

## 2.0 METHODOLOGY

The Paradox/San Juan, Uinta/Piceance, Greater Green River, and Powder River basins, and the Montana Thrust Belt, compose the five study areas in this inventory. They were delineated by the aggregation of oil and/or natural gas resource plays<sup>1</sup> in these basins as defined by the USGS National Assessment of Oil and Gas Resources. Resource play boundaries and oil and gas resource estimates within the plays were obtained in GIS format from the USGS. These plays were aggregated in a GIS to create a resource density map layer for each study area.

Land status was compiled from the “Status” dataset from BLM’s land records database to generate GIS maps for the analyses. Oil and gas leasing stipulation data were obtained for each jurisdiction from BLM Field Offices and USDA-FS Offices in the study areas. Most of the data were available in GIS format; some existed only as hardcopy and had to be digitized to create GIS digital map files.

Stipulations attached to oil and gas leases currently in effect are not maintained in an automated system and therefore some existing stipulations may not have been used in this inventory. The stipulations used are primarily those contained in the National Forest Plans and BLM Resource Management Plans in effect as of the date of this inventory (August 2002), and are those applied when new oil and gas leases are issued. To the extent that current leases were issued under, and are stipulated according to an existing land use plan, the inventory reflects an accurate situation. Older leases issued before the relevant plan's effective date may not be stipulated accordingly. To completely characterize stipulations on existing leases, an extensive manual file search would have to be performed. However, it is reasonably accurate to consider the plan stipulations as a proxy, because the environmental conditions that necessitate stipulations often are the driver for conditions of approval that are attached to drilling permits on older leases in order to achieve the needed environmental protection.

The analyses for the EPCA inventory entailed spatial intersection (in a GIS) of oil and gas resource information with data on land status and leasing stipulations. Because stipulations are conditions that are attached to oil and gas leases for environmental protection and other reasons, they are subject to change over time. This inventory represents a "snapshot in time" of the conditions present within the study areas. The inventory also takes into account how leasing stipulations are implemented in practice by Federal land managers by considering the effect of directional drilling and the frequency with which exceptions to the stipulations are granted.

Additional factors that affect oil and gas exploration and development on Federal lands generally cannot be quantified geographically prior to the receipt of a specific drilling application, nor are there requisite data available for quantitative analysis. These include:

- Protection for threatened and endangered species and surveys to determine whether a lease contains habitat for such species;

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<sup>1</sup> A play is a set of known or postulated oil and gas accumulations sharing similar geologic, geographic, or temporal properties (source rock, migration pathway, timing, trapping mechanism, hydrocarbon type, etc.). For the Paradox and Uinta basins, due to overlapping plays, the EPCA study area boundaries were defined by the outline of Uinta plays. The Uinta/Piceance study areas thus contain portions of some Paradox Basin plays.

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- Archaeological reviews required by the National Historic Preservation Act, and related issues involving cultural resources including consultation with Native American tribes;
- Air quality impacts, especially visibility considerations in the Interior West, and resulting restrictions on activities that may affect air quality;
- Visual impacts of oil and gas operations;
- Noise from oil and gas operations;
- Conflicts between oil and gas and other mineral operations, such as coal and potash;
- Suburban encroachment on oil and gas fields and county government restrictions;
- “Sense of Place,” i.e., an emotional or spiritual attachment to certain locations which has been used as justification for designating certain areas as off limits to drilling;

Typically these requirements manifest themselves as conditions of approval attached to drilling permits following a specific analysis under the National Environmental Policy Act (NEPA). These requirements can delay or modify a planned oil and gas development activity at the permit stage and in some cases preclude it altogether. Because these requirements were not easily quantifiable, there were not included in this inventory.

The rest of this section provides a more detailed description of the EPCA inventory methodology.

### **2.1 PROCEDURES FOR COLLECTING AND ANALYZING LAND STATUS AND LEASE STIPULATIONS**

#### **2.1.1 Land Status**

For the EPCA inventory, all Federal lands<sup>2</sup> and split estate<sup>3</sup> within the study areas were examined.

##### *2.1.1.1 Sources of Land Status Data*

Land status carries with it a complex definition involving both ownership and availability of the surface and mineral estates. Inherent in a Federal mineral lease is a limited right of surface use in order to develop the mineral estate. For the purpose of this inventory, land status refers both to Federal ownership of the oil and gas mineral estate and to the availability of the Federal mineral estate for oil and gas leasing.

The source of Federal land status data is the BLM’s Land Status Database. These data, which are stored in alphanumeric format, were converted for this inventory into a GIS layer by using commercially available software. The software interpolated the legal descriptions contained in the Status Database against a public land survey GIS layer derived from either the BLM’s Geographic Coordinate Database (GCDB) or other sources such as digitized USGS 7-1/2 minute quadrangle maps.

##### *2.1.1.2 Land Status Data Preparation*

Maps of the Federal land status for the study areas are presented in figures 2a through 2e. See Appendix 3 for a more detailed description of land status data preparation.

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<sup>2</sup> Indian lands were not included in this inventory.

<sup>3</sup> Federal split estate resources are subject to the same Federal restrictions as those implemented on Federal lands because access to these resources through leasing and permitting is a Federal action.

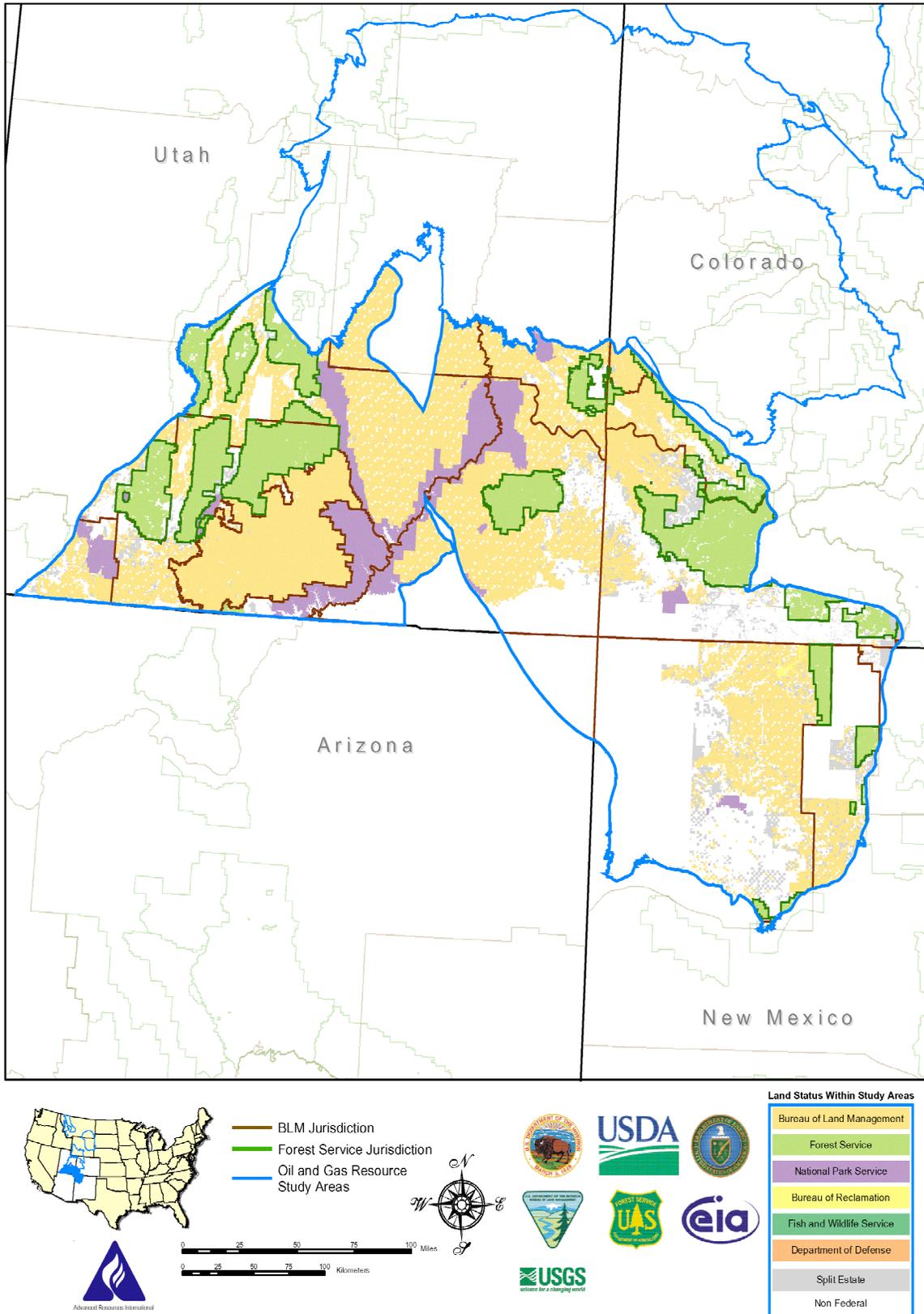
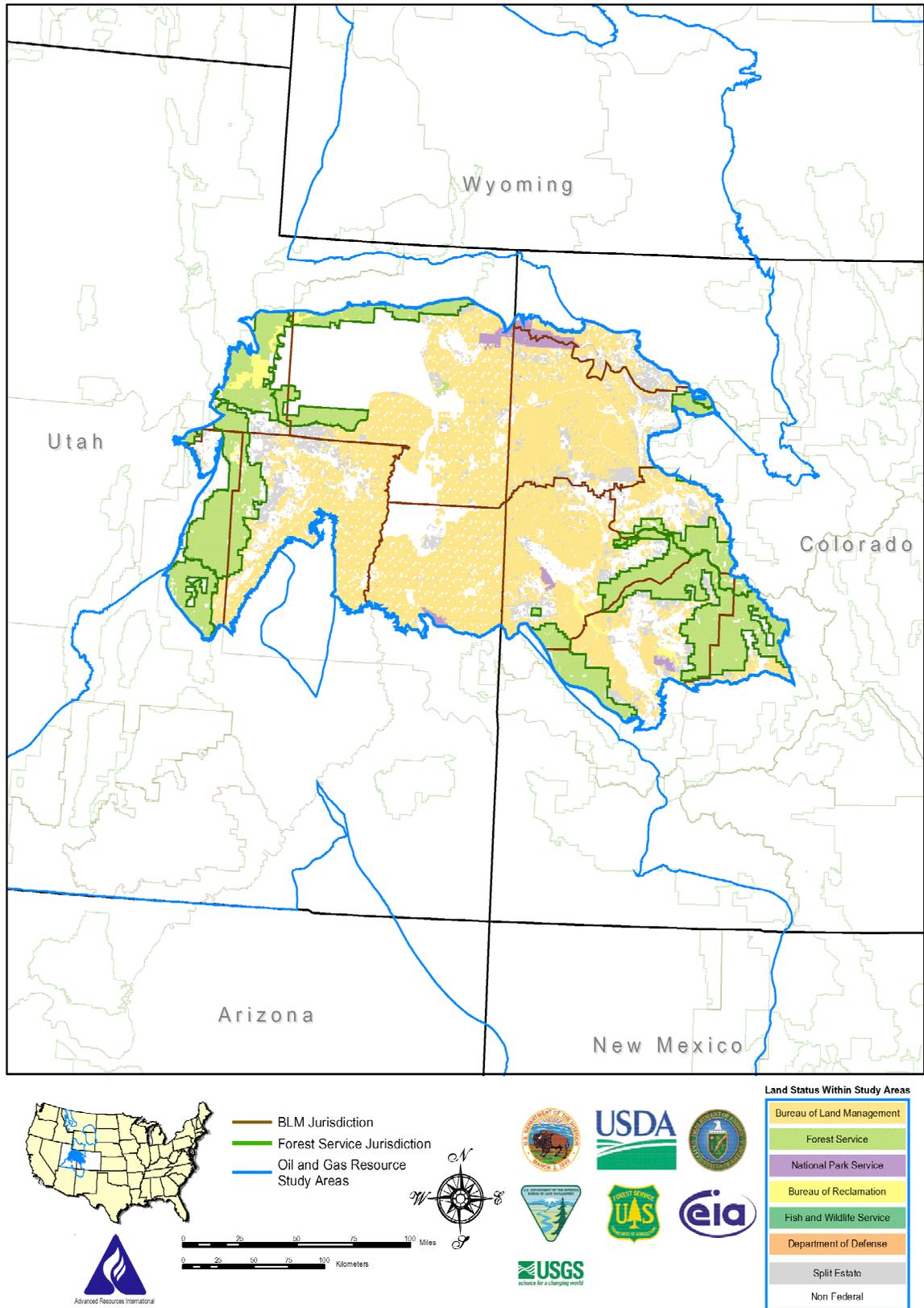


Figure 2a Federal Land Status Map -- Paradox/San Juan Study Area

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**Figure 2b** Federal Land Status Map – Uinta/Piceance Study Area

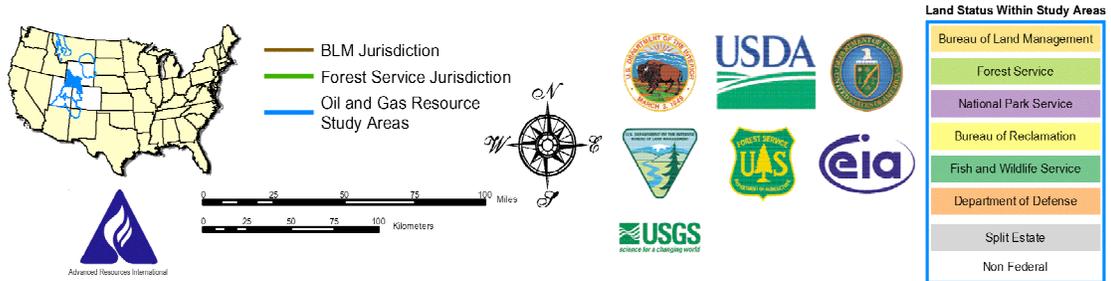
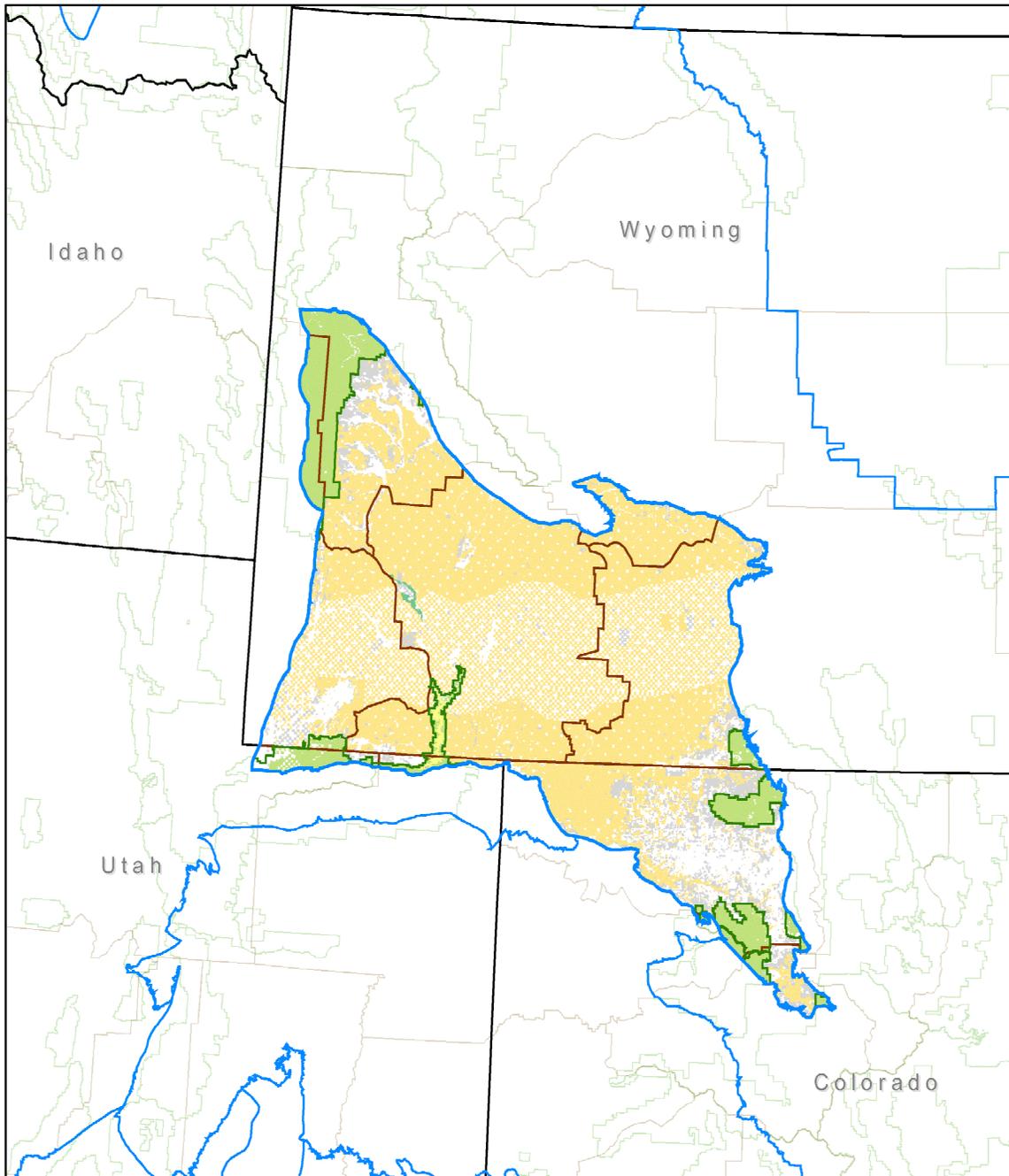
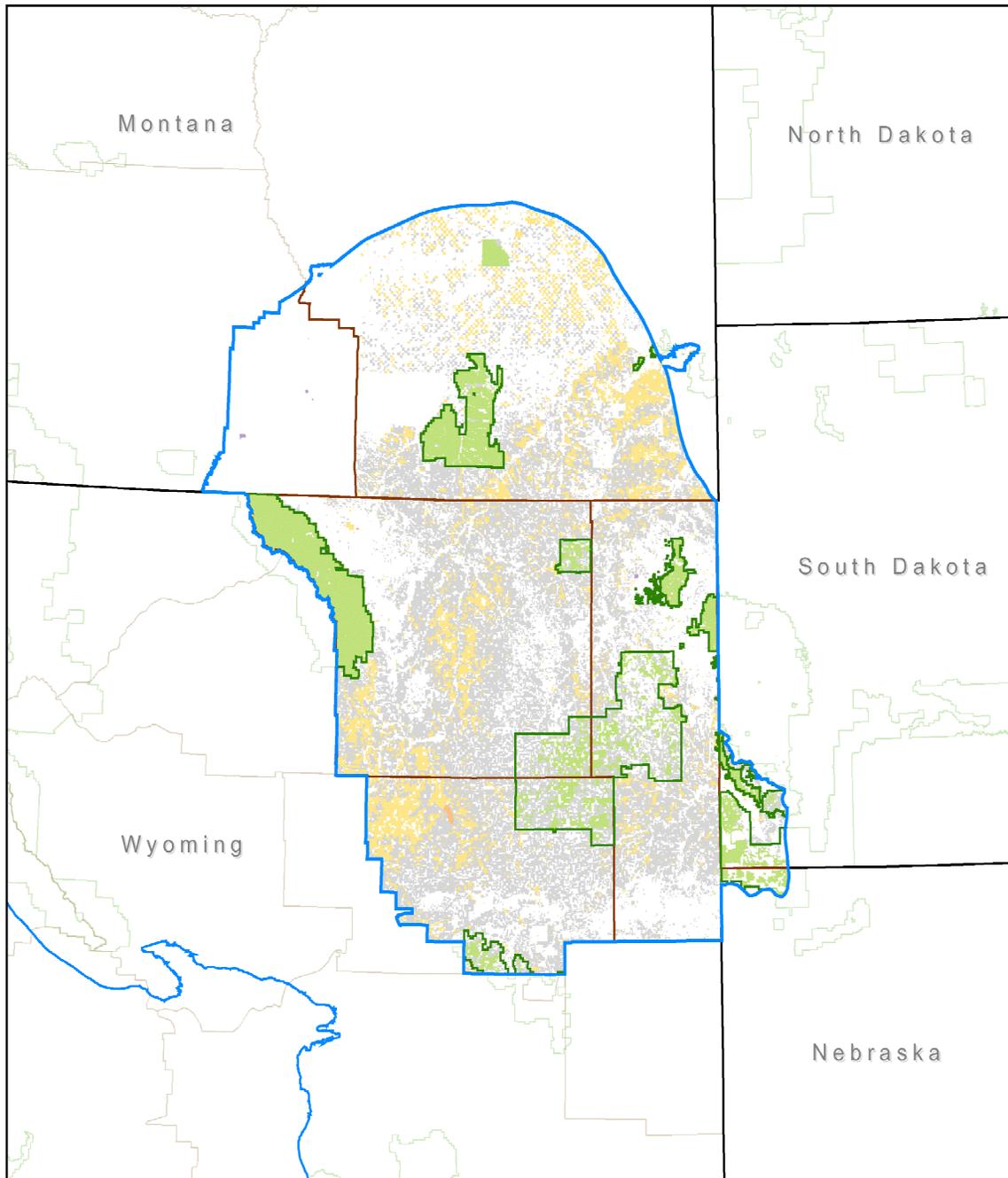
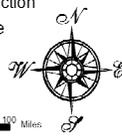


Figure 2c Federal Land Status Map – Greater Green River Study Area

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- BLM Jurisdiction
- Forest Service Jurisdiction
- Oil and Gas Resource Study Areas



Land Status Within Study Areas

Bureau of Land Management
Forest Service
National Park Service
Bureau of Reclamation
Fish and Wildlife Service
Department of Defense
Split Estate
Non Federal

Figure 2d Federal Land Status Map – Powder River Study Area

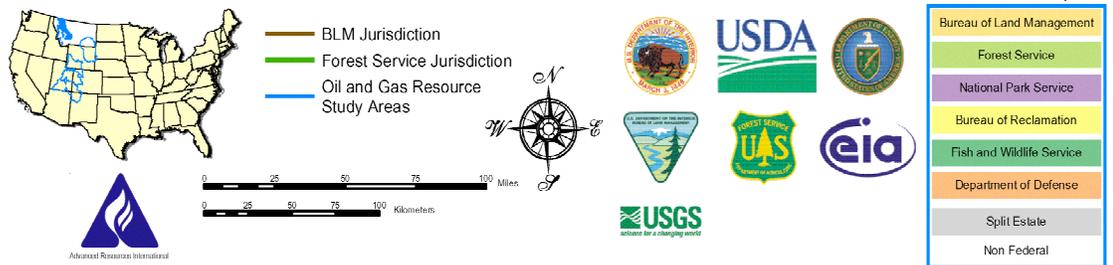
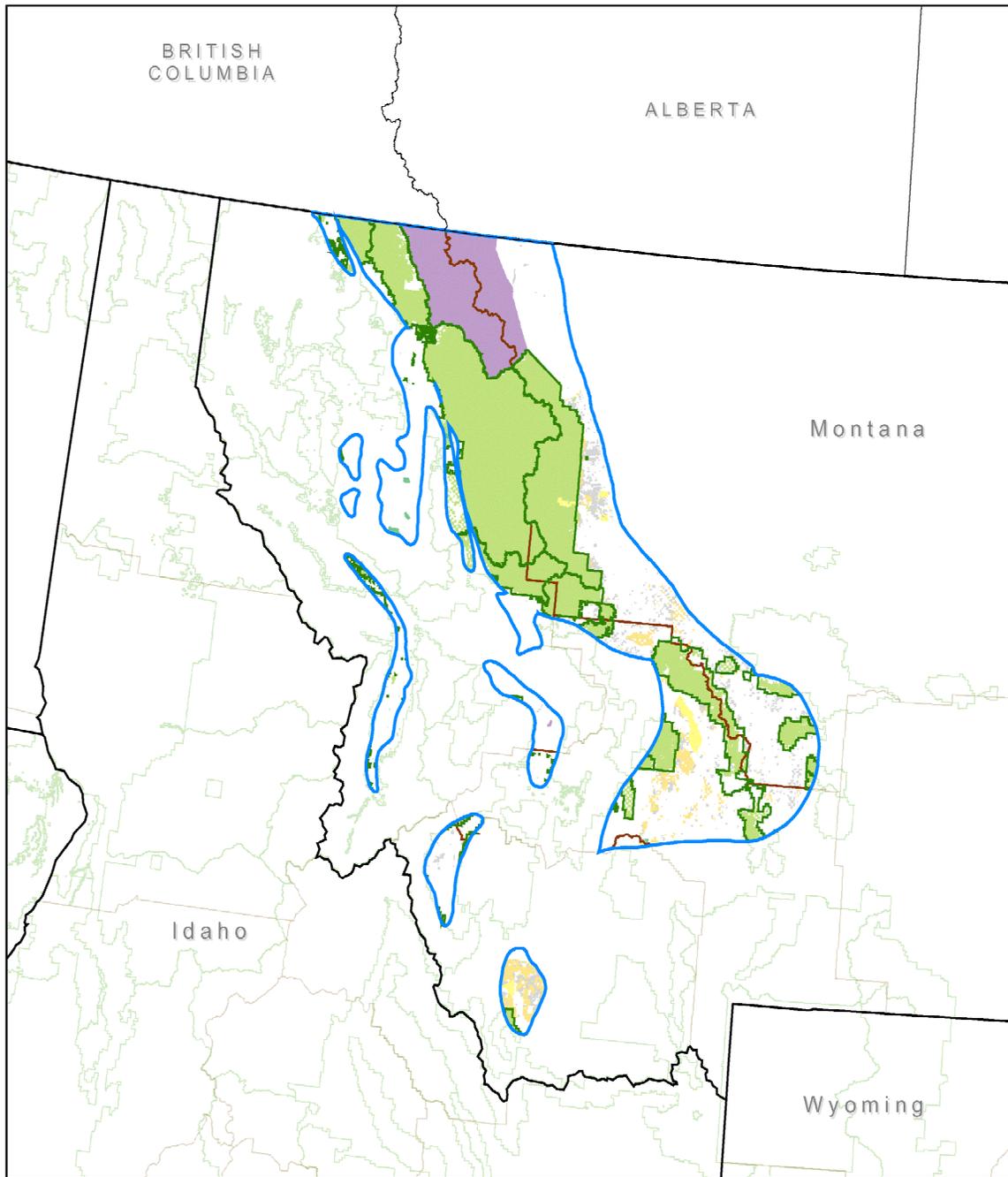


Figure 2e

Federal Land Status Map – Montana Thrust Belt Study Area

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### ***2.1.1.3 Land Status Data-Related Caveats***

The land status data are spatially accurate down to 40 acres. The BLM considers this information complete and up to date as of August 2002.

The GIS files created using the processes described in Appendix 3 were interpolated from the legal land descriptions contained in BLM's Land Record database. If a legal description referenced a small survey lot or tract by number, a nominal location was mapped through a process that referenced the Legal Land Description dataset. This dataset is limited to a 40-acre description and therefore carries a minor degree of generalization in complex areas.

This mapping process uses public land survey data derived from various sources. The spatial location of the land status parcels so derived matches the accuracy of the survey data.

### **2.1.2 Lease Stipulations**

All Federal onshore oil and gas leases contain terms and conditions specified in the standard Federal lease form. Some of these terms and conditions govern land use and resource development to a certain extent. Environmental and other considerations, which are identified during the land use planning process, determine the need for additional terms and conditions, also known as stipulations. For example, a lease may contain a stipulation that prohibits surface disturbance where land slopes exceed 35 percent. These stipulations may represent constraints to the exploration for and development of oil and natural gas on Federal lands.

#### ***2.1.2.1 Sources of Lease Stipulation Data***

Oil and gas lease stipulations are derived from the surface management agency's land use plans. The BLM's planning documents are referred to as Resource Management Plans (RMPs); the USDA-Forest Service's are referred to as Forest Plans. These plans are produced and generally maintained by their respective agencies on a Field Office jurisdictional basis (in the case of the BLM), or on a National Forest/Grassland basis (in the case of the USDA-FS).

Most of the lease stipulation data are maintained by the agencies as GIS data layers (digital map files). Some offices, particularly where the planning effort pre-dated the widespread availability of GIS technology, still maintain this information in the form of hardcopy maps. These maps were digitized, stored, and analyzed as GIS layers for this inventory.

Hard copy and digital data showing the mapped lease stipulation areas were collected from BLM and Forest Service offices within the study areas (listed in Table 1a). Copies of guidance documents, such as RMPs and Forest Plans, were also obtained. Appendix 8 lists the guidance documents used in this inventory, and Appendix 9 (available on CD-ROM or website only) lists the actual stipulations themselves.

For the Paradox/San Juan, Powder River, and Montana Thrust Belt study areas, data were collected in the winter of 2001-2002. For the Uinta/Piceance study area, data were collected in the fall of 2001. For the Greater Green River (GGR) study area, data were used from the DOE's

Federal lands analysis<sup>10</sup> collected during the fall and winter of 2000-2001; these data were verified with the local BLM and USDA-FS offices and are current as of August 2002.

#### *2.1.2.2 Lease Stipulation Data Preparation*

The bulk of the data preparation consisted of the gathering, digitizing, and compiling of the gathered data in multi-layered digital map files. Federal Geographic Data Committee Standards (FGDC)-compliant supporting documentation (metadata) for the resulting GIS layers were also created<sup>11</sup>.

This inventory is limited to those Federal lands within the aggregate resource play boundaries of the five study areas, which are based on geology as defined in the USGS National Assessment of Oil and Gas Resources. The land status and stipulation digital map files, which corresponded to Federal land management agency jurisdiction boundaries, were cut to fit within each of the study area boundaries using the GIS. Data contained within the compiled digital map files were then queried for unique leasing stipulation values. The results were then saved as separate map files. Each digital map file represents a unique stipulation value.

For an example of the specific data preparation steps, see Appendix 4.

#### *2.1.2.3 Lease Stipulation Data-Related Caveats*

All stipulations for which GIS data were available from the Federal land management agencies were used in the analysis. A majority of the stipulations within the study areas were available in GIS data formats. However, supporting documentation was not generally provided with GIS files. This can lead to inaccuracies due to undocumented differences in technical parameters. Any such errors are minor in terms of the scope of the inventory.

Stipulations not available in GIS format were digitized and any resulting inaccuracies have only minor effects upon the analysis.

In a few cases neither hardcopy nor digital maps were available for certain stipulations. The result is that the ensuing analyses may underestimate the extent of restrictions on land access. This occurred for less than 10 percent of the stipulations.

The lease stipulation data are generally accurate to 40 acres. The information is considered complete and up to date as of August 2002.

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<sup>10</sup> Federal Lands Analysis, Natural Gas Assessment, Southern Wyoming and Northwestern Colorado, Study Methodology and Results, June 2001, available on the DOE website:  
[http://fossil.energy.gov/techline/tl\\_ggrb\\_gas.shtml](http://fossil.energy.gov/techline/tl_ggrb_gas.shtml).

<sup>11</sup> GIS layers from surface management agency land status, stipulations, and the analyses, as well as the associated metadata, are available on the CD-ROMs and the web sites.

## 2.2 PROCEDURES FOR COLLECTING AND ANALYZING OIL AND GAS RESOURCE DATA

### 2.2.1 Sources of Oil and Gas Resource Data

In conformance with EPCA, the volumes of undiscovered technically recoverable oil and gas resources in each oil and gas play are supplied exclusively by the USGS.

#### **Oil and gas resources occur in four categories:**

The *In-place resource* is the total volume of oil and gas thought to exist (both discovered and yet-to-be discovered) without regard to the ability to either access or produce it. Although the in-place resource is primarily a fixed, unchanging volume, the current understanding of that volume is continually changing as technology improves.

*Technically recoverable resources* are a subset of the in-place resource that includes only that oil and gas (both discovered and undiscovered) that is expected to be producible given *available* technology with no regard to current costs. Technically-recoverable resources are therefore dynamic, constantly changing to reflect our increased understanding of both the in-place resource as well as the likely nature of future technology.

*Economically recoverable resources* are a subset of the technically recoverable that includes only that oil and gas that is expected to be producible at a profit. This is a very dynamic category, changing not only with increasing knowledge and technology, but also with the rapid and sometimes unpredictable changes in economic conditions, prices, and regulation.

*Reserves* are oil and gas that has been proven by drilling and is available for profitable production. Reserves are also subject to economic conditions.

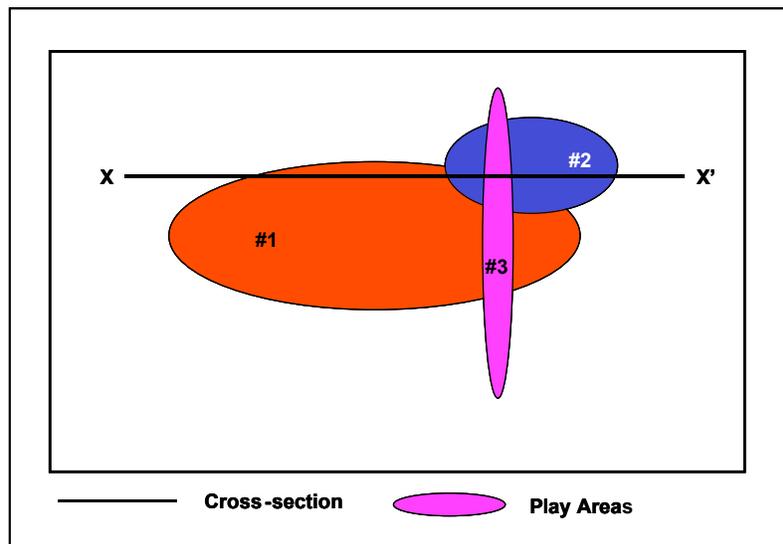
Technically recoverable resources are those hydrocarbon resources that, on the basis of geologic information and theory, are estimated to exist outside of known producing fields. This class of hydrocarbon resources is that which can be produced using current technology but without regard to economic profitability. Technically recoverable resources are the subset of resources-in-place that could be expected to be recovered over an exploration and development life cycle measured in decades.

An economic analysis of the undiscovered technically recoverable resources would require a number of assumptions about future costs of exploration and development, transportation and infrastructure that can change significantly with time. Such an analysis is a subjective exercise, and is not appropriate for Federal land use decisions or allocation. An economic analysis on a project-specific basis is most appropriate when used by the private sector in its decision making process.

The resources included in this study comprise oil, natural gas liquids (NGLs), associated dissolved (AD) natural gas, non-associated (NA) natural gas and liquids in gas reservoirs. Oil is a natural liquid of mostly hydrocarbon molecules. NGLs are liquid when produced to the surface but exist in the gas phase in the subsurface. Natural gas is a mixture of hydrocarbon gases consisting primarily of methane. Associated dissolved natural gas is that produced from oil fields, whereas non-associated natural gas is that produced "dry" from gas fields. The USGS assesses technically recoverable resources for each of these resource types, and those volumes were provided for this effort. However, for this inventory, undiscovered oil, NGL, and liquids

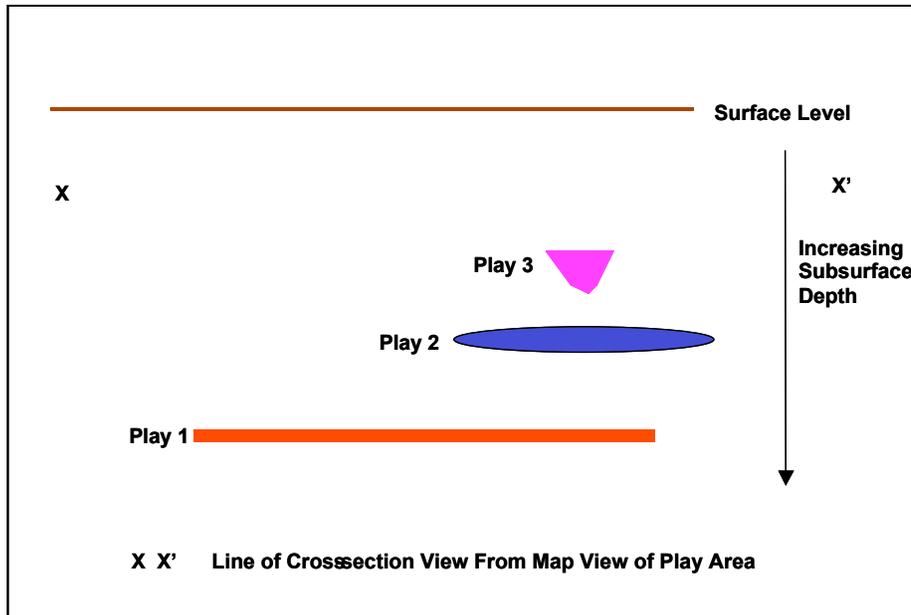
associated with natural gas reservoirs were subsequently merged into a single "Total Liquids" resource category (table 2a).

The USGS uses the resource "play" as the unit of assessment. A play is defined by a set of common geological conditions (source rock, migration, charge, traps, seals, etc.) that characterize a group of hydrocarbon accumulations in the subsurface. The USGS specifically states in the assessment process that resource volumes are not homogeneously distributed within a play. However, a homogeneous distribution of resource within a play boundary is assumed for the GIS analysis in this inventory in the absence of more specific information. Nonetheless, variation in the vertical sense is captured by the use of play stacking. The geometry of a resource play is defined by geological environments and has horizontal and vertical expression. The areal extent of resource plays is represented in map view (figure 2f) by vertically projecting their subsurface locations to the surface. In cross-section, the relative depths of individual plays are represented in figure 2g. The plays are commonly "stacked" in the subsurface so that a given surface land parcel can overlie numerous plays.



*Figure 2f*      *Map View of Resource Plays*

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*Figure 2g Cross Section of Resource Plays*

In this inventory, there are two resource play types: conventional and continuous (unconventional, which includes coalbed gas). Conventional plays contain discrete hydrocarbon accumulations often associated with hydrocarbon/water contacts. Continuous plays exist as pervasive accumulations that can cross rock unit boundaries, lack discrete borders and exhibit other atypical reservoir properties (figure 2h). The majority of the resources in the study areas are continuous in nature. Compared to conventional plays, continuous accumulations typically are more geographically extensive.

Coalbed methane (CBM), also known as coalbed natural gas, is natural gas from coal beds and is one form of continuous play. Coalbed natural gas resources are the second largest resource component in this inventory.

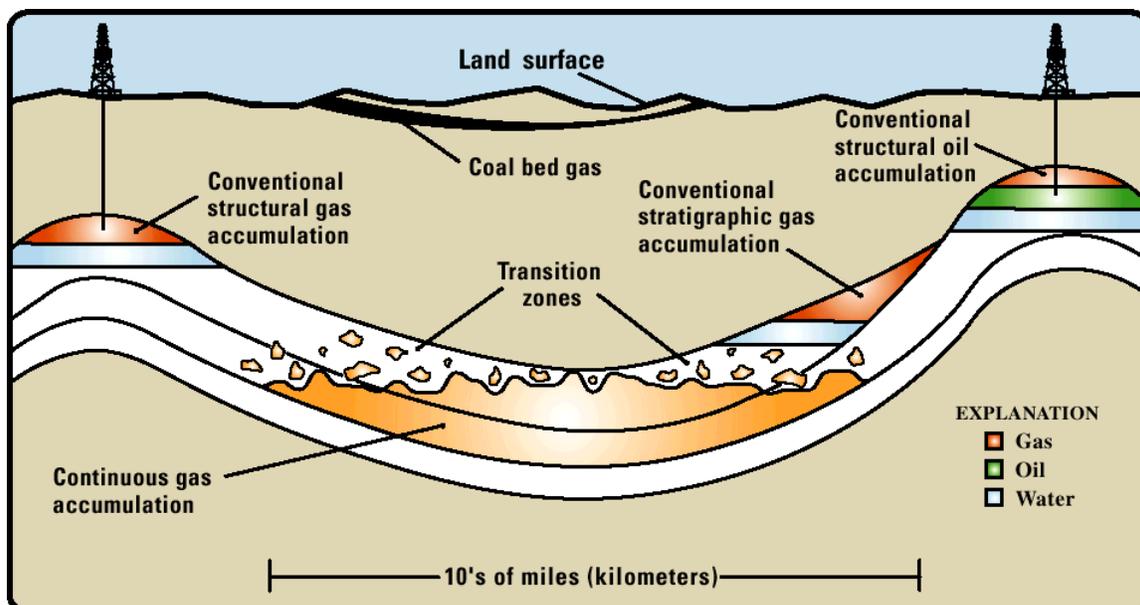


Figure 2h. Conventional vs. Continuous Accumulations

## 2.2.2 Oil and Gas Resource Data Preparation

The USGS identified eighty-eight discrete plays of oil and natural gas resources in the EPCA inventory areas. The mean probabilistic estimates of hydrocarbon resource volumes for each USGS-defined play were utilized for this inventory (Table 2a).

For this inventory, an important simplifying assumption was made that the oil and gas resources are evenly distributed within each resource play area. Therefore, resource volume is calculated to be proportional to surface area within each play. A resource density map for each basin was created in the GIS by a spatial summation of the oil and gas volumes contributed by each resource play. The densities are expressed as thousand cubic feet (MCF) of gas per acre and barrels (BBL) of oil per acre.

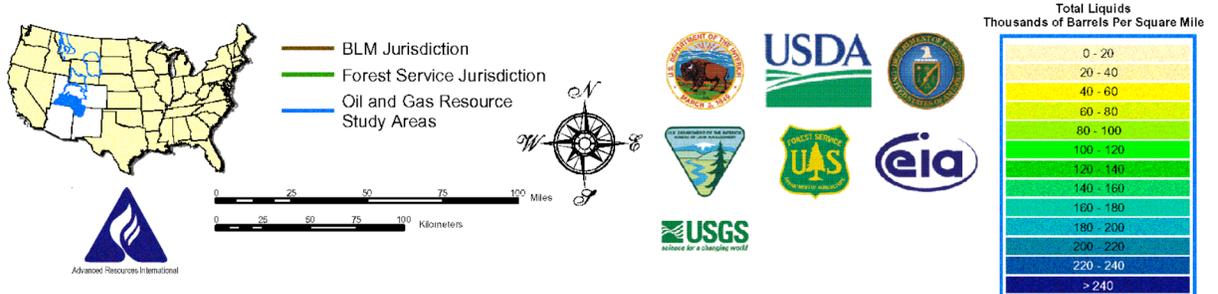
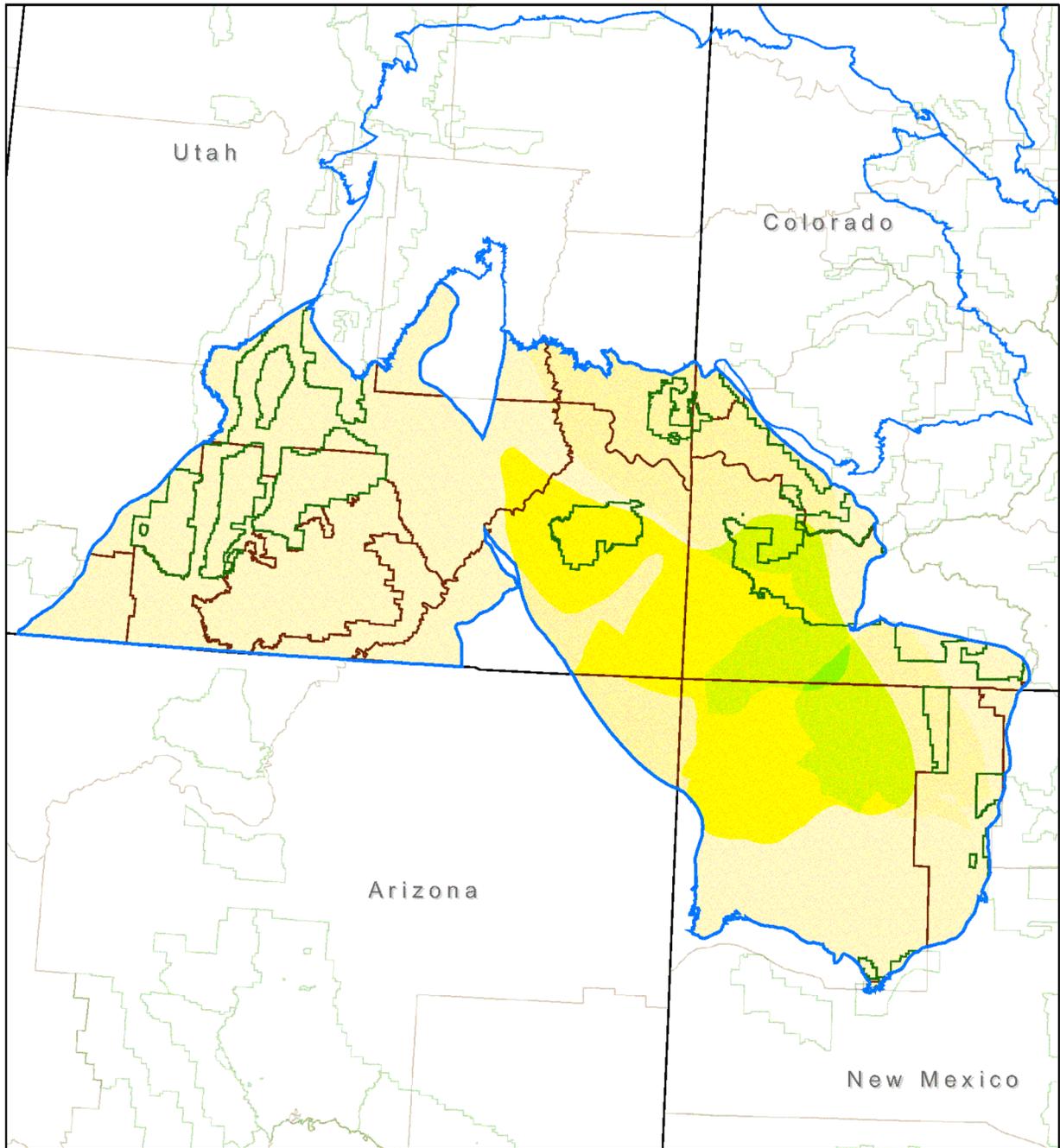
The products of the oil and gas resource data preparation work are maps of hydrocarbon volumes, projected to the surface. These maps depict areas of varying potential resource richness based on play resource volumes and play stacking. The distributions of undiscovered technically recoverable resources are shown by study area for liquids in figures 2i through 2m and for gas in figures 2n through 2r. See Appendix 5 for a more detailed description of the USGS methodology for the assessment and allocation of undiscovered oil and gas resources.

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USGS Province Name	USGS Code	USGS Play or Assessment Unit Name	Play Type	Total Liquids** (MMBbl)	Total Natural Gas*** (Bcf)
Paradox Basin	2101	Buried Fault Blocks, Older Paleozoic	Conventional	62	292
Paradox Basin	2102	Porous Carbonate Buildup	Conventional	192	482
Paradox Basin	2103	Fractured Interbed	Continuous	242	194
Paradox Basin	2104	Permian-Pennsylvanian Marginal Clastics	Conventional	3	56
Paradox Basin	2105	Salt Anticline Flank	Conventional	20	396
Paradox Basin	2106	Permo-Triassic Unconformity	Conventional	21	2
Paradox Basin	2107	Cretaceous Sandstone	Conventional	1	58
San Juan Basin	50220101	Tertiary Conventional Gas	Conventional	1	80
San Juan Basin	50220161	Pictured Cliffs Continuous Gas	Continuous Gas	17	5,640
San Juan Basin	50220181	Fruitland Fairway Coalbed Gas	Coalbed Gas	3	3,981
San Juan Basin	50220182	Basin Fruitland Coalbed Gas	Coalbed Gas	3	19,595
San Juan Basin	50220261	Lewis Continuous Gas	Continuous Gas	31	10,177
San Juan Basin	50220302	Gallup Sandstone Conventional Oil and Gas	Conventional	2	<.5
San Juan Basin	50220303	Mancos Sandstones Conventional Oil	Conventional	14	58
San Juan Basin	50220304	Dakota-Greenhorn Conventional Oil and Gas	Conventional	3	22
San Juan Basin	50220361	Mesaverde Central-Basin Continuous Gas	Continuous Gas	5	1,317
San Juan Basin	50220362	Mancos Sandstones Continuous Gas	Continuous Gas	76	5,116
San Juan Basin	50220363	Dakota-Greenhorn Continuous Gas	Continuous Gas	16	3,929
San Juan Basin	50220381	Menefee Coalbed Gas	Coalbed Gas	3	664
San Juan Basin	50220401	Entrada Sandstone Conventional Oil	Conventional	3	6
Uinta - Piceance Basin	50200101	Conventional Ferron Sandstone Gas	Conventional	<.5	40
Uinta - Piceance Basin	50200161	Deep (6,000 feet plus) Coal and Sandstone Gas	Continuous Gas	1	59
Uinta - Piceance Basin	50200181	Northern Coal Fairway/Drunkards Wash	Coalbed Gas	1	752
Uinta - Piceance Basin	50200182	Central Coal Fairway/Buzzards Bench	Coalbed Gas	1	537
Uinta - Piceance Basin	50200183	Southern Coal Fairway	Coalbed Gas	1	153
Uinta - Piceance Basin	50200184	Joes Valley and Messina Grabens	Coalbed Gas	1	NA
Uinta - Piceance Basin	50200185	Southern Coal Outcrop	Coalbed Gas	1	11
Uinta - Piceance Basin	50200201	Uinta-Piceance Basin Conventional Gas	Conventional	1	66
Uinta - Piceance Basin	50200261	Uinta Basin Continuous Gas Mesaverde TPS	Continuous Gas	11	7,391
Uinta - Piceance Basin	50200262	Uinta Basin Transitional Gas	Continuous Gas	2	1,493
Uinta - Piceance Basin	50200263	Piceance Basin Continuous Gas Mesaverde TPS	Continuous Gas	9	3,064
Uinta - Piceance Basin	50200264	Piceance Basin Transitional Gas	Continuous Gas	1	302
Uinta - Piceance Basin	50200281	Uinta Basin Blackhawk Coalbed Gas	Coalbed Gas	1	499
Uinta - Piceance Basin	50200282	Mesaverde Group Coalbed Gas	Coalbed Gas	1	368
Uinta - Piceance Basin	50200361	Piceance Basin Continuous Gas Mancos/Mowry TPS	Continuous Gas	2	1,653
Uinta - Piceance Basin	50200362	Uinta Basin Continuous Gas Mancos/Mowry TPS	Continuous Gas	6	3,111
Uinta - Piceance Basin	50200363	Uinta-Piceance Transitional and Migrated Gas	Continuous Gas	2	1,755
Uinta - Piceance Basin	50200401	Hanging Wall	Conventional	5	28
Uinta - Piceance Basin	50200402	Paleozoic/Mesozoic	Conventional	8	50
Uinta - Piceance Basin	50200501	Uinta Green River Conventional Oil and Gas	Conventional	11	29
Uinta - Piceance Basin	50200502	Piceance Green River Conventional Oil	Conventional	NA	NA
Uinta - Piceance Basin	50200561	Deep Uinta Overpressured Continuous Oil	Continuous Oil	43	64
Southwestern Wyoming	50370101	Sub-Cretaceous Conventional Oil and Gas	Conventional	58	1,383
Southwestern Wyoming	50370201	Mowry Conventional Oil and Gas	Conventional	12	206
Southwestern Wyoming	50370401	Hilliard-Baxter-Mancos Conventional O&G	Conventional	1	15
Southwestern Wyoming	50370501	Mesaverde Conventional Oil and Gas	Conventional	3	56
Southwestern Wyoming	50370601	Mesaverde-Lance-Fort Union Conventional O&G	Conventional	17	320
Southwestern Wyoming	50370701	Lewis Conventional Oil and Gas	Conventional	8	195
Southwestern Wyoming	50370801	Lance-Fort Union Conventional Oil and Gas	Conventional	2	246
Southwestern Wyoming	50370361	Niobrara Continuous Oil	Continuous Oil	107	62
Southwestern Wyoming	50370261	Mowry Continuous Gas	Continuous Gas	171	8,543
Southwestern Wyoming	50370461	Hilliard-Baxter-Mancos Continuous Gas	Continuous Gas	752	11,753
Southwestern Wyoming	50370561	Almond Continuous Gas	Continuous Gas	200	13,350
Southwestern Wyoming	50370562	Rock Springs-Ericson Continuous Gas	Continuous Gas	146	12,178
Southwestern Wyoming	50370661	Mesaverde-Lance-Fort Union Continuous Gas	Continuous Gas	614	13,635
Southwestern Wyoming	50370761	Lewis Continuous Gas	Continuous Gas	541	13,536
Southwestern Wyoming	50370861	Lance-Fort Union Continuous Gas	Continuous Gas	76	7,583
Southwestern Wyoming	50370581	Mesaverde Coalbed Gas	Coalbed Gas	1	249
Southwestern Wyoming	50370681	Mesaverde Coalbed Gas	Coalbed Gas	1	27
Southwestern Wyoming	50370682	Fort Union Coalbed Gas	Coalbed Gas	1	81
Southwestern Wyoming	50370881	Lance Coalbed Gas	Coalbed Gas	1	165
Southwestern Wyoming	50370882	Fort Union Coalbed Gas	Coalbed Gas	1	943
Southwestern Wyoming	50370981	Wasatch-Green River Coalbed Gas	Coalbed Gas	1	65
Powder River Basin	3301	Basin Margin Subthrust	Conventional	21	20
Powder River Basin	3302	Basin Margin Anticline	Conventional	7	4
Powder River Basin	3303	Leo Sandstone	Conventional	81	5
Powder River Basin	3304	Upper Minnelusa Sandstone	Conventional	522	31
Powder River Basin	3305	Lakota Sandstone	Conventional	55	22
Powder River Basin	3306	Fall River Sandstone	Conventional	200	115
Powder River Basin	3307	Muddy Sandstone	Conventional	88	449
Powder River Basin	3309	Deep Frontier Sandstone	Conventional	58	193
Powder River Basin	3310	Turner Sandstone	Conventional	25	32
Powder River Basin	3312	Sussex-Shannon Sandstone	Conventional	72	54
Powder River Basin	3313	Mesaverde-Lewis	Conventional	62	58
Powder River Basin	50330101	E. Basin Margin Upper Fort Union Sandstone	Conventional	1	27
Powder River Basin	50330181	Wasatch Formation	Coalbed Gas	1	1,934
Powder River Basin	50330182	Upper Fort Union Formation	Coalbed Gas	1	12,132
Powder River Basin	50330183	Lower Fort Union-Lance Formations	Coalbed Gas	1	198
Powder River Basin	50330261	Mowry Continuous Oil Assessment Unit	Continuous Oil	209	198
Powder River Basin	50330361	Niobrara Continuous Oil Assessment Unit	Continuous Oil	240	227
Powder River Basin	50330461	Shallow Continuous Biogenic Gas AU	Continuous Gas	1	787
Montana Thrust Belt	50270101	Thrust Belt Conventional Gas and Oil	Conventional	134	5,761
Montana Thrust Belt	50270102	Sawtooth Range Structure Conventional O&G	Conventional	18	795
Montana Thrust Belt	50270103	Frontal Structures Conventional Oil and Gas	Conventional	68	1,192
Montana Thrust Belt	50270201	Helena Salient Conventional Oil and Gas	Conventional	15	639
Montana Thrust Belt	50270401	Blacktail Salient Conventional Oil and Gas	Conventional	6	16
Montana Thrust Belt	50270561	Marias River Shale Continuous Oil	Continuous Oil	33	111
Montana Thrust Belt	50270701	Tertiary Basins Oil and Gas	Conventional	73	124
Totals				5,510	183,204

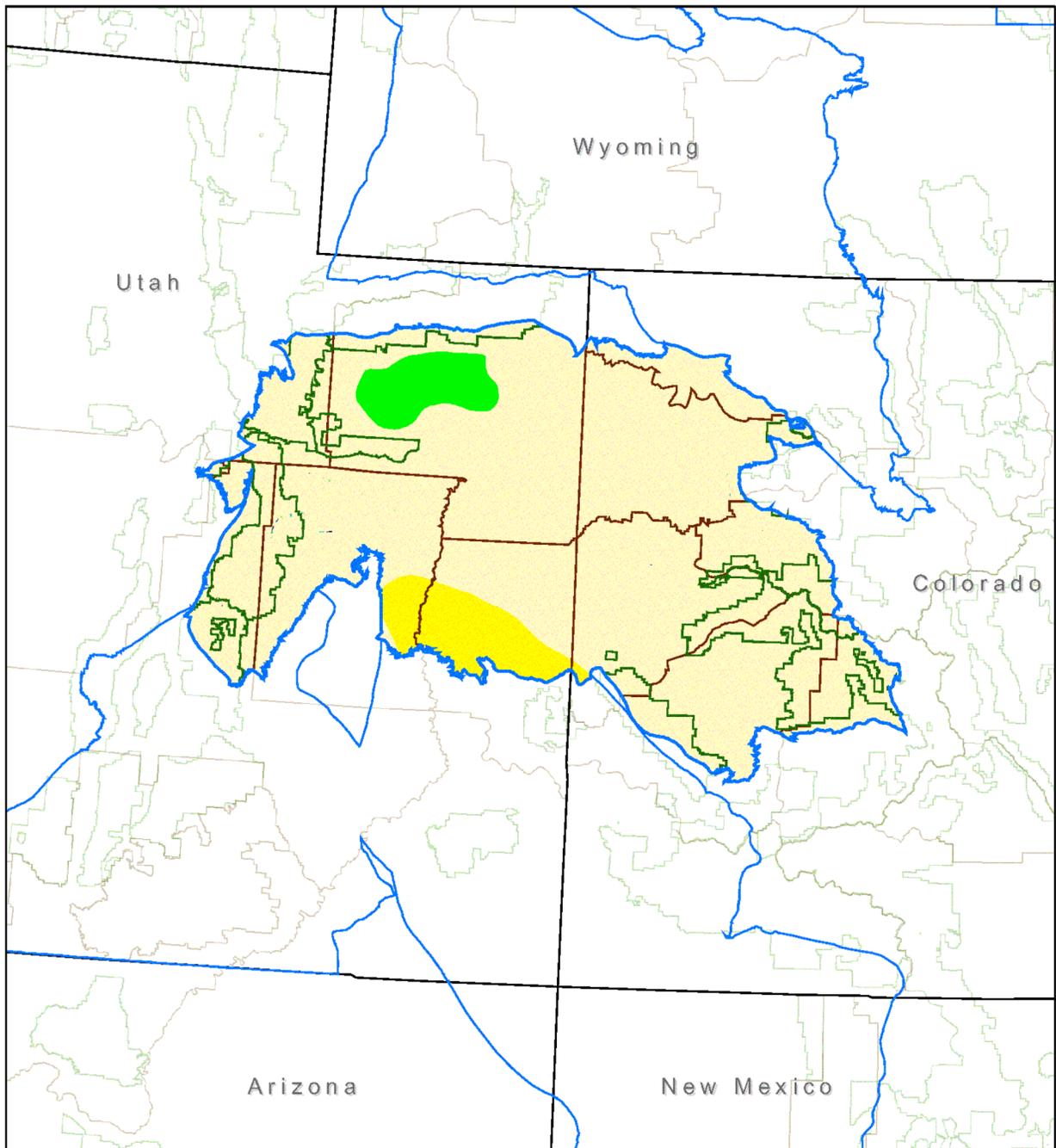
\* All values are mean resource values from the USGS National Assessment of Oil and Gas Resources (assessment unit resources from the 2002 Update; play resources from the

NA -- not assessed

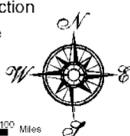


**Figure 2i** Total Liquids Map – Paradox/San Juan Study Area

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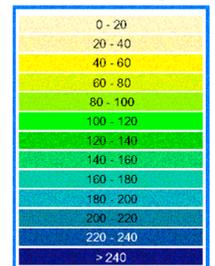
- BLM Jurisdiction
- Forest Service Jurisdiction
- Oil and Gas Resource Study Areas



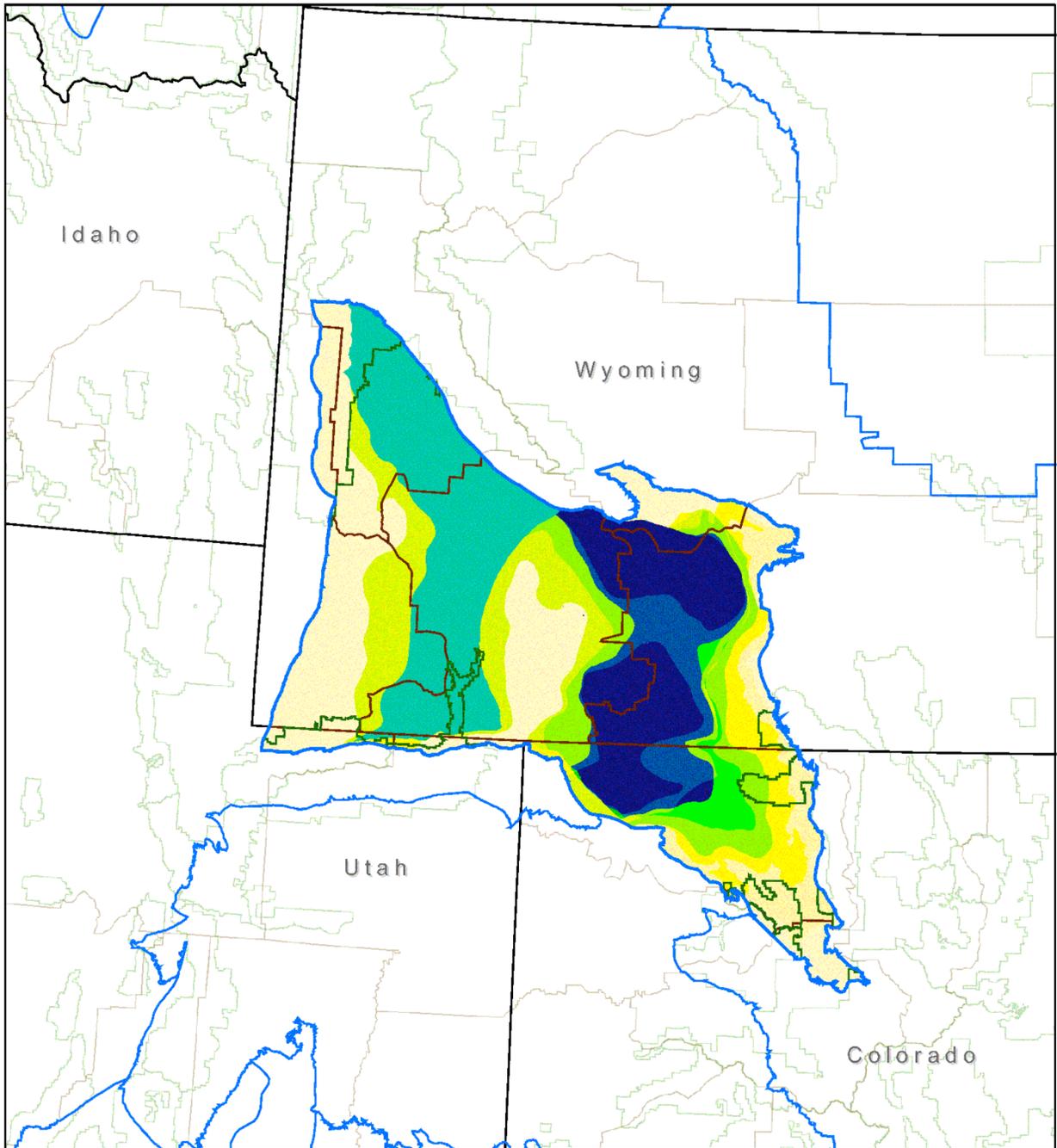
0 25 50 75 100 Miles  
0 25 50 75 100 Kilometers



Total Liquids  
Thousands of Barrels Per Square Mile



**Figure 2j Total Liquids Map – Uinta/Piceance Study Area**



- BLM Jurisdiction
- Forest Service Jurisdiction
- Oil and Gas Resource Study Areas

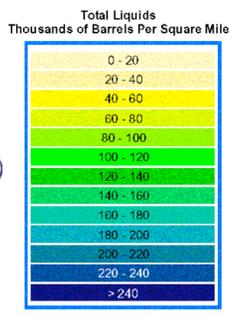
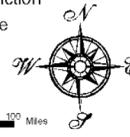
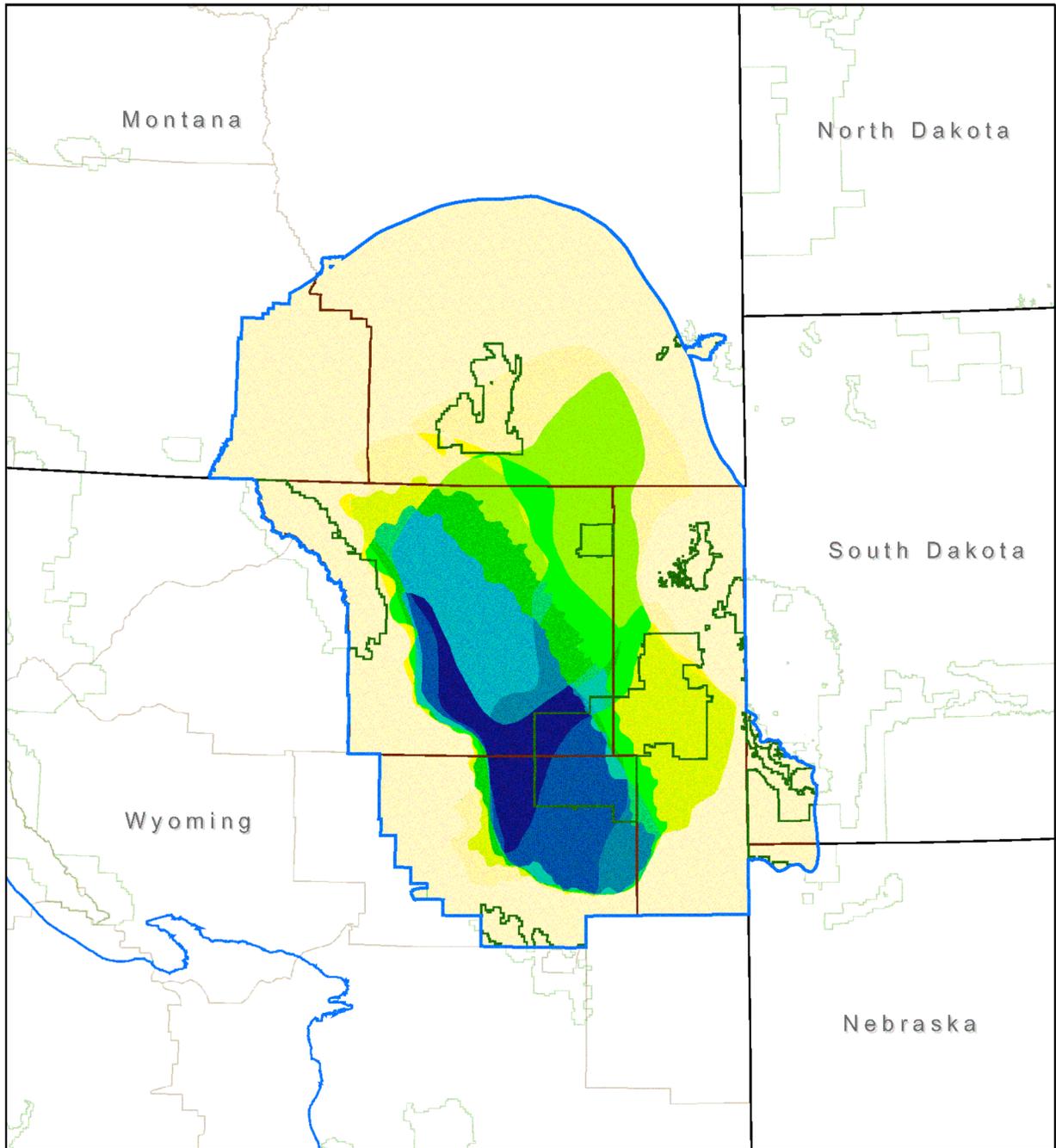
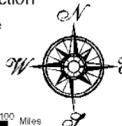


Figure 2k Total Liquids Map – Greater Green River Study Area

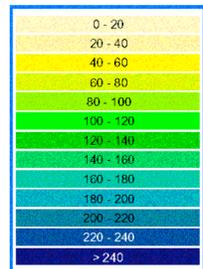
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-  BLM Jurisdiction
-  Forest Service Jurisdiction
-  Oil and Gas Resource Study Areas



Total Liquids  
Thousands of Barrels Per Square Mile



**Figure 21** Total Liquids Map – Powder River Study Area

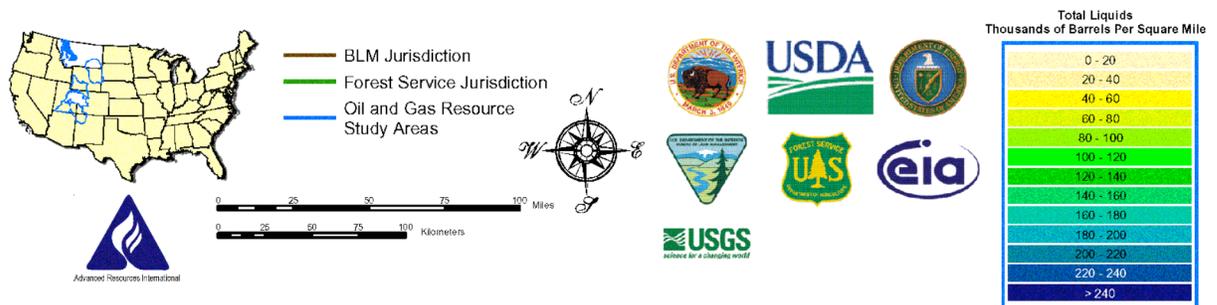
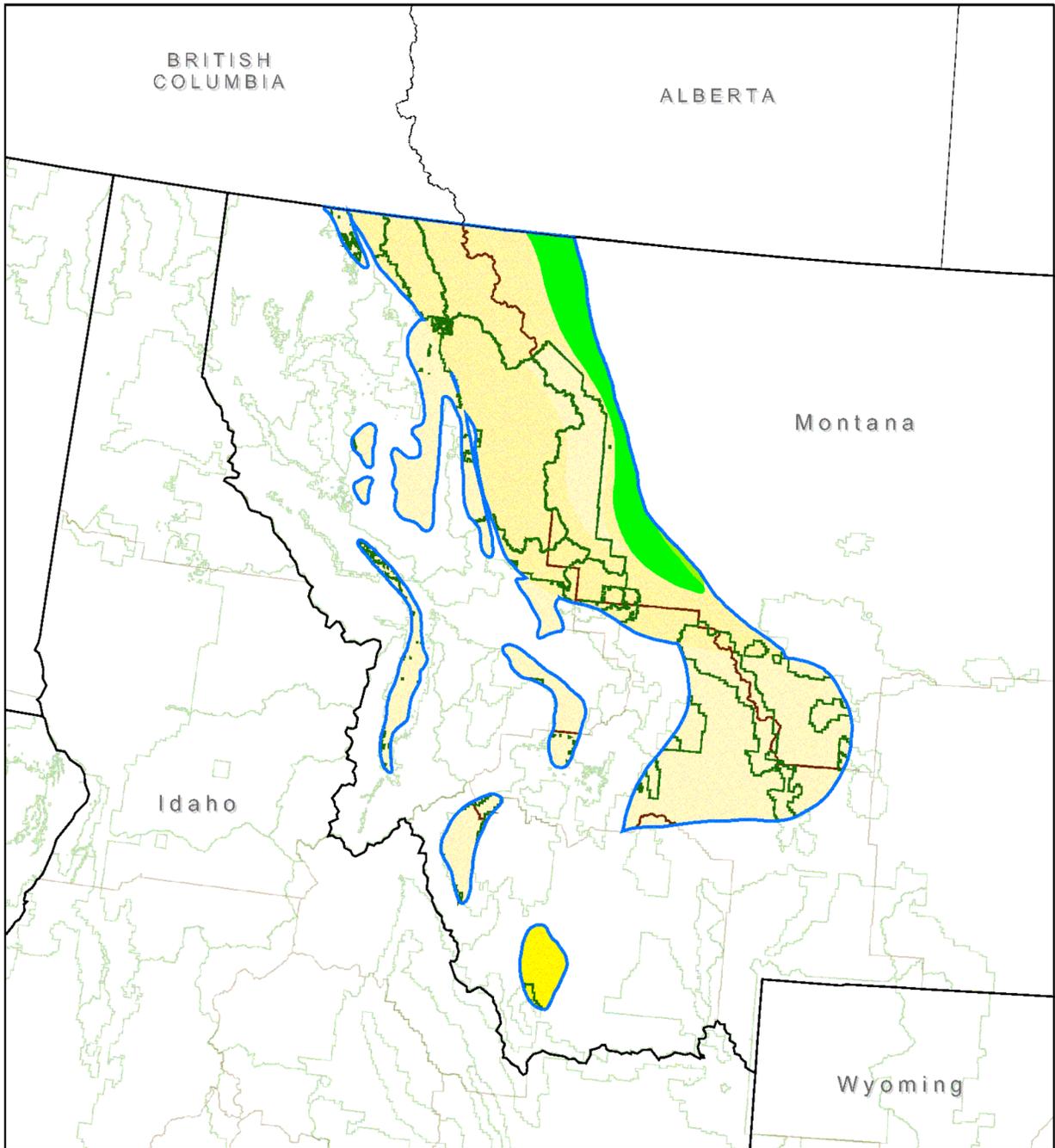
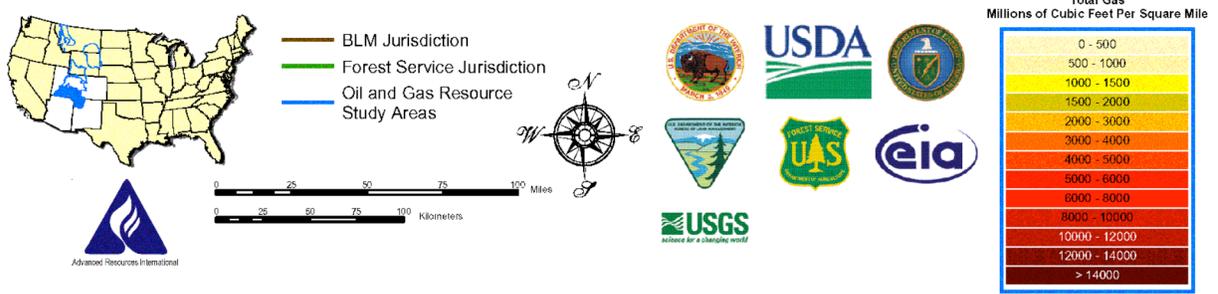
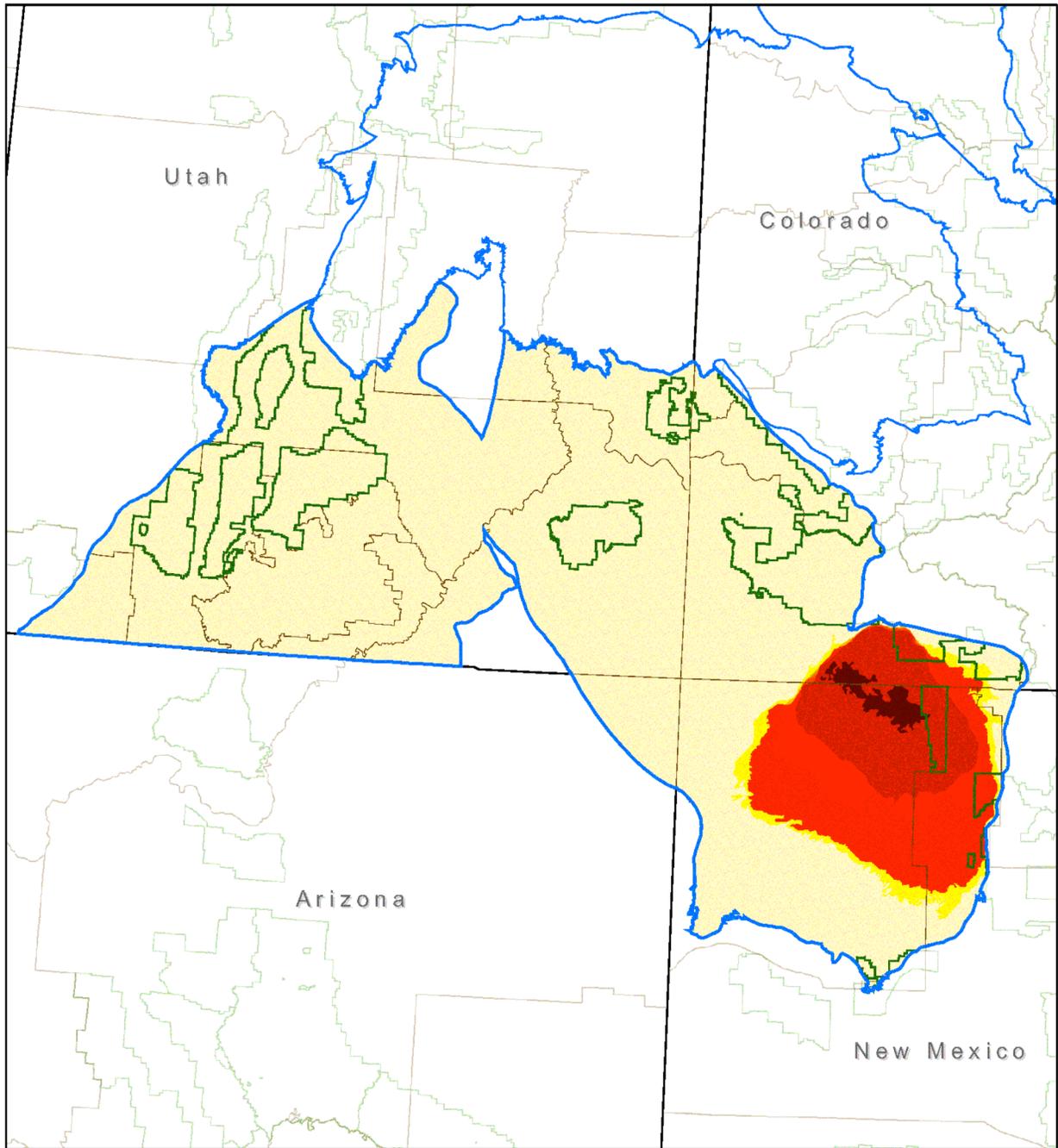


Figure 2m Total Liquids Map – Montana Thrust Belt Study Area

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**Figure 2n** Total Gas Map – Paradox/San Juan Study Area

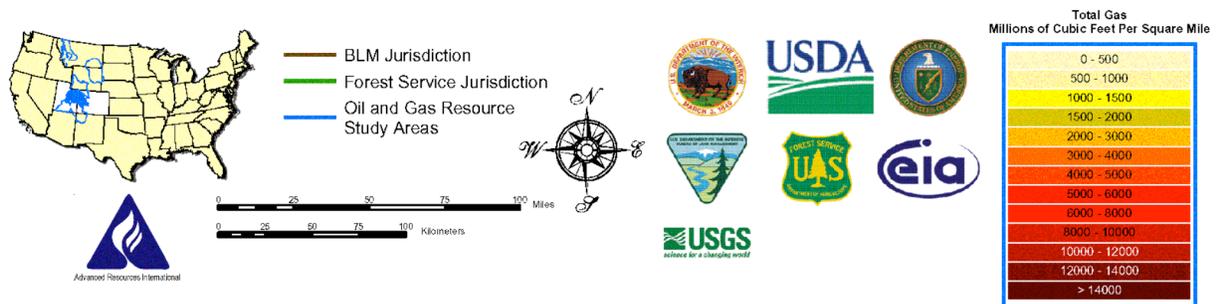
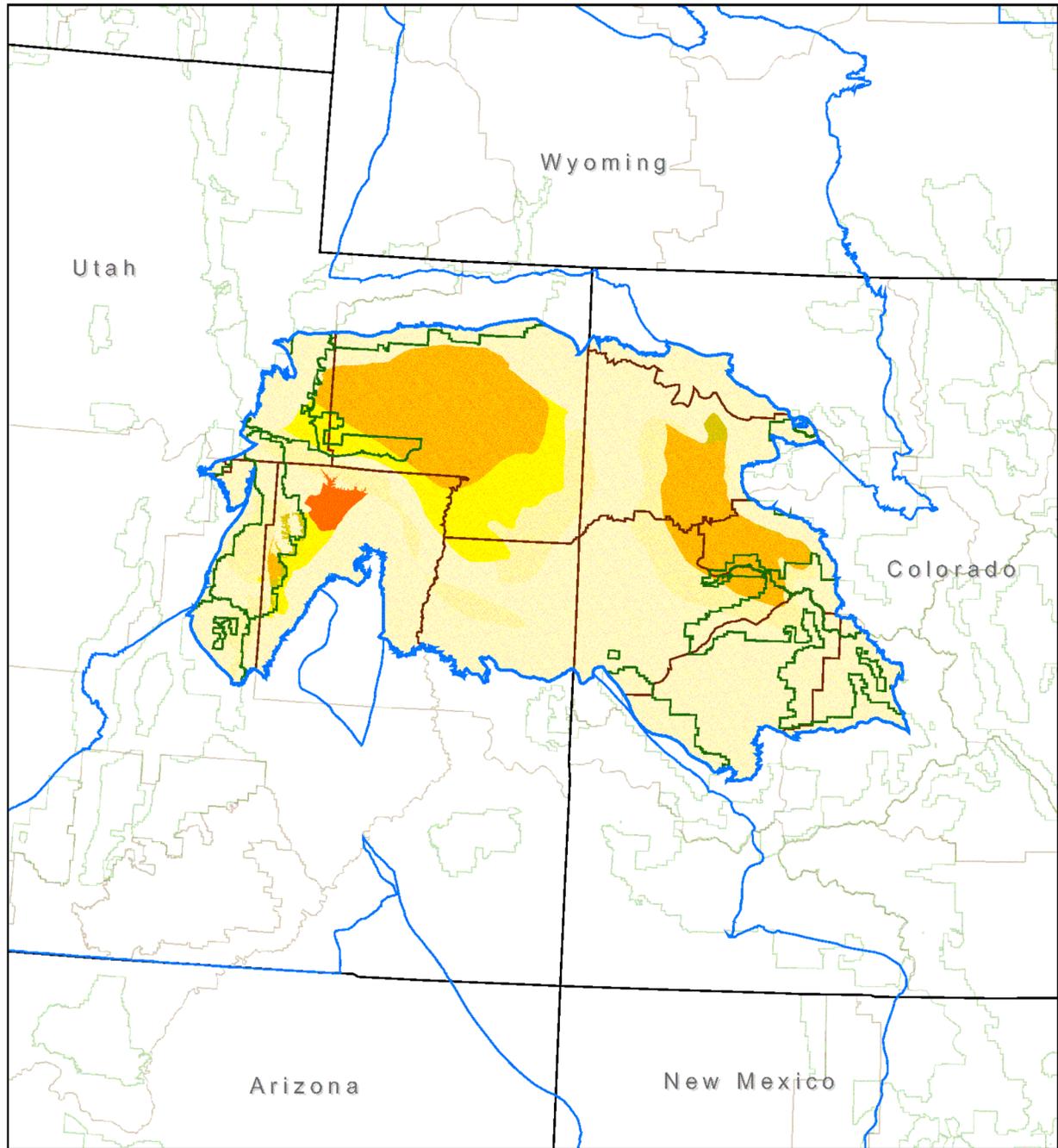
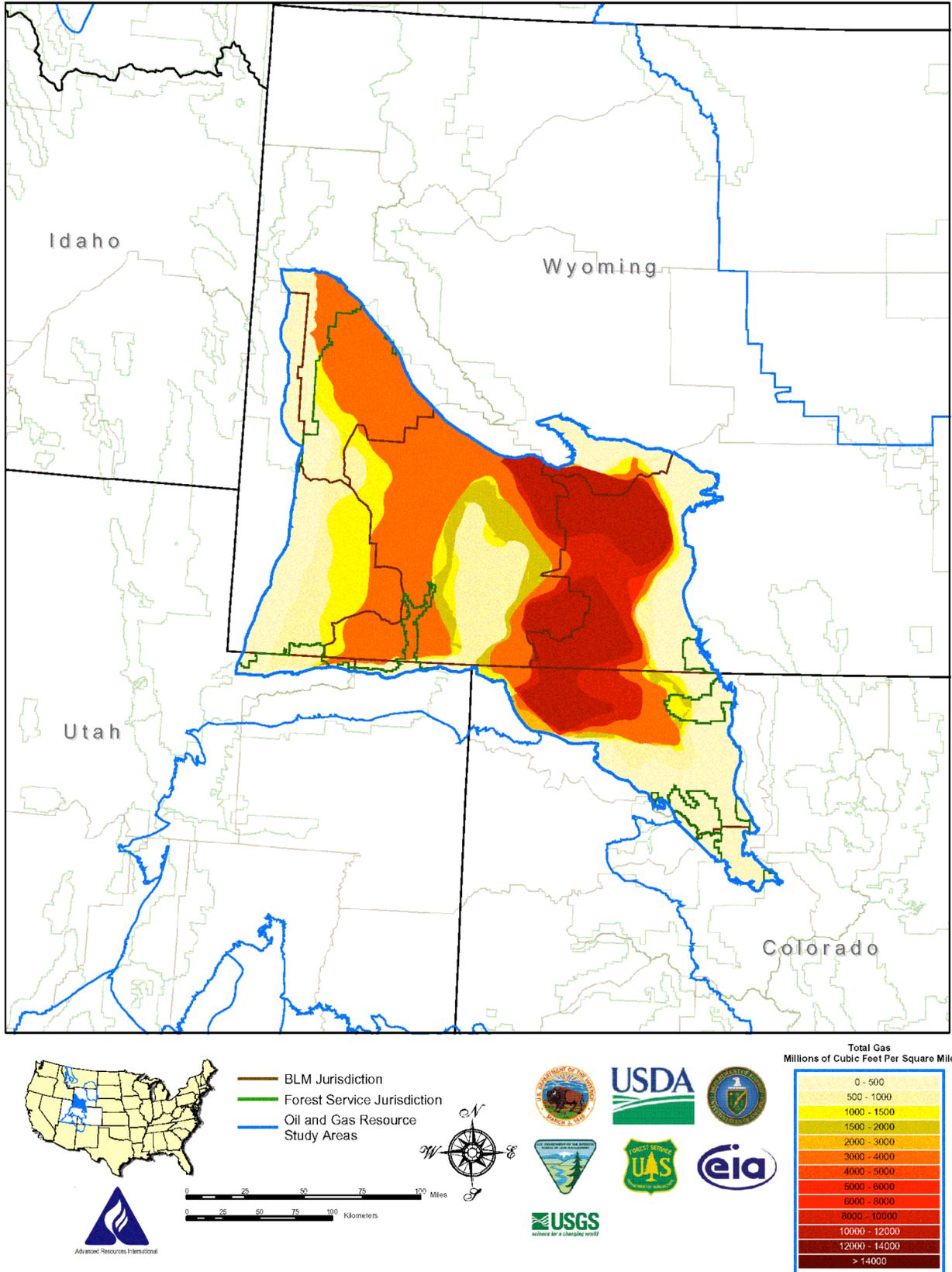
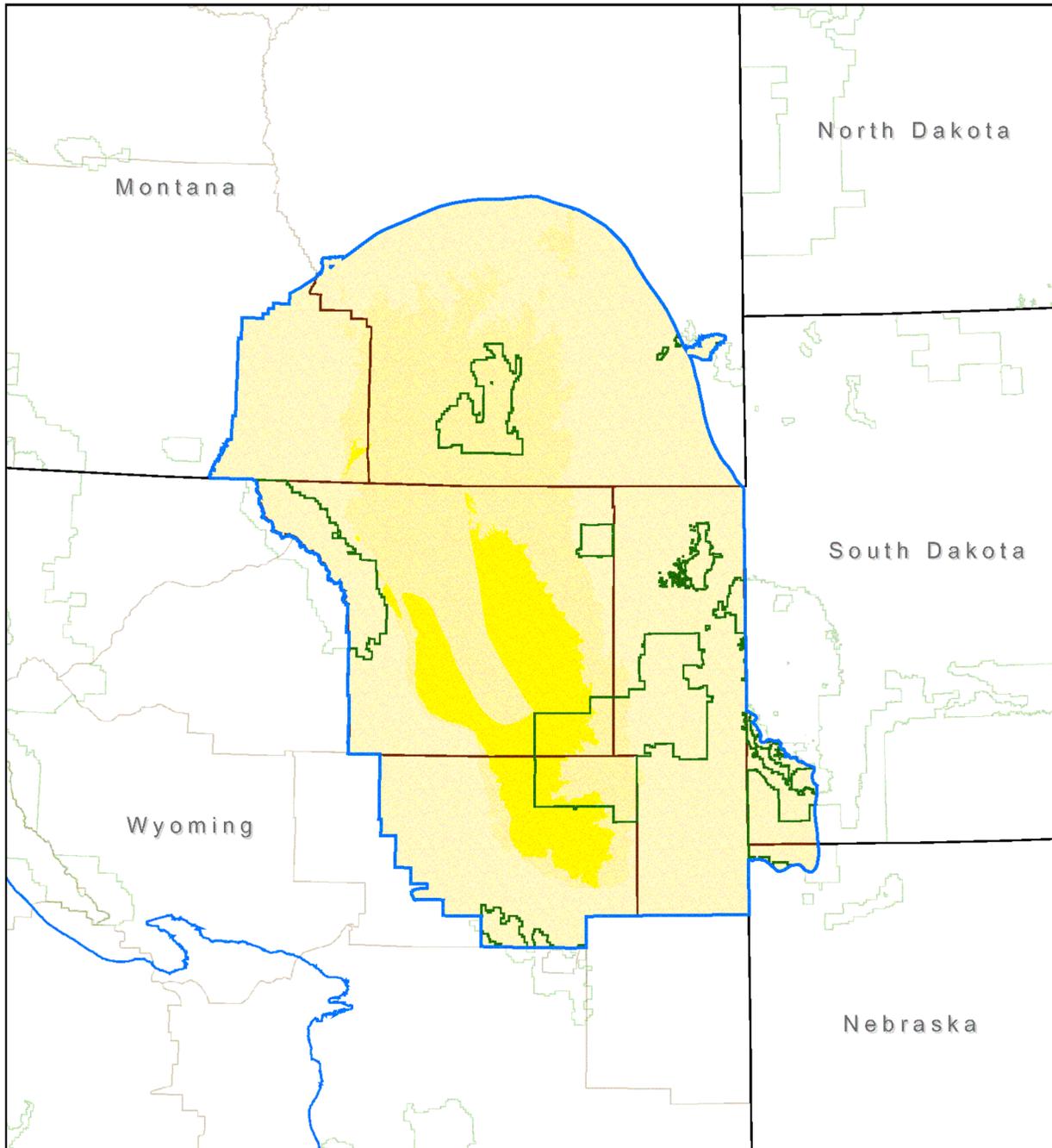


Figure 2o Total Gas Map – Uinta/Piceance Study Area

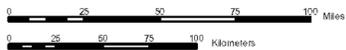
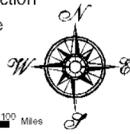
**Section 2  
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**Figure 2p** Total Gas Map – Greater Green River Study Area



- BLM Jurisdiction
- Forest Service Jurisdiction
- Oil and Gas Resource Study Areas



Total Gas  
Millions of Cubic Feet Per Square Mile

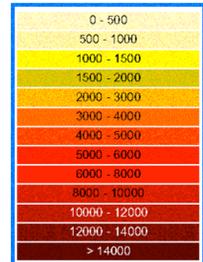
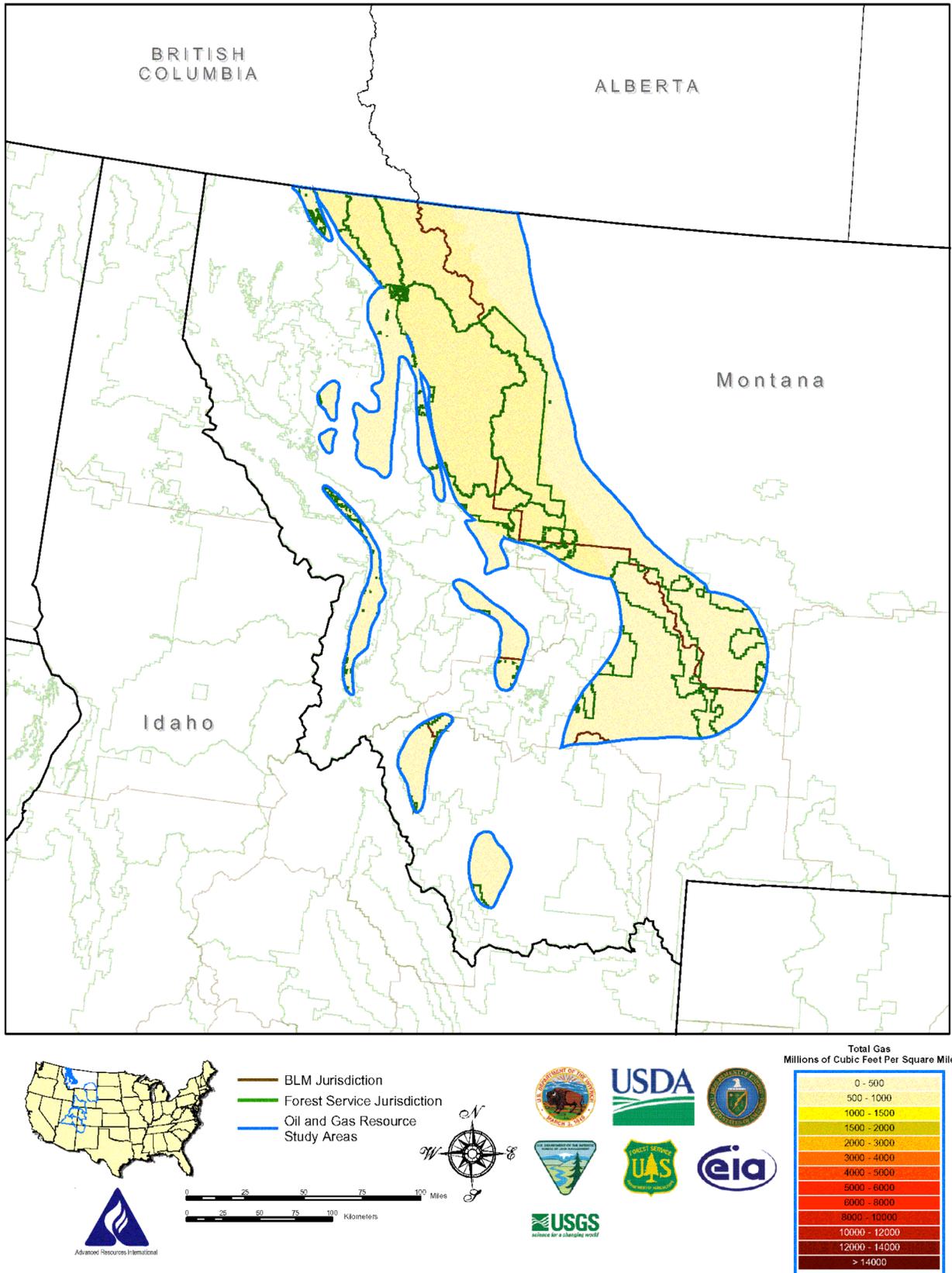


Figure 2q Total Gas Map – Powder River Study Area

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**Figure 2r** Total Gas Map – Montana Thrust Belt Study Area

### 2.2.3 Oil and Gas Resource Data-Related Caveats

The estimation of technically recoverable resources is inherently uncertain, as reflected by the fact that the USGS develops cumulative probability distributions for the resource estimates of all of its plays. These distributions are used to derive 95 percent probable (a 19-in-20 chance of that volume or more), 5 percent probable (a 1-in-20 chance of that much or more) and mean resource volumes. The mean volume, used in this inventory, represents the arithmetic average of all possible resource outcomes weighted by their probability of occurrence. Therefore, the analytical results shown here do not explicitly reflect the range of uncertainty in the resource assessments.

In addition, not all of the resource plays recognized by the USGS within the boundaries of this inventory have been evaluated, typically because there are hypothetical plays that lack sufficient supporting data to calculate resource estimates. To the extent that these plays contain significant volumes of resources, the results presented here would be different relative to a larger resource base.

Given these considerations, it should be understood that no resource assessments are set in stone. Not only is it difficult to accurately assess the resource at any one point in time, but the resource itself is constantly changing in response to the advance of technology and the evolving economic and policy conditions under which extraction is likely to occur. Nonetheless, it is of vital importance that accurate and up-to-date assessments of the potential resources are continually provided to ensure that public policy decisions are conducted with the most timely information possible.

## 2.3 PROCEDURES FOR COLLECTING AND ANALYZING PROVED OIL AND GAS RESERVES DATA

The EPCA Section 604 responsibility of the Energy Information Administration is to provide data and analysis relevant to proved reserves of crude oil, natural gas, and natural gas liquids which are associated with already discovered fields that underlie Federal onshore lands. This responsibility involves:

- provision of estimates of proved reserves for these fields at the highest possible level of detail consonant with a legal requirement to protect the confidentiality of field operators' proprietary estimates of proved reserves,
- estimation of future ultimate recovery appreciation for currently producing fields, and
- provision of inputs to the estimation of additional land access requirements that may be consequent to the expected ultimate recovery appreciation.

Proved reserves are defined as those quantities of crude oil, natural gas, or natural gas liquids that geological and engineering data demonstrate with reasonable certainty (defined as 90 percent or more probable) to be recoverable *in future years* from *known* reservoirs *under existing economic and operating conditions*. Proved reserves are, in effect, the current “inventory on-the-shelf” portion of the total resource endowment.<sup>4</sup>

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<sup>4</sup> The full technical definition of proved reserves is available on the Society of Petroleum Engineers website at [http://www.spe.org/spe/cda/views/shared/viewChannelsMaster/0,2883,1648\\_19738\\_19746\\_24741,00.html](http://www.spe.org/spe/cda/views/shared/viewChannelsMaster/0,2883,1648_19738_19746_24741,00.html)

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Estimates of future ultimate recovery appreciation (URA), sometimes referred to as “reserves growth” are not included as a part of this analysis. The URA estimate will be provided as part of a future revision to this inventory.

### 2.3.1 Sources and Data-Related Caveats of Proved Oil and Gas Reserves Data

Comprehensive deterministic estimates of the domestic proved reserves of crude oil, natural gas, and natural gas liquids are prepared annually by the EIA. These estimates are a combination of reported and statistically imputed volumes based on:

- thousands of individual proved reserves and production estimates reported annually either at the field level or at the State level as described below, submitted to EIA by a statistical sample of the operators of domestic oil and gas wells on Form EIA-23 “Annual Survey of Domestic Oil and Gas Reserves.” Of the 22,519 operators in the 2001 survey, 1,867 were included in the sample.
- all operators of active domestic natural gas processing plants who annually report their operations on Form EIA-64A “Annual Report of the Origin of Natural Gas Liquids Production.” For the 2001 survey, there were 525 active plants, all of which responded.

Only the largest oil and gas well operators (those producing 1.5 million barrels or more of crude oil or 15 billion cubic feet or more of natural gas, or both) are required to maintain and submit to EIA both proved reserves and production estimates by field for all of their operated properties. There were 172 large operators in the 2001 survey, all of which were included in the sample. Their response rate was 100 percent.

Intermediate size operators (those producing less than the largest operators but at least 400,000 barrels of crude oil, or at least 2 billion cubic feet of natural gas, or both) are required to submit production estimates by field for all of their operated properties, but are only required to submit proved reserves estimates by field when they maintain them in their records. There were 439 mid-sized operators in the 2001 survey. All were included in the sample and their response rate was also 100 percent.

Small operators are those with production less than the other limits. There were 21,908 small operators in the 2001 survey. Of these, 1,175 were sampled with certainty at an associated response rate of 98 percent and an additional 622 were randomly sampled at an associated response rate of 95 percent.

Because the EIA reserves survey is expressly designed to minimize the respondents’ reporting burden and yet provide highly reliable estimates at the State and National levels of data aggregation, the EIA does not have in its files operator-submitted, field-specific proved reserves information covering every oil or gas field in the country. For example:

- The EIA may have only partial reported proved reserves estimates for a field that has two or more operators, at least one of which is not required to report proved reserves by field.
- Especially for small fields, the EIA may not have any reported proved reserves estimates.

However, because the large and intermediate size operators tend to operate the larger fields, whereas the small operators are primarily active in the far more numerous small fields, the EIA does have in its files field-specific, operator-submitted proved reserves estimates covering about 90 percent of all estimated domestic proved reserves.

These types of deficiencies in the EIA's field-specific reserves information were satisfactorily remedied for this inventory by use of additional procedures based on either publicly available production data or reserve-to-production ratio analogs. The procedures used are detailed in Appendix 6.

Beyond the necessity to develop complete proved reserves estimates when complete operator-submitted estimates were lacking, there were two additional limitations:

(1) As collected in the EIA reserves survey, field location is at the county level. Attainment of the much more precise field locations required for this inventory's GIS-based methodology necessitated cross-correlation of the EIA's reserves data files with commercial sources of field and/or well information which provide far more precise field location data. This process involved much highly detailed, often well-by-well, work owing to the existence of non-standard field names and codes, or the occasional lack of a field name, in the commercial data sources.

(2) EIA is obligated by law to ensure the confidentiality of the data submitted by each reserves survey respondent. Within the EPCA study areas, there were many situations where a field was operated by a single operator or where one operator was heavily dominant. In such instances, EIA cannot disclose the proved reserves estimates for the field in absence of a written agreement in which the operator waives its right to confidentiality. Such agreements are exceedingly rare. Therefore, to avoid the release of confidential information while still adequately informing this inventory, EIA elected not to present field-specific proved reserves estimates even in instances where doing so would not have compromised a respondent's submission. Instead, the fields have uniformly been classified into a range of proved reserves categories that are broad enough to prevent extraction of the proved reserves estimates for any specific field. The resulting summary of proved reserves is shown in table 2b.

The proved oil and gas reserves are not mapped as are the undiscovered technically recoverable resources in figures 2i through 2r and figures 3l through 3ad. However, the reserves figures, presented in table 2b, are included in the summary tables and pie charts (table ES-1, figure ES-2, tables 3a through 3f and figures 3a through 3f). Proved reserves are included in the "Leasing, Standard Lease Terms (SLT)" category since by definition they are accessible with minimal constraints.

See Appendix 6 for a more detailed explanation of proved reserves estimation and field boundary construction.

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Basin	Number of Fields	Total Liquid Reserves (Mbbbl)	Federal Land Liquid Reserves (Mbbbl)	% Federal	Total Gas Reserves (MMcf)	Federal Land Gas Reserves (MMcf)	% Federal	Total BOE* Reserves (Mbbbl)	Federal Land BOE Reserves (Mbbbl)	% Federal
<i>Paradox-San Juan</i>	250	174,193	53,103	30.5	20,653,622	11,033,357	53.4	3,616,464	1,891,996	52.3
<i>Uinta-Piceance</i>	180	254,329	142,495	56.0	7,181,669	3,779,755	52.6	1,451,274	772,454	53.2
<i>Greater Green River</i>	281	177,362	122,234	68.9	12,703,038	10,081,667	79.4	2,294,535	1,802,512	78.6
<i>Powder River</i>	543	193,456	110,783	57.3	2,398,604	927,738	38.7	593,223	265,406	44.7
<i>Montana Thrust Belt</i>	1	1	0	0.0	0	0	0.0	1	0	0.0
<b>Total</b>	1,255	799,341	428,616	53.6	42,936,933	25,822,517	60.1	7,955,497	4,732,368	59.5

\*Barrels of Oil Equivalent

**Table 2b Proved Reserves Summary Statistics, 2001**

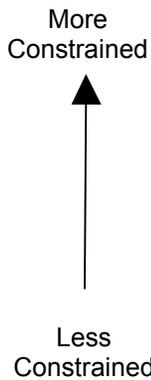
**2.4 DATA INTEGRATION AND SPATIAL ANALYSIS**

Data integration and spatial analysis were performed as described below. The assumptions that were made as a part of the modeling process are described and the spatial analysis performed in the GIS are described in Appendix 7.

**2.4.1 Categorization for Federal Land Status and Lease Stipulations**

Two factors affect access to oil and gas resources on Federal lands: land status (Section 2.1.1) and leasing stipulations (Section 2.1.2). To simplify the analysis and present meaningful results, these two factors were combined into a hierarchy of categories that represents varying levels of access as shown in table 2c. This categorization was necessary to enable a reasonable quantitative analysis given the fact that approximately 1,000 unique stipulations exist within the study areas.

Level	Access Category	Comments
1.	No Leasing (Statutory/Executive Order), (NLS)	Status set by Law or Executive Order; drilling prohibited
2.	No Leasing (Administrative), Pending Land Use Planning or NEPA Compliance (NLA/LUP)	Status set by Federal surface management agency; drilling prohibited
3.	No Leasing (Administrative), general category (NLA)	
4.	Leasing, No Surface Occupancy (NSO)	Directional drilling permitted from off-lease locations*
5.	Leasing, Cumulative Timing Limitations on Drilling >9 Months (TLs >9)	Categorized by the cumulative effect of seasonal
6.	Leasing, Cumulative Timing Limitations on Drilling 6-9 Months (TLs 6-9)	leasing stipulations during which drilling is prohibited, generally for protection of wildlife
7.	Leasing, Cumulative Timing Limitations on Drilling 3-6 Months (TLs 3-6)	
8.	Leasing, Cumulative Timing Limitations on Drilling <3 Months (TLs <3)	
9.	Leasing, Controlled Surface Use (CSU)	Drilling permitted, specialized mitigation plan required
10.	Leasing, Standard Lease Terms (SLTs)	Drilling permitted, mitigation plan required



\*Resources under margins of NSO areas may be accessible by directional drilling.

**Table 2c Categorization Hierarchy**

The hierarchy of categories was formulated to ensure that the potential for oil and gas development could be appropriately assessed (especially for areas of multiple, overlapping stipulations), and to ensure that the cumulative impacts on access would be examined. In addition, the hierarchy was formulated based upon the accessibility of the lands for leasing, for areas in which leasing is permitted, and the impacts relative to the costs to operators for conducting drilling.

The categorization is ordered from No Leasing to Leasing with Standard Lease Terms as follows:

1. **No Leasing (Statutory/Executive Order) (NLS)** are areas that cannot be leased due to Congressional or Presidential action. Examples include national parks, national monuments, and wilderness areas.
2. **No Leasing (Administrative) Pending Land Use Planning or NEPA Compliance (NLA/LUP)** are Federal administrative areas that are currently undergoing land use planning or NEPA analysis and are not currently available for leasing.<sup>5</sup> Table A7-1 in Appendix 7 shows the NLA/LUP jurisdictions within the EPCA inventory area.
3. **No Leasing (Administrative) (NLA)** are areas in which leasing does not occur based on discretionary decisions made by the Federal land management agency. NLAs include endangered species habitat and historical sites.
4. **Leasing, No Surface Occupancy (NSO)** are areas that can be leased but stipulations generally prohibit surface occupancy for natural gas and oil exploration and development activities to protect identified resources such as special status plant species habitat. NSO areas are treated in the analysis as no access areas (administrative); however, these areas can be accessed by directional drilling as described later in this document.
- 5-8. **Leasing, Cumulative Timing Limitations (TLs)** are areas that can be leased, but stipulations limit the time of the year when oil and gas exploration and drilling can take place. Timing limitation stipulations prohibit surface use during specified time intervals to protect identified resources such as sage grouse habitat or elk calving areas.
9. **Leasing, Controlled Surface Use (CSU)** are areas that can be leased, but stipulations control the surface location of natural gas and oil exploration and development activities by excluding them from certain portions of the lease. For example, a CSU stipulation could require an operator to develop a specialized mitigation plan based on the presence of steep slopes within a lease area.
10. **Leasing, Standard Lease Terms (SLT)** are areas that can be leased, and where no additional stipulations are added to the standard lease form. Standard lease terms, however, still dictate that the lessee comply with a number of environmentally protective and other requirements.

Appendix 9 (available on the CD-ROMs or the web sites) provides a listing and coding of the individual stipulations for each of the study areas.

## 2.4.2 Analytical Modeling of Federal Lands and Resources

See Appendix 7 for a detailed description of the GIS methodology used to categorize the Federal lands and resources for the inventory.

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<sup>5</sup> This category was determined on a case-by-case basis as the initiation of a new land use plan or plan revision does not generally preclude leasing under an existing plan.