Undiscovered Natural Gas and Petroleum Resources Beneath Inventoried Roadless and Special Designated Areas on Forest Service Lands

Analysis and Results

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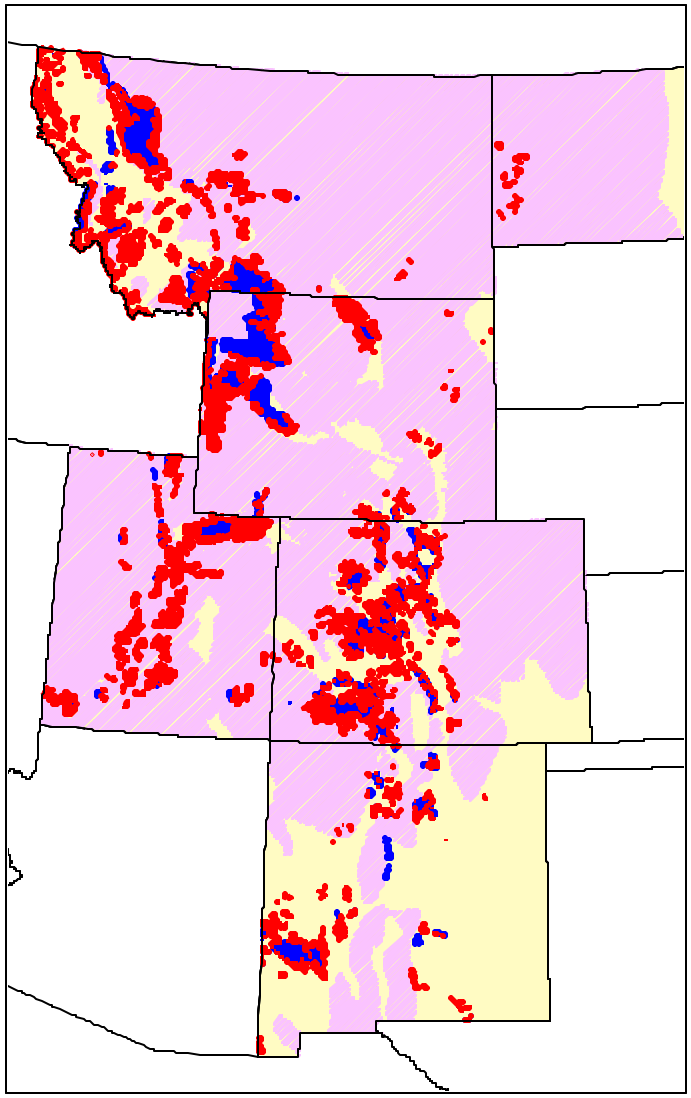
Overview

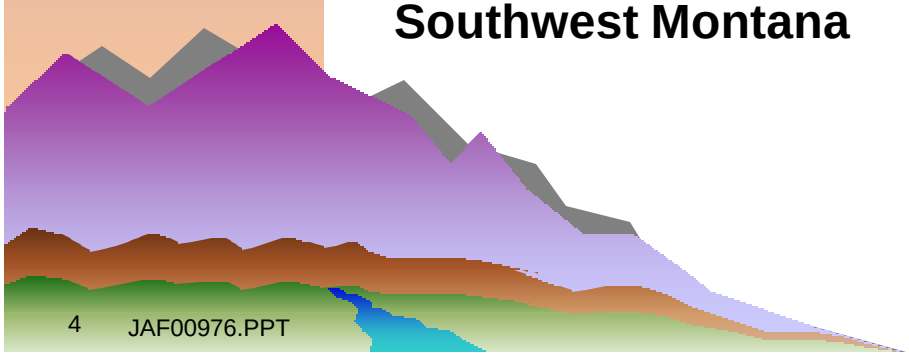
- **Purpose**
  - **The analysis examines undiscovered natural gas and oil resources (technically recoverable) associated with the U.S. Forest Service's *Inventoried Roadless Areas (IRAs)* and *Special Designated Areas (SDAs)***
- **Briefing**
  - **Methodology**
  - **Results**

Six Rocky Mountain States Comprise the Study Area



Nineteen Rocky Mountain Provinces/Basins Were Examined

- Western Great Basin
- Eastern Great Basin
- Uinta - Piceance Basin
- Paradox Basin
- San Juan Basin
- Albuquerque - Santa Fe Rift
- Northern Arizona
- Montana Thrust Belt
- North-Central Montana
- Southwest Montana
- Williston Basin
- Powder River Basin
- Big Horn Basin
- Wind River Basin
- Wyoming Thrust Belt
- Southwestern WY
- Park Basins
- Denver Basin
- Raton Basin - Sierra Grande Uplift



Methodology

- **Resources were compiled, by play, for undiscovered natural gas and oil resources in the study area**
  - **Estimates of high, mean and low resources were made.**
  - **Data sources comprise the USGS 1995 Assessment, supplemented by Advanced Resources' and published data for select plays, similar to the 1999 NPC study.**
  - **A homogeneous distribution of resources was assumed.**
  - **208 plays were examined; 116 have resources in IRAs or SDAs.**
- **Determined areas of intersection between the plays and the IRAs and SDAs**
  - **IRAs and SDAs have minor areas of overlap.**
  - **These two domains were considered independently in the analysis.**

Methodology (cont'd)

- **Areas of intersection between the plays and the IRAs and SDAs were for the subdivided into accessible and "high slope" areas**
  - **High slope areas are considered as difficult areas for exploration and drilling.**
  - **High slope areas were defined by grades of greater than 30%, consistent with leasing stipulations in the western U.S.**

Methodology (cont'd)

– **Estimates of high, mean and low resources (based upon USGS F_5, mean, F_{95}) were made as follows:**

		F_5	Mean	F_{95}
High	Slope <30%	X		
	Slope >30%		X	
Mean	Slope <30%		X	
	Slope >30%			X
Low	Slope <30%			X
	Slope >30%			

Results*

- **Inventoried Roadless Areas contain moderate to significant amounts of natural gas and oil.**
- **Special Designated Areas contain moderate to significant amounts of natural gas only.**

	Natural Gas (Tcf)			Petroleum (MMBO)		
	High	Mean	Low	High	Mean	Low
Inventoried Roadless Areas	23.1	11.3	3.5	1,212	550	69
Special Designated Areas	9.7	3.6	0.3	1.3	0.5	0.2
Rocky Mountain Region	641	323	119	17,574	8,218	1,456

The Appendix contains a listing of results by play.

Results (cont'd)

- IRAs impact the following areas most:
  - For natural gas resources,
    - Uinta/Piceance (3.9 Tcf)
    - Wyoming Thrust Belt (3.2 Tcf)
    - Southwestern Wyoming (2.0 Tcf)
    - Montana Thrust Belt (1.6 Tcf)
  - For oil,
    - Wyoming Thrust Belt (411 MMBO).
- SDAs, which contain natural gas but little oil resources, impact the following provinces:
    - Uinta/Piceance Basin (2.3 Tcf)
    - Southwestern Wyoming (0.8 Tcf)
    - Wyoming Thrust Belt (0.3 Tcf).

Results (cont'd)

- **Implementation of the proposed roadless areas would add about 9.4 Tcf of gas to the "no access" categorization in the 1999 NPC study as "standard lease terms" and "access restrictions" resources move to the "no access" category.**

NPC Categorization	IRAs Natural Gas Resource (Tcf)
Standard Lease Terms	7.0
No Access	1.9
Access Restrictions	2.4
Total	11.3

"Top Nine" Plays Impacted by IRAs

- **The largest nine plays in the study area comprise 83% of the total impacted natural gas resource but occupy only 14% of the area of the IRAs.**

USGS Province	Play	Code	IRAs (acres)	Natural Gas, Bcf (mean)
Montana Thrust Belt	Imbricate Thrust Gas	2701	1,192,787	1,618
Wyoming Thrust Belt	Moxa Arch Extension	3601	206,303	1,568
Wyoming Thrust Belt	Northern Thrusts	3603	749,469	1,508
Uinta - Piceance Basin	Uinta Basin - Emery	2052	60,882	1,159
Southwestern WY	Greater Green River Basin - Mesaverde	3741	65,322	950
Uinta - Piceance Basin	Tight Gas Uinta Tertiary West	2016	12,194	789
Uinta - Piceance Basin	Tight Gas Piceance Mesaverde Williams Fork	2007	218,522	642
Southwestern WY	Greater Green River Basin - Cloverly-Frontier	3740	105,206	566
Uinta - Piceance Basin	Piceance Basin - Western Basin Margin	2054	113,576	545
Totals			**2,724,260**	**9,346**
Portion of total Rocky Mountain Region			**14%**	**83%**

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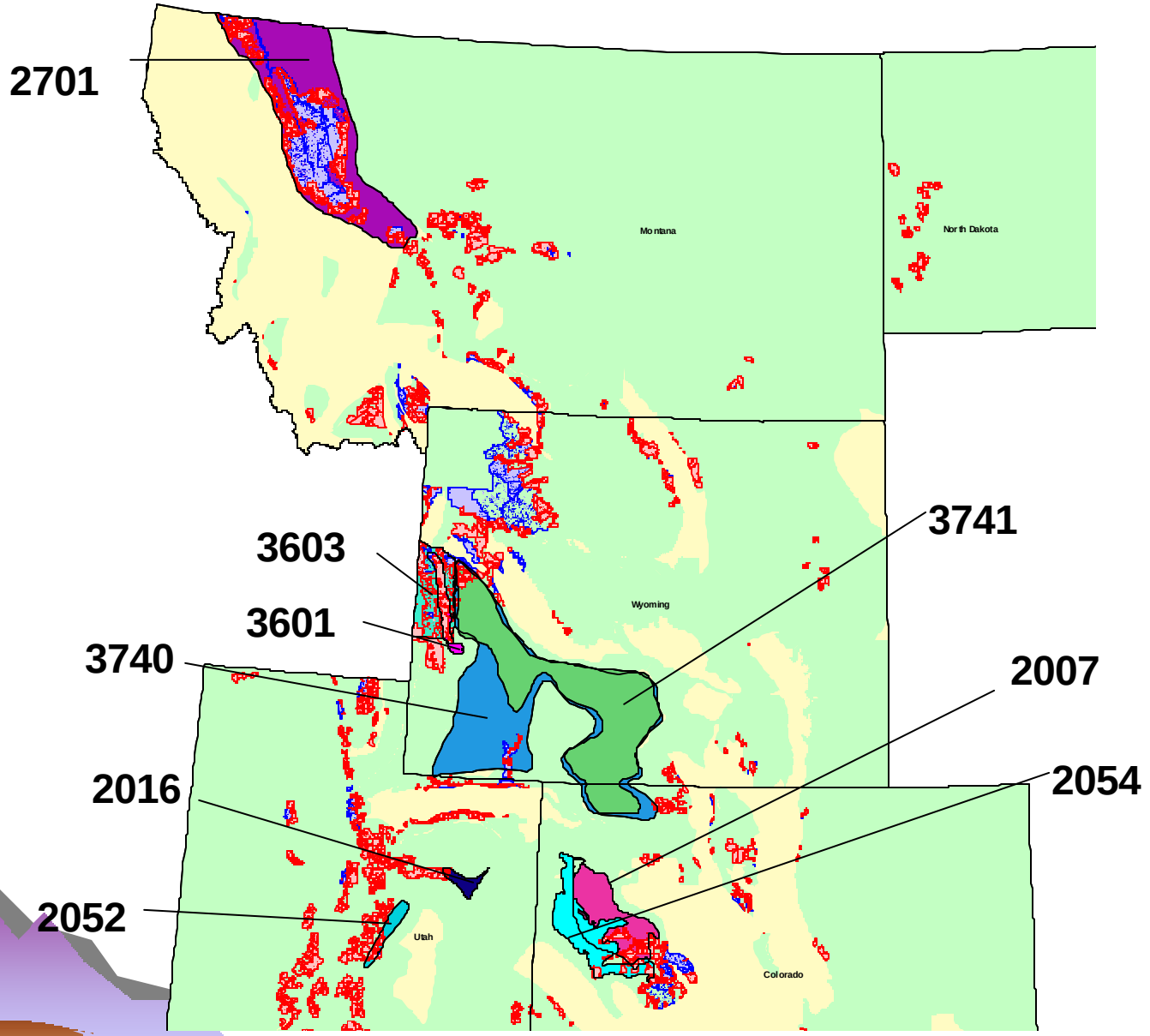
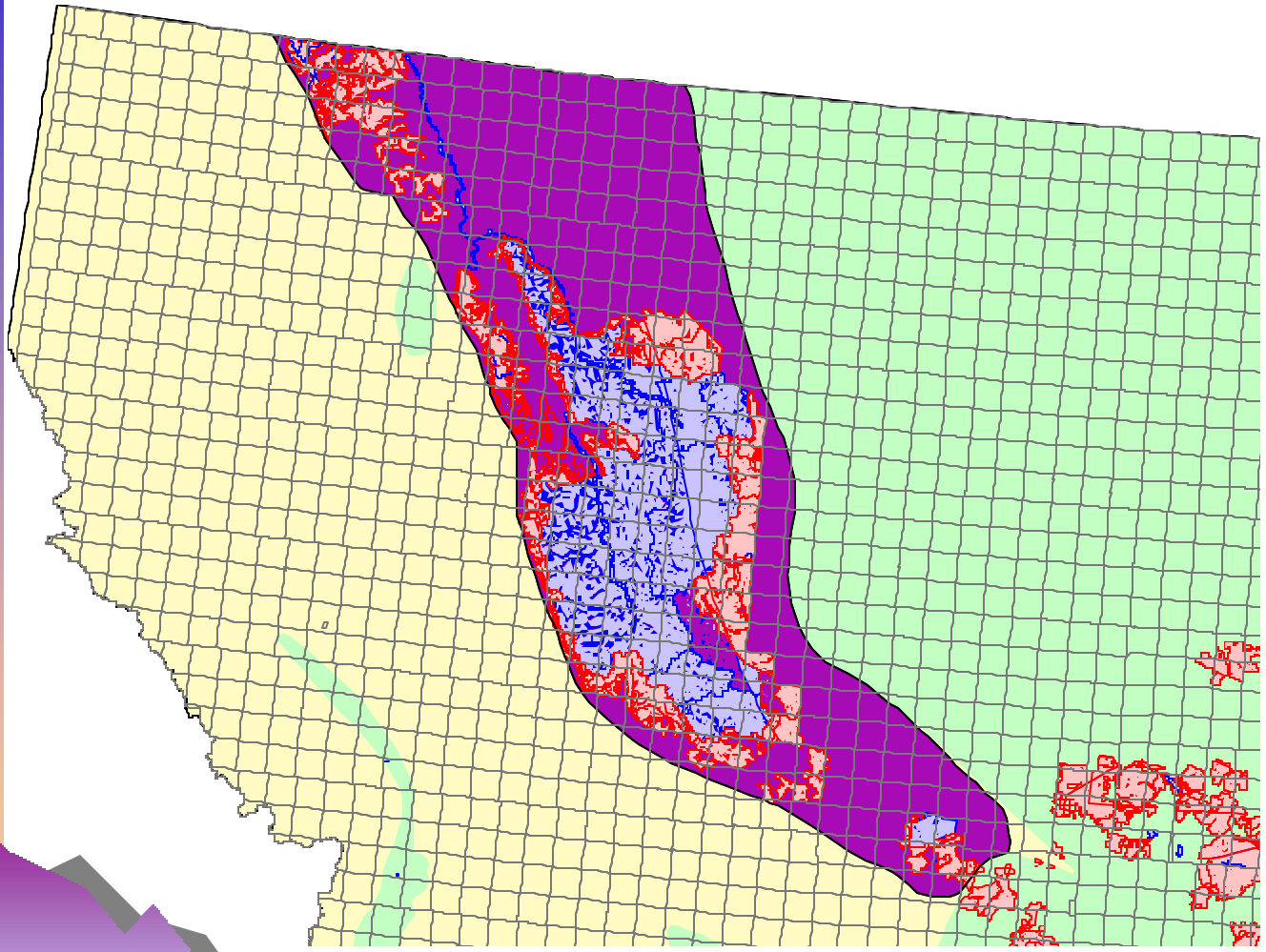
- **These nine plays represent slightly less than 5% of all IRAs nationwide.**

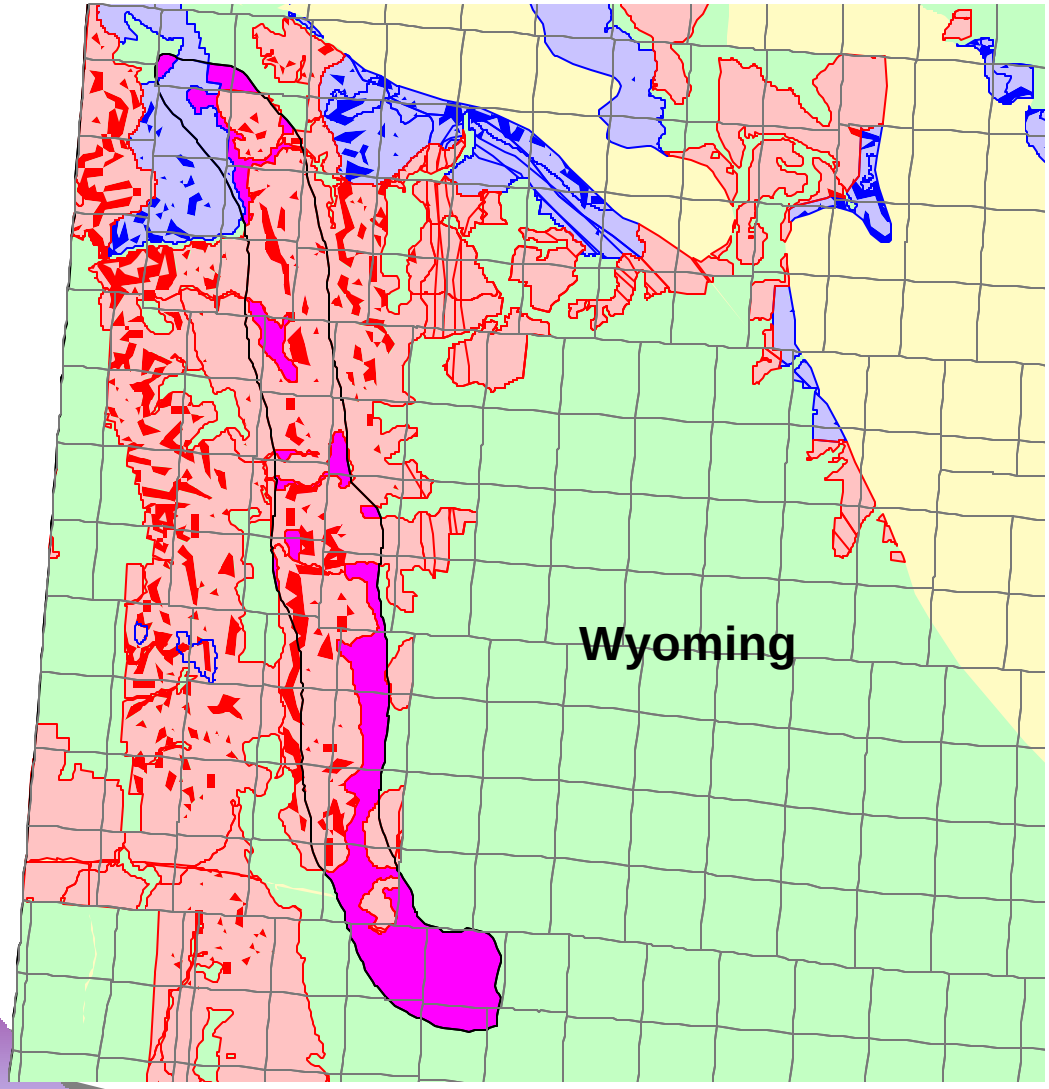
Top Nine Impacted Plays



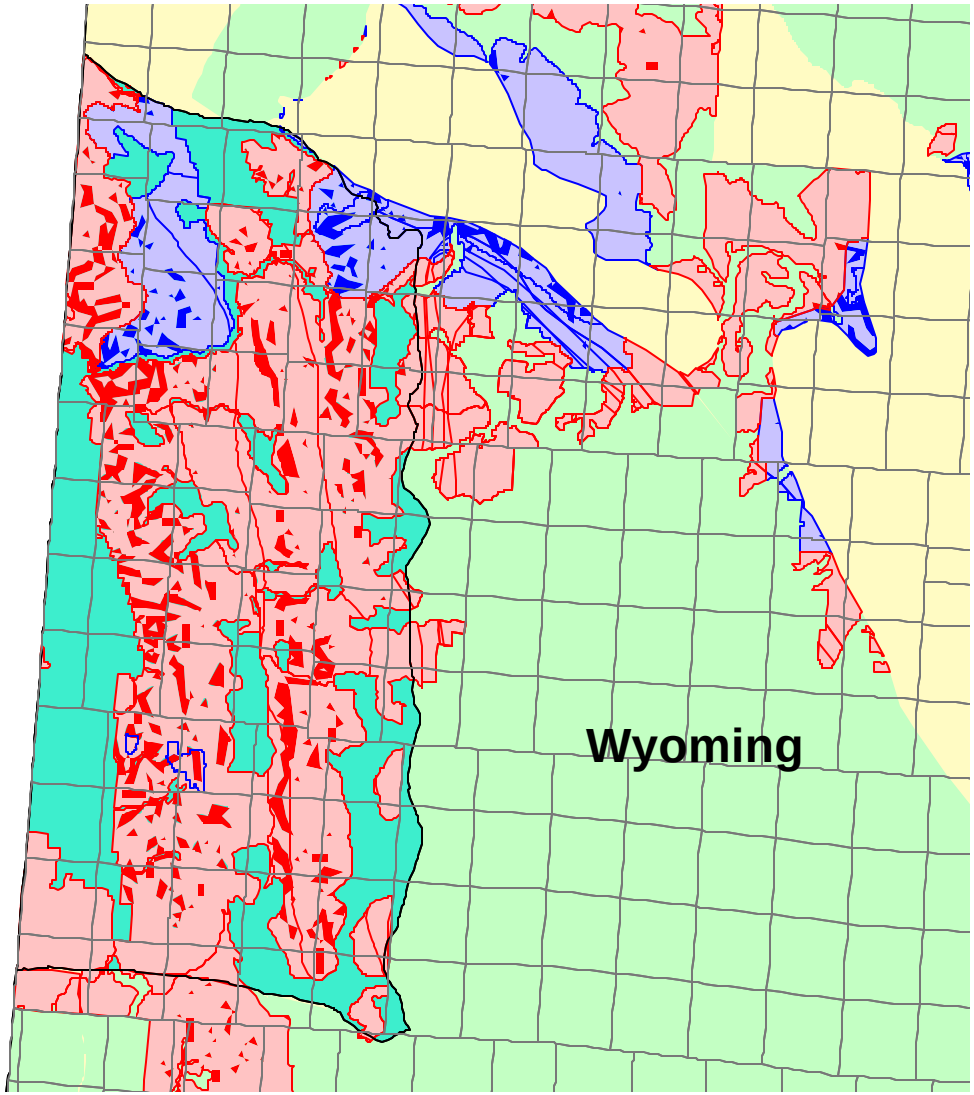
Play 2701 (IRAs: 1.19 MM acres, 1.6 Tcf)



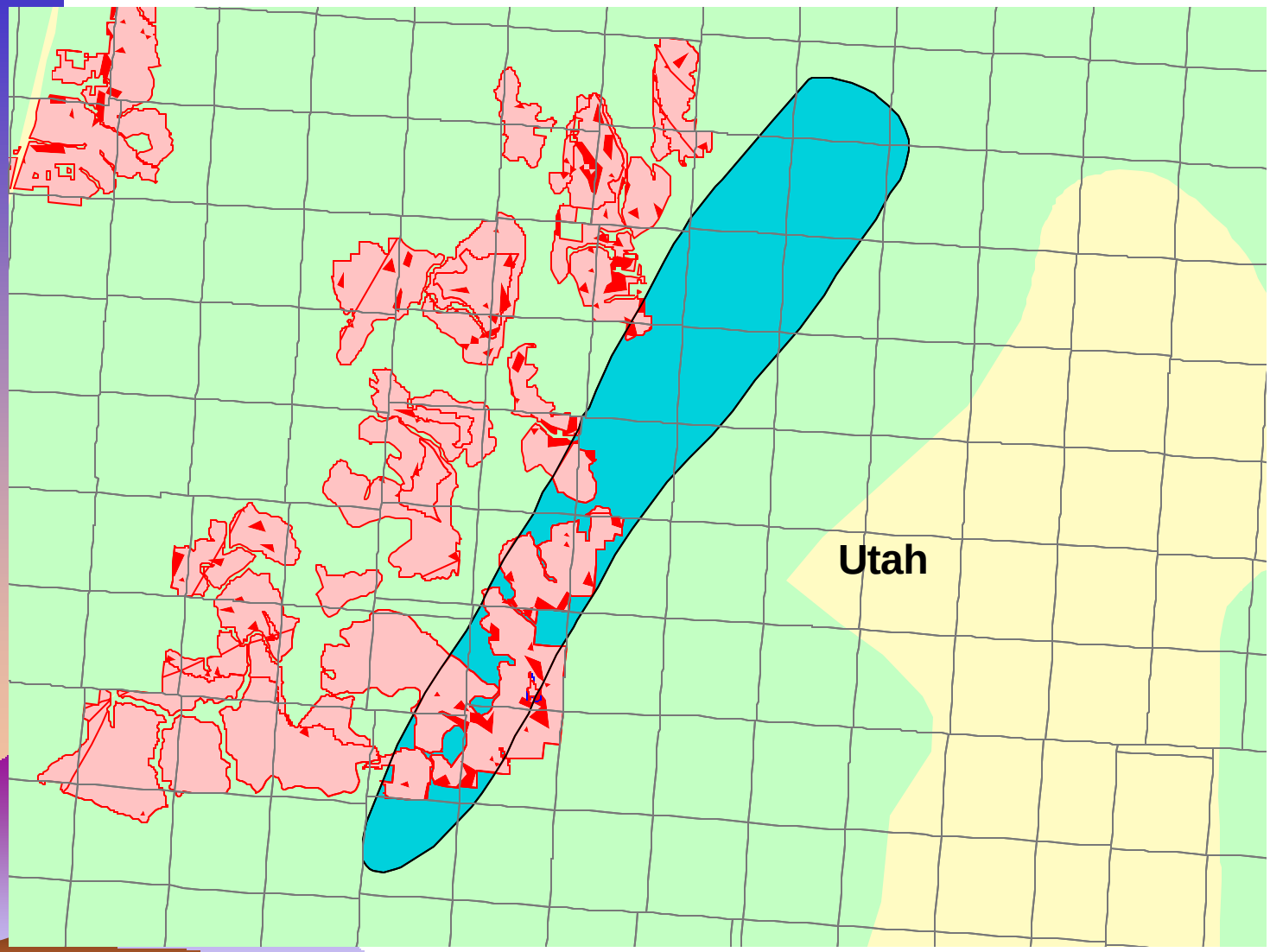
Play 3601 (IRAs: 0.21 MM acres, 1.6 Tcf)



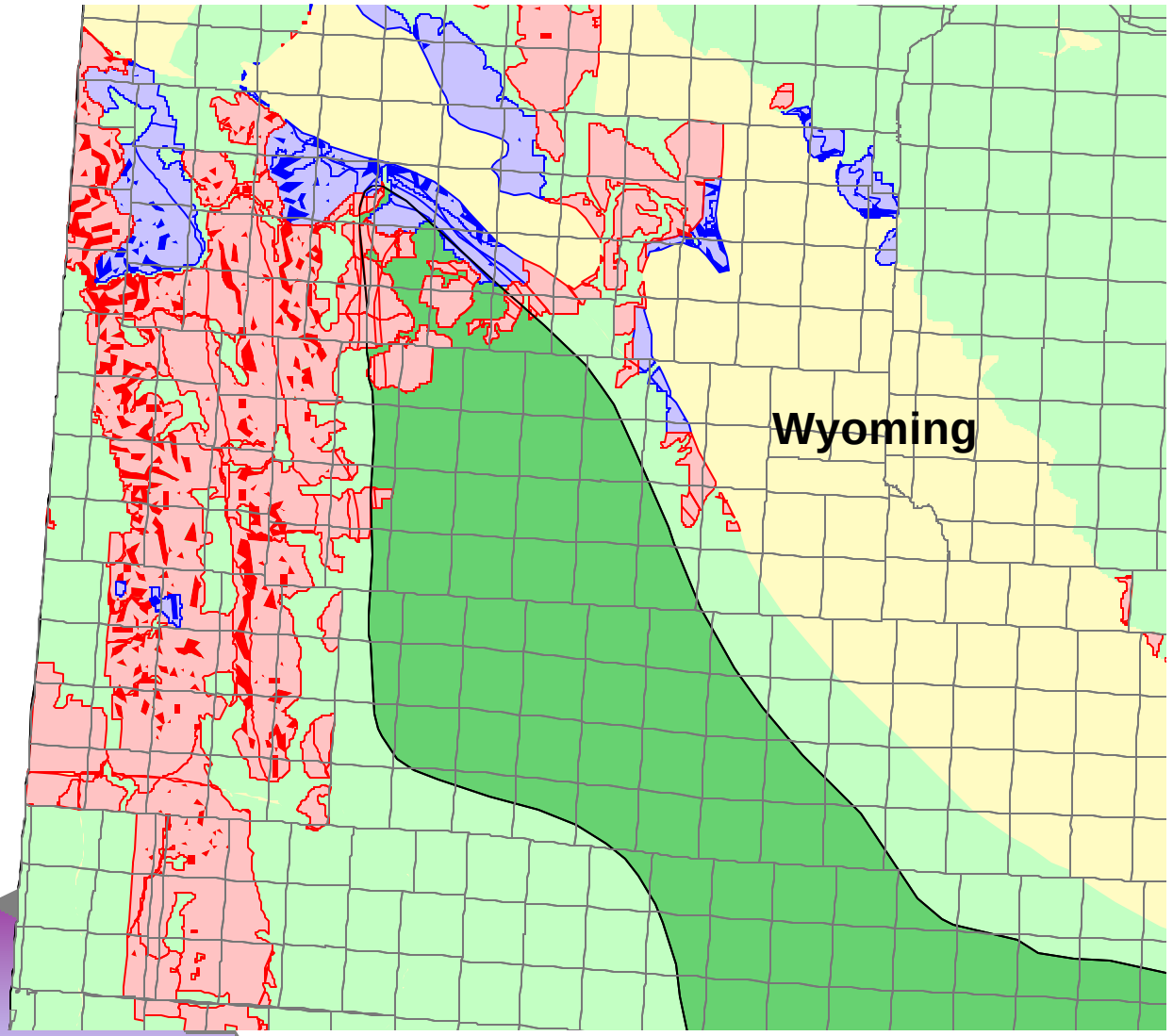
Play 3603 (IRAs: 0.75 MM acres, 1.5 Tcf)



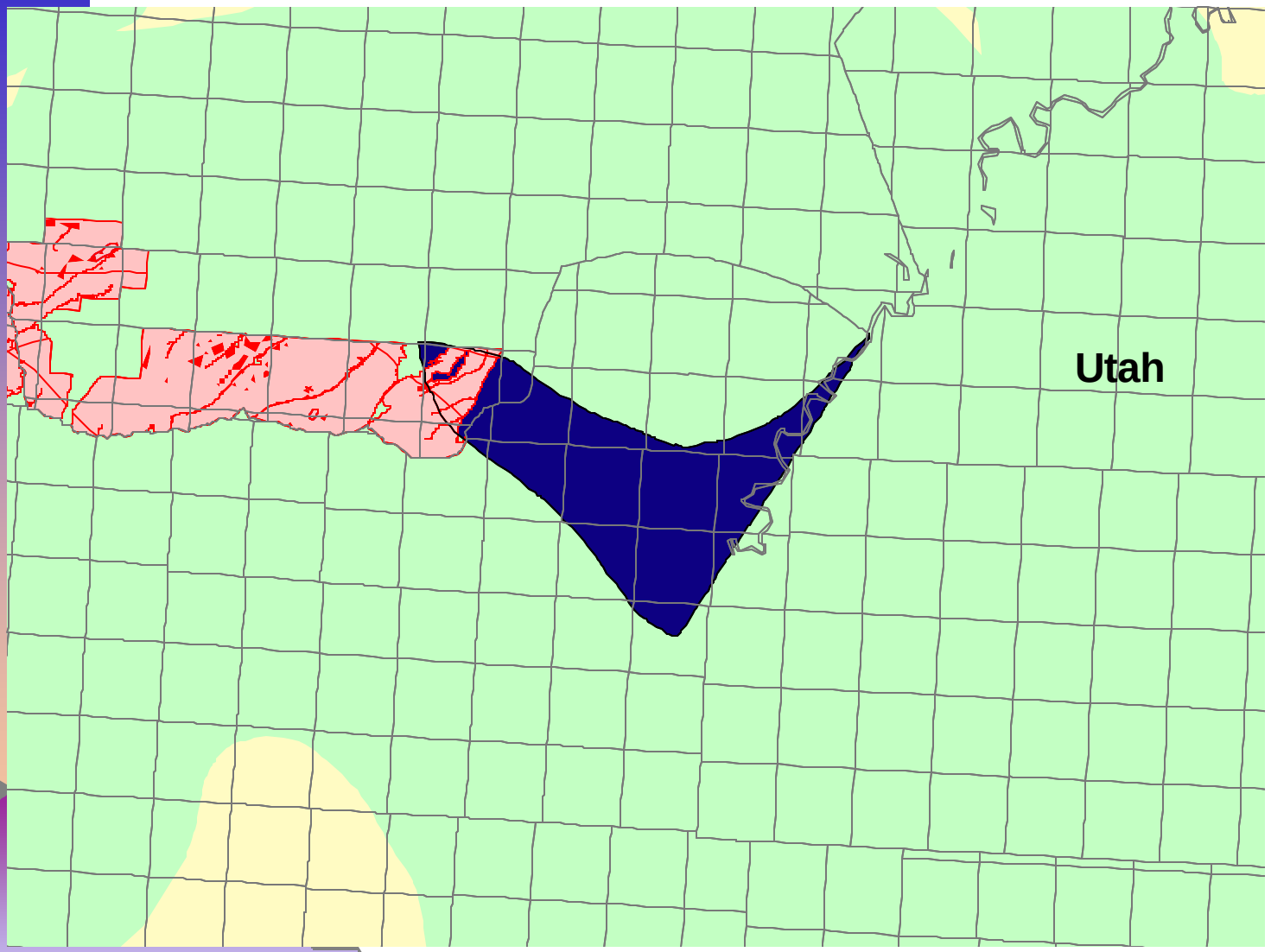
Play 2052 (IRAs: 0.06 MM acres, 1.2 Tcf)



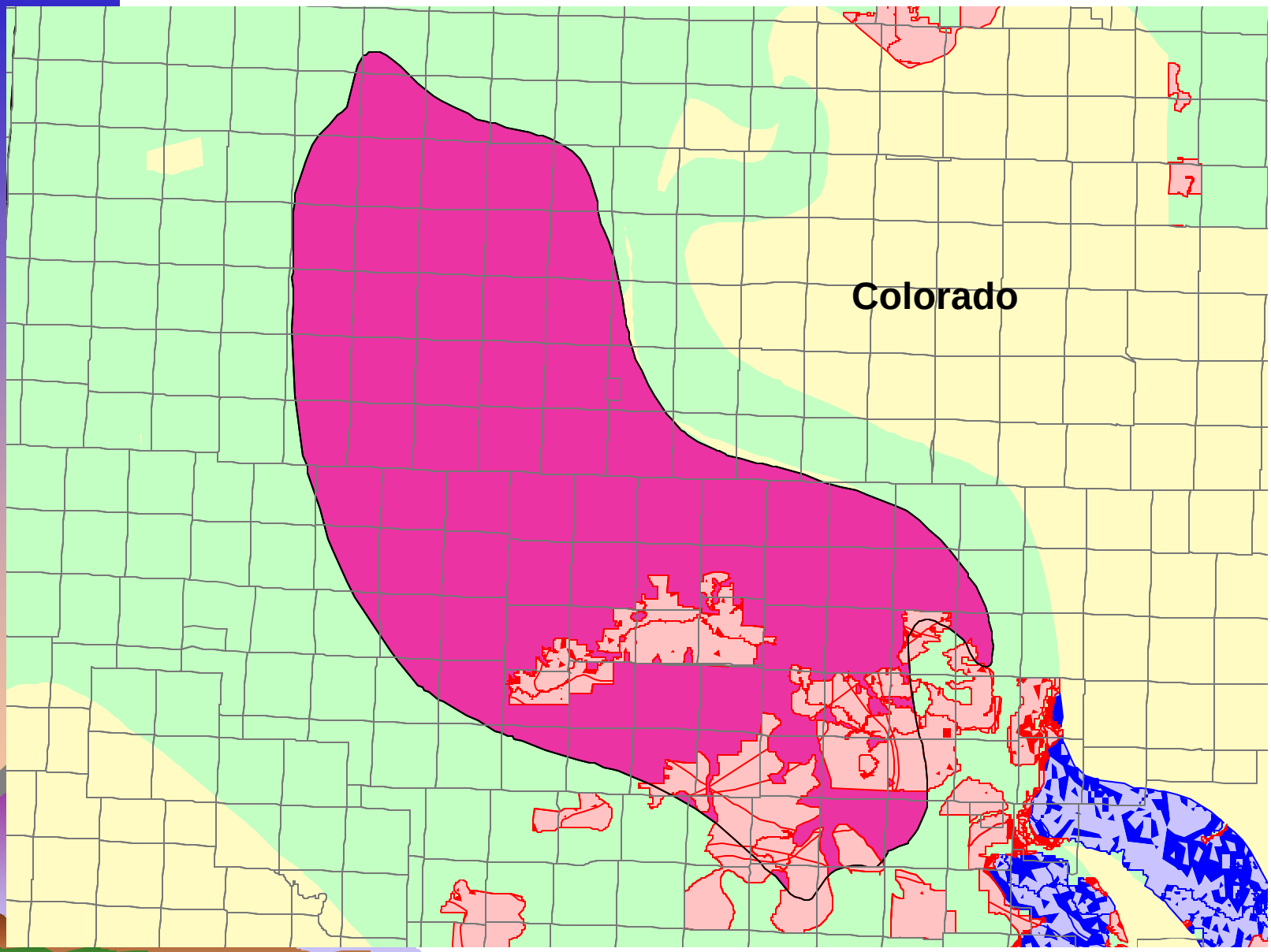
Play 3741 (IRAs: 0.07 MM acres, 1.0 Tcf)



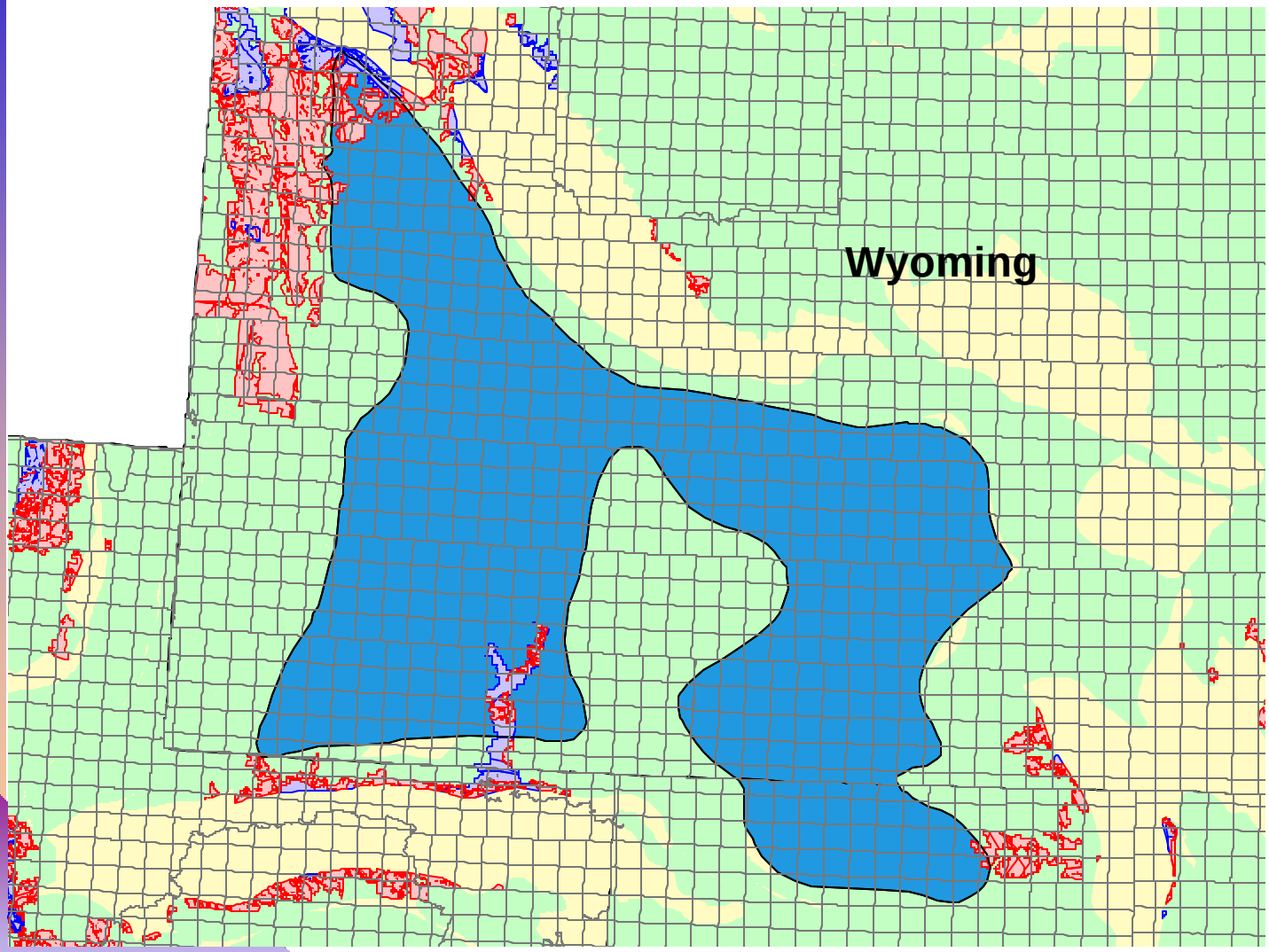
Play 2016 (IRAs: 0.01 MM acres, 0.8 Tcf)



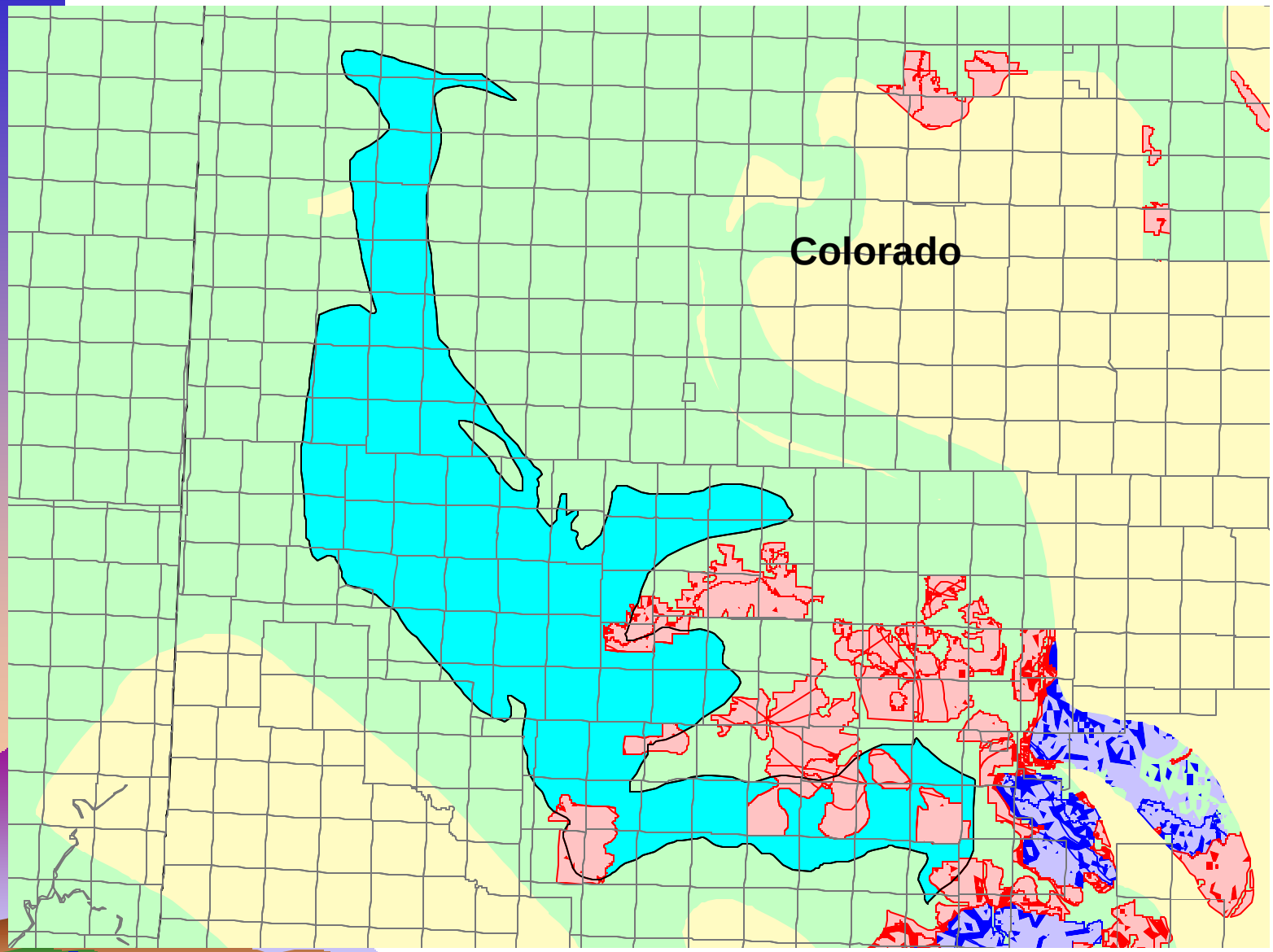
Play 2007 (IRAs: 0.22 MM acres, 0.6 Tcf)



Play 3740 (IRAs: 0.11 MM acres, 0.6 Tcf)



Play 2054 (IRAs: 0.11 MM acres, 0.5 Tcf)



Appendix

- **Table of Resource Distribution by Play**

Appendix: Inventoried Roadless Areas and Special Designated Areas
Undiscovered Resource Analysis

			Inventoried Roadless Areas						Special Designated Areas					
			Natural Gas, Bcf			Petroleum, MMBO			Natural Gas, Bcf			Petroleum, MMBO		
USGS Province	Play	Play code	High	Mean	Low	High	Mean	Low	High	Mean	Low	High	Mean	Low
Western Great Basin	Permian-Triassic Source Rocks Northwestern	1803	-	-	-	-	-	-	-	-	-	0.1	0.0	-
Eastern Great Basin	Unconformity "A"	1901	0.3	0.1	0.0	2.6	0.9	0.0	0.1	0.0	0.0	-	-	-
	Late Paleozoic	1902	1.3	0.2	-	2.0	0.2	-	0.2	0.0	-	-	-	-
	Younger Tertiary Basins	1905	1.1	0.2	-	0.2	0.0	-	0.3	0.1	-	-	-	-
	Sevier Frontal Zone	1907	198.8	40.6	-	19.6	4.0	-	6.6	1.1	-	-	-	-
Uinta - Piceance Basin	Piceance Tertiary Conventional	2001	112.8	70.8	5.4	0.4	0.3	-	-	-	-	-	-	-
	Uinta Tertiary Oil and Gas	2002	22.4	11.9	1.4	4.4	2.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0
	Upper Cretaceous Conventional	2003	54.8	37.5	3.6	0.4	0.3	-	9.7	5.2	0.5	-	-	-
	Cretaceous Dakota to Jurassic	2004	23.1	13.4	2.5	0.4	0.2	0.1	16.7	9.1	1.6	-	-	-
	Permian-Pennsylvanian Sandstones and Carb.	2005	270.3	81.4	3.4	37.3	11.2	0.5	0.4	0.1	0.0	-	-	-
	Tight Gas Piceance Mesaverde Williams Fork	2007	845.4	642.3	468.0	4.2	3.2	2.3	-	-	-	-	-	-
	Cretaceous Self-Sourced Fractured Shales	2009	1.2	0.8	0.5	3.9	2.6	1.6	-	-	-	-	-	-
	Tight Gas Piceance Mesaverde	2010	406.9	302.7	212.6	1.6	1.2	0.9	-	-	-	-	-	-
	Basin Margin Subthrusts	2014	15.0	2.1	-	1.6	0.3	-	7.9	1.0	-	-	-	-
	Tight Gas Uinta Tertiary East	2015	-	-	-	-	-	-	-	-	-	1.2	0.5	0.2
	Tight Gas Uinta Tertiary West	2016	1,805.3	789.4	248.8	0.6	0.3	0.1	-	-	-	-	-	-
	Basin Flank Uinta Mesaverde	2018	86.5	48.9	23.7	0.6	0.4	0.2	-	-	-	-	-	-
	Uinta Basin - Emery	2052	1,527.0	1,158.7	788.7	na	na	na	10.3	7.8	5.6	na	na	na
	Piceance Basin - Western Basin Margin	2054	685.8	544.6	417.8	na	na	na	-	-	-	na	na	na
	Piceance Basin - Divide Creek Anticline	2056	284.9	160.4	76.8	na	na	na	-	-	-	na	na	na
	Piceance Basin - Igneous Intrusion	2057	27.4	8.8	-	na	na	na	33.0	9.9	-	na	na	na
Paradox Basin	Buried Fault Blocks, Older Paleozoic	2101	16.7	6.2	0.6	3.7	1.3	0.1	3.6	1.3	0.1	-	-	-
	Porous Carbonate Buildup	2102	15.2	9.0	0.7	6.0	3.6	0.2	4.2	2.6	0.2	-	-	-
	Fractured Interbed	2103	12.6	5.0	1.2	15.8	6.3	1.5	3.3	1.3	0.3	-	-	-
	Permian-Pennsylvanian Marginal Clastics	2104	44.9	16.6	-	2.2	0.9	-	7.4	2.6	-	-	-	-
	Salt Anticline Flank	2105	18.4	8.4	0.6	1.7	0.4	0.0	4.0	1.8	0.1	-	-	-
	Permo-Triassic Unconformity	2106	0.5	0.2	-	5.2	1.9	-	0.0	0.0	-	-	-	-
	Cretaceous Sandstone	2107	30.3	14.4	1.7	0.0	0.0	-	0.0	0.0	0.0	-	-	-
San Juan Basin	Entrada	2204	0.0	0.0	-	0.1	0.1	0.0	-	-	-	-	-	-
	Dakota Central Basin Gas	2205	103.8	56.3	25.5	0.0	-	-	-	-	-	-	-	-
	Basin Margin Dakota Oil	2206	3.6	2.2	0.3	0.9	0.6	0.1	2.1	1.1	0.1	-	-	-
	Tocito/Gallup Sandstone Oil	2207	1.7	0.8	0.1	0.4	0.2	0.0	-	-	-	-	-	-
	Mancos Fractured Shale	2208	1.1	0.5	0.2	2.2	1.1	0.4	-	-	-	-	-	-
	Central Basin Mesaverde Gas	2209	138.6	65.8	23.3	0.0	-	-	-	-	-	-	-	-
	Basin Margin Mesaverde Oil	2210	0.0	0.0	-	0.0	0.0	-	-	-	-	-	-	-
	Pictured Cliffs Gas	2211	38.3	22.4	11.4	-	-	-	-	-	-	-	-	-
	Fruitland-Kirtland Fluvial Sandstone Gas	2212	2.3	1.8	0.1	0.1	0.1	0.0	-	-	-	-	-	-
	San Juan Basin - Overpressured	2250	100.5	80.8	63.8	na	na	na	-	-	-	na	na	na
	San Juan Basin - Underpressured	2253	2.1	1.4	0.8	na	na	na	-	-	-	na	na	na
Albq. - Santa Fe Rift	Albuquerque Basin	2301	4.7	1.1	-	0.4	0.1	-	2.0	0.5	-	-	-	-
	Hagan - Santa Fe Embayment	2302	0.2	0.0	-	0.2	0.0	-	0.1	0.0	-	-	-	-
	San Juan Sag	2305	38.2	9.4	-	18.5	5.1	-	26.5	6.4	-	-	-	-
Northern Arizona	Late Proterozoic (Chuar-Sourced)	2403	45.8	6.7	-	17.1	2.7	-	2.0	0.3	-	-	-	-
Montana Thrust Belt	Imbricate Thrust Gas	2701	4,885.5	1,618.1	-	2.5	0.8	-	6,973.9	2,342.7	-	-	-	-
	Helena Salient Gas	2704	12.5	3.2	-	0.0	0.0	-	-	-	-	-	-	-
	Blacktail Salient Oil	2705	0.1	0.0	-	0.5	0.1	-	-	-	-	-	-	-
	Tertiary Basins Oil and Gas	2706	1.2	0.2	-	0.1	0.0	-	0.4	0.1	-	-	-	-
	Imbricate Thrust Oil	2707	0.9	0.1	-	0.8	0.1	-	0.6	0.1	-	-	-	-
North-Central Montana	Cambrian-Ordovician Sandstones	2802	4.7	1.3	-	0.7	0.2	-	1.3	0.4	-	-	-	-
	Bakken Shale Fracture Systems	2804	1.8	0.3	-	2.2	0.4	-	0.5	0.1	-	-	-	-
	Devonian-Mississippian Carbonates	2805	1.0	0.5	0.1	1.8	1.1	0.2	0.3	0.2	0.0	-	-	-
	Tyler Sandstone	2806	0.1	0.0	0.0	0.6	0.3	0.0	0.0	0.0	0.0	-	-	-
	Fractured-Faulted Carbonates in Anticlines	2807	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	-	-	-
	Jurassic-Cretaceous Sandstones	2808	0.9	0.6	0.1	0.4	0.2	0.0	0.4	0.3	0.0	-	-	-
	Shallow Cretaceous Biogenic Gas	2809	6.3	4.0	0.5	-	-	-	2.1	1.3	0.1	-	-	-
	Northern Great Plains Biogenic Gas, Modera	2811	147.5	67.6	22.3	-	-	-	0.7	0.3	0.1	-	-	-
	Northern Great Plains Biogenic Gas, Low Porosity	2812	172.3	72.9	20.1	-	-	-	-	-	-	-	-	-
Southwest Montana	Crazy Mountains and Lake Basins Cretaceous	2901	5.9	3.0	0.4	0.0	0.0	-	0.0	0.0	0.0	-	-	-
	Nye-Bowler Wrench Zone Oil and Gas	2903	5.5	1.3	-	0.8	0.2	-	2.0	0.5	-	-	-	-
	Beartooth Frontal Oil and Gas	2904	21.7	4.6	-	8.7	1.7	-	11.5	2.4	-	-	-	-
	Snowcrest-Greenhorn Frontal	2906	1.5	0.4	-	5.6	1.4	-	0.0	0.0	-	-	-	-
	Tertiary Basins Oil and Gas	2907	2.9	0.5	-	0.4	0.1	-	1.5	0.2	-	-	-	-
	Crazy Mountains and Lake Basins Oil	2910	1.2	0.2	-	1.0	0.1	-	-	-	-	-	-	-

Appendix: Inventoried Roadless Areas and Special Designated Areas
Undiscovered Resource Analysis

			Inventoried Roadless Areas						**Special Designated Areas**					
			Natural Gas, Bcf			Petroleum, MMBO			Natural Gas, Bcf			Petroleum, MMBO		
USGS Province	Play	Play code	High	Mean	Low	High	Mean	Low	High	Mean	Low	High	Mean	Low
Williston Basin	Madison (Mississippian)	3101	1.5	0.8	0.1	1.6	0.9	0.1	-	-	-	-	-	-
	Red River (Ordovician)	3102	3.1	1.8	0.2	0.9	0.5	0.1	-	-	-	-	-	-
	Middle and Upper Devonian (Pre-Bakken)	3103	1.0	0.6	0.1	0.4	0.3	0.0	-	-	-	-	-	-
	Pre-Prairie Middle Devonian and Silurian	3105	2.7	1.9	0.2	1.0	0.7	0.1	-	-	-	-	-	-
	Post-Madison through Triassic Clastics	3106	0.1	0.0	0.0	0.2	0.1	0.0	-	-	-	-	-	-
	Pre-Red River Gas	3107	2.9	1.1	0.1	0.1	0.0	-	-	-	-	-	-	-
	Bakken Fairway	3110	13.0	7.9	4.4	14.5	8.9	4.9	-	-	-	-	-	-
	Bakken Intermediate	3111	1.2	0.8	0.4	1.6	1.0	0.6	-	-	-	-	-	-
Powder River Basin	Basin Margin Subthrust	3301	8.0	1.4	-	8.3	1.5	-	-	-	-	-	-	-
	Basin Margin Anticline	3302	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-
	Leo Sandstone	3303	0.2	0.1	-	3.0	0.9	-	-	-	-	-	-	-
	Upper Minnelusa Sandstone	3304	0.1	0.1	0.0	1.8	1.0	0.1	-	-	-	-	-	-
	Lakota Sandstone	3305	0.4	0.2	0.0	0.9	0.4	0.0	0.0	0.0	0.0	-	-	-
	Fall River Sandstone	3306	2.4	1.1	0.1	4.1	1.9	0.2	0.0	0.0	0.0	-	-	-
	Muddy Sandstone	3307	6.6	3.2	0.2	1.3	0.6	0.0	0.0	0.0	0.0	-	-	-
	Deep Frontier Sandstone	3309	5.6	2.6	0.3	1.7	0.8	0.1	-	-	-	-	-	-
	Turner Sandstone	3310	0.2	0.1	0.0	0.2	0.1	0.0	-	-	-	-	-	-
	Sussex-Shannon Sandstone	3312	0.6	0.3	0.0	0.8	0.3	0.0	-	-	-	-	-	-
	Mesaverde-Lewis	3313	0.9	0.4	0.0	0.9	0.4	0.0	-	-	-	-	-	-
Big Horn Basin	Basin Margin Subthrust	3401	28.8	5.8	-	12.4	2.4	-	1.1	0.2	-	-	-	-
	Basin Margin Anticline	3402	1.1	0.5	0.1	0.4	0.2	0.0	0.1	0.1	0.0	-	-	-
	Deep Basin Structure	3403	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-	-
	Sub-Absaroka	3405	1.4	0.6	-	68.6	29.3	2.4	4.8	2.0	-	-	-	-
	Phosphoria Stratigraphic	3406	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-
	Tensleep Paleotopography	3407	0.1	0.0	-	0.8	0.2	-	0.0	0.0	-	-	-	-
	Greybull-Cloverly-Muddy SS Stratigraphy	3408	1.7	0.8	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-	-	-
Wind River Basin	Basin Margin Subthrust	3501	12.8	4.4	0.4	2.9	0.9	0.1	3.4	1.2	0.1	-	-	-
	Basin Margin Anticline	3502	0.1	0.1	0.0	0.0	0.0	0.0	-	-	-	-	-	-
Wyoming Thrust Belt	Moxa Arch Extension	3601	3,354.0	1,568.4	226.3	100.6	47.1	6.9	268.4	132.1	19.5	-	-	-
	Crawford-Meade Thrusts	3602	9.2	3.6	0.3	0.1	0.0	-	-	-	-	-	-	-
	Northern Thrusts	3603	3,134.4	1,508.2	111.9	652.2	310.7	33.7	491.9	240.6	17.9	-	-	-
	Absaroka Thrust	3604	260.6	157.8	9.9	84.0	53.6	3.9	-	-	-	-	-	-
	Hogsback Thrust	3606	4.6	2.3	0.2	0.9	0.4	0.0	-	-	-	-	-	-
	Cretaceous Stratigraphic	3607	0.0	0.0	-	0.2	0.1	0.0	-	-	-	-	-	-
Southwestern WY	Axial Uplift	3703	0.7	0.3	0.1	0.4	0.2	0.0	-	-	-	-	-	-
	Moxa Arch-LaBarge	3704	3.5	1.8	0.1	0.3	0.1	0.0	-	-	-	-	-	-
	Basin Margin Anticline	3705	9.6	3.1	0.3	1.7	0.6	0.1	7.6	2.4	0.2	-	-	-
	Subthrust	3706	44.8	12.8	-	10.8	3.0	-	27.3	7.7	-	-	-	-
	Platform	3707	3.4	1.1	0.2	2.5	0.9	0.2	0.1	0.0	0.0	-	-	-
	Jackson Hole	3708	10.3	3.6	0.8	1.9	0.7	0.1	13.0	4.5	1.0	-	-	-
	Greater Green River Basin - Cloverly-Frontier	3740	1,286.2	565.9	171.8	15.3	6.7	2.1	1,230.9	541.4	164.3	-	-	-
	Greater Green River Basin - Mesaverde	3741	1,651.1	950.1	401.1	16.8	9.7	4.1	295.2	169.8	71.7	-	-	-
	Greater Green River Basin - Fox Hills-Lance	3743	442.8	206.4	64.8	4.4	2.1	0.6	86.1	40.1	12.6	-	-	-
	Greater Green River Basin - Iles	3751	38.1	15.9	-	na	na	na	-	-	-	na	na	na
	Greater Green River Basin - Williams Fork	3752	208.3	134.9	80.3	na	na	na	-	-	-	na	na	na
	Greater Green River Basin - Almond	3753	62.2	30.2	-	na	na	na	-	-	-	na	na	na
	Greater Green River Basin - Lance	3754	11.9	3.8	-	na	na	na	-	-	-	na	na	na
	Greater Green River Basin - Fort Union	3755	83.8	25.4	-	na	na	na	154.0	46.7	-	na	na	na
Park Basins	Cretaceous - Upper Jurassic Structural	3801	2.0	0.7	0.1	3.1	1.2	0.2	0.3	0.1	0.0	-	-	-
	Subthrust	3802	4.7	0.8	-	7.5	1.3	-	1.2	0.2	-	-	-	-
Denver Basin	Dakota Group (Combined J and D Sandstones)	3905	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-
	Permian-Pennsylvanian	3908	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-
Raton Basin - SG Uplift	Upper Cretaceous - Lower Tertiary	4101	2.6	0.9	-	0.1	0.0	-	-	-	-	-	-	-
	Northern Raton Basin	4150	82.6	69.8	42.8	na	na	na	-	-	-	na	na	na
Totals			**23,071**	**11,307**	**3,545**	**1,212**	**550**	**69**	**9,721**	**3,590**	**296**	**1.3**	**0.5**	**0.2**

JAF20071.XLS

na=not assessed (typically a CBM play that would not contain oil)