Hydrocarbon Targeted Depth

Algorithm that analyzes perforation interval length, number of zones perfed and perforation sessions

Note: vertical wells were used for this analysis
Horizontals can be added, but need more data preparation

Stratigraphic units can be 2,000+ feet in width
Perforations are a better indicator of where an operator thinks there are hydrocarbons

There are 8609 named stratigraphic units in Eagleford counties, 7561 that have less than 5 mentions in RRC records
RRC does not require pay zone formation be disclosed - formations and perforations are completely separated

Top RRC formation mentions

AUSTIN CHALK	15899
ANACACHO	7276
OLMOS	6754
EAGLE FORD	6027
EAGLEFORD	5293
WILCOX	4656
PECAN GAP	4096
NAVARRO	3995
ESCONDIDO	3286
BUDA	3222
QUEEN CITY	2934
MIDWAY	2601
SAN MIGUEL	2348
YEGUA	2000
CARRIZO	1777

Formations can be different spellings

Webb county (alone) has 1500+ unique formations reported

WEBB	1559
LAVACA	908
GOLIAD	732
COLORADO	699
MCMULLEN	679
LIVE OAK	642
BEE	586
LEON	541
DE WITT	518

AUSTIN CHALK	28
AUSTIN	25
AUSITN CHALK	17
AUSTIN CHALK TOP	10

Austin Chalk is found in 28 different counties
A misspelled version is reported in 17 counties?!

There are over 200 different spellings (misspellings of Austin Chalk)
Aursin Chalk, Ausin Chalk, Ausin Chalk Upper, Ausin Chalk, Upper, Ausint Chalk, Ausitn, Ausitn Chalk, Ausitn Chalk, Ausstin Chalk, Austhin Chalk, Austiin Chalk, Austin, Austin Chalk, Austin "A", Austin "A" Marker, Austin "Chalk, Austin "D" Marker, Austin "F", Austin (Chalk), Austin (E-Log), Austin (Wilcox Massive E), Austin (Wilcox Massive), Austin 1, Austin 2, Austin 3, Austin 7, Austin A, Austin A Marker, Austin Ash, Austin Ash Marker, Austin Ash-Marker, Austin B, Austin B1, Austin B-1, Austin Base, Austin C, Austin Cahalk, Austin Cahlk, Austin Calk, Austin Ch., Austin Chak, Austin Chal, Austin Chalck, Austin Chald, Austin Chalk, Austin Chalk - Lower, Austin Chalk - (Lower), Austin Chalk - (Upper), Austin Chalk - 3, Austin Chalk - B, Austin Chalk - C, Austin Chalk - D, Austin Chalk - Disposal, Austin Chalk - H2s, Austin Chalk - H2s, Disposal, Austin Chalk - Lost Circulation, Austin Chalk - Lower, Austin Chalk - Md, Austin Chalk - Production, Austin Chalk - Tvd, Austin Chalk - Upper, Austin Chalk "A", Austin Chalk "A" Marker, Austin Chalk "B", Austin Chalk "C", (etc)

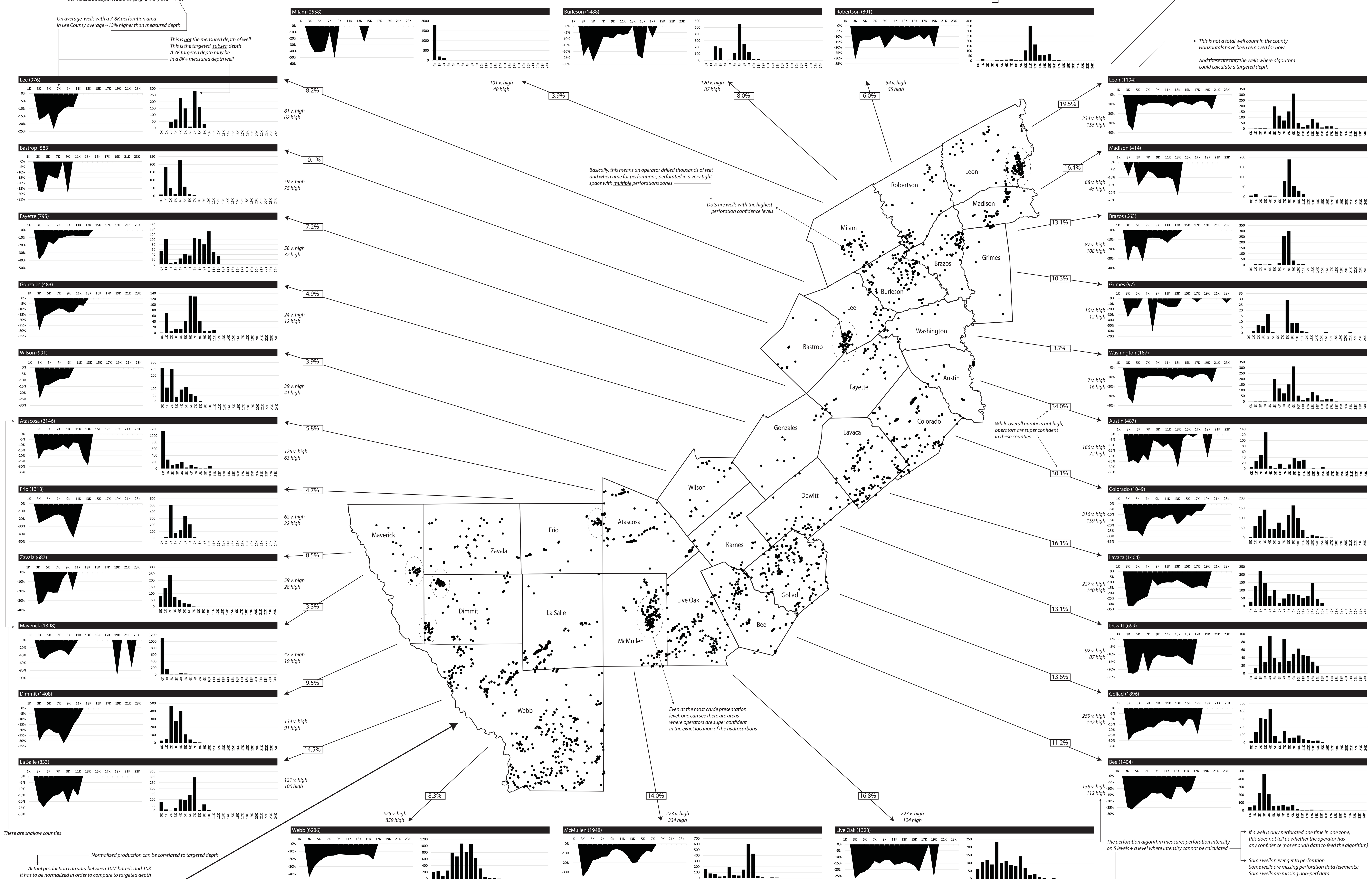
Bottom line...
RRC allowed free typed formations for a long time
Operators obfuscate formation reporting
Formations and perforations are not correlated in the data

Our findings...
RRC is not strict about formation reporting (tops and bottoms)
But RRC is strict about where operators perforate a well

*(i.e.) If a well that has a perforation target of 7500 feet, the measured depth would be (avg) 8475 (7500 * 1.13)*

On average, wells with a 7-8K perforation area in Lee County average ~13% higher than measured depth

This is not the measured depth of well
This is the targeted subsea depth
A 7K targeted depth may be in a 8K+ measured depth well



The perforation algorithm measures perforation intensity on 5 levels + a level where intensity cannot be calculated

If a well is only perforated one time in one zone, this does not tell us whether the operator has any confidence (not enough data to feed the algorithm)

Some wells never get to perforation
Some wells are missing perforation data (elements)
Some wells are missing non-perf data

(i.e.) Level zero (confidence) may be 2+ perforation zones on the same day that are 3000+ feet apart (we call this a shotgun approach)

Normalized production can be correlated to targeted depth

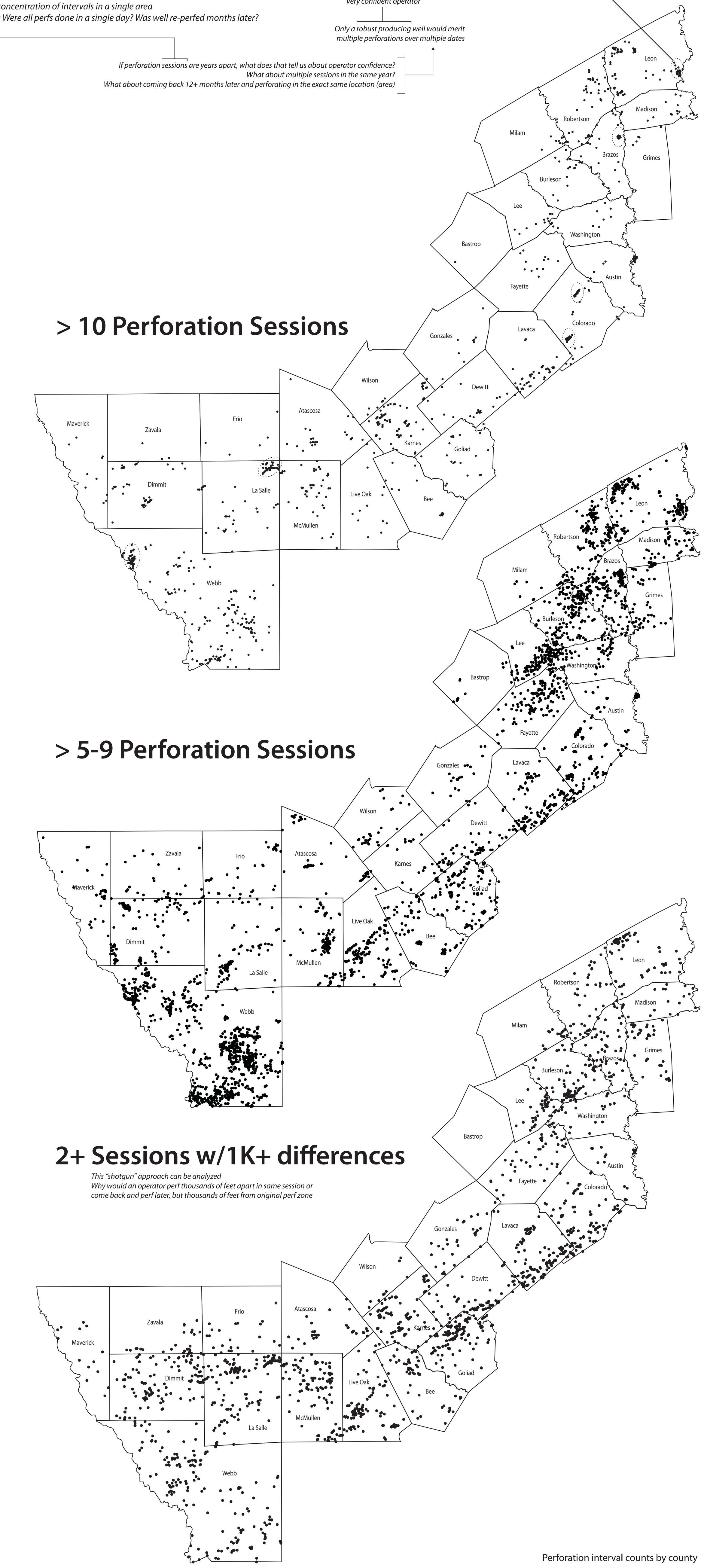
Actual production can vary between 10M barrels and 10K
It has to be normalized in order to compare to targeted depth

One part of the algorithm analyzes if the operator came back and perforated the exact same well more than once (on different dates)

Definitions:
Perforation interval: An area with top and bottom measurements where gun was fired
Perforation zone: A concentration of intervals in a single area
Perforation sessions: Were all perfs done in a single day? Was well re-perfed months later?

If perforation sessions are years apart, what does that tell us about operator confidence?
What about multiple sessions in the same year?
What about coming back 12+ months later and perforating in the exact same location (area)

very confident operator
Only a robust producing well would merit multiple perforations over multiple dates

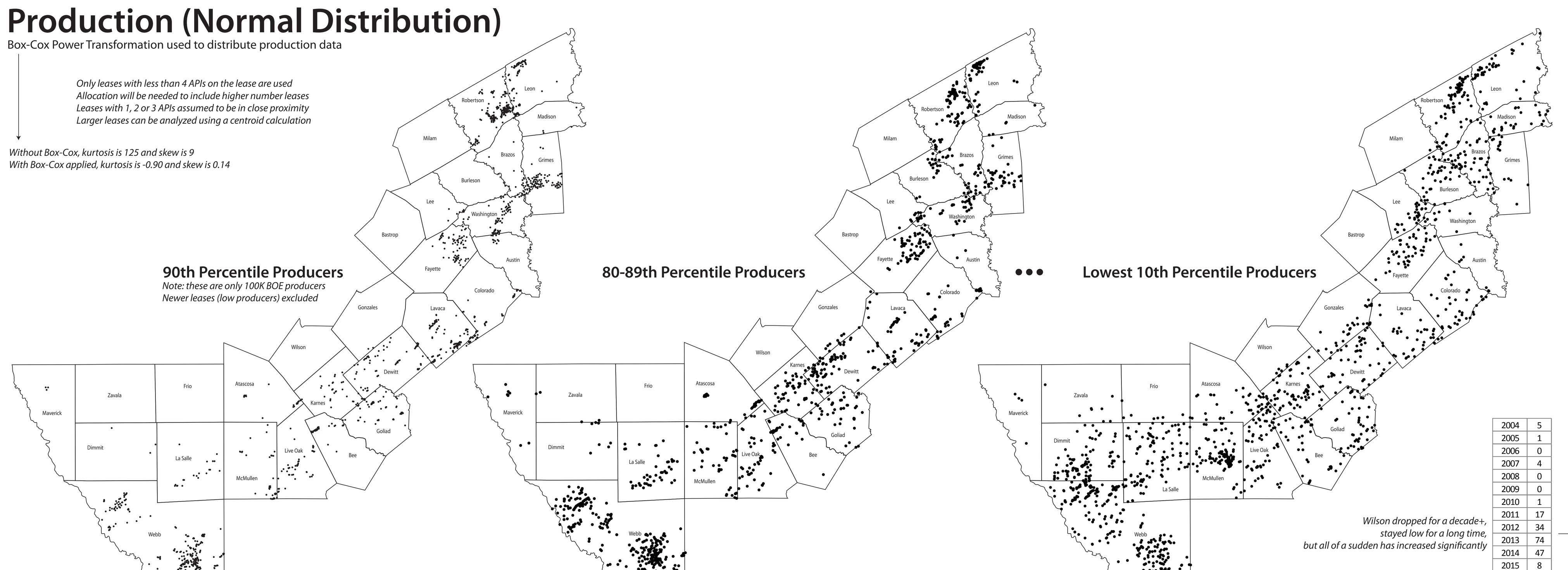


Production (Normal Distribution)

Box-Cox Power Transformation used to distribute production data

Only leases with less than 4 APIs on the lease are used
Allocation will be needed to include higher number leases
Leases with 1, 2 or 3 APIs assumed to be in close proximity
Larger leases can be analyzed using a centroid calculation

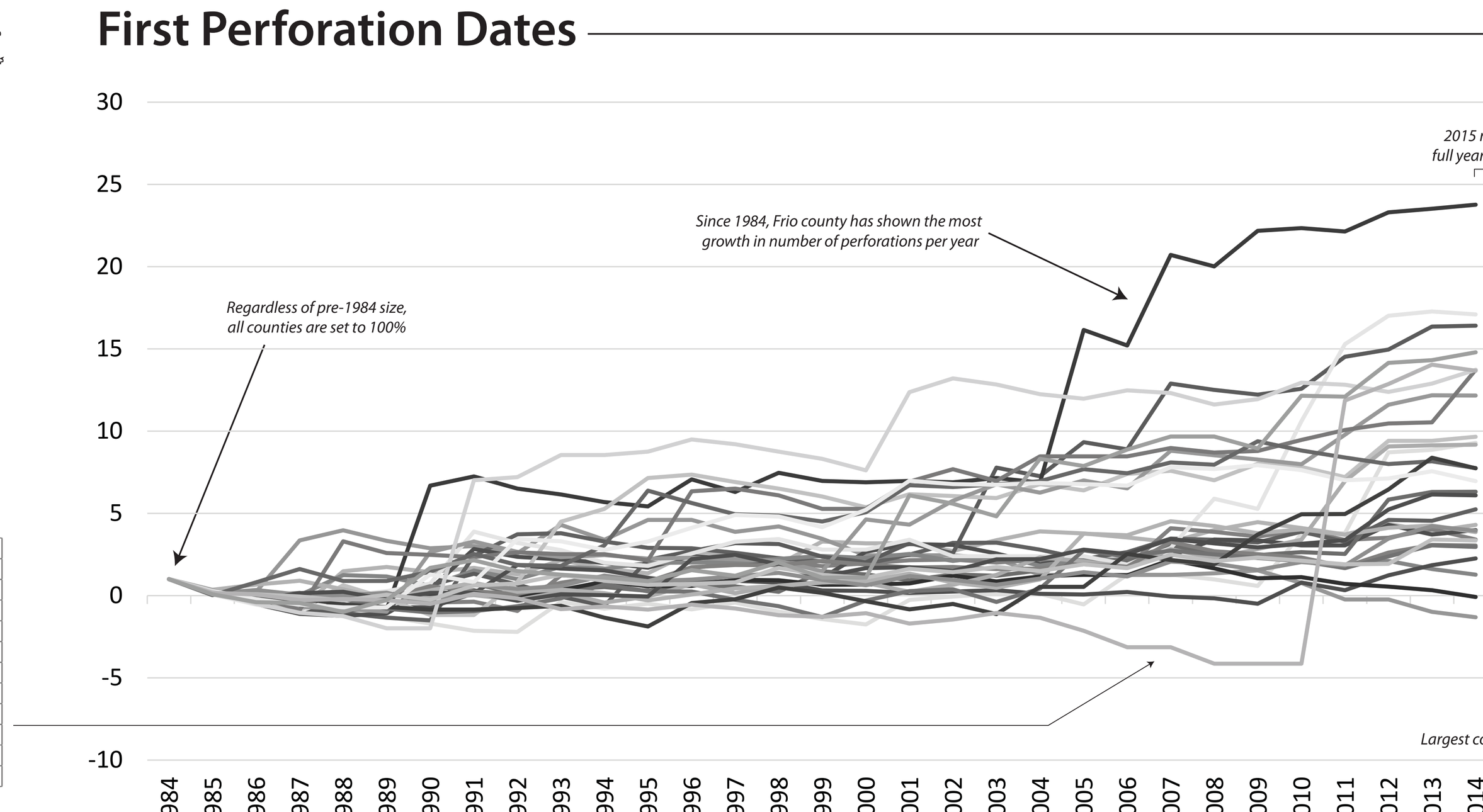
Without Box-Cox, kurtosis is 125 and skew is 9
With Box-Cox applied, kurtosis is -0.90 and skew is 0.14



2004	5
2005	1
2006	0
2007	4
2008	0
2009	0
2010	1
2011	17
2012	34
2013	74
2014	47
2015	8

Wilson dropped for a decade+, stayed low for a long time, but all of a sudden has increased significantly

First Perforation Dates



Totals by County

Atascosa	3048
Austin	846
Bastrop	714
Bee	2283
Brazos	2197
Burleson	3031
Colorado	2540
De Witt	2330
Dimmit	4036
Fayette	2243
Frio	2651
Goliad	3055
Gonzales	1948
Grimes	574
Karnes	2788
La Salle	3582
Lavaca	3137
Lee	2088
Leon	2129
Live Oak	2978
Madison	993
Maverick	1863
Mcmullen	3943
Milam	2888
Robertson	1782
Washington	674
Webb	10605
Wilson	1462
Zavala	1641

Count of wells rating very low confidence

Devon Energy Production Co, L.P.	331
Apache Corporation	182
Endeavor Energy Resources L.P.	82
Enervest Operating, L.L.C.	77
ConocoPhillips Company	71
XTO Energy Inc.	66
Basa Resources, Inc.	60
Samson Lone Star, LLC	60
Anadarko E&P Onshore LLC	59

These need to be compared to total wells with targeted depths

One operator can be on both lists - this needs further analysis as this only looks at extreme behavior

Operators with confidence in well perforations

Count of wells rating very high confidence

XTO Energy Inc.	590
Hilcorp Energy Company	512
Denbury Onshore, LLC	456
Kinder Morgan Production Co LLC	334
Basa Resources, Inc.	300
Exxon Corp.	261
Apache Corporation	247
Occidental Permian Ltd.	226
Breitburn Operating L.P.	182
Chevron U. S. A. Inc.	175
Texas Petroleum Investment Co.	154
Merit Energy Company	138
Devon Energy Production Co, L.P.	133
Lewis Petro Properties, Inc.	130
ConocoPhillips Company	121
EOG Resources, Inc.	106
Anadarko E&P Onshore LLC	103

Perforation interval counts by county

	Sum of perforation_intervals	*Average per well*
Atascosa	6,109	2.03
Austin	2,094	2.87
Bastrop	1,343	1.89
Bee	3,683	1.86
Brazos	4,100	2.37
Burleson	5,120	1.92
Colorado	4,517	2.67
De Witt	3,955	1.94
Dimmit	7,030	1.90
Fayette	3,486	1.84
Frio	3,837	1.54
Goliad	5,127	2.01
Gonzales	2,850	1.52
Grimes	971	2.03
Karnes	5,333	2.07
La Salle	6,345	1.97
Lavaca	4,795	2.11
Lee	3,356	1.96
Leon	5,218	3.02
Live Oak	4,974	2.01
Madison	1,998	2.46
Maverick	3,193	1.77
Mcmullen	7,184	1.99
Milam	3,758	1.33
Robertson	3,668	2.55
Washington	1,090	2.07
Webb	22,625	2.43
Wilson	2,442	1.72
Zavala	2,440	1.63

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