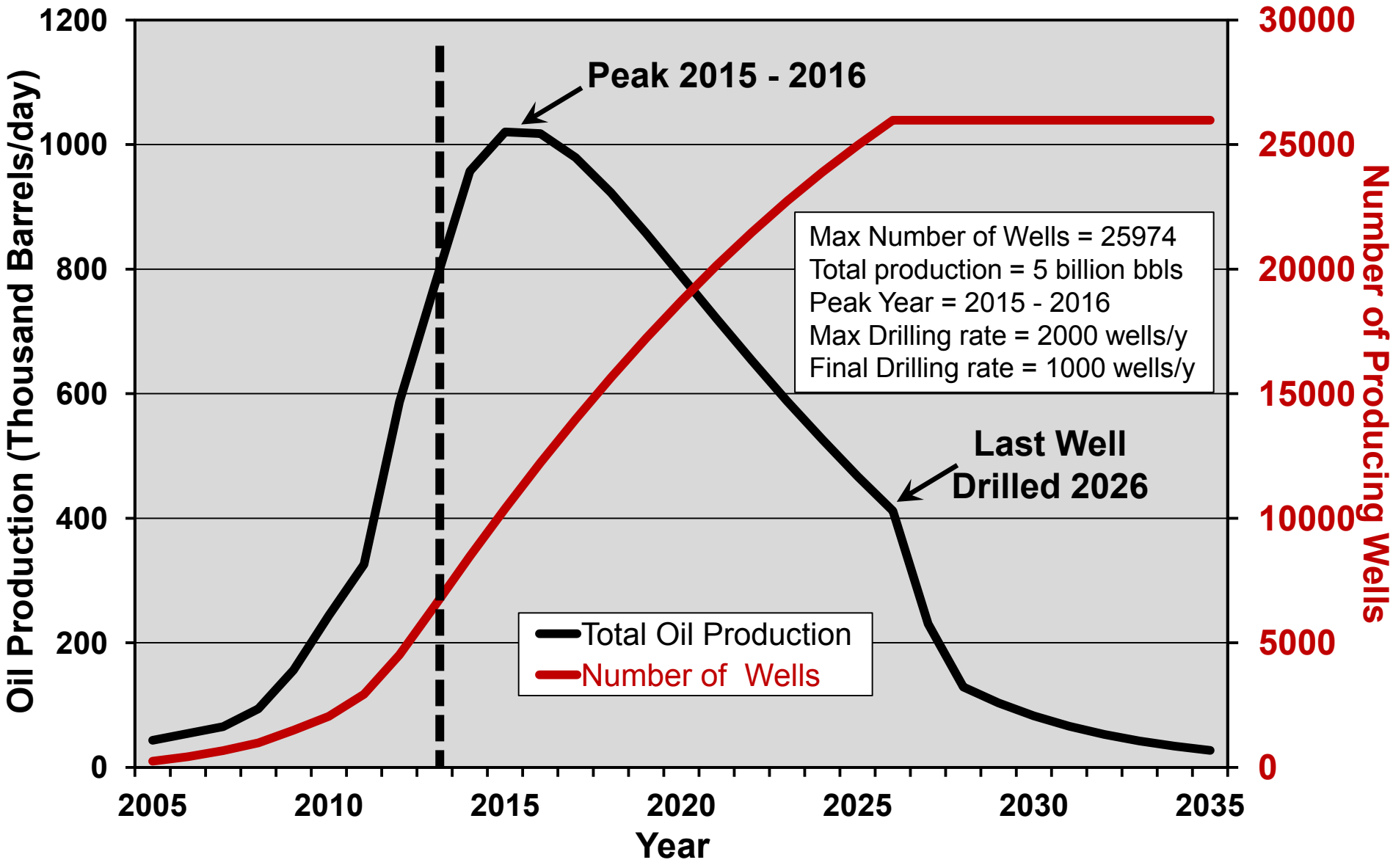
Horizontal Well Development in the Parshall Area
Sweet Spot of the Bakken



3 Miles

(data from North Dakota DNR, 2013)

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



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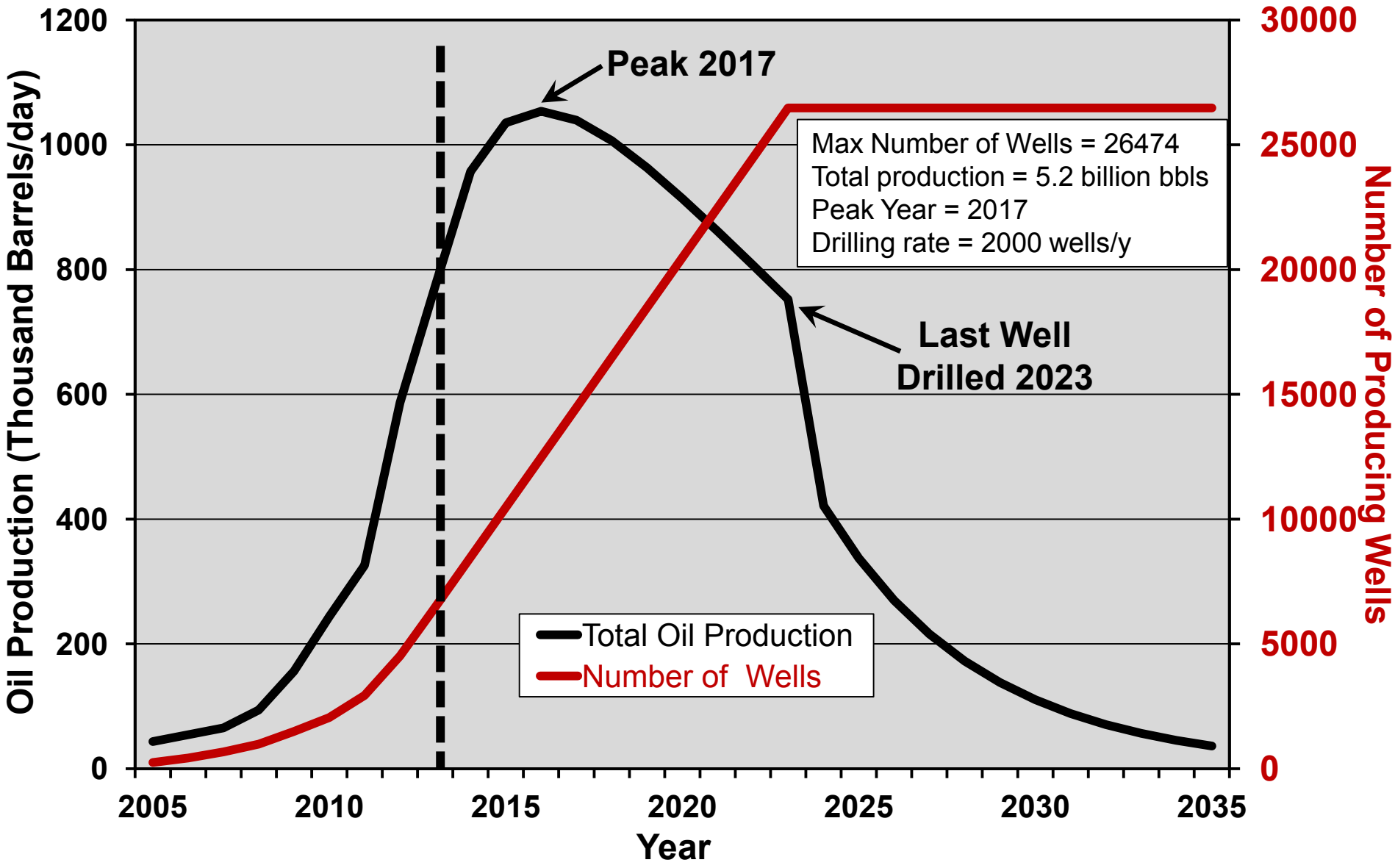
Bakken Oil Production - Constant Drilling Rate Scenario, (2000 wells/year), 2005-2035



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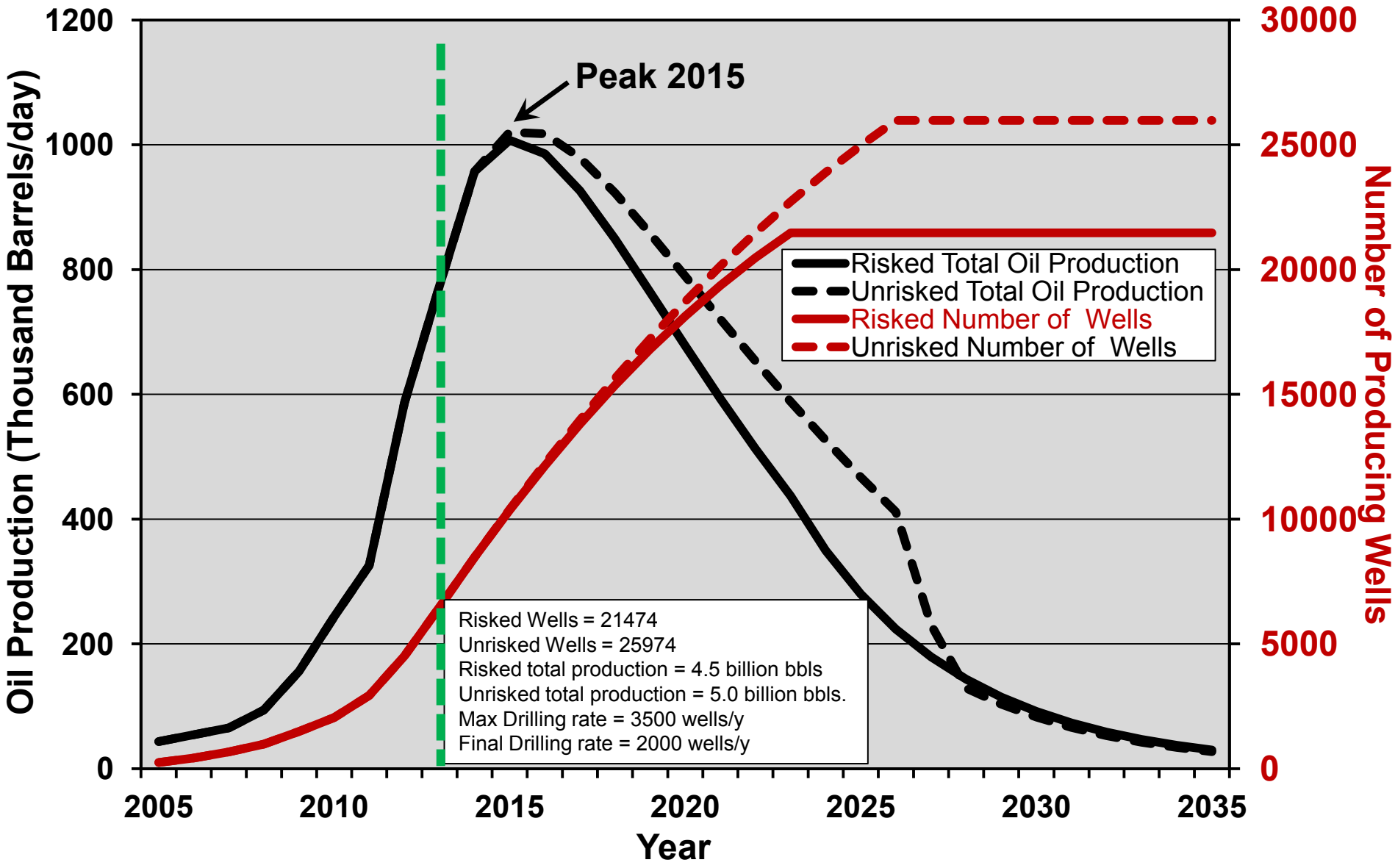
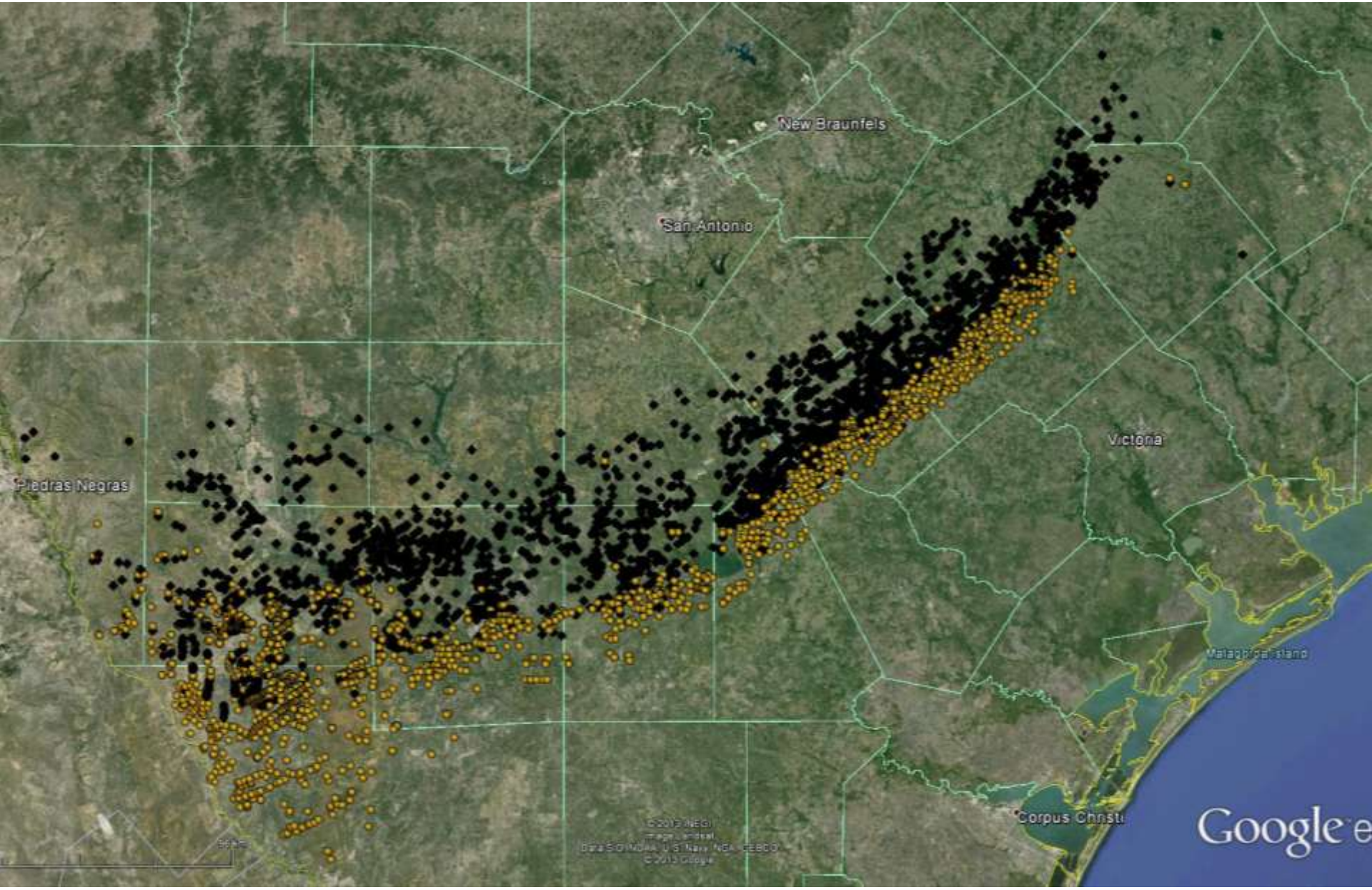
Bakken Oil Production - Declining Drilling Rate Scenario, Risked at 80% for locations versus Unrisked, 2005-2035



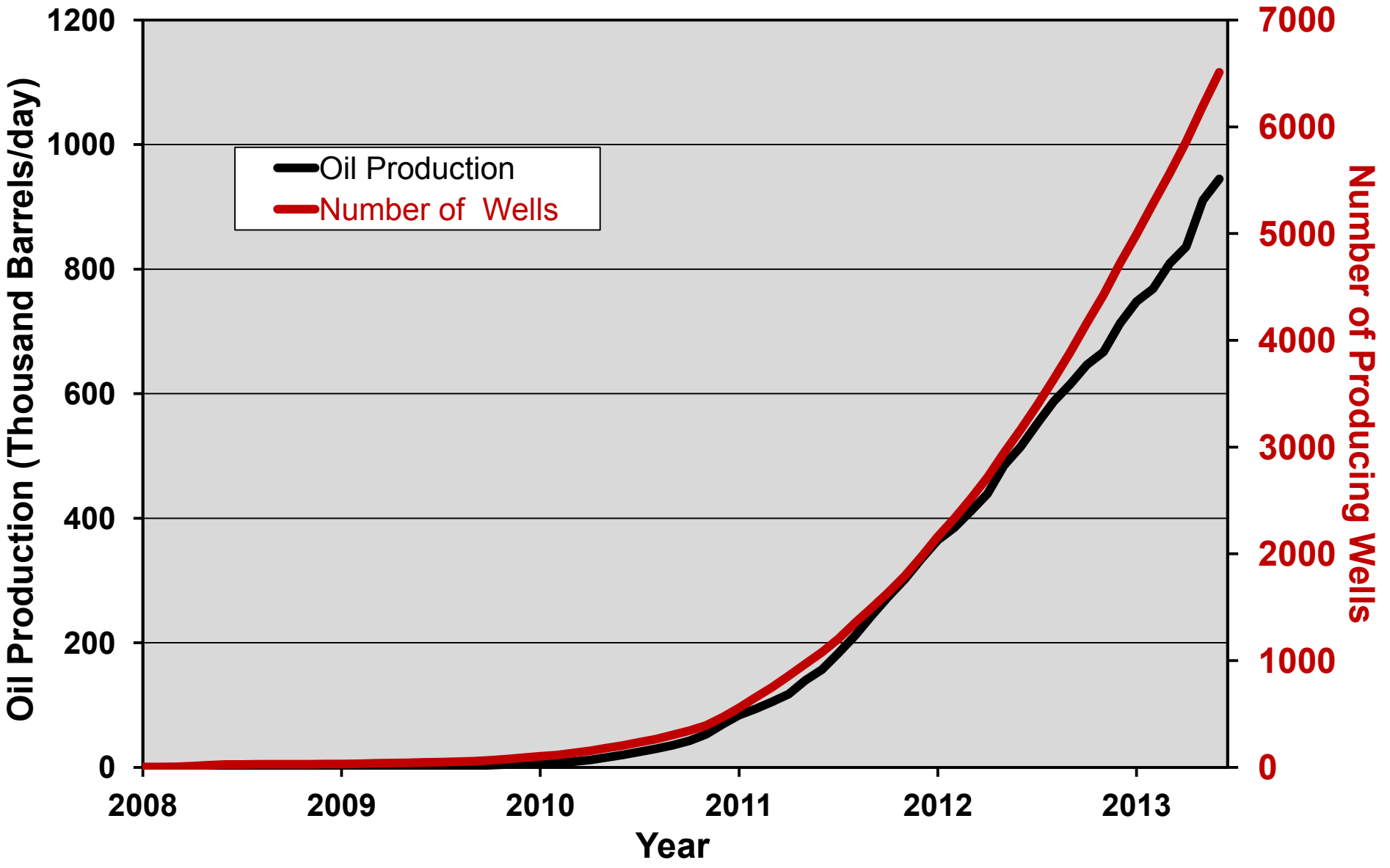
(data from Drillinginfo, October, 2013)

Eagle Ford Gas and Oil Well Distribution through mid-2013



(data from Drillinginfo, October 2013

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



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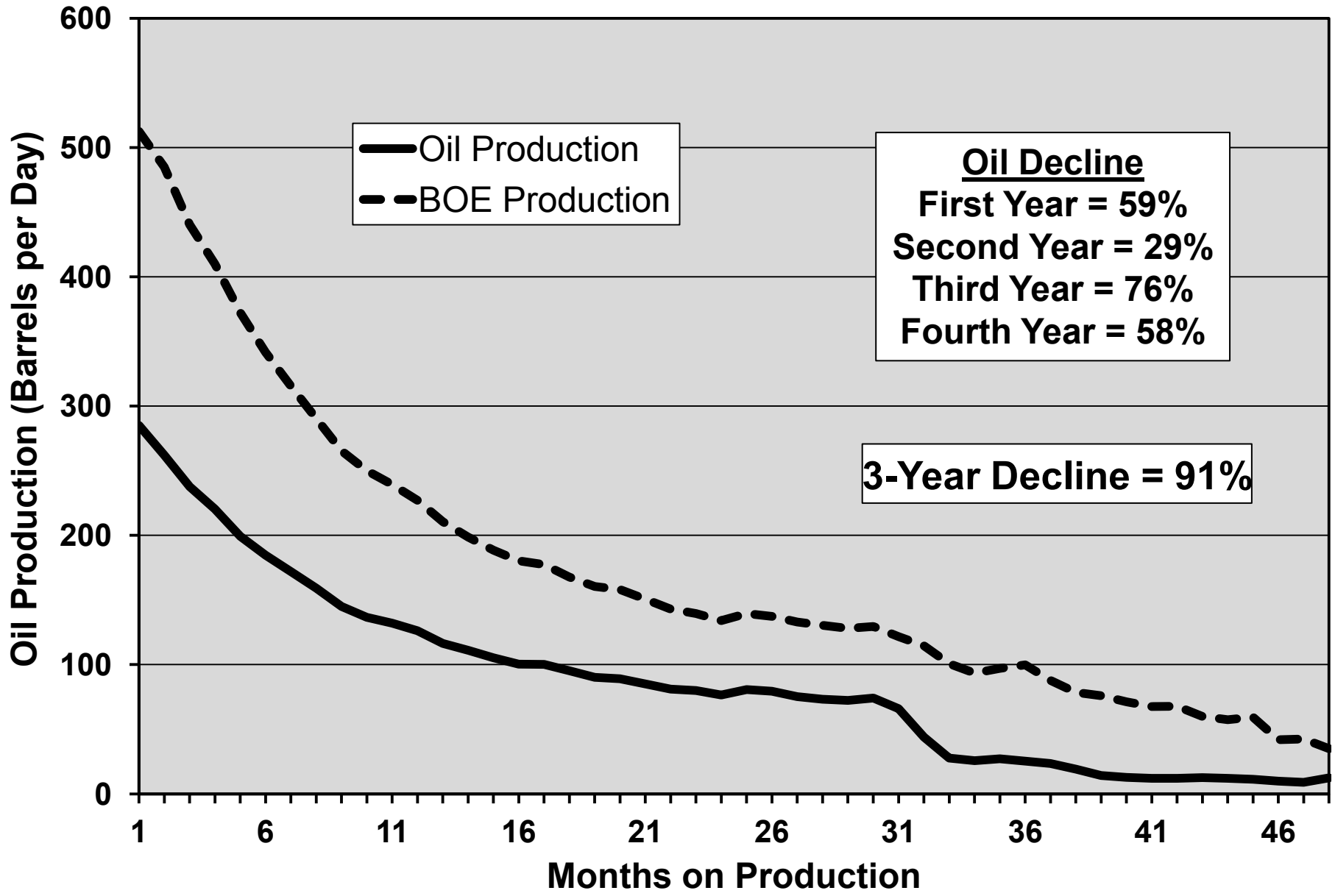
Eagle Ford Type Oil and Barrels of Oil Equivalent Well Decline Curves



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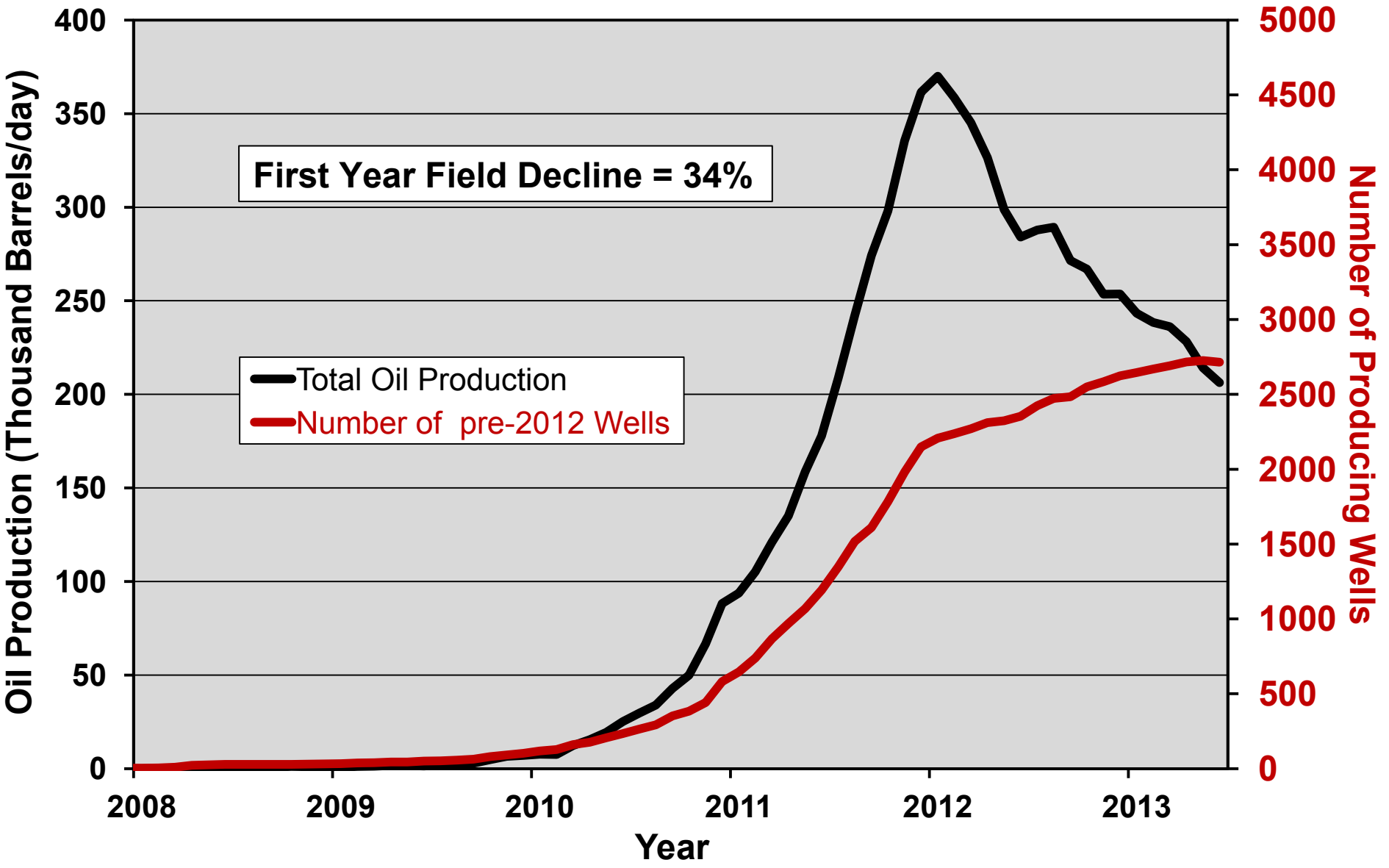

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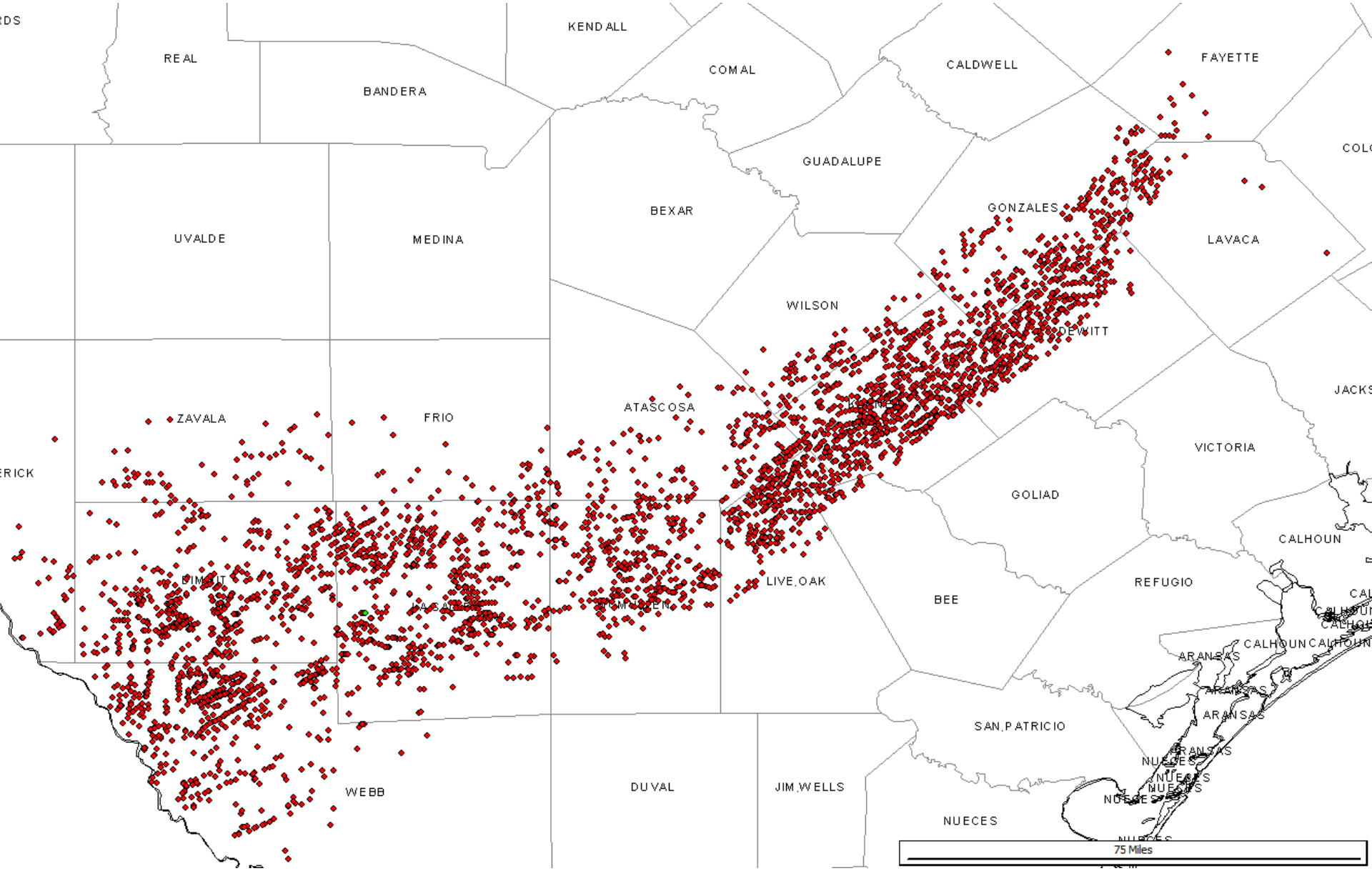

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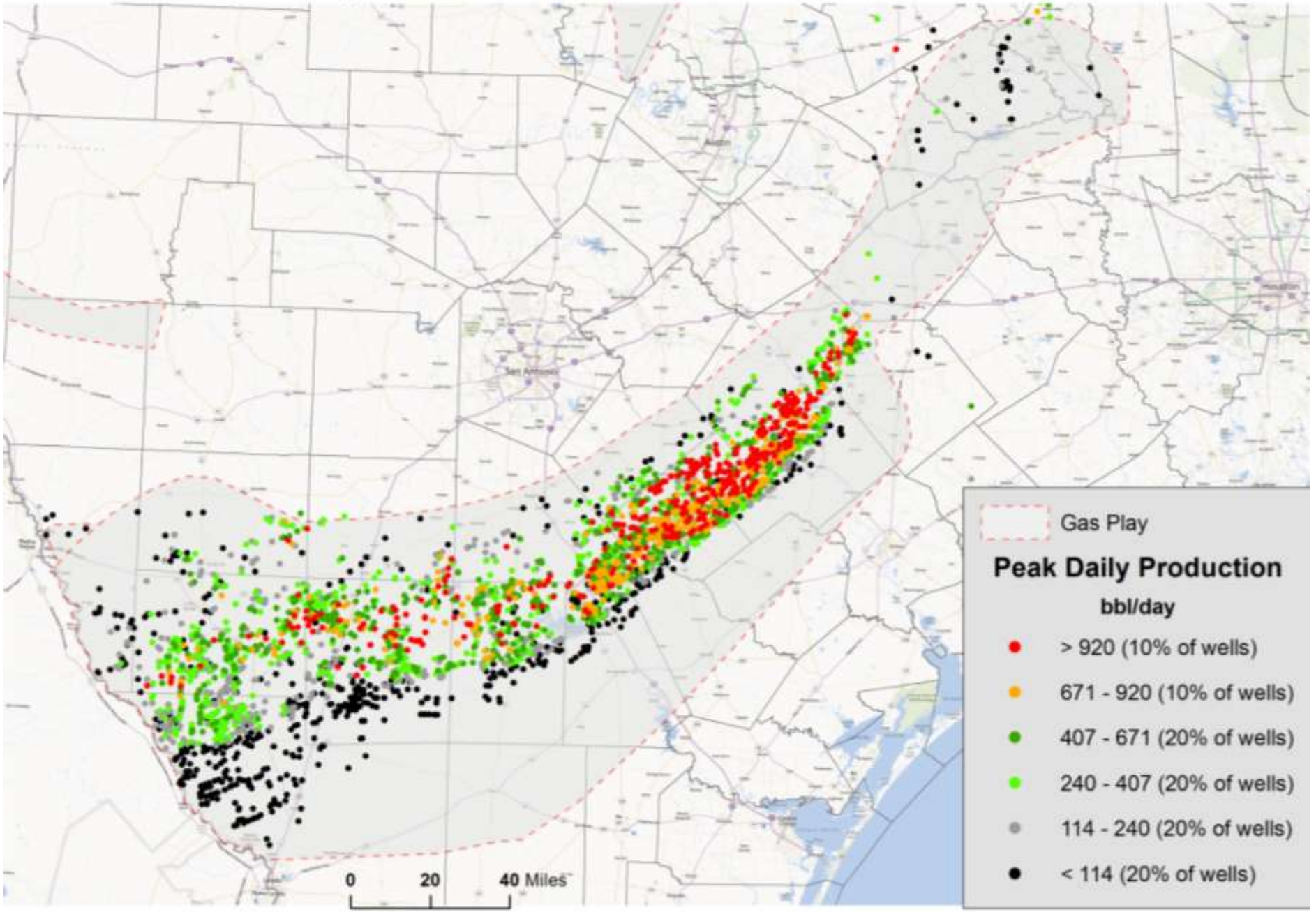
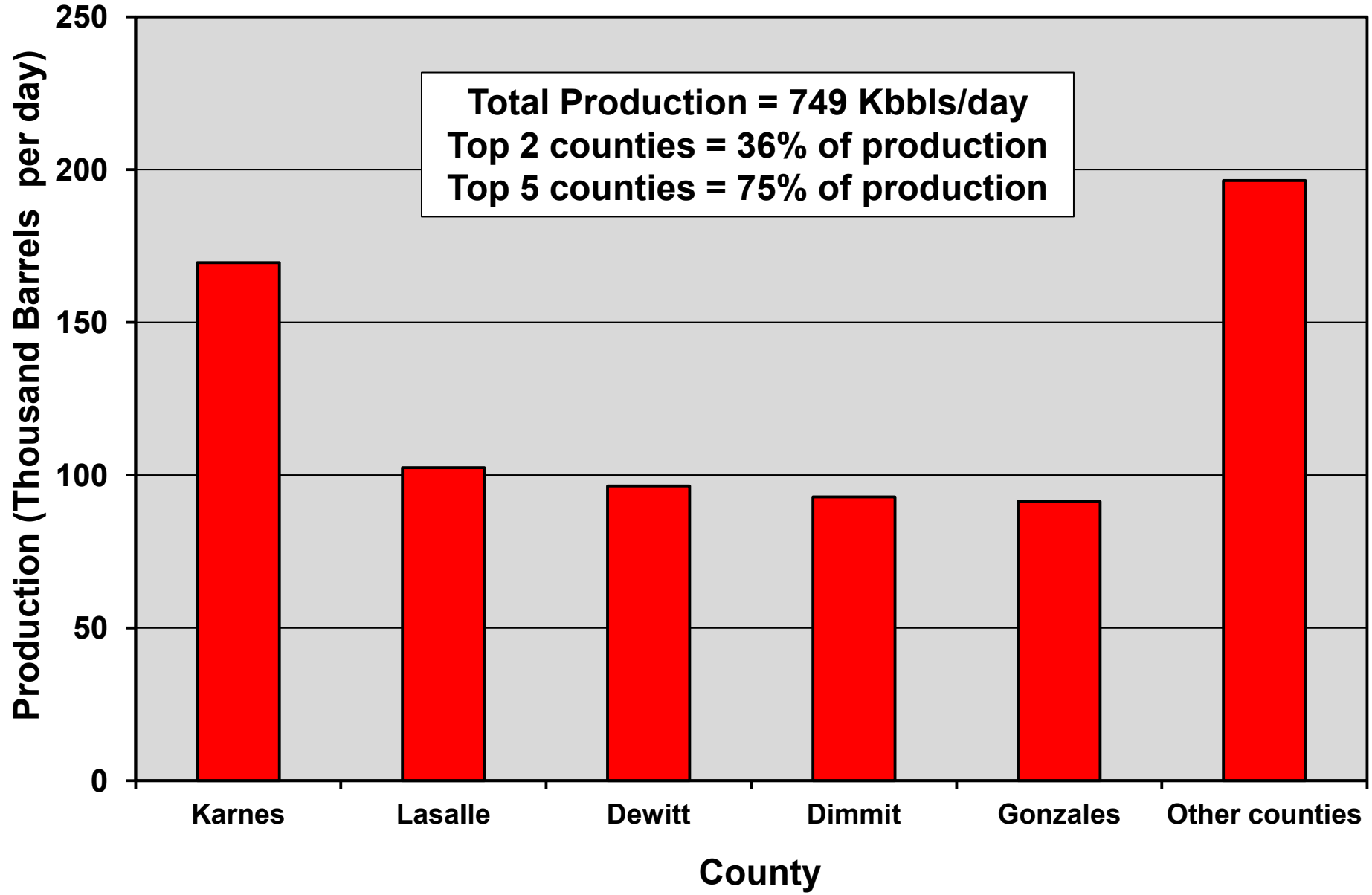
Spatial Distribution of Peak Oil Production

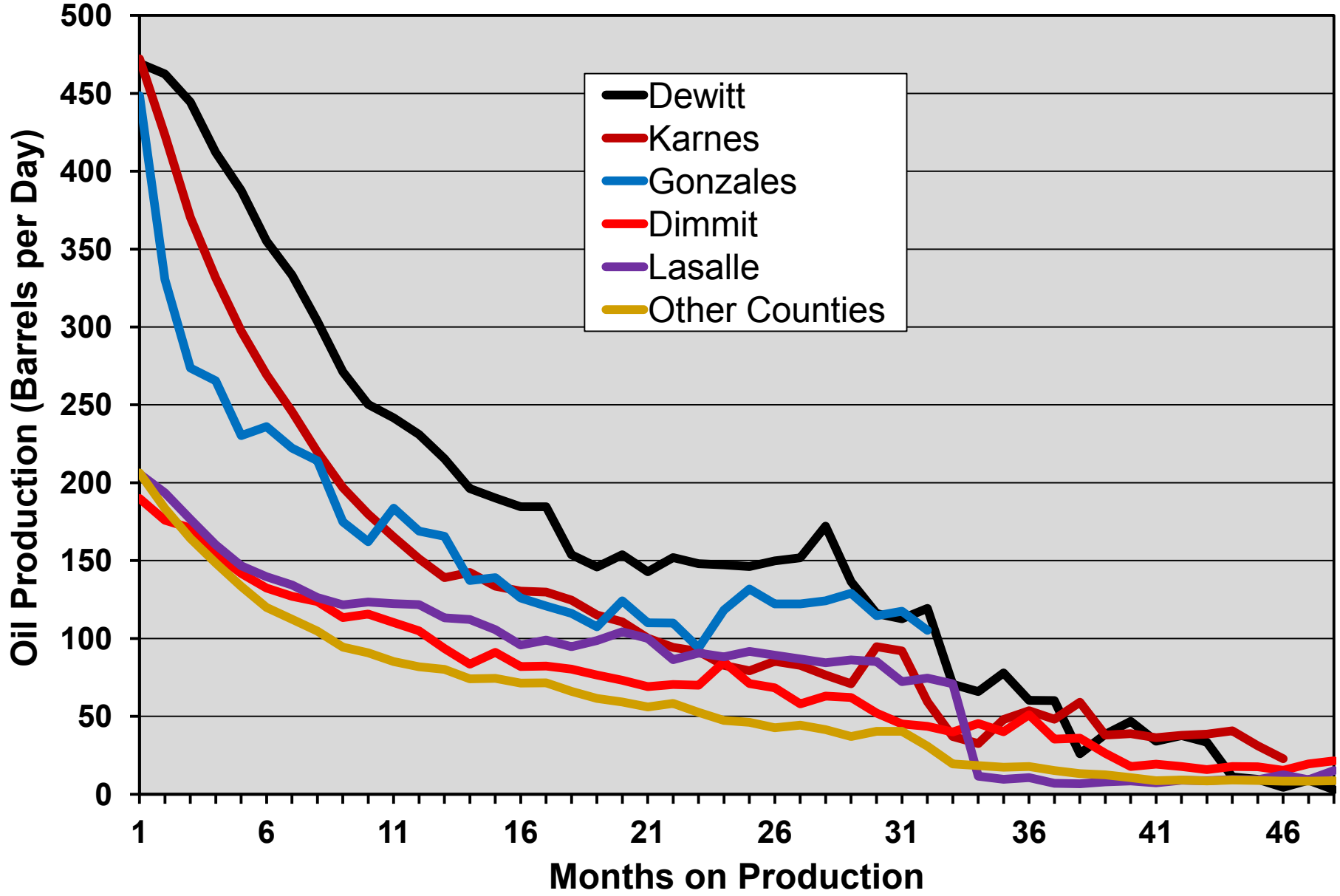


Eagle Ford Oil Production By County, June, 2013



(note that this is 79% of total liquids production, the balance being NGLs; data from Drillinginfo, October, 2013)

Eagle Ford Type Oil Well Decline Curves by County and Region



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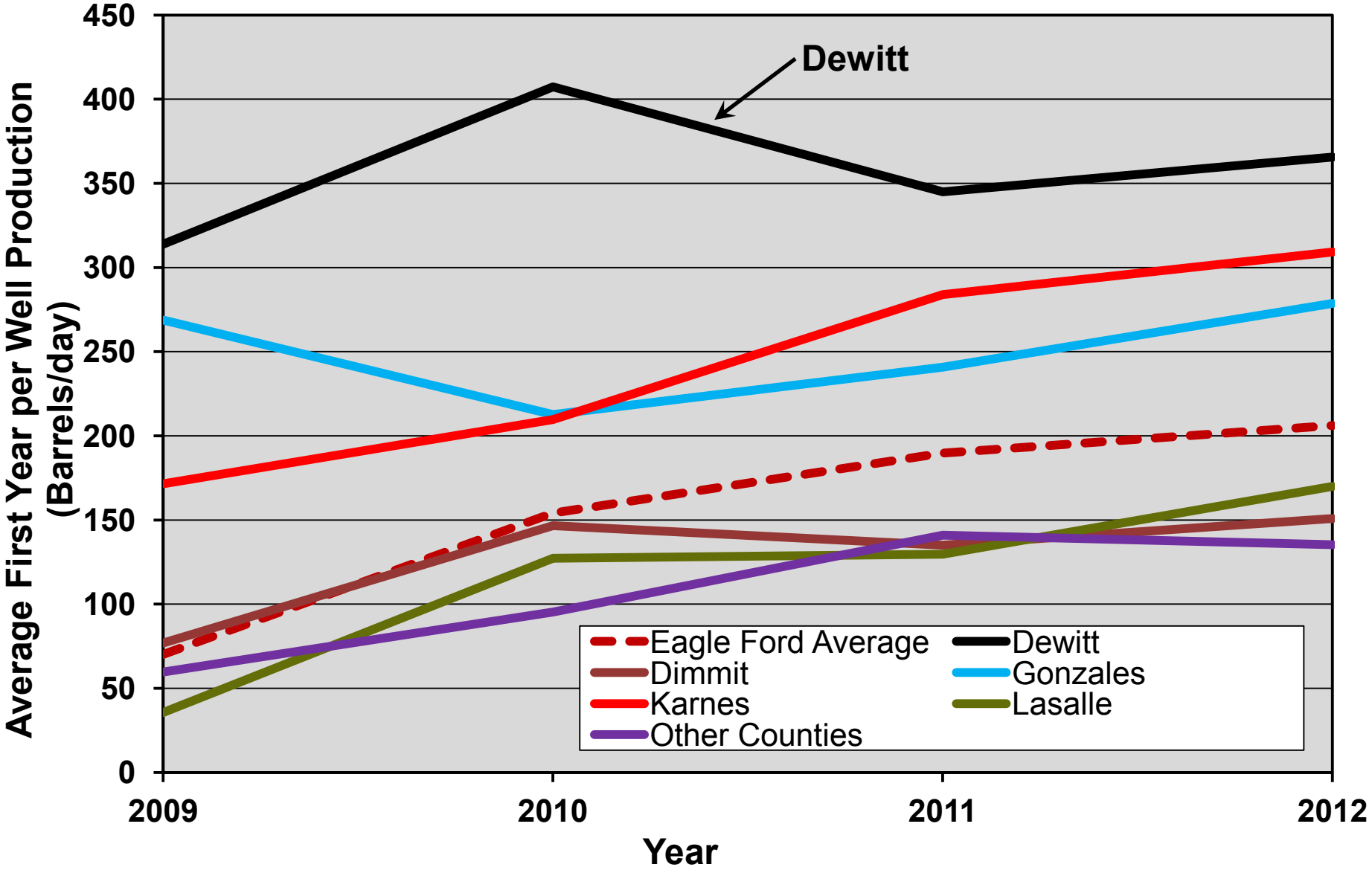

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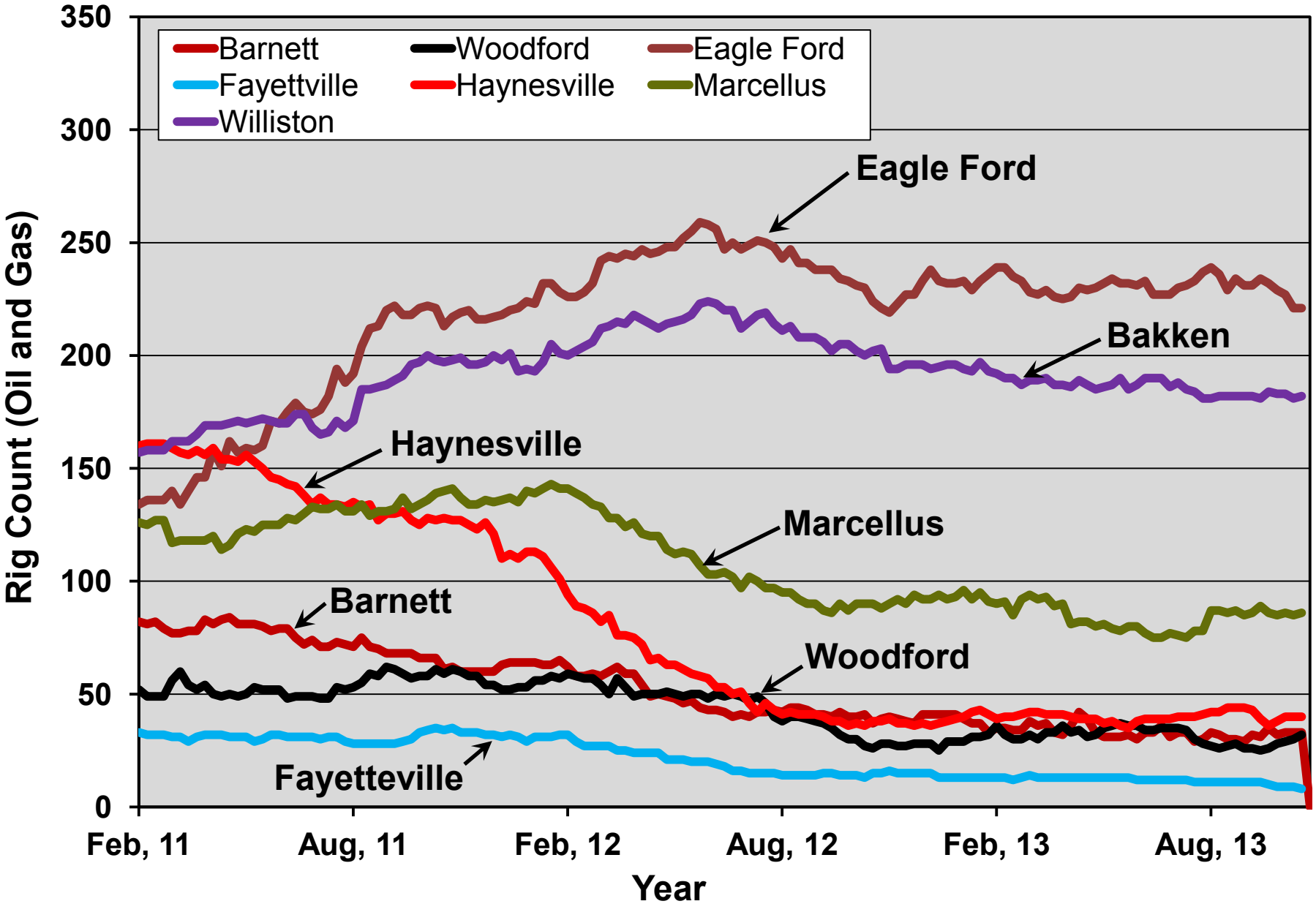

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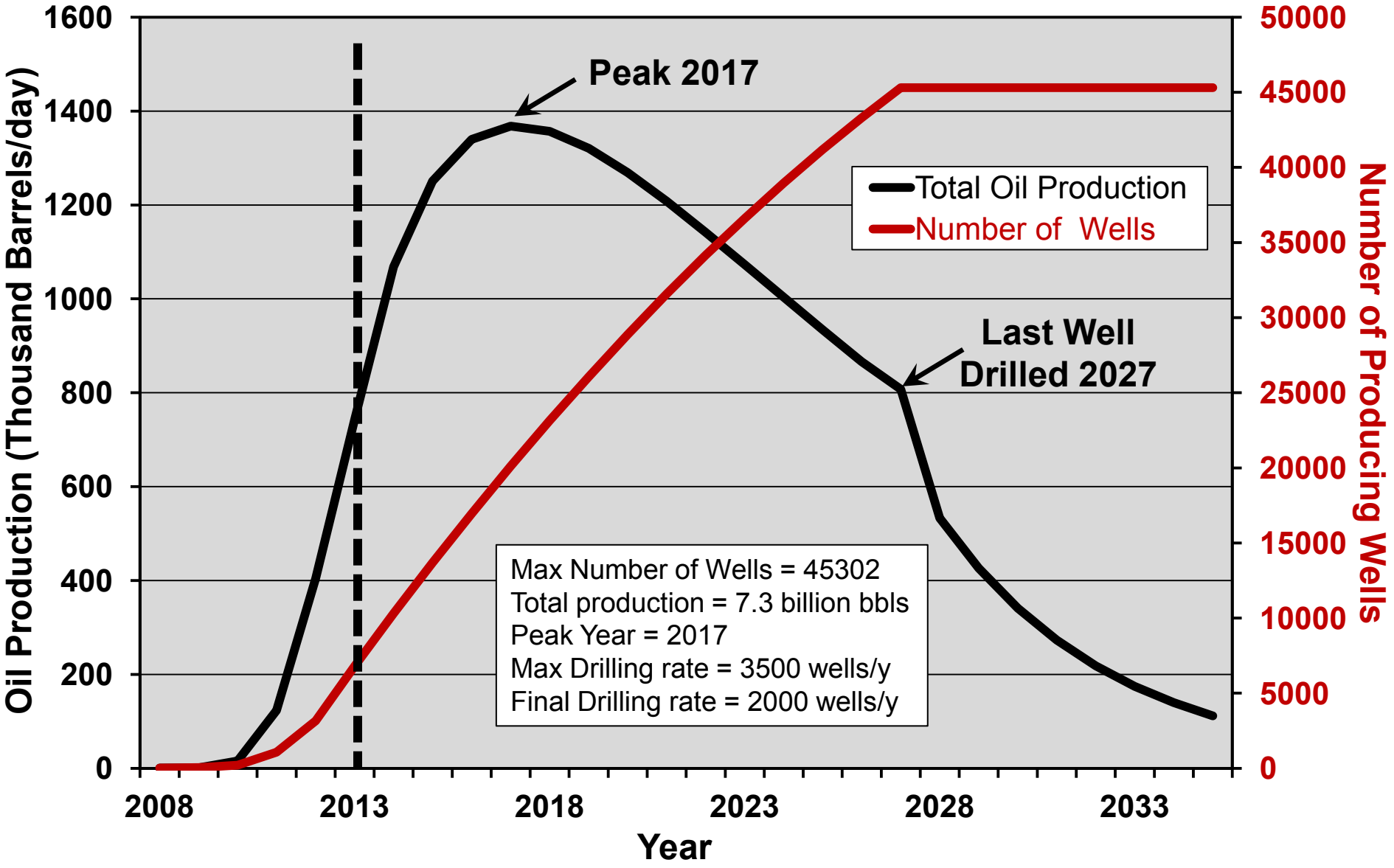
Eagle Ford Oil Production - Declining Drilling Rate Scenario, (3500 wells/year declining to 2000 wells/year), 2008-2035



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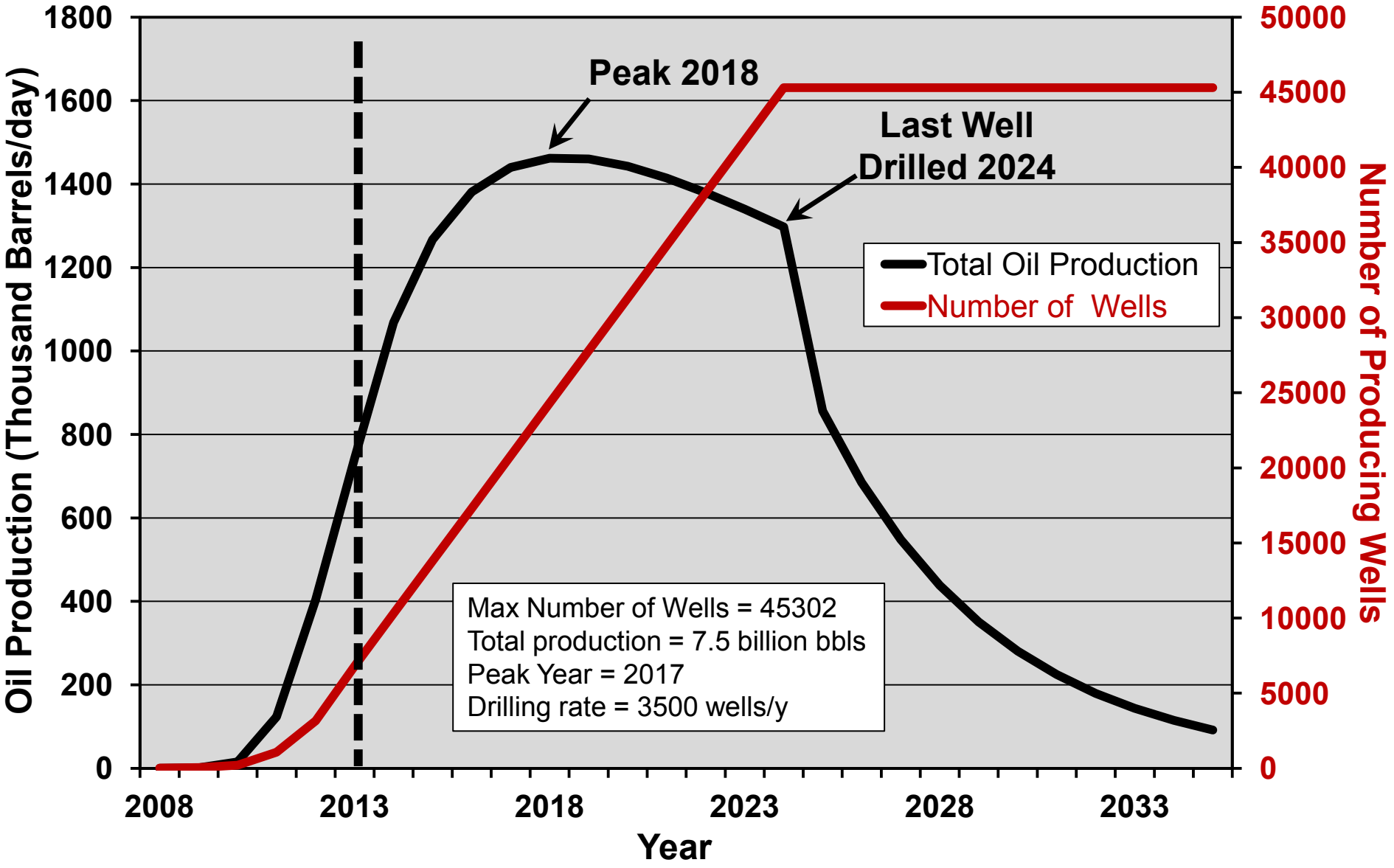
Eagle Ford Oil Production - Constant Drilling Rate Scenario, (3500 wells/year), 2008-2035



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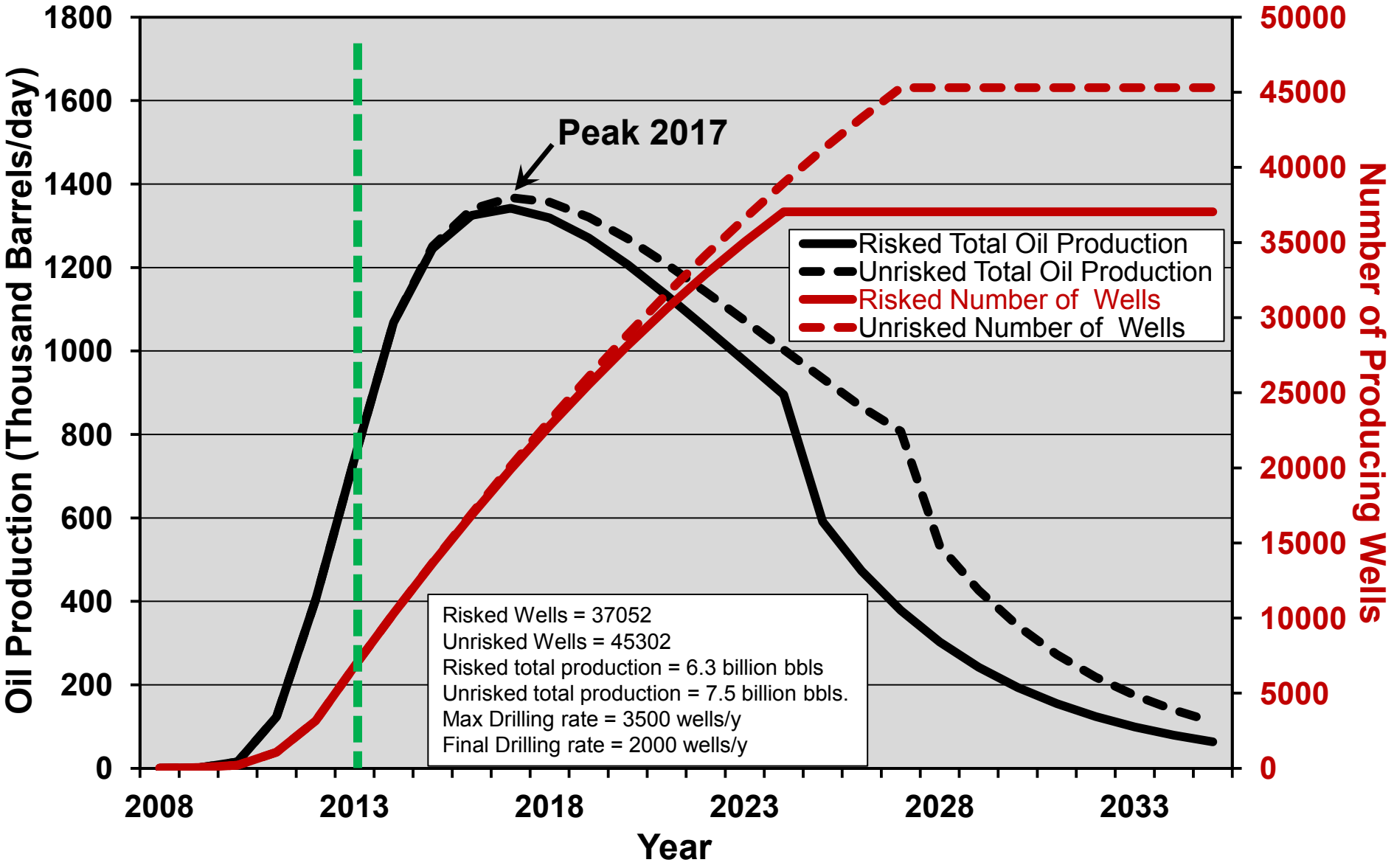
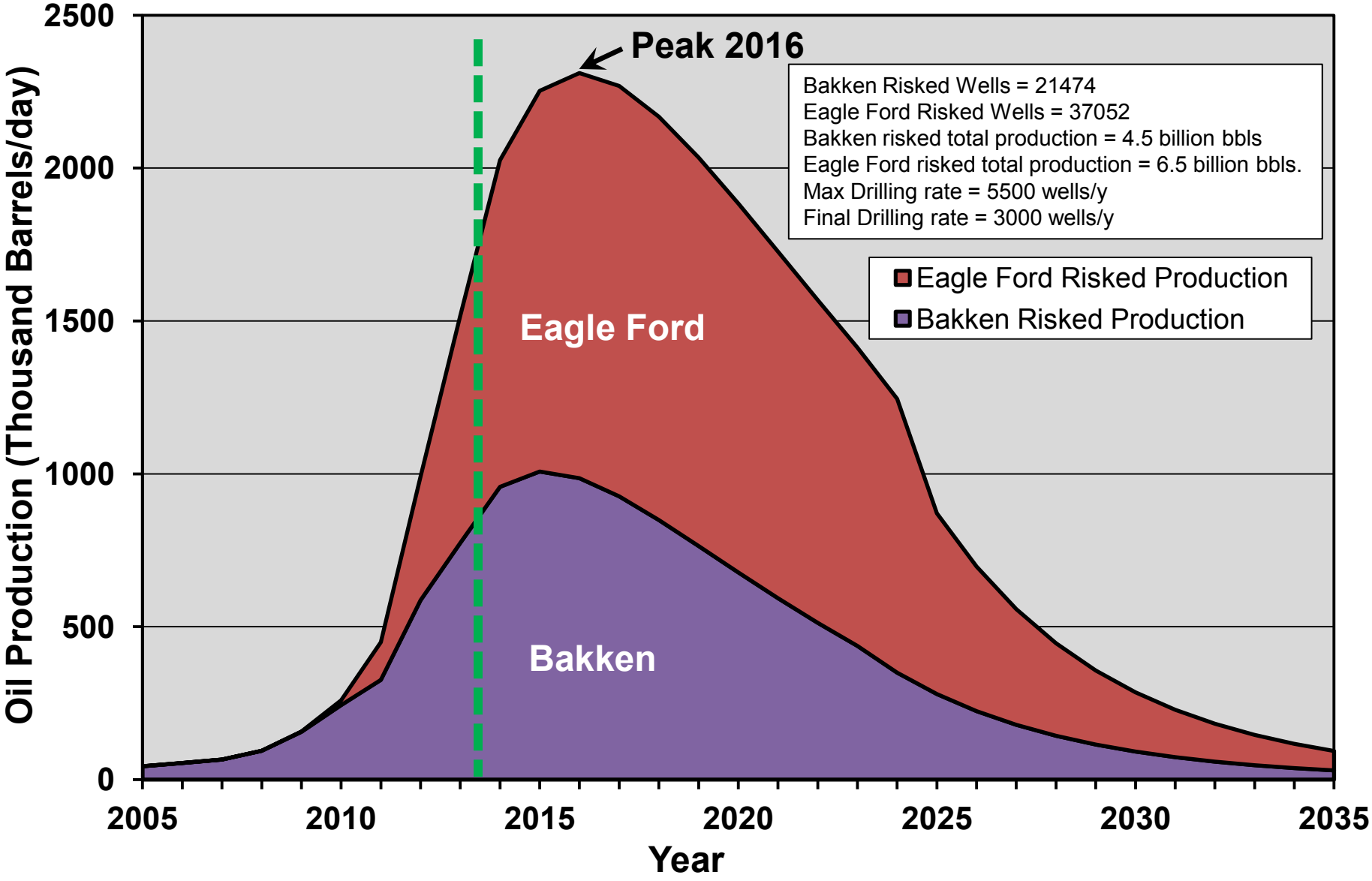


(data from Drillinginfo, October, 2013)

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



(data from Drillinginfo, October, 2013)

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)

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.