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Estimates of undiscovered conventional resources of oil and gas for Federal Lands, and for Indian and Native Lands of the Continental United States.

by

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SUMMARY

This report presents the results of the assessment of undiscovered conventional oil and gas resources for Federal lands, and for Indian and Native lands of the continental United States. A primary objective of this work was to provide a measure of the extent to which the Federal government could affect the discovery and development of new resources through its Federal land management and energy policies. In order to more fully understand the Federal position, these Federal land estimates are aggregated with estimates of undiscovered oil and gas resources for the Federal Outer Continental Shelf and Exclusive Economic Zone, reported in USGS-MMS Department of Interior Joint publication "Estimates of undiscovered conventional oil and gas resources in the United States-a part of the Nation's energy endowment" (Mast and others, 1989). Estimates for Indian and Native lands resources were made because of the general interest in the amounts of undiscovered resources that these lands might contain.

In 1987, the U.S. Geological Survey (USGS), in conjunction with the Minerals Management Service (MMS), completed an assessment of the undiscovered conventional resources of crude oil and natural gas of the United States (Mast and others, 1989). The USGS was responsible for assessment of the onshore United States and adjoining State waters, and the MMS for the Federally owned Outer Continental Shelf (OCS).

For the USGS study, the United States was divided into 9 regions, which were further divided into 80 geologic provinces. The province resource estimates that are published (Mast and others, 1989), were based on geologic studies and analysis of oil and gas plays in those provinces. Probability procedures were used in derivation of the estimates and because of the uncertainty in estimating undiscovered resources the quantities are reported as a range of values that correspond to different probabilities of occurrence. As part of the USGS study, estimates of undiscovered oil and gas resources were also made for: 1) onshore Federal lands, and 2) Indian and Native lands areas. All of the estimates are as of January 1, 1987.

The resources assessed were: (1) those considered recoverable under current technology and (2) those that could be developed and produced economically, if found, under specified price and cost relationships. The study focused on the traditional conventional sources of oil and gas which have been the basis of the world-wide petroleum industry. It did not include unconventional resources such as tar deposits, intractable heavy oil deposits, oil shales, gas in low-permeability (less than 0.1 millidarcy in-situ) "tight" reservoirs, coalbed methane, gas in geopressured shales and brines, or natural gas hydrates (clathrates).

Of the total land area of the United States, approximately 32 percent is Federally owned, another 2.4 percent is Indian owned and administered by the Bureau of Indian affairs, while about 1.6 percent is owned by Native corporations in Alaska. About 5 percent of the total oil and gas produced annually in the United States comes from Federally owned onshore mineral leases and about 1 percent from Indian and Native leases.

Estimates of undiscovered recoverable conventional resources for oil beneath Federal lands range from 4.0 to 26.4 billion barrels, with a mean value of 12.1 billion barrels, and for gas range from 25.3 to 132.6 trillion cubic

feet, with a mean of 65.8 trillion cubic feet (table 1). The range estimates correspond to 95 percent probability (19 in 20 chance) and 5 percent probability (1 in 20 chance) of at least those amounts occurring. Corresponding estimates of undiscovered recoverable conventional resources for oil beneath Indian and Native lands range from 0.1 to 3.3 billion barrels, with a mean of 1.0 billion barrels, and for gas range from 0.6 to 18.3 trillion cubic feet, with a mean of 5.6 trillion cubic feet.

Not all of these resources are attainable in an economic sense, particularly those in Alaska, where large field sizes are required for economic development. In the Lower 48 States, where development and operating costs are lower than in Alaska, we estimate that more than 90 percent of the onshore undiscovered recoverable oil and gas under Federal or Indian and Native ownership is economically recoverable. The economically recoverable resources are also given in Table 1.

Table 1. Estimated undiscovered oil and gas resources for the United States [BBO, represents billions barrels of oil; TCFG, trillion cubic feet of gas. Fractile values (F_{95}, F_5) are not additive. Mean value totals may not equal sums of the component means due to independent rounding]

	Recoverable			Economically recoverable		
	F95	Mean	F5	F95	Mean	F5
Onshore Federal						
Oil (BBO)	4.0	12.1	26.4	1.8	8.3	21.6
Gas (TCFG)	25.3	65.8	132.6	14.8	26.2	42.0
Indian & Native						
Oil (BBO)	0.1	1.0	3.3	<0.1	0.7	2.5
Gas (TCFG)	0.6	5.6	18.3	0.6	1.8	4.0
Offshore Federal*						
Oil (BBO)	9.2	16.1	25.6	4.0	8.2	14.3
Gas (TCFG)	97.8	145.1	204.8	44.3	74.0	113.8
Onshore & Offshore Federal						
Oil (BBO)	15.9	28.2	45.1	6.9	16.4	31.6
Gas (TCFG)	141.7	210.9	298.3	67.0	100.2	142.3
Entire United States (regardless of ownership)*						
Oil (BBO)	33.2	49.4	69.9	20.7	34.8	53.8
Gas (TCFG)	306.8	399.1	507.2	208.2	262.7	325.5

*Mast and others (1989).

Estimated undiscovered recoverable oil and gas resources under Federal lands and offshore waters, based on the mean values given in Table 1, include 57 percent of the undiscovered conventional recoverable oil and 53 percent of the undiscovered recoverable gas resources assessed for the entire United States; values for undiscovered economically recoverable resources are 47 percent of the oil and 38 percent of the gas. The reduction in the Federal share of economically recoverable resource as compared to recoverable resources reflects the fact that most of the Federal undiscovered oil and gas resources are in the offshore (OCS) and in onshore Alaska, areas where operating and

development costs are generally high. The amount of this resource which is currently under lease is unknown. Over 85 percent of the estimated undiscovered recoverable Federal resources are located in the OCS and in onshore Alaska. These are the same areas that are estimated to have the potential for very large hydrocarbon accumulations as opposed to the smaller estimated accumulation sizes in the onshore Lower 48 States. Large increases in petroleum production are usually achieved through the development of very large new accumulations of oil or gas, such as occurred with development of Prudhoe Bay Field in Alaska. In many areas of Federal holdings, particularly in parts of the offshore and over much of Alaska, little or no infrastructure currently exists. Therefore, production from undiscovered resources in these areas will require very long lead times to develop, if and when new fields are discovered. A considerable part of the estimated undiscovered recoverable resources beneath government-managed lands and waters in much of the offshore and Alaskan areas can be developed only if the economic climate for oil and gas exploration improves. Based on the above factors, it is concluded that the Federal government can have a strong influence on the Nation's ability to supply domestic oil and gas from Federal land and waters through its short- and long-term land management and energy policies.

INTRODUCTION

In 1985, the U.S. Geological Survey (USGS) and the Minerals Management Service (MMS) agreed to undertake a cooperative study to estimate the undiscovered conventional oil and gas resources of the United States, including the Outer Continental Shelf (OCS) and Exclusive Economic Zone (EEZ). The summary results of that study were initially published by the Department of Interior as a joint USGS-MMS publication, "Estimates of undiscovered conventional resources in the United States - A part of the Nation's Energy endowment (Mast and others, 1989). This joint assessment, which was completed in 1987, reflects data and information available to both Agencies as of January 1, 1987. As part of the base study, the USGS also estimated undiscovered resources for onshore Federal lands, and for Indian and Native lands of the United States. This report provides those estimates, as they were derived in the original work, and summarizes data sources, assumptions, and methodologies used in their development. Methodologies of the base study are described in detail by USGS/MMS (1988) and Mast and others (1989).

The estimates reported here were derived from judgments based upon a variety of geologic data, records of exploration success and failure, production history, and assumptions concerning economic and technologic conditions. Oil and gas plays were the basic building blocks for the assessment. Methodologies developed to assist in making decisions under conditions of uncertainty were employed and the assessment results are presented as ranges of values with associated probabilities of occurrence.

Conventional resources were assessed in two categories: (1) **undiscovered recoverable resources**, which encompass accumulations of sufficient size and quality to be produced with current conventional recovery technologies, without regard to economic viability, and (2) undiscovered **economically recoverable** resources encompassing accumulations which could be economically developed and produced, if discovered, under conditions of current conventional technologies and imposed economic assumptions. The estimates of economically recoverable resources were derived from the estimates of the undiscovered recoverable

resources (Mast and others, 1989). The classes of resources assessed are shown in the heavily framed and hachured areas on the resources classification chart (fig. 1).

In recognition of the uncertainties associated with the estimation of undiscovered accumulations of oil and natural gas, the estimates are presented as a range of possibilities: a low case having a 95 percent probability of that amount or more occurring, a high case having a 5 percent probability of that amount or more occurring, and a mean case representing an arithmetic average of all possible outcomes. Finally, the estimates are reported as fully "risked" estimates, a category which includes the possibility that some areas may be devoid of the kinds of oil or natural gas accumulations assessed.

The assessment addresses only those undiscovered resources in oil and gas reservoirs which are amenable to production by conventional well bore production techniques in use at the time of the assessment. The estimates of resources do not include intractable heavy oil deposits or tar deposits, oil shales, gas from fractured shale reservoirs or low-permeability "tight" gas sandstone reservoirs with in-situ reservoir permeabilities to gas less than 0.1 millidarcy, coalbed methane, gas in geopressured shales and brines, or gas hydrates (clathrates). These kinds of occurrences, which are treated as "unconventional" resources, are recognized as potentially important future sources of hydrocarbons, and some oil and gas is currently produced from them.

In some geologic settings the boundaries between conventional and unconventional resources are gradational or zones of each may be intermixed and, given the data available, difficult to draw. Stratigraphic and geographic boundaries have been used in some of these instances. Unconventional resources are, in many cases, of such uncertain recoverability and economics, however, that they are a class of resources that is best treated separately, particularly with reference to more traditional sources. Many require a level of detail of geologic data and interpretation that is not yet generally available to support engineering and economic studies needed to assess their recoverability. A discussion of resources in several of these categories is presented in USGS-MMS (1988) and Finley and others (1988).

DISTRIBUTION OF FEDERAL, INDIAN AND NATIVE LANDS

The total area of the 50 States of the United States is 2.3 billion acres. At the time of the assessment, Federal civil and defense agencies administered 781 million acres or 34 percent of the total land area of the United States. Of this amount, approximately 727 million acres were Federally owned (BLM, 1987a), and approximately 54 million were lands administered in trust for the Indians (Dunnington, 1985), as is shown in Table 2. Plate 1 (in pocket) shows Federal ownership and trusteeship by administering agency in 1968, however, the map scale (1:7,500,000) does not permit depiction of areas of nongovernment lands smaller than a township contained within the designated boundaries. The Indian lands are enclosed by boundaries established by treaties or proclamations and, in most cases, these boundaries enclose more acreage than is now held in trust (USGS, 1970).

The Indian and Native lands, even where administered in trust by the United States, are not Federal lands and are treated separately in this report. In addition to trust lands, Native Corporations in Alaska possess and

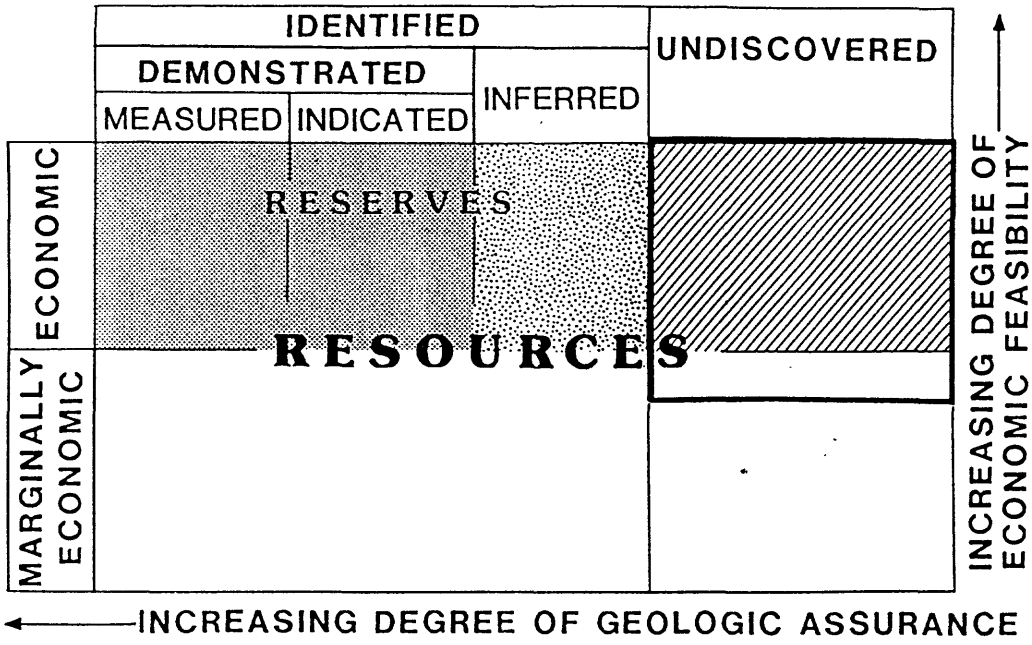

Figure 1. Diagrammatic representation of petroleum resource classification (modified from U.S. Bureau of Mines and U.S. Geological Survey, 1980). The figure represents conventional oil and gas resources. The area within the heavy frame on the upper right represents the undiscovered recoverable resources estimated in this study. The hachured area within the heavy frame indicates the quantities of undiscovered resources that are estimated to be economically recoverable.

independently administer more than 34 million acres of Interim Conveyed and patented Native lands under terms of the Alaska Native Claims Settlement Act (ANCSA) of 1971 (BLM, 1987b). More detailed maps of Federal, Indian and Native lands and mineral ownership are available from State offices of the Bureau of Land Management, generally at scales of 1:500,000 or 1:100,000, and were the primary source of land data used in the assessment.

As of 1987, the Bureau of Land Management (BLM), an agency of the Department of Interior, had responsibilities for 334 million acres, or 46 percent of the Federally owned lands, over half of which is in Alaska. Most of the remainder is in the 11 westernmost conterminous States. These BLM lands are primarily public domain lands which have never left Federal ownership. Additional landholding agencies of the Department of the Interior include the Fish and Wildlife Service, National Park Service, and Bureau of Reclamation. Two other large landholding agencies of the Federal Government are the Department of Agriculture, with over 180 million acres in the National Forest system, and the Department of Defense, with nearly 31 million acres.

Geographic distribution of Federal, Indian and Native lands is very uneven, as is readily shown on the map enclosure and in Table 2. Federal ownership in Alaska is approximately 87 percent of the land area of the State, followed closely by Nevada, with 85 percent, and more distantly by Idaho, Wyoming, and California. Indian and Native lands are mostly located in the States of Alaska, Arizona, New Mexico, Montana and South Dakota, followed more distantly by Utah, Washington, and other western States. They are constituted of both tribal and allotted lands.

Table 2.--Amount of Federal and Indian Lands, by State [From Public Land Statistics-1987 (BLM, 1988); Annual Report of Indian Lands-September 30, 1985 (Dunnington [BIA], 1985). *Does not include over 34 million acres of Interim Conveyed and patented Native Lands (BLM, 1987b)]

State	Total of State (acres)	Federally owned (acres)	(percent)	Indian-owned under BIA jurisdiction* (acres)	(percent)
Alabama	32,678,400	1,131,564	3.5	213	<.1
Alaska	365,481,600	318,356,732	87.1	970,872*	0.3*
Arizona	72,688,000	31,672,884	43.6	20,019,723	27.5
Arkansas	33,599,360	3,399,440	10.1	Neg.	<.1
California	100,206,720	46,322,958	46.2	568,766	0.6
Colorado	66,485,760	24,188,875	36.4	788,375	1.2
Connecticut	3,135,360	13,806	0.4	1,201	<.1
Delaware	1,265,920	30,358	2.4	0	0
D.C.	39,040	10,852	27.8	0	0
Florida	34,721,280	4,279,982	12.3	153,840	0.4
Georgia	37,295,360	2,298,881	6.2	0	0
Hawaii	4,105,600	687,042	16.7	0	0
Idaho	52,933,120	33,759,328	63.8	791,378	1.5
Illinois	35,795,200	499,831	1.4	0	0
Indiana	23,158,400	437,215	1.9	0	0
Iowa	35,860,480	160,308	0.4	4,164	<.1

Table 2.--Amount of Federal and Indian lands by State --continued

Kansas	62,510,720	581,100	1.1	29,678	<.1
Kentucky	25,312,320	1,400,802	5.5	0	0
Louisiana	28,867,840	1,181,474	4.1	437	<.1
Maine	19,847,680	150,303	0.8	212,699	1.1
Maryland	6,319,360	197,124	3.1	0	0
Massachusetts	5,034,880	82,926	1.6	0	0
Michigan	36,492,160	3,529,236	9.7	21,656	<.1
Minnesota	51,205,760	3,459,745	6.8	765,282	1.5
Mississippi	30,222,720	1,678,474	5.6	17,734	<.1
Missouri	44,248,320	2,072,406	4.7	374	<.1
Montana	93,271,040	28,236,115	30.3	5,208,686	5.6
Nebraska	49,031,680	714,186	1.5	64,843	0.1
Nevada	70,264,320	59,814,558	85.1	1,223,780	1.7
New Hampshire	5,768,960	740,420	12.8	0	0
New Jersey	4,813,440	150,974	3.1	0	0
New Mexico	77,766,400	25,870,579	33.3	7,747,940	10.0
New York	30,680,960	1,459,700	4.8	0	0
North Carolina	31,402,880	2,218,702	7.1	56,460	0.2
North Dakota	44,452,480	1,942,214	4.4	851,600	1.9
Ohio	26,222,080	322,486	1.2	0	0
Oklahoma	44,087,680	867,380	2.0	1,105,801	2.5
Oregon	61,598,720	30,031,220	48.8	768,666	1.2
Pennsylvania	28,804,480	638,790	2.2	0	0
Rhode Island	677,120	4,795	0.7	0	0
South Carolina	19,374,080	1,169,109	6.0	0	0
South Dakota	48,881,920	2,733,177	5.6	5,080,817	10.4
Tennessee	26,727,680	1,988,154	7.4	0	0
Texas	168,217,600	3,335,478	2.0	0	0
Utah	52,696,960	33,568,979	63.7	2,319,917	4.4
Vermont	5,936,640	321,942	5.4	0	0
Virginia	25,496,320	2,455,076	9.6	0	0
Washington	42,693,760	12,459,162	29.2	2,553,722	6.0
West Virginia	15,410,560	1,165,040	7.6	0	0
Wisconsin	35,011,200	1,889,677	5.4	417,911	1.2
Wyoming	62,343,040	31,431,416	50.4	1,887,261	3.0
Total	2,271,343,360	727,112,975	32.0	53,633,797	2.4

COMMODITIES ASSESSED

The commodities assessed are undiscovered crude oil, natural gas, and natural gas liquids (NGL) in conventional reservoirs. Crude oil is a mixture of hydrocarbons, which is present in a liquid state in underground reservoirs and remains in a liquid state when produced from wells. Natural gas is a mixture of gaseous hydrocarbons classified by occurrence into the following categories:

Associated gas -- free natural gas, occurring as a gas cap in contact with an oil accumulation within a reservoir;

Dissolved gas -- natural gas dissolved in crude oil within a reservoir;

and

Non-associated gas -- natural gas that is not dissolved in, or associated with, crude oil within a reservoir.

Natural gas liquids (NGL) are "those portions of reservoir gas which are liquefied at the surface in lease separators, field facilities, or gas processing plants. Natural gas liquids include but are not limited to ethane, propane, butanes, pentanes, natural gasoline, and condensate" (American Petroleum Institute, 1976, p. 6).

Both crude oil and natural gas normally include small quantities of various nonhydrocarbon impurities. Where significant, these impuritites are excluded from the volumes reported.

Amounts of oil and NGL are reported in standard stock tank barrels (42 gallons per barrel); and gas is reported in standard cubic feet (14.73 pounds per square inch and 60 degrees F).

AREA OF STUDY

For purposes of this study, the land area of the United States was divided into 9 regions (fig. 2). These regions were further divided into 80 petroleum provinces, which encompass adjoining State waters. Hawaii, Puerto Rico, and the Trust Territory of the Pacific were not assessed.

The Regions shown in figure 2 are geographic in character, however, their formulation represents an attempt to group the individual petroleum provinces along broad geologic lines (provinces are shown in detail in Appendix A, figs. A1 and A2). The individual provinces are based on natural geologic entities and may include a single dominant structural element or a number of contiguous elements. Their boundaries follow State and county lines where possible to facilitate the use of production, reserve, and other data which are reported for such political units. Provinces are named for structural or physiographic features within their boundaries.

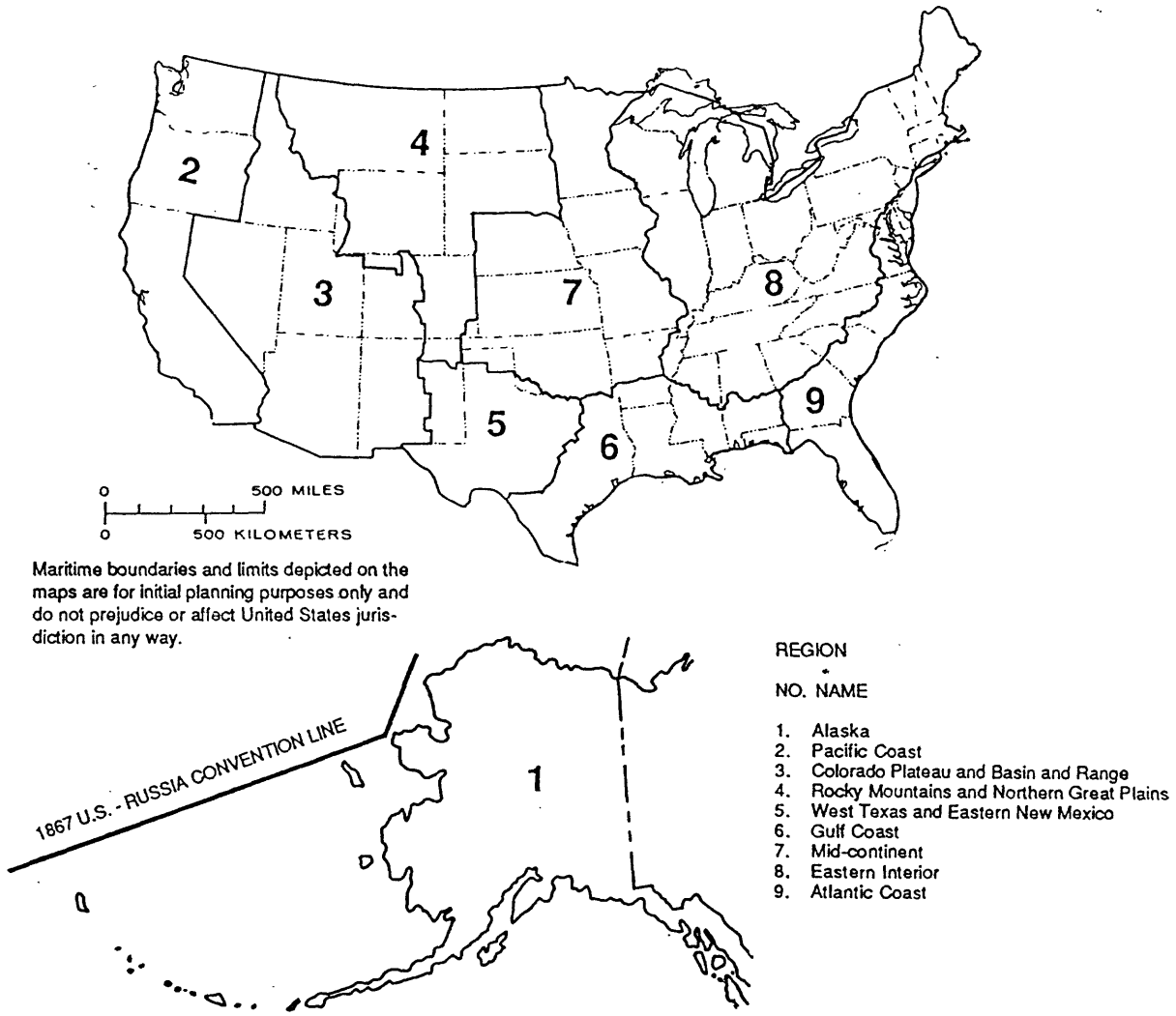

Figure 2. Index map showing petroleum Regions assessed in this study. Heavy lines are region boundaries, dotted lines are State boundaries.

DATA SOURCES

Development of estimates for the undiscovered oil and natural gas resources for the United States required the compilation and analysis of a large quantity of geologic, geophysical, geochemical, engineering and economic data. Geologic data included information from previous assessments, data from State geological surveys, published literature, USGS studies in progress, and all available pertinent data and interpretations dealing with geologic, geochemical, and geophysical issues. Analog data were drawn from similar provinces, both domestic and foreign. Data also were obtained from petroleum plays in the offshore, through consultation and coordination with MMS resource assessment personnel. Reports of the geologic framework for each province, including description of the petroleum geology of the basins or uplifts and the geology of the oil and gas plays, have been released in open file.

Computerized drilling and completion data from more than 1.8 million oil and gas exploratory and development wells came from the Well History Control System (Petroleum Information Corporation, 1986). These data were incorporated into exploration and development maps that show exploratory wells and the areal size and distribution of known oil and gas accumulations in each play. In addition, annual and cumulative drilling statistics were developed from this data base.

Computerized oil and gas field data were available from both the Petroleum Data System (Petroleum Information Corporation, 1986) and the Significant Oil and Gas Fields of the United States file (NRG Associates Inc., 1986). Data for fields greater than 1 million barrels of oil (1 MMBO) or 6 billion cubic feet of gas (6 BCFG) ultimate recovery (reserves plus cumulative production), were taken from the Significant Oil and Gas Fields file and used in the play assessment. Published sources of production and reserve data, particularly State statistical data, were used to supplement and verify data in the Significant Oil and Gas Fields file. Data for fields smaller than 1 MMBO and 6 BCFG were developed from the National Production System file (Petroleum Information Corporation, 1987).

Information regarding onshore and State waters production and reserves of oil and natural gas used in the base study of undiscovered resources of the United States was derived from data published by the Energy Information Administration (EIA, 1987) and from State statistical summaries. Reserve data are not available separately for onshore Federal mineral leases or for Indian and Native lands. However, production data from Federal and Indian leases are available on a statewide basis from US Minerals Management Service (MMS, 1987) and are here given by region in Tables 3 and 5.

Land ownership (land status) and mineral ownership maps produced by BLM and State agencies were used to determine distribution of 1) Federal land and mineral ownership and 2) Indian and Native lands for the petroleum provinces and plays in the large western public land states. These maps were generally at scales of 1:500,000 and 1:100,000. In Alaska, a preliminary map of Native and Federal lands produced from the BLM Alaska Automated Land and Mineral Record System (AALMRS) by the Earth Resources Observation System (EROS) Data Center at scales of 1:2,500,000 and 1:4,000,000 was employed. Elsewhere, Federal Land ownership maps were specially compiled by the USGS and in some states, USGS 1:100,000 scale 30 x 60 minute quadrangle base maps and State topographic maps, at a scale of 1:500,000, and land status maps published by American Petroleum

Institute were also accessed. Principal map sources used are shown in Appendix C.

For assessment of Federal lands, we utilized maps of Federal ownership of lands and minerals as the basic data source. In general, where mineral ownership maps were lacking, any lands owned by the Federal Government were included in the assessment under the assumption that if the Government owned the land, it also owned the mineral rights. Study of available land ownership and mineral ownership maps shows that for the vast majority of the lands owned by the Government, the Government also holds the mineral rights. In some areas the Government owns mineral rights where it does not own surface rights to the land. In these instances, the Government often holds the rights to specific minerals (e.g. the large coal mineral rights held by the Government in the Powder River and Williston basins of the Rocky Mountains). Areas where these mineral rights included oil and gas were included in the assessment. Areas where the Government has mineral ownership other than oil and gas, and does not own the land, were excluded from the assessment under the assumption that the Government is not a participant in oil and gas development. In some regions, maps of Federal land and mineral ownership are either incomplete or nonexistent, particularly outside of the western States. This is especially true for mineral ownership. In poor data areas, we developed from existing maps the best Federal land maps we could for use in the assessment. It is our opinion, that although the Federal land and mineral rights data are incomplete, the available data were adequate for the purpose of allocating play resources to these lands. Although it would be desirable to have better data concerning these lands, we do not believe that it would significantly alter the overall results. Much of the missing data is probably for small tracts and, in comparison to the known Federal land and mineral ownership, is probably only a small part of the total. One other aspect of maps of Federal lands needs to be mentioned. Many maps show proclamation boundaries. This is the case for many National Forests. Often, the Government owns only a fraction of the lands and minerals inside these boundaries, particularly those Forests in the midwest and eastern U.S. Generally, intermediate-scale maps (e.g., 1:100,000 land status and mineral ownership maps) are available for these areas which show the amount of Government ownership. Where available, these intermediate-scale maps were used to estimate Government ownership in the assesssment process. Land and minerals inside of the proclamation boundaries may be acquired by the Federal Government on a continuing basis, so that land maps for these areas can become out of date. Maps used in the assessment are of recent vintage, and it is our opinion that this is not a serious problem and should not significantly affect the overall results.

Map information showing Indian lands is probably somewhat more generalized than for Federal land. In the case of Indian lands, we usually employed the reservation boundaries shown on the above maps. Also available to us were unpublished USGS mineral assessment reports for some of the Indian lands which contained land maps showing Indian ownership. In Alaska, the previously cited map of Native and Federal lands produced by the BLM's Alaska Automated Land and Minerals Record System (AALMRS) was employed. Although the overall data quality of the maps employed is probably less reliable than for Federal lands, and the depicted areas subject to inclusion of some unowned lands, we believe the maps were adequate for our objectives to estimate the magnitude of oil and gas resources on Indian and Native lands. One possible exception to this is in Alaska, where large changes in land ownship are occurring each year (BLM, 1987b;

BLM, 1990). Here, Native and State lands are increasing as selections are made and Federal lands conveyed to Native and State ownership. As this occurs, some of the estimated undiscovered Federal resources may be converted to Native and State ownership.

METHODS OF ASSESSMENT

Assessment of undiscovered resources for the Federal lands and Indian and Native lands of the United States was based upon an overall assessment of resources within the singular plays contained within each province and upon the assessment of resources in small accumulations (<1MMBO or 6BCFG) in each province. The assessments were based upon review and analysis of each province's petroleum geology and exploration history, incorporating new geologic and geophysical information and several major computer data bases. In this assessment, 250 plays covering the onshore areas were identified, and for each play, undiscovered oil and gas resources were estimated. The reader is referred to Mast and others (1989) and USGS/MMS (1988) for a discussion of this basic assessment, its assumptions, methods, and results.

In the play analysis method, geologic settings of oil and gas occurrence are modeled. The play is treated as a collection of accumulations conceived as having similar geologic risks and sharing common geologic characteristics such as particular reservoir rocks, source rocks, and known or suspected trapping conditions. Geologists make judgments as to the probability of occurrence of the geologic factors necessary for the formation of oil or gas accumulations and quantitatively assess sizes and numbers of accumulations as probability distributions. A computer program performed the resource calculations on the basis of the assessed information, employing an analytical method based on probability theory (Crovelli and Balay, 1986; Crovelli, 1986, 1987).

Probabilistic estimates of recoverable oil and gas in accumulations smaller than the cutoffs (1MMBO, 6BCFG) were made separately. These estimates were based primarily on log-geometric extrapolations of numbers of fields into field size classes smaller than the play analysis cut-offs. Estimates of undiscovered resources for these small fields were made for the province as a whole, rather than by play.

Ratios of associated-dissolved gas to oil and NGL to gas were estimated from historical production data and used for calculation of these components.

Estimates of resources beneath Federal and Indian and Native lands derive from the above basic estimates for the plays and provinces. For each play, estimates were made of the percentage of undiscovered oil and gas resources of the play within areas of 1) Federal land ownership, and 2) Indian and Native land ownership. These estimates were based on the geographic distribution of Federal or Indian and Native lands relative to the geology of the play and to the distribution and intensity of exploration activity and its results. The percentage allocation of undiscovered small field resources in each province was calculated from the contribution of the involved plays. Recoverable and economically recoverable resources of the plays and small fields were then allocated to Federal, Indian and Native lands on the percentage bases estimated. Where Federal or Indian and Native ownership of undiscovered oil or gas resources was estimated to be less than 1 percent, it was considered to be negligible, since our land data and geologic data were not adequate to produce definitive estimates for such small holdings.

Estimates of resources are presented as a range of values corresponding to probabilities of occurrence in order to express the inherent uncertainty involved in assessment of unknowns. Cumulative probability distributions represent the full estimated range of the quantity of undiscovered resources. From these distributions, the low (F_{95}), the high (F_5), and the mean estimates are obtained. To arrive at the estimated quantity of undiscovered resources for larger areas, such as provinces, regions or the Nation, distributions for the basic assessment units were progressively aggregated, incorporating dependency at each level. The reader is referred to Mast and others (1989) for a more complete discussion of methodology employed.

FEDERAL LAND RESOURCES

The undiscovered recoverable conventional oil and gas resources of onshore Federal lands in the United States are estimated to range from 4.0 to 26.4 BBO and from 25.3 to 132.6 TFC of gas, corresponding to the 95 percent and 5 percent probability levels, respectively. Figures 3 and 4 show the estimated cumulative probability distributions for the total undiscovered recoverable resources of crude oil and natural gas on Federal lands, with accompanying curves for economically recoverable resources. Estimates for undiscovered recoverable natural gas liquids (NGL) are 0.5 to 2.4 BB. The economically recoverable portion of these resources is estimated to range from 1.8 to 21.6 BBO for oil and from 14.8 to 42.0 TCF for gas, with economic NGL resources estimated to range from 0.2 to 1.0 BB.

The regional distribution of estimated undiscovered recoverable conventional petroleum resources on Federal lands is shown in Table 3 and by figures 5 and 6. For reference, cumulative production (MMS, 1987) is also shown. The individual province estimates are given in Tables A.1 and A.2. The importance of Alaska and the western regions with large amounts of Federal land is apparent and contrasts with the very small Federal land contribution of the Gulf Coast, the Mid-continent, and Eastern Interior. Except for Alaska, all of these regions are in a relatively mature stage of exploration for conventional hydrocarbons, typified by the large proportion of produced volumes compared to the undiscovered volumes. As shown by table 3 and figure 7, approximately 70 percent of the estimated undiscovered recoverable oil resources of the Federal onshore and 60 percent of the recoverable natural gas resources are in Alaska.

The onshore potential for very large oil and gas accumulations is mainly in Alaska, an area where long lead times are required for development and delivery of commodities to market and an area where economic constraints are serious. Consequently, about half of the estimated undiscovered recoverable resources of oil in Alaska and little of the gas is currently considered economically recoverable (Table 3), the latter largely due to the lack of a delivery system. Large numbers of relatively small oil and gas accumulations typify the lower 48 States, where development times are relatively short and commodities are readily accessible to markets, and most of the assessed undiscovered recoverable resource is considered to be economically recoverable.

The estimated percentage of undiscovered recoverable petroleum of the United States beneath Federal lands (Table 4) is similar to that estimated in 1980 (Dolton and others, 1981). The general correspondence of the percentages of undiscovered recoverable resources on Federal lands between the two studies,

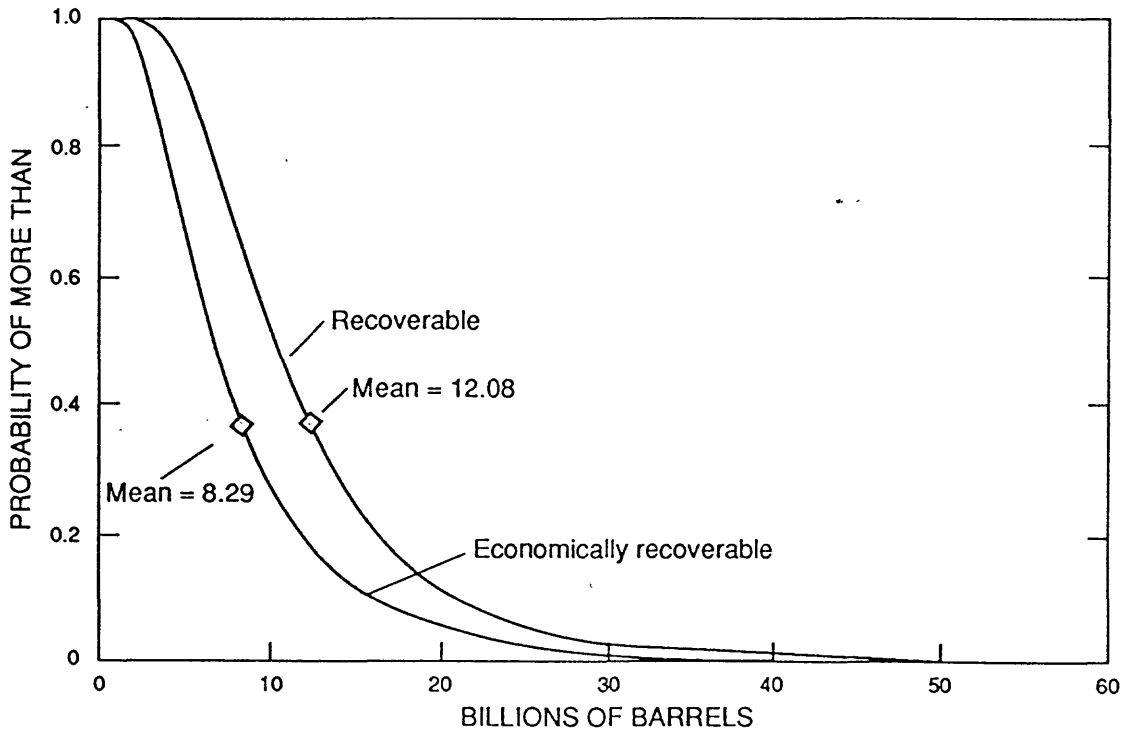

Figure 3. Onshore Federal Lands--Cumulative probability distributions for undiscovered recoverable and economically recoverable conventional crude oil resources of the Federal lands of the United States.

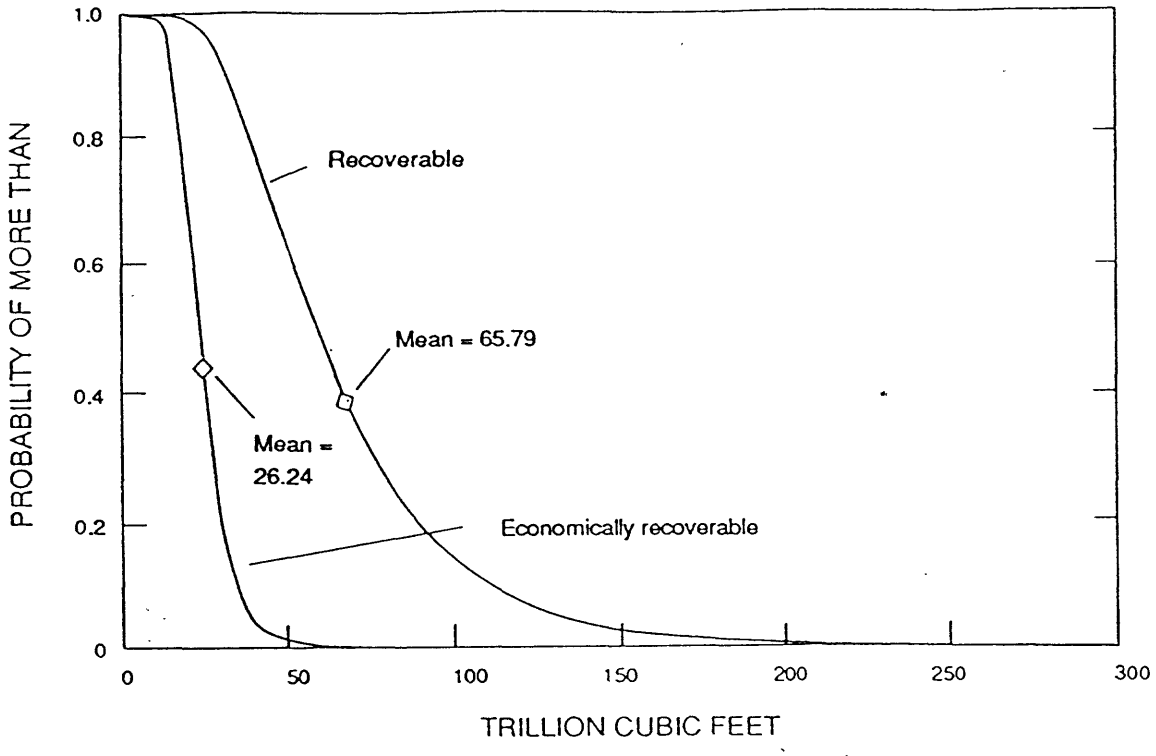

Figure 4. Onshore Federal Lands--Cumulative probability distributions for undiscovered recoverable and economically recoverable conventional natural gas resources of the Federal lands of the United States.

Table 3.—Onshore Federal Lands—Estimates of undiscovered conventional oil and natural gas resources and cumulative production by region [Oil in BB; gas in TCF; NGL, natural gas liquids in BB; NR indicates not reported. Fractile values are not additive; mean value totals may not equal totals due to independent rounding]

Region	Cumulative Production 1920–86	Undiscovered recoverable resources F_{95}	Mean	F_5	Undiscovered economically recoverable resources F_{95}	Mean	F_5
1 Alaska							
Oil	.21	1.79	8.44	22.19	.47	4.92	16.21
Gas	1.29	8.37	38.87	101.71	<.01	.12	.47
2 Pacific Coast							
Oil	1.39	.09	.44	1.20	.09	.44	1.10
Gas	1.61	.24	1.06	2.75	.24	1.04	2.49
3 Colorado Plateau & Basin & Range							
Oil	.85	.23	.91	2.23	.20	.86	2.16
Gas	10.06	5.46	13.38	26.16	5.35	13.21	25.95
4 Rocky Mountains & Northern Great Plains							
Oil	3.58	1.04	2.01	3.42	.88	1.81	3.19
Gas	6.30	3.21	8.81	18.32	2.85	8.35	17.92
5 West Texas & Eastern New Mexico							
Oil	1.04	.01	.03	.09	.01	.03	.09
Gas	8.89	.21	.90	2.27	.20	.87	2.22
6 Gulf Coast							
Oil	.22	.01	.06	.17	.01	.06	.13
Gas	1.67	.29	1.44	3.85	.29	1.42	2.41
7 Mid-continent							
Oil	.04	.01	.03	.07	.01	.03	.07
Gas	.83	.13	.41	.92	.11	.38	.89
8 Eastern Interior							
Oil	.01	.03	.05	.07	.03	.05	.07
Gas	.06	.20	.90	2.33	.20	.85	2.15
9 Atlantic Coast							
Oil	<.01	.02	.11	.29	.02	.11	.25
Gas	.00	<.01	.01	.02	<.01	.01	.02
Total Onshore Federal Lands							
Oil	7.33	3.96	12.08	26.42	1.79	8.29	21.63
Gas	30.72	25.33	65.79	132.65	14.82	26.24	42.03
NGL	NR	.49	1.21	2.38	.24	.55	1.03
Lower 48 Onshore Federal Lands							
Oil	7.12	2.12	3.64	5.71	1.79	3.37	5.38
Gas	29.42	15.33	26.92	42.86	14.72	26.12	41.90
NGL	NR	.24	.56	1.07	.24	.55	1.03

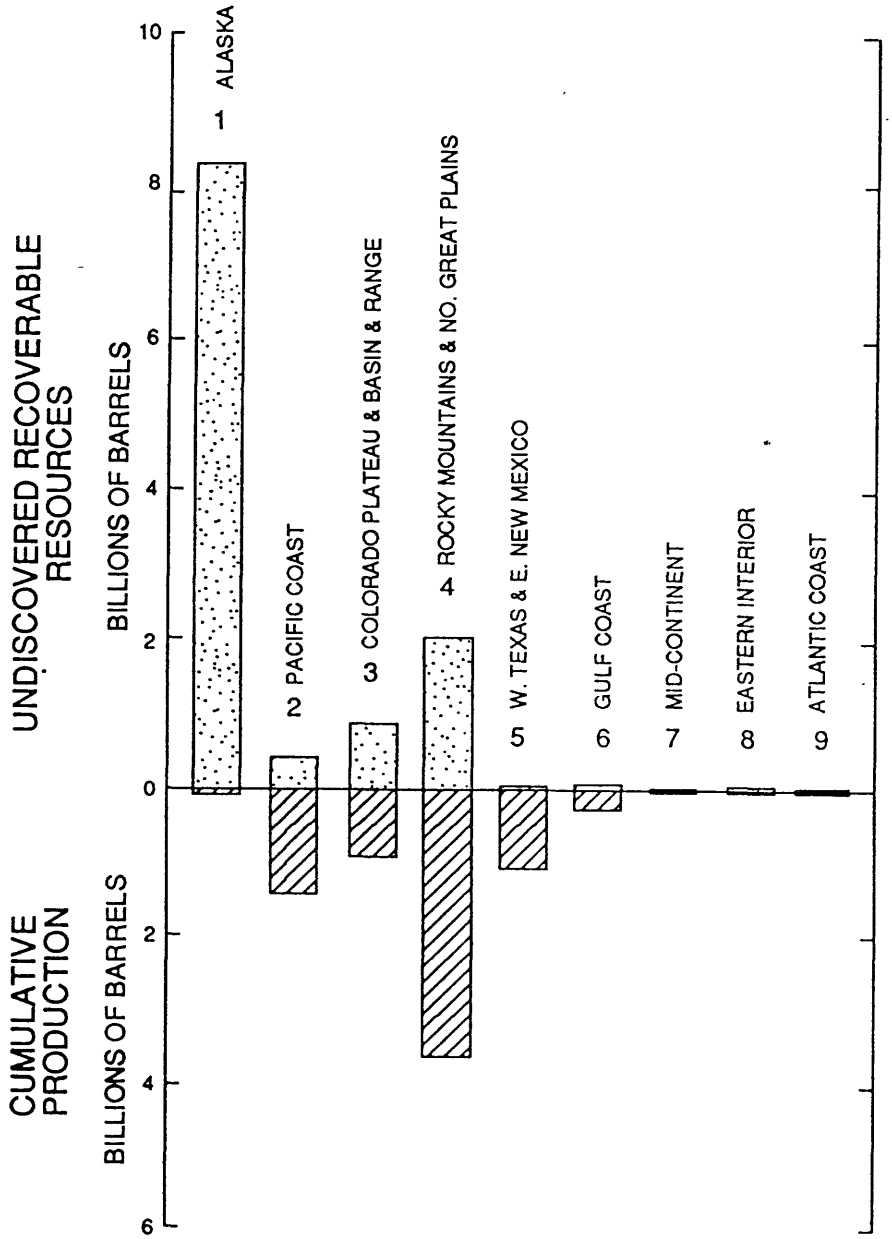

Figure 5. Onshore Federal Lands--Bar graph comparing regional mean estimates of undiscovered recoverable oil resources (stippled bars) and cumulative production (lined bars) for the Federal lands of the United States.

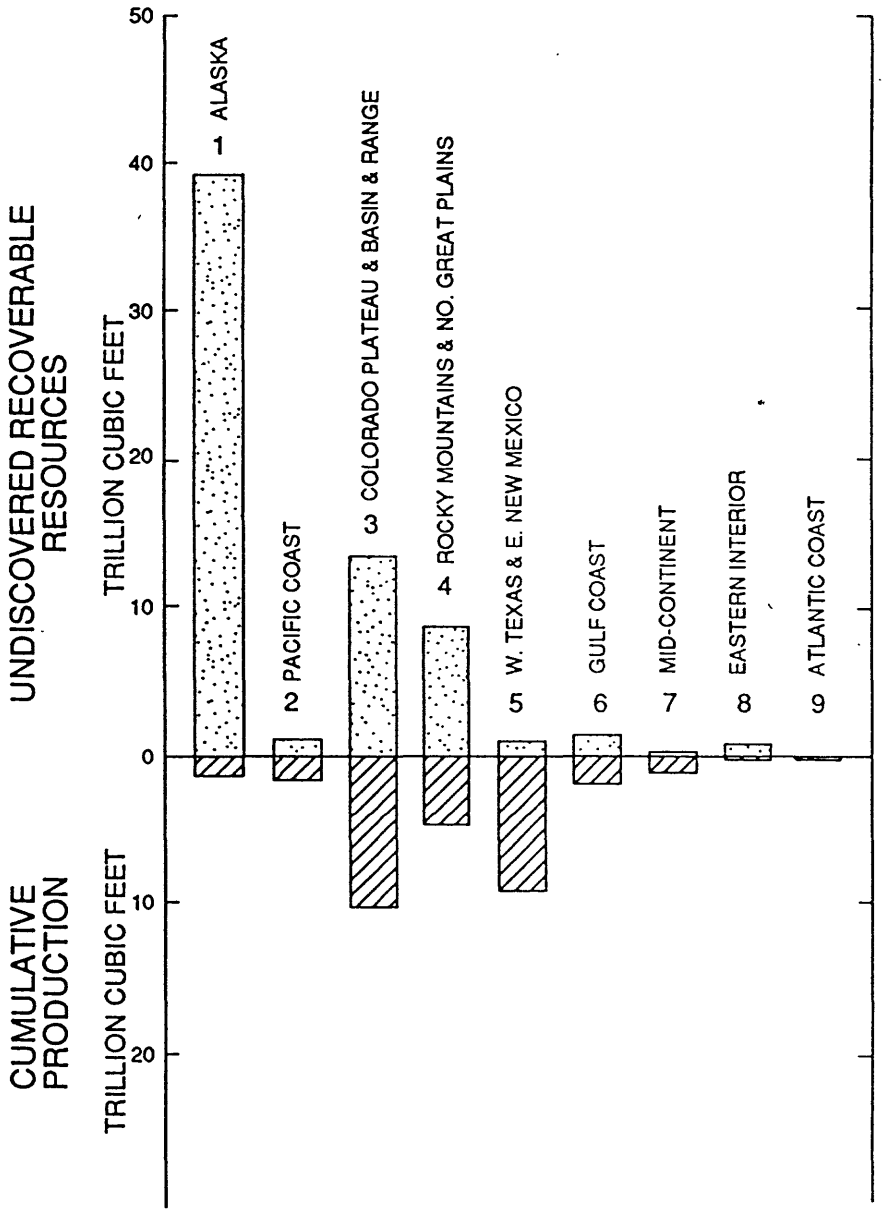

Figure 6. Onshore Federal Lands--Bar graph comparing regional mean estimates of undiscovered recoverable natural gas resources (stippled bars) and cumulative production (lined bars) for Federal lands of the United States.

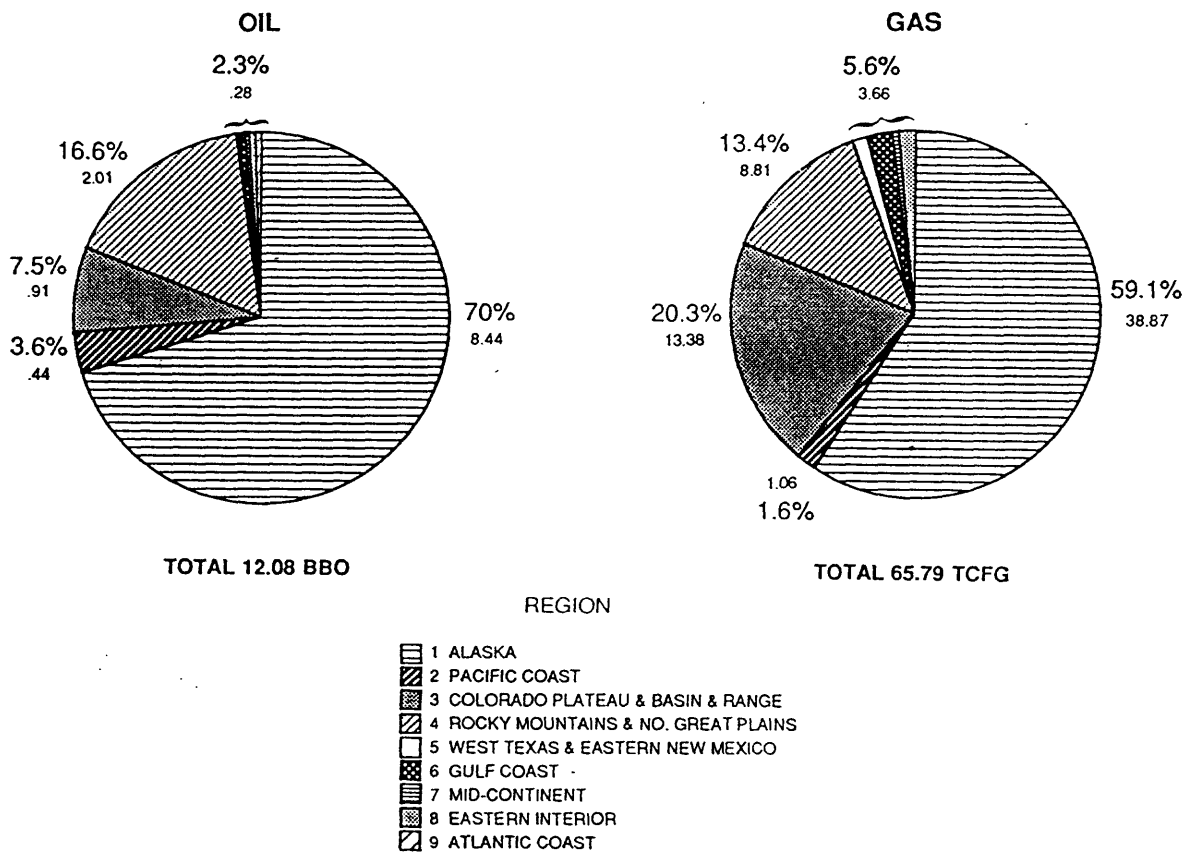

Figure 7. Onshore Federal Lands--Pie diagrams showing distribution of undiscovered recoverable conventional crude oil and natural gas resources for Federal lands based on mean estimates by region. Resource values in billions of barrels and trillions of cubic feet, respectively. Sums may not equal totals shown due to independent rounding.

except for two regions, probably reflects the fact that, for the most part, the available maps of Federal land and mineral ownership were essentially the same and the geologic perception of resource distribution relative to these lands had not fundamentally changed. It is worth noting, however, that in our study the percentages of undiscovered resources on Federal land were estimated for plays and for the small fields in each province, then aggregated; in the 1980 study, percentage of resources on Federal lands were estimated directly at the province level (Varnes and Dolton, 1982). In each study, the regional percentage estimates were calculated from the aggregated resource results. Differences in underlying province evaluations between the two studies leads in some cases to notable differences in regional estimates. For example, the gas percentage estimates for the Pacific Coast region are strikingly different, reflecting lower estimates of gas resources in this study in Washington and Oregon, where Federal land holdings are large. The difference in the percentage estimates for the Atlantic Coast result because most of the estimated resources in this study are located in an area of South Florida, where Federal ownership is proportionally large.

Table 4.--Comparison of 1981 and current estimates of the percentage of undiscovered recoverable oil and gas resources under Federal lands for each onshore Region [*This study combines the previous Michigan, Eastern Interior, and Appalachian regions into the present Eastern Interior Region. NR, indicates not reported]

Region	Dolton and others, 1981		This study	
	Oil	Gas	Oil	Gas
Alaska	NR		64%	67%
Pacific Coast	10%	25%	13%	10%
Colorado Plateau and Basin and Range	70%	70%	60%	63%
Rocky Mountains and northern Great Plains	50%	55%	45%	58%
West Texas and eastern New Mexico	5%	5%	2%	4%
Gulf Coast	Neg.	Neg.	1%	2%
Mid-Continent	Neg.	Neg.	2%	1%
[Michigan Basin]*	[5%	5%]		
Eastern Interior [Eastern Interior]*	[Neg.	Neg.] }	3%	5%
[Appalachians]*	[5%	5%]		
Atlantic Coast	10%	5%	51%	55%

Nevertheless, estimates of the resources thereby calculated for the Federal lands have decreased from the 1981 study as a consequence of a decrease in the underlying assessment of province resources for the United States reported by Mast and others (1989). Much of this decline is due to re-evaluations reflecting new geological data from exploration drilling in several regions expected to have major petroleum potential, and as noted by Mast and others, most regions simply did not meet expectations of resource occurrence that were postulated earlier. The massive exploration effort of industry of the late 1970's and early 1980's did not confirm some of the geological expectations for new large accumulations included in earlier estimates, and almost every play having sufficient data showed a continuing decline in sizes of fields discovered, as would be expected in mature plays (Mast and others, 1989). The interim discovery of oil and gas also has caused a shift of some estimated resources from the undiscovered to the identified (discovered) or produced category, and some changes also resulted from

different assumptions and data. This study had more specific and detailed data requirements, including a more direct use of exploratory drilling data, and field-size data from discovered fields, which data were not generally available for earlier USGS studies. The assessment of Dolton and others (1981) also considered continued development and application of new technology, although not specifying future recovery efficiencies, while the current study used current recovery efficiency.

Unconventional resources of gas are also believed to be large in some areas in comparison to undiscovered conventional resources (USGS/MMS, 1988) and fall within several large Federal land areas of the Rocky Mountains, including the Uinta-Piceance, Green River, and San Juan basins. Such resources include gas in tight sandstone and fracture shale reservoirs and coal beds. Estimates of resources in some of these settings have been reported Johnson and others (1987); Law and others (1989); the National Petroleum Council (1980); Potential Gas Committee (1983, 1989); Finley and others (1988); and USGS/MMS (1988). Some gas is now produced from these sources. Improved economic incentives and new technologies could accelerate their development and influence long term energy supply estimates.

INDIAN AND NATIVE LAND RESOURCES

Estimated undiscovered conventional oil and gas resources on Indian and Native lands are shown in figures 8 and 9. Estimates, by region, are shown in table 5 and in figures 10, 11 and 12. These lands, as may be noted on Plate I, reside mostly in the western United States and Alaska, as do Federal lands, and reflect the overall resource values of those areas. Approximately 65 percent of the undiscovered recoverable oil and gas resources on Indian or Native lands are in Alaska, largely on the North Slope; of this, about two thirds of the oil and none of the gas is economically recoverable. On the other hand, over 90 percent of the undiscovered recoverable oil and gas resources on Indian lands in the lower 48 States is estimated to be economically recoverable (table 5). The individual province estimates of undiscovered resources are given in Tables A.3 and A.4.

As in the case of Federal lands, unconventional resources may be locally important on Indian and Native lands, particularly in tight gas sandstones and coalbeds, as in the San Juan and Uinta basins of the Rocky Mountains.

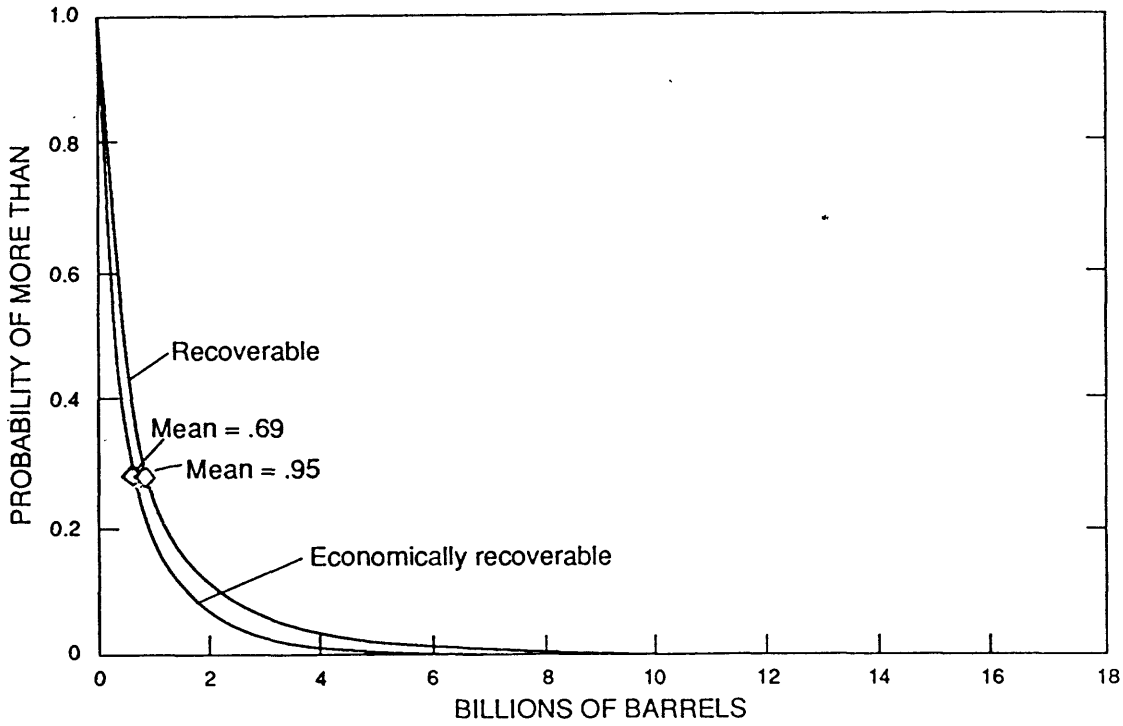

Figure 8. Indian and Native Lands--Cumulative probability distributions for undiscovered recoverable and economically recoverable conventional crude oil resources of the Indian and Native lands of the United States.

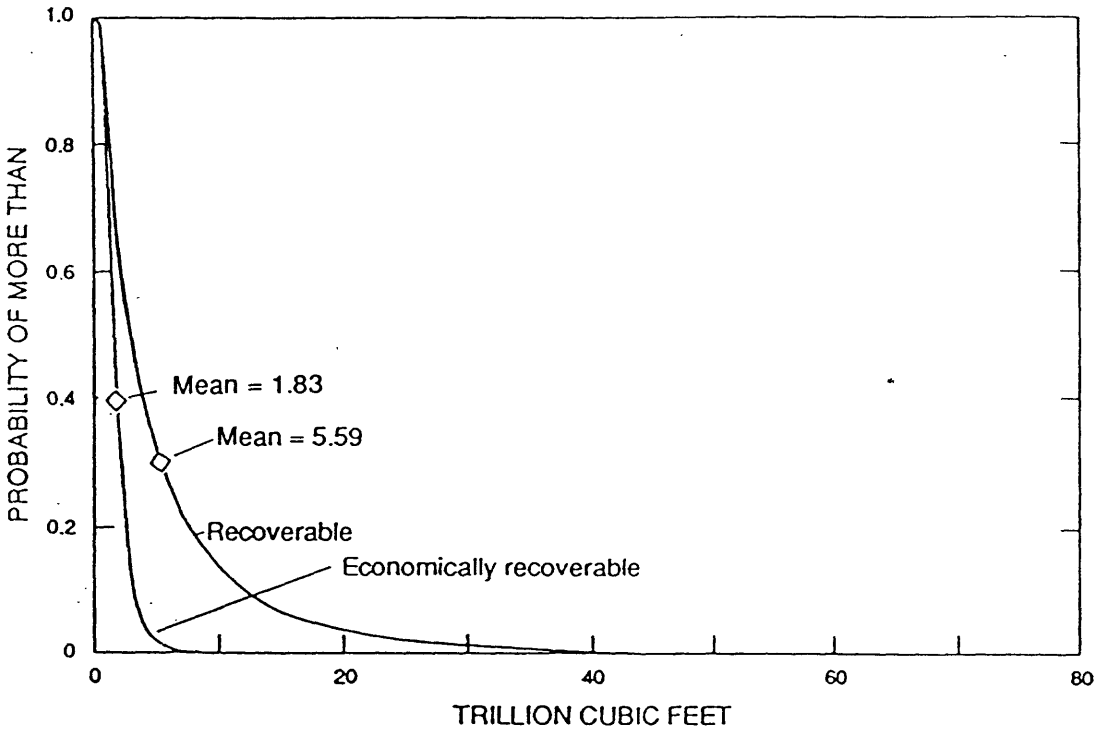

Figure 9. Indian and Native Lands--Cumulative probability distributions for undiscovered recoverable and economically recoverable conventional natural gas resources of the Indian and Native lands of the United States.

Table 5.—Indian and Native Lands—Estimates of undiscovered conventional oil and natural gas resources and cumulative production by region [Oil in BB; gas in TCF; NGL, natural gas liquids in BB; NR, indicates not reported; Negl., indicates negligible. Fractile values are not additive; mean value totals may not equal totals due to independent rounding]

Region		Cumulative Production 1920–86	Undiscovered recoverable resources F_{95}	Mean	F_5	Undiscovered economically recoverable resources F_{95}	Mean	F_5
1	Alaska							
	Oil	.00	.02	.62	2.37	.00	.40	1.57
	Gas	<.01	.18	3.70	13.56	.00	.00	.00
2	Pacific Coast							
	Oil	.00	.00	.00	.00	.00	.00	.00
	Gas	<.01	.01	.12	.40	.01	.11	.39
3	Colorado Plateau & Basin & Range							
	Oil	0.53	.04	.18	.47	.03	.17	.47
	Gas	2.45	.34	.79	1.50	.33	.77	1.48
4	Rocky Mountains & Northern Great Plains							
	Oil	0.34	.07	.15	.26	.04	.12*	.24
	Gas	0.35	.15	.96	2.78	.13	.92	2.76
5	West Texas & Eastern New Mexico							
	Oil	.00	<.01	<.01	<.01	<.01	<.01	<.01
	Gas	.00	<.01	<.01	<.01	<.01	<.01	<.01
6	Gulf Coast							
	Oil	.00	.00	.00	.00	.00	.00	.00
	Gas	.00	.00	.00	.00	.00	.00	.00
7	Mid-continent							
	Oil	.36*	<.01	.01	.01	<.01	.01	.01
	Gas	.28*	<.01	.01	.02	<.01	.01	.02
8	Eastern Interior							
	Oil	0.04	.00	.00	.00	.00	.00	.00
	Gas	<.01	<.01	.02	.07	<.01	.02	.07
9	Atlantic Coast							
	Oil	<.01	<.01	<.01	<.01	<.01	<.01	<.01
	Gas	.00	<.01	<.01	<.01	<.01	<.01	<.01
Total Indian & Native Lands								
	Oil	1.23	.07	.95	3.32	.03	.69	2.53
	Gas	3.69	.55	5.59	18.26	.55	1.83	4.02
	NGL	NR	.01	.07	.25	<.01	.02	.06
Lower 48 Indian & Native Lands								
	Oil	1.23	.07	.33	.66	.03	.30	.63
	Gas	3.68	.55	1.89	4.03	.55	1.83	4.02
	NGL	NR	<.01	.02	.06	<.01	.02	.06

* Production figures do not include Osage Indian Lands

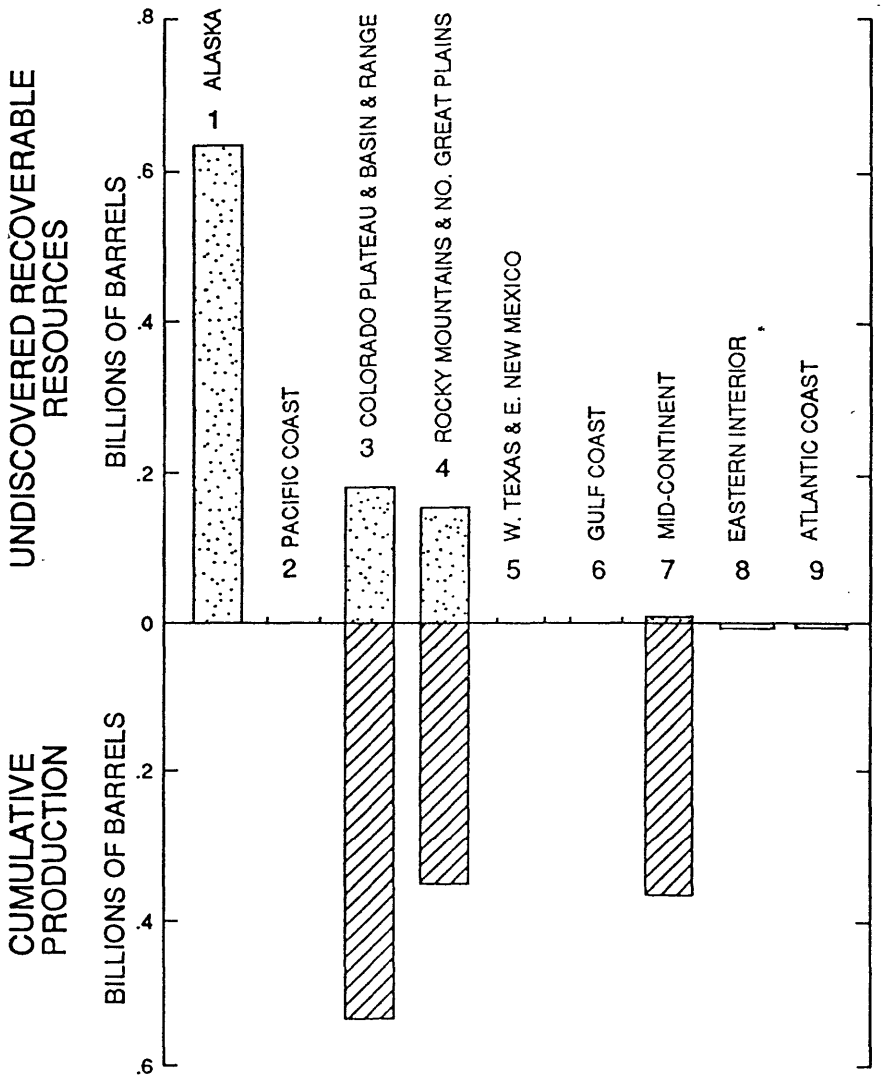

Figure 10. Indian and Native Lands--Bar graph comparing regional mean estimates of undiscovered recoverable oil resources (stippled bars) and cumulative production (lined bars) for Indian and Native lands of the United States.

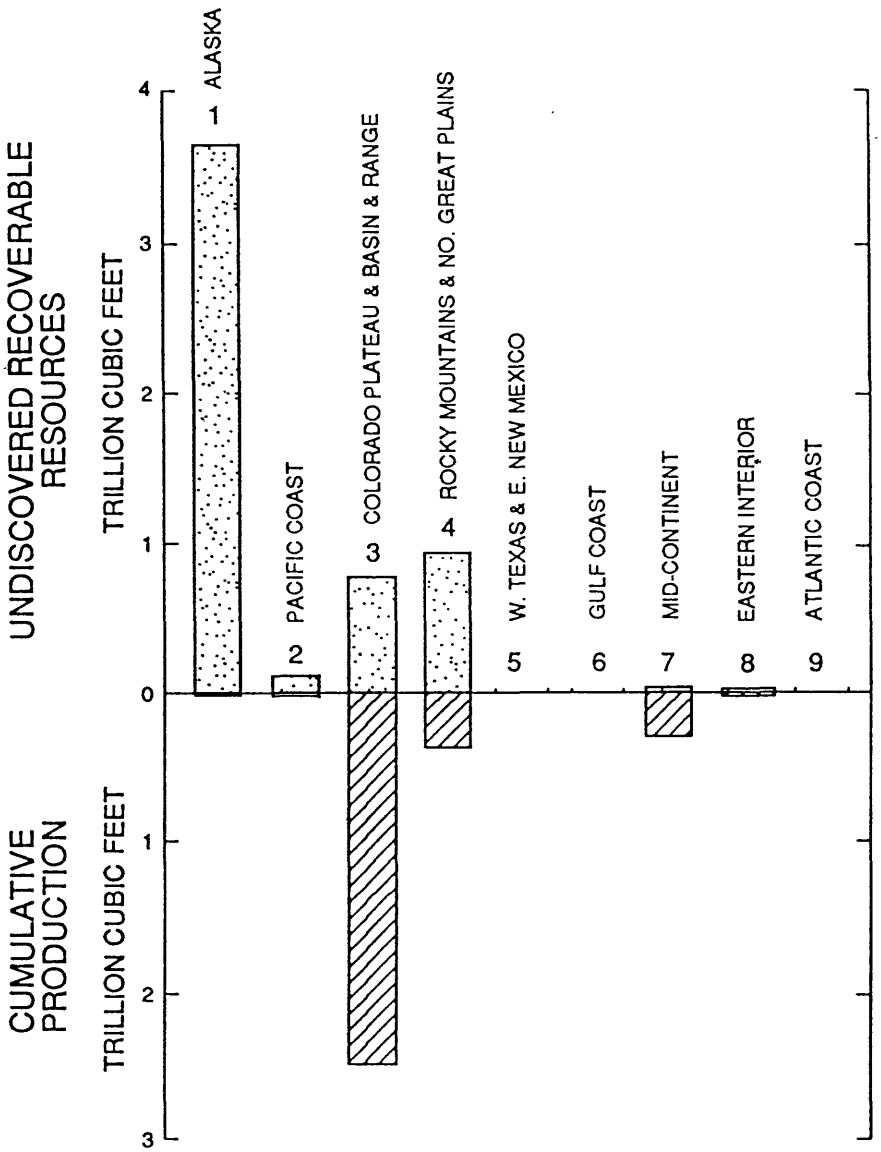

Figure 11. Indian and Native Lands--Bar graph comparing regional mean estimates of undiscovered recoverable natural gas resources (stippled bars) and cumulative production (lined bars) for Indian and Native lands of the United States.

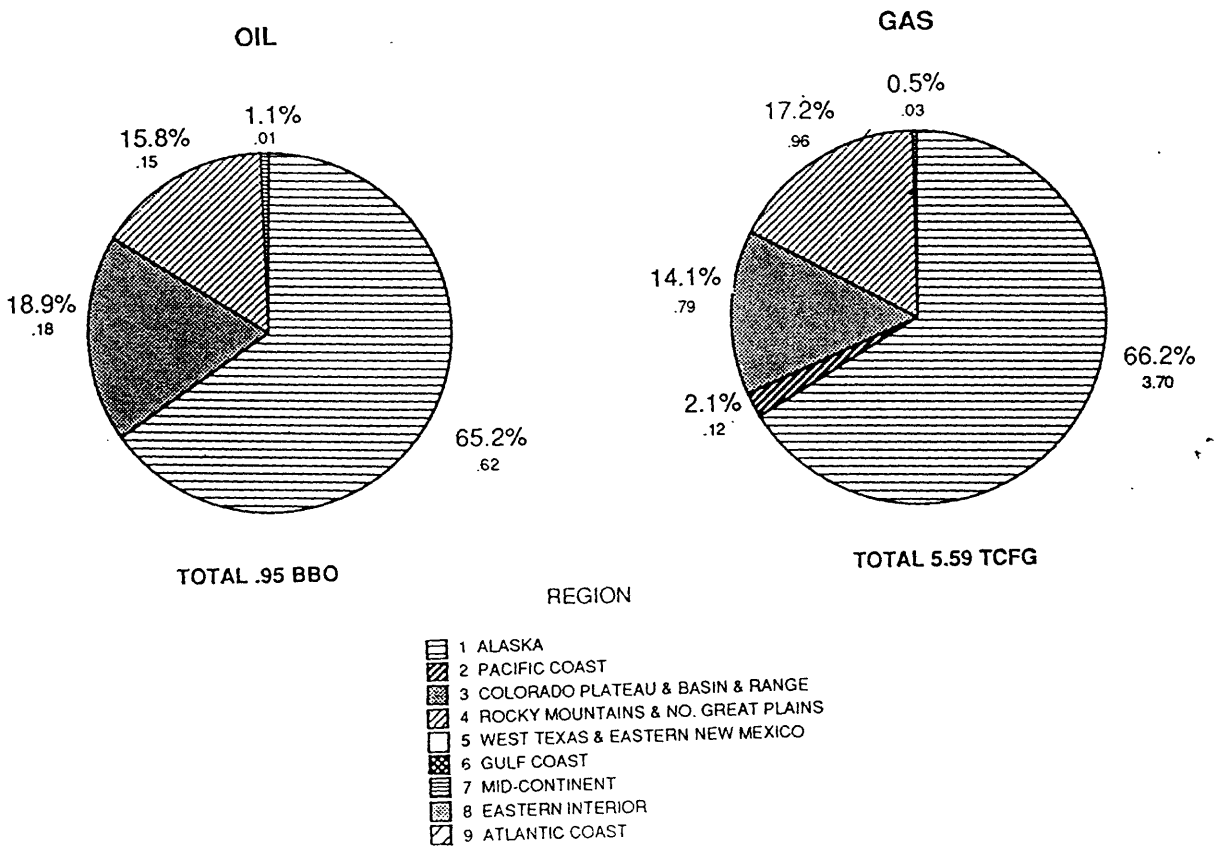

Figure 12. Indian and Native Lands--Pie diagrams showing distribution of undiscovered recoverable conventional crude oil and natural gas resources for Indian and Native lands, based on mean estimates, by region. Resource values in billions of barrels and trillions of cubic feet, respectively. Sums may not equal totals shown due to independent rounding.

ONSHORE AND OFFSHORE FEDERAL RESOURCES

Although resource estimates are subject to change as our knowledge of the petroleum geology improves and new technologies emerge, these estimates do provide an understanding of our resource potential as we now view it. Often, the question is asked, what is the potential for new oil and gas resources under Federal lands and waters? In order to provide an answer to that question, we aggregated the MMS estimates for the Federal offshore, published in Mast and others (1989), with our estimates of resources under Federal lands. Both sets of estimates were developed at the same time and are considered to be comparable even though they were made by different agencies using somewhat different methods and data types. They are considered comparable because they were produced at the same time using the same set of basic assumptions. The results of this aggregation are given in table 6 and shown on figures 13 and 14.

Table 6.--Estimated undiscovered oil and gas resources for the United States [BBO, represents billions barrels of oil; TCFG, trillion cubic feet of gas. Fractile values (F_{95}, F_5) are not additive. Mean value totals may not equal sums of the component means due to independent rounding]

	Recoverable			Economically recoverable		
	F95	Mean	F5	F95	Mean	F5
Onshore Federal						
Oil (BBO)	4.0	12.1	26.4	1.8	8.3	21.6
Gas (TCFG)	25.3	65.8	132.6	14.8	26.2	42.0
Indian & Native						
Oil (BBO)	0.1	1.0	3.3	<.1	0.7	2.5
Gas (TCFG)	0.6	5.6	18.3	0.6	1.8	4.0
Offshore Federal*						
Oil (BBO)	9.2	16.1	25.6	4.0	8.2	14.3
Gas (TCFG)	97.8	145.1	204.8	44.3	74.0	113.8
Onshore & Offshore Federal						
Oil (BBO)	15.9	28.2	45.1	6.9	16.4	31.6
Gas (TCFG)	141.7	210.9	298.3	67.0	100.2	142.3
Entire United States (regardless of ownership)*						
Oil (BBO)	33.2	49.4	69.9	20.7	34.8	53.8
Gas (TCFG)	306.8	399.1	507.2	208.2	262.7	325.5

* Mast and others (1989)

Based on the mean values, more than one half of the Nation's estimated undiscovered recoverable conventional resources, that is, 57 percent of the oil and 53 percent of the gas, are beneath Federal lands and waters. In excess of 85 percent of these Federal resources are beneath the OCS and onshore Alaska; less than 15 percent are in the onshore lower 48 States. Of economically recoverable resources nationally, 47 percent of the oil and 38 percent of the gas is beneath Federal lands and waters. Of these Federally owned economically recoverable resources, 80 percent of the oil and 74 percent of the gas are beneath the OCS and onshore Alaska.

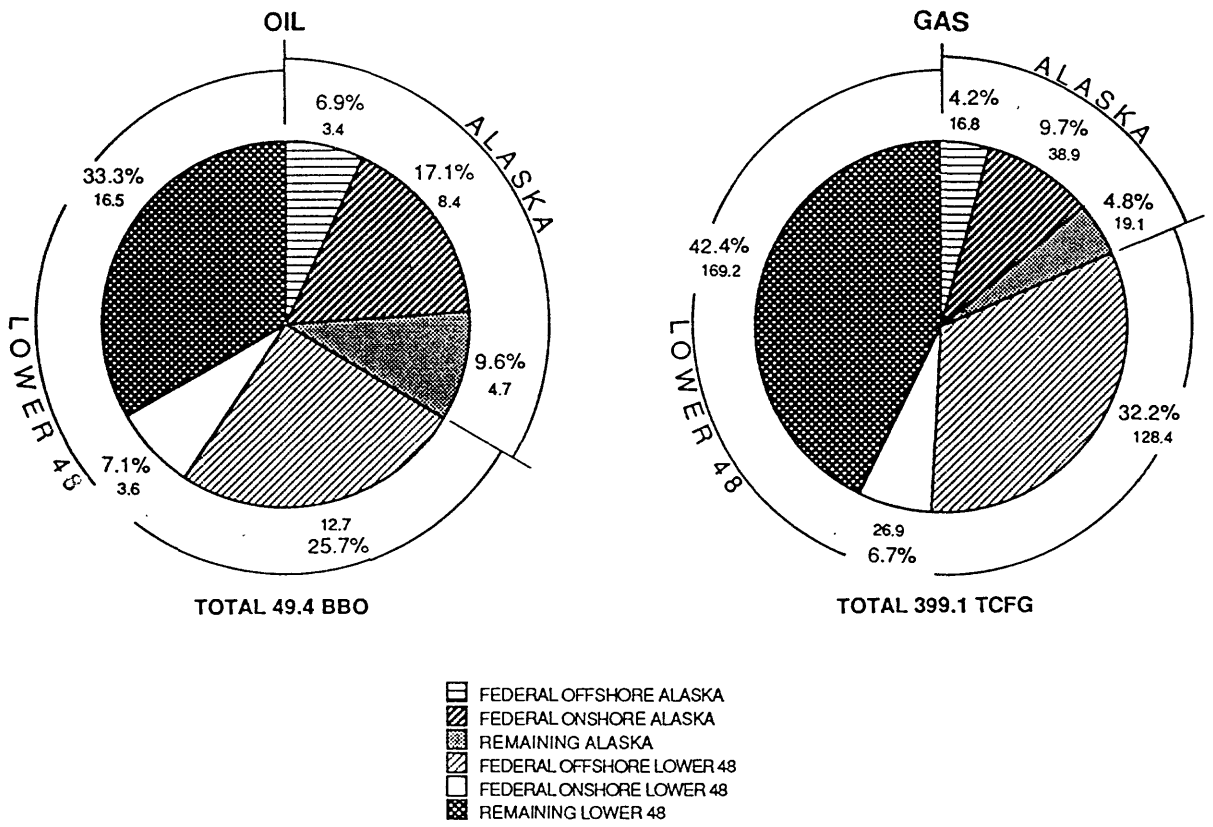

Figure 13. Pie diagrams showing distribution of undiscovered recoverable conventional crude oil and natural gas resources in Alaska and the Lower 48 States, based on mean estimates, showing Federally owned resources as part of the undiscovered resources of the United States. Resource values in billions of barrels and trillions of cubic feet, respectively. Federal offshore estimates from Mast and others, 1989. Sums may not equal totals shown due to independent rounding.

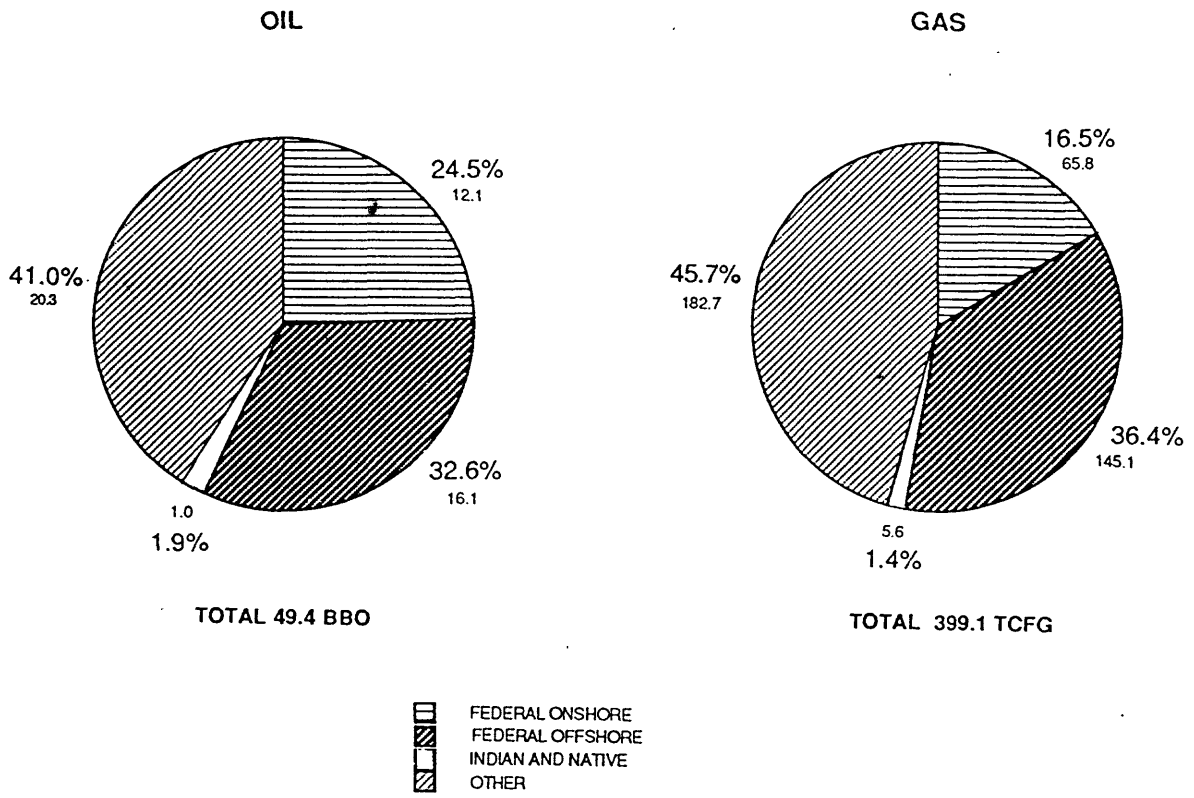

Figure 14. Pie diagrams showing distribution of undiscovered recoverable conventional crude oil and natural gas resources for the entire United States showing Federal, Indian and Native ownership, onshore and offshore, and the remainder, based on mean estimates. Resource values in billions of barrels and trillions of cubic feet, respectively. Federal offshore estimates from Mast and others, 1989. Sums may not equal totals shown due to independent rounding.

CONCLUSIONS

Substantial resources of oil and gas exist beneath areas of onshore Federal ownership. The sum of the mean estimates of undiscovered recoverable conventional resources of oil, natural gas, and NGL beneath Federal lands of the onshore United States, shown in table 3, when converted on a BTU basis, yield about 24 billion barrels oil equivalent, or approximately 20 percent of the undiscovered recoverable resources of the United States; the economically recoverable resource is approximately 13 billion barrels of oil equivalent, or approximately 15 percent of the undiscovered economically recoverable resources of the United States.

Undiscovered conventional oil and gas resources estimated to exist beneath Indian and Native lands of the United States, though significant, are much less than those of Federal lands. It is worth noting, however, that the Indian and Native lands, overall, tend to be richer than the Federal lands when compared to their areas. The Native lands of northern Alaska are particularly rich in terms of resource potential.

Resource additions which might be expected from future enhanced recovery techniques and practices beyond the current recovery assumed in this assessment may be significant, as may be additions attributable to "unconventional" resources, which in large part are also dependent upon future technologic advances and improved economic incentives.

The government now manages lands and offshore waters of the U.S. that collectively contain more than half of the estimated undiscovered recoverable oil and gas resources for the Nation. Approximately 87 percent of the estimated Federal undiscovered recoverable resources are located in the OCS and Alaska. These are the same areas that are estimated to have the potential for very large hydrocarbon accumulations as opposed to the smaller estimated accumulation sizes in the onshore Lower 48 States. Large increases in petroleum production are usually achieved through the development of very large new accumulations of oil or gas, such as occurred with development of Prudhoe Bay Field in Alaska. In many areas of Federal holdings, particularly in parts of the offshore and much of Alaska, little or no infrastructure currently exists. Therefore, production from undiscovered resources will require long lead times to develop, if and when new fields are discovered in these areas. Because of high development and operating costs, economic undiscovered resources in Alaska and the offshore, are estimated to be approximately 13.1 BBO and 74.1 TCFG, causing the economically recoverable portion of resources to be proportionally less than in the onshore Lower 48. In Alaska and offshore areas, a considerable part of the estimated undiscovered recoverable resources can be developed only if the economic climate for oil and gas exploration improves. Based on the above factors, it is concluded that the Federal government can have a strong influence on the Nation's ability to supply domestic oil and gas from Federal lands and waters through its short- and long-term land management and energy policies.

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APPENDIX A: ESTIMATES OF RESOURCES OF UNDISCOVERED CONVENTIONAL OIL, GAS, AND NATURAL GAS LIQUIDS FOR FEDERAL, INDIAN AND NATIVE LANDS BY GEOLOGIC PROVINCE

The tables in this section, A1 through A4, present the estimates of undiscovered recoverable and economically recoverable conventional oil, gas, and natural gas liquids resources for the Federal onshore, and the Indian and Native lands of the petroleum provinces of the United States. Figures A1 and A2 show the boundaries of the provinces assessed. The province numbers on the maps correspond to those in tables A1 through A4.

Values of economic resources reported in a few instances in Alaska (Provinces 58, 59, 60, and 67, in Tables A.2 and A.4), are less than the minimum economic field size assumed. The reasons for this are threefold. First, resources on Federal or Indian and Native lands are percentage estimates of resources of entire plays and incorporate the possibility that some portions of economic fields may reside beneath such lands. Second, several provinces include plays which contain risk, hence, fully-risked resources calculated for them incorporate that risk and may show values below the stated minimum field sizes. Third, the analytical methodology used for aggregation, which precisely calculates means and standard deviations for the individual plays, also uses a lognormal model for determination of aggregation fractile values and has the characteristic in some instances of producing values less than minimum economic field sizes. We believe the first factor to be the most significant of these. (Economic field size cut-offs in Alaska used in this study were 384 million barrels oil for northern Alaska and 4 million barrels oil and 24 billion cubic feet of gas for Cook Inlet.)

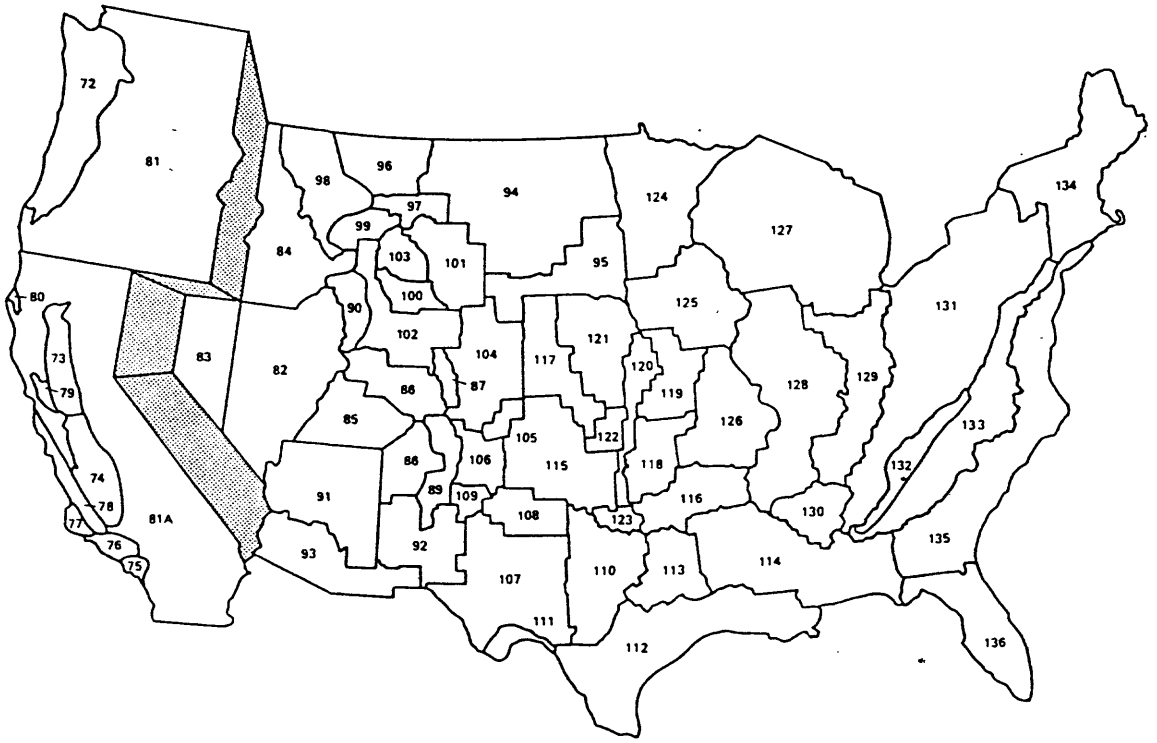

Figure A1. Index map of lower 48 States showing provinces assessed. Names of provinces listed by number in appendix A, tables A1 through A4.

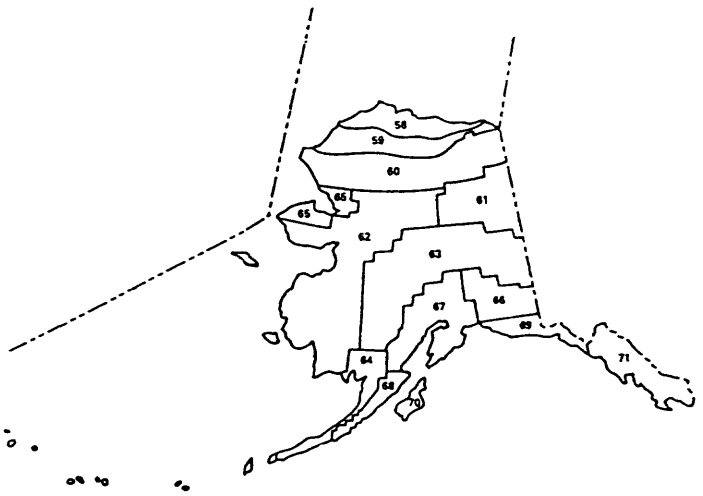

Figure A2. Index map of Alaska showing provinces assessed. Names of provinces listed by number in appendix A, tables A1 through A4.

Table A.1—Province estimates of Federal onshore undiscovered recoverable conventional oil, gas, and natural gas liquids resources of the United States [Mean value totals may not be equal to the sums of the component means given elsewhere because numbers have been independently rounded. Fractile values (F95, F5) are not additive. F95 represents a 19 in 20 chance and F5 represents a 1 in 20 chance of the occurrence of at least the amount tabulated. Gas includes both nonassociated and associated-dissolved gas. Negl., negligible quantity; dash indicates resources not estimated, not considered significant].

		Crude oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
		F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 1—Alaska										
058	Arctic Coastal Plain	0.95	17.16	5.94	3.11	69.39	22.93	0.06	1.28	0.43
059	Northern Foothills	.17	6.25	1.88	1.44	35.89	11.59	.02	.56	.18
060	Southern Foothills	.01	1.40	.36	.09	11.03	2.91	.00	.13	.03
061	Kandik	.00	.46	.10	.00	.46	.10	.00	.00	.00
062	Alaska Interior	.00	.00	.00	.19	1.87	.76	<.01	<.01	<.01
063	Interior Lowlands (incl. in 062)									
064	Bristol basin	.00	.00	.00	.02	.16	.06	.00	.00	.00
065	Hope basin	–	–	–	–	–	–	–	–	–
066	Copper River (incl. in 062)									
067	Cook Inlet	<.01	.09	.03	.01	.57	.15	<.01	<.01	<.01
068	Alaska Peninsula (incl. in 062)									
069	Gulf of Alaska	.01	.41	.13	.02	1.3	.36	<.01	<.01	<.01
070	Kodiak	–	–	–	–	–	–	–	–	–
071	Southeastern Alaska	–	–	–	–	–	–	–	–	–
	Region Total	1.79	22.19	8.44	8.37	101.71	38.87	.14	1.67	.65

Table A.1—Province estimates of Federal onshore undiscovered recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

		Crude oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
		F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 2—Pacific Coast										
072	Western Oregon-Washington	0.00	0.00	0.00	0.05	0.55	0.22	0.00	0.00	0.00
073	Sacramento basin	.00	.00	.00	<.01	.12	.03	<.01	<.01	<.01
074	San Joaquin basin	.01	.39	.11	.01	.64	.19	<.01	.03	.01
075	Los Angeles basin	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
076	Ventura basin	<.01	.21	.06	.01	.39	.11	<.01	.01	<.01
077	Santa Maria basin	.04	.23	.11	.03	.21	.10	<.01	.01	.01
078	Central Coastal basins	.02	.48	.16	.02	.38	.13	<.01	.01	<.01
079	Sonoma-Livermore basin	.00	<.01	<.01	.00	<.01	<.01	.00	.00	.00
080	Humboldt basin	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
081	Eastern Oregon-Washington	.00	.00	.00	.05	.85	.29	<.01	<.01	<.01
81A	Eastern California	-	-	-	-	-	-	-	-	-
	Region Total	.09	1.20	.44	.24	2.75	1.06	<.01	.06	.02
Region 3—Colorado Plateau and Basin and Range										
082	Eastern Basin and Range	0.08	0.59	0.26	0.03	0.43	0.15	<.01	0.01	<.01
083	Western Basin and Range	<.01	.04	.01	<.01	.12	.04	<.01	<.01	<.01
084	Idaho-Snake River	.00	.00	.00	<.01	.02	.01	.00	.00	.00
085	Paradox basin	<.01	.49	.13	.02	.09	.25	<.01	.01	<.01
086	Uinta-Piceance basin	.01	.28	.09	.68	2.48	1.40	<.01	.02	.01
087	Park basins	<.01	.01	<.01	<.01	.02	.01	.00	.00	.00
088	San Juan basin	.02	.09	.05	.78	1.73	1.20	<.01	<.01	<.01
089	Albuquerque-Santa Fe rift	<.01	.02	.01	.01	.10	.03	.00	.00	.00
090	Wyoming thrust belt	.10	.75	.33	3.59	21.03	10.03	.06	.70	.27
091	Northern Arizona	<.01	.02	.01	<.01	<.01	<.01	.00	.00	.00
092	South Central New Mexico	<.01	.05	.02	.05	.64	.24	.00	.00	.00
093	Southern Arizona-Southwestern New Mexico	<.01	<.01	<.01	<.01	.08	.03	.00	.00	.00
	Region Total	.23	2.23	.91	5.46	26.16	13.38	.07	.72	.29

Table A.1—Province estimates of Federal onshore undiscovered recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

	Crude oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
	F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 4—Rocky Mountains and Northern Great Plains									
094 Williston basin	0.06	0.19	0.12	0.06	0.18	0.11	<.01	0.01	0.01
095 Sioux Arch (incl. in 094)									
096 Sweetgrass Arch	<.01	.01	.01	.05	.20	.10	<.01	<.01	<.01
097 Central Montana	<.01	.01	<.01	<.01	<.01	<.01	.00	.00	.00
098 Montana thrust belt	<.01	.02	<.01	.30	7.43	2.40	.01	.16	.05
099 Southwestern Montana	<.01	.03	.01	.01	.48	.15	<.01	.01	.01
100 Wind River basin	.05	.23	.12	.50	2.39	1.23	<.01	.02	.01
101 Powder River basin	.67	2.40	1.37	.78	3.10	1.70	.02	.08	.04
102 Southwestern Wyoming	.04	.36	.15	.95	5.23	2.54	.01	.07	.03
103 Bighorn basin	.08	.42	.21	.13	1.23	.51	<.01	.02	.01
104 Denver basin	.01	.05	.03	.02	.07	.04	<.01	<.01	<.01
105 Las Animas Arch	–	–	–	–	–	–	–	–	–
106 Raton-Sierra Grande	<.01	.01	<.01	.01	.11	.04	<.01	<.01	<.01
Region Total	1.04	3.42	2.01	3.21	18.32	8.81	.05	.32	.15
Region 5—West Texas and Eastern New Mexico									
107 Permian basin	0.01	0.09	0.03	0.18	2.13	0.82	<.01	0.03	0.01
108 Palo Duro basin	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	.00	.00	.00
109 Pedernal uplift	–	–	–	–	–	–	–	–	–
110 Bend Arch-Ft. Worth basin	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
111 Marathon fold belt	.00	.00	.00	.02	.17	.08	<.01	<.01	<.01
Region Total	.01	.09	.03	.21	2.27	.90	<.01	.03	.01
Region 6—Gulf Coast									
112 Western Gulf basin	<.01	0.08	0.02	0.17	2.14	0.82	<.01	0.06	0.02
113 East Texas basin	<.01	.05	.02	<.01	.13	.04	<.01	.01	<.01
114 La.-Miss. Salt basins	.01	.05	.02	.06	1.86	.58	.01	.16	.05
Region Total	.01	.17	.06	.29	3.85	1.44	.01	.22	.07

Table A.1—Province estimates of Federal onshore undiscovered recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

	Crude oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
	F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 7—Mid-Continent									
115 Anadarko basin	<.01	0.01	<.01	0.01	0.36	0.11	<.01	0.01	<.01
116 Arkoma basin	<.01	.02	.01	.09	.55	.26	.00	.00	.00
117 Central Kansas uplift	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
118 Cherokee platform	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
119 Forest City basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
120 Nemaha uplift	<.01	.01	.01	.01	.02	.01	<.01	<.01	<.01
121 Salina basin	<.01	.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
122 Sedgwick basin	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
123 Southern Oklahoma	<.01	.03	.01	<.01	.07	.02	<.01	<.01	<.01
124 Sioux uplift (incl. in 125)									
125 Iowa Shelf	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
126 Ozark uplift	–	–	–	–	–	–	–	–	–
Region Total	.01	.07	.03	.13	.92	.41	<.01	.01	<.01
Region 8—Eastern Interior									
127 Michigan basin	0.01	0.05	0.03	0.04	0.69	0.24	<.01	0.01	0.01
128 Illinois basin	.01	.02	.01	<.01	.08	.02	<.01	<.0	<.01
129 Cincinnati Arch	–	–	–	–	–	–	–	–	–
130 Black Warrior basin	<.01	<.01	<.01	.05	.24	.13	<.01	<.01	<.01
131 Appalachian basin	<.01	.01	.01	.02	1.11	.31	<.01	.03	.01
132 Blue Ridge thrust belt	.00	.00	.00	.03	.63	.20	.00	.00	.00
133 Piedmont	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
134 New England-Adirondack (incl. in 132)									
Region Total	.03	.07	.05	.20	2.33	.90	<.01	.04	.01

Table A.1—Province estimates of Federal onshore undiscovered recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

	Crude oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
	F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 9—Atlantic Coast									
135 Atlantic Coastal Plain (incl. in 133)									
136 Southern Florida	0.02	0.29	0.11	<.01	0.02	0.01	0.00	0.00	0.00
Region Total	.02	.29	.11	<.01	.02	.01	.00	.00	.00
U.S. Total	3.96	26.42	12.08	25.33	132.65	65.79	0.49	2.38	1.21

Table A.2—Province estimates of Federal onshore undiscovered economically recoverable conventional oil, gas, and natural gas liquids resources of the United States [Mean value totals may not be equal to the sums of the component means given elsewhere because numbers have been independently rounded. Fractile values (F95, F5) are not additive. F95 represents a 19 in 20 chance and F5 represents a 1 in 20 chance of the occurrence of at least the amount tabulated. Gas includes both nonassociated and associated-dissolved gas. Negl., indicates negligible quantity; dash indicates resources not estimated, not considered significant]

	Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
	F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 1—Alaska									
058 Arctic Coastal Plain	0.00	12.40	3.58	0.00	0.00	0.00	0.00	0.00	0.00
059 Northern Foothills	.00	4.13	1.08	.00	.00	.00	.00	.00	.00
060 Southern Foothills	.00	.93	.23	.00	.00	.00	.00	.00	.00
061 Kandik	.00	.00	.00	.00	.00	.00	.00	.00	.00
062 Alaska Interior	.00	.00	.00	.00	.00	.00	.00	.00	.00
063 Interior Lowlands (incl. in 062)									
064 Bristol basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
065 Hope basin	–	–	–	–	–	–	–	–	–
066 Copper River (incl. in 062)									
067 Cook Inlet	<.01	.08	.02	<.01	.47	.12	<.01	<.01	<.01
068 Alaska Peninsula (incl. in 062)									
069 Gulf of Alaska	.00	.00	.00	.00	.00	.00	.00	.00	.00
070 Kodiak	–	–	–	–	–	–	–	–	–
071 Southeastern Alaska	–	–	–	–	–	–	–	–	–
Region Total	.47	16.21	4.92	<.01	.47	.12	<.01	<.01	<.01

Table A.2—Province estimates of Federal onshore undiscovered economically recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

		Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
		F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 2—Pacific Coast										
072	Western Oregon-Washington	0.00	0.00	0.00	0.08	0.41	0.21	0.00	0.00	0.00
073	Sacramento basin	.00	.00	.00	<.01	.11	.03	<.01	<.01	<.01
074	San Joaquin basin	.01	.39	.11	.01	.64	.19	<.01	.03	.01
075	Los Angeles basin	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
076	Ventura basin	<.01	.14	.06	.01	.25	.11	<.01	.01	<.01
077	Santa Maria basin	.04	.19	.11	.03	.17	.10	<.01	.01	.01
078	Central Coastal basins	.02	.47	.16	.02	.38	.13	<.01	.01	<.01
079	Sonoma-Livermore basin	.00	<.01	<.01	.00	<.01	<.01	.00	.00	.00
080	Humboldt basin	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
081	Eastern Oregon-Washington	.00	.00	.00	.04	.82	.28	<.01	<.01	<.01
81A	Eastern California	-	-	-	-	-	-	-	-	-
	Region Total	.09	1.10	.44	.24	2.49	1.04	<.01	.06	.02
Region 3—Colorado Plateau and Basin and Range										
082	Eastern Basin and Range	0.07	0.56	0.24	0.02	0.41	0.14	<.01	0.01	<.01
083	Western Basin and Range	<.01	.04	.01	<.01	.11	.03	<.01	<.01	<.01
084	Idaho-Snake River	.00	.00	.00	<.01	.02	.01	.00	.00	.00
085	Paradox basin	<.01	.46	.12	.01	.84	.23	<.01	.01	<.01
086	Uinta-Piceance basin	.01	.27	.09	.66	2.44	1.38	<.01	.02	.01
087	Park basins	<.01	.01	<.01	<.01	.02	.01	.00	.00	.00
088	San Juan basin	.02	.09	.05	.77	1.71	1.18	<.01	<.01	<.01
089	Albuquerque-Santa Fe rift	<.01	.02	.01	<.01	.08	.02	.00	.00	.00
090	Wyoming thrust belt	.10	.74	.33	3.55	20.93	9.96	.06	.70	.27
091	Northern Arizona	<.01	.02	.01	<.01	<.01	<.01	.00	.00	.00
092	South Central New Mexico	<.01	.04	.01	.04	.61	.22	.00	.00	.00
093	Southern Arizona-Southwestern New Mexico	<.01	<.01	<.01	<.01	.08	.02	.00	.00	.00
	Region Total	.20	2.16	.86	5.35	25.95	13.21	.07	.72	.28

Table A.2—Province estimates of Federal onshore undiscovered economically recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

		Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
		F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 4—Rocky Mountains and Northern Great Plains										
094	Williston basin	0.03	0.14	0.07	0.04	0.13	0.08	<.01	0.01	<.01
095	Sioux Arch (incl. in 094)									
096	Sweetgrass Arch	<.01	.01	<.01	.04	.20	.10	<.01	<.01	<.01
097	Central Montana	<.01	.01	<.01	<.01	<.01	<.01	.00	.00	.00
098	Montana thrust belt	<.01	.02	<.01	.30	7.37	2.37	.01	.16	.05
099	Southwestern Montana	<.01	.03	.01	.01	.47	.14	<.01	.01	<.01
100	Wind River basin	.04	.23	.11	.46	2.42	1.20	<.01	.02	.01
101	Powder River basin	.57	2.24	1.23	.66	2.92	1.54	.02	.08	.04
102	Southwestern Wyoming	.04	.35	.14	.80	5.19	2.40	.01	.06	.03
103	Bighorn basin	.08	.41	.20	.11	1.26	.49	<.01	.02	.01
104	Denver basin	.01	.06	.02	.01	.08	.03	<.01	<.01	<.01
105	Las Animas Arch	–	–	–	–	–	–	–	–	–
106	Raton-Sierra Grande	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
	Region Total	.88	3.19	1.81	2.85	17.92	8.35	.05	.32	.15
Region 5—West Texas and Eastern New Mexico										
107	Permian basin	0.01	0.09	0.03	0.17	2.09	0.79	<.01	0.03	0.01
108	Palo Duro basin	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	.00	.00	.00
109	Pedernal uplift	–	–	–	–	–	–	–	–	–
110	Bend Arch-Ft. Worth basin	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
111	Marathon fold belt	.00	.00	.00	.02	.17	.07	<.01	<.01	<.01
	Region Total	.01	.09	.03	.20	2.22	.87	<.01	.03	.01
Region 6—Gulf Coast										
112	Western Gulf basin	<.01	0.04	0.02	0.43	1.36	0.82	0.01	0.04	0.02
113	East Texas basin	<.01	.05	.02	<.01	.12	.04	<.01	.01	<.01
114	La.-Miss. Salt basins	<.01	.04	.02	.22	1.13	.57	.02	.09	.05
	Region Total	.01	.13	.06	.29	2.41	1.42	.01	.12	.07

Table A.2—Province estimates of Federal onshore undiscovered economically recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

	Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
	F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 7—Mid-Continent									
115 Anadarko basin	<.01	0.01	<.01	0.01	0.36	0.11	<.01	0.01	<.01
116 Arkomaa basin	<.01	.02	.01	.08	.52	.24	.00	.00	.00
117 Central Kansas uplift	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
118 Cherokee platform	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
119 Forest City basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
120 Nemaha uplift	<.01	.01	.01	.01	.02	.01	<.01	<.01	<.01
121 Salina basin	<.01	.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
122 Sedgwick basin	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
123 Southern Oklahoma	<.01	.02	.01	<.01	.06	.02	<.01	<.01	<.01
124 Sioux uplift (incl. in 125)									
125 Iowa Shelf	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
126 Ozark uplift	-	-	-	-	-	-	-	-	-
Region Total	.01	.07	.03	.11	.89	.38	<.01	.01	<.01
Region 8—Eastern Interior									
127 Michigan basin	0.01	0.05	0.03	0.04	0.67	0.23	<.01	0.01	0.01
128 Illinois basin	.01	.02	.01	<.01	.08	.02	<.01	<.01	<.01
129 Cincinnati Arch	-	-	-	-	-	-	-	-	-
130 Black Warrior basin	<.01	<.01	<.01	.04	.26	.12	<.01	<.01	<.01
131 Appalachian basin	<.01	.01	.01	.02	.04	.29	<.01	.03	.01
132 Blue Ridge thrust belt	.00	.00	.00	.03	.46	.19	.00	.00	.00
133 Piedmont	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
134 New England-Adirondack (incl. in 132)									
Region Total	.03	.07	.05	.20	2.15	.85	<.01	.04	.01

Table A.2—Province estimates of Federal onshore undiscovered economically recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

	Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
	F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 9—Atlantic Coast									
135 Atlantic Coastal Plain (incl. in 133)									
136 Southern Florida	0.02	0.25	0.11	<.01	0.02	0.01	0.00	0.00	0.00
Region Total	.02	.25	.11	<.01	.02	.01	.00	.00	.00
U.S. Total	1.79	21.63	8.29	14.82	42.03	26.24	.24	1.03	.55

Table A.3—Province estimates of Indian and Native undiscovered recoverable conventional oil, gas, and natural gas liquids resources of the United States. [Mean value totals may not be equal to the sums of the component means given elsewhere because numbers have been independently rounded. Fractile values (F95, F5) are not additive. F95 represents a 19 in 20 chance and F5 represents a 1 in 20 chance of the occurrence of at least the amount tabulated. Gas includes both nonassociated and associated-dissolved gas. Negl., indicates negligible quantity; dash indicates resources not estimated, not considered significant].

		Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
		F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 1—Alaska										
058	Arctic Coastal Plain	0.01	1.17	0.30	0.02	4.88	1.26	<.01	0.08	0.02
059	Northern Foothills	.01	1.02	.26	.09	7.42	2.00	<.01	.11	.03
060	Southern Foothills	<.01	.14	.04	<.01	1.29	.35	<.01	.01	<.01
061	Kandik	.00	.02	.01	.00	.02	.01	.00	.00	.00
062	Alaska Interior	.00	.00	.00	<.01	.15	.04	<.01	<.01	<.01
063	Interior Lowlands (incl. in 062)									
064	Bristol basin	.00	.00	.00	<.01	.02	.01	.00	.00	.00
065	Hope basin	-	-	-	-	-	-	-	-	-
066	Copper River (incl. in 062)									
067	Cook Inlet	-	-	-	-	-	-	-	-	-
068	Alaska Peninsula (incl. in 062)									
069	Gulf of Alaska	<.01	.04	.01	<.01	.10	.03	<.01	<.01	<.01
070	Kodiak	-	-	-	-	-	-	-	-	-
071	Southeastern Alaska	-	-	-	-	-	-	-	-	-
	Region Total	.02	2.37	.62	.18	13.56	3.70	<.01	.20	.05

Table A.3—Province estimates of Indian and Native undiscovered recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

		Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
		F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 2—Pacific Coast										
072	Western Oregon-Washington	0.00	0.00	0.00	–	–	–	0.00	0.00	0.00
073	Sacramento basin	.00	.00	.00	0.00	0.00	0.00	.00	.00	.00
074	San Joaquin basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
075	Los Angeles basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
076	Ventura basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
077	Santa Maria basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
078	Central Coastal basins	.00	.00	.00	.00	.00	.00	.00	.00	.00
079	Sonoma-Livermore basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
080	Humboldt basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
081	Eastern Oregon-Washington	.00	.00	.00	.01	.40	.12	<.01	<.01	<.01
81A	Eastern California	–	–	–	–	–	–	–	–	–
	Region Total	.00	.00	.00	.01	.40	.12	<.01	<.01	<.01
Region 3—Colorado Plateau and Basin and Range										
082	Eastern Basin and Range	–	–	–	–	–	–	–	–	–
083	Western Basin and Range	–	–	–	–	–	–	–	–	–
084	Idaho-Snake River	0.00	0.00	0.00	–	–	–	–	–	–
085	Paradox basin	<.01	.02	.01	.01	.02	.01	<.01	<.01	<.01
086	Uinta-Piceance basin	<.01	.20	.06	.08	.73	.30	<.01	.01	<.01
087	Park basins	.00	.00	.00	.00	.00	.00	.00	.00	.00
088	San Juan basin	.01	.05	.02	.21	.72	.42	<.01	<.01	<.01
089	Albuquerque-Santa Fe rift	<.01	.01	<.01	<.01	.10	.03	.00	.00	.00
090	Wyoming thrust belt	.00	.00	.00	.00	.00	.00	.00	.00	.00
091	Northern Arizona	.02	.24	.09	.01	.06	.03	.00	.00	.00
092	South Central New Mexico	–	–	–	–	–	–	–	–	–
093	Southern Arizona-Southwestern New Mexico	–	–	–	–	–	–	–	–	–
	Region Total	.04	.47	.18	.34	1.50	.79	<.01	.01	<.01

Table A.3—Province estimates of Indian and Native undiscovered recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

	Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
	F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 4—Rocky Mountains and Northern Great Plains									
094 Williston basin	0.04	0.13	0.08	0.06	0.12	0.07	<.01	0.01	<.01
095 Sioux Arch (incl. in 094)									
096 Sweetgrass Arch	<.01	.02	.01	.02	.08	.04	<.01	<.01	<.01
097 Central Montana	.00	.00	.00	.00	.00	.00	.00	.00	.00
098 Montana thrust belt	.00	.00	.00	.02	1.42	.39	<.01	.04	.01
099 Southwestern Montana	.00	.00	.00	.00	.00	.00	.00	.00	.00
100 Wind River basin	.02	.13	.06	.14	1.03	.45	<.01	.01	<.01
101 Powder River basin	<.01	.01	<.01	<.01	.01	<.01	<.01	<.01	<.01
102 Southwestern Wyoming	.00	.00	.00	.00	.00	.00	.00	.00	.00
103 Bighorn basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
104 Denver basin	.00	.00	.00	.00	.00	.00	.00	.00	.0
105 Las Animas Arch	.00	.00	.00	.00	.00	.00	.00	.00	.00
106 Raton-Sierra Grande	.00	.00	.00	.00	.00	.00	.00	.00	.00
Region Total	.07	.26	.15	.15	2.78	.96	<.01	.05	.02
Region 5—West Texas and Eastern New Mexico									
107 Permian basin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
108 Palo Duro basin	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
109 Pedernal uplift	–	–	–	–	–	–	–	–	–
110 Bend Arch-Ft. Worth basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
111 Marathon fold belt	.00	.00	.00	.00	.00	.00	.00	.00	.00
Region Total	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
Region 6—Gulf Coast									
112 Western Gulf basin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
113 East Texas basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
114 La.-Miss. Salt basins	–	–	–	–	–	–	–	–	–
Region Total	.00	.00	.00	.00	.00	.00	.00	.00	.00

Table A.3—Province estimates of Indian and Native undiscovered recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

	Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
	F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 7—Mid-Continent									
115 Anadarko basin	–	–	–	–	–	–	–	–	–
116 Arkoma basin	–	–	–	–	–	–	–	–	–
117 Central Kansas uplift	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
118 Cherokee platform	<.01	.01	.01	.01	.02	.01	<.01	<.01	<.01
119 Forest City basin	–	–	–	–	–	–	–	–	–
120 Nemaha uplift	.00	.00	.00	.00	.00	.00	.00	.00	.00
121 Salina basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
122 Sedgwick basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
123 Southern Oklahoma	–	–	–	–	–	–	–	–	–
124 Sioux uplift (incl. in 125)									
125 Iowa Shelf	.00	.00	.00	.00	.00	.00	.00	.00	.00
126 Ozark uplift	–	–	–	–	–	–	–	–	–
Region Total	<.01	.01	.01	<.01	.02	.01	<.01	<.01	<.01
Region 8—Eastern Interior									
127 Michigan basin	–	–	–	–	–	–	–	–	–
128 Illinois basin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
129 Cincinnati Arch	.00	.00	.00	.00	.00	.00	.00	.00	.00
130 Black Warrior basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
131 Appalachian basin	.00	.00	.00	<.01	.07	.02	<.01	<.01	<.01
132 Blue Ridge thrust belt	.00	.00	.00	Negl.	Negl.	Negl.	.00	.00	.00
133 Piedmont	.00	.00	.00	.00	.00	.00	.00	.00	.00
134 New England-Adirondack (incl. in 132)									
Region Total	.00	.00	.00	<.01	.07	.02	<.01	<.01	<.01

Table A.3—Province estimates of Indian and Native undiscovered recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

	Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
	F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 9—Atlantic Coast									
135 Atlantic Coastal Plain (incl. in 133)									
136 Southern Florida	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	0.00	0.00	0.00
Region Total	<.01	<.01	<.01	<.01	<.01	<.01	.00	.00	.00
U.S. Total	.07	3.32	.95	.55	18.26	5.59	.01	.25	.07

Table A.4—Province estimates of Indian and Native undiscovered economically recoverable conventional oil, gas, and natural gas liquids resources of the United States. [Mean value totals may not be equal to the sums of the component means given elsewhere because numbers have been independently rounded. Fractile values (F95, F5) are not additive. F95 represents a 19 in 20 chance and F5 represents a 1 in 20 chance of the occurrence of at least the amount tabulated. Gas includes both nonassociated and associated-dissolved gas. Negl., indicates negligible quantity; dash indicates resources not estimated, not considered significant]

		Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
		F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 1—Alaska										
058	Arctic Coastal Plain	0.00	0.91	0.22	0.00	0.00	0.00	0.00	0.00	0.00
059	Northern Foothills	.00	.58	.14	.00	.00	.00	.00	.00	.00
060	Southern Foothills	.00	.09	.03	.00	.00	.00	.00	.00	.00
061	Kandik	.00	.00	.00	.00	.00	.00	.00	.00	.00
062	Alaska Interior	.00	.00	.00	.00	.00	.00	.00	.00	.00
063	Interior Lowlands (incl. in 062)									
064	Bristol basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
065	Hope basin	–	–	–	–	–	–	–	–	–
066	Copper River (incl. in 062)									
067	Cook Inlet	–	–	–	–	–	–	–	–	–
068	Alaska Peninsula (incl. in 062)									
069	Gulf of Alaska	.00	.00	.00	.00	.00	.00	.00	.00	.00
070	Kodiak	–	–	–	–	–	–	–	–	–
071	Southeastern Alaska	–	–	–	–	–	–	–	–	–
	Region Total	.00	1.57	.40	.00	.00	.00	.00	.00	.00

Table A.4—Province estimates of Indian and Native undiscovered economically recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

		Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
		F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 2—Pacific Coast										
072	Western Oregon-Washington	0.00	0.00	0.00	–	–	–	0.00	0.00	0.00
073	Sacramento basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
074	San Joaquin basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
075	Los Angeles basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
076	Ventura basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
077	Santa Maria basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
078	Central Coastal basins	.00	.00	.00	.00	.00	.00	.00	.00	.00
079	Sonoma-Livermore basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
080	Humboldt basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
081	Eastern Oregon-Washington	.00	.00	.00	.01	.39	.11	<.01	<.01	<.01
81A	Eastern California	–	–	–	–	–	–	–	–	–
	Region Total	.00	.00	.00	.01	.39	.11	<.01	<.01	<.01
Region 3—Colorado Plateau and Basin and Range										
082	Eastern Basin and Range	–	–	–	–	–	–	–	–	–
083	Western Basin and Range	–	–	–	–	–	–	–	–	–
084	Idaho-Snake River	0.00	0.00	0.00	–	–	–	–	–	–
085	Paradox basin	<.01	.01	.01	0.01	0.02	0.01	<.01	<.01	<.01
086	Uinta-Piceance basin	<.01	.19	.06	.07	.73	.29	<.01	.01	<.01
087	Park basins	.00	.00	.00	.00	.00	.00	.00	.00	.00
088	San Juan basin	.01	.05	.02	.21	.71	.41	<.01	<.01	<.01
089	Albuquerque-Santa Fe rift	<.01	.01	<.01	<.01	.10	.03	.00	.00	.00
090	Wyoming thrust belt	.00	.00	.00	.00	.00	.00	.00	.00	.00
091	Northern Arizona	.02	.24	.09	.01	.06	.03	.00	.00	.00
092	South Central New Mexico	–	–	–	–	–	–	–	–	–
093	Southern Arizona-Southwestern New Mexico	–	–	–	–	–	–	–	–	–
	Region Total	.03	.47	.17	.33	1.48	.77	<.01	.01	<.01

Table A.4—Province estimates of Indian and Native undiscovered economically recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

	Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
	F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 4—Rocky Mountains and Northern Great Plains									
094 Williston basin	0.02	0.09	0.05	0.02	0.09	0.05	<.01	<.01	<.01
095 Sioux Arch (incl. in 094)									
096 Sweetgrass Arch	<.01	.02	.01	.02	.08	.04	<.01	<.01	<.01
097 Central Montana	.00	.00	.00	.00	.00	.00	.00	.00	.00
098 Montana thrust belt	.00	.00	.00	.02	1.41	.38	<.01	.04	.01
099 Southwestern Montana	.00	.00	.00	.00	.00	.00	.00	.00	.00
100 Wind River basin	.01	.14	.06	.11	1.11	.44	<.01	.01	<.01
101 Powder River basin	<.01	.01	<.01	<.01	.01	<.01	<.01	<.01	<.01
102 Southwestern Wyoming	.00	.00	.00	.00	.00	.00	.00	.00	.00
103 Bighorn basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
104 Denver basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
105 Las Animas Arch	.00	.00	.00	.00	.00	.00	.00	.00	.00
106 Raton-Sierra Grande	.00	.00	.00	.00	.00	.00	.00	.00	.00
Region Total	.04	.24	.12	.13	2.76	.92	<.01	.05	.02
Region 5—West Texas and Eastern New Mexico									
107 Permian basin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
108 Palo Duro basin	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.
109 Pedernal uplift	–	–	–	–	–	–	–	–	–
110 Bend Arch-Ft. Worth basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
111 Marathon fold belt	.00	.00	.00	.00	.00	.00	.00	.00	.00
Region Total	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
Region 6—Gulf Coast									
112 Western Gulf basin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
113 East Texas basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
114 La.-Miss. Salt basins	–	–	–	–	–	–	–	–	–
Region Total	.00	.00	.00	.00	.00	.00	.00	.00	.00

Table A.4—Province estimates of Indian and Native undiscovered economically recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

	Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
	F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 7—Mid-Continent									
115 Anadarko basin	-	-	-	-	-	-	-	-	-
116 Arkoma basin	-	-	-	-	-	-	-	-	-
117 Central Kansas uplift	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
118 Cherokee platform	<.01	.01	.01	<.01	.02	.01	<.01	<.01	<.01
119 Forest City basin	-	-	-	-	-	-	-	-	-
120 Nemaha uplift	.00	.00	.00	.00	.00	.00	.00	.00	.00
121 Salina basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
122 Sedgwick basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
123 Southern Oklahoma	-	-	-	-	-	-	-	-	-
124 Sioux uplift (incl. in 125)									
125 Iowa Shelf	.00	.00	.00	.00	.00	.00	.00	.00	.00
126 Ozark uplift	-	-	-	-	-	-	-	-	-
Region Total	<.01	.01	.01	<.01	.02	.01	<.01	<.01	<.01
Region 8—Eastern Interior									
127 Michigan basin	-	-	-	-	-	-	-	-	-
128 Illinois basin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
129 Cincinnati Arch	.00	.00	.00	.00	.00	.00	.00	.00	.00
130 Black Warrior basin	.00	.00	.00	.00	.00	.00	.00	.00	.00
131 Appalachian basin	.00	.00	.00	<.01	.07	.02	<.01	<.01	<.01
132 Blue Ridge thrust belt	.00	.00	.00	Negl.	Negl.	Negl.	.00	.00	.00
133 Piedmont	.00	.00	.00	.00	.00	.00	.00	.00	.00
134 New England-Adirondack (incl. in 132)									
Region Total	.00	.00	.00	<.01	.07	.02	<.01	<.01	<.01

Table A.4—Province estimates of Indian and Native undiscovered economically recoverable conventional oil, gas, and natural gas liquids resources of the United States—continued

	Crude Oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
	F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Region 9—Atlantic Coast									
135 Atlantic Coastal Plain (incl. in 133)									
136 Southern Florida	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	0.00	0.00	0.00
Region Total	<.01	<.01	<.01	<.01	<.01	<.01	.00	.00	.00
U.S. Total	.03	2.53	.69	.55	4.02	1.83	<.01	.06	.02

APPENDIX B: TERMINOLOGY

The terminology in this report reflects definitions and usage practiced by the oil and natural gas industry and the resource estimation community. A detailed listing of common industry definitions is not included; however, several definitions that are essential to the proper understanding of the information in this report are presented. These definitions should be viewed as general explanations rather than strict technical definitions of the terms being addressed.

Undiscovered resources.--Resources estimated to exist, on the basis of broad geologic knowledge and theory, outside of known fields or known accumulations (see figure 1). Also included are resources from undiscovered pools within known fields to the extent that they occur as unrelated accumulations controlled by distinctly separate structural features or stratigraphic conditions.

Undiscovered recoverable resources.--Resources in undiscovered accumulations analogous to those in existing fields producible with current recovery technology and efficiency but without reference to economic viability. These accumulations are considered to be of sufficient size and quality to be amenable to conventional recovery technology. These resources occupy the area of the heavily framed box in figure 1.

Undiscovered economically recoverable resources.--Part of the undiscovered recoverable resource category that is economically recoverable under conditions of current conventional technology and imposed economic assumptions. The economically recoverable resources occupy the hachured area on the resources classification chart (fig. 1).

Conventional resources.--Resources included in this category are crude oil, natural gas, and natural gas liquids that exist in conventional reservoirs or in a fluid state amenable to extraction techniques employed in traditional development practices, as indicated below. They occur as discrete accumulations. These resources do not include oil occurring within extremely viscous and intractable heavy oil deposits, tar deposits, or oil shales, or gas from low-permeability "tight" sandstone and fractured shale reservoirs having in situ permeabilities to gas of less than 0.1 millidarcy, coalbed methane, gas in geopressured shales and brines, or gas hydrates.

Conventionally recoverable resources.--Oil and natural gas resources that may be produced at the surface from a well bore as a consequence of natural pressure within the subsurface reservoir; artificial lifting of oil from the reservoir to the surface, where economically applicable; and the maintenance of reservoir pressure by means of water or gas injection.

Measured reserves.--Part of the identified economic resource that is estimated from geologic evidence supported directly by engineering data. They are demonstrated with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions and are generally equivalent to "proved reserves" (Energy Information Administration, 1987). See figure 1.

Indicated reserves.--Reserves in known productive reservoirs in existing fields, in addition to measured reserves, which are expected to respond to improved recovery techniques, such as fluid injection, 1) where an improved recovery technique has been installed but its effects are not yet known or 2) where an improved technique has been installed in another similar reservoir and the results of that installation can be used to estimate the quantity of additional resources. See figure 1.

Inferred reserves.--That part of the identified economic resources over and above measured and indicated reserves that will be added through extensions and revisions, and with the addition of new pay zones in discovered fields. See figure 1.

Cumulative probability distributions.--The resource estimates are derived in the form of cumulative probability distributions. These distributions include the resource estimates reported in this publication: a low estimate having a 95 percent probability (19 in 20 chance) of at least that amount (F_{95}), a high estimate having a 5 percent probability (1 in 20 chance) of at least that amount (F_5), and a mean estimate representing an average of all of the possible resource outcomes.

Risked (unconditional) estimates.--Estimates of the volumes of oil or natural gas that may exist in an area may incorporate the possibility that the area is devoid of oil or natural gas. The risked mean quantity may be determined through multiplication of the mean of a conditional distribution by the related marginal probability, however, other points of the risked distribution must be determined by use of probabilistic methods. Estimates presented in this report are risked (unconditional) estimates.

APPENDIX C: PRINCIPAL MAP SOURCES

Bureau of Land Management and U.S. Geological Survey (listed alphabetically, by State).

[Untitled Land Status Map], State of Alaska, 1974, Bureau of Land Management, Alaska State Office, Anchorage, Alaska, scale 1:2,500,000.

Alaska Federal Mineral Land Information System - Surface Ownership, State of Alaska, 1984, U.S. Geological Survey, preliminary map done in cooperation with BLM, EROS Data Center, Sioux Falls, South Dakota, scale 1:4,000,000 and 1:2,500,000.

Minerals Management Responsibility, State of Arizona, 1980, Bureau of Land Management, Arizona State Office, Phoenix, Arizona, scale 1:500,000.

Surface Management Responsibility, State of Arizona, 1980, Bureau of Land Management, Arizona State Office, Phoenix, Arizona, scale 1:500,000.

Federal Public Land Responsibility, State of California, 1978, Bureau of Land Management, California State Office, Sacramento, California, scale 1:750,000, (2 parts).

Land Status, State of Colorado, 1983, Bureau of Land Management, Colorado State Office, Denver, Colorado, scale 1:500,000.

Surface Management Responsibilities, State of Idaho, 1982, Bureau of Land Management, Idaho State Office, Boise, Idaho, scale 1:500,000.

Land Status, State of Montana, 1984, Bureau of Land Management, Montana State Office, Billings, Montana, scale 1:500,000, (2 parts).

Minerals Management, Northern Great Plains Resources Program, State of Montana, 1974, Bureau of Land Management, Montana State Office, Billings, Montana scale 1:500,000 (2 parts).

Land Status, State of New Mexico, 1982, Bureau of Land Management, New Mexico State Office, Santa Fe, New Mexico, scale 1:500,000.

Major Federal and State Lands, State of Oregon, 1983, Bureau of Land Management, Oregon State Office, Portland, Oregon, scale 1:500,000.

Areas of Responsibility and Land Status, State of Utah, 1977, Bureau of Land Management, Utah State Office, Salt Lake City, Utah, scale 1:500,000.

Minerals Status, State of Utah, 1983, Bureau of Land Management, Utah State Office, Salt Lake City, Utah, scale 1:500,000.

Land Status, State of Wyoming, 1975, Bureau of Land Management, Wyoming State Office, Cheyenne, Wyoming, scale 1:500,000.

Minerals Status, State of Wyoming, 1979, Bureau of Land Management, Wyoming State Office, Cheyenne, Wyoming, scale 1:500,000.

Surface Management Status and Mineral Management Status, 1975-1986, 30 x 60 minute quadrangle map series, variously BLM and USGS-BLM, [see Index to Intermediate-scale mapping: 1:100,000 scale quadrangle mapping, U.S. Geological Survey and Bureau of Land Management; available from USGS Map Sales, Denver, Colorado].

Quadrangle maps, various dates, 30 x 60 minute quadrangle map series, U.S. Geological Survey, scale 1:100,000, [see Index to Intermediate-scale mapping: U.S. Geological Survey and Bureau of Land Management; available from USGS Map Sales, Denver, Colorado].

State topographic maps, various dates, U.S. Geological Survey, scale 1:500,000.

American Petroleum Institute

Federal Land Status Maps of Alaska, Arizona, California, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming, 1981, American Petroleum Institute, Washington, D.C., scale 1:1,000,000, except for Alaska at 1:2,500,000.

Federal Land Status: Great Lakes States, 1981, American Petroleum Institute, Washington, D.C., scale 1:1,500,000.

Federal Land Status: Northeastern States, 1981, American Petroleum Institute, Washington, D.C., scale 1:1,500,000.

Federal Land Status: Southeastern states, 1981, American Petroleum Institute, Washington, D.C., scale 1:1,500,000.

State Agencies:

Land Status, State of Nevada, 1972, 2nd Edition, Nevada Bureau of Mines and Geology, University of Nevada, Reno, Nevada, scale 1:500,000.

Availability Status of Federal Land for Exploration and Development, State of Washington, (Banister, D.P., Barnes, D.J., and Longwill, W.D.), 1984, Washington State Department of Natural Resources and U.S. Bureau of Mines, State Division of Geology and Earth Sciences Geologic Map GM-30, scale 1:500,000.