Well Spacing & Case Studies

FundamentalEdge | September 2019

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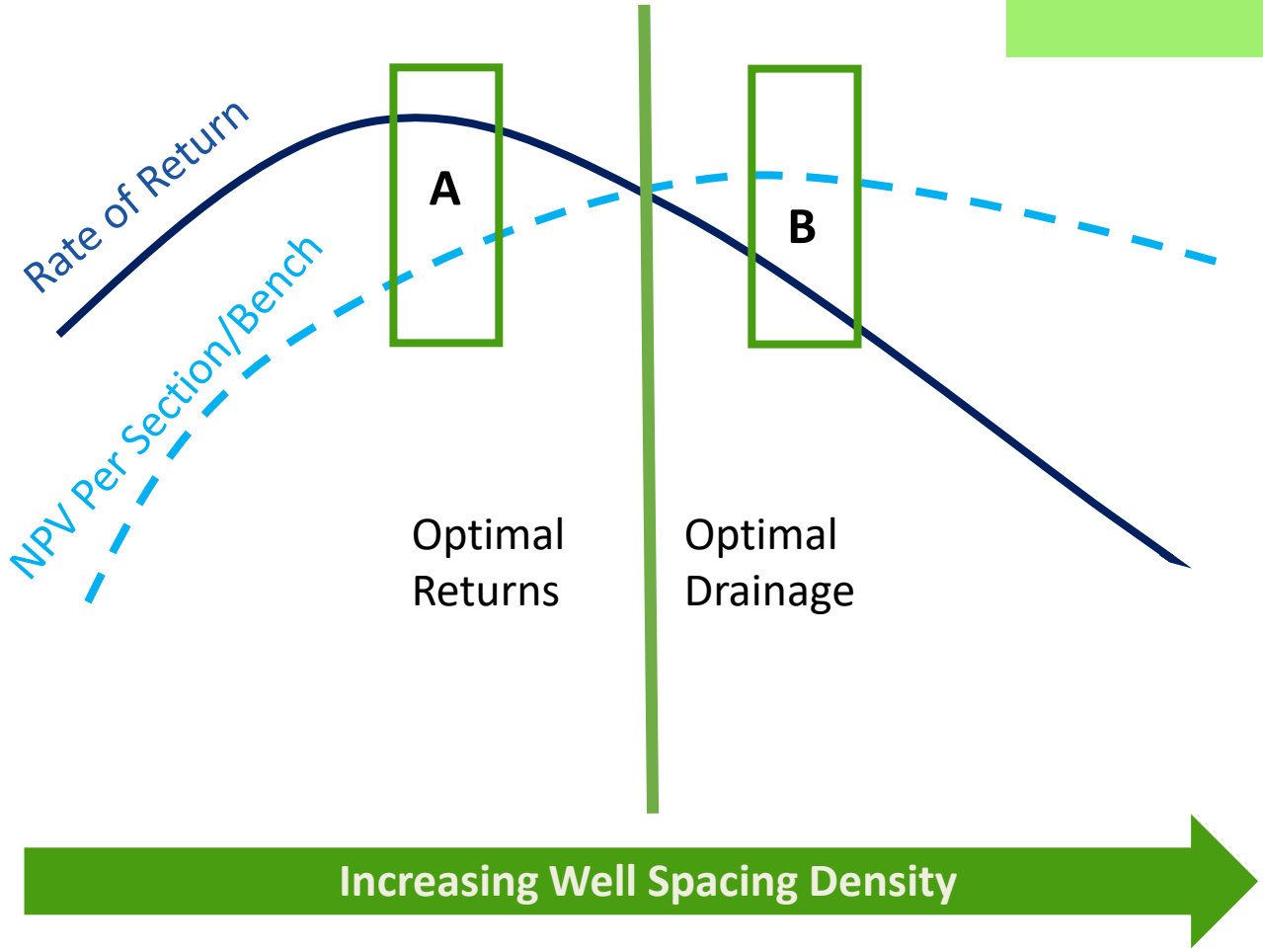
Introduction

- This month's update of the FundamentalEdge report series introduces the concept of well spacing and its importance in a "Free Cash Flow Era."
- One of the biggest challenges for US onshore field development is understanding well spacing, as everyone is trying to answer two main questions:
  - What is optimal spacing at which we should drill wells?
  - How many wells can we drill to optimally drain an area while being cognizant of optimal returns?
- Also at the forefront of the industry is the impact of parent and child well development and well interactions. This raises many questions: Are neighboring wells interacting with each other? Are they degrading well performance? Do offset wells benefit from interference from a newly drilled infill well?
- Decisions on optimal well spacing are quite complex and are a function of multiple geological, engineering, operational and economic variables.
- The case studies shown in this report are just a few examples that were studied utilizing Enverus's "Well Spacing" platform to help answer:
  - How are operators spacing their wells in an area and how has this spacing evolved over time?
  - Do well cost efficiency savings offset productivity loss?
  - What spacing, completions, and geology-related parameters are representative of maximum well productivity?
  - Are neighboring wells interacting with each other? Are they degrading well performance?



A) 4 Wells per Section with 50% IRR each and $8MM Total NPV10
Or
B) 8 Wells Per Section with 20% IRR each and $1.5MM NPV10 Per Well

Key Takeaways

- Spacing is a complex problem. Solving it leads to optimal spacing within a drilling unit. Additionally, it is key to proper development of a particular formation in an area to get the highest per well returns and minimize productivity degradation and handle parent/child interactions.

- Figuring out how to optimize well spacing to maximize productivity is an incredibly complex challenge. This changes from basin to basin, formation to formation, sometimes even section to section.

- Understanding parent-child relationships and optimized spacing at a basin level is insightful to understand trends. But one has to get more granular and dive deeper to get the full picture and this requires a reliable, robust, and engineered dataset.

- Enverus's Well Spacing Solutions give the user the ability to dive through the most comprehensive Well Spacing dataset available. By combining geology, completion, production, M&A as well as well placement and timing data sets rather than looking at well spacing metrics in a vacuum, Enverus reveals the important factors that impact operations and productivity.

- The parent/child interactions, future field developments and inventory studies, cost savings through spacing pilot and formation delineation programs must be mastered to facilitate operations excellence as well as deliver growth, cash flow and returns for shareholders. Enverus's Well Spacing Solutions is a comprehensive and technically robust well-spacing solution that can help companies navigate through all these challenges and drive value.

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VALUE OF ENVERUS WELL SPACING – WILLISTON EXAMPLE

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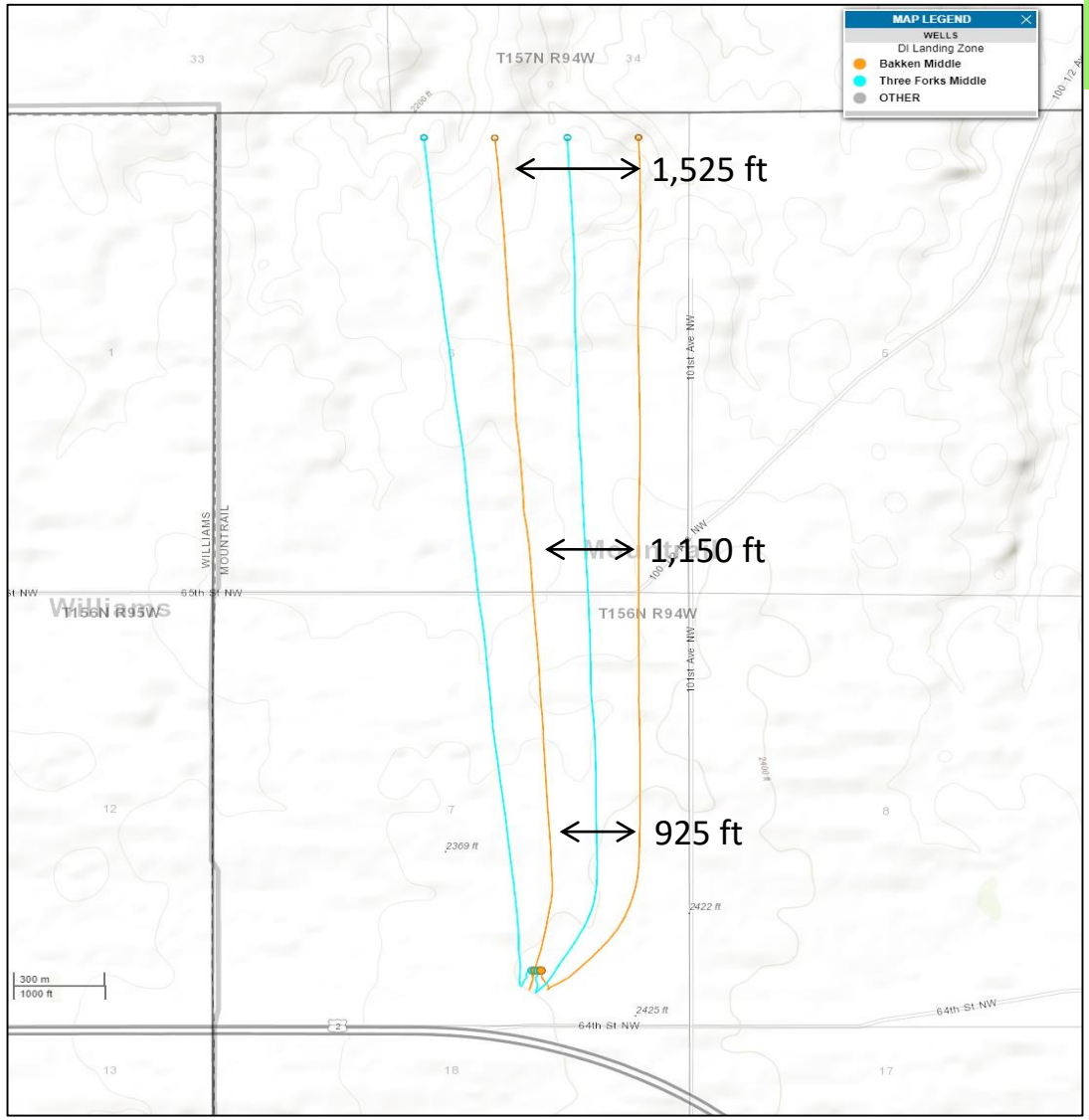
Williston Well Spacing Example

Well Spacing Is Complex

- Understanding well spacing is like peeling back an onion. It is far more complex than something that can be understood by a single distance measurement.
  - Horizontal and Vertical Dimension
  - Same Zone and All Zones Dimension
  - Wellbores Aren't Straight Lines
- Enverus used to calculate spacing in a simple way that was yielding inadequate, inaccurate results.
  - Midpoint/Similar Elementary Calculations
- Enverus's Well Spacing now does it the right way, calculating more than 300 comprehensive attributes.
  - Horizontal, Vertical, and True Distances
  - Same Zone and All Zones
  - Min, Max, and Mean Calculations
  - Ability to Understand Distance Variations
  - Synthetic Trajectories (modeled before directional surveys are available)
- In the graphic on the right are four wells in the Williston Basin: 2 Middle Bakken, 2 Three Forks formation. For the Middle Bakken wells:
  - Midpoint = 1,150 ft Spacing
  - Min-Max = < 925 ft – 1,525 ft Spacing
  - DI Spacing Avg = 1,333 ft Spacing
  - Midpoint Overestimates Min Spacing > 19%
  - Midpoint Underestimates Avg Spacing 16%
  - Midpoint Underestimates Max Spacing 32%
- Across the whole Williston Basin, a midpoint approach would underestimate Middle Bakken formation spacing by 10%.

Basin	Formation	Midpoint (ft)	DI (ft)	Difference
Williston	Middle Bakken	866	954	10%

Williston Well Spacing Example



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Source: Enverus, Well Spacing

Enverus's Well Spacing prevents costly errors

An inaccurate, simple spacing metric has ripple effects across all parts of the industry.

With a simple spacing metric, an operator might plan to drill 12 wells in an acreage position in Mountrail Co. (Williston Basin).

With Enverus's enhanced spacing metrics, they realize that optimal spacing requires 16% fewer wells, ending up with 10 instead.

Scenarios	E&P	Minerals	Midstream	OFS
This table illustrates the impact of drilling 10 wells over 10 months using the Enverus's Spacing algorithm vs. 12 wells over 12 months using a simple, inaccurate spacing methodology.	The change in implied NPV10 resulting from drilling two fewer wells in an acreage position is $26MM lower. The simple spacing metric results in a 22% overvaluation.	Assuming a 20% royalty, with a simple spacing metric, the minerals company would have overvalued the 10% discounted royalties from the acreage position by $15MM.	Assuming a $0.50/Bbl gathering & $0.65/Mcf gathering & processing cost, with a simple spacing metric, midstream would overestimate present value by $1.9MM (discounted at 10%).	Assuming a $9.4MM D&C cost, an OFS company that had planned to service the operator on 12 wells this year would overestimate their revenues during the year from the acreage position by $19MM.
Simple Spacing 12 Wells	$116MM	$67MM	$8.5MM	$113MM
DI Spacing 10 Wells	$90MM	$52MM	$6.6MM	$94MM
Difference ($)	**-$26MM**	**-$15MM**	**-$1.9MM**	**-$19MM**
Difference (%)	**-22%**	**-22%**	**-22%**	**-16%**

Type curve based on Mountrail Co. wells drilled after 7/1/2017 normalized to 10K ft. & 1,200 lbs/ft prop.
20-yr. half-cycle economics. $60/Bbl WTI & $2.75/MMBtu HH. $2/Bbl & $0.60/MMBtu diff.

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Source: Well Spacing, WellCast

CASE STUDIES – SCOOP/STACK/MERGE

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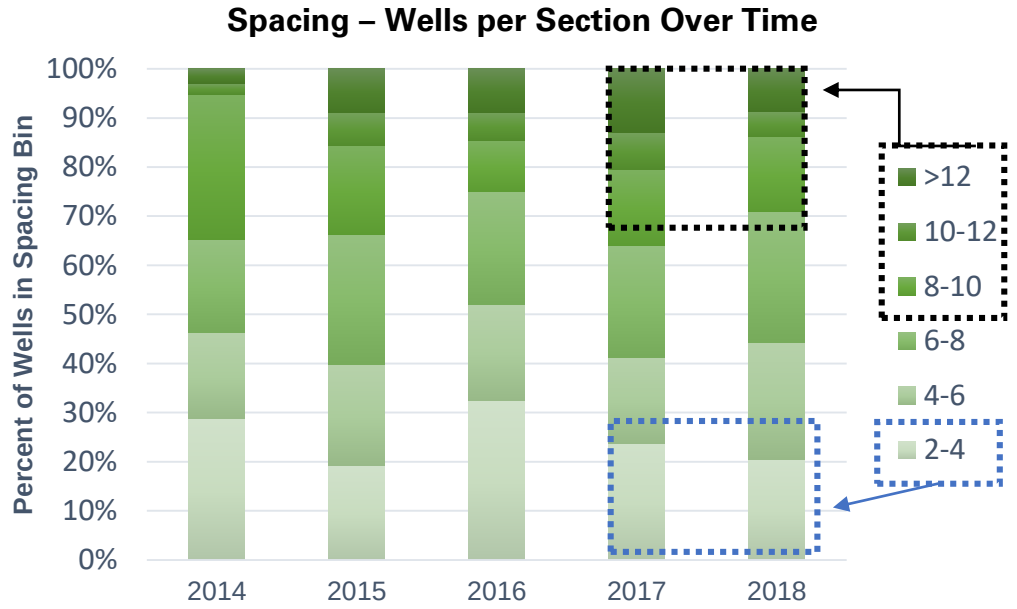
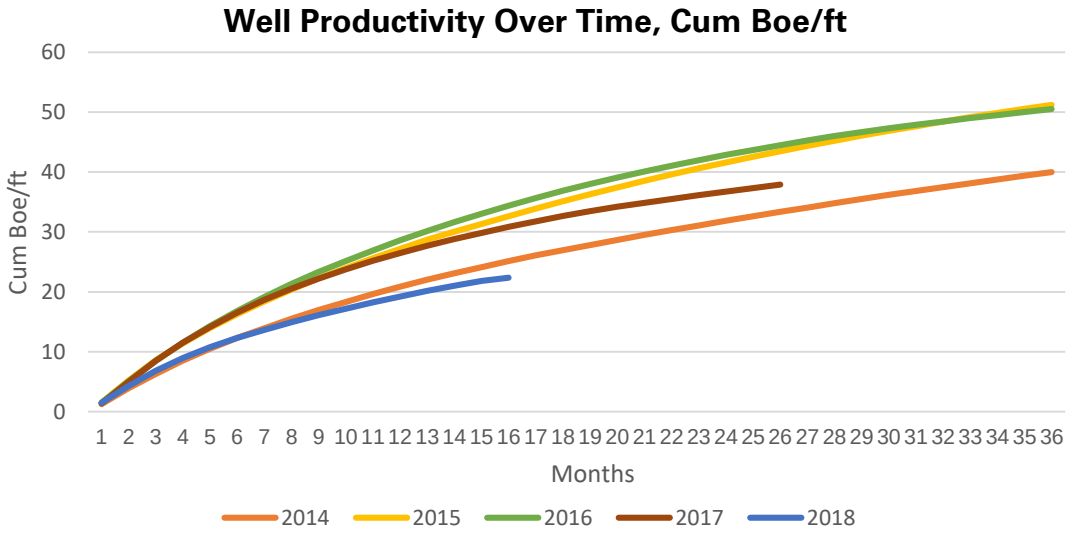
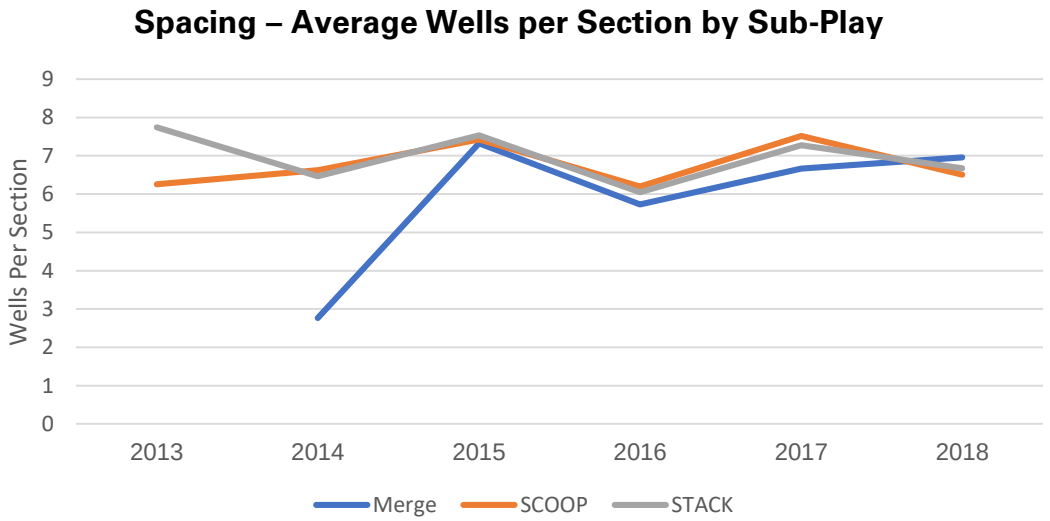
SCOOP/STACK: SPACING TRENDS

- In the SCOOP/STACK, there have been increasing concerns that aggressive down-spacing programs have negatively impacted well productivity.
- While there does appear to be type curve degradation at the play level, operators have consistently been spacing wells at an average of six to seven wells per section prior to any type curve degradation trends.
- The amount of “cube” pad development has been offset by activity expanding out of the core to less-developed regions with much smaller pads, noted on the bar chart; 20-25% of wells are drilled in both the large and small pad bins.
- This equal distribution of well spacing practices illustrates the difference in the operational philosophies and geological variance in the play. Isolated analysis is required to understand spacing impacts. Spacing has been consistent across each of the sub-plays, as seen in the graph to the lower right.







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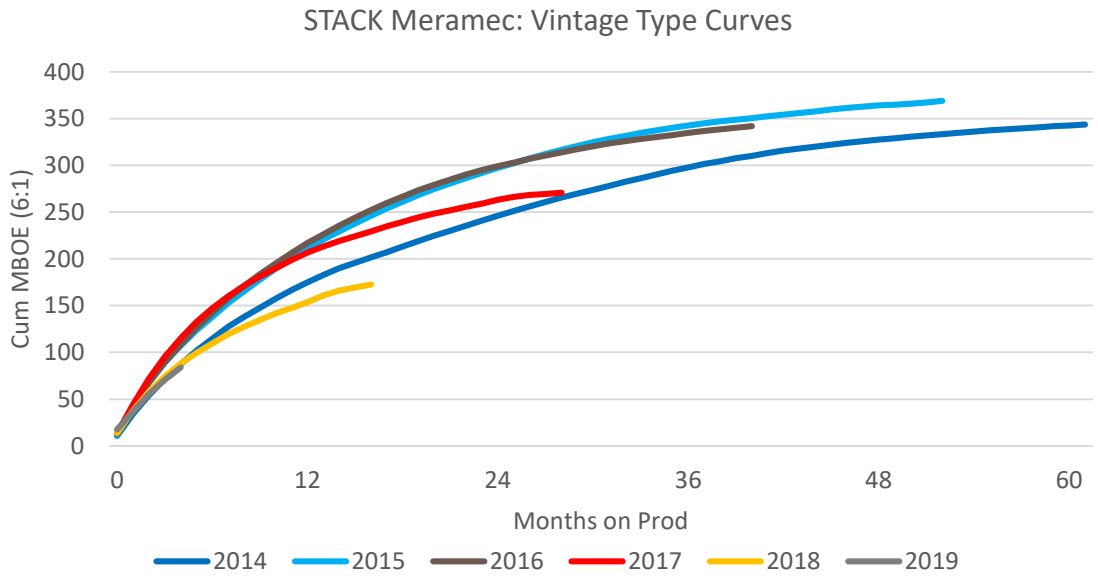
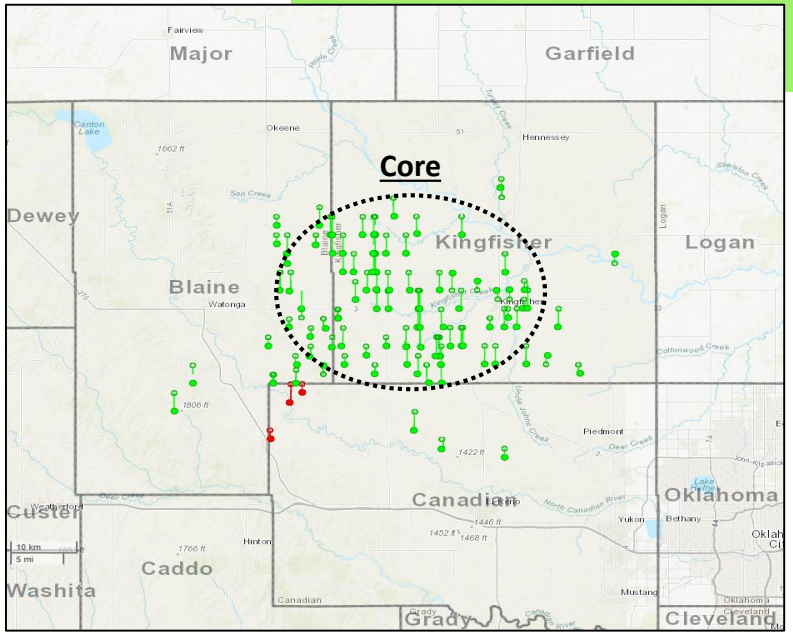
Source: Well Spacing, Basin Studies

Simple Doesn’t Cut It

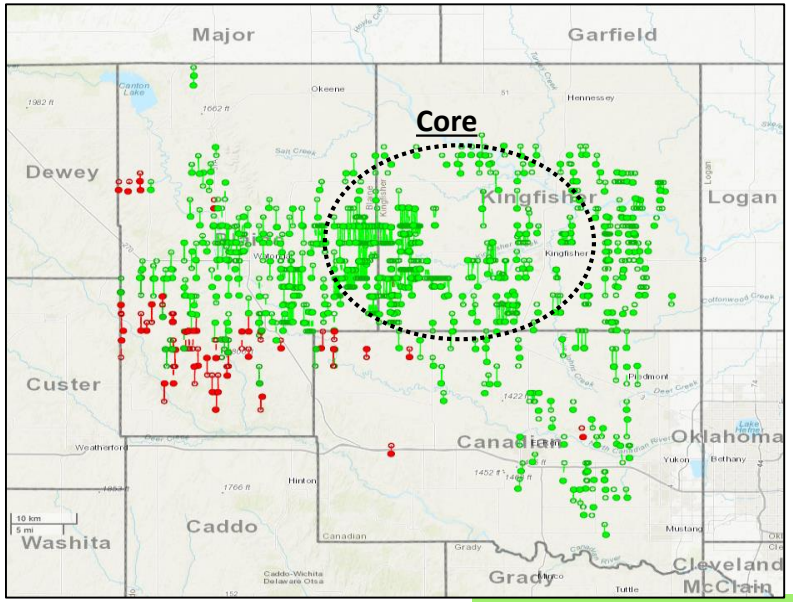
- As per the vintage STACK Meramec formation cumulative type curves in the chart, single well productivity peaked in 2015 and type curve degradation has been observed since, particularly in 2017+.
- STACK has been under scrutiny due to the perceived parent/child and downspacing impacts on productivity. However, a simple look would show that, although average spacing has stayed the same, the productivity has suffered.
- The devil lies in the details, as the issue is twofold:
  - Operators moving out of the core to lower tier areas.
  - Downspacing and parent/child well issues in the core.
- It is insufficient to attribute all productivity declines to spacing issues, and the impact of lower tier drilling must be isolated from the analysis to understand the true impact of spacing on productivity.



2015 STACK MERAMEC WELLS



2017+ STACK MERAMEC WELLS



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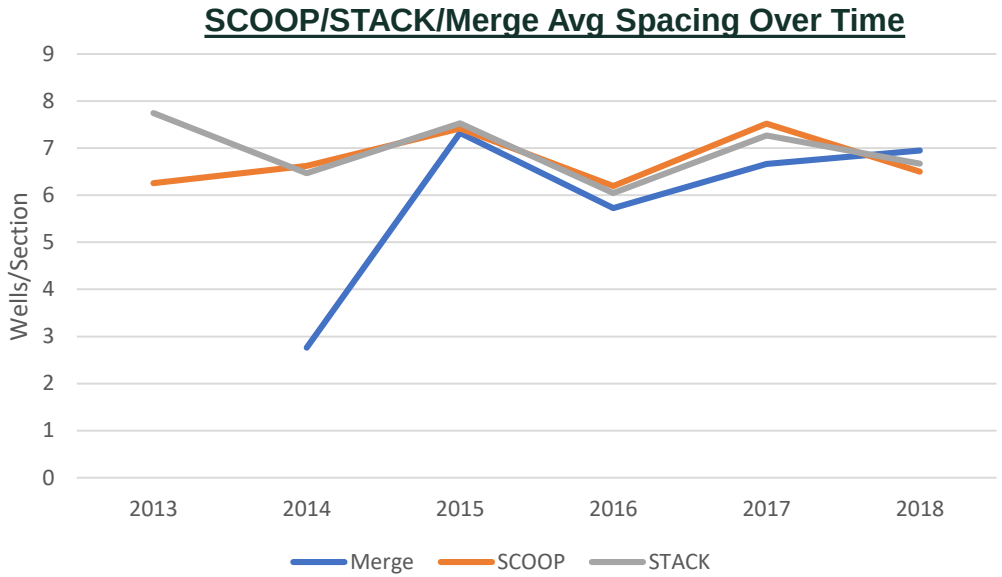
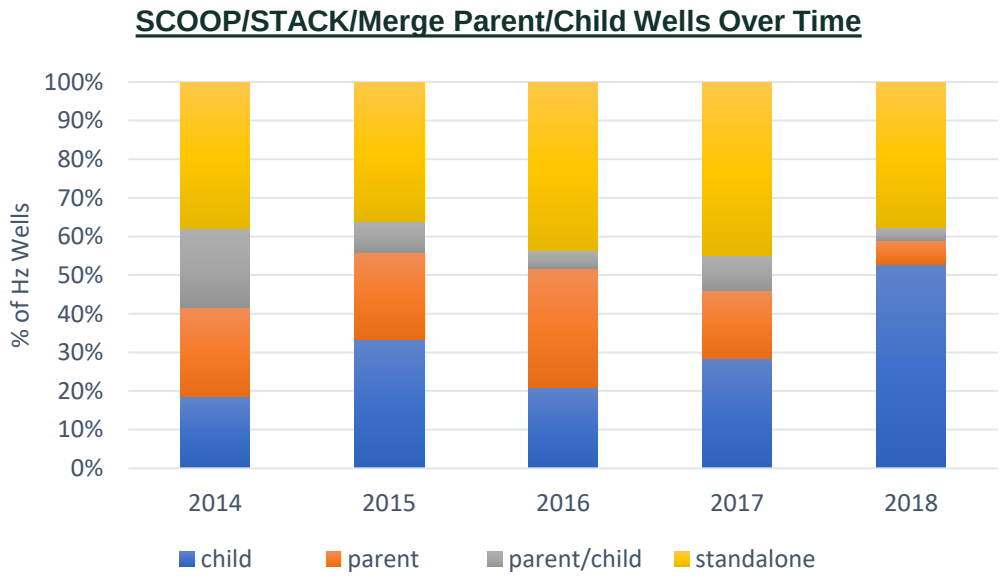
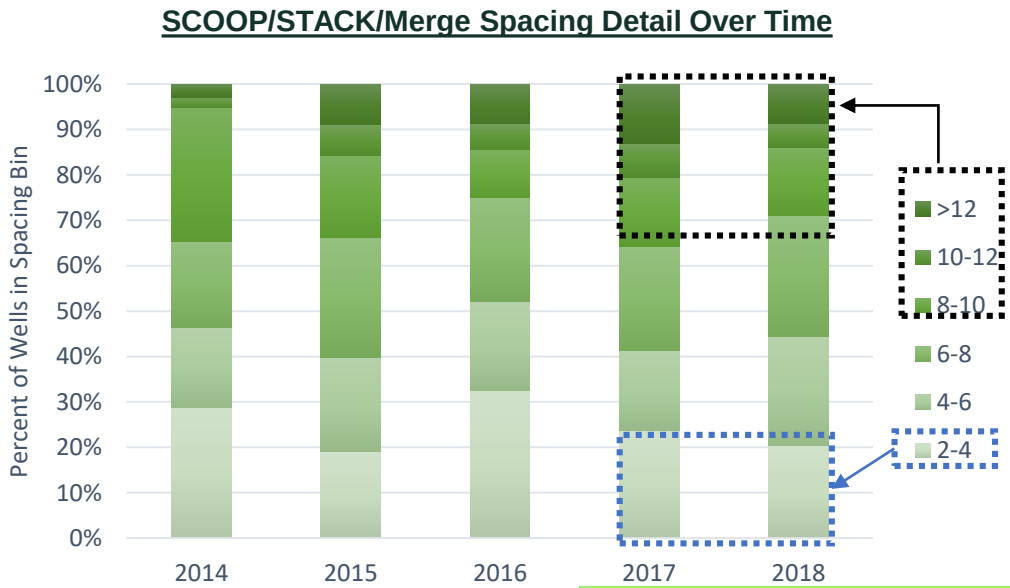
Source: Enverus

Unpacking the Details

- Since the simple average spacing metrics do not show a change in STACK spacing over time, they are not helpful or representative of what is happening in the basin.
- The detailed spacing shows that the mix of 2-4 wells/section and the 8+ wells/section has increased, however. The 2-4 wells/section are outside of the core. The 8+ wells/section are in the core. Meaning the average is misleading and the type curve degradation needs to be measured for the more tightly spaced core areas.
- Additionally, understanding which wells are parents for those tighter spaced areas and which ones are child wells is crucial in understanding productivity degradation from a sub-optimal spacing and well timing perspective.







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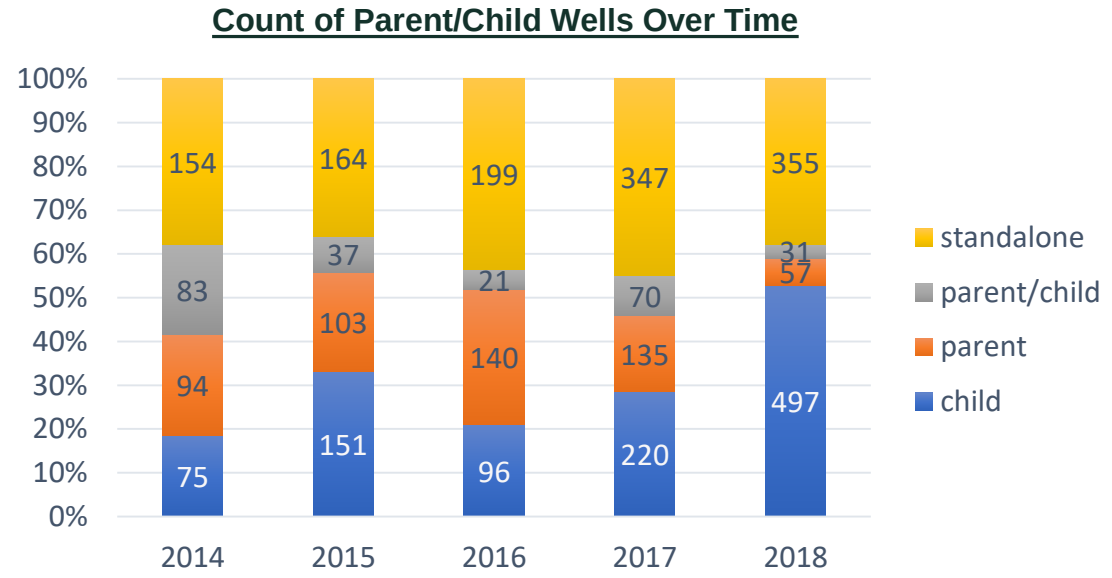
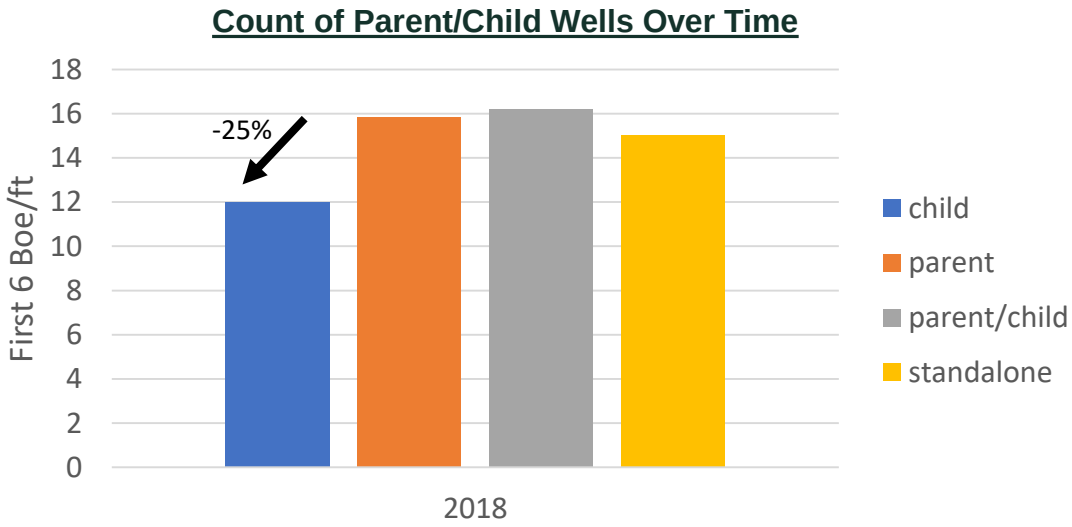
Source: Well Spacing

SCOOP/STACK: Parent/Child Productivity

- The other component of analyzing well interference is analyzing parent/child well relationships.
- The number of child wells drilled per year has greatly increased over the past two years, approximately five times the number from 2016 to 2018.
- By isolating wells that were completed in 2018, there is a 25% productivity decrease from parent to child wells.
- The SCOOP/STACK has a handful of emerging regions. Standalone wells (no offset wells in a half-mile radius) have accounted for roughly 40% of new wells drilled since 2016.
- While the wells in the emerging, non-core areas will not have interference issues, an operator may still be learning best practices in the area.
- Although the performance degradation of the basin may not be all because of well interference and parent/child issues, Enverus's spacing analysis shows that it is clearly playing a role.





Notes: The spacing status is analyzed for current time, not when the wells were drilled. The "parent/child" status is when a well is a parent to a well or a group of wells and also a child to a well or group of wells.

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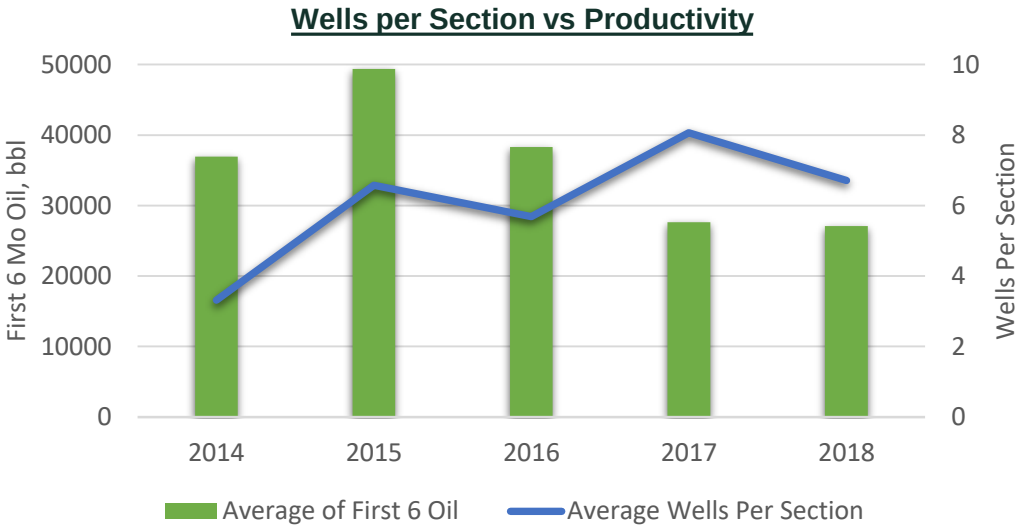
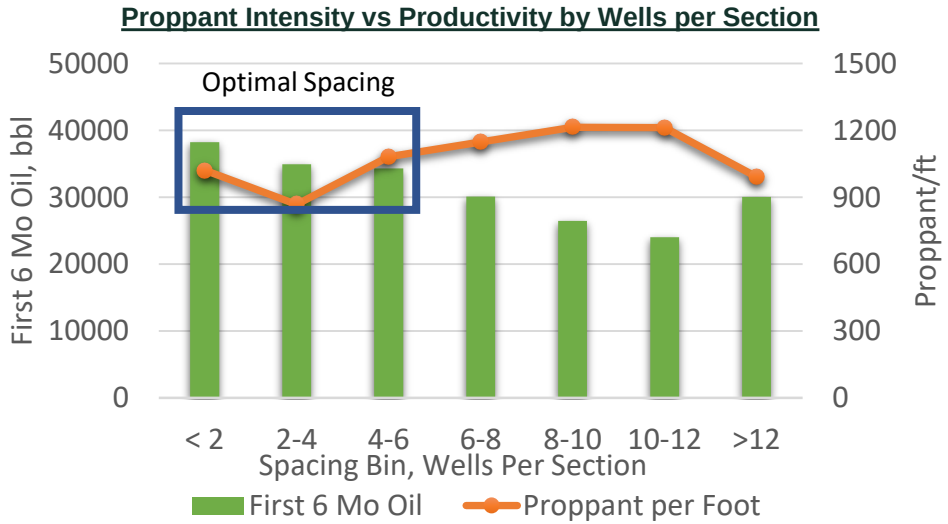
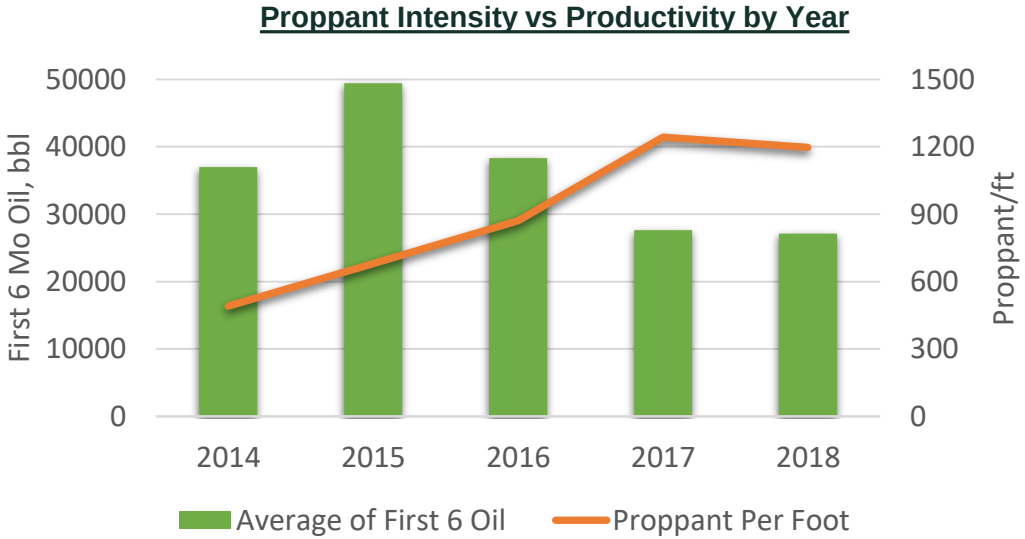
Source: Well Spacing, Basin Studies

SCOOP/STACK: A Case Study

- This slide analyzes a case study for an operator targeting the Mississippian in the normal-pressured window of the STACK in Kingfisher County.
- The operator increased their well spacing from six to eight wells per section from 2016 to 2017. At the same time, they increased proppant intensity ~40%. This resulted in a ~30% loss in productivity, shown in the graphs on the right.
- Optimal spacing and completion combination appears to be six wells per section, with a frac of 800-1,000 lbs/ft for this operator in the area and formation.
- An aggressive development plan of increasing frac intensity and down-spacing can greatly impact productivity to the negative side.







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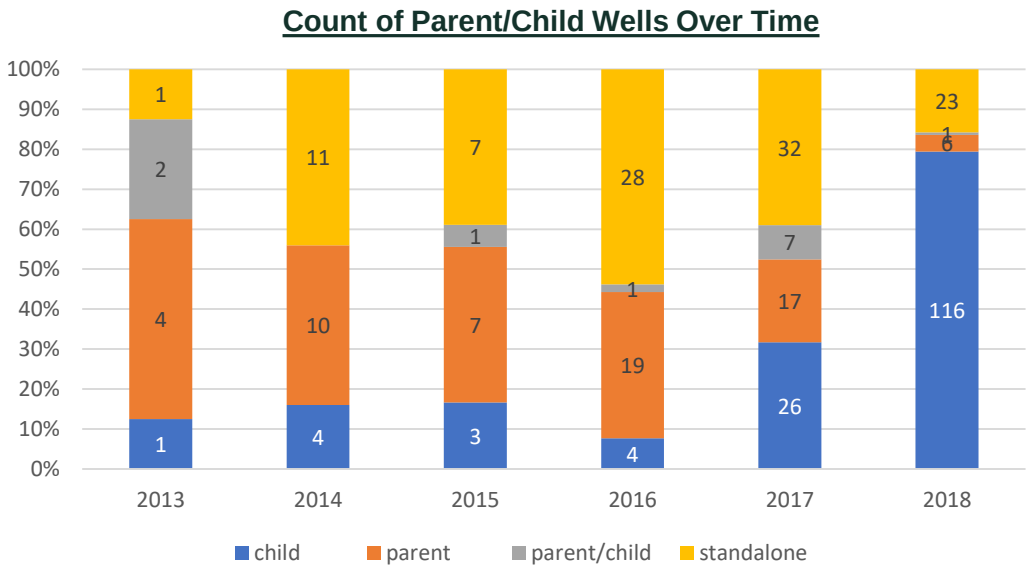
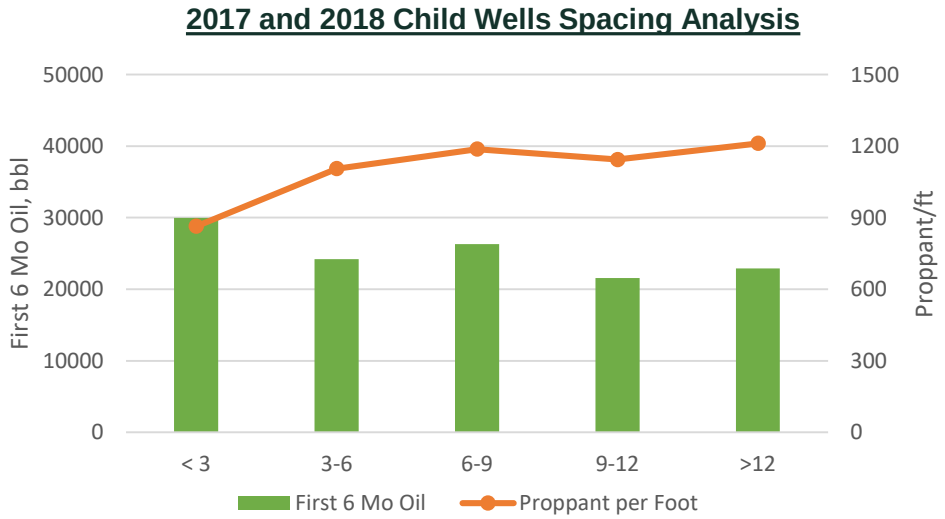
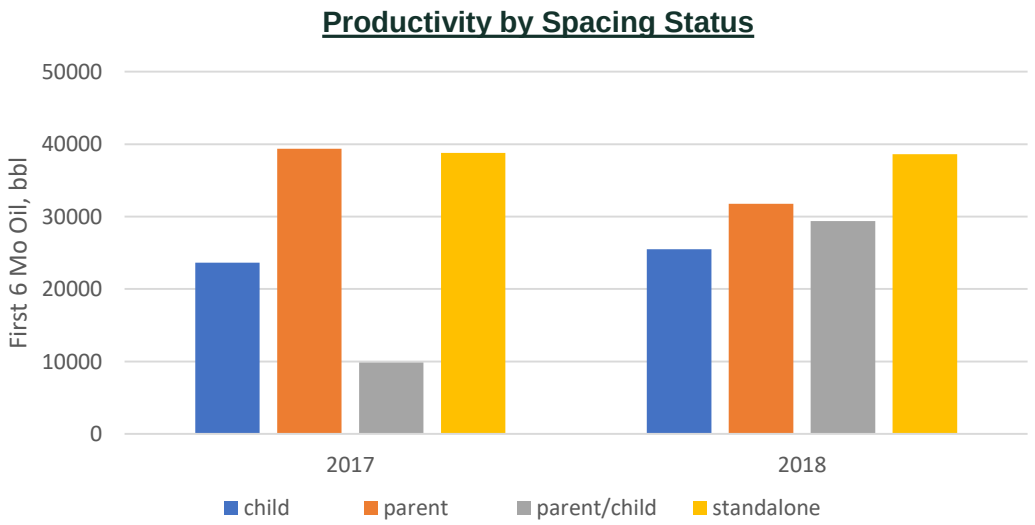
Source: Well Spacing, Basin Studies

SCOOP/STACK: A Case Study (Cont.)

- Using the same data from the previous page, a few insights can be gained by studying parent/child well relationships.
- As with most development programs, the number of child wells drilled has greatly increased over time.
- Standalone and parent wells did have issues with the larger frac designs from 2017 & 2018, but child wells have the most noticeable degradation, seen in the graphic at bottom right.
- By isolating the dataset down to child wells that were completed in 2017 and 2018, it appears that increasing frac intensity while down-spacing negatively impacted productivity. Tightly spaced, high-intensity child wells had roughly half the productivity of 2015 and 2016 wells.







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Source: Well Spacing, Basin Studies

CASE STUDIES – PARSLEY EXAMPLE

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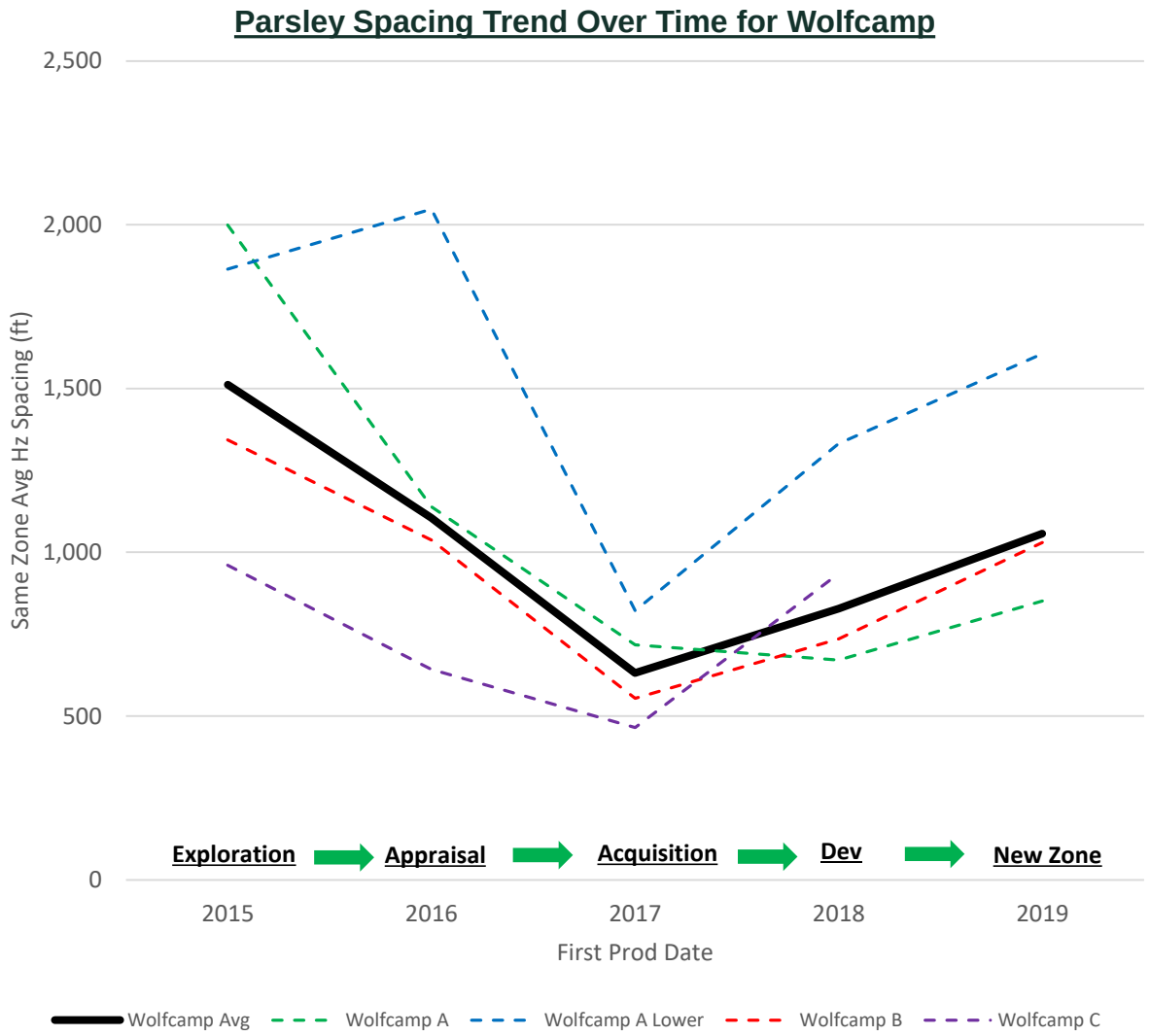
Parsley Example

- Spacing is impacted by many different variables. Understanding the reasons for spacing practices is key. The chart on the right shows spacing of Parsley's Wolfcamp wells.
- In 2015, average spacing was ~1,500 ft as exploration and delineation to hold acreage for Parsley was the main objective.
- In 2016, average spacing tightened to slightly over 1,000 ft as appraisal of acreage positions started picking up.
- In 2017, spacing tightened significantly to just over 600 ft. However, this was due to the acquisition of Double Eagle, which was spacing wells much tighter.
- In 2018, Parsley "upspaced" from 2017, but the reality is that they were taking over the Double Eagle assets and developing them at their own discretion.
- YTD 2019, the spacing got even wider. Although spacing for the more developed formations like Wolfcamp A and Wolfcamp B may come back in toward 2018 averages, the delineation of the Wolfcamp A Lower with wider spacing will continue to impact the average to the upside.



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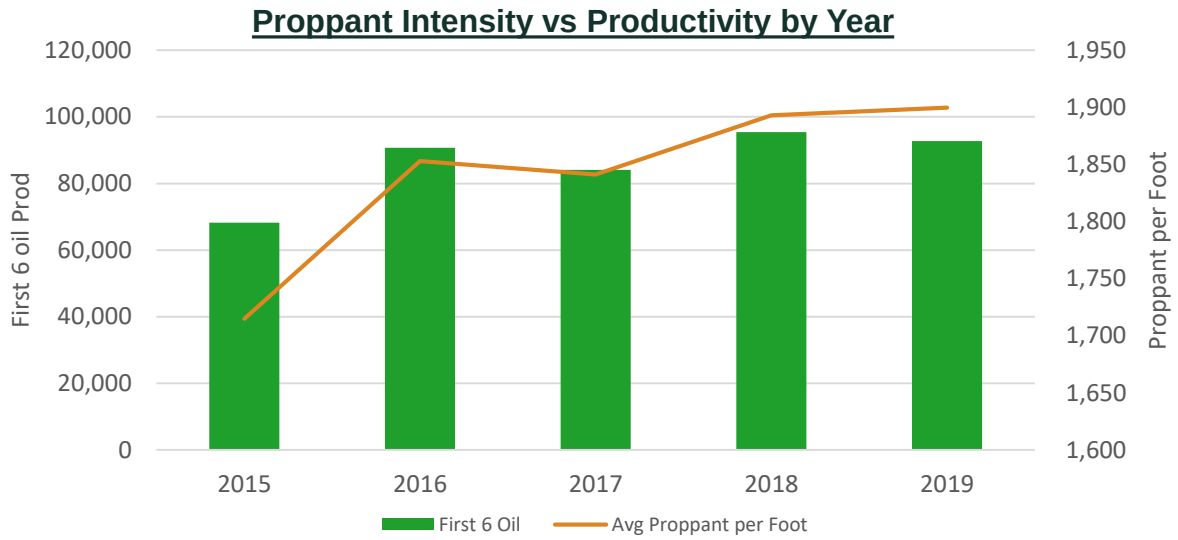
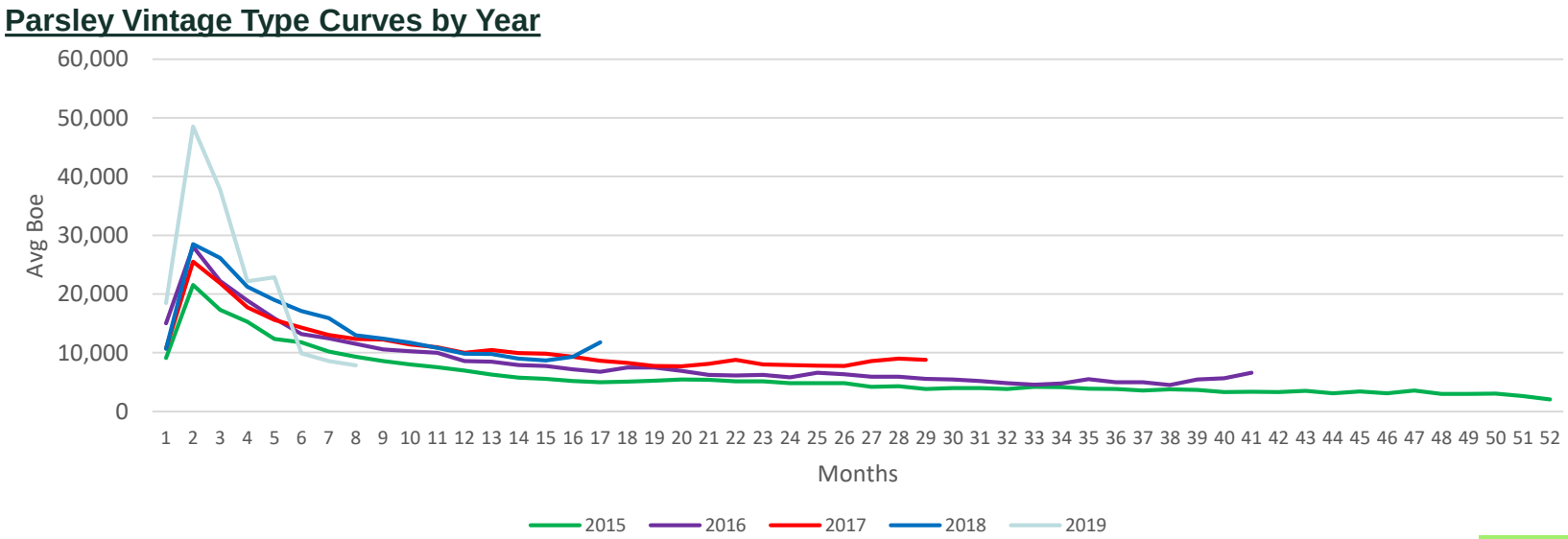
Source: Well Spacing

Parsley Example (Cont.)

- Charts show the productivity and proppant usage and the trend over time for the same set of wells from previous slide.
- The average Boe type curve during 2017 was worse than seen in both 2016 and 2018, signaling the spacing tightening affecting the performance of the wells. Better average results are seen with upspacing in the Wolfcamp formation.
- Along with the tighter spacing in 2017 with the acquisition, proppant per foot also went down in comparison to 2016. The proppant loading has been increasing since 2017 along with upspacing, which also correlates with higher first 6 months oil production.
- The spacing data along with insights to proppant and type curves also show that Parsley was aware of the best completion practices for their development, and after finalizing the Double Eagle acquisition, they started developing the assets their way and increased productivity and have been successful.





Source: Well Spacing

Enverus's WELL SPACING PLATFORM V1.0

The Well Spacing product is currently available as a subscription service and also available to be used on consulting projects through the Enverus's Strategy & Analytics team.

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