

2.0 Methodology

The Inventory examines the following geological provinces in detail:²⁰

- Northern Alaska (NAK)
- Central Alaska – Yukon Flats (YKF)
- Southern Alaska (SAK)
- Eastern Oregon-Washington (EOW)
- Ventura Basin (VEN)
- Eastern Great Basin (EGB)
- Uinta-Piceance Basin (UPB)
- Paradox Basin (PDX)
- San Juan Basin (SJB)
- Montana Thrust Belt (MTB)
- Williston Basin (WIL)
- Powder River Basin (PDR)
- Wyoming Thrust Belt (WTB)
- Southwestern Wyoming (SWW)²¹
- Denver Basin (DEN)
- Florida Peninsula (FLP)
- Black Warrior Basin (BWB)
- Appalachian Basin (APB).

The study areas were delineated by aggregating oil and/or natural gas resource plays²² within the provinces 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 then aggregated in a GIS to create a resource density map layer for each study area.

²⁰ The study areas in this document are referenced in USGS Oil and Gas province order.

²¹ Southwestern Wyoming was referred to as the “Greater Green River Basin” in the Phase I and II releases. The name has been changed to follow USGS nomenclature.

²² “Plays,” more recently referred to as “assessment units,” are a set of known or postulated oil and gas accumulations having similar geologic origins. The term plays is used generically in this document (see section 2.2.1 for further explanation).

Where play boundaries span more than a single geologic province, one province was selected over the other in order to preserve geographic uniqueness for the purposes of this Inventory. For example, at the boundary of the PDX and UPB study areas, the UPB was defined by the outline of Uinta plays even though these plays overlap plays from the Paradox Basin. The Uinta-Piceance study area thus contains some Paradox Basin resources and reserves. Likewise, the WTB and SWW study areas were defined by the SWW USGS boundaries and the DEN and PDR study areas by the PDR USGS province boundaries.

Federal land status was generated using the “Status” dataset from the BLM’s Legacy Rehost 2000 (LR-2000) system to create GIS maps. Oil and gas leasing stipulation and COA data were obtained for each jurisdiction from BLM field offices and FS offices in the study areas. Most of the stipulation data were available in GIS format; some existed only as hardcopy and had to be digitized to create GIS map files.

Stipulations²³ and COAs are additional requirements that are attached to Federal oil and gas leases and drilling permits for environmental protection and other reasons and are subject to change over time. This Inventory represents a “snapshot” of the conditions within the study areas at the time of data collection. The stipulations used in the Inventory are those applied when new

²³ Different land use planning documents refer to their mitigation/protection restrictions by a number of different names, including Guidelines, Standards, and Required Operating Procedures (ROP). For the purpose of this report, all of these restrictions are referred to as “stipulations.”

oil and gas leases are issued and are those contained primarily in National Forest Plans (FPs) and BLM Resource Management Plans (RMPs) in effect as of December 2006. Some stipulations are not maintained in an automated system and may not have been available for use in this Inventory (see Section 2.1.2 for further discussion).²⁴

After lease issuance, and prior to approval of any drilling activities, the operator must submit an Application for Permit to Drill (APD). An APD provides operational and geologic information as well as the applicant's proposal for use of the surface. The COAs are post-lease requirements that are attached to an approved APD for environmental protection, safety, and conservation of resource. The COAs were developed over a number of years as mitigation measures for surface disturbing activities and are based upon lease notices and/or administrative policy actions.

To the extent that current leases were issued under, and are stipulated according to, an existing land use plan, the Inventory accurately reflects the access situation. Older leases issued before the effective date of the relevant plans may not be subject to stipulations from the current land use planning document. It is reasonable, however, to consider the plan stipulations as applicable. Environmental conditions that necessitate stipulations often are the driver for COAs that are attached to drilling permits on older leases. The surface managing agency is therefore able to achieve the needed environmental protection.

²⁴ For quality control purposes, after the stipulation lists were compiled, they were made available to the individual field offices, who were encouraged to review the stipulations and offer any changes to stipulations or their access categorization. All changes suggested by offices were incorporated into the Inventory.

Additional factors exist that affect oil and gas exploration and development on Federal lands. Many cannot be quantified prior to the receipt of a specific drilling application. The factors include:

- Protection for threatened, endangered, and sensitive species. Surveys are sometimes required to determine whether a lease contains habitat for such species.
- Archaeological surveys are sometimes required under the authority of the National Historic Preservation Act. Related issues involve other cultural resources and consultation with Native American tribes.
- Air quality impacts and resulting restrictions on activities that may affect air quality.
- Visual impacts of oil and gas operations.
- Noise from oil and gas operations.
- Suburban encroachment on oil and gas fields and county government restrictions.

Section 4 of this report presents these issues in greater detail. Many of these requirements manifest themselves as COAs 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. Site-specific COAs have been incorporated into the Inventory and further described in Section 2.1.3.

Analytically, the Inventory entailed the spatial intersection (in a GIS) of oil and gas resource information with data on Federal land ownership and access constraints. 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 general frequency with which exceptions to the stipulations are granted.²⁵

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

2.1 Procedures for Collecting and Preparing Land Status and Oil and Gas Access Constraints

2.1.1 Federal Land Status

This section briefly presents the process for determination of land status. See Appendix 3 for a more detailed description.

2.1.1.1 Sources of Land Status Data

The primary source of Federal land status data outside of the Eastern areas was the BLM's LR-2000 Status Dataset, which was supplemented by other records from Federal, state, and county governments. For the Eastern study areas the mapping of Federal lands was completed based upon detailed

research of multiple sources of information that describe the nature and extent of Federal surface and mineral interests. In the Alaska study areas, the primary source of land status data was the State of Alaska supplemented by records from other Federal and state government sources.

2.1.1.2 Land Status Data Preparation

Land Status data, which are often stored in alphanumeric format, were converted, as necessary, for this Inventory into a GIS layer by using commercially available software. The software interpolated the legal descriptions contained in the Status Dataset 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.

Maps of the Federal land status for the study areas are presented in Figures 2-1 through 2-18. Maps of the Federal land status for Extrapolation Areas by region are included as Figures 2-19 through 2-21, and use information from the publicly available National Atlas.²⁶

²⁵ Areas within the EPCA inventory with less than 5 BCF (equivalent) of gas were analyzed by extrapolating the land access data from nearby areas with greater resources. This includes areas in Jarbidge, ID BLM; Kremmling, CO BLM; La Jara, CO BLM; Klamath Falls, OR BLM; and Colville, Fremont, Gifford-Pinchot, Mt. Baker-Snoqualmie, Mt. Hood, Wenatchee, and Winema National Forests. These areas were included in the total resource values for their respective basins.

²⁶ National Atlas, <http://www.nationalatlas.gov/mld/fedlanp.html>

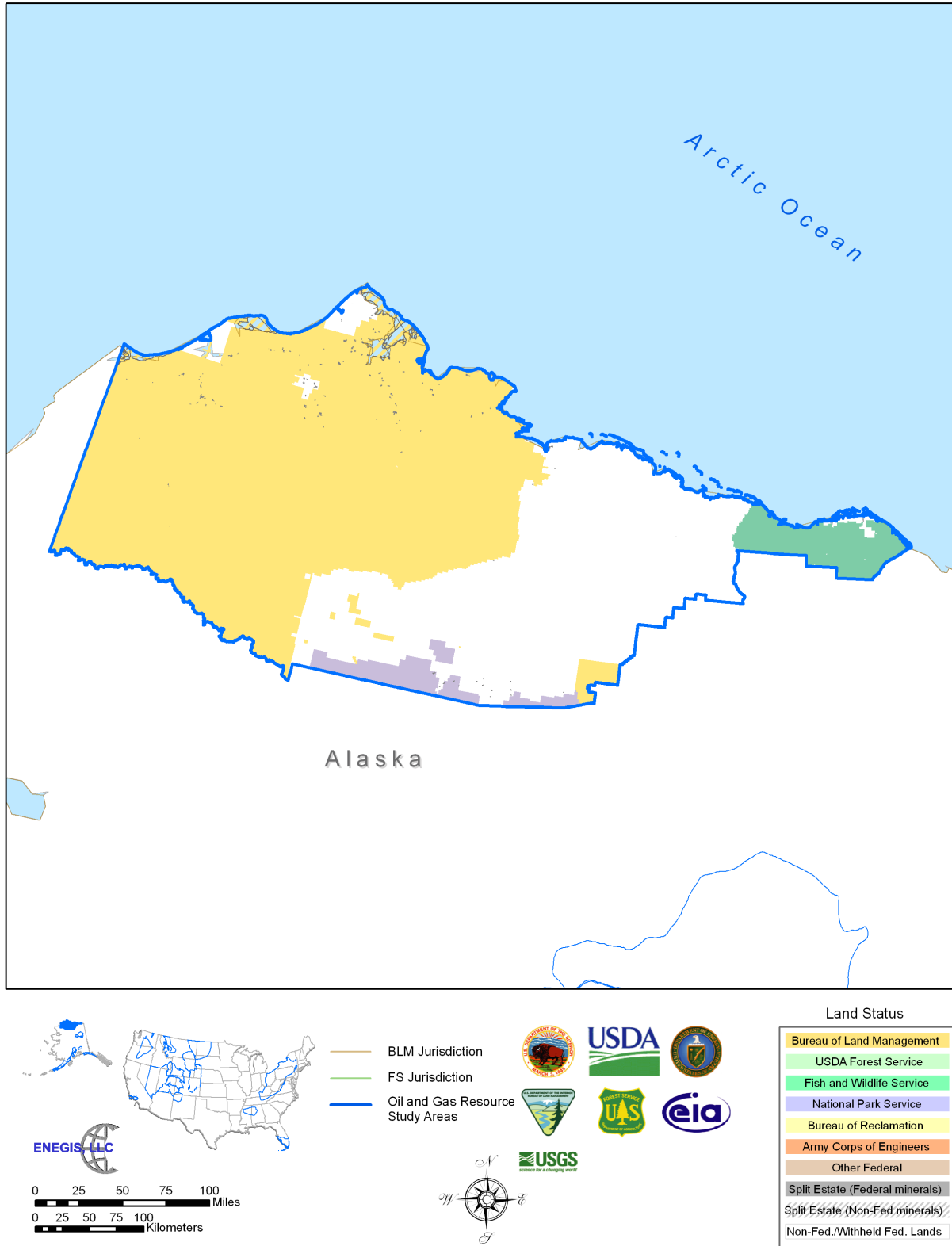


Figure 2-1. Federal Land Status Map, Northern Alaska Study Area

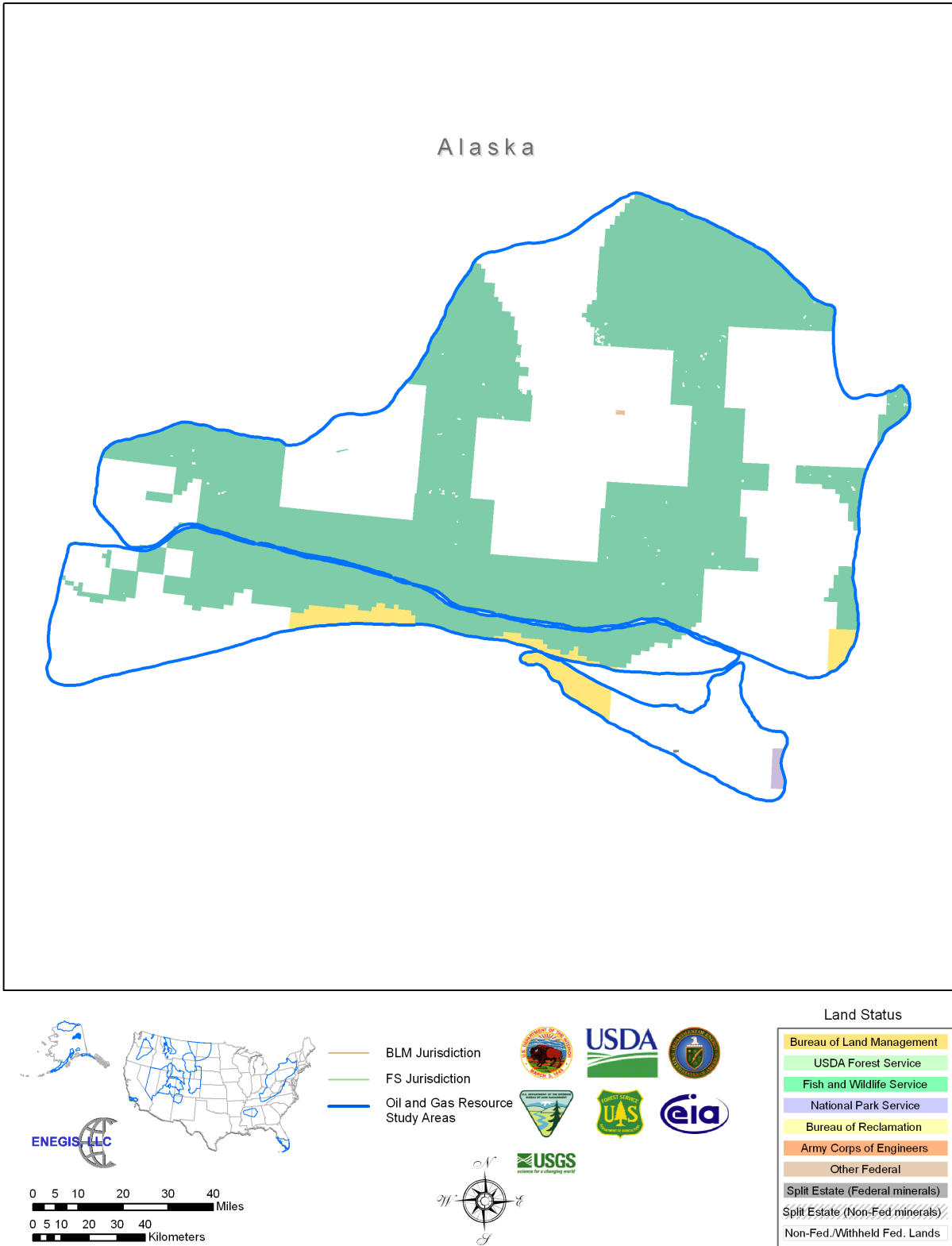


Figure 2-2. Federal Land Status Map, Central Alaska - Yukon Flats Study Area

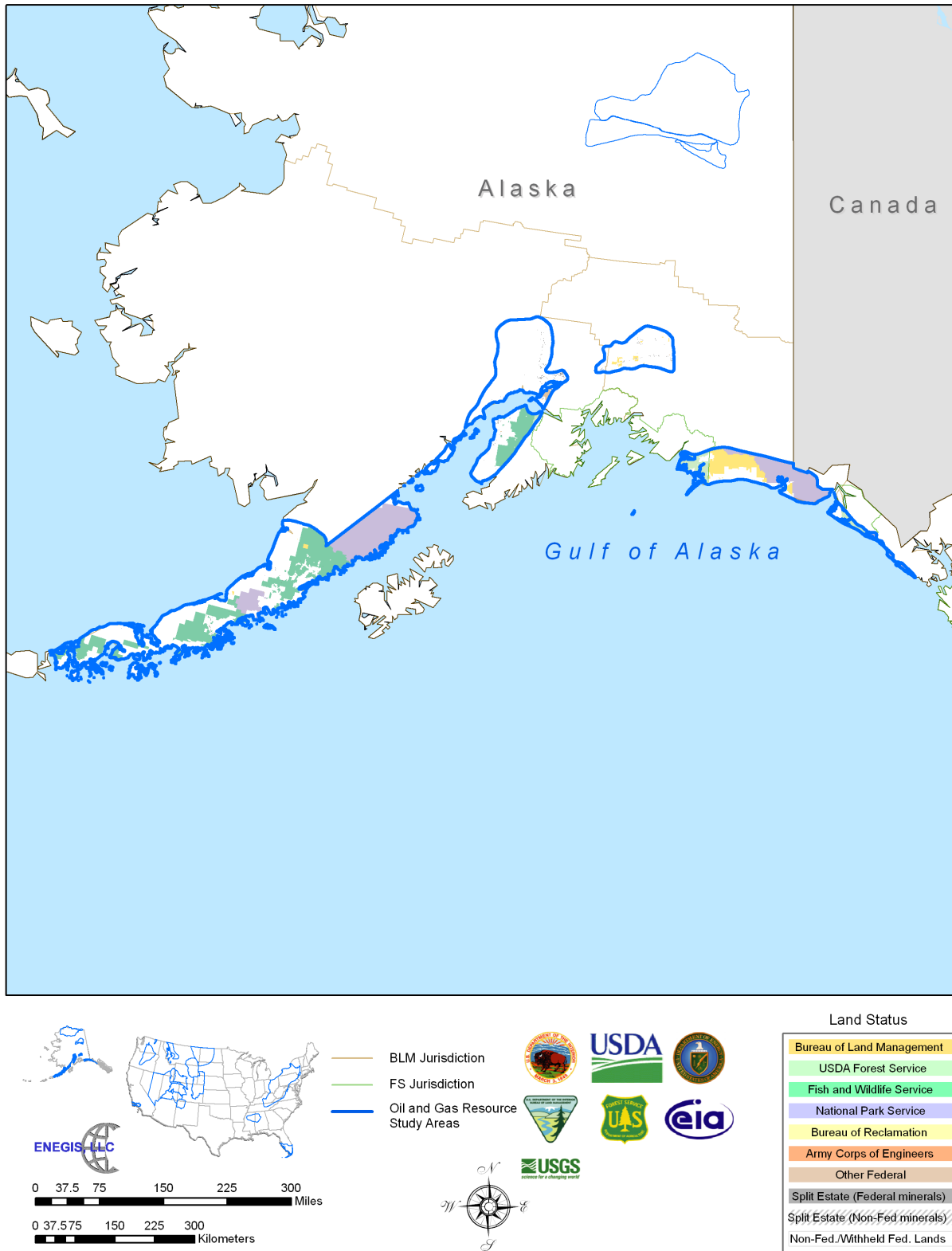


Figure 2-3. Federal Land Status Map, Southern Alaska Study Area

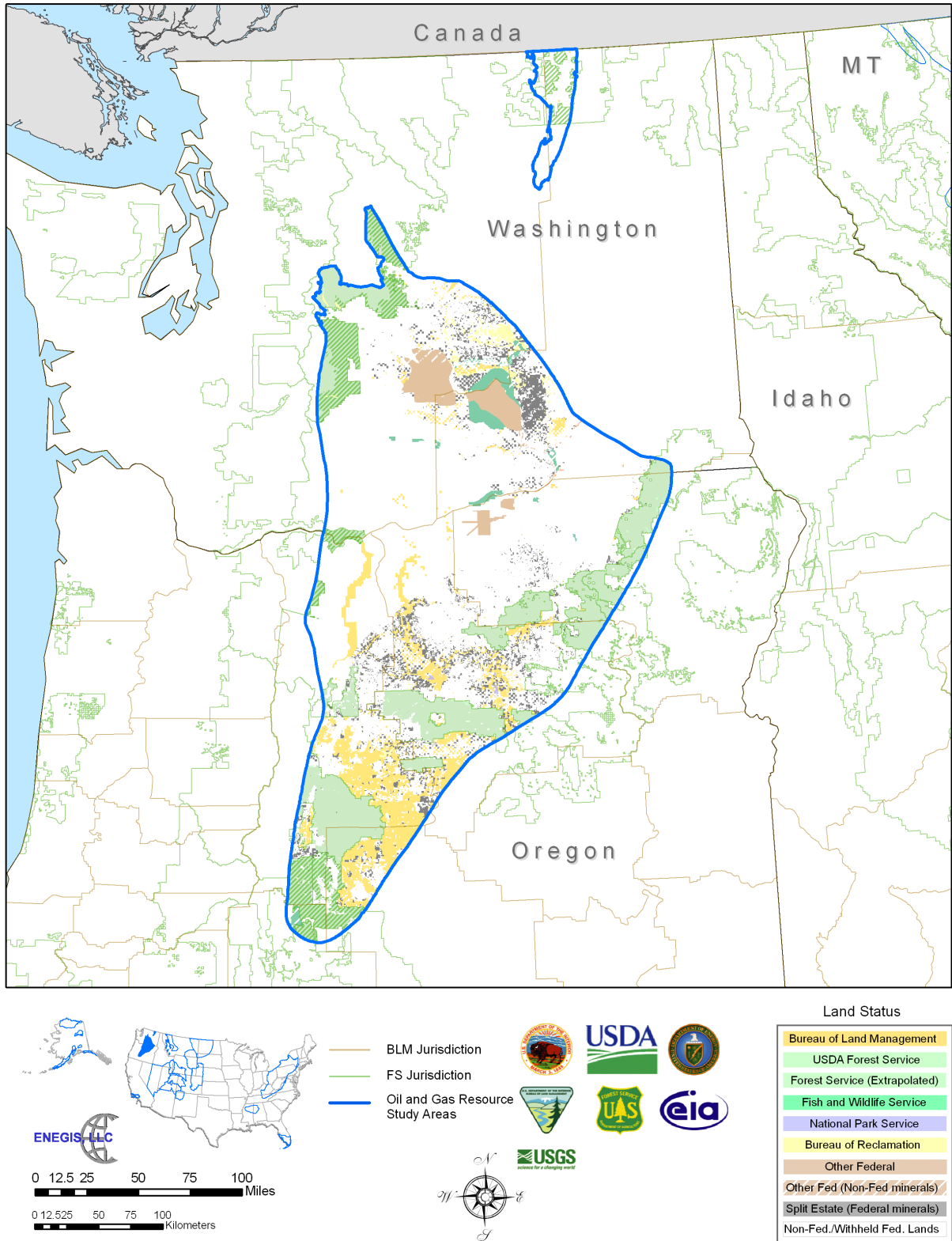


Figure 2-4. Federal Land Status Map, Eastern Oregon-Washington Study Area



Figure 2-5. Federal Land Status Map, Ventura Basin Study Area

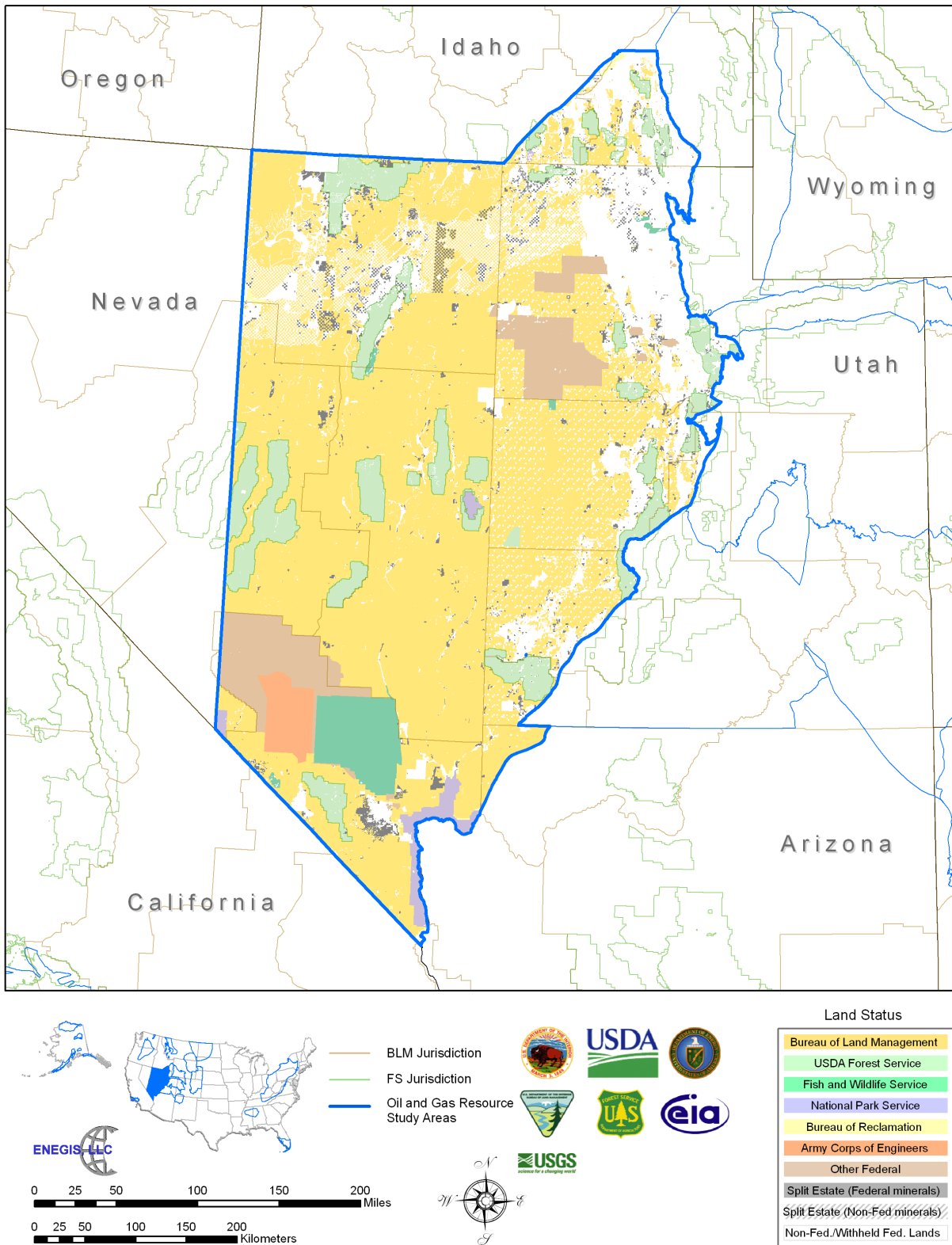


Figure 2-6. Federal Land Status Map, Eastern Great Basin Study Area

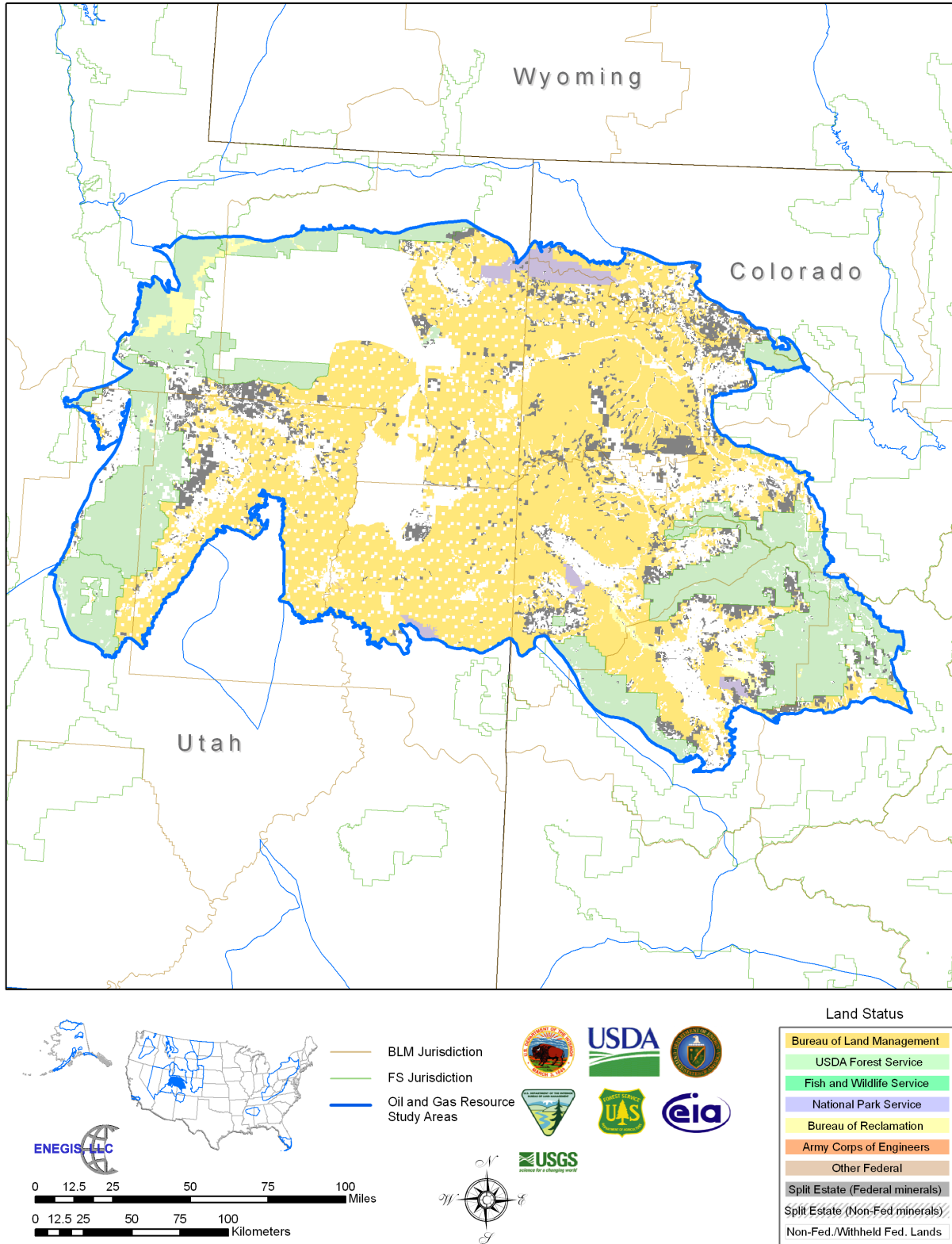


Figure 2-7. Federal Land Status Map, Uinta-Piceance Basin Study Area

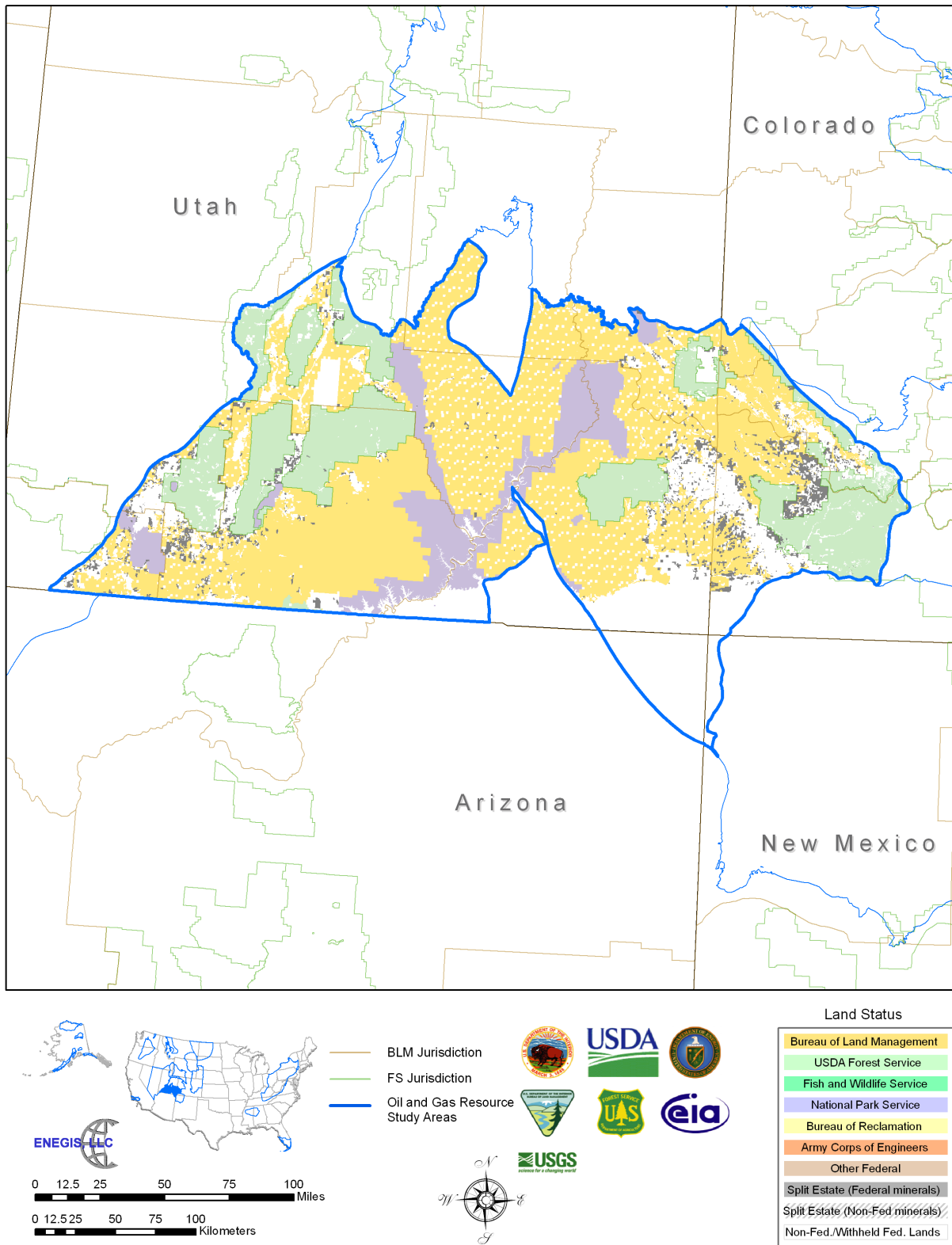


Figure 2-8. Federal Land Status Map, Paradox Basin Study Area

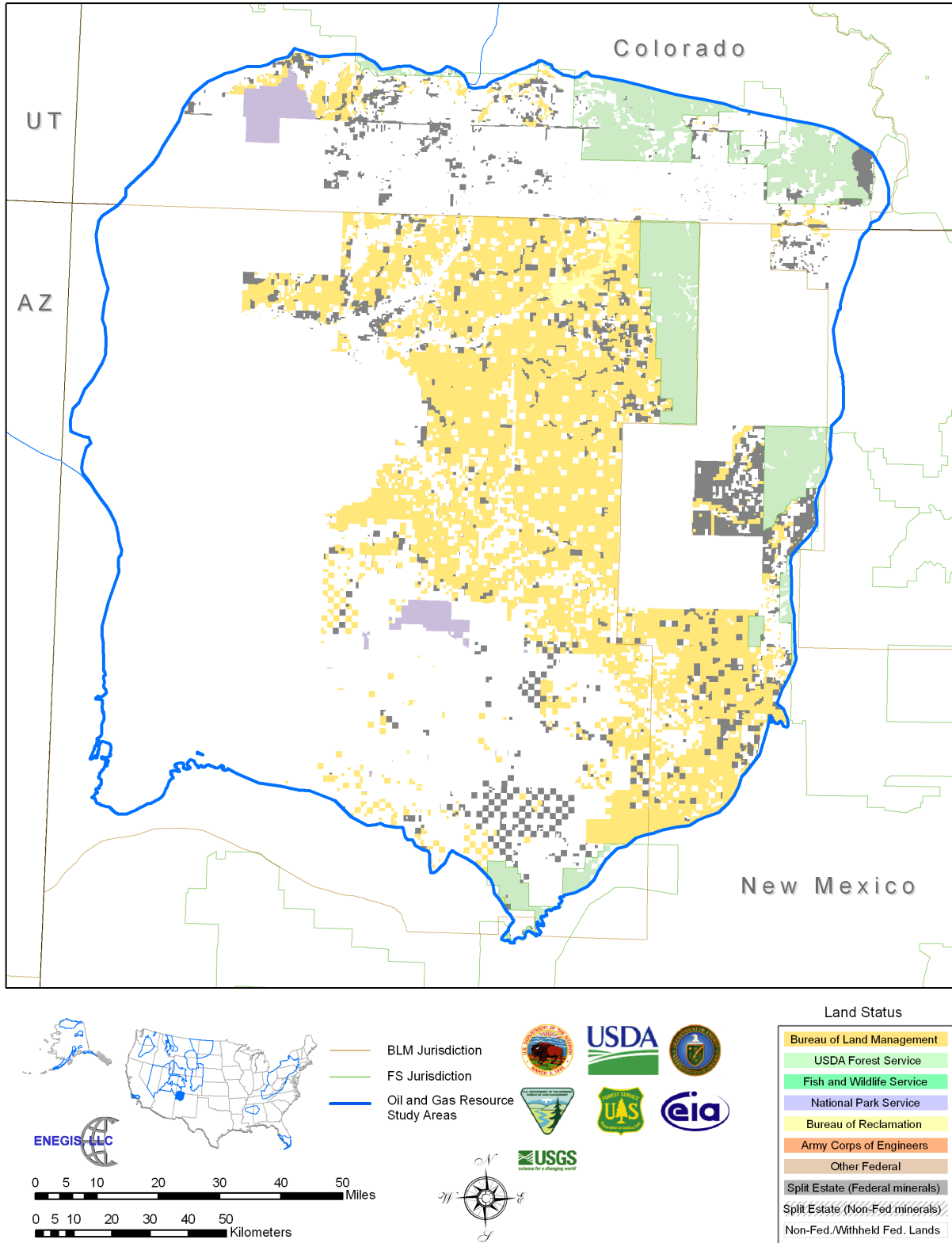


Figure 2-9. Federal Land Status Map, San Juan Basin Study Area

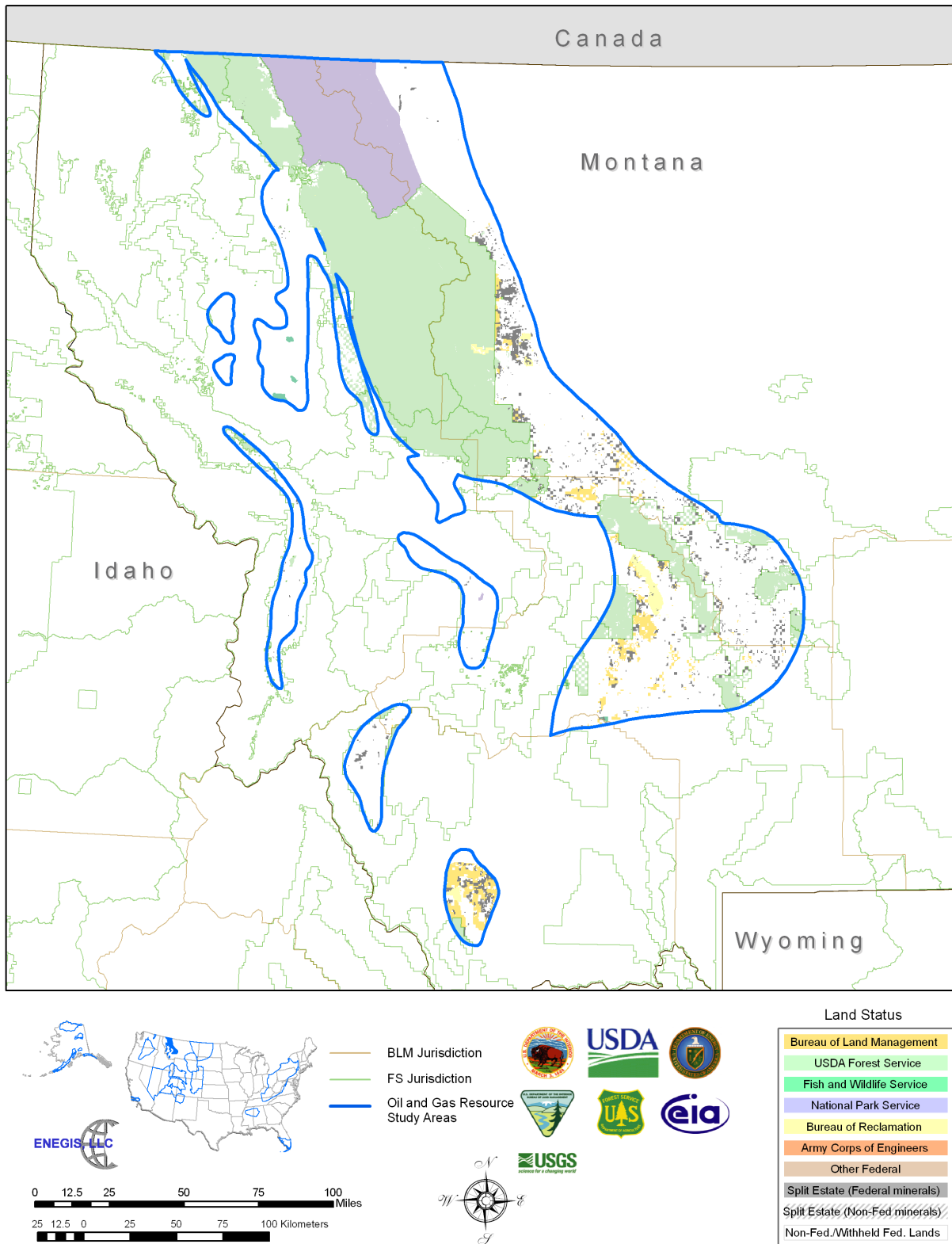


Figure 2-10. Federal Land Status Map, Montana Thrust Belt Study Area

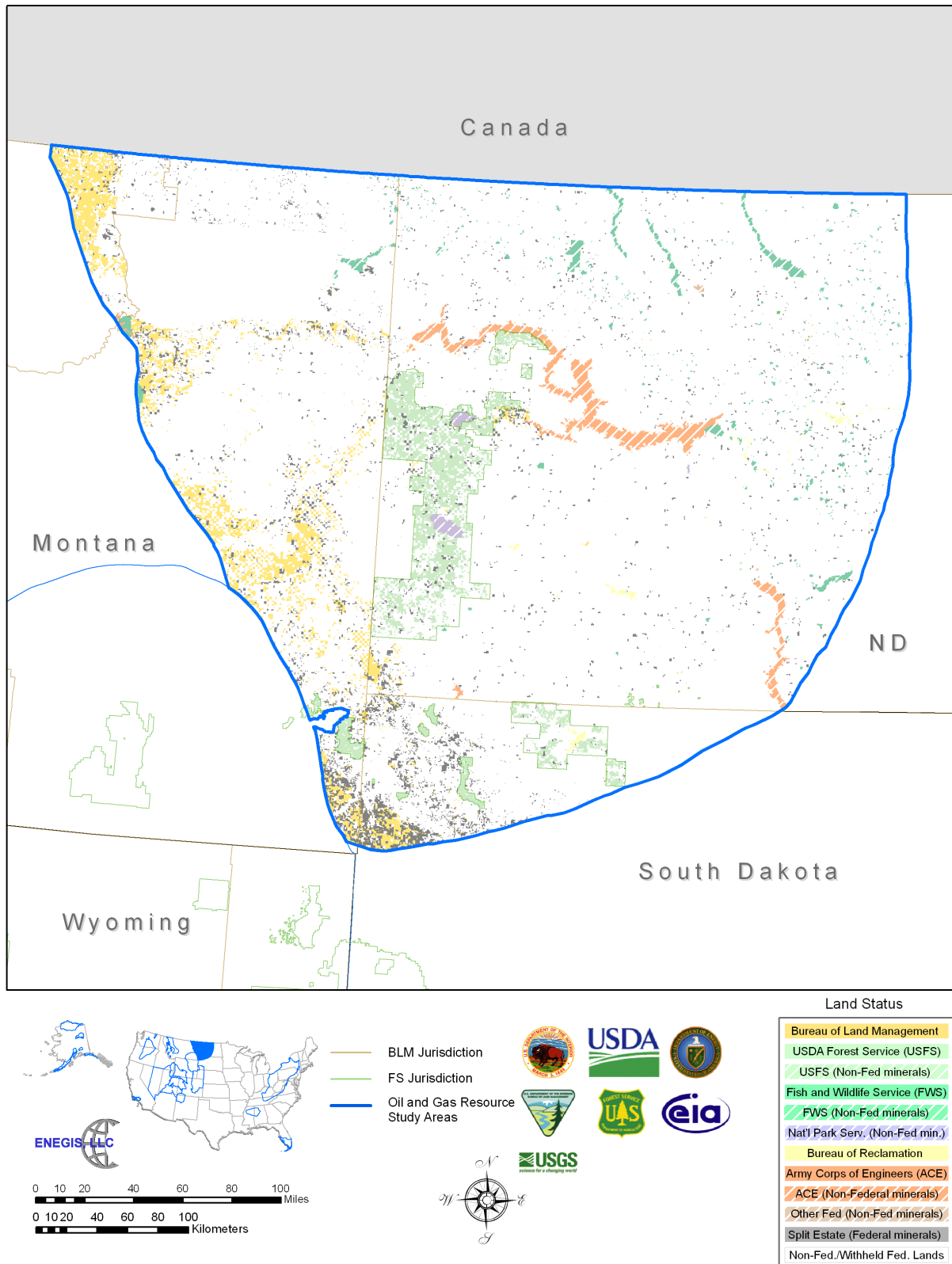


Figure 2-11. Federal Land Status Map, Williston Basin Study Area

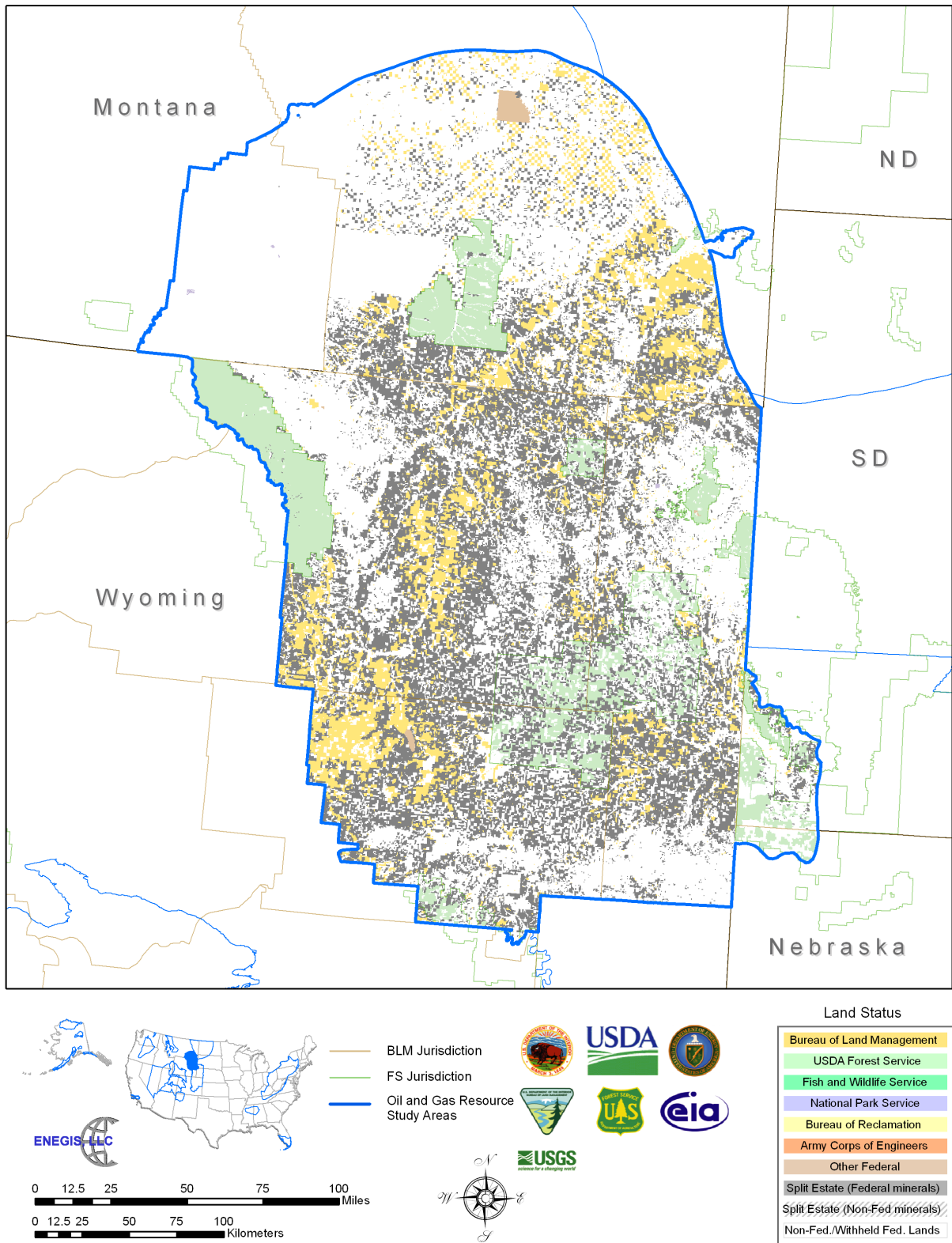


Figure 2-12. Federal Land Status Map, Powder River Basin Study Area

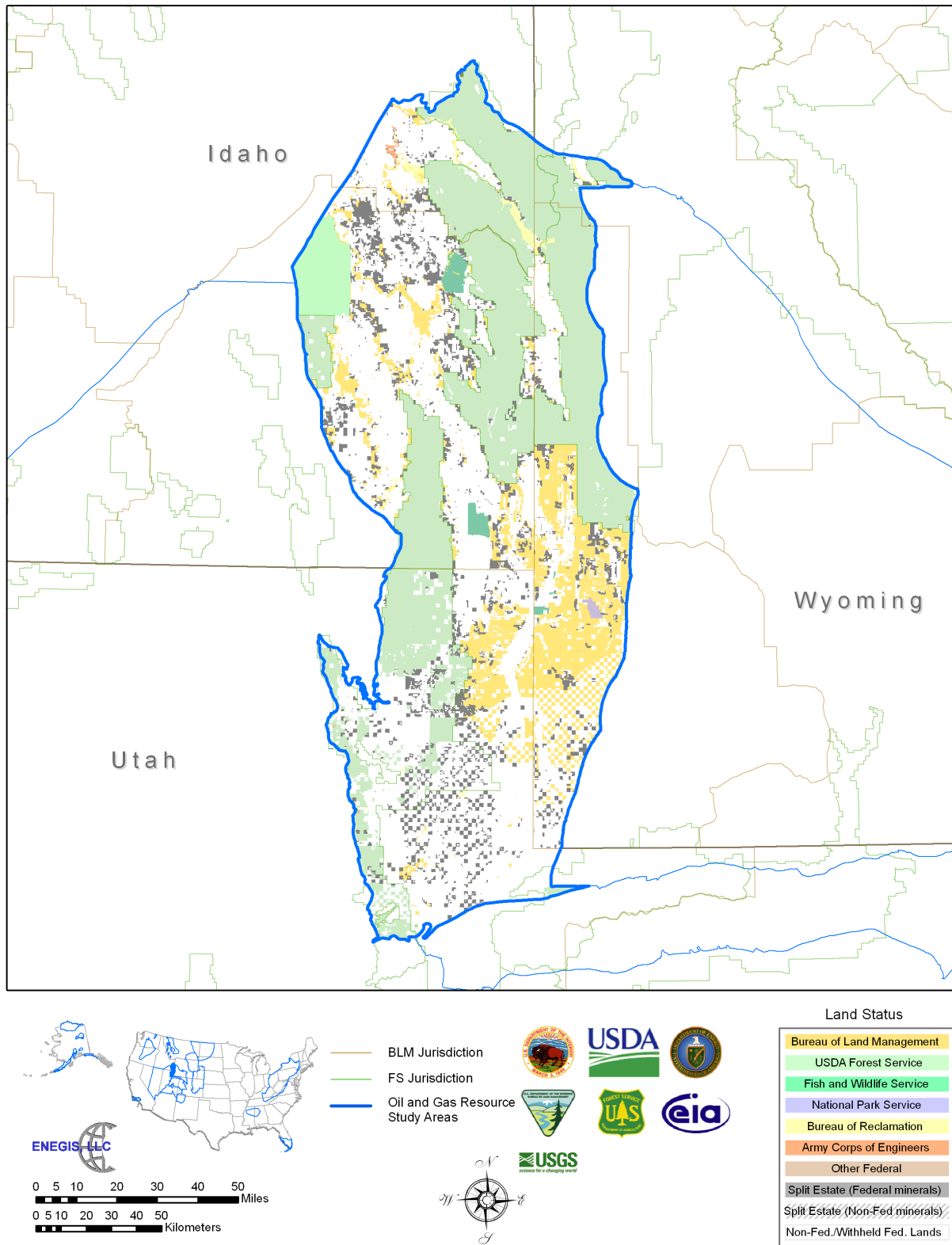


Figure 2-13. Federal Land Status Map, Wyoming Thrust Belt Study Area

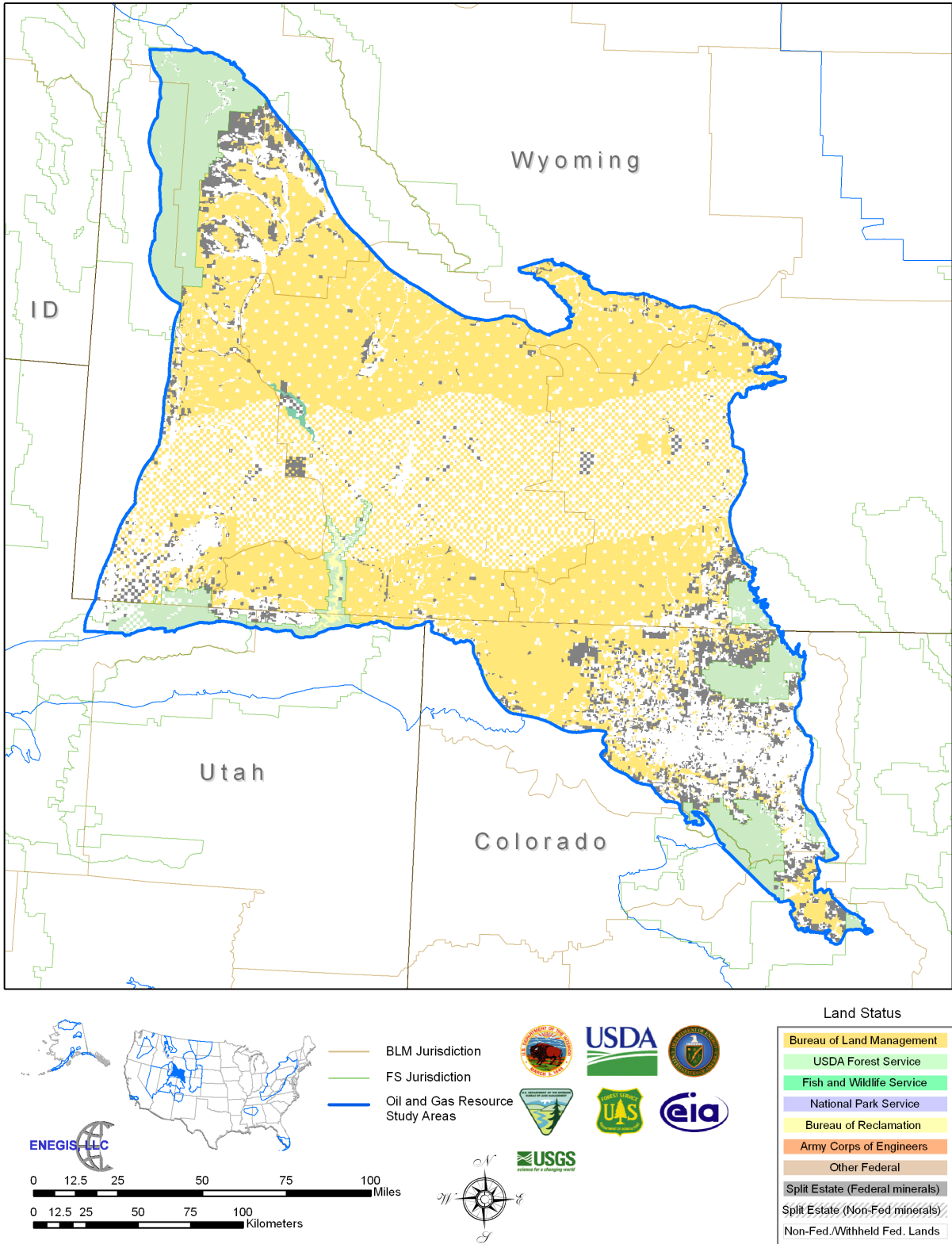


Figure 2-14. Federal Land Status Map, Southwestern Wyoming Study Area

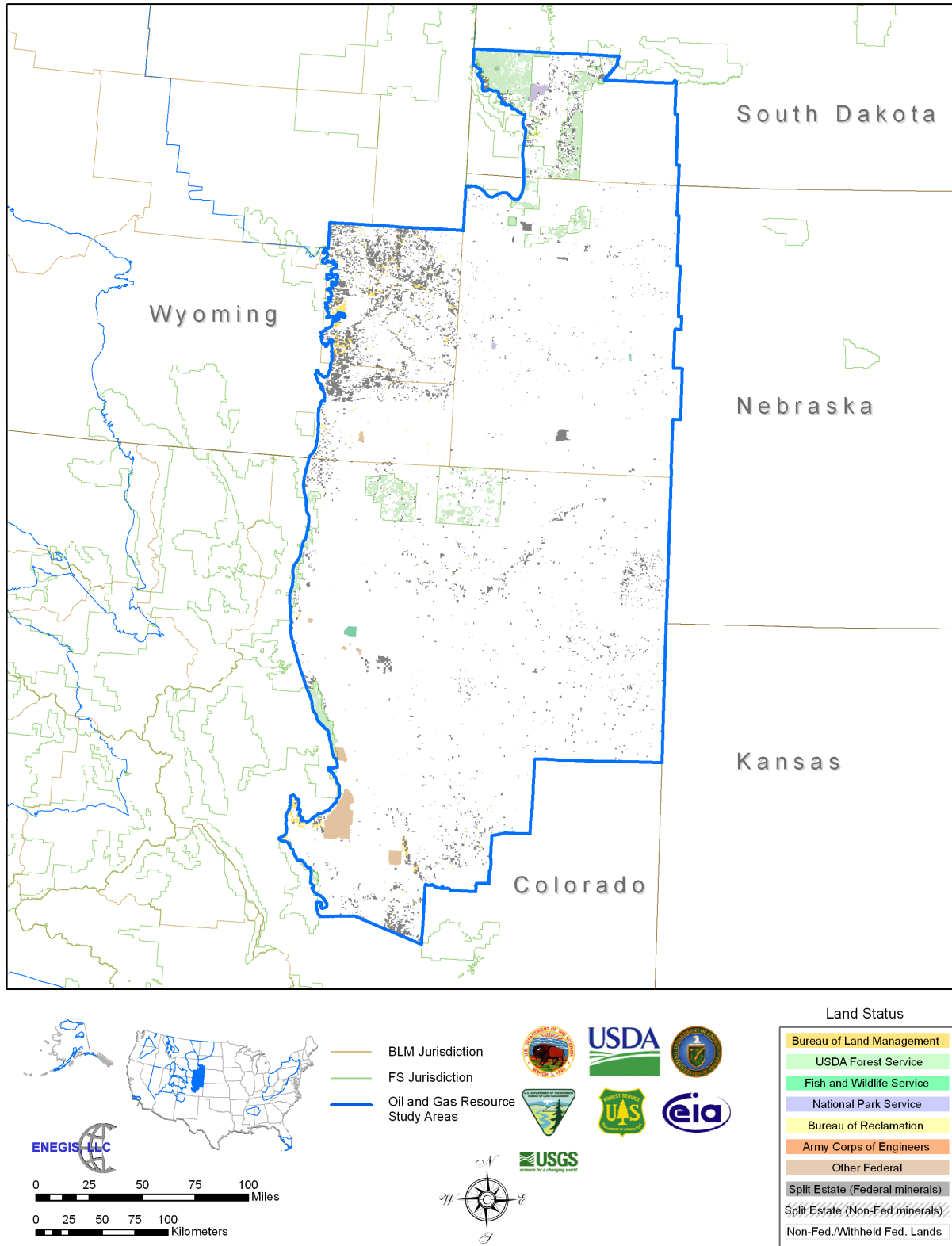


Figure 2-15. Federal Land Status Map, Denver Basin Study Area

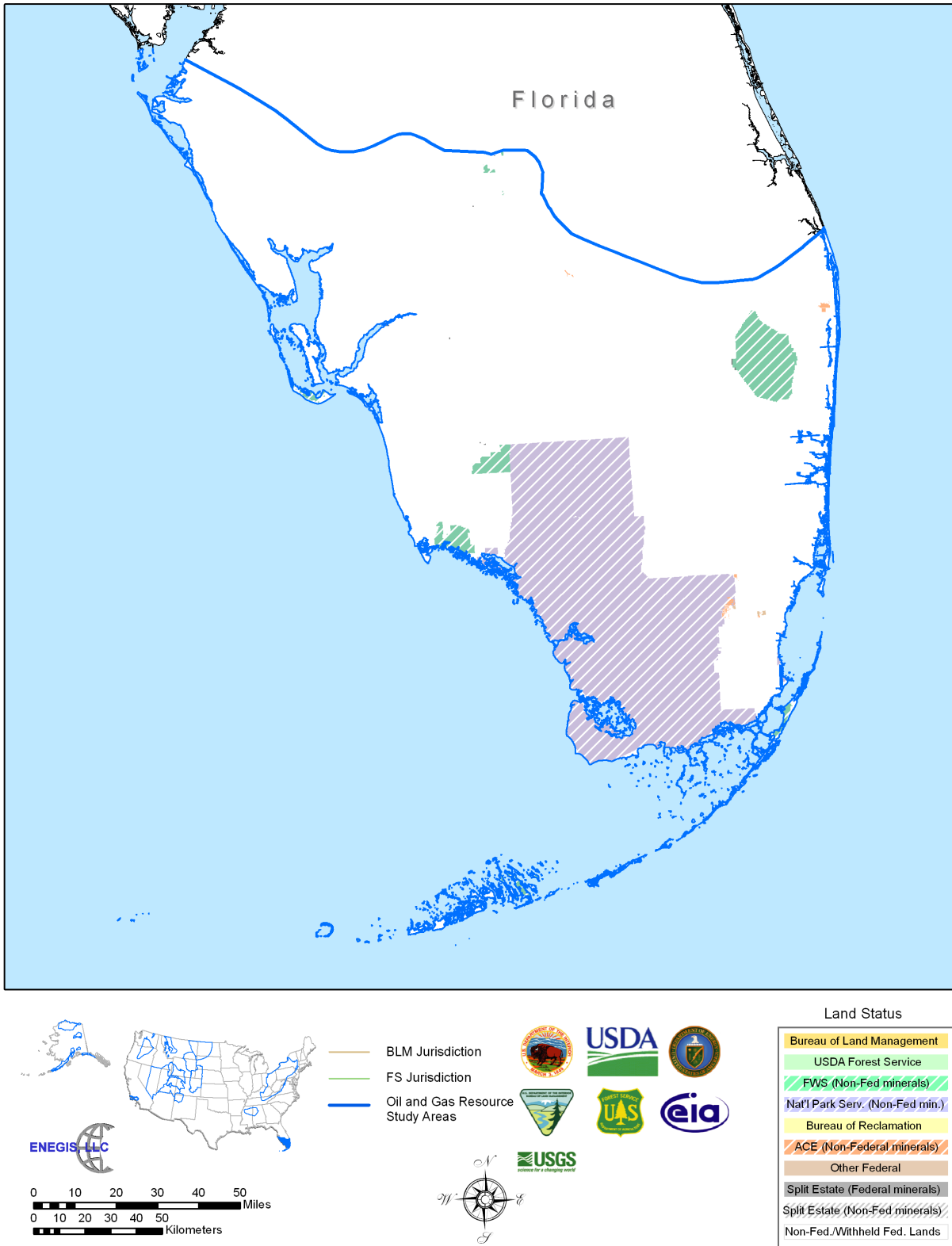


Figure 2-16. Federal Land Status Map, Florida Peninsula Study Area

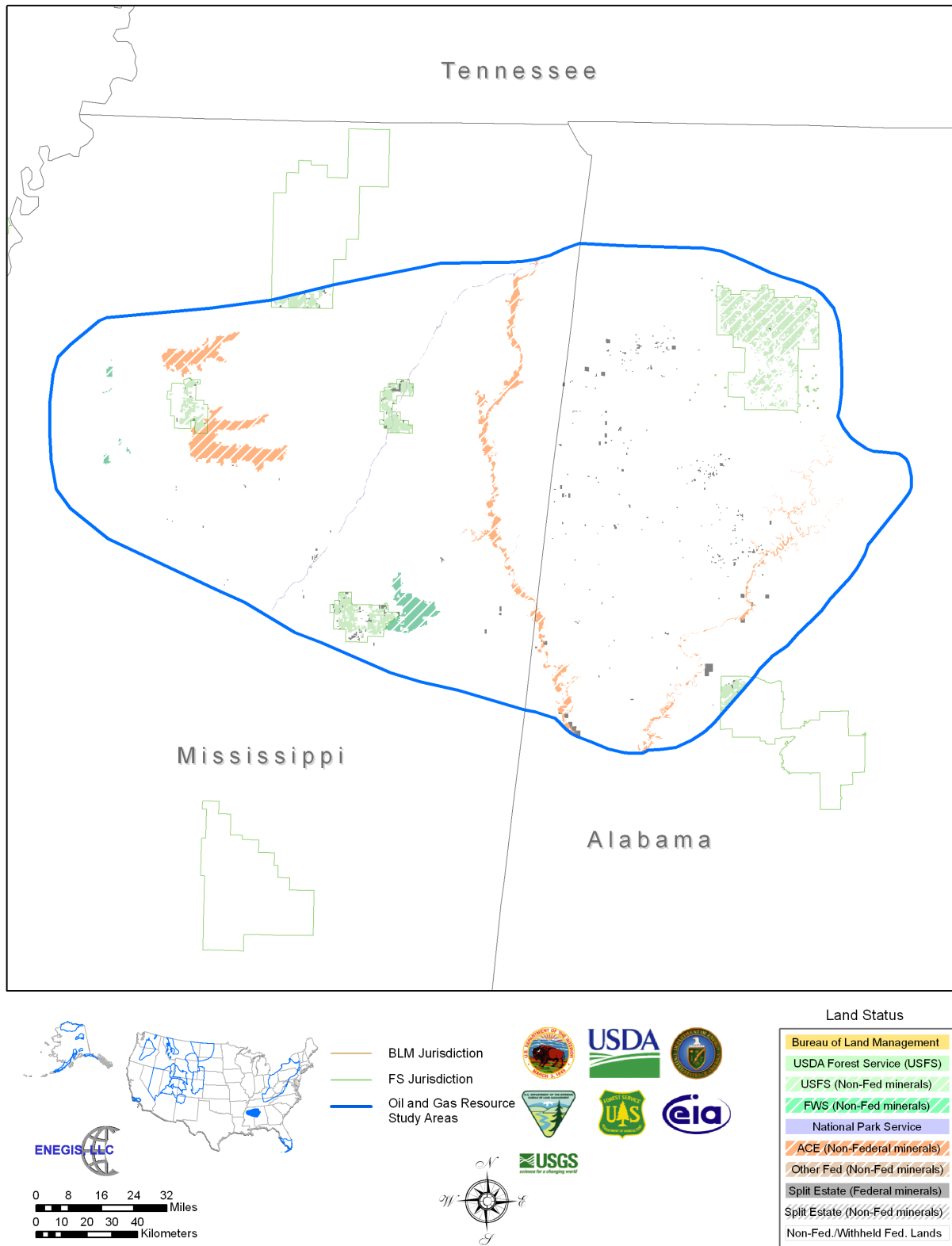


Figure 2-17. Federal Land Status Map, Black Warrior Basin Study Area

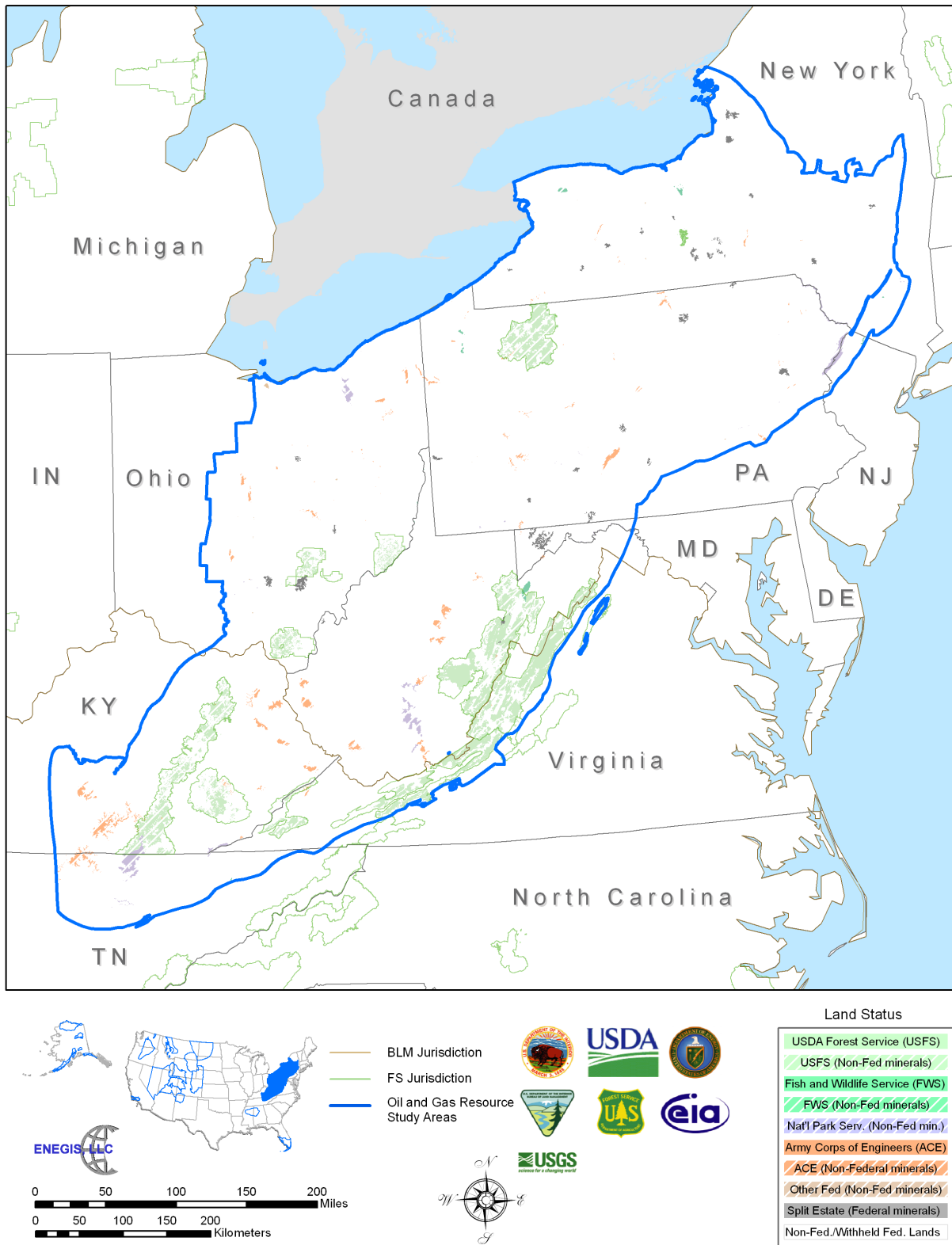


Figure 2-18. Federal Land Status Map, Appalachian Basin Study Area

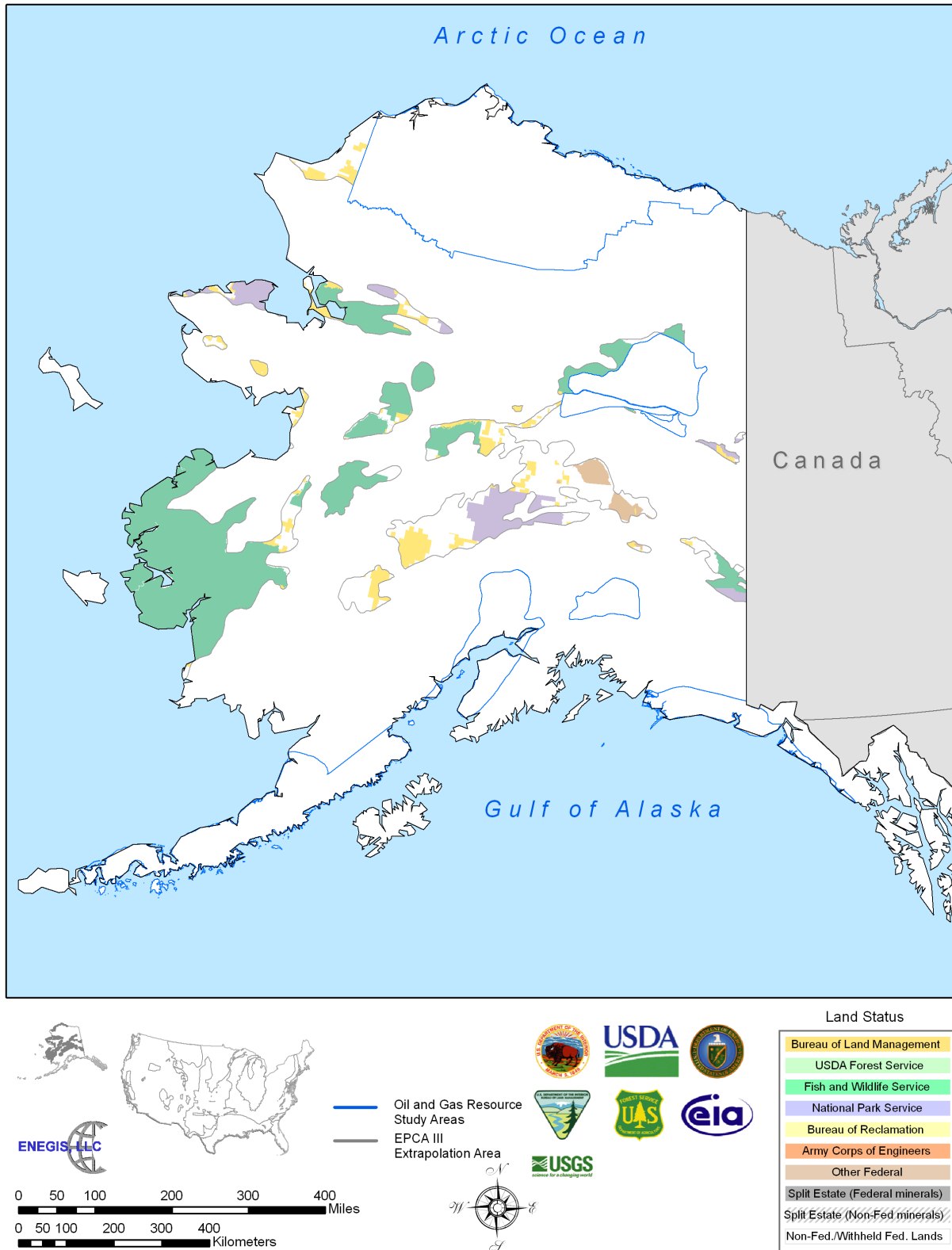


Figure 2-19. Federal Land Status Map, Alaska Extrapolation Area

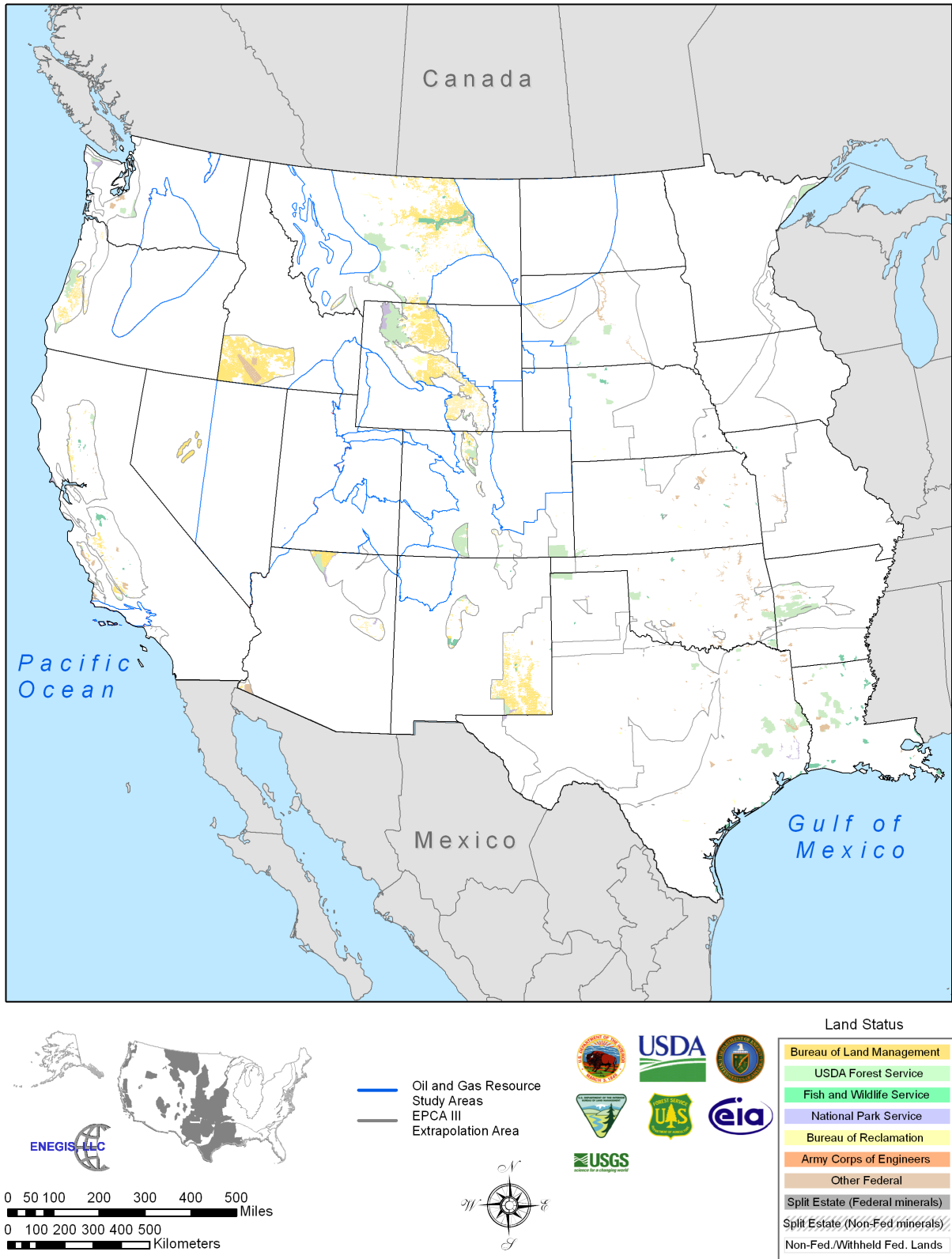


Figure 2-20. Federal Land Status Map, Western Extrapolation Area

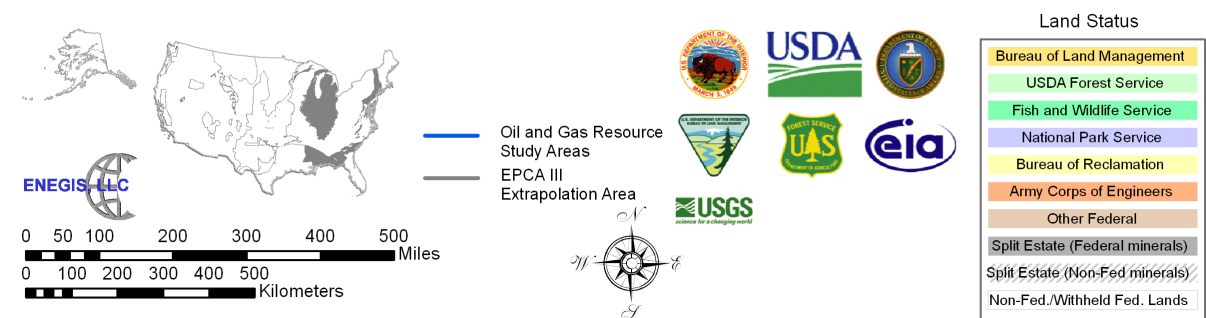


Figure 2-21. Federal Land Status Map, Eastern Extrapolation Area

2.1.1.3 Land Status Data-Related Caveats

The following precautions are advised when reviewing this Inventory:

- The land status data are generally spatially accurate down to 40 acres for the lower 48 States. In Alaska, the data are spatially accurate down to 640 acres.
- The GIS files, created using the processes described in detail in Appendix 3, were interpolated from the legal land descriptions contained in the BLM's LR-2000 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. Isolated parcels of less than 40 acres, particularly in the Eastern study areas, were not included in the Inventory.

- 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.
- Some land status GIS data are restricted from public release by agency request. Such data were used in the analyses presented in this report, but are not contained in the public datasets.

For purposes of this Inventory, Federal lands include split estate lands. In cases of split estate lands, where the Federal government holds a partial interest in the oil and gas mineral estate, the Federal government was assumed to hold total mineral interest. Table 2-1 depicts Federal lands by surface management agency within the Inventory. Note that the table includes both comprehensively studied areas and extrapolated areas.

Table 2-1. Federal Land Acreage by Surface Management Agency

Federal Surface Management Agency	Detailed Study Areas (acres)	Extrapolated Areas (acres)	Total Phase III Inventory Acreage (acres)	Extrapolated (percent)
Bureau of Land Management (including split estate)	114,438,133	26,994,121	141,432,254	19%
Forest Service, U.S. Department of Agriculture	36,015,422	23,853,805	59,869,227	40%
Fish and Wildlife Service	12,979,860	29,493,919	42,473,779	69%
National Park Service	11,834,570	6,289,748	18,124,318	35%
Department of Defense	4,791,945	7,668,537	12,460,482	62%
Army Corps of Engineers	2,407,574	0	2,407,574	0%
Bureau of Reclamation	776,843	739,111	1,515,954	49%
Tennessee Valley Authority	50,993	332,162	383,155	87%
Other Federal Lands	237,292	135,183	372,475	36%
Total Federal Lands	183,532,631	95,506,586	279,039,217	34%

2.1.2 Federal Oil and Gas Availability for Leasing and Lease Stipulations

All onshore Federal oil and gas leases contain terms and conditions as specified on the standard lease form (BLM Form 3100-11).²⁷ 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 lease stipulations. For example, a lease may contain a stipulation that prohibits surface disturbance during certain time periods for wildlife. Such stipulations on land use and timing may constrain exploration and development of oil and natural gas on Federal lands.

Some Federal lands are unavailable for leasing. See Table A9-2 in Appendix 9 for a listing of agencies and Federal designations that generally prohibit oil and gas leasing.

The Federal government does not issue oil and gas leases for areas where it has surface ownership but no mineral rights. In such instances, the Federal government, while allowing access to the subsurface resources owned by another party, typically uses surface occupancy restrictions (SORs) to protect surface resources. From the standpoint of the Inventory, SORs and lease stipulations have similar impacts. Thus, for the purposes of this study, the term “stipulation” is used generically to include SORs.

2.1.2.1 Sources of Lease Stipulation Data

Oil and gas lease stipulations are derived

from the Federal surface management agency’s land use plans, e.g., RMPs for the BLM and FPs for the FS. These plans are generally produced and 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 FS). Land use planning documents are revised every 10 to 15 years, or on an as-needed basis, but may be amended to address specific land use issues. Table 2-2 lists the land use planning documents used for this Inventory.

Hardcopy and digital data showing the mapped lease stipulation areas were collected from BLM and FS offices within the study areas (see Table 1-1). During office visits, copies of land use planning documents, such as RMPs and FPs, were also obtained.

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 predated the widespread availability of GIS technology, maintain this information in the form of hardcopy maps. For this Inventory, these maps were digitized, stored, and analyzed as GIS layers. The digitized maps were then returned to the originating field offices for review and future use. For some BLM and FS plans, maps are not available for some stipulations either in GIS or hardcopy form.

Data for this study were collected during the three phases of the Inventory. For the UPB, PDX, SJB, PDR, and MTB study areas, data were initially collected in the winter of 2001-2002. For the SWW study area, data were used from the DOE’s Federal

²⁷ The form is available at <https://www.blm.gov/FormsCentral/show-form.do?nodeId=687#>

Table 2-2. Land Use Plans by Study Area

Study Area	Land Use Plan	Year Published
Northern Alaska	Alaska-NE NPRA Final Integrated Activity Plan/EIS -- Amendment	2006
	Alaska-NW NPRA Final Integrated Activity Plan/EIS	2003
	Utility Corridor Proposed RMP and Final EIS	1989
Central Alaska - Yukon Flats	RMP for the Steese National Conservation Area	1986
	RMP for the White Mountains National Recreation Area	2004
Southern Alaska	Revised Land and RMP for Chugach NF	2003
	Revised Land and RMP for Tongass NF	1997
Eastern Oregon-Washington	Lakeview RMP	2003
	Brothers/LaPine RMP	1989
	John Day River Management Plan, Two Rivers, John Day, and Baker RMP Amendments	2001
	Two Rivers RMP	1986
	Upper Deschutes ROD and RMP	2005
	Proposed Spokane RMP and Amended Final EIS	1992
	Baker RMP	1989
	Ochoco NF, Oil & Gas Leasing Analysis Final EIS	1993
	Deschutes NF Plan	1990
	Umatilla and Malheur NFs, O&G Leasing Final EIS	1995
Ventura Basin	Caliente RMP	1997
	South Coast RMP and ROD	1994
	Revised Land Management Plan and Final EIS for Angeles NF	2000
	Revised Land Management Plan and Final EIS for Los Padres NF	2005
Eastern Great Basin	Arizona Strip DO RMP/EIS	1992
	Egan RMP Approved Oil & Gas Leasing Amendment and ROD	1994
	Tonopah RMP and ROD	1997
	Cassia RMP	1985
	Monument RMP	1986
	Cedar Beaver Garfield Antimony RMP	1986
	Pinyon MFP	1983
	Elko RMP and List of Stipulations	1987
	Wells ROD and List of Stipulations	1985
	House Range Resource Area RMP and ROD Rangeland Program Summary	1987
	Warm Springs Resource Area RMP Rangeland Program Summary	1987
	Big Desert Management Plan	1981
	Las Vegas RMP and Final EIS	1998
	Pocatello & Medicine Lodge Resource Areas RMP	1988
Henry Mtn., Parker Mtn., and Mtn. Valley MFP	1982	

Table 2-2. Land Use Plans by Study Area (continued)

Study Area	Land Use Plan	Year Published
Eastern Great Basin (continued)	Bear River EA	1994
	ROD and Rangeland Summary for the Box Elder RMP	1986
	ROD for the Pony Express RMP and Rangeland Program Summary for Utah County	1990
	Revised Forest Plan for the Caribou NF	2003
	Humbolt and Toiyabe Forest Plan and Amendments	2003
	Final EIS for Oil & Gas Leasing on Lands Administered by the Manti-La Sal NF	1992
Uinta/Piceance Basin	Ashley NF Stipulation for Lands of the NF System	1992
	Glenwood Springs Resource Area Final Supplemental EIS	1999
	Grand Mesa, Uncompahgre and Gunnison (GMUG) NFs ROD Oil & Gas Leasing Final EIS	1993
	Grand Junction Resource Area Management Plan and ROD	1987
	Gunnison Resource Area RMP	1993
	Routt NF Land and RMP Revision	1997
	Uncompahgre Basin RMP and ROD	1989
	Thunder Basin Nat. Grassland Land and RMP	2002
	Land and RMP—Manti-La Sal NF	1986
	Book Cliffs RMP ROD and Rangeland Program (combine with Diamond Mtn into Vernal RMP)	1985
	Leasing Stipulations, Craig-Little Snake BLM	1991
	Price River Resource Area MFP	1982
	San Rafael RMP	1991
	Gunnison Gorge NCA Approved RMP and ROD	2004
	Land and RMP Revision—Uinta NF	2003
	San Juan/San Miguel RMP Amendment (San Miguel updated with Uncomphagre RMP)	1991
	San Juan/San Miguel RMP Amendment (San Juan RMP revision)	1991
	Diamond Mountain Recreation Area ARMP/ROD (combine with Book Cliffs into Vernal RMP)	1994
	White River Resource Area RMP	1997
	White River RMP, Oil and Gas Final EIS/ROD	1993
Paradox Basin	Vermillion MFP	1981
	Grand Resource Area RMP	1985
	San Juan ROD & Rangeland Program Summary	1991
	Paria MFP	1981
	Escalante MFP	1981
	Zion MFP	1981

Table 2-2. Land Use Plans by Study Area (continued)

Study Area	Land Use Plan	Year Published
San Juan Basin	Rio Puerco RMP (Now the Albuquerque FO. Update Document 2001. RMP revision TBD)	1992
	New Mexico BOR–Navajo Reservoir (Draft EA Navajo Reservoir Area RMP)	2005
	Carson NF Plan (Valle Vidal amendments in progress)	1986
	Cedar Beaver Garfield Antimony RMP	1986
	Cibola NF Plan (Grasslands RMP under revision)	1985
	Cibola NF Plan (Forests RMP revision to start 2007)	1985
	Farmington Oil and Gas Leasing Amendment	1991
	Taos Field Office Oil & Gas Leasing Stipulations	1985
	St. George FO-ROD and RMP	1999
Montana Thrust Belt	Beaverhead NF EIS	1996
	Headwaters RMP/EIS (South Headwaters update will be part of new Butte FO RMP)	1984
	Dillon RMP	2006
	Headwaters RMP/EIS (North Headwaters RMP revision)	1984
	Helena NF Plan and ROD	1986
	Lewis and Clark NF, Oil and Gas Leasing Final EIS	1997
	Garnet RMP	1986
Powder River Basin	Black Hills NF Plan of Land and RMP	1991
	Buffalo RMP	2001
	Bighorn NF Revised Land and RMP	2005
	South Dakota RMP	1986
	Platte River RMP Revised & Updated Decisions (renamed Casper RMP)	2001
	Billings RMP	2003
	Miles City BLM Oil and Gas Amendment (Miles City RMP Revision 2007)	1994
	Nebraska NF Revised Land and RMP FEIS/RD	2002
	Newcastle FO, ROD & Approved RMP	2000
Williston Basin	Valley MFP	1978
	Big Dry RAMP - Maintenance Version	1996
	Powder River RAMP Maintenance Version	1985
	North Dakota RMP	1988
	Dakota Prairie Grasslands Northern Region Land and RMP FEIS/ROD	2002
Wyoming Thrust Belt	Targhee NF Revised Forest Plan	2000
	Pocatello & Medicine Lodge Resource Areas RMP (Pocatello RMP pending)	1988

Table 2-2. Land Use Plans by Study Area (concluded)

Study Area	Land Use Plan	Year Published
Southwestern Wyoming	Bridger-Teton NF Land and RMP	1990
	Kemmerer RMP/ROD	1986
	Lander RMP	1987
	Medicine Bow NF Revised Land and RMP	2003
	Pinedale Anticline Oil & Gas Exploration and Development Project EIS ROD	2000
	Pinedale RMP amended 2000 for oil & gas	2000
	Lease Stipulations, Rawlins BLM	2001
	ROD and Jack Morrow Hills CAP/Green River RMP Amendment	2006
	ROD and Green River RMP	1997
	Wasatch-Cache NF, Revised Forest Plan	2003
Denver Basin	Arapaho-Roosevelt NFs, Pawnee NG Revision of the Land and Resource Management Plan	1997
	Nebraska RMP	1992
	Pike & San Isabel NF, Cimarron & Comanche NG, O&G Leasing Final EIS (Grasslands)	1992
	Pike & San Isabel NF, Cimarron & Comanche NG, O&G Leasing Final EIS (Forests)	1992
	Royal Gorge RMP and NE Royal Gorge RMP	1991
Florida Peninsula	Florida RMP/ROD	1995
	Big Cypress General Management Plan/ Final EIS	1991
Black Warrior Basin	Alabama NFs—Revised Land and RMP	2004
	Mississippi EA report—O&G leasing on the NFs	1976
Appalachian Basin	Allegheny NF Land and RMP	1986
	Mosquito Creek Lake DR	2000
	Berlin Lake Project DR; Conemaugh River Lake Project EA	1985
	Daniel Boone NF Revised Land and RMP	2004
	Seneca Army Depot and Sampson State Park	1993
	George Washington NF—Final revised Land and RMP	1993
	Jefferson NF—Revised Land and RMP	2004
	Monongahela NF and Amendments Land and RMP	1986
	Wayne NF ROD for the Final EIS Land and RMP	2006

lands analysis²⁸ collected during the fall and winter of 2000-2001; these data were verified with the local BLM and FS offices and were current as of August 2002. The data for NAK were collected in the fall of 2003. Data for the WTB, DEN, BWB, FLP and APB were collected during 2004. Data for the YKF, SAK, EOW, VEN, EGB, and WIL were collected during 2006. Also during 2006, offices from areas analyzed in the first two phases of the Inventory were canvassed for any updated data, which were collected and incorporated into the Inventory. These data were verified with the local BLM and FS offices and were current as of December 2006.

2.1.2.2 Lease Stipulation Data Preparation

Most of the lease stipulation data preparation consisted of the gathering, digitizing, and compiling of the data in multi-layered digital map files. Federal Geographic Data Committee Standards (FGDC)-compliant supporting documentation (metadata) for the resulting GIS layers was also created.

This Inventory concerns only Federal lands within the aggregate resource play boundaries of the study areas, which are based on geology as defined in the USGS National Assessment of Oil and Gas Resources. Consequently, the land status and stipulation digital map files, which correspond to Federal land management agency jurisdiction boundaries, were clipped using GIS to fit within each of the study area boundaries. Data contained within the compiled digital map files were then queried

for unique leasing stipulation values. The results were saved as separate map files. Each digital map file represents a unique stipulation value.

For a description of the specific data preparation steps, see Appendix 4.

2.1.2.3 Lease Stipulation

Data-Related Caveats

The following precautions are advised when reviewing this study:

- All stipulations for which GIS data were available from the Federal land management agencies were used in the analysis. Most of the stipulations within the study areas were available in GIS data formats; however, supporting documentation was not generally provided with GIS files. Although this can lead to inaccuracies due to undocumented differences in technical parameters, such errors are minor in terms of the scope of the Inventory.
- The GIS data for areas with steep slopes in the Manti-La Sal National Forest could not be modeled in the form provided by the office, due to the file's extremely large size. All polygons with an area smaller than 1 acre were excluded from the data prior to modeling in order to reduce the file size and allow for geoprocessing. This process is expected to cause the area reported for the forest to be available for leasing with no surface occupancy to be slightly smaller than the actual area.
- Many stipulations not available in GIS format were digitized. Any resulting inaccuracies due to this process are likely to have insignificant impacts upon the analysis.

²⁸ 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/programs/oilgas/publications/fla/Federal_Lands_Assessment_Report.html.

- Neither hardcopy nor digital maps were available for some stipulations (see Section 2.3.1.1 for further discussion).
- The lease stipulation data are generally accurate to a minimum of 40 acres in the lower 48 states, and 640 acres in Alaska.

Some lease stipulation GIS data are restricted from public release by agency request. Such data were used in the Inventory's analysis but are not contained in the public datasets.

2.1.3 Federal Drilling Permit Conditions of Approval (COA)

As described in Section 2.1.2, a Federal oil and gas lease conveys the right to develop such resources on the leased land subject to reasonable regulations as determined by the land managing agency. The purpose of the inclusion of COAs in this Inventory is to enhance the land access constraints analysis and thus provide a more complete assessment of the onshore Federal lands' availability for oil and gas exploration and development.

The COAs arise from a variety of controlling authorities, but the most significant and wide-ranging are those governed by four Federal laws; specifically, the Federal Land Policy and Management Act (FLPMA), the NEPA, the Endangered Species Act (ESA) and the National Historic Preservation Act (NHPA). The COAs attached to each APD can be general in nature or site-specific, and thus vary from one BLM Field Office to another.

Some COAs can be identified as "best management practices" while others are included as a standard set by the approving office. In the Inventory study areas, approximately 157 types of COAs provide

mitigation for surface-disturbing activities. For example, COAs can address:

- Big game winter range
- Protection of wildlife habitat
- Protection of cultural resources
- Noise reduction
- Road construction and maintenance
- Tanks and pits for fluid storage
- Pipeline and power line construction
- Wildfire suppression
- Management of noxious weeds
- Reclamation
- Erosion control
- Fertilizer application

In order to examine COAs and their effects upon land access, it was necessary for the BLM to review extensively the APD well records in its field offices. The methodology for the assessment of COAs is described in Appendix 5.

2.1.3.1 Sources of Conditions of Approval Data

For the Inventory, a number of APDs for all study areas were sampled. A stratified random sampling protocol was used on a list of all Federal APDs approved during fiscal years 1999-2004. The sample represents approximately 10 percent of the total population. The BLM Field Offices were visited and information on site-specific COAs was abstracted from the hardcopy well files. A summarized version of the COAs and stipulations that affected oil and gas access in each selected APD was noted.

In addition, information was obtained from BLM Field Office personnel to qualitatively assess the extent of negotiations that occur prior to the submission of an APD, including adjustments at the time of well staking and are presented in Appendix 5.

2.1.3.2 Conditions of Approval Data Preparation

The COAs data preparation consisted of compiling the collected information into spreadsheets and spatial GIS displays. The

abstracted information was grouped into general classes that were assigned unique codes. Table 2-3 presents a list by BLM office. Appendix 5 contains details on the data preparation task.

Table 2-3. COAs by BLM Field Office

BLM FO	Well Population	Sample Size	Sample Wells w/ COAs
Albuquerque	48	30	4
Bakersfield	11	11	1
Battle Mountain	3	3	1
Buffalo	5,077	200	69
Casper	170	30	25
Elko	3	3	-
Ely	13	13	2
Farmington	2,713	200	74
Glenwood Springs	349	53	16
Grand Junction	40	30	22
Kemmerer	96	30	22
Lander	11	11	7
Little Snake	63	30	23
Miles City	391	66	37
Milwaukee	14	14	2
Moab	23	23	10
Monticello	9	9	3
New Castle	76	30	8
North Dakota	175	25	15
Northern Alaska	39	25	4
Pindale	710	107	72
Rawlins	714	107	50
Rock Springs	173	30	15
Royal Gorge	39	30	23
Salt Lake	1	1	-
San Juan	35	30	22
South Dakota	6	6	1
Uncompahgre	7	7	7
Vernal	861	130	35
White River	320	48	22
Total	12,190	1,332	592

2.1.3.3 Conditions of Approval Data-Related Caveats

The APDs examined were randomly sampled. To the extent that the sample is not representative of the population, extrapolation of sample results could introduce error.

Because of the large number of approved Federal APDs, the sample for the Inventory was restricted to represent a portion of the total number, but has been improved by means of a stratified sampling protocol explained in Appendix 5. This method reduces the impact of potential inaccuracies introduced due to extrapolation of results to general areas. Some field offices had small populations of wells (<30), which can lead to relatively poor samples. In such cases, all wells in an office were sampled.

2.1.4 Extrapolation of Federal Lands and Resources Outside Detailed Study Areas

In order to inventory all Federal onshore oil and gas resources, the analytical model includes an extrapolation of the land and resource categorization to the lands outside the detailed study areas. The areas to be extrapolated were delineated using the USGS 1995 National Oil and Gas Assessment for the United States²⁹ and new assessments completed³⁰ since then. The National Atlas Federal lands layer was used for land status within the extrapolated areas.³¹ Land area was tallied by Federal surface management agency (see Table 2-1). Additionally, the reserves growth were

extrapolated to account for the remaining resources outside the detailed study areas using the proved reserves estimates compiled by the EIA for each state. A detailed explanation of the analytical process for extrapolation can be found in Appendix 9. The results are summarized in Section 3.

2.2 Procedures for Collecting and Preparing Oil and Gas Resource, Reserves Growth, and Reserves Data

2.2.1 Undiscovered Oil and Gas Resources

2.2.1.1 Sources of Oil and Gas Resources Data

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

Undiscovered 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. These resources can be produced using current technology without regard to economic profitability. Technically recoverable resources are a subset of the total resource-in-place that could be expected to be recovered over an exploration and development life cycle measured in decades.

The USGS assesses oil and gas resources in geologic “plays” or “assessment units.” A play is a set of known or postulated oil and gas accumulations defined by common geological conditions (source rock, migration, timing, charge, traps, seals, etc.) that characterize a group of hydrocarbon

²⁹ USGS National oil and gas assessment. <http://energy.cr.usgs.gov/oilgas/noga/1995.html>

³⁰ Completed before February 2007

³¹ The National Atlas of the United States. <http://www.nationalatlas.gov/>

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 geologic knowledge and 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 economics. Technically recoverable resources are therefore dynamic, and change in response to 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 the increasing knowledge and technology but also with the rapid and sometimes unpredictable changes in economic conditions, prices, markets, 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.



accumulations in the subsurface. An assessment unit is defined as a mappable volume of rock within a total petroleum system that encompasses accumulations (discovered and undiscovered) that share similar geologic traits and socio-economic factors. Accumulations within an assessment unit should constitute a sufficiently homogeneous population such that the chosen methodology of resource assessment is applicable. A total petroleum system might equate to a single assessment unit. If necessary, a total petroleum system can be subdivided into two or more assessment units so that each unit is sufficiently homogeneous to assess individually.

The USGS assesses two resource play types: conventional and continuous. Conventional plays contain discrete

hydrocarbon accumulations often associated with hydrocarbon/water contacts. Continuous plays are pervasive hydrocarbon accumulations that can cross rock unit boundaries, lack discrete structural boundaries, and exhibit other atypical reservoir properties (Figure 2-22). They include tight gas sands, gas shales, and coalbed natural gas (also referred to as coal gas, coalbed gas or coalbed methane). Compared to conventional plays, continuous accumulations typically are more geographically extensive. Most of the resources in the study areas in the lower-48 states are of the continuous type.

There are 208 discrete oil and natural gas resource plays in the Inventory detailed study areas. The probabilistic mean estimate of hydrocarbon resource volumes for each USGS-defined play was utilized for

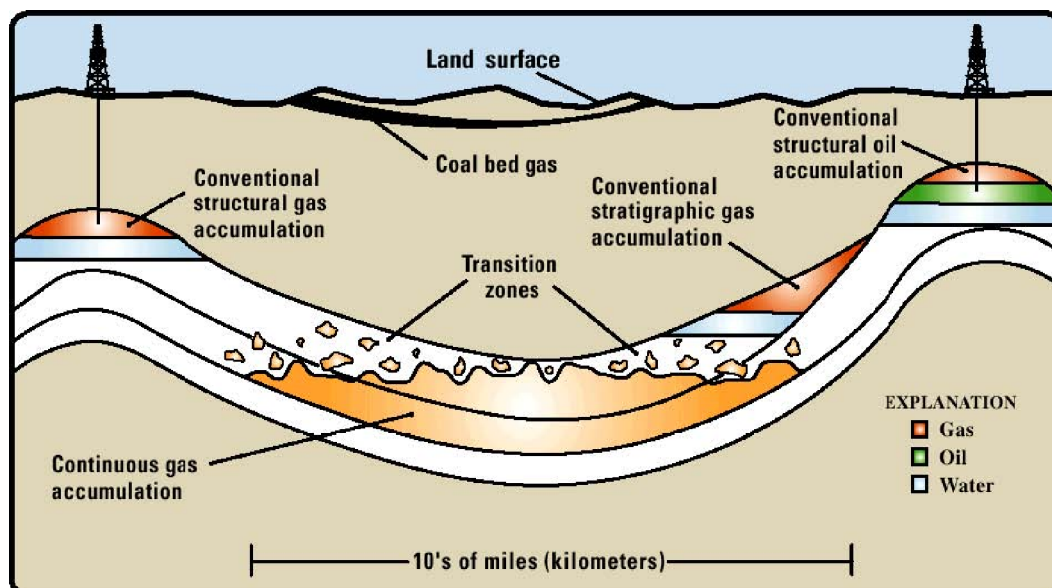


Figure 2-22. Conventional vs. Continuous Accumulations

this Inventory (Table 2-4). The assessed resources include oil, natural gas liquids (NGLs), associated dissolved (AD) natural gas, non-associated natural gas (NAG) and liquids in gas reservoirs. Oil is a natural liquid of mostly hydrocarbon molecules. The 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 from gas fields. The USGS assesses technically recoverable resources for each of these resource types, and estimates their volumes. While modeled discretely in this analysis, for purposes of presentation in this Inventory, undiscovered oil, NGLs, and liquids associated with natural gas reservoirs were subsequently aggregated into a single “Total Oil” resource category. Similarly, AD and non-associated natural gases were combined as “Total Natural Gas.”

2.2.1.2 Oil and Gas Resource Data Preparation

The geometry of an oil and gas play is defined by its geology and extends horizontally and vertically in the subsurface. Figure 2-23 is an idealized block diagram showing how three different plays can occur in a single area. Plays are commonly “stacked” in the subsurface so that a given surface land parcel can overlie numerous plays.

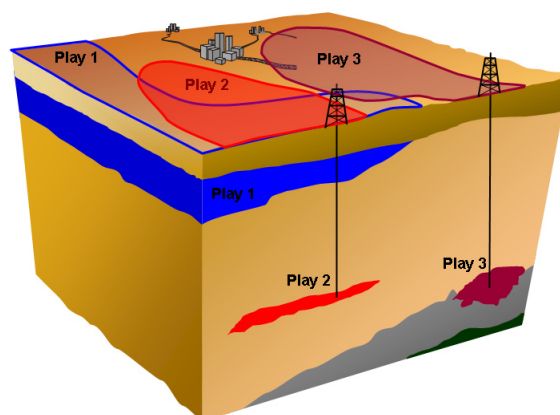


Figure 2-23. Conceptual Block Diagram of Oil and Gas Plays

Table 2-4. Undiscovered Technically Recoverable Resources by Play

USGS Province Name	USGS Code	USGS Play or Assessment Unit Name	Play Type	Total Liquids ^a (MMbbl)	Total Natural Gas ^b (Bcf)
(01) Northern Alaska	anwr001	Wedge	Conventional	509	259
(01) Northern Alaska	anwr002	Undeformed Franklin	Conventional	134	353
(01) Northern Alaska	anwr003	Turbidite	Conventional	1680	1400
(01) Northern Alaska	anwr004	Topset	Conventional	6196	1704
(01) Northern Alaska	anwr005	Thompson	Conventional	420	691
(01) Northern Alaska	anwr006	Thin-Skinned Thrust Belt	Conventional	1172	1787
(01) Northern Alaska	anwr007	Niguanak-Aurora	Conventional	411	532
(01) Northern Alaska	anwr008	Kermik	Conventional	63	129
(01) Northern Alaska	anwr009	Ellesmerian Thrust Belt	Conventional	18	876
(01) Northern Alaska	anwr010	Deformed Franklin	Conventional	92	860
(01) Northern Alaska	NAK025	Brookian Topset	Conventional	452	919
(01) Northern Alaska	NAK026	Brookian Clinoform	Conventional	1740	8260
(01) Northern Alaska	NAK027	Kemik-Thomson	Conventional	303	2762
(01) Northern Alaska	NAK028	Beaufortian Kuparac Topset	Conventional	184	672
(01) Northern Alaska	NAK029	Beaufortian Cretaceous Shelf Margin	Conventional	8	598
(01) Northern Alaska	NAK030	Beaufortian Upper Jurassic Topset East	Conventional	7	146
(01) Northern Alaska	NAK031	Beaufortian Upper Jurassic Topset West	Conventional	151	432
(01) Northern Alaska	NAK032	Beaufortian Clinoform	Conventional	130	1124
(01) Northern Alaska	NAK033	Brookian Topset Structural North	Conventional	265	395
(01) Northern Alaska	NAK034	Brookian Topset Structural South	Conventional	38	2392
(01) Northern Alaska	NAK035	Brookian Clinoform Structural North	Conventional	149	397
(01) Northern Alaska	NAK036	Brookian Clinoform Structural South	Conventional	43	2558
(01) Northern Alaska	NAK037	Beaufortian Structural	Conventional	36	2137
(01) Northern Alaska	NAK038	Ellesmerian Structural	Conventional	20	1502
(01) Northern Alaska	NAK039	Basement Involved Structural	Conventional	62	3030
(01) Northern Alaska	NAK040	Thrust Belt Triangle Zone	Conventional	91	3874
(01) Northern Alaska	NAK041	Thrust Belt Lisburne	Conventional	121	3663
(01) Northern Alaska	NAK042	Triassic Barrow Arch	Conventional	411	496
(01) Northern Alaska	NAK043	Ivishak Barrow Flank	Conventional	5	387
(01) Northern Alaska	NAK044	Lisburne Barrow Arch	Conventional	134	129
(01) Northern Alaska	NAK045	Lisburne Barrow Flank	Conventional	13	1035
(01) Northern Alaska	NAK046	Endicott Truncation	Conventional	80	85
(01) Northern Alaska	NAK047	Endicott	Conventional	6	500

Table 2-4. Undiscovered Technically Recoverable Resources by Play (continued)

USGS Province Name	USGS Code	USGS Play or Assessment Unit Name	Play Type	Total Liquids ^a (MMbbl)	Total Natural Gas ^b (Bcf)
(01) Northern Alaska	NAK048	Franklinian	Conventional	13	17
(01) Northern Alaska	NAK049	Nanushuk Formation Coalbed Gas	Coalbed Gas	35	15047
(01) Northern Alaska	NAK050	Prince Creek-Tuluvak Formation	Coalbed Gas	-	778
(01) Northern Alaska	NAK051	Sagavanirtoke Formation Coalbed Gas	Coalbed Gas	5	2231
(01) Northern Alaska	npra001	Torok Structural	Conventional	35	17905
(01) Northern Alaska	npra002	Thrust Belt	Conventional	6	1521
(01) Northern Alaska	npra003	Ellesmerian Ivishak	Conventional	84	106
(01) Northern Alaska	npra004	Ellesmerian Structural	Conventional	-	1990
(01) Northern Alaska	npra005	Ellesmerian Lisburne Total	Conventional	29	668
(01) Northern Alaska	npra006	Ellesmerian Endicott Total	Conventional	3	1073
(01) Northern Alaska	npra007	Ellesmerian Echooka Total	Conventional	7	512
(01) Northern Alaska	npra008	Brookian Topset Structural	Conventional	137	10606
(01) Northern Alaska	npra009	Brookian Topset	Conventional	239	192
(01) Northern Alaska	npra010	Brookian Clinoform	Conventional	2787	12272
(01) Northern Alaska	npra011	Beaufortian Upper Jurassic Topset	Conventional	7035	10357
(01) Northern Alaska	npra012	Beaufortian Lower Jurassic Topset	Conventional	83	793
(01) Northern Alaska	npra013	Beaufortian Cretaceous Topset Total	Conventional	103	2534
(01) Northern Alaska	npra014	Beaufortian Clinoform	Conventional	12	822
(02) Central Alaska - Yukon Flats	YKF001	Tertiary Sandstone	Conventional	288	5283
(02) Central Alaska - Yukon Flats	YKF002	Subthrust	Conventional	1	17
(02) Central Alaska - Yukon Flats	YKF003	Crooked Creek	Conventional	10	163
(02) Central Alaska - Yukon Flats	YKF004	Coalbed Gas	Coalbed Gas	-	-
(03) Southern Alaska	301	Alaska Peninsula Mesozoic	Conventional	52	52
(03) Southern Alaska	302	Alaska Peninsula Tertiary	Conventional	9	188
(03) Southern Alaska	303	Cook Inlet Beluga-Sterling Gas	Conventional	-	738
(03) Southern Alaska	304	Cook Inlet Hemlock-Tyonek Oil	Conventional	647	647
(03) Southern Alaska	305	Cook Inlet Late Mesozoic Oil	Conventional - Not quantitatively assessed	-	-
(03) Southern Alaska	306	Copper River Upper Cretaceous - Tertiary Biogenic Gas	Conventional - Not quantitatively assessed	-	-

Table 2-4. Undiscovered Technically Recoverable Resources by Play (continued)

USGS Province Name	USGS Code	USGS Play or Assessment Unit Name	Play Type	Total Liquids ^a (MMbbl)	Total Natural Gas ^b (Bcf)
(03) Southern Alaska	307	Copper River Mesozoic Oil	Conventional - Not quantitatively assessed	-	-
(03) Southern Alaska	308	Gulf of Alaska Yakataga Fold Belt	Conventional	173	173
(03) Southern Alaska	309	Gulf of Alaska Yakutat Foreland	Conventional	57	57
(05) Eastern Oregon-Washington	pr501g	Northwestern Columbia Plateau Gas	Conventional	1	235
(05) Eastern Oregon-Washington	pr502g	Central and Northeastern Oregon Paleogene Gas	Conventional	0	78
(05) Eastern Oregon-Washington	pr503g	Columbia Basin - Basin-Centered Gas	Continuous-type gas	122	12200
(13) Ventura Basin	pr1301g	Paleogene - Onshore	Conventional	140	338
(13) Ventura Basin	pr1302g	Neogene - Onshore	Conventional	257	251
(13) Ventura Basin	pr1303g	Pliocene Stratigraphic	Conventional - Not quantitatively assessed	-	-
(13) Ventura Basin	pr1304g	Cretaceous	Conventional - Not quantitatively assessed	-	-
(13) Ventura Basin	pr1311g	Paleogene - Offshore State Waters	Conventional	327	784
(13) Ventura Basin	pr1312g	Neogene - Offshore State Waters	Conventional	256	250
(19) Eastern Great Basin	EGB001	Neogene Basins	Conventional	833	108
(19) Eastern Great Basin	EGB002	Ranges and Other Structures	Conventional	524	61
(19) Eastern Great Basin	EGB003	Sevier Thrust System	Conventional	326	100
(20) Uinta-Piceance Basins	50200101	Conventional Ferron Sandstone Gas	Conventional	<.5	40
(20) Uinta-Piceance Basins	50200161	Deep (6,000 feet plus) Coal and Sandstone Gas	Continuous Gas	-	59
(20) Uinta-Piceance Basins	50200181	Northern Coal Fairway/Drunkards Wash	Coalbed Gas	-	752
(20) Uinta-Piceance Basins	50200182	Central Coal Fairway/Buzzards Bench	Coalbed Gas	-	537
(20) Uinta-Piceance Basins	50200183	Southern Coal Fairway	Coalbed Gas	-	153

Table 2-4. Undiscovered Technically Recoverable Resources by Play (continued)

USGS Province Name	USGS Code	USGS Play or Assessment Unit Name	Play Type	Total Liquids ^a (MMbbl)	Total Natural Gas ^b (Bcf)
(20) Uinta-Piceance Basins	50200184	Joes Valley and Messina Grabens	Coalbed Gas–Not quantitatively assessed	-	-
(20) Uinta-Piceance Basins	50200185	Southern Coal Outcrop	Coalbed Gas	-	11
(20) Uinta-Piceance Basins	50200201	Uinta-Piceance Basin Conventional Gas	Conventional	1	66
(20) Uinta-Piceance Basins	50200261	Uinta Basin Continuous Gas Mesaverde TPS	Continuous Gas	11	7391
(20) Uinta-Piceance Basins	50200262	Uinta Basin Transitional Gas	Continuous Gas	2	1493
(20) Uinta-Piceance Basins	50200263	Piceance Basin Continuous Gas Mesaverde TPS	Continuous Gas	9	3064
(20) Uinta-Piceance Basins	50200264	Piceance Basin Transitional Gas	Continuous Gas	1	302
(20) Uinta-Piceance Basins	50200281	Uinta Basin Blackhawk Coalbed Gas	Coalbed Gas	-	499
(20) Uinta-Piceance Basins	50200282	Mesaverde Group Coalbed Gas	Coalbed Gas	-	368
(20) Uinta-Piceance Basins	50200361	Piceance Basin Continuous Gas Mancos/Mowry TPS	Continuous Gas	2	1653
(20) Uinta-Piceance Basins	50200362	Uinta Basin Continuous Gas Mancos/Mowry TPS	Continuous Gas	6	3111
(20) Uinta-Piceance Basins	50200363	Uinta-Piceance Transitional and Migrated Gas	Continuous Gas	2	1755
(20) Uinta-Piceance Basins	50200401	Hanging Wall	Conventional	5	28
(20) Uinta-Piceance Basins	50200402	Paleozoic/Mesozoic	Conventional	8	50
(20) Uinta-Piceance Basins	50200501	Uinta Green River Conventional Oil and Gas	Conventional	11	29
(20) Uinta-Piceance Basins	50200502	Piceance Green River Conventional Oil	Conventional–Not quantitatively assessed	-	-
(20) Uinta-Piceance Basins	50200561	Deep Uinta Overpressured Continuous Oil	Continuous Oil	43	64
(21) Paradox Basin	2101	Buried Fault Blocks, Older Paleozoic	Conventional	62	292
(21) Paradox Basin	2102	Porous Carbonate Buildup	Conventional	192	482
(21) Paradox Basin	2103	Fractured Interbed	Continuous	242	194

Table 2-4. Undiscovered Technically Recoverable Resources by Play (continued)

USGS Province Name	USGS Code	USGS Play or Assessment Unit Name	Play Type	Total Liquids ^a (MMbbl)	Total Natural Gas ^b (Bcf)
(21) Paradox Basin	2104	Permian-Pennsylvanian Marginal Clastics	Conventional	3	56
(21) Paradox Basin	2105	Salt Anticline Flank	Conventional	20	396
(21) Paradox Basin	2106	Permo-Triassic Unconformity	Conventional	21	2
(21) Paradox Basin	2107	Cretaceous Sandstone	Conventional	1	58
(22) San Juan Basin	50220101	Tertiary Conventional Gas	Conventional	1	80
(22) San Juan Basin	50220161	Pictured Cliffs Continuous Gas	Continuous Gas	17	5640
(22) San Juan Basin	50220181	Fruitland Fairway Coalbed Gas	Coalbed Gas	-	3981
(22) San Juan Basin	50220182	Basin Fruitland Coalbed Gas	Coalbed Gas	-	19595
(22) San Juan Basin	50220261	Lewis Continuous Gas	Continuous Gas	31	10177
(22) San Juan Basin	50220302	Gallup Sandstone Conventional Oil and Gas	Conventional	2	<.5
(22) San Juan Basin	50220303	Mancos Sandstones Conventional Oil	Conventional	14	58
(22) San Juan Basin	50220304	Dakota-Greenhorn Conventional Oil and Gas	Conventional	3	22
(22) San Juan Basin	50220361	Mesaverde Central-Basin Continuous Gas	Continuous Gas	5	1317
(22) San Juan Basin	50220362	Mancos Sandstones Continuous Gas	Continuous Gas	76	5116
(22) San Juan Basin	50220363	Dakota-Greenhorn Continuous Gas	Continuous Gas	16	3929
(22) San Juan Basin	50220381	Menefee Coalbed Gas	Coalbed Gas	-	664
(22) San Juan Basin	50220401	Entrada Sandstone Conventional Oil	Conventional	3	6
(27) Montana Thrust Belt	50270101	Thrust Belt Conventional Gas and Oil	Conventional	134	5,761
(27) Montana Thrust Belt	50270102	Sawtooth Range Structure Conventional Oil and Gas	Conventional	18	795
(27) Montana Thrust Belt	50270103	Frontal Structures Conventional Oil and Gas	Conventional	68	1,192
(27) Montana Thrust Belt	50270201	Helena Salient Conventional Oil and Gas	Conventional	15	639
(27) Montana Thrust Belt	50270401	Blacktail Salient Conventional Oil and Gas	Conventional	6	16
(27) Montana Thrust Belt	50270561	Marias River Shale Continuous Oil	Continuous Oil	33	111
(27) Montana Thrust Belt	50270701	Tertiary Basins Oil and Gas	Conventional	73	124

Table 2-4. Undiscovered Technically Recoverable Resources by Play (continued)

USGS Province Name	USGS Code	USGS Play or Assessment Unit Name	Play Type	Total Liquids ^a (MMbbl)	Total Natural Gas ^b (Bcf)
(31) Williston Basin	pr3101g	Madison (Mississippian)	Conventional	183	169
(31) Williston Basin	pr3102g	Red River (Ordovician)	Conventional	106	372
(31) Williston Basin	pr3103g	Middle and Upper Devonian (Pre-Bakken - Post-Prairie Salt)	Conventional	60	126
(31) Williston Basin	pr3105g	Pre-Prairie Middle Devonian and Silurian	Conventional	78	203
(31) Williston Basin	pr3106g	Post-Madison to Triassic Clastics	Conventional	18	6
(31) Williston Basin	pr3107g	Pre-Red River Gas	Conventional	2	95
(31) Williston Basin	pr3110g	Bakken Fairway	Continuous-type oil	73	65
(31) Williston Basin	pr3111g	Bakken Intermediate	Continuous-type oil	70	56
(31) Williston Basin	pr3112g	Bakken Outlying	Continuous-type oil	8	7
(31) Williston Basin	pr3113g	Southern Williston Basin Margin - Niobrara Shallow Biogenic	Continuous-type gas	-	1,894
(33) Powder River Basin	3301	Basin Margin Subthrust	Conventional	21	20
(33) Powder River Basin	3302	Basin Margin Anticline	Conventional	7	4
(33) Powder River Basin	3303	Leo Sandstone	Conventional	81	5
(33) Powder River Basin	3304	Upper Minnelusa Sandstone	Conventional	522	31
(33) Powder River Basin	3305	Lakota Sandstone	Conventional	55	22
(33) Powder River Basin	3306	Fall River Sandstone	Conventional	200	115
(33) Powder River Basin	3307	Muddy Sandstone	Conventional	104	389
(33) Powder River Basin	3309	Deep Frontier Sandstone	Conventional	58	193
(33) Powder River Basin	3310	Turner Sandstone	Conventional	25	32
(33) Powder River Basin	3312	Sussex-Shannon Sandstone	Conventional	72	54
(33) Powder River Basin	3313	Mesaverde-Lewis	Conventional	62	58
(33) Powder River Basin	50330101	Eastern Basin Margin Upper Fort Union Sandstone	Conventional	-	27

Table 2-4. Undiscovered Technically Recoverable Resources by Play (continued)

USGS Province Name	USGS Code	USGS Play or Assessment Unit Name	Play Type	Total Liquids ^a (MMbbl)	Total Natural Gas ^b (Bcf)
(33) Powder River Basin	50330181	Wasatch Formation	Coalbed Gas	-	1,934
(33) Powder River Basin	50330182	Upper Fort Union Formation	Coalbed Gas	-	12,132
(33) Powder River Basin	50330183	Lower Fort Union-Lance Formations	Coalbed Gas	-	198
(33) Powder River Basin	50330261	Mowry Continuous Oil Assessment Unit	Continuous Oil	395	12
(33) Powder River Basin	50330461	Shallow Continuous Biogenic Gas Assessment Unit	Continuous Gas	-	3,368
(36) Wyoming Thrust Belt	au360101	Thrust Belt Conventional	Conventional	96	557
(36) Wyoming Thrust Belt	au360281	Frontier-Adaville-Evanstone Coalbed Gas	Continuous	-	361
(37) Southwestern Wyoming	50370101	Sub-Cretaceous Conventional Oil and Gas	Conventional	58	1,383
(37) Southwestern Wyoming	50370201	Mowry Conventional Oil and Gas	Conventional	12	206
(37) Southwestern Wyoming	50370261	Mowry Continuous Gas	Continuous Gas	171	8,543
(37) Southwestern Wyoming	50370361	Niobrara Continuous Oil	Continuous Oil	107	62
(37) Southwestern Wyoming	50370401	Hilliard-Baxter-Mancos Conventional Oil and Gas	Conventional	1	15
(37) Southwestern Wyoming	50370461	Hilliard-Baxter-Mancos Continuous Gas	Continuous Gas	752	11,753
(37) Southwestern Wyoming	50370501	Mesaverde Conventional Oil and Gas	Conventional	3	56
(37) Southwestern Wyoming	50370561	Almond Continuous Gas	Continuous Gas	200	13,350
(37) Southwestern Wyoming	50370562	Rock Springs-Ericson Continuous Gas	Continuous Gas	146	12,178
(37) Southwestern Wyoming	50370581	Mesaverde Coalbed Gas	Coalbed Gas	-	249
(37) Southwestern Wyoming	50370601	Mesaverde-Lance-Fort Union Conventional Oil and Gas	Conventional	17	320
(37) Southwestern Wyoming	50370661	Mesaverde-Lance-Fort Union Continuous Gas	Continuous Gas	614	13,635
(37) Southwestern Wyoming	50370681	Mesaverde Coalbed Gas	Coalbed Gas	-	27
(37) Southwestern Wyoming	50370682	Fort Union Coalbed Gas	Coalbed Gas	-	81

Table 2-4. Undiscovered Technically Recoverable Resources by Play (continued)

USGS Province Name	USGS Code	USGS Play or Assessment Unit Name	Play Type	Total Liquids ^a (MMbbl)	Total Natural Gas ^b (Bcf)
(37) Southwestern Wyoming	50370701	Lewis Conventional Oil and Gas	Conventional	8	195
(37) Southwestern Wyoming	50370761	Lewis Continuous Gas	Continuous Gas	541	13,536
(37) Southwestern Wyoming	50370801	Lance-Fort Union Conventional Oil and Gas	Conventional	2	246
(37) Southwestern Wyoming	50370861	Lance-Fort Union Continuous Gas	Continuous Gas	76	7,583
(37) Southwestern Wyoming	50370881	Lance Coalbed Gas	Coalbed Gas	-	165
(37) Southwestern Wyoming	50370882	Fort Union Coalbed Gas	Coalbed Gas	-	943
(37) Southwestern Wyoming	50370981	Wasatch-Green River Coalbed Gas	Coalbed Gas	-	65
(39) Denver Basin	au390181g	Denver Formation Coals	Coalbed Gas—Not quantitatively assessed	-	-
(39) Denver Basin	au390182g	Laramie Formation Coals	Coalbed Gas—Not quantitatively assessed	-	-
(39) Denver Basin	au390201g	Fractured Niobrara Limestone Transitional	Conventional	1	1
(39) Denver Basin	au390261g	Fractured Niobrara Limestone (Silo Field Area)	Continuous Oil	8	8
(39) Denver Basin	au390361g	Fractured Pierre Shale	Continuous Oil—Not quantitatively assessed	-	-
(39) Denver Basin	au390401g	Dakota Group and D Sandstone	Conventional	39	45
(39) Denver Basin	au390402g	Subthrust Structural	Conventional	17	41
(39) Denver Basin	au390501g	Permian-Pennsylvanian Reservoirs	Conventional	11	5
(39) Denver Basin	au390601g	Pierre Shale Sandstones	Conventional	3	18
(39) Denver Basin	au390661g	Niobrara-Codell (Wattenberg Area)	Continuous Oil	64	322
(39) Denver Basin	au390662g	Dakota Group Basin-Center Gas	Continuous Gas	11	1,095
(39) Denver Basin	au390761g	Niobrara Chalk	Continuous Gas	-	984
(50) Florida Peninsula	au500101g	Lower Cretaceous Shoal-Reef Oil	Conventional	274	29

Table 2-4. Undiscovered Technically Recoverable Resources by Play (continued)

USGS Province Name	USGS Code	USGS Play or Assessment Unit Name	Play Type	Total Liquids ^a (MMbbl)	Total Natural Gas ^b (Bcf)
(50) Florida Peninsula	au500201g	Pre-Punta Gorda Dolomite Gas and Oil	Conventional	152	1,629
(65) Black Warrior Basin	au650101g	Pre-Mississippian Carbonates AU	Conventional	6	1,087
(65) Black Warrior Basin	au650102g	Carboniferous Sandstones AU	Conventional	8	368
(65) Black Warrior Basin	au650281g	Black Warrior Basin AU	Continuous	-	7,056
(67) Appalachian Basin	au670101g	Rome Trough	Conventional	4	616
(67) Appalachian Basin	au670301g	Lower Paleozoic Carbonates in Thrust Belt	Conventional	3	302
(67) Appalachian Basin	au670302g	Knox Unconformity	Conventional	36	574
(67) Appalachian Basin	au670303g	Black River-Trenton Hydrothermal Dolomite	Conventional	35	1,919
(67) Appalachian Basin	au670304g	Lockport Dolomite	Conventional	2	207
(67) Appalachian Basin	au670361g	Clinton-Medina Basin Center	Continuous	108	10,833
(67) Appalachian Basin	au670362g	Clinton-Medina Transitional Northeast	Continuous	16	1,619
(67) Appalachian Basin	au670363g	Clinton-Medina Transitional	Continuous	141	11,771
(67) Appalachian Basin	au670364g	Tuscarora Basin Center	Continuous	10	2,620
(67) Appalachian Basin	au670401g	Oriskany Sandstone-Structural	Conventional	2	386
(67) Appalachian Basin	au670402g	Oriskany Sandstone-Stratigraphic	Conventional	1	65
(67) Appalachian Basin	au670403g	Greenbrier Limestone	Conventional	4	128
(67) Appalachian Basin	au670404g	Mississippian Sandstones	Conventional	6	113
(67) Appalachian Basin	au670461g	Greater Big Sandy	Continuous	63	6,323
(67) Appalachian Basin	au670462g	Northwestern Ohio Shale	Continuous	53	2,654
(67) Appalachian Basin	au670463g	Devonian Siltstone and Shale	Continuous	31	1,294
(67) Appalachian Basin	au670464g	Marcellus Shale	Continuous	12	1,925

Table 2-4. Undiscovered Technically Recoverable Resources by Play (concluded)

USGS Province Name	USGS Code	USGS Play or Assessment Unit Name	Play Type	Total Liquids ^a (MMbbl)	Total Natural Gas ^b (Bcf)	
(67) Appalachian Basin	au670465g	Catskill Sandstones and Siltstones	Continuous	235	11,741	
(67) Appalachian Basin	au670466g	Berea Sandstone	Continuous	163	6,800	
(67) Appalachian Basin	au670581g	Pocahontas Basin	Continuous	-	3,577	
(67) Appalachian Basin	au670582g	Eastern Dunkard Basin	Continuous	-	4,823	
All values are mean resource values from the USGS National Assessment of Oil and Gas Resources. Note that the resource values presented here include some offshore areas (state waters) that are not analyzed in the inventory.				Total Resources	37,467	419,429

^a Comprising oil, NGLs, and liquids associated with natural gas reservoirs.

^b Comprising associated dissolved and nonassociated natural gas

For this Inventory, a homogeneous distribution of resource within a play boundary is assumed because of the lack of more geographically specific information. In fact, the USGS indicates that resources are generally not homogeneously distributed within a play. This is particularly true for conventional accumulations, and less so for continuous accumulations. Despite the assumption of homogeneous distribution of resources in the plays, various oil and gas densities can be mapped as a result of play stacking.

2.2.1.3 Oil and Gas Resource Data-Related Caveats

The estimation of undiscovered technically recoverable resources is inherently uncertain, as reflected by the fact that the USGS develops cumulative probability distributions of the estimated resources for each play. These distributions are used to derive 95 percent probable resource (a 19-in-20 chance of that volume or more), 5 percent probable resource (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. The analytical results in the Inventory use the mean and therefore do not explicitly reflect the range of uncertainty in the resource assessments.

Not all of the resource plays recognized by the USGS within the boundaries of this Inventory were evaluated. The USGS has identified hypothetical plays that lack sufficient data to estimate undiscovered resources. To the extent that hypothetical plays contain significant resources, the results presented here would be an underestimate.

It should be understood that all resource assessments change over time. Not only is it difficult to assess accurately the resource at any one point in time, but the recoverable portion of the resource changes in response

to advances in technology, and changes in other conditions under which extraction occurs. Nonetheless, accurate and up-to-date assessments of the potential resources must be continually provided to ensure that public policy decisions are conducted with the best information possible.

For this Inventory, the assumption is made that the estimated oil and gas volumes are evenly distributed under the surface area of each play. A resource density map for each basin was created in the GIS by using a spatial summation of the oil and gas volumes contributed by each play. The densities are expressed as millions of cubic feet (MMCF) of gas per square mile and thousands of barrels (Mbbls) of oil per square mile.

2.2.2 Proved Ultimate Recovery Growth (“Reserves Growth”)

The EIA’s role in this Inventory is to provide data and analysis relevant to proved reserves and reserves growth of crude oil, natural gas, and natural gas liquids that are associated with already discovered fields underlying Federal onshore lands. This responsibility involves:

- Providing estimates of proved reserves for these fields at the highest possible level of detail consistent with a legal requirement to protect the confidentiality of field operators’ proprietary data.
- Estimating future ultimate recovery appreciation for currently producing fields.
- Providing inputs to estimate additional land access constraints that may result from expected ultimate recovery appreciation.

The estimation of proved reserves is necessary for developing reserves growth estimates.

The proved ultimate recovery (PUR) of an oil or gas field is the estimated volume of oil or gas that will ultimately be produced from the field. At any point in time, the PUR is the sum of a field’s estimated proved reserves and its cumulative production. The estimated PUR for a new oil or gas field generally increases with time, as a result of new geologic and engineering knowledge gained during operation of the field.

This phenomenon is variously termed “reserves growth,” “reserves appreciation,” “ultimate recovery appreciation” or “proved ultimate recovery growth.” Proved ultimate recovery growth (PURG), the term preferred by the EIA, has been recognized since 1960 and currently accounts for the majority of annual additions to domestic proved reserves. Owing to its importance to present and future domestic oil and gas supply, EIA has been highlighting PURG in the overview section of its annual reserves reports since 1992. Since 1976 PURG has grown in all but one year for both oil plus lease condensate and natural gas. From 1976 through 1994 only 12 percent of proved reserves additions of crude oil and lease condensate and 11 percent of proved reserve additions of wet natural gas were booked as new field discoveries. The rest came from the proved reserves categories related to the proved ultimate recovery appreciation process.³²

³² Energy Information Administration, U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 2004 Annual Report, November 2005, available online at http://www.eia.doe.gov/oil_gas/natural_gas/data_publications/crude_oil_natural_gas_reserves/cr.html.

The proved ultimate recovery for an individual field or group of fields in a basin “grows” with time due to such factors as:

- Delineation and development drilling that extends the area of known reservoirs
- Discovery of new producing zones (deeper or shallower)
- Application of improved reservoir management and well completion practices and technologies
- Economic factors that increase wellhead prices or reduce operating costs thus extending the economic life of producing fields.

Initial estimates of PUR are usually conservative owing to the small knowledge base available at that time regarding a field’s performance. Annual estimates of a field’s PUR normally increase significantly in the early post-discovery years as the field is delineated. In later years, PUR continues to grow due to such factors as installation of improved recovery technology, increased knowledge of field performance, and infill drilling, although generally the annual rate of growth slows. Consequently, the growth factors are large during the early years of field development and then often decline as PUR asymptotically approaches a maximum value, i.e., reserves growth usually slows as field development matures.

For the Inventory’s study areas, the EIA estimated remaining proved ultimate recovery growth (RPURG), the future reserves growth resource. The resources attributed to future reserves growth for the detailed study areas are 10.2 billion barrels of oil and 37.8 TCF of gas. See Appendix 7 for a detailed explanation of the estimation methodology.

The EIA’s selected reserves growth estimates covering Federal and non-Federal lands in the detailed study areas are provided in Table 2-5. The reserves growth estimates for Federal lands, including the extrapolated areas, are provided in Table 2-7.³³ Not all of the Inventory’s study areas could be evaluated owing to insufficient data.

Table 2-5. Remaining Proved Ultimate Recovery Growth (“Reserves Growth”) by Study Area (Federal and non-Federal)

Study Area	Remaining Ultimate Recovery Growth (Reserves Growth)	
	Oil (MMbbls)	Gas (BCF)
Northern Alaska	5,724	14,285
Central Alaska - Yukon Flats	-	-
Southern Alaska	-	-
Eastern Oregon-Washington	-	-
Ventura Basin	999	1,156
Eastern Great Basin	14	-
Uinta/Piceance Basin	434	3,354
Paradox Basin	25	485
San Juan Basin	93	1,793
Montana Thrust Belt	-	-
Williston Basin	1,641	2,801
Powder River Basin*	794	548
Wyoming Thrust Belt	7	1,106
Southwestern Wyoming	202	10,260
Denver Basin	170	839
Florida Peninsula	-	-
Black Warrior Basin	3	1,149
Appalachian Basin	-	-
Total	10,106	37,776

Note: A dash (-) means there is insufficient data for analysis

³³ Note that Table 2-7 does not include reserves growth associated with state waters, which are significant in Alaska.

2.2.2.1 Sources of Remaining Proved Ultimate Recovery Data

The EIA compiled the historical increase in estimates of PUR for oil and gas fields in each study area and projected these data to estimate the PUR of the fields at abandonment. RPURG is the estimated future portion of the growth in PUR from 2003, for Phase I and II basins and from 2004 for Phase III basins, to the time of field abandonment.

For each study area, the EIA created a database containing field names, field discovery dates, annual oil and gas production for each field, estimated cumulative production, and annual estimates of oil and gas proved reserves for each field.³⁴ Each field in a study area was assigned to a vintage year according to its date of first production or its date of discovery. The annual proved reserves estimates were usually available only from 1977 to present. The resulting files contained vintage year, number of fields in each vintage (in barrels of oil equivalent), PUR for each field vintage, annual natural gas PUR for each vintage, and annual liquid PUR for each vintage.

Many field names and codes had to be altered, corrected, and matched across the multiple data sources in order to accumulate properly the field data. Obvious major errors were corrected, but many apparent data discontinuities and variations within vintages were mostly accepted “as-is.” Reserves data were used as reported by the field operators unless very obvious errors

were found. Specific vintages that did not fit the trend of most of the data for a basin were excluded. Attempts to divide the data within a basin into conventional reservoirs, tight formation, and coal gas resources were largely unsuccessful because of the limited number of vintages, the short histories available for some of the fields, and frequent inability to separate the data by reservoir type within a field.

The EIA used a hyperbolic incremental growth factor model to estimate RPURG for each study area and resource type. The hyperbolic model depends on incremental growth factors by vintage, or age of the fields in the basin. Both are asymptotic functions that use time as the sole driver. Although other potential drivers such as drilling rates or wellhead prices are not directly used, these factors have affected the historical data that feed into the models. The application for estimating PURG for a basin over time is described in Appendix 7.

There were insufficient data geographically and temporally from the APB and MTB for a PURG analysis. Separate estimates for tight reservoirs were not made for the DEN, BWB and the WTB owing to a combination of data anomalies and data interpretation concerns. In all study areas, the available coalbed natural gas data were deemed to be insufficiently dependable for development of separate conventional natural gas and coalbed natural gas PURG estimates.

2.2.2.2 Remaining Proved Ultimate Recovery Data Preparation

The estimated remaining proved ultimate recovery or “reserves growth” resources for each study area were incorporated into the Inventory by adding a reserves growth resource layer to the USGS undiscovered technically recoverable resources. As

³⁴ Data sources included the EIA Reserves and Production Division’s Oil and Gas Integrated Field File (RPD OGIFF), the EIA Field Code Master List (FCML), the EIA-23 Reserves Survey, various state web sites, and commercial sources (mainly IHS Energy Group).

with the undiscovered resource layer, the Inventory assumes that the reserves growth resources are homogeneously distributed within the geographic boundaries of the reserves growth resource layer. This is a simplifying assumption, which may be modified in the future as new reserves growth methodologies and findings become available.

The geographic boundary of the reserves growth resource layer was created for each study area from a union of the field boundaries of all the producing oil and gas fields identified by the EIA within the study area. Within the resource plays, individual field boundaries were extended an additional mile in all directions prior to the union, so the geographic boundary of the reserves growth resource layer extends a mile beyond the 2003 boundaries of the actual fields incorporated into the layer. This was done to approximate future extensions to the proved area of producing fields, which contributes to reserves growth. Next, the total reserves growth resource estimated for each study area was homogeneously distributed within the geographic boundary of the reserves growth resource layer for the study area. Lastly, the two resource layers, the USGS undiscovered technically recoverable resource layer and the EIA RPURG resource layer, were combined to create the oil and natural gas resource maps shown in Section 2.2.3.

2.2.2.3 Remaining Proved Ultimate Recovery Estimate Data-Related Caveats

The estimated reserves growth resources for the Phase III study areas are lower than generally would be expected, especially compared to previously published reserves growth estimates including the USGS

1995 National Assessment³⁵, the NPC³⁶, the Potential Gas Committee (PGC),³⁷ as well as some operators' not necessarily representative anecdotal reports of estimated reserves growth for fields in some study areas.³⁸ Reserves growth in most of the study areas ranged from 3 percent to 25 percent of current proved reserves. However, the BWB reserves growth was estimated to be over 200 percent of proved reserves.

It is unlikely that there is a single cause of the differences with other studies. Certainly there are some significant differences in methodology and input data. For example, the PGC uses a non-statistical, reservoir-specific approach that relies on expert judgment to estimate the probable resources associated with the additional development of an already discovered reservoir. Historically, the most successful estimates of reserves growth have relied on the use of reservoir level data, rather than the more aggregate field level data on which this Inventory's estimates are based. This is not particularly surprising since most factors that affect the reserves growth phenomenon

³⁵ Root, D.H. and others, 1995, Estimates of inferred reserves for the 1995 USGS national oil and gas resource assessment, U.S. Geological Survey Open-File Report 95-75L.

³⁶ National Petroleum Council, 2003, *Balancing Natural Gas Policy-Fueling Demands of a Growing Economy*, September 2003. The Supply Task Group estimated reserves growth for natural gas.

³⁷ Potential Gas Committee, 2005, *Potential Supply of Natural Gas in the United States as of December 31, 2004*, September 2005. The PGC estimates "Probable Resources" for natural gas. PGC defines Probable Resources as resources associated with known fields including supply from future extensions of existing pools in known productive reservoirs, infill drilling, and future new pool discoveries within existing fields.

³⁸ For example, EnCana reports significant reserves growth in Jonah and Mamm Creek fields.

are reservoir-specific and will not necessarily apply to an entire field when it consists of multiple reservoirs as many fields do.³⁹ Unfortunately, reservoir level proved reserves data are only rarely available for onshore United States fields and the RPURG estimation must therefore be done using the field level data that are available. It should also be noted that this is, insofar as we know, the first time that field level RPURG analysis has been attempted on a scale comparable to that of this Inventory.

The EIA methodology used for the Inventory's study areas and the methodology used by the USGS to estimate reserves growth for the most recent National Assessment are both statistical extrapolations of historical reserves growth and are subject to the same inherent limitations,⁴⁰ although the methodologies differ in detail. These limitations introduce substantial uncertainty into the final results, which the USGS is currently addressing in an ongoing review of their reserves growth estimation methodology (see below). In a recent test, the USGS found that two different statistical extrapolation methodologies produce reserves growth estimates that differed by approximately 25 percent and were as much as 60 percent higher than actual volumetric data.⁴¹ The results shown in Tables A7-1 through A7-3 should be interpreted with these limitations in mind:

- Inherent uncertainty in the underlying data (for example, 'reserves' are defined differently by different operators and different commercial/private databases; fields and reservoirs are inconsistently defined).
- Current statistical methodologies rely on field age (since field discovery) as a surrogate for field development effort. Other factors such as reserves recognition practices, differential application of new technology and production monitoring practices, different operating environments, and access to markets may not be adequately represented by field age alone.
- Large fields have more weight in the analysis, which may bias the results toward the development histories of the largest fields in a basin or study area. Large fields may be more likely than smaller fields to receive consistently applied development efforts and new technology applications, and be less sensitive to economic factors.
- Uncertainties are not addressed directly, such as variance of the input data and uncertainties in the underlying assumed field development scenarios.

A phenomenon observed in the 1995 USGS National Assessment may also be operating, in which the estimated reserves growth based on a dataset for the lower-48 states as a whole produced greater reserves growth estimates than the sum of reserves growth estimated independently for individual regions. In October 2006, the USGS commenced a scoping project to evaluate possible improvements to existing reserves growth methodology, identify alternative methodologies, and recommend a robust reserves growth methodology that

³⁹ *The Intricate Puzzle of Oil and Gas "Reserves Growth,"* available online at http://www.eia.doe.gov/pub/oil_gas/petroleum/feature_articles/1997/intricate_puzzle_reserves_growth/m07fa.pdf

⁴⁰ From Klett, Timothy, *One-Year Reserve-Growth Scoping Project, Fiscal Year 2006*, presentation to American Association of Petroleum Geologists, Committee on Resource Evaluation, February 9, 2006.

⁴¹ *Ibid*; slide titled "Test of Modified Arrington and USGS Least Squares/Monotonic Methods".

can be universally applied.⁴² The EIA is investigating whether it might be possible to develop improved, less labor-intensive means of cleansing the field level data of its apparent anomalies and errors and whether the estimates can be improved by moving to a multi-parameter estimation methodology. The findings and recommendations of the USGS reserves growth scoping project will be incorporated into the reserves growth assessment for any subsequent phases of this Inventory. Consequently, the reserves growth volumes estimated for this report may be re-evaluated and are subject to change.

2.2.3 Oil and Natural Gas Resource Maps

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 often vertically stacked play resource volumes. The distributions of undiscovered technically recoverable resources and reserves growth are shown by study area for oil in Figures 2-24 through 2-44 and for natural gas in Figures 2-45 through 2-65. Note that the resources maps of the extrapolated areas include resources for the comprehensively studied areas.

⁴² Brenda S. Pierce, USGS, personal communication to Jeffrey Eppink, Advanced Resources International,, regarding USGS Energy Resources Team Reserves Growth Scoping Project, project number 8930C1K.

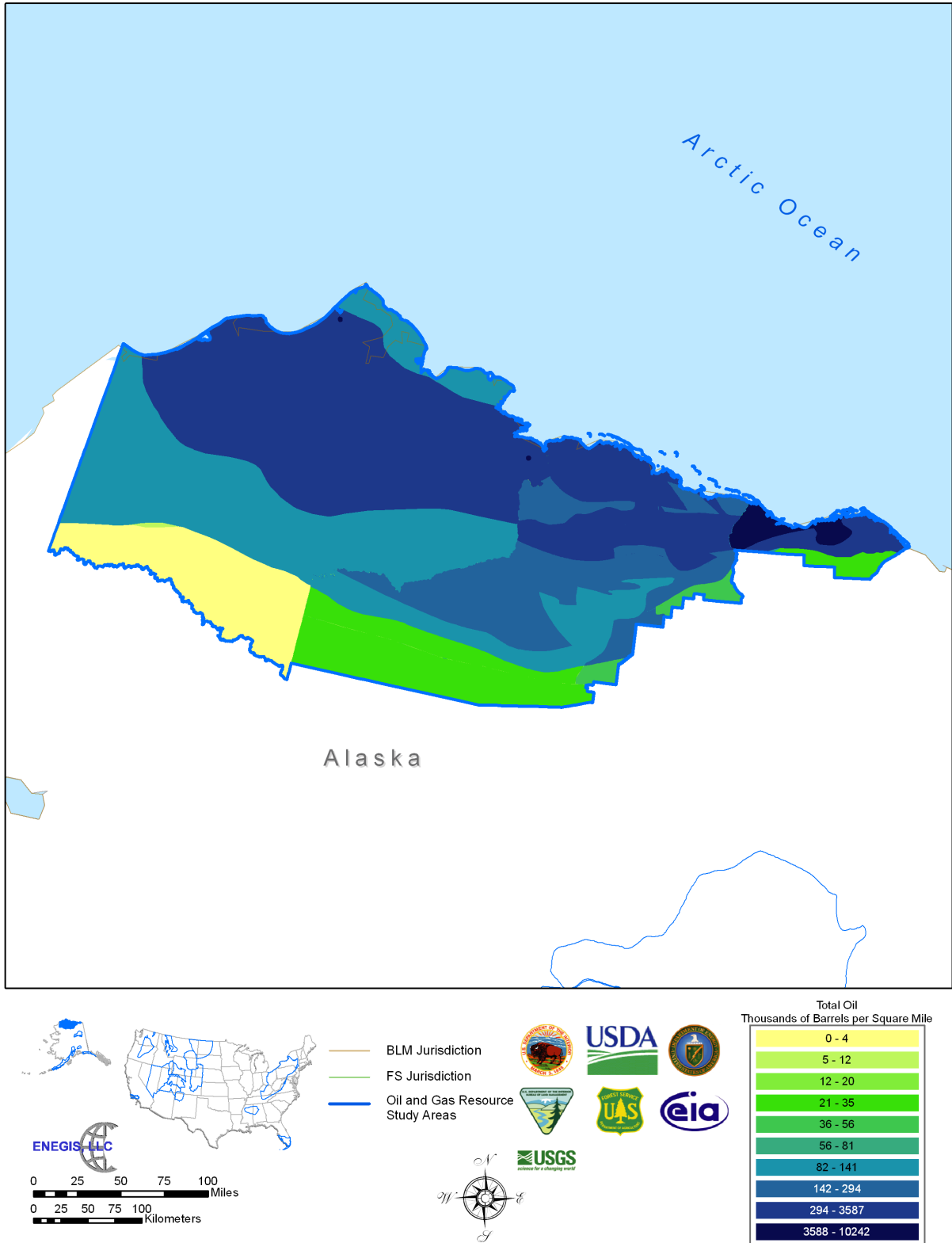


Figure 2-24. Total Oil Map, Northern Alaska Study Area

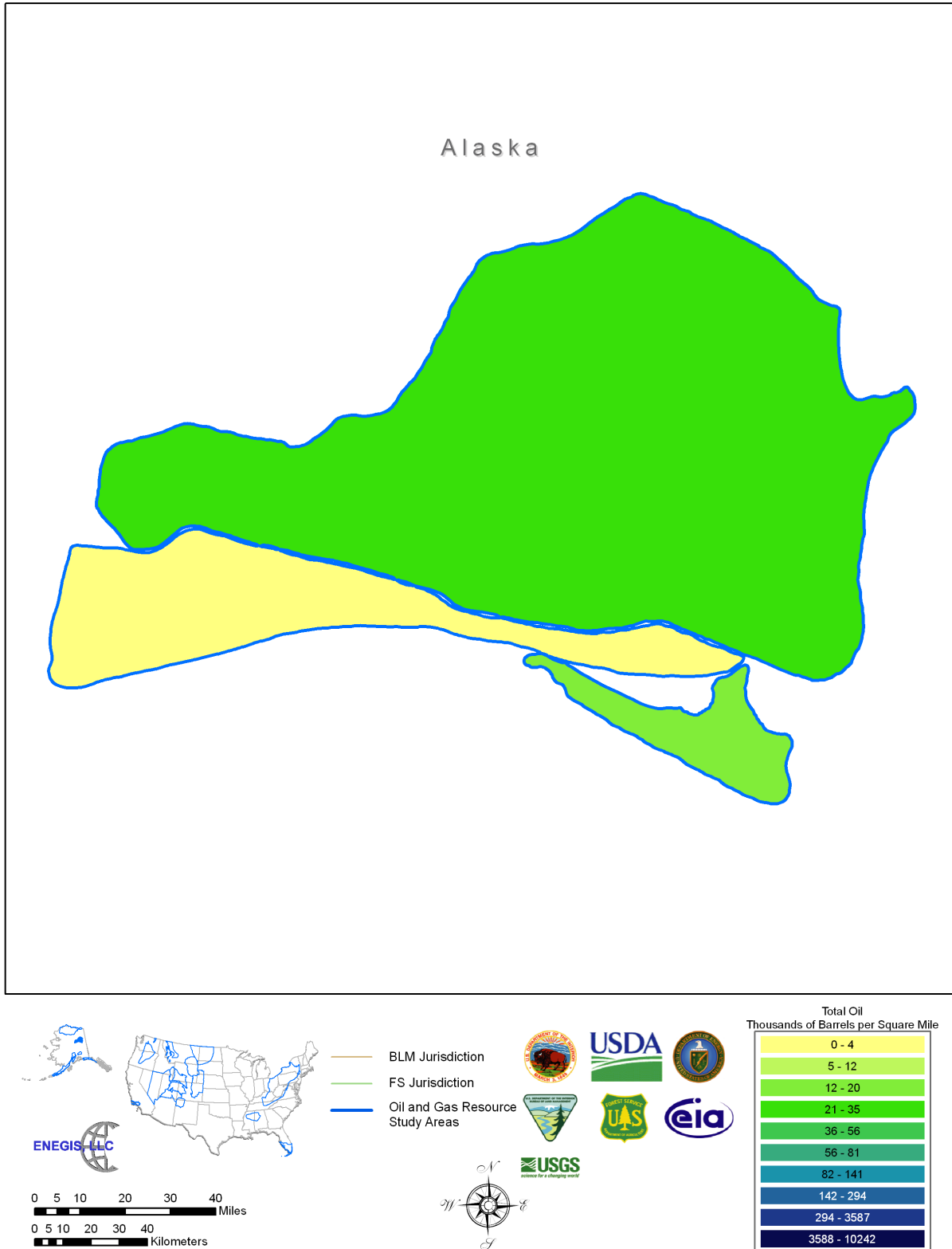


Figure 2-25. Total Oil Map, Central Alaska - Yukon Flats Study Area

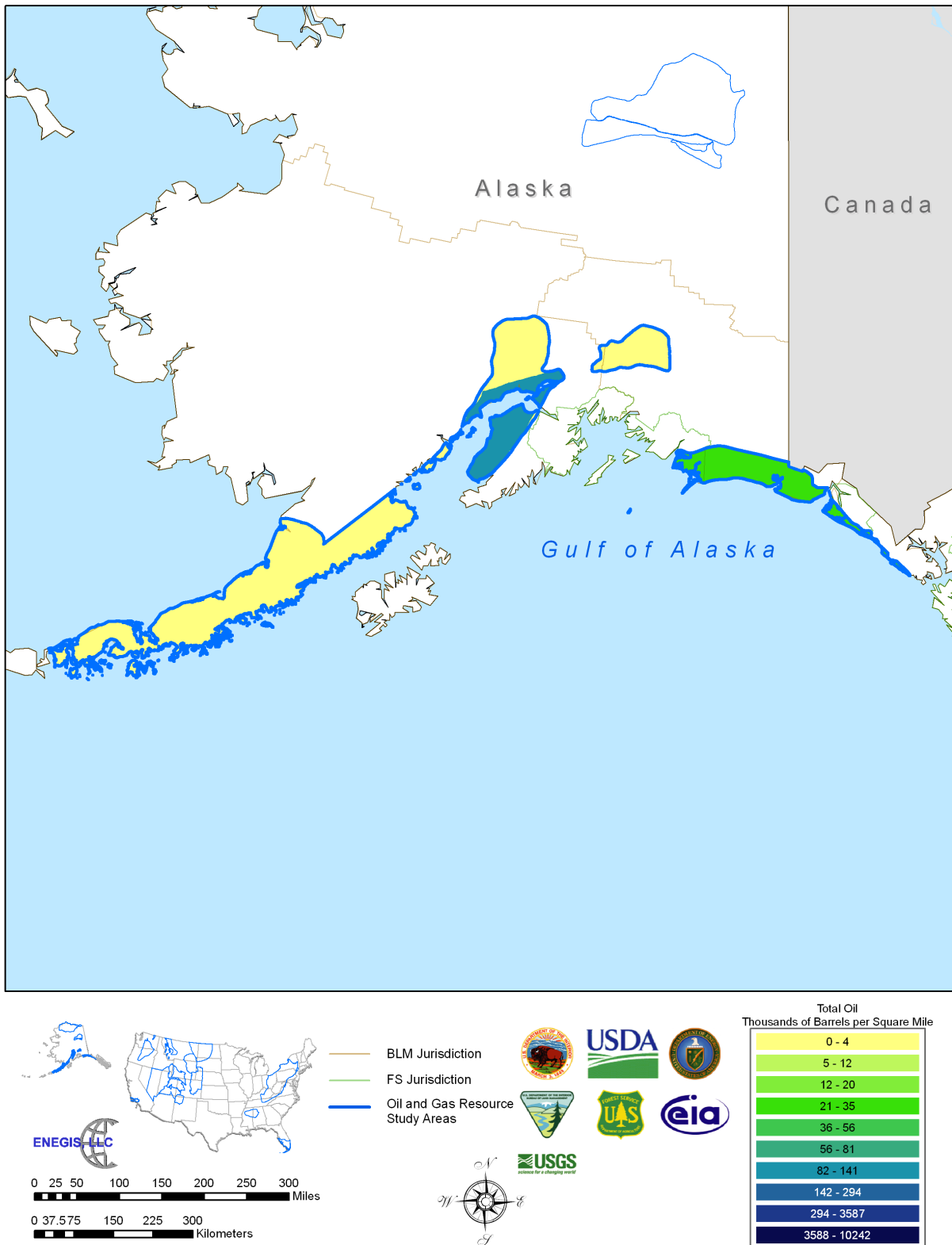


Figure 2-26. Total Oil Map, Southern Alaska Study Area

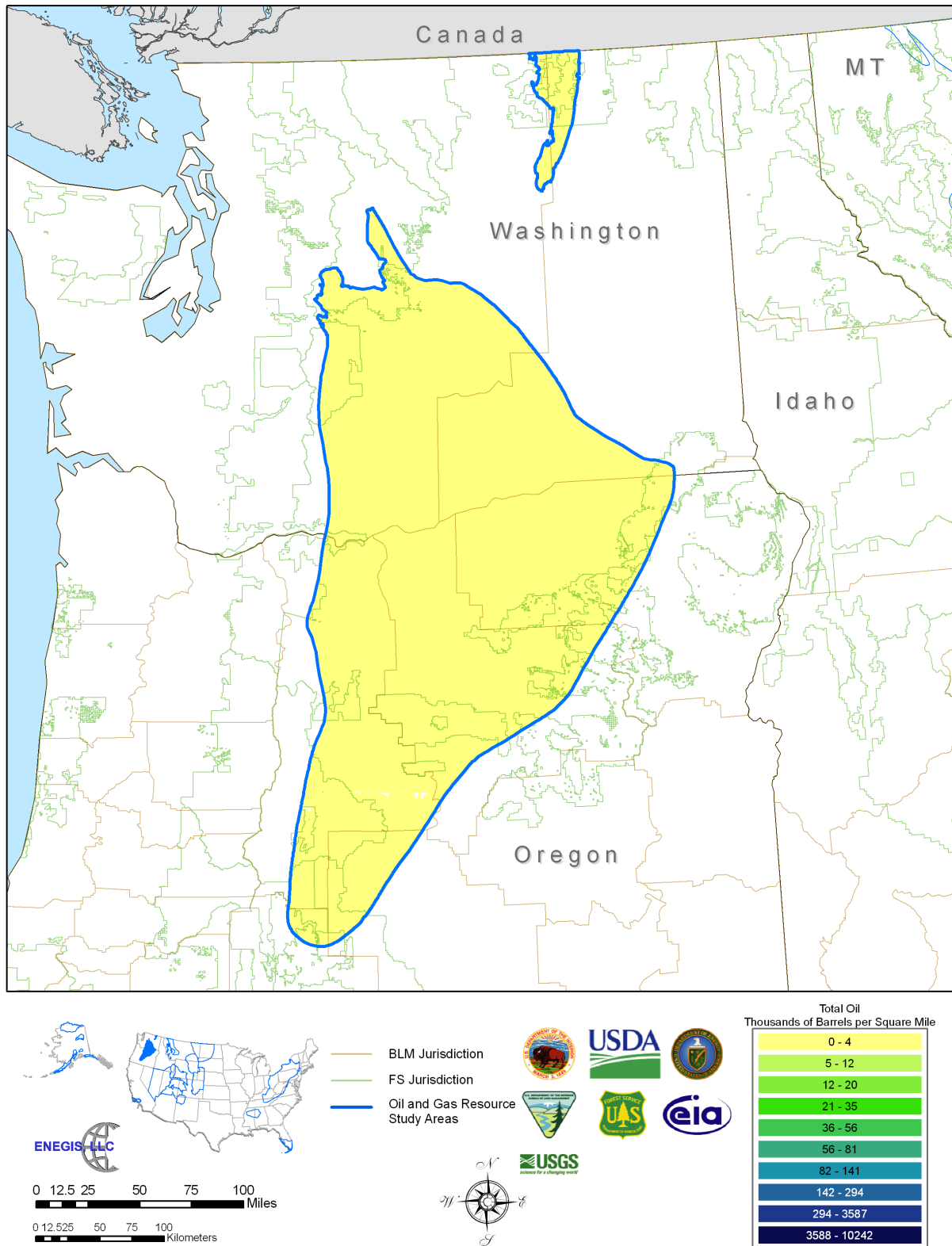


Figure 2-27. Total Oil Map, Eastern Oregon-Washington Study Area

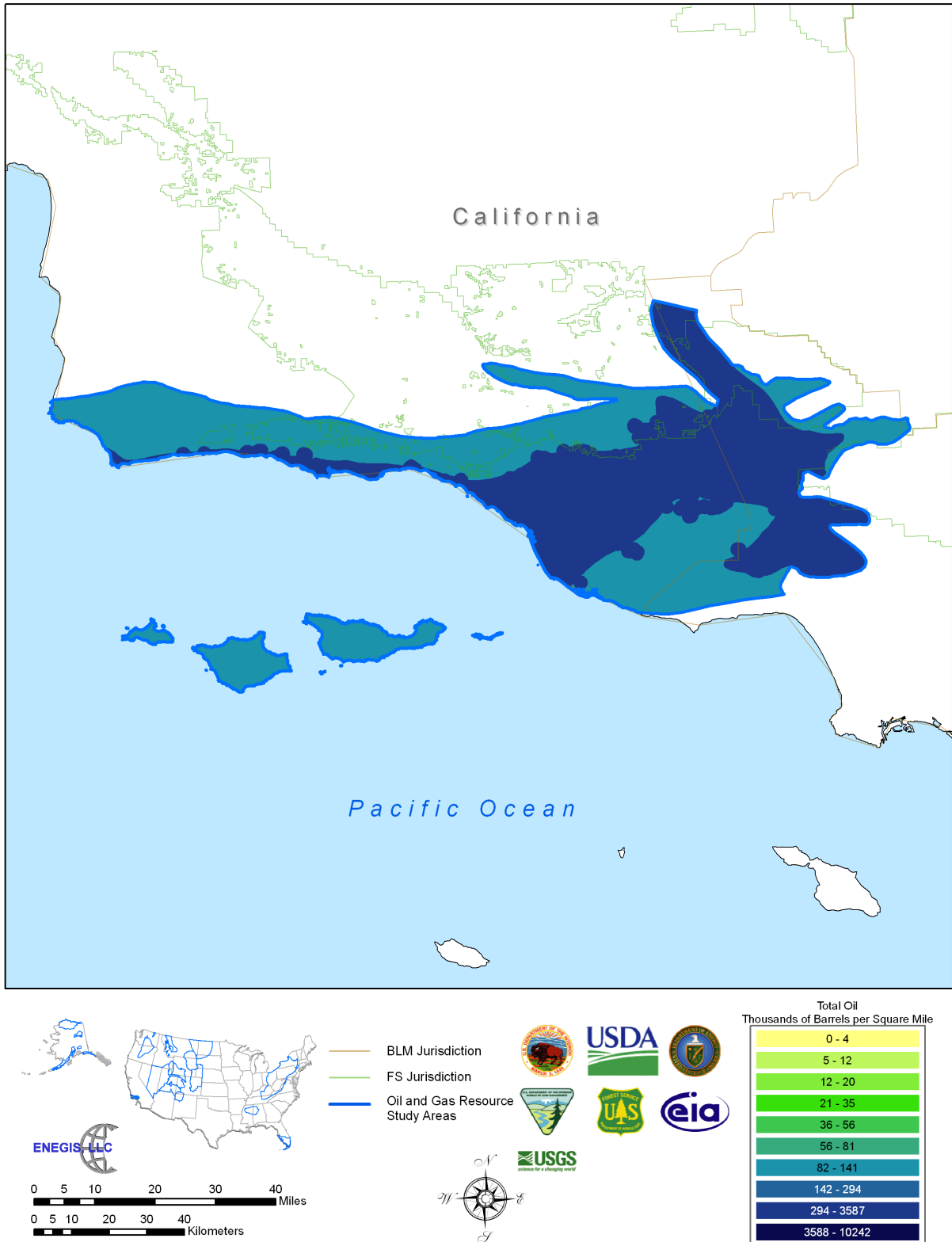


Figure 2-28. Total Oil Map, Ventura Basin Study Area

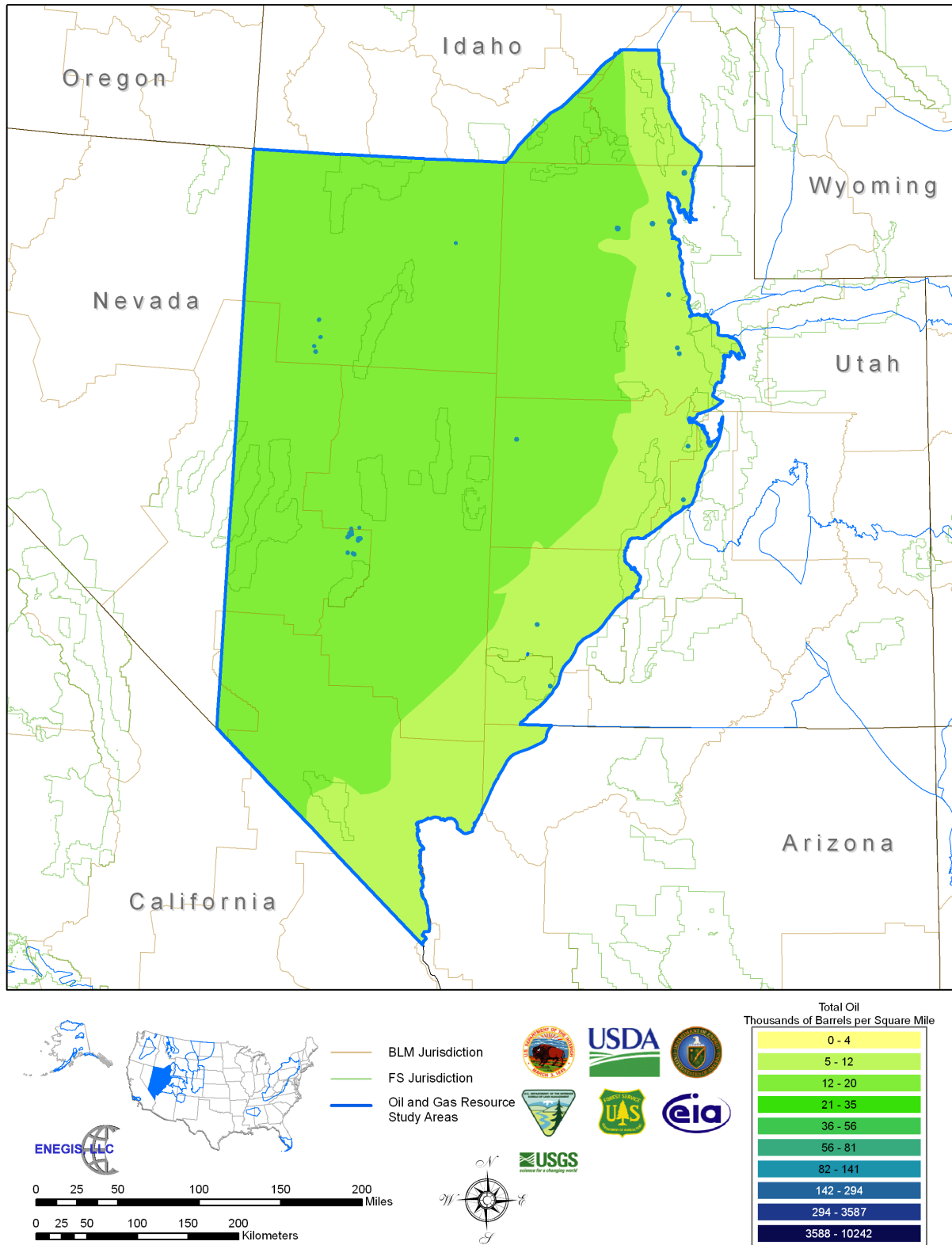


Figure 2-29. Total Oil Map, Eastern Great Basin Study Area

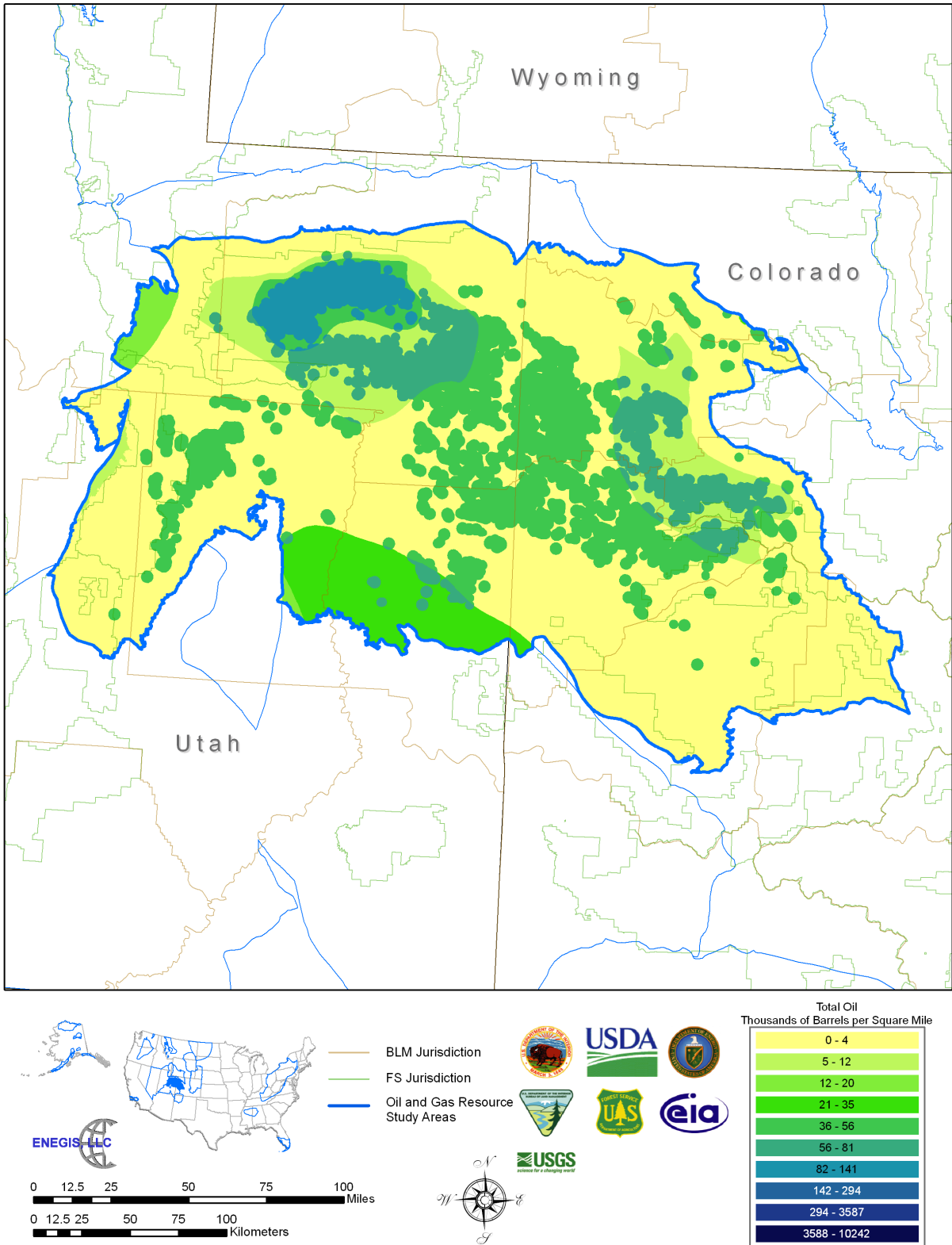


Figure 2-30. Total Oil Map, Uinta-Piceance Basin Study Area

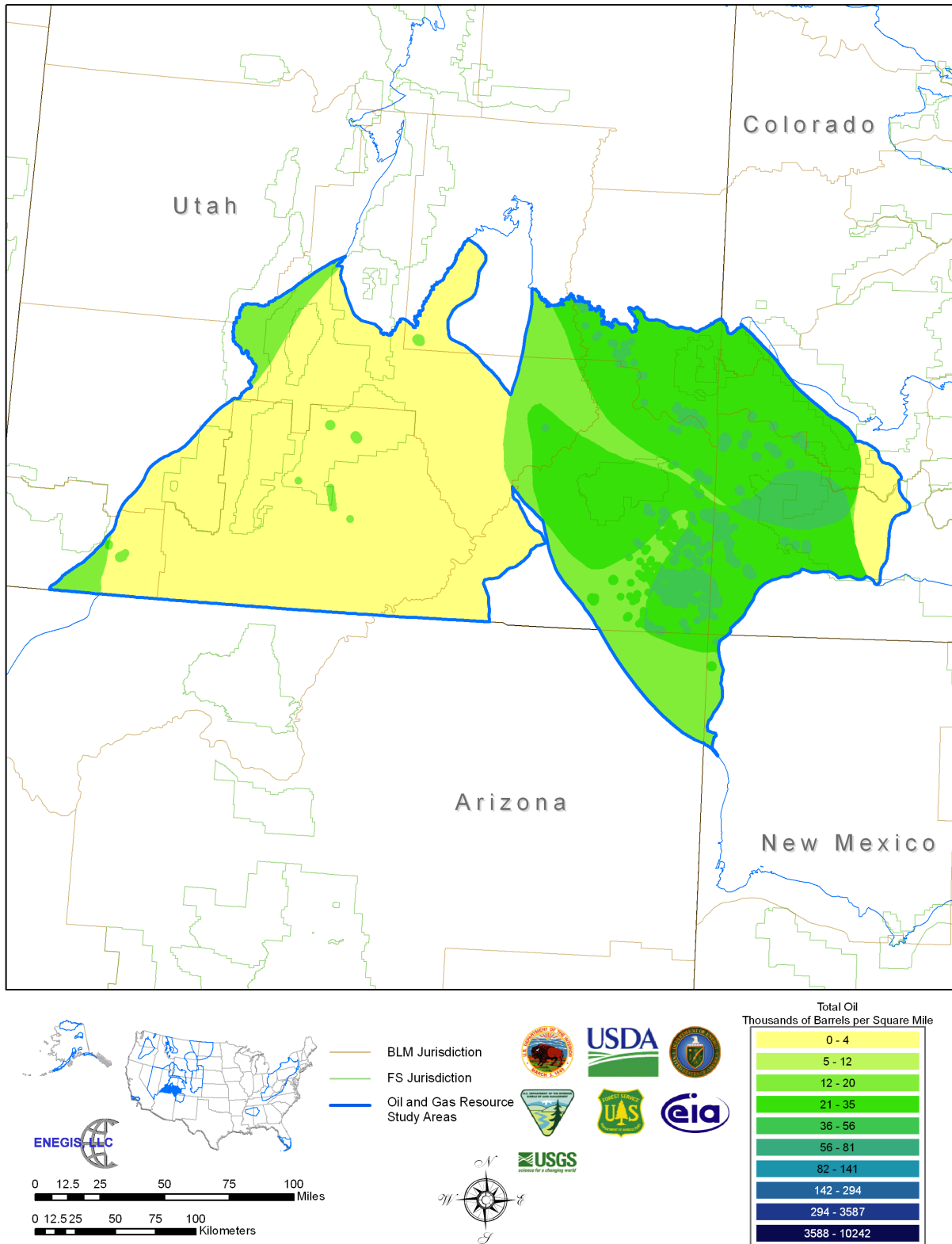


Figure 2-31. Total Oil Map, Paradox Basin Study Area

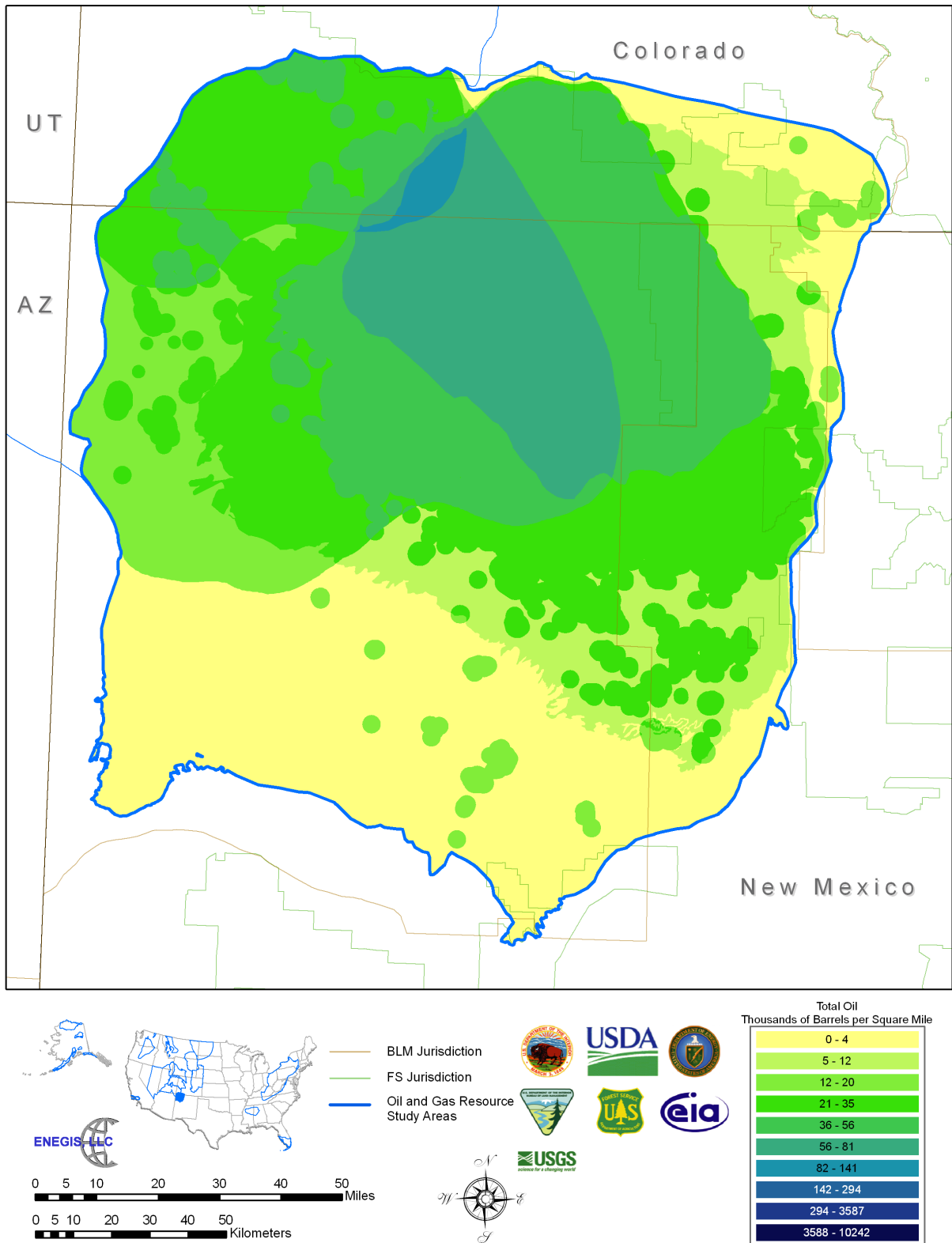


Figure 2-32. Total Oil Map, San Juan Basin Study Area

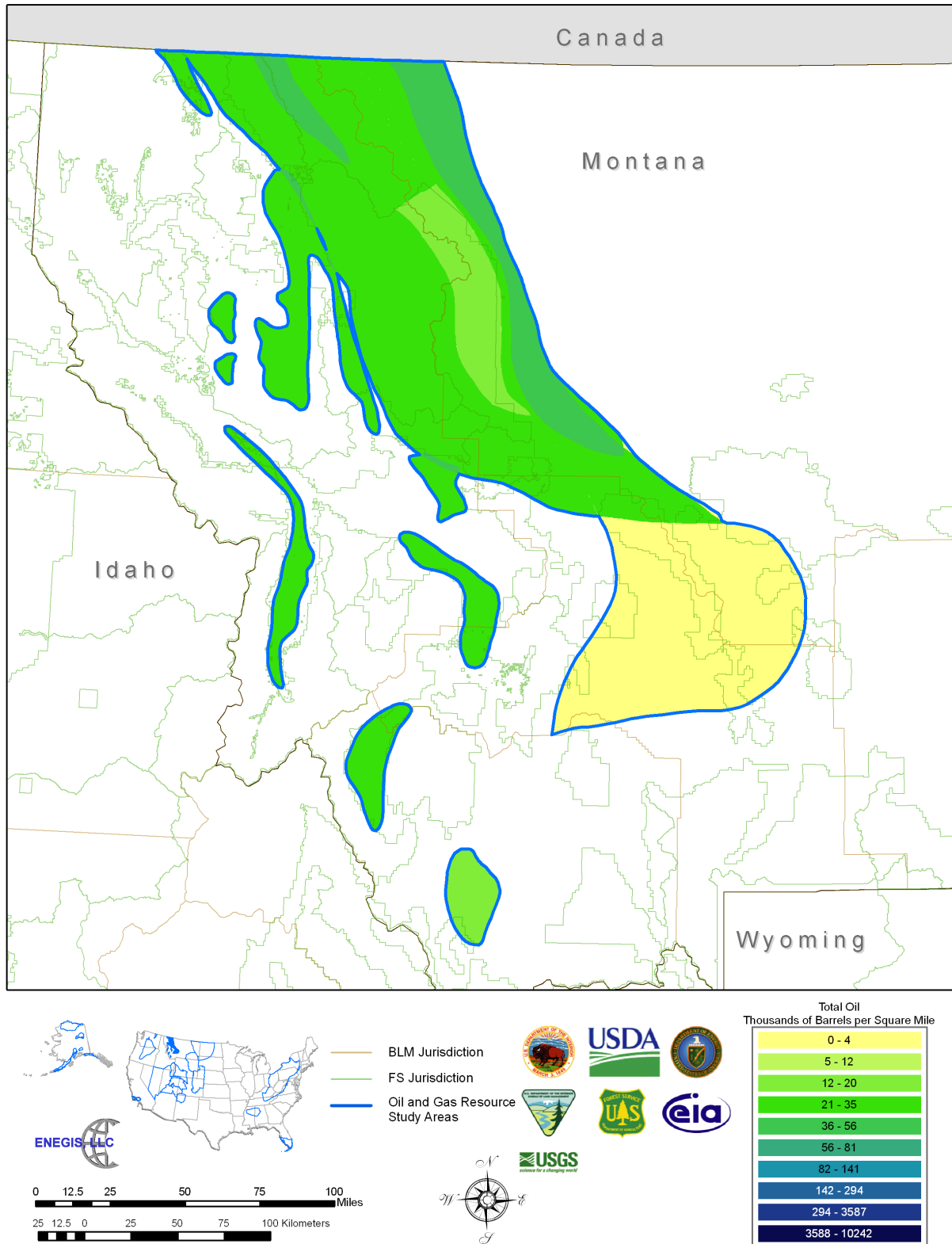


Figure 2-33. Total Oil Map, Montana Thrust Belt Study Area

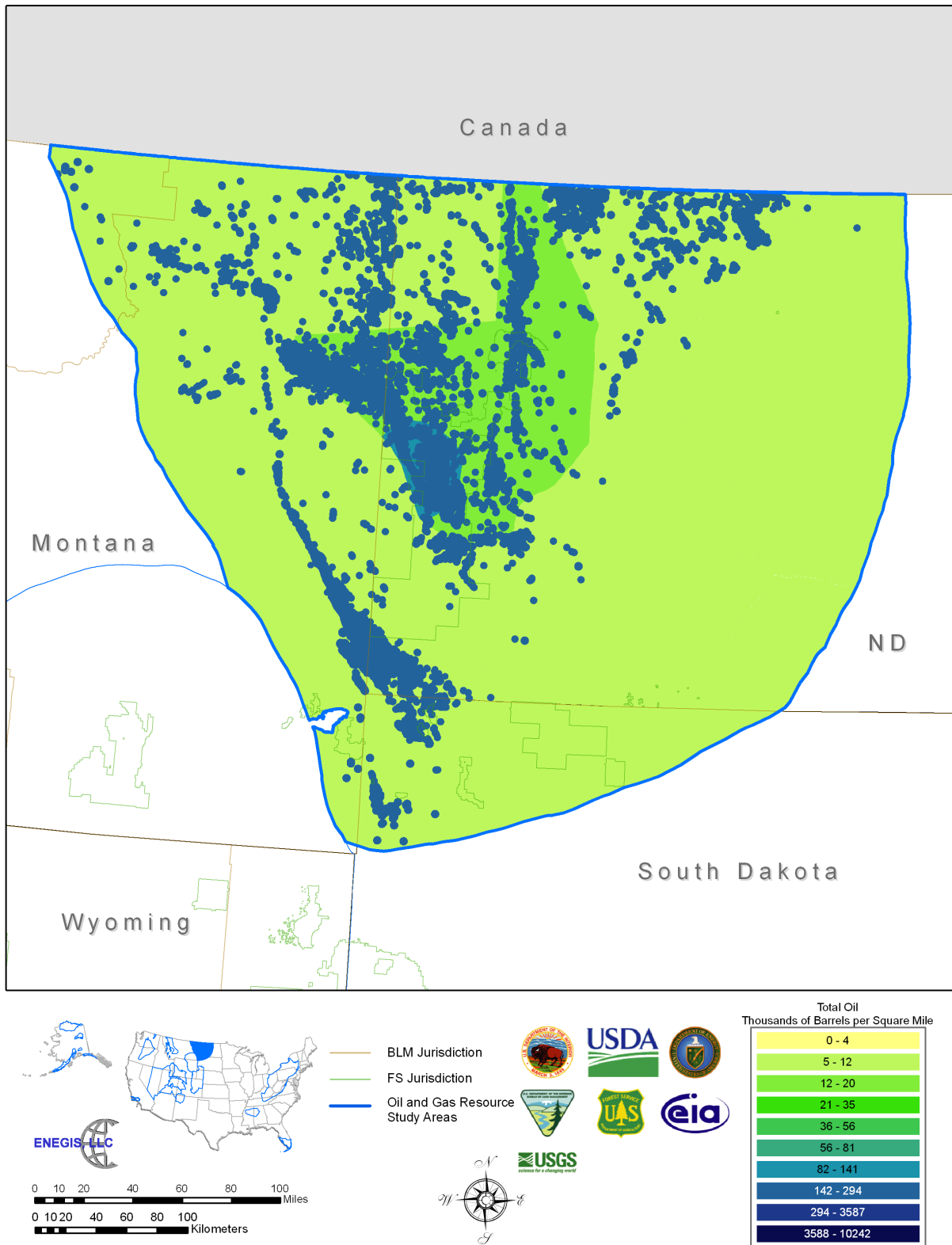


Figure 2-34. Total Oil Map, Williston Basin Study Area

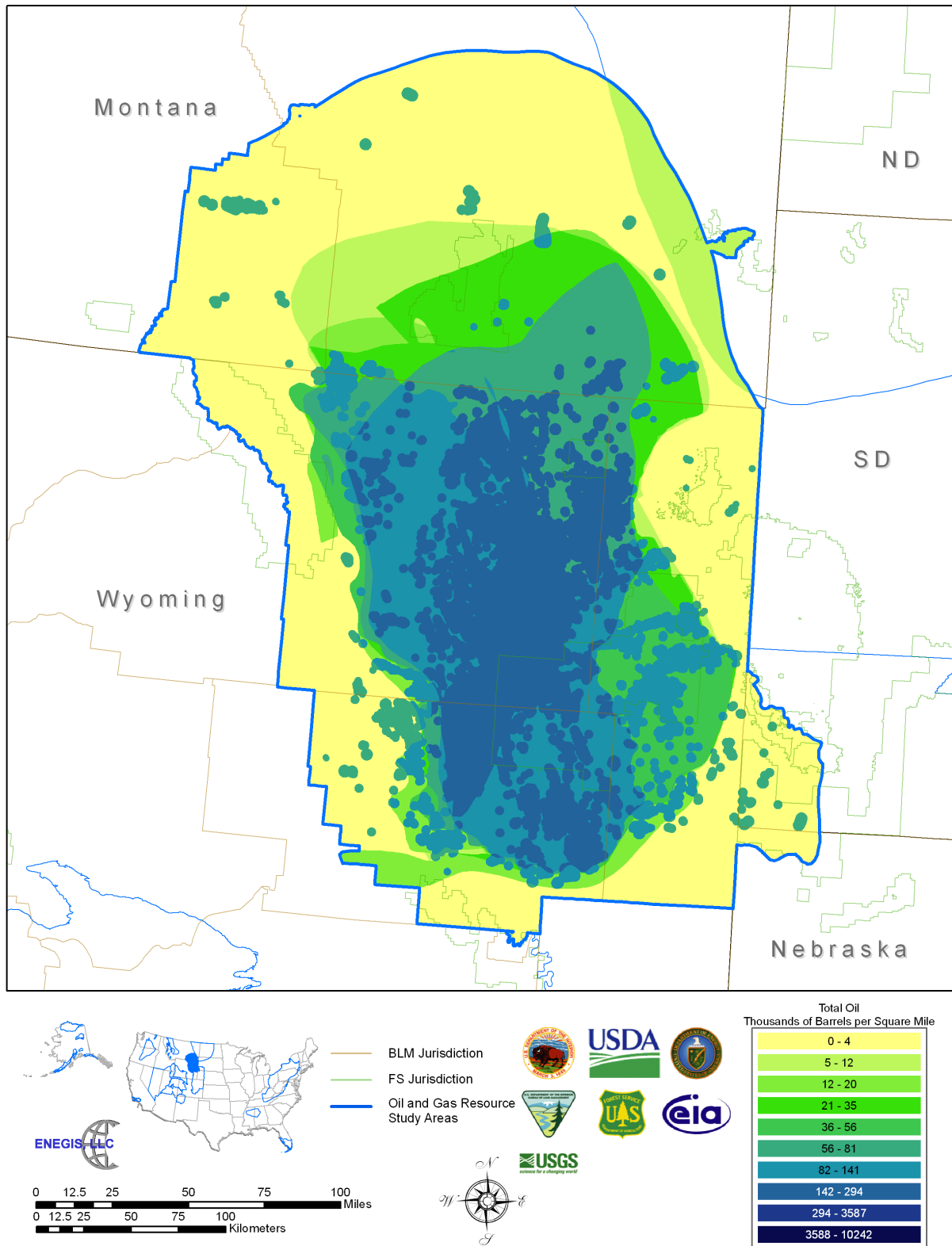


Figure 2-35. Total Oil Map, Powder River Basin Study Area

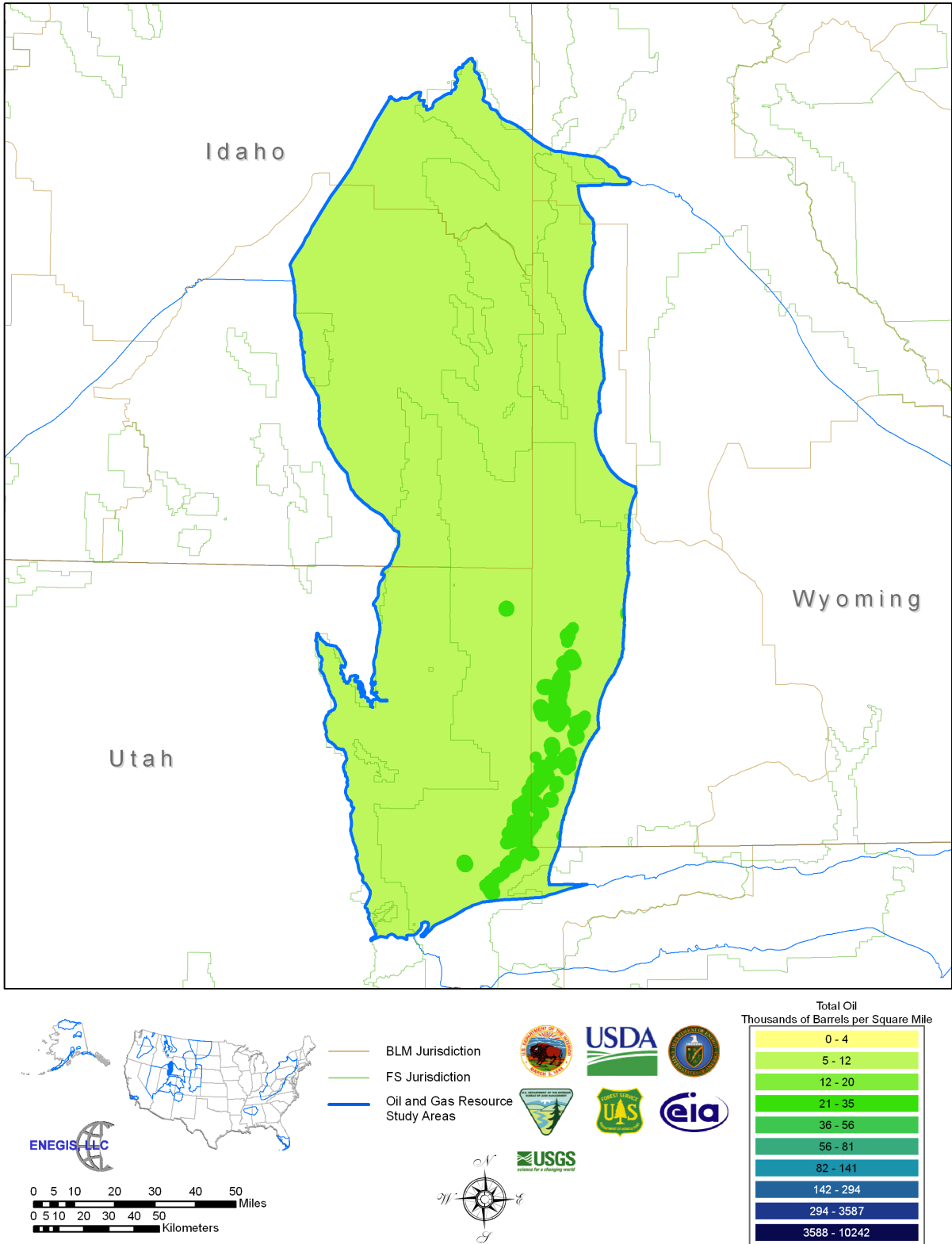


Figure 2-36. Total Oil Map, Wyoming Thrust Belt Study Area

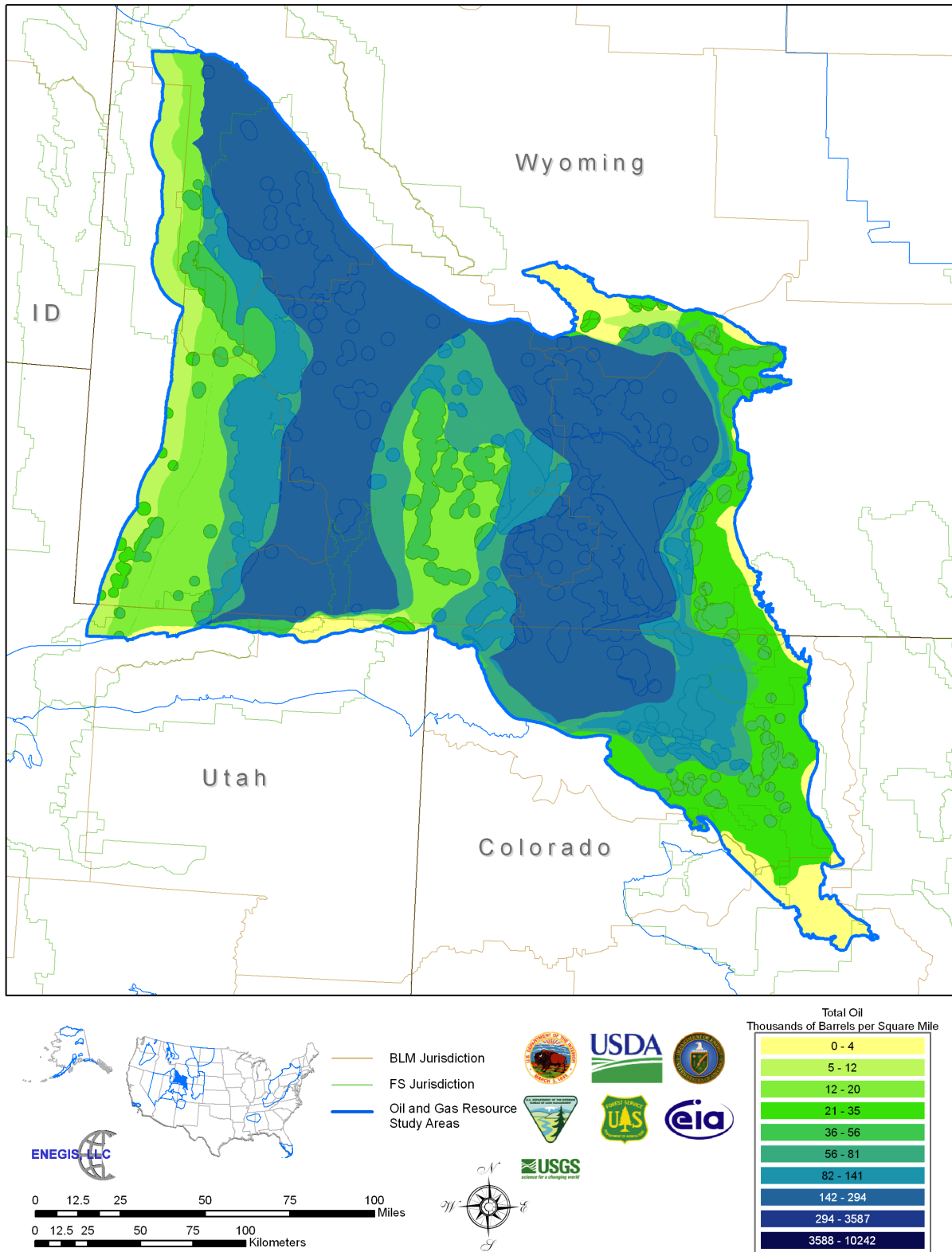


Figure 2-37. Total Oil Map, Southwestern Wyoming Study Area

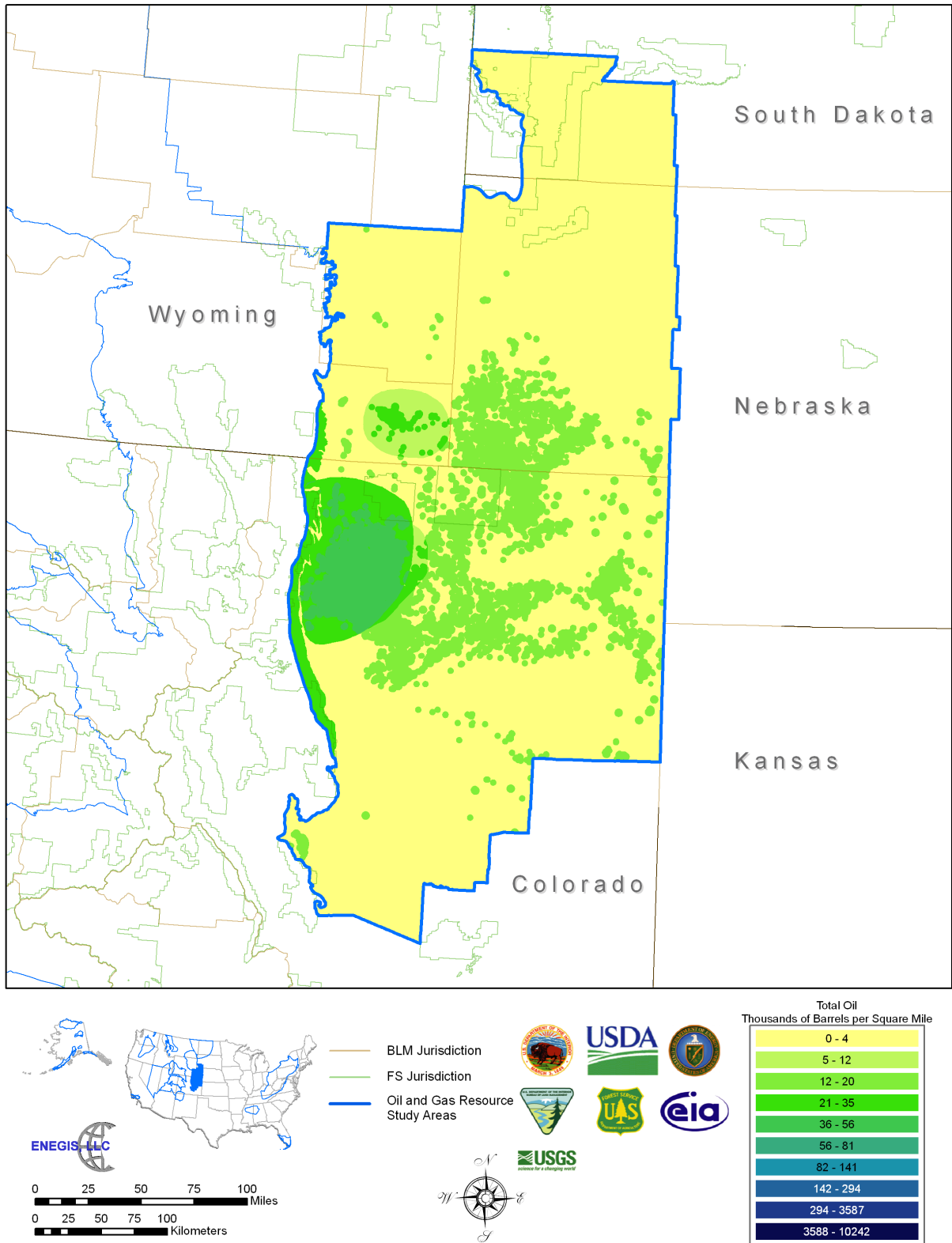


Figure 2-38. Total Oil Map, Denver Basin Study Area

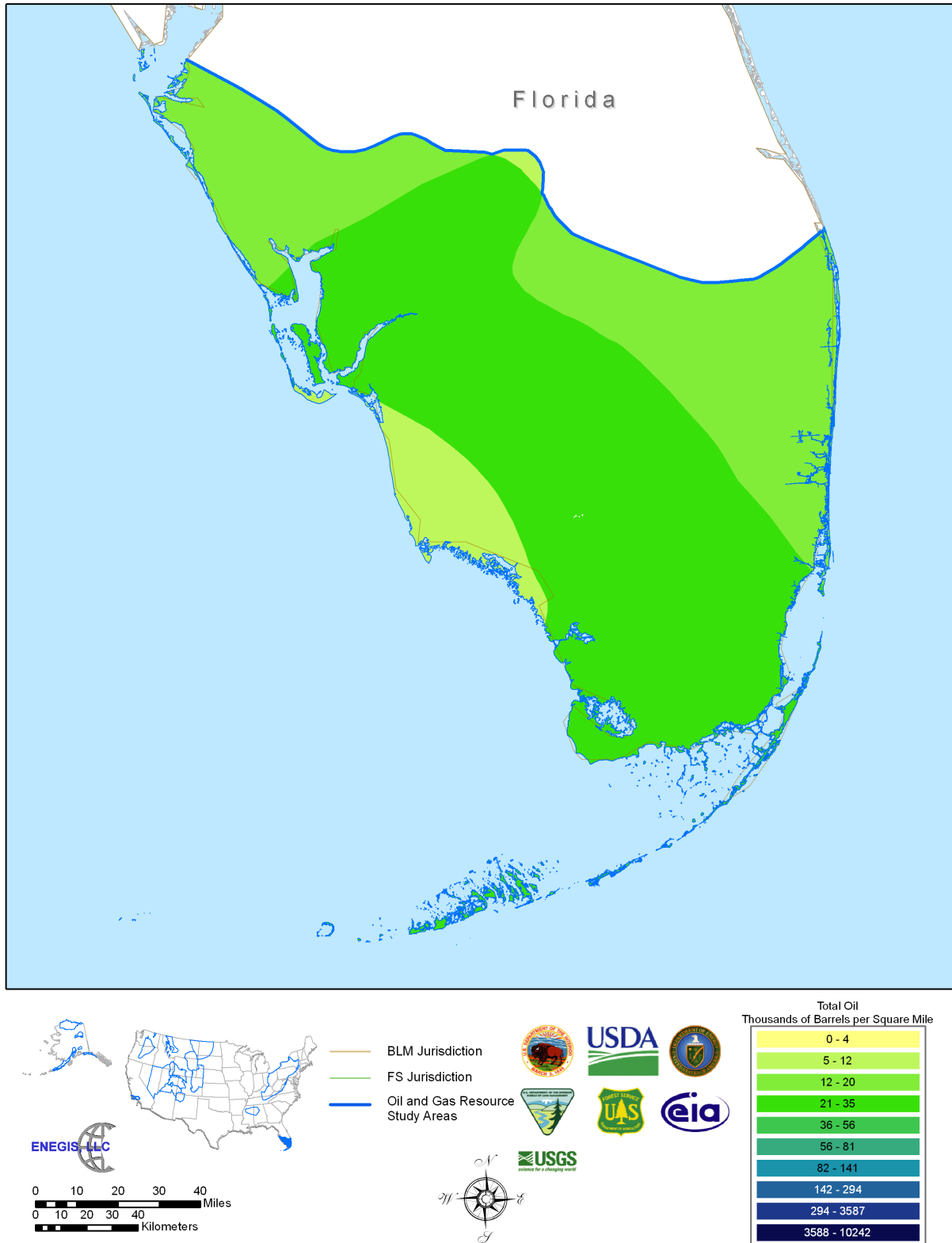


Figure 2-39. Total Oil Map, Florida Peninsula Study Area

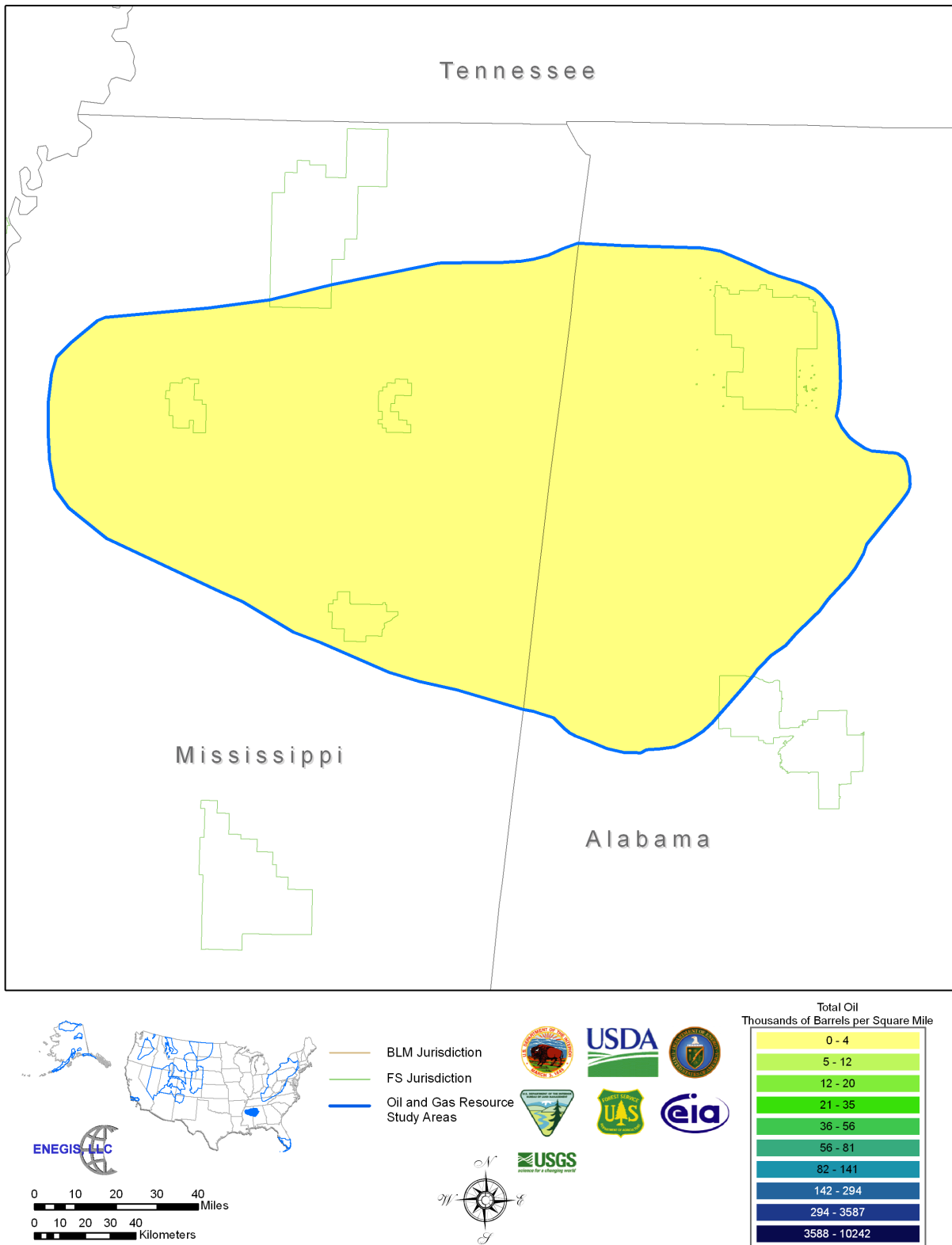


Figure 2-40. Total Oil Map, Black Warrior Basin Study Area

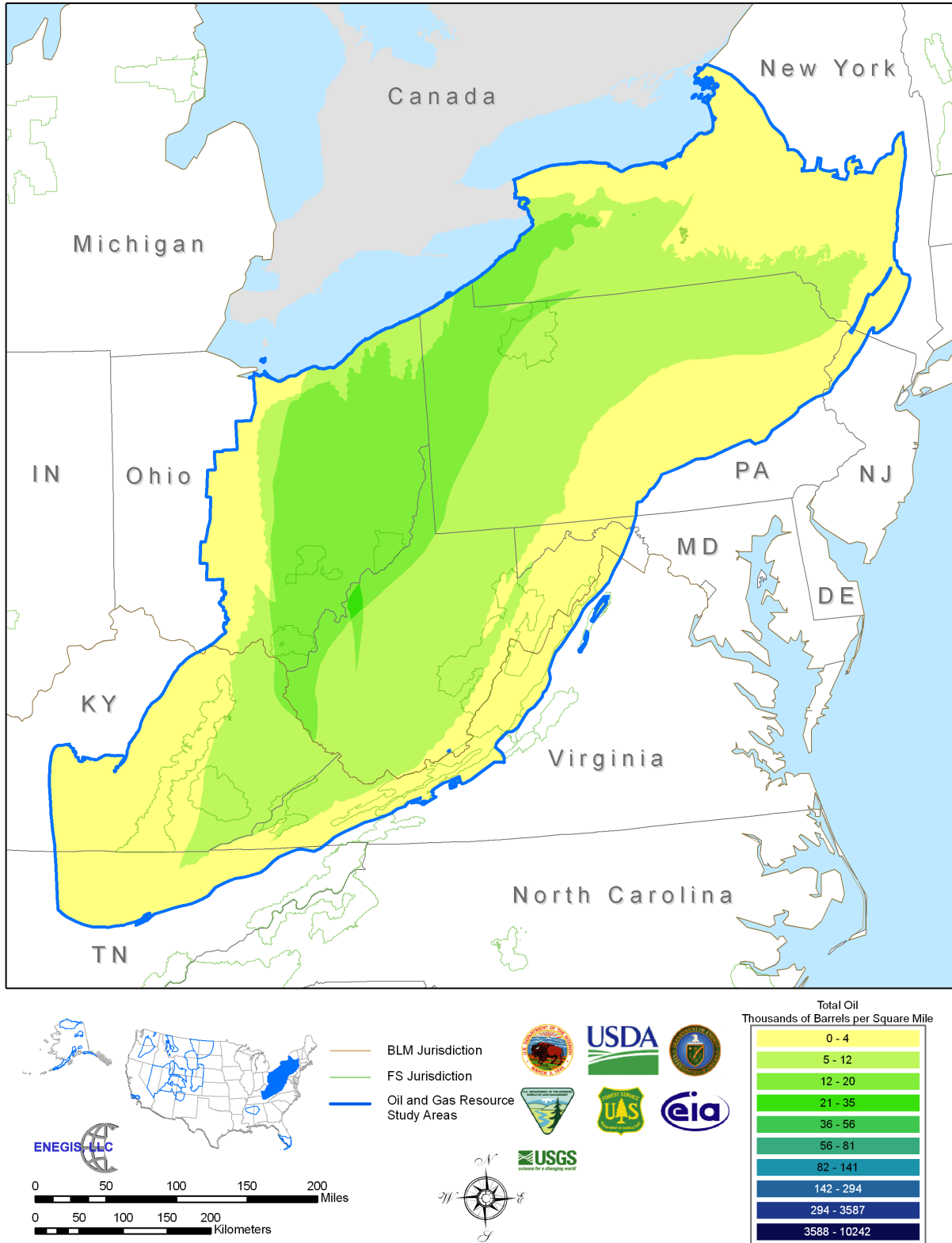


Figure 2-41. Total Oil Map, Appalachian Basin Study Area

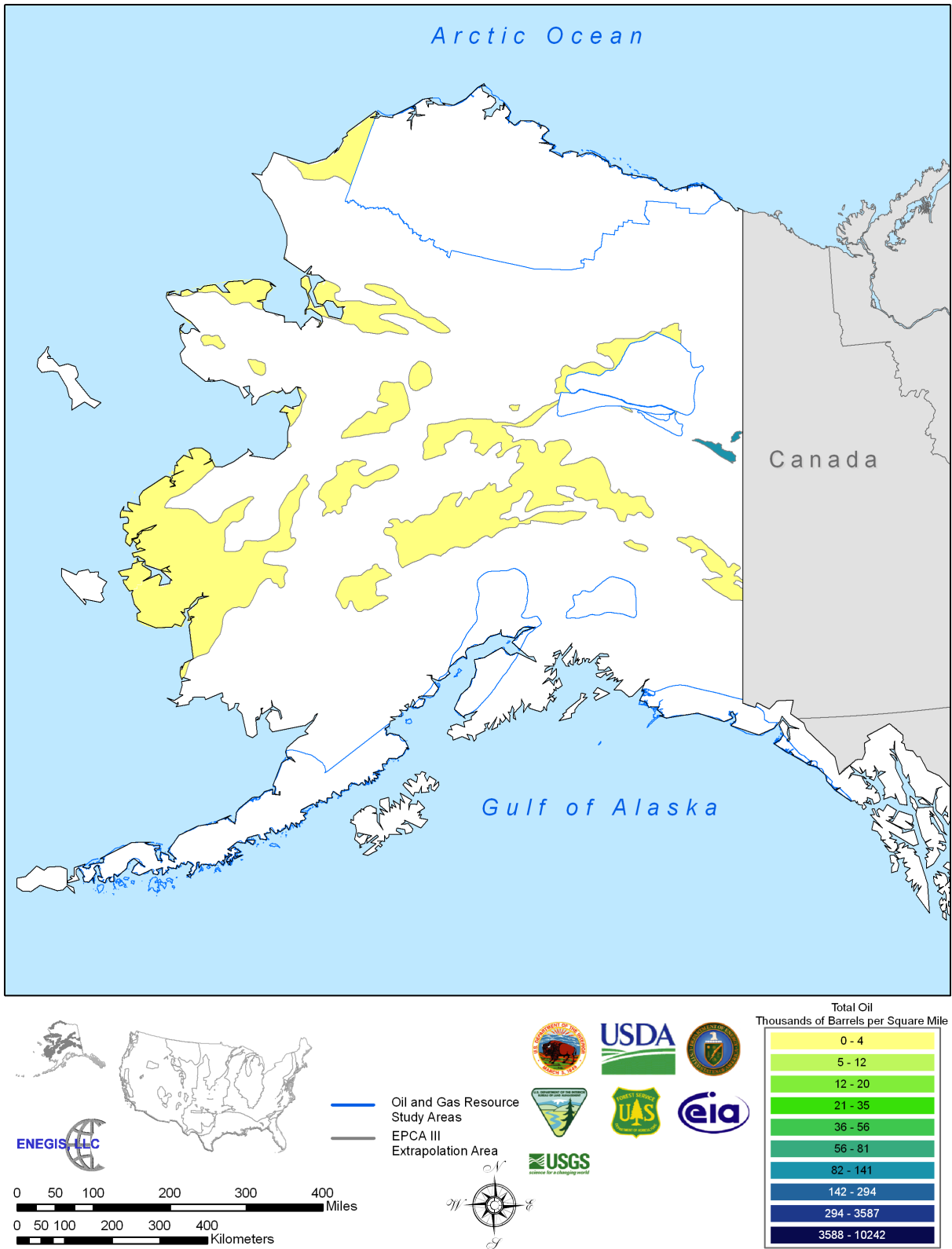


Figure 2-42. Total Oil Map, Alaska Extrapolation Area

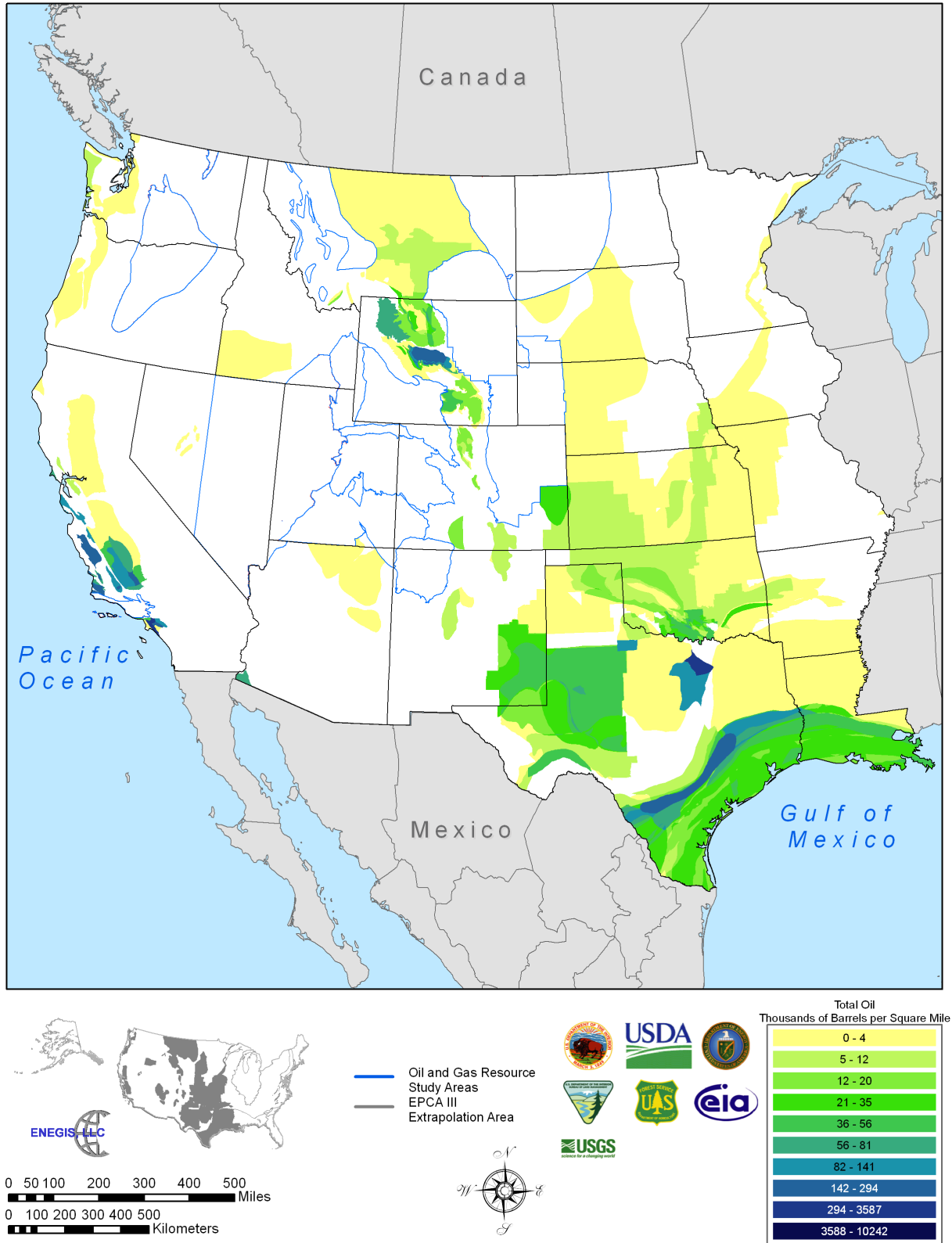


Figure 2-43. Total Oil Map, Western Extrapolation Area

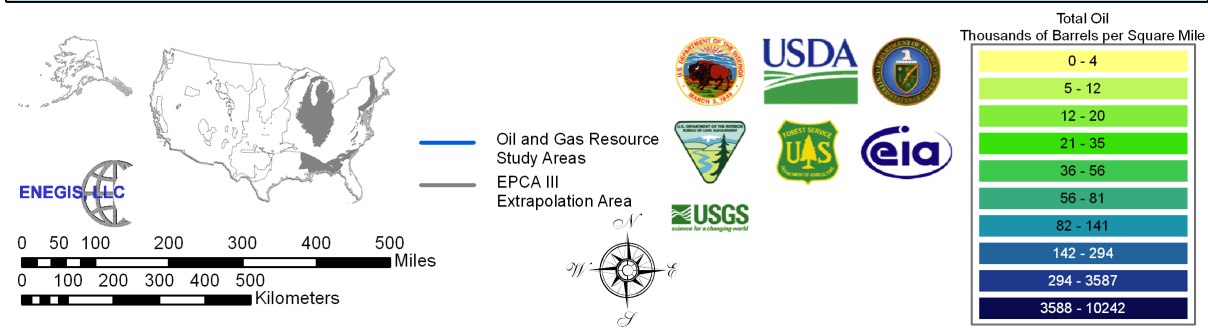
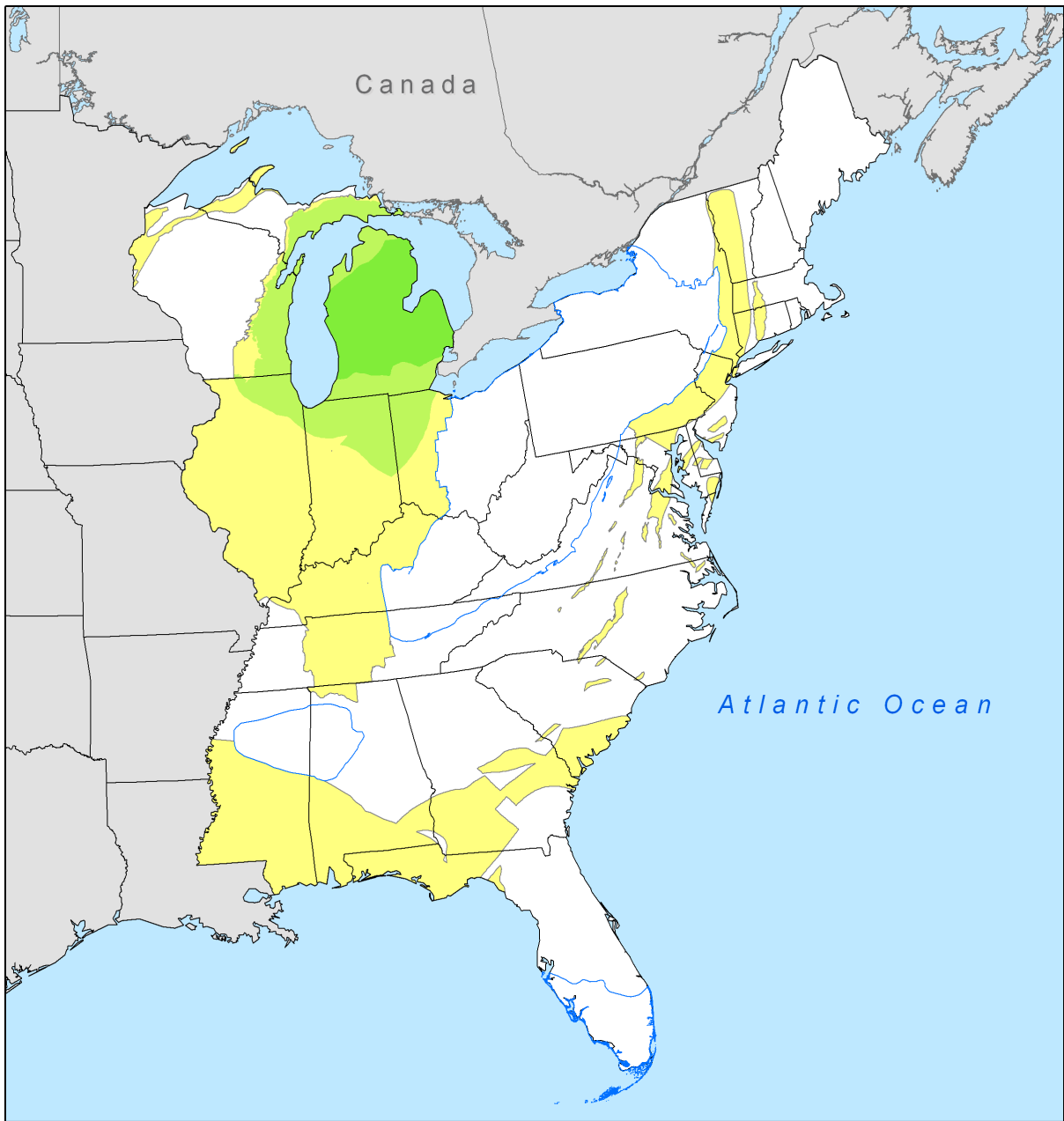


Figure 2-44. Total Oil Map, Eastern Extrapolation Area

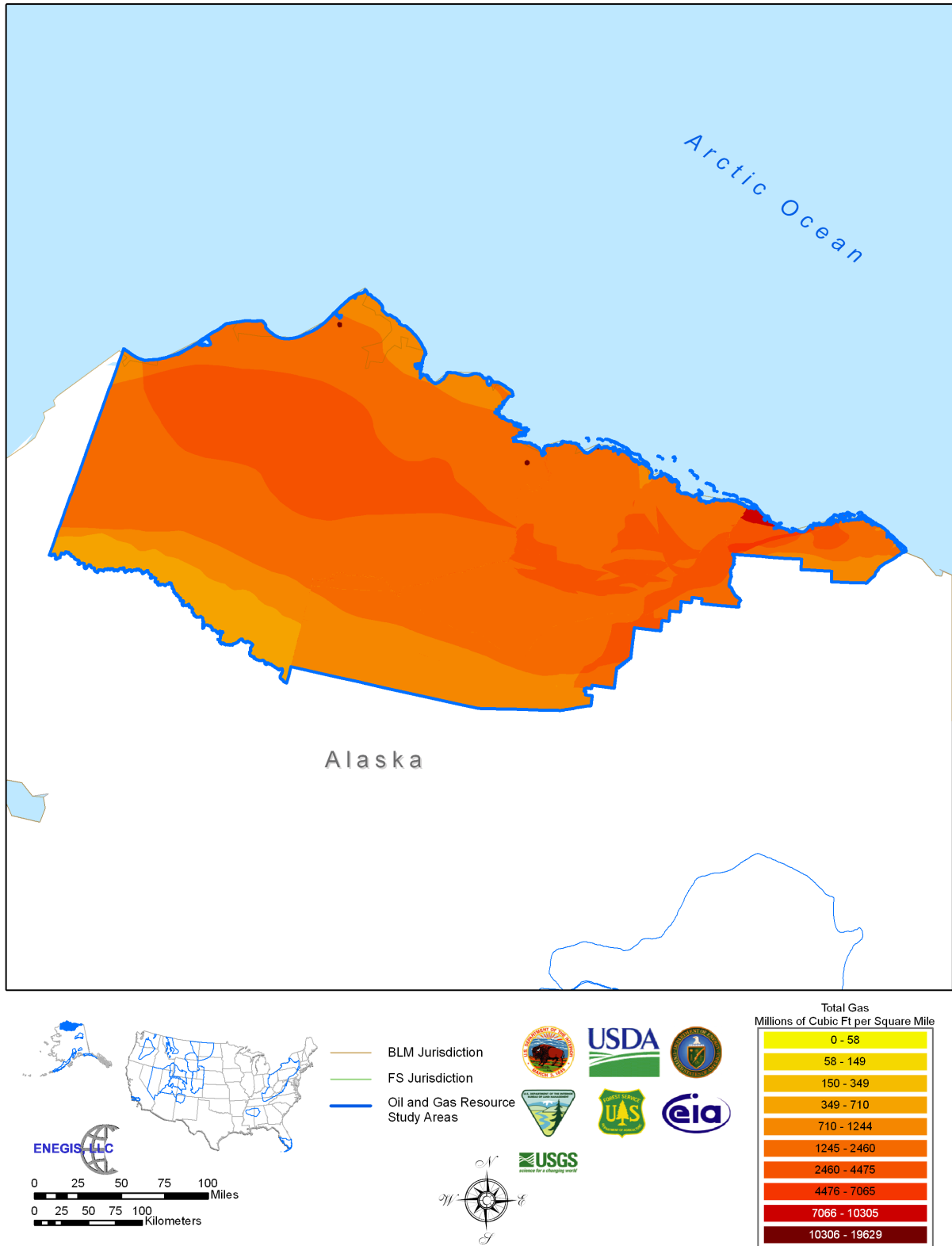


Figure 2-45. Total Natural Gas Map, Northern Alaska Study Area

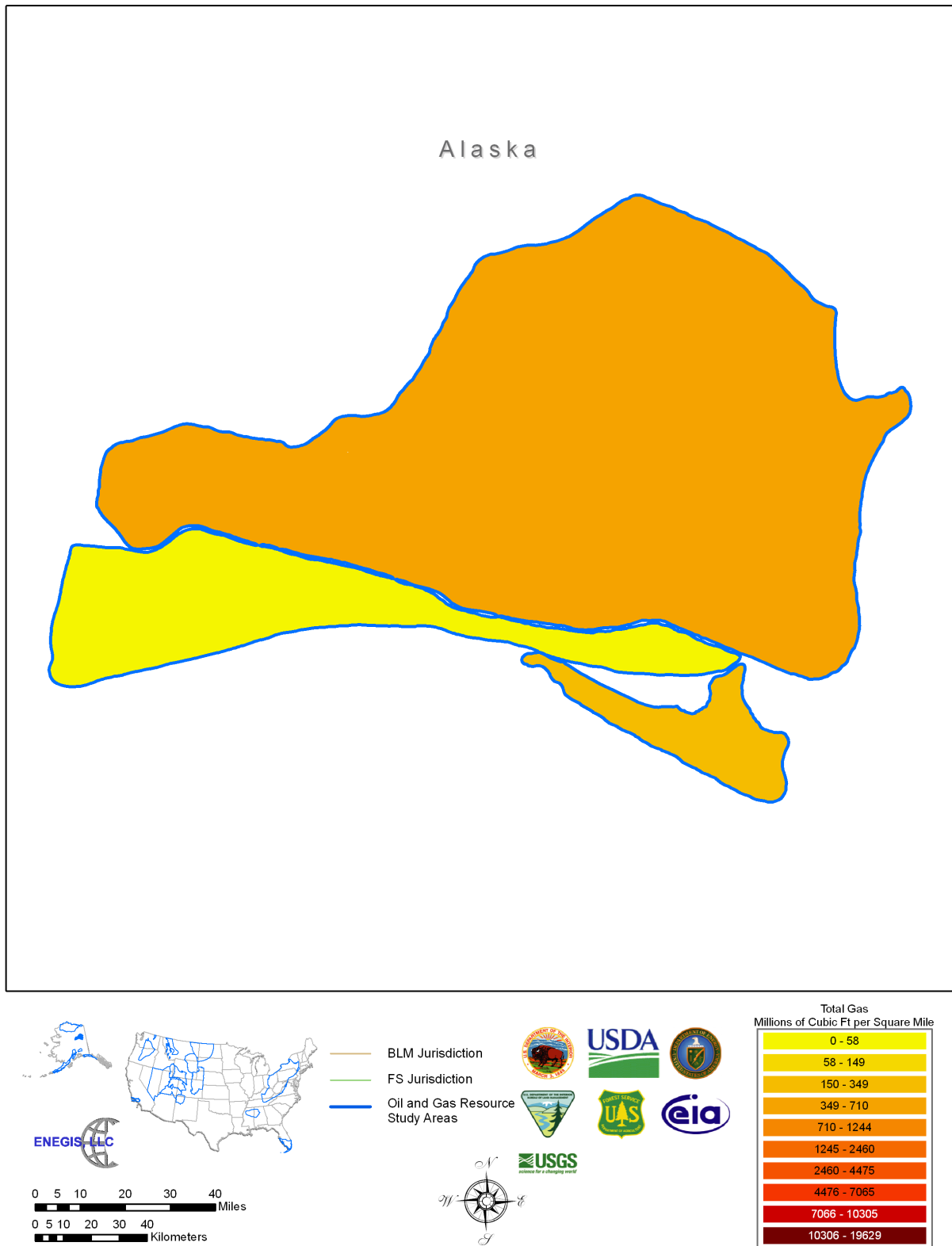


Figure 2-46. Total Natural Gas Map, Central Alaska - Yukon Flats Study Area

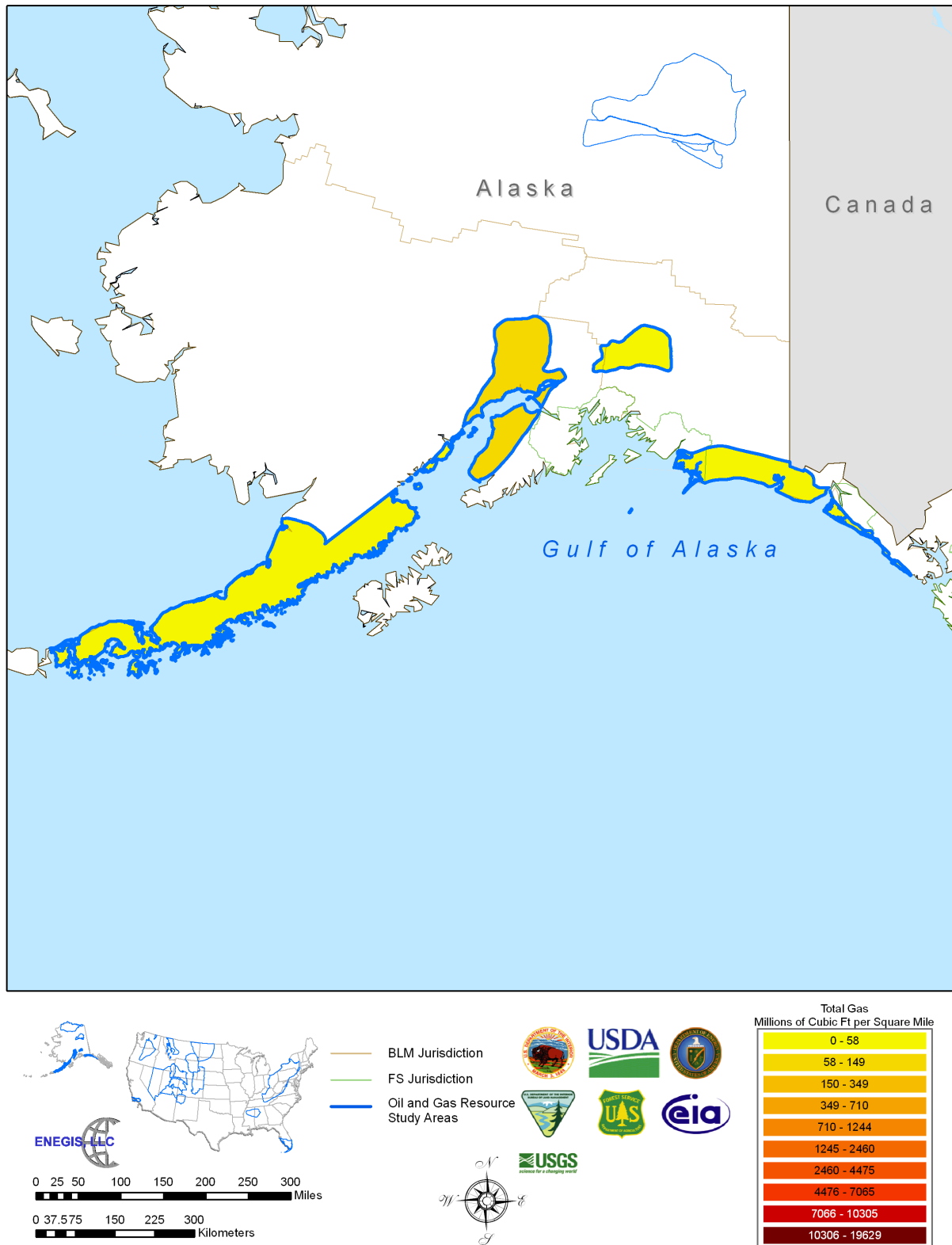


Figure 2-47. Total Natural Gas Map, Southern Alaska Study Area

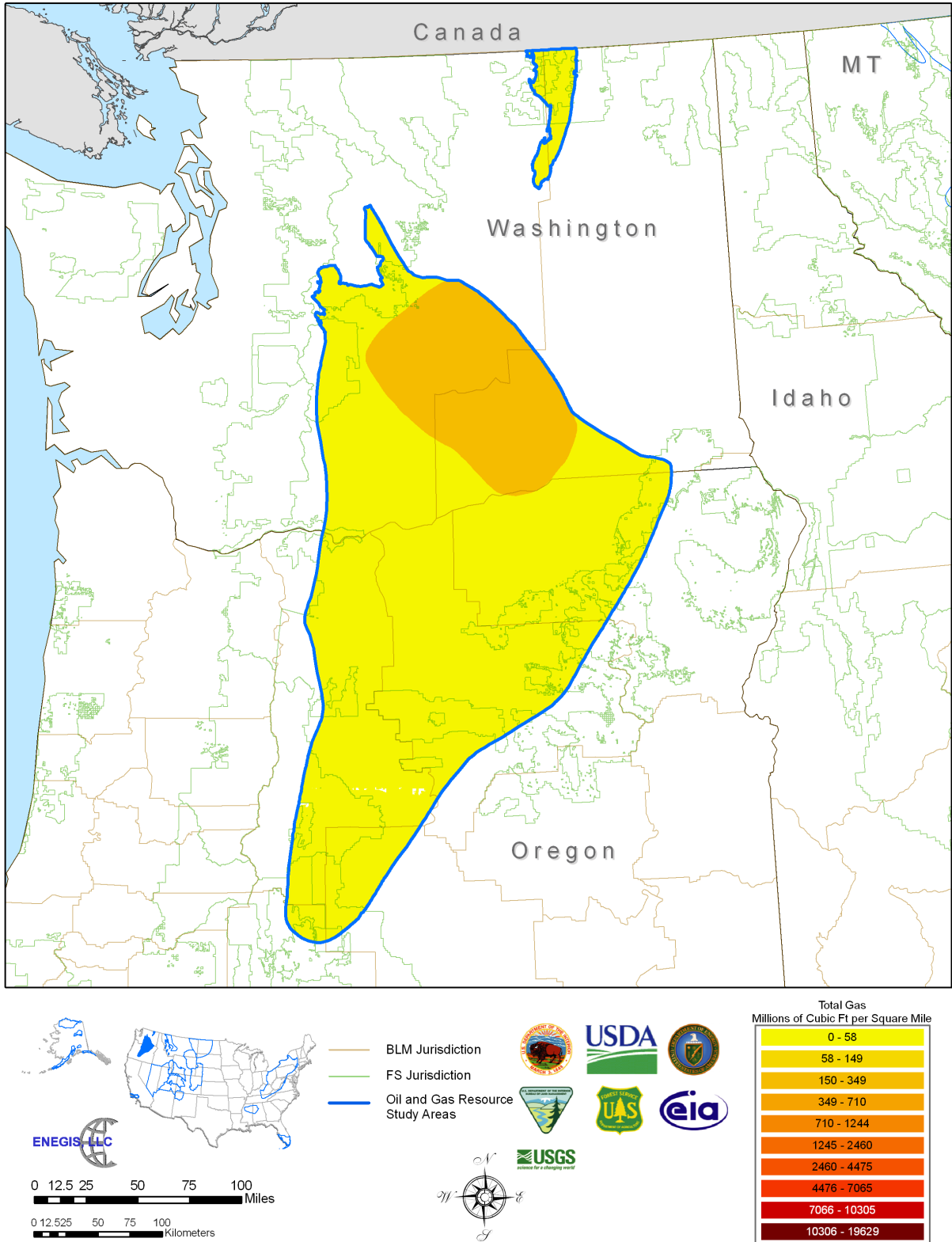


Figure 2-48. Total Natural Gas Map, Eastern Oregon-Washington Study Area

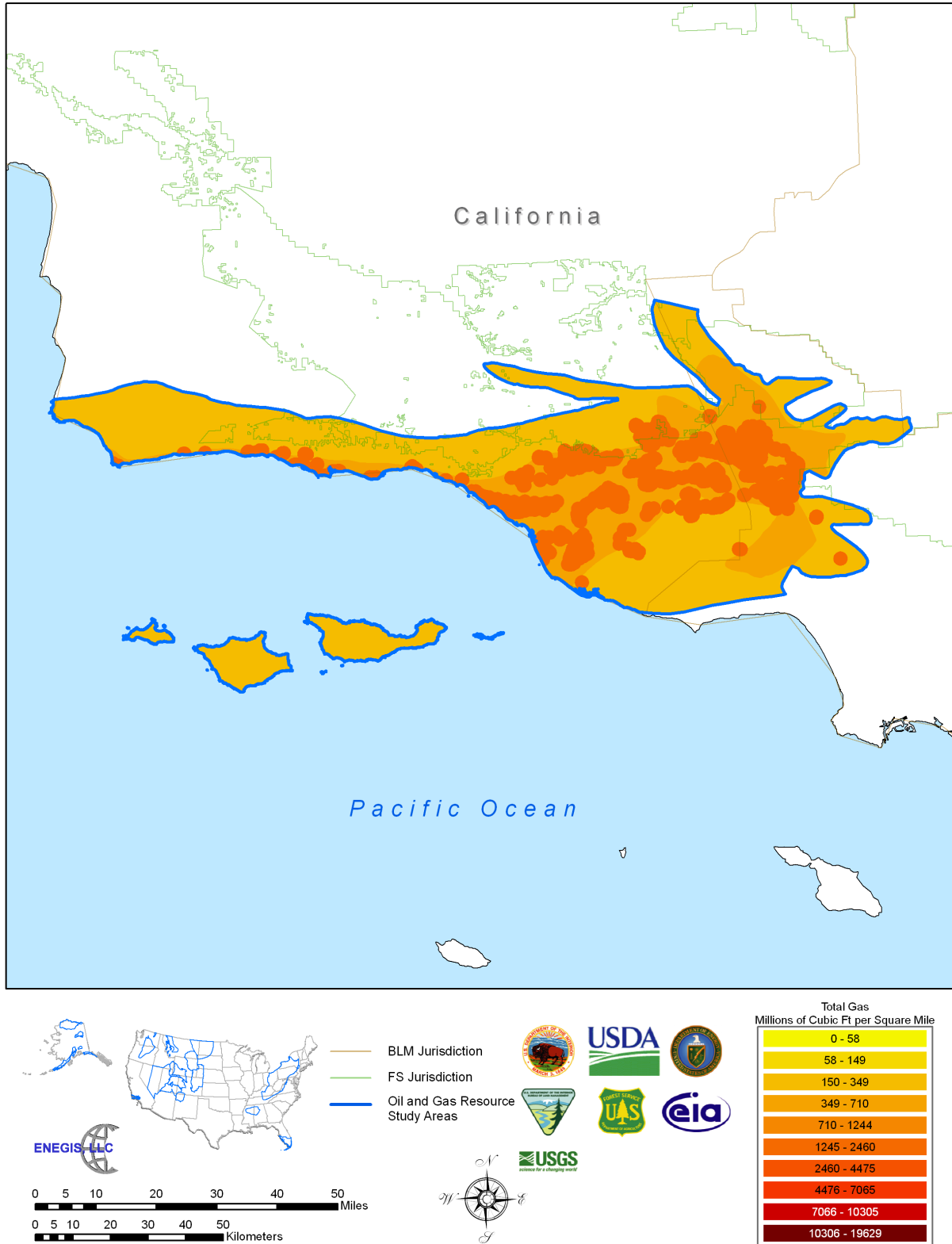


Figure 2-49. Total Natural Gas Map, Ventura Basin Study Area

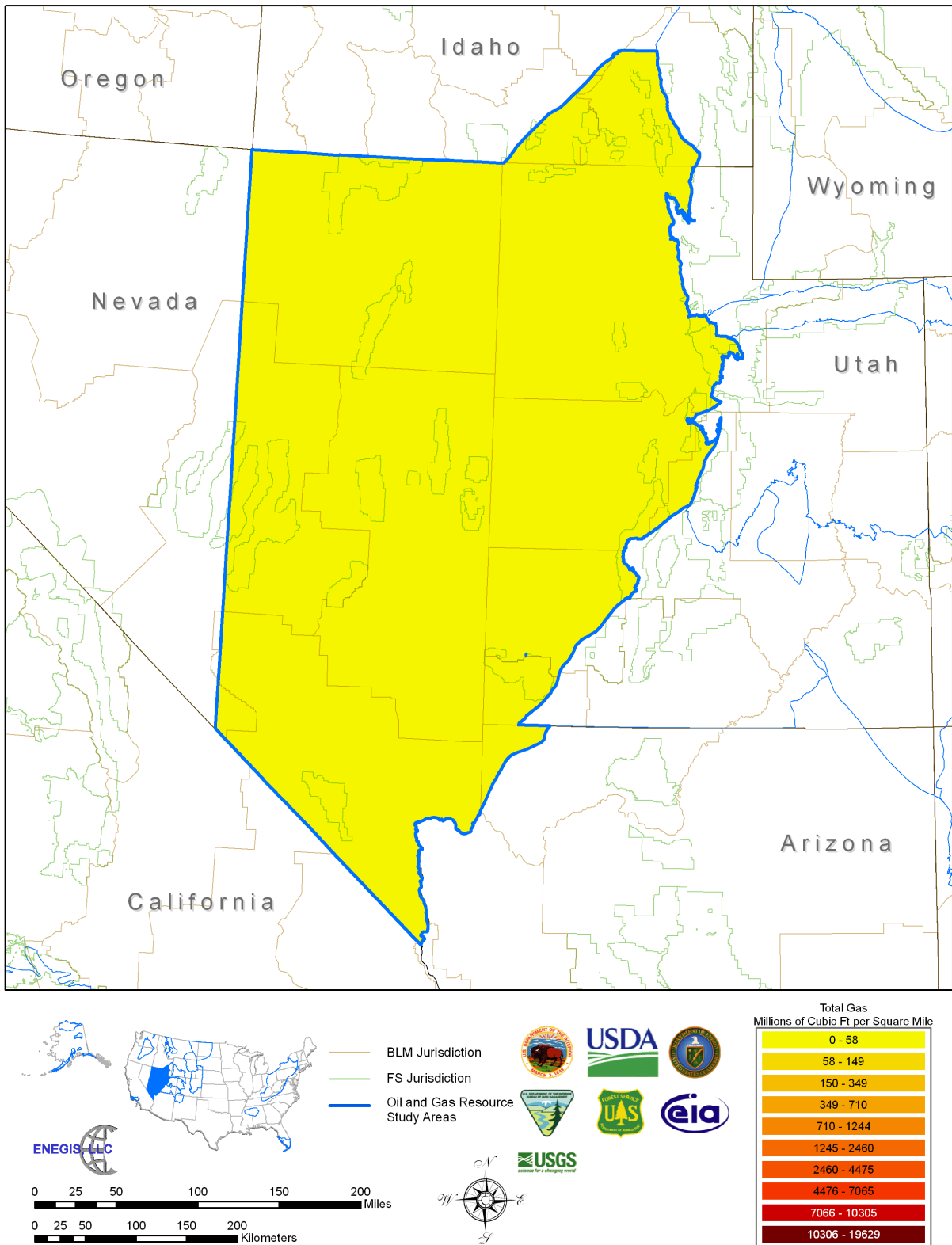


Figure 2-50. Total Natural Gas Map, Eastern Great Basin Study Area

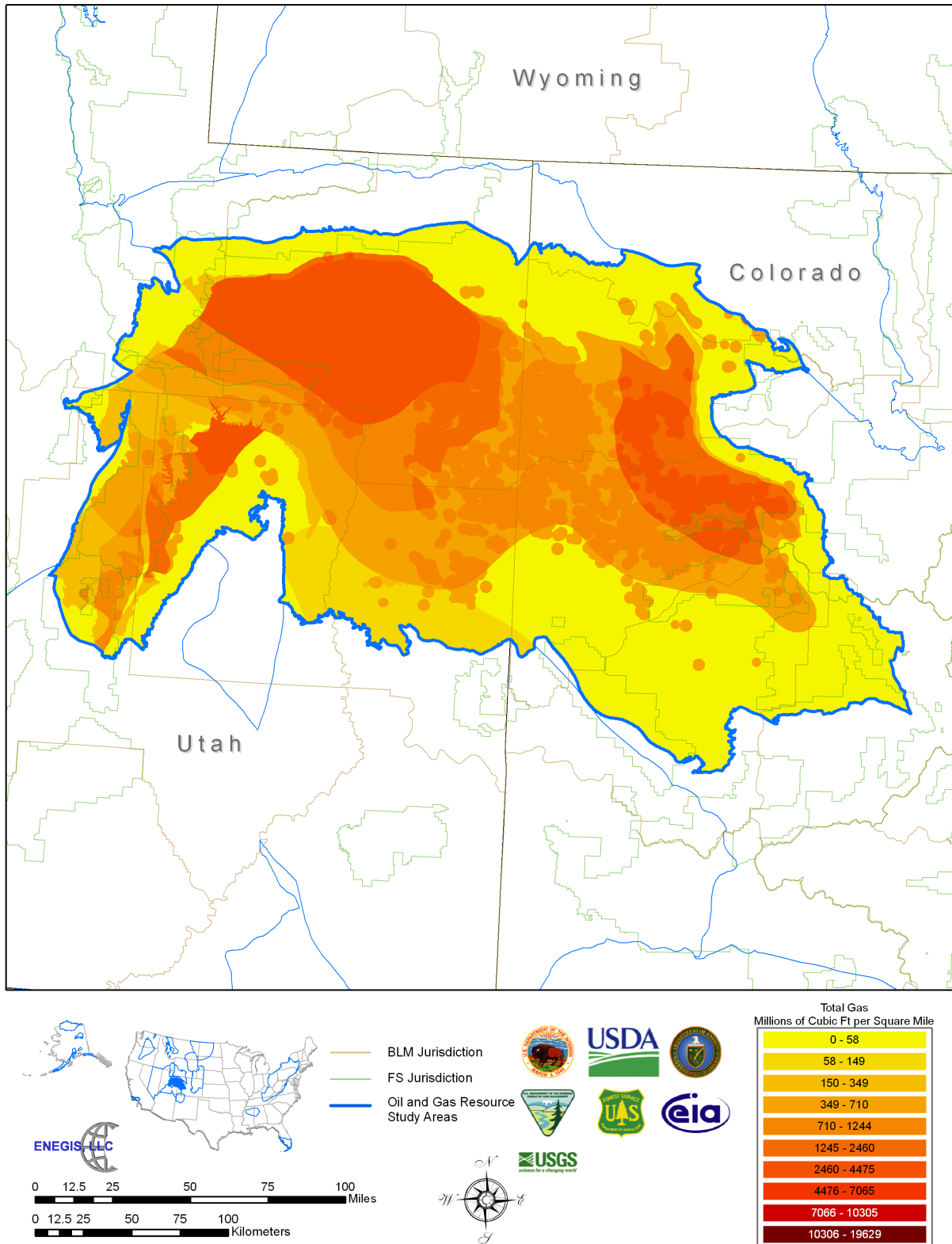


Figure 2-51. Total Natural Gas Map, Uinta-Piceance Basin Study Area

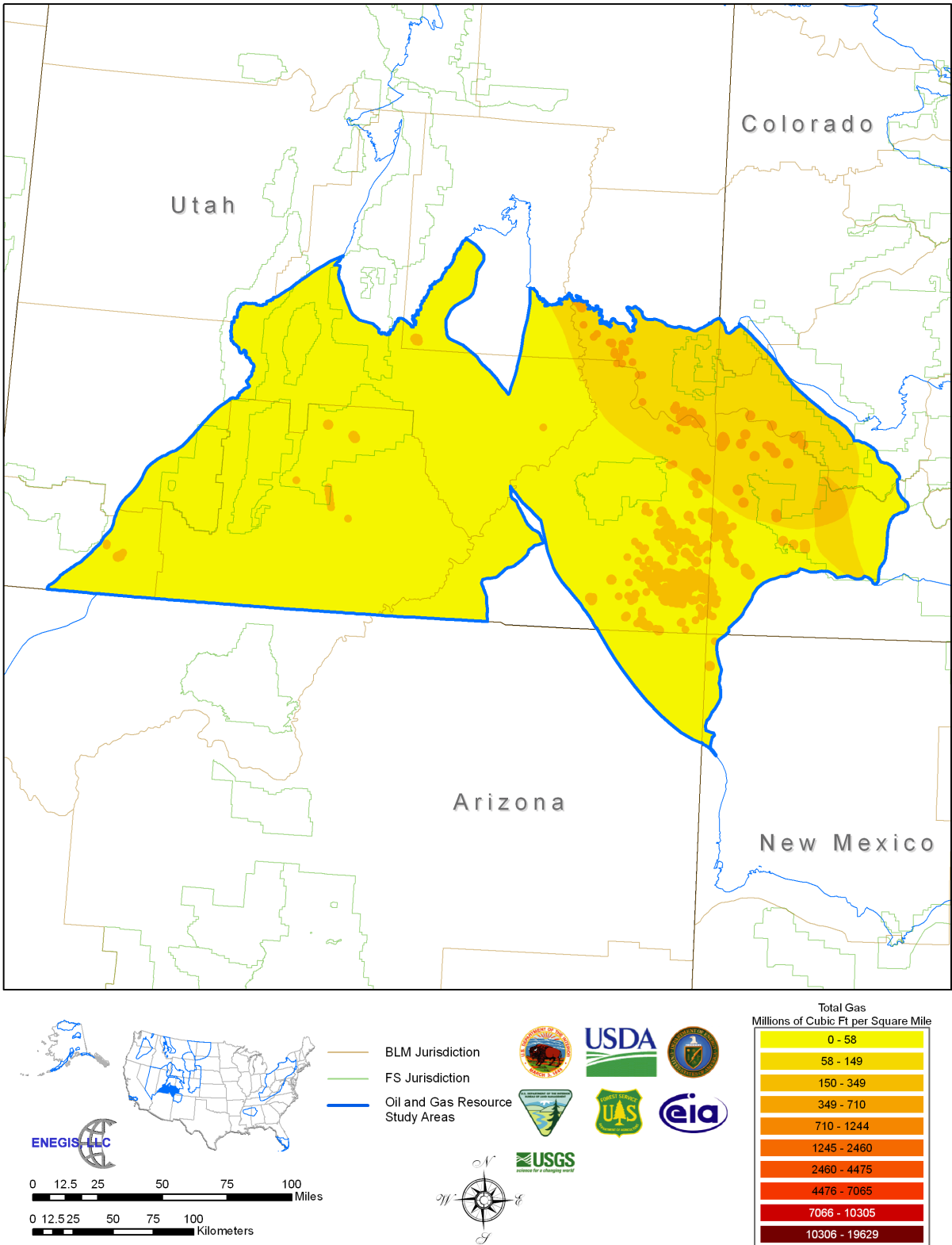


Figure 2-52. Total Natural Gas Map, Paradox Basin Study Area

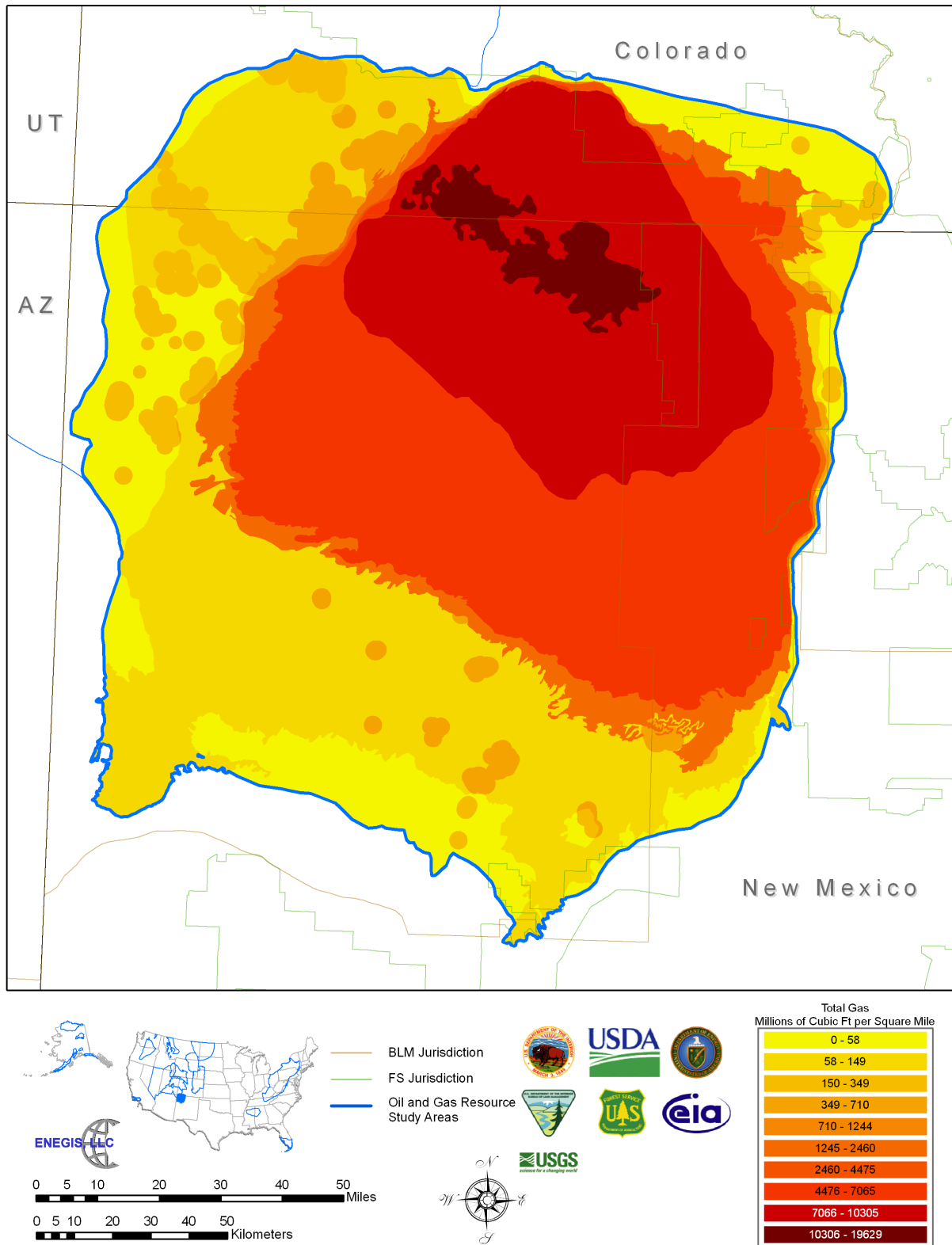


Figure 2-53. Total Natural Gas Map, San Juan Basin Study Area

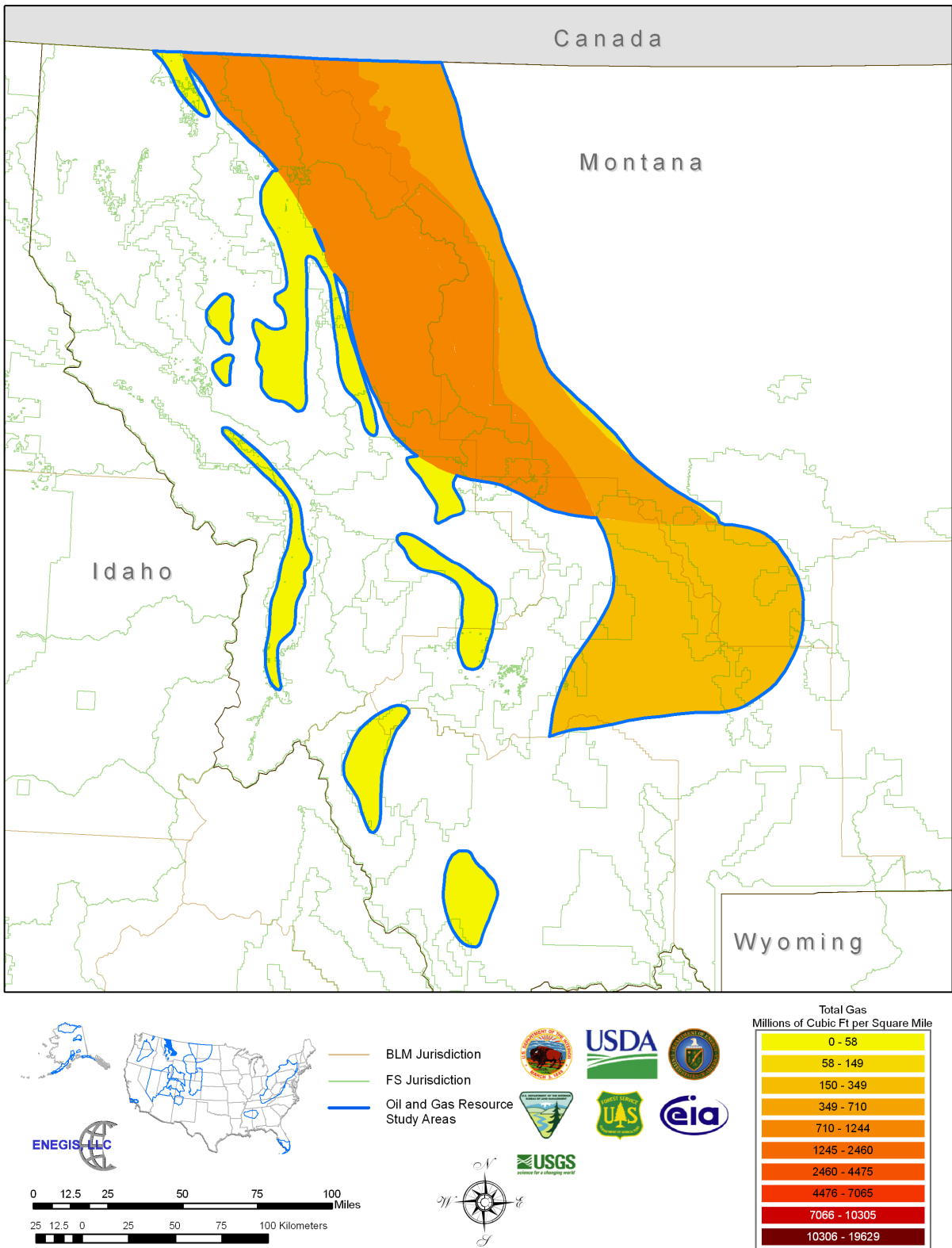


Figure 2-54. Total Natural Gas Map, Montana Thrust Belt Study Area

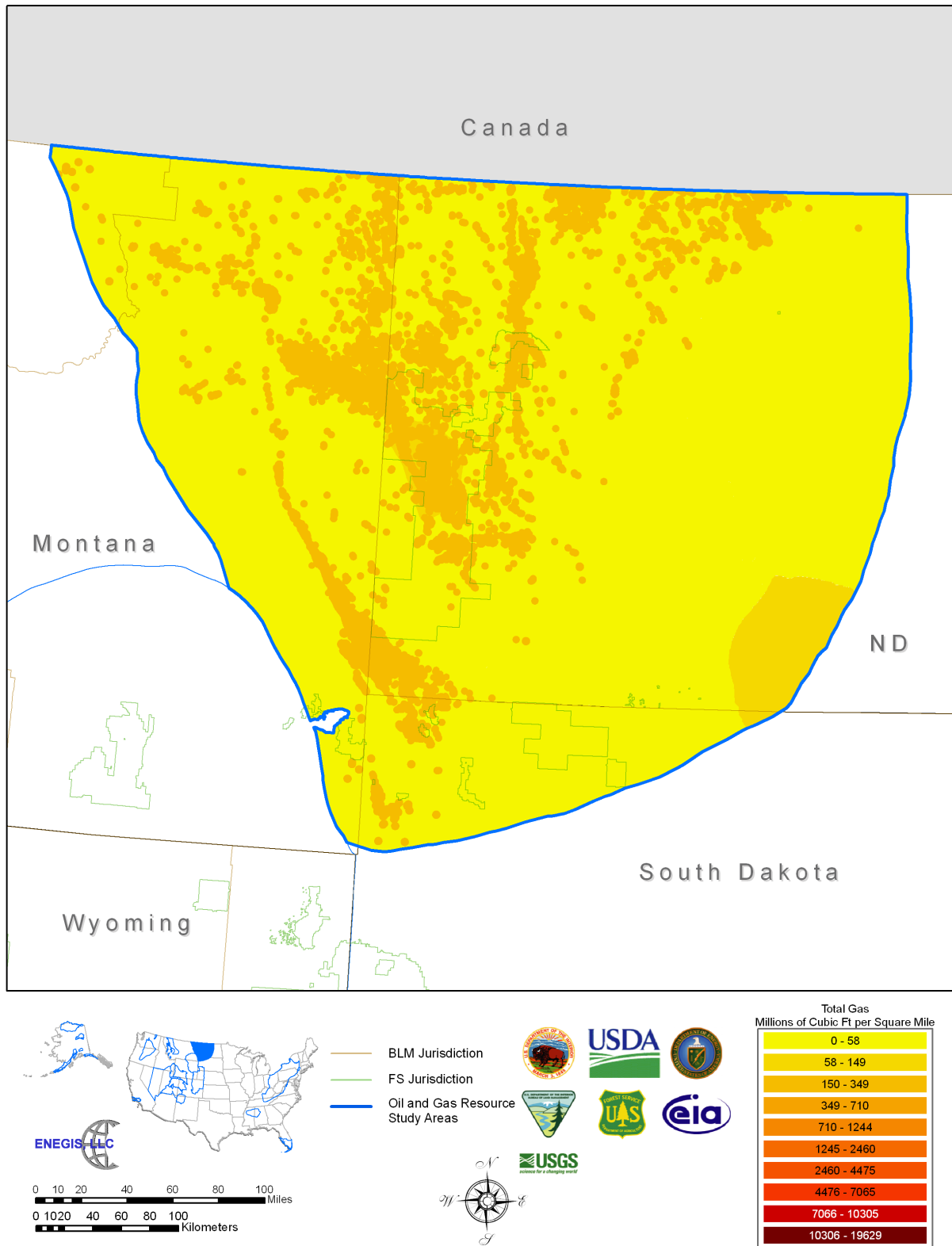


Figure 2-55. Total Natural Gas Map, Williston Basin Study Area

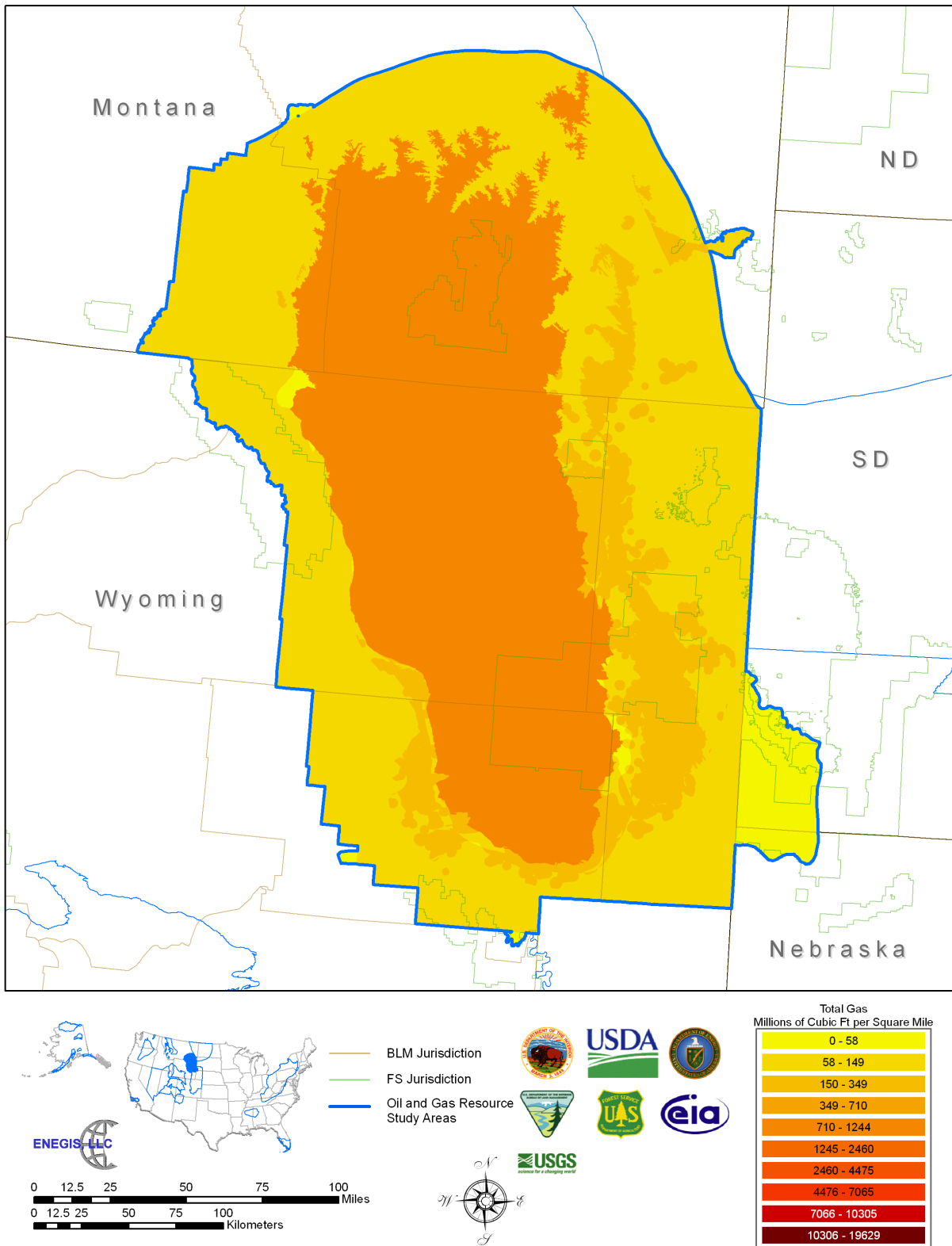


Figure 2-56. Total Natural Gas Map, Powder River Basin Study Area

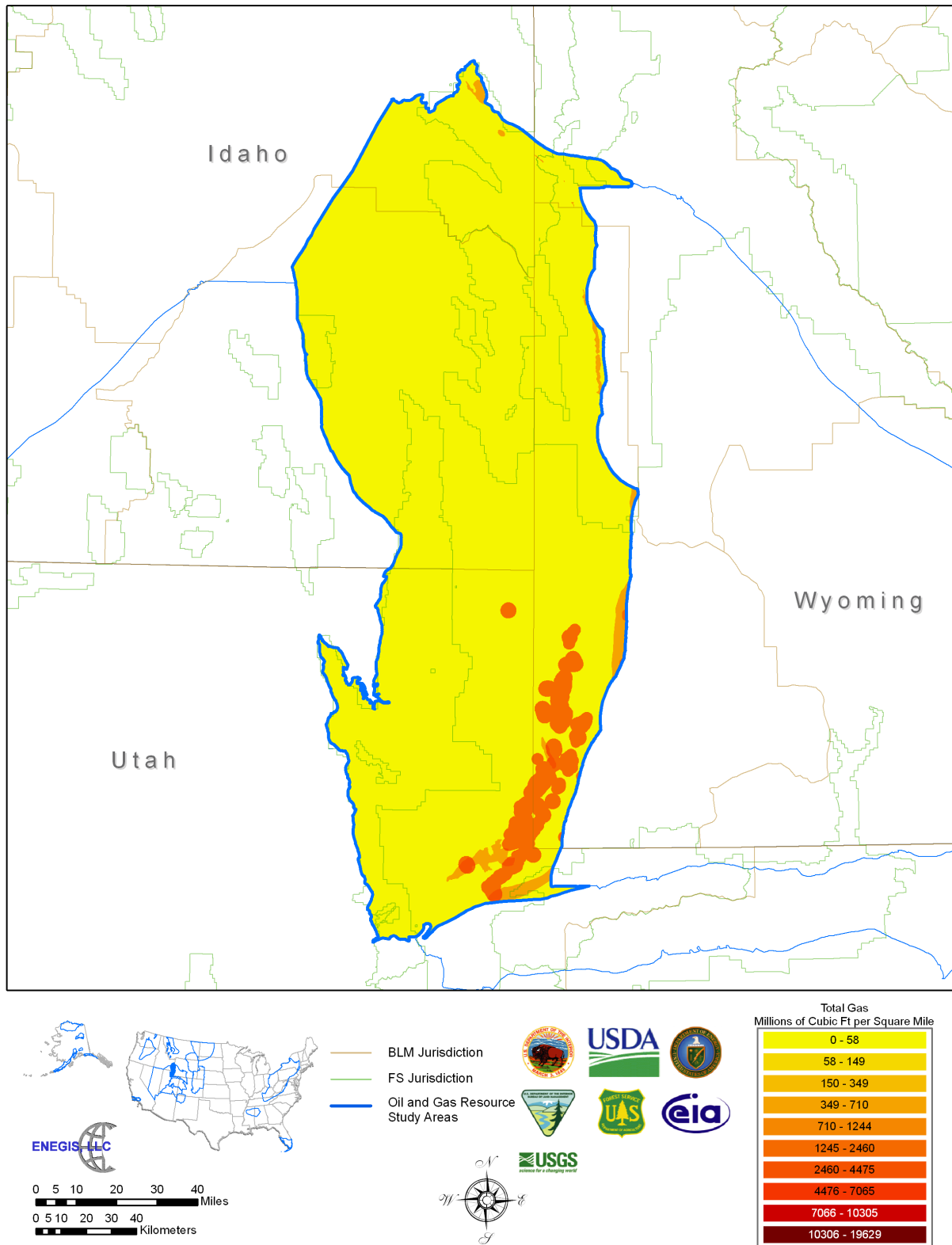


Figure 2-57. Total Natural Gas Map, Wyoming Thrust Belt Study Area

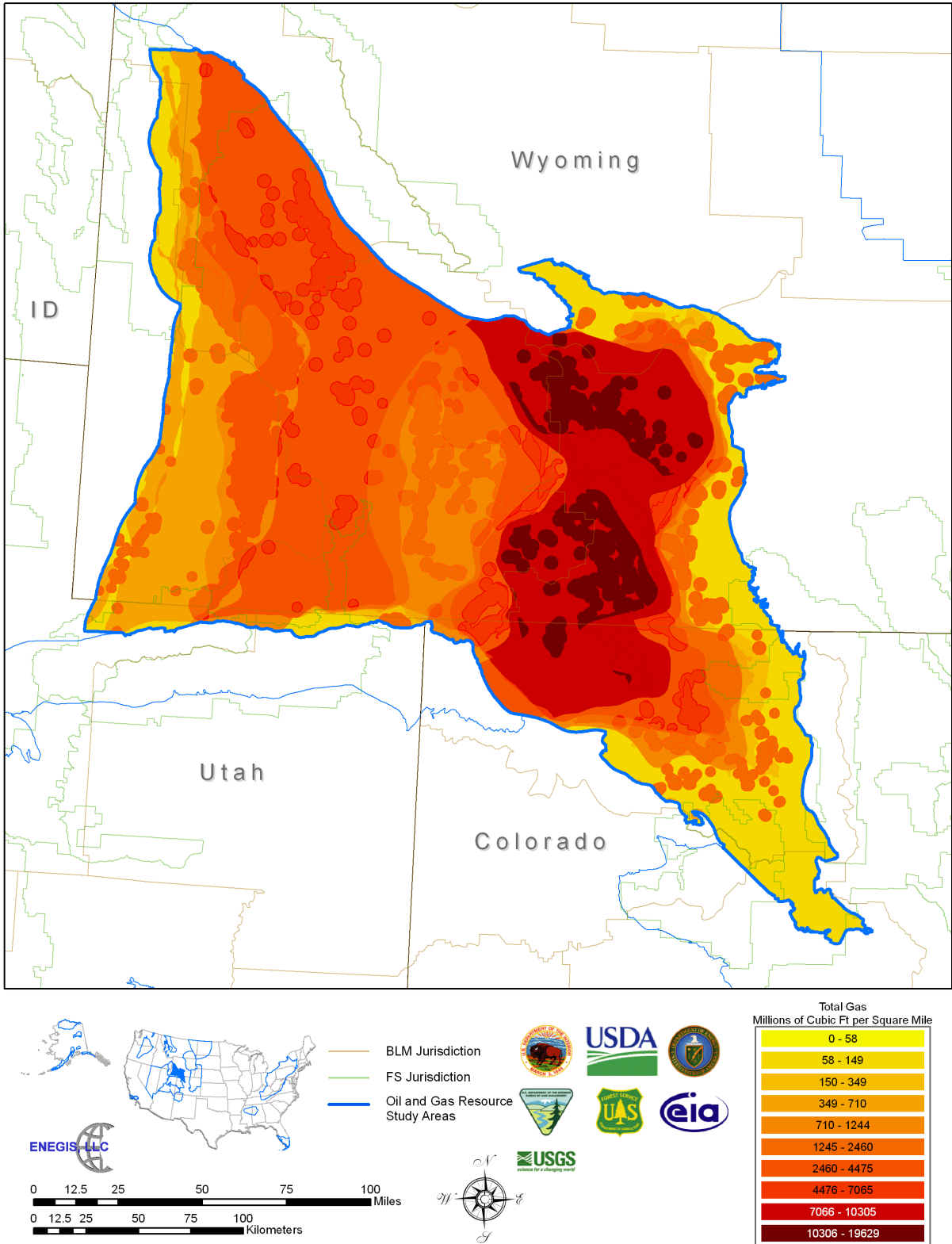


Figure 2-58. Total Natural Gas Map, Southwestern Wyoming Study Area

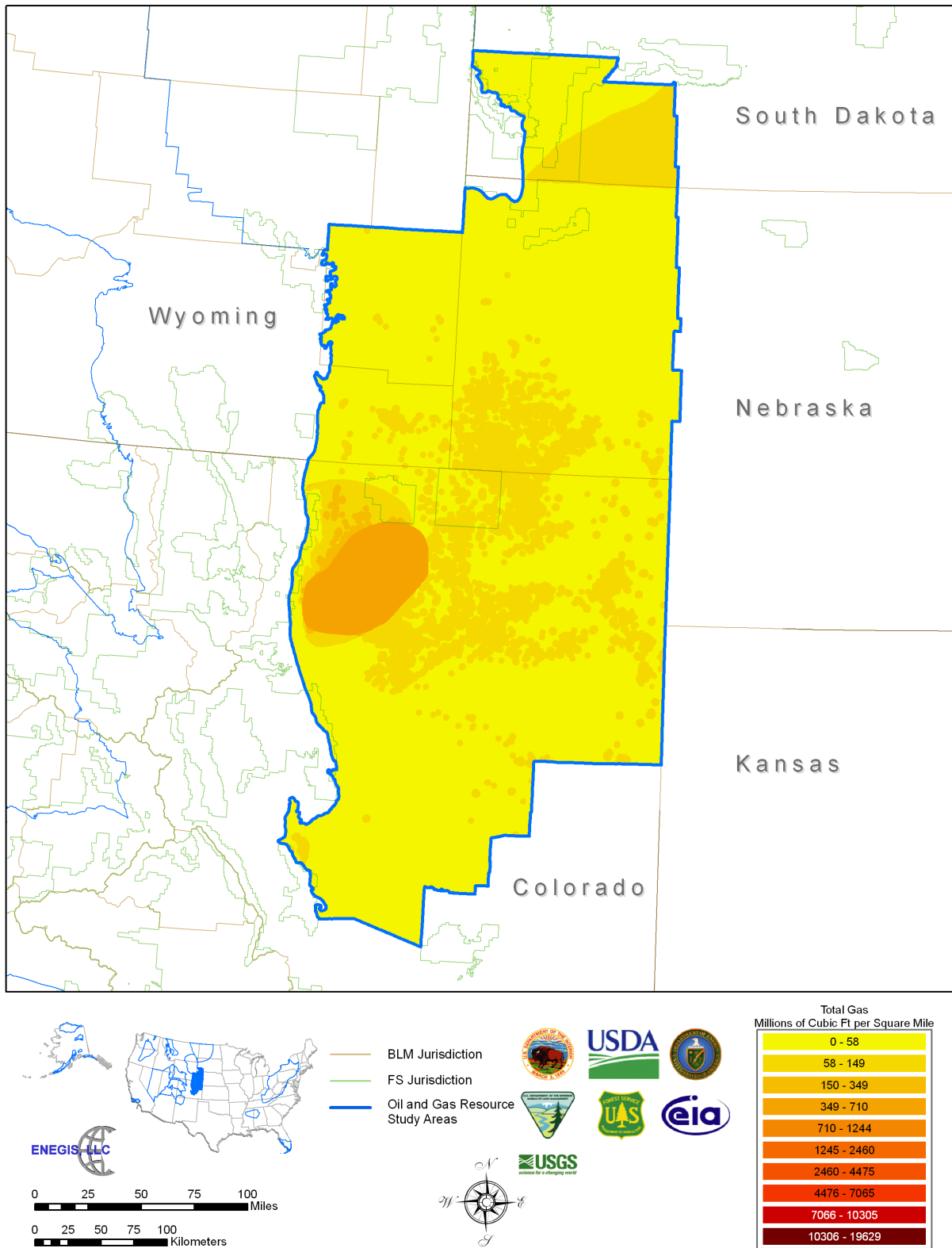


Figure 2-59. Total Natural Gas Map, Denver Basin Study Area

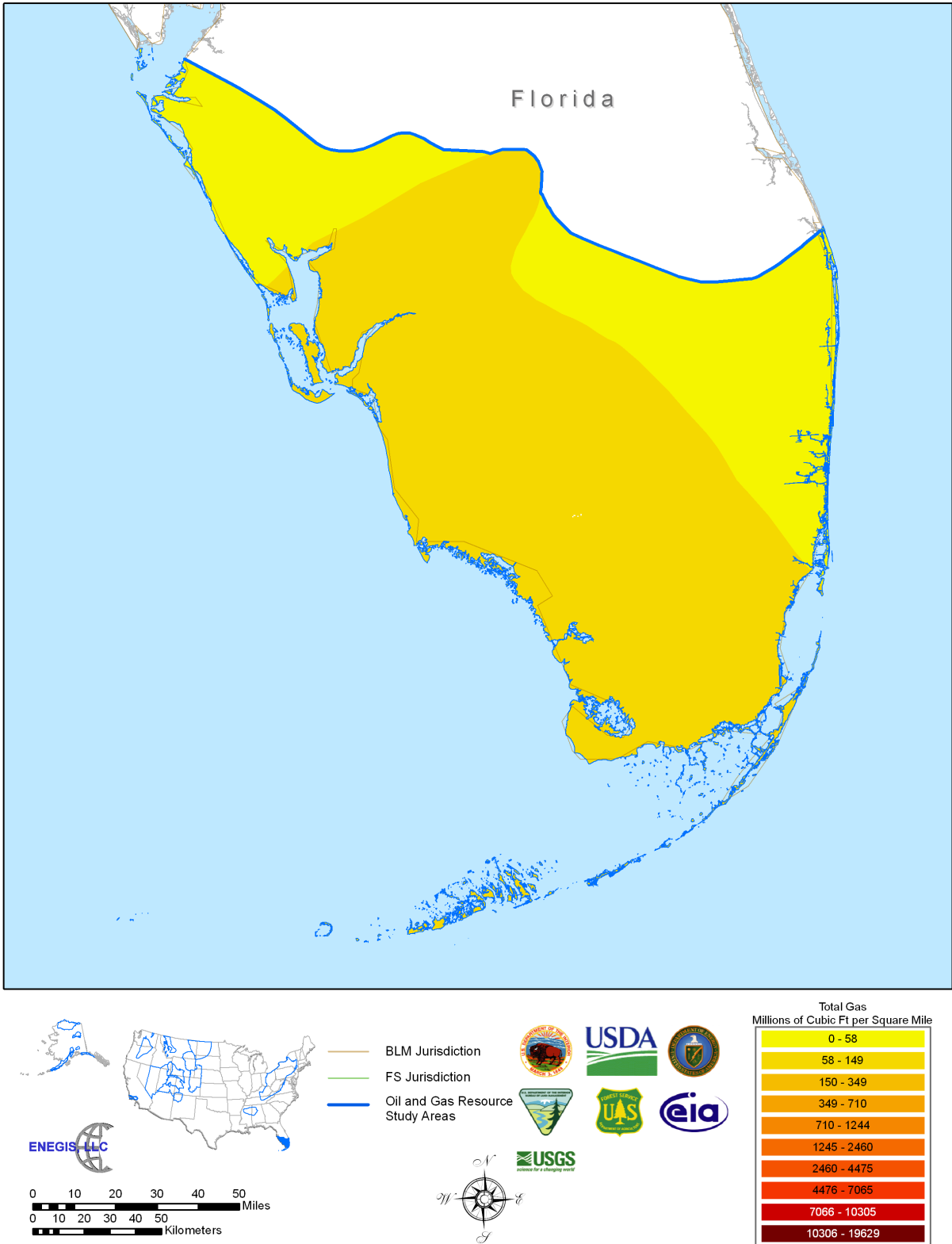


Figure 2-60. Total Natural Gas Map, Florida Peninsula Study Area

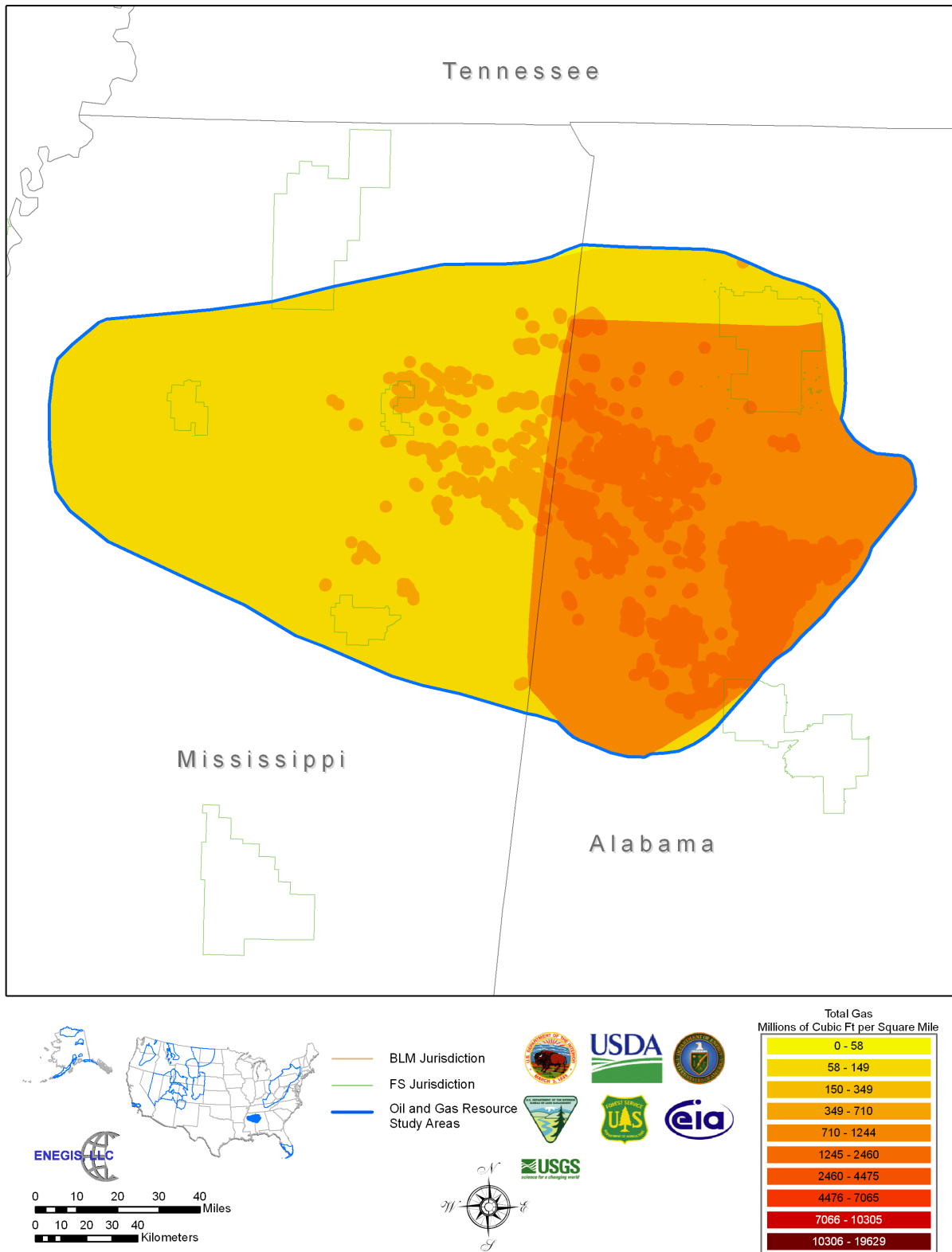


Figure 2-61. Total Natural Gas Map, Black Warrior Basin Study Area

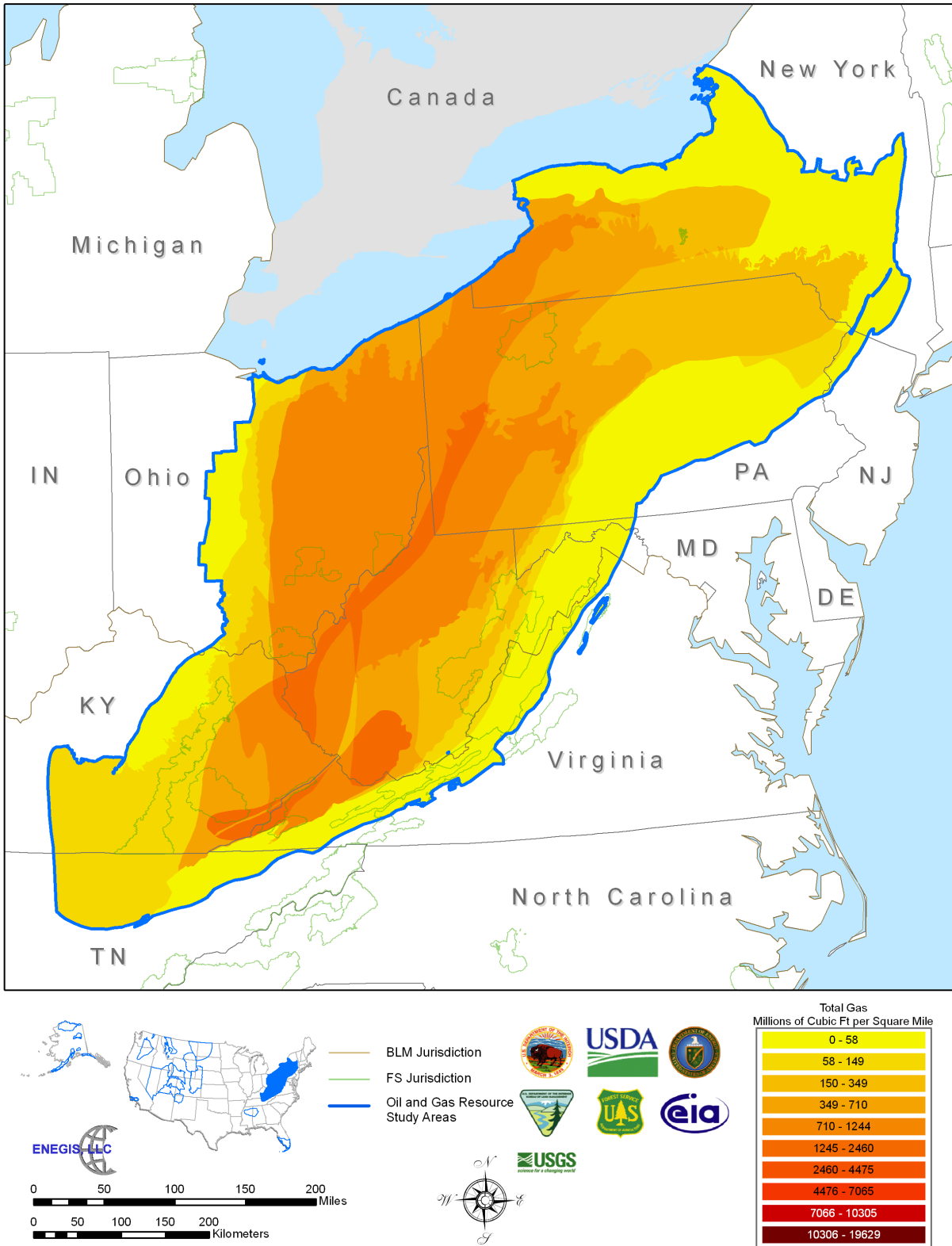


Figure 2-62. Total Natural Gas Map, Appalachian Basin Study Area

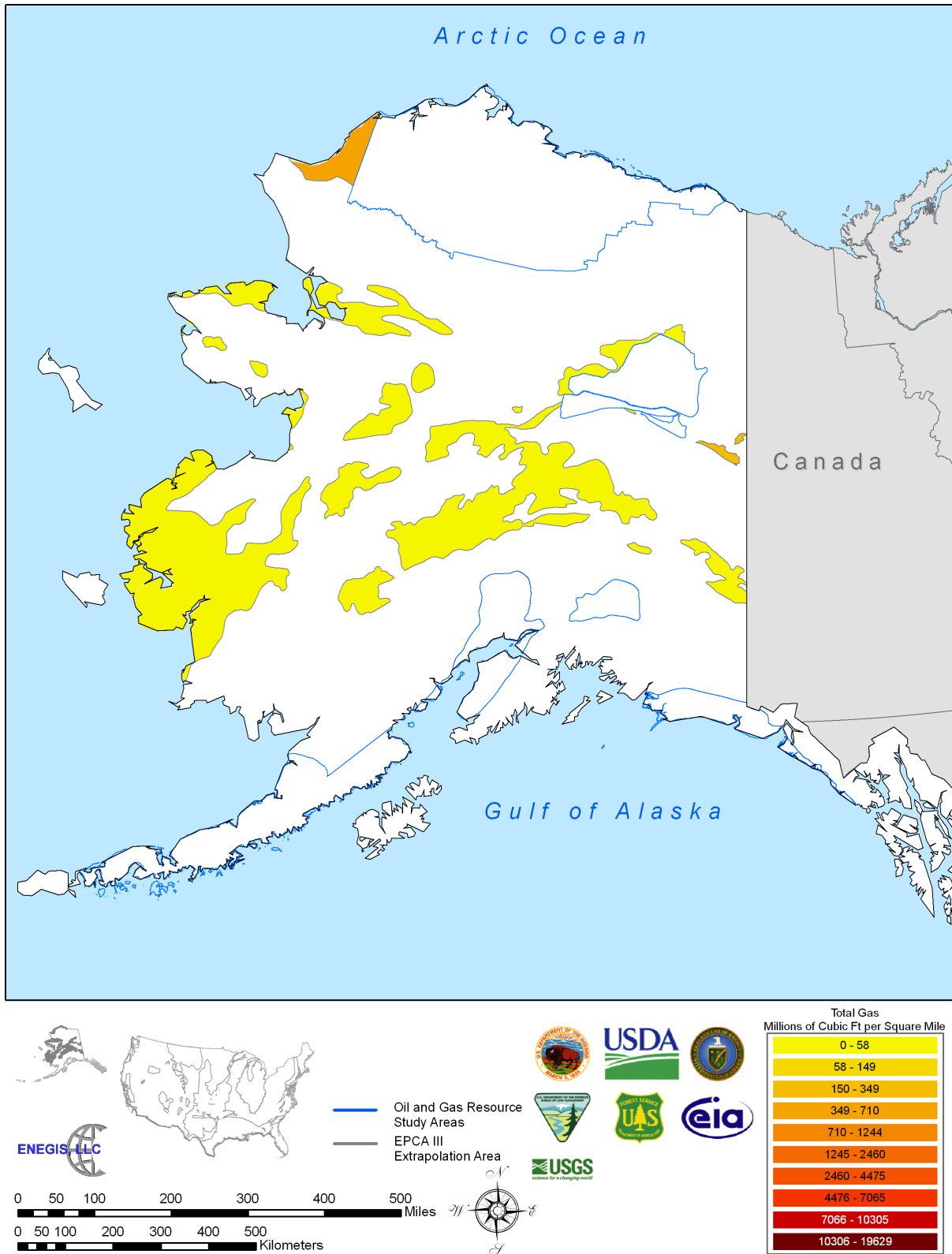


Figure 2-63. Total Natural Gas Map, Alaska Extrapolation Area

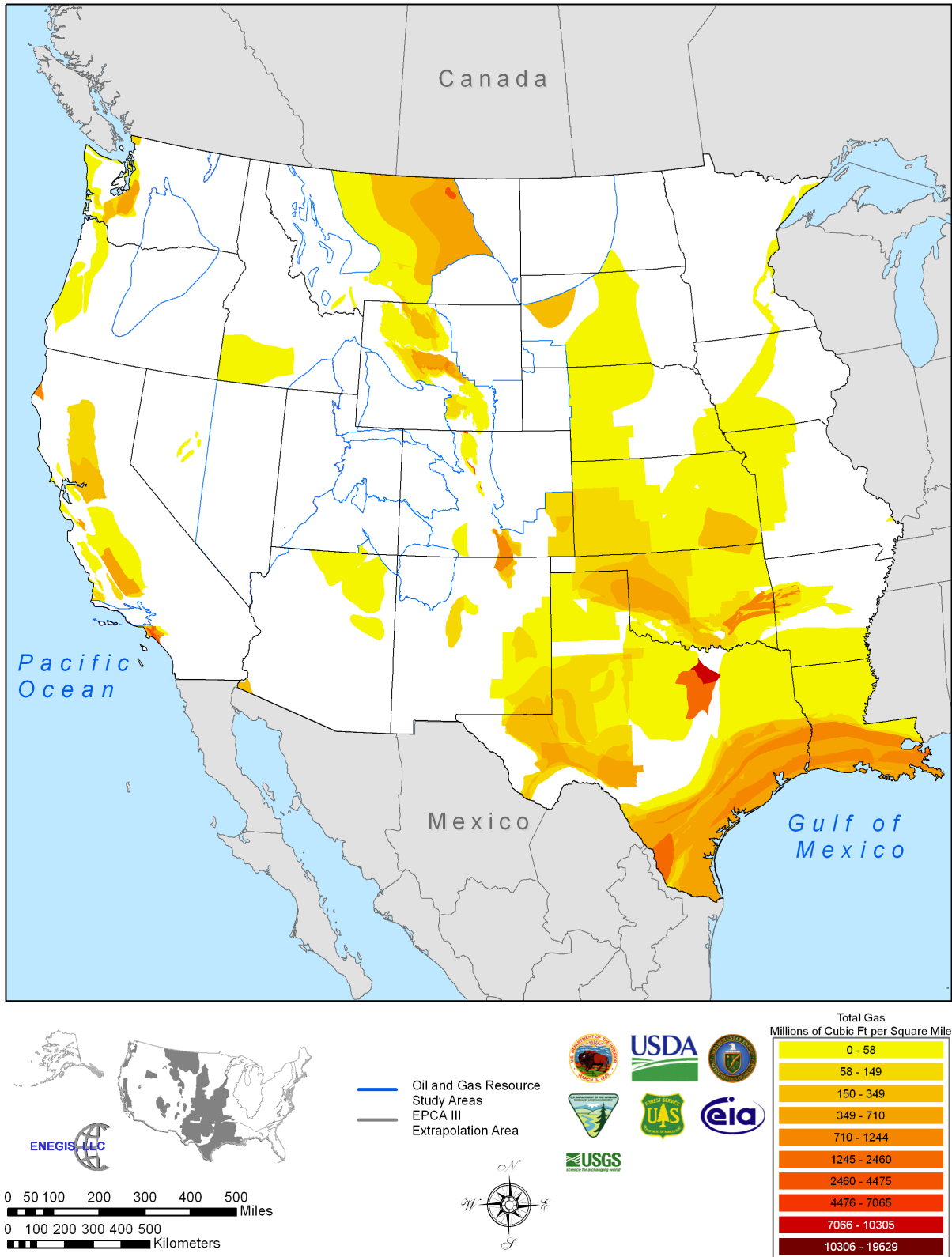


Figure 2-64. Total Natural Gas Map, Western Extrapolation Area

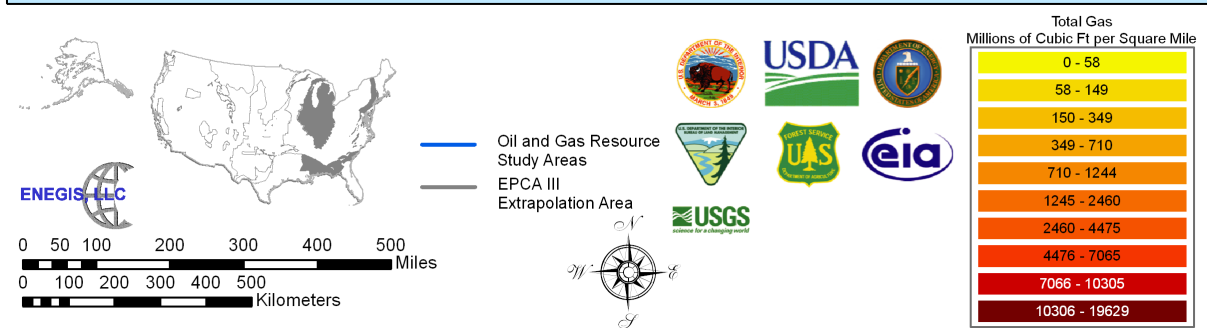
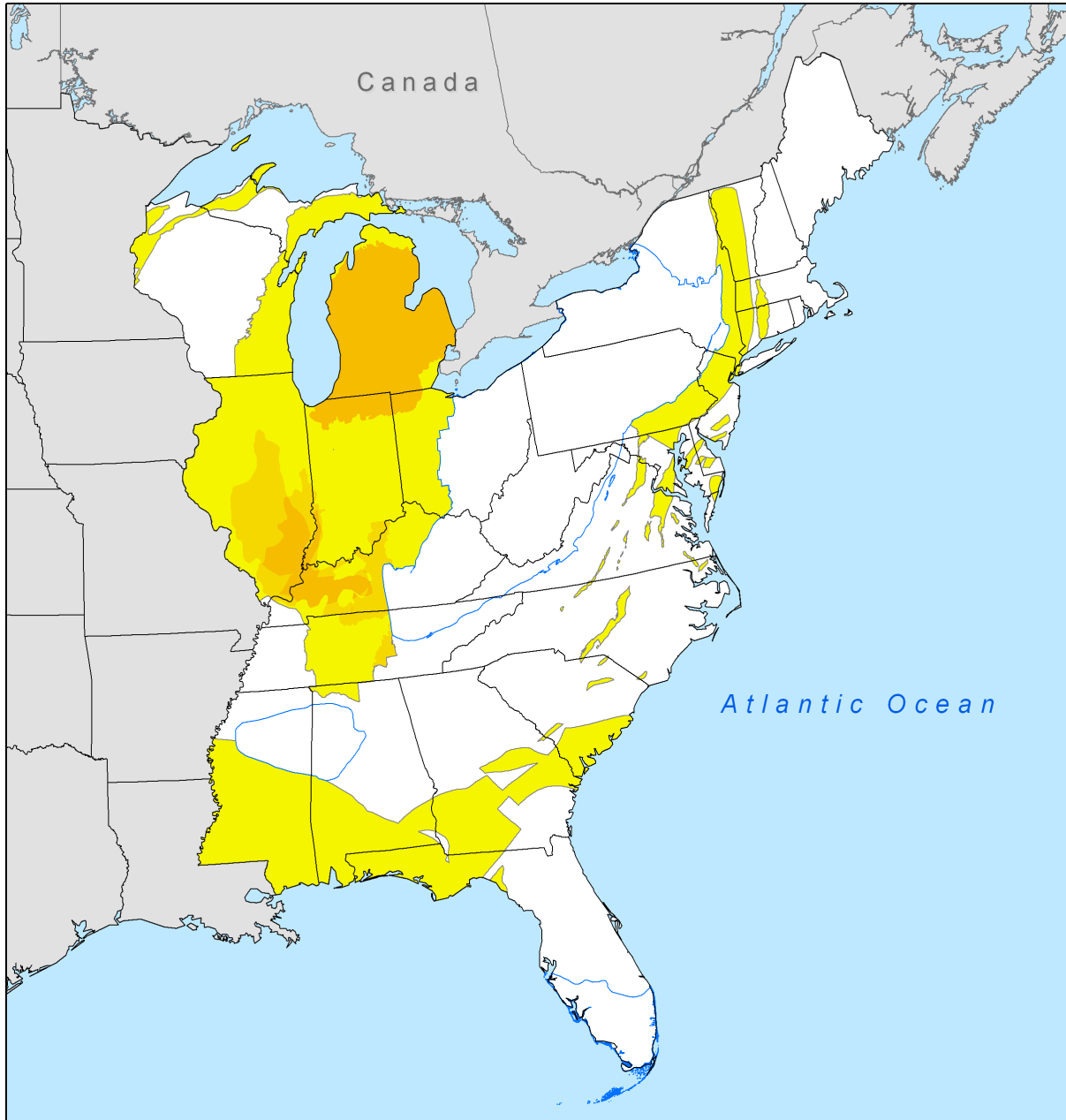


Figure 2-65. Total Natural Gas Map, Eastern Extrapolation Area

2.2.4 Proved Reserves

Proved reserves are defined as quantities of crude oil, natural gas, or natural gas liquids that geological and engineering data demonstrate with reasonable certainty (defined as greater than 90 percent probability) to be recoverable from known reservoirs under existing economic and operating conditions. Proved reserves are, in effect, the current “inventory on-the-shelf” portion of total resource endowment.⁴³

2.2.4.1 Sources of Proved Oil and Gas Reserves Data

Comprehensive 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 to EIA annually,⁴⁴ either at the field level or at the state level by a representative sample of the operators of domestic oil and gas wells. Of the 20,670 operators in the 2004 survey, 1,341 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 2004 survey, 488 active gas processing plants responded to the survey. The response rate was 100 percent.

Only the largest oil and gas well operators (those producing 1.5 MMbbl or more of crude oil, or 15 billion cubic feet (BCF) or more of natural gas per year) are required to submit to EIA proved reserves and production estimates by field for all of their operated properties. There were 164 large operators in the 2004 survey, all of which were included in the sample. The 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 BCF of natural gas per year) 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 532 mid-sized operators in the 2004 survey. All were included in the sample and their response rate was also 100 percent.

Small operators are those with production less than 400,000 barrels of crude oil or 2 BCF of natural gas per year. There were 19,994 small operators in the 2004 survey. Of these, 275 were sampled with certainty at an associated response rate of 93.8 percent and an additional 370 were randomly sampled at an associated response rate of 94.6 percent.

2.2.4.2 Proved Oil and Gas Reserves Data Preparation

The procedures used to prepare the proved oil and gas reserves data are described in Appendix 8.

2.2.4.3 Proved Reserves Data-Related Caveats

Because the EIA’s proved reserves survey is expressly designed to minimize the respondents’ reporting burden and yet

⁴³ The full technical definition of proved reserves is at the Society of Petroleum Engineers website at http://www.spe.org/spe/jsp/basic/0,,1104_12169,00.html

⁴⁴ Form EIA-23 “Annual Survey of Domestic Oil and Gas Reserves.”

provide reliable estimates at the state and national level of data aggregation, the EIA does not have operator-submitted, field-specific proved reserves information covering every oil or gas field in the country. However, the EIA has data reported for about 90 percent of all estimated domestic proved reserves. The EIA may have only partial reported estimates for a field that has two or more operators if one is not required to report proved reserves by field.

These deficiencies in the EIA's field-specific proved reserves information were remedied for this Inventory by use of additional procedures based on either publicly available production data or reserve-to-production ratio analogs.

In addition to gaps and omissions in operator-reported estimates of proved reserves, the proved reserves data are subject to two further caveats:

1. For the EIA survey, field location is reported at the county level. The precise field locations needed for this Inventory's GIS-based methodology required correlation of the EIA's reserves data files with commercial sources of field and/or well information that provide more precise location data. This process involved detailed, often well-by-well, effort owing to the existence of non-standard field names and codes, or the occasional lack of a field name, in the commercial or State data sources.
2. The EIA is obliged by law to ensure the confidentiality of the data submitted by each reserves survey respondent. Within the Inventory's study areas, there are situations where a field is operated by a single operator, or where a single operator is dominant. In such cases, the

EIA cannot disclose the proved reserves estimates for the field without a written agreement from the operator waiving the right to confidentiality. Such agreements are rare and time-consuming to obtain. To avoid the release of confidential information while still adequately supporting this Inventory, the EIA elected not to present field-specific proved reserves estimates even where doing so would not have compromised a respondent's identity. Instead, the fields have been grouped into a range of proved reserves categories that are broad enough to prevent extraction of the estimates for any specific field.

Table 2-6 provides a summary of proved reserves on Federal and non-Federal lands. Note that proved oil and gas reserves are not presented on Figures 2-24 through 2-65. See Appendix 8 for a more detailed explanation of proved reserves estimation and field boundary construction.

This Inventory is designed to portray the constraints on future access to the potential oil and gas resource base. Consequently, undiscovered technically recoverable resources and reserves growth resources are included in the categorization, but not proved reserves.⁴⁵ Table 2-7 and Figure 2-66 summarize the oil and gas resource types on Federal lands for the study areas and extrapolation areas. Table 2-8 summarizes the total acreage and oil and gas resource types for the onshore United States. Note that the total resource values listed in

⁴⁵ Proved reserves were incorporated into the EPCA Phase I inventory. Due to the revision of inventory requirements by the Energy Policy Act of 2005, proved reserves volumes are reported in this Phase III inventory but are excluded from the access categorization.

Table 2-6. Proved Reserves Summary Statistics

Study Area	Number of Fields	Total Liquid Reserves (MMbbl)	Federal Land Liquid Reserves (MMbbl)	Federal Portion of Total Liquid Reserves	Total Gas Reserves (Bcf)	Federal Land Gas Reserves (Bcf)	Federal Portion of Total Gas Reserves
Northern Alaska	23	4,034	3	0.08%	6,334	5	0.08%
Central Alaska - Yukon Flats	-	-	-	-	-	-	-
Southern Alaska	27	3	0	7.98%	1,335	48	3.58%
Eastern Oregon-Washington	-	-	-	-	-	-	-
Ventura Basin	86	215	12	5.6%	254	19	7.6%
Eastern Great Basin	29	4	4	99.5%	0	0	94.7%
Uinta-Piceance Basin	180	254	143	56.2%	7,182	3,794	52.8%
Paradox Basin	171	119	36	30.4%	14,156	7,497	53.0%
San Juan Basin	79	55	17	30.4%	6,498	3,441	53.0%
Montana Thrust Belt	-	-	-	-	-	-	-
Williston Basin	955	769	173	22.5%	841	173	20.6%
Powder River Basin	543	193	109	56.3%	2,399	936	39.0%
Wyoming Thrust Belt	28	35	14	39.8%	1,141	475	41.6%
Southwestern Wyoming	281	177	122	69.0%	12,703	10,064	79.2%
Denver Basin	1,638	148	3	1.7%	2,737	30	1.1%
Florida Peninsula	21	20	-	0.0%	0	-	0.0%
Black Warrior Basin	235	1	0	0.4%	1,248	18	1.4%
Appalachian Basin	3,354	79	0	0.2%	9,550	28	0.3%
Alaskan Extraoplation Area	-	493	0	0.1%	508	3	0.7%
Western Extrapolation Area	-	14,649	4,701	32.1%	76,217	42,046	55.2%
Eastern Extrapolation Area	-	3,496	6	0.2%	43,452	184	0.4%
Total	7,650	24,745	5,344	21.6%	186,553	68,760	36.9%

Note: The smallest reserves amounts round to zero. A dash (-) indicates there are no fields reporting proved reserves in the study area.

* Number of fields was not extrapolated for these areas.

Table 2-7. Summary of All Federal Oil and Gas Resources by Study Area and Resource Type

Study Area	Undiscovered Resources		Reserves Growth		Proved Reserves	
	Oil (MMbbls)	Gas (BCF)	Oil (MMbbls)	Gas (BCF)	Oil (MMbbls)	Gas (BCF)
Northern Alaska	16,991	77,723	766	1,912	3	5
Central Alaska - Yukon Flats	149	2,721	-	-	-	-
Southern Alaska	268	394	-	-	0	48
Eastern Oregon-Washington	4	856	-	-	-	-
Ventura Basin	185	342	96	111	12	19
Eastern Great Basin	1,347	204	8	-	4	0
Uinta-Piceance Basin	79	11,881	288	2,230	143	3,794
Paradox Basin	298	778	14	270	36	7,497
San Juan Basin	108	24,282	42	818	17	3,441
Montana Thrust Belt	171	6,308	-	-	-	-
Williston Basin	113	184	254	434	173	173
Powder River Basin	892	8,848	397	289	109	936
Wyoming Thrust Belt	42	286	2	347	14	475
Southwestern Wyoming	1,949	61,290	133	6,743	122	10,064
Denver Basin	13	66	4	22	3	30
Florida Peninsula	74	323	-	-	-	-
Black Warrior Basin	1	354	0	37	0	18
Appalachian Basin	33	2,423	-	-	0	28
Alaskan Extrapolation Area	53	1,816	571	519	0	3
Western Extrapolation Area	1,326	11,995	3,738	2,736	4,701	42,046
Eastern Extrapolation Area	75	1,016	19	419	6	184
Total	24,169	214,088	6,333	16,887	5,344	68,760

Note: Federal lands include split estate, A dash (-) means there is insufficient data for analysis. Onshore resources only

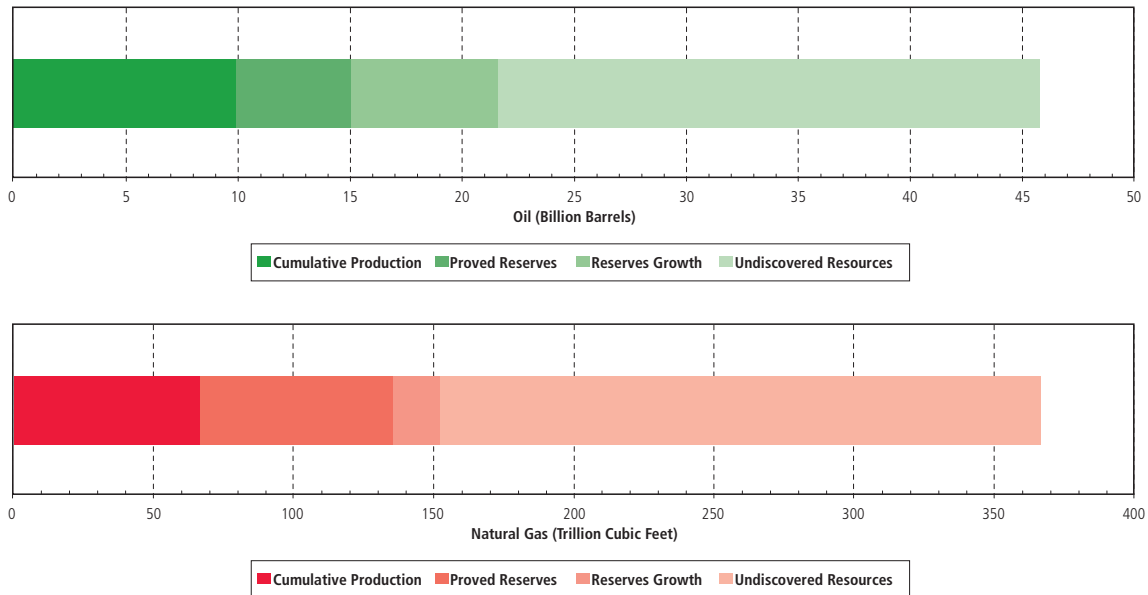


Figure 2-66. Distribution of Total Federal Onshore Hydrocarbon Endowment by Type and Resource Category

the table will be larger than for the Inventory primarily due to the exclusion of resources under state waters.

2.3 Data Integration and Spatial Analysis

2.3.1 Categorization of Oil and Gas Access Constraints

The main factors that affect access to oil and gas resources on Federal lands are land availability (Section 2.1.1) and leasing and drilling restrictions (Sections 2.1.2 and 2.1.3). To simplify the analysis and present meaningful results, these factors were categorized into a hierarchy that represents varying levels of access as shown in Table 2-9. This categorization was necessary to enable a reasonable quantitative analysis, given the fact that approximately 3,125 individual stipulations from 128 Federal land use plans (LUPs) exist for the study areas within the Inventory.

The hierarchy of categories was formulated to ensure that the constraints on 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, and for areas where leasing is permitted, the impacts relative to the difficulty for conducting drilling operations.

The Federal lands categorization hierarchy is ordered from “No Leasing” (most constrained) to “Leasing with Standard Lease Terms” (least constrained) as follows:

1. **No Leasing (Statutory/Executive Order) (NLS)** are lands that cannot be leased due to Congressional or Presidential action. Examples include national parks, national monuments, and wilderness areas.

Table 2-8. Summary of All Oil and Gas Resources by Type

	Area	Undiscovered Resources		Reserves Growth		Proved Reserves		Total Resources	
	(Acres)	Oil (MMbbls)	Natural Gas (Bcf)	Oil (MMbbls)	Natural Gas (Bcf)	Oil (MMbbls)	Natural Gas (Bcf)	Oil (MMbbls)	Natural Gas (Bcf)
Detailed Study Areas	477,277,102	33,056	395,554	7,661	31,811	6,105	66,377	46,822	493,742
Alaskan Extrapolation Area	51,849,954	64	3,303	697	945	493	508	1,254	4,756
Western Extrapolation Area	475,461,923	12,013	164,344	33,867	37,485	14,649	76,217	60,529	278,046
Eastern Extrapolated Area	210,863,789	962	14,736	240	6,078	3,496	43,452	4,698	64,266
Non-Resource areas	1,164,511,392	0	0	0	0	0	0	0	0
Total U.S.	2,379,964,160	46,095	577,937	42,465	76,319	24,745	186,553	113,303	840,810

Note: Onshore resources only. Includes non-Federal lands.

Table 2-9. Federal Land Access Categorization Hierarchy

Level	Access Category	Comments
1	No Leasing (Statutory/Executive Order), (NLS)	Accessibility determined by Law or Executive Order; drilling prohibited
2	No Leasing (Administrative), general category (NLA)	Accessibility determined by Federal surface management agency; drilling prohibited
3	No Leasing (Administrative), Pending Land Use Planning or NEPA Compliance (NLA/LUP)	Status set by Federal surface management agency; drilling prohibited pending planning or NEPA compliance
4	Leasing, No Surface Occupancy (NSO) (Net NSO for O&G Resources)	Not accessible for drilling except for resources within an extended drilling zone
5	Leasing, Cumulative Timing Limitations (TLs) on Drilling >9 Months	Categorized by the cumulative effect of seasonal leasing stipulations during which drilling is prohibited, generally for protection of wildlife
6	Leasing, Cumulative Timing Limitations (TLs) on Drilling >6 - ≤9 Months	
7	Leasing, Cumulative Timing Limitations (TLs) on Drilling >3 - ≤6 Months	
8	Leasing, Controlled Surface Use (CSU)	Drilling permitted, specialized mitigation plan required (this category includes Cumulative Timing Limitations (TLs) on Drilling ≤3 Months, which are minimal)
9	Leasing, Standard Lease Terms (SLTs)	Drilling permitted, mitigation plan required

2. **No Leasing (Administrative) (NLA)** are lands that are withheld from leasing based on discretionary decisions made by the Federal land management agency. The NLA areas can include endangered species habitat and historical sites.
3. **No Leasing (Administrative), Pending Land Use Planning or NEPA Compliance (NLA/LUP)** are lands that have not yet undergone or are currently undergoing land use planning or NEPA analysis, and that are generally not available for leasing. In the cases where there is no land use plan in effect, non-Federal mineral estate underlying Federal land is categorized as NLA/LUP to reflect the fact that access to mineral estate can be allowed through the NEPA process.
4. **Leasing, No Surface Occupancy (NSO) (Net NSO for Oil & Gas Resources)** are lands that can be leased but ground-disturbing oil and natural gas exploration and development activities are prohibited. These stipulations protect identified resources such as special status plant species habitat. Their surface areas are mapped as described by the LUPs. However, at least some of the resources can be accessed by directional drilling from nearby lands where surface occupancy is allowed. This is accounted for by creating an extended drilling zone (EDZ, as described in Appendix 9) that reduces the size of the NSO area. The area removed is then placed in the next most restrictive resource access category (5 through 9, below) that would otherwise apply in the absence of the NSO stipulation. Within the EDZ area the underlying resource is considered accessible even though the surface above it cannot be occupied by drilling equipment. After the EDZ is removed, the NSO area that remains is referred to as “Net NSO” (NNSO) and the resources under it are therefore considered inaccessible.
5. **Leasing, Cumulative Timing Limitations (TLs) on drilling of >9 Months** are lands that can be leased, but stipulations and/or COAs limit the time of the year when oil and gas exploration and drilling can take place to less than 3 months. Timing limitations prohibit surface use during specified time intervals to protect identified resources such as sage grouse habitat or elk calving areas.
6. **Leasing, Cumulative Timing Limitations (TLs) on drilling of >6 to ≤9 Months** are lands that can be leased, but stipulations and/or COAs limit the time of the year when oil and gas exploration and drilling can take place from 3 to 6 months.
7. **Leasing, Cumulative Timing Limitations (TLs) on drilling of >3 to ≤6 Months** are lands that can be leased, but stipulations and/or COAs limit the time of the year when oil and gas exploration and drilling can take place from 6 to 9 months.
8. **Leasing, Controlled Surface Use (CSU)** are lands where stipulations and/or COAs control the surface location of natural gas and oil exploration and development activities by excluding them from portions of the lease. For example, a CSU stipulation could require an operator to develop a specialized mitigation plan based on the presence of moderately steep slopes. This category also includes the minimal

areas that have timing limitations of less than three months.

9. **Leasing, Standard Lease Terms**

(SLTs) areas are lands 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 must comply with many environmental standards and other requirements (see Section 2.1.2, above).

Categorizations were made on the basis of LUPs and discussions with Federal land management agencies. In most cases categorization is relatively straightforward; in other cases judgments were made based upon experience with stipulation datasets. For the FS, FPs standards and guidelines are both included in the definition of “Management Direction” at 36 CFR 219.3 (Forest Planning), and were used synonymously without distinction in evaluating FS stipulations.

All categorizations were made available to field offices for review and comment.

2.3.1.1 Data Integration and Spatial Analysis-Related Caveats

The following precautions are advised when reviewing this study:

- A total of 3,125 stipulations in 128 LUPs were analyzed in the Inventory. Substantial efforts were made to assess stipulations where no GIS data

were available, either by digitizing or obtaining data from other sources. Despite these efforts, not all stipulations have corresponding GIS data. While it is impossible to assess the absolute magnitude of this issue, it is nevertheless believed to be significant. By item count, approximately 49 percent of total stipulations in the Inventory do not have GIS associated with them. To the extent that this issue exists, the Inventory overestimates access to lands and resources. The induced error is likely to be less than 49 percent as many of the missing stipulations are not likely to have large geographic coverage or may be outside a given study area. This issue points to a data gap to be addressed by the surface managing agencies.

- In NSO areas that abut non-Federal lands, no assumption was made about the availability of adjacent non-Federal lands as a base from which to drill under Federal lands. It is estimated that this situation has a minimal effect, affecting less than one half of one percent of the resources in the study areas. Therefore, an EDZ was not applied to NSO lands adjacent to non-Federal lands.

2.3.2 Analytical Modeling of Federal Lands and Resources

See Appendix 9 for a detailed description of the GIS methodology used to categorize the Federal lands and resources for the Inventory.