



# Impact of Shale Gas

Anchorage, AK  
August 5-9, 2013

North Slope Gas & LNG Symposium

# Conventional versus Unconventional Resources

1. Unconventional oil and gas are down the resource pyramid – more difficult and expensive
2. Very few, if any, outright dry holes, but many disappointing wells that fail to break even
3. Within an unconventional play, there is enormous variability between winners from losers
4. Operational competence is important but rarely a source of long-term comparative advantage as best practices and technology spread easily
5. Value creation is mostly captured in the initial de-risking phases
6. Unconventional assets are extremely modular – companies can stop and start without impacting project economics

# What Is Unconventional Gas?

**Cows**  
**520 MMtons**

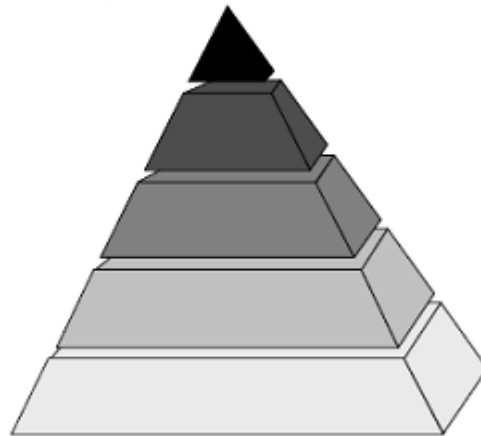
**Sheep and Goats**  
**105 MMtons**

**Chickens**  
**48 MMtons**

**Ants**  
**5,000 MMtons**

Resource Pyramid  
(for minerals)

Highly concentrated  
Easy extraction/access



Increasing cost  
of extraction  
(including  
**MORE  
ENERGY**)

Low concentration  
Difficult extraction/access

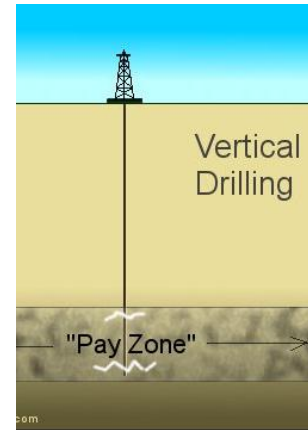
Better quality  
resource

# Better Technology to the Rescue

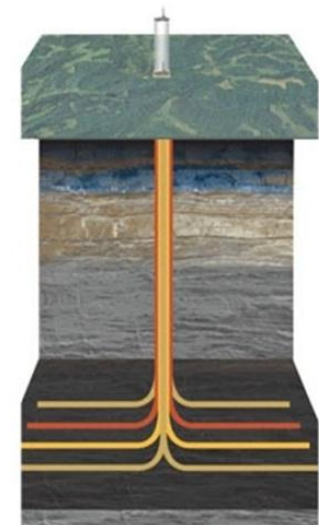
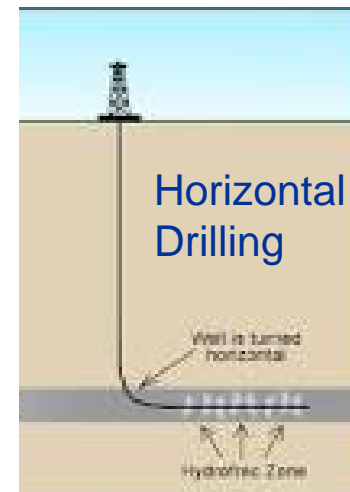
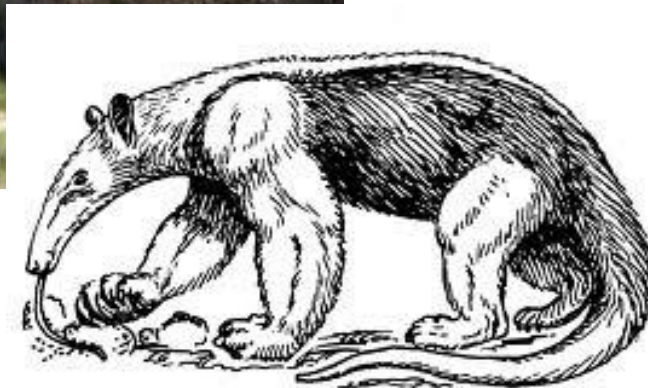
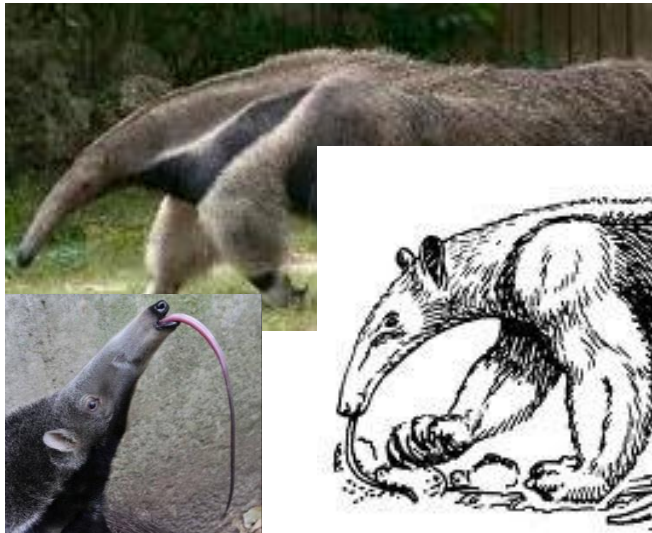
## The Problem with Ants (and Unconventional Resources):



If you pick them up and eat them one at a time, energy output is greater than input.



## The Solution



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## **Life Stage and Value Creation Framework**

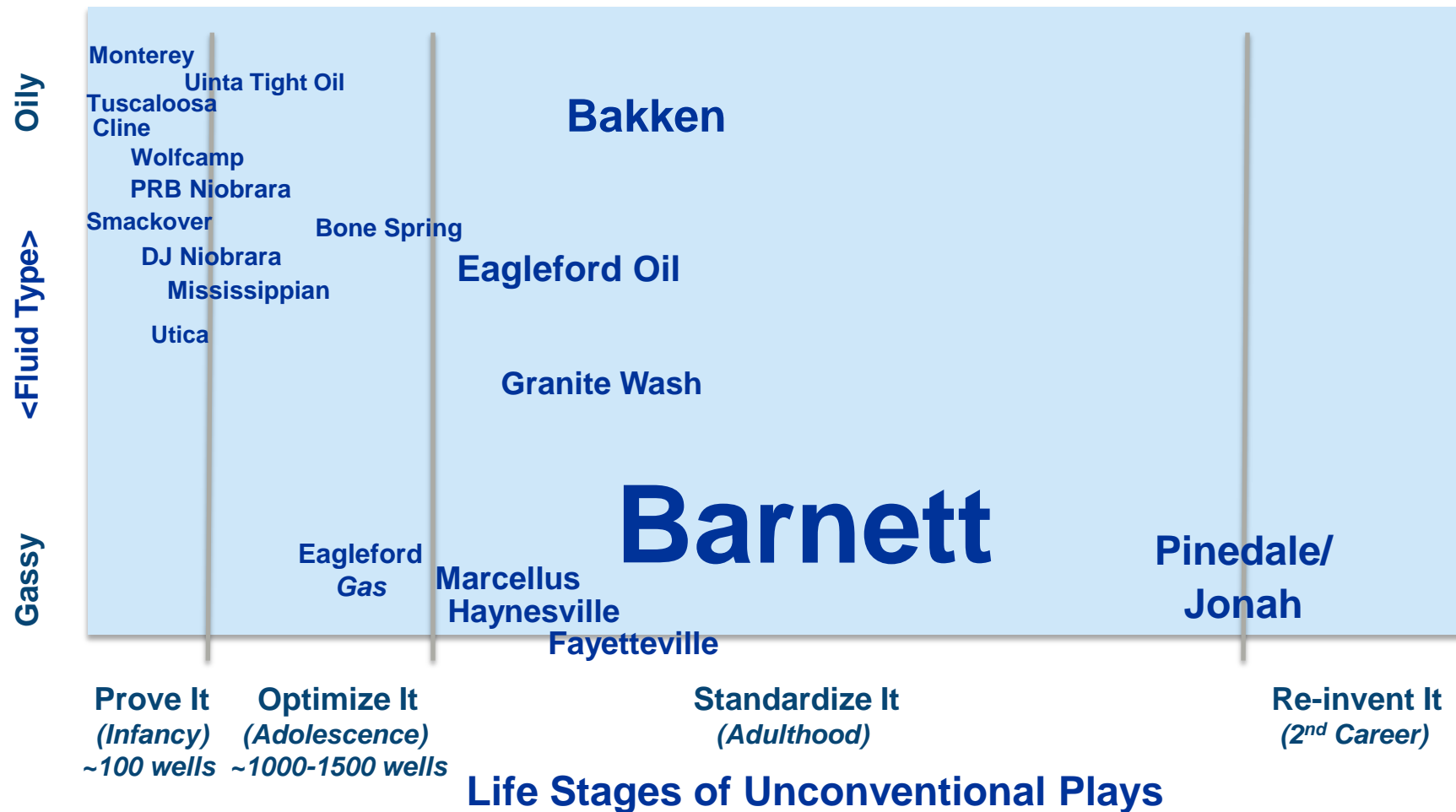
Ingredients of Successful Plays

Skill Sets

Play Reviews

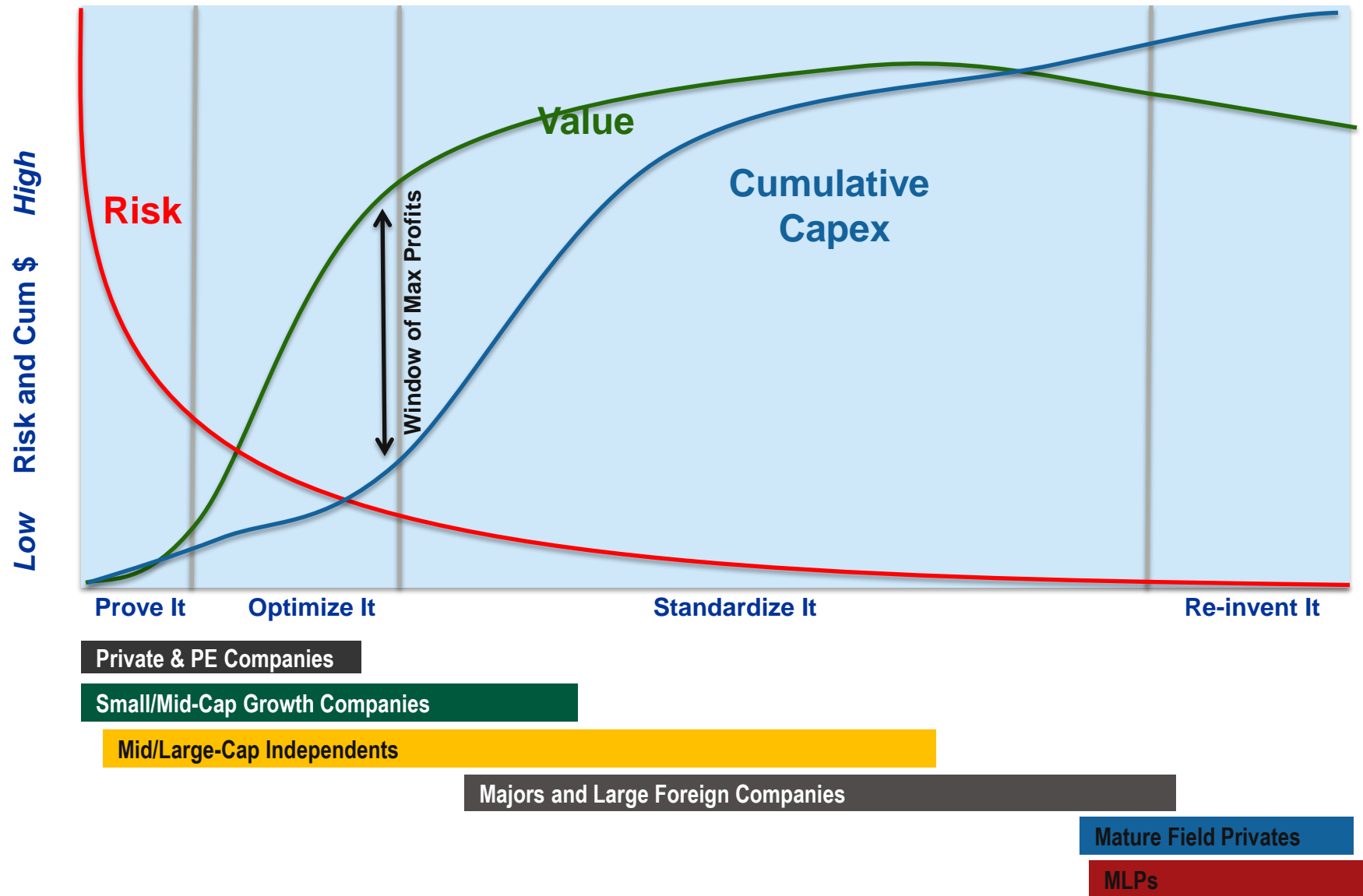
# Life Stages of Unconventionals

- Plays pass through distinct life stages as they mature.
- Pace of maturation varies tremendously



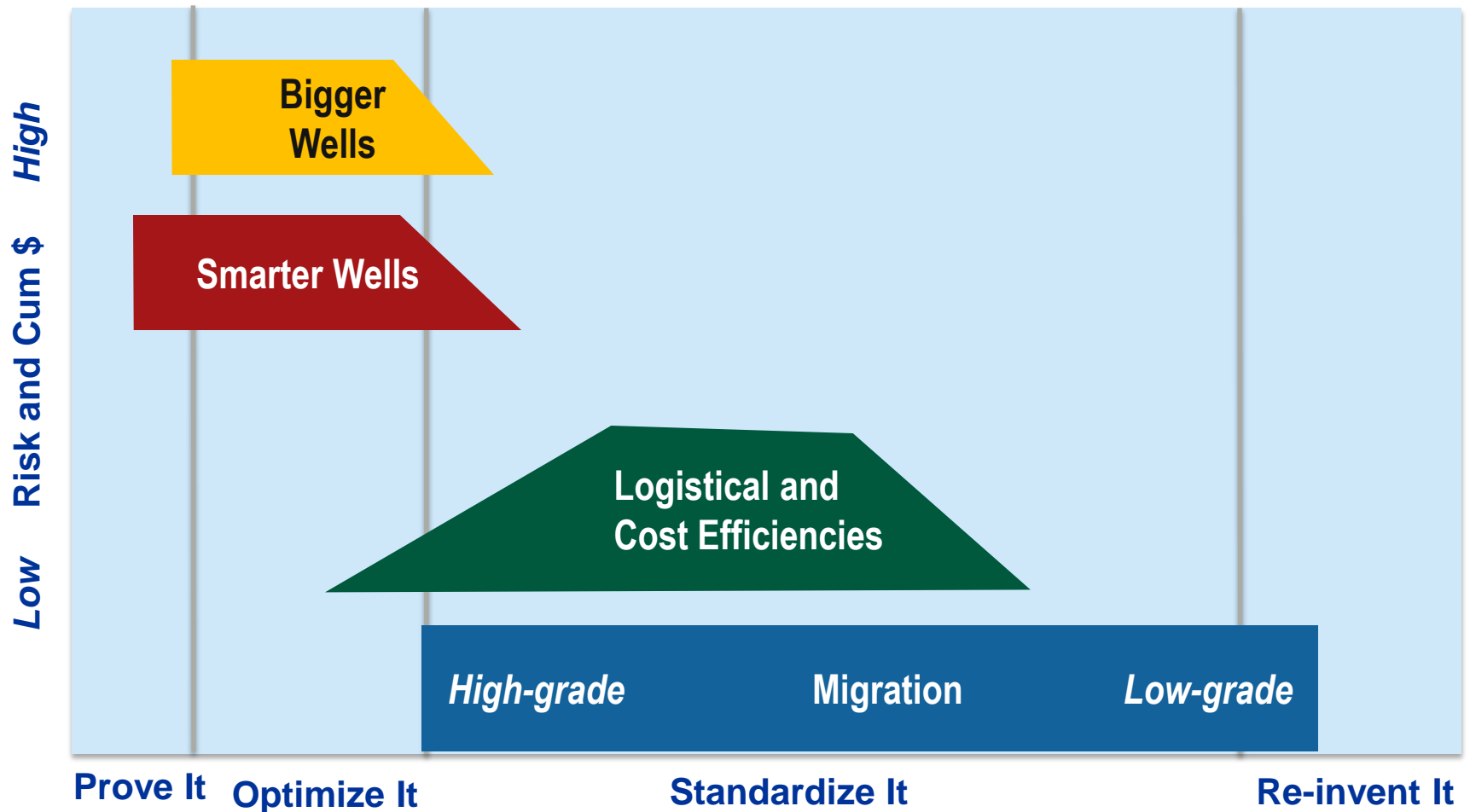


# The Game and Its Players



# The Game and Its Players

- Companies have 4 primary levers to pull to improve individual well results
- When companies achieve these In early stages, these gains compound, but each tends to reach a plateau eventually





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Life Stage and Value Creation Framework

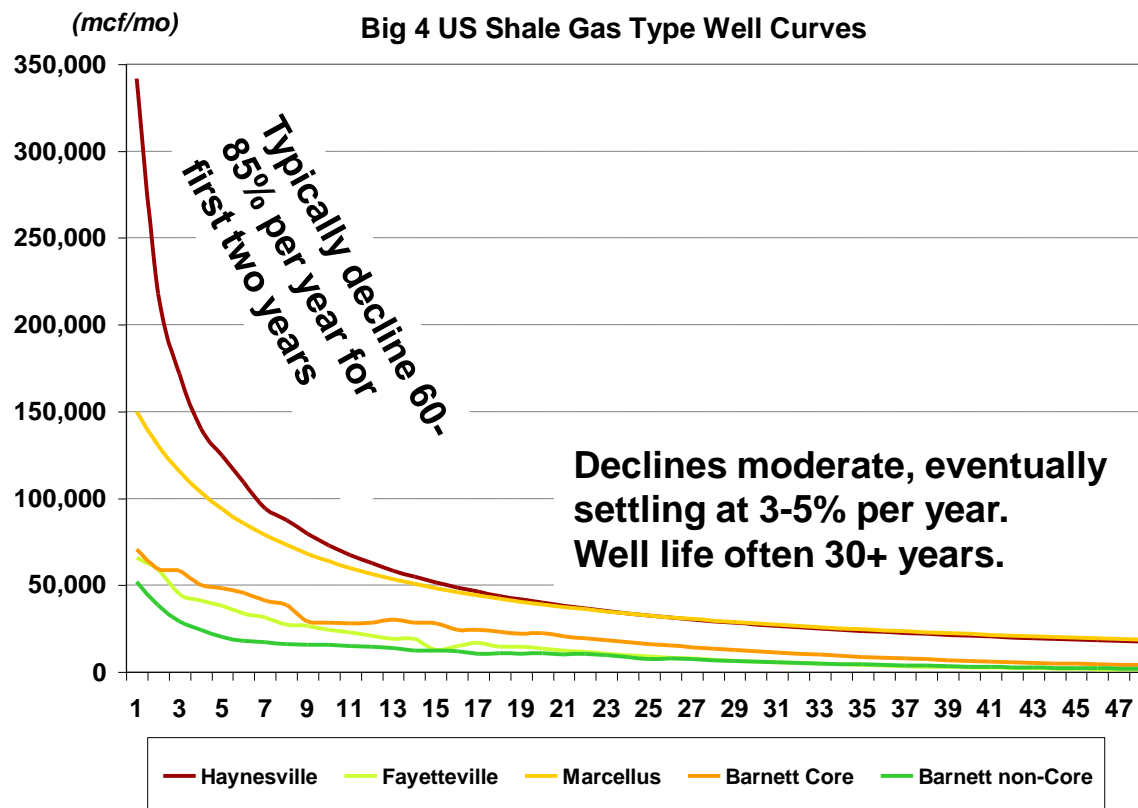
**Ingredients of Successful Plays**

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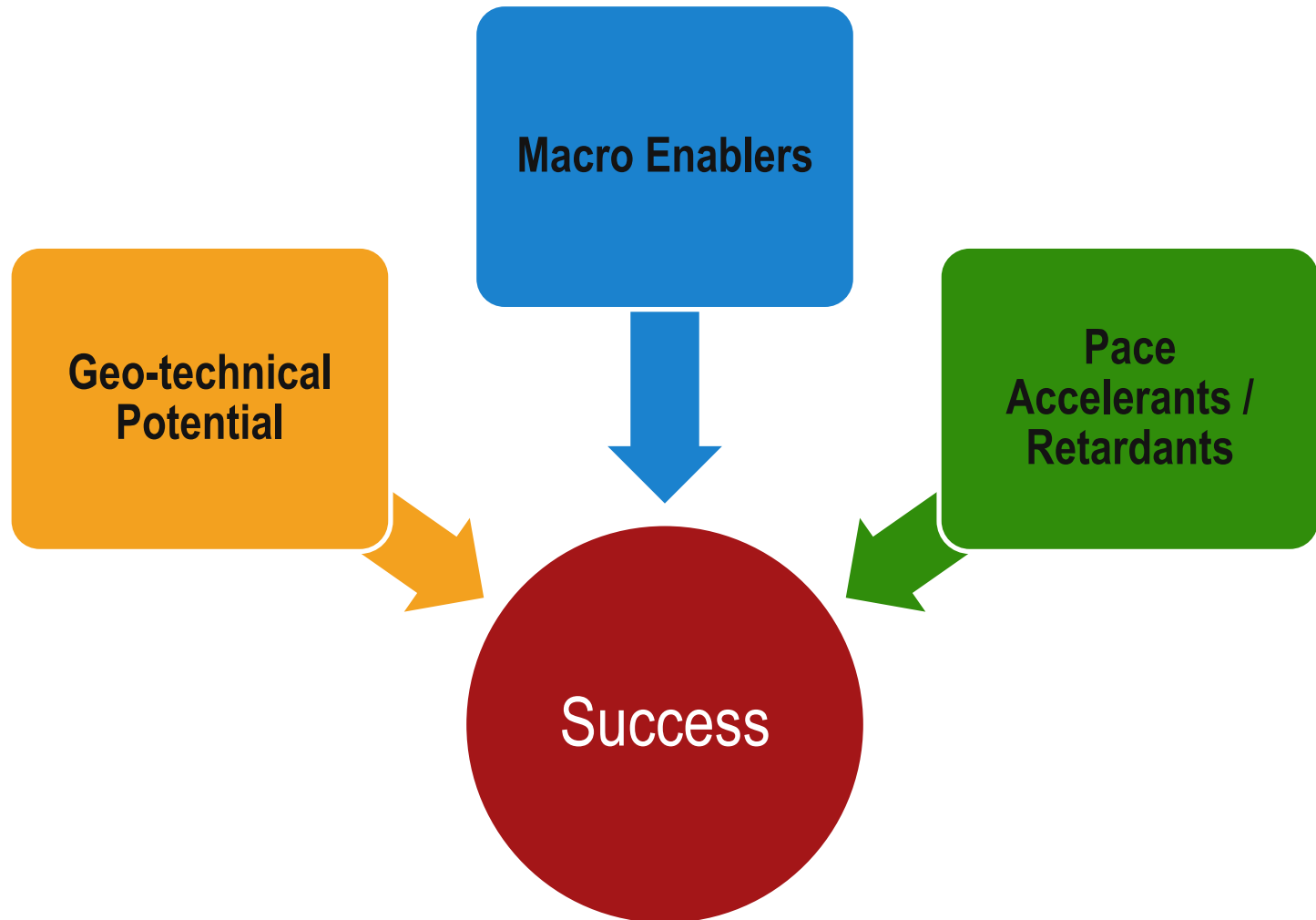
Play Reviews

# Characteristics of Shale/Tight Gas Plays

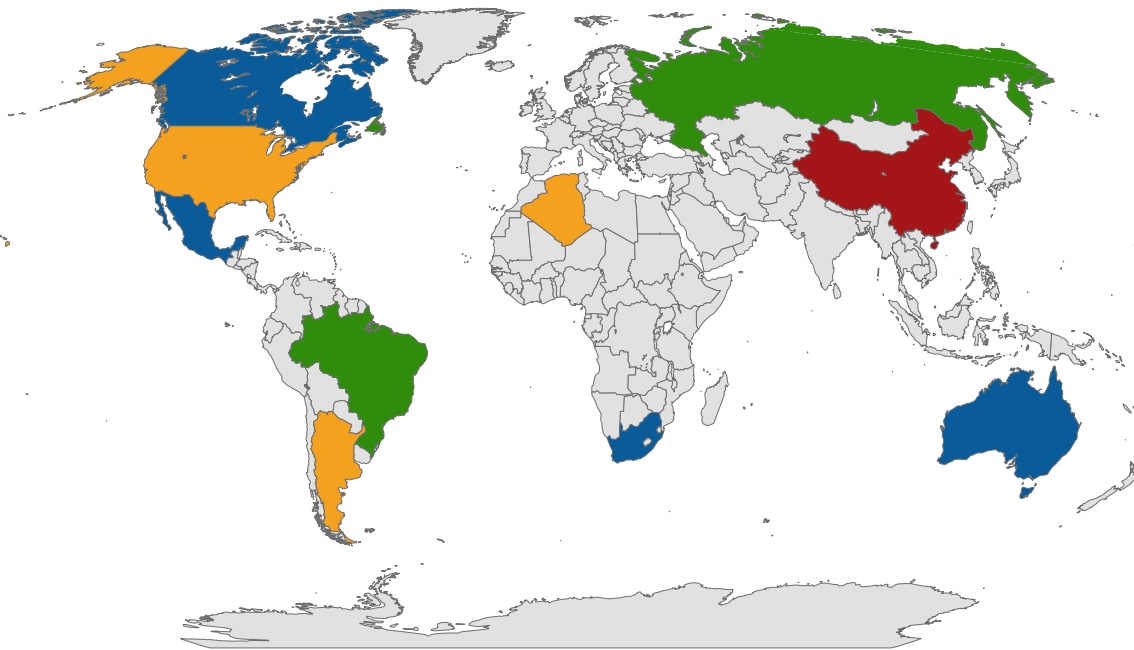
- Petrophysics means that production is front-loaded
  - Enhances NPV significantly by reducing payout time
- Profile creates treadmill effect, forcing constant reinvestment to avoid decline
- **There is debate about industry estimates of well reserves and life**
- **PFC analysis suggests**
  - Core areas volumes are in line with company claims
  - Different areas within play can diverge sharply
  - Well life should be measured in decades



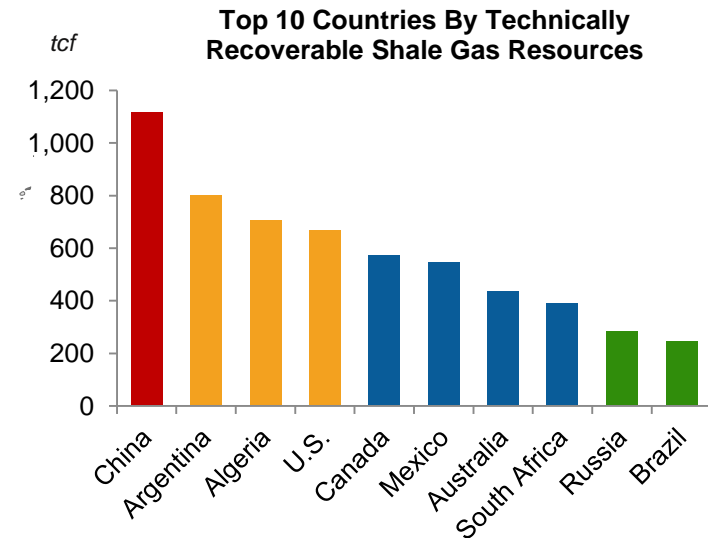
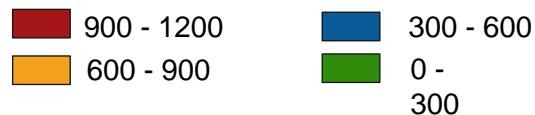
# Three Kinds of Factors Seem Necessary for



# The Top Ten Countries with Largest Shale Gas Resources



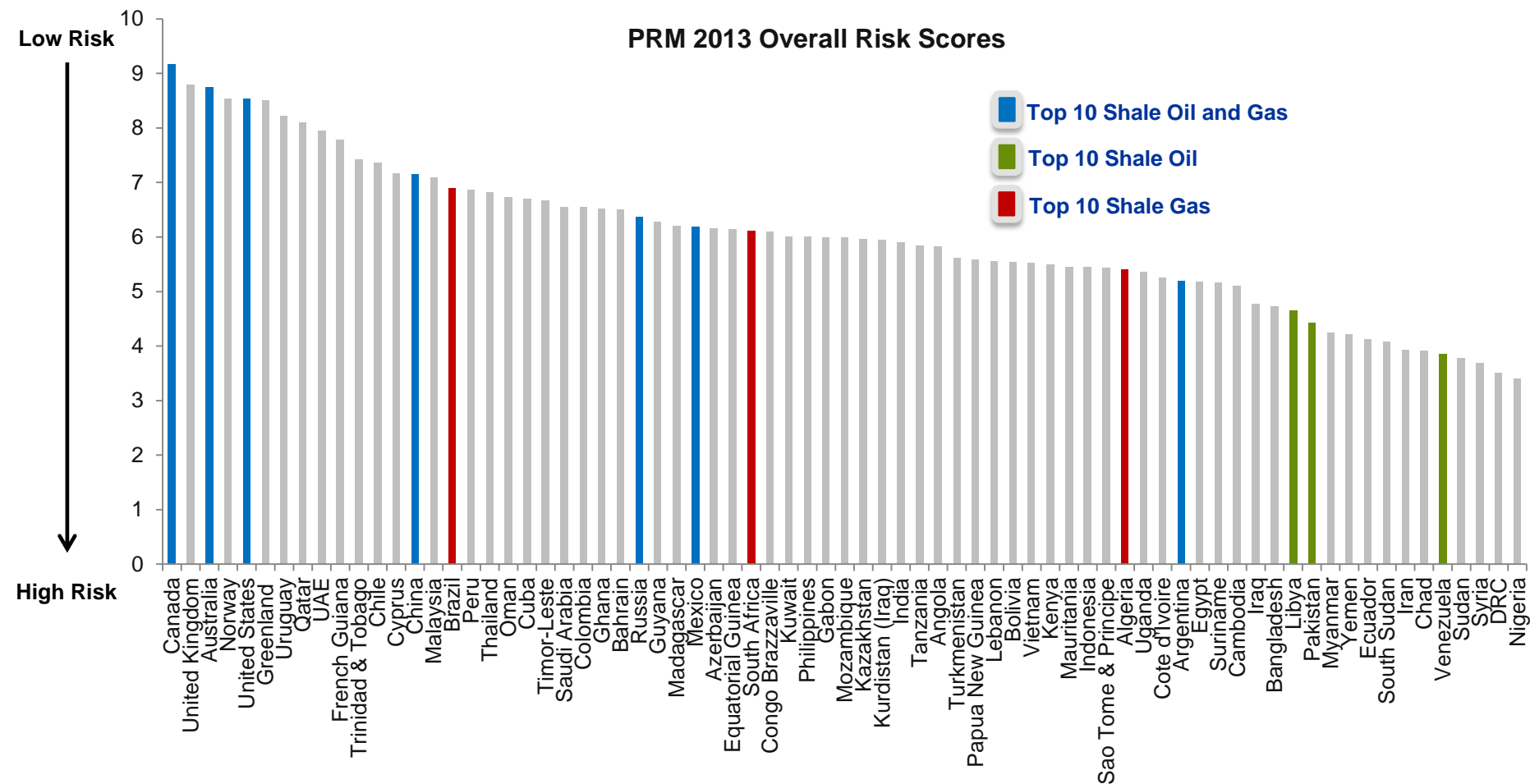
**Shale Gas**  
(trillion cubic feet)



Source: EIA Report, June 10 2013

While there is a large range in the distribution of shale gas resources among the top ten, no single country is overwhelmingly dominant.

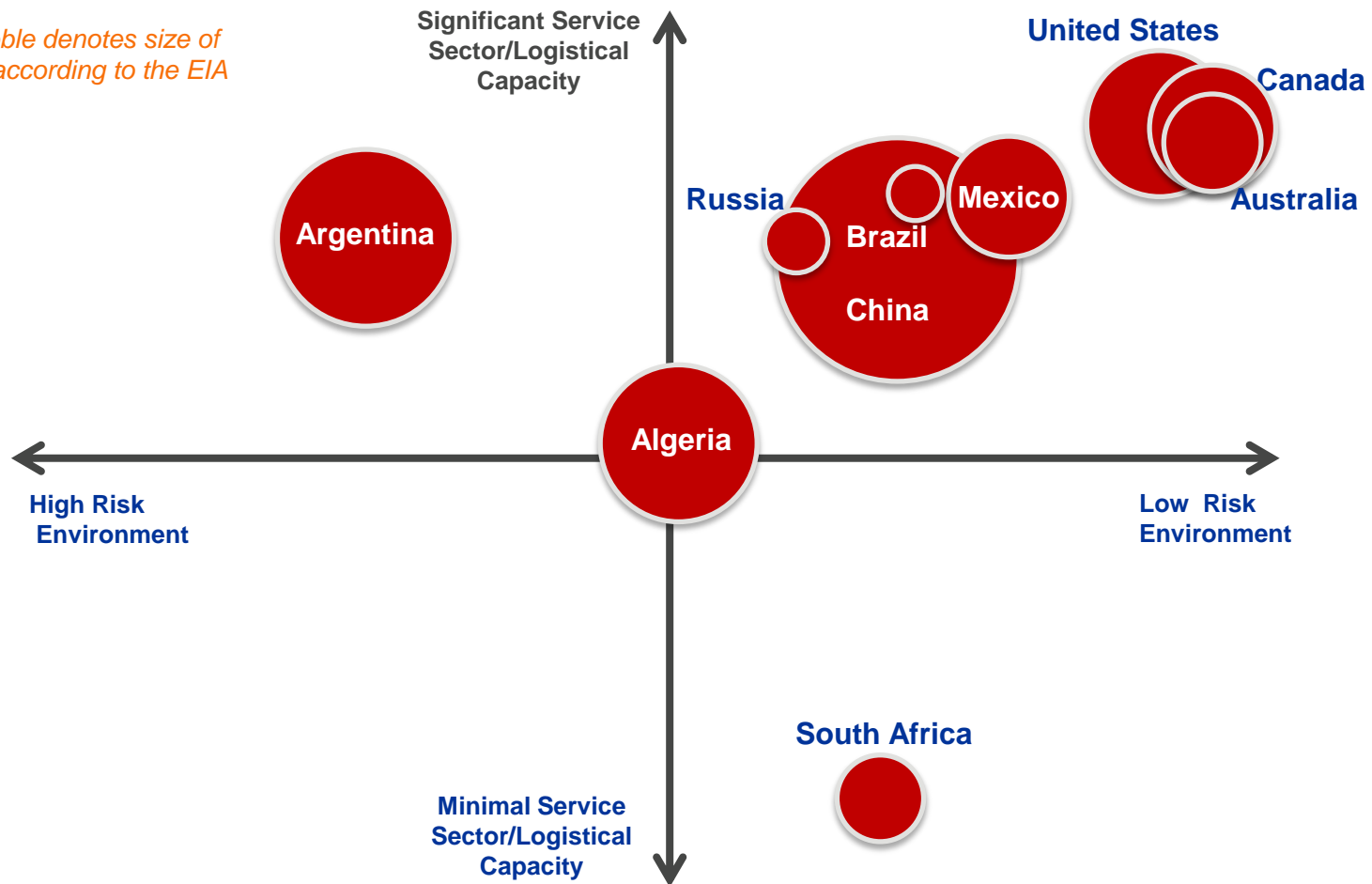
# Top 10 Shale Oil and Gas Resources: Span the Gamut of Above-Ground Risk



Countries identified by the EIA with the largest unconventional resources vary widely in terms of overall above-ground risk – but those in the top ten for both shale gas and shale oil are mostly found in the top half of the risk range.

# Top 10 Shale Gas Countries per EIA Study

*Size of bubble denotes size of resources according to the EIA*



Shale gas resources are concentrated in the countries with the most manageable above-ground risk as well as strong infrastructure/service sector capacity. The two main outliers are Argentina and South Africa.

# Unconventional Success Has Resulted from a Complex System of Favorable Factors

Critical Ingredients of the System	<i>Lwr-48</i>	<i>China</i>	<i>Alaska</i>	<i>Geo-tech</i>	<i>Macro Enabler</i>	<i>Pace Governor</i>
Rock characteristics/ resource base quality				X		
Resource base quantity				X		
Responsiveness to frack				X		
Well control						X
Land Tenure/Parcel Size						X
Local advocates and beneficiaries					X	
Lease structure forcing establishment of production						X
High number of operators/dispersion						X
Company ability /willingness to spend significant capital quickly						X
High company risk appetite for trial and error						X
Service sector availability					X	
Rapid transmission of learnings via leaky service sector and external company orientation						X
Pipes, Gathering to allow processing/delivery					X	
Water and other essential frac materials					X	
Skilled oil and gas labor pool					X	
Favorable natural gas prices and available markets					X	
Cooperative governments and incentives					X	



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Life Stage and Value Creation Framework

Ingredients of Successful Plays

**Skill Sets**

Play Reviews

# Stage 1: Prove It

- What is Happening?
  - Companies proving the reservoir will flow in likely commercial quantities.
- Major Activities
  - Geoscience/ Basin studies
  - Land acquisition
  - Pilot wells
- Strategies for Success: Violate the Usual Rules of Oil and Gas
  - Run a Science Experiment
  - Attract other operators
  - Capture acreage even where geo scientists don't suspect sweet spot
  - Select service sector partner based on science/experience, not cost
- Key Metrics to Evaluate
  - \$/acre of land acquired
  - Quantity and distribution of leasehold
  - Reservoir information derived from each drilling dollar

# Stage 2: Optimize It

- What is Happening?
  - Derive the optimal recipe for drilling and fracing wells in this particular play
  - Establish the limits and quality map of the play
- Major Activities
  - Try everything
  - Gain scale & scope
  - Ramp drilling/create hubs
- Strategies for Success: Creative Engineering for Peak Efficiency
  - Integrate diverse data streams and draw correct conclusions
  - Orient externally: collect and share information and scout heavily
  - Choose multiple service sector companies to maximize creativity
- Key Metrics to Evaluate
  - \$/acre paid during consolidation of companies w/ weaker results
  - Change in standard deviation of frac techniques and results
  - Slope of IP evolution

# Stage 3: Industrialize It

- What is Happening?
  - Play is turned from potential into cash flow by massive investment with cookie cutter approach
- Major Activities
  - Large, steady programs
  - Focus on above ground efficiencies
- Strategies for Success: Standardize to Grind Down Unit Costs
  - Coordinate chain of resources and companies flawlessly
  - Ensure ancillary infrastructure such as midstream and transport
  - Apply no-frills approach to service partners & seek volume discount
- Key Metrics to Evaluate
  - Cost of capital and free cash flow at bottom of cycle
  - Spud to market timing efficiency
  - Speed of convergence vs. peers and predictability of well results
  - Sequential unit cost reduction (opex and capex)

# Stage 4: Rethink It

- What is Happening?
  - Rejuvenate the play and manage its operations
- Major Activities
  - Transfer of ownership
  - Choose between three paths
    - Downspace further      Rework and refrac      Expansion
- Strategies for Success: Sweat the Small Stuff... and Bring Imagination
  - Keep it cheap and focus
  - Leverage existing well bores, infrastructure, and field personnel
  - Find new zones and new technology
- Key Metrics for Investors to Evaluate
  - \$/boe attributed to probables and possibles
  - Use of existing wellbores and infrastructure
  - Success rate in finding overlooked sweet spots
  - Change in rate of base decline

# What Does It Take to Win?

- All of these athletes won gold medals in London. Guess the sport.

**100m Sprint**

**Marathon**

**Weightlifting**



- If the London gold medal decathlete had entered all the event finals, he would have placed last in 8<sup>and</sup> in the bottom half of the other two.
- Retraining is difficult (think Michael Jordan in baseball or Lance Armstrong in the NYC marathon).

**Deep excellence comes from thorough-going specialization, but that also shapes the entity in a way that makes it difficult to succeed in a different contest.**

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Life Stage and Value Creation Framework

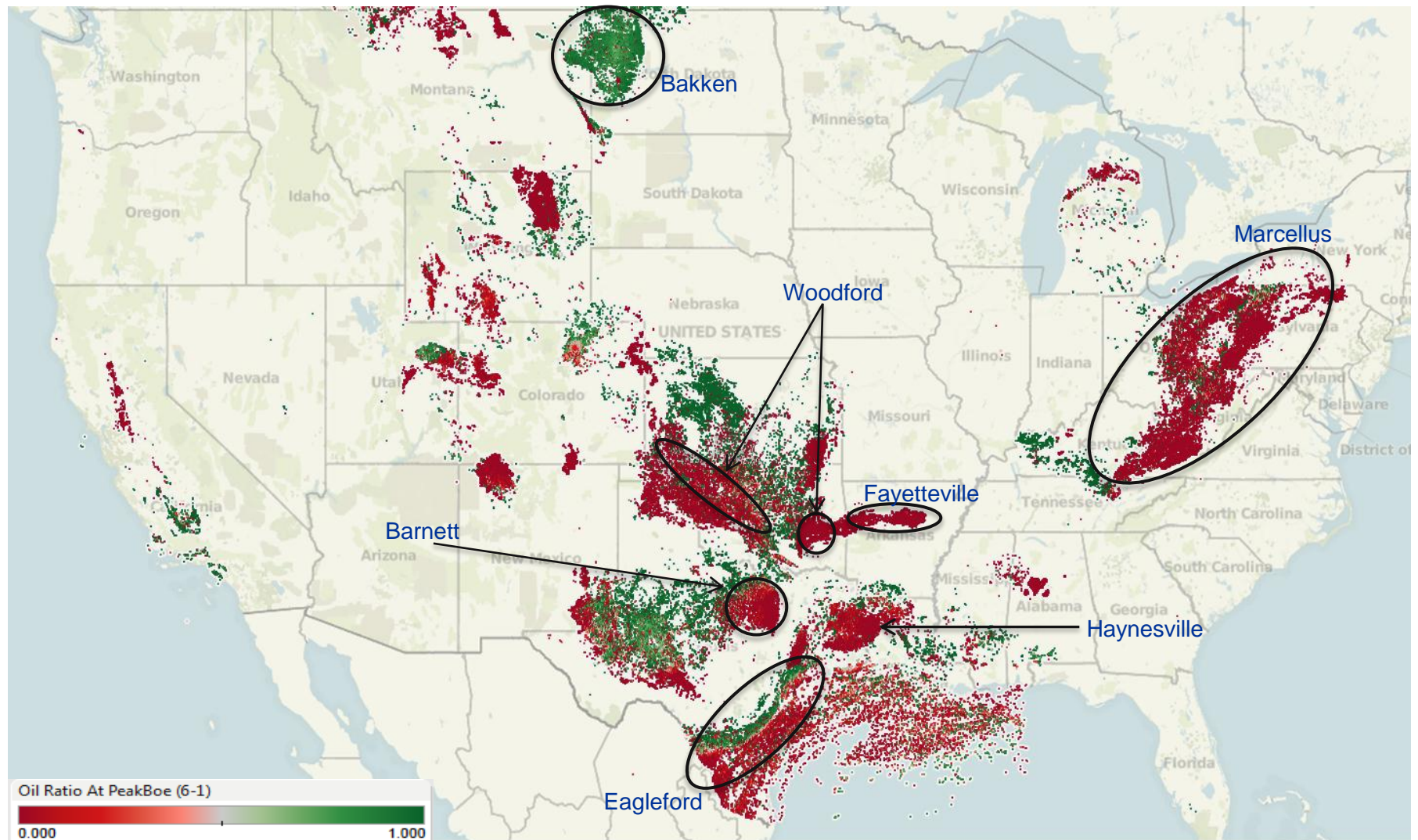
Ingredients of Successful Plays

Skill Sets

**Play Reviews**



# Lower 48 Map of Producing Wells

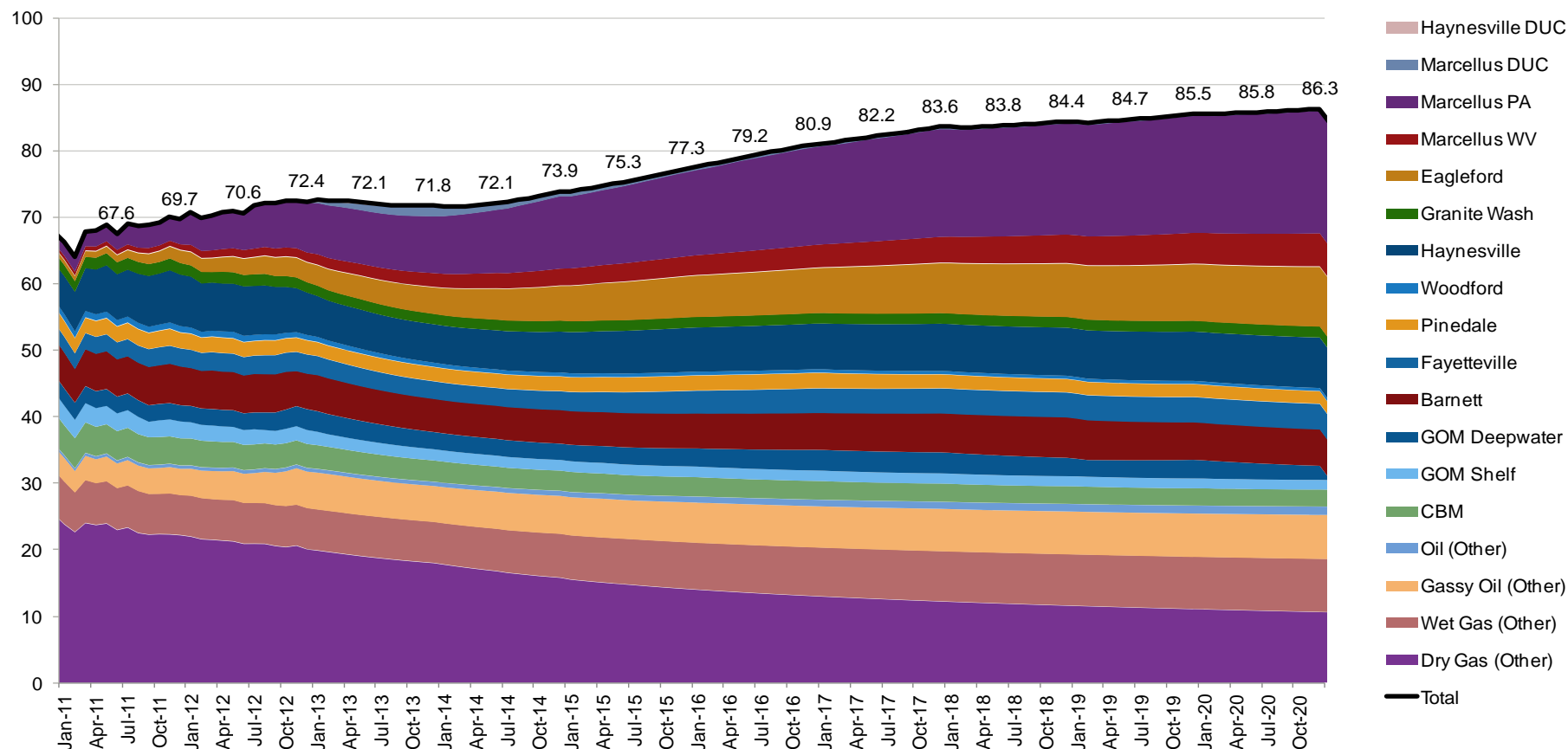


# Lower 48 Shale Gas is Primary Contributor to Growth

- Marcellus production, primarily in Pennsylvania, is projected to be a key driver of growth in domestic natural gas through 2020.

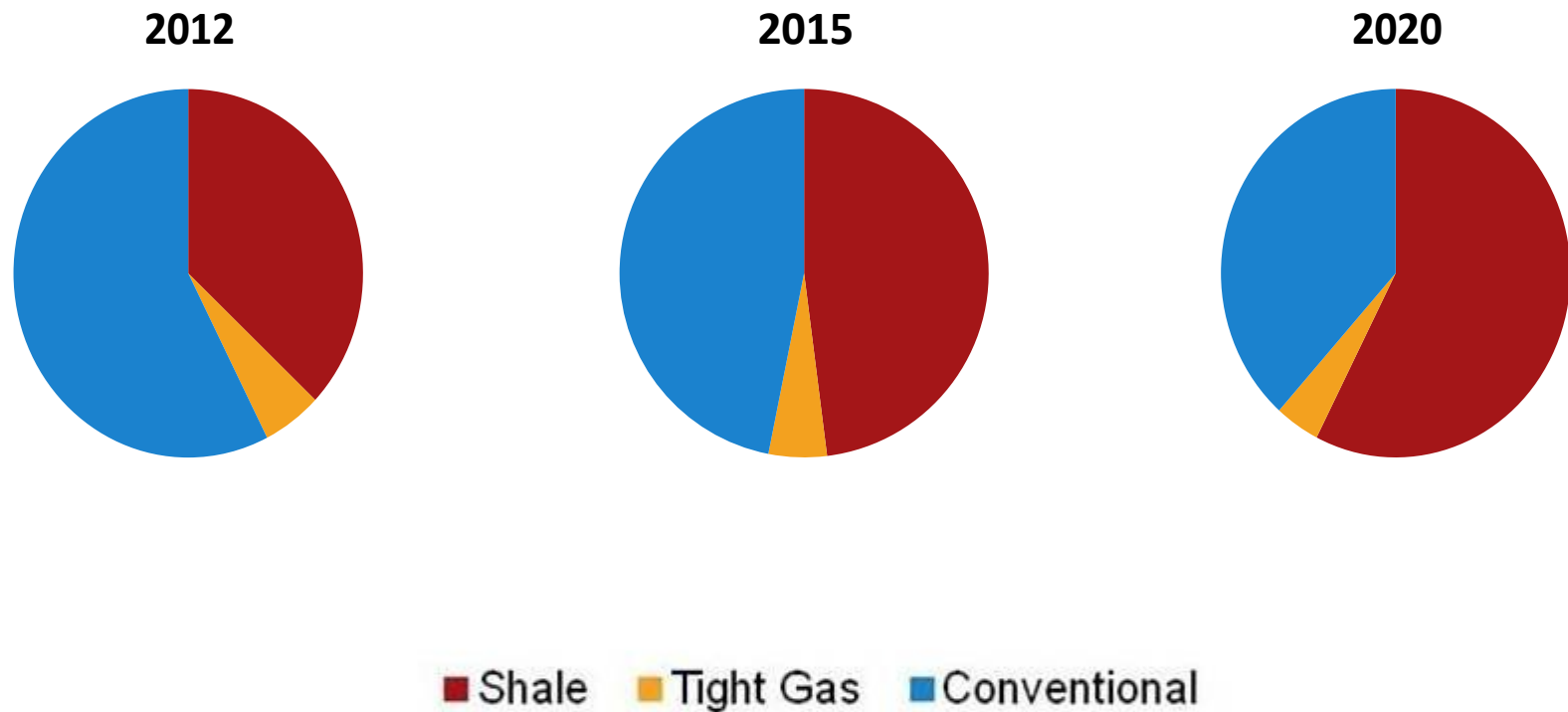
Production  
in bcf/d

## Lwr-48 Gross Natural Gas Production Estimate



# Shales Projected to Grow Market Share Substantially

- By 2020, Shales are projected to source over half of Lower-48 production.



# Haynesville Shale Play



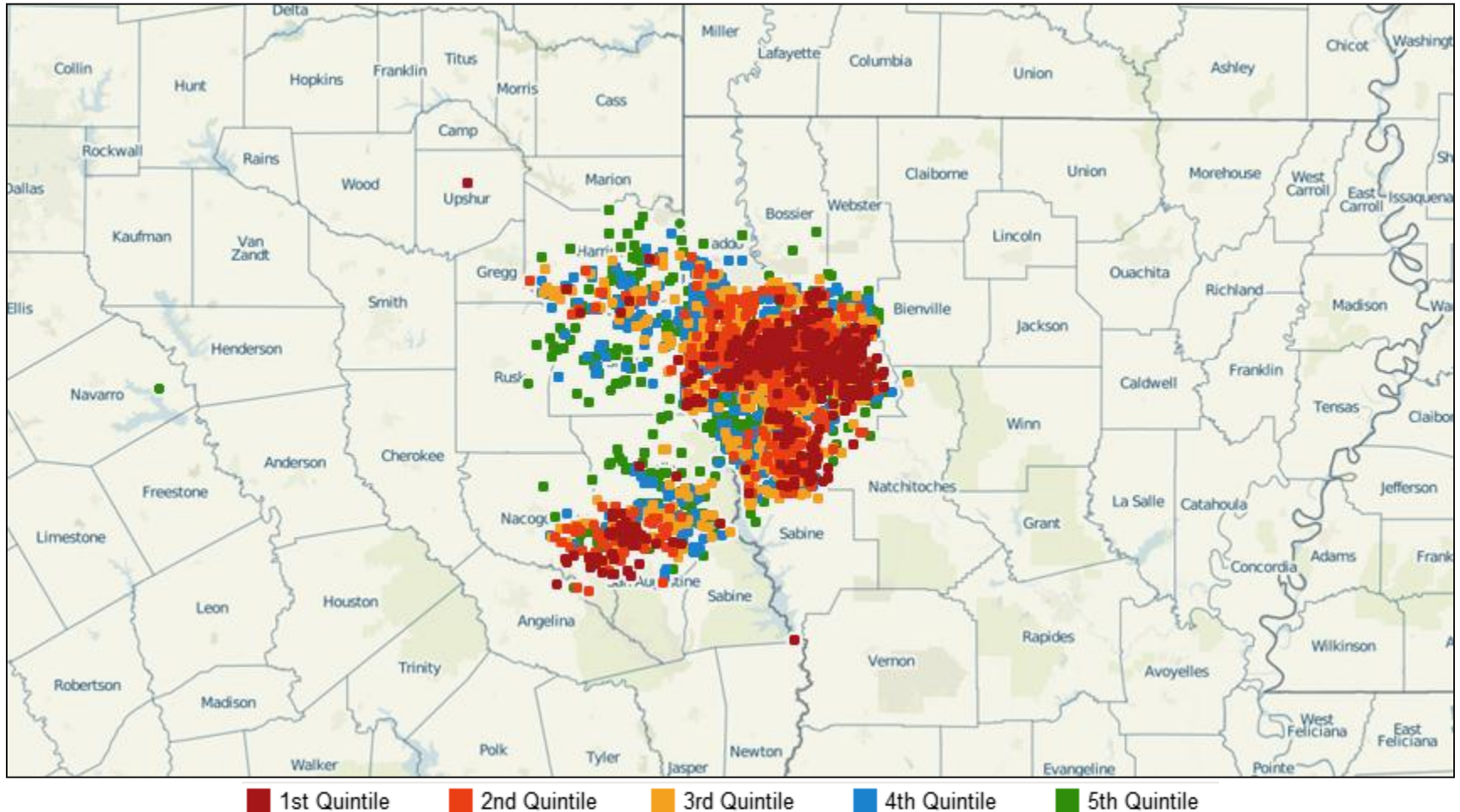
# Haynesville: Key Facts

Life Cycle	Though the Haynesville has a large inventory of wells still to be drilled, low gas prices are not incentivizing operators to return to the play. Thus, though it has quite mature technologically, it may never reach its full potential.
Well Count	By March of 2013, nearly 3,500 wells were producing from the Haynesville.
Competitive Landscape	Over 40 operators have producing assets, though the largest six operators hold nearly 50% of the wells
Oil vs. Gas	Haynesville production is more than 98% gas.
Sweet Spot	Activity in the sweet spot of the play has nearly exhausted the inventory of best acreage. Given the current pricing environment, focused activity is expected to continue.
Productivity Distribution	1 <sup>st</sup> quintile wells are 1.5 times as productive as 2 <sup>nd</sup> quintile wells and 4.3 times more productive than 5 <sup>th</sup> quintile.
Type Curve Trends	Minor improvements in peak production are still observed, while newer vintage wells outperform older wells nearly 7-to-1 after 12 months (2011 vs. 2007).



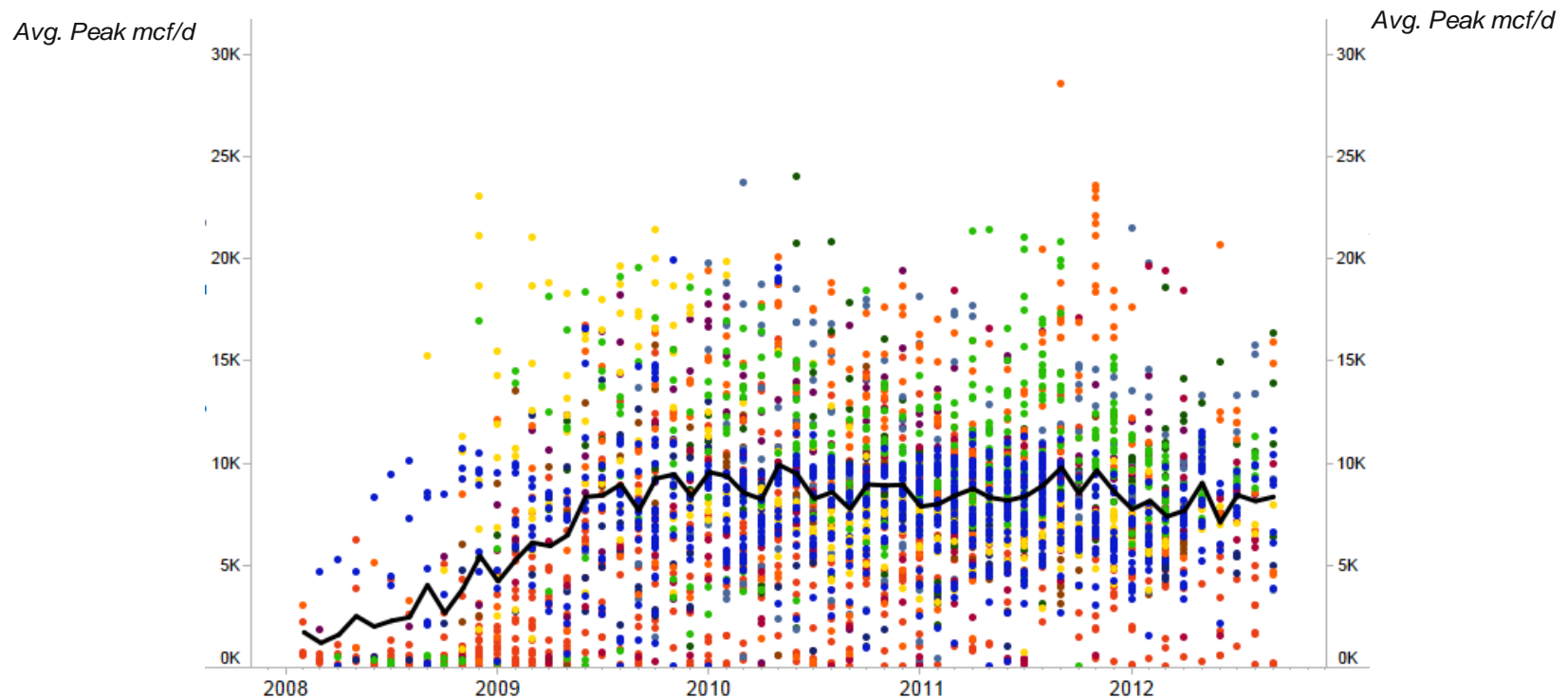
## Highly Concentrated Area of Peak Productivity Centralized Activity

- Most efficient wells are concentrated geographically in a very small area in LA. Rock productivity decreases significantly in a radial manner as operators have delineated the expanses of the play.



# Peak Gas Production Has Hit Plateau

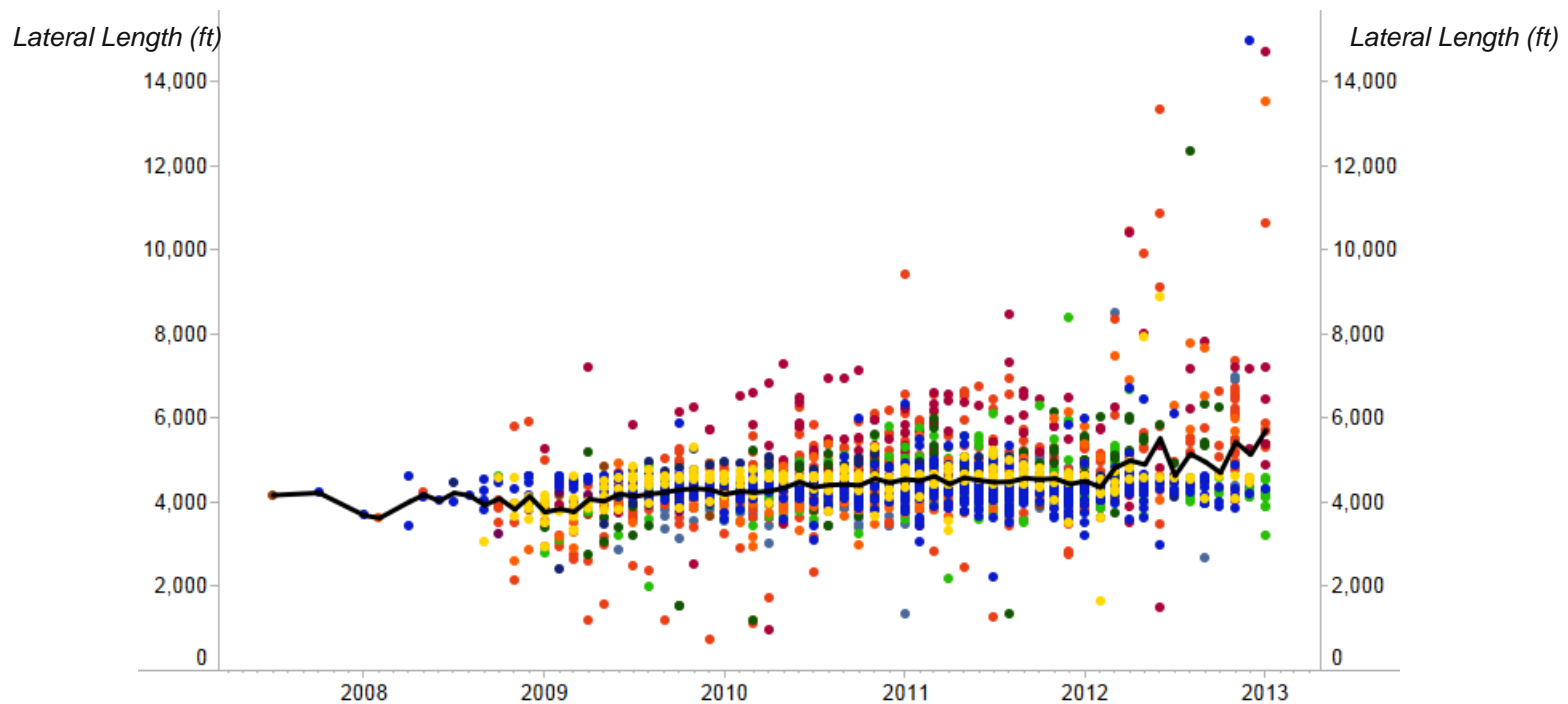
- Productivity in the play is at best stagnant being that it has not improved and operator results are converging on the plays inherent average. Additionally recent trends have shown operators are high-grading within their individual portfolios which further supports a bearish outlook.





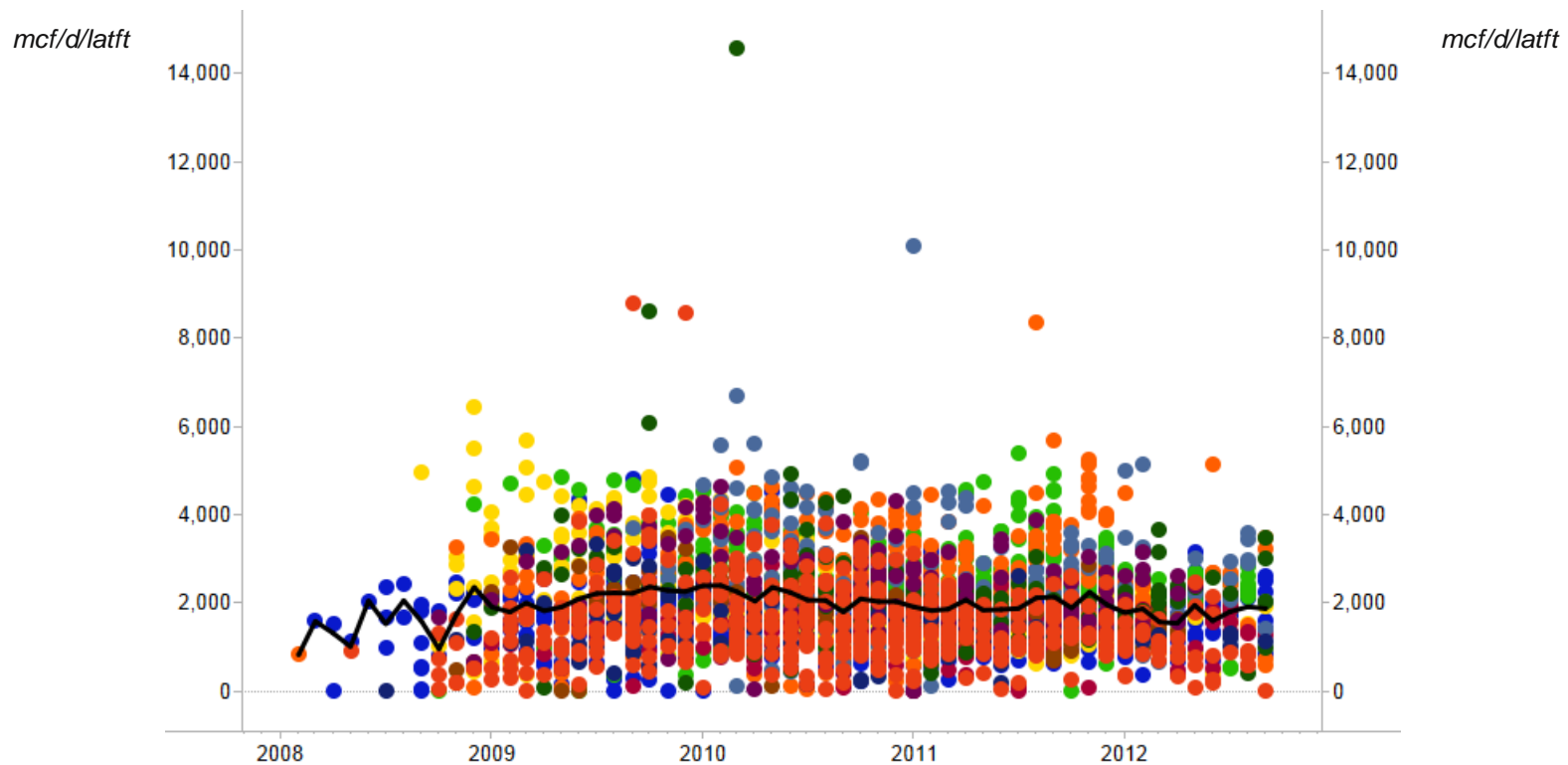
# Lateral Lengths Showing Incremental Gains Only

- Despite operators having determined an optimal lateral length for the play during attractive gas prices. The decline in pricing has seen operators attempt multilaterals as an effort to buoy economic results.



# Well Productivity per Lateral Foot is Highly Predictable

- Resulting from longer laterals and stagnant peak rates, peak productivity has slightly declined. Operators are drilling more lower quintile assets showing possible exhaustion of higher quintile sites.



# Marcellus Shale Play

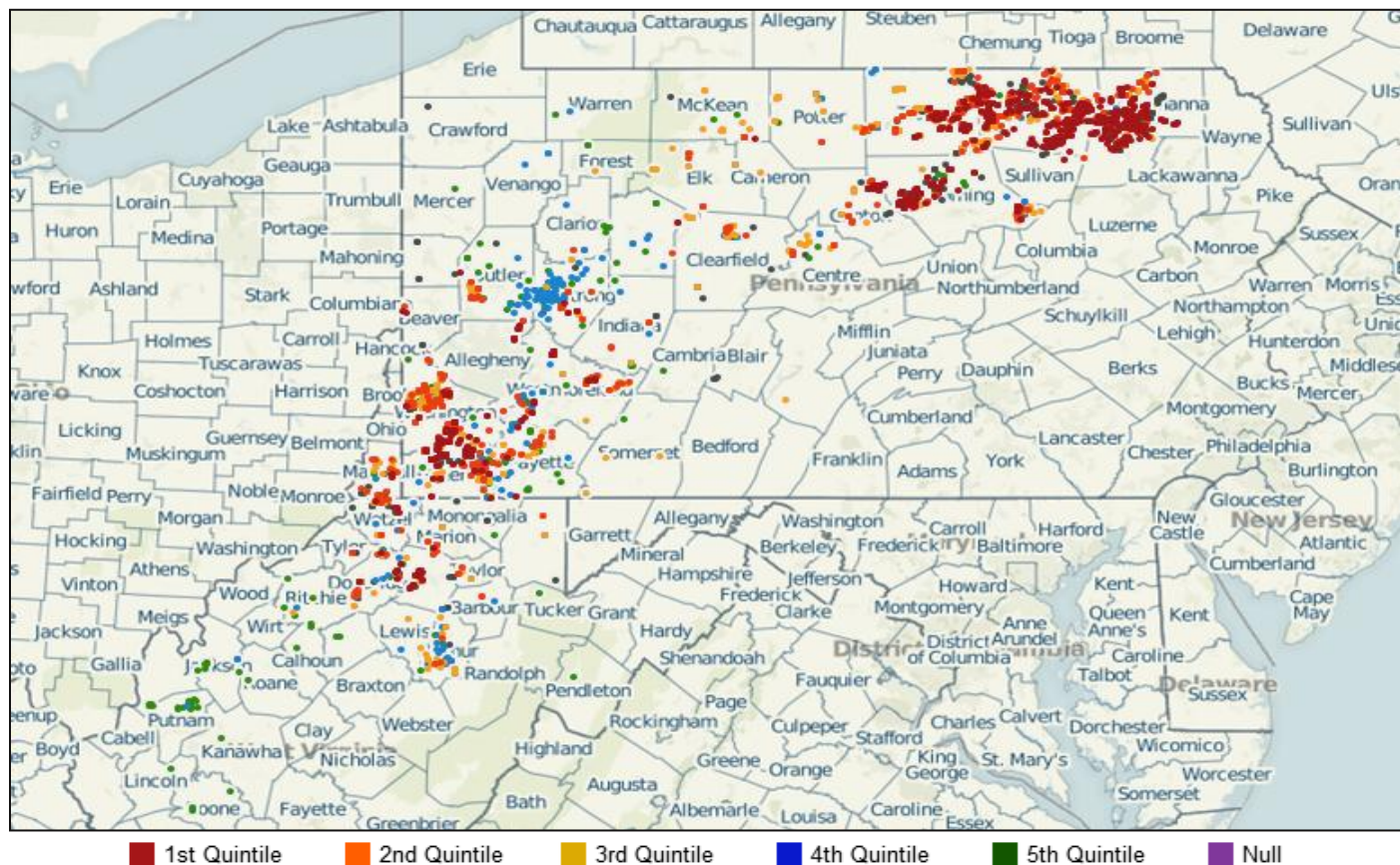


# Marcellus: Play Conclusions

Life Cycle	Developing in two main sub-regions, operators have found their best results in the northeast and southwest extents of Pennsylvania. Though much of the geographical footprint remains undeveloped, the core areas are clearly seeing standardized operations.
Well Count	The latest data, capturing the majority of the play through the end of 2012, accounted for over 5,600 producing wells.
Competitive Landscape	130 operators generate volumes from the Marcellus, though only seven operators have more than 200 wells
Oil vs. Gas	Though some operators have found substantial NGL volumes, Marcellus production is more than 96% gas at the wellhead
Sweet Spot	Operators have found the most economic production in the northeast and southwest portions of Pennsylvania.
Productivity Distribution	1 <sup>st</sup> quintile wells are 2 times as productive as 2 <sup>nd</sup> quintile wells and 8 times more productive than 5 <sup>th</sup> quintile.
Type Curve Trends	Type curves have shown no meaningful improvements in the past 3 years.

# Marcellus: Map of Peak/Latft Gas Quintiles

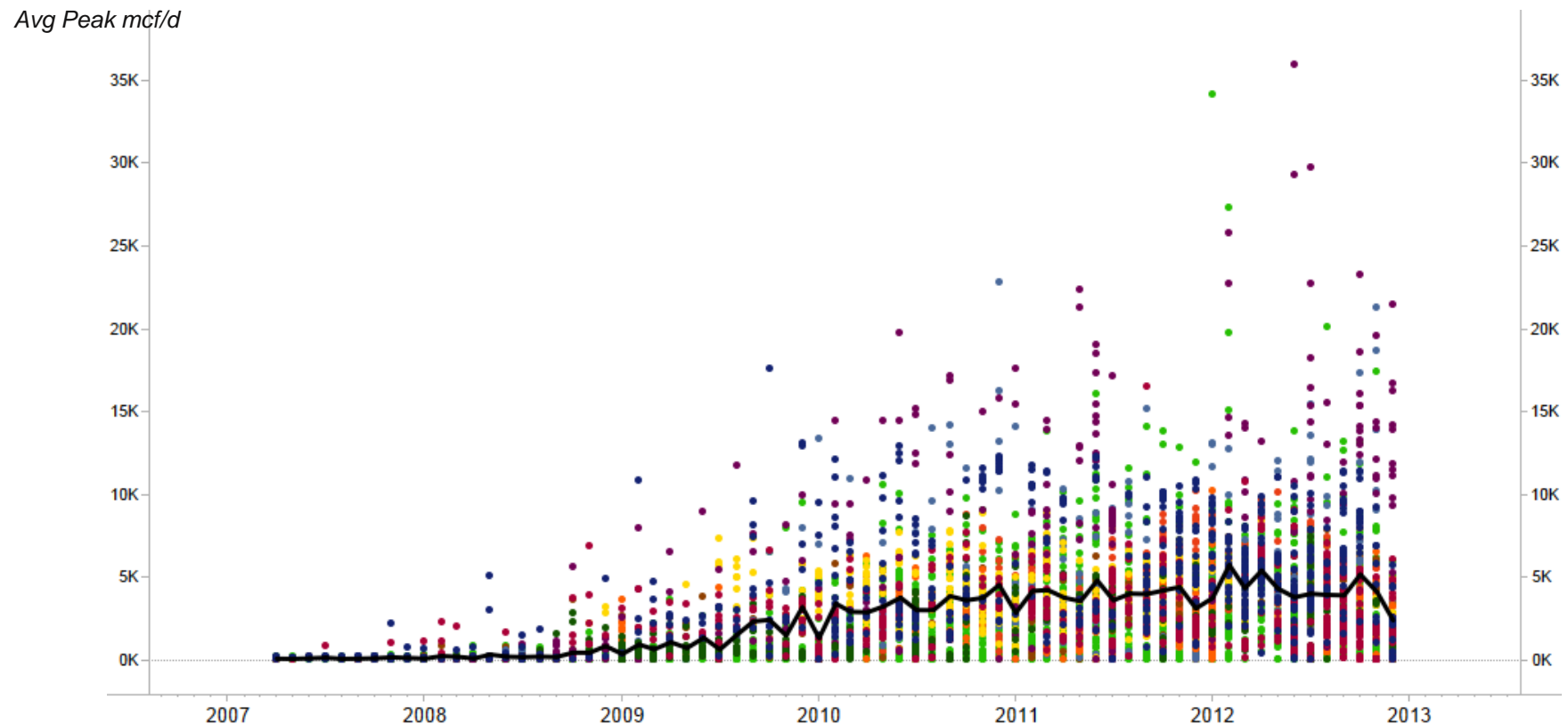
- Despite the large areal extent of the play, high quality wells are concentrated in the northeast and southwest regions of the play. Operators continue to delineate the most productive areas of the play, leaving the middle portion of Pennsylvania largely undeveloped.





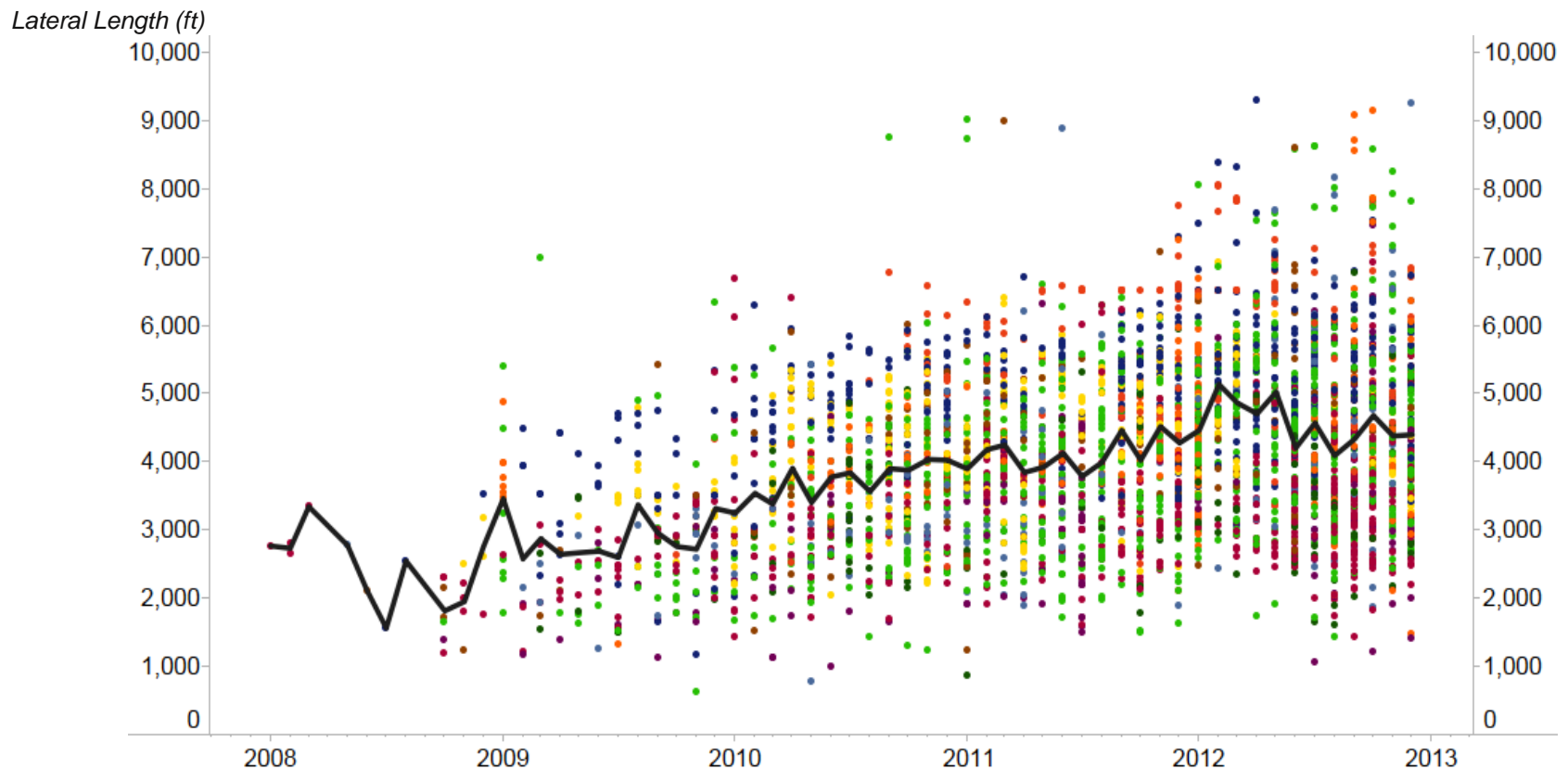
# Marcellus: Peak Gas

- Peak rates have shown incredible consistency since early 2012, though the variance in peaks has increased. Omitting the “super wells”, mainly drilled by Cabot and EQT, the play’s average peak has slightly declined.



# Marcellus: Lateral Length

- Though the average lateral length in the play is holding steady, there is still a large variance throughout the play. In northeastern Pennsylvania, lateral lengths average approximately 1,000 feet longer than in the southwestern portion of the play.

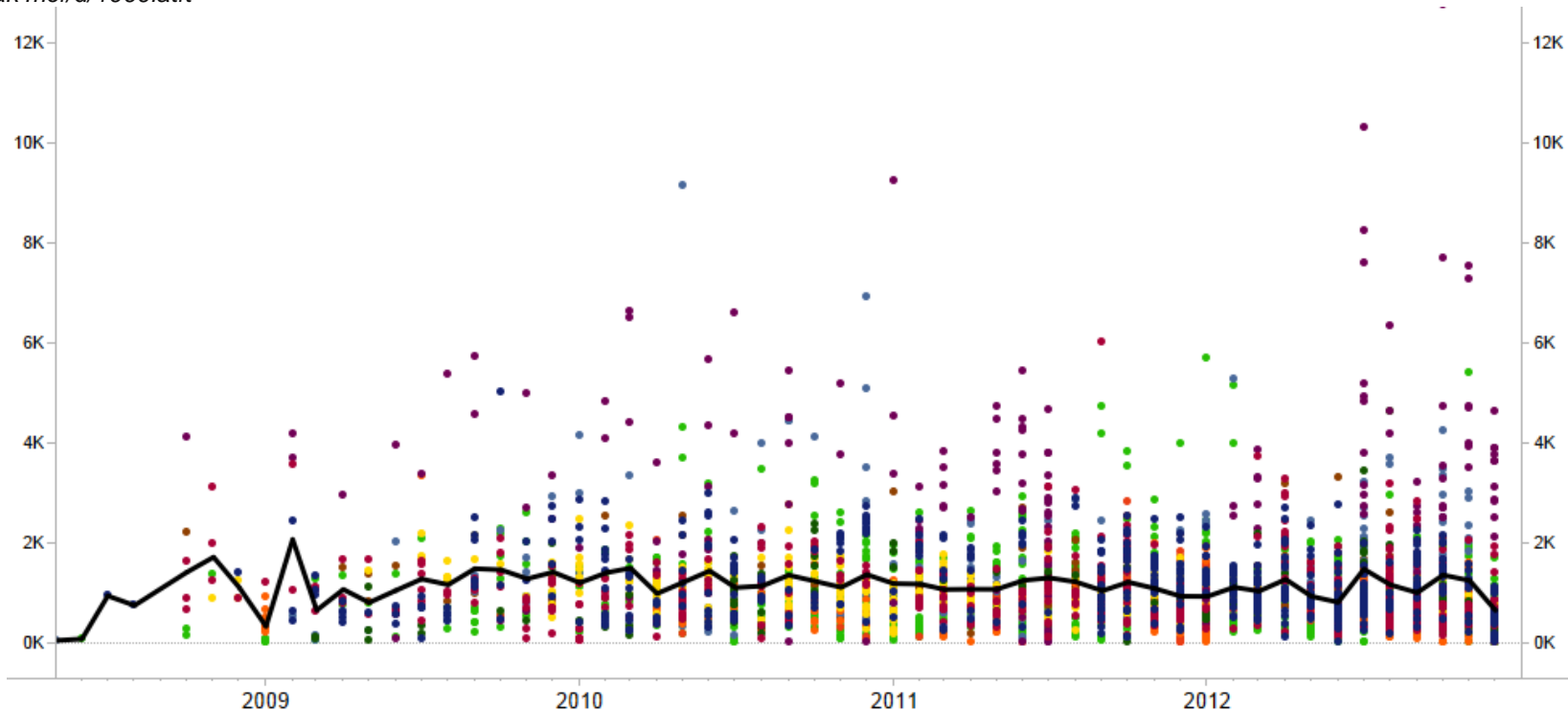




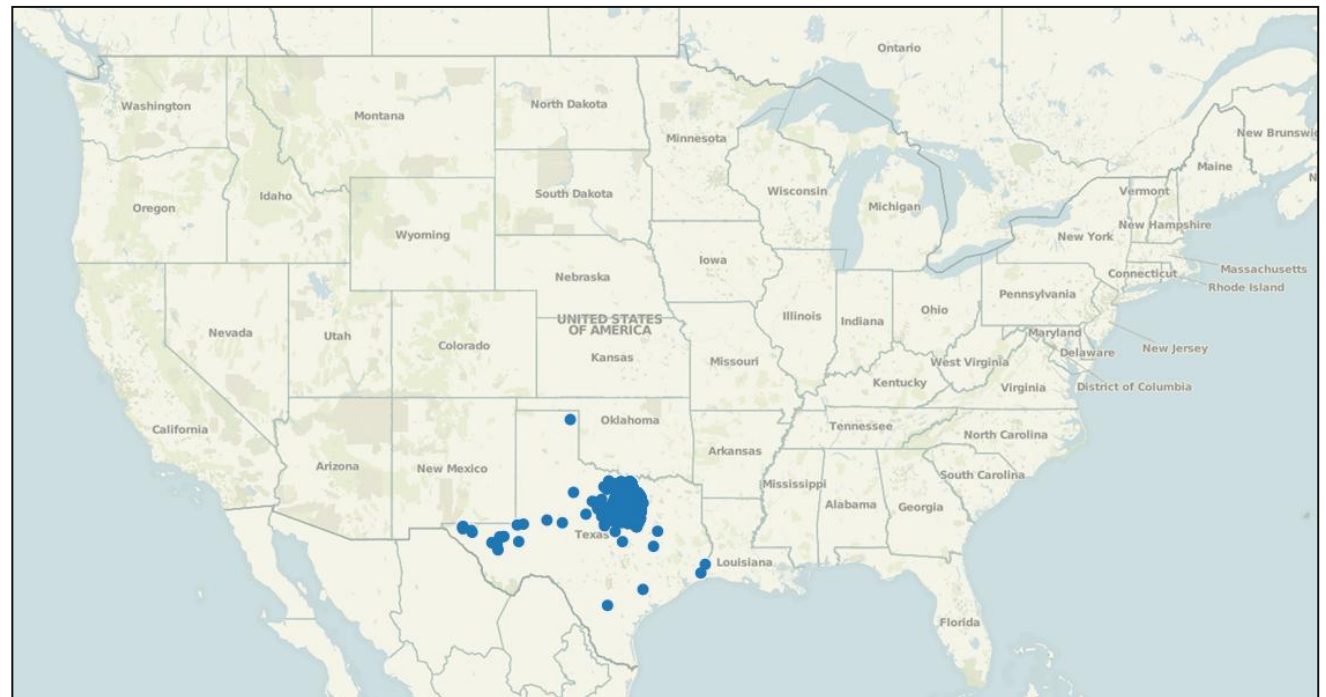
# Marcellus: Peak/Latft Gas

- The natural result of peak production rates and lateral lengths both holding steady is that peak per lateral foot has been flat as well. Operators have largely delineated and held quality acreage and are content to develop those areas and hope for higher gas prices to justify more exploration.

Avg Peak mcf/d/1000latft



# Barnett Shale Play

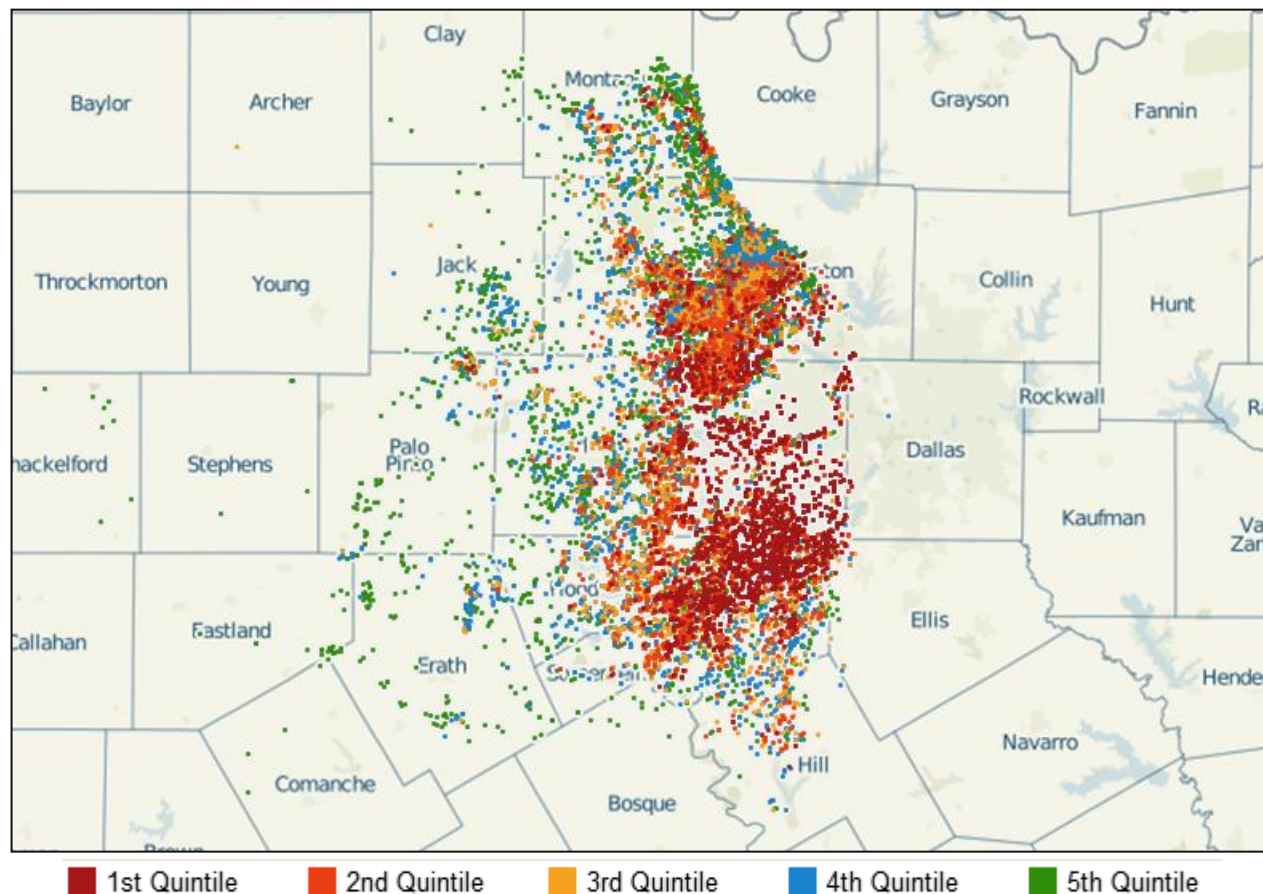


# Barnett: Key Facts

Life Cycle	The Barnett is well into the optimization phase, and may be experiencing some sweet spot exhaustion. Liquids production in the northern portion counties have breathed new life into the play.
Well Count	Since 2001, over 17,000 wells have begun production in the play.
Competitive Landscape	Since 2008, over 130 operators have drilled at least one active well. However, of the 9,000 wells drilled since 2008, Chesapeake, Devon, EOG, and ExxonMobil combine to account for 6,000 of them.
Oil vs. Gas	Over 91% of the wells in the Barnett produce dry gas (wellhead volumes >90% gas at 6-1 conversion). However, in the northern reaches of the play, liquids production has been increasing.
Sweet Spot	The sweet spot in parts of Wise, Johnson, and Tarrant counties have seen the most activity, though activity in all three has been decreasing from the peak in 2008.
Productivity Distribution	1 <sup>st</sup> quintile wells in the Barnett are nearly twice as productive as 2 <sup>nd</sup> quintile wells, and are 8 times as productive as 5 <sup>th</sup> quintile wells.
Type Curve Trends	2012 was the first year the Barnett type curves did not improve.

# Core Located on Eastern Edge of Play, With Productivity Delineations Clearly Visible to the West

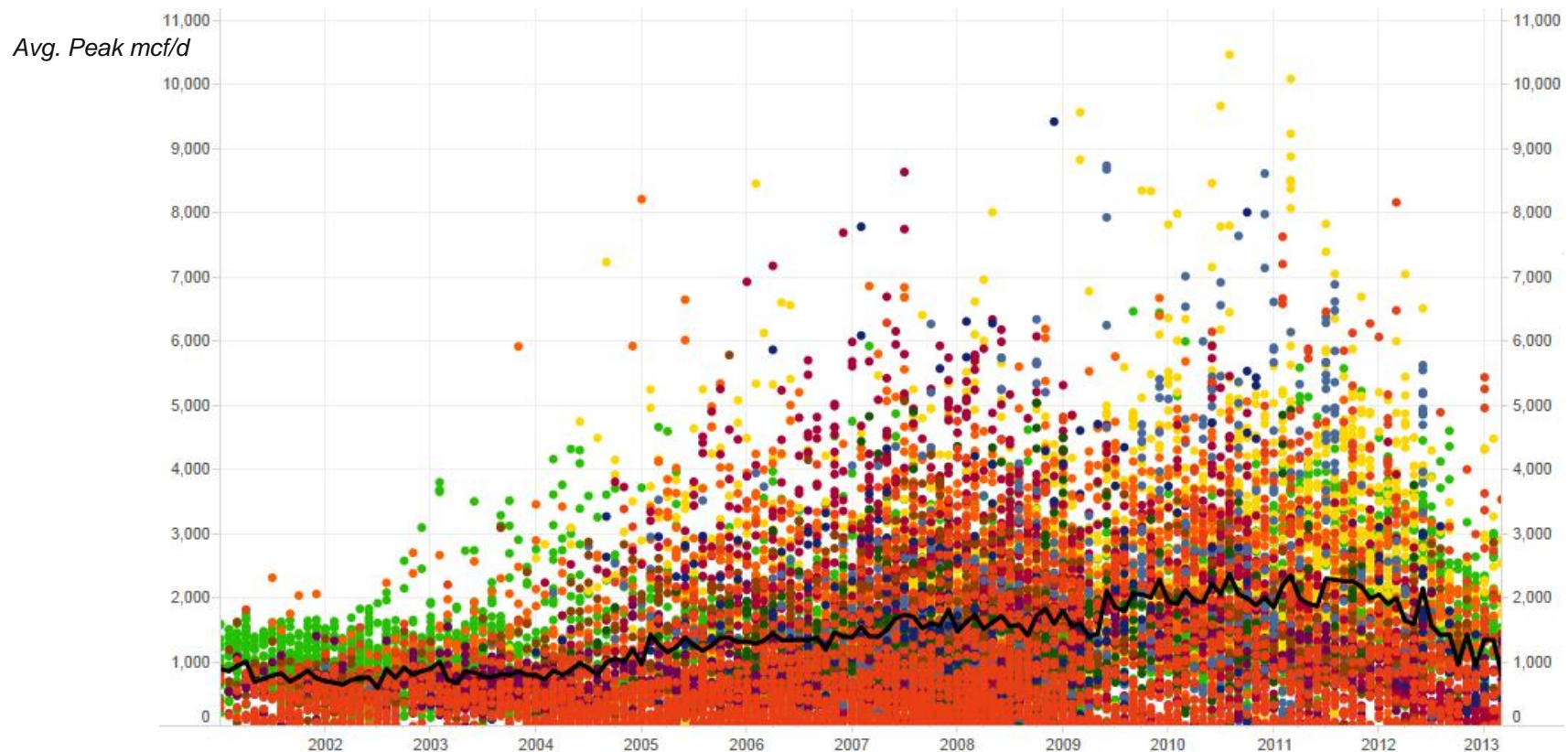
- As the oldest unconventional play in the US, the Barnett has seen over 18,000 wells produce volumes. Though overall production has grown, an exhaustion of best drill sites and a reduction in activity point to a possible decline in production.





# Peak Production Rates Still Holding Steady

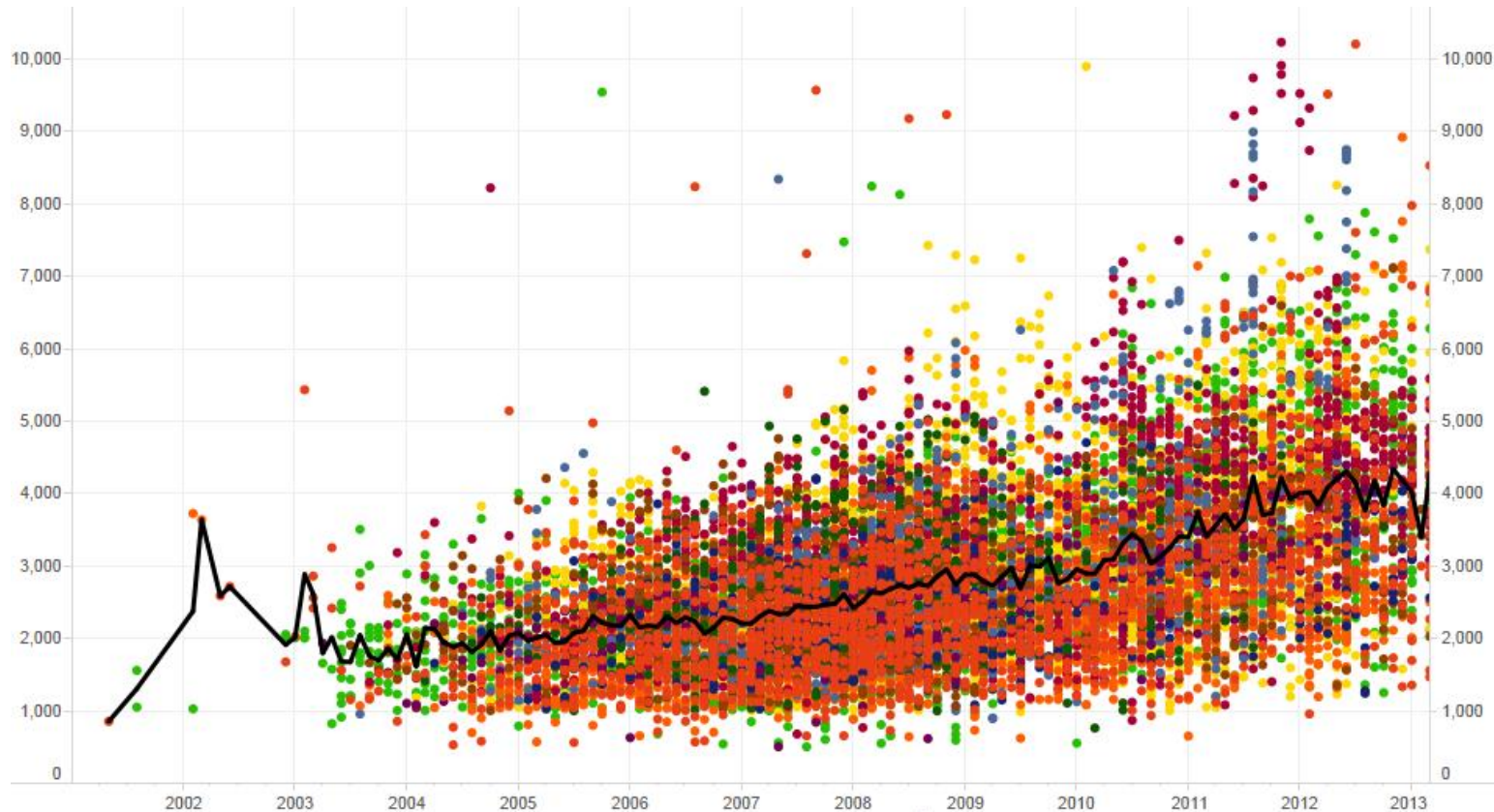
- As operators are unable to drill top producing wells, overall gas productivity has experienced a significant decline in recent years.



# Lateral Lengths Continue to Grow, Despite Play's Age

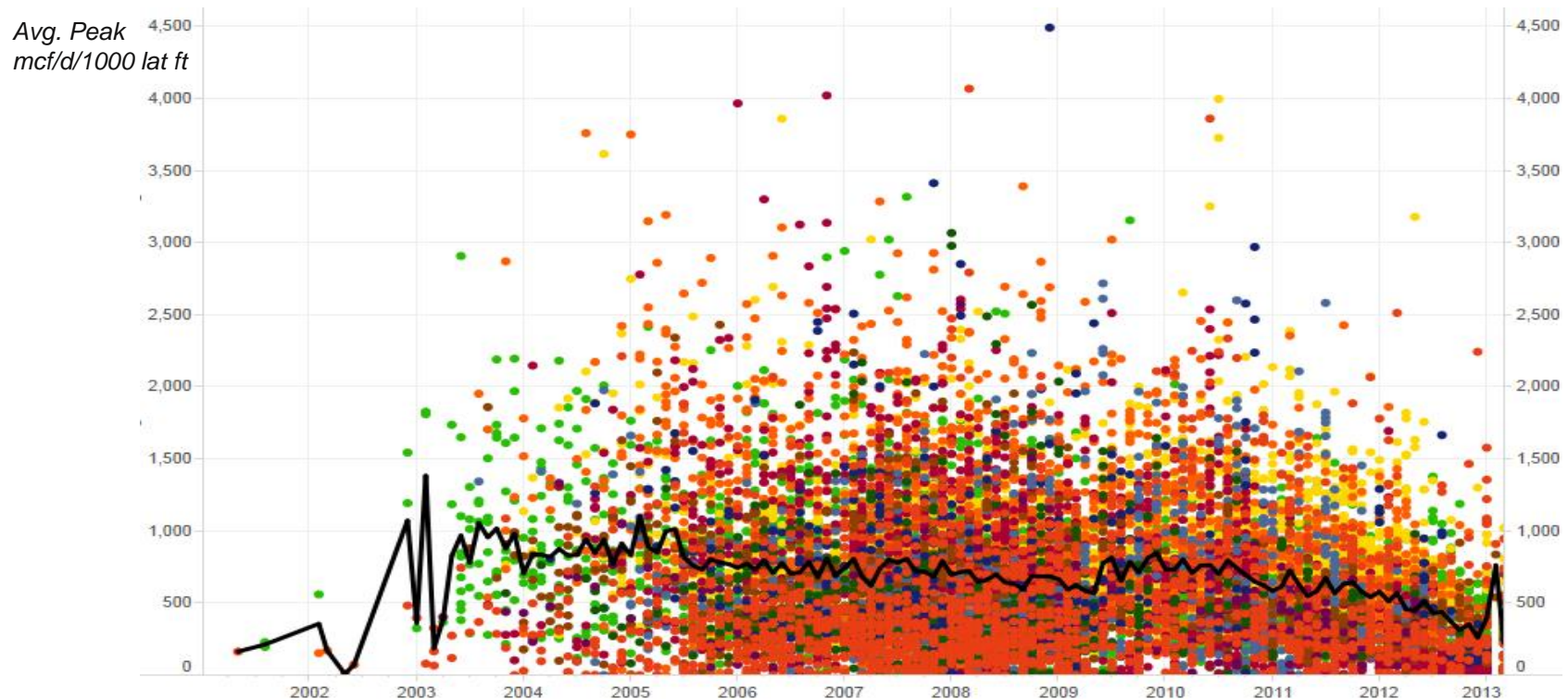
- Lateral lengths in the play have been trending upwards, as operators seek to generate more production per well bore by drilling larger wells. The current average is nearly 4,000 feet, though some operators have clearly experimented with multi-laterals

*Ft*



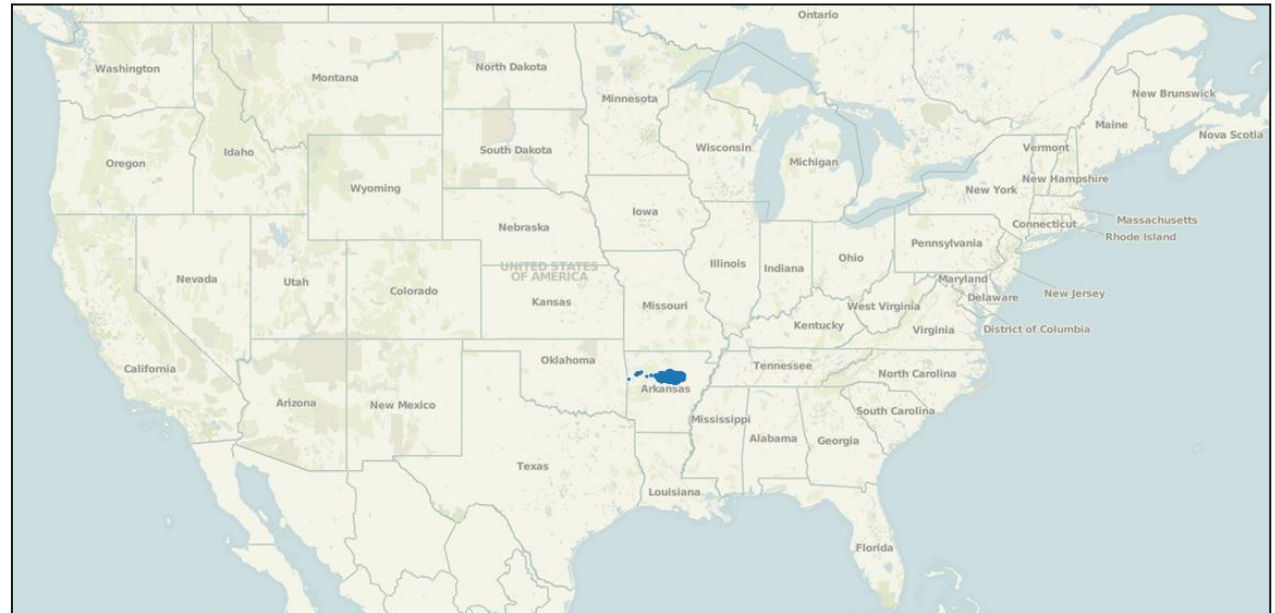
# Production per Lateral Foot Falling, Partly Driven by Longer Lateral Lengths

- As operators drill longer laterals with lower peak gas rates, the compounding effect has eroded overall productivity in the play. As sweet-spot exhaustion becomes more of an issue in the play, operators will have to drill a larger number of wells to compensate for lower productivity.





# Fayetteville Shale Play



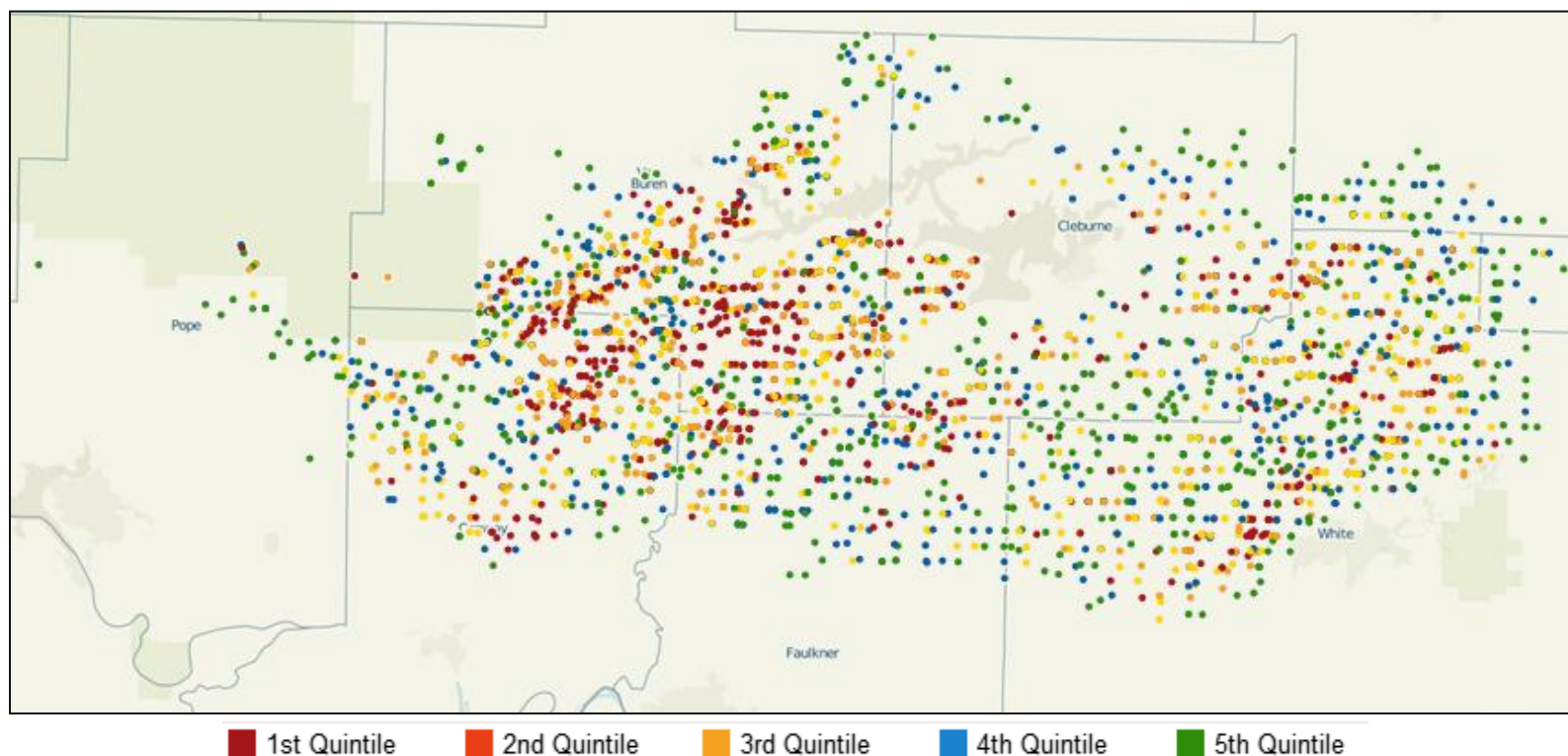


# Fayetteville: Key Facts

Life Cycle	With the play dominated by one operator, Southwestern, standardized operations have been seen for several years. However, Southwestern appears to have recently ceased acreage holding activities and is now focusing on infill drilling
Well Count	5,500 wells currently generate production in the Fayetteville
Competitive Landscape	Southwestern rules the play with nearly 60% of producing assets.
Oil vs. Gas	No liquids are found in the Fayetteville
Sweet Spot	Several areas of highly productive rock have been identified, though no core sweet spot has been determined.
Productivity Distribution	1 <sup>st</sup> quintile wells are 1.5 times more productive than 2 <sup>nd</sup> quintile wells and five times as productive as 5 <sup>th</sup> quintile.
Type Curve Trends	Type curves have shown no significant improvements since 2010, though if Southwestern's acreage holding is complete, high-grading is expected.

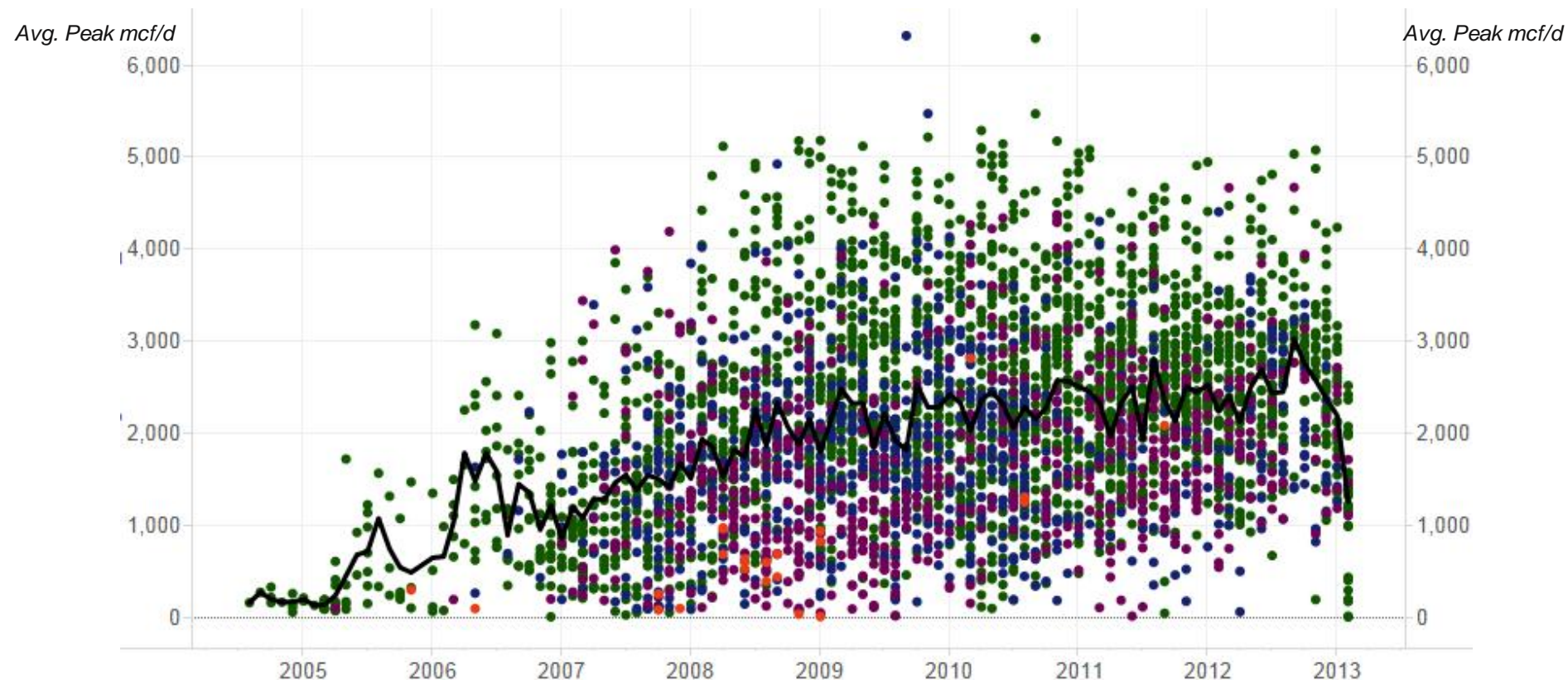
# Fayetteville: Map of Peak/Latft Gas Quintiles

- Southwestern is the dominant asset holder in this play, having actively developed acreage since 2006. As acreage holding activities have largely subsided, Southwestern has been completing infill drilling in their most productive areas.



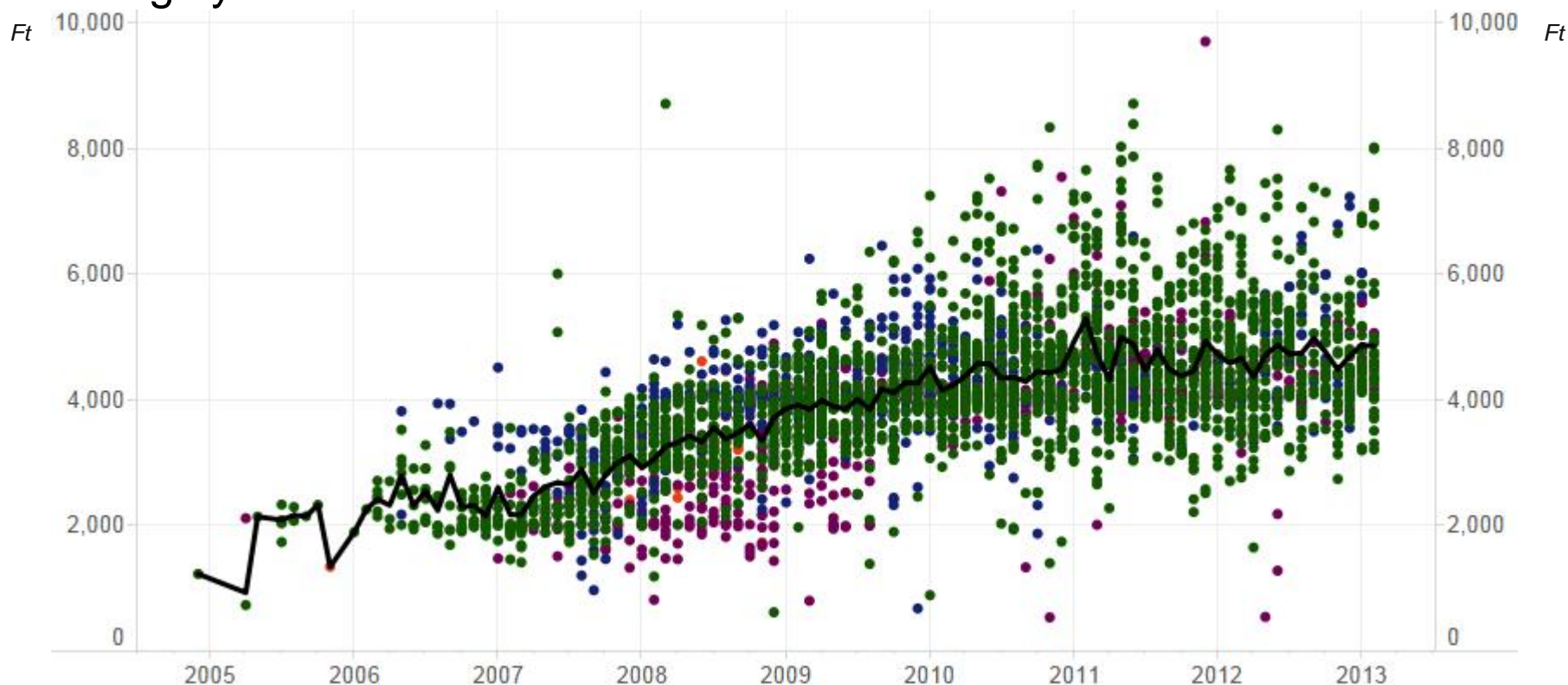
# Fayetteville: Peak Gas

- Operators have shown small but steady improvements in peak gas rates. Additionally, the variance in peak rate is decreasing, implying operators have been at least modestly successful in high-grading efforts.



# Fayetteville: Lateral Length

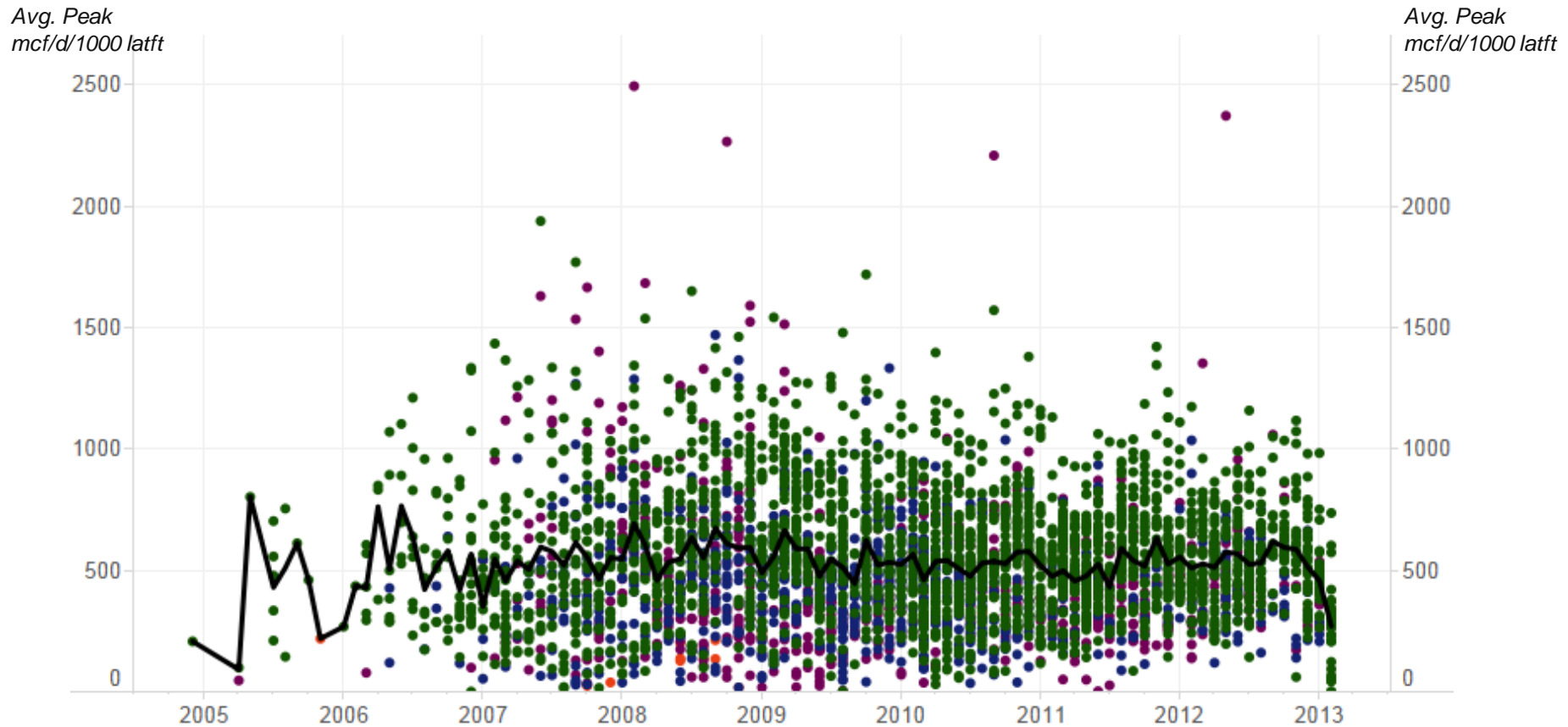
- Given regulatory hurdles to drill across section lines (one square mile), lateral lengths are likely to remain below 5,000'. Operators have pushed that limit and have shown minimal deviations, indicating that under the current regulations, the technical limits of the play have largely been realized.





# Fayetteville: Peak/Latft Gas

- Peak productivity has remained predictable, and in much the same as peak rates and lateral lengths, the variability in results has decreased. As Southwestern continues a methodological development of the play, results will maintain their predictability.



# Pinedale-Jonah Play

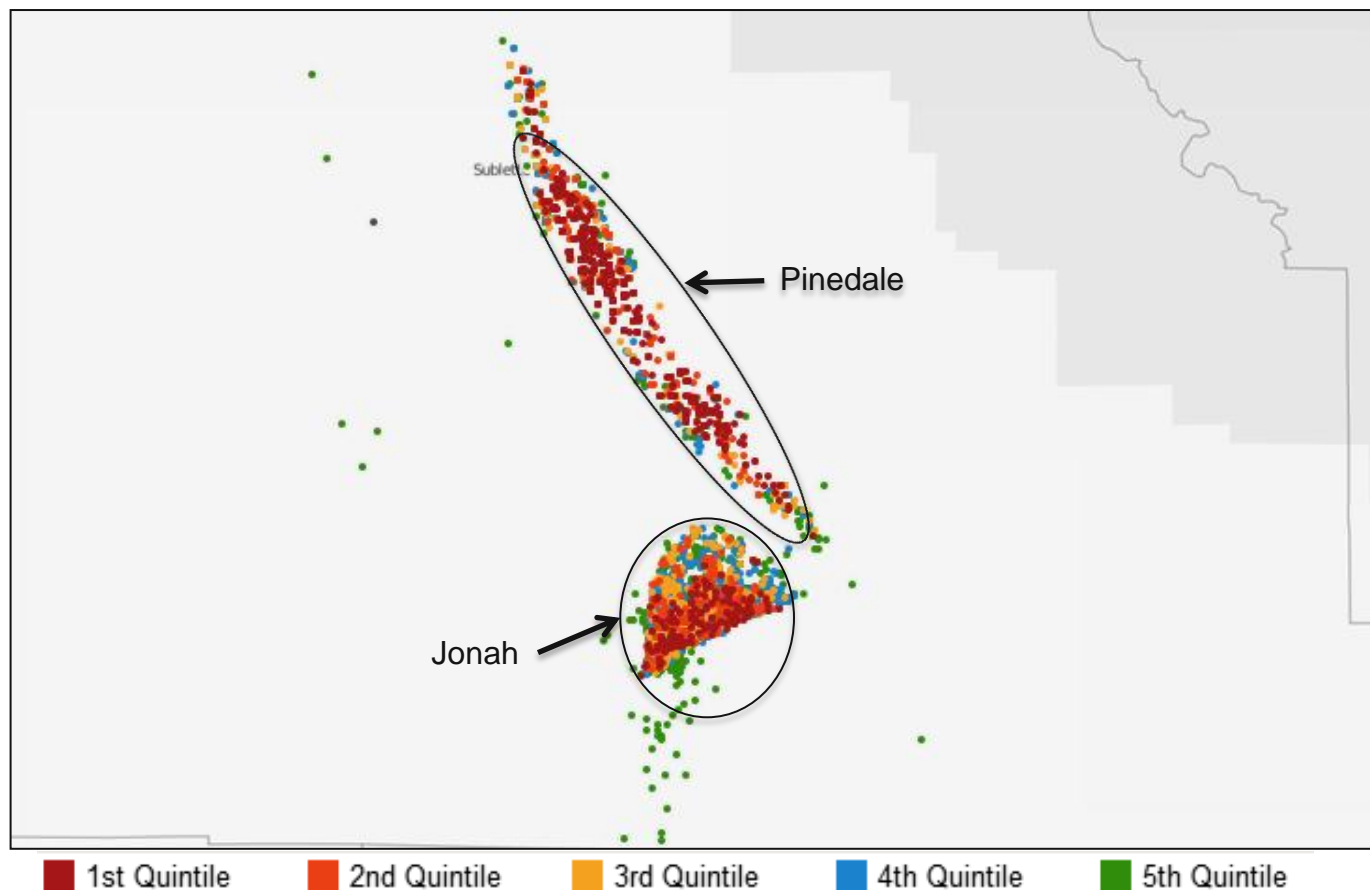


# Pinedale-Jonah: Key Facts

Life Cycle	The Pinedale has shown steady cumulative growth from 2001. This play is in the re-invent stage of life as operators are testing the limits of infill activity.
Well Count	3900 wells are currently producing from the Pinedale-Jonah.
Competitive Landscape	Ultra Petroleum rules the competitive landscape with 40% of 1 <sup>st</sup> quintile wells with premium acreage in the northern part of the play.
Oil vs. Gas	There is essentially no liquid production from the Pinedale-Jonah.
Sweet Spot	The northern part of the play encompassing a 90 square mile area is the clear sweet spot in this play with almost $\frac{3}{4}$ of the 1 <sup>st</sup> quintile wells.
Productivity Distribution	1 <sup>st</sup> quintile wells are two times more productive than 3 <sup>rd</sup> quintile and 5 times as productive as 5 <sup>th</sup> quintile.
Type Curve Trends	Decline trends have shown slight increases over the last few years as operators test the technological limits of infill drilling.

# Pinedale-Jonah: Map of Peak/Boe Gas Quintiles

- The Pinedale field dominates this play with almost 75% of the 1<sup>st</sup> quintile wells. Ultra Petroleum operates the majority of the Pinedale wells, while Encana is the dominant operator in the Jonah.





# Pinedale-Jonah: Peak Gas

- As the play has been experiencing infill drilling, peak rates have slightly declined due to communication and interference between wells. This, combined with low gas prices, has led to a significant reduction in activity in the play.

