

Water Sources and Disposal Related to Hydraulic Fracturing in Texas*

Jean-Philippe Nicot¹, Bridget R. Scanlon², Robert C. Reedy², and Ruth A. Costley²

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Abstract

Considerable controversy continues about hydraulic fracturing (HF) and its potential for contamination of shallow aquifers and impacting water resources. In this communication, we focus on the latter and use several plays in the state of Texas, including the oldest shale play in the world, the Barnett Shale, as examples for analyzing historical patterns of water use, consumption, reuse/recycling, and disposal. Data were obtained from commercial and state databases, river authorities, groundwater conservation districts, and operators. For example, in the Barnett Shale, cumulative water use from ~18,000 (mostly horizontal) wells since 1993 through 2012 totaled ~170 thousand AF (~210 Mm³) including 26 kAF (32 Mm³) in 2011. Increases in water use per well by 60% (from 3 to 5 Mgal/well; 0.011–0.019 Mm³) since the mid-2000s reflect the near-doubling of horizontal-well lengths (from ~2000 to ~3800 ft), offset by a reduction in water-use intensity by 40% (from ~2000 to ~1200 gal/ft; 2.3–1.4 m³/m). In the Barnett Shale, water sources include fresh surface water and groundwater in approximately equal amounts, whereas south and west Texas rely mostly on groundwater. In Texas, most of the water used for HF is consumed and relatively little reuse/recycling occurs. Most of the flowback / produced water is disposed through injection wells. The median Barnett horizontal well produces back >100% of the amount of water injected for fracturing, albeit of lesser quality, in the course of the few years following completion, an amount larger than other well-known shale gas plays. For example, Eagle Ford Shale wells return ~40% of the amount injected. The communication will provide detailed material documenting these findings. Understanding the historical evolution of water use in the longest-producing shale plays should be valuable for assessing potential impacts of HF on water resources in other regions.



Water Sources and Disposal Related to Hydraulic Fracturing in Texas

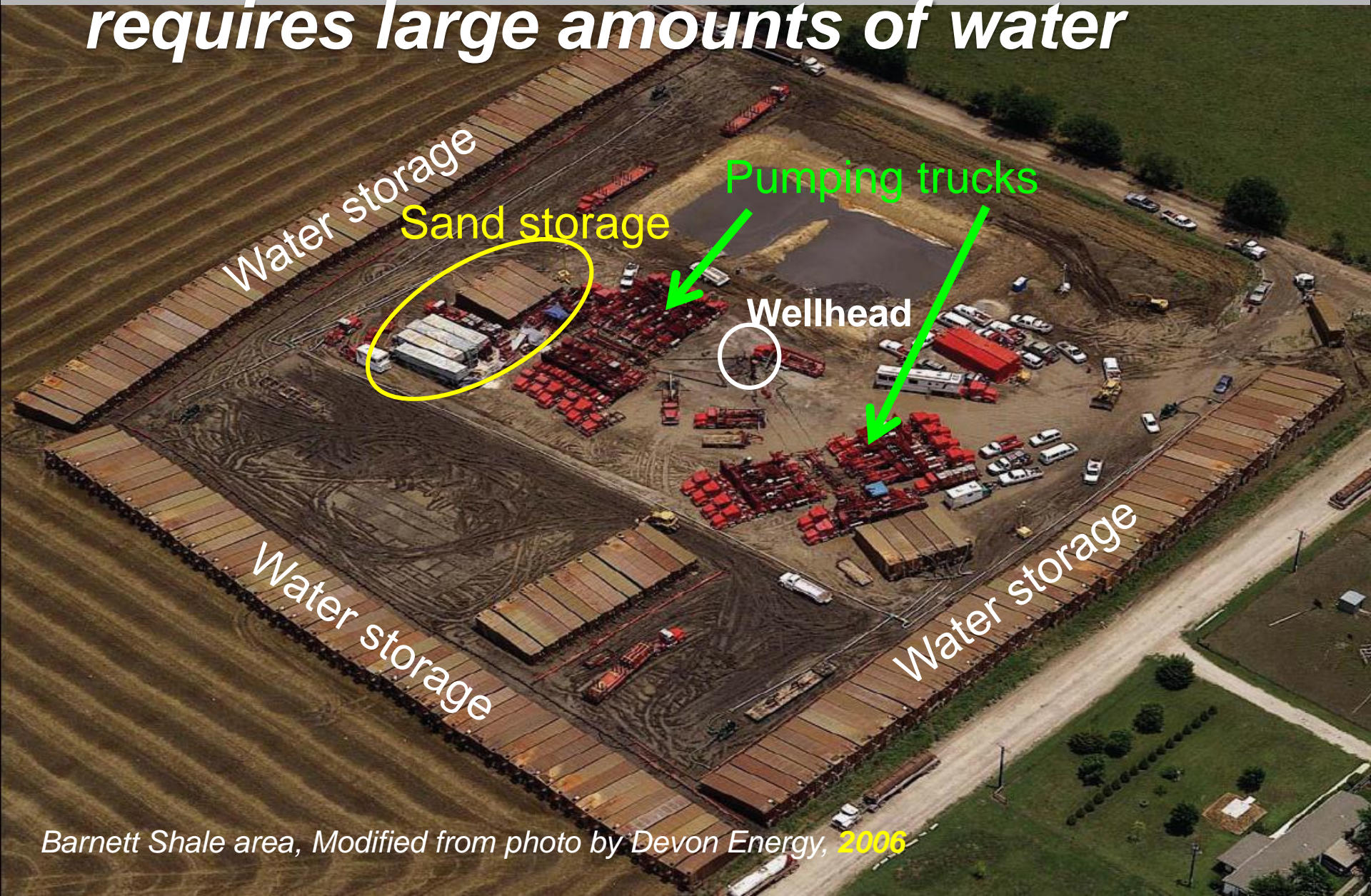
**Jean-Philippe 'JP' Nicot with
Bridget Scanlon, Bob Reedy, and Ruth Costley**

**Bureau of Economic Geology
Jackson School of Geosciences
The University of Texas at Austin**

2014 AAPG Annual Convention & Exhibition

Houston, TX – April 7, 2014

Hydraulic fracturing (HF) of a well requires large amounts of water

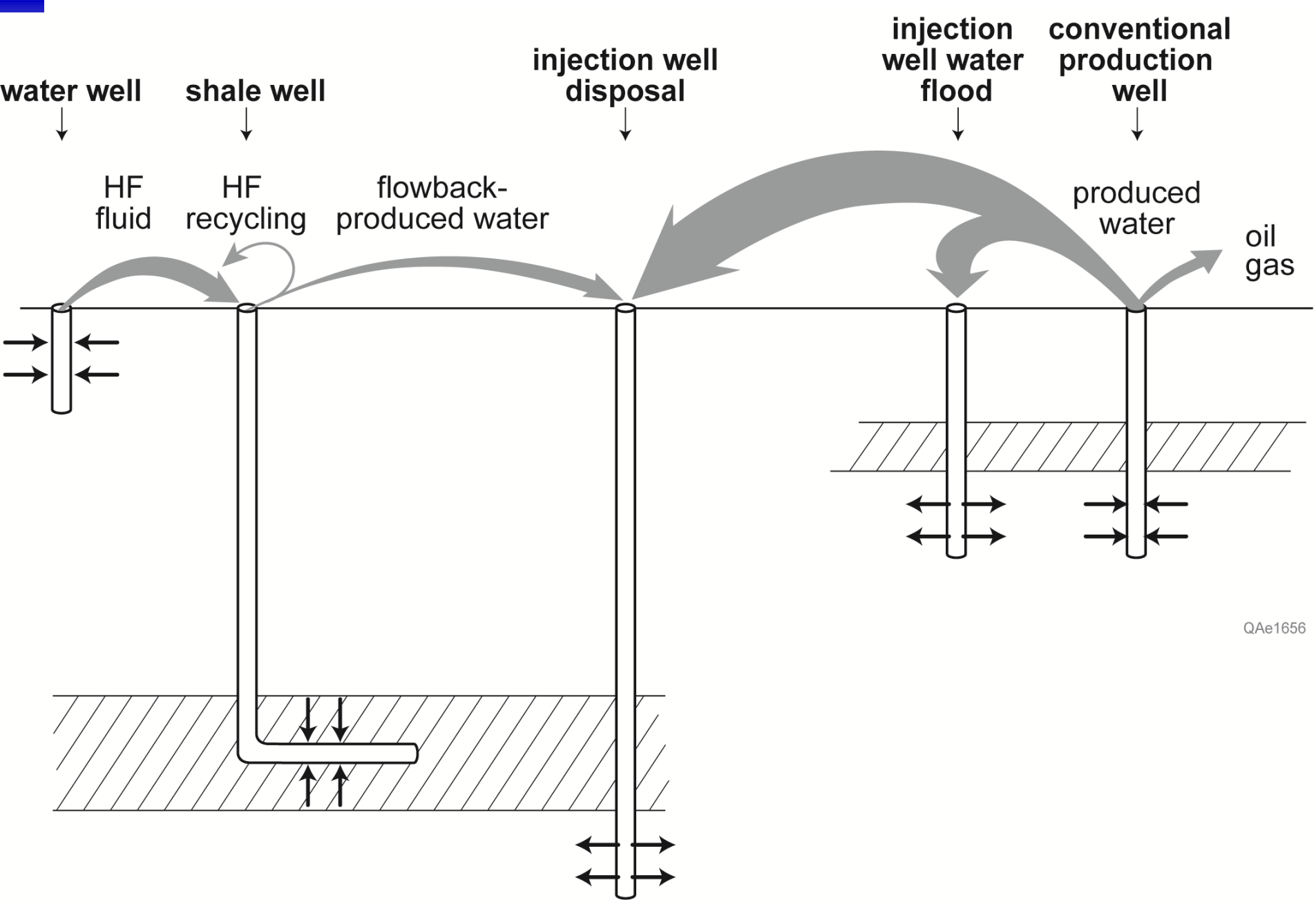


Barnett Shale area, Modified from photo by Devon Energy, 2006

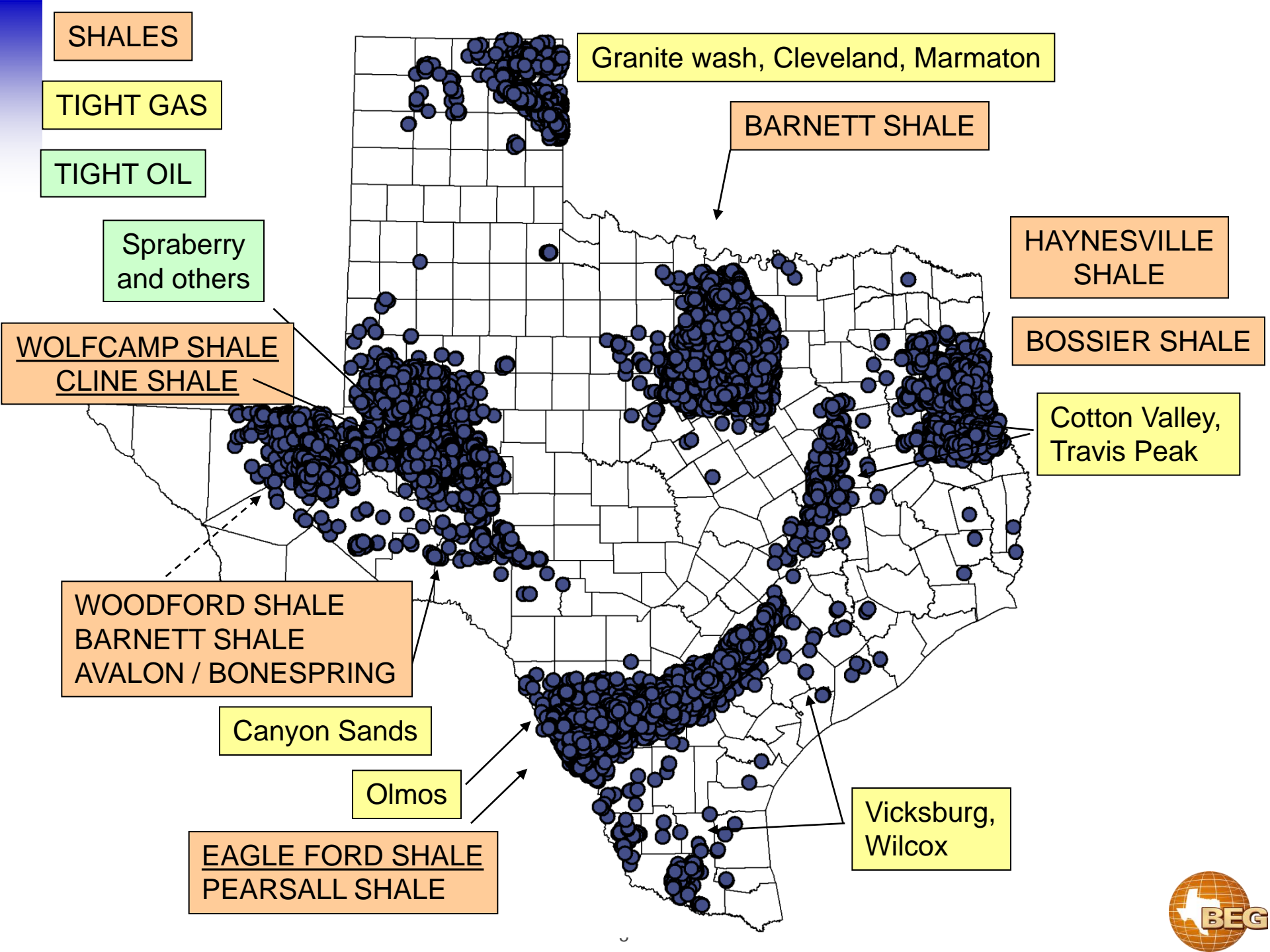
*but only some of it flows back to
the surface*



Marcellus Shale area, photo by NETL, 2011



QAe1656



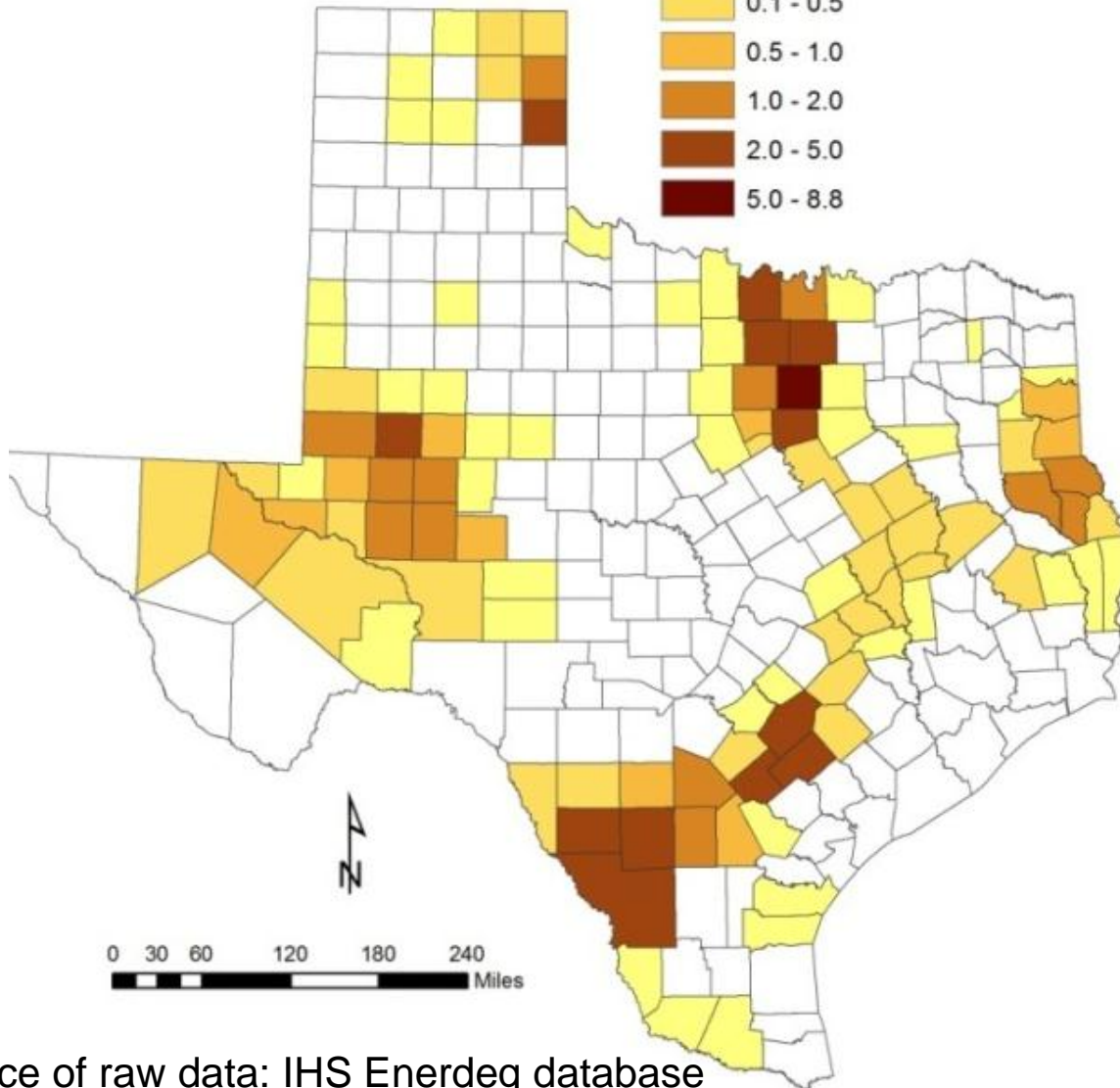
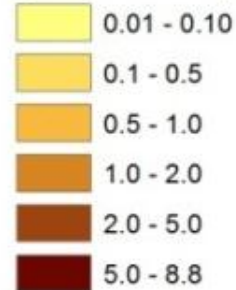
Hydraulic fracturing water use

1 AF = 325,851 gallons

1 kAF = 0.775 million bbl

1kAF = 1.23×10^6 m³

HF Water Use (year 2011)
(thousand AF)



2011: 81.5 kAF

~0.5% of state
water use

2013: >100 kAF

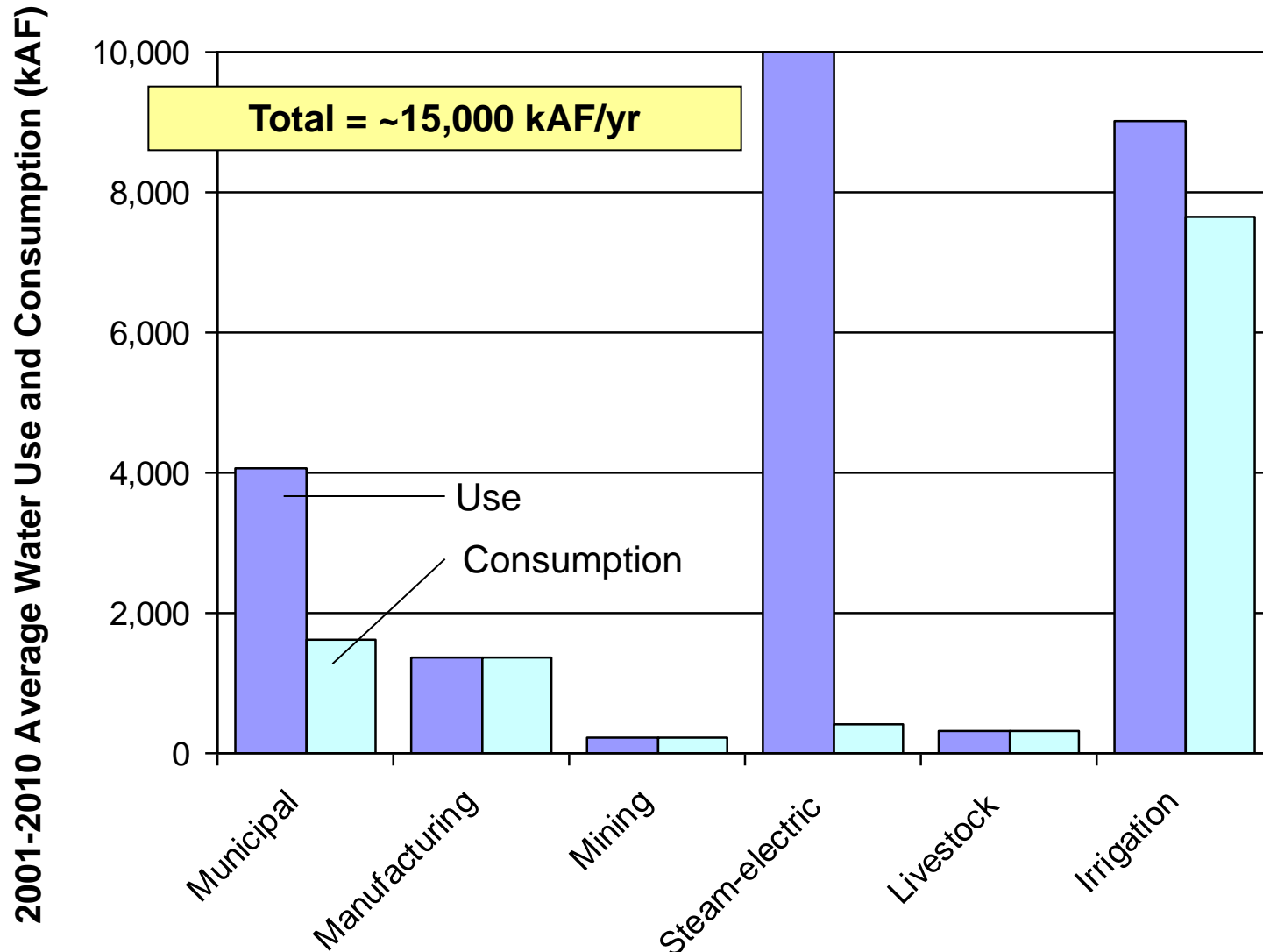
IHS, FracFocus, Skytruth

Source of raw data: IHS Enerdeq database



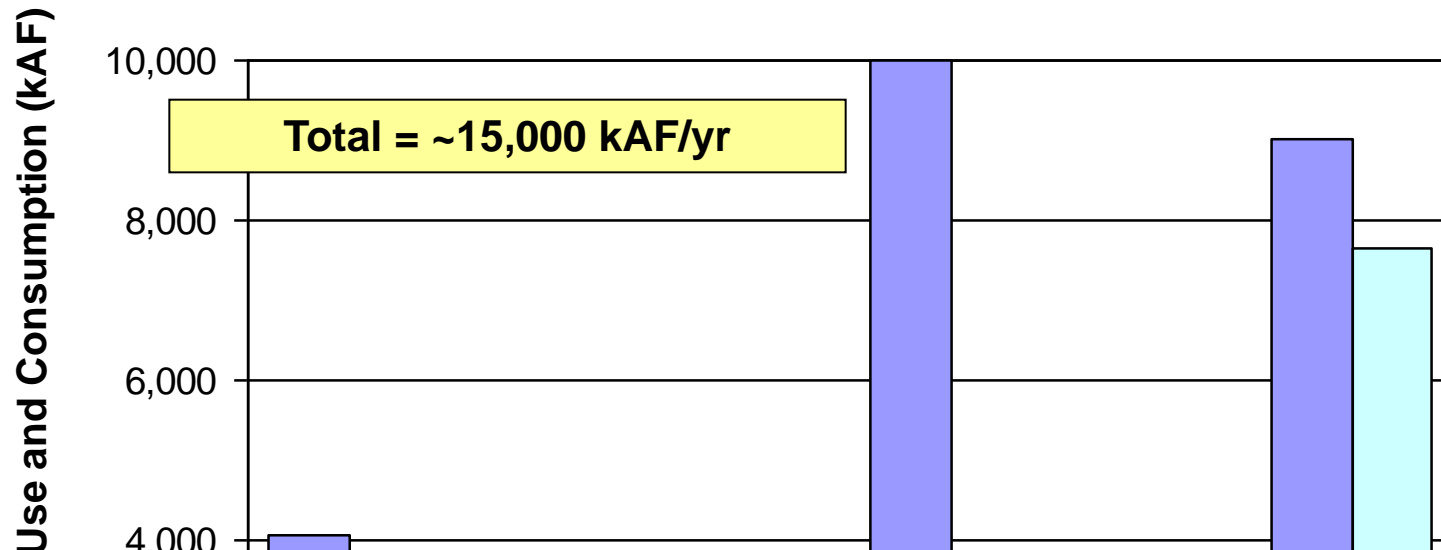
State water use and consumption

Bureau of Economic Geology



State water use and consumption

Bureau of Economic Geology



2008 Mining consumption:

Oil and Gas = ~60 kAF (~36 kAF HF)
(HF, drilling, waterflooding)

Coal/Lignite = ~20 kAF

Aggregates = ~70 kAF

Others = ~10 kAF

Total = ~160 kAF

2011 Mining consumption:

Oil and Gas = ~120 kAF water use
(HF, drilling, waterflooding)

HF = ~81.5 kAF water use

HF = ~65 kAF water consumption

All others = ~100 kAF

Total consumption = ~190 kAF

Water use in other states

Bureau of Economic Geology

- Large volumes, 10's of thousands of HF wells in the US, generally small % of total state water use (~2013)
- ND (Bakken): ~22 kAF (27 Mm³)
- PA (Marcellus): >20 kAF (>25 Mm³)
- CO: ~20 kAF (25 Mm³)
- OK: ~15 kAF (18 Mm³)
- TX: ~100 kAF (123 Mm³)



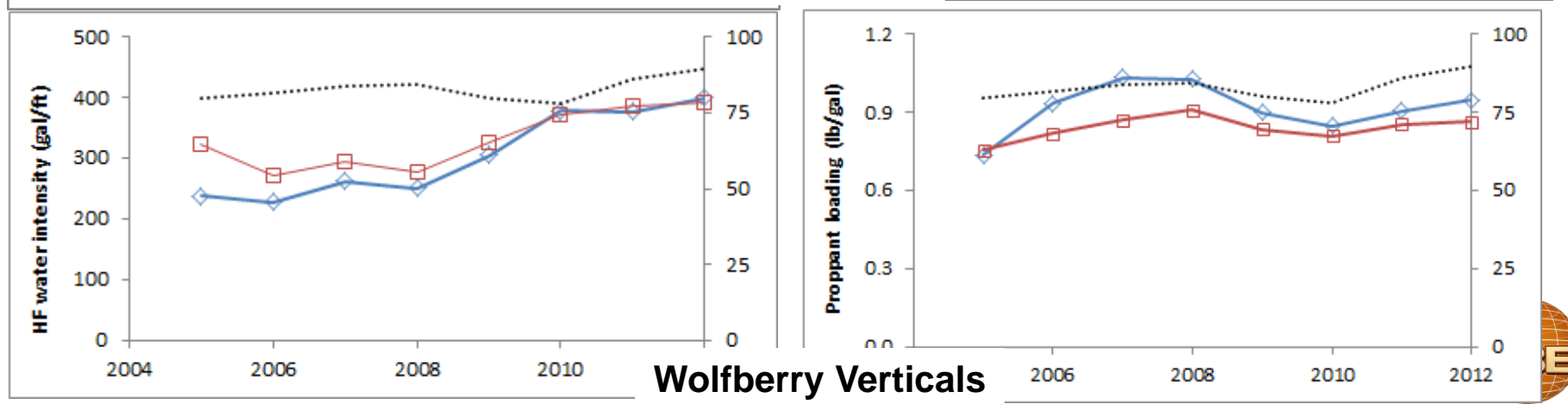
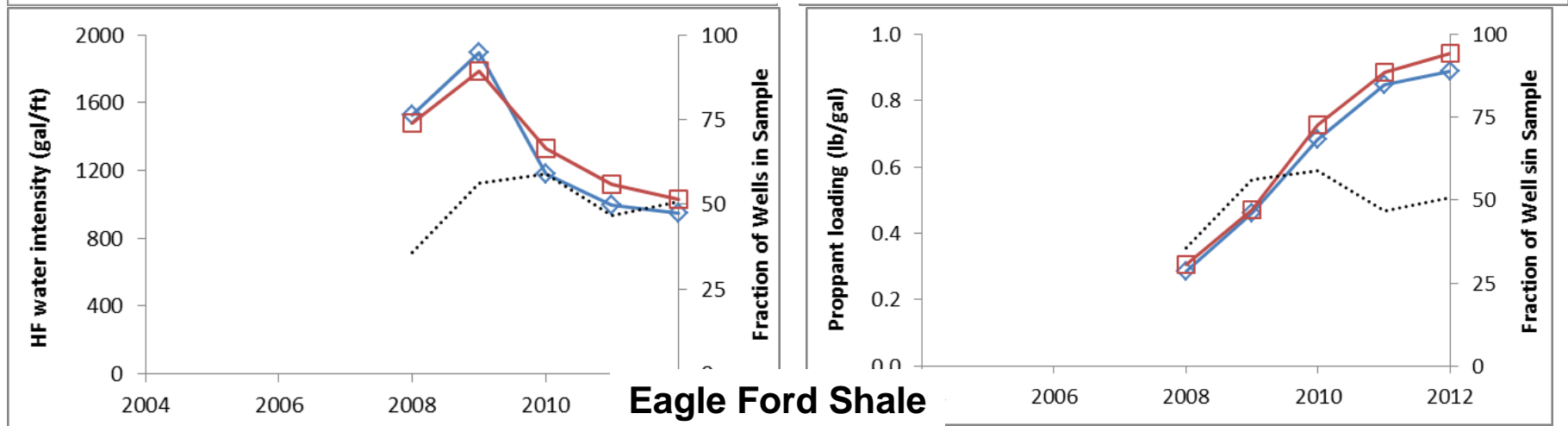
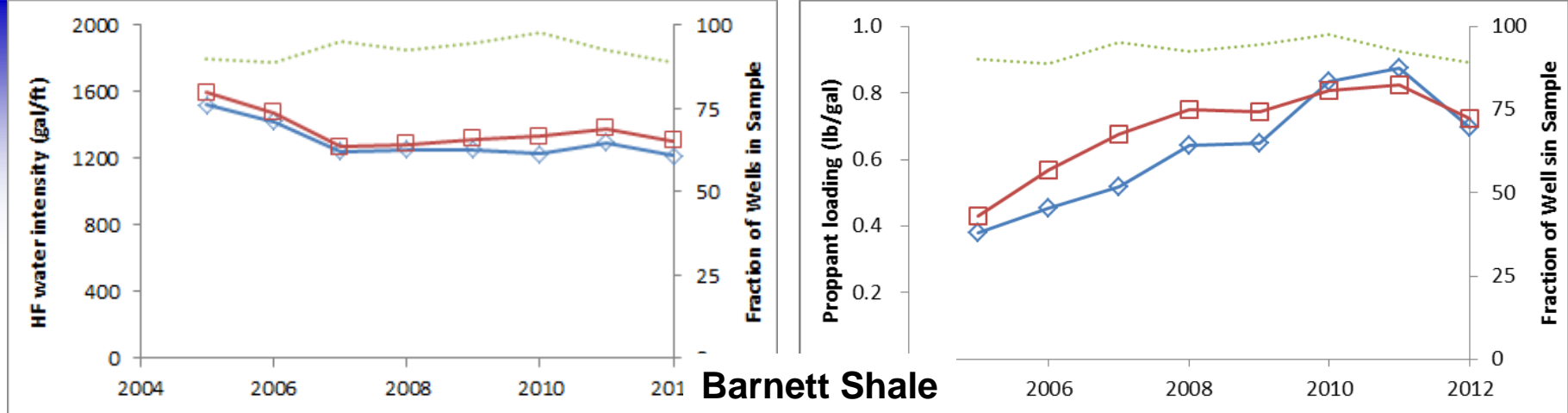
Bakken area, ND, 2013

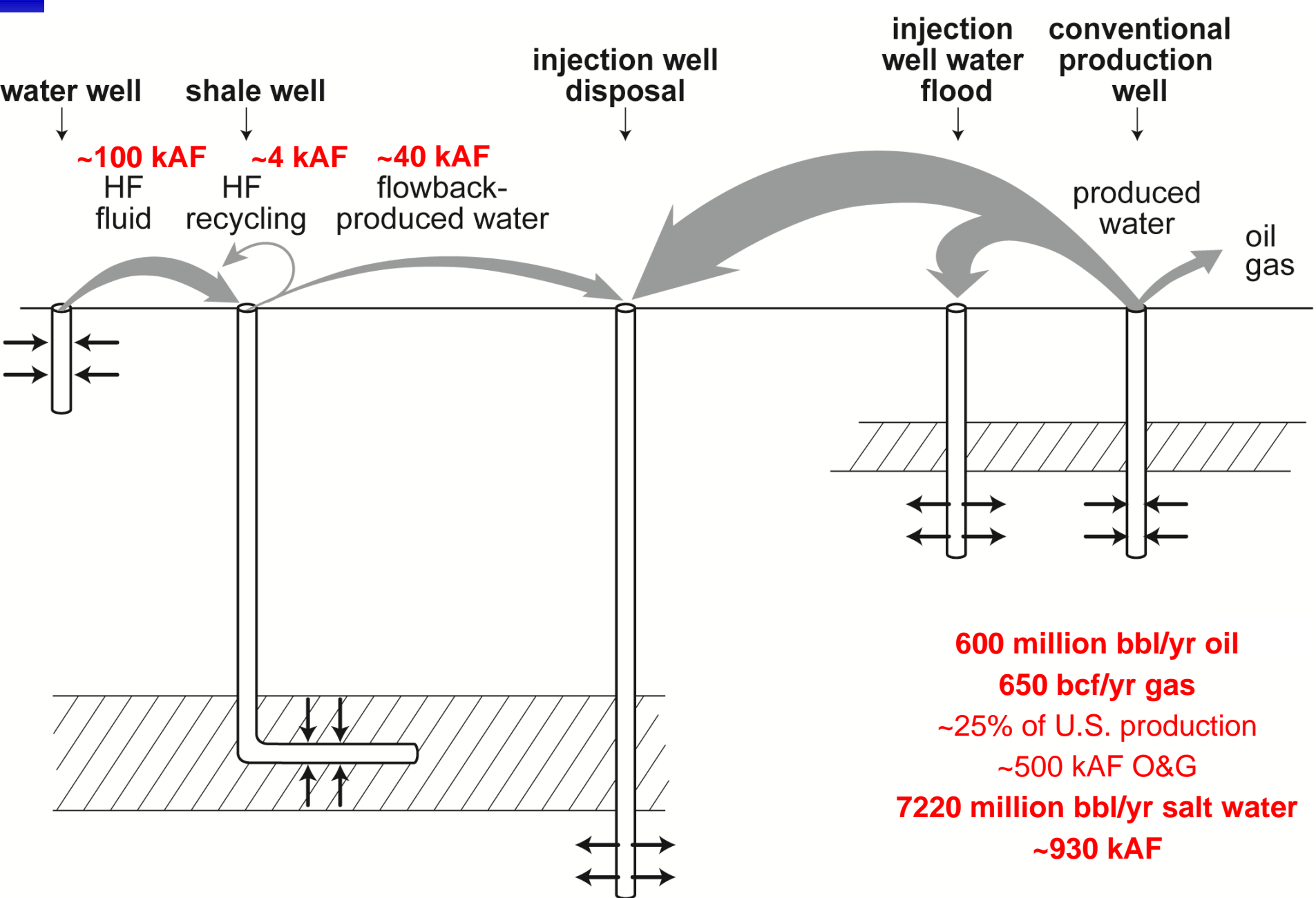
Vern Whitten Photography

Data QC and accuracy

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- **Water intensity (gal/ft):**
 - amount of water per unit length of lateral
 - around 1000 gal/ft
- **Proppant loading (lb/gal):**
 - amount of proppant per unit volume of fluid
 - around 0.5 to 2 lb/gal

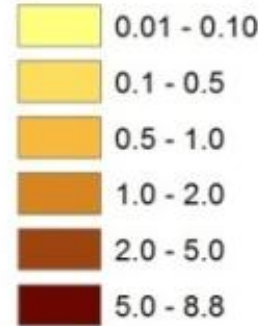




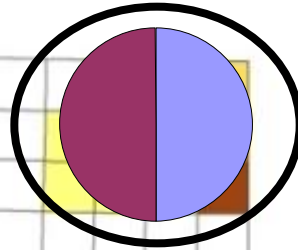
Approximate values for ~2012-2013

Fraction from recycling / reuse and brackish water

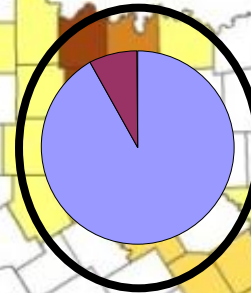
HF Water Use (year 2011)
(thousand AF)



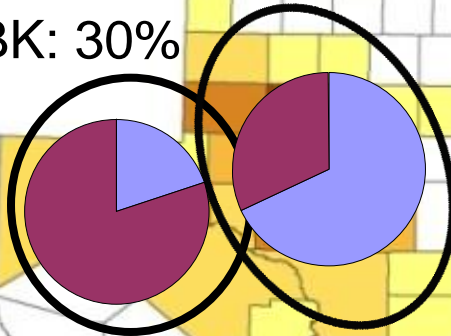
Anadarko:
R/R: 20%
BK: 30%



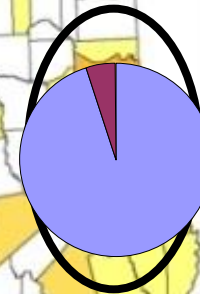
Barnett:
R/R: 5%
BK: 3%



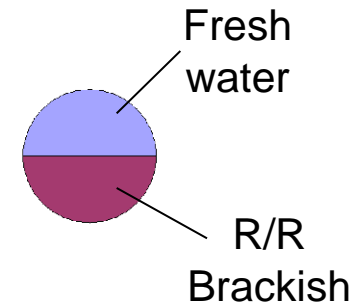
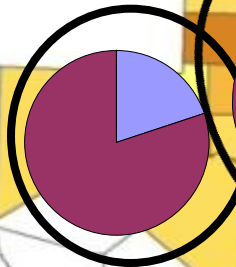
Midland:
R/R: 2%
BK: 30%



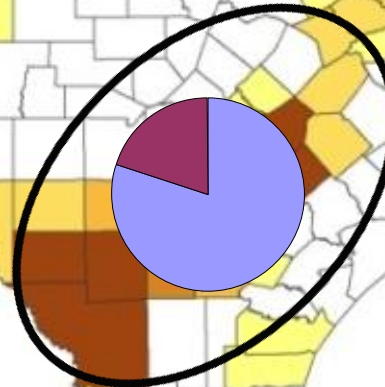
East Texas:
R/R: 5%
BK: ~0%



Delaware:
R/R: 0%
BK: 80%



Eagle Ford:
R/R: ~0%
BK: 20%



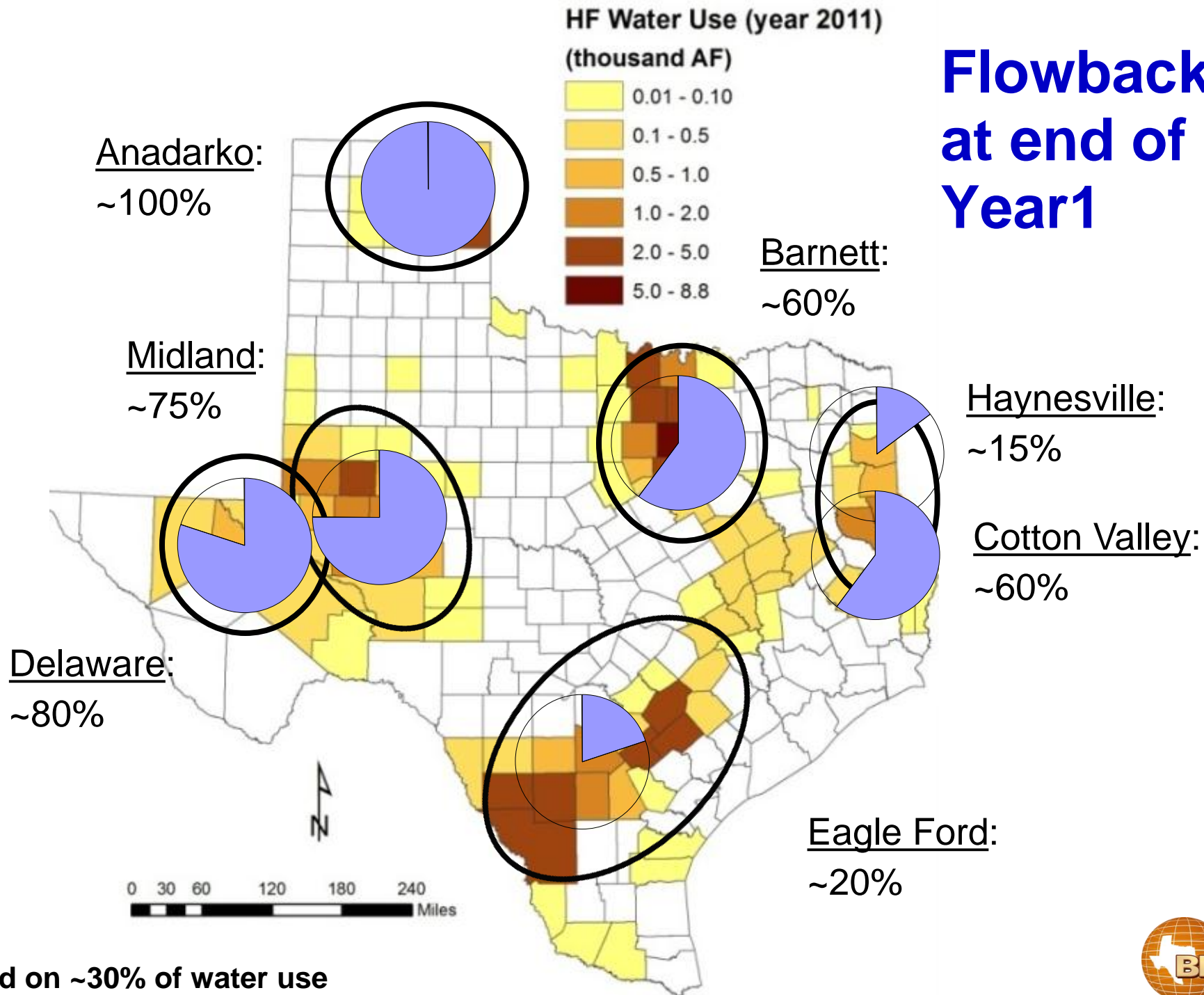
0 30 60 120 180 240 Miles



Based on ~30% of water use

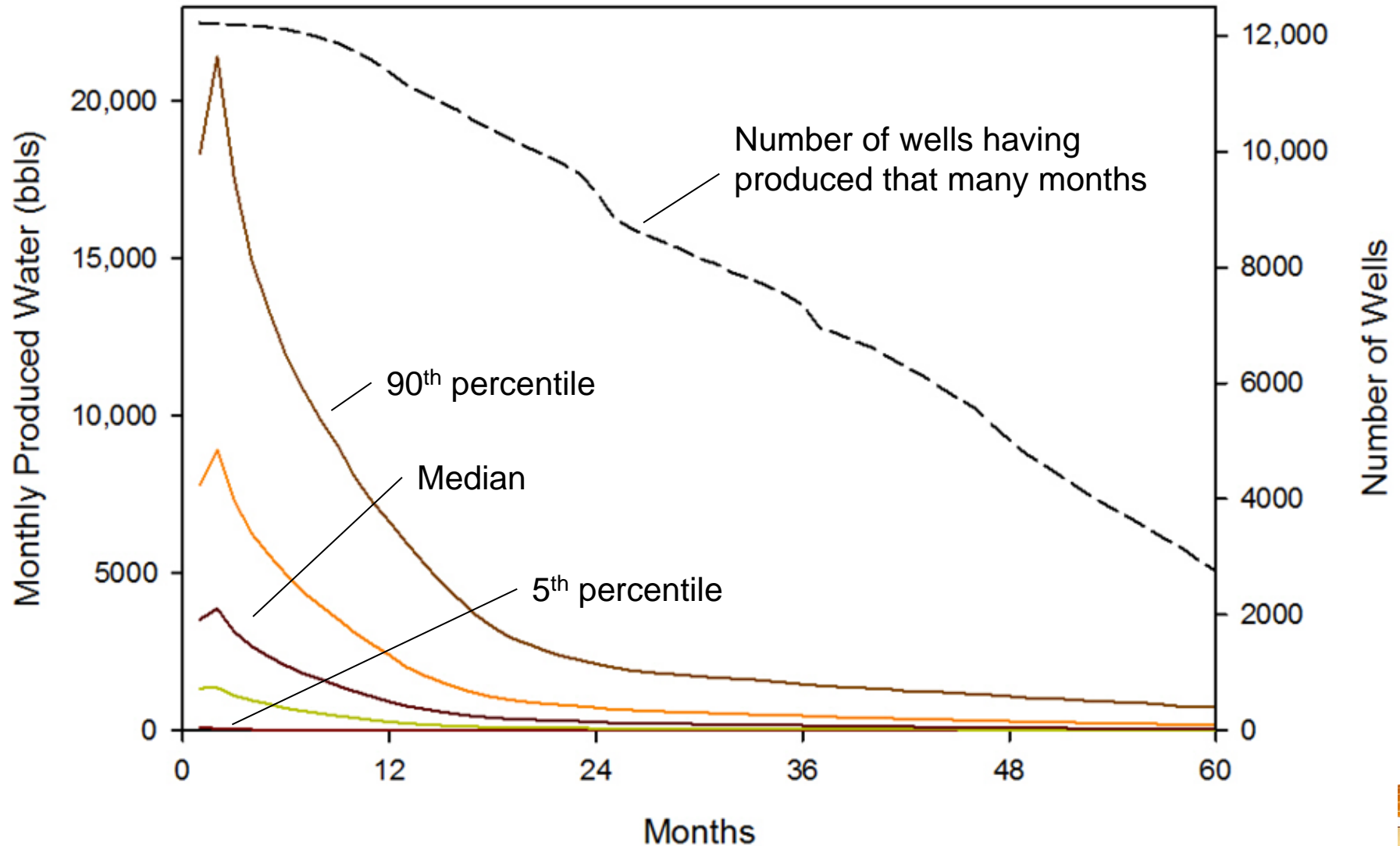


Flowback at end of Year1



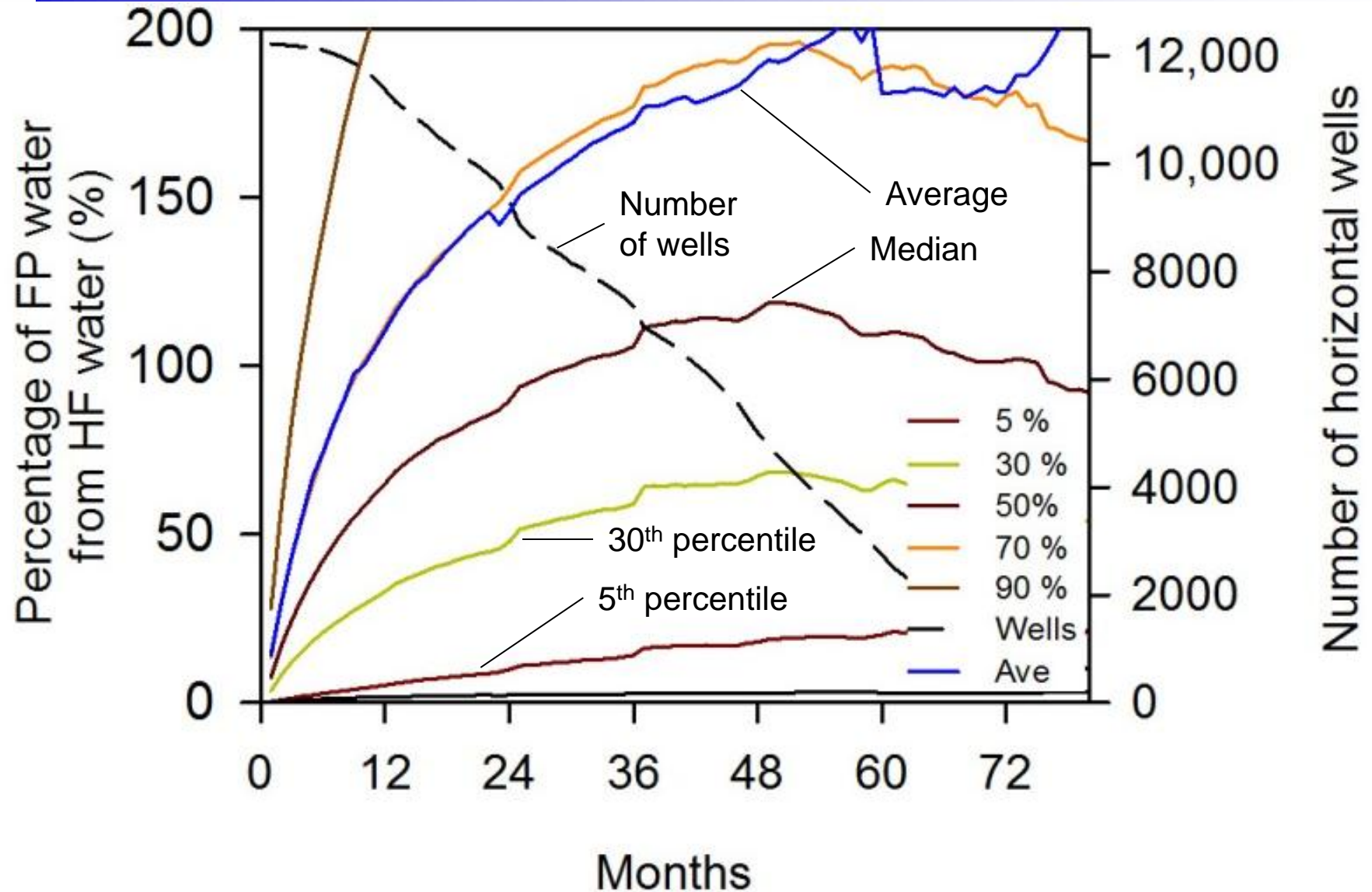
Monthly produced water percentiles – Barnett Shale

Bureau of Economic Geology



Cumulative produced water percentiles – Barnett Shale

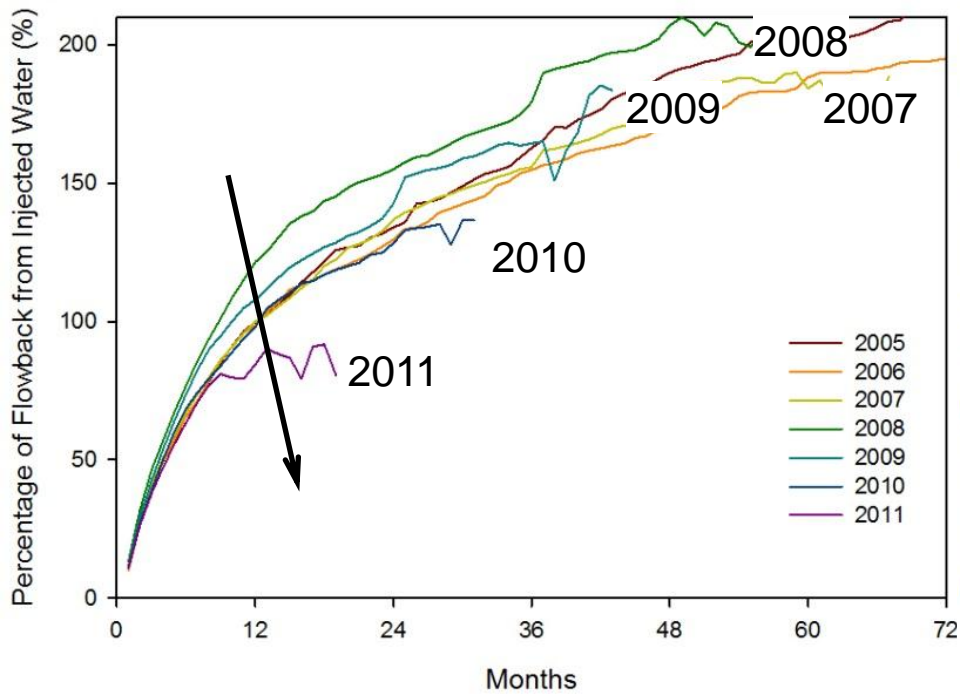
Bureau of Economic Geology



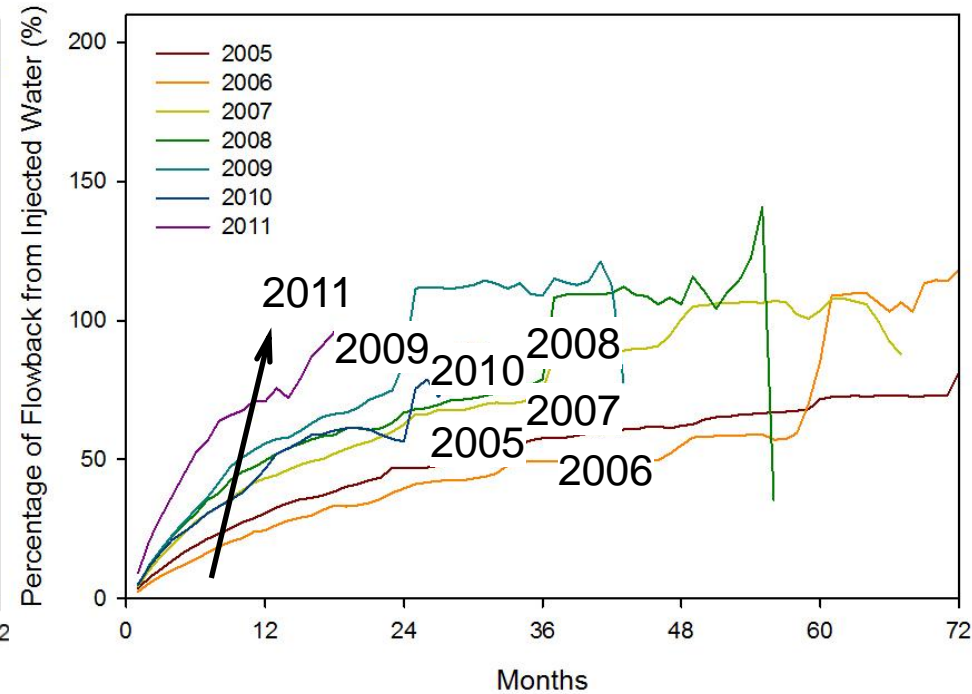
Time variability of produced water fraction

Bureau of Economic Geology

Percentage of Flowback Medians For Johnson County

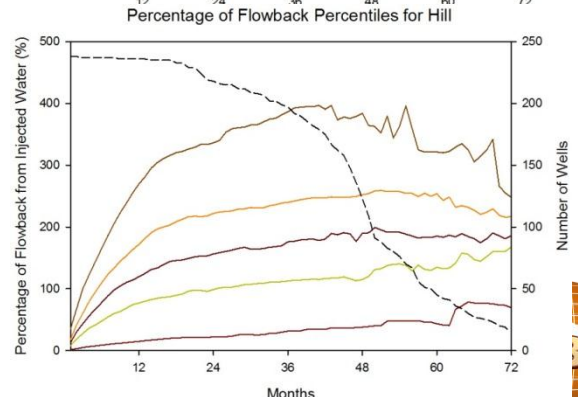
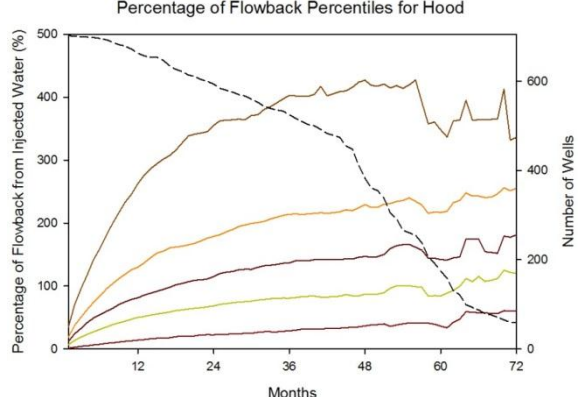
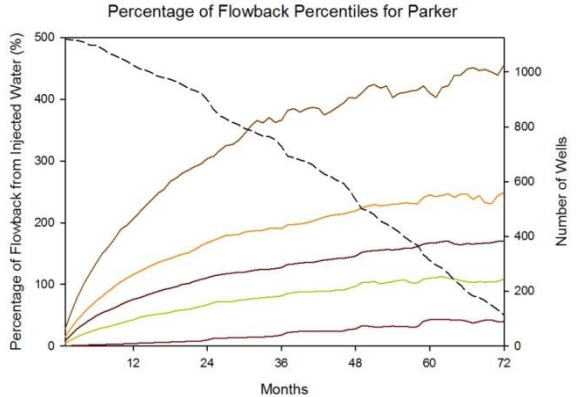
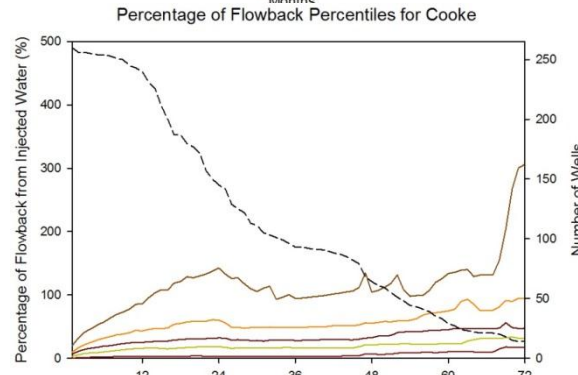
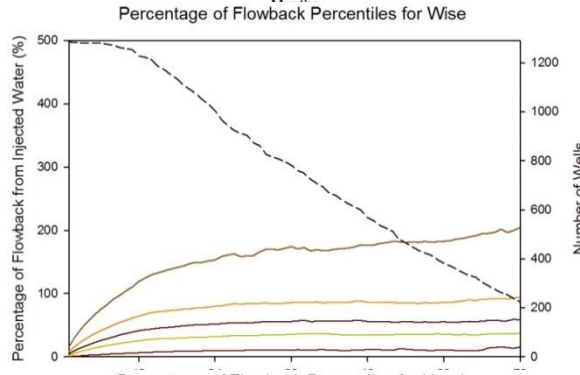
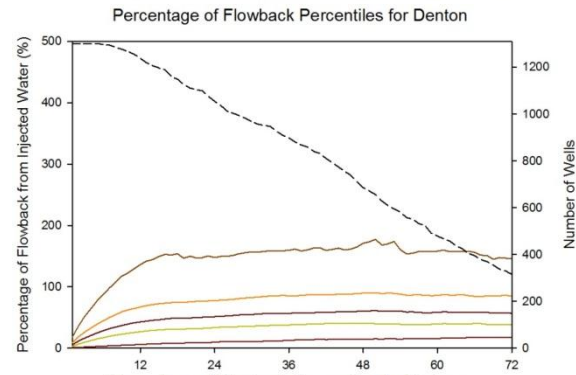
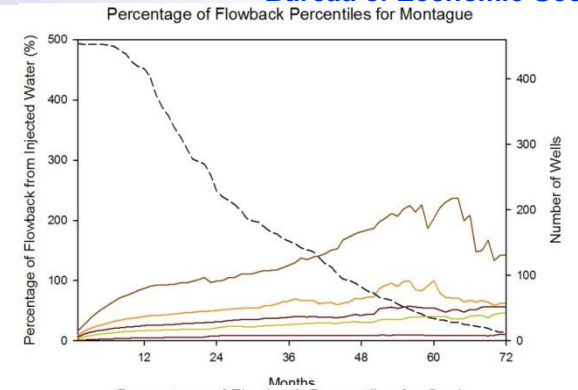
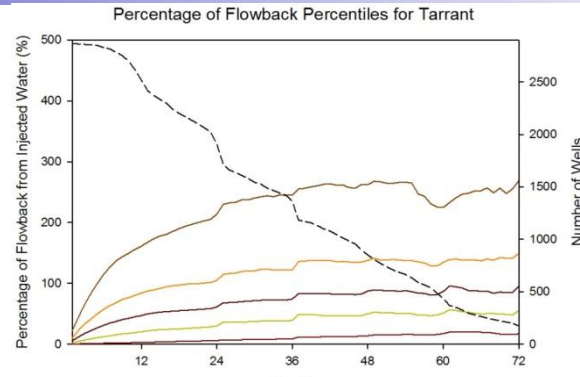
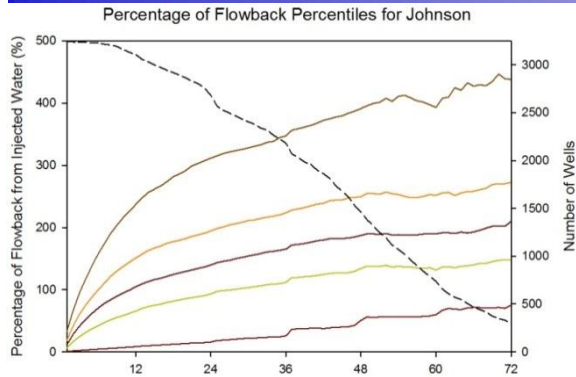


Percentage of Flowback Medians for Tarrant County



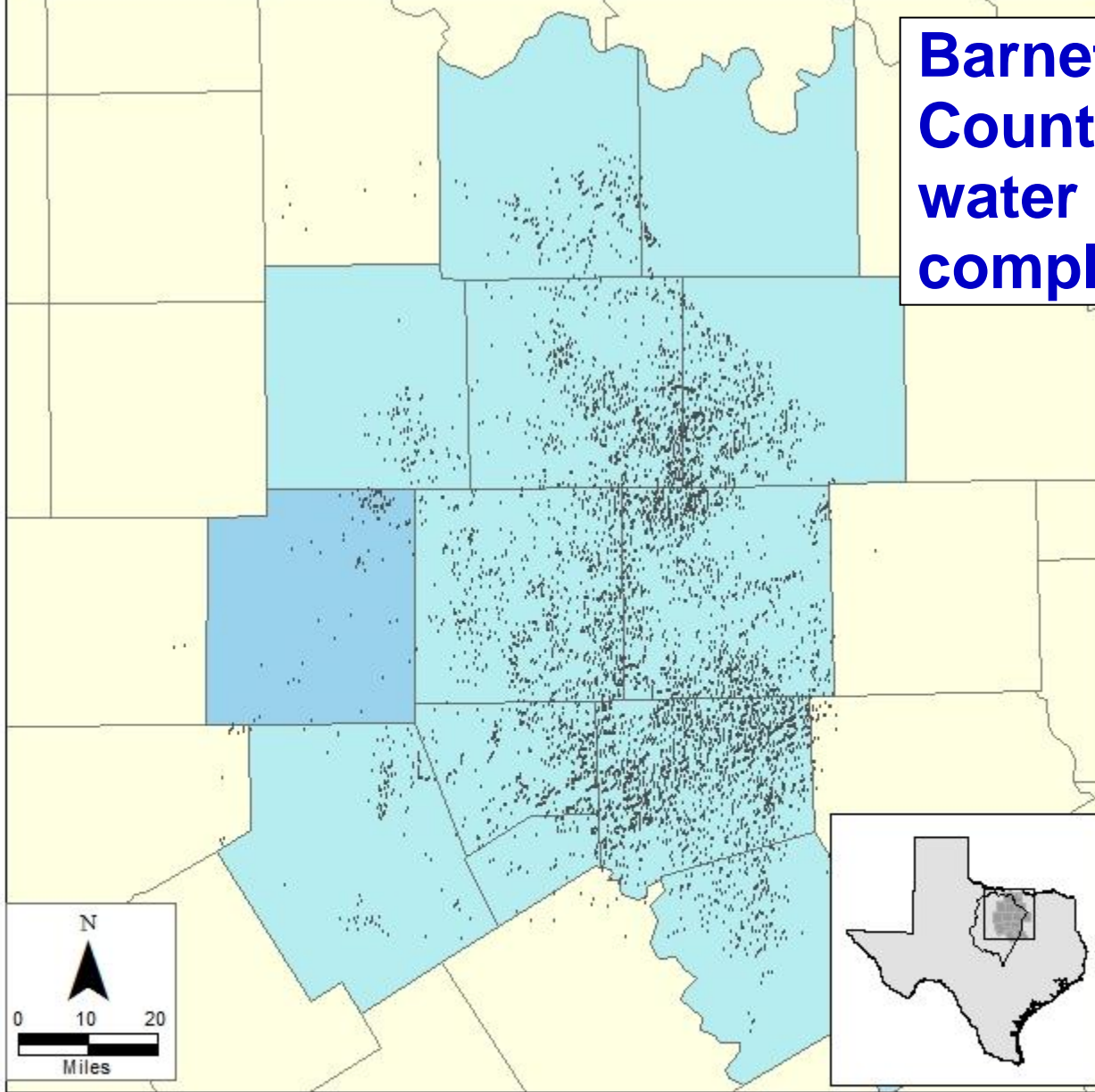
County-level produced water fraction

Bureau of Economic Geology



Barnett Shale: County-level produced water fraction from well completion

- 1 month

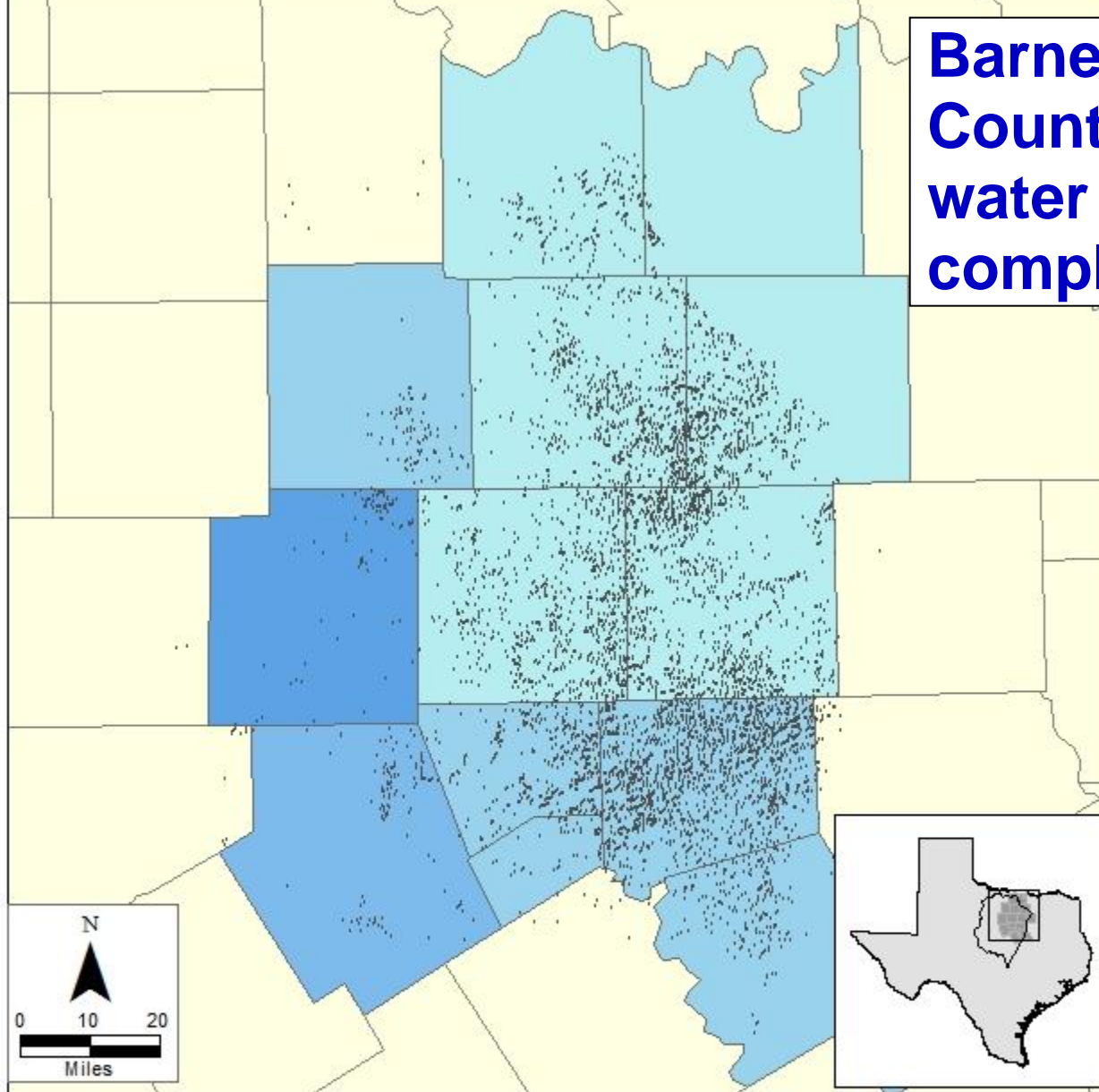


1 Month Median Flowback



Barnett Shale: County-level produced water fraction from well completion

- 1 month
- 2 months



2 Month Median Flowback

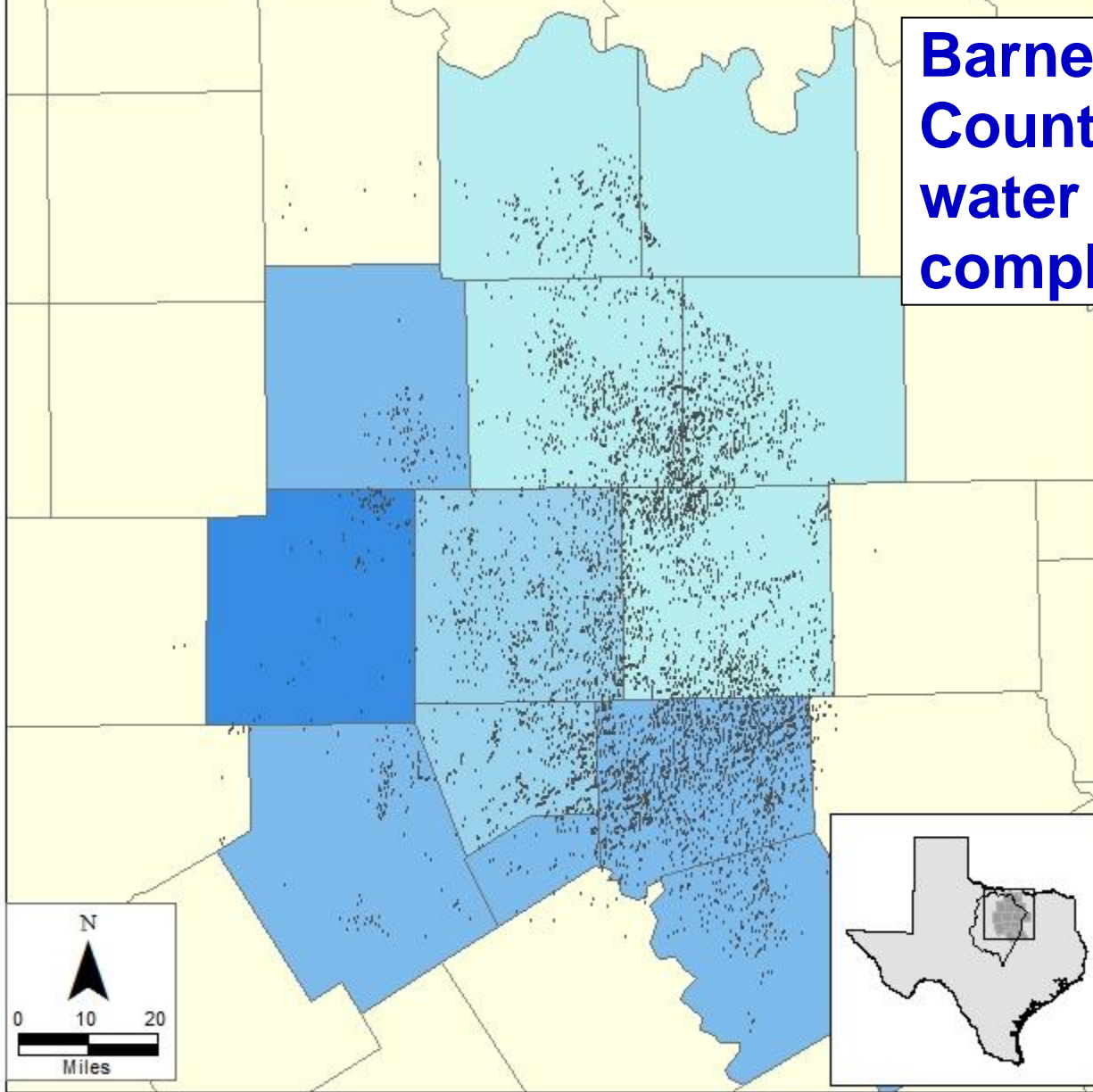


0-20 20-40 40-60 60-80 80-100 100-120 120-140 140-160 160-180 180-200

Wells

Barnett Shale: County-level produced water fraction from well completion

- 1 month
- 2 months
- 3 months

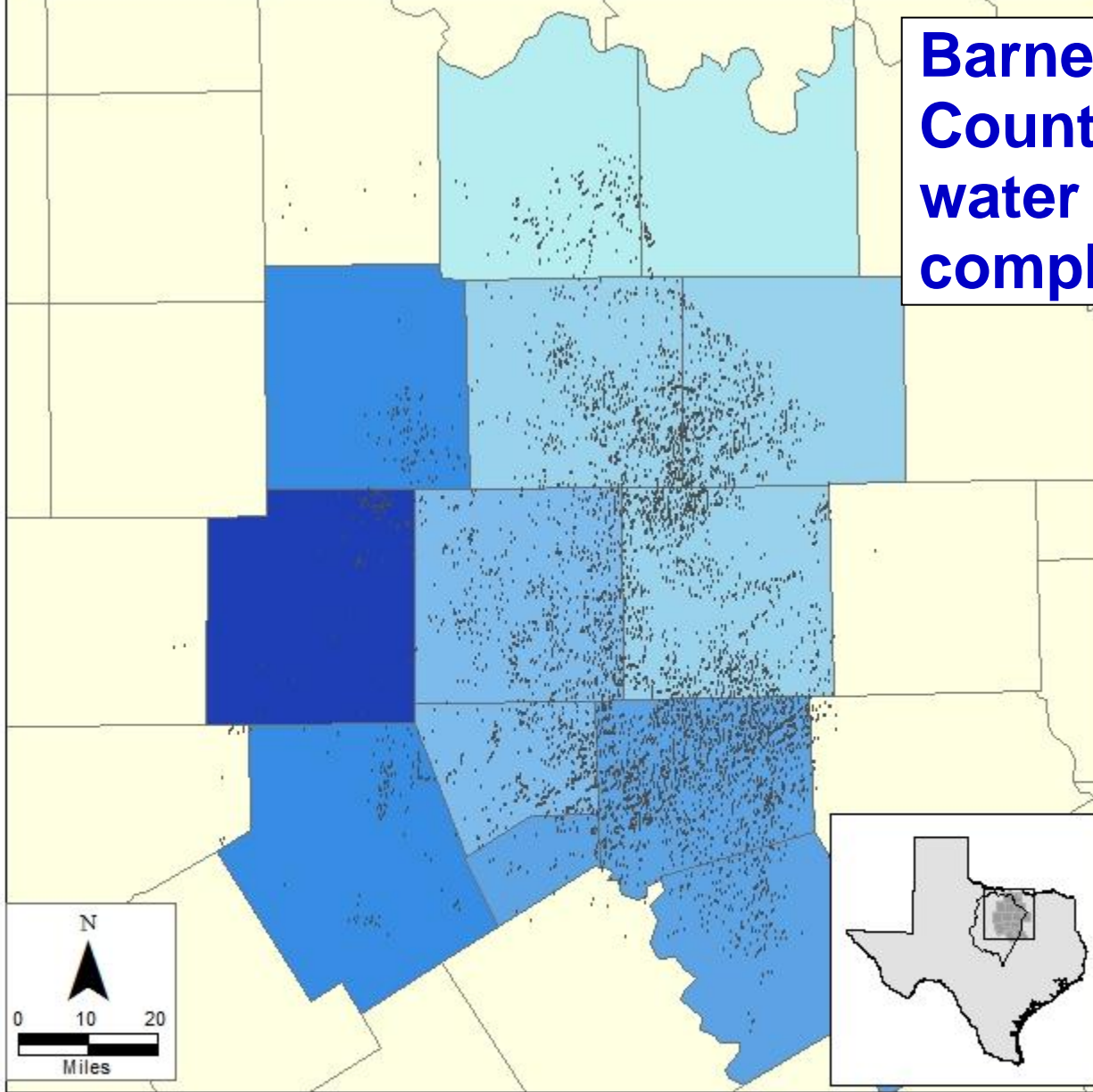


3 Month Median Flowback



Barnett Shale: County-level produced water fraction from well completion

- 1 month
- 2 months
- 3 months
- 6 months

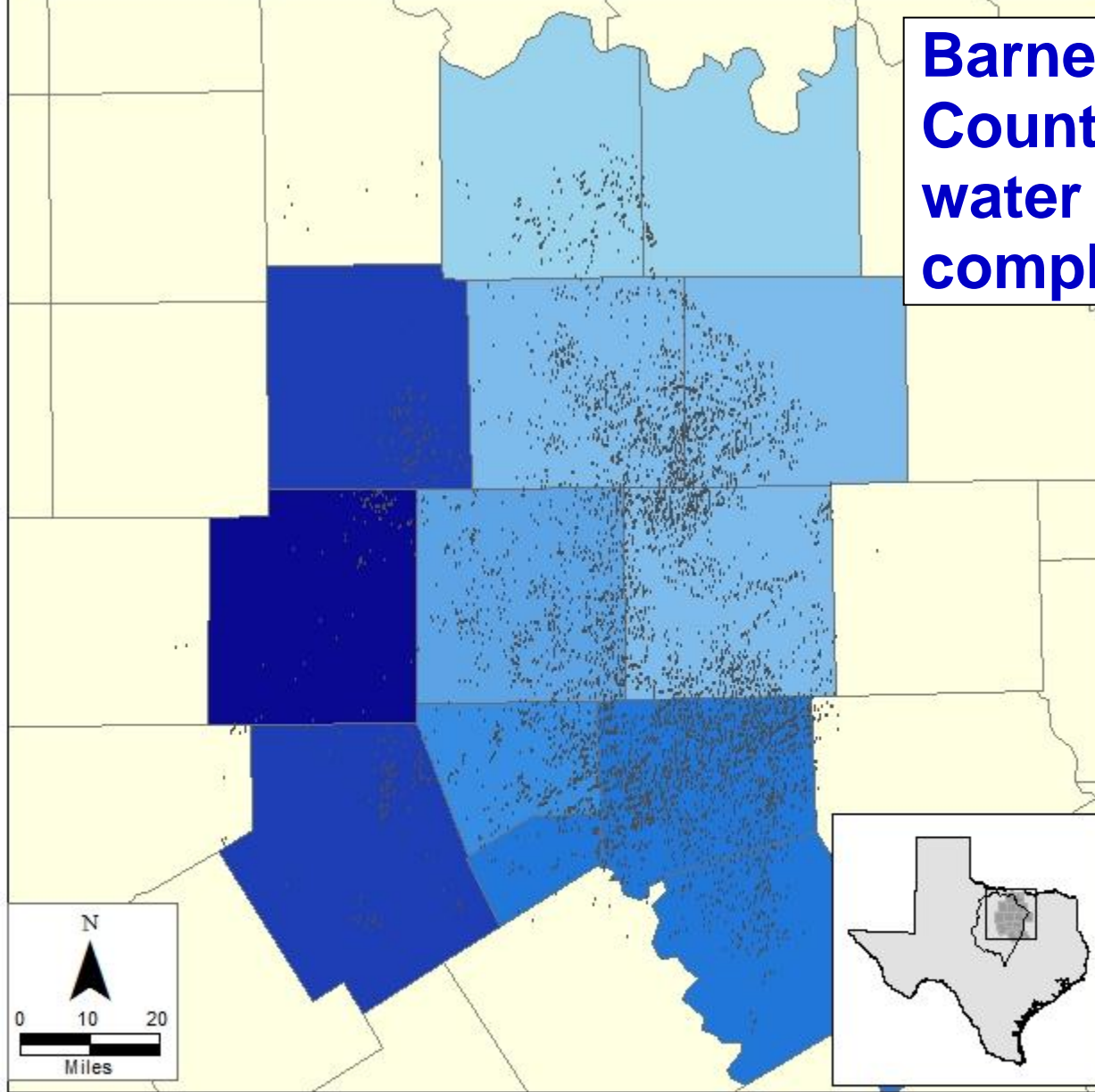


6 Month Median Flowback



Barnett Shale: County-level produced water fraction from well completion

- 1 month
- 2 months
- 3 months
- 6 months
- 1 year

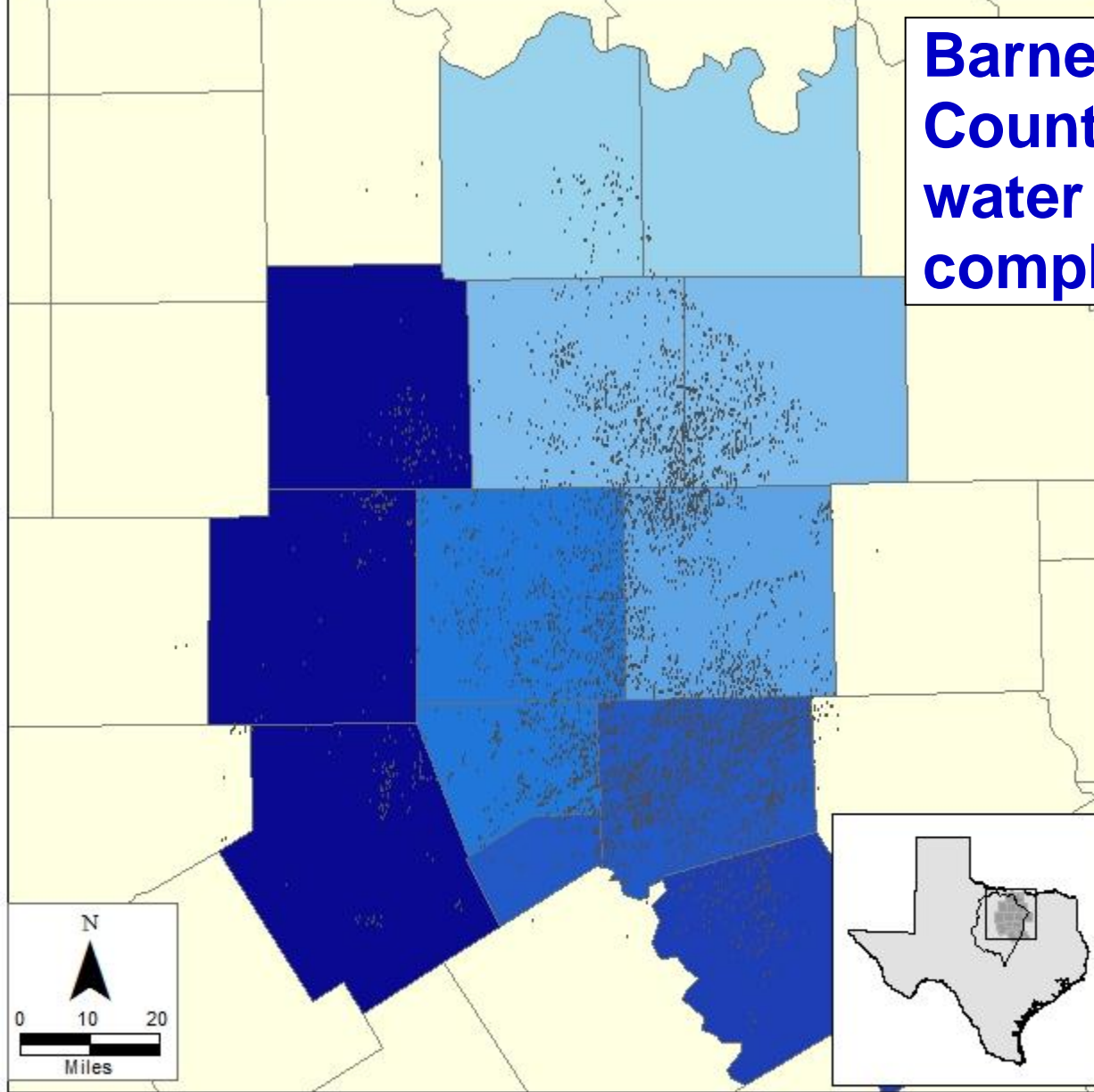


12 Month Median Flowback



Barnett Shale: County-level produced water fraction from well completion

- 1 month
- 2 months
- 3 months
- 6 months
- 1 year
- 2 years

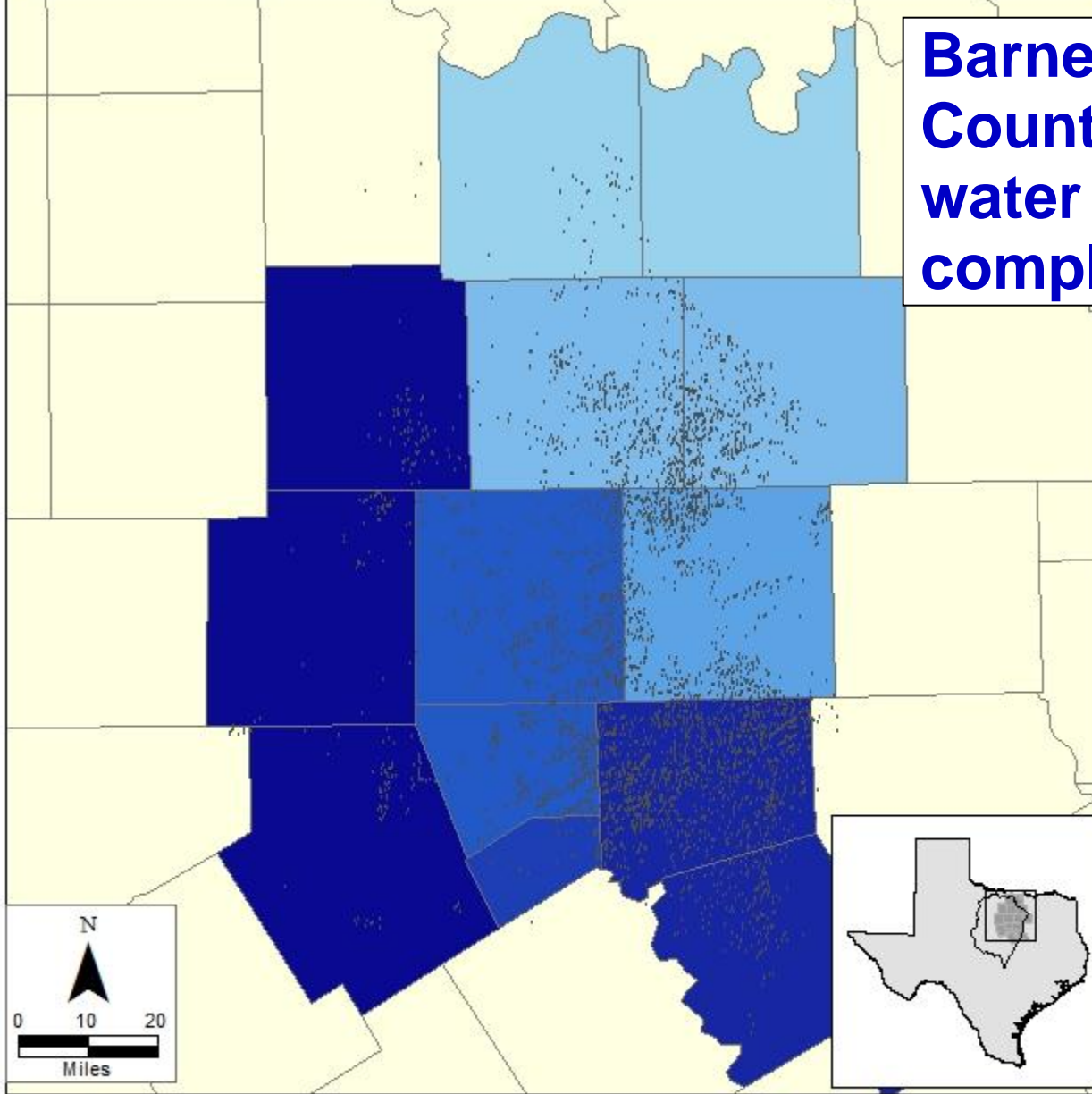


24 Month Median Flowback



Barnett Shale: County-level produced water fraction from well completion

- 1 month
- 2 months
- 3 months
- 6 months
- 1 year
- 2 years
- 3 years

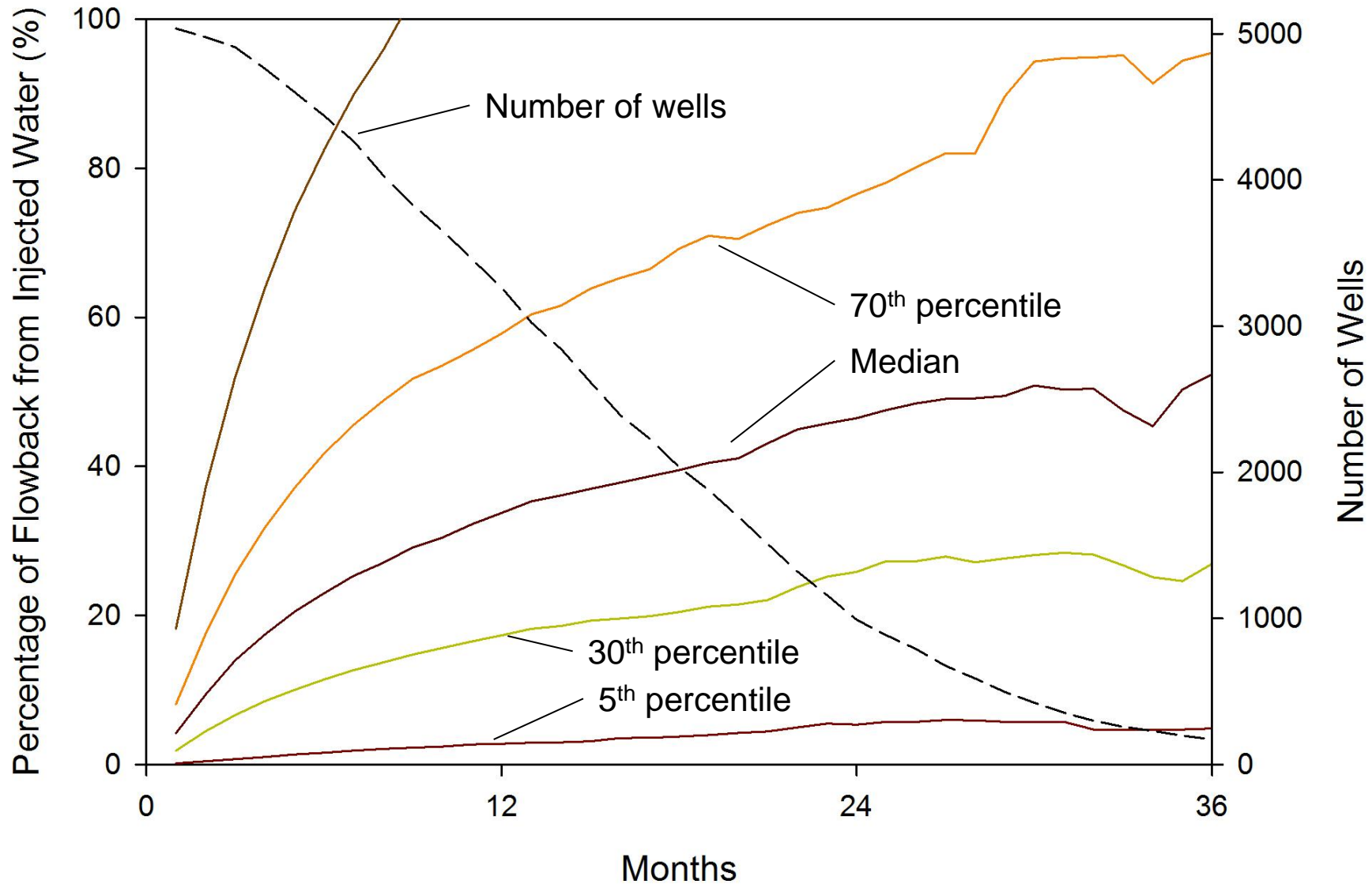


36 Month Median Flowback



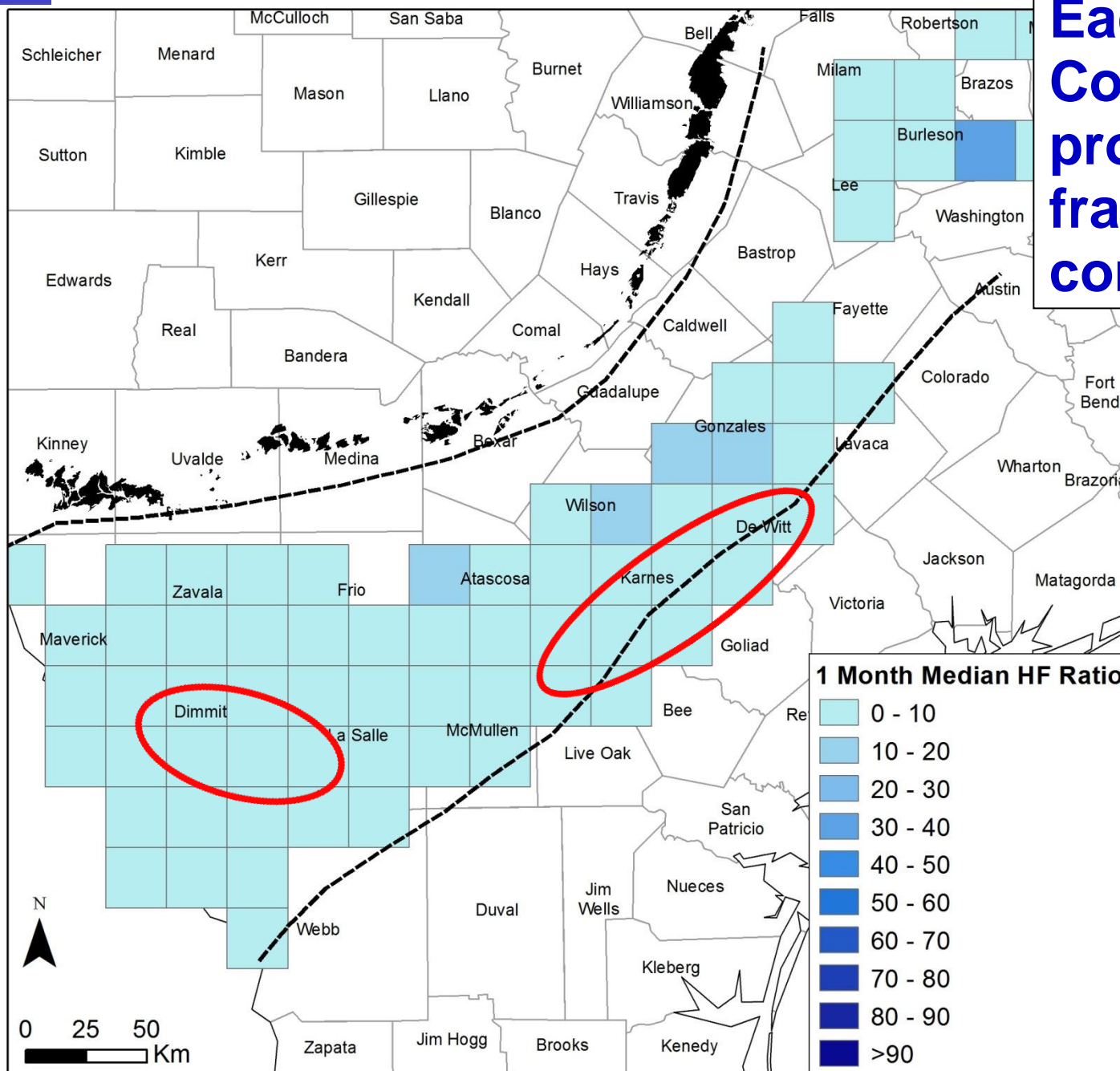
Cumulative produced water percentiles – Eagle Ford

Bureau of Economic Geology



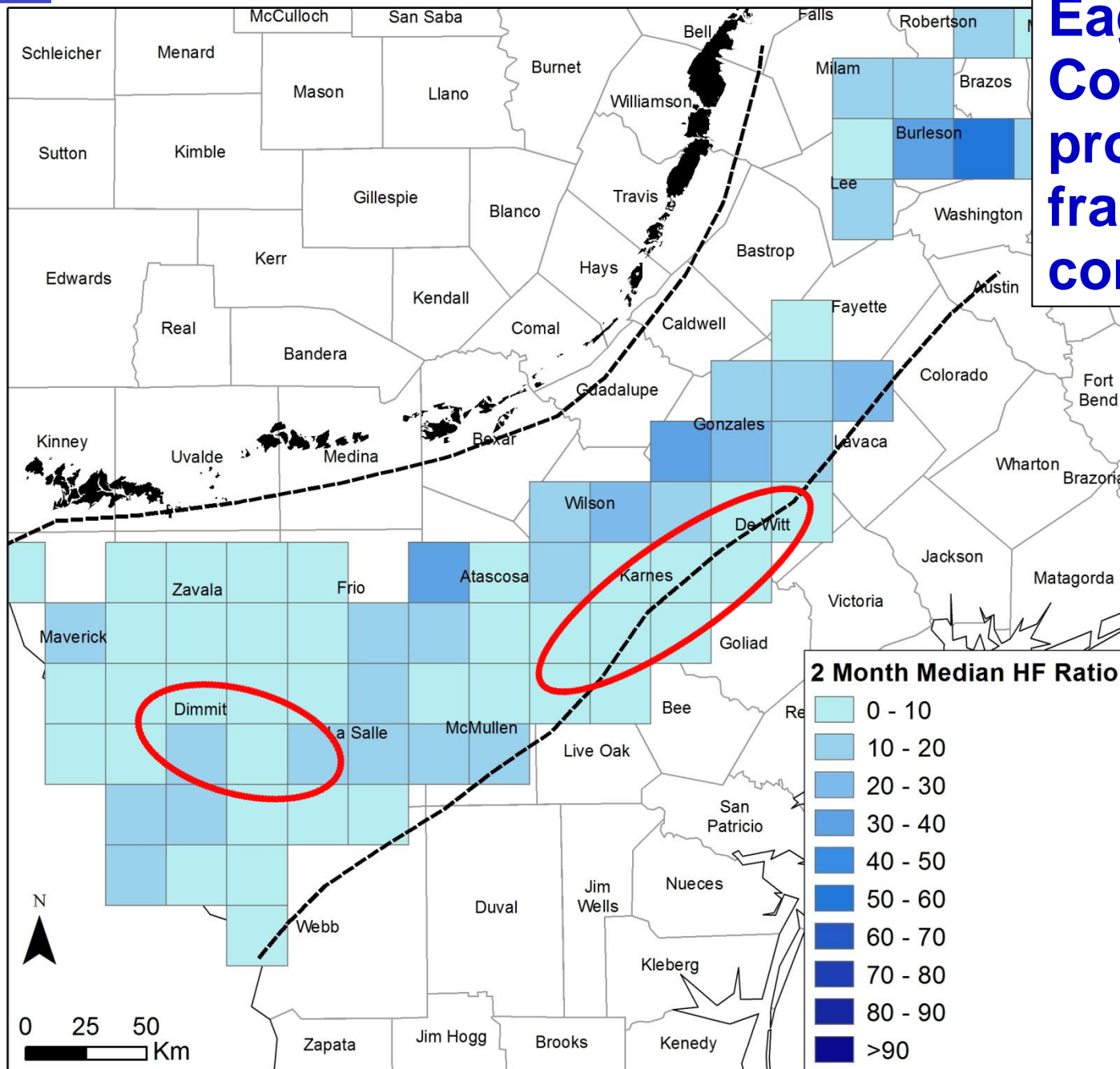
Eagle Ford Shale: County-level produced water fraction from well completion

- 1 month



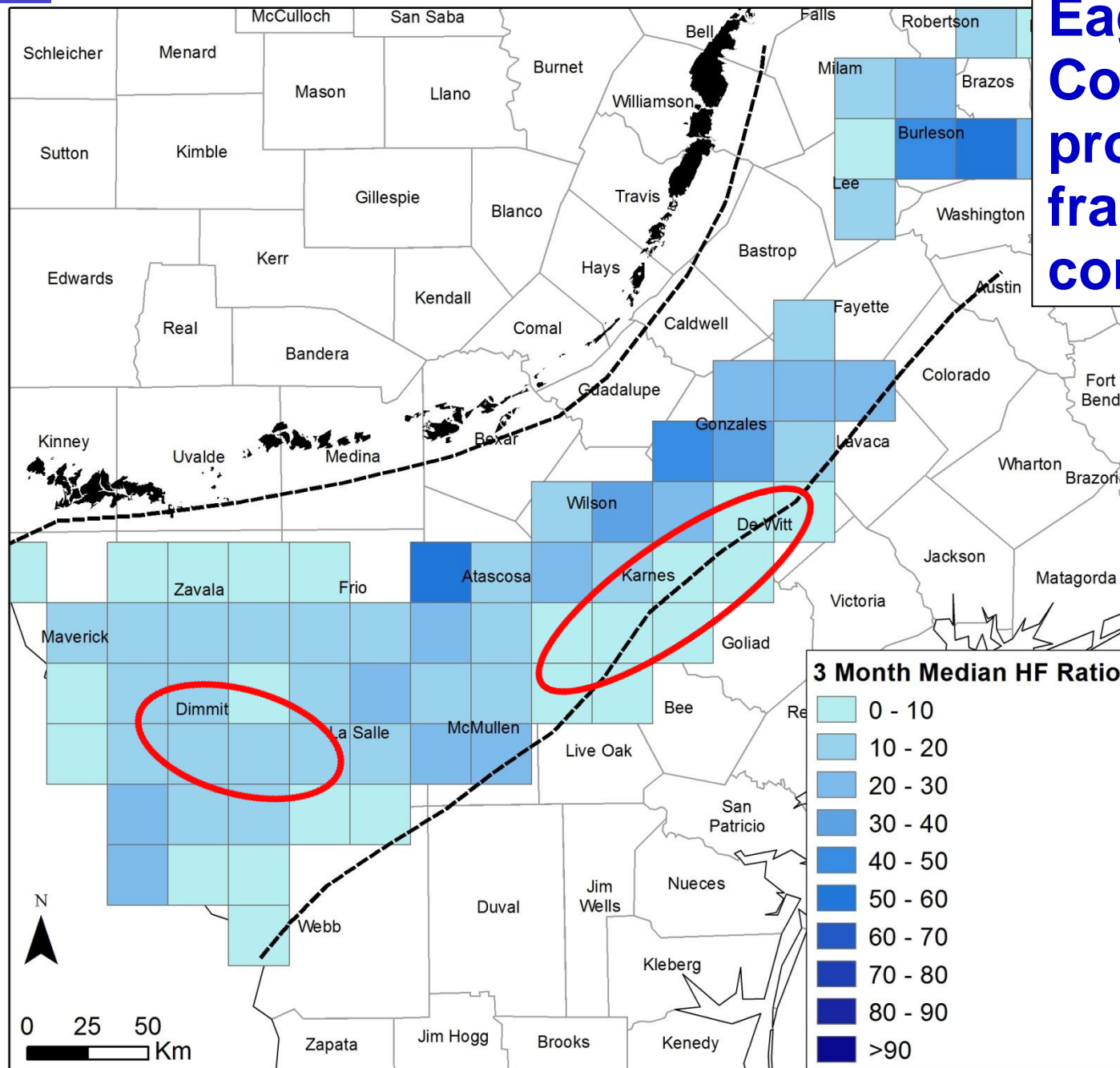
Eagle Ford Shale: County-level produced water fraction from well completion

- 1 month
- 2 months



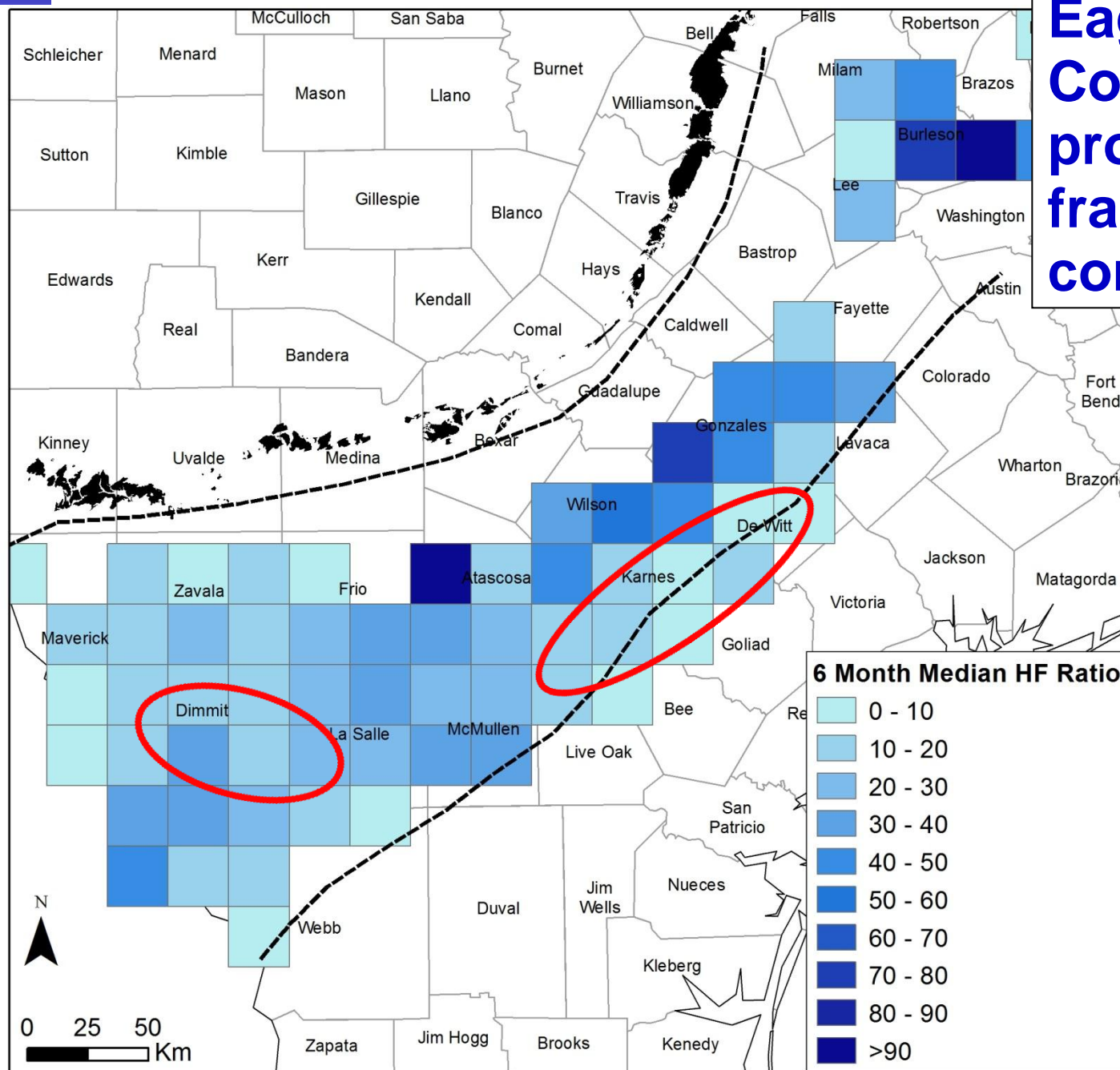
Eagle Ford Shale: County-level produced water fraction from well completion

- 1 month
- 2 months
- 3 months

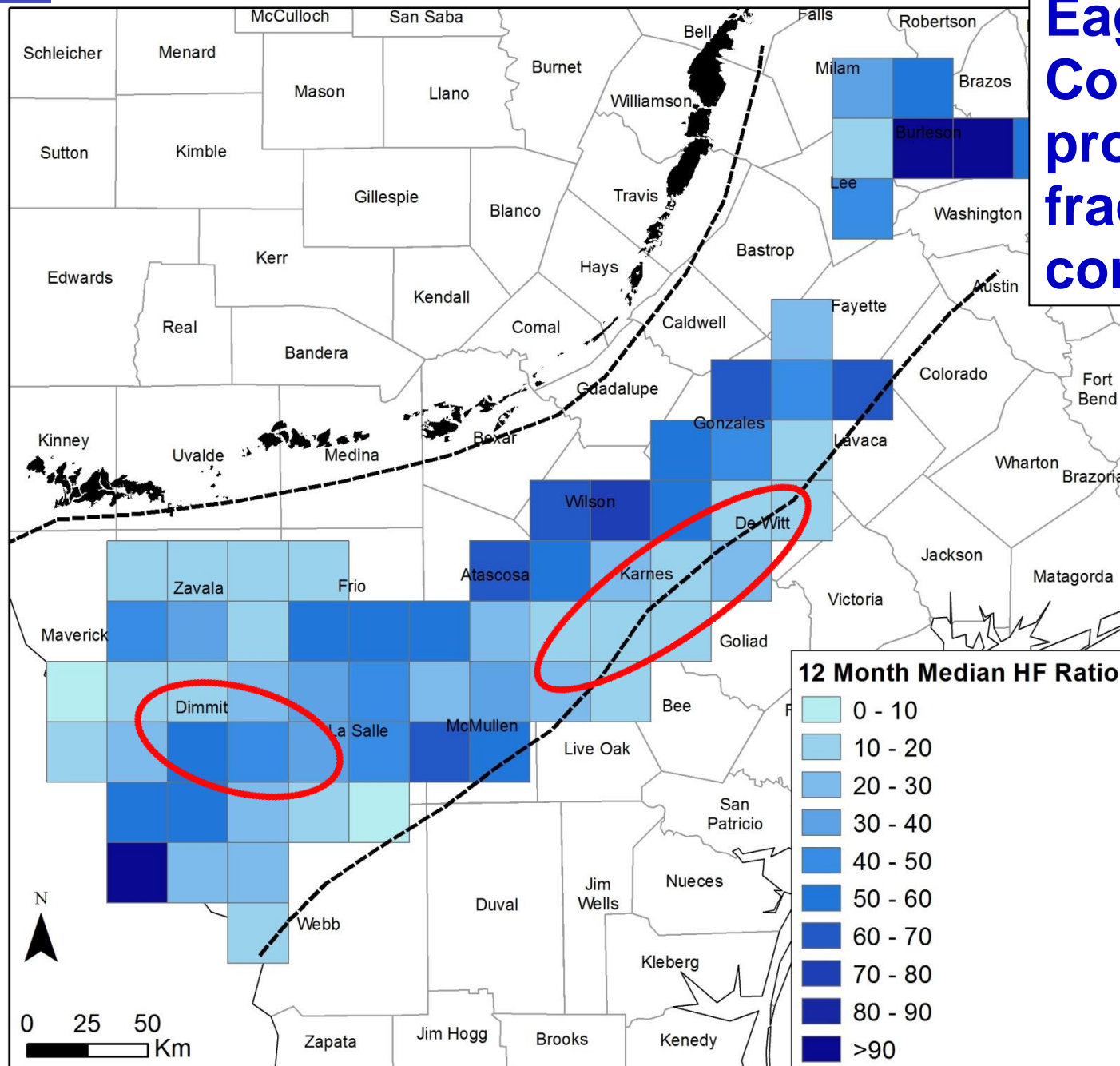


Eagle Ford Shale: County-level produced water fraction from well completion

- 1 month
- 2 months
- 3 months
- 6 months



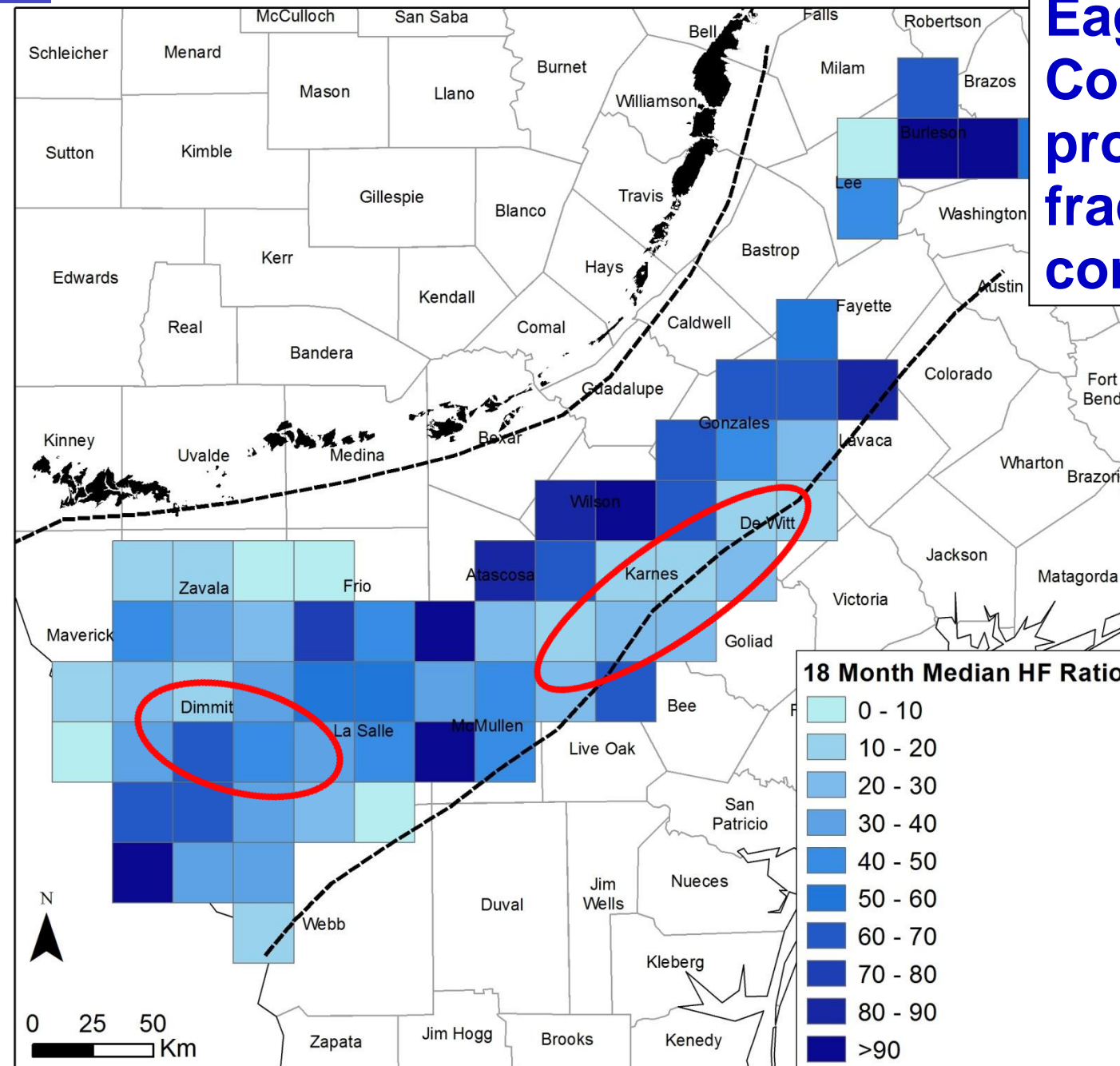
Eagle Ford Shale: County-level produced water fraction from well completion



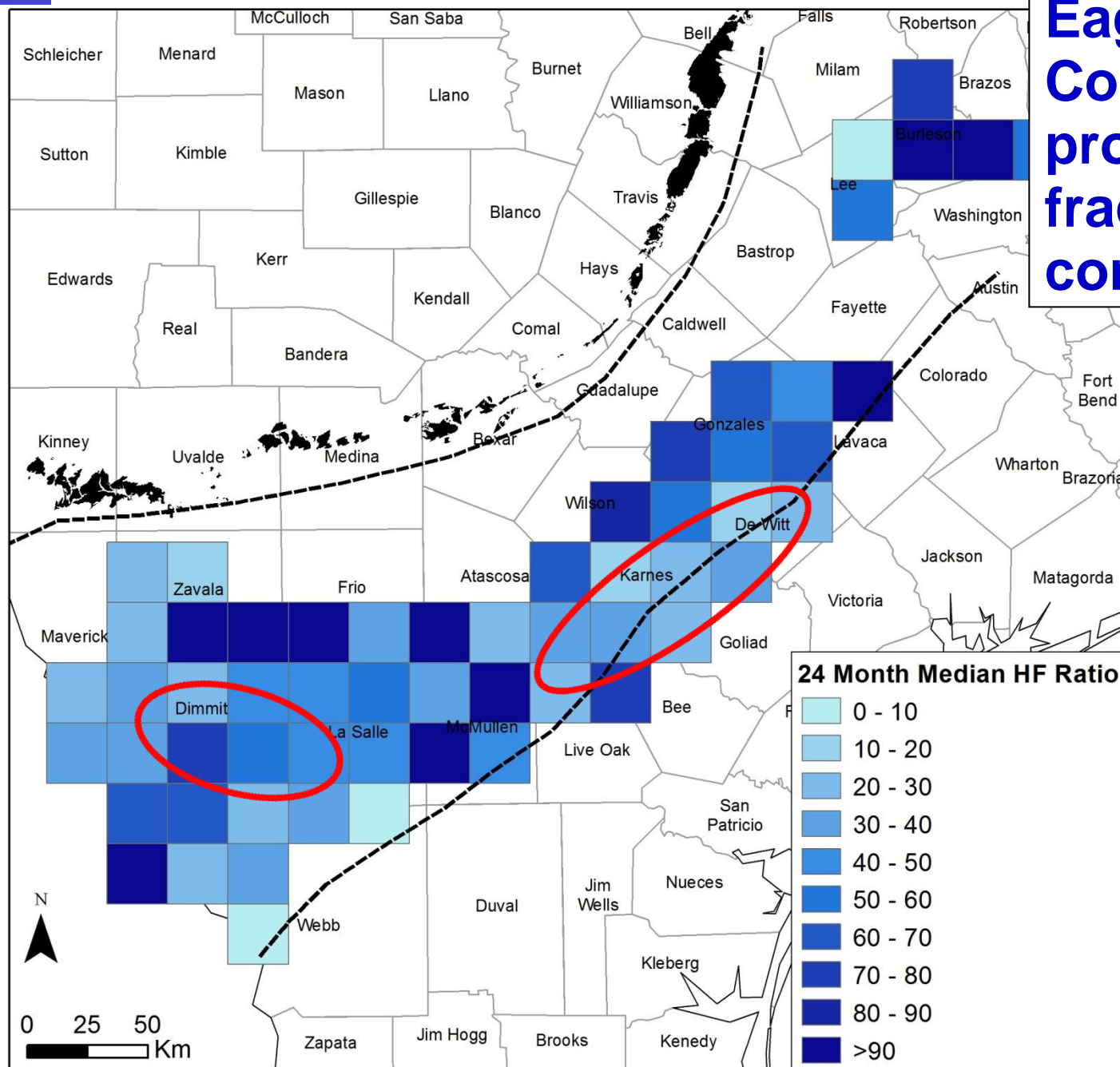
- 1 month
- 2 months
- 3 months
- 6 months
- 1 year

Eagle Ford Shale: County-level produced water fraction from well completion

- 1 month
- 2 months
- 3 months
- 6 months
- 1 year
- 1.5 years

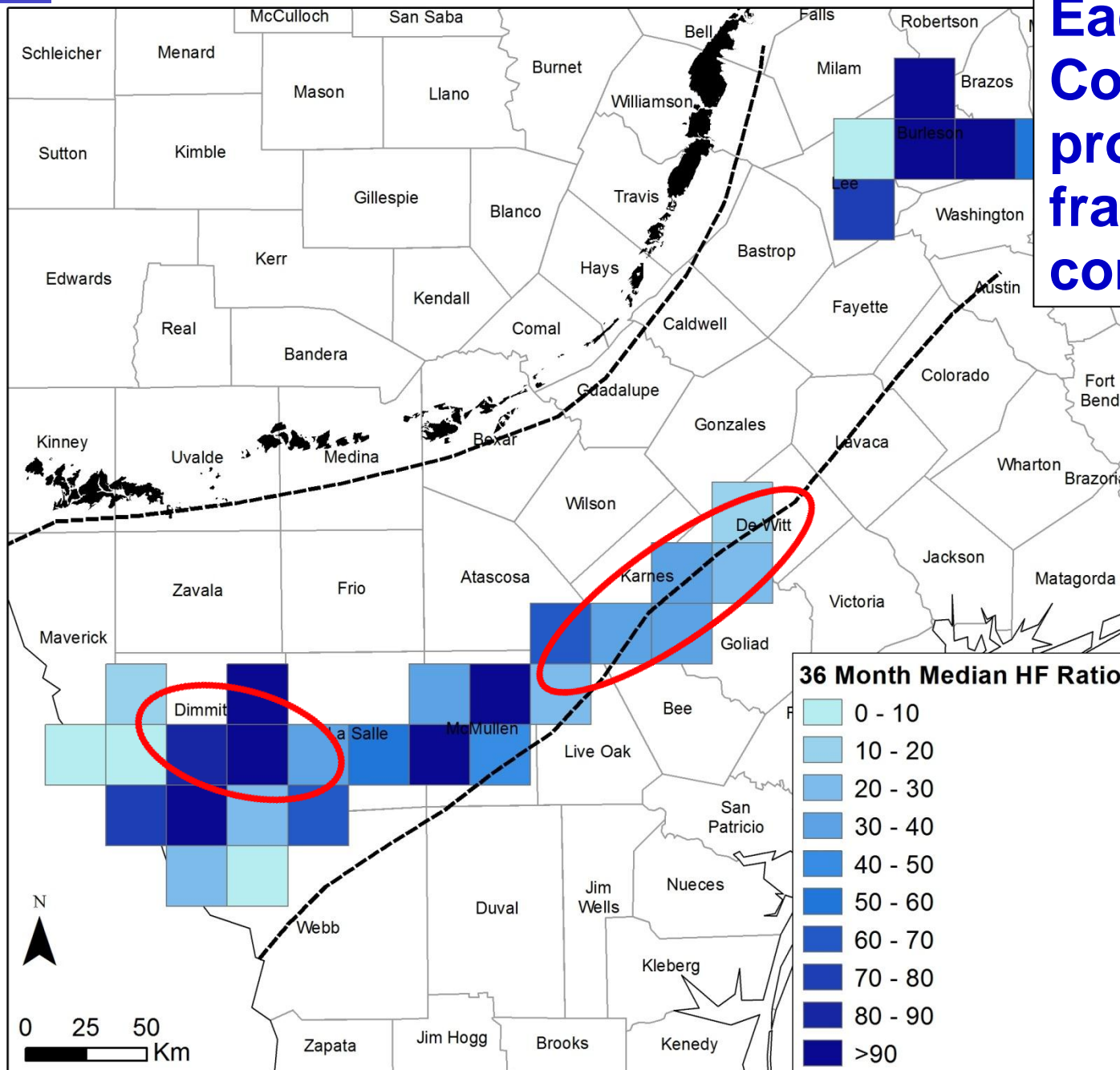


Eagle Ford Shale: County-level produced water fraction from well completion



- 1 month
- 2 months
- 3 months
- 6 months
- 1 year
- 1.5 years
- 2 years

Eagle Ford Shale: County-level produced water fraction from well completion

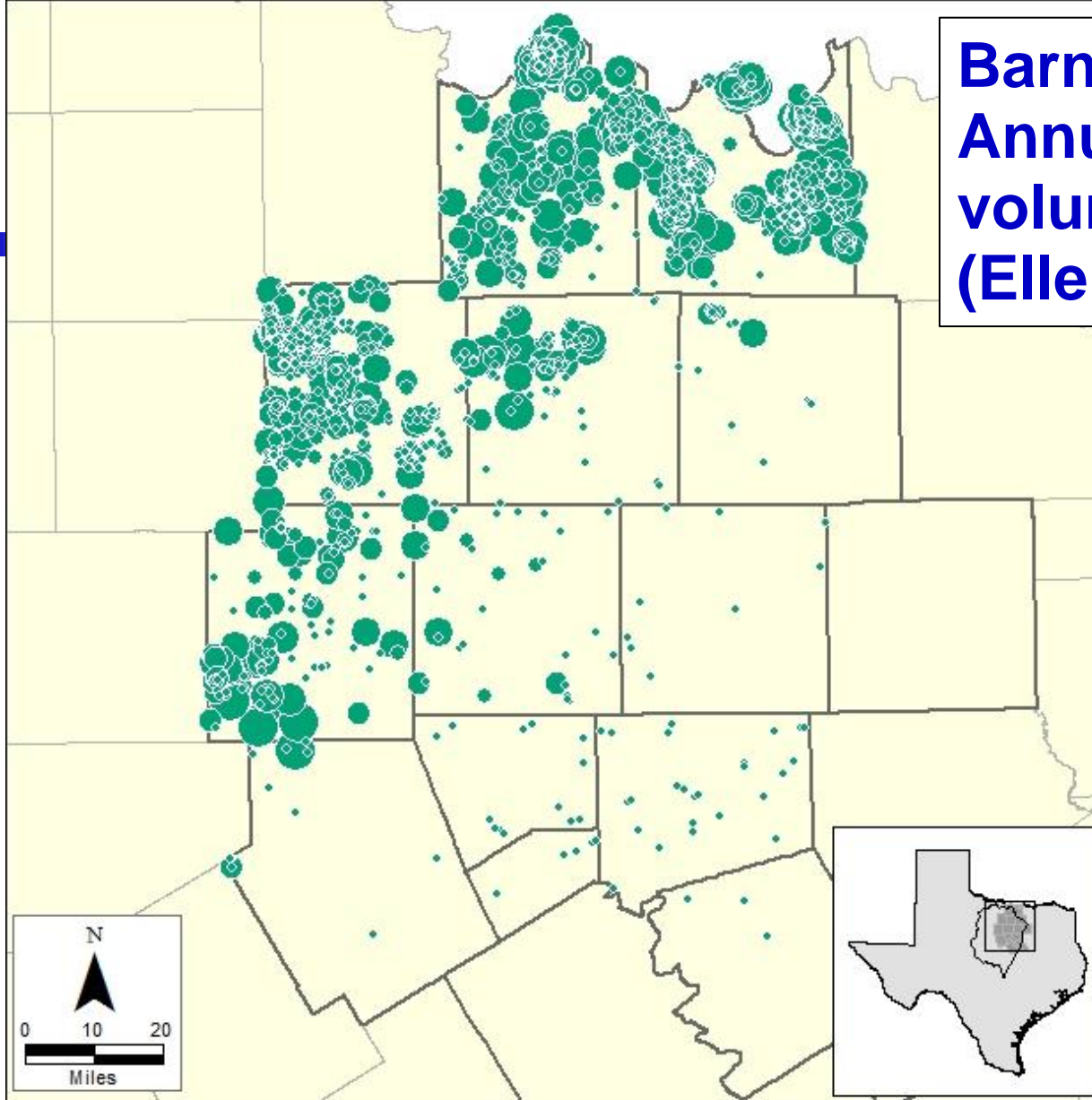


- 1 month
- 2 months
- 3 months
- 6 months
- 1 year
- 1.5 years
- 2 years
- 3 years



Barnett Shale: Annual injection well volumes through time (Ellenburger Fm.)

• 2000

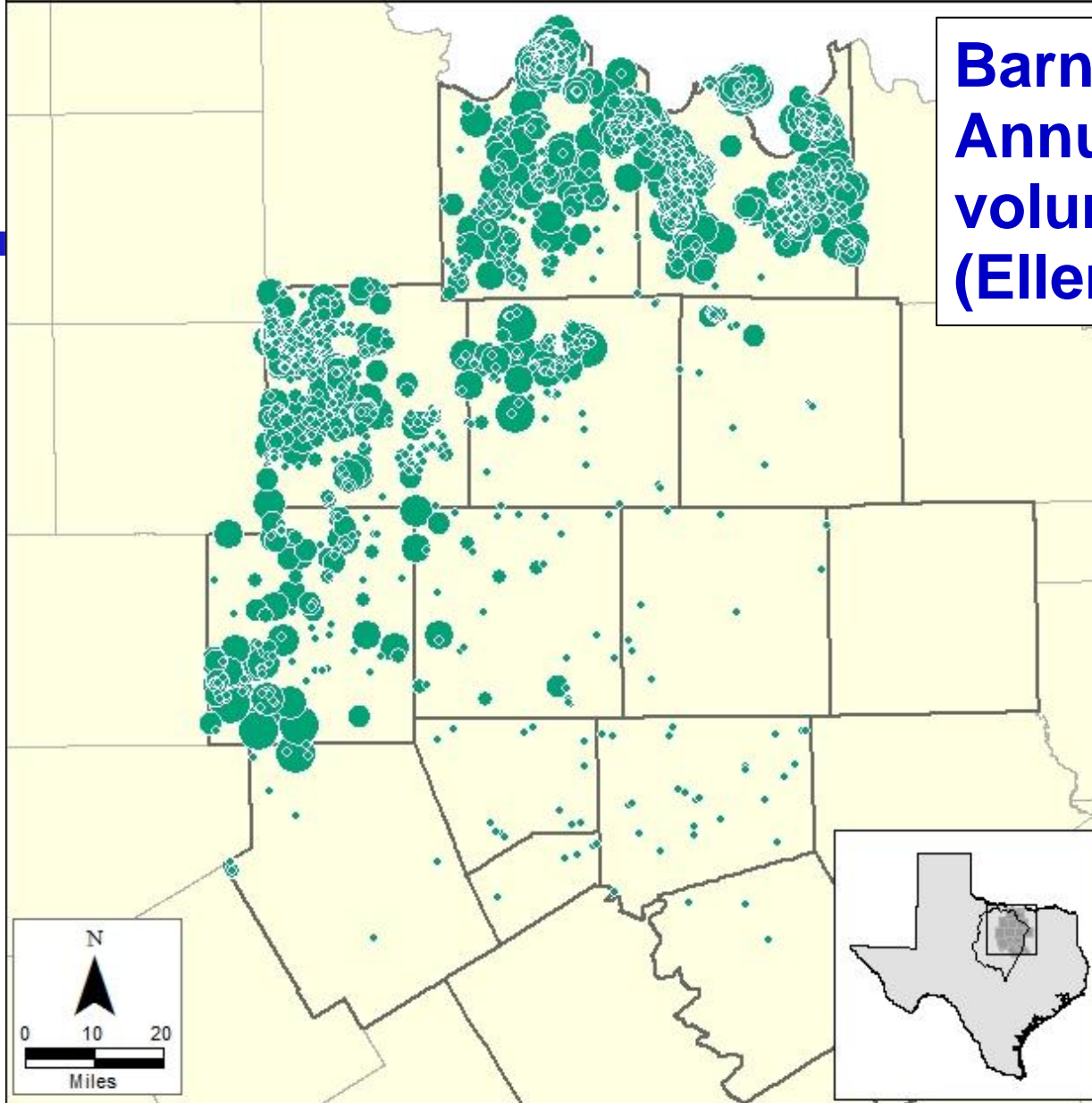


2000 Injection Wells
bbls

• 0	24000 - 55000
• 1 - 8000	55000 - 170000
• 8000 - 24000	>170000

Barnett Shale: Annual injection well volumes through time (Ellenburger Fm.)

- 2000
- 2001



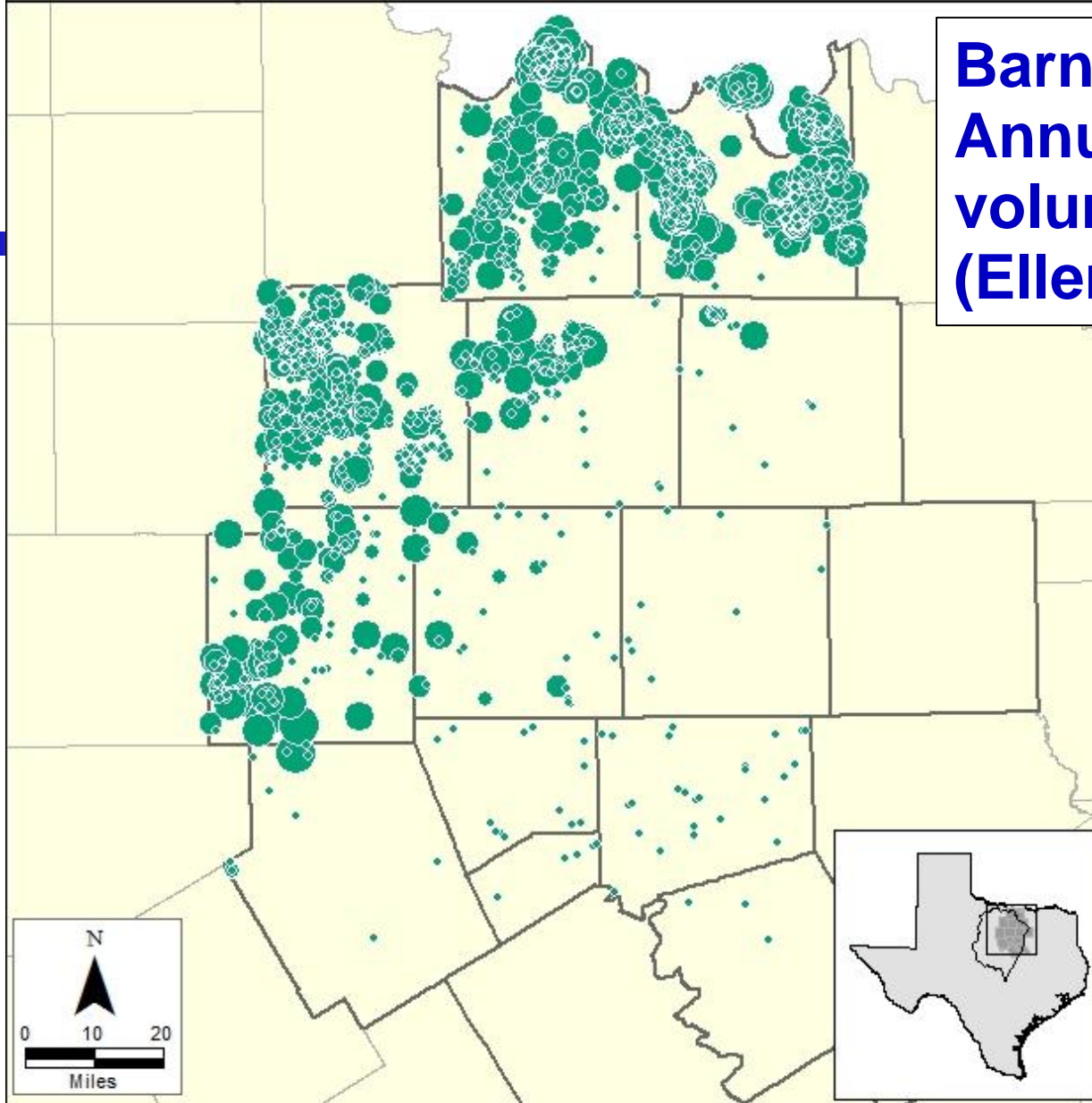
2001 Injection Wells

● 0	● 24000 - 55000
● 1 - 8000	● 55000 - 170000
● 8000 - 24000	● >170000

bbls

Barnett Shale: Annual injection well volumes through time (Ellenburger Fm.)

- 2000
- 2001
- 2002



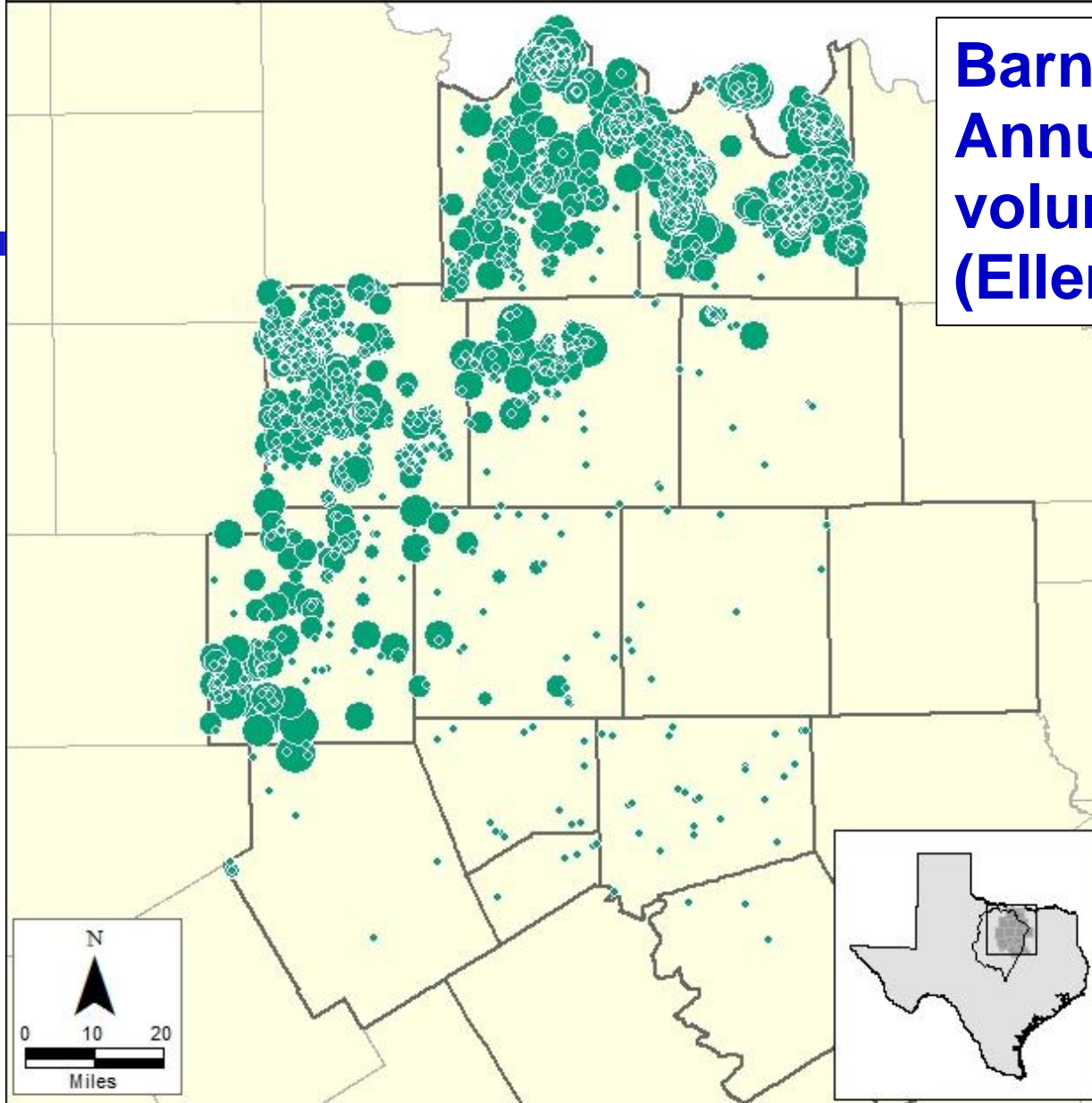
2002 Injection Wells

● 0	● 24000 - 55000
● 1 - 8000	● 55000 - 170000
● 8000 - 24000	● >170000

bbls

Barnett Shale: Annual injection well volumes through time (Ellenburger Fm.)

- 2000
- 2001
- 2002
- 2003



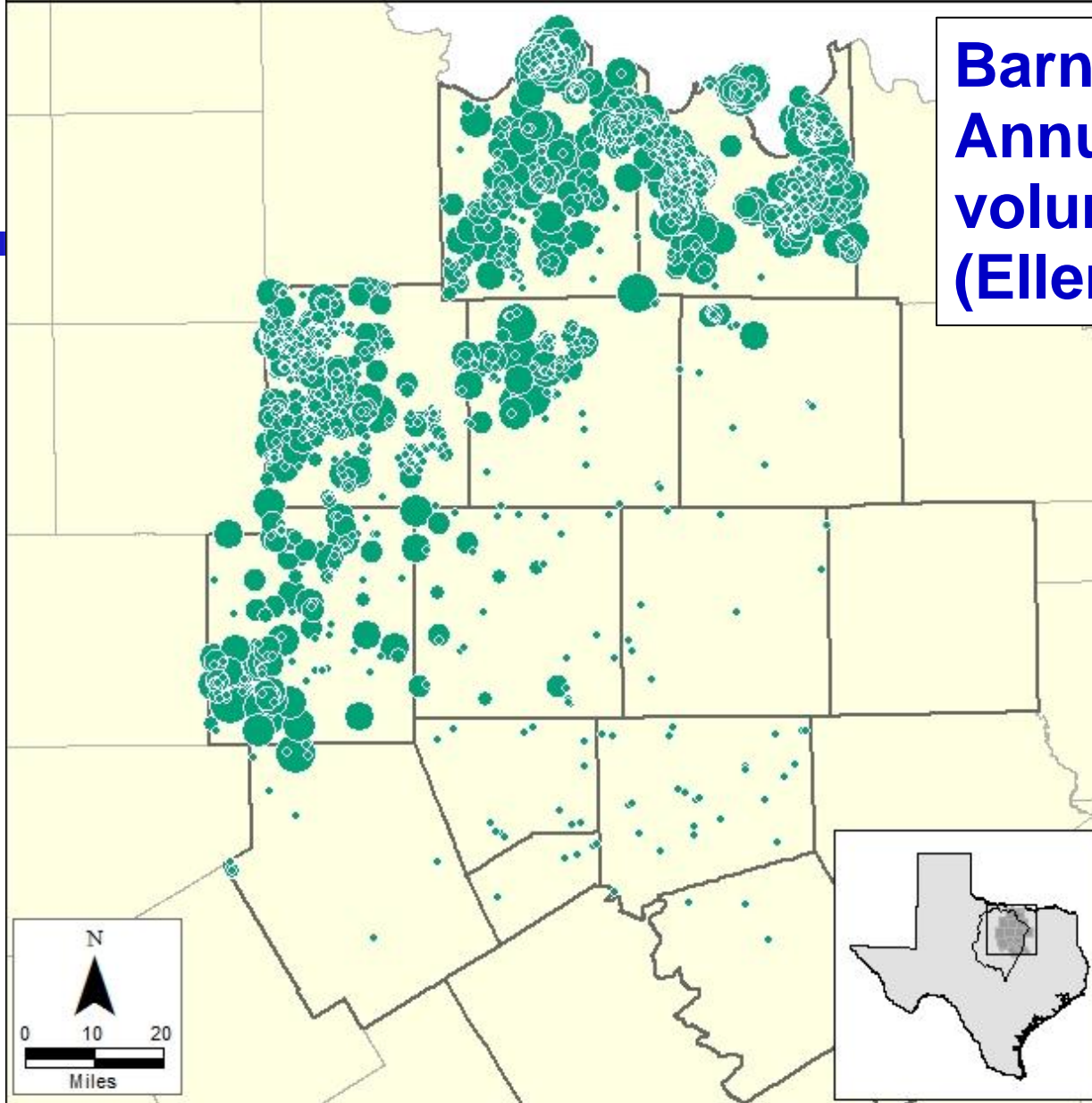
2002 Injection Wells

● 24000 - 55000
● 55000 - 170000
● >170000
• 0
• 1 - 8000
• 8000 - 24000

bbls

Barnett Shale: Annual injection well volumes through time (Ellenburger Fm.)

- 2000
- 2001
- 2002
- 2003
- 2004



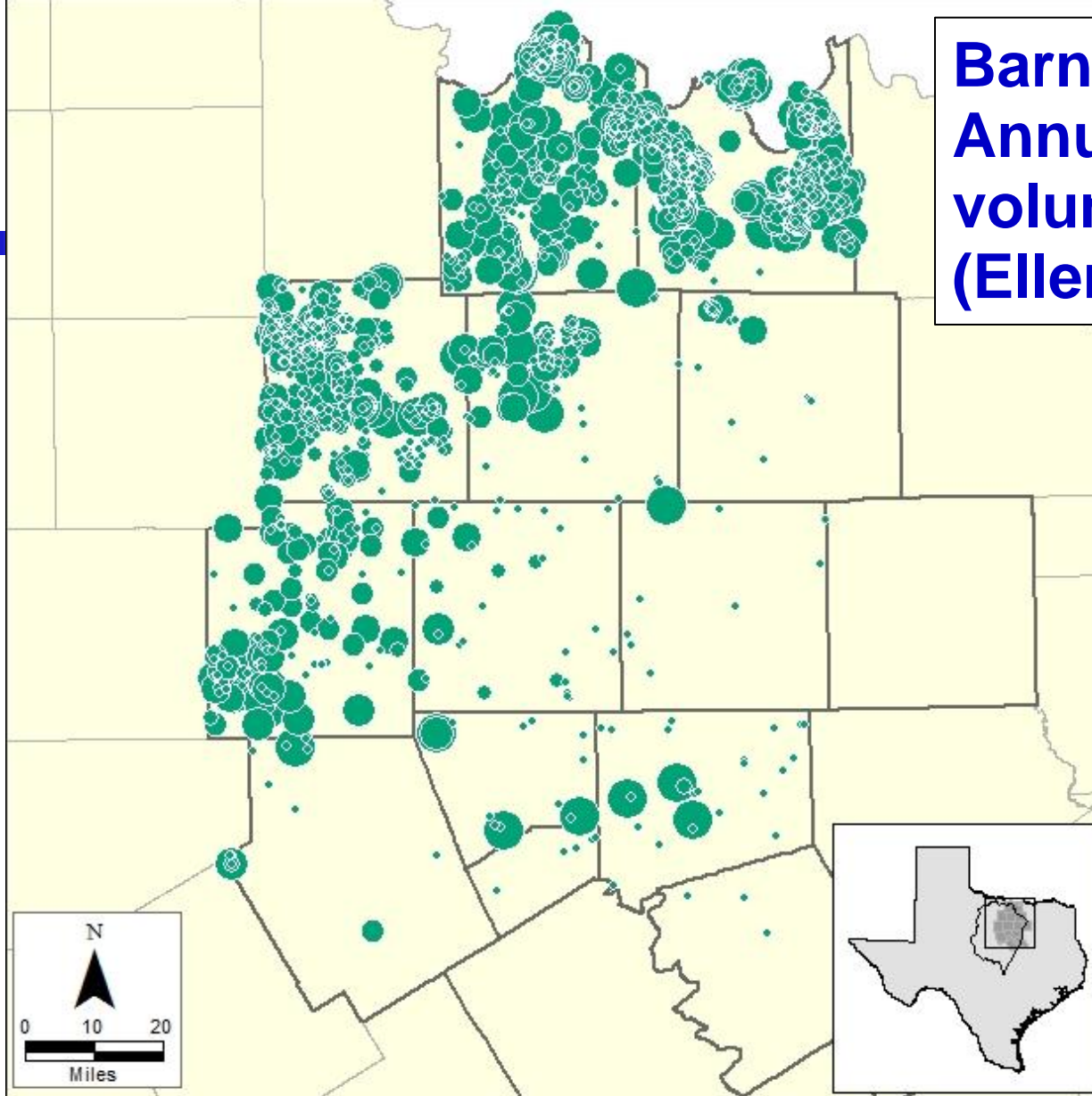
2003 Injection Wells

● 0	● 24000 - 55000
● 1 - 8000	● 55000 - 170000
● 8000 - 24000	● >170000

bbls

Barnett Shale: Annual injection well volumes through time (Ellenburger Fm.)

- 2000
- 2001
- 2002
- 2003
- 2004
- 2005



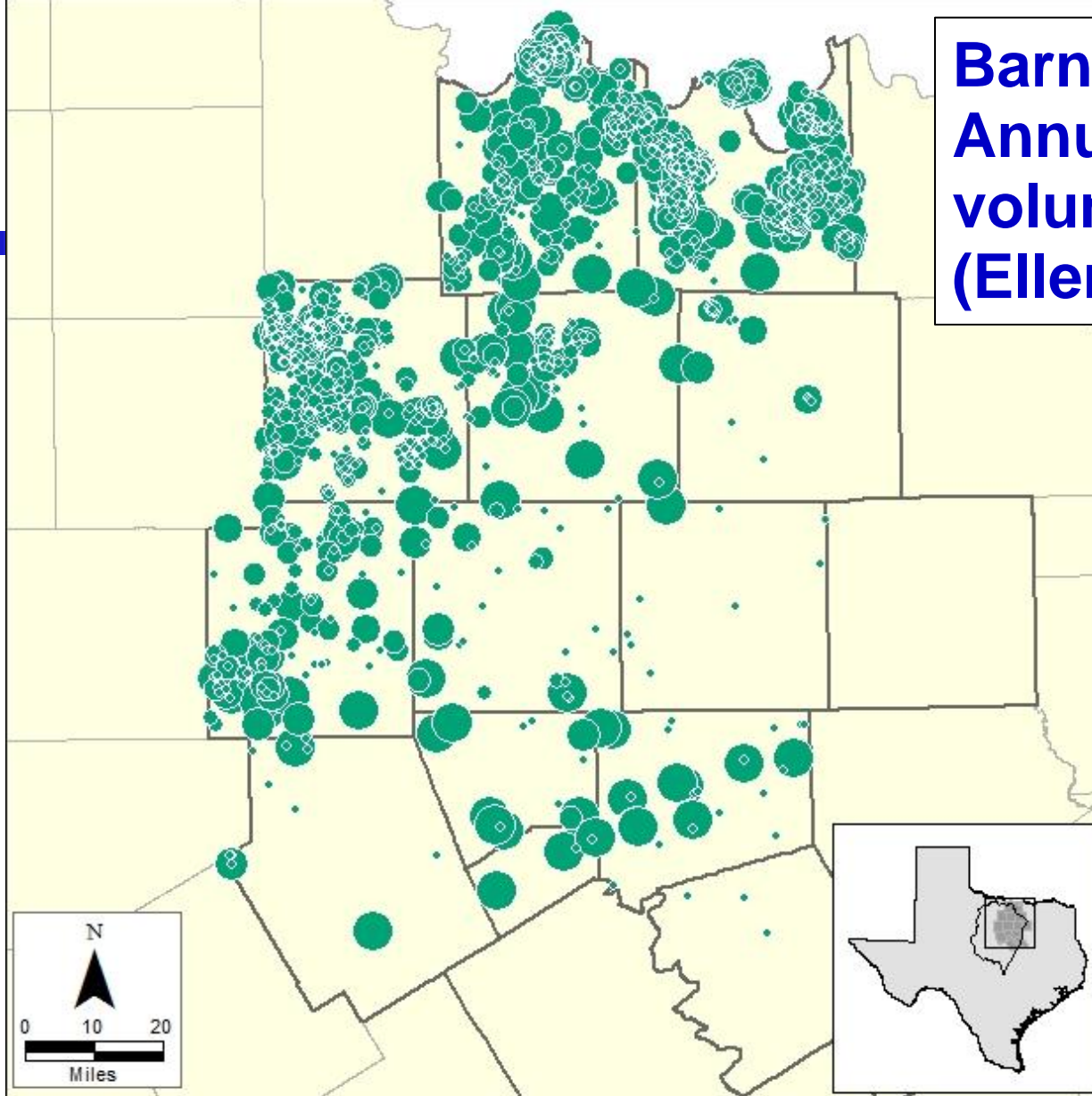
2005 Injection Wells

● 0	● 24000 - 55000
● 1 - 8000	● 55000 - 170000
● 8000 - 24000	● >170000

bbls

Barnett Shale: Annual injection well volumes through time (Ellenburger Fm.)

- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006



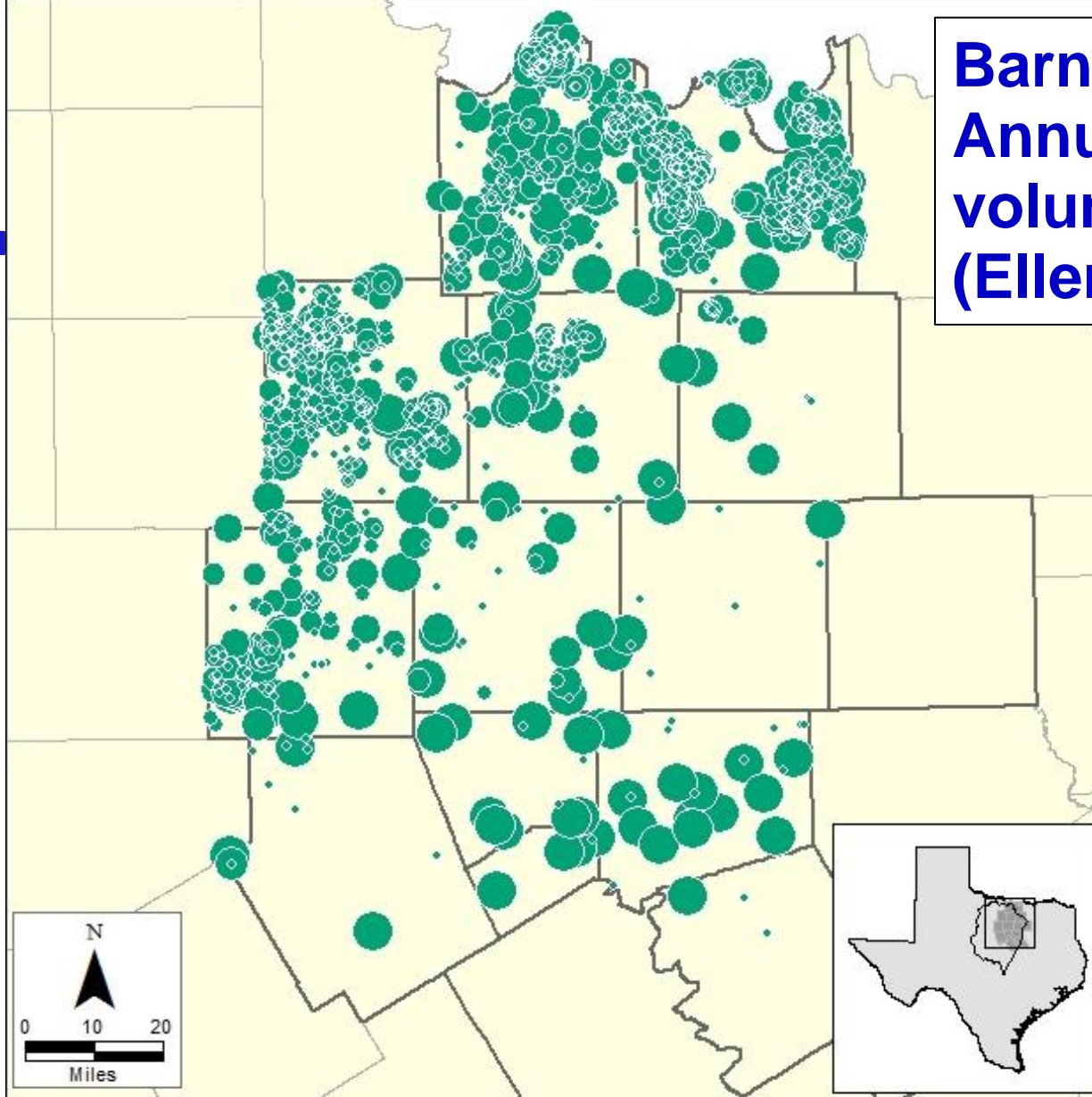
2006 Injection Wells

● 0	● 24000 - 55000
● 1 - 8000	● 55000 - 170000
● 8000 - 24000	● >170000

bbls

Barnett Shale: Annual injection well volumes through time (Ellenburger Fm.)

- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007

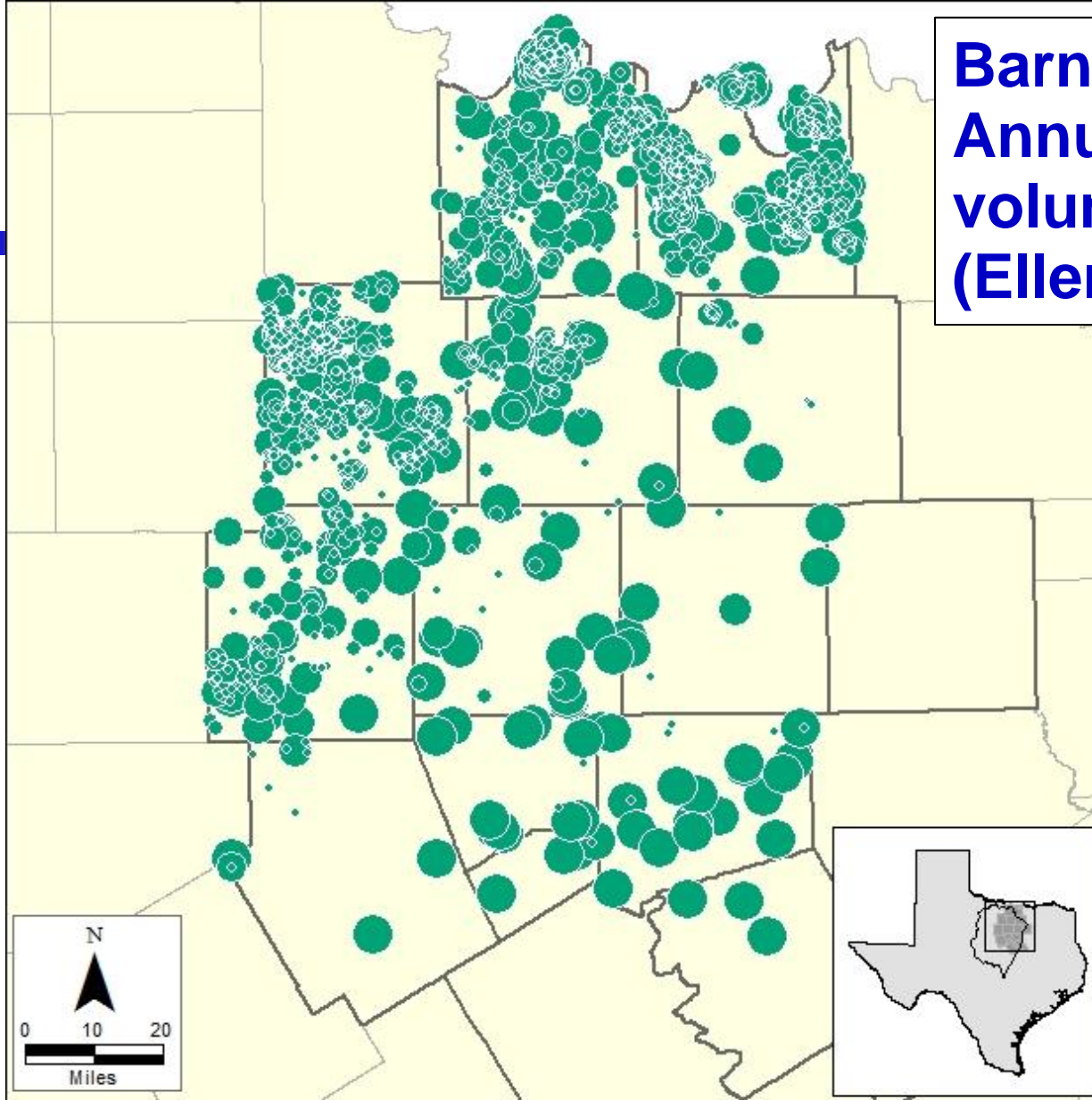


2007 Injection Wells
bbls

• 0	● 24000 - 55000
• 1 - 8000	● 55000 - 170000
• 8000 - 24000	● >170000

Barnett Shale: Annual injection well volumes through time (Ellenburger Fm.)

- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008

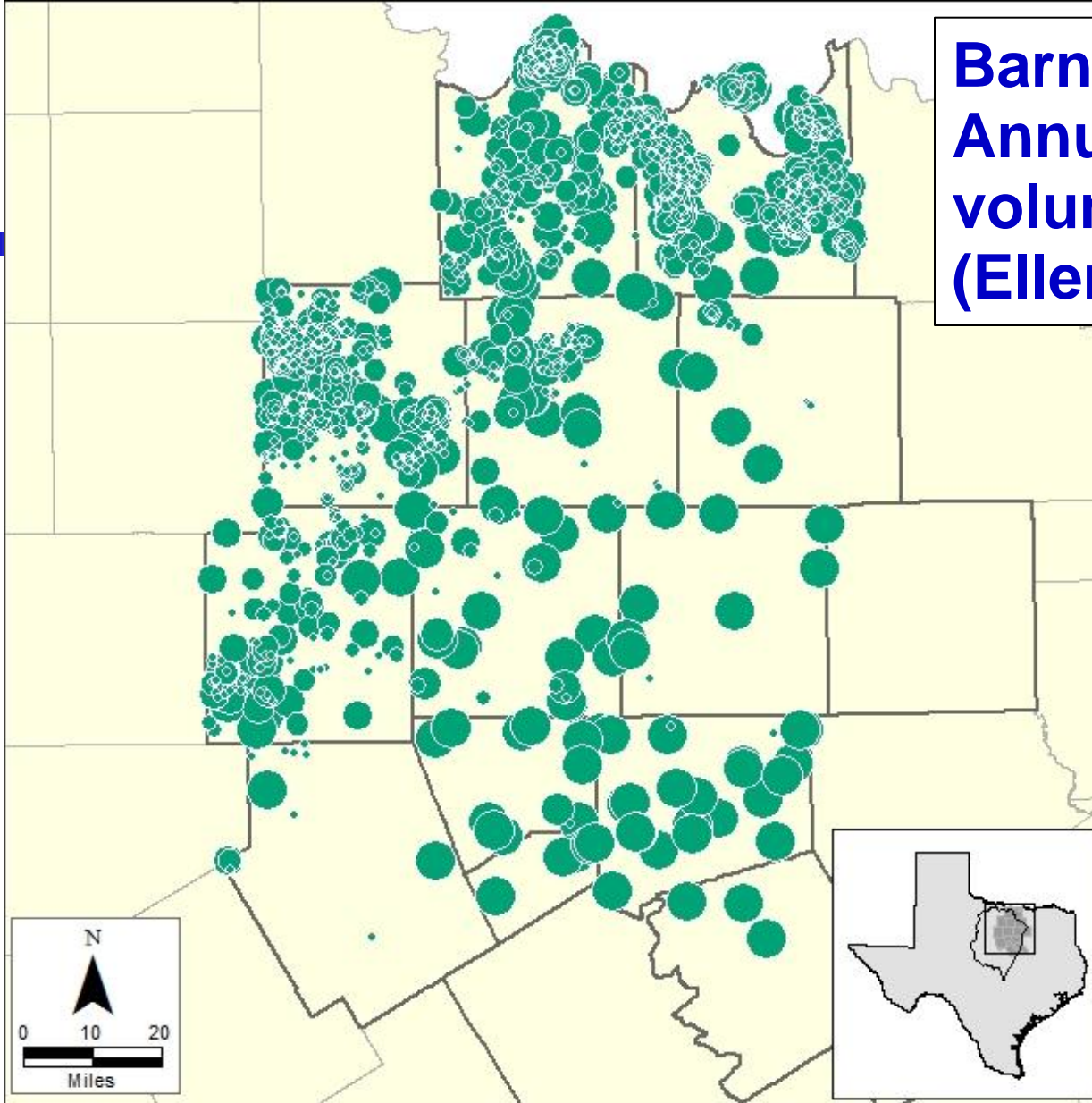


2008 Injection Wells
bbls

• 0	24000 - 55000
• 1 - 8000	55000 - 170000
• 8000 - 24000	>170000

Barnett Shale: Annual injection well volumes through time (Ellenburger Fm.)

- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009

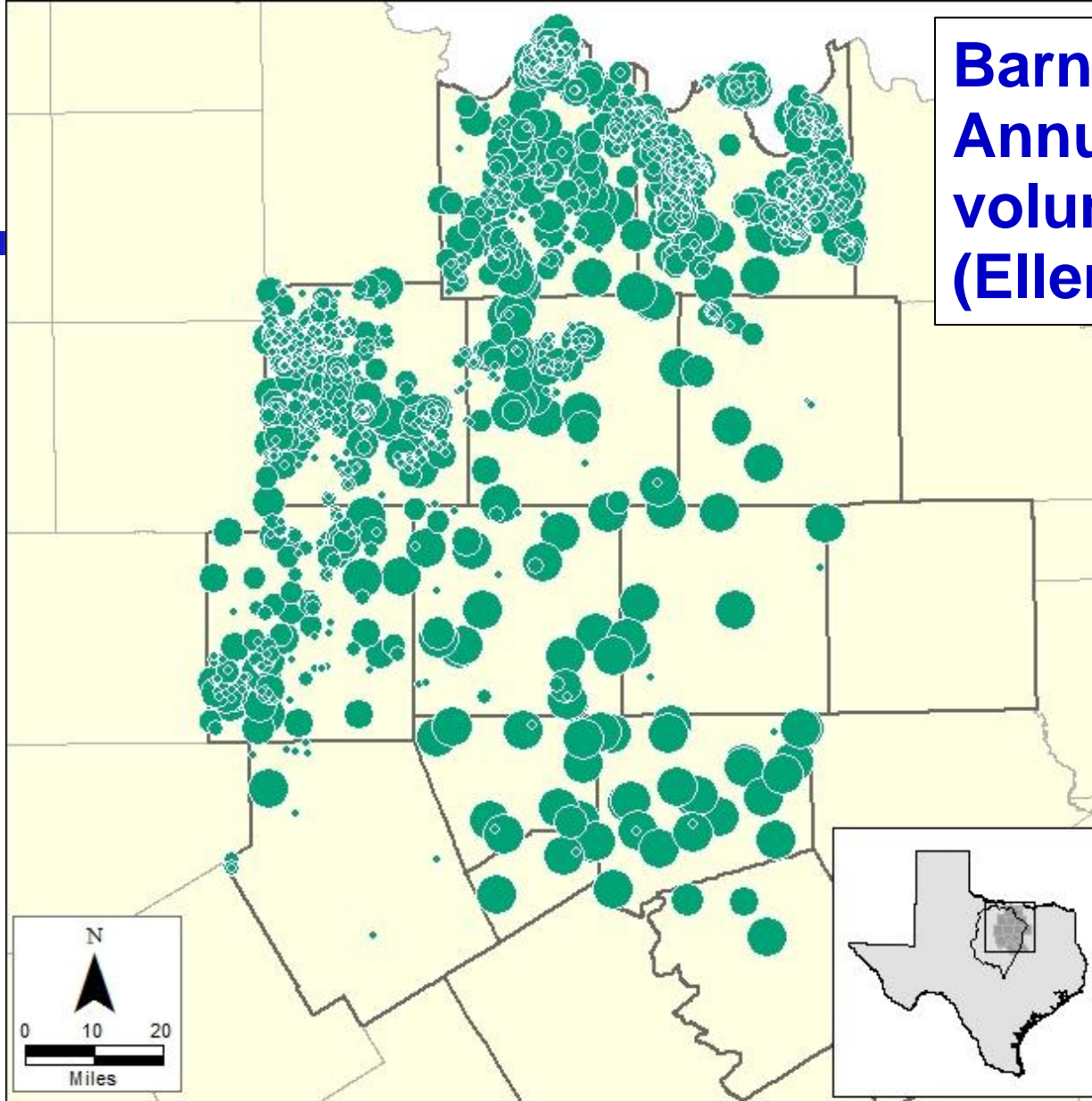


2009 Injection Wells

● 0	● 24000 - 55000
● 1 - 8000	● 55000 - 170000
● 8000 - 24000	● >170000

bbls

Barnett Shale: Annual injection well volumes through time (Ellenburger Fm.)



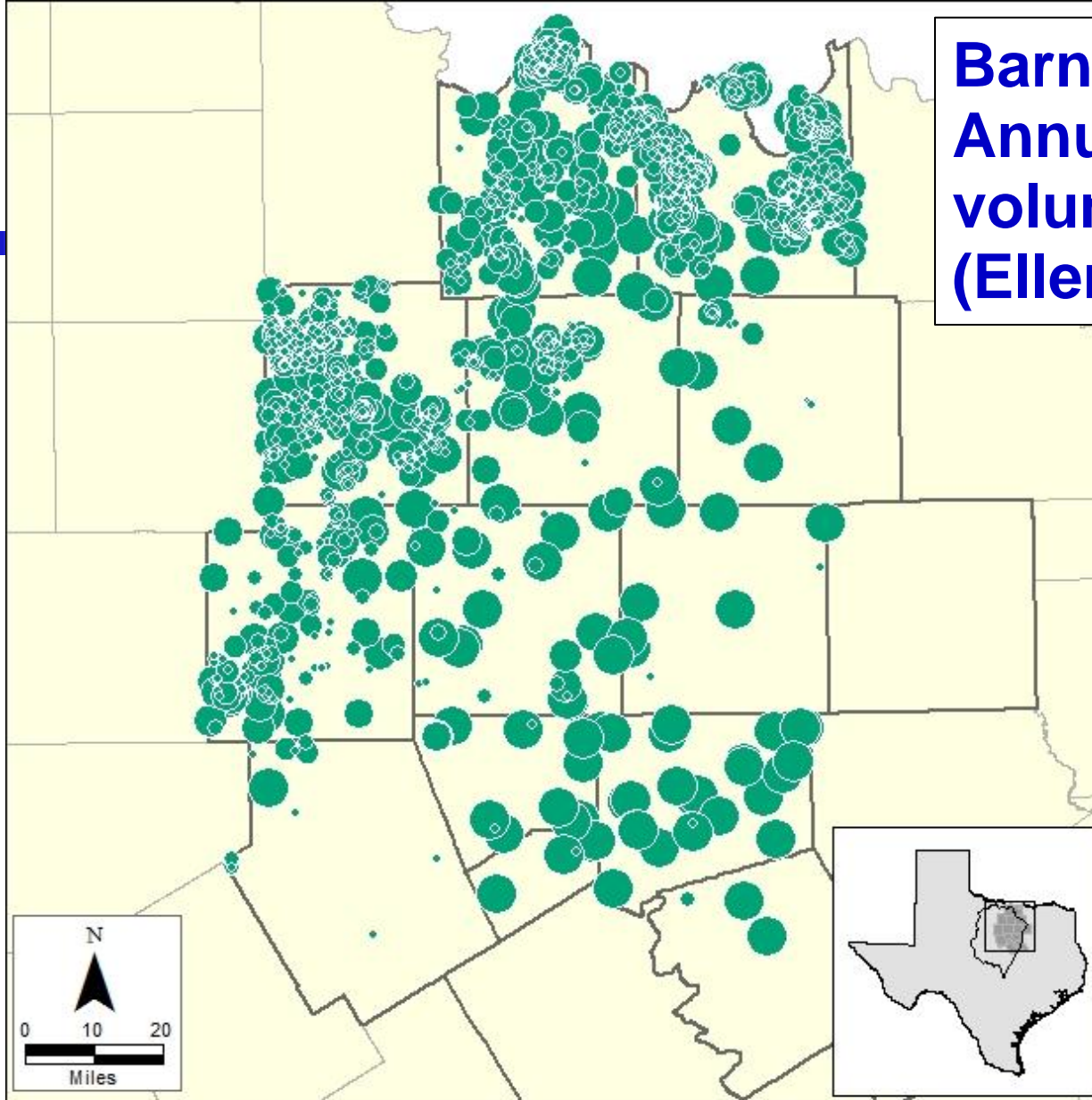
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010

2010 Injection Wells

• 0	24000 - 55000
• 1 - 8000	55000 - 170000
• 8000 - 24000	>170000

bbls

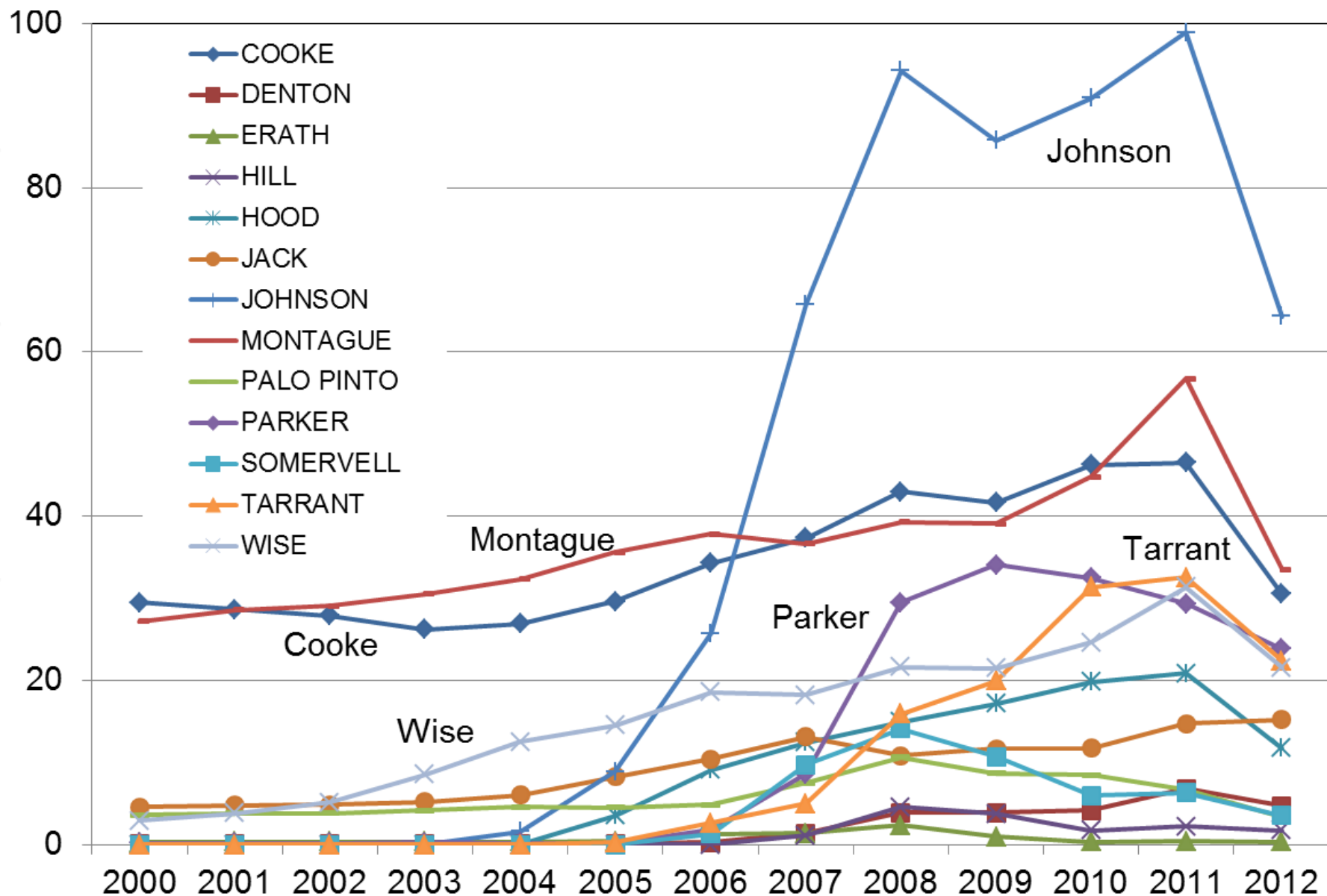
Barnett Shale: Annual injection well volumes through time (Ellenburger Fm.)

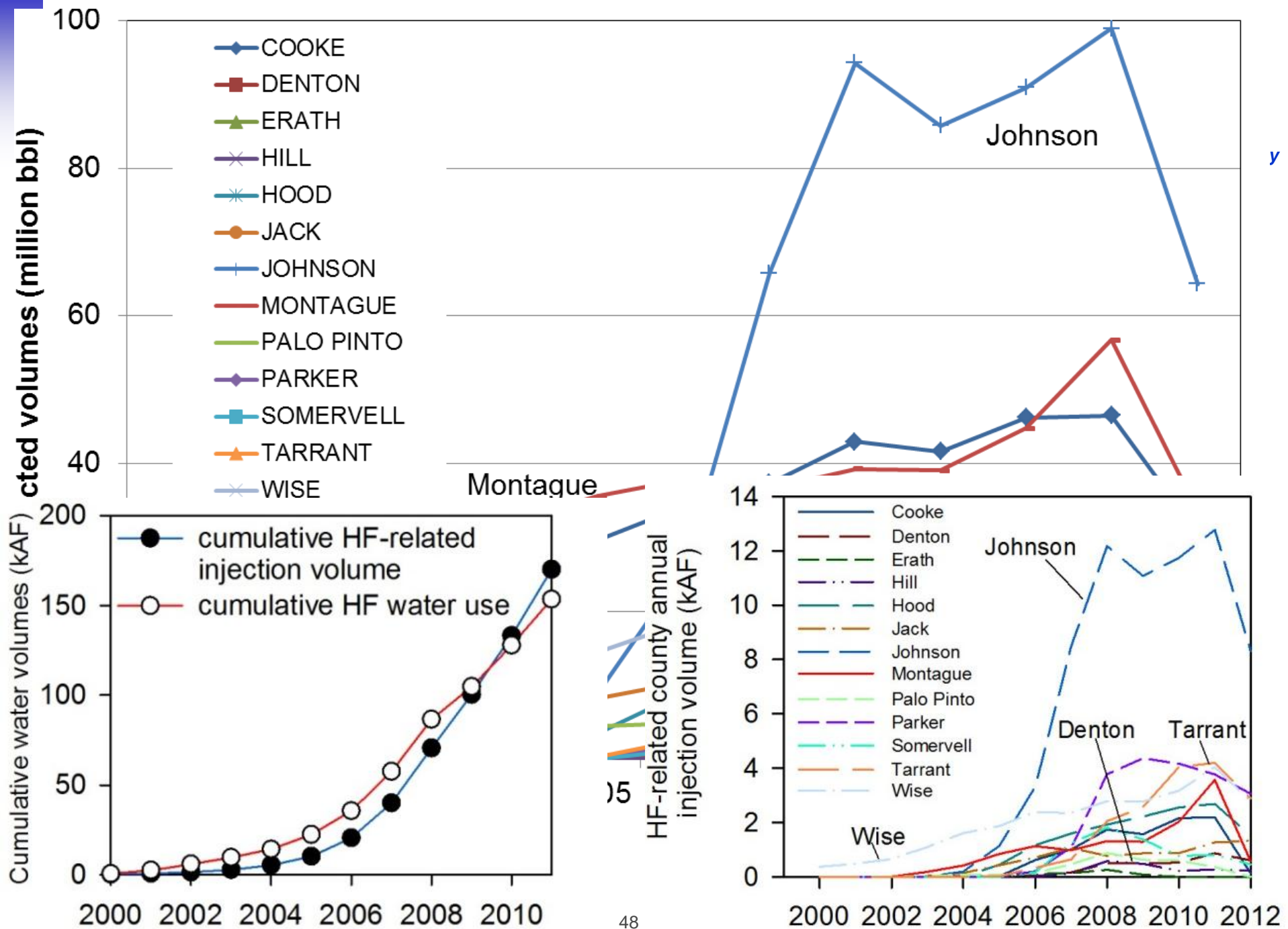


- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011

2011 Injection Wells
bbls

• 0	● 24000 - 55000
• 1 - 8000	● 55000 - 170000
• 8000 - 24000	● >170000





Summary

- Amount of flowback / produced (FP) water is very variable; higher for tight formations
- Water production decline is similar to that of oil and gas but in general faster
- Only a small and early fraction of the FP water is recycled
- Deep-well injection of produced water is the norm in Texas but overall unconventional FP volumes are small relative to other sources
- Amount of FP water is negatively correlated with well productivity

QUESTIONS?

San Antonio

Eagle Pass+

Houston

C.C.

Laredo+

The Valley

Credit: **NASA - NOAA**

