Hydraulic Fracturing and Water Resources: A Texas Study*

Jean-Philippe (J-P) Nicot[1]

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Abstract

Hydraulic fracturing has a long history in the state of Texas with (1) several established plays, such as the Barnett Shale, (2) plays of recent interest, such as the Eagle Ford or the Wolfcamp, and (3) older plays being revisited such as the Spraberry or the Granite Wash. We compiled water consumption and use for year 2011 (about 82,000 acre-feet) and compared it to an older analysis done for year 2008 (about 36,000 acre-feet). A private database compiling water use information is complemented by industry data to access fresh water consumption, recycled water use, and brackish water use.

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Website

USDA, National Drought Mitigation Center, 2013, Current U.S. Drought Monitor: map. Web accessed 14 May 2013. http://droughtmonitor.unl.edu/

Hydraulic fracturing and water resources: a Texas study

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AAPG Geosciences Technology Workshop
Solving Water Issues in the Oil Field: Using Geology and More

Fort Worth, TX – February 26, 2012

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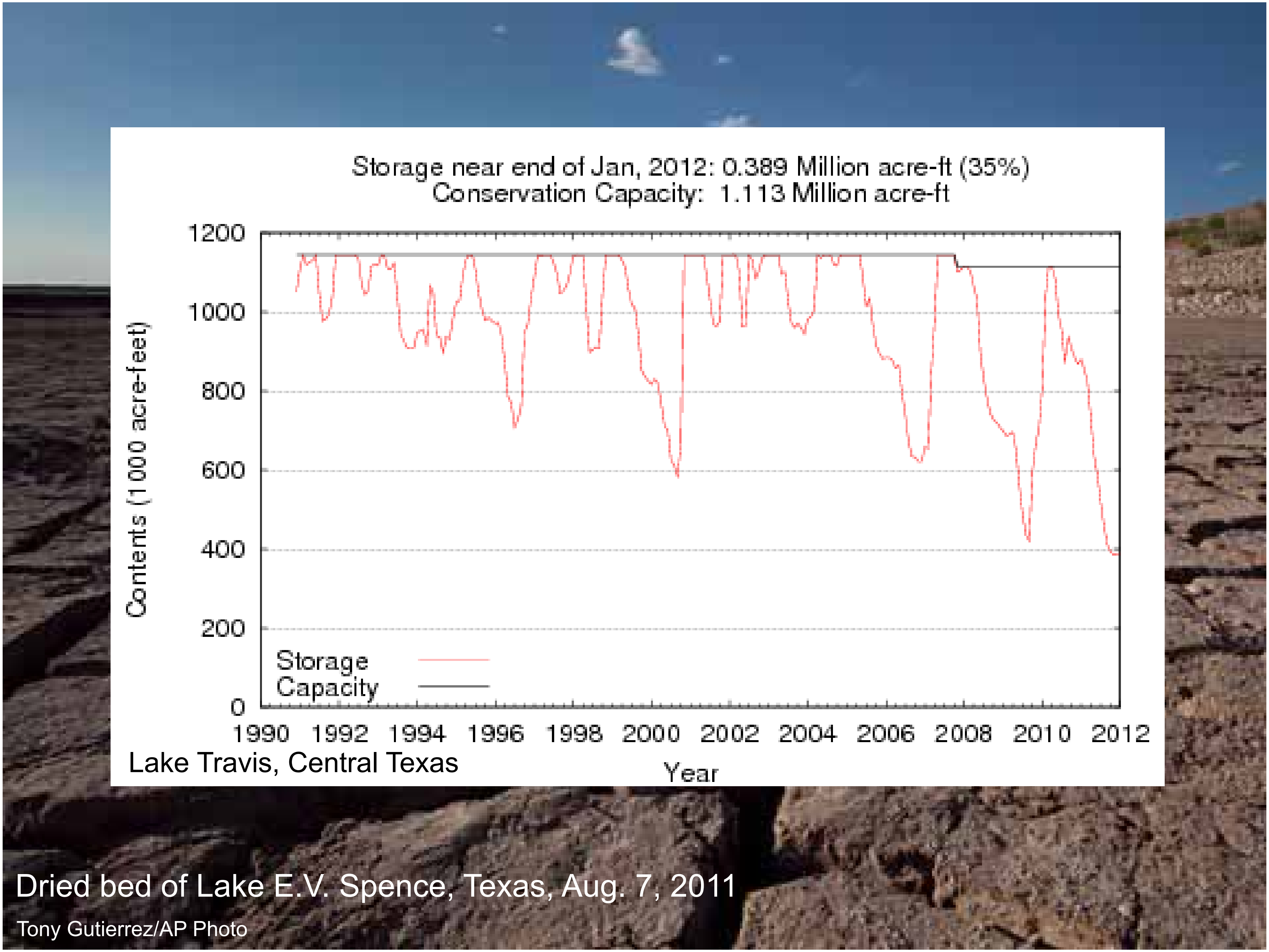
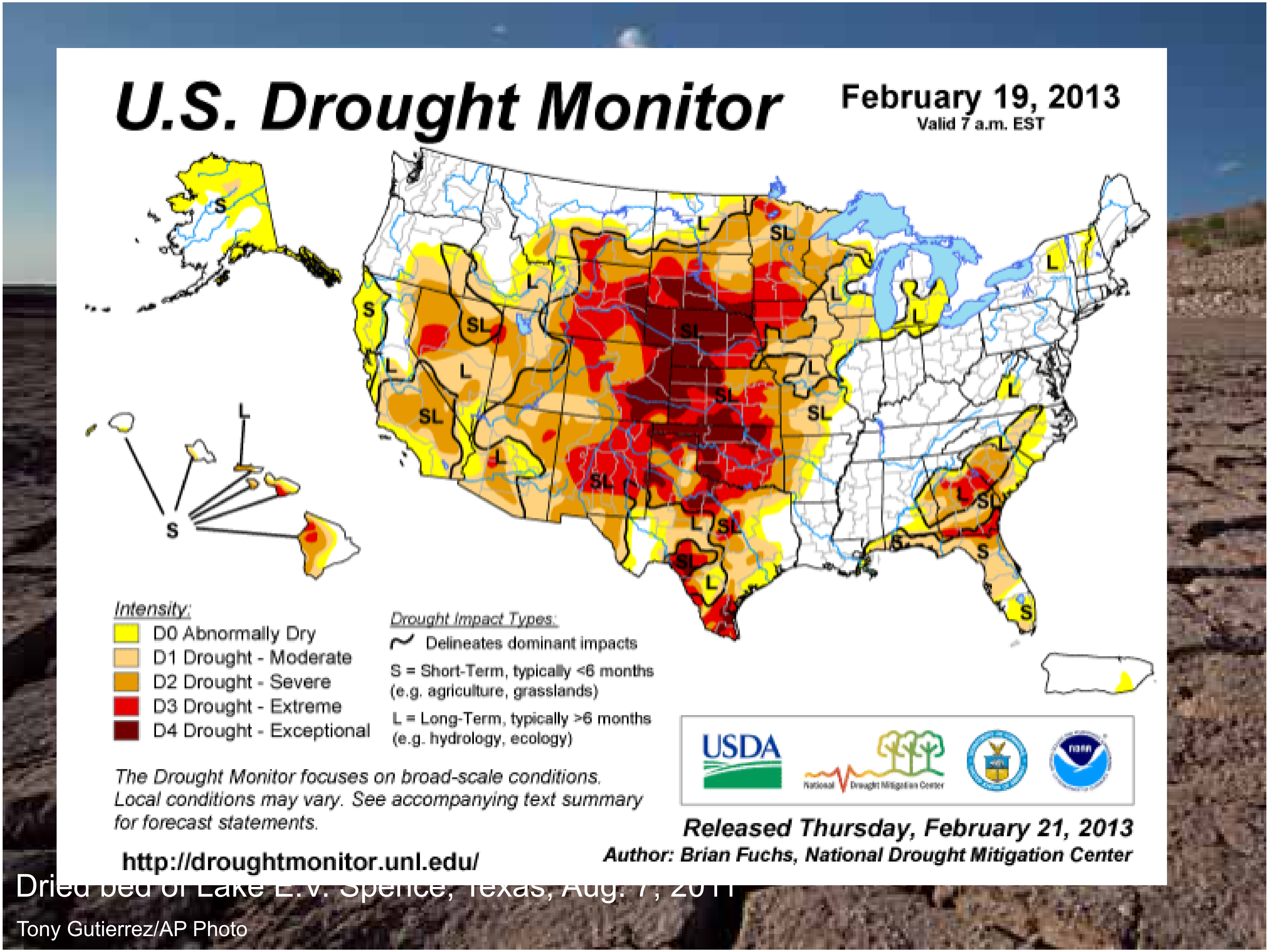
Texas Water Development Board (TWDB), Texas Oil and Gas Association (TXOGA) and the DOE / RPSEA program



Dried bed of Lake E.V. Spence, Texas, Aug. 7, 2011

Tony Gutierrez/AP Photo



Dried bed of Lake E.V. Spence, Texas, Aug. 7, 2011

Tony Gutierrez/AP Photo

Development – Population Growth:

Barnett: DFW Metroplex
Eagle Ford: I-35 Corridor

x2 in the next 50 years: increase in municipal water use

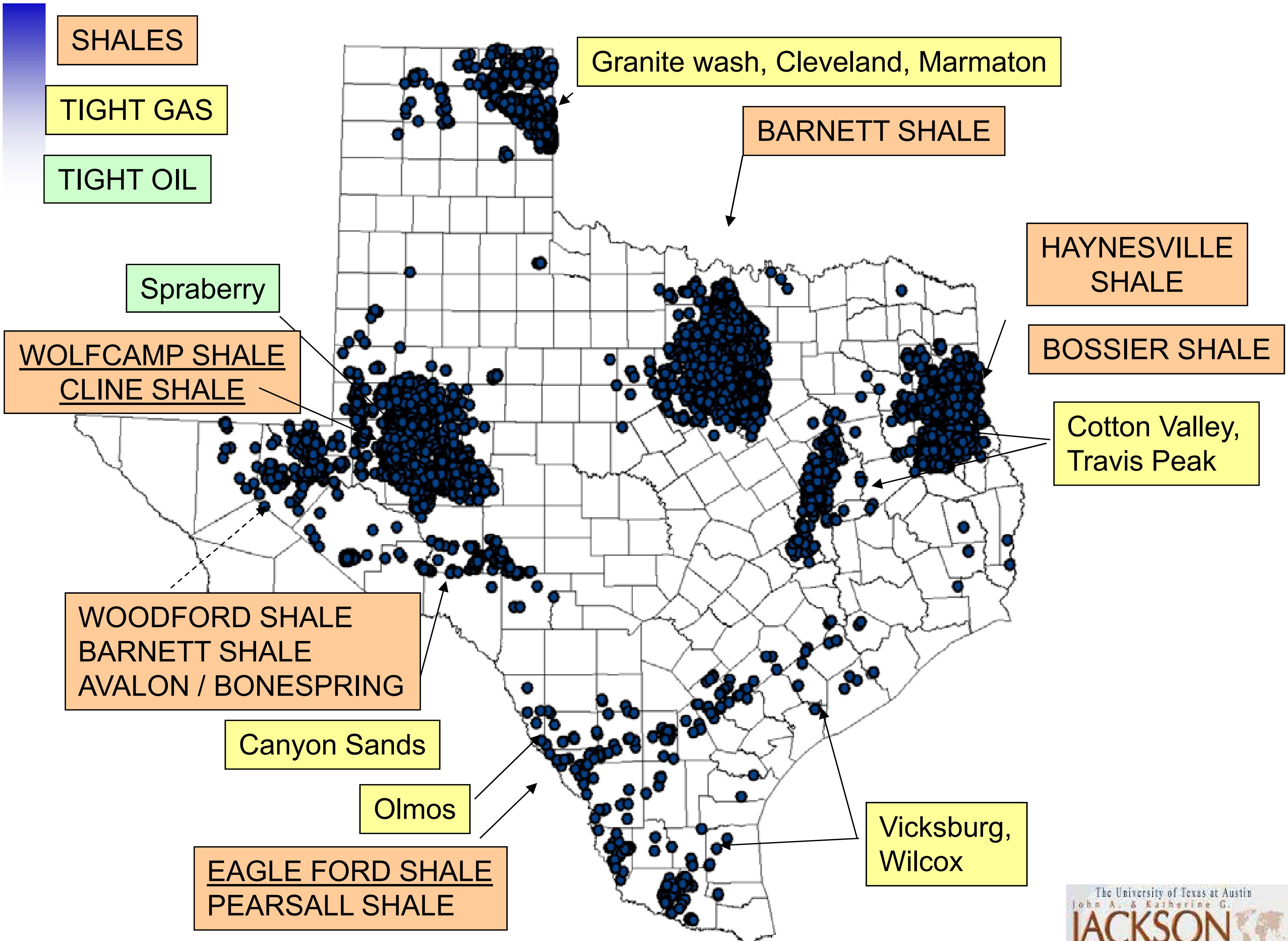
Semi-conductor plant – Austin, TX

W.A. Parish, Houston area,TX – NRG Energy

Increase in manufacturing and electric water use

What is the impact of hydraulic fracturing on water supplies?

Modified from photo by Devon Energy, ***2006***



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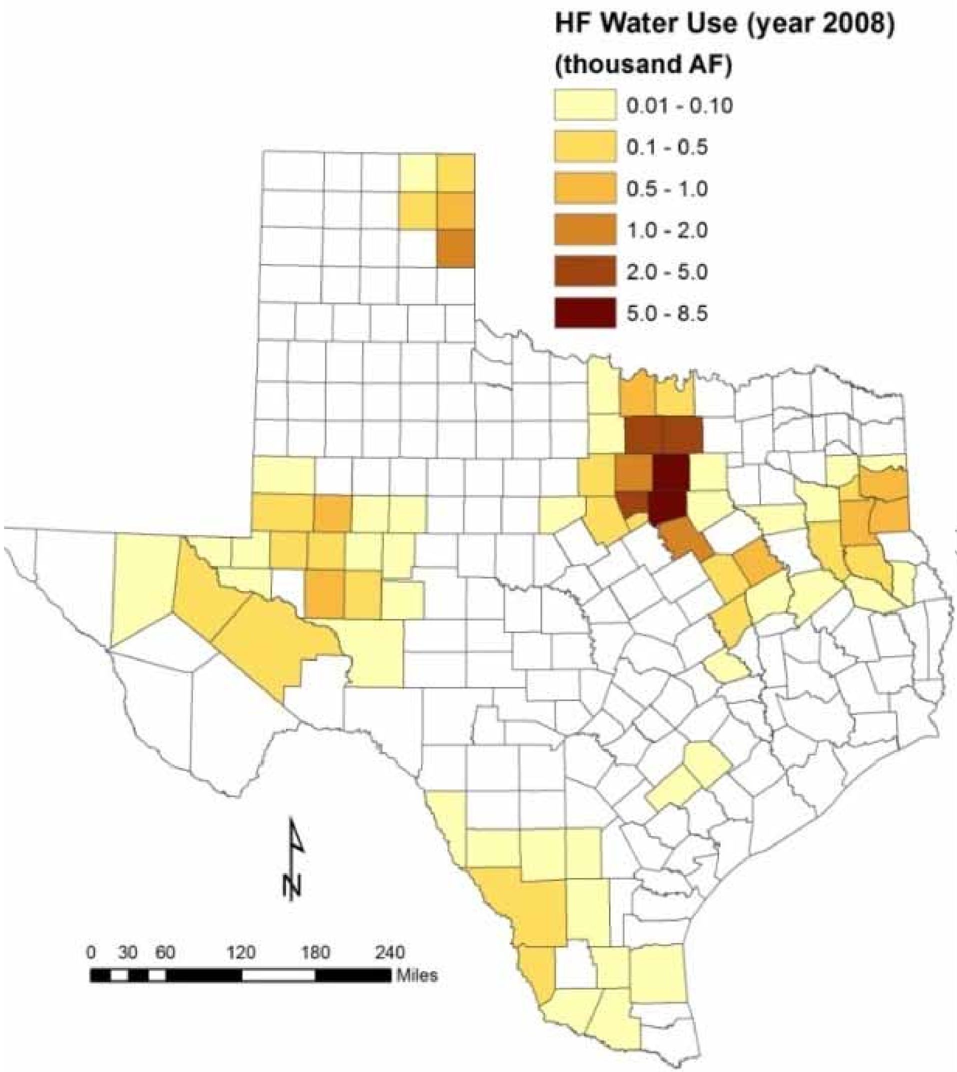
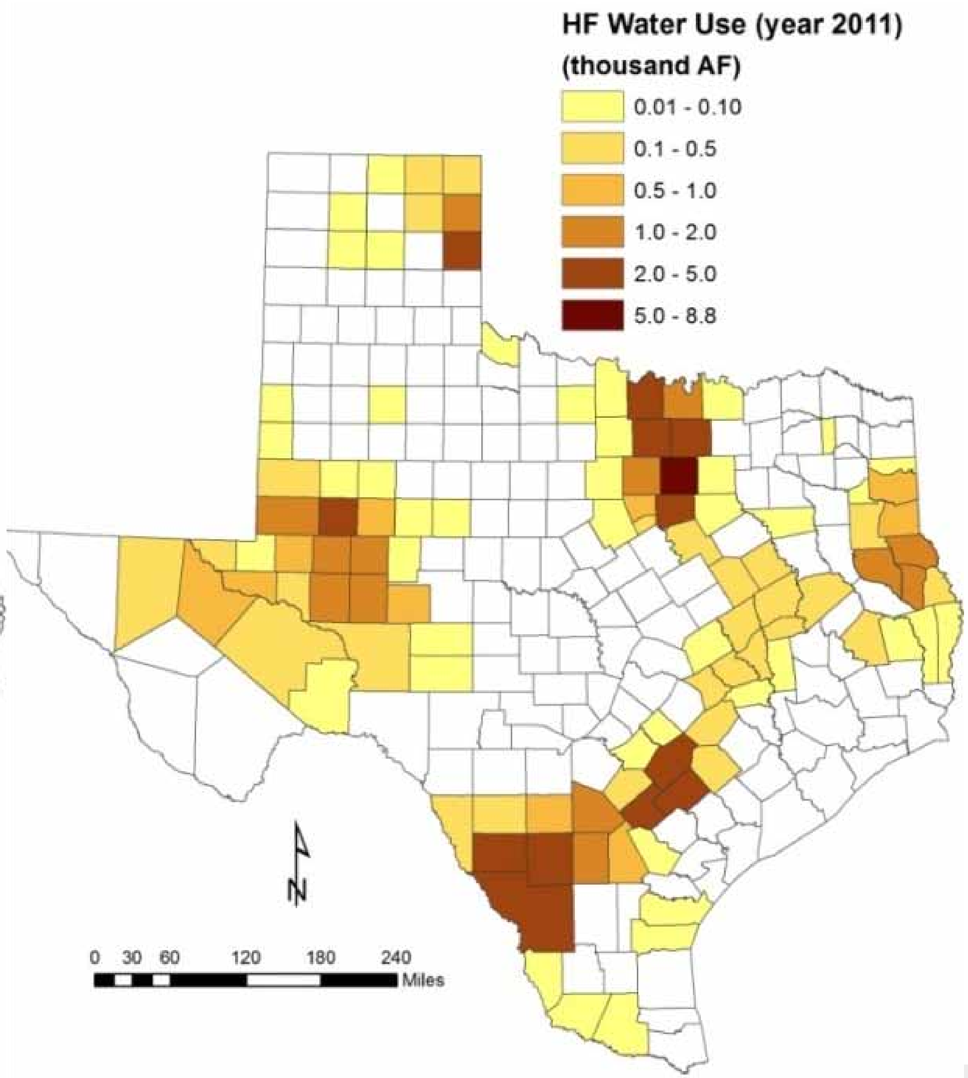
Hydraulic Fracturing Water Use

1 AF = 325,851 gallons

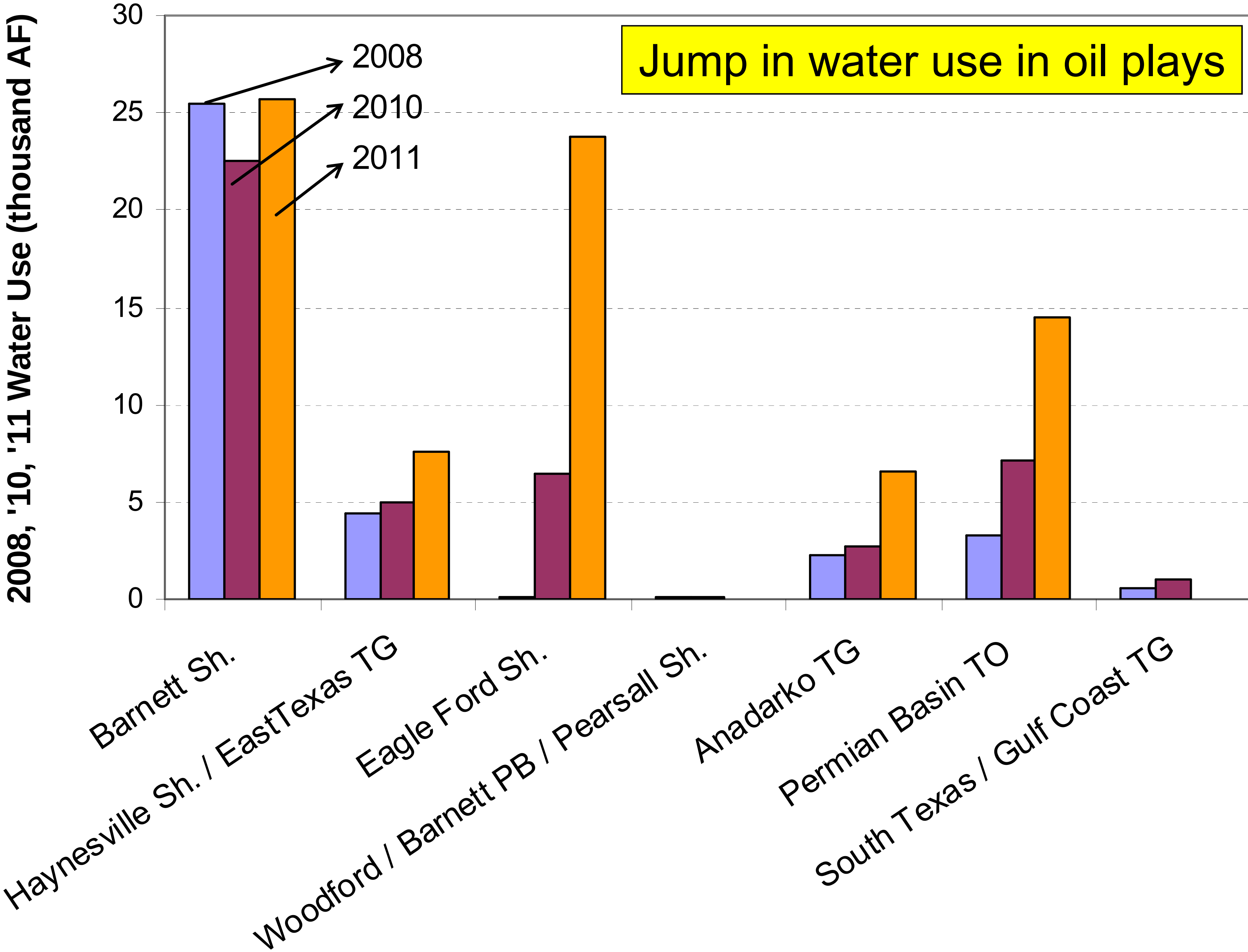
1kAF = 1.23×10⁶ m³





2008: 36 kAF

2011: 81.5 kAF



Jump in water use in oil plays
2008
2010
2011
2008, '10, '11 Water Use (thousand AF)
30
25
20
15
10
5
0
Barnett Sh.
Haynesville Sh. / EastTexas TG
Eagle Ford Sh.
Woodford / Barnett PB / Pearsall Sh.
Anadarko TG
Permian Basin TO
South Texas / Gulf Coast TG

A few numbers….

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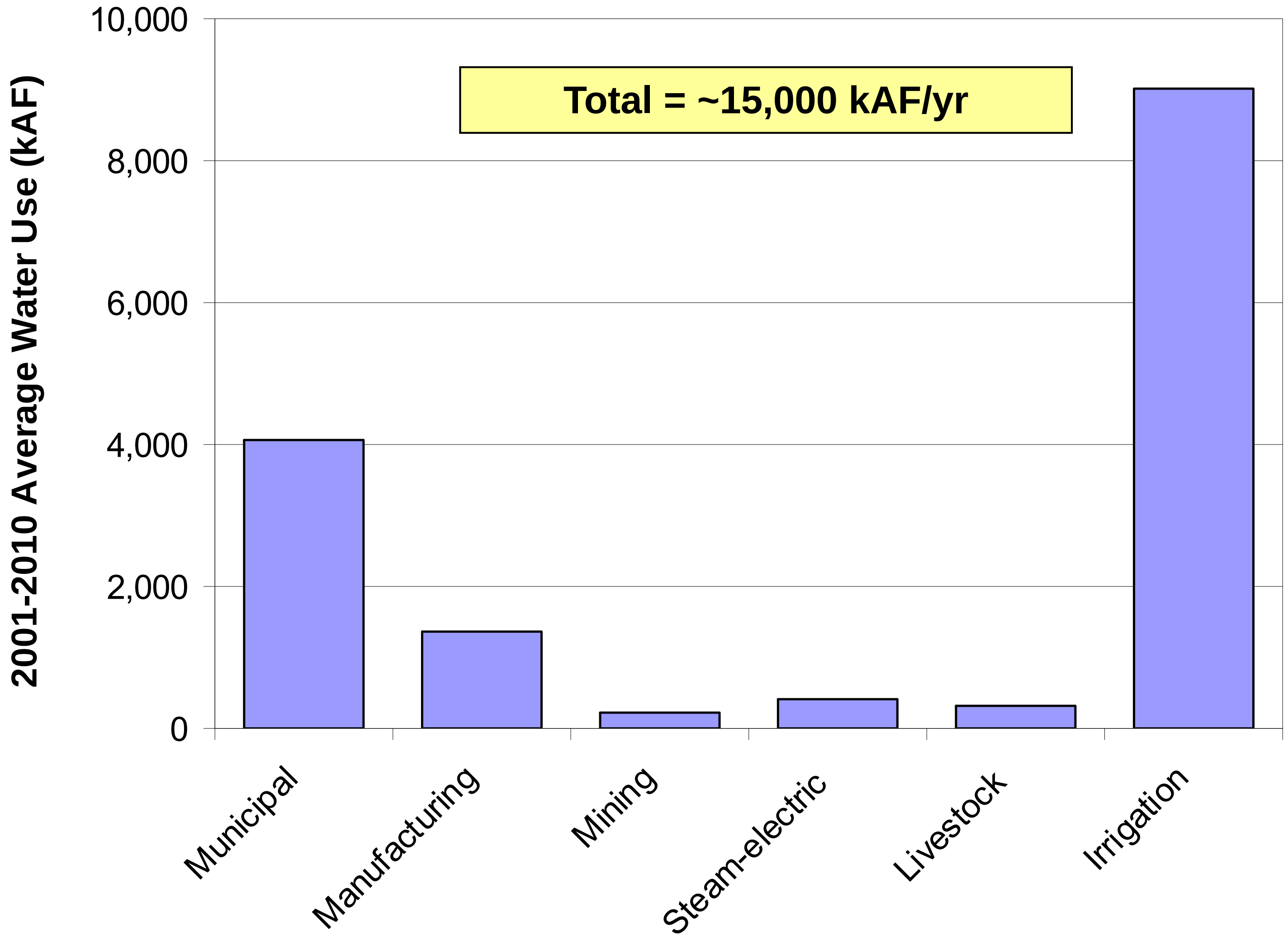
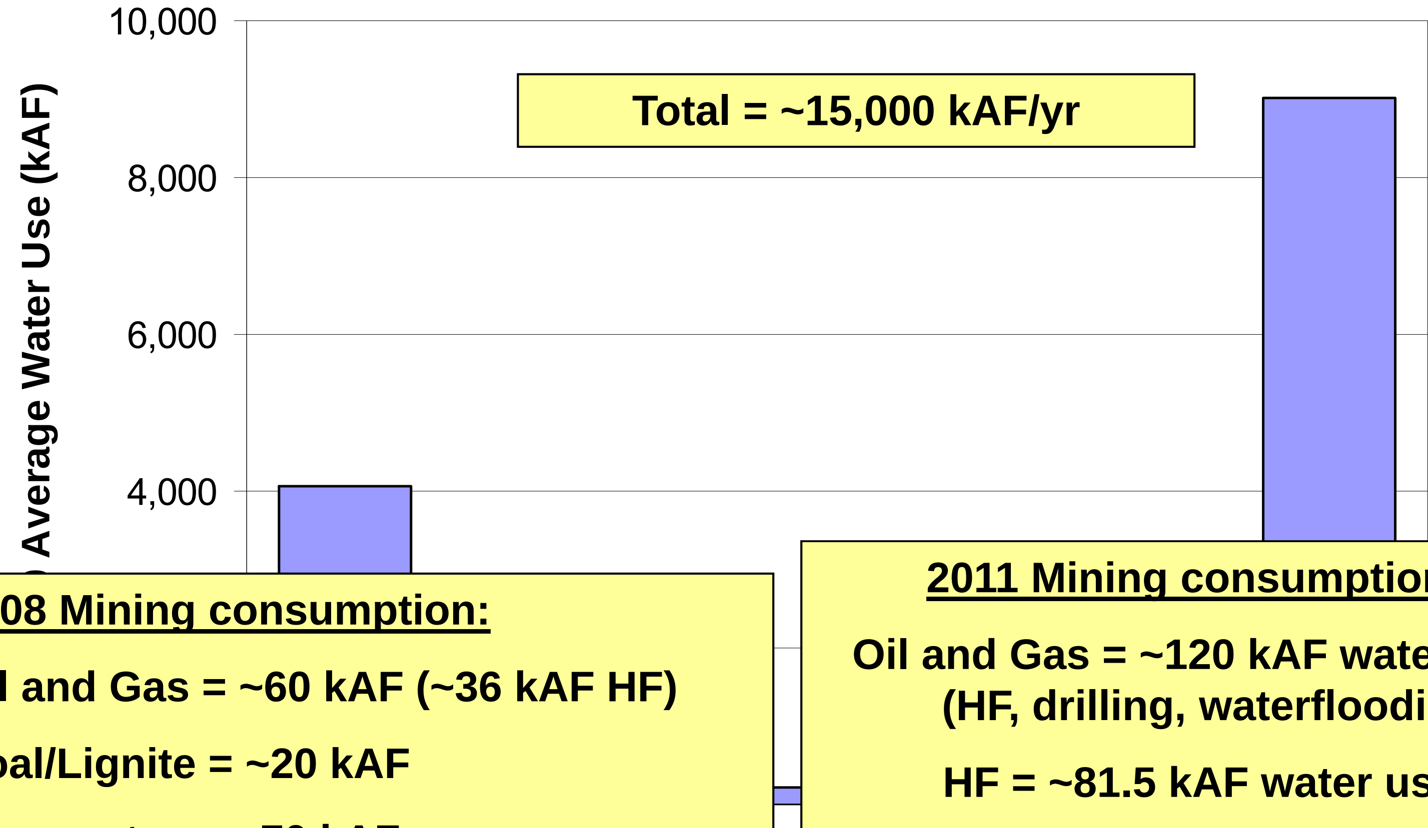


A few numbers….



2008 Mining consumption:

Oil and Gas = ~60 kAF (~36 kAF HF)

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)

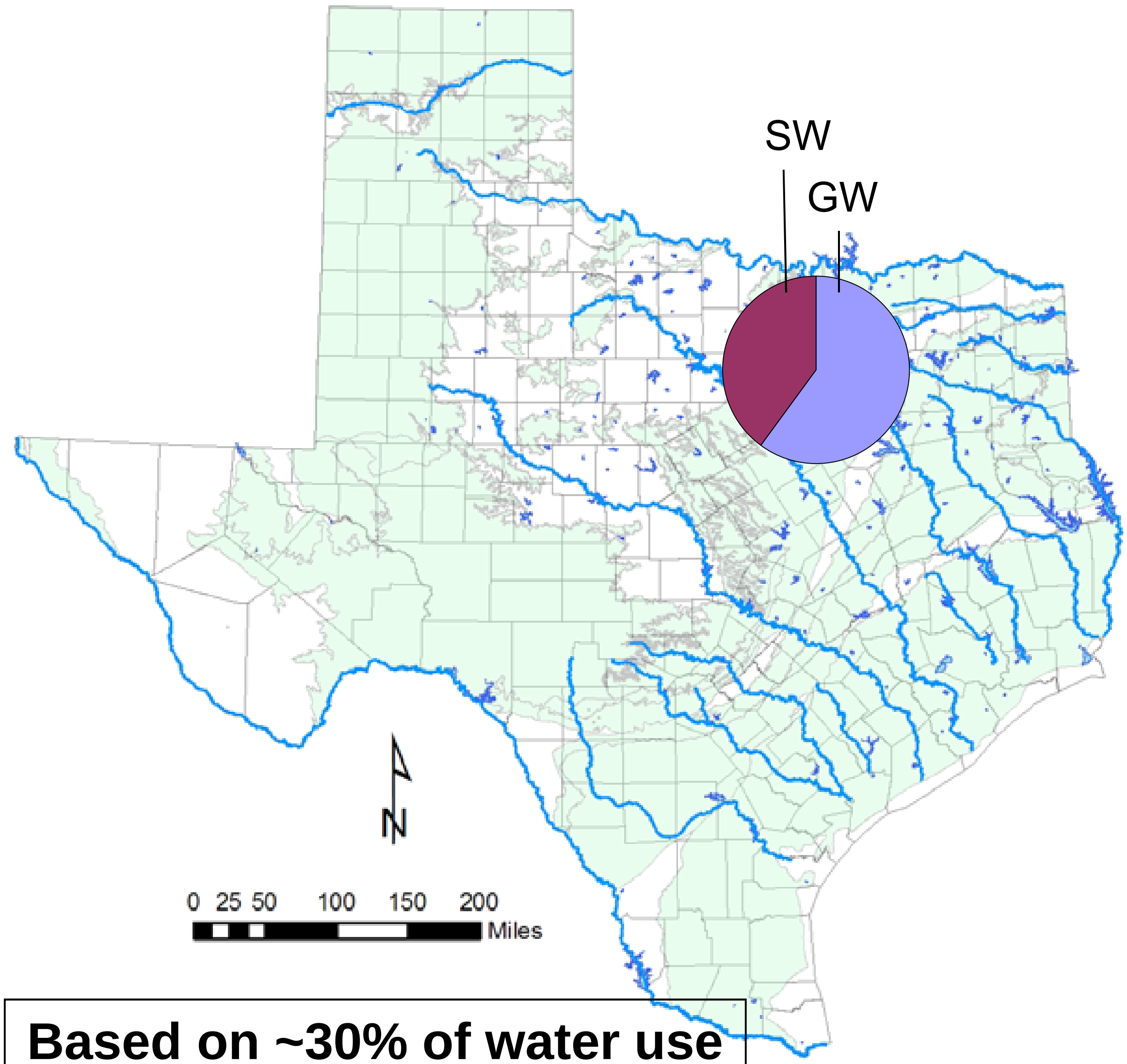
HF = ~81.5 kAF water use

HF = ~65 kAF water consumption

All others = ~100kAF

Total consumption = ~190 kAF

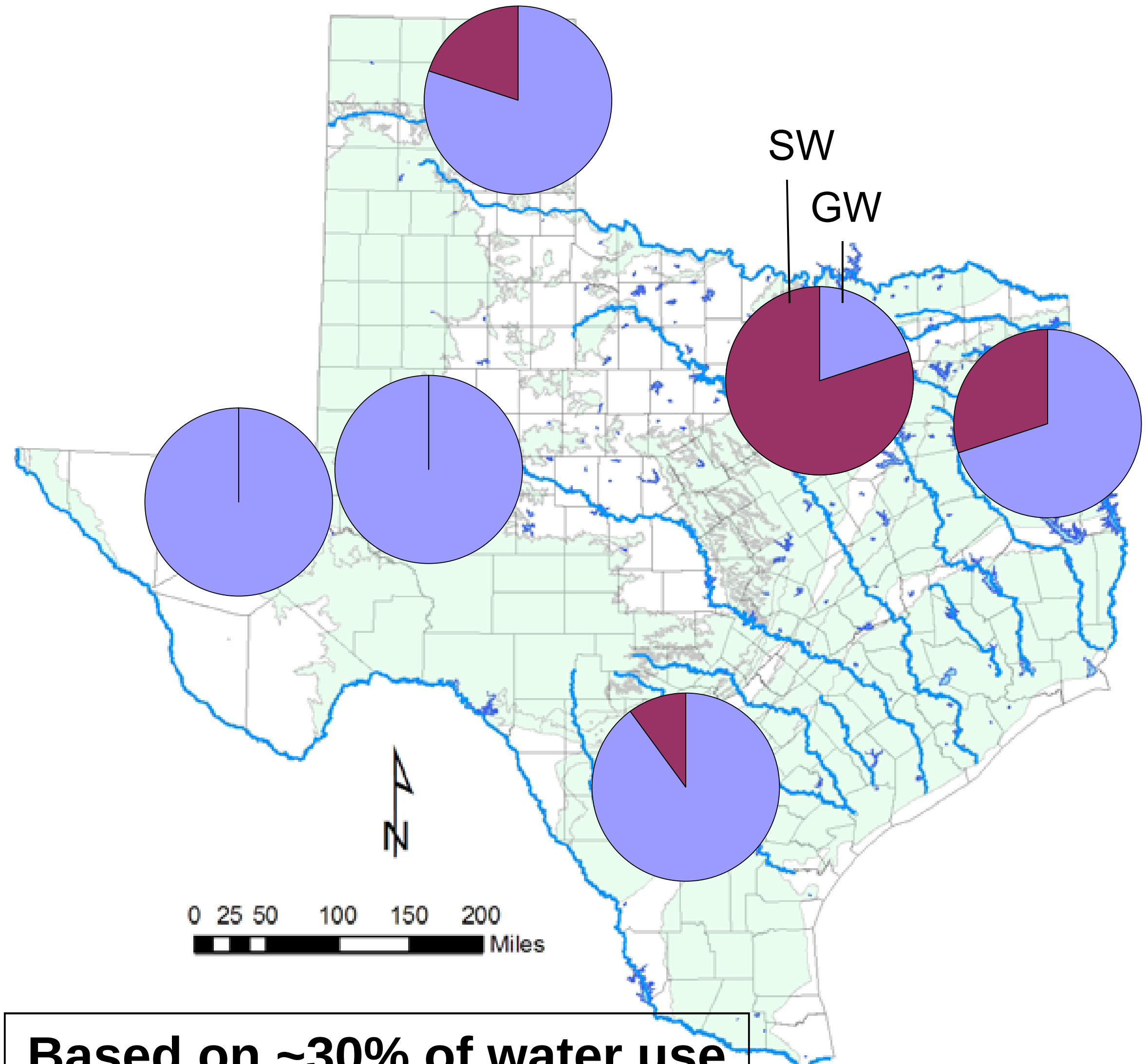
GW/SW split: little known



2006 survey in Barnett:
~60% groundwater

Based on ~30% of water use

GW/SW split: little known



2006 survey in Barnett: ~60% groundwater

2012 Barnett: ~20% groundwater

2012 Haynesville-ETx: ~70% groundwater

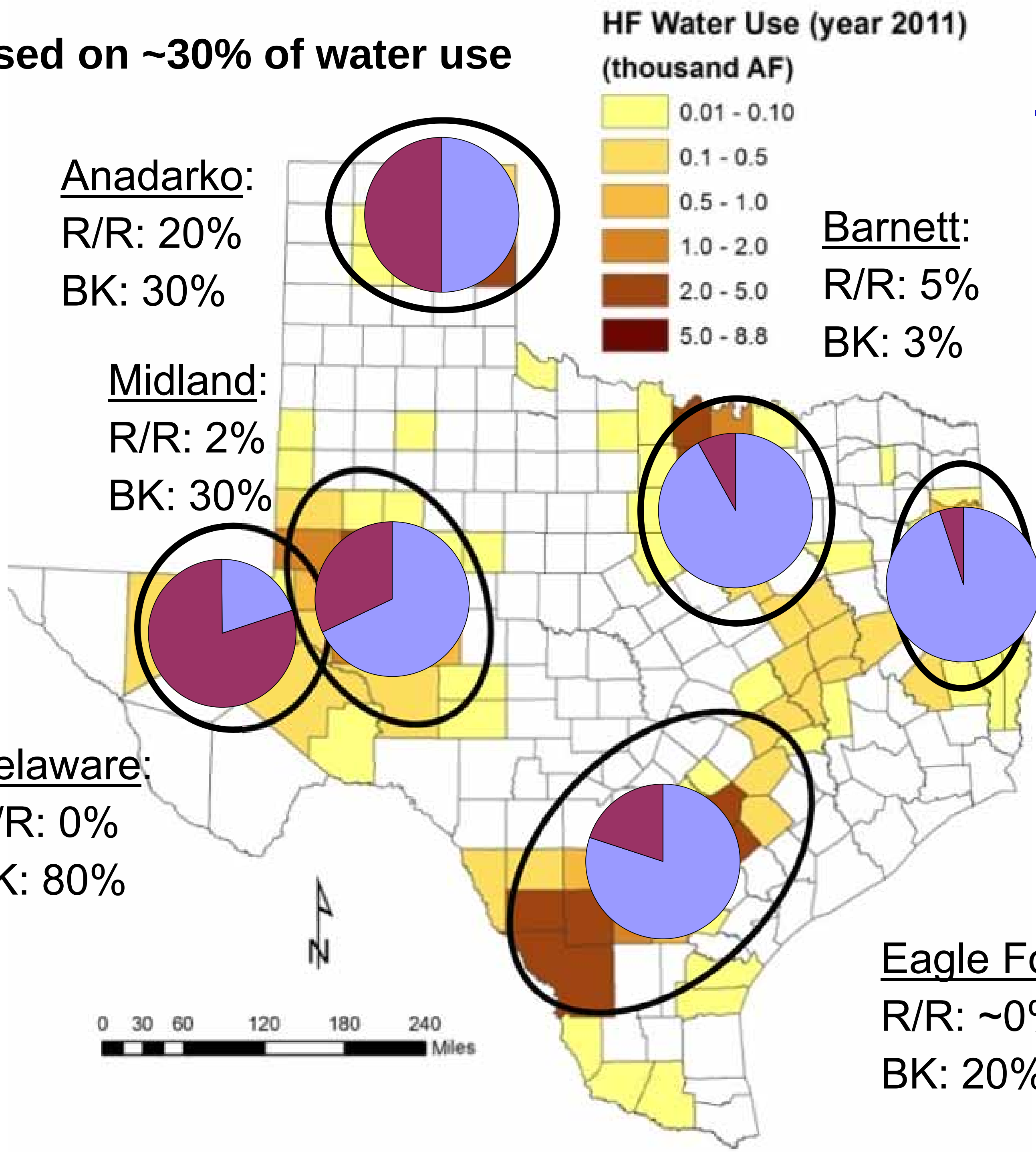
2012 Eagle Ford: ~90% groundwater

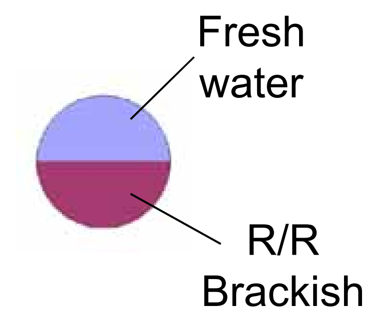
2012 Permian B.: ~100% groundwater

Based on ~30% of water use

Fraction from recycling / reuse

Based on ~30% of water use





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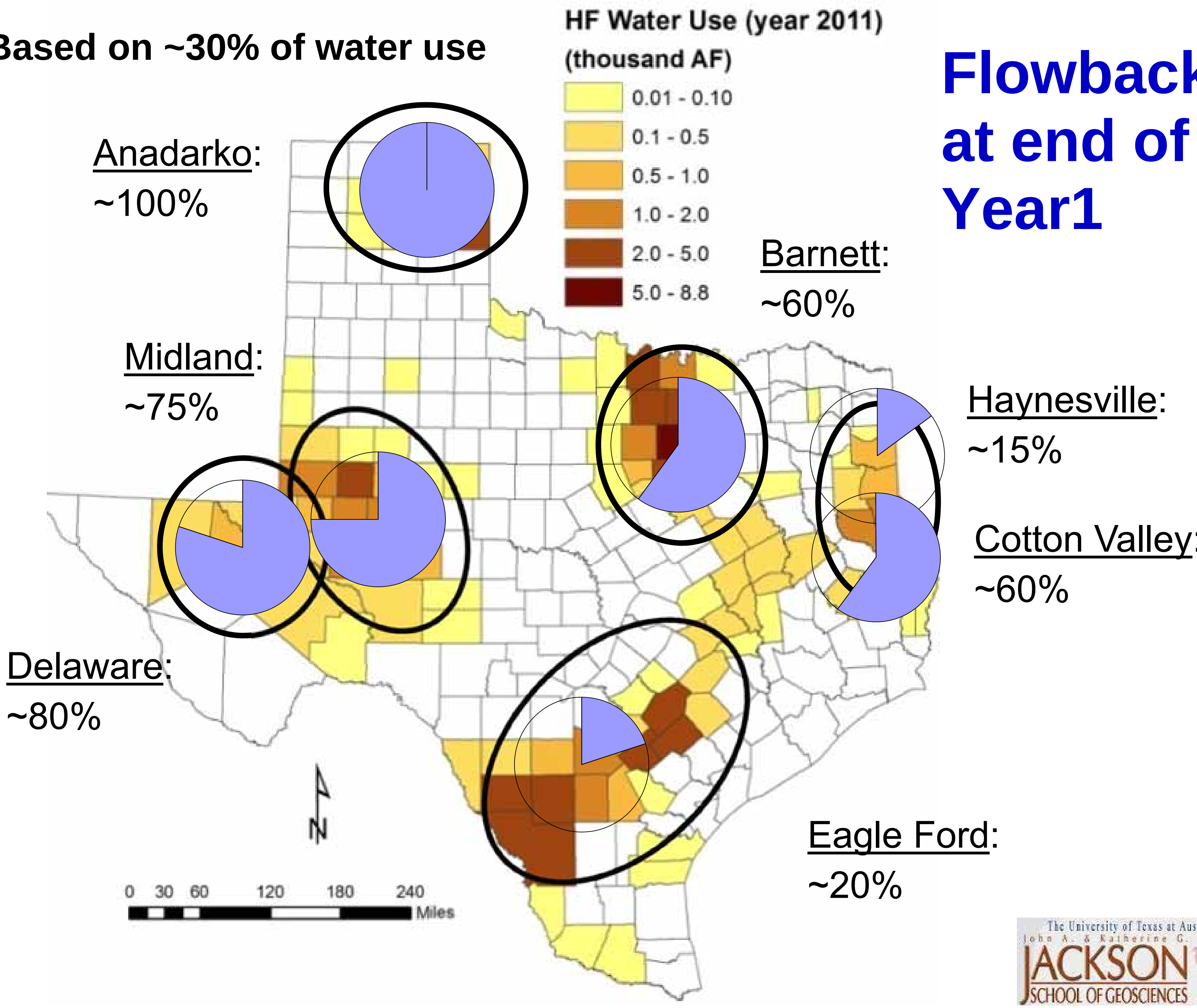
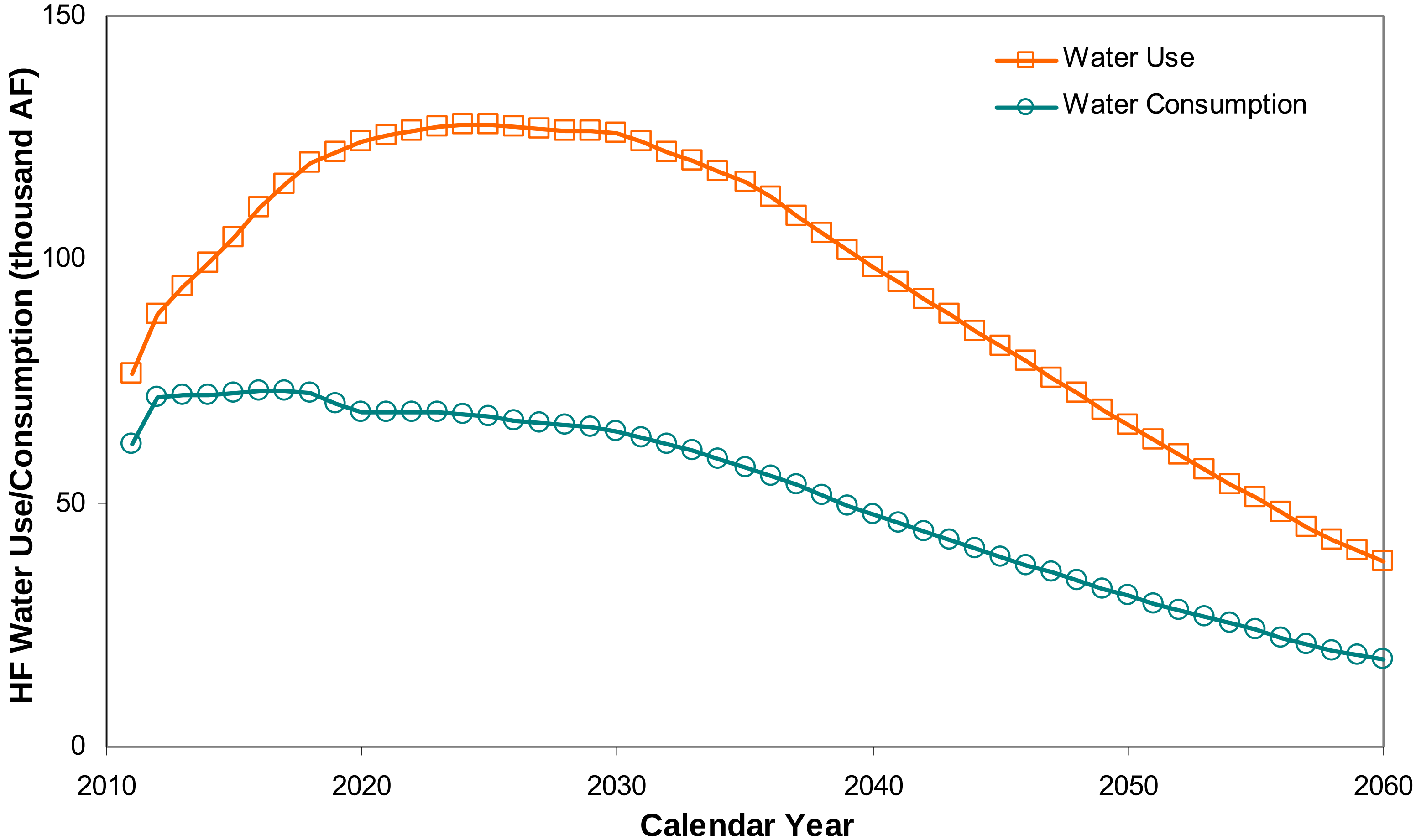
Flowback at end of Year1

Based on ~30% of water use



O&G water use and consumption projections

Bureau of Economic Geology



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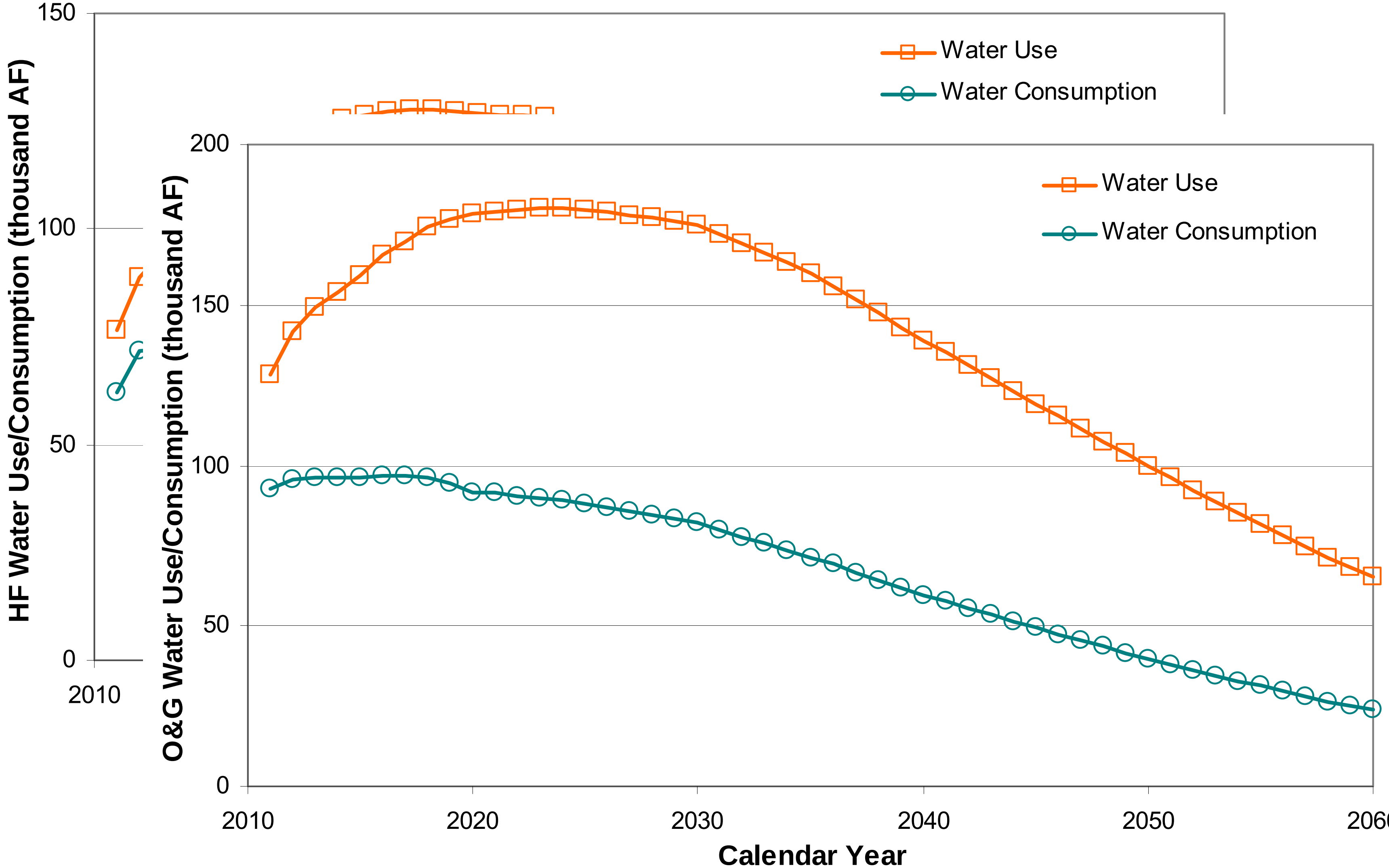
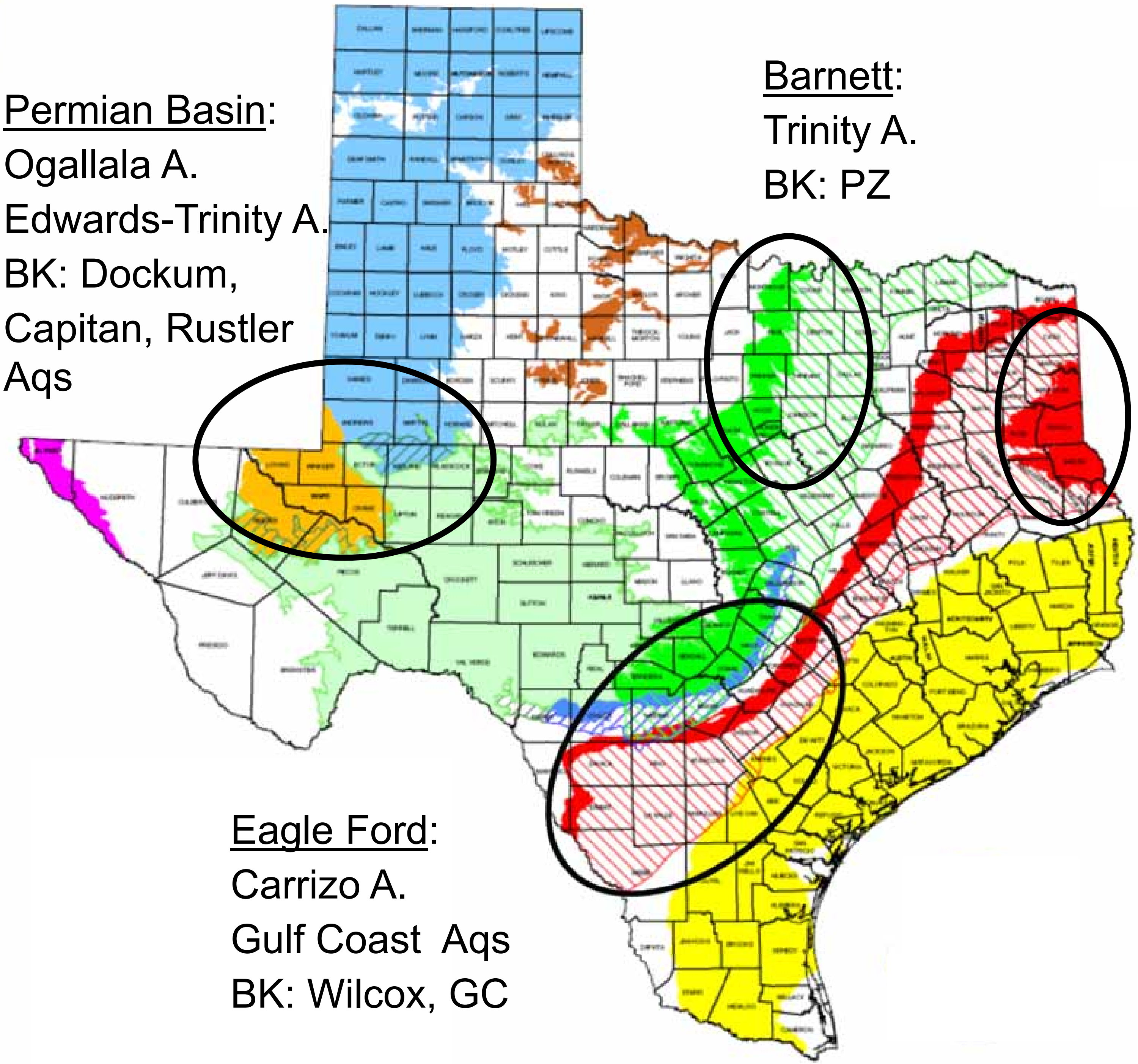
O&G water use and consumption projections



Permian Basin:
Ogallala A.
Edwards-Trinity A.
BK: Dockum,
Capitan, Rustler
Aqs

Barnett:
Trinity A.
BK: PZ

Haynesville:
Carrizo-
Wilcox A.



Eagle Ford:
Carrizo A.
Gulf Coast Aqs
BK: Wilcox, GC

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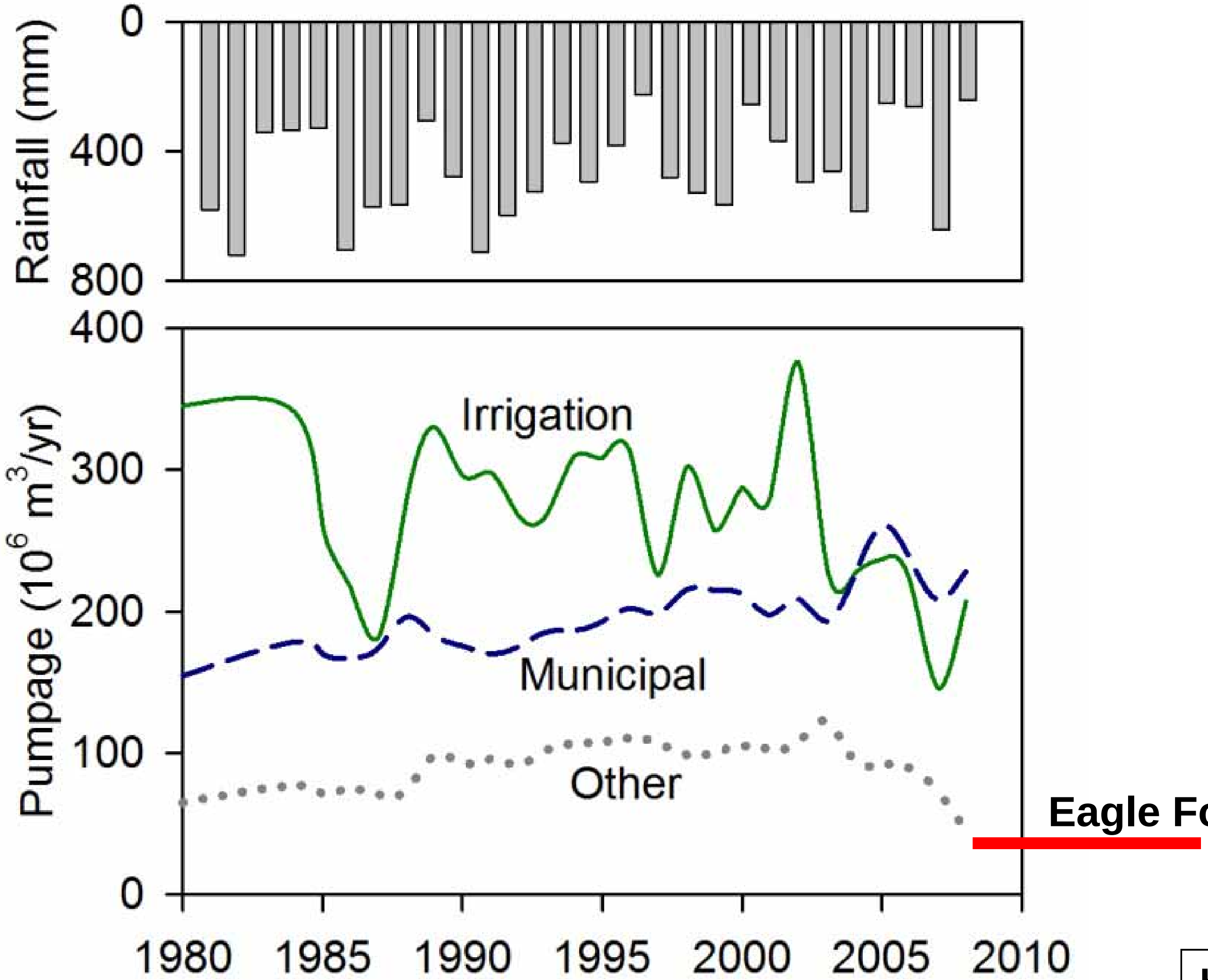
Historical water use
Carrizo-Wilcox aquifer (state-wide)

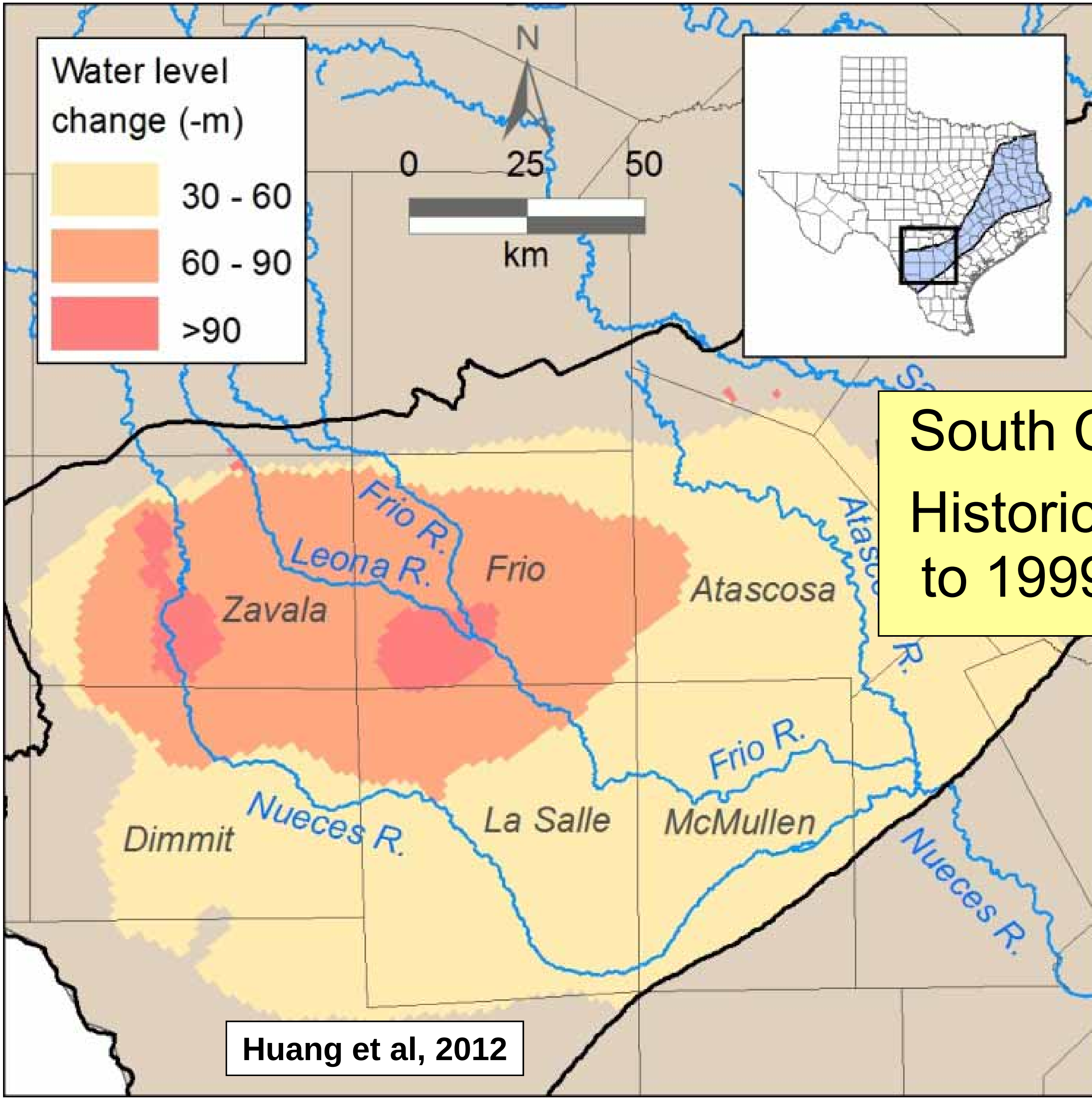
Bureau of Economic Geology



Eagle Ford + Haynesville

Huang et al, 2012

South Carrizo:
Historical drawdown to 1999 (irrigation)



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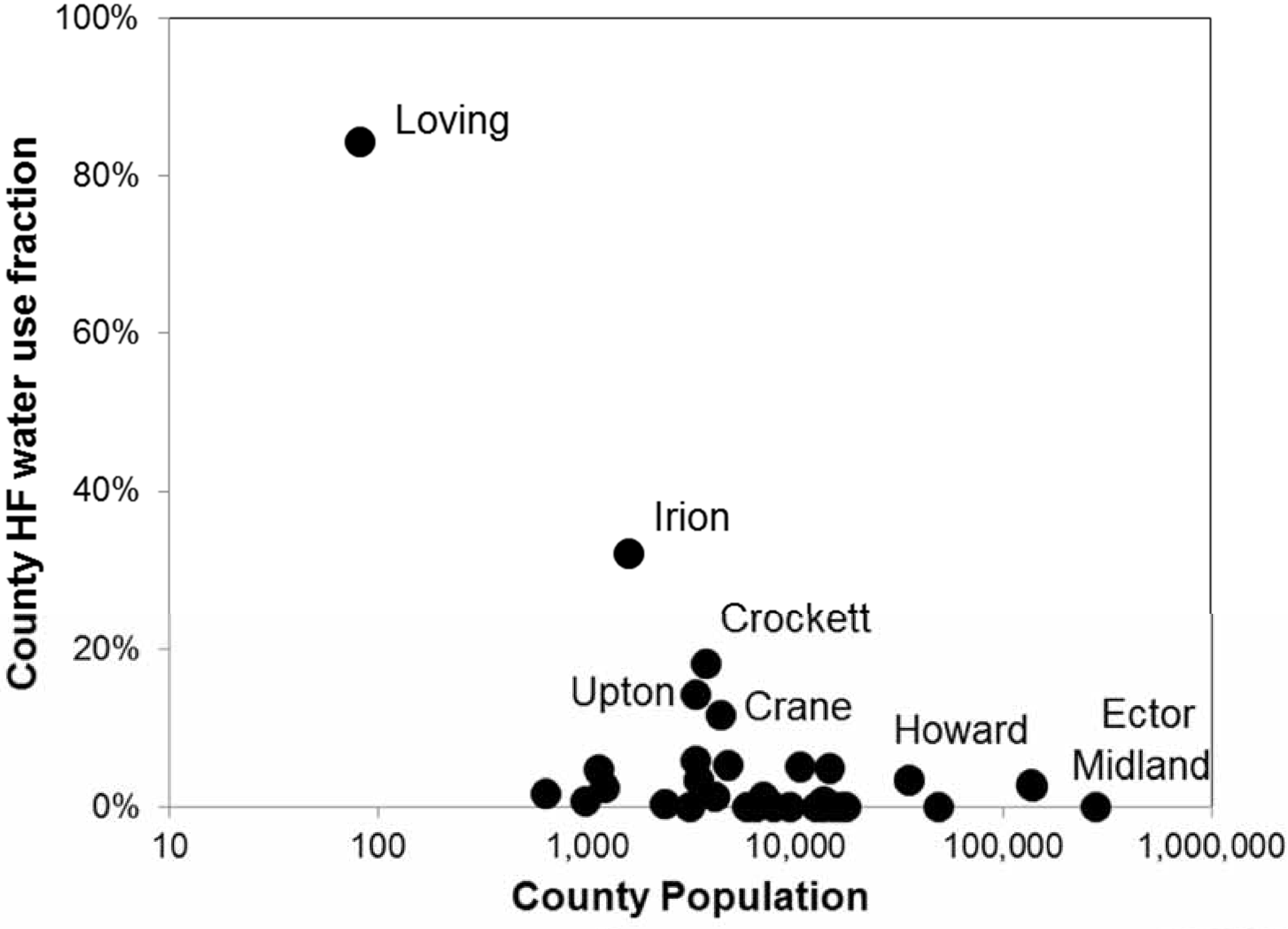
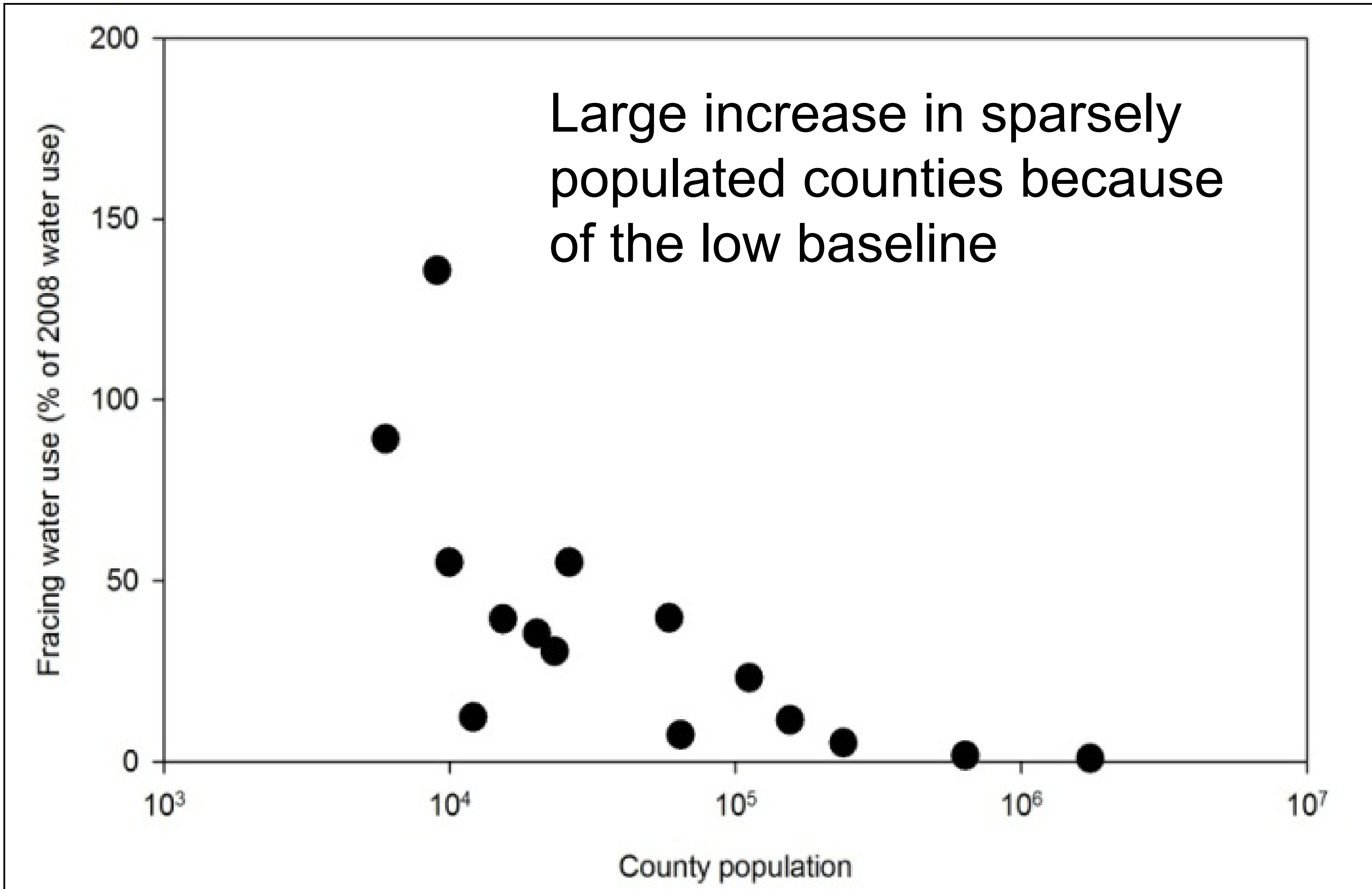
Water Use Fraction: PB



Water Use Fraction: EF



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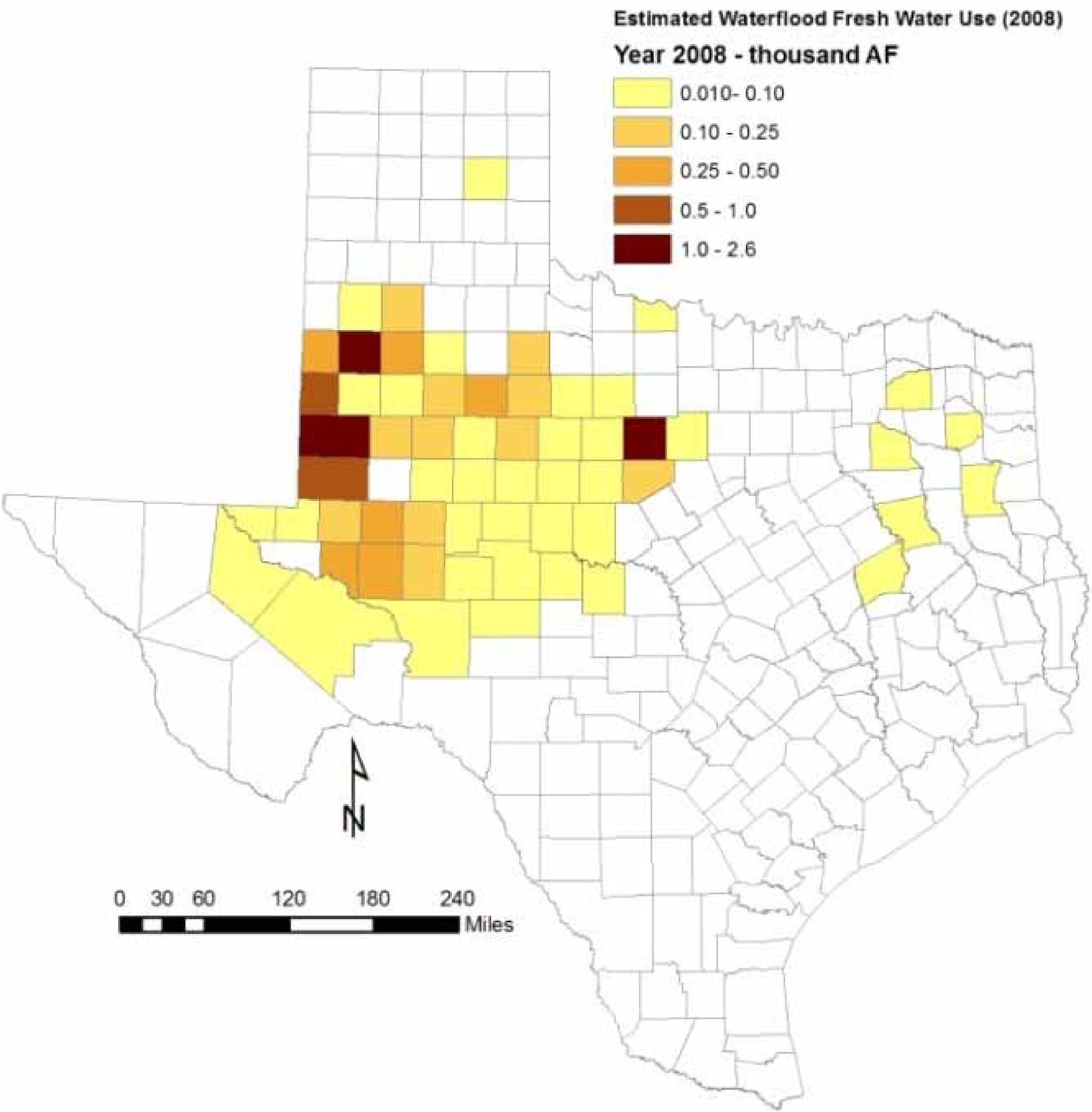
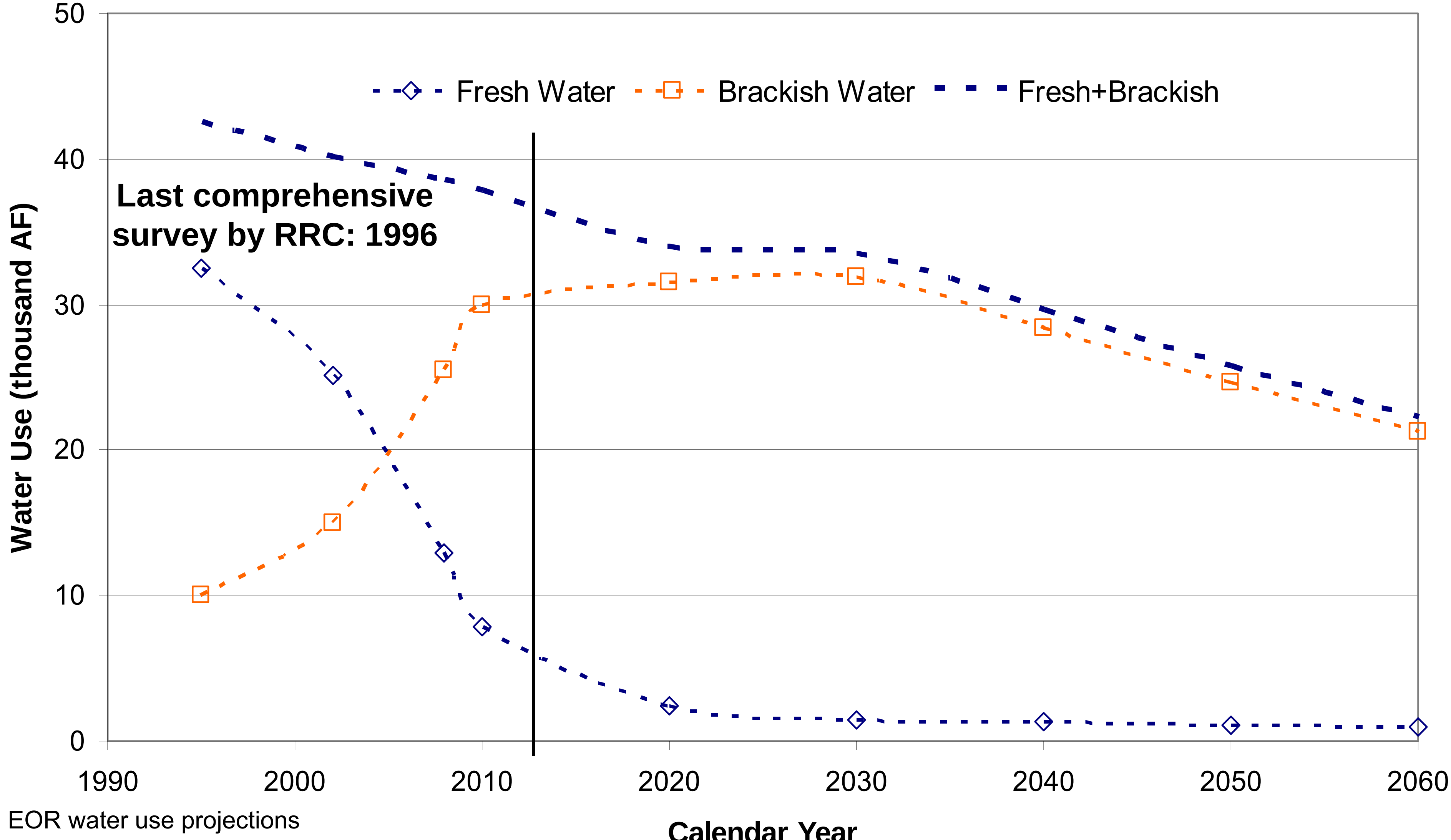
Waterflood: Permian Basin

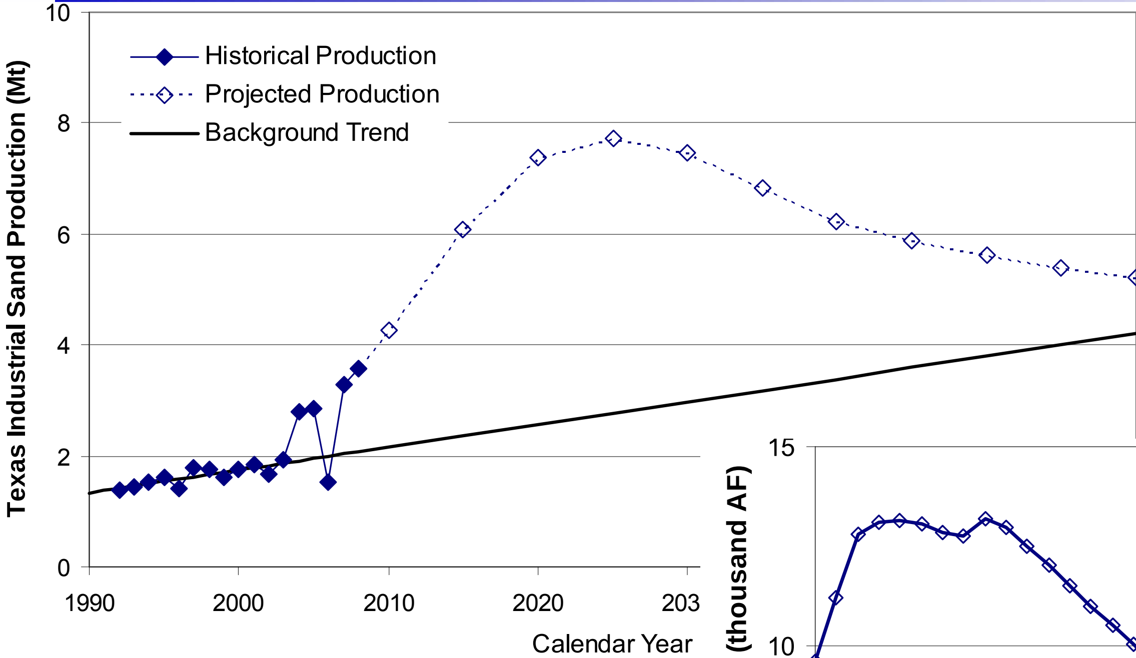


Waterflood: Permian Basin



EOR water use projections
(Courtesy of Peter Galuski, Texerra)

Auxiliary water use



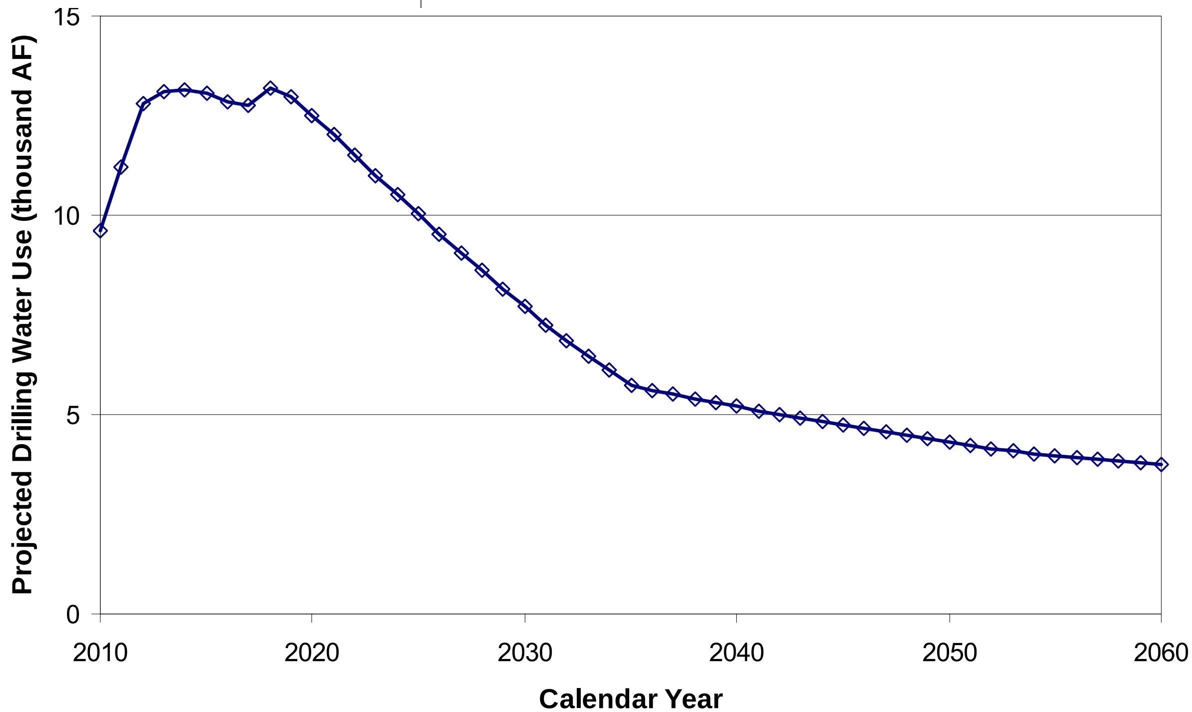
Proppant mining and drilling water use accounts for 10-25% of fracking water use

Consumption: ~500 gal/ton

1 Mt ==> ~1,600 AF

Proppant loading:

0.5 – 1 lb/gal



Conclusions and final thoughts

- Upstream oil and gas uses little water at the state level
- However:
  - Frac water use can have a large impact locally, particularly on groundwater
  - Diffuse, transient pumping, no interlocutor (≠ well field)
  - Population growing in a state where droughts are frequent: competition with other users
- There is a need to develop alternative sources of water (brackish, reuse, etc) and less water-intensive techniques for HF

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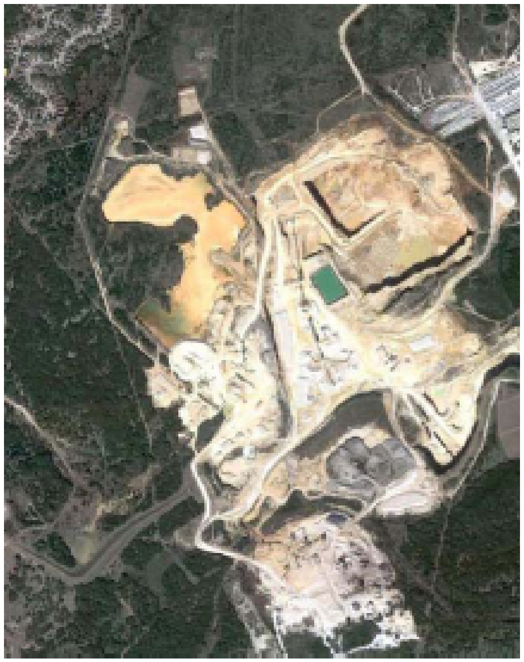
June 2011

Current and Projected W
Texas Mining and Oil an



Prepared for
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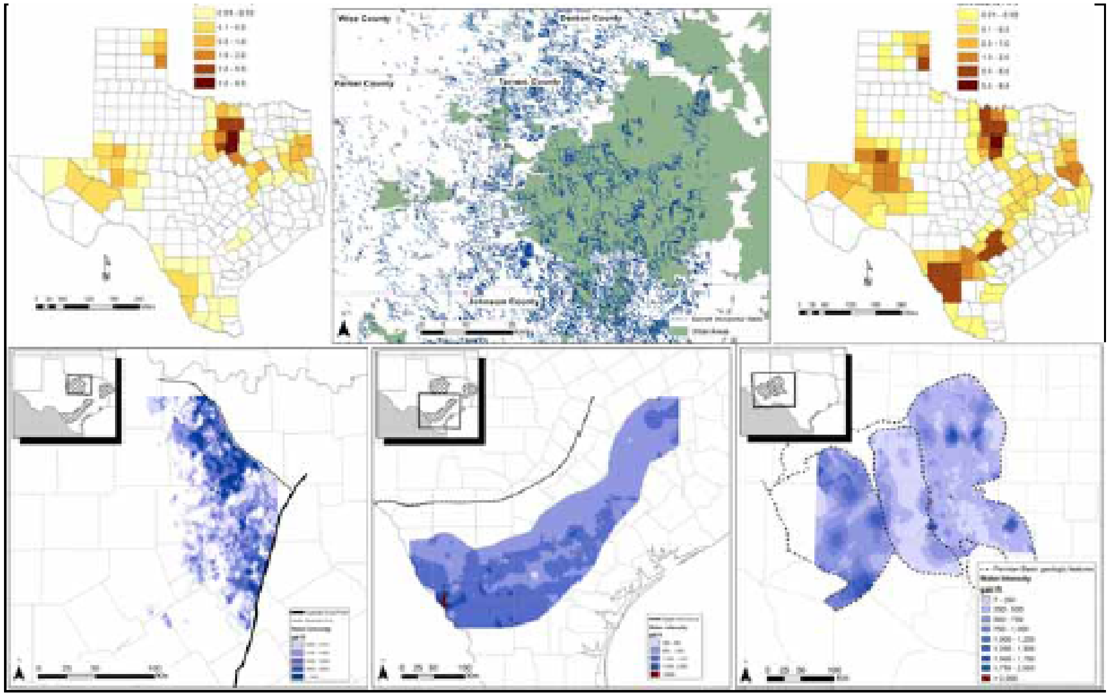
Oil & Gas Water Use in Texas: Update to the 2011 Mining Water Use Report



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GCAGS JOURNAL

CURRENT AND FUTURE WATER DEMAND O[I] TEXAS OIL AND GAS AND MINING SECTOR[S] POTENTIAL IMPACT ON AQUIFERS

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ABSTRACT

The Texas mining industry, in addition to oil and gas, produces mostly lignite coal and aggregat crushed rocks). Operations always involve water, either as an aid in extraction or as a byproduct. current water use in the various sectors of the mining industry and made projections for the next 5(cerned the upstream segment of the oil and gas industry (drilling, hydraulic fracturing, waterfloods) (washing included but no further processing), the coal industry (pit dewatering and aquifer depress stances mined in a fashion similar to that of aggregates (industrial sand, lime, etc.), as well as through s in 2008, the industry used ~160 thousand acre-ft (kAF), including 35 kAF for hydraulic fracturing and poses in the oil and gas industry. The coal and aggregate industries used 20 kAF and 71 kAF, respec trial sand dominates the remainder. Approximately three-fourths of the water used is consumed, and a of the water consumed is groundwater. Projection estimates call for a steady increase in water use in duction and a sharp increase, followed by a slow decrease, in the oil and gas industry. Operators favor plentiful, but groundwater is a more drought-proof source. Because the various segments of the energy across the state, they impact many different aquifers. Mining withdrawals represent only ~1% of total level but can be much higher locally and compete with other uses, such as municipal usage or irrigation.

INTRODUCTION

Mineral resources in Texas fall into four categories: (1) hydrocarbons (oil and gas), (2) lignite and coal, (3) crushed rock and sand and gravel (collectively known as aggregates), and (4) other substances. Oil and gas make up most of the dollar value and compose a significant fraction in terms of volume with the aggregate category (Table 1). Oil and gas are produced from almost every county in the state (Fig. 1a), whereas lignite mines are located in a narrow band in the middle of the state (Fig. 1c) and parallel to the coast (Kyle, 2008; Kyle and Clift, 2008). Sand and gravel are exploited mostly along rivers (Fig. 1d). Crushed-stone quarries are present mostly in the footprint of the Edwards Limestone. The objective of a recent study performed for the Texas Water Development Boa mine county-level historical and proje Texas, focusing on fresh water (total [TDS] < 1000 mg/L). Disregarding oi oil- and gas-related facilities, the U.S listed a total of 11 lignite mines, 100+ sand and gravel operations, many of th facilities of a different type, neither Texas in 2000. More details about min detailed account of water use, can be fo

Oil and gas resources are generall and unconventional categories (Figs. represents the archetypal reservoir tra carbonates and is made up of interco 'easy' communication with the well bo characterized by the use of advanced te different types of formation and/or extr tions (pressure and temperature). Ch tional resources of interest relevant to t meability and a need to stimulate the r

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Water Use for Shale-Gas Production in Texas, U.S.

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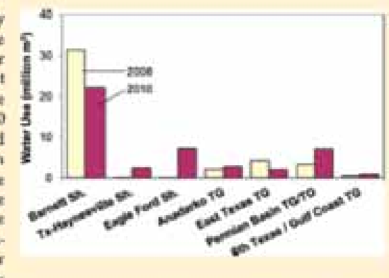
Supporting Information

ABSTRACT: Shale-gas production using hydraulic fracturing of mostly horizontal wells has led to considerable controversy over water-resource and environmental impacts. The study objective was to quantify net water use for shale-gas production using data from Texas, which is the dominant producer of shale gas in the U.S. with a focus on three major plays: the Barnett Shale (~15 000 wells, mid-2011), Texas-Haynesville Shale (390 wells), and Eagle Ford Shale (1040 wells). Past water use was estimated from well-completion data, and future water use was extrapolated from past water use constrained by shale-gas resources. Cumulative water use in the Barnett totaled 145 Mm^3 (2000–mid-2011). Annual water use represents ~9% of water use in Dallas (population 1.3 million). Water use in younger (2008–mid-2011) plays, although less (6.5 Mm^3 Texas-Haynesville, 18 Mm^3 Eagle Ford), is increasing rapidly. Water use for shale gas is <1% of statewide water withdrawals; however, local impacts vary with water availability and competing demands. Projections of cumulative net water use during the next 50 years in all shale plays total ~4350 Mm^3, peaking at 145 Mm^3 in the mid-2020s and decreasing to 23 Mm^3 in 2060. Current freshwater use may shift to brackish water to reduce competition with other users.



INTRODUCTION

Natural gas has spurred intense interest in reducing greenhouse gases and enhancing energy security. Natural gas produces emissions that are much lower than those from oil and coal: 30%–40% lower for CO_2, 80% for NO, and ~100% for SO_2, particulates, and mercury.[1] Natural gas is used widely for industrial (31%), electric power (27%), residential (22%), commercial (14%), and other purposes (mean 2000–2010).[2] Production of natural gas from hydrocarbon-rich shales is referred to as shale gas. Shales contain gas in micropores, fractures, and adsorbed onto organic matter. Conventional gas has been produced from permeable geologic formations for decades; however, within the past decade, advances in directional drilling, combined with breakthroughs in fracking in Texas, have allowed large-scale expansion of gas production from low-permeability shale formations at depths of >1 km. Shale-gas reservoirs differ from typical oil and gas reservoirs in that the shale serves as the source rock, reservoir, and seal. Although older wells in older plays, such as the Barnett, and exploratory wells in newer plays are vertical (Supporting Information, A), most wells are currently drilled vertically almost to the depth of the shale formation, then deviated to the horizontal and drilled horizontally within the shale. Fracking involves injection of water containing chemical additives and proppant (e.g., sand) under high pressure to fracture the shales.[3] Early expansion of shale-gas production was restricted primarily to the Barnett Shale in Texas, which was the main producer in the 2000s, accounting for 66% of shale-gas production in the U.S. in 2007–2009;[2] however, shale gas is currently produced in 22 of the 50 states, and production increased by an annual average rate of ~50% between 2006 and 2010.[4] Shale-gas production is projected to increase from 23% of U.S. natural gas production in 2009 to 47% by 2035.

Energy and water production are interdependent. In the shale-gas context, there is a strong correlation between water injected and gas production (Supporting Information, B). Most studies of water-resource impacts from shale-gas exploration and production have focused on effects of fracking on water quality;[5] however, some studies also emphasize impacts on water quantity.[6–10] Few published studies quantify water use for shale-gas production and their environmental impact.[11–13] Water use for hydraulically fracturing wells varies with the shale-gas play, the operator, well depth, number of fracking stages, and length of laterals. To date, generally fresh water (total dissolved solids <1000 mg/L) has been used for fracking, sourced from surface water or groundwater, depending on local availability. The commonly used polyacrylamide additives (friction reducers) function best in fresh water.[14]

Impacts of water production for shale-gas development depend on water availability in the region and competing demands for water from other users. Limited water availability in semiarid regions may restrict shale-gas production. Impacts range from declining water levels at the regional[10–12] or local[6]

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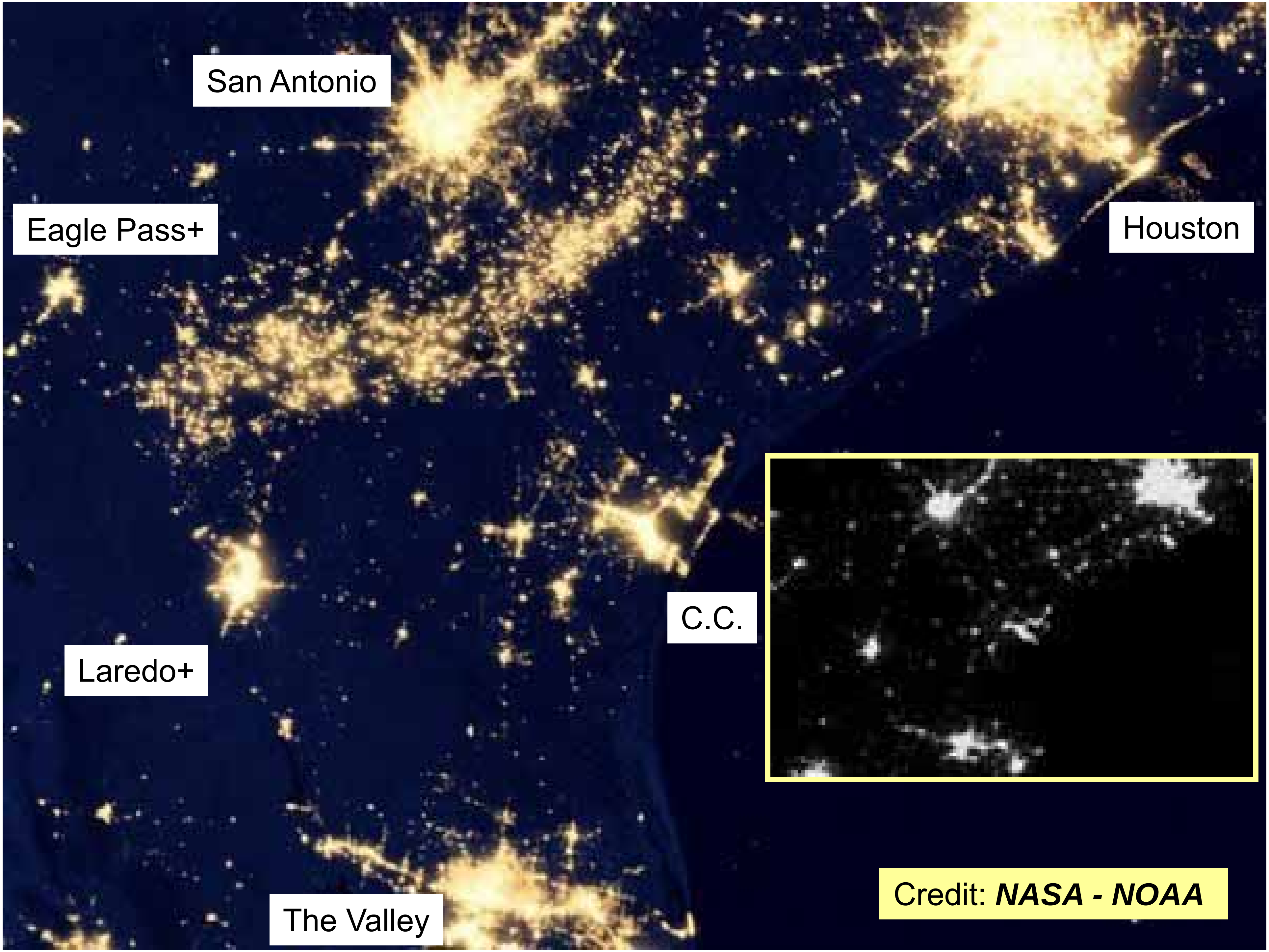
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