U.S. Shale-Gas Reserves and Production Forecast: A Bottom-Up Approach*

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Abstract

This presentation develops an estimate for the Barnett and Fayetteville shales of their technically recoverable reserves (TRR) and their estimated ultimate recovery (EUR). The key drivers of both reserve estimates are discussed and the key distinguishing characteristics between the two fields are discussed.

The analysis is based on field-wide geologic mapping and well-by-well production analysis of every producing well in each field. Well-by-well EUR's are determined using an innovative decline analysis technique. The acreage is then into divided 10 production quality tiers per field. Individual drainage areas are then determined for each well. The remaining acreage available for development is then used to determine a drillwell location inventory assuming an average well for each rock quality tier. The location inventory added to the EUR of existing wells creates a theoretical technically recoverable reserve for each field. A production model is then used to predict the pace of development of the drillwell location inventory constrained by well economics. The pace and production impact of expected drilling is then tracked for each year through 2030 to determine a field-wide EUR. The study investigates how EUR will be impacted by many of the underlying drivers.

Several results of the study are new to industry. Our approach to decline analysis assuming linear transient flow better aligns with physical models. Our study generally points to higher recovery across smaller drainage areas than is commonly accepted. These estimates result in a higher estimate of TRR than has been estimated previously by EIA and USGS. However, the development of the TRR will be greatly constrained by the economic thresholds for development in each rock quality tier leading to a smaller EUR as a percent of TRR than previous estimates.

The study will highlight the differences in the Fayetteville and Barnett. The study draws insights that will be helpful as other shale gas fields are developed with each exhibiting their individual characteristics. This study serves to highlight the key issues that control industry's ability to estimate TRR and to fully develop into EUR.

References Cited

Fu, Q., S. Horvath, E.C. Potter, F. Roberts, S.W. Tinker, S. Ikonnikova, W.L. Fisher, and J. Yan, in press, Log-derived thickness and porosity of the Barnett Shale Play, Fort Worth Basin, Texas: A proxy for reservoir-quality assessment: AAPG Bulletin, in press.

Montgomery, S.L., D.M. Jarvie, K.A. Bowker, and R.M. Pollastro, 2005, Mississippian Barnett Shale, Fort Worth Basin, north-central Texas; gas-shale play with multitrillion cubic foot potential: AAPG Bulletion, v. 89/2, p. 155-175.

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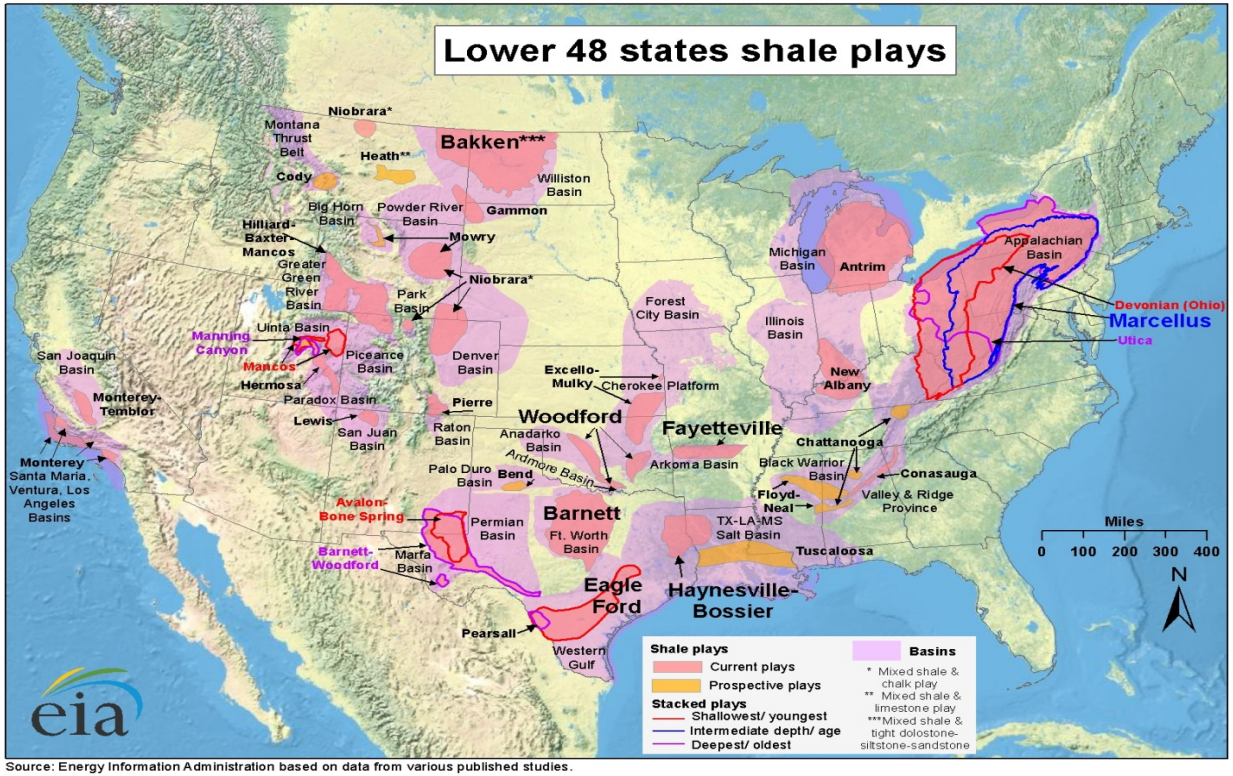
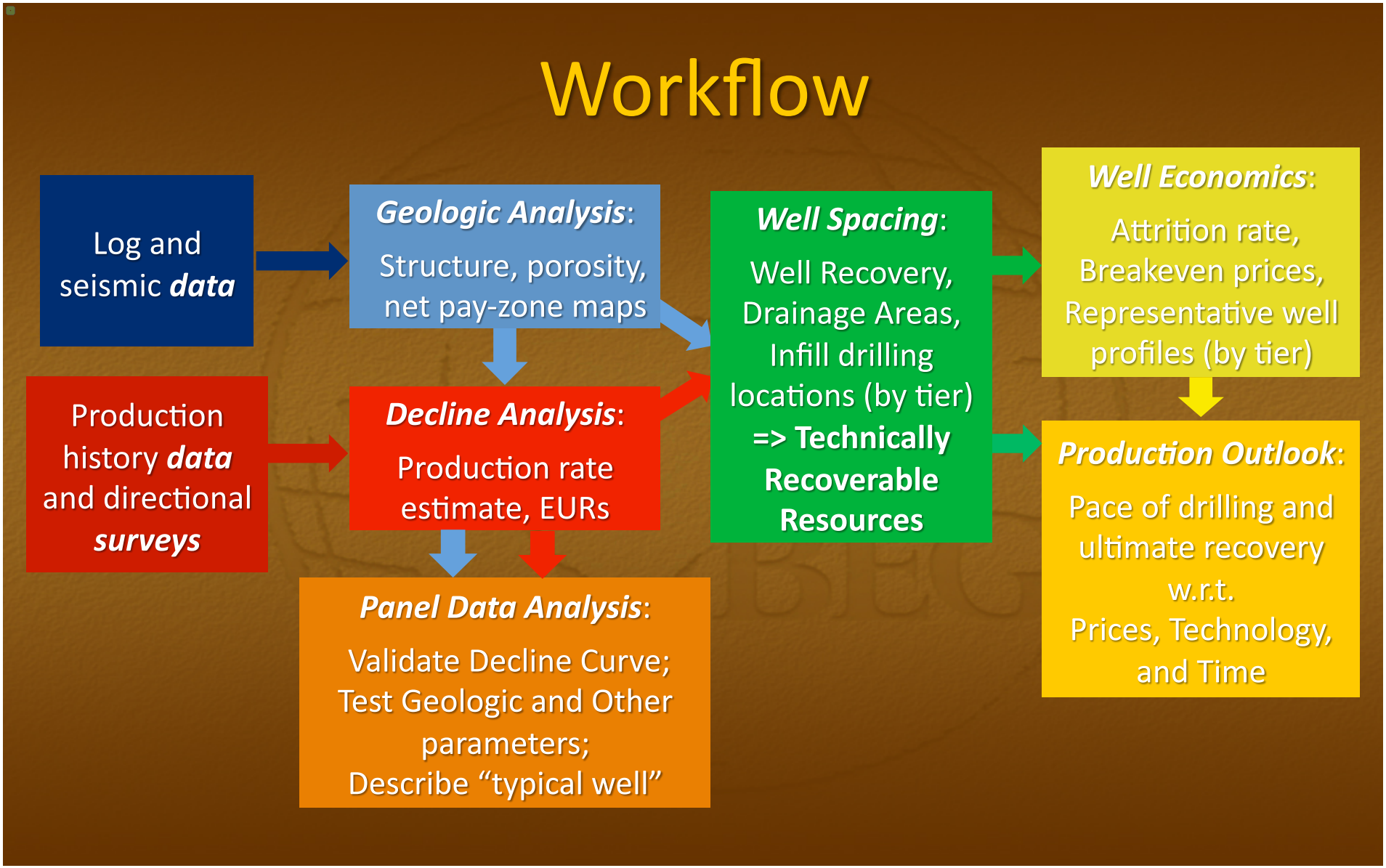
U.S. Shale Gas Plays



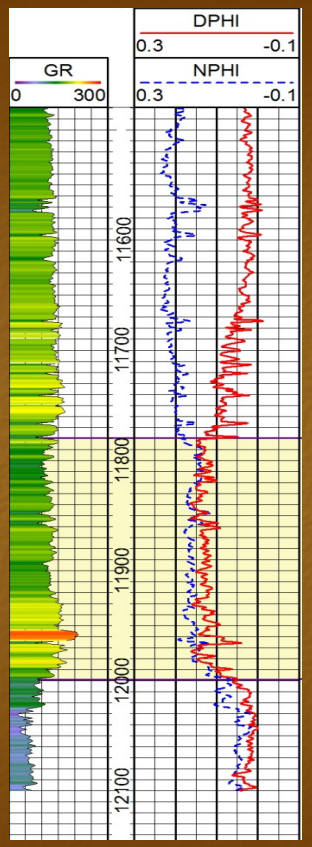
Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

Workflow


Log and seismic *data*
Production history *data* and directional *surveys*
Geologic Analysis: Structure, porosity, net pay-zone maps
Decline Analysis: Production rate estimate, EURs
Panel Data Analysis: Validate Decline Curve; Test Geologic and Other parameters; Describe "typical well"
Well Spacing: Well Recovery, Drainage Areas, Infill drilling locations (by tier) => Technically Recoverable Resources
Well Economics: Attrition rate, Breakeven prices, Representative well profiles (by tier)
Production Outlook: Pace of drilling and ultimate recovery w.r.t. Prices, Technology, and Time

Geological Approach

- Utilize gamma ray, density, and neutron porosity logs to pick pay-zone
- Calibrate density porosity using core data
- Map pay-zone thickness and porosity (cf. Ver Hoeve et al. 2010), and depth across the field
- Calculate original free gas-in-place and compare to production to determine main drivers
- Look at other geologic drivers/barriers, e.g. natural fractures, swelling clays.



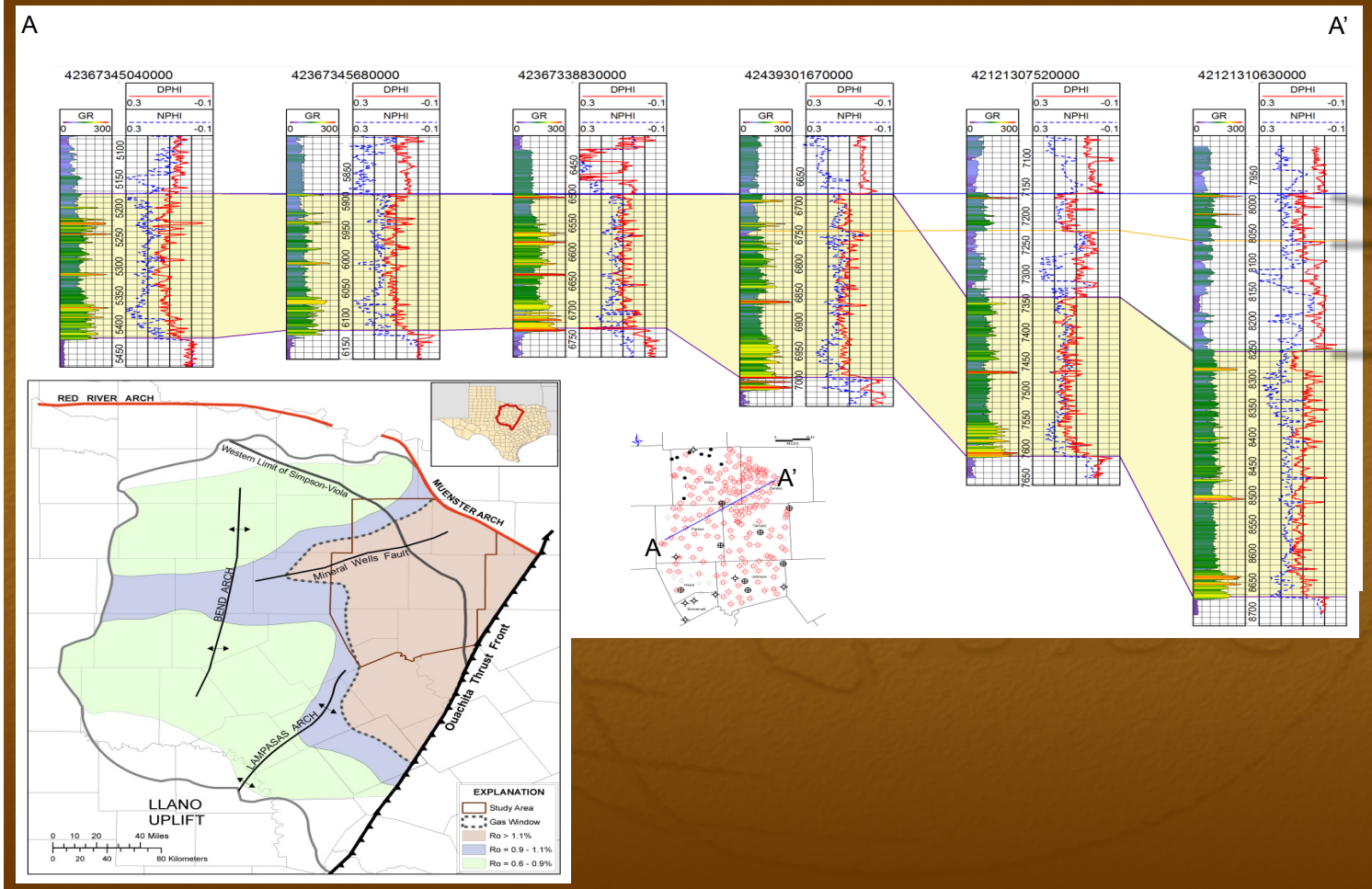
porosity and thickness maps

$$OGIP^{free} = 43560 \cdot 10^{-9} \cdot (1 - S_w) \cdot \phi \cdot H \cdot {}^{640}/_{B_g}$$

assumed 0.25

includes depth-specific reservoir pressure and temperature

Barnett Shale



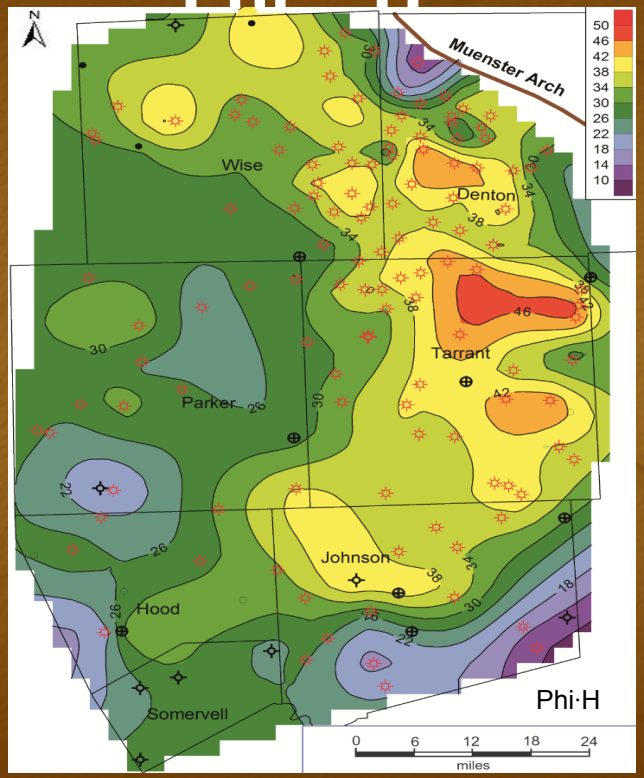
Top of the Barnett
Top of the Forestburg

Top of the pay-zone
(lower Barnett)

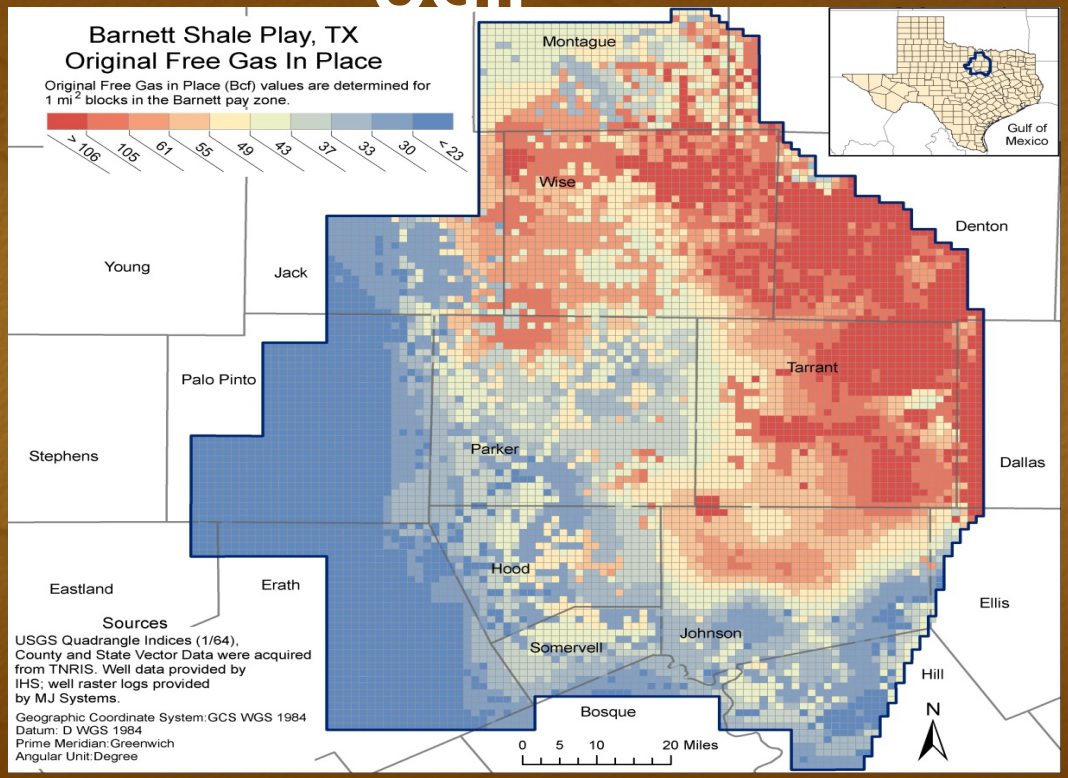
Modified from Montgomery et al. (2005)

Barnett Shale

Phi * H

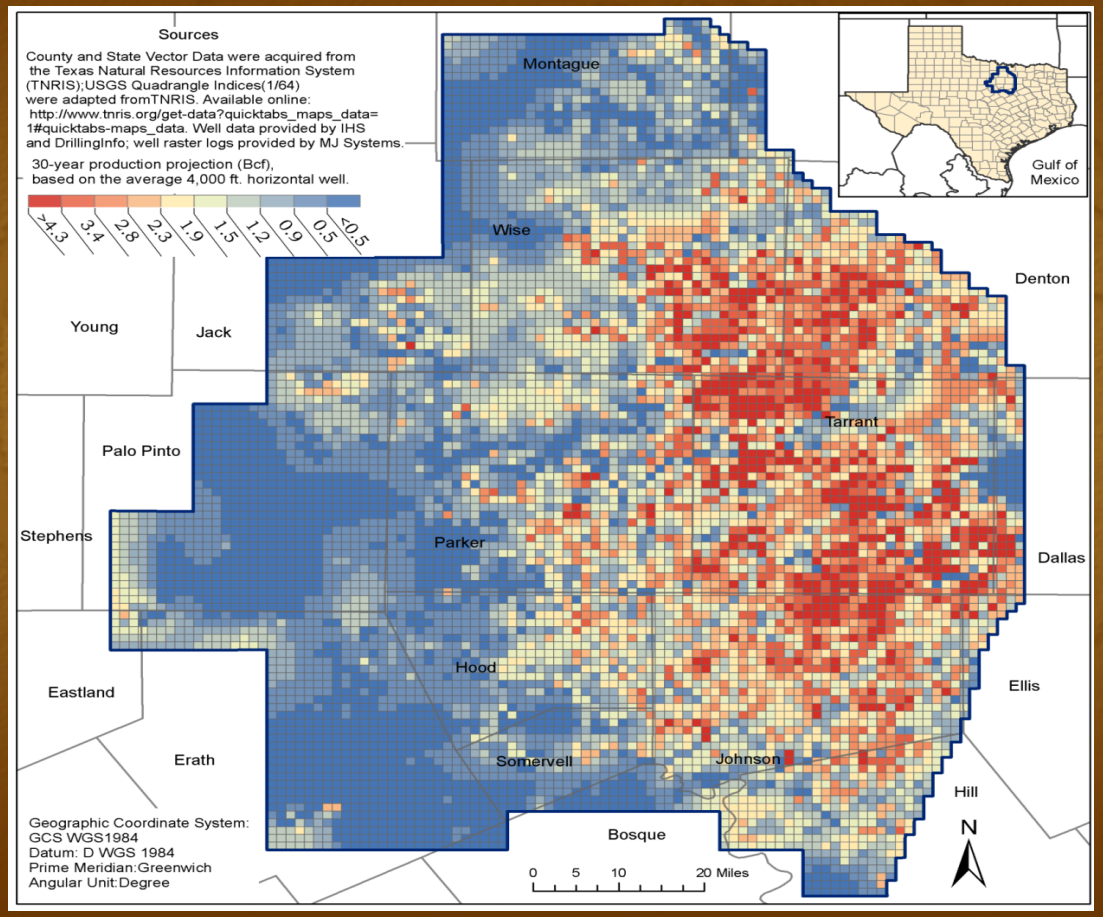


OGIP^{free}

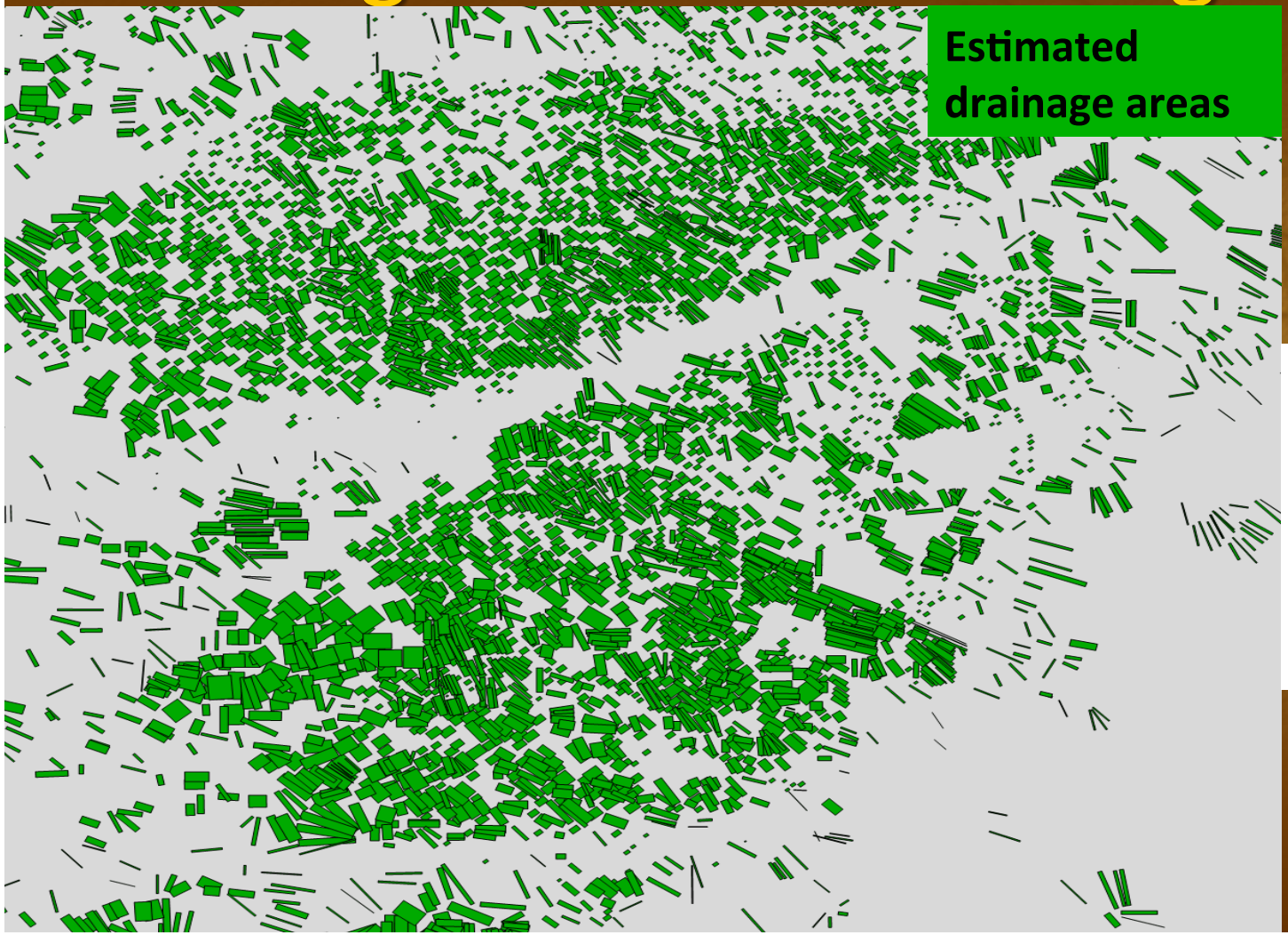


For complete Barnett geologic analysis see Fu et al. (AAPG Bulletin *in press*)

Barnett Productivity Tiers



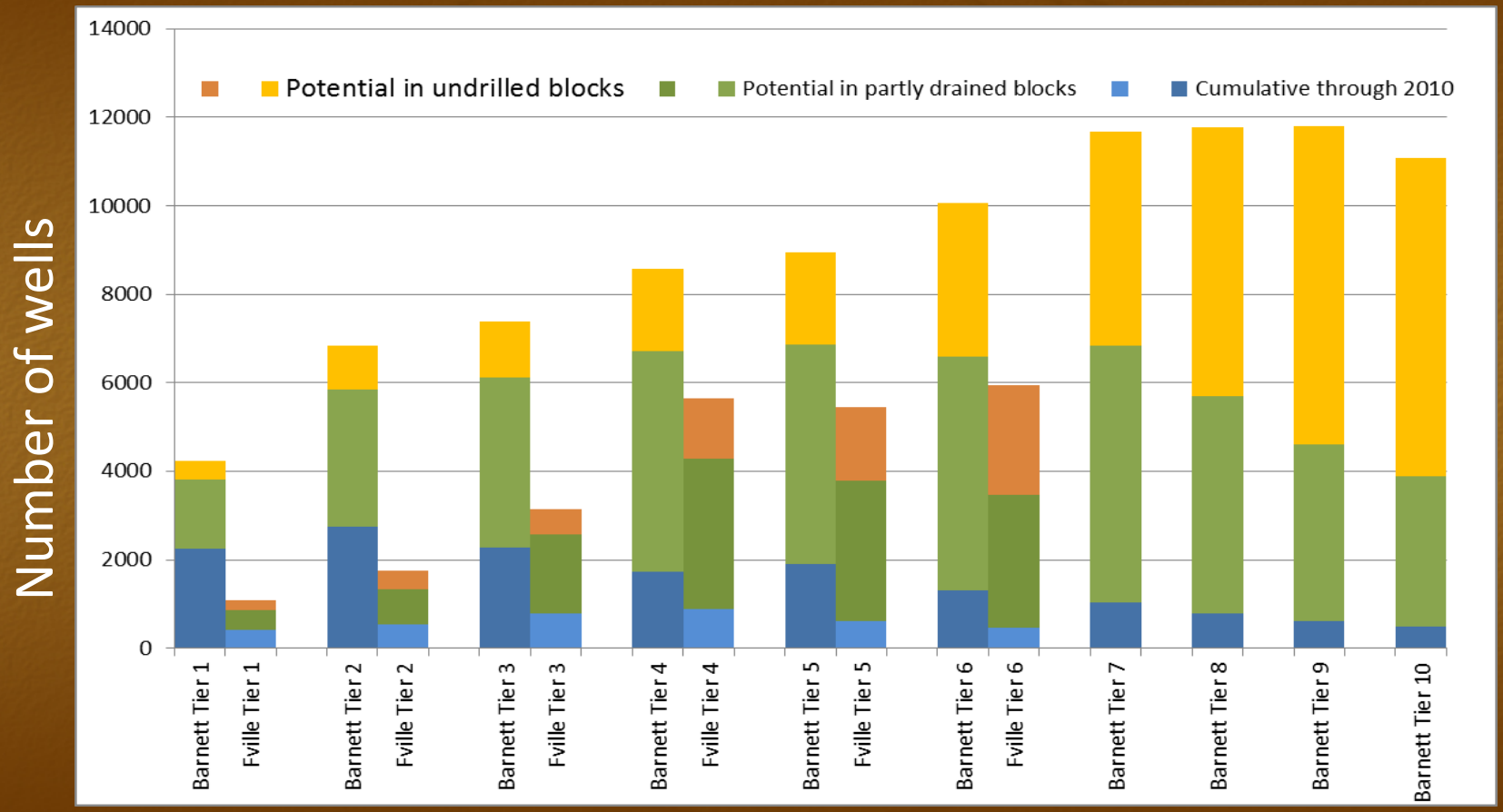
Drainage Areas and Drilling Patterns



Barnett:

- Smaller leases
- Multiple operators
- Wide range of completion types

Inventory of Future Wells



OGIP and Technically Recoverable

	Barnett
$OGIP^{free}$ (Tcf) Total area/**Developed**	444/**280**
TRR^{free} (Tcf)	86

Summary

- Multidisciplinary study by geologists, engineers, and economists, linking geologic mapping, production analysis, well economics, and development forecasting.
- Development of a physics-based decline curve that accounts for interfracture interference later in well life.
- Well-by-well analysis of production and calculation of individual well EUR for all wells.
- Improved granularity for reserve forecasting and economics through productivity tiers.
- Quantification of well-drainage volumes and recovery factors.
- Calculation of OGIPfree and TRR for each square mile.
- Work is basis for field production forecast and EUR estimate