SHALE PLAYS
What Works & Where

Wright & Company, Inc.
Petroleum Consultants

6th Annual
DEVELOPING UNCONVENTIONALS
DUG EAST

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Wright & Company, Inc.

Petroleum Consultants

Our Mission

- **Wright & Company, Inc. 's mission is to be client driven with the most reliable, responsive and cost effective professional services possible within the oil and gas industry. This mission is achieved with personal service, understanding, sound judgment and credibility.**

Experience

- **Founded in 1988 by D. Randall Wright, P.E.**
- **With over 130 years of combined experience with major integrated and independent oil and gas companies, major financial institutions and various consulting firms, our engineers and geologists offer sound judgment, experience and dedication**
- **Clients include major and independent exploration and production companies, investment and commercial banks, law firms, individuals and other consulting firms for specific expertise.**

Services

- **Property Evaluations:** Evaluations of developed and undeveloped properties, both domestic and abroad, including facilities and development plans
- **Audits/Reasonableness Reviews:** Unbiased audits and opinions on both in-house and third party estimates of reserves and economics
- **Reservoir Analysis:** Formation evaluations, reservoir simulations, enhanced recoveries, work-overs, well testing, log analysis, operations and completion optimization
- **Acquisition and Divestiture:** Representation of sell-side, buy-side, joint venture opportunities and financial investments
- **Reserves Estimation:** Volumetric calculations, history match and performance, forecasting future production and cash flow

Extensive Shale Expertise

- **Marcellus/Devonian**
- **Utica/Point Pleasant**
- **New Albany**
- **Haynesville-Bossier**
- **Huron**
- **Mississippian Line**
- **Eagle Ford**
- **Antrim**
- **Niobrara**
- **Chattanooga**
- **Permian Basin**
- **Marble Falls**

Unconventional Resource Plays

- **Coal Bed Methane**
- **Tight Gas Sands**
- **Vertical and Horizontal Drilling**
- **Anadarko Basin (Horizontal) – Granite Wash**

International Representation

- **Representation of various companies throughout the world in due diligence, reserves and economic analysis for investment opportunities in emerging US shale plays including Marcellus, Eagle Ford and Niobrara**

Mid-Stream

- **Evaluations of development plans, Estimated Ultimate Recovery determination, estimating pipeline volumes and future production rates and anticipated sales volumes**

Fair Market Value

- **Fairness opinions, negotiations, borrowing base determination for bank financing**

ACTIVITY – MANY EVALUATIONS

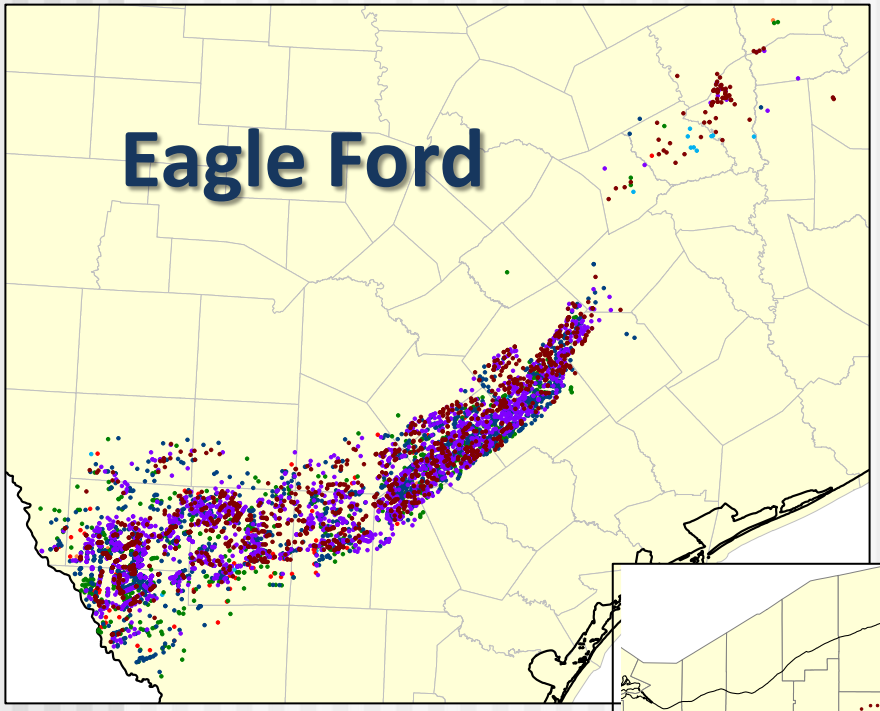
- Organic Shales
  - More than 40,000 wells drilled, competed, and producing
  - May be hundreds of thousands more to go

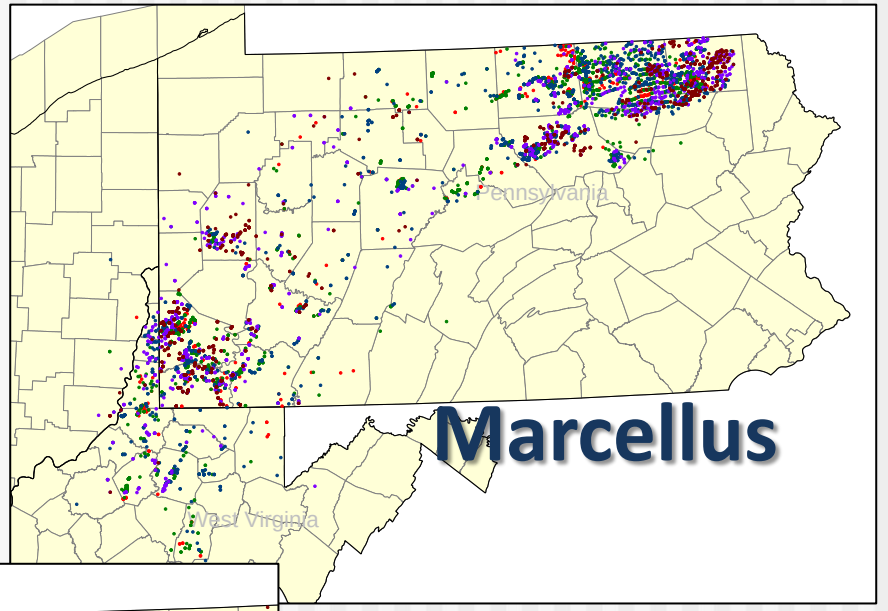
- Number of horizontal wells through early 2014
  - Barnett: > 16,000 – where it all started over 15 years ago
  - Marcellus: > 7,000 – 2008 started rapid growth
  - Eagle Ford: > 6,500 – 2010 – Number of PUD wells doubled in 2013
  - Utica: > 700 – 2011

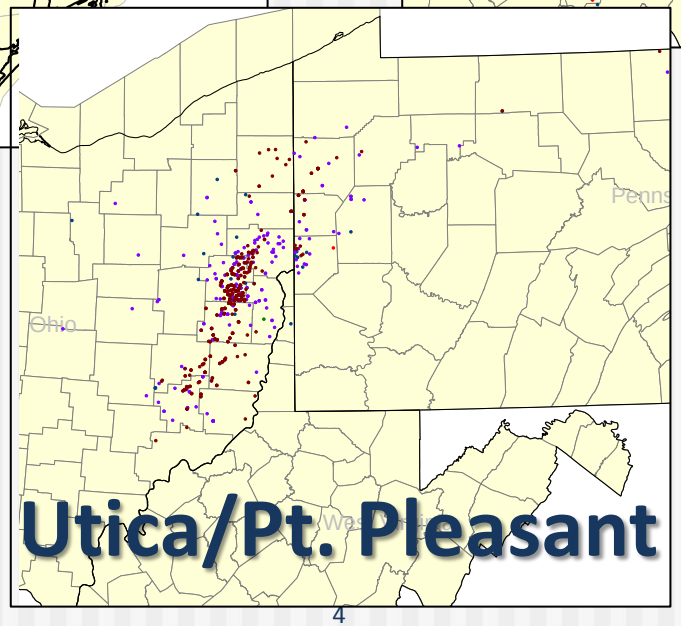
- At least 30,000 – Most in less than 10 years

WIDESPREAD COVERAGE OF SHALE PLAYS

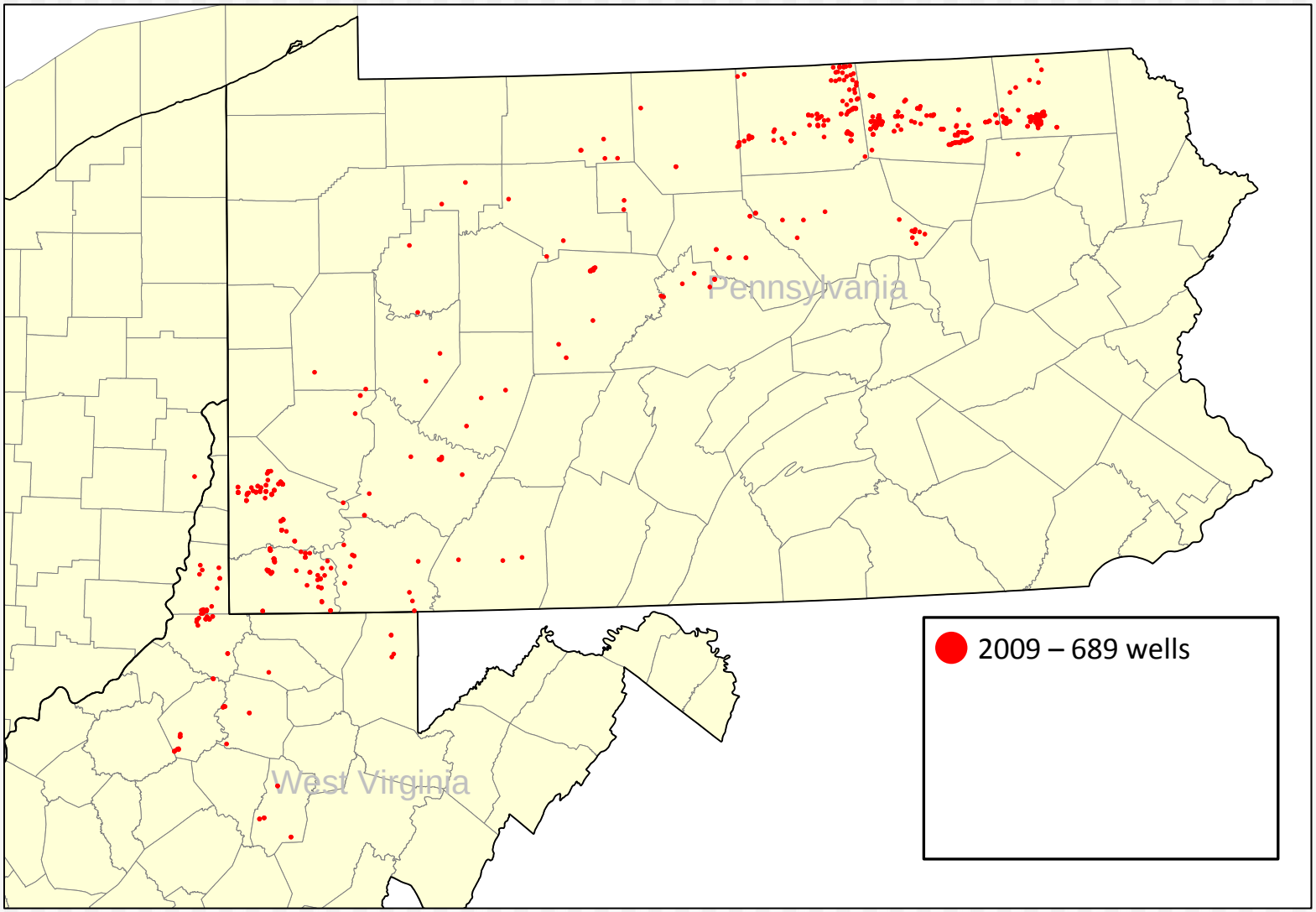
PERFORMANCE DATA







MARCELLUS HORIZONTAL WELLS SPUD



Source: Drilling Information May 2014

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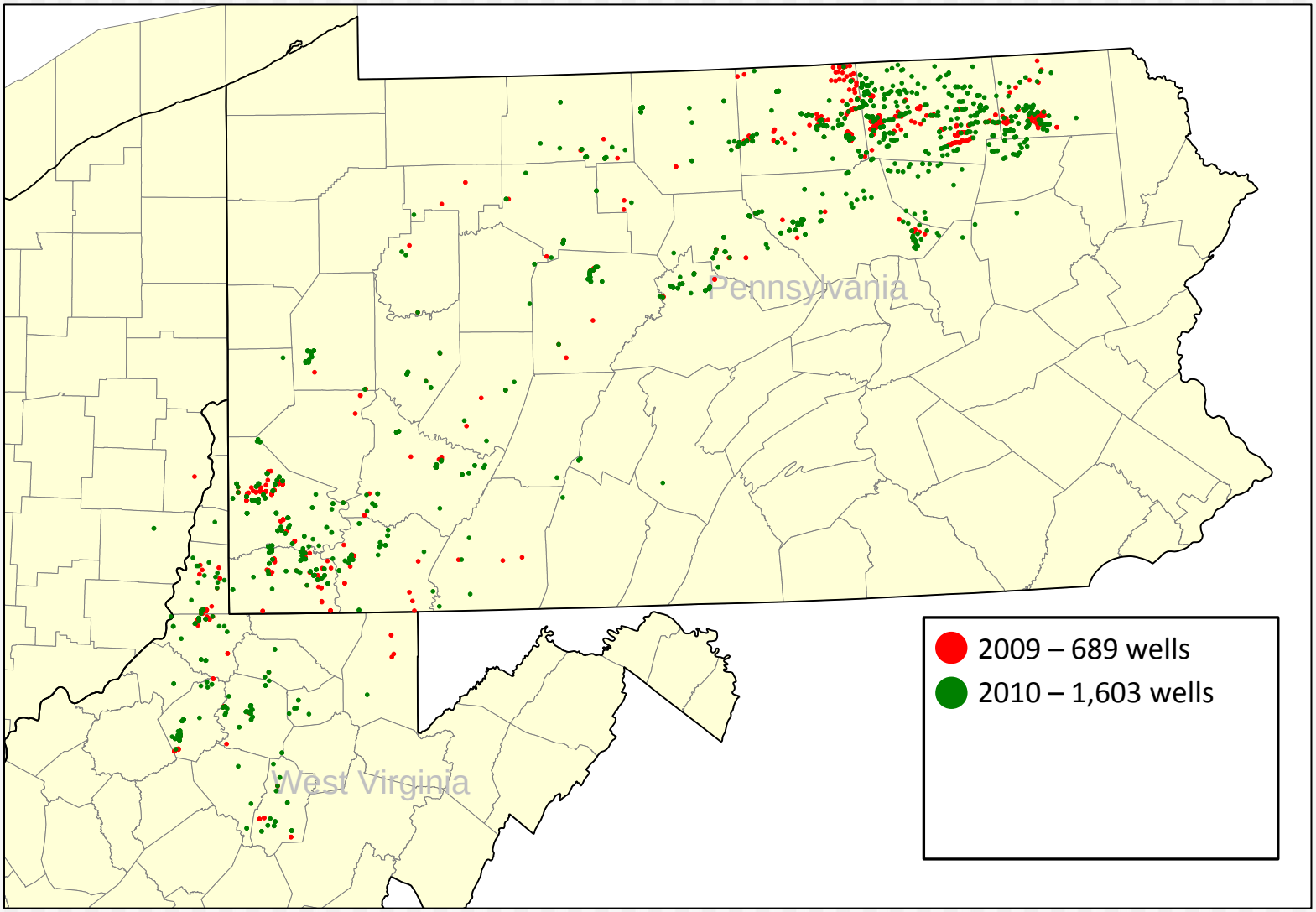

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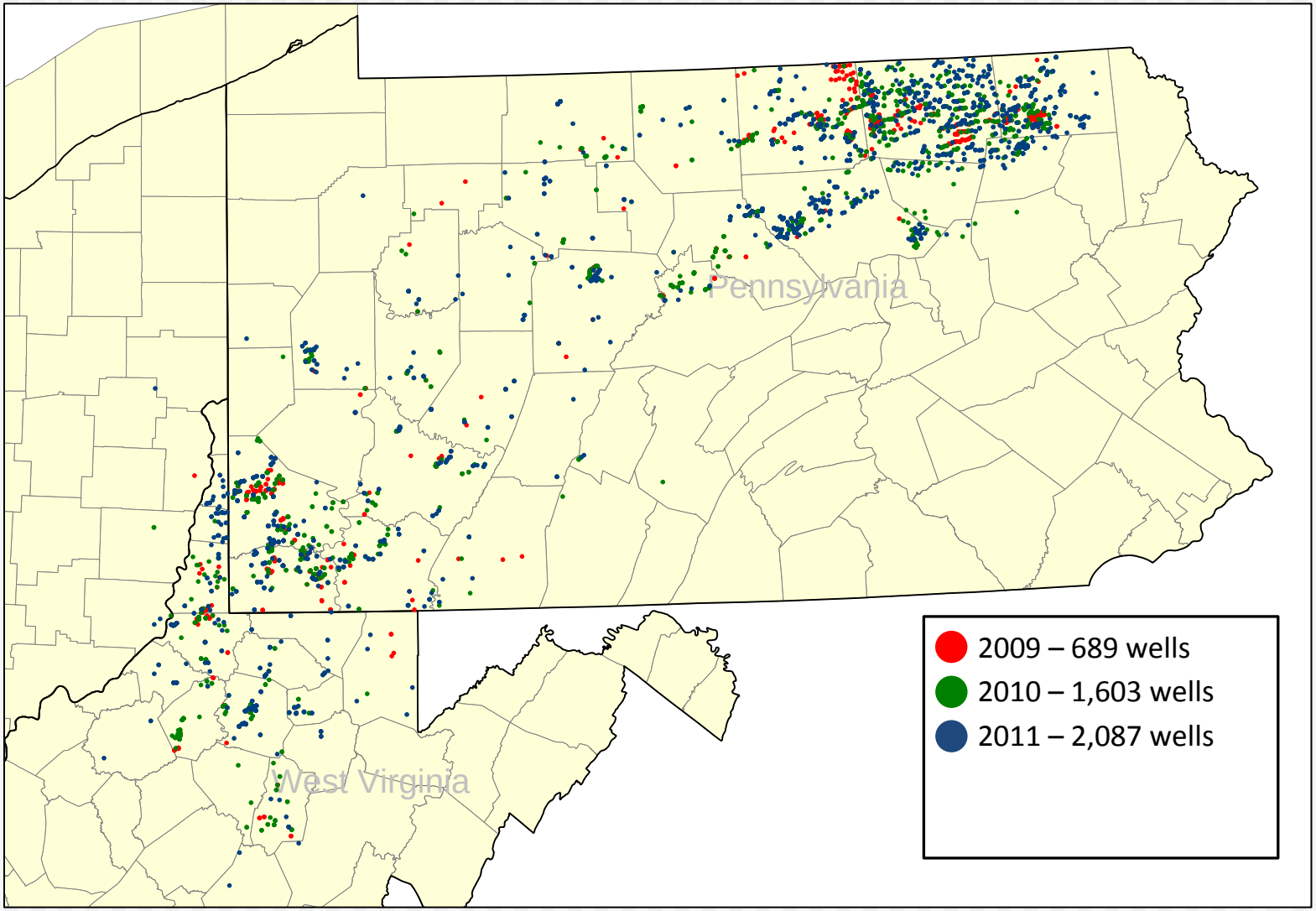

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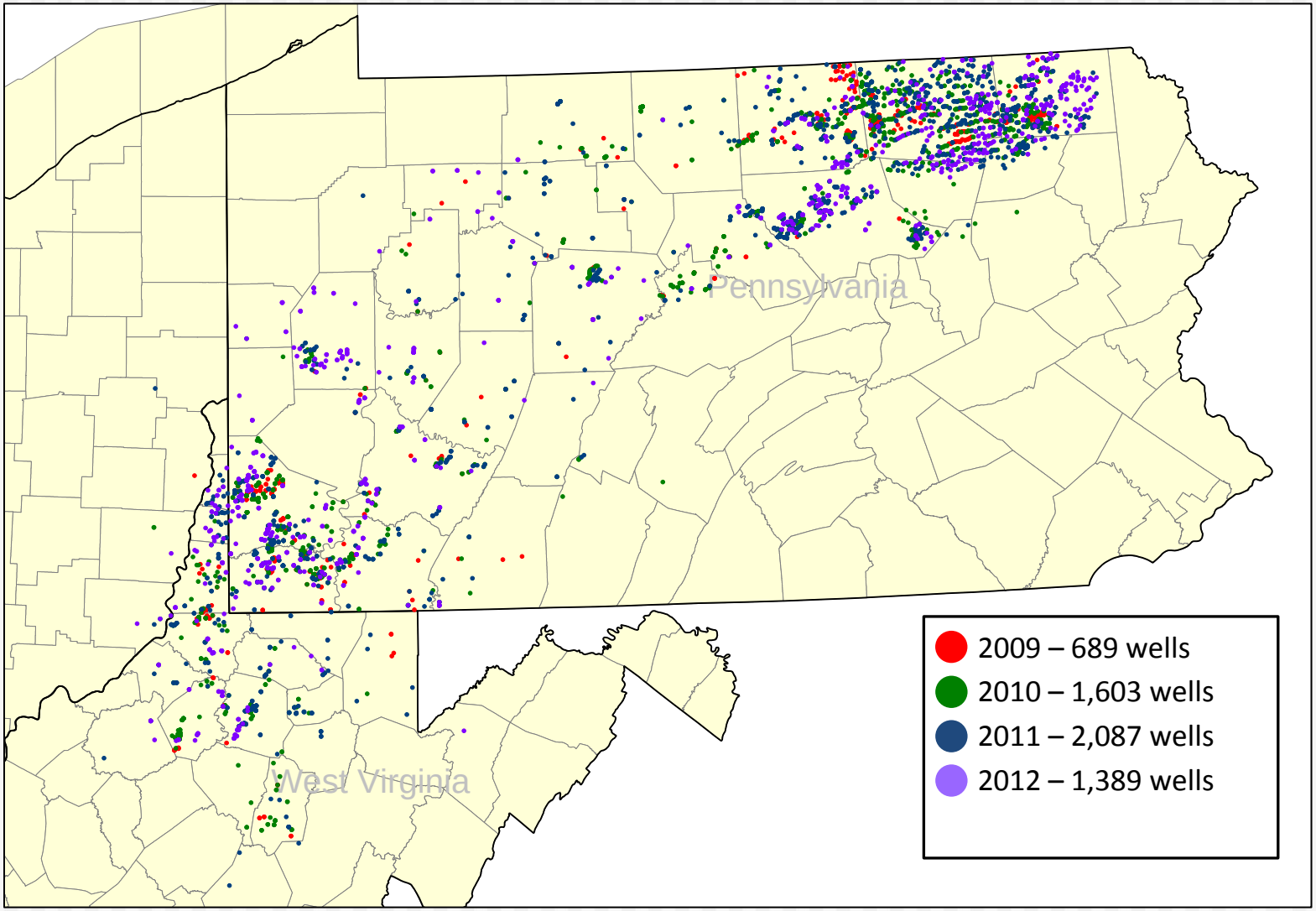

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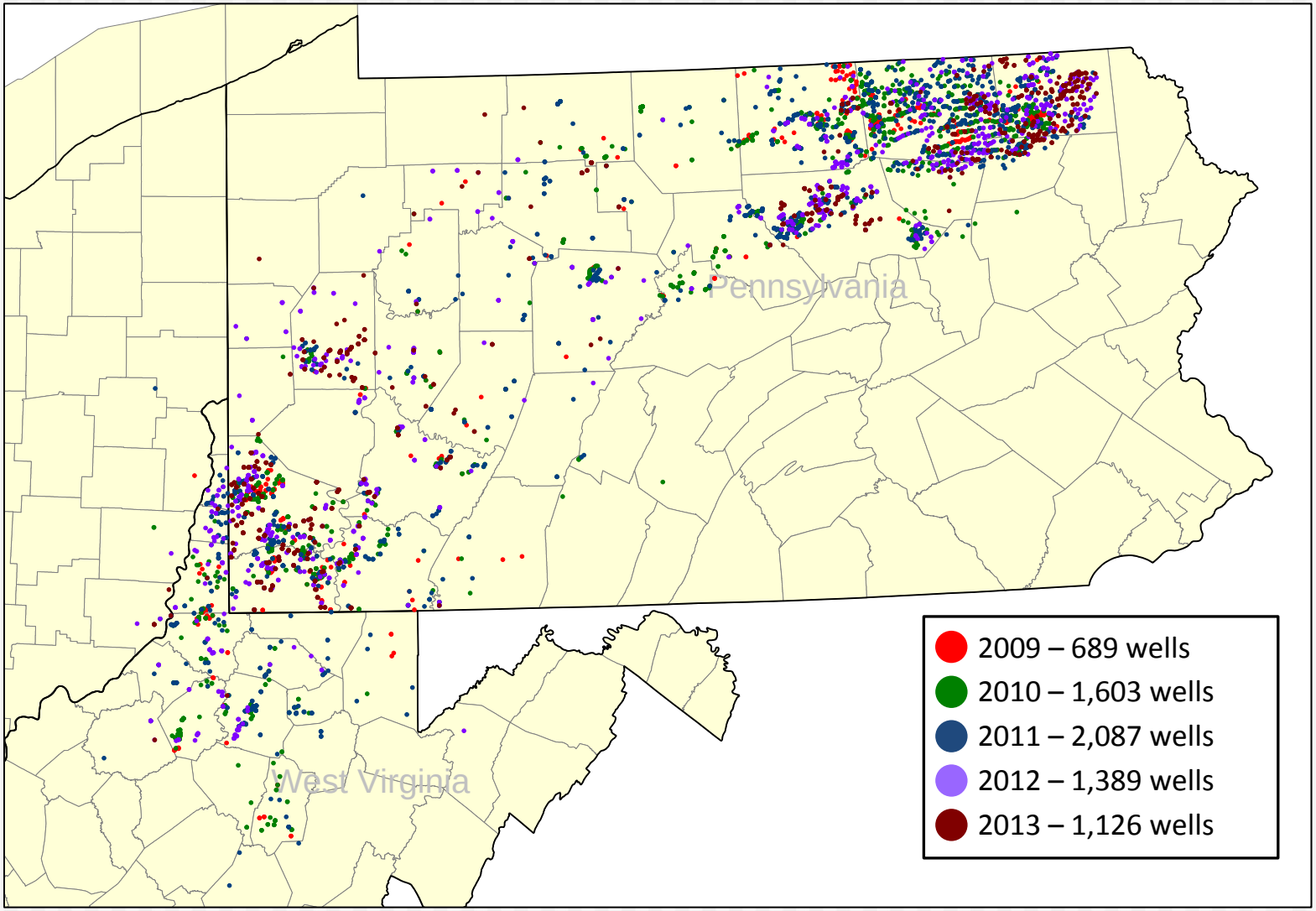

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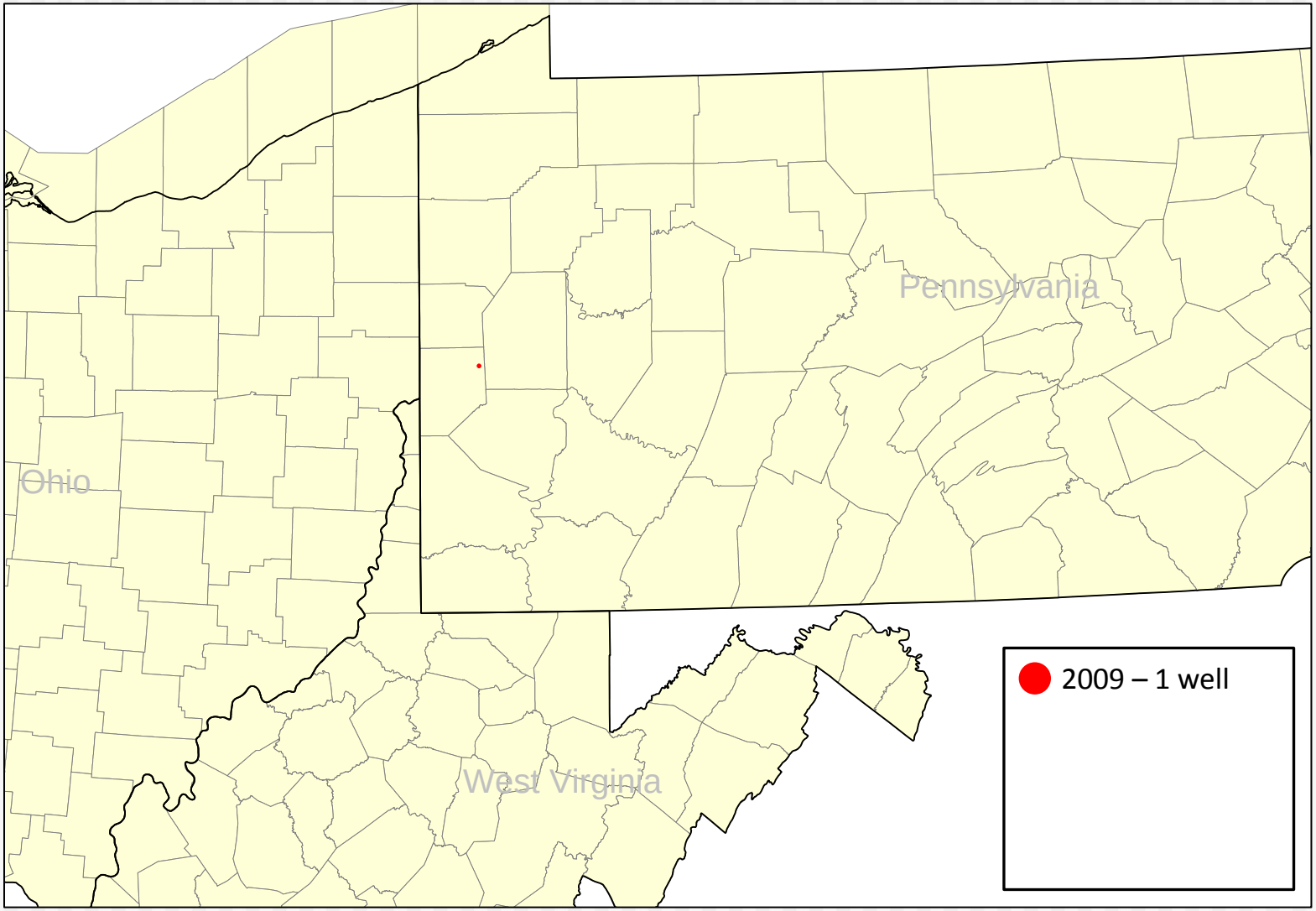
UTICA/PT. PLEASANT HORIZONTAL WELLS SPUD



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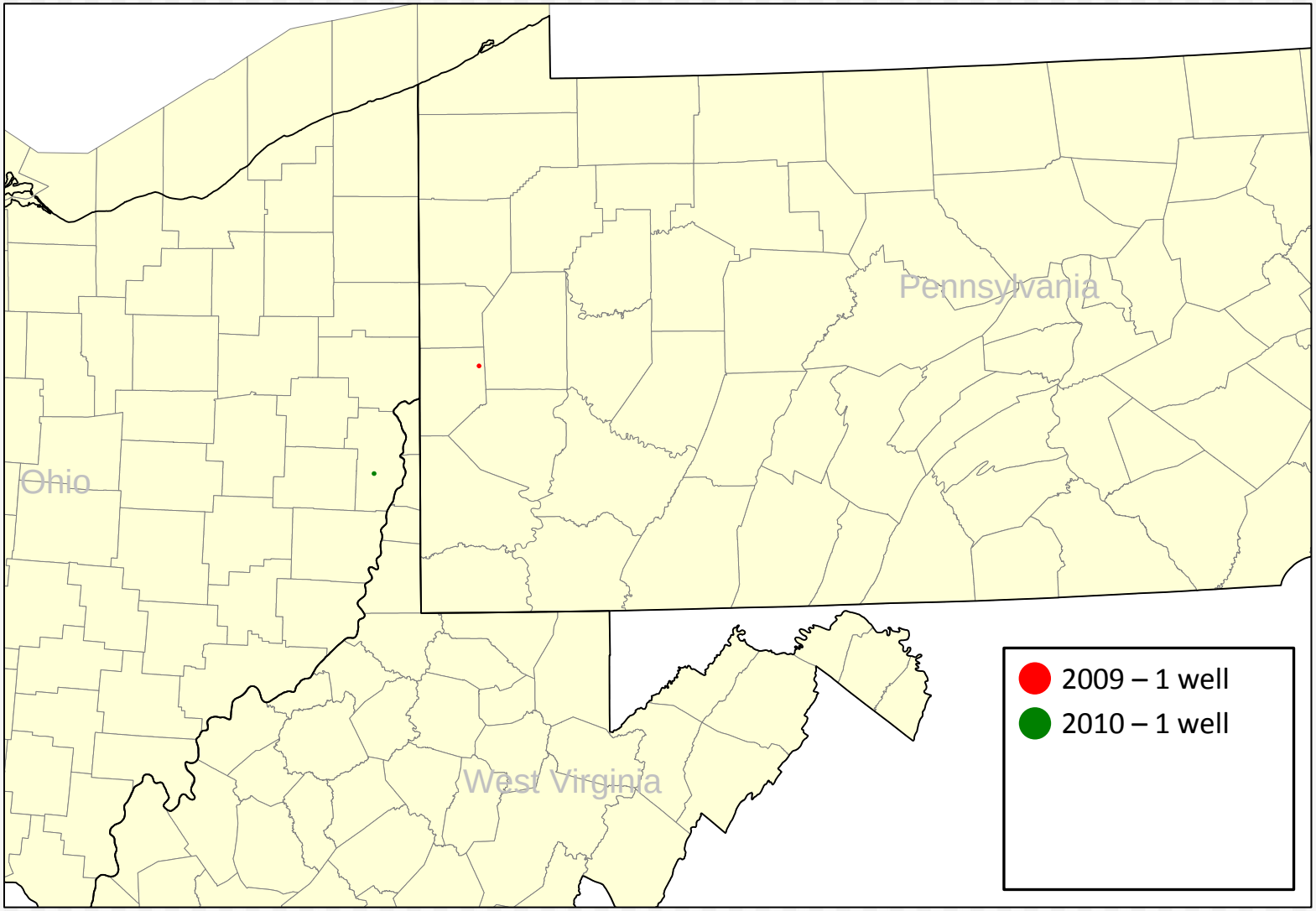

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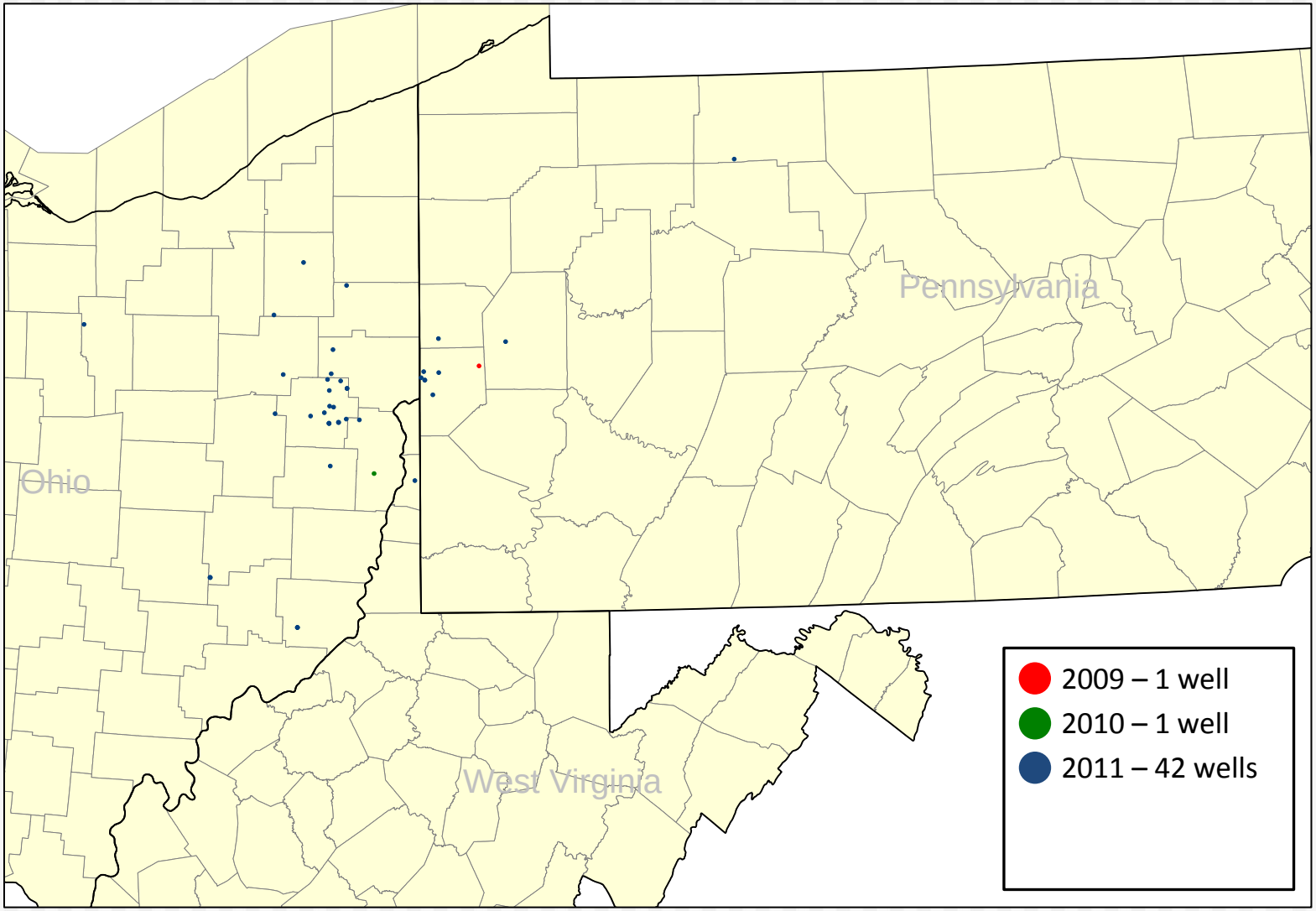

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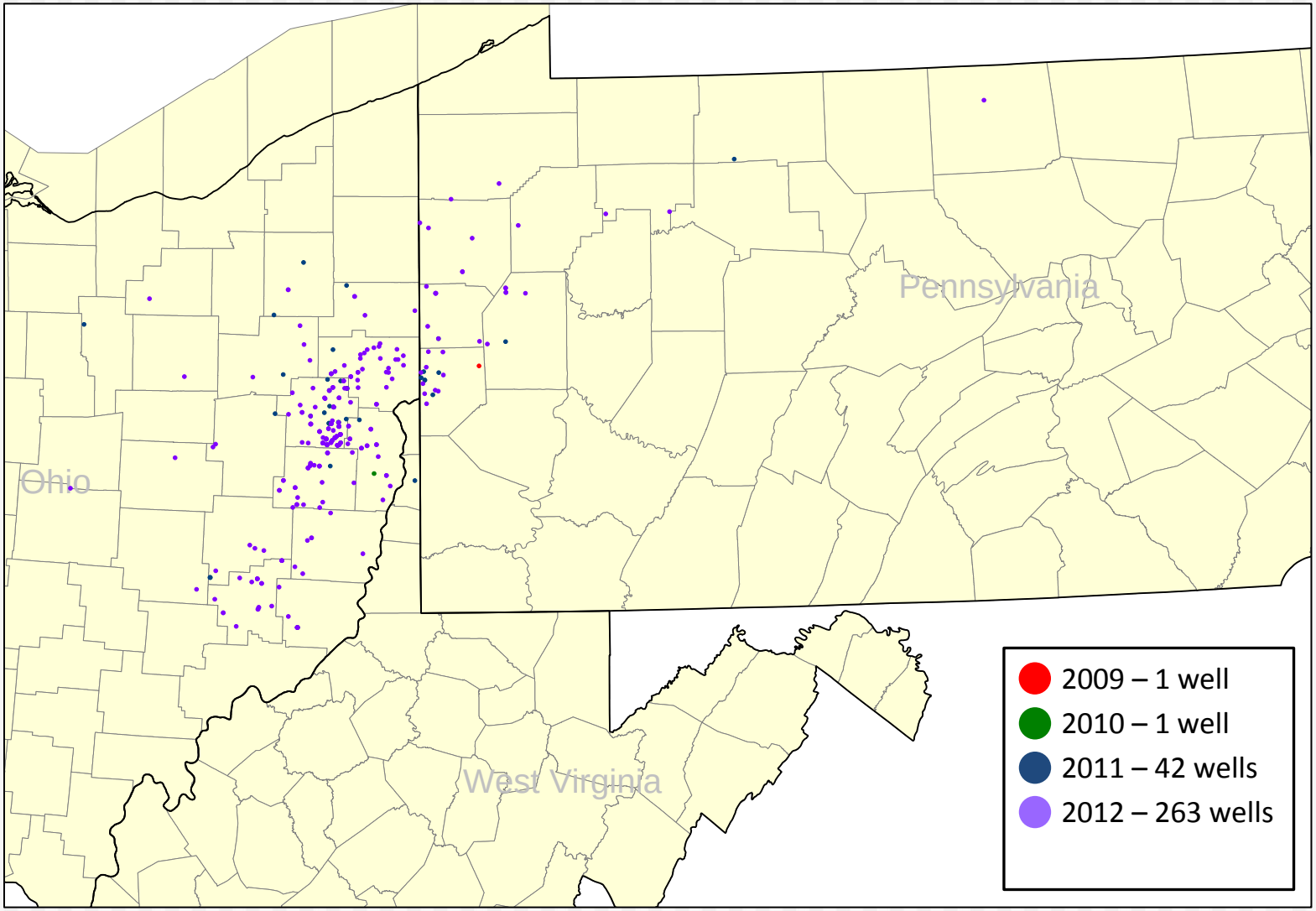

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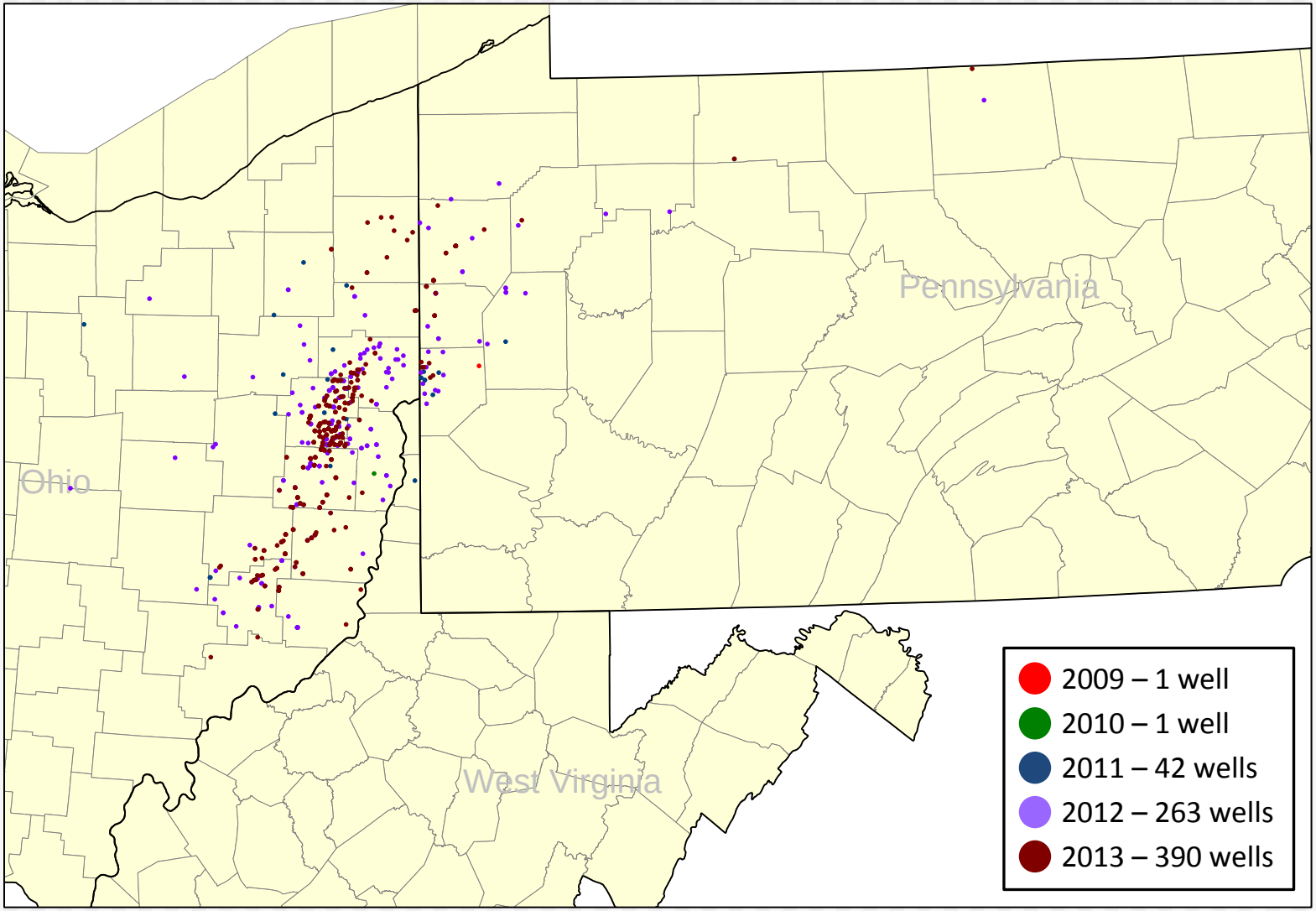
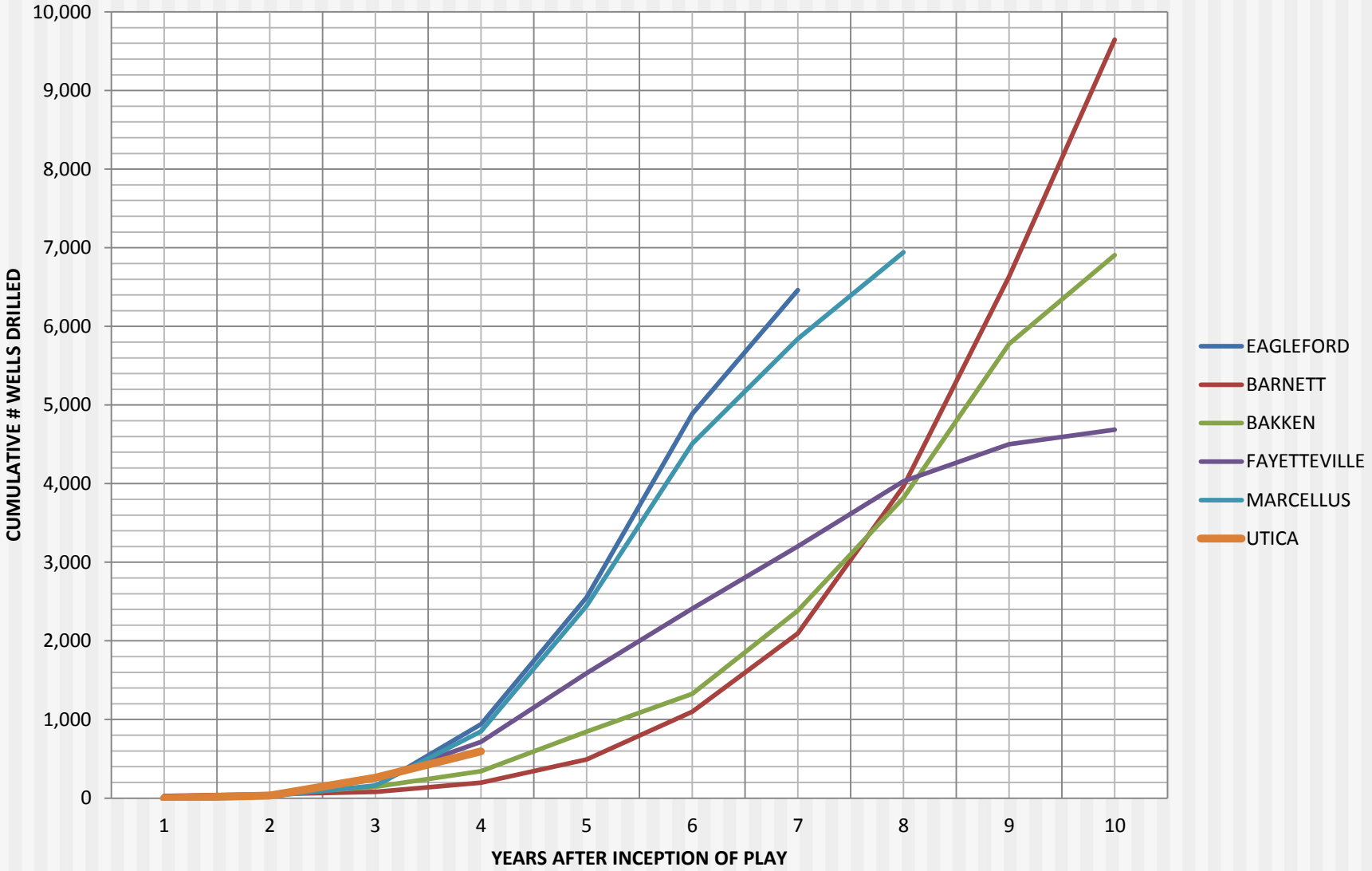


Source: Drilling Information May 2014

TOTAL NUMBER OF WELLS vs. AGE OF PLAY



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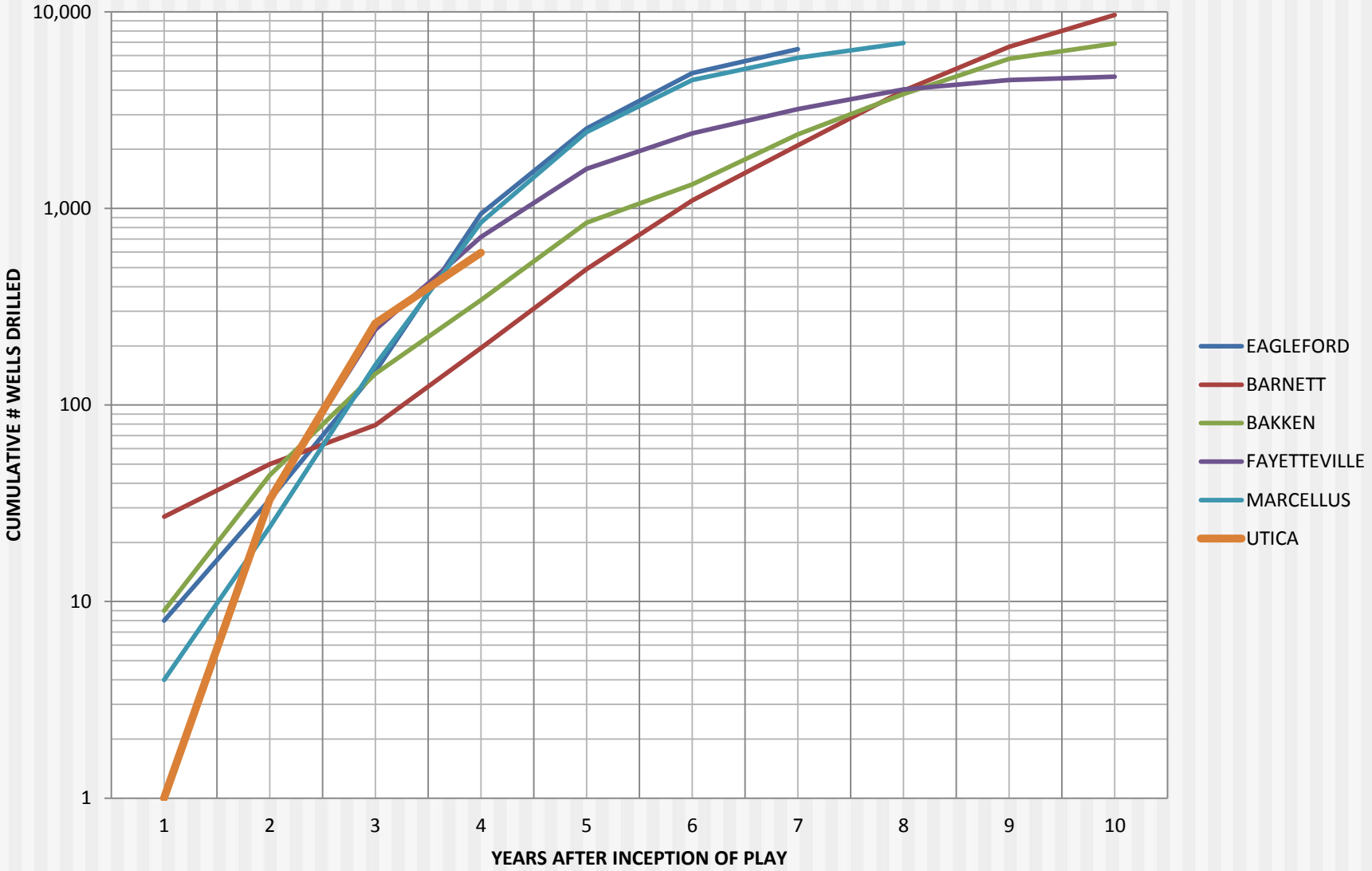

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HOW QUICKLY THINGS CHANGE

- Early Development: Generation 1
  1) Low cost acreage: $50 to $500 per acre
  2) Drilled on acreage held-by-production (HBP)
  3) Shorter lateral lengths, some less than 3,000 feet
  4) Analogy to other shale plays

- Now: Generation 2
  1) High cost acreage: $10,000 to $20,000 per acre
  2) High drilling and completion investment
     – $4-10 MM$ per well
  3) Longer lateral lengths, greater than 5,000 feet
  4) Shale play specific

- In Generation 1, many companies made lots of money by selling, joint ventures, financing, and mergers

- In Generation 2, the real question is how do companies recoup hundreds of millions of dollars

WHAT IS A RESOURCE PLAY

TIER 1 CRITERIA

- Wells exhibit a repeatable statistical distribution of EUR
  - Generation 1 – shorter lateral lengths, frac design, 300' stages
  - Generation 2 – Longer lateral lengths, reduced cluster spacing (RCS), spacing concerns
- Offset well performance is always **NOT** a reliable predictor
  - Why?

TIER 2 CRITERIA

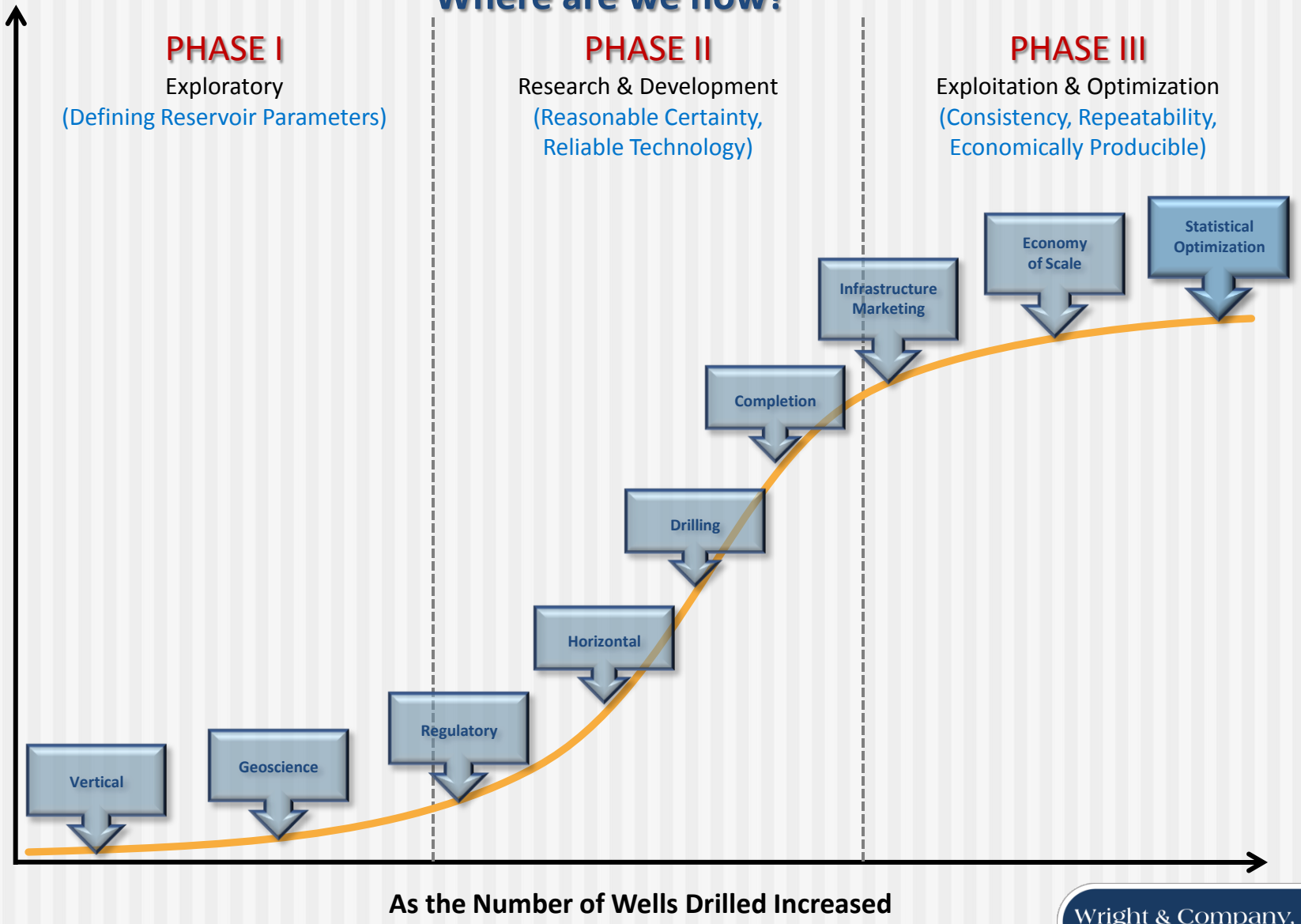
- Requires extensive stimulation to produce economically
- Large areal extent but **NOT** necessarily homogeneous
- Performance different → due to rock variability

Source: SPEE Monograph 3, 2011

RESOURCE PLAY LEARNING CURVE

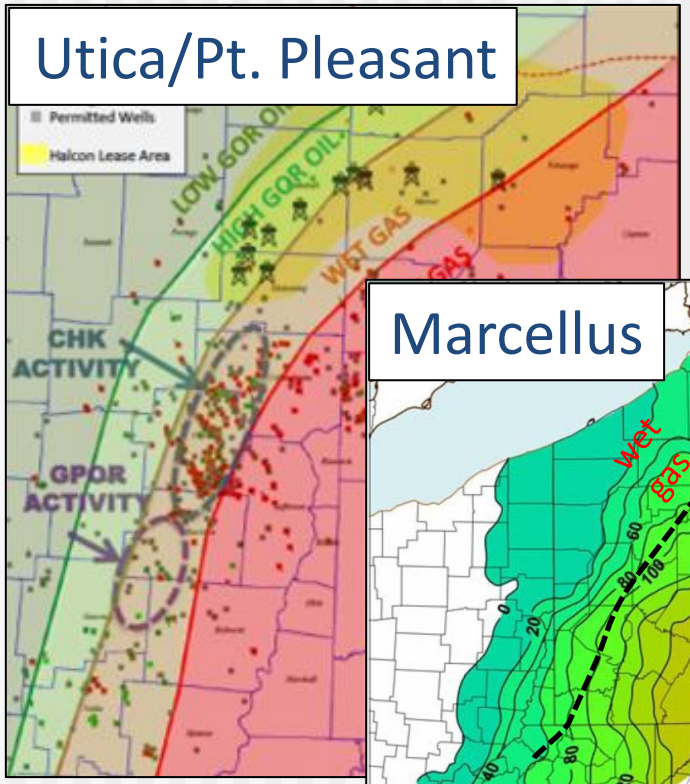
First DUG East Conference – 2009

Where are we now?



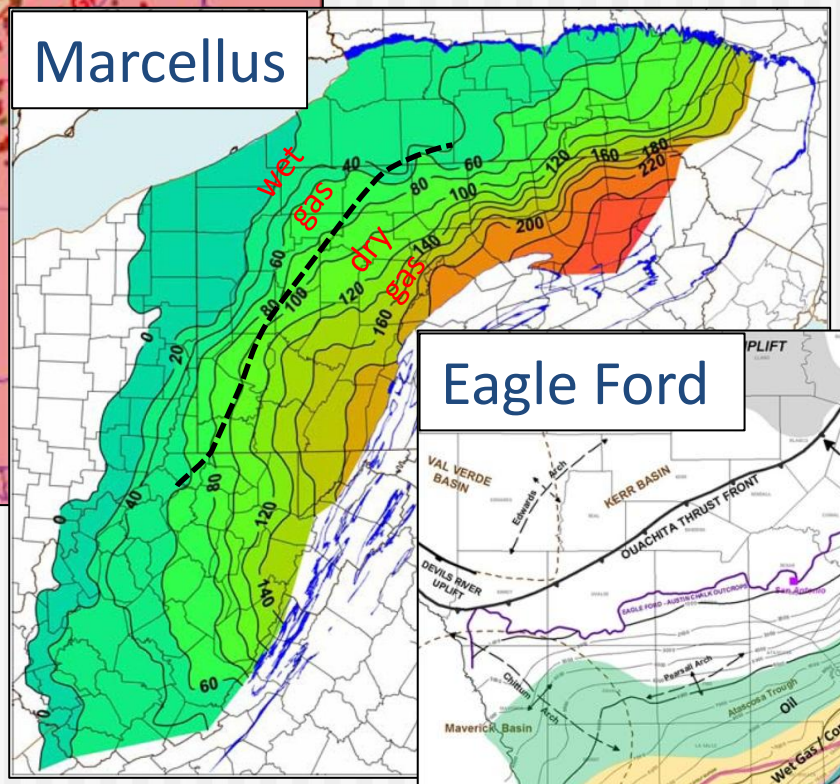
HOW DO YOU EVALUATE SHALE RESERVES?

Utica/Pt. Pleasant



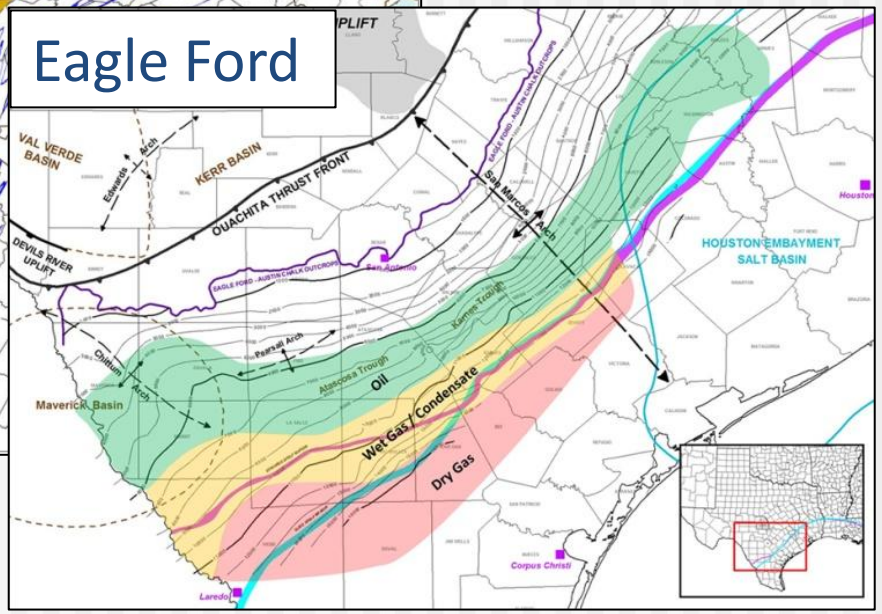
Source: www.ogfj.com

Marcellus



Source: marcellus.psu.edu

Eagle Ford



Source: EIA.gov

SHALE EVALUATION CONSIDERATIONS

- Common parameters of timing, technology, and geology
  - Timing: As operators gain knowledge, better performance
    - New Learning Curve
  - Technology:
    - Lateral placement → geosteering and spacing
    - Completion design
      - Optimize stage distance/reduced cluster spacing (RCS)
      - Proppant type and concentration
      - You get what you frac, thus higher recovery factor
  - Geology:
    - Must connect "to" the "quality" reservoir
    - Not all areas will be economically productive
    - Identify "sweet spots" in zone and area
- "New Learning Curve Uplift"
  - Improving estimated ultimate recovery per effective lateral length (EUR/1,000 ft.)

TYPE CURVE DEVELOPMENT

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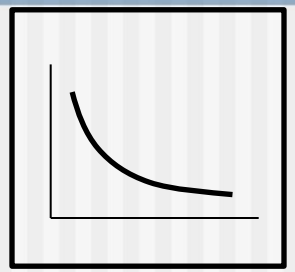
"JUST WANT ONE TYPE CURVE"

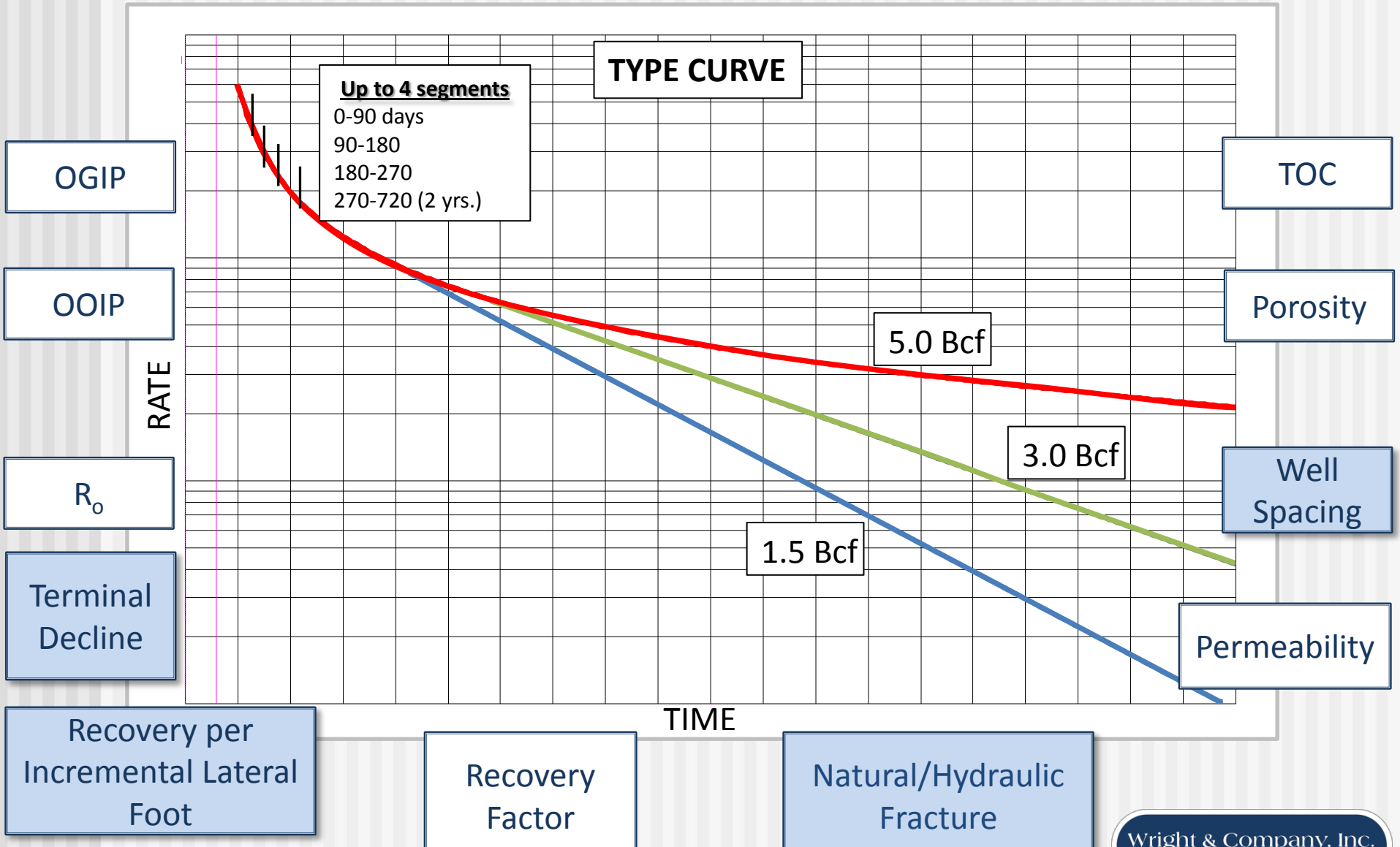
Shale Resource Play



What's the IP, decline, and EUR for the typical horizontal shale well?

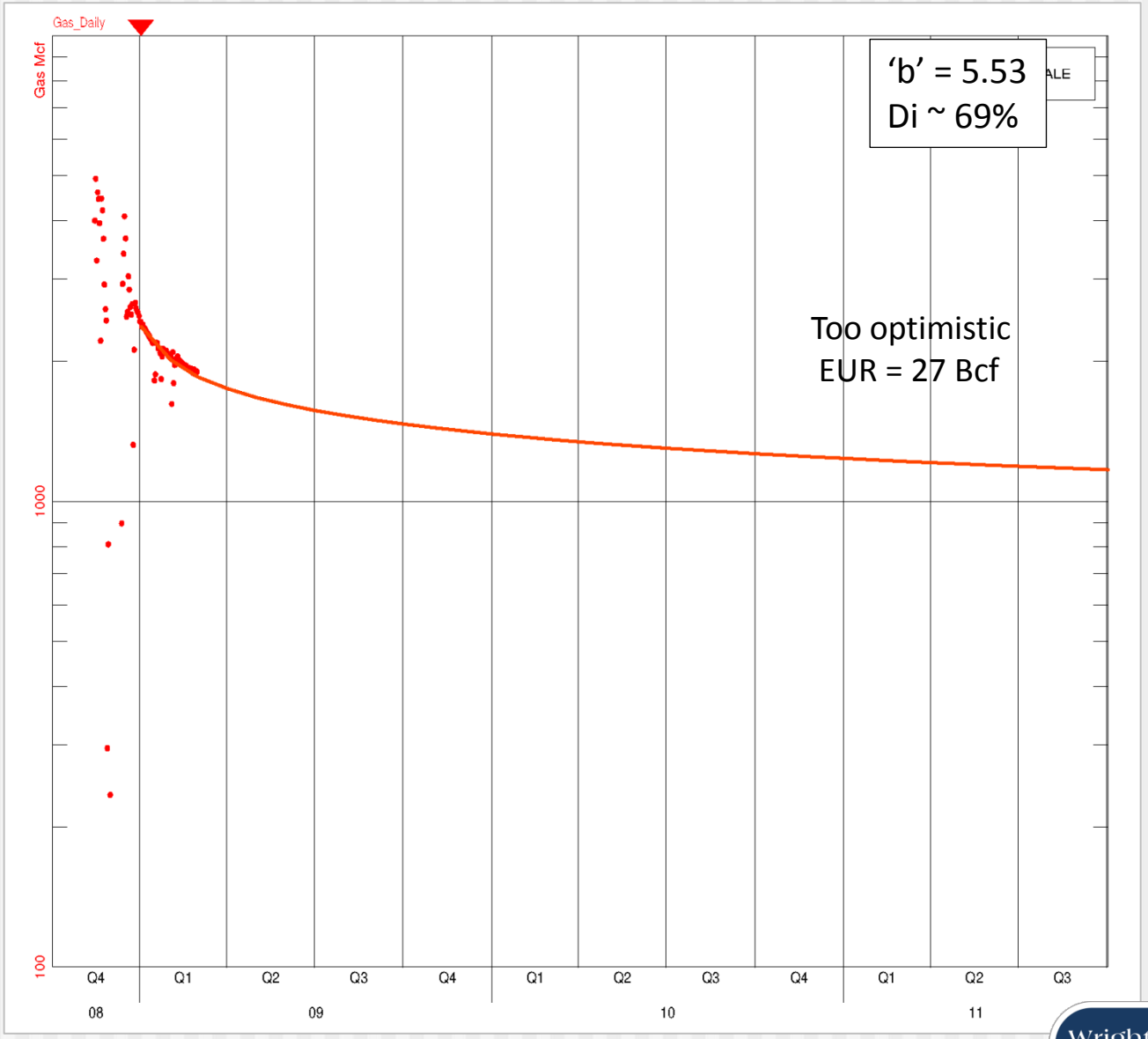
By: 1) State
2) County
3) Formation (Eagle Ford, Marcellus, Utica)
4) Windows
   > Oil/condensate "window"
   > Wet Gas "window"
   > Dry Gas "window"

MANY FACTORS INFLUENCE WELL PERFORMANCE



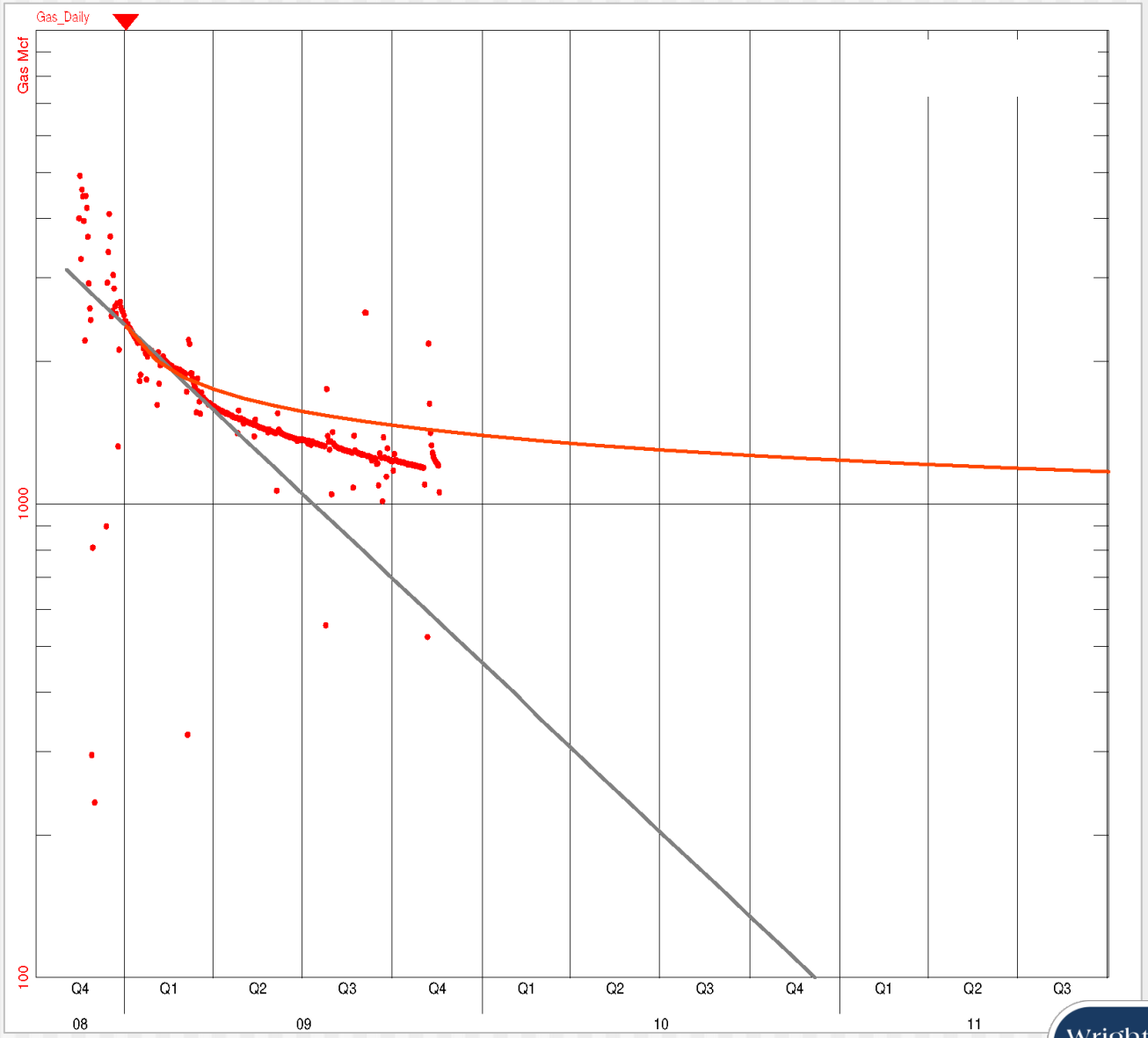
SELECTED PERFORMANCE TREND ANALYSIS

Segment 1 (First 3 Months)



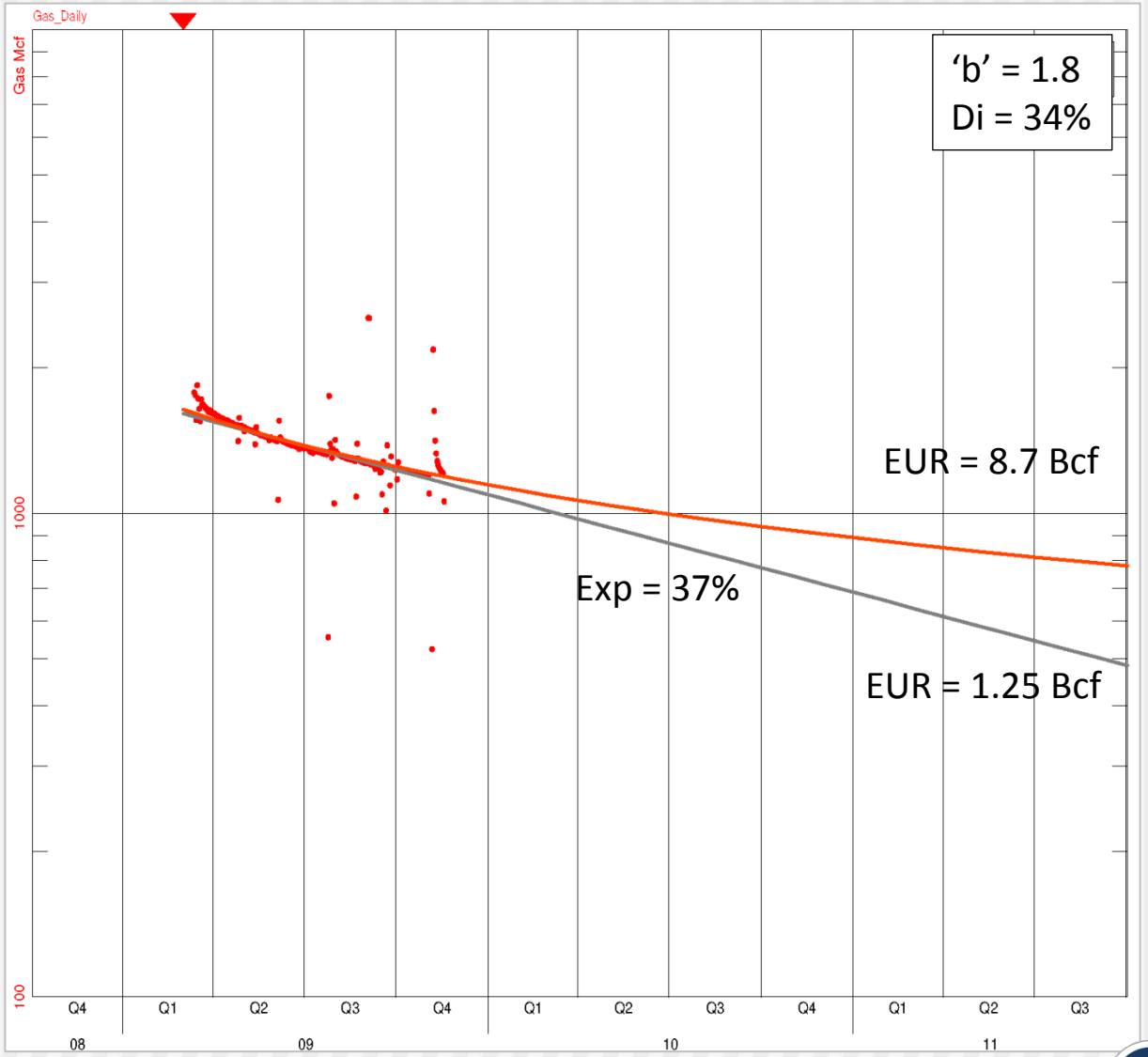
PERFORMANCE TREND ANALYSIS

How Profile Changes Quickly



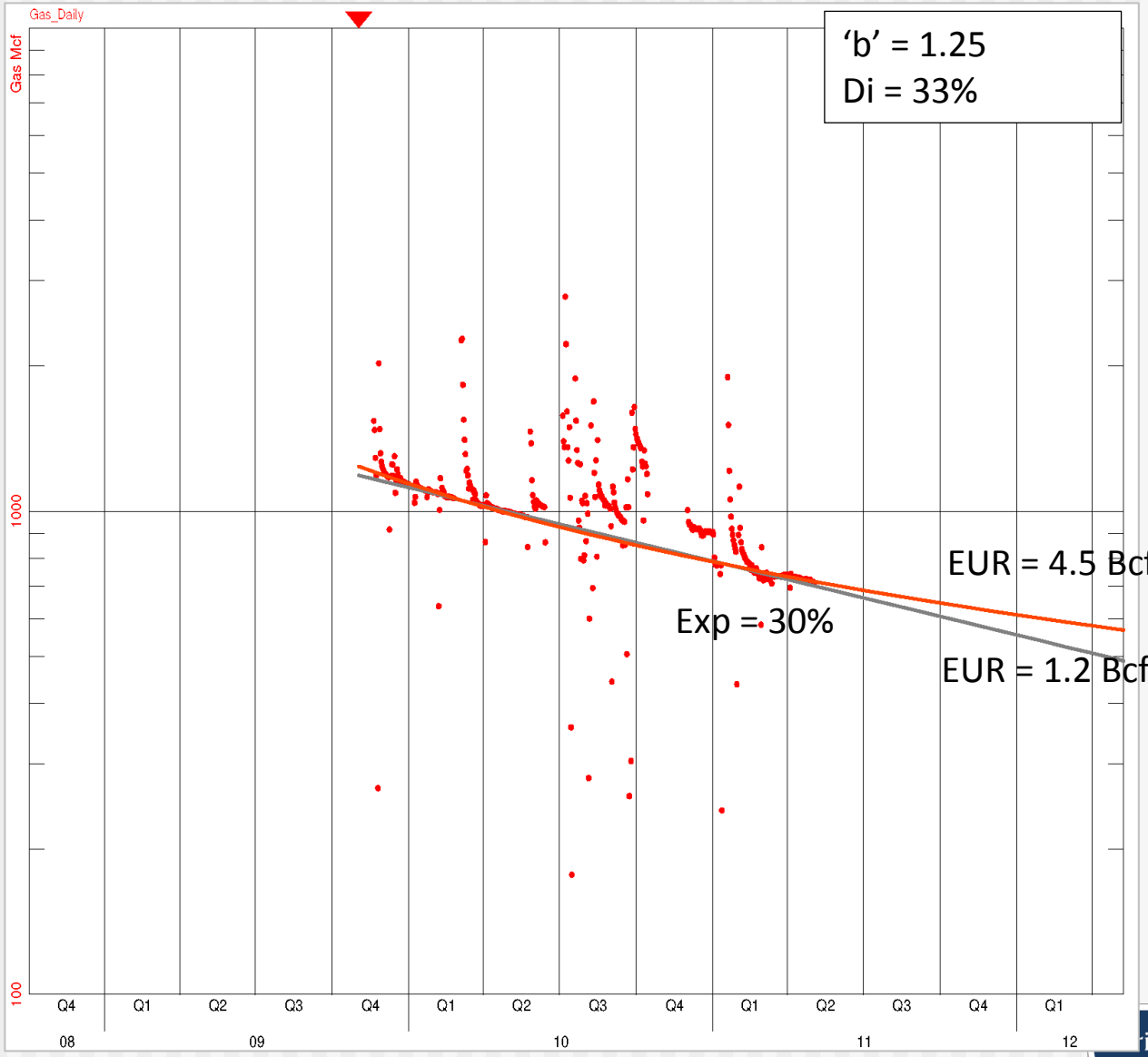
SELECTED PERFORMANCE TREND ANALYSIS

Segment 2 (Next 9 Months)



PERFORMANCE TREND ANALYSIS

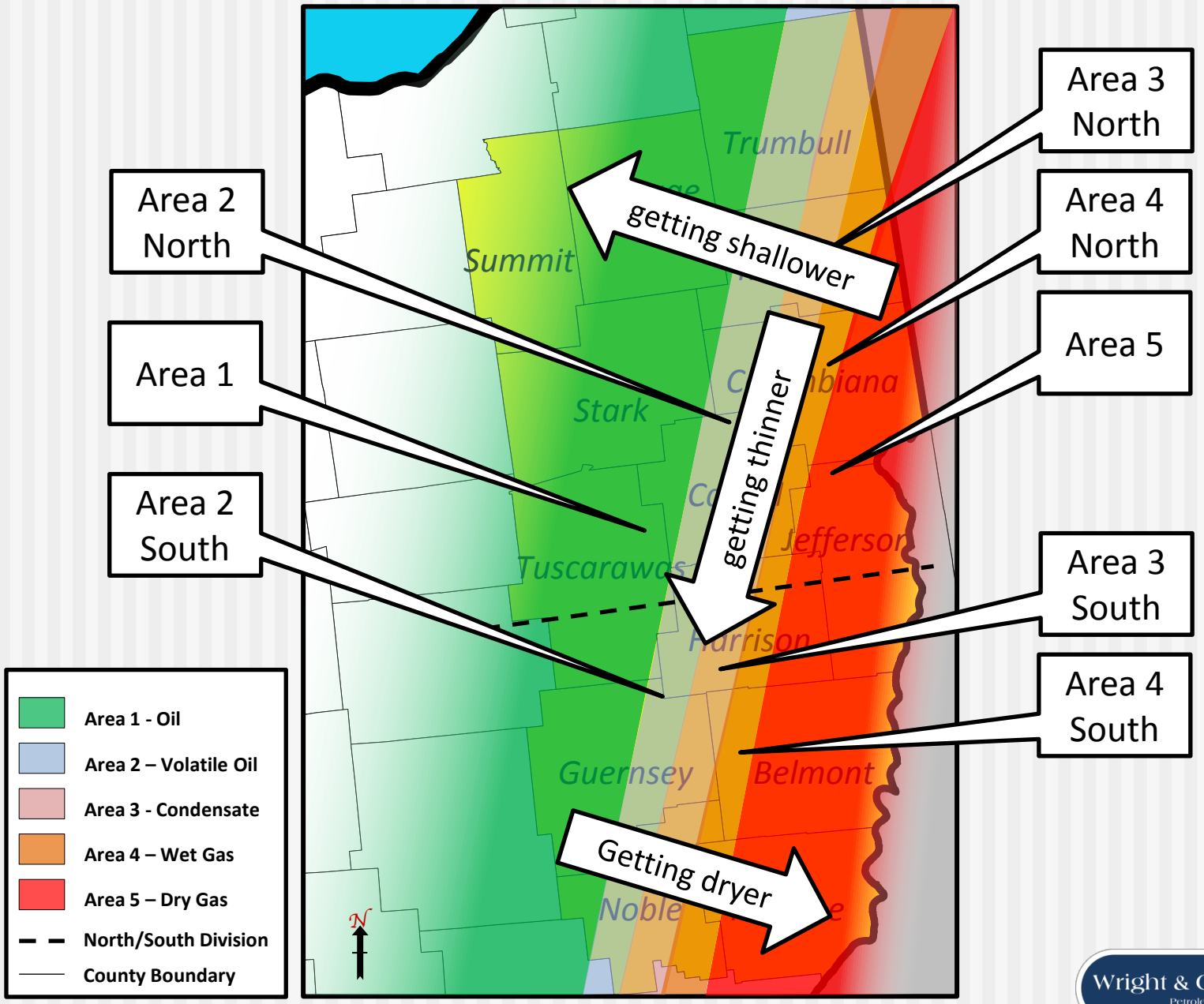
Segment 3 (12-24 months)



WHAT WE KNOW BY REVIEWING EARLY RESULTS

- Type curves tend to look similar for shales
  - Several “b” factors; initial declines; EURs on public websites
  - Difference depends on location and reservoir quality
  - Drilling and completion techniques
  - Spacing between laterals
- Well results are widely distributed
  - Vertical – less than 0.200 up to 1.2 Bcfe
  - Horizontal
    - Initially 2.5 – 3.3 Bcfe → Generation 1
    - More recently 5.0 – 8.0 or greater Bcfe with longer lateral lengths
    - Averages now claimed to be 7.0 – 12.0 Bcfe → Generation 2

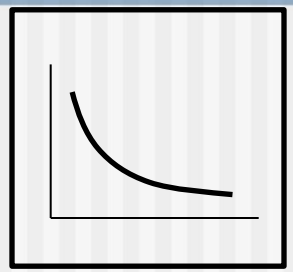
CONSIDERATION OF MULTIPLE TYPE CURVES

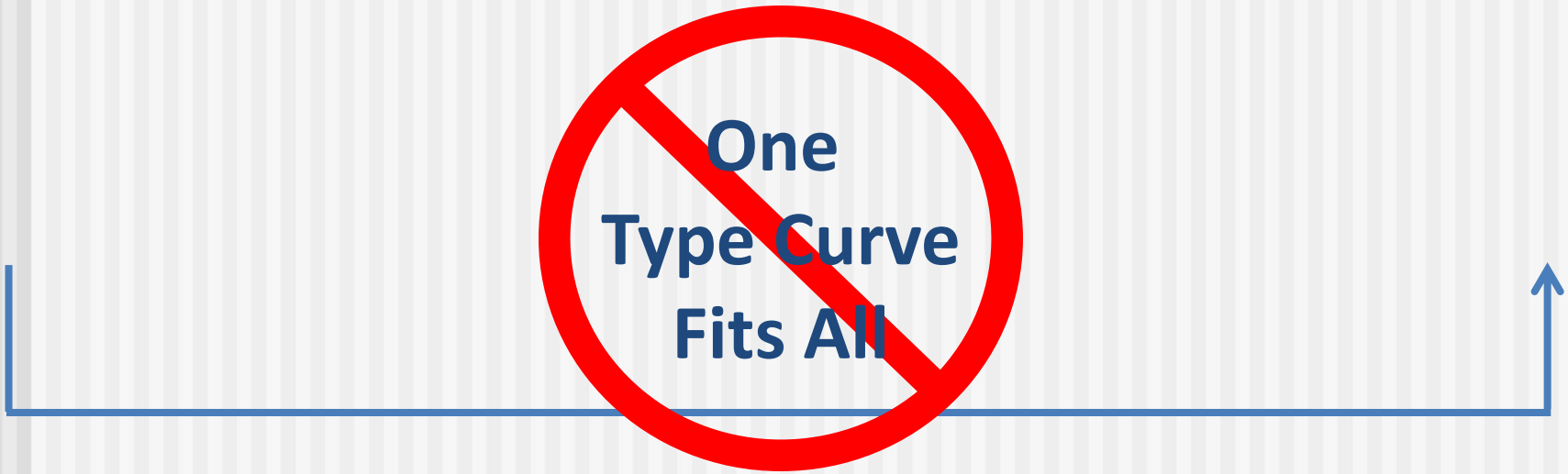


ONLY ONE TYPE CURVE?

Resource Play

Not so easy my friends





THE NEW LEARNING CURVE
Areas of Improvement

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GENERATION 1 vs. GENERATION 2

Generation 1:

- Older wells – 3 to 5 years production history
- Shorter laterals - 2,800 to 3,500 feet
- Lower on Learning Curve
- Wide stage placement (~300 feet)
- Pre-optimization
- Lateral placement within zone (Brittle or Ductile)
- Generally lower EUR/1,000 feet of effective lateral length - 0.8 to 1.3 Bcf/1,000 ft.
- Wells generally on 1,000 feet spacing between laterals
- Geosteering/Geomechanics – in and out of zone , effect on rock quality

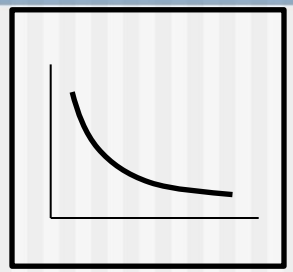
Generation 2:

- Newer wells – Less than 1 to 2 years production history
- Longer laterals – 4,000 to 7,500+ feet
- Higher on Learning Curve
- Reduced Cluster Spacing (RCS)
- Optimized – Implement what was learned
- Generally higher EUR/1,000 feet of effective lateral length – 1.2 to 2.0 Bcf/1,000'
- Down spacing – drainage and/or interference 400-750 feet between lateral
- Geosteering/Geomechanics – more consistency within zone

GENERATION 2 – NEW FOCUS

Resource Play

Science + Experience = Advances in Learning Curve



Geology → Drilling & Well Design → Frac Design → Completion & Production

- Structure
- Perm
- Thickness
- TOC
- Clay Content
- Thermal Maturity
- Dry Gas
- Retrograde Condensate
- Black Oil

- Temp
- Pressure Gradients
- Ductile vs. Brittle
- Sw affects "resting"
- uphole connected pay zones
- Salt-Filled Fractures
- Lateral spacing and length
- Vertical placement
- Reduced cluster spacing (RCS)

- Thin lenses
- Visibility on Log vs. core
- Naturally fractured zone – avoid or tap?
- **Connectivity – Get what you frac**

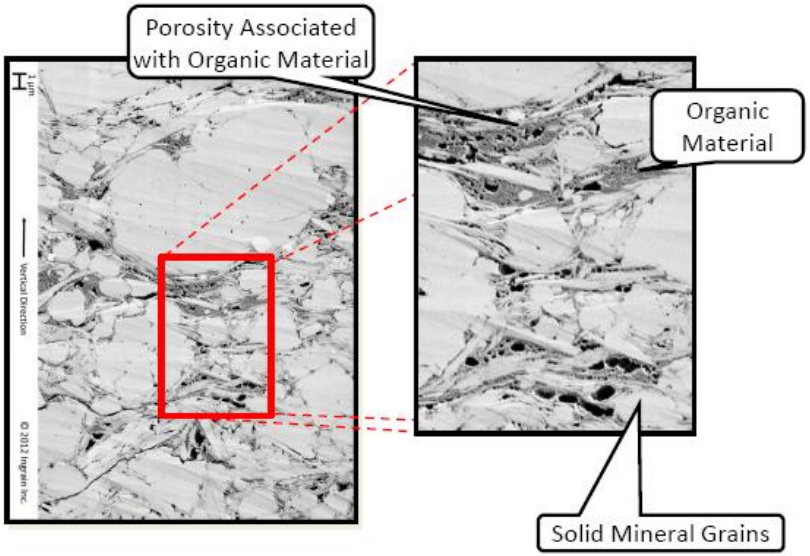
THE NEW LEARNING CURVE:
Areas of Improvement

- Digital core analysis
- Lateral spacing – infill or development plan
- Geosteering – target zone
- Stage spacing – reduced cluster spacing (RCS)
- Geomechanics – in situ stress influencing frac growth

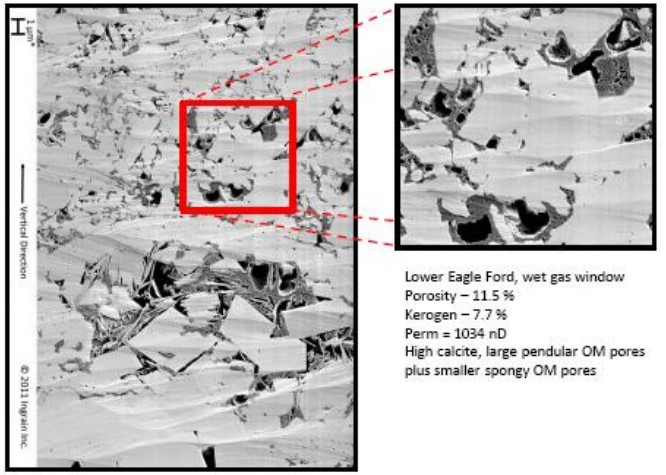
DIGITAL CORE ANALYSIS

Utica Shale – Eagle Ford Analog

Utica Shale – Point Pleasant Interval



Eagle Ford



Lower Eagle Ford, wet gas window
Porosity – 11.5 %
Kerogen – 7.7 %
Perm = 1034 nD
High calcite, large pendular OM pores
plus smaller spongy OM pores

- Ion-milled SEM images show extensive organic porosity development in Point Pleasant formation
  - Organic matter porosity creates superior porosity and permeability in the rock
- Similar organic porosity development in Eagle Ford formation

Source: Gulfport Energy Corporation Investor Presentation; www.gulfportenergy.com

LATERAL DOWNSPACING: 750’ TO 500’

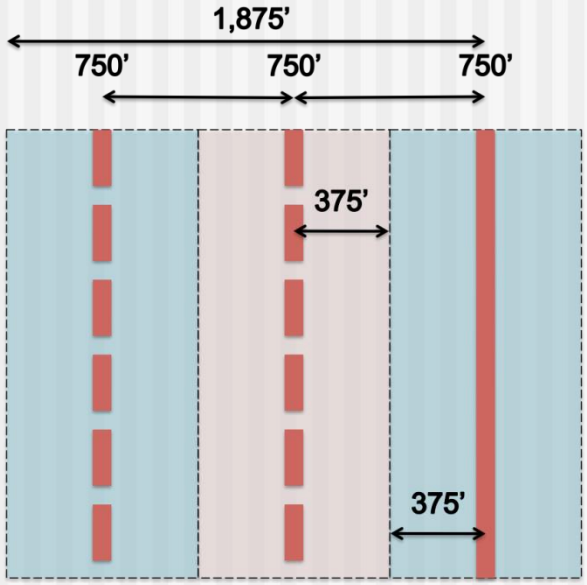
If 750’ EUR = 100%, 500’ EUR = X%

750’ SPACING
No “overlap”

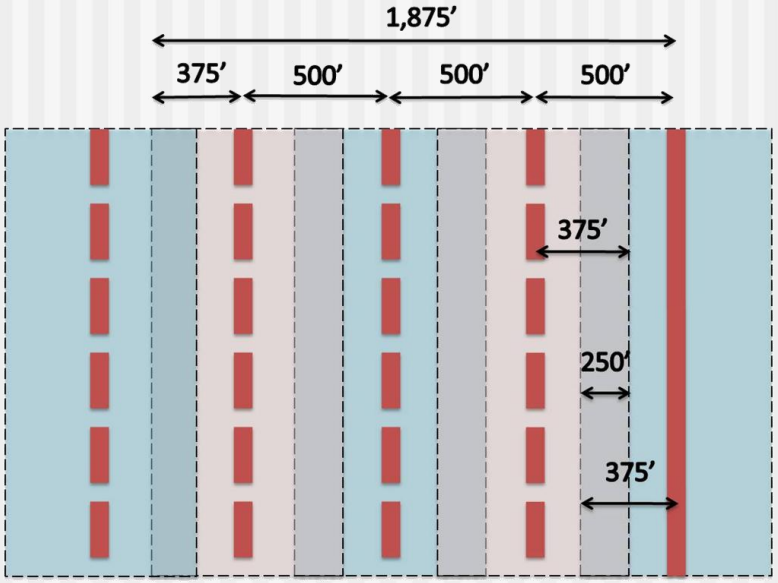
500’ SPACING
250’ of “overlap” between each pair

Improved frac density?
Or sharing reserves?

750’ CASE



500’ CASE



DOWN-SPACING POTENTIAL

Eagle Ford:

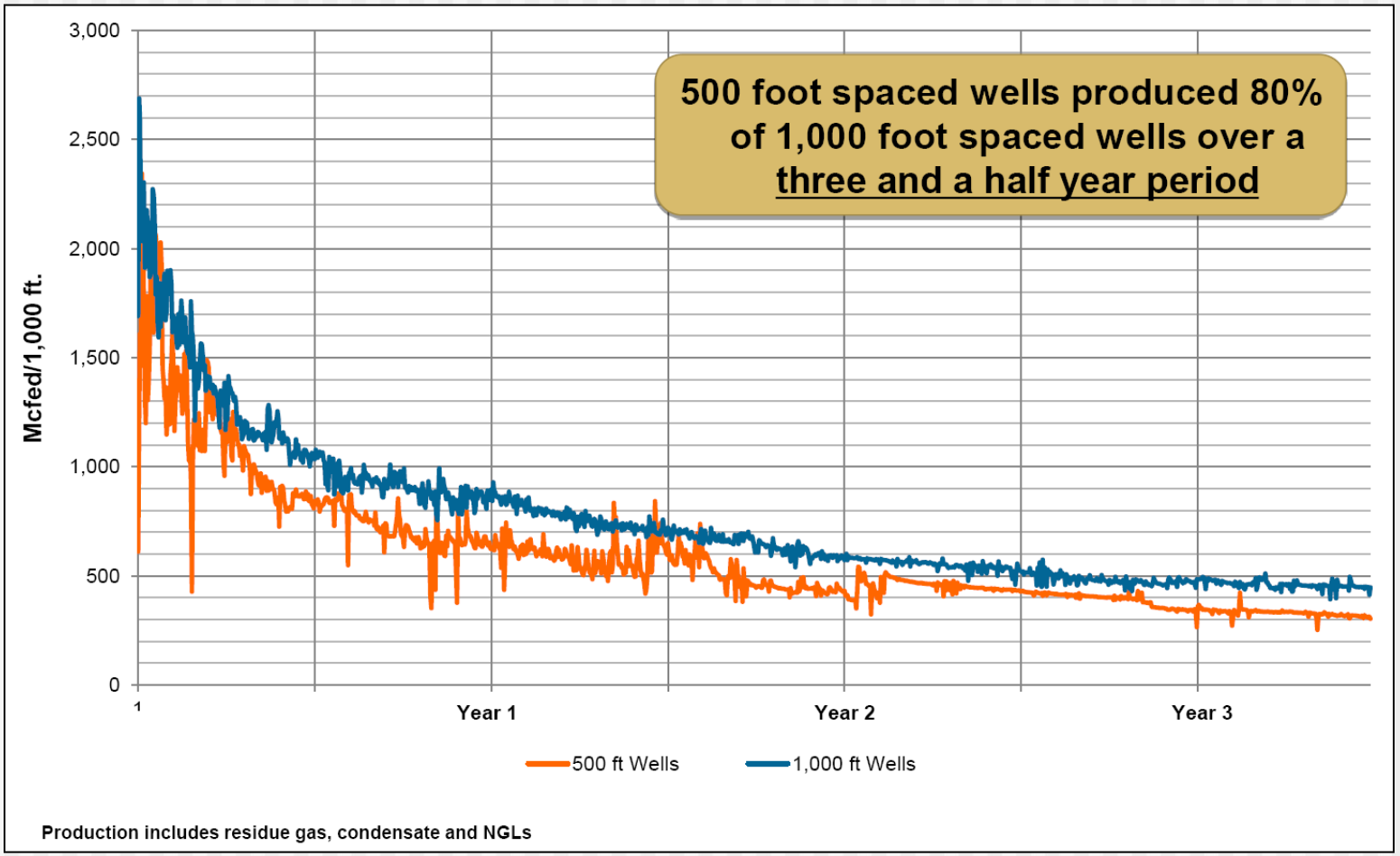
- Initial development on 1,000 feet spacing
- Operators are experimenting with 330 feet to 550 feet spacing and are evaluating early results
- ***Generally***, 500 feet EURs ***are expected to be*** between 70% and 90% of 1,000 feet spaced EURs
  - Based on numerical simulation – little definitive data yet
  - Similar IP's, but different terminal decline rates expected
  - Economics of 330 feet to 550 feet spaced wells comparable to 1,000 feet spaced wells
- Certain operators already drilling on 330 feet spacing (EOG)

Utica:

- Initial development on 1,000 feet spacing
- Observed fracture half-lengths indicate that some down-spacing may be effective with little or no hindrance to EUR
- 500 feet spacing in North, 700 feet spacing in South
- Down-spacing could significantly increase number of undeveloped locations

RESULTS OF MARCELLUS TIGHTER SPACING PILOT PROJECTS

Projects conducted in the Super-Rich and Wet areas of the Marcellus



Source: Range Resources Corporation Company Presentation , March 6, 2014

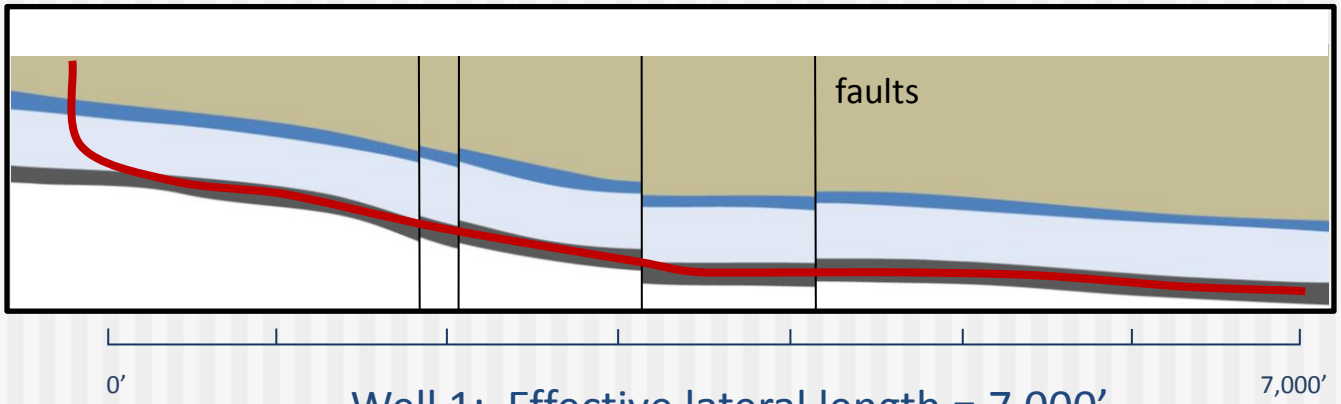
MARCELLUS SHALE SPACING EXAMPLE

Pseudo Well Name	Status	Effective Lateral	EUR (Bcf)	EUR/1,000 (Bcf)	
600' Well #1	Gas	5,285	4.903	0.928	
600' Well #2	Gas	4,124	4.814	1.167	
600' Well #3	Gas	4,502	4.303	0.956	
600' Well #4	Gas	5,386	4.605	0.855	
600' Well #5	Gas	5,335	4.869	0.913	
600' Well #6	Gas	5,125	5.003	0.976	
600' Well #7	Gas	5,074	3.624	0.714	
600' Well #8	Gas	5,680	5.687	1.001	
600' Well #9	Gas	5,154	3.837	0.744	
600' Well #10	Gas	5,085	4.356	0.857	
600' Well #11	Gas	5,100	4.508	0.884	
				0.909	Average EUR/1,000
400' Well #1	Gas	6,613	4.142	0.626	
400' Well #2	Gas	6,230	3.863	0.620	
400' Well #3	Gas	5,504	3.109	0.565	
400' Well #4	Gas	5,813	3.478	0.598	
				0.602	Average EUR/1,000
EUR/1,000 for 400' spaced wells as a percent of 600' spaced wells				66%	

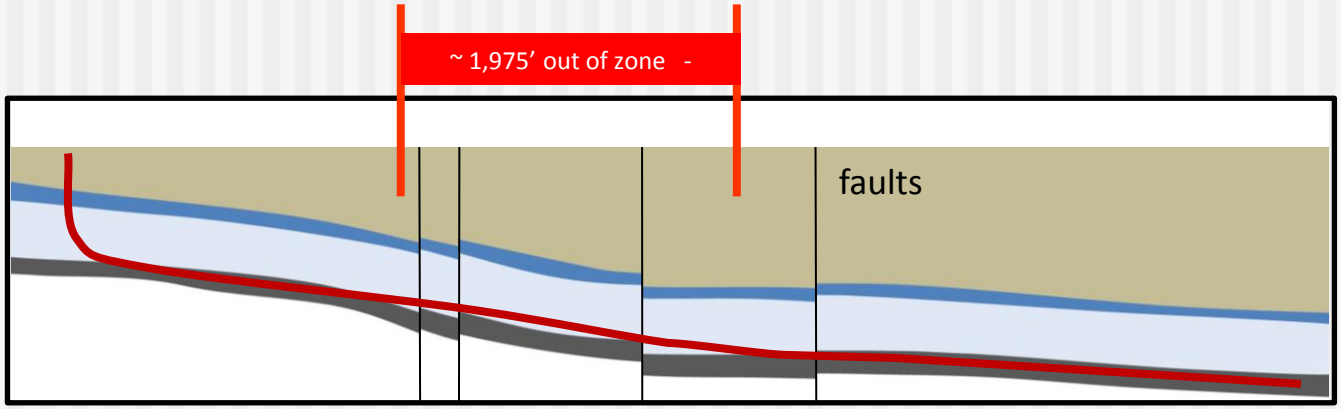
PLACEMENT IN CORRECT LANDING ZONE

Geosteering

7000’ Horizontal Well



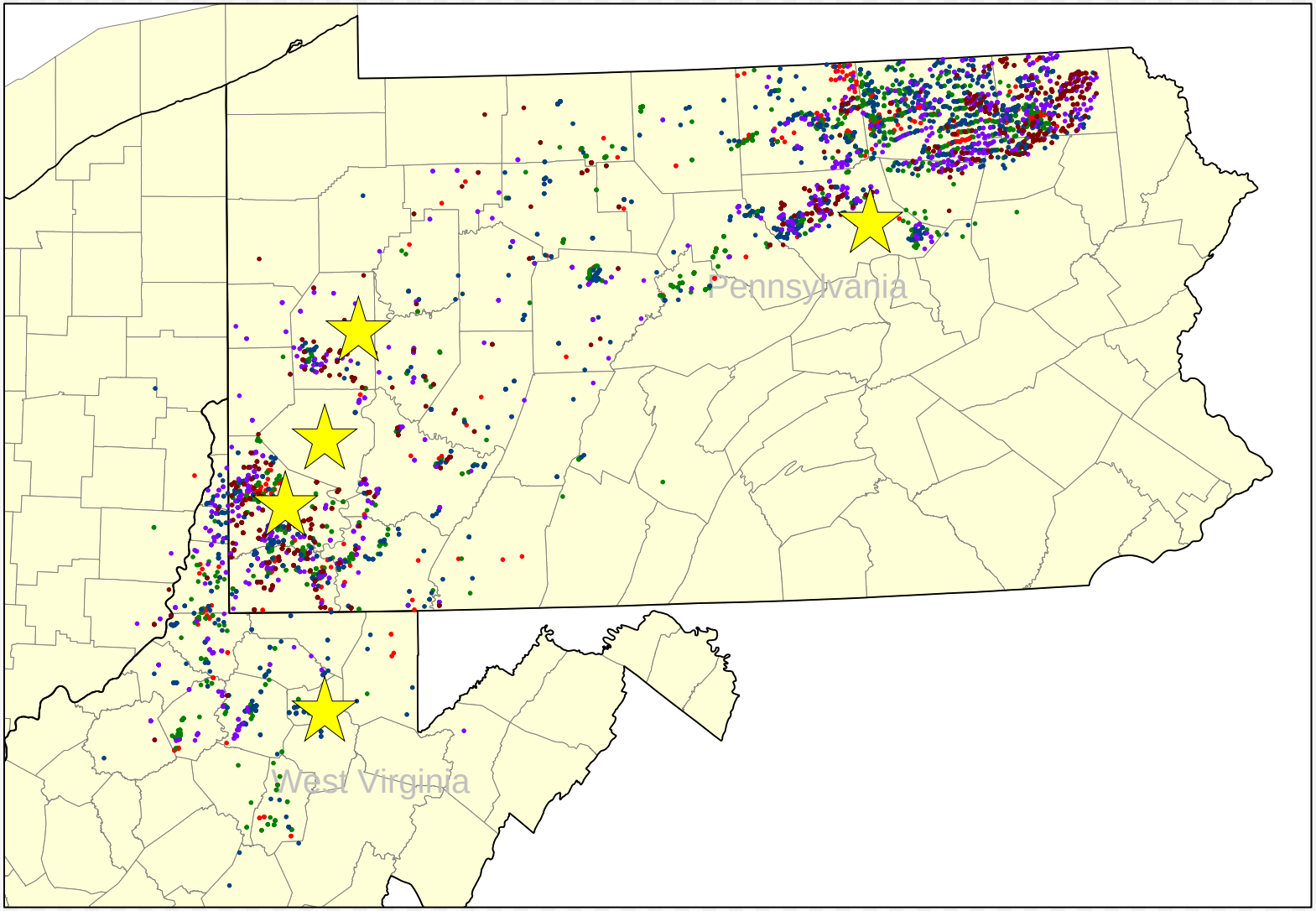
Well 1: Effective lateral length = 7,000’



Well 2: Effective lateral length = 5,025’

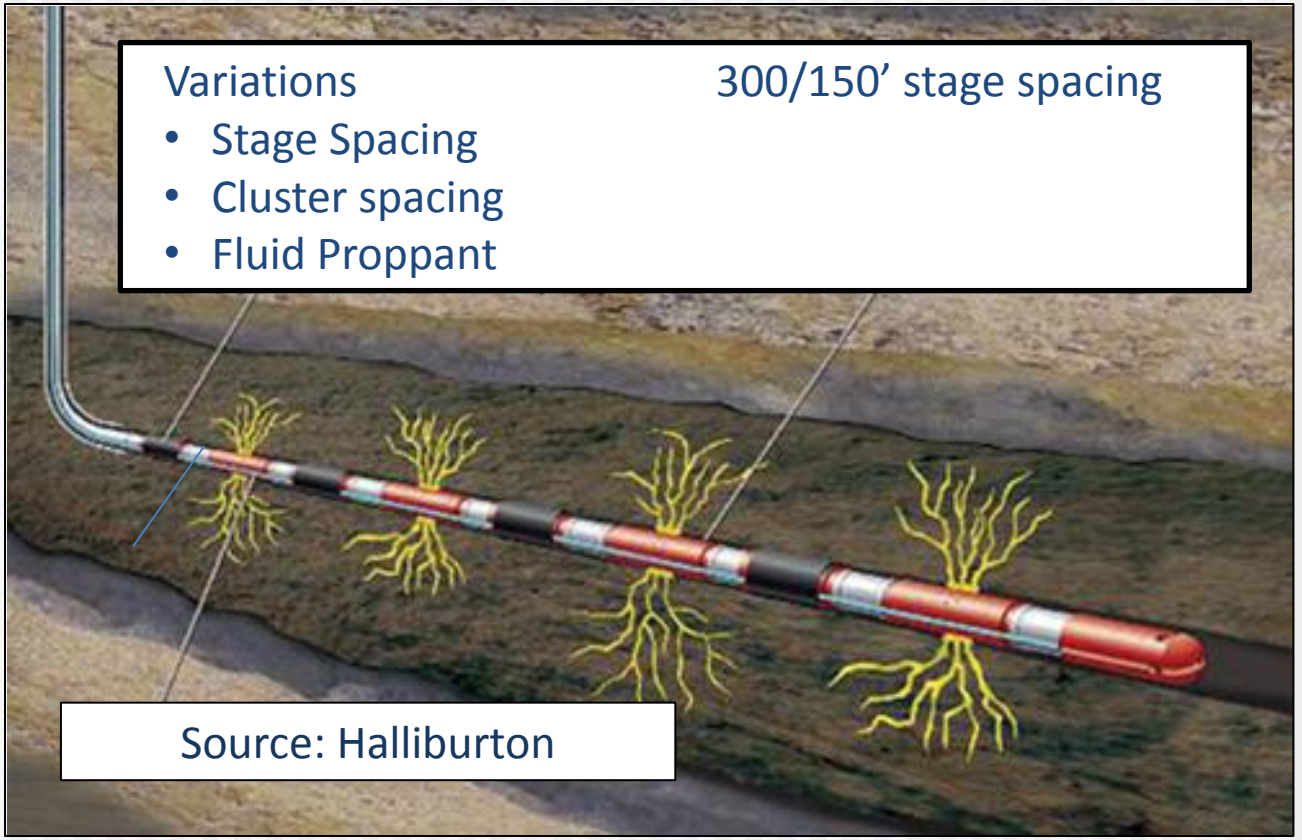
30% reduction in EUR?

WRIGHT STAGE SPACING STUDY AREAS



Source: Drilling Information May 2014

COMPLETION CONSIDERATIONS



AREAS OF IMPROVEMENT:

Stage Spacing

- In the Marcellus, Wright has observed a consistent uplift in EUR/1,000' for short stage spacing versus long stage spacing (Generation 2 vs. Generation1). Total of ~400 wells studied

Marcellus example in <u>one area</u> of the play:

- Generation 1
  - ~300' stage spacing
  - # wells = 30
  - Average EUR/1000' = 1.3
- Generation 2
  - ~150' stage spacing
  - # wells = 33
  - Average EUR/1000' = 1.6

<u>Improvement of ~ 20%</u>

HOW DO WE USE THIS?

Generation 1 (Old) vs. Generation 2 (New)

- If we are evaluating undeveloped locations with many Generation 1 producers nearby, we may need to account for planned development according to Generation 2 practices
- Must also include the extra expense/time associated with more frac stages in AFE and development schedule.
- If undeveloped locations are **clearly** analogous to the Generation 1 producers and show consistent resource characteristics, it may be appropriate to multiply the average demonstrated EUR/1,000' times a "Learning Curve Factor" or "uplift"
- From previous example, the Learning Curve Factor could be ~1.2 (~20% uplift)
- Must consider proved undeveloped reserves definitions of Securities and Exchange Commission (SEC) if we apply "uplift"

CONCLUSIONS

- Many factors have been optimized, and EUR/1000' has generally increased, as operators have moved from the original Learning Curve to a new Learning Curve in the various shale plays
- Accounting for the Learning Curve improvements may be appropriate when comparing Generation 1 to Generation 2
- Reserves assignments should represent planned future development practices, not out-dated ones
- Wright has been able to quantify potential "uplift" factors in many parts of the Marcellus, Utica/Pt. Pleasant, and other shale plays
- Application of Learning Curve factors must still conform to SEC guidelines
- The "Learning Curve Uplift" may be reasonable based on individual operator experience
- Every operator has their own "Learning Curve" and may not be repeated trying to "do what they did"

ESTIMATING RESERVES

- There are **Known-Knowns** – Things we know that we know
- There are **Known-Unknowns** – Things we know that we do not know
- There are **Unknown-Unknowns** – Things we do not know that we do not know.

- Former U.S. Secretary of Defense Donald Rumsfield

THANK YOU!

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