

# Production Forecasting in the Scoop/Stack Play

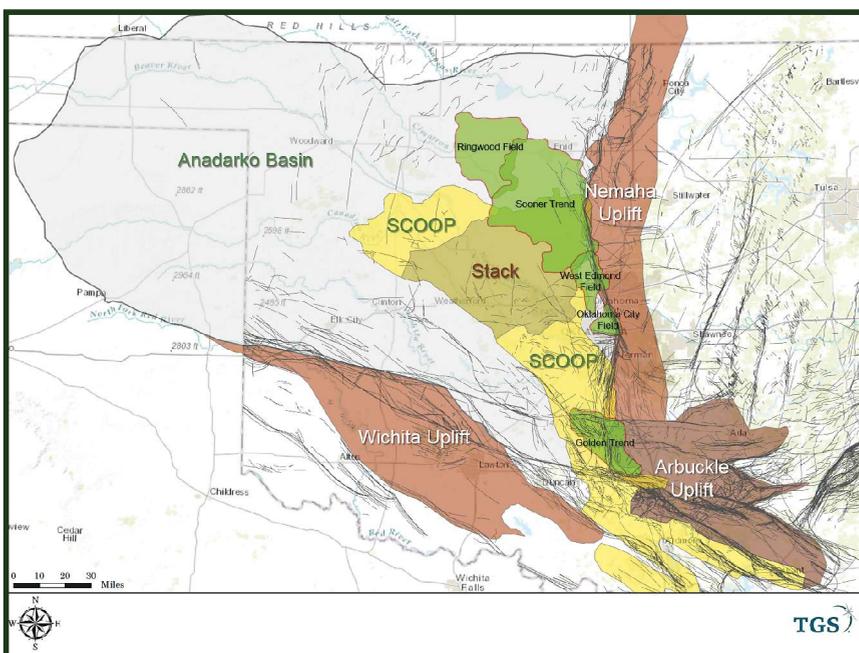
*Advances in forecasting algorithms facilitate an EUR analysis of the last 10 years of well completions.*

**By Ted Mirenda and James Keay**  
Contributing Editors

Oklahoma is one of the most mature oil- and gas-producing states, yet the industry continues to innovate and make headlines with new investment opportunities. As the industry focuses on resource plays, advances in drilling and completion technologies along with the accumulated geoscience knowledge continue to tighten constraints on technical uncertainties. The science of running risk-based economics has migrated to a broader matrix of engineering sensitivities focused on optimizing operational investments. Fundamental to calibrating these complex economics is the accuracy and availability of well performance data for forecast models. Investment decisions continue to pivot on the context that forecasting provides in terms of ultimate recoveries and breakeven points.

Operators are often able to forecast with confidence using proprietary data in their operating area but industry investors looking along trends and assessing new and unfamiliar opportu-

nities must often work on comparison forecasts with public data. State production recording and databases continue to improve; however, they can be notoriously incomplete and ambiguous. In part, this is due to a lack of standardization of oil and gas reporting procedures and requirements. As the industry improves forecasting algorithms, production volume data can be qualified more efficiently but nomenclature used to describe and isolate the zones(s) of production continues to be a challenge.



A generalized extent of the Anadarko Basin with Nemaha and Wichita uplifts bounding the east and south flanks is shown. The Scoop/Stack trend in central Oklahoma is adjacent to and overlaps some of Oklahoma's most famous giant fields, shown in green. Faults (gray lines) are modified from Oklahoma Geological Survey shapefiles. (All images courtesy of TGS)

The science of forecasting depends on the ability to correctly categorize local nomenclature, nicknames, abbreviations and handling entry errors such as spelling mistakes. In terms of data useful for forecasting, the TGS database accesses reservoir fluid data vintage 1973; however, in today's domain the data TGS requires is well-based production from horizontals that it can calibrate—typically, relevant data are from the past 10 years.

In this chapter, TGS introduces advances to forecasting algorithms, in particular for lease reporting states such as Texas and Oklahoma. The company illustrates some of the many spatial and temporal relationships the TGS datasets can provide and highlights some of the extensive basin analytic capabilities.

This study uses a select well dataset covering the Scoop/Stack. The primary targets the data support include the generic Mississippian system, the Meramec group, the Devonian Woodford and Silurian Hunton formations as well as data in the Oswego, Springer and numerous Pennsylvanian reservoirs.

As a brief overview, the Scoop multizone play trend extends about 200 miles north-south in central Oklahoma, along the eastern edge of the Anadarko Basin corresponding to one of the most prolific conventional oil production areas on the continent. Numerous historic giant (more than 100 MMbbl) oil fields have been discovered along this trend.

It's interesting to look back at the long and colorful history of exploration here. Most accounts agree the Oklahoma oil boom began around Bartlesville near the turn of the 20th century, but the first series of major discoveries occurred between 1926 and 1928, including the Oklahoma City Field in 1928. The field is a huge anticlinal structure with production initially from the Arbuckle Limestone and ultimately from the Basal Oil Creek sand and the Ordovician Wilcox sand. The Oklahoma City field produced more than 1 Bbbl. From the late '20s through the war years when demand skyrocketed, numerous giants were discovered, including the Ringwood and West Edmond Field, which was located using reflection seismic. In 1947 a cluster of fields termed the Golden Trend

were discovered in south Oklahoma, and by the mid-1950s the string of major discovery activity was waning with the Sooner Trend. By this time the Woodford Shale—with naturally fractured chert zones—was one of the primary targets as well as the tight Mississippian carbonates interbedded with marls and chert. Fast forward to present and the Scoop and Stack are recognized as a light oil and gas liquids trend along the western flank of the historic Sooner Trend, straddling the edge of the overpressured corridor that extends down dip into the basin and exploiting many of the same historic producing zones.

There are dozens of reservoir zones in the Scoop/Stack extending through the Mississippian system and the Woodford and Hunton formations. The ongoing effort and objective is to subdivide the Mississippian system for production allocation using completion data, perf information and well reports, and confirm production from the Chester, Sycamore, Meramec, Osage and possibly more detailed intervals.

### Production forecast model

In this analysis, TGS utilizes and leverages its newly released Production Forecast Database. This database is a library of every well in the U.S. containing both a monthly production projection and EUR value for all active wells. The forecast database combined with the Longbow desktop visualization tool provides the backbone of the analysis and results contained within this report.

TGS Production Forecast creates projections of producing oil and gas data streams, which allow the calculation of EURs and other values needed to perform well, field and basin evaluations. The projection of oil and gas data can be challenging because of the variety of reservoir and outside influences that can change producing trends. Production Forecast is designed to recognize production variations and to forecast future production based on the best available data, accomplishing this through proprietary algorithms and heuristic rule-based decisions.

The forecast engine leverages the TGS Well Performance Database of monthly well production volumes to create forward curves for all active

producing wells derived from historical production data. Curves are generated utilizing hyperbolic fitting, but this model’s advantage includes Extended Kalman Filter (EKF) techniques incorporated into the process. EKF emphasizes the most recent data, identifies trends and adjusts logic on the fly using a series of matrix math techniques, resulting in improved efficiency and accuracy. Wells are forecasted to their economic limit based on multiple parameters including estimated operating costs. Every month the new historical production volumes are updated into the database, then new forecast curves are generated for all active producing wells. The database is kept current and all wells are updated once a month.

### The Scoop/Stack dataset defined

For this study, TGS took a comprehensive look at the last 10 years of well completions in the Scoop/Stack play (Figure 1). The dataset used in this analysis consists of about 5,300 wells. The wells and corresponding data were extracted from TGS’ Well Performance Database and specific criteria for including wells in the study were:

- The location of the well had to fall within the county boundaries that constitute the geo-

graphical description of Scoop/Stack;

- The well was completed and put on IP after Jan. 1, 2007. TGS was looking at the last 10 years of activity in the play; and
- The well is still actively producing.

### Future drilling activity

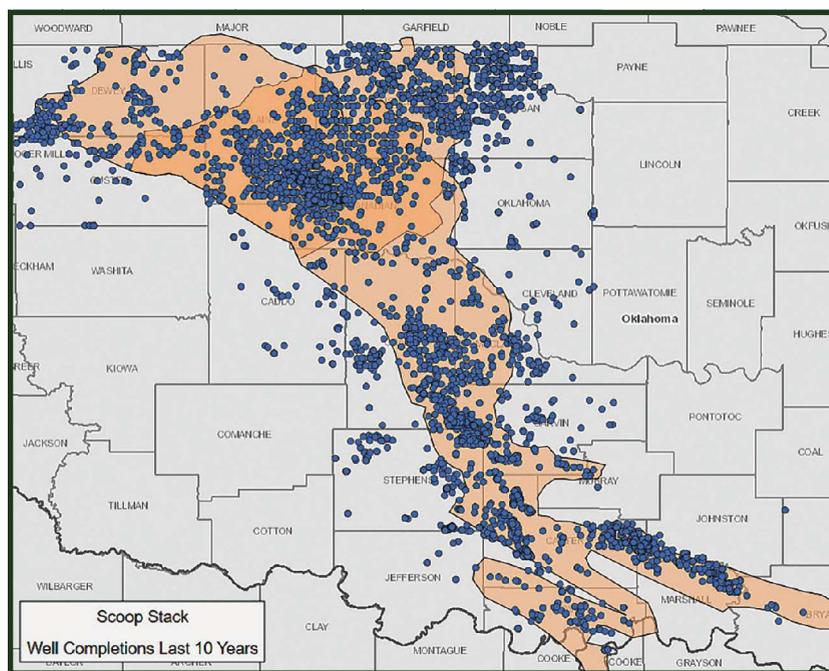
What do future drilling activity levels look like in the play? Before analyzing historical production rates and EUR forecast trends of the completions in the Scoop/Stack, let’s take a look at expected upcoming drilling activity in the near term for our study area. Drilling permits, which are valid for six months from the date of approval in the state of Oklahoma, are a leading indicator of expected drilling activity. Analyzing recent drilling permit counts by month in the Scoop/Stack indicate high industry confidence in the continued economic viability of our area of interest (Figure 2). While the industry as a whole and many basins individually saw an enormous crash in permit activity beginning in early 2015, the recent permit counts in the Scoop/Stack have returned to remarkably high levels. In fact, March 2017 tallied 165 new approved permits-to-drill, which signifies the third highest monthly level in the

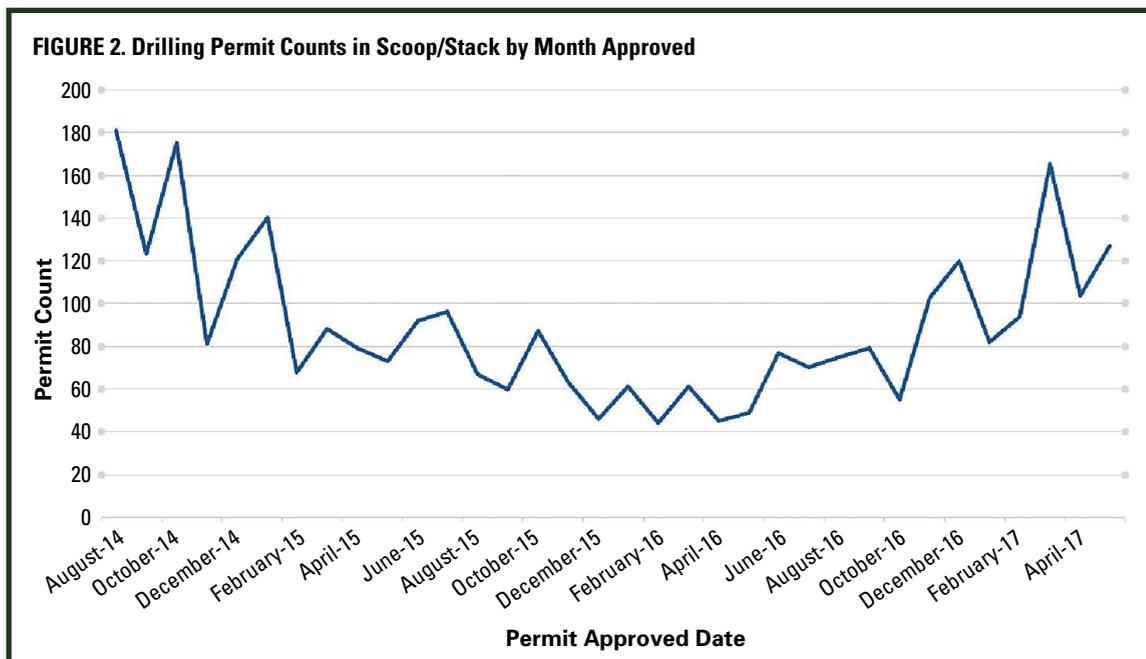
last five years of Scoop/Stack permit activity.

### Where are the new locations?

Drilling permit locations in the Scoop/Stack approved in last five years are color-coded in Figure 3 by the year the permit was approved. Red indicates the most recent permit locations—those approved in 2017. Spatial patterns indicate, as resource development matures and industry conditions transform, where the newer locations geographically focus. Although the play

**FIGURE 1. Last 10 Years of Well Completions**





reflects a wide swath with numerous location opportunities, TGS clearly sees high concentrations of the 2017 new locations across northern half of the Stack.

### Which operators are investing in new locations?

In the last 12 months 1,206 new drilling permits have been approved in the Scoop/Stack, which corroborates industry commitment to belief in sustained economic viability of the play. Further, there is a wide range of players as 133 different operating companies filed permits in the last 12 months (Figure 4). The top 10 operators in the region account for 748 permits or 62% of the total.

### EUR analysis of the play

Where are the biggest wells? EUR hot-spot maps are an effective way to visually reveal high value wells across an entire play or basin. Since the Scoop/Stack is both an oil- and liquids-rich province, when calculating EURs and ranking commercial success of wells, one must consider many wells produce both gas and oil and, therefore, account for the economic value of different commodity streams. Calculating EURs requires three different unit-of-measurement perspectives (boe, oil and gas) to obtain accurate results. To properly identify spatial patterns of the

highest performing wells within the area of interest, mapping of EURs is best performed as a three-tier approach. The first look is total boe ultimate (bbl), defined as the total EUR of a well using a 6-1 ratio to convert Mcf to barrels equivalent. The second is total oil ultimate (bbl), and last total gas ultimate (Mcf). Finally, combining hot-spot maps with a gas-oil-ratio (GOR) window map (cf/bbl) completes the picture between oil and gas commodity streams. Figure 5 shows forecast data from all producing formations in the area of interest.

### Interpreting the oil and gas window-GOR (cf/bbl)

The TGS Well Performance Database calculates and maintains GOR values for all wells. The GOR value is calculated from the monthly oil and gas production volumes reported for each well. The individual volumes are summarized to a cumulative total and a ratio calculated and measured as gas (cf) per oil (bbl). Mapping GOR values across the play visually interprets the wet and dry windows relative to oil and gas EUR values. Asset evaluators can focus on high value acreage correlated to the different commodity streams. Additionally, GOR maps are normalized to a specific producing formation to identify the transition line from oil to gas for a specific zone. As

An oil derrick is at work on the Oklahoma plains. (Photo courtesy of Anthony Butler, Shutterstock.com)

FIGURE 3. Drilling Permit Locations Approved in Last Four Years

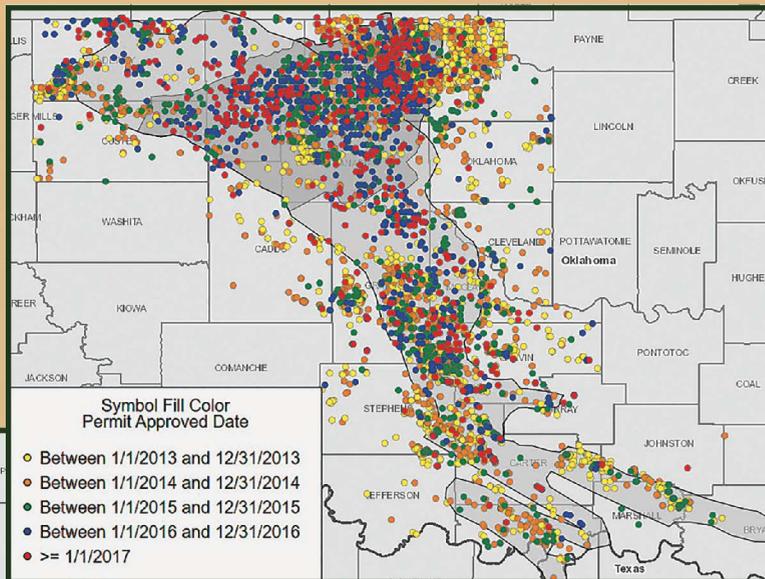


FIGURE 4. Top 10 Scoop/Stack Operators

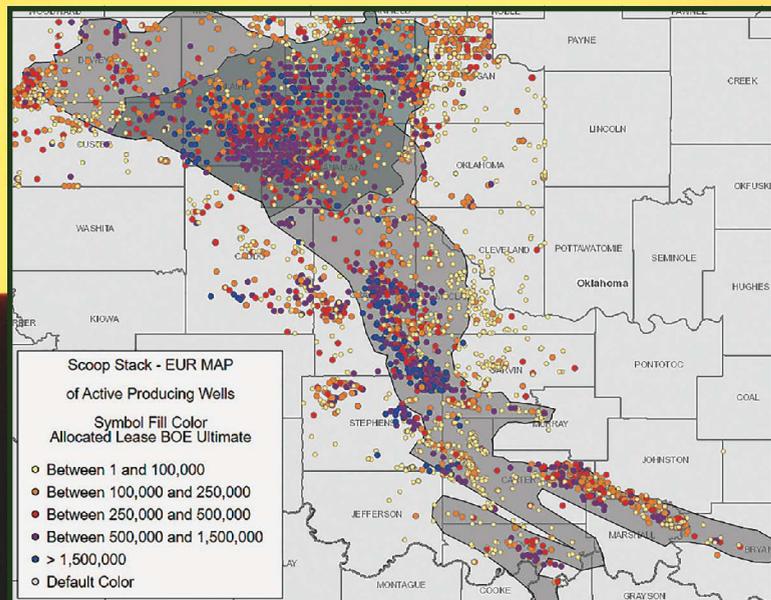
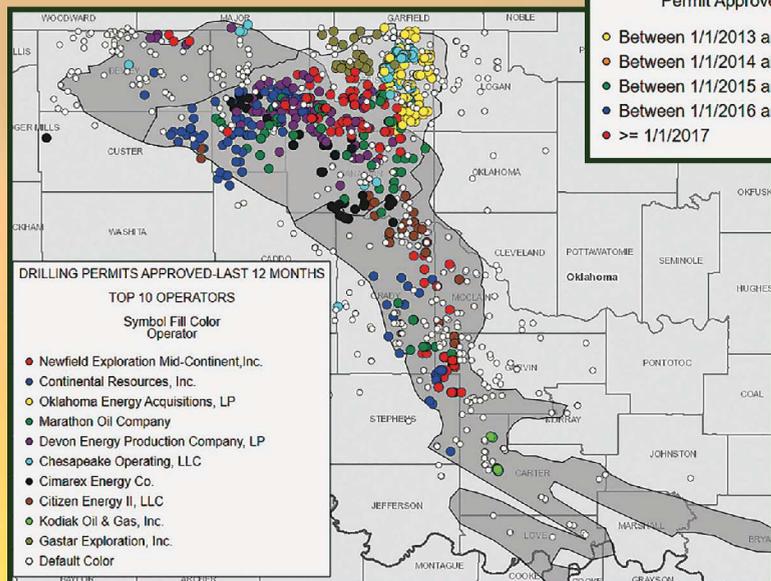


FIGURE 5. Left, the high-performing wells are spotted across the trend suggesting a broad distribution of high recovery potential and opportunity to grow the play.

an example and contrast, figure 9 shows GOR for all wells/all zones and figure 10 shows GOR perspective for the Woodford Formation only.

### Horizontal drilling impact on EURs

Despite recent hardships in the oil and gas industry, the Scoop/Stack area has experienced renewed interest and revitalization by horizontal drilling while remembering its past is home to some of Oklahoma’s legacy hydrocarbon production. Companies continue to test which areas show the most promise and what completion processes provide the best well performance. Utilizing scatter plot visualization confirms the dramatic effect horizontal drilling and new completion techniques have made. Comparing well completions by year displays constant improvement in well performance and EUR totals year-to-year with an upward trend (Figure 6, below).

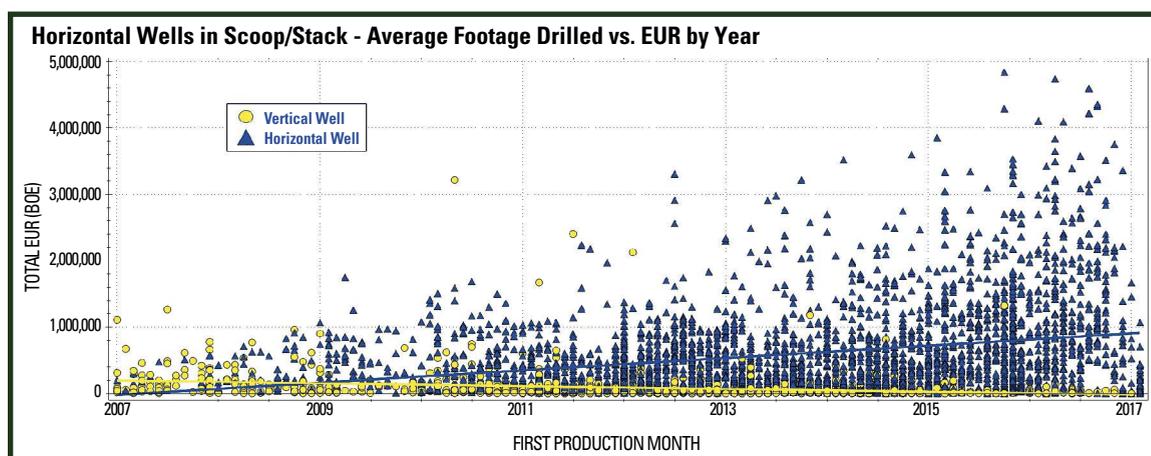
### Footage drilled vs. well performance

How has the length of the well impacted economic success? Taking the same dataset, TGS compared footage drilled vs. well performance over time, normalized for horizontal well type only, to ensure data integrity by utilizing comparable well types (Figure 11). Looking first at the play over-all (all zones),

### OPPOSITE PAGE

**FIGURE 7.** The oil EUR map shows the highest performing wells clustered across the central to eastern Stack and highlight the central and southern part of the Scoop. **FIGURE 8.** The gas EUR map shows the highest performing wells focus on western side of the Stack and highlight western and southeastern part of the Scoop. The value of the well based on commodity type abruptly shifts where the “big” wells are located. The EUR values can also be calculated by producing formation for further comprehensive analysis.

**FIGURE 9.** Representation of GOR from Pennsylvanian through Silurian Hunton formations is shown. In general, TGS observes a transition from low GOR (black oil) along the northeast to dry gas in the southwest for the combined zones. **FIGURE 10.** TGS restricts the data to the Woodford Formation only and the transition from oil to dry gas in this source rock is more distinct. This suggests the liquids yield in the Woodford may be predictable along this trend. On the left display, the scattered distribution and clusters of downdip oil suggest fluid migration and/or source zones other than the Woodford.



**FIGURE 6.** In the above plot the X-axis represents first production date and the Y-axis is a measure of well performance, in this case total EUR is used. Additionally, vertical wells are indicated as yellow circles and horizontal wells as blue triangles. There are 5,000 datapoints on the plot. Progressing across the X-axis first production date, a dramatic shift from vertical to horizontal completions intensifying in late 2012 and beyond is seen, correlating to rapid increase in well performance EURs. The industry continues to improve and verify optimum completion techniques, and trend lines indicate improvement will continue.

Oil rig in the Oklahoma sun.  
 (Photo courtesy of Stephen  
 Kumor, Shutterstock.com)

FIGURE 8. Gas EUR of Active Producing Wells

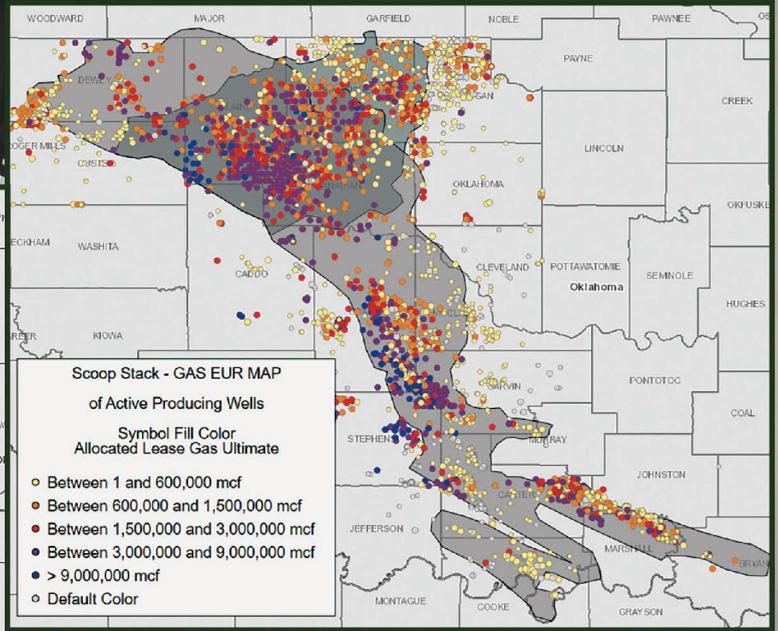


FIGURE 7. Oil EUR of Active Producing Wells

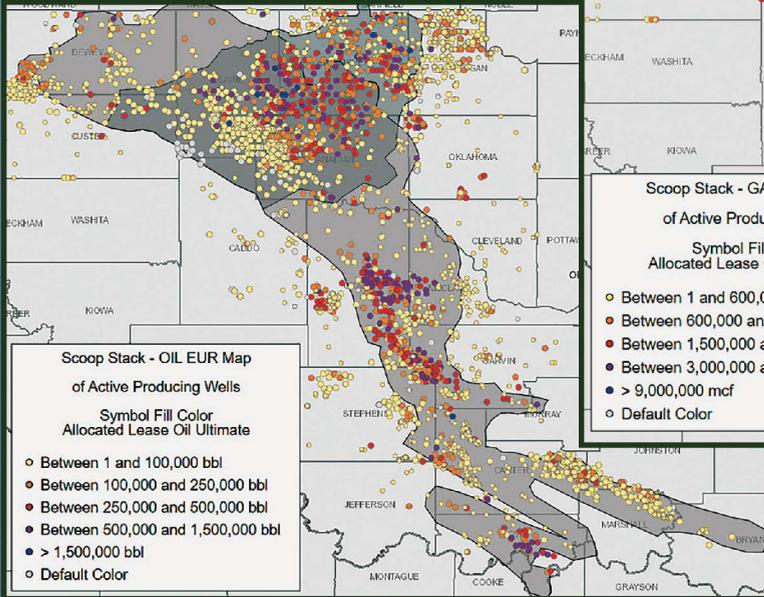


FIGURE 10. Woodford GOR Total Average

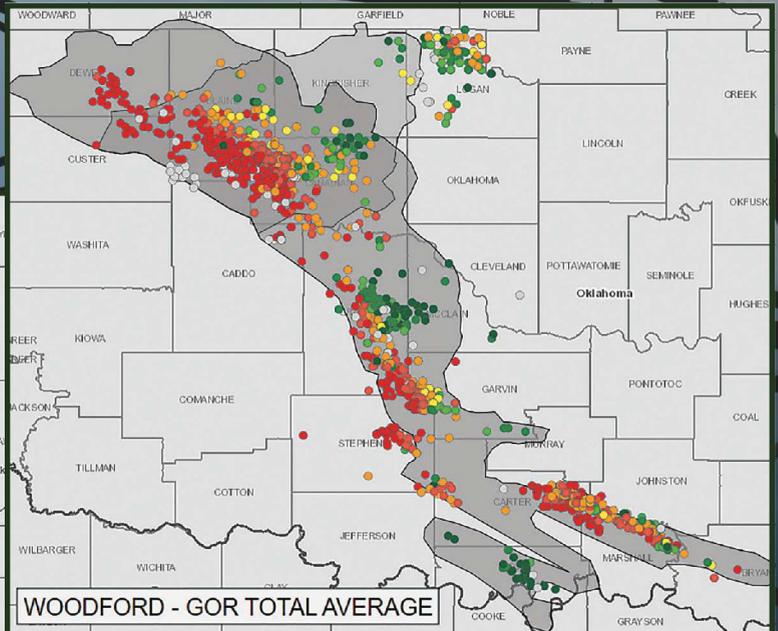
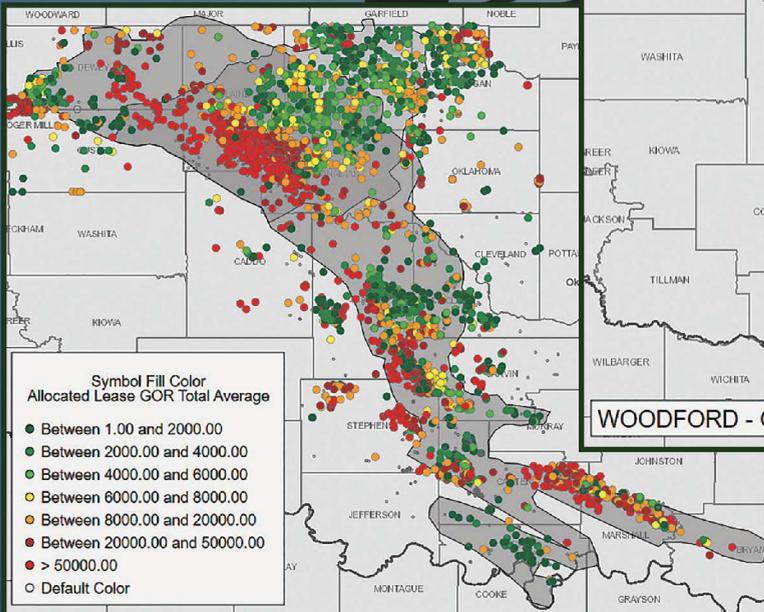
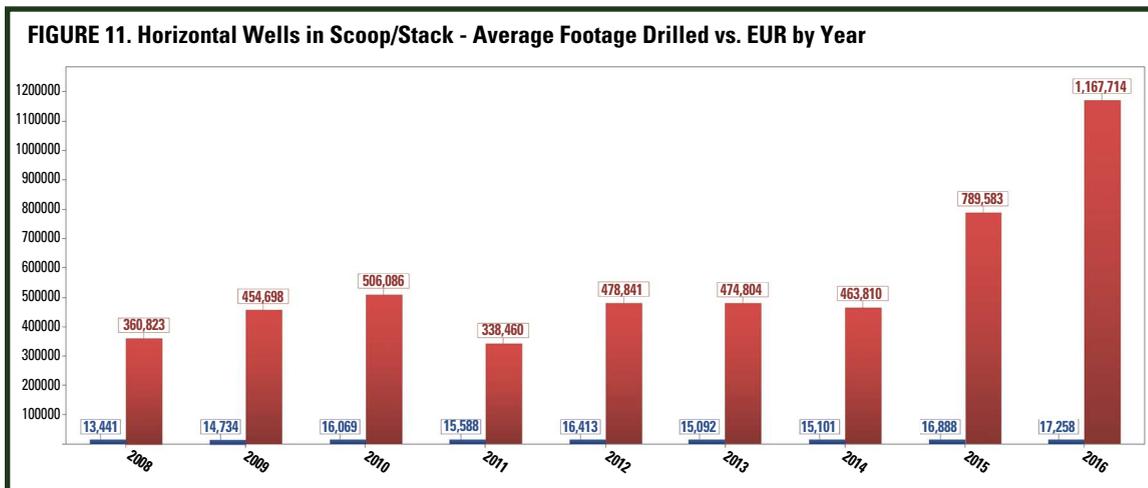


FIGURE 9. Allocated Lease GOR Total Average





average footage drilled per well has increased nearly 4,000 ft over the company’s time line while impact on well performance has more than tripled.

Further analysis of footage drilled vs. well performance now normalized by producing formation reveals the top producing formation targets for operators: Woodford, Mississippian and Hunton (Figure 12).

In the Woodford average footage drilled has increased by more than 5,000 ft—the average well length in 2016 increased to 19,457 ft—with well performance tripling. Mississippian analysis shows average footage drilled per well increased by 3,200 ft over TGS’ time line—the average well length increased to 16,120 ft—while well performance improved a whopping five times over earlier, shorter-length wells. In the Hunton there is a smaller dataset of horizontal producing wells to analyze and the recognized

increase in footage drilled and well performance is a more current phenomenon. The major increase in length and performance transpires moving from 2015 to 2016. Hunton doesn’t show the more gradual increase as the Woodford and Mississippian results. However, as this is a much smaller sample size, TGS continues to analyze these recent trends going forward to see if the 2016 increases are maintained in 2017 and beyond as the Hunton continues to be developed horizontally.

### Average EURs by formation

TGS’ final analysis will continue to narrow the scope and explore EURs within the play down to the producing formation (Figure 13). To effectively do this, it is important TGS conditions the data from its raw form. Historical monthly production data used in production forecast model originate, as reported

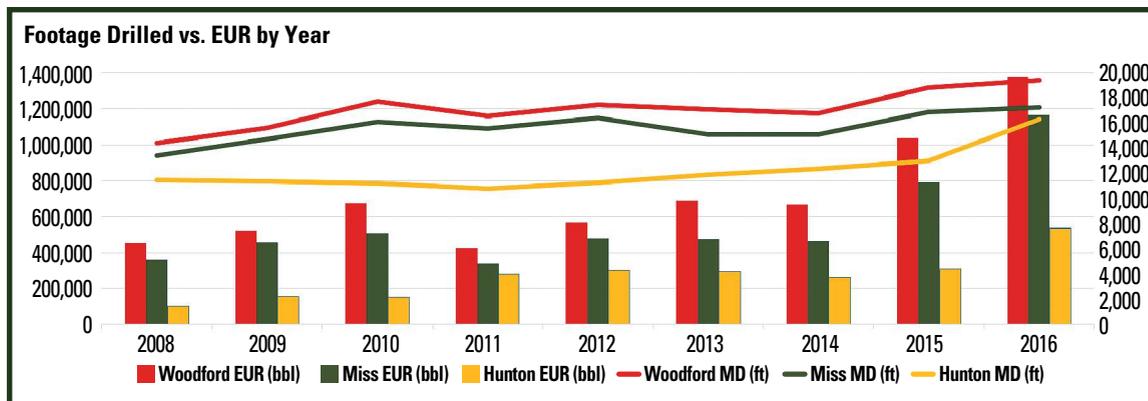


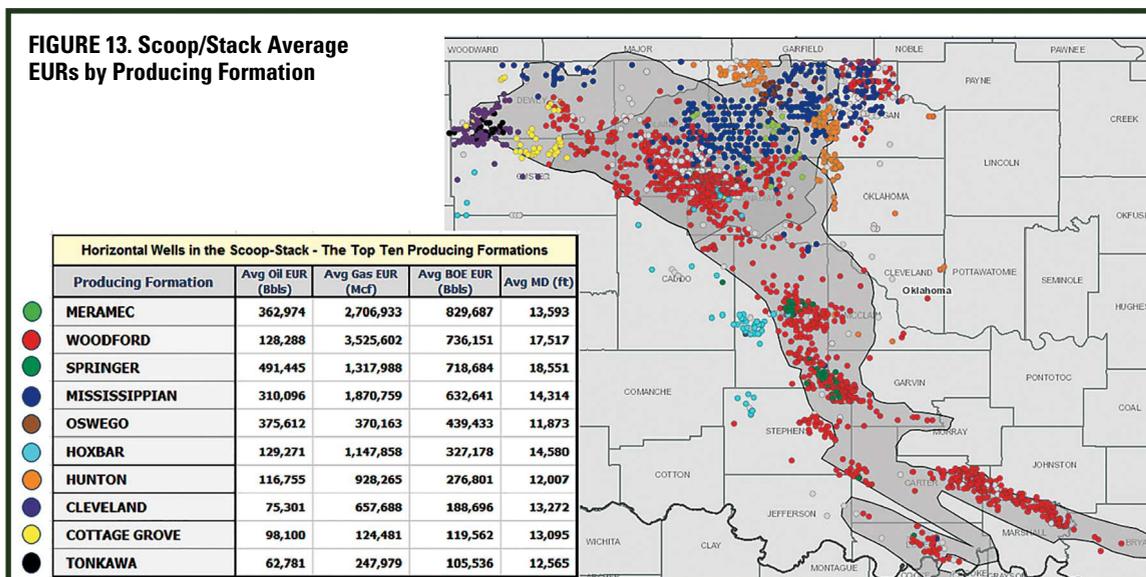
FIGURE 12. The left Y-axis represents EUR (bbl) and the right Y-axis represents footage drilled (ft).

publicly, from the state regulatory authority—in this case, the Oklahoma Tax Commission and Oklahoma Corporation Commission. To derive accurate EUR results at the formation level, TGS' approach only considers horizontal wells in its original dataset that report single-formation production streams. In other words, wells that report monthly volumes comingled among two or more formations are not included in the calculation of formation EUR statistics and averages. TGS includes the undifferentiated Mississippian as a separate EUR calculation as many wells are publically reported as such. Other wells are specifically reported as Meramec and isolating

Scoop, are provided for additional reference. TGS is seeing horizontal well activity in these reservoirs producing economically successful EURs.

### Summary

This article has shown numerous high level and detailed examples of forecasting and basic analytics in the Scoop/Stack. Analyzing permit counts, new well locations, drilling costs and completion techniques and calculating EURs show favorable economics with future growth opportunities. Improvements in forecasting models aided by formation assignments to individual well production streams continue to increase the vol-



those enables accurate EUR calculations specifically for that zone. Taking these precautions and standardizations with the raw data improves confidence and results in quality, accurate playwide statistics by improving and normalizing the original public data.

Results in this study show the highest average EURs are producing from Meramec, Woodford, Springer and undifferentiated Mississippi. From an oil EUR perspective, the top formations include Springer, Oswego, Meramec and undifferentiated Mississippi. The top gas EUR performance is seen from Woodford, Meramec, undifferentiated Mississippi and Springer. Other Pennsylvanian age reservoirs (Cleveland, Cottage Grove, Oswego, Hoxbar and Tonkawa), which some consider part of the

ume of data and quality of interpretation and results. Ongoing efforts for consistency in the assignment of production to ever more granular formation and zone designations assist our industry colleagues leveraging high powered, machine-learning tools. TGS does this through straightforward database cleanup supported with direct input from completion reports and perforation data to better qualify zone assignments. The future is exciting for the Scoop/Stack play as a major U.S. producing province and the data that help us get there. ■

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