Oil-Prone Shale Plays:
The Illusion of Energy Independence

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Houston SIPES Continuing Education Seminar
Halliburton Conference Theater
October 19, 2012

Shale Magical Thinking

"I know not any thing more pleasant, or more instructive, than to compare experience with expectation, or to register from time to time the difference between idea and reality. It is by this kind of observation that we grow daily less liable to be disappointed."
--Samuel Johnson: Letter to Bennet Langton

What few people realize:

- While oil production has increased, the U.S. is not going to become energy independent.
- Resources are not reserves, and reserves are not supply.
- Shale oil wells have high decline rates and require substantial capital expenditure to keep production flat much less increasing.
- Oil production from the Eagle Ford and Bakken shales will probably increase U.S. supply by 1-2 million barrels per day by 2020 depending on oil price.

The Good News Propaganda Campaign About Oil

THE WALL STREET JOURNAL.
WSJ.com

OPINION | March 19, 2012, 7:24 p.m. ET

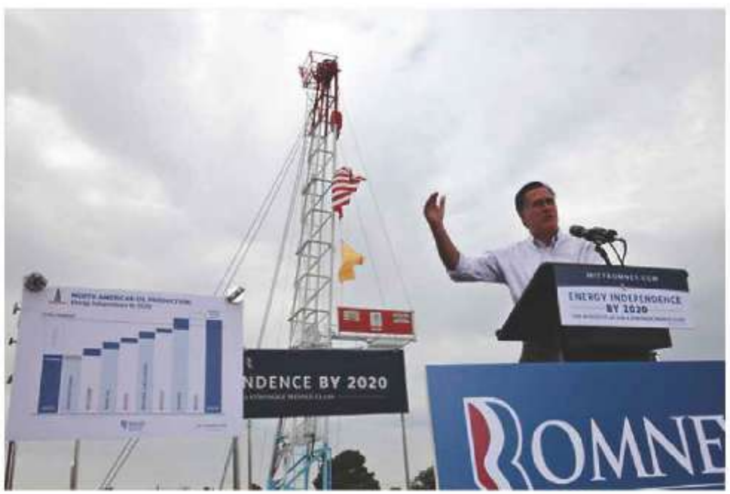
Move Over, OPEC—Here We Come

In energy, North America is becoming the new Middle East. The only thing that can stop it is domestic politics.

Bloomberg

Americans Gaining Energy Independence With U.S. as Top Producer

Romney Unveils Plan for Energy Independence



September 13, 2012, 2:53 p.m. ET
THE JOURNAL REPORT: INVESTING IN ENERGY

Making Sense of the U.S. Oil Boom

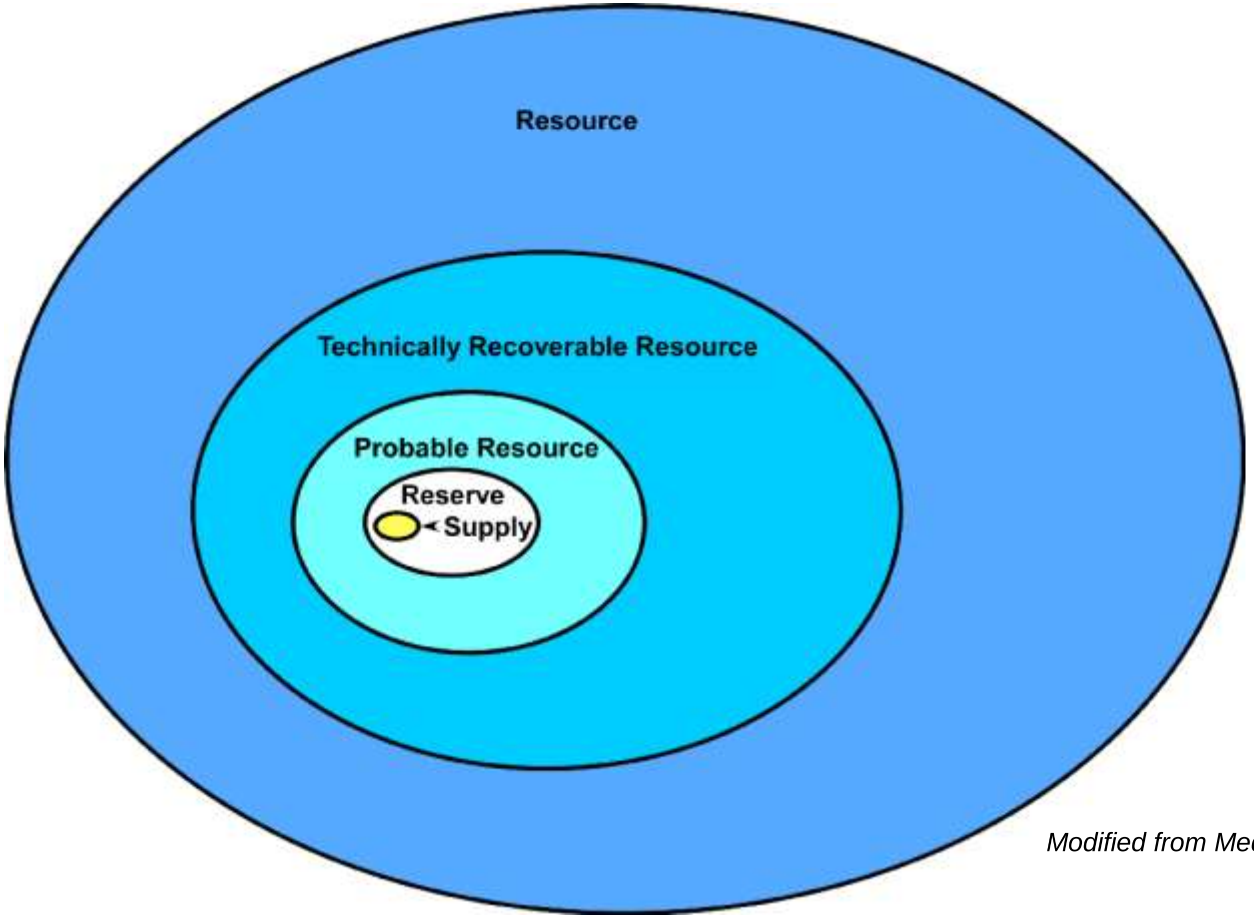
Daniel Yergin talks about where it's coming from and what it will mean for the U.S.—and the world

Article | Comments (42)

By ÁNGEL GONZÁLEZ

Associated Press

Resources ≠ Reserves ≠ Supply

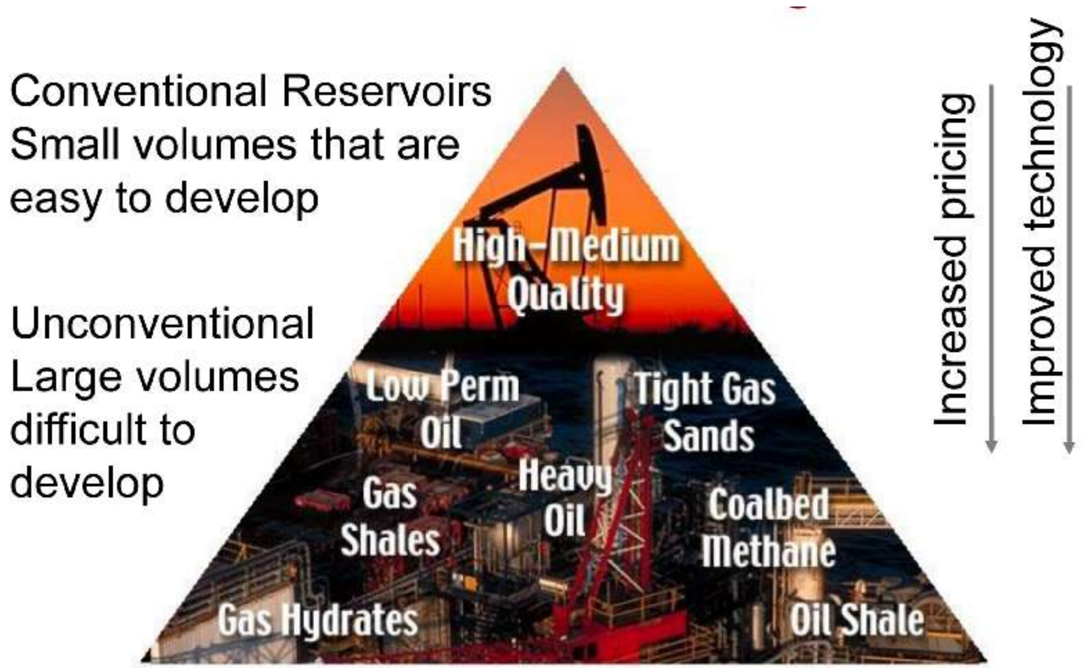


Modified from Medlock (2010)

- Reserves are a very small sub-set of resources.
- Reserves take years of development drilling to become supply.
- Proved undeveloped reserves may never be developed.

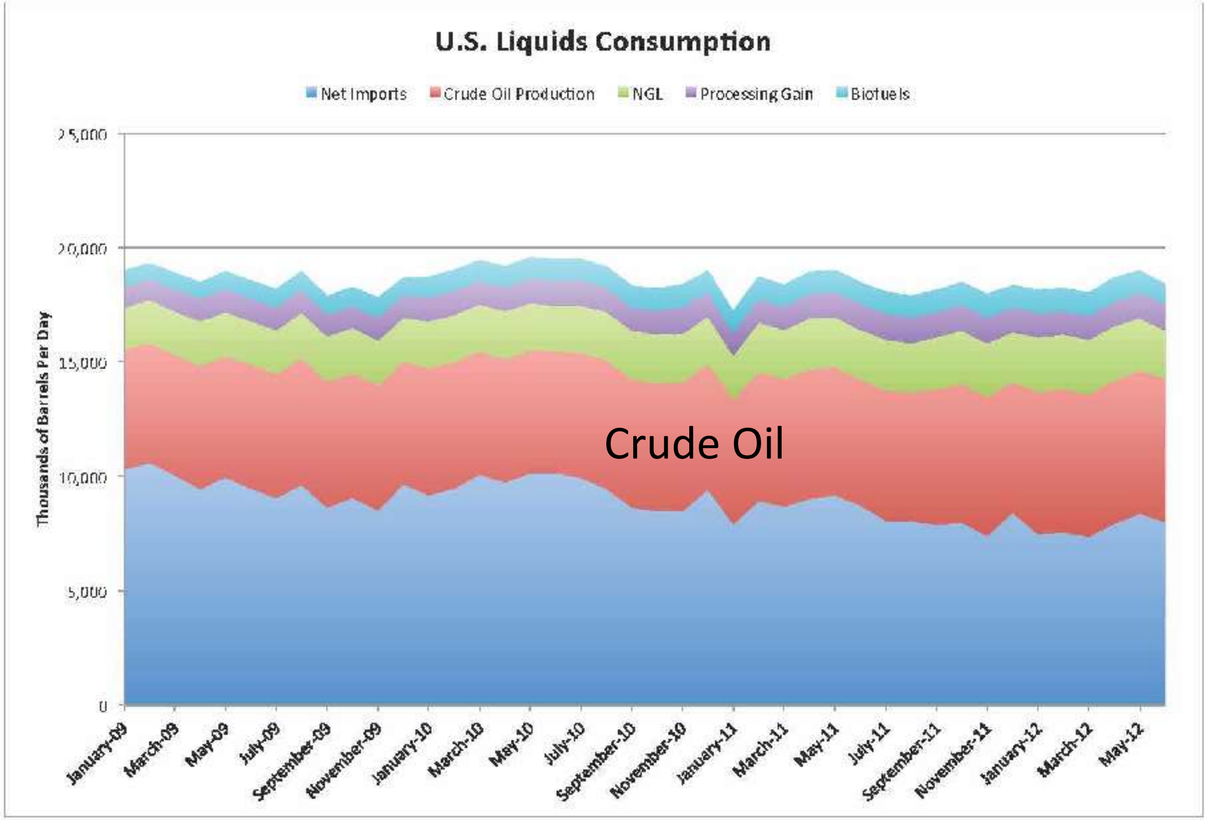
A view from the bottom of the resource pyramid

• Unconventional plays became important as better plays were exhausted.
• There is no technological revolution, just improvement through extensive & expensive trial-and-error.
• Shale reservoirs will not perform as well as conventional reservoirs.
• Economics depend on high oil prices.
• And the drilling treadmill never ends because of high decline rates.
• Demand destruction will limit oil price and, therefore, the long end of the unconventional production curve.



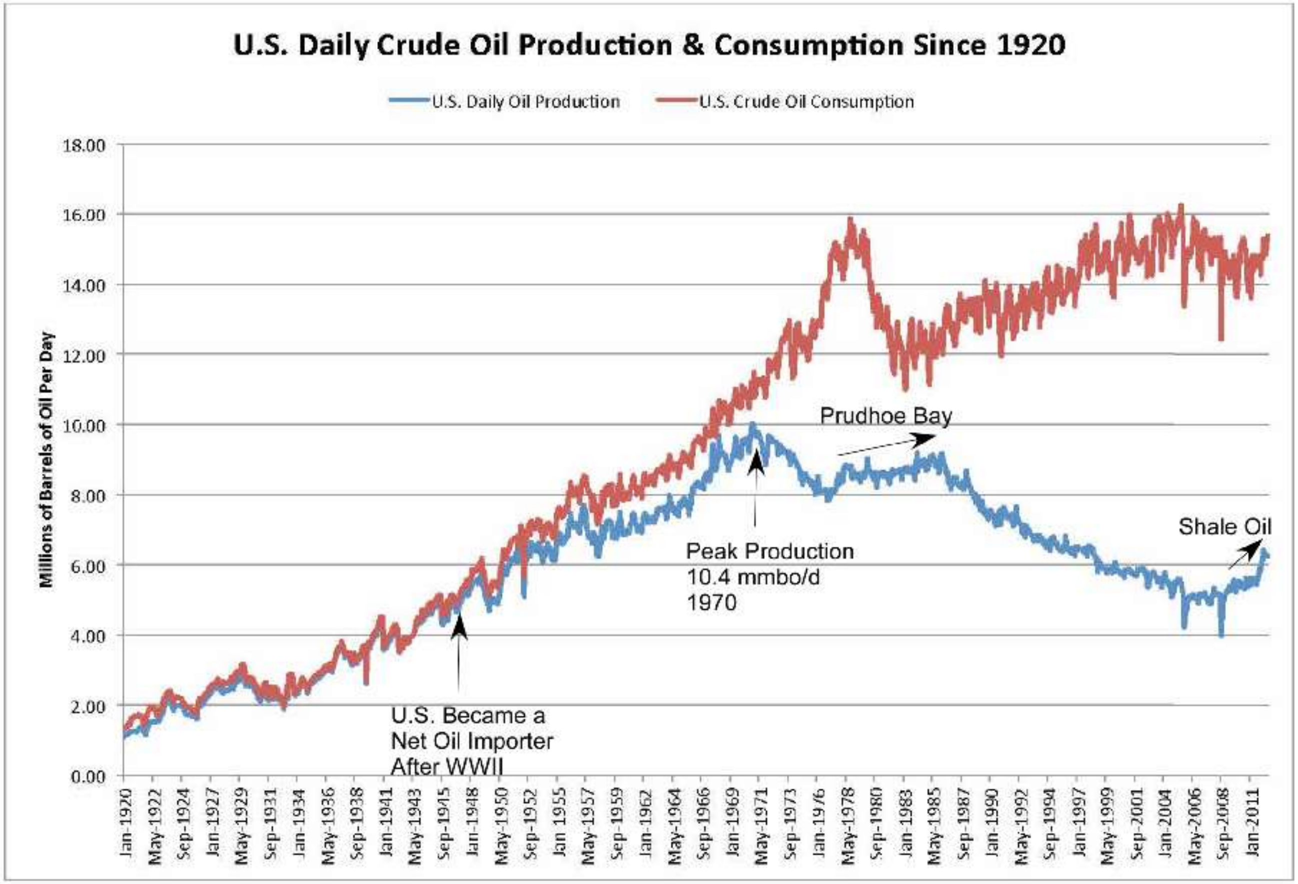
From Holdich (2011)

Oil vs. Liquids



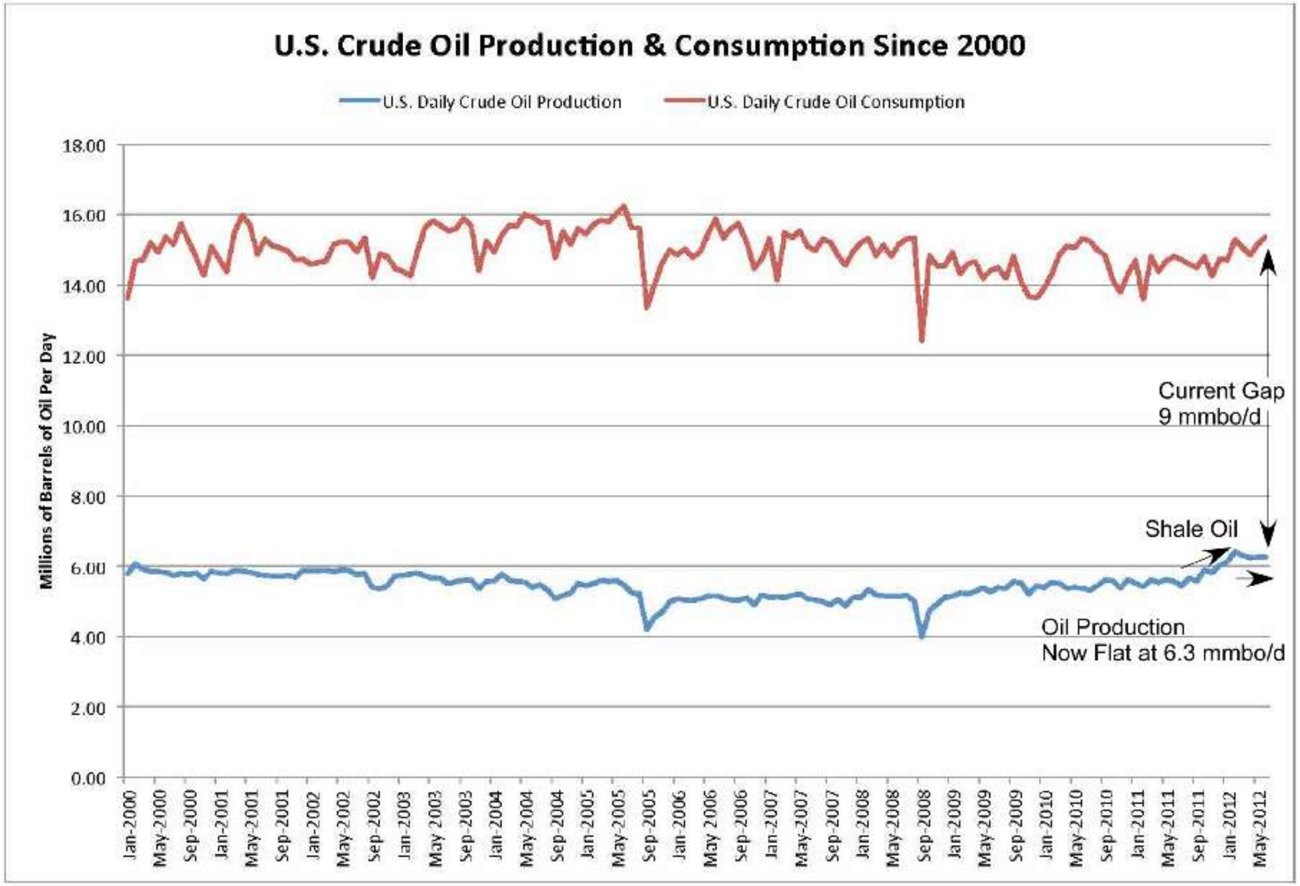
- Crude oil, petroleum products & petroleum liquids are commonly grouped together.
- They are not the same.
- Natural gas liquids have lower heat content than oil, and are not used for transport. NGLs must be distilled from natural gas.
- Refinery processing gain results from refining crude oil into products with lower specific gravity.
- Biofuels are not made from petroleum & have lower heat content.

U.S. Oil Production



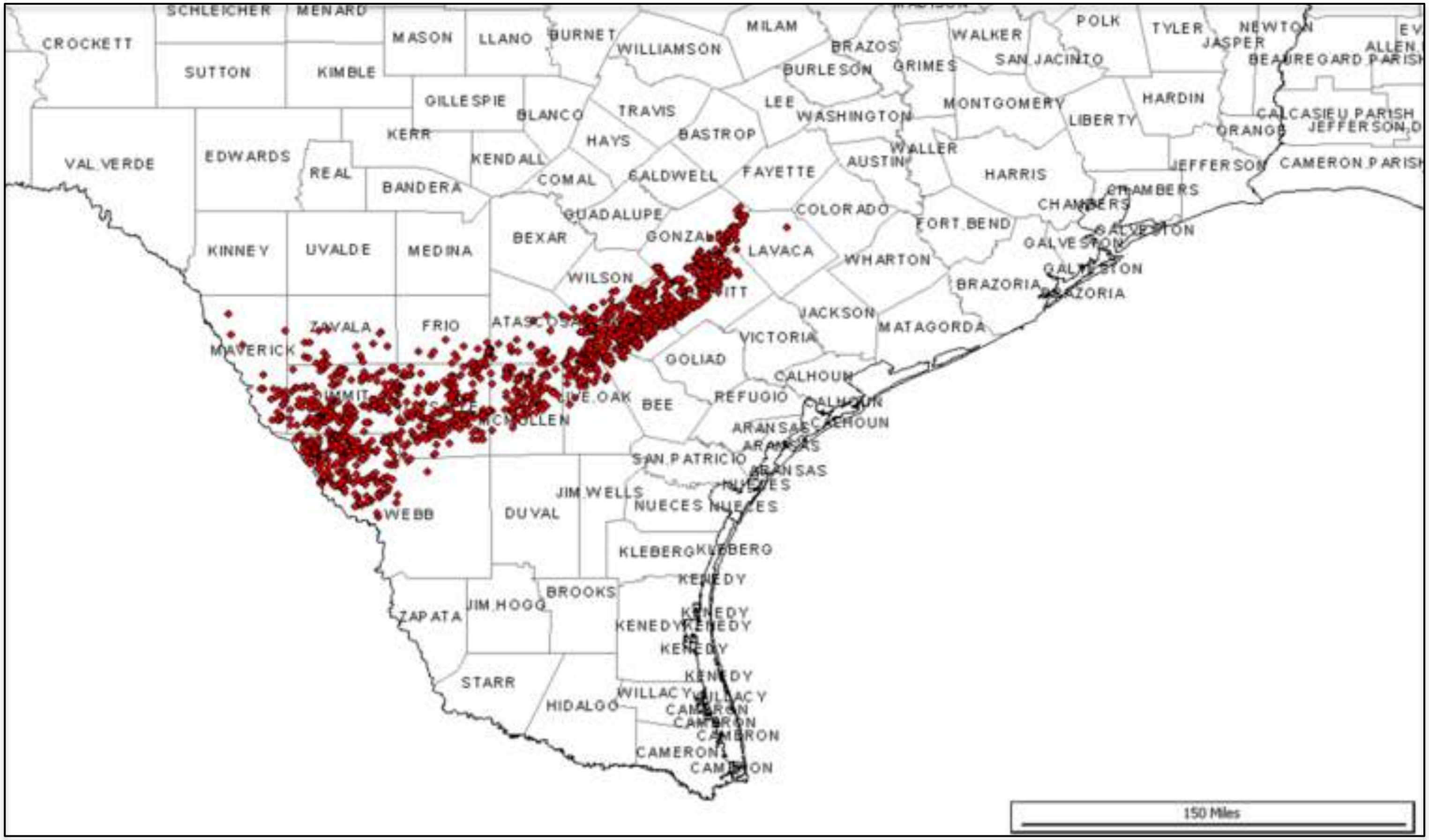
- The U.S. has been a net oil importing country since WWII.
- Crude oil production in the U.S. peaked in 1970 at 10 MMbo/day.
- Prudhoe Bay—the largest oil field in the U.S. (12.8 Mmbo to date)—reversed decline for 9 years.
- Shale oil has reversed decline for 18 months.

U.S. Oil Production



- U.S. oil production is now flat at 6.3 mmbo/day.
- U.S. crude oil consumption is 15.4 mmbo/day.
- The gap between production and consumption is 9 mmbo/day.
- It is unlikely that the U.S. will become energy independent.

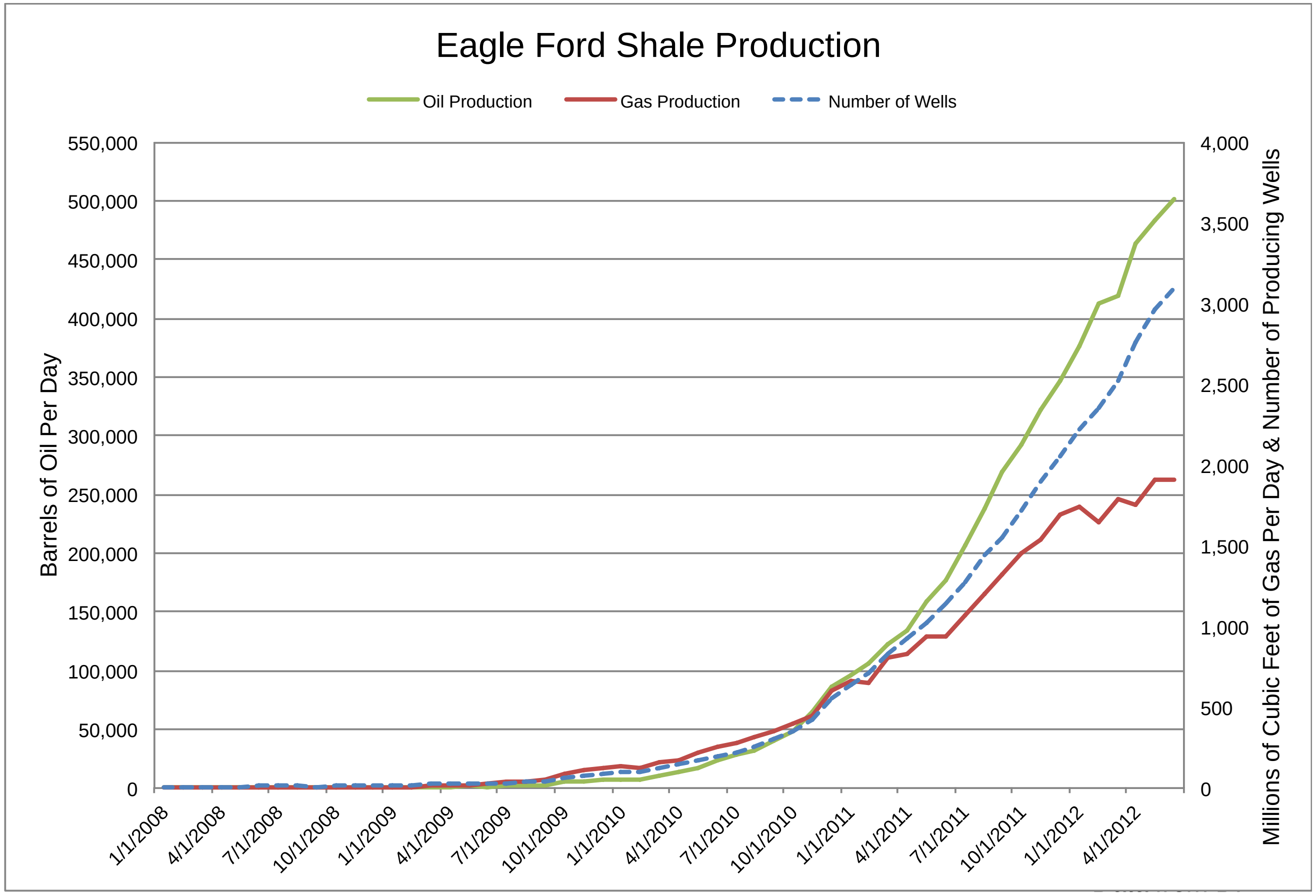
Eagle Ford Shale Location Map



Data from DI

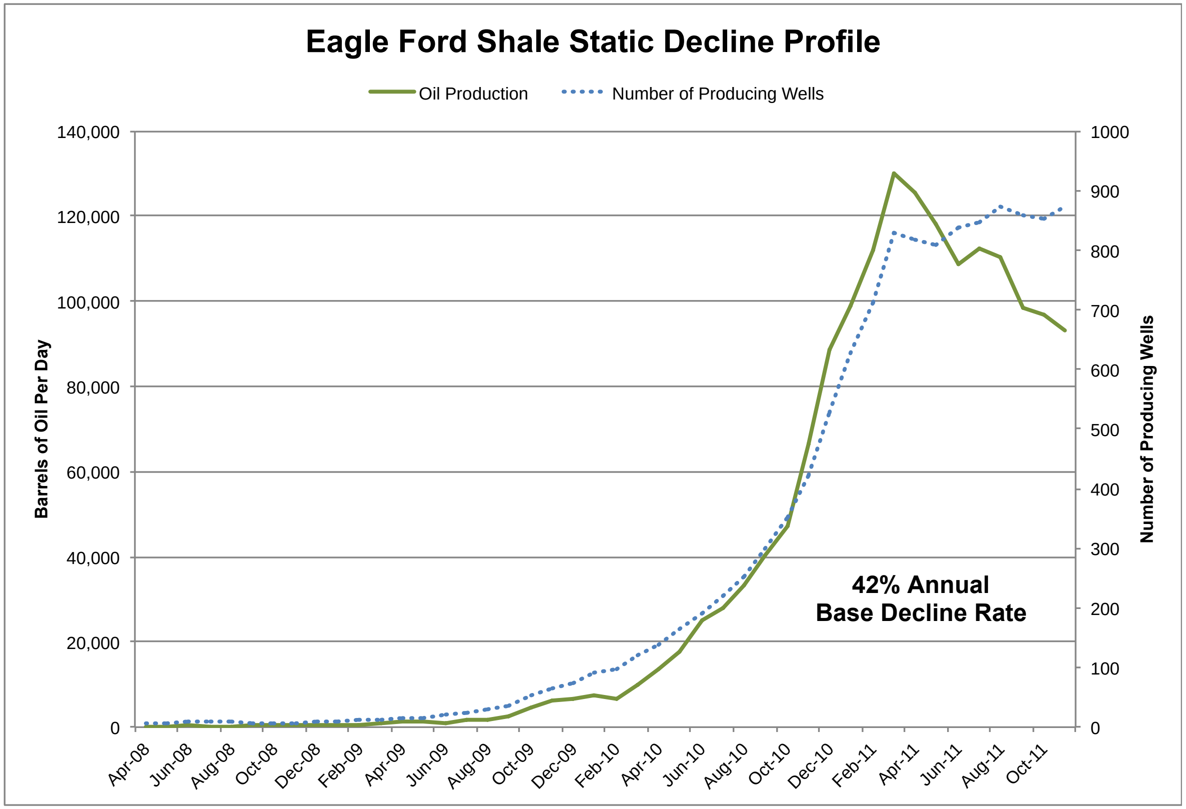
- 240 rigs drilling in the Eagle Ford.
- Highest rig count of any play in the U.S.

Eagle Ford Shale Production



- Since the play began in 2008, oil production has increased to 502,000 barrels of oil per day and 1.9 bcfg/d.
- More than 3,092 producing wells.
- Average well is 160 barrels of oil per day & 0.6 mmcf gas per day. Well cost is $10 million.

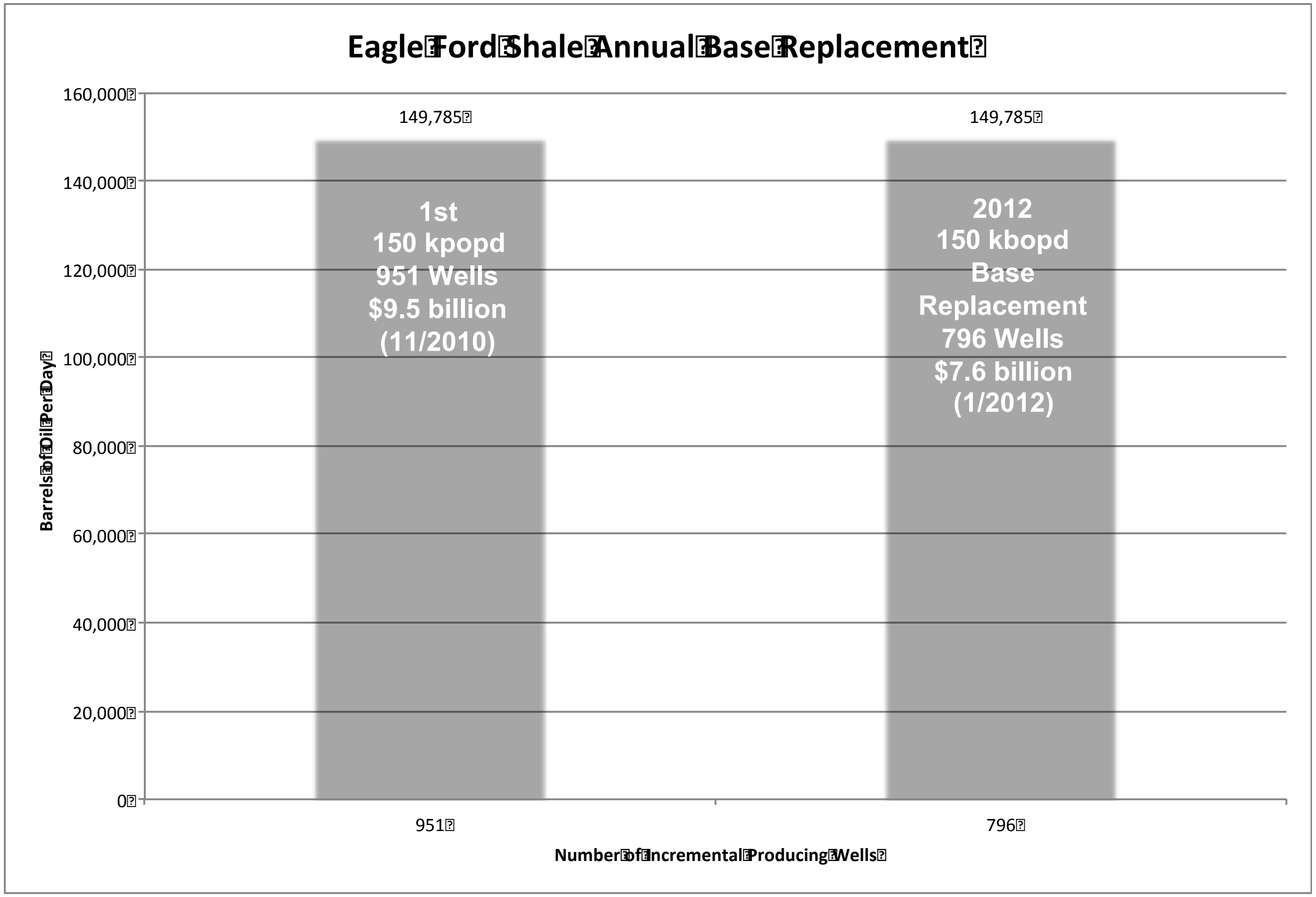
Eagle Ford Shale Annual Base Replacement



Data from DI

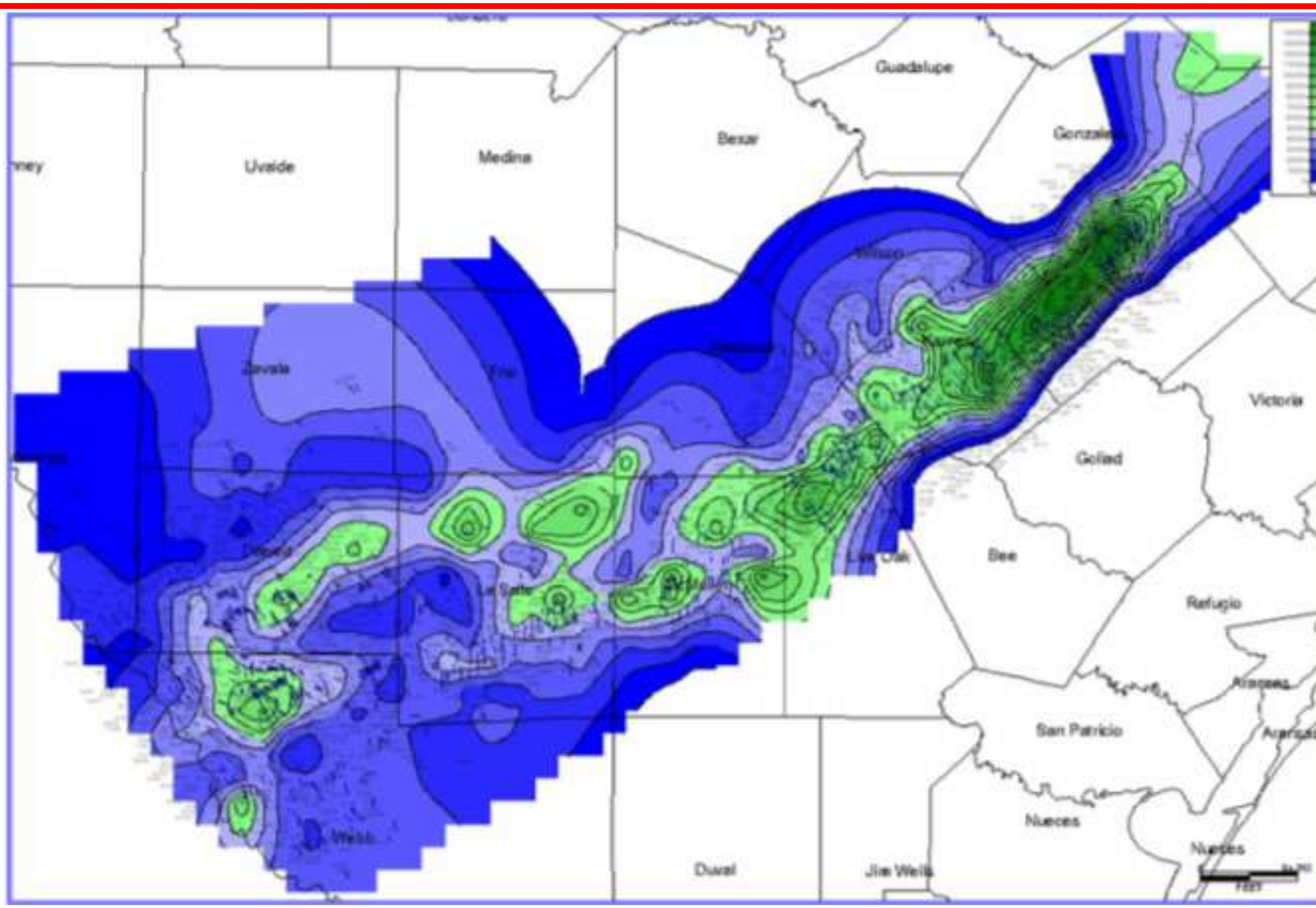
- 42% annual decline rate.
- Must replace 150,000 bo/d each year to maintain supply.
- That means approximately 800 new producing wells/year at a cost of ~ $8 billion.
- 1274 wells began production in the past 12 months ($13 billion).

Eagle Ford Shale Annual Base Replacement



- Fewer wells required today to replace same volume as in 2010—finding the sweet spots.
- Operators are becoming more efficient.
- More wells will be needed to replace volumes in the future when production is higher and the better prospects have already been drilled.

Eagle Ford Shale 6-month Cumulative Production Map



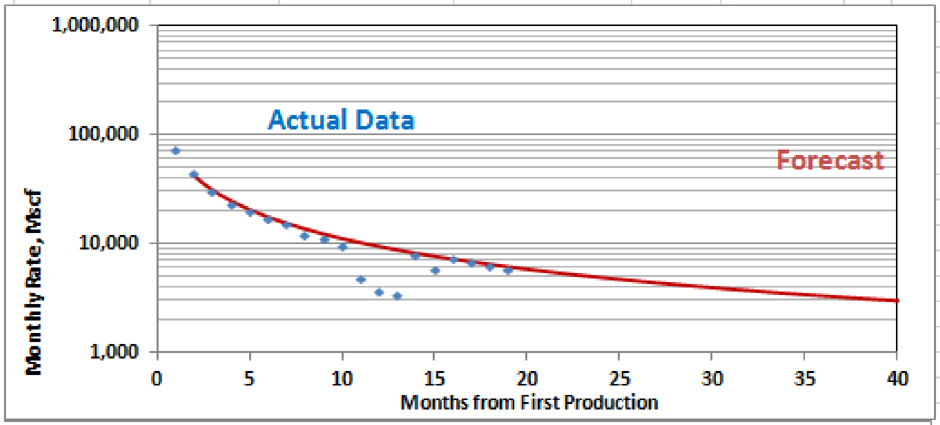
- Green areas indicate break-even or greater production volumes
- Indicates that production is from discreet fields that follow similar trends as fields from younger reservoirs.

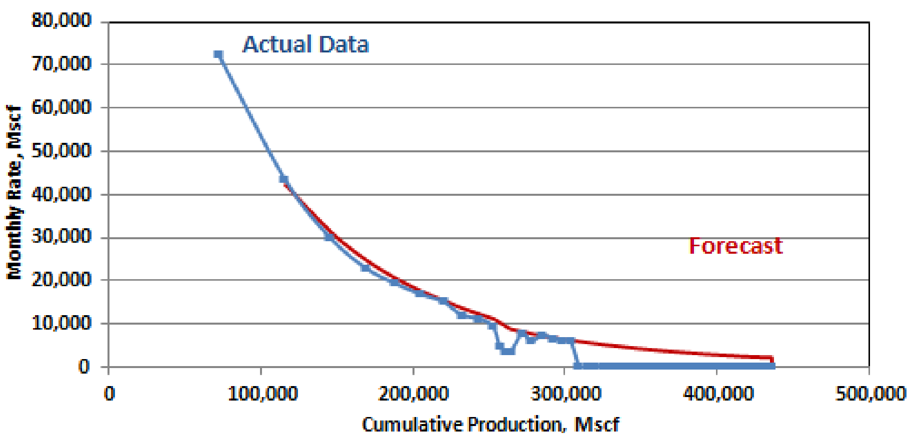
Decline Curve Analysis: Karnes County, High b-exponent Oil Example

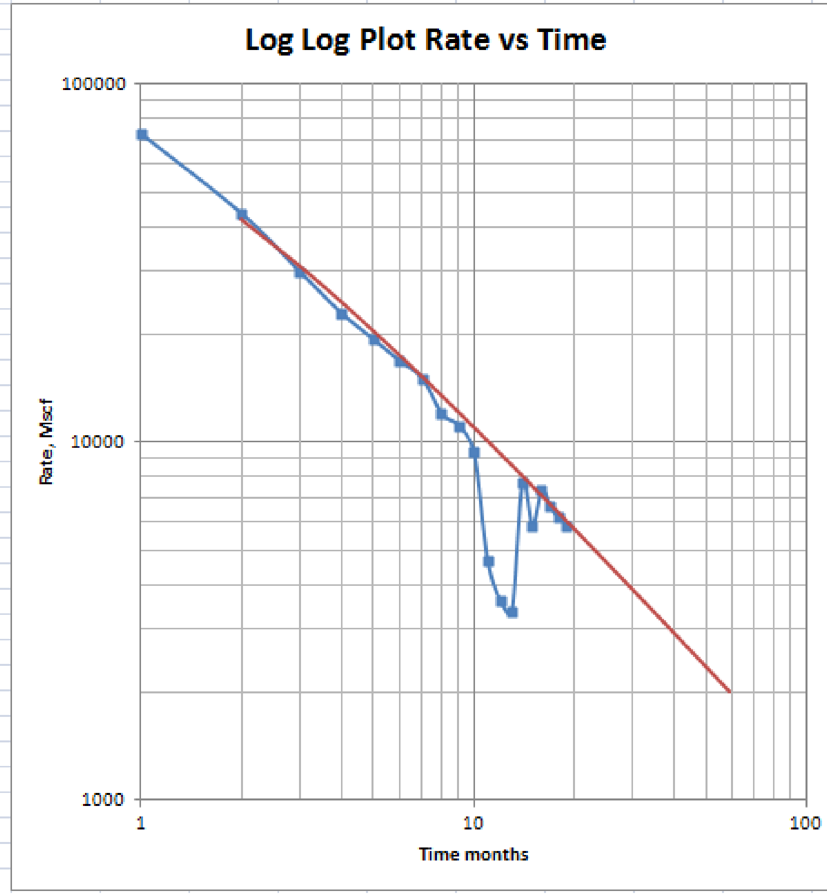
GUS TIPS GAS UNIT 1

Di = 6.50 b exponent = 1

No Terminal Decline	Mscf	Terminal Decline Rate =	15%
Remaining Reserve =	132,426	Remaining Reserve =	132,426
Cumulative Production =	303,744	Cumulative Production =	303,744
EUR =	436,170	EUR =	436,170





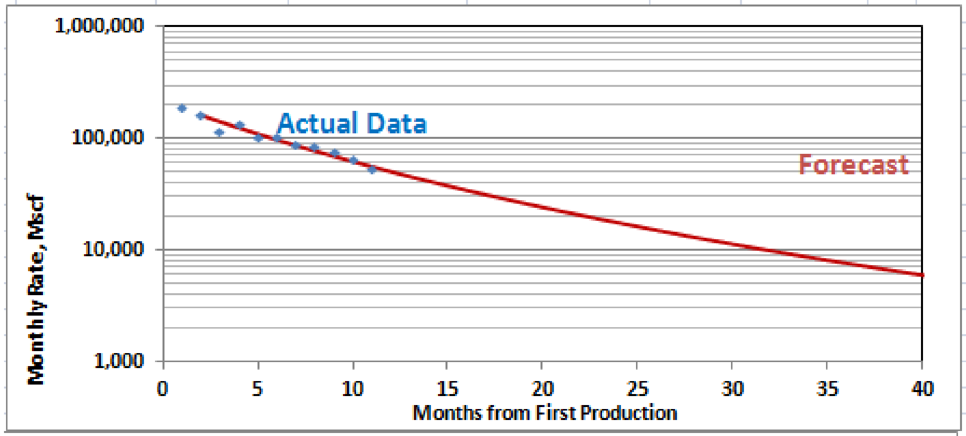


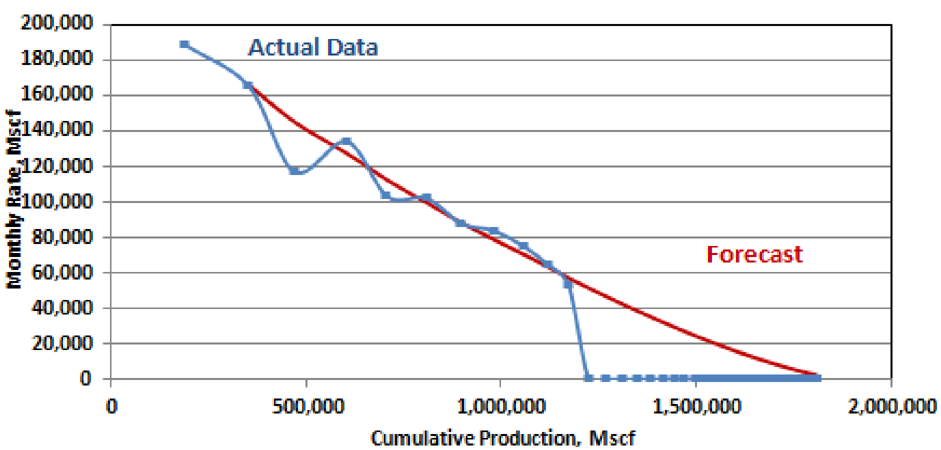
Decline Curve Analysis: Karnes County, Low b-exponent Oil Example

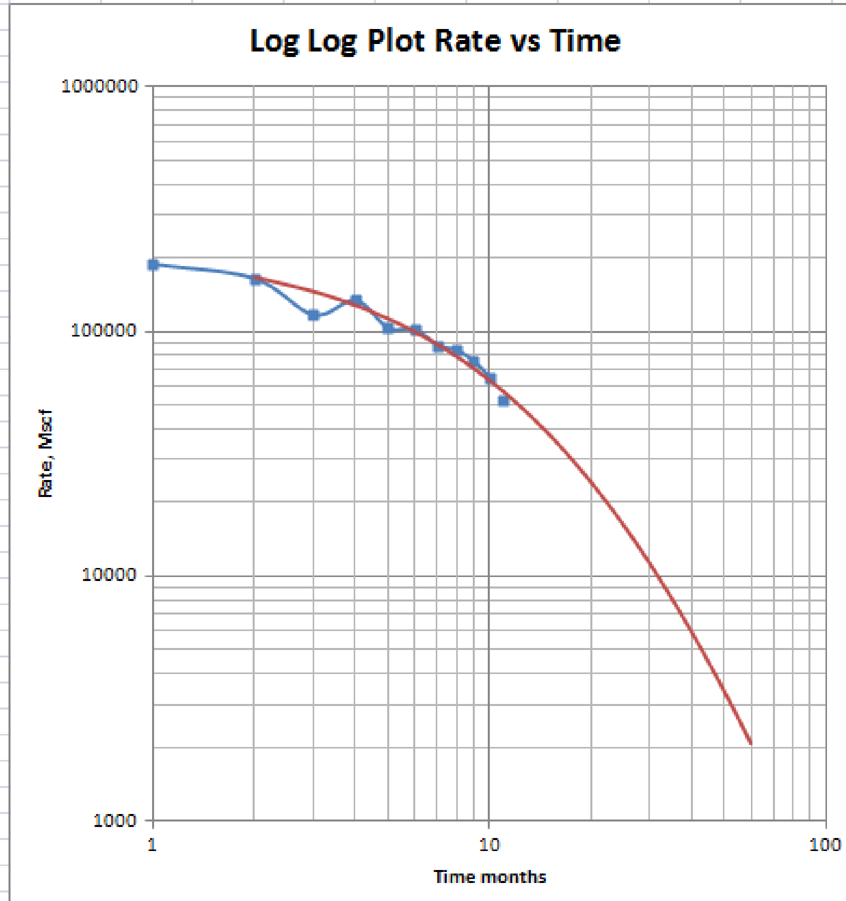
HAVEMAN 01

Di = 1.70 | b exponent = 0.25

No Terminal Decline	Mscf	Terminal Decline Rate =	15%
Remaining Reserve =	634,759	Remaining Reserve =	634,759
Cumulative Production =	1,174,103	Cumulative Production =	1,174,103
EUR =	1,808,862	EUR =	1,808,862





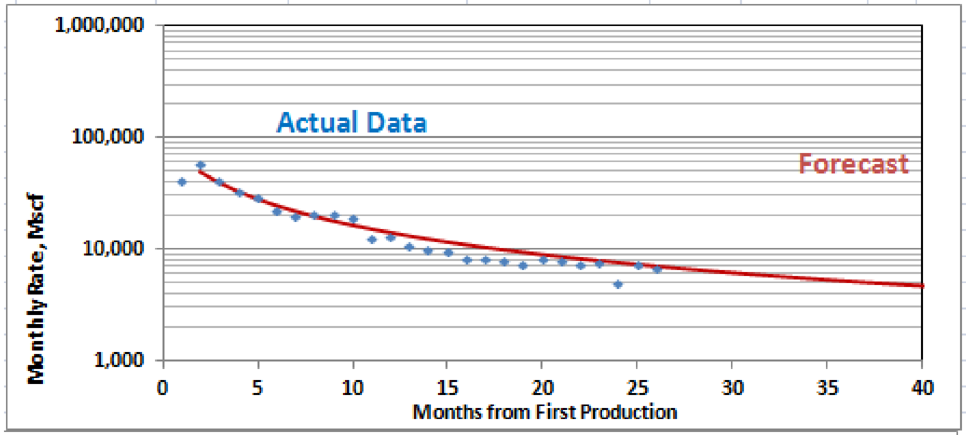


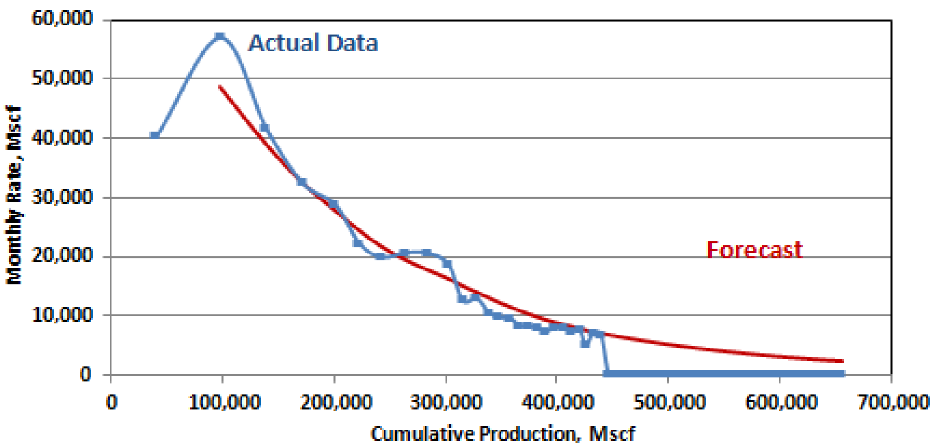
Decline Curve Analysis: La Salle County, High b-exponent Gas Example

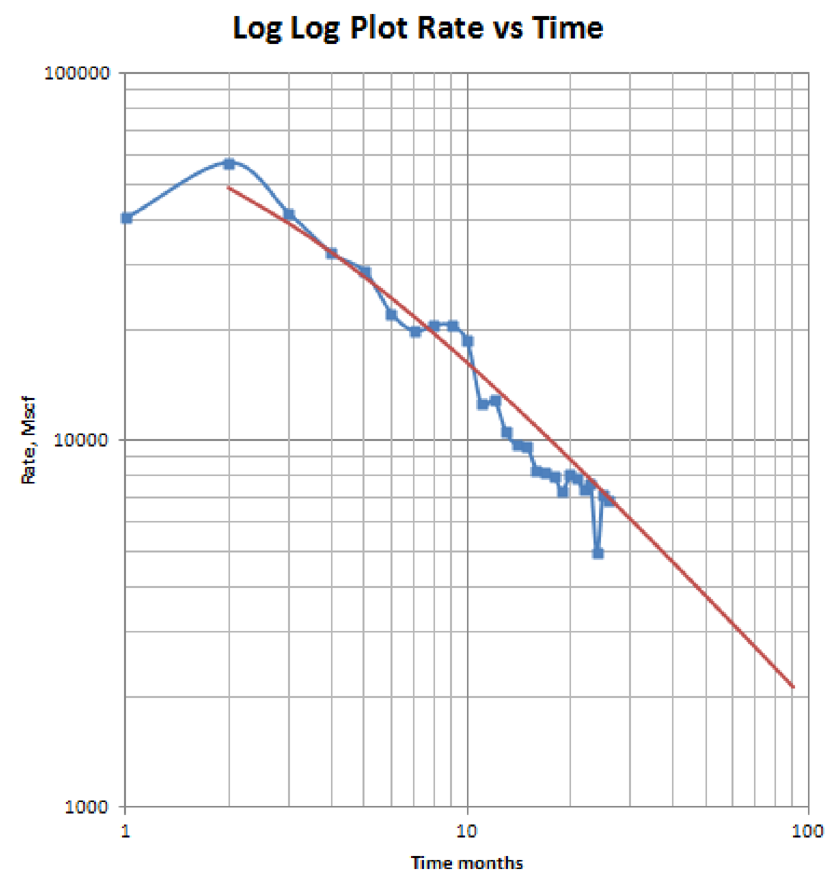
EVANS H 1

Di = 4.00 b exponent = 1

No Terminal Decline	Mscf	Terminal Decline Rate =	10%
Remaining Reserve =	241,821	Remaining Reserve =	241,821
Cumulative Production =	439,239	Cumulative Production =	439,239
EUR =	681,060	EUR =	681,060







Eagle Ford Shale Summary

Eagle Ford Decline Curve Analysis, May, 2012

Summary of Mean Values

County (E-W)	EUR Gas, MMscf	EUR Oil, MBO	EUR Economic Equiv MBOE	GOR, scf/bbl	6-Month Cum, MBOE	EUR/6 Mo Cum Ratio	Avg Max Rate, Mscfd	# Wells in DCA
Dewitt	1,526	277	405	5,666	121	3.4	4,000	30
Karnes	929	176	254	6,093	77	3.3	3,400	32
McMullen	1,189	77	176	15,401	50	3.6	3,300	18
LaSalle	2,690	48	224	56,800	49	4.6	5,500	21
Dimmit	1,046	160	248	6,800	39	6.3	1,400	23
Webb	2,340	74	227	32,469	37	6.1	3,400	27
Mean Value	1,620	135	256	20,538	62	4.6	3,500	Total = 151

Economic Equivalency Based On:

1) 11.9 Mscf = 1 boe assuming 120 bbl/MMscf NGL yield, 20% shrinkage, 50% NGL price discount to WTI, $100/bbl WTI, $3/MMBtu for Karnes, Dewitt, Dimmit and McMullen Counties

1) 15.3 Mscf = 1 boe assuming 80 bbl/MMscf NGL yield, 15% shrinkage, 50% NGL price discount to WTI, $100/bbl WTI, $3/MMBtu for Webb and La Salle counties

County	F&D, $/ Economic BOE	F&D, $/ Economic BOE
Dewitt	$19.26	$30.12
Karnes	$30.71	$48.03
McMullen	$44.32	$69.32
LaSalle	$34.82	$54.46
Dimmit	$31.45	$49.19
Webb	$34.36	$53.74

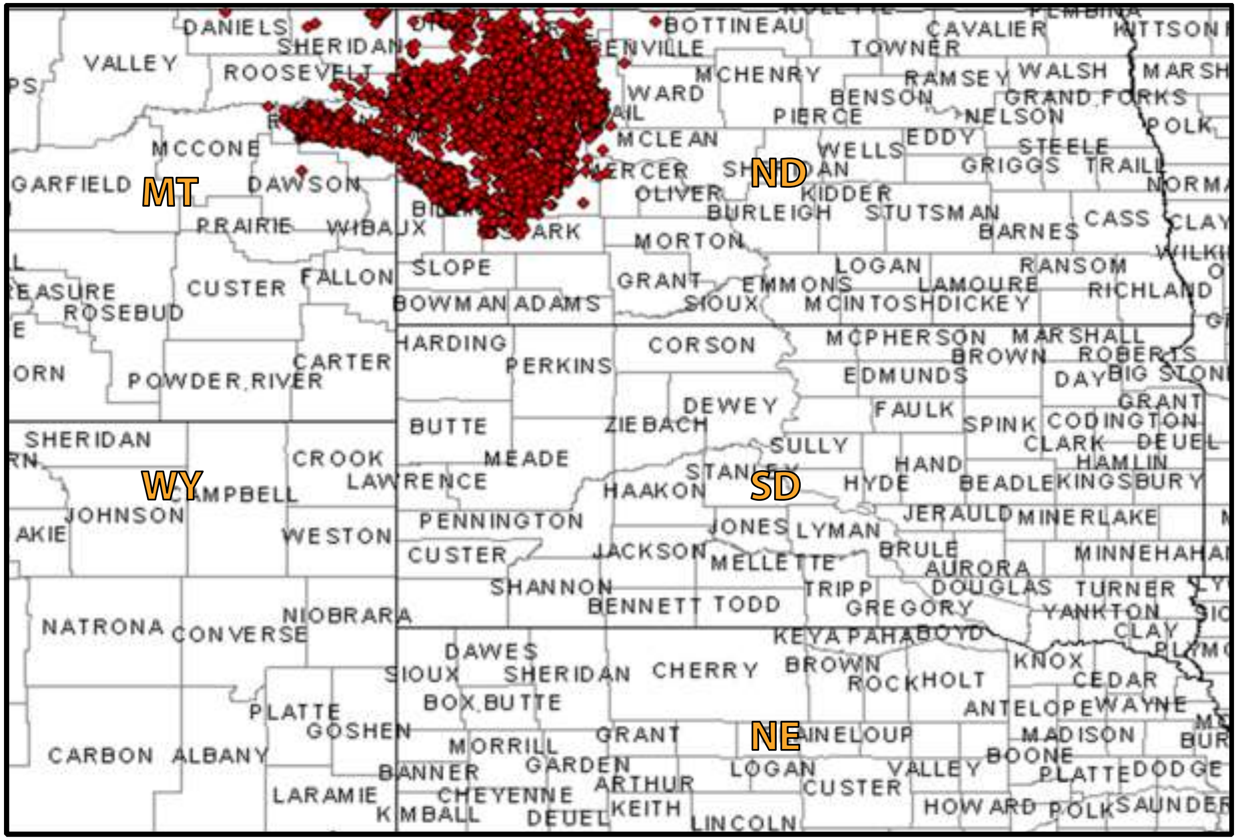
Assumptions:

D&C $MM	$7	$9
$/acre	5,000	10,000
acres/well	160	320

320 acre/well represents 1/2 acreage drilled

- Dewitt County outperforming others and wells are making money.
- At $7MM D&C cost plus $5 M/acre at 160 acres/well, most other counties are marginal to slightly profitable.
- At $9 MM D&C cost plus $10 M/acre at 320 acres/well, Dewitt is commercial but other counties are losing money.

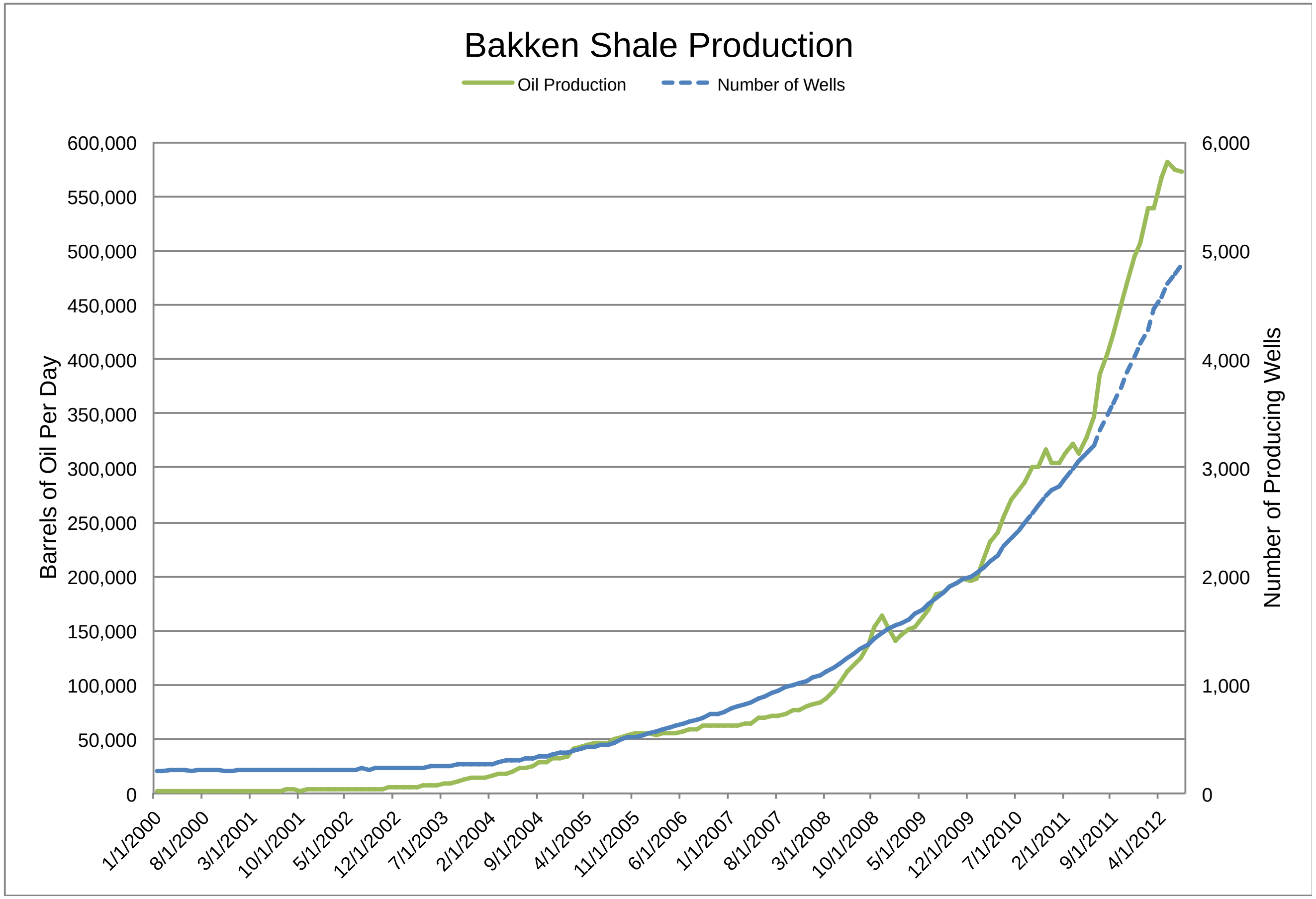
Bakken Shale Location Map



Data from DI

- 236 rigs drilling in the Bakken.
- Second highest rig count.

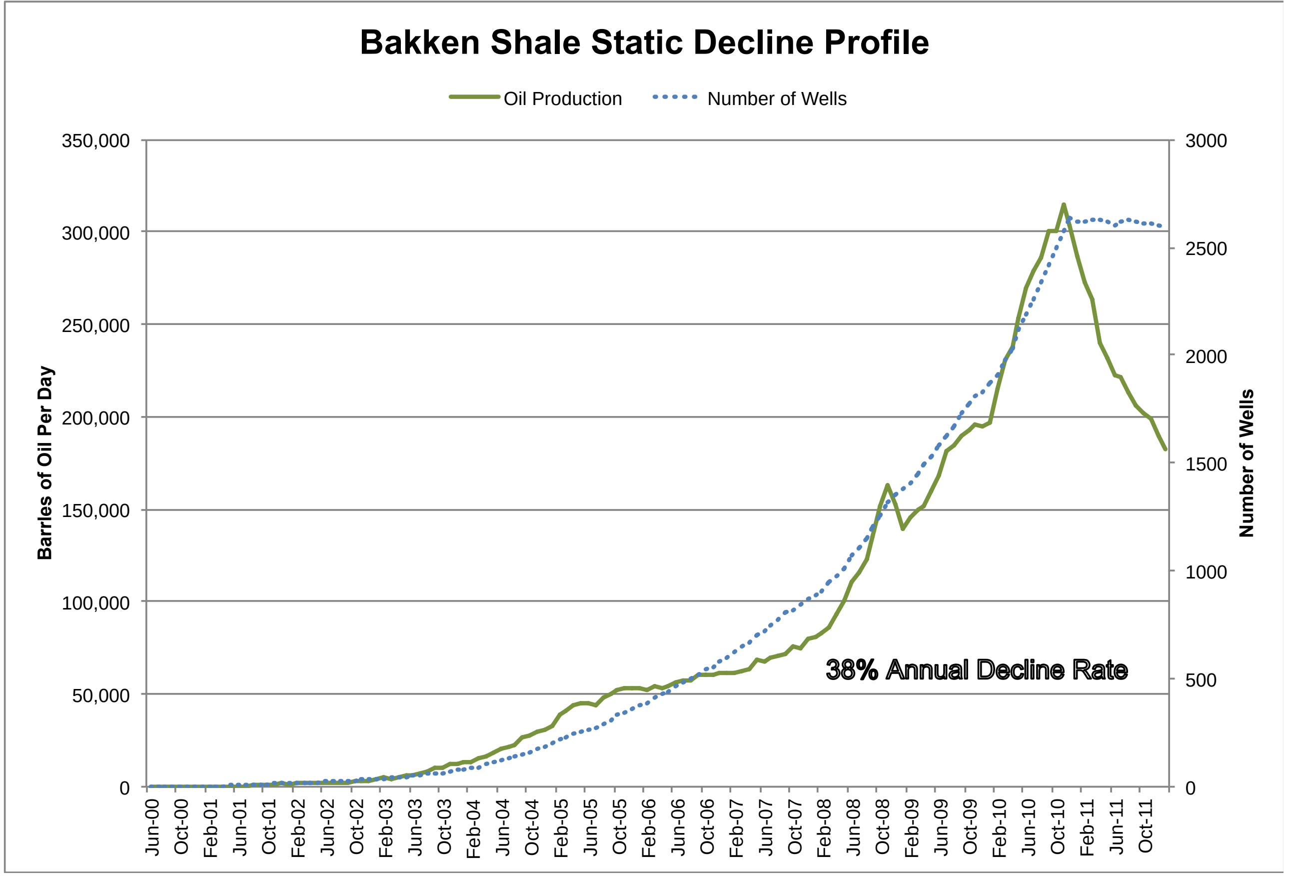
Bakken Shale Total Production



Data from DI

- Oil production has increased to 573,000 barrels per day from 4874 producing wells.
- Average well is 118 barrels of oil per day. Well cost is $11.5 million.

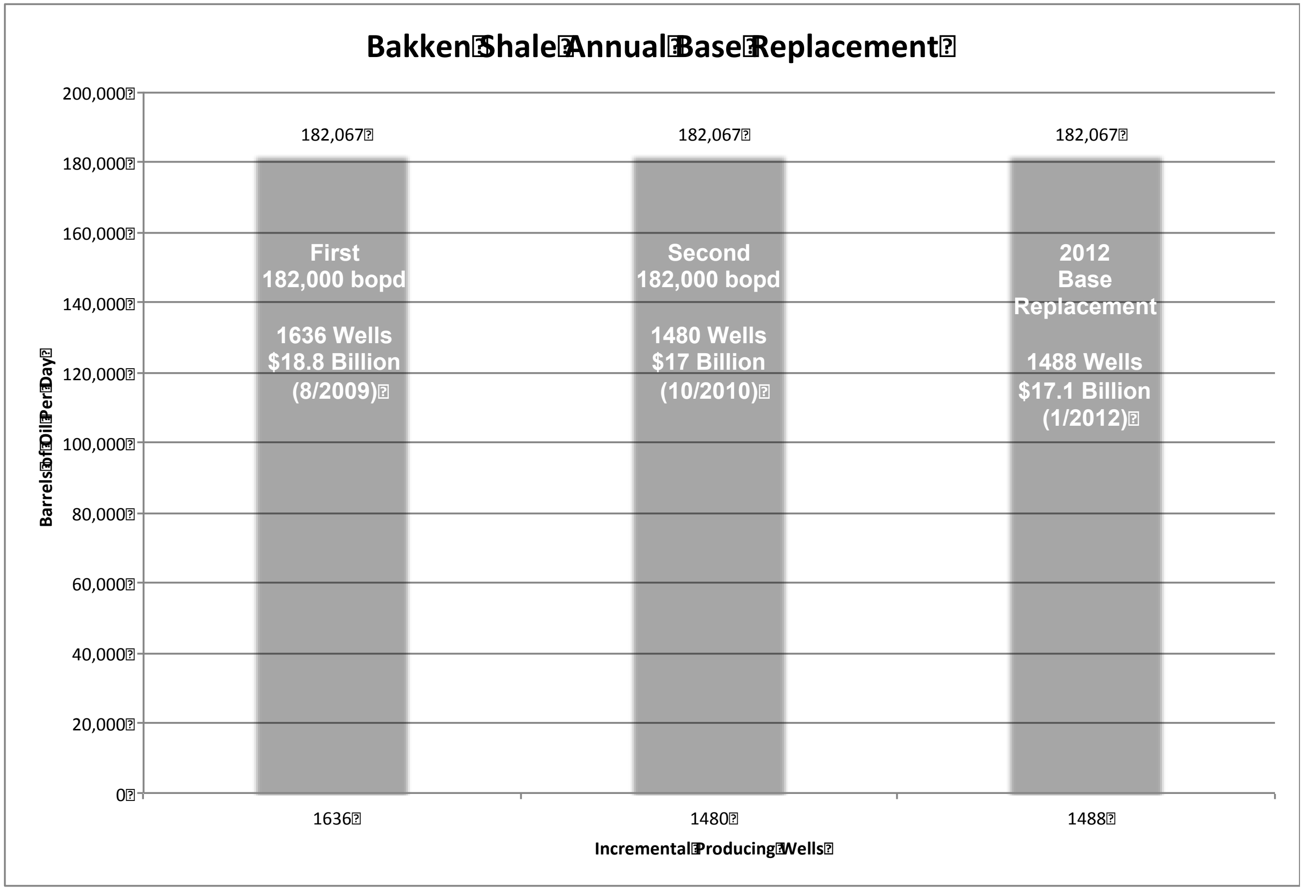
Bakken Shale Annual Base Replacement



Data from DI

- 38% annual decline rate.
- Must replace 182,000 bo/d each year to maintain supply.
- That means approximately 1,488 new producing wells/year at a cost of ~ $17 billion.
- 1130 new producing wells were added in last 12 months ($13 billion).

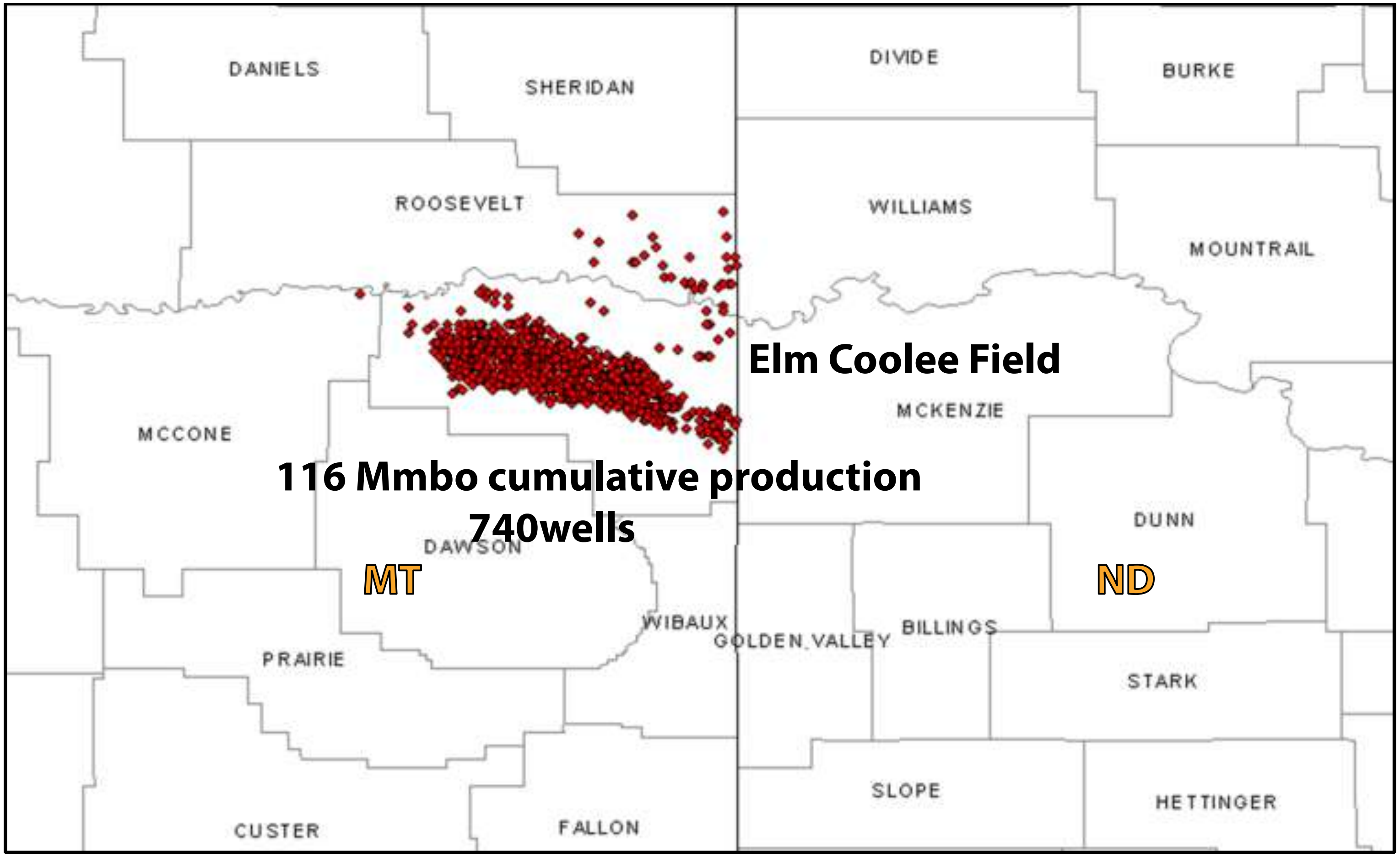
Bakken Shale Annual Base Replacement



Data from DI

- Fewer wells required today to replace same volume as in 2009.
- No improvement in efficiency between 2010 and 2011—same reasons as for the Eagle Ford Shale play.

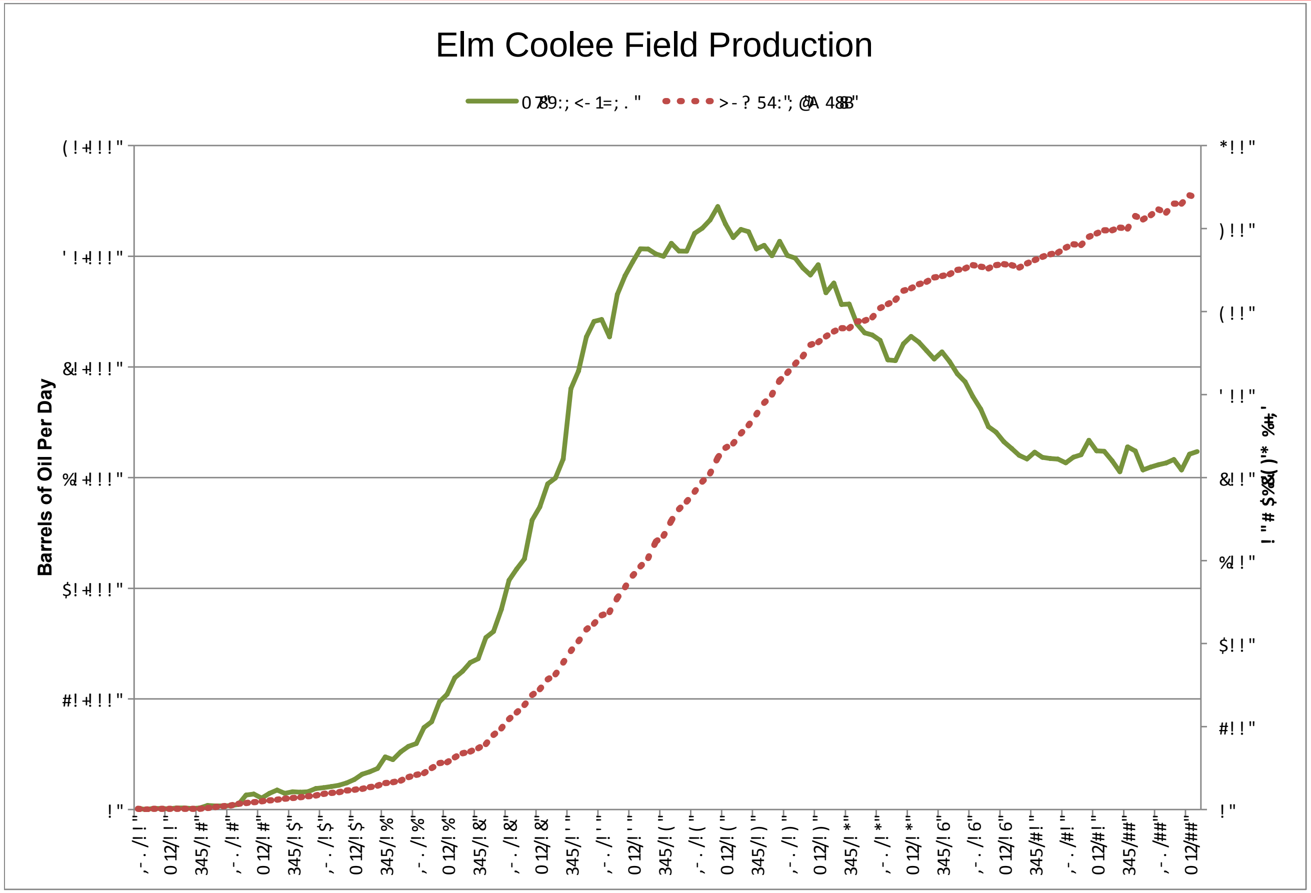
Bakken Shale Elm Coolee Field



Data from DI

- The field is in Montana.
- Discovered in 2000.
- The play is a dolomite within a tight carbonate shale.

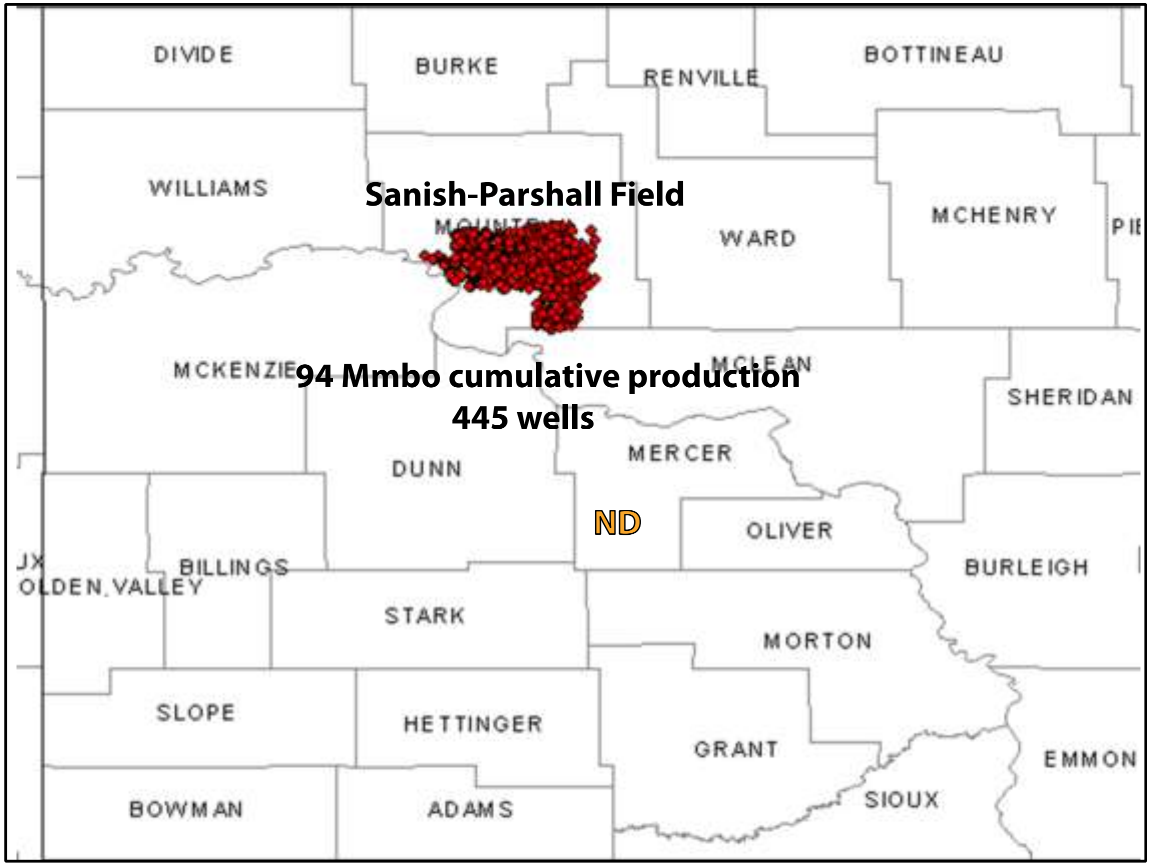
Elm Coolee Field Production



Data from DI

- The field began to decline after 5 years from first oil production.
- Drilling more wells has stabilized the decline rate for now.
- This is because newer wells benefit from newer technology that did not exist in the earlier drilling of the field.

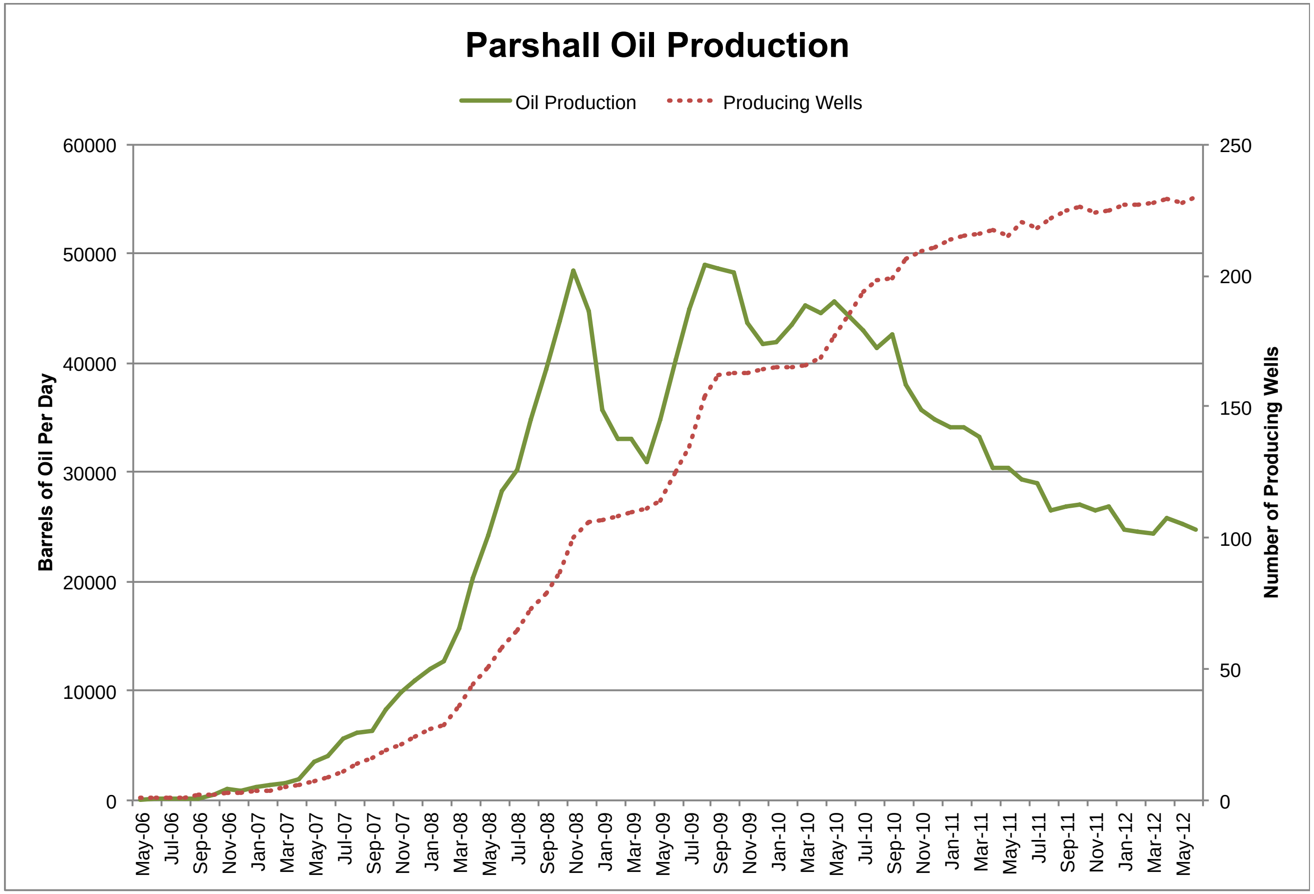
Sanish-Parshall Field Location Map



Data from DI

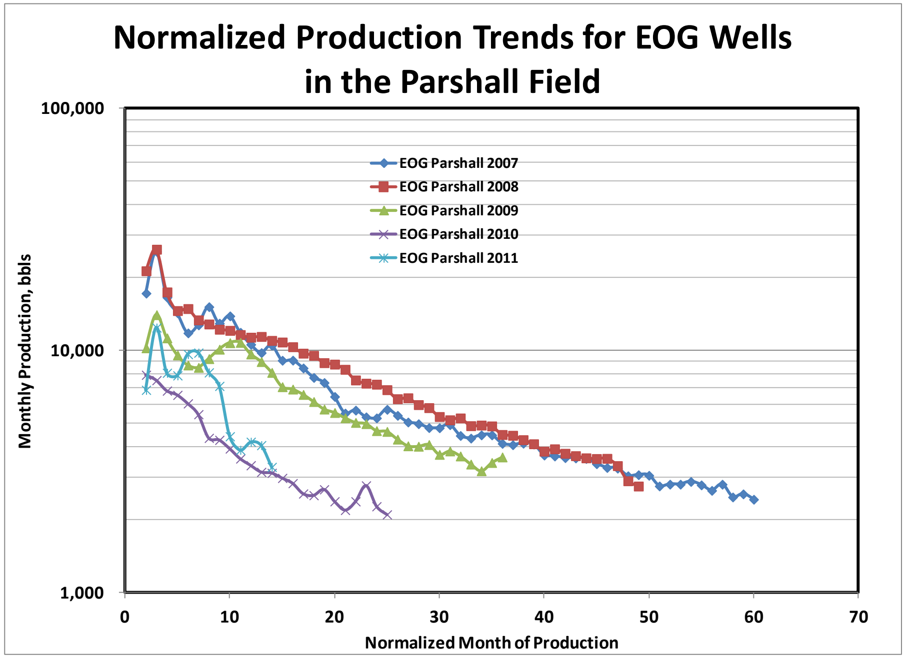
- The field is in North Dakota.
- It is the newest "hot" play in the Bakken Shale.

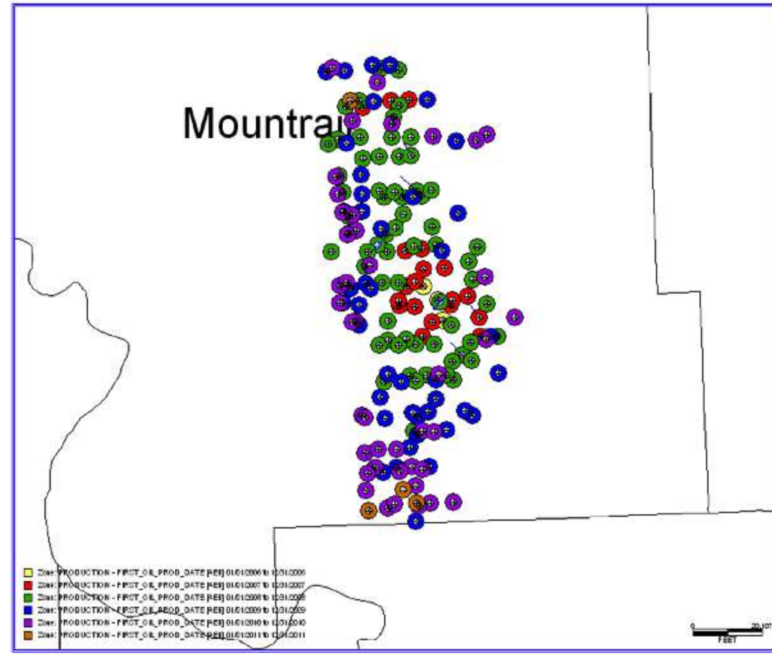
Parshall Production



- The field was discovered in 2006 and began to decline 3 years after first oil production.
- Cumulative production is 58 million barrels of oil.
- Drilling more wells has not arrested the decline (15%/year).

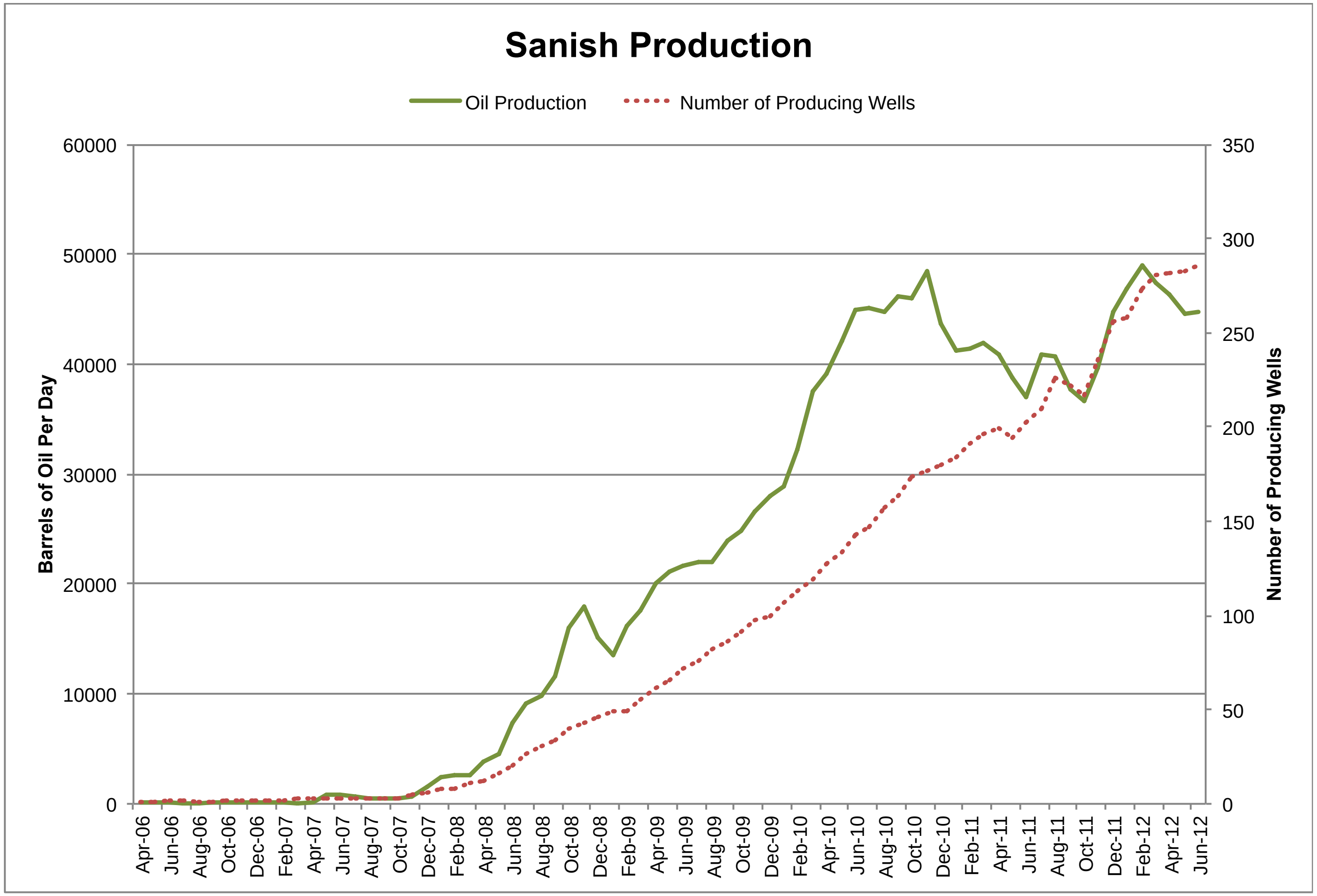
Parshall Well Performance





- Well performance has declined since 2009.
- Vintaging wells by year of first production shows that this is because the operator is moving to the margins of the field…just like in a conventional reservoir.

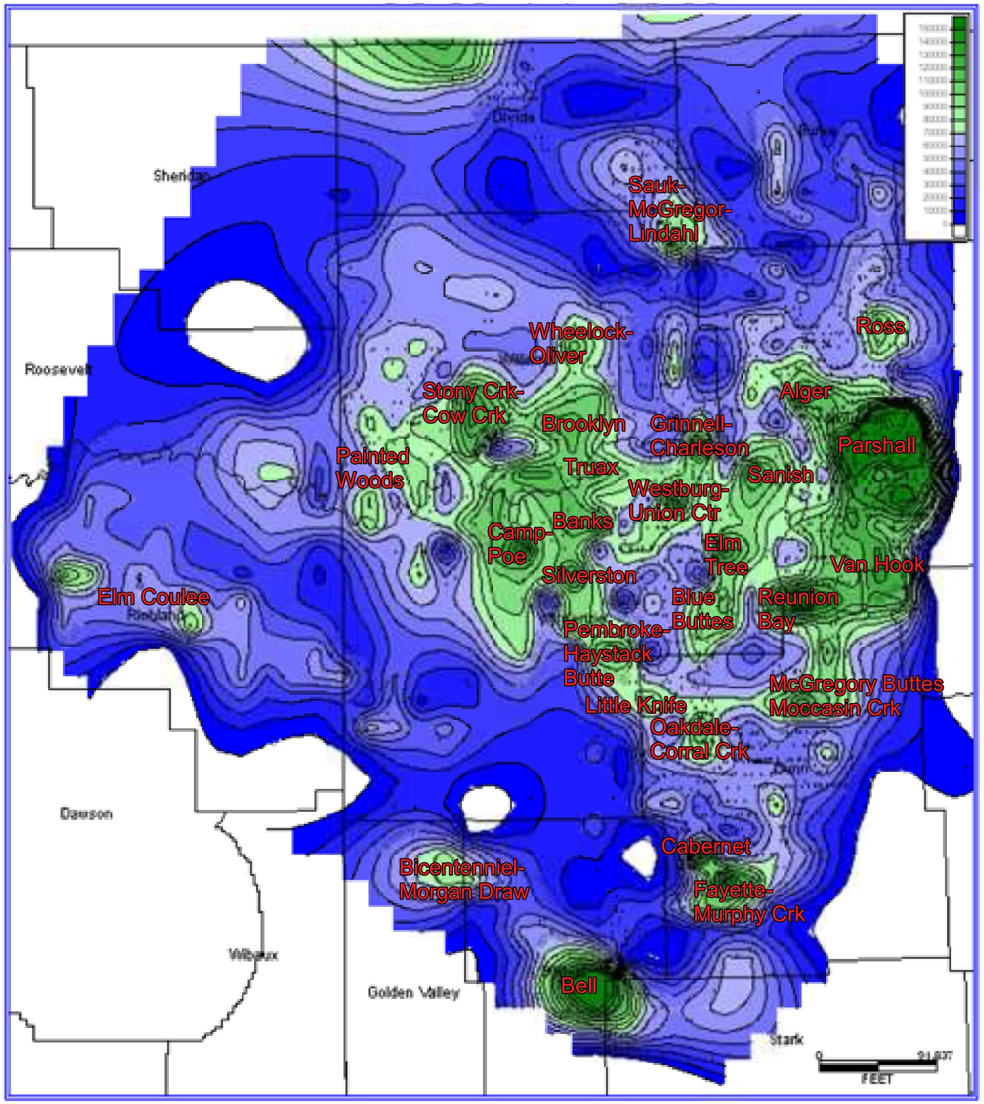
Sanish Field Production



Data from DI

- It was discovered in 2006 and has had an irregular production history.
- Cumulative production is 49 million barrels of oil.
- Production is declining (21%/year) despite adding new wells.

Bakken 12-month Cumulative Production Map



12-Month Bakken Cumulative Oil Production and Fields in This Study.

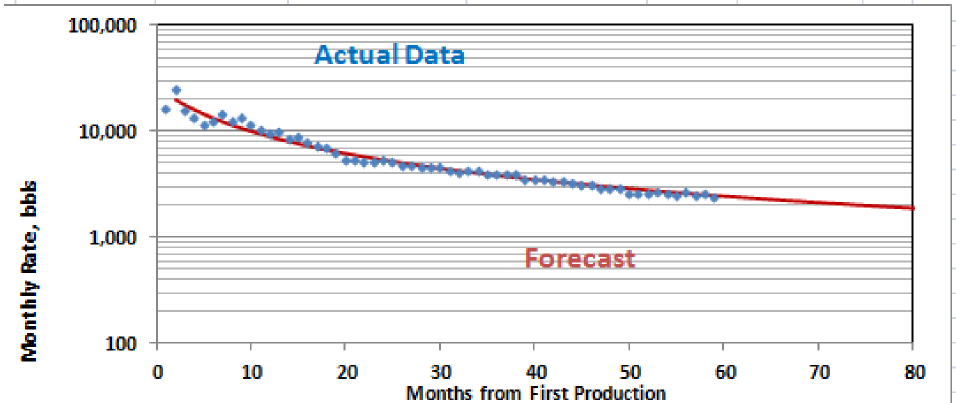
- Map shows wells with first production in 2006 or later.
- Green areas indicate break-even or greater production volumes
- Most production on the map is from the Three Forks reservoir.
- Indicates that production is from discreet fields.

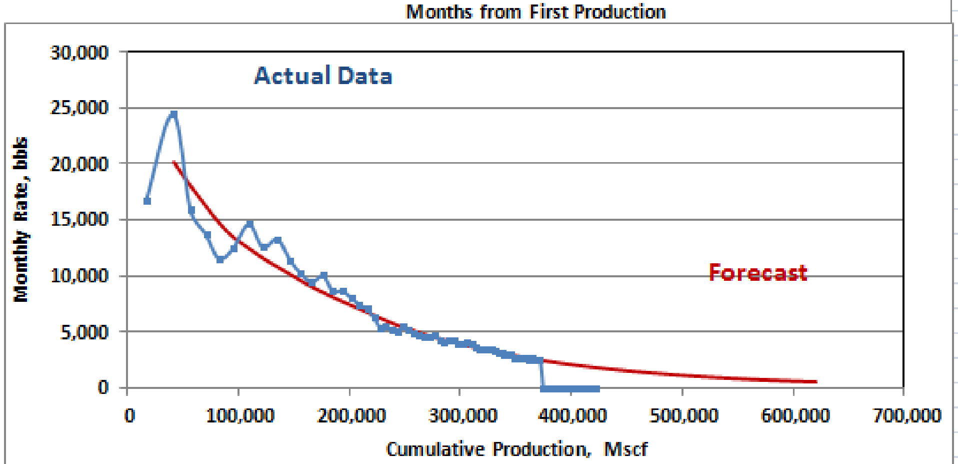
Decline Curve Analysis: Parshall, High b-exponent Example

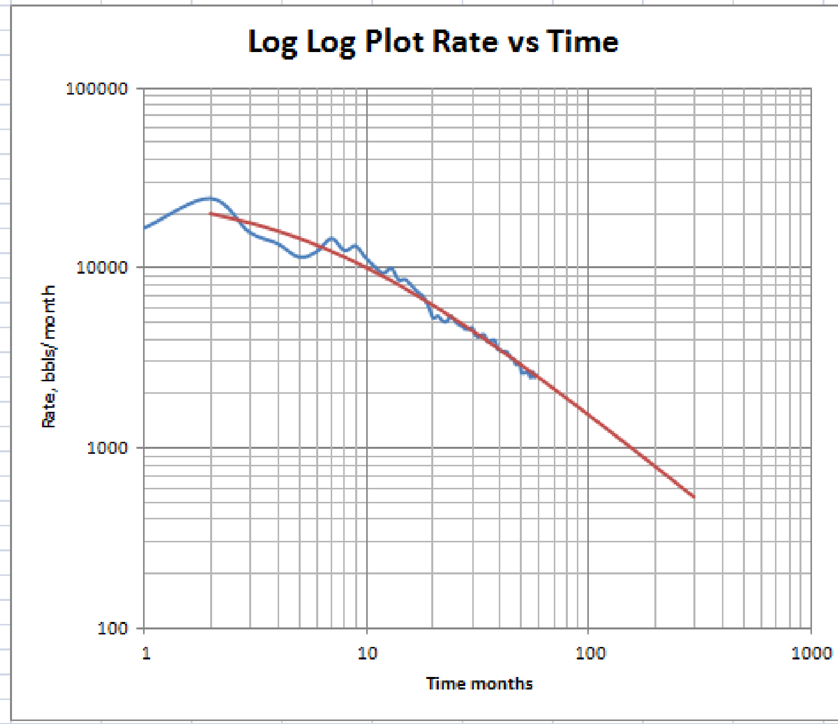
All Parshall 2007

Di = 1.70 b exponent = 1

No Terminal Decline	Mscf	Terminal Decline Rate =	10%
Remaining Reserve =	378,630	Remaining Reserve =	249,152
Cumulative Production =	371,613	Cumulative Production =	371,613
EUR =	750,242	EUR =	620,764



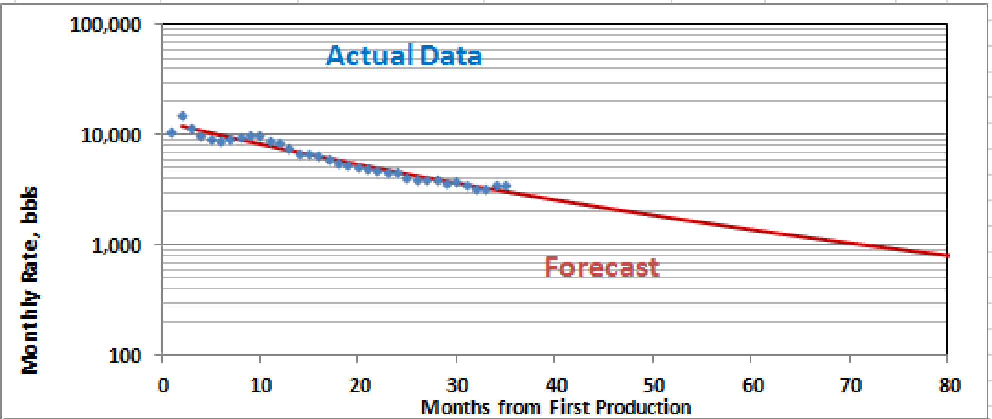


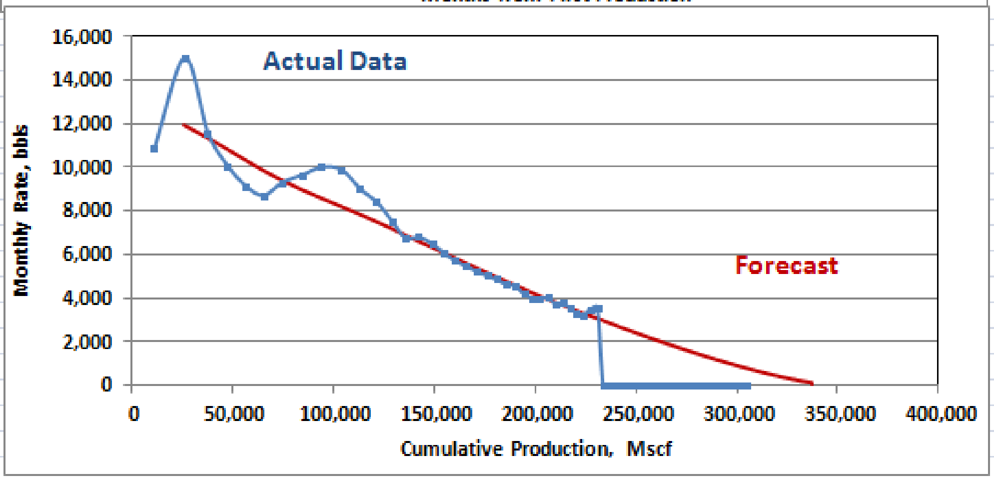


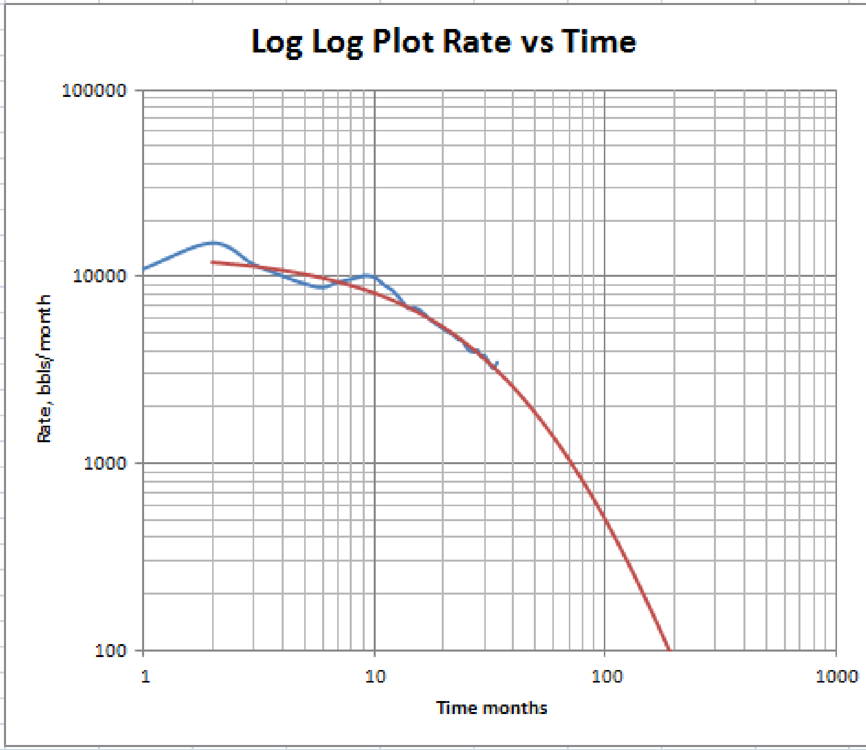
Decline Curve Analysis: Parshall, Low b-exponent Example

All Parshall 2009

Di =	0.60	b exponent =	0.25
No Terminal Decline	Mscf	Terminal Decline Rate =	10%
Remaining Reserve =	103,654	Remaining Reserve =	103,654
Cumulative Production =	230,879	Cumulative Production =	230,879
EUR =	334,532	EUR =	334,532







Bakken Decline Curve Analysis Summary

Operator/Field/Vintage	Well Count	EUR, MBO/well	Di	b Factor	12-Month Cumulative, MBO	EUR/12-Mo Cum Ratio
EOG Parshall 2007	19	596	0.75	1.30	173	3.5
EOG Parshall 2008	64	565	0.50	0.90	179	3.1
EOG Parshall 2009	43	384	0.50	0.90	122	3.1
EOG Parshall 2010	43	165	0.50	0.90	63	2.6
EOG Parshall 2011	9	202	0.50	0.90	87	2.3
Weighted Average		410			132	3.0
Whiting Sanish 2008	23	624	0.50	0.52	153	4.1
Whiting Sanish 2009	37	393	0.50	0.80	122	3.2
Whiting Sanish 2010	69	518	0.75	0.80	137	3.8
Whiting Sanish 2011	82	388	0.75	0.60	79	4.9
Weighted Average		457			114	4.1
Marathon Reunion Bay 2008	5	277	0.75	0.50	49	5.7
Marathon Reunion Bay 2009	9	348	0.75	0.35	56	6.2
Marathon Reunion Bay 2010	9	673	0.75	0.20	82	8.2
Marathon Reunion Bay 2011	17	485	0.75	0.50	100	4.8
Weighted Average		470			80	6.0
Brigham Alger 2008	5	198	0.75	0.25	46	4.3
Brigham Alger 2009	2	459	0.50	0.60	141	3.3
Brigham Alger 2010	10	491	0.75	1.00	155	3.2
Brigham Alger 2011	17	355	0.75	1.20	116	3.1
Weighted Average		378			119	3.3
Slawson Van Hook 2008	3	271	0.75	1.50	84	3.2
Slawson Van Hook 2009	9	271	1.00	2.00	81	3.4
Slawson Van Hook 2010	19	463	1.00	1.00	107	4.3
Slawson Van Hook 2011	23	517	1.00	1.30	125	4.1
Weighted Average		443			109	4.0
All Other Bakken 2008	388	177	1.00	1.20	41	4.3
All Other Bakken 2009	349	226	1.00	1.10	53	4.3
All Other Bakken 2010	632	287	1.00	1.10	72	4.0
All Other Bakken 2011	1,118	307	1.00	1.10	72	4.3
Weighted Average		270			64	4.2
Overall Average =		299	MBO/well			4.1

- Average of all wells is ~ 300 MBO, which should be slightly above the commercial threshold.
- Commercial wells appear to be located within defined field boundaries.
- Poorer Parshall recent well performance due to finding field limits.

Shale Oil Observations

- Shale oil obeys the laws of physics:
  - ✓ Considerable areas of commercial success in Eagle Ford & Bakken plays,
  - ✓ Commercial oil is found in fields,
  - ✓ Plays are not fields,
  - ✓ Overall play results are marginally commercial to non-commercial,
  - ✓ Largest fields usually found early in the exploration cycle,
  - ✓ Later discoveries generally smaller and less profitable,
  - ✓ Plays will contract to fields that will represent a smaller portion of the play area along with corresponding reserves,
- Fields will reach peak production in 3-5 years and then decline.
- The oil plays require very high oil prices to be commercial.
- The total contribution of shale oil to U.S. supply is presently 1.2 mmbo/d and will probably not increase to more than 2 mmbopd (14% of consumption) by 2020 because of high decline rates.
- Oil prices must remain high to sustain drilling required to replace annual base and add production.
- The shale oil plays we analyzed are commercially attractive.
- Their contribution to U.S. supply is notable.
- It is unlikely that oil from shale plays will result in energy independence.

U.S. Shale Plays

Oil-Prone Shale Plays:
The Illusion of Energy Independence

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Houston SIPES Continuing Education Seminar
Halliburton Conference Theater
October 19, 2012