Analytics in Unconventional Plays

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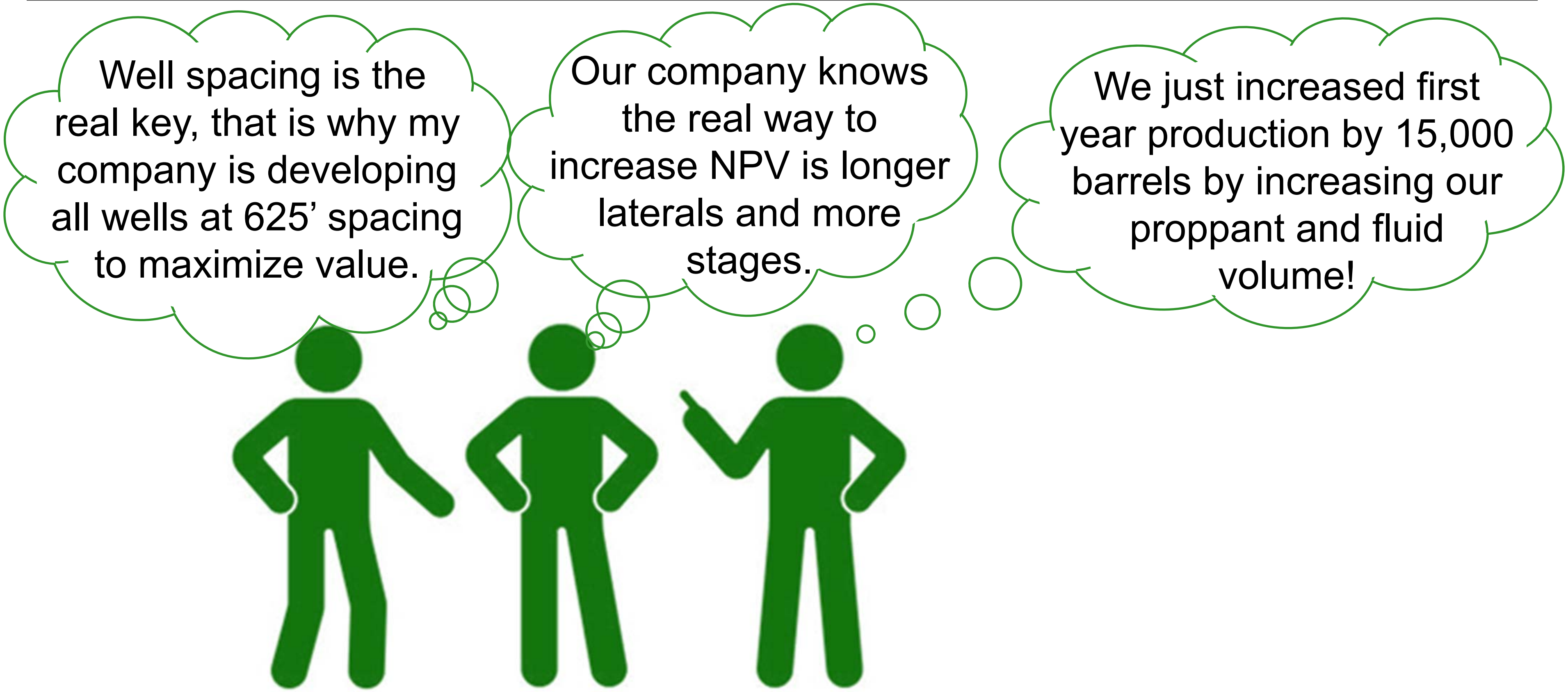
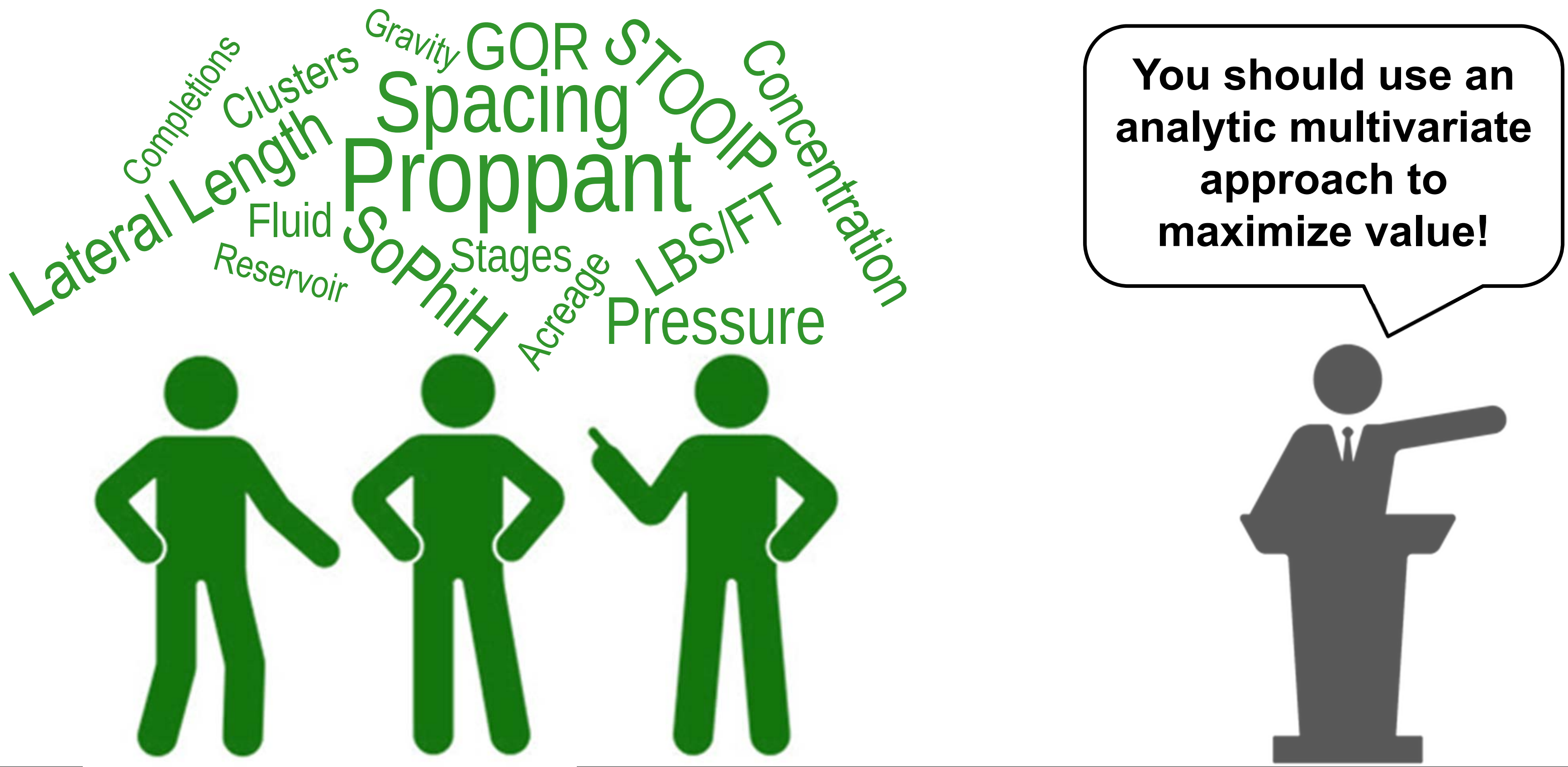
Ryder Scott Company

What You Are Thinking



What You Are Thinking



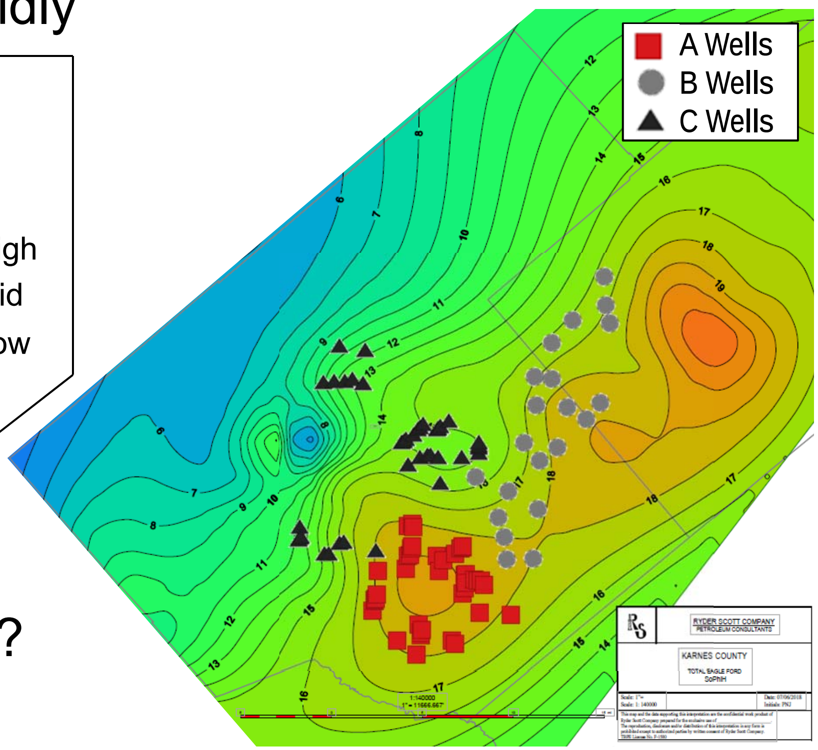
The Challenge

- Completion designs are changing rapidly

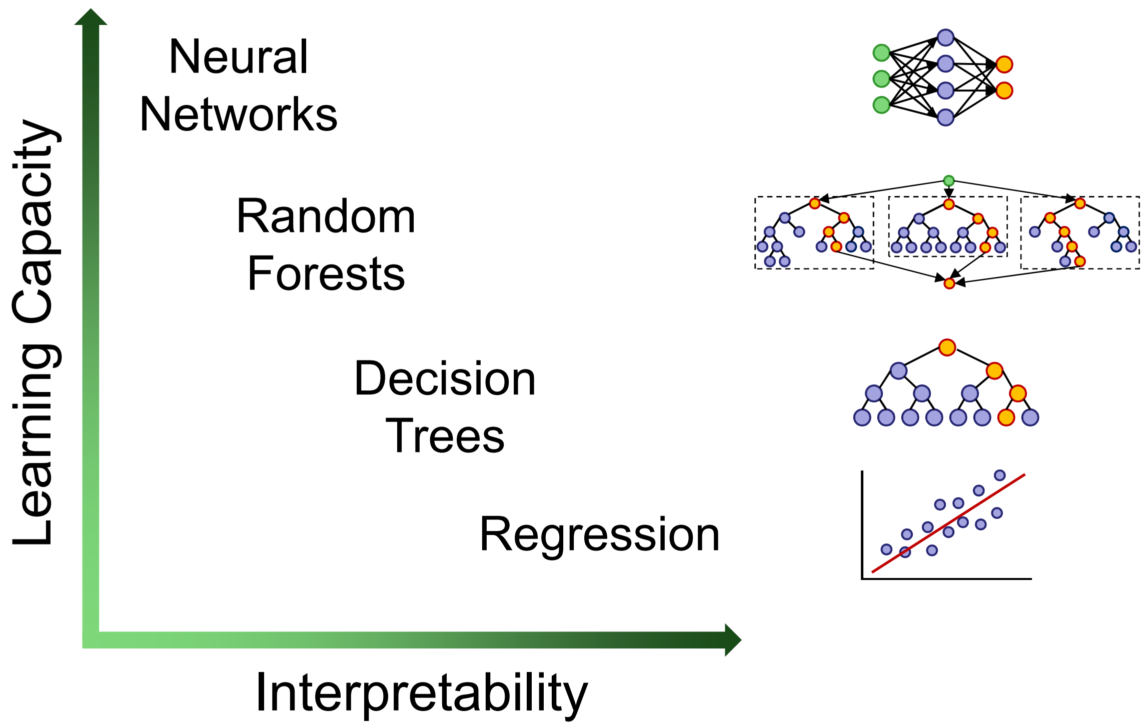
	A	B	C
Geology	Best	Good	OK
Lateral Length	5,000	7,500	9,500
Proppant LBS/FT	2,000	1,500	2,500
Stage Length	300	280	200
Well Spacing	262	625	525
Reserves BBL/LatFT	**61**	**72**	**60**

High
Mid
Low

- Considering all factors, can an operator create a better development plan to maximize value of future wells?



Methodologies

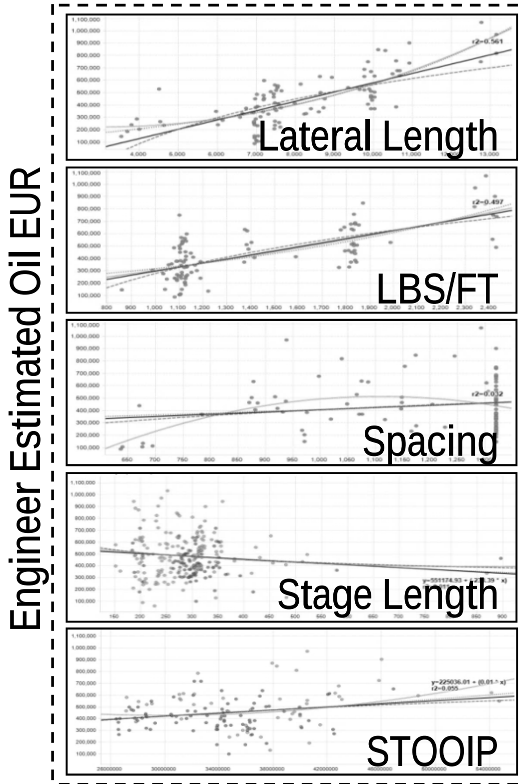


Linear Regression:

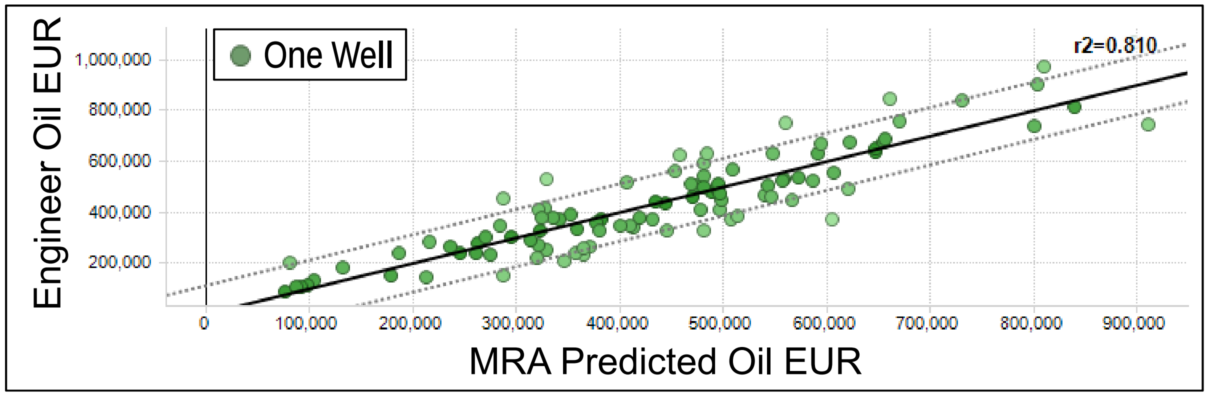
- Meaningful insights
- Easy to interpret
- Very accessible

What is Multivariate Regression Analysis

Single Variable Relationships



Combined Multivariate Relationship

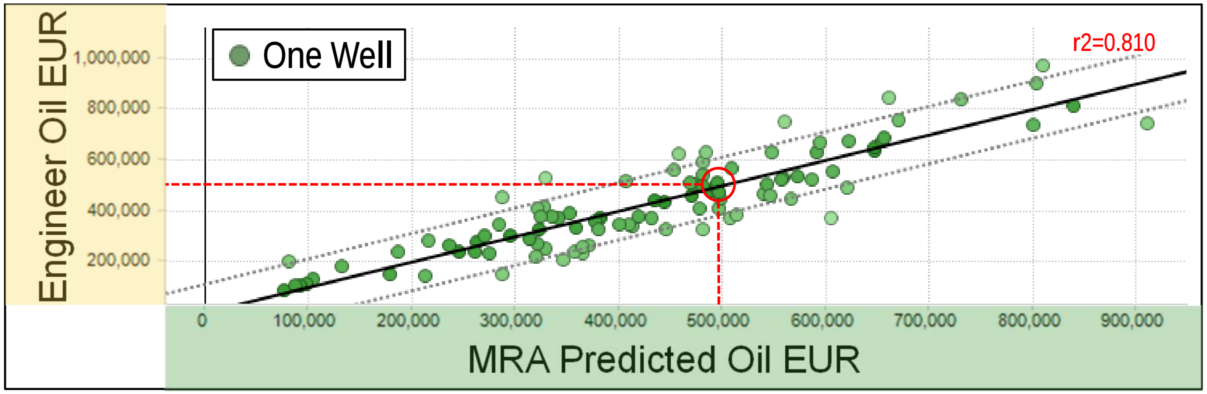


Statistical Analysis Aids Understanding:

- Significance of geologic variables
- Impacts of individual variables
- Impacts of ever changing completion designs
- Value improvement insights

What is Multivariate Regression Analysis

R^2 is the amount of variation in the dependent variable explained by the independent variables

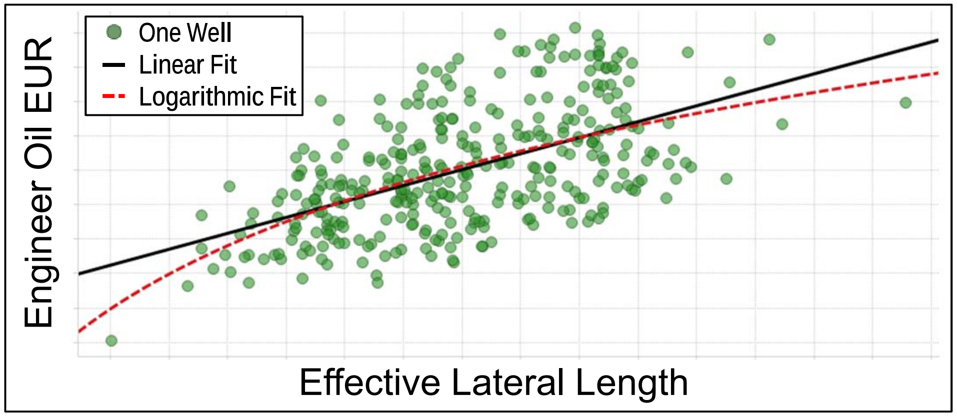


Multivariate Regression Analysis generates an equation

Variable List	MRA Weights		Well Values		MRA Equation
• Intercept	- 200,000			=	- 200,000
• Lateral Length	56	x	7,000	=	392,000
• Proppant LBS/FT	120	x	1,200	=	144,000
• Well Spacing	300	x	500	=	150,000
• Stage Length	- 400	x	350	=	- 140,000
• STOOIP (MMBLS)	8,000	x	19	=	152,000
				Σ	**498,000**

Relationship Considerations

- Each continuous variable is described by a line or curve
- A linear relationships implies that each incremental lateral foot will bring about an equal change in reserves or production
- Other relationships, such as a logarithmic fit, imply a diminishing return in reserves or production for each addition foot drilled

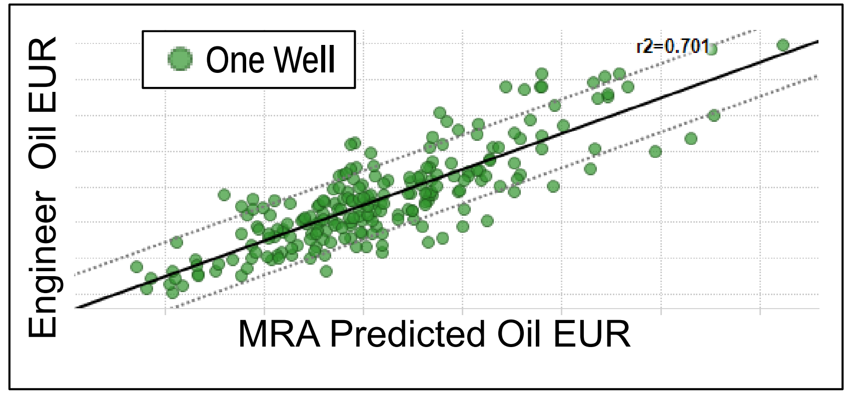


Engineers and Geologists need to work with the statistician

- Engineering and geology principles are applied and need to be continuously considered

Variable Importance and Time

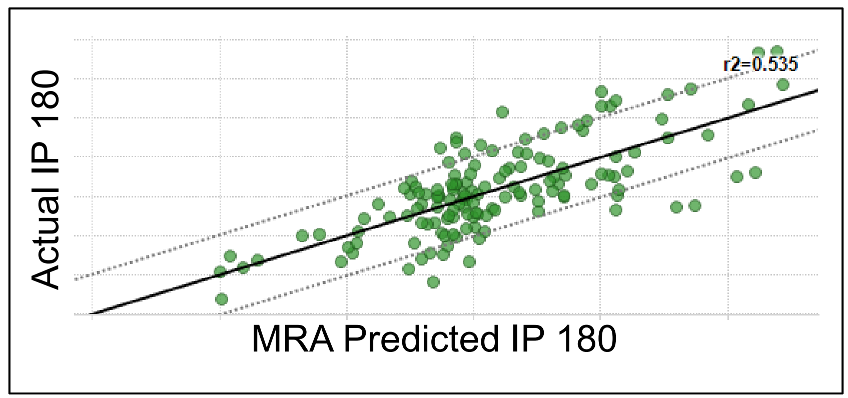
- Variable importance changes depending on the period of time or area under study
- Early time: Completion variables are more impactful
- EUR: Geologic/spacing variables are more impactful



EUR Variable List

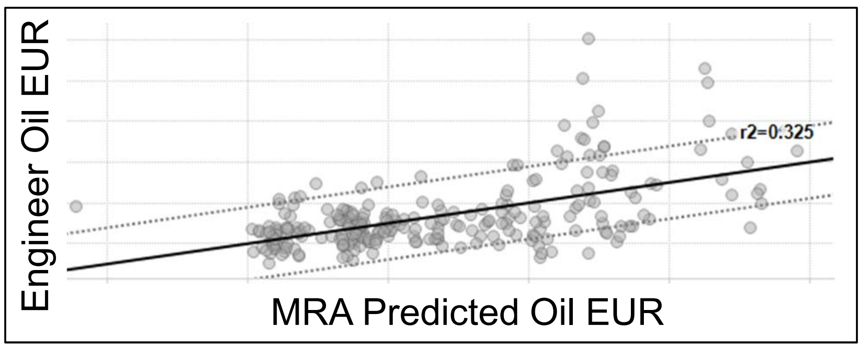
- Effective Lateral Length
- Proppant LBS/FT
- Proppant Concentration
- Stage Length
- STOOIP
- Well Spacing

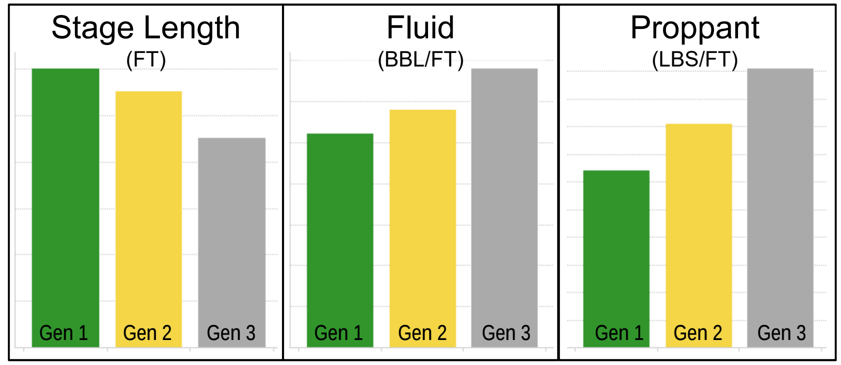
IP 180 Day Variable List

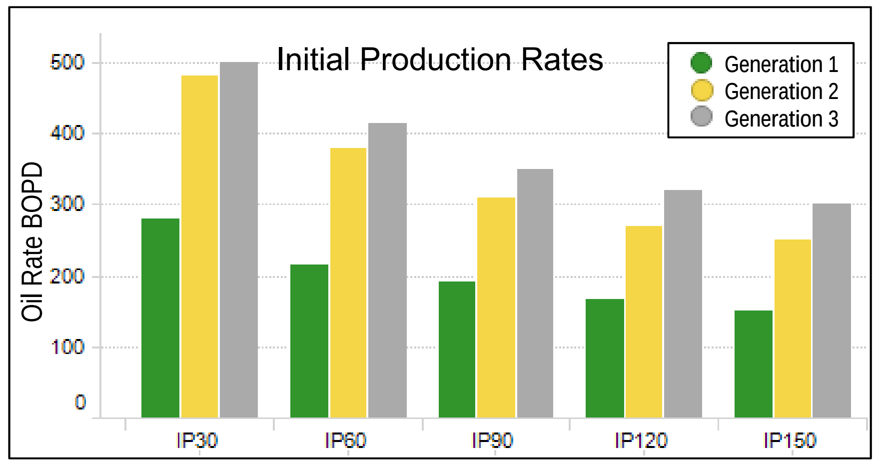


Key Variable Impact

- With completion designs changing, how should reserves volumes be estimated?
- Are these variables actually causing a change in reserves?
- Are there additional variables that should be considered?







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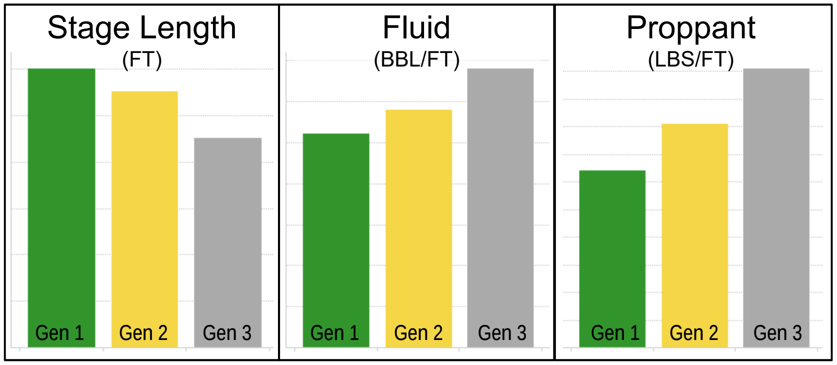
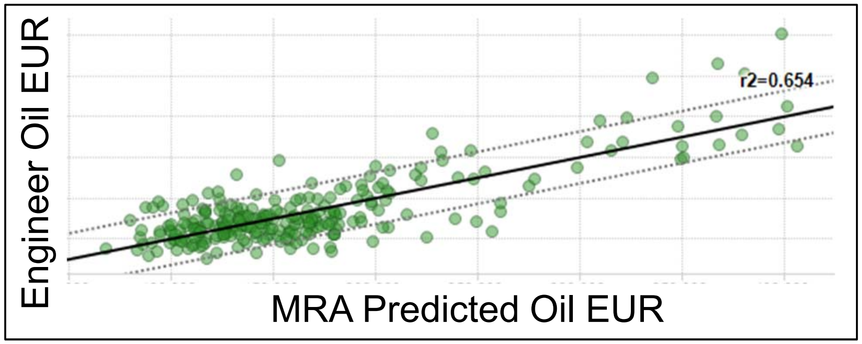
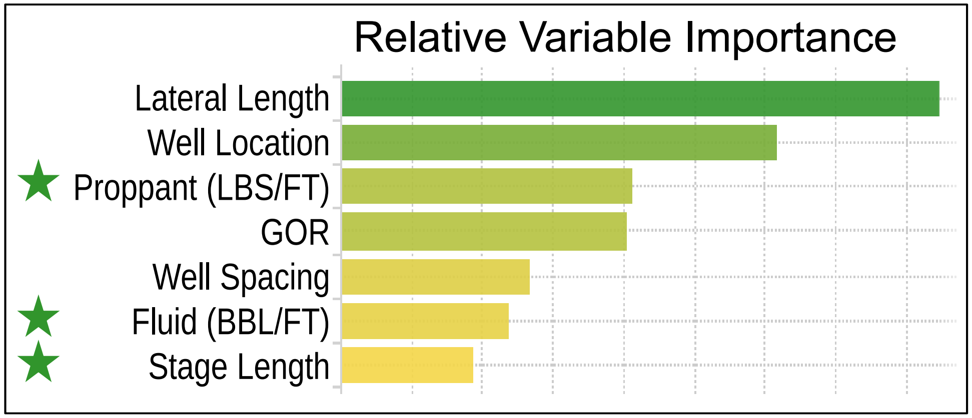


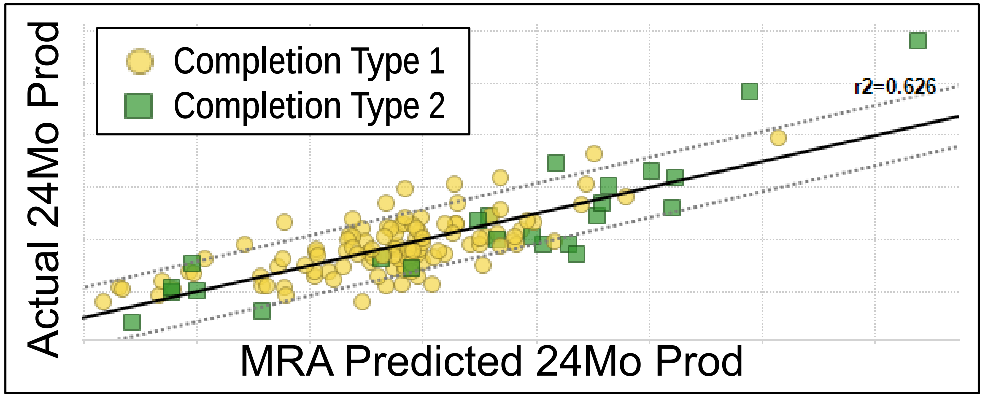


R^2 increases from 0.32 to 0.65



Determination of Categorical Differences

- Is there a difference in completion type performance?
  Completion Type 2 wells produce 35,000 additional bbls in the first two years of production



Variable List

- Effective Lateral Length
- Proppant LBS/FT
- Stage Length
- Well Spacing
- Fluid Properties
- Completion Type
- Geology

Determination of Categorical Differences

- Is there a difference in completion type performance?

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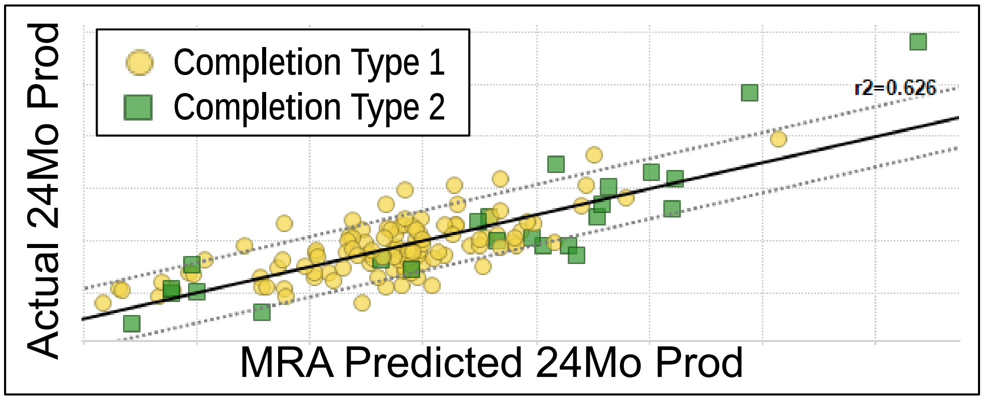


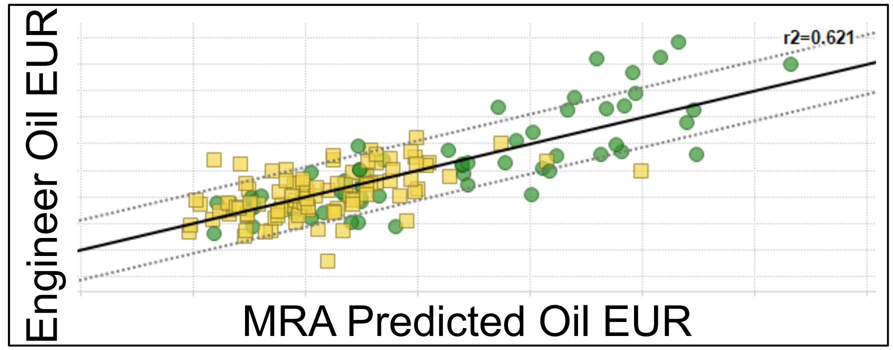
- What other categorical differences could be tested?
  - Reservoirs

    Do they act similarly to completions when limited geology is available?
  - Operators

    Do they achieve similar results?

Benchmarking

Determine if an operator with overlapping acreage is performing better or worse than other operators when taking into account relevant differences



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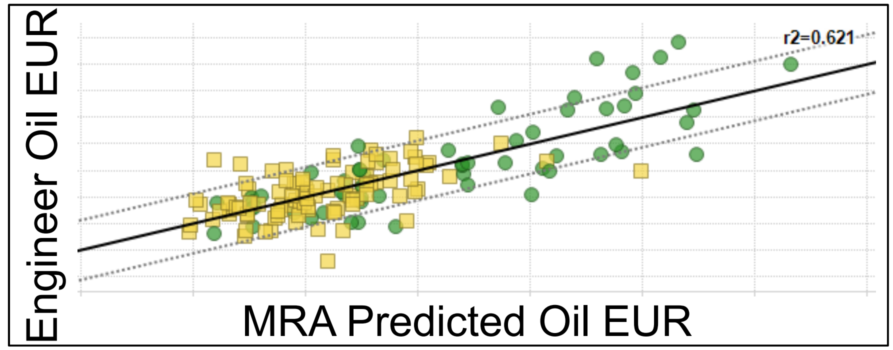
• Lateral Length	56	x	7,000	=	392,000
• Proppant LBS/FT	120	x	1,200	=	144,000
• Well Spacing	300	x	500	=	150,000
• Infill Drilling Factor	- 400	x	350	=	- 140,000
• STOOIP	8,000	x	19	=	152,000
• Operator **A**/B	50,000	x	0	=	0
				Σ	**498,000**

Benchmarking

Determine if an operator with overlapping acreage is performing better or worse than other operators when taking into account relevant differences



What is different between the operators?

Variable List	MRA Weights		Well Values	MRA Equation	
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• Lateral Length	56	x	7,000	=	392,000
• Proppant LBS/FT	120	x	1,200	=	144,000
• Well Spacing	300	x	500	=	150,000
• Infill Drilling Factor	- 400	x	350	=	- 140,000
• STOOIP	8,000	x	19	=	152,000
• Operator A/**B**	50,000	x	1	=	50,000
				Σ	**548,000**

Estimating Variable Impact

Variable List	MRA Weights		Well Values		MRA Equation	Sensitivity
• Intercept	- 200,000			=	- 200,000	
• Lateral Length	56	x	7,000	=	392,000	7.9 %
• Proppant LBS/FT	120	x	1,200	=	144,000	2.9 %
• Well Spacing	300	x	500	=	150,000	3.0 %
• Stage Length	- 400	x	350	=	- 140,000	-2.8 %
• STOOIP (MMBLS)	8,000	x	19	=	152,000	
				Σ	**498,000**	
Lateral Length	56	x	700	=	39,200	7.9 %

Examine how a 10% change in the Well Value affects the equation results.

Sensitivity testing the equation evaluates the impact of each individual variable

Estimating Variable Impact

Passing Results

Variable List	Sensitivity
• Intercept	
• Lateral Length	7.9 %
• Proppant LBS/FT	2.9 %
• Well Spacing	3.0 %
• Stage Length	-2.8 %
• STOOIP (MMBLS)	

Failing Results

Variable List	Sensitivity
• Intercept	
• Lateral Length	**19.4 %**
• Proppant LBS/FT	6.5 %
• Well Spacing	1.4 %
• Stage Length	-2.2 %
• Fluid BBLS/FT	2.2 %
• Well Location	

Screen for outsized individual variable impacts

Sensitivity testing the equation evaluates the impact of each individual variable

Estimating Variable Impact

Passing Results

Variable List	Sensitivity
• Intercept	
• Lateral Length	7.9 %
• Proppant LBS/FT	2.9 %
• Well Spacing	3.0 %
• Stage Length	-2.8 %
• STOOIP (MMBLS)	

Failing Results

Variable List	Sensitivity
• Intercept	
• Lateral Length	**19.4 %**
• Proppant LBS/FT	6.5 %
• Well Spacing	1.4 %
• Stage Length	-2.2 %
• Fluid BBLS/FT	2.2 %
• Well Location	

Screen for outsized individual variable impacts

Gain insights into trends of impact variables

Ryder Scott has seen general trends for specific parameters during sensitivity testing

Is This Reliable Technology?

{2008} *(25) Reliable technology. Reliable technology is a grouping of one or more technologies (including computational methods) that has been field tested and has been demonstrated to provide reasonably certain results with consistency and repeatability in the formation being evaluated or in an analogous formation.*

- Multivariate regression analysis can be considered reliable technology
- Reliability should be demonstrated on a case by case basis
- Sufficient evidence as to what constitutes reliable technology should also be determined on a case by case basis

Conclusion

- Engineering and geology concepts still apply
- Multivariate analysis aids understanding:
  - Significance of geologic variables
    - To what degree does the well's location impact performance?
  - Impacts of individual variables
    - How much will reserves increase if the average lateral length increases?
    - Will additional completions intensity increase production enough to offset costs?
  - Impacts of ever changing completion design
    - With many design elements changing, what is causing the observed change in performance?
  - Value improvement insights
    - Optimization of completions designs and field development plans