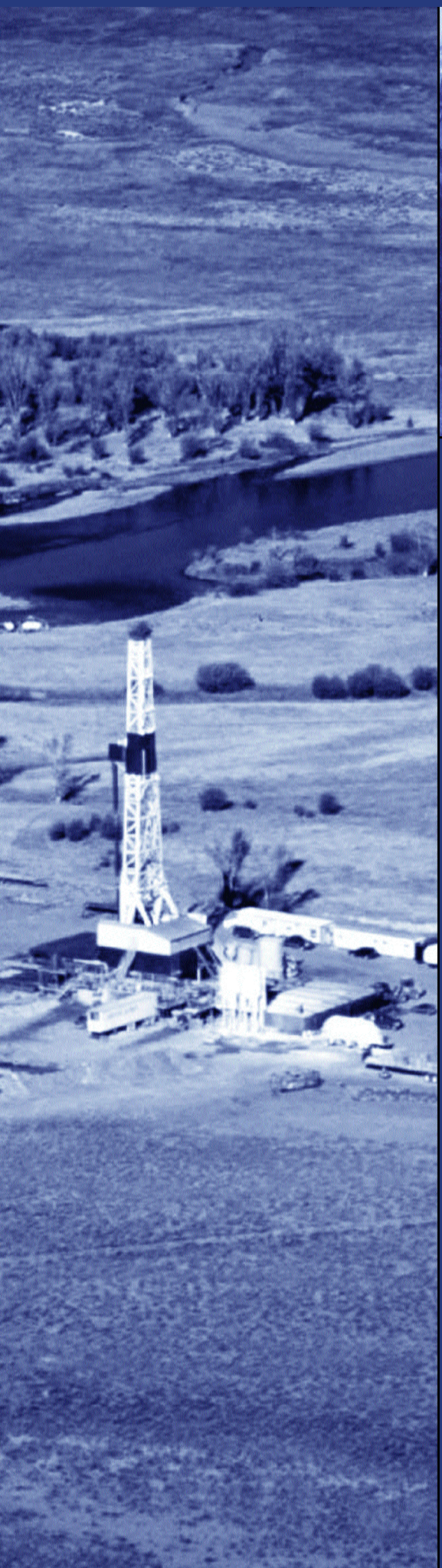

Energy & Western Wildlands:

A GIS Analysis of Economically Recoverable Oil and Gas

Economic Analysis

SCIENCE FROM

THE WILDERNESS SOCIETY

Energy & Western Wildlands:

A GIS Analysis of Economically Recoverable Oil and Gas

By
Pete Morton, Ph.D.
Chris Weller
and
Janice Thomson, Ph.D.

The Wilderness Society

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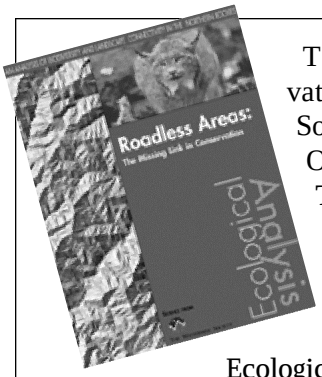
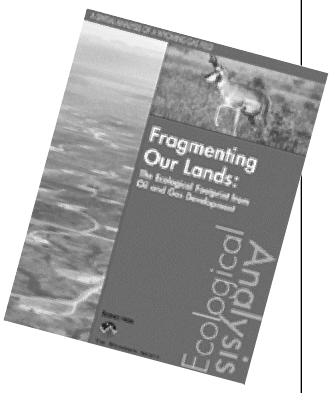


This science report is one of a series that stems from conservation research studies conducted by The Wilderness Society's Ecology and Economics Research Department. Other recent reports in the series include "Roadless Areas: The Missing Link in Conservation (An Analysis of Biodiversity and Landscape Connectivity in the Northern Rockies)" and "Fragmenting Our Lands: The Ecological Footprint from Oil and Gas Development (A Spatial Analysis of a Wyoming Gas Field)." These reports are available on The Wilderness Society website (www.wilderness.org) or from The Wilderness Society, Communications Department, 1615 M Street, NW, Washington, DC 20036 (202-833-2300 or 1-800-THE-WILD).



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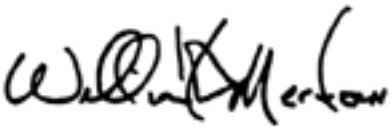
Preface

Recent debate surrounding our nation's domestic oil and gas supply has prompted renewed interest in potential energy resources on America's public lands. New national energy policy guidelines promote exploration and extraction in the remote wildlands of our national forests as well as in Presidentially designated national monuments in the American West.

"Energy and Western Wildlands: A GIS Analysis of Economically Recoverable Oil and Gas" assesses the gas and oil resources that lie under national forest roadless areas in six Rocky Mountain states as well as in fifteen national monuments located across the western United States. Using The Wilderness Society's state-of-the-art landscape analyses, the report provides a necessary link between the potential amount of gas and oil production from these inherently pristine places and total U.S. energy supply and consumption. This comprehensive analysis also examines industry access to potential energy resources in areas currently safeguarded by environmental stipulations in government leases.

Compiled by Resource Economist Pete Morton from our Four Corners Regional Office in Denver along with GIS Technician Chris Weller and Landscape Scientist Janice Thomson of the TWS Center for Landscape Analysis in Seattle, "Energy and Western Wildlands: A GIS Analysis of Economically Recoverable Oil and Gas" makes an important contribution to the public debate over energy resource extraction from our nation's wildlands and, accordingly, to the on-going formulation of national energy policy.



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Report Highlights

This report presents the findings from two analyses conducted by The Wilderness Society in relation to gas and oil resources on public lands in the American West.

The first analysis focused on potential economically recoverable gas and oil resources on national forest roadless areas in six Rocky Mountain States and 15 national monuments managed by the Bureau of Land Management in the western states. Our work clearly documents that the amount of natural gas and oil under the roadless areas and monuments is extremely small relative to U.S. demand. Among our key findings:

- Economically recoverable gas in national forest roadless areas of our study area would meet total U.S. gas consumption for about 9 to 11 weeks.
- Economically recoverable oil in those roadless areas would meet total U.S. oil consumption for less than 24 days.
- The 15 national monuments contain less than six days of gas use and 15 days of oil use for the United States.

Our second analysis focused on three recent reports that indicate substantial amounts of potential gas and oil resources are off limits to development, primarily because of environmental stipulations in government leases. We found that the reports failed to take into consideration a number of important criteria, including a full accounting of the costs of bringing the resources to market. A careful examination of their flawed assumptions and methods indicates that environmental stipulations do not pose a major roadblock to exploration and development of potential energy resources on public lands.

Common weaknesses among the reports include inappropriate use of technically recoverable gas rather than economically recoverable gas in reaching conclusions, a failure to consider improved access to gas from directional drilling and drill bit technology, and a failure to examine access to existing gas reserves.

We believe that the information documented through our analyses will lead to a more informed public debate as national energy policy emerges. The following recommendations are meant to improve assessments of the energy potential on public wildlands, including Bureau of Land Management studies mandated by the Energy Policy and Conservation Act of 1999. The goal is to improve the quality of information that will be included in the public debate.

- Begin the assessments with USGS mean estimates of economically recoverable resources.
- Include a full accounting of environmental costs in economic analyses.
- Include proven gas and oil reserves.
- Include both private and public lands.
- Take into account access that is available through directional drilling.
- Take into account the positive effect of emerging technology on access.
- Include an analysis of drilling opportunities.
- Collect baseline data and fund long-term monitoring.
- Increase assurance bonding requirements in government leases.

1. Introduction

This report presents the results of more than 18 months of research conducted by Wilderness Society scientists and economists with regard to potential gas and oil resources on western wildlands. The findings focus on economically recoverable gas and oil that remains undiscovered in national forest roadless areas managed by the U.S. Forest Service and in national monuments managed by the Bureau of Land Management (BLM). The report also addresses the question of access to gas and oil resources on public lands, with special attention on lease stipulations that are meant to protect the environment.

Much of our research was guided by the need to examine the explicit and implicit assumptions behind the National Energy Plan unveiled by the current administration in May 2001. That plan proposed 1,300 new power plants (approximately five a month over the next 20 years, including nuclear facilities), 38,000 miles of gas pipelines, and 263,000 miles of distribution lines. It called for oil drilling in the Arctic National Wildlife Refuge, the opening of more western public lands to gas and oil drilling, and the use of directional drilling as one means of reducing environmental impacts.

In relation to environmental safeguards, the plan required a review of the status of public lands (protected, partly protected, unprotected, etc.) and of lease stipulations that may impede industry access to potential gas and oil resources. Executive Order 13212, issued around the time of the National Energy Plan, required federal land management agencies to expedite their review of gas and oil exploration and development permits and thus accelerate completion of energy projects. A new White House task force was also established to oversee agency efforts to speed up the permit process.

The National Energy Plan was developed partly in response to public reaction to the cold winter and high energy prices of late 2000 and early 2001, and to the energy blackouts and brownouts that occurred in California as a result of deregulating the energy markets. At that time, forecasters predicted rolling blackouts across large portions of the country. Gas and home heating bills rose dramatically, primarily because of low inventories in underground storage (Morton 2002a).

In response to the perception of an energy crisis, the incoming administration vowed to analyze "every piece of property that is federal land and come up with a cost-benefit analysis" (Mikkelsen 2001). On June 6, 2001, the Department of Energy released a study, "Federal Lands Analysis, Natural Gas Assessment, Southern Wyoming and Northwestern Colorado," which alleged that various environmental safeguards in federal gas leases either place off limits or significantly restrict access to approximately 68 percent of federal gas resources in the Upper Green River Basin. The study implied that if these safeguards were reduced or removed, there would be a substantial increase in the nation's supply of available gas and, hence, a corresponding drop in energy prices for families and businesses.

At the same time, BLM listed 20 tasks to implement the National Energy Plan, including establishment of a charter team to evaluate bottlenecks and streamlining methods to help expedite the processing of drilling permits. In Utah, the BLM state director ordered employees to make the issuance of new drilling permits their highest priority. That office is currently offering leases in 12 proposed wilderness areas.

Against this background, The Wilderness Society undertook its energy research project that has resulted in testimony before Congress and several

▼
The National Energy Plan calls for opening up more western public lands to gas and oil drilling and for the use of directional drilling as a means to reduce environmental impacts.
▲

Missouri River winding through the "badlands" habitat of the Upper Missouri River Breaks National Monument, Montana. The Bureau of Land Management oversees this monument as part of the agency's National Landscape Conservation System.

publications. This report focuses on our top objective—to estimate how much of the undiscovered gas and oil in western wildlands is economical to extract—and a second objective to determine whether stipulations in gas and oil leases that are meant to protect the environment unduly limit industry access to potential gas and oil resources.

The report begins with a terminology section in which we establish that economically recoverable resources are the policy-relevant measure for assessments of undiscovered gas and oil in western wildlands. The next section describes the methods we used to estimate undiscovered economically recoverable gas and oil in western wildlands, focusing on national forest roadless areas and national monuments managed by BLM. Section 4 presents the results of the analysis. Section 5 addresses the issue of environmental stipulations and industry access to potential energy resources on public lands. We then make recommendations based on our findings that are aimed at improvements in the analytical processes that lead to estimates of gas and oil resources on public lands for use in emerging U.S. energy policy.

2. Terminology

Conventional and Unconventional Gas

The debate over energy on western public lands centers on methane (natural) gas.[1] Very little oil underlies those lands, and drilling for oil there will not reduce U.S. dependency on foreign oil.

Scientists at the U.S.Geological Survey (USGS) classify natural gas as conventional or unconventional, based on the technology used during extraction. Unconventional gas typically has higher production costs because it requires a significant degree of stimulation—hydraulic fracturing, for example, or other unconventional production techniques—to attain sufficient levels for economic production (Energy Information Administration 2001).

The two main unconventional gases are coal bed methane and continuous-type gas, commonly called tight sands (stone) gas.[2] Coal bed methane is a form of natural gas trapped within coal formations, while tight sands gas is trapped in low permeability sandstone. The Rocky Mountain states contain a very high proportion of unconventional gas resources, meaning that recovery will be subject to higher production costs and substantial uncertainty (LaTourrette et al. 2002).[3] Tight sands gas accounts for about 65 percent of the unproved technically recoverable natural gas resources in the Rockies. Conventional gas accounts for 19 percent of those resources, and coal bed methane for 16 percent (Energy Information Administration 2001).

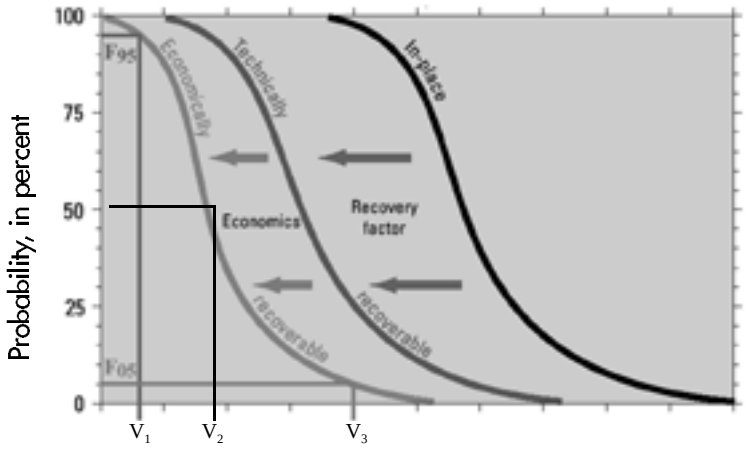
Discovered and Undiscovered Gas

There is a clear distinction between discovered gas reserves—known to be both technically and economically recoverable—located near existing pipelines, and undiscovered gas resources—yet to be proved either technically or economically recoverable—in distant wildlands far from markets.[4] This distinction takes on even more importance given the current focus on undiscovered resources on public lands and particularly in light of inadequate

FIGURE 1.

Gas volumes and probabilities for estimating undiscovered quantities

There is a 95% chance of at least V1 of economically recoverable gas, a 50% chance of at least V2 of economically recoverable gas, and a 5% chance of at least V3 of economically recoverable gas. Adapted from U.S. Geological Survey 2001.



[1] The principle hydrocarbons in natural gas are methane, ethane, butane, and pentanes (Attanasi 1998).

[2] Gas located in low permeability shales is an unconventional gas that is not discussed in this report because gas shales account for less than one percent of unproved gas in the American West (Energy Information Administration 2001).

[3] While unconventional gas is typically associated with high production costs, locating and drilling for coal bed methane from shallow coal beds has reduced the costs of producing coal bed methane gas from these wells.

[4] USGS (Attanasi 1998) defines reserves as "estimated quantities of crude oil, natural gas, or natural gas liquids which geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions."

consideration of the prominent role played by already-discovered and proven gas reserves in the overall supply picture.

Technically Recoverable and Economically Recoverable Gas

To estimate quantities of undiscovered resources, USGS makes a distinction between gas in place, technically recoverable gas, and economically recoverable gas (Figure 1). Gas in place includes gas that may exist underground but without consideration as to whether the gas can be extracted with current technology. Gas in place that is estimated to exist in sufficient quantities for recovery with current technology, but without regard to profit or extraction costs, is called technically recoverable gas. Technically recoverable gas estimated to be profitable to extract is called economically recoverable gas.

The costs that USGS uses to assess economically recoverable gas and oil include the direct costs of exploration, development, and production at the wellhead, plus a profit margin. It is important to note that USGS estimates do not include transportation costs, nonmarket costs, or off-site mitigation costs such as increased water treatment costs.

To be profitable to extract, gas resources must either be located close to existing extraction and transportation infrastructure or be profitable after all necessary infrastructure augmentation costs are accounted for (LaTourrette et al. 2002).

The USGS 50-percent estimate (the mean, see Figure 1) for economically recoverable gas represents the best unbiased estimate currently available.[5] Estimated quantities of undiscovered gas or oil that are based on the five-percent probability shown in Figure 1 should be viewed with skepticism. Such estimates are expected to be wrong 19 out of 20 times.

To account for the uncertainty inherent in price forecasts, USGS uses a range of prices, rather than a single-point estimate, to attain its estimates of economically recoverable gas. According to USGS, 39 percent to 66 percent of undiscovered technically recoverable gas, both conventional and unconventional, in the lower 48 states can be extracted profitably when prices (adjusted for inflation to 2002 dollars) are between $2.17 and $3.62 per thousand cubic feet (mcf) (Attanasi 1998).

As context, from 1996 to 1999, wellhead gas prices in the United States averaged about $2.16 per mcf, with $2.00 per mcf viewed as the long-term price trend (Energy Information Administration 2002). At these prices, more than 60 percent of technically recoverable gas in the lower 48 states cannot be extracted profitably regardless of environmental regulations.

Economically Recoverable Gas: The Appropriate Starting Place

The opportunity cost of a policy or action that protects the environment equals the net benefits that are foregone as a consequence of that policy or action. Therefore, the opportunity cost to protect roadless areas, monuments, wilderness, wildlife, watersheds, or other aspects of the environment is the amount of economically recoverable gas that is foregone as a result of such actions, not the amount of gas that is technically recoverable.

The incorrect use of technically recoverable gas, rather than economically recoverable gas, in the determination of opportunity costs is similar to the incorrect use of gross revenues, rather than net

Based on long-term price trends, more than 60 percent of technically recoverable gas in the lower 48 states cannot be extracted profitably regardless of environmental regulations.

[5] The mean is technically an average for the mathematically derived probability distribution that is generally close to the 50-percent probability. However, the statistical procedure used to derive mean estimates tends to produce a number that is larger than the outcome of estimates with a 50-percent probability (Economic Associates, Inc. 1982).

revenues, in evaluations of regulations or decisions to limit access to gas resources. One example is estimates of revenues and jobs from a proposed coal mine in the Grand Staircase-Escalante National Monument, which were based on technically recoverable coal, ignoring the high transportation costs associated with bringing the coal to market (Duffield et al. 1995). In numerous other cases, the costs of bringing undiscovered resources to the market place, if properly included in economic analyses, cause the opportunity costs associated with designation of national monuments, protection of roadless areas, and conservation of wildlife habitat to drop dramatically.[6]

The Congressional Research Service (Corn et al. 2001) recommends economically recoverable resources as the basis of policy analysis. Virtually every report on gas supply in the past 20 years has reported results in terms of economically recoverable resources (Environmental Law Institute 1999). If economic constraints on production are ignored, resource assessments will overestimate the quantity of gas that is potentially off limits because of its location in a protected area.

An economic analysis of recoverable gas must include a full accounting of the non-market costs, as well as those more readily observed and measured in market prices (Loomis 1993). In contrast, a financial analysis examines only costs and benefits as measured by market price. Because the USGS economic analysis excludes non-market costs, it more closely resembles a financial analysis than an economic analysis. Therefore, USGS estimates are just the starting point to determine whether undiscovered gas is economically viable to extract.

A more accurate estimate of economically recoverable gas should include a full accounting of all the hidden, non-market costs, including the costs associated with erosion, declining water and air quality, and loss of wildlife habitat. To account for the full array of costs and benefits, economists have derived a "total economic valuation framework" (Krutilla 1967, Randall and Stoll 1983, Peterson and Sorg 1987, Loomis and Walsh 1992) as the appropriate measure to compare wilderness benefits to opportunity costs in relation to the energy resources foregone.

[6] Rosy supply forecasts also tend to drop when economics are taken into account. Consider the bold predictions from the oil industry in the early 1980s about the huge supply of oil from oil shales in western Colorado and then the oil shale bust a few years later. Oil shale deposits, while perhaps technically recoverable, could not be extracted profitably.

3. Methods

GIS Data and Methods

In January 2001, The Wilderness Society undertook a Geographic Information System (GIS) mapping assessment of the energy potential on western federal lands. We used government data to complete a GIS overlay analysis of gas and oil plays within the boundaries of roadless areas in six Rocky Mountain states (Montana, North Dakota, Wyoming, Utah, Colorado, and New Mexico) and in 15 national monuments managed by the BLM in Oregon, California, Idaho, Utah, Montana, Colorado, New Mexico, and Arizona (Figure 2).

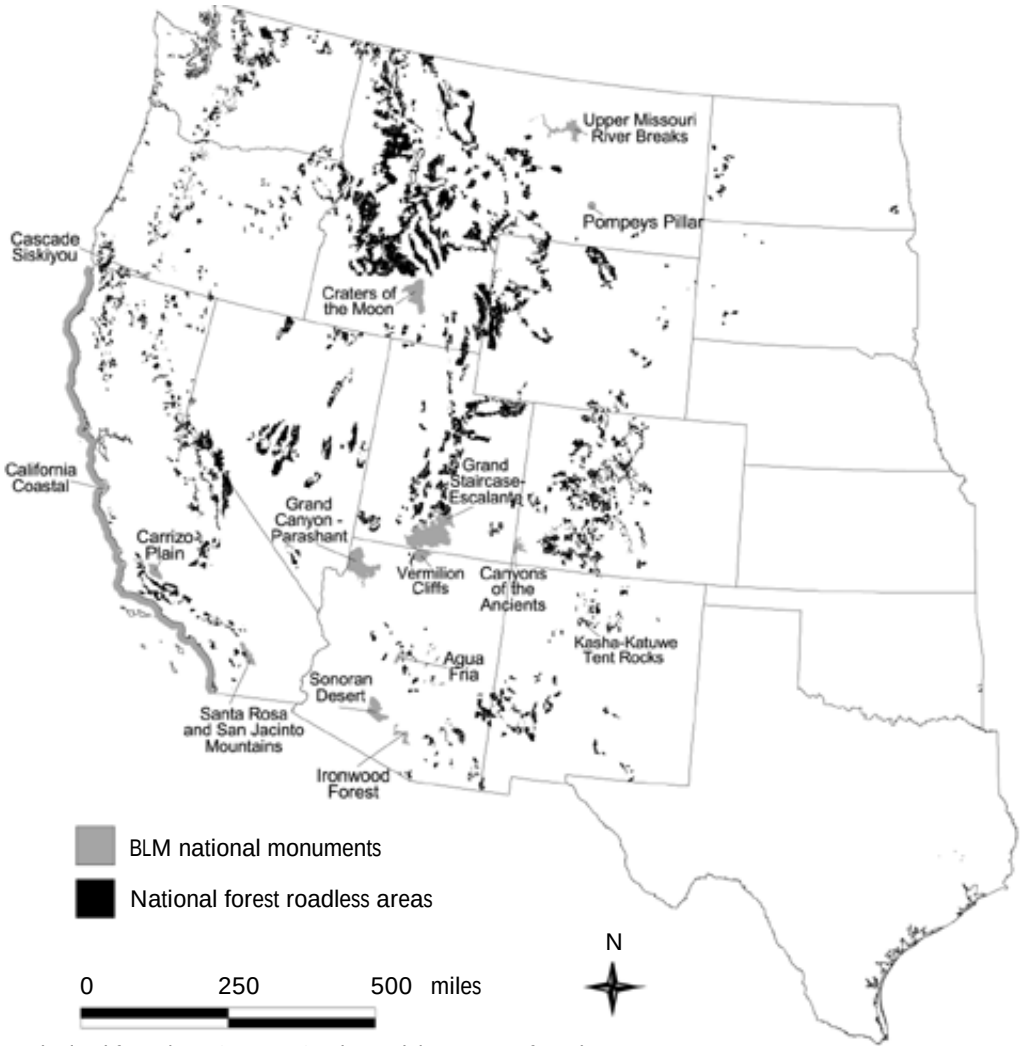
We obtained data on undiscovered gas and oil resources from the USGS 1995 National Assessment of United States Oil and Gas Resources (U.S. Geological Survey 1996), which divided the country into eight regions and subdivided those regions into 72 geologic provinces.

Each province contains a number of individual plays. USGS defines plays as a set of known or postulated accumulations of gas or oil that share similar geologic, geographic, and temporal properties. The significance of play analysis is that it links statistics of gas and oil exploration and development to geological expertise (Gautier 1997). Figure 3 shows a series of hypothetical gas plays as they might exist underground.

For our roadless area analysis, we obtained a separate GIS coverage in ArcInfo export format for each of the 200 plays in the six states of our study area. These coverages define the boundaries of the gas and oil plays. We downloaded the National Inventoried Roadless Areas GIS coverage for all of the lower 48 states in ArcInfo export format from the USDA Forest Service Roadless Area Conservation website. Additional play coverages from the USGS were used for our analysis of national monuments, and we also obtained boundaries for those monuments in a single shape file from the

FIGURE 2.

National monuments managed by the BLM and national forest roadless areas in the western United States



Data obtained from the U.S. Forest Service and the Bureau of Land Management.

BLM. These data were converted to an ArcInfo coverage prior to conducting the analysis.

We used GIS and ArcInfo software to determine the area of overlap between the inventoried roadless areas and gas and oil plays. We clipped the roadless area coverage to the boundary of each of the six states in the study area to create roadless area coverages for each state. The state coverages were then overlaid with each play in the corresponding state to identify any roadless areas that overlap plays. We could not append the plays into a single gas and oil coverage because different plays are located within different geologic formations. Therefore, their geographic boundaries often overlap each other.

We used the area of intersection, estimated in the overlay analyses, to calculate the number of acres of each play that lie within a roadless area, as well as the number of acres of each individual roadless area that overlap with different plays. We also determined the total acres of each play to obtain the percent of each play that coincides with roadless areas. To estimate technically recoverable gas and oil resources in roadless areas, we multiplied the overlay percentages by the estimated gas and oil resources for each play, taken from the USGS 1995 assessment.

Figures 4 and 5 and Table 1 illustrate how the GIS overlay analysis was used to estimate gas and oil resources. Our estimates are based on the USGS mean value (estimated with a 50-percent probability) for the gas and oil resources.

We developed economic recovery rates to convert our estimates of technically recoverable gas to estimates of economically recoverable gas. Our recovery rates equal the percent of technically recoverable gas that USGS estimates to be economically recoverable based on the agency's financial cost functions developed for gas and oil provinces (Attanasi 1998).

FIGURE 3.

Cross-sectional view of oil and gas plays as they might exist underground

The plays we examined were located anywhere from several hundred feet to more than 25,000 feet below the surface.

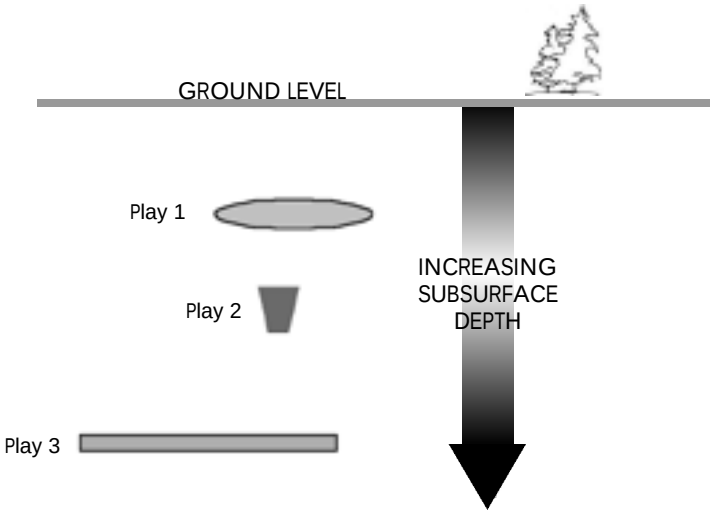


FIGURE 4.

Overhead view of three hypothetical gas plays

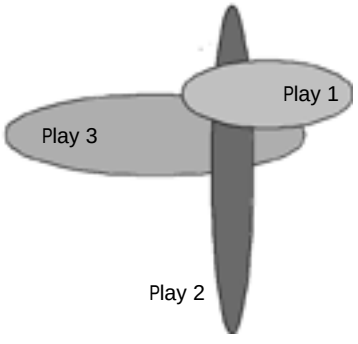


FIGURE 5.

Overhead view of gas plays with hypothetical roadless area overlay

The results of the overlay are shown in Table 1.

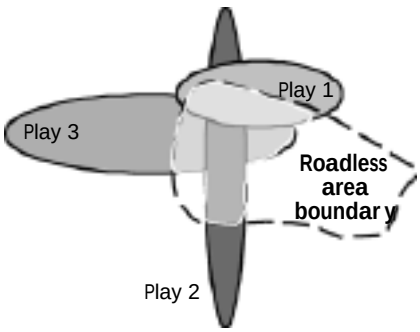


TABLE 1.

Sample calculation of gas in a hypothetical roadless area

All numbers represent thousand cubic feet.

Play	Gas in play	Percent of play in roadless area	Gas in roadless area
1	100	45	45
2	300	60	180
3	200	40	80
Total gas in roadless area			**305**

We used the USGS low and high price scenario to provide a range of estimates for the undiscovered gas and oil that is economically recoverable and adjusted those prices to 2002 dollars. Our estimates are thus based on prices of $2.17 (low end) and $3.62 (high end) per mcf of gas and on prices of $19.50 or $32.50 per barrel of oil.

Our gas resource estimates combine conventional and unconventional gas, including both tight sands gas and coal bed methane. We combined conventional and unconventional oil with natural gas liquids to derive estimates for the oil resource.

Assumptions

It was necessary to make several assumptions to complete our analysis. First, we assumed that gas and oil quantities are distributed evenly across a play. The U.S. Department of Energy (2001) and the National Petroleum Council (1999) used similar assumptions in their reports, and such assumptions will be used in upcoming BLM studies of gas on western wildlands that are required by the Energy Policy Conservation Act of 1999 (see pages 22 and 23 of this report). Nevertheless, we recognize the potential error associated with this assumption and consider our gas and oil estimates "first order" estimates useful for policy analysis.

Second, and as noted earlier, we assumed that the USGS estimates of the mean expected value of undiscovered economically recoverable gas and oil provide the best, unbiased estimate available.[7] As Gautier (1997) notes:

> Data assembled by scientists at the U.S. Geological Survey for use in the National Oil and Gas Assessment are useful for other purposes as well. In fact, the U.S. Geological Survey is uniquely positioned to provide users, especially land-use managers, an historical view of a specified area of interest in combination with a look at possible future oil and gas activity. The capability to study an area prospectively and retrospectively is the real power of national assessment data files.

Third, we assumed that economic recovery rates estimated with USGS data apply to economic recovery of gas and oil for all plays within a province. This assumption should lead to more reliable results than use of national averages to estimate economically recoverable gas in a region.

We also assumed that USGS estimates for economically recoverable gas and oil fully account for all of the market costs associated with extracting gas and oil. The costs of exploration, development, and production that USGS used to assess economically recoverable gas and oil do not include the costs of transporting gas and oil from the wellhead to the marketplace. If those costs were included, the amount of economically recoverable gas would likely drop, perhaps significantly in relation to remote wildlands.[8]

---

[7] The USGS gas estimates do not include carbon dioxide, which is produced and sometimes released into the atmosphere as part of the gas and oil production process. For some wells, carbon dioxide is the primary commercial product. For example, much of the gas produced in the Canyons of the Ancients National Monument is carbon dioxide that is piped, primarily to Texas, for injection back into the ground for enhanced recovery of oil.

[8] The Rocky Mountain region lacks pipeline infrastructure relative to other regions of the country. In 2002, the Federal Energy Regulatory Commission approved a doubling of the capacity of the Kern River Pipeline by extending the pipeline 716 miles through Wyoming, Utah, Nevada, and California. But low prices for gas increase the risk to investors and may slow down or prevent the project from proceeding.

Finally, we assumed that USGS economic estimates fully account for the non-market costs associated with extracting gas and oil. We know, however, that the USGS economic calculus does not include non-market costs that arise when energy resource extraction causes negative impacts on public resources such as watersheds. If those costs were included in the USGS economic analysis, the economically recoverable quantities of gas and oil reported here would be smaller.

We understand the significance of our assumptions and make recommendations at the end of this report to improve the USGS economic analysis and other energy resource assessment processes.

4. Results

National Forest Roadless Areas

We merged all of the gas and oil plays in the six Rocky Mountain states of our study area into one layer. The objective was to show all land with energy potential. We then incorporated the GIS layer that includes roadless areas. As Figure 6 illustrates, national forest roadless areas account for less than four percent of all land in the six-state study area that has gas and oil potential. (Similar estimates and maps for all Rocky Mountain states are located at The Wilderness Society's website: www.wilderness.org /standbylands/roadless/.

Table 2 shows estimates of the quantities of undiscovered gas and oil that can be extracted profitably from national forest roadless areas in the study area. (See Appendix for state-by-state summaries.) Using the low-end and high-end prices for gas discussed on pages 5 and 9, roadless areas in the six states contain approximately 3.9 trillion cubic feet to 4.9 trillion cubic feet of economically recoverable gas. That equals 48 percent to 59 percent of the technically recoverable gas in the roadless areas.

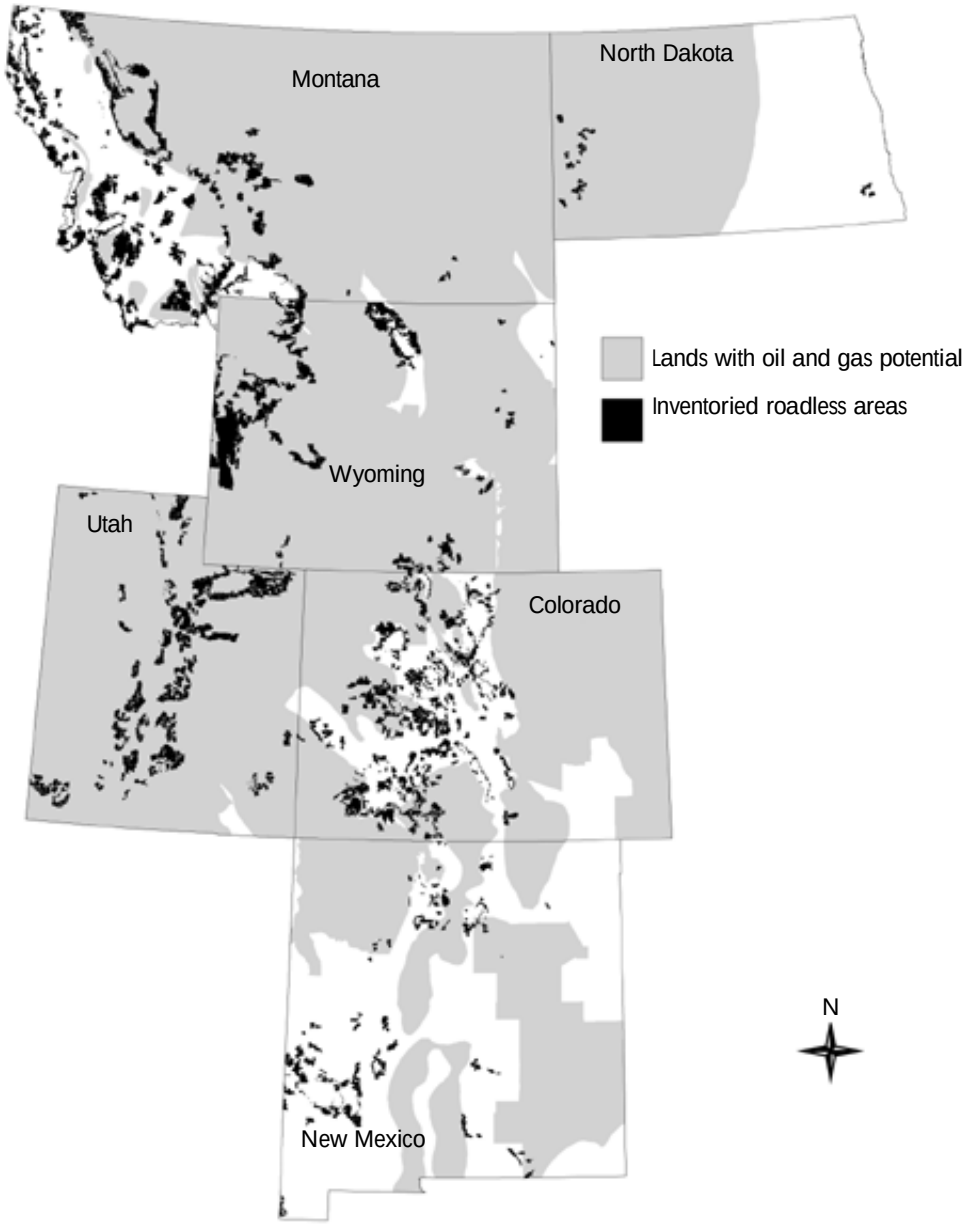
The roadless areas contain approximately 410 million barrels to 478 million barrels of economically recoverable oil, representing 69 percent to 81 percent of the technically recoverable oil in the roadless areas.

National forest roadless areas in Wyoming and Colorado contain the majority of economically recoverable gas and oil, much of which is located in the

FIGURE 6.

Potential gas and oil resources and roadless areas in six Rocky Mountain states

National forest roadless areas account for less than four percent of the land that has gas and oil potential.



Data obtained from the U.S. Forest Service and the U.S. Geological Survey.

TABLE 2.

Estimates of economically recoverable gas and oil on national forest roadless areas in six Rocky Mountain states [a]

Resource	Economically recoverable Economically recoverable quantity	Economically recoverable as % of technically recoverable (as %)	in relation to total U.S. consumption (in days)
Conventional gas	3,223 – 3,665 billion cubic feet	74 – 84	52 – 59
Tight sands gas	199 – 285 billion cubic feet	8 – 11	3 – 5
Coal bed methane gas	500 – 943 billion cubic feet	41 – 77	8 – 15
Total Gas	**3,922 – 4,893 billion cubic feet**	**48 – 59**	**63 – 79**
Oil and natural gas liquids	410 – 478 million barrels	69 – 81	21 – 24

[a] Montana, North Dakota, Wyoming, Utah, Colorado, and New Mexico

TABLE 3.

Estimates of economically recoverable gas and oil in 15 national monuments managed by the Bureau of Land Management

Monument	Economically recoverable in relation to total U.S. consumption	
	Oil	**Gas**
Agua Fria, AZ	0	0
Canyons of Ancients, CO	1 - 3 hours	2 - 8 hours
Carrizo Plain, CA	10 - 18 hours	2 - 4 days
Cascade-Siskiyou, OR	0	0
Craters of the Moon, ID	0	0
Grand Canyon-Parashant, AZ	Less than 1 minute	10 - 15 minutes
Grand Staircase-Escalante, UT	0 - 1 hour	1 - 4 hours
Ironwood Forest, AZ	0	0
Kasha-Katuwe Tent Rocks, NM	Less than 1 minute	Less than 1 minute
Pompeys Pillar, MT	Less than 1 minute	Less than 1 minute
Santa Rosa/San Jacinto Mts, CA	0	0
Sonoran Desert, AZ	0	0
Upper Missouri River Breaks, MT	12 - 14 hours	18 - 65 minutes
Vermilion Cliffs, AZ	0 - 8 minutes	0 - 10 minutes
Subtotal	**11 - 13 hours**	**1.3 - 2.5 days**
California Coastal (with state waters)[a]	3.4 - 5.3 days	8.2 - 12.5 days
Total (with California state waters)	**3.9 - 5.8 days**	**9.6 - 15.1 days**

[a] These estimates dramatically overestimate the amount of gas and oil in the California Coastal National Monument. Not only do the estimates include state waters, but they ignore the legal and technical difficulties that will come from drilling small islands and rock formations along the coast of California.

Bridger-Teton National Forest south of Jackson Hole, Wyoming, and the San Juan National Forest near Durango, Colorado.

What does this mean to the total demand for gas and oil in the United States? Based on current energy consumption rates, economically recoverable gas in these roadless areas would meet total U.S. gas consumption for about 9 to 11 weeks. Economically recoverable oil in the roadless areas would meet total U.S. oil consumption for 21 days to 24 days.

Obviously, the gas would be produced over a much longer period of time, but this estimate provides an indication of the relatively small amount of economically recoverable gas and oil in national forest roadless areas.

National Monuments

We repeated our analysis for the 15 recently designated national monuments managed by BLM (Table 3). Our results indicate that these monuments contain, from a national perspective, less than 15

days of oil use and six days of gas use. (For additional information, visit The Wilderness Society web site: www.wilderness.org/standbylands/monuments/.)

A word of caution, however. These estimates are far too high. Because of spatial inaccuracies in the GIS layer, our estimate for the California Coastal National Monument includes energy resources underlying California State waters. The GIS analysis was completed using a single polygon for the hundreds of individual polygons needed to represent the islands and rocks that are included as part of the monument. Much of the area in the overlay therefore included state waters that extend three miles out from shore. If a more accurate boundary were used, the amount of gas and oil in the California Coastal National Monument as well as the total for all monuments would drop dramatically.

There are some who contend that the Grand Staircase-Escalante National Monument contains coal and hence coal bed methane. We agree with the USGS conclusion: there is no economically recoverable gas in that monument. If, in fact, the gas exists and is technically recoverable, it is unlikely to be economically viable to bring to market because of high transportation costs (see Duffield et al. 1995).

5. Access to Western Public Lands

Closely related to the issue of how much gas and oil exists on wildlands is the topic of industry access to those potential energy resources. To determine how accessible public lands in the Rocky Mountains are, we first provide a review of western public land acres that are open to gas and oil leasing and a summary of recent trends in approved drilling permits. We examine lease stipulations that are the focus of industry criticism and then assess three recent reports that examine access to public lands. Although the reports used similar methods, changes in parameters and assumptions led to a gradual increase in the amount of gas estimated to be off limits.

Public Lands Under Lease

There are currently 94,000 producing gas and oil wells on public land that account for 11 percent of the nation's natural gas production and five percent of its oil production (Bureau of Land Management 2002). In addition, the BLM sells leases that give private parties contractual rights to explore, develop, and sell the gas or oil that may be located on national forest and BLM-managed public lands.

The amount of national forest land across the country that is under gas and oil leases dropped from 35 million acres in the mid-1980s to about five million acres today, primarily because of higher production costs and low prices (USDA Forest Service 2001). There are currently 759,000 acres of national forest roadless areas under lease (USDA Forest Service 2001). Most of these areas are in the agency's Intermountain, Northern, and Rocky Mountain regions that include the states of Idaho, Utah, Montana, North Dakota, Wyoming, and Colorado.

In 2000, approximately 35 million acres of the vast and biologically significant public rangelands, prairies, and desertlands managed by the BLM were under lease for gas and oil development (Bureau of Land Management 2000). In fiscal years 2000 and 2001, the BLM issued leases on more than 8,300 parcels covering 9.7 million acres of public land (Bureau of Land Management 2002).

Environmental Stipulations

As part of the leasing process, BLM or Forest Service officials may subject the leases to environmental stipulations that are meant to protect wildlife and the environment by stating where, how, and when drilling activities may occur. Such stipulations, designed by agency professionals, may include seasonal closures of critical habitat to benefit wildlife such as elk, antelope, and sage grouse; no surface occupancy provisions to protect campgrounds and recreation areas; and controlled use provisions to protect archaeological and other important cultural sites.

Lease stipulations also help ensure the protection of watersheds and of recreation activities such as fishing and hunting that have substantial economic benefits and that add to the quality of life for local residents and visitors. The box on page 15 briefly describes several typical lease stipulations.

In 1995 the BLM completed an assessment of the leasing stipulations for public lands that the agency manages in Colorado, Montana, New Mexico, Utah,

TABLE 4.

BLM acreage by type of gas and oil lease stipulations, 1995

State	Standard stipulations (% of total)	Seasonal and other stipulations (% of total)	No surface occupancy (% of total)	Off limits (% of total)
Colorado	45	46	5	4
Montana	58	38	2	2
New Mexico	84	10	1	5
Utah	64	26	6	4
Wyoming	49	46	3	3
Five-state total	**61**	**32**	**3**	**4**

Source: Bureau of Land Management 1995

and Wyoming and found that 61 percent of that land can be leased under standard stipulations (Table 4). Thirty-two percent of the land would be leased under seasonal stipulations, and three percent under no surface occupancy stipulations. Just four percent is off-limits. Based on these findings, more than 95 percent of public land managed by the BLM is open to gas and oil leasing in the five states.

Once a tract is leased, firms submit applications for permits to drill. In FY 2001, the BLM issued 4,800 new drilling permits (Bureau of Land Management 2002). Between June 2000 and May 2002, approximately 17,000 permits for drilling on public and private land in Wyoming were approved (Wyoming Oil and Gas Commission 2002). During 2000 and 2001, approximately 1,600 drilling permits were approved in Utah and 3,800 in Colorado (Utah Oil and Gas Commission 2002, Colorado Oil and Gas Conservation Commission 2002). In total, more than 22,000 drilling permits were issued in these three states in just the last two years.

Terms and stipulations included in gas and oil leases

Standard lease terms apply to all BLM gas and oil leases. They include prohibitions against construction when the soil is saturated and against drilling within 500 feet of water and riparian areas, on slopes exceeding 25 percent gradient, and within one-quarter mile of an occupied dwelling.

Seasonal stipulations limit energy exploration and development for specific periods of time in specific areas; for example, in sage grouse strutting areas when in use, hawk nesting areas when in use, and calving habitat for big game wildlife species when in use. Seasonal stipulations are often imposed at the request of state wildlife officials and to comply with U.S. Fish and Wildlife Service requests to protect sensitive species. Seasonal timing stipulations are only applied during the exploratory and development drilling phases of operations for undiscovered gas and oil. They do not apply to production of gas from discovered reserves.

No surface occupancy provisions prohibit operations directly on the surface of a leased tract to protect other operations or resources such as underground mining operations, archeological sites, caves, recreation areas, steep slopes, campsites, and important wildlife habitat. However, these stipulations allow directional drilling from off-site locations.

Controlled surface use provisions prohibit drilling in certain sections of a leased area; as examples, a buffer zone surrounding a wetland or a stream and a buffer zone around a campground or recreation area.

Off limits provisions apply to lands in Wilderness Study Areas, designated Wilderness areas, national monuments, and incorporated cities and towns.

Three Access Reports

Despite the obvious public benefits of lease stipulations, some energy developers state that the stipulations prevent access. Several industry and government reports have examined the issue of access. Below we briefly summarize three recent reports and present a critique of their assumptions and methods.

Access to Gas in the Rocky Mountains (National Petroleum Council 1999)

The purpose of the National Petroleum Council (NPC), a federally chartered and privately funded advisory committee, is to "solely represent the views of the oil and natural gas industries in advising, informing, and making recommendations to the Secretary of Energy" (National Petroleum Council 2002). For its 1999 gas report, NPC contracted with a consulting firm to estimate gas resources in the Rocky Mountains that are inaccessible to industry (Advanced Resources International 1999).

The study examined six "calibration areas" representing about 1.5 million acres, and then assumed the results from the calibration areas applied to all 14.8 million acres of federal public land in the Rocky Mountain states of Montana, Wyoming, Colorado, Utah, and New Mexico.[9]

The results indicated that 60 percent of the undiscovered gas on federal lands in the Rocky Mountains is accessible

[9] The six calibration areas include three BLM districts (Pinedale and Rock Springs in Wyoming and Price in Utah) and three Forest Service districts (Bridger-Teton in Wyoming and Manti-La Sal and Uinta in Utah).

TABLE 5.

Estimates of access to gas resources in the western United States [a]

Study (year)	Area covered	Area available for leasing (%)	Comment[b]
BLM (1995)	Rocky Mt. BLM Land	95	Acres open
NPC (1999)	Rocky Mt. Region	91	PUB, UTR, NSD
DOE (2001)[c]	Green River (WY, CO)	71	Base case, PUB, UTR, NSD
DOE (2001)[c]	Green River (WY, CO)	79	Sensitive case, PUB, UTR, 1/4-mile SD
DOE (2001)[c]	Green River (WY,CO)	83	Sensitive Case, PUB, UTR, 1/4-mile SD, PR
EIA (2001)	Rocky Mt. Region	69	PUB, PR, UTR, NSD, RE

[a] Estimates vary because of different assumptions and methods in the studies.
[b] PUB = public land, PR = private land, RE= reserves, UTR = undiscovered technically recoverable, SD = slant drilling, NSD = no slant drilling
[c] See discussion on this page.

under standard leasing terms, 32 percent is accessible subject to seasonal stipulations, and nine percent is inaccessible. In other words, the study estimated that more than 90 percent of the potential undiscovered gas resource on federal public land in the Rockies is available for leasing.

Access to Gas in the Upper Green River Basin (U.S. Department of Energy 2001)

In June 2001, the Department of Energy (DOE) released a report on access to gas resources in the Upper Green River Basin in southwestern Wyoming and northwestern Colorado. The report came out two weeks after the unveiling of the administration's National Energy Plan that called for an examination of access to public land. Advanced Resources International (2001a) prepared the report, and it is very similar to the study that company completed for NPC in 1999. However, some assumptions were changed, and as a result, estimates of inaccessible gas increased.

The DOE report contained the results of two analyses, a base case and a sensitivity case. The base case analysis suggests that 32 percent of the undiscovered technically recoverable gas on federal lands in the Upper Green River Basin is accessible under standard leasing terms and 37 percent under seasonal stipulations. Twenty-nine percent of the undiscovered gas was estimated to be inaccessible. Based on the DOE base case, 71 percent of gas resource on public land in the Upper Green River is available for energy leasing.

In the sensitivity case analysis, assumptions were relaxed to reflect actual conditions more closely than under the base case. Results of the sensitivity case analysis suggested that approximately 79 percent of the undiscovered technically recoverable gas is available for leasing.

Access to Gas in the Rocky Mountains (Energy Information Administration 2001)

In December 2001, the Energy Information Administration released a report that included an examination of the impacts of removing federal restrictions on access to gas resources in the Rocky Mountains states of Arizona, Colorado, Idaho, Montana, Nevada, western New Mexico, North Dakota, South Dakota, Utah, and Wyoming. EIA based its impact analysis on a July 2001 report (Advanced Resources International 2001a) from the same consulting firm responsible for the access studies in the 1999 NPC report and the 2001 DOE Green River report.

EIA estimated that 52 percent of the unproved technically recoverable gas in the report's study area is available under standard leasing terms, while 17 percent is

available with seasonal stipulations. The report included a new category called "no access-de facto" that accounts for 20 percent of the unproved gas in the study area, while the "no access-legal" category accounts for 11 percent of the total.[10]

Based on the access categories and methods used by EIA, the amount of potential gas in the Rocky Mountains that is available for leasing drops to 69 percent. The newly created "no access-de facto" category represents almost two-thirds of the unproved technically recoverable gas estimated to be inaccessible. Legal and no surface occupancy stipulations account for the remaining third.

Critique

Table 5 summarizes estimates regarding access to gas resources in the western United States from the three studies just described and from the 1995 BLM study. The estimates vary because of different methods and assumptions used in each study. Not included in the table are estimates that BLM is preparing for five basins in the Rocky Mountains as required by the Energy Policy and Conservation Act of 1999 (see pages 22 and 23 of this report).

Common weaknesses among the reports include inappropriate use of technically recoverable gas rather than economically recoverable gas in reaching conclusions, a failure to consider improved access from directional drilling and drill bit technology, and a failure to examine access to existing gas reserves.

The reports also fail to analyze directly observable, easily measured indicators of access to gas resources such as drilling permits approved by the BLM and oil and gas conservation commissions in each state, which have greatly expanded access to public and private lands in the West.

Failure to Examine Access to Economically Recoverable Gas

Undiscovered gas in wildlands may or may not be technically recoverable. But if the USGS estimates that the gas is not profitable to extract to begin with, there are no adverse impacts on gas supply from any additional costs associated with lease stipulations designed to protect wildlife, archeological sites, recreation sites, and other public resources. Lack of access is not an issue.

A major flaw in the NPC, DOE, and EIA reports is that they failed to fully account for the financial constraints on production and therefore overestimated the quantity of gas that is potentially off limits.[11] For gas to be considered profitable to recover, the full costs of gas recovery must be less than or equal to the price for gas. In the Rocky Mountains, the USGS estimates that less than 20 percent of technically recoverable gas is economically recoverable (Table 6).

TABLE 6.

Economic recovery rates for technically recoverable gas based on prices of $2.17 and $3.62 per thousand cubic feet [a]

Region USGS	Economic recovery rates[b]
United States	38% - 46%
Rockies and Northern Plains	13% - 18%
Southwestern Wyoming	1% - 5%

[a] 2002 dollars

[b] Percent of technically recoverable gas in reserves and gas left undiscovered that is profitable to extract (before accounting for environmental costs). Excludes recovery rates for off-shore gas.

Source: Root et al. 1997, Attanasi 1998, LaTourrette et al. 2002

In other words, more than 80 percent of the gas is off limits simply because it cannot be extracted profitably, even before environmental costs are considered. Why such a low economic recovery rate in this region? Primarily because most of the gas is unconventional (tight sands gas and coal bed gas), which generally costs more to extract than the price paid for the gas, and because in more remote areas, it is costly to transport the gas to market.

[10] Gas resources that are estimated to exist but have not yet been proven to exist are called "unproved resources" (Energy Information Administration 2001).

[11] The consultant's study for the EIA 2002 report did not consider economics. However, the market assessment completed by EIA did consider extraction costs.

In the Upper Green River basin of Wyoming and Colorado, 90 percent of the technically recoverable gas is tight sands gas located in low permeability geologic strata (U.S. Department of Energy 2001). Based on recovery rates estimated for southwestern Wyoming, more than 95 percent of the gas is off limits because of economic constraints (LaTourrette et al. 2002).

The Green River study area also contains coal bed methane, but most of the coal fields are more than 5,000 feet underground. In the Rockies, USGS scientists (Attanasi 1998) estimate that, at prices of $2.17 and $3.62 per mcf, between 34 percent and 77 percent of the technically recoverable coal bed methane is profitable to extract.

However, under current market conditions it is not profitable to drill for coal bed methane located more than 5,000 feet underground (Silverman 2002). Therefore, coal bed methane located 10,000 feet underneath, say, a sage grouse lek will not be produced in the current market regardless of whether seasonal stipulations to protect sage grouse are waived. When economic realities such as the costs of drilling deeper wells are factored in, the actual impacts on gas supplies from lease stipulations to protect the environment are significantly less than estimated in the DOE Green River report.

Failure to Consider Open Access to Proven Gas Reserves

Gas in proven reserves is already economically viable to produce. But the NPC and DOE reports failed to discuss open access to the discovered gas reserves in developed gas fields.[12] Instead the reports focused exclusively on access to more speculative undiscovered gas, bringing into question the accuracy of their estimates.

A major consequence of excluding proven gas reserves and growth in those reserves from resource assessments is to overestimate the impact of lease stipulations on access to economically viable gas resources (LaTourrette et al. 2002). The 68 percent figure cited by DOE, for example, stems from an incomplete analysis that overstates the amount of gas potentially off limits because it did not examine access to all gas resources readily available to industry in developed fields.

Failure to Consider Access Available through Directional Drilling Technology

History has shown that advances in drilling technology, including directional and slant drilling, have increased industry's ability to access resources several miles away from a drill site. Nevertheless, the NPC, DOE, and EIA reports did not take into account access that occurs because of directional or slant drilling technology. This failure moved all gas leases managed with no surface occupancy stipulations into the no access legal category and exaggerated the amount of the potential gas resource that is off limits.[13]

The energy industry itself has stated that contemporary drilling technology enables operators to reach gas resources at considerable distances from a drill site to reduce the impacts on sensitive habitats. For example, the National Petroleum Council (1999) notes that "extended reach drilling allows access to resources 5 to 6 miles from the drill site."

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[12] Appendix J of the 1999 NPC report included results for proven reserves, but NPC chose to present results for only unproved reserves in the main report (National Petroleum Council 1999).

[13] In its resource assessment, the 1999 NPC report included resources that may be recoverable in the future given an assumed rate of technological advancement. However, in its access examination, the report did not assume any rate of technological advancement that tends to increase access.

EIA Report Incorrectly Included Roadless Areas

The EIA report wrongly included all roadless areas in the no access legal category, even though 759,000 acres of roadless areas are currently under lease. And if the report had completed the access analysis with a reasonable three- to four-mile directional drilling distance, it would have concluded that most gas in roadless areas is accessible with current technology.[14] For example, based on our GIS analysis, less than one percent of the national forest roadless areas in Wyoming and Colorado are more than four miles from an existing road.

"No Access-De Facto" Category Overestimates Inaccessible Resources

The consultant's report for the EIA study estimated gas in a new "no access-de facto" category based on the "prohibitive effect" of compliance with environmental laws and pipeline restrictions. The consultant's report did not describe the criteria, decision rules, or analysis used to estimate acreage in this category. Thus, it is not possible to ascertain what led to the ultimate conclusions.

In addition, all potential gas resources estimated to be "no access-de facto" in the EIA report are unconventional gas (Energy Information Administration 2001). As noted above, unconventional gas, especially tight sands gas, has higher production costs than conventional gas. If an economic analysis of the "no access-de facto" category were conducted, it is likely that there would be little or no gas left in the category because the gas would be off limits for economic reasons.

Incorrect Assumptions About Seasonal Wildlife Stipulations

All three reports generally assumed that seasonal stipulations in leases to protect wildlife are never waived or exempted. In fact, a review of BLM stipulation exception data for the Pinedale District in Wyoming indicates that seasonal wildlife stipulations are waived quite frequently.[15] This calls into question their effectiveness in protecting the resources and values they are designed to conserve. During the 2001-2002 winter season, 77 percent of the 107 wildlife range exceptions that were requested were granted (Andrews 2002).

Access Increases If Directional Drilling and Stipulation Waivers Are Considered

The DOE report's sensitivity case analysis attempted to account for actual enforcement of gas leases by assuming that stipulations are waived 20 percent to 30 percent of the time. In addition, the analysis included estimates of the amount of gas that is accessible with a one-quarter-mile directional drilling distance, far less than the distance industry states is possible. Under even these small changes in assumptions, the amount of potential gas resources subject to standard lease terms increases substantially—from 32 percent to 47 percent, while the amount of gas estimated to have no access drops from 29 percent to 21 percent (Table 7). Based on the slightly more realistic DOE sensitivity case, 79 percent of the potential gas resource on public lands in the Upper Green River area is available for leasing.

The relatively large increase in accessible gas indicates that the results presented

Seasonal closures for wildlife do not prevent energy industry access to public land. Closures lasting three to seven months, for example, allow access during the remaining nine to five months each year.

[14] This does not imply consent to drill in roadless areas. Any decision to proceed with drilling in any roadless area must include full consideration of the wildland values that are likely to be lost or seriously compromised if drilling proceeds.

[15] The DOE Green River report did include a sensitivity case that examined stipulation waivers.

TABLE 7.

Technically recoverable, undiscovered gas by stipulation category in the Green River study area

Stipulation category	Base case: federal land	Sensitivity case: federal land	Sensitivity case: federal and private land
	PERCENT OF TOTAL		
No access statutory	1	1	1
No access administrative/ no surface occupancy	28	20	16
Seasonal stipulations	37	30	22
Controlled surface use	2	2	1
Standard lease terms	32	47	34
Private land standard lease terms	na	na	27

Source: Department of Energy 2001. www.fossil.energy.gov/oil_gas/reports/fla/

in the base case are very sensitive to changes in the key parameters, waiver rates, and directional drilling distance. If a more realistic (higher) waiver rate or a more reasonable (greater) directional drilling distance were applied, the increase in potential gas resources estimated as accessible would be larger still.

Accessible Gas Increases When Private Lands Are Considered

In assessments of gas resources, it important to account for the entire resource base, including private and public lands. In the Rocky Mountains, for example, approximately 42 percent of the undiscovered gas lies under non-federal land (EIA 2001). A narrow focus on public lands will overestimate potential gas resources that are subject to access restrictions. Consideration of the total land therefore reduces the amount of the potential gas resource that is subject to potential access restrictions.

When private lands are added to the DOE Green River sensitivity case, as an example, the potential undiscovered gas resources that are accessible under standard leasing terms increases from 47 percent to 61 percent of the total. Based on the DOE sensitivity case with private land included, therefore, 83 percent of undiscovered gas resource in the Upper Green River is available for leasing to the gas industry (see Table 5).[16]

DOE Report Included Drilling Opportunity Analysis

Seasonal closures of critical wildlife habitat may limit the time when drilling activities can occur, but they do not prevent access to gas. One way to estimate the impact of seasonal closures on access is to examine the drilling opportunities that are available based on an analysis of drilling depths, drilling times, and multi-season drilling operations.

The DOE report included an analysis of drilling opportunities in the Green River study area. While the methods should be improved (Morton 2001a), the initial results from the drilling opportunity analysis are useful to evaluate access. Those results show that industry has drilling opportunities on, and hence access to, a majority of the landscape in the Upper Green River study area. This is consistent with statistics from the BLM that indicate there were over 20 million acres of land under lease in Wyoming in 2000 (Minerals Management Service 2000).

Still, methods used in the drilling opportunity analysis could be improved. For example, that analysis assumed that wells deeper than 14,000 feet are precluded in areas with seasonal closures for more than six months in any year. This assumption ignores the fact that wells much deeper than 14,000 feet have been drilled in less than six months. For example, in 2001, a gas well 16,700 feet deep was drilled in just 69 days. (Wyoming Oil and Gas Commission 2002).

In addition, advances in drilling technology, in general, and improved drill bit

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Most oil and gas wells can be drilled in less than four months. In Wyoming, a gas well 16,700 feet deep was drilled in just 69 days.

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[16] When the 30 trillion cubic feet of gas expected from proven reserves in the region are also considered, the percent of gas available for leasing under standard lease terms increases substantially (LaTourrette et al. 2002).

technology, specifically, will continue to reduce drill times and eventually eliminate the majority of impacts that seasonal wildlife stipulations may have on access to resources. For example, a 15,000-foot well in Oklahoma takes about 39 days to drill, a decrease from 80 days in 1970 (DOE 1999). And if necessary, deep wells can be easily drilled over multiple seasons. By failing to examine the increase in drilling opportunities available with technological advances, the DOE drilling opportunity analysis overestimated the potential gas resources that are off limits.

Based on a review of the drilling opportunity analysis, LaTourrette et al. (2002) estimate that nearly all of the potential gas resources in the Green River study area subject to seasonal timing stipulations are accessible for production using standard drilling operations. That analysis demonstrates that seasonal closures and other stipulations do not necessarily prohibit resource extraction, even when using standard cost, single-season drilling techniques. If multi-season drilling were modeled, even more of the potential gas resources would be accessible.

PHOTO COURTESY PETER AENGST

Upper Green River Basin, Wyoming. Shown here: severe fragmentation of wildlife habitat caused by a maze of gas and oil drilling pads.

6. Discussion and Recommendations

As shown in this report, national forest roadless areas in the Rocky Mountains and national monuments scattered across the West contain a very small amount of economically viable gas and oil resources. Yet much of the debate over development of U.S. energy resources focuses on undiscovered gas and oil in wildlands.

We believe that emphasis is misplaced. Based on our analysis of USGS data, it is clear that extraction of gas and oil resources that potentially underlie national forest roadless areas and national monuments in the West will do little to affect America's energy future.

Indeed, the USGS estimates that only a small portion of undiscovered gas and oil resources on all public lands can be recovered at a profit. In addition, our analysis of government data indicates that private lands, not public lands, hold a majority (51 percent) of the undiscovered economically recoverable gas in the United States (Attanasi 1998, Minerals Management Service 2001).

Federal public lands are expected to contribute just 12 percent of America's economically recoverable undiscovered gas. Based on analysis of USGS data, drilling for undiscovered resources on federal land, including national parks, national forests, lands managed by BLM, and national wildlife refuges, would only meet U.S. demand for gas and oil for 1.7 years and 222 days, respectively (Table 8). The Arctic National Wildlife Refuge could possibly add up to six months of oil (Morton 2002b).

It is important to note that the current 15 years of oil and 21 years of gas in U.S. reserves and growth of those reserves does not take into consideration investments in energy conservation, energy efficiency, and alternative energy sources. Such investments will likely mean that the reserves will last longer—between 20 and 40 years.

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The Energy Information Administration (2001) predicted that waiving all lease stipulations and opening "de facto no-access" public lands to drilling will make no significant difference in prices that consumers pay for energy. By 2020, the average home heating bill might drop $5.00 a year.

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Recommendations

In addition to the three studies that we analyzed in this report, BLM is currently assessing industry access to gas on public lands in the Rocky Mountains. Those assessments, required by the Energy Policy and Conservation Act, focus on five areas: San Juan and Paradox basins in New Mexico and Colorado, Uinta-Piceance Basin in Utah and Colorado, Greater Green River Basin of Colorado and Wyoming, Powder River Basin of Wyoming and Montana, and Montana's Overthrust Belt. The assessments will be used as supporting documents in BLM plans for the basins. They may also affect manage-

TABLE 8.

Economically recoverable gas and oil in the United States [a]

	Economically recoverable in relation to total U.S. consumption	
	Oil	**Gas**
Reserve and reserve growth (existing wells and fields)	14.6 years	21.4 years
Drill all on-shore federal lands (undiscovered resources)[b]	222 days	1.7 years
Drill Arctic National Wildlife Refuge (undiscovered resources)	162 days	None
Drill private and state lands (undiscovered resources)	2.6 years	12.9 years

[a] The years and days of consumption were estimated by comparing our economically recoverable estimates with total U.,S. consumption for the year 2001 (www.eia.doe/emeu/cabs/usa.html).
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Sources: Attanasi 1998, Minerals Management Service 2000.

ment of the Bridger-Teton National Forest in Wyoming, national forests along the Rocky Mountain front in Montana and other national forests with gas resources. The BLM plans to complete the assessments by November 2002.

The following recommendations are intended to improve BLM's evaluation process and other assessments of potential gas and oil reserves on public lands across this country, including USGS assessments and studies by entities such as the National Petroleum Council, Department of Energy, and Energy Information Administration.

Begin assessments with USGS mean estimates of economically recoverable resources. BLM and other energy resource assessments should use USGS mean estimates of economically viable gas as a starting point to evaluate various land management alternatives. The USGS estimates the likely amount of undiscovered gas that can be produced profitably, without consideration of non-market costs or off-site water mitigation costs. Planning documents such as a simple survey of industry's drilling desires should not rely on technically recoverable resources or other measures that ignore economics. Planning documents that use technically recoverable gas as the basis for economic impact studies will overestimate the potential number of jobs that will result from gas drilling alternatives and the amount of revenue that state and country governments can expect.

USGS mean estimates provide the best, least biased estimates of the expected economic value of undiscovered resources. To account for uncertainty in price projections, the BLM should develop low and high mean estimates of economically recoverable gas, using a range of price estimates (Attanasi 1998).

Include a full accounting of the environmental costs in economic analyses. The USGS analysis must be improved. It currently does not account for all market and non-market costs. One omission is the cost of transporting the gas or oil from the wellhead to the market. And while many non-market costs such as erosion, loss of wildlife habitat, loss of ecosystem services, proliferation of noxious weeds, and increased air pollution are difficult to estimate, academic and federal agency economists have made great advances in developing methods to do so (Table 9). Many such costs are now quantifiable and available to agency officials who are responsible for the policies and procedures that guide public land management (Morton et al. 2002).

We thus recommend that the USGS incorporate non-market costs such as lost wildland benefits into updates of its national assessment of economically recoverable gas and oil resources. We also recommend that the BLM and the Forest Service include full accounting of non-market costs in the NEPA analysis for leasing and drilling decisions.[17]

As a first order approximation of the environmental costs of drilling, LaTourrette et al. (2002) recommend the mapping of spatial indices of areas with vulnerable environments. This creative technique, at least on the surface, has the potential to incorporate difficult-to-quantify non-market environmental costs associated with energy development. An appropriate environmental vulnerability index based on, for example, riparian areas, steep slopes, archeological sites, critical wildlife

The USGS economic analysis does not include a full accounting of the hidden, non-market costs associated with gas drilling.

[17] NEPA, the National Environmental Policy Act of 1969, established a national goal of protecting the environment and required analysis of the environmental impacts of proposed projects and actions by the federal government.

habitat, roadless areas, wilderness study areas, and other important conservation lands could well be an important factor in efforts to incorporate non-market environmental costs into public land management decisions.

Include gas and oil reserves in resource assessments. In addition to assessments of undiscovered, economically recoverable resources, the BLM should examine gas and oil resources in the already discovered and proven U.S. reserves. Most undiscovered gas and oil is located where it has already been found—in or near existing reserves—and the USGS predicts that this trend will continue. Proven reserves and growth in those reserves should be a central part of any assessment of energy resources.

TABLE 9.

Economic Costs of Gas and Oil Extraction

Cost category	Description of potential cost	Methods for estimating costs
Direct use	Decline in quality of recreation, including hunting, fishing, hiking, biking, horseback riding. Loss of productive land for grazing and farming.	Travel cost and contingent valuation surveys.
Community	Air, water, and noise pollution negatively impacts quality of life for area residents with potential decline in the number of retirees and households with non-labor income, loss of educated workforce, and negative impacts on non-recreation businesses. Decline in recreation visits and return visits negatively impact recreation businesses. Socio-economic costs of boom-bust cycles.	Surveys of residents and businesses. Averting expenditure methods for estimating costs of mitigating health and noise impacts. Changes in recreation visitation, expenditures and business income. Documented migration patterns.
Science	Oil and gas extraction in roadless areas reduces value of area for study of natural ecosystems and as an experimental control for adaptive ecosystem management.	Change in management costs, loss of information from natural studies foregone.
Off site	Air, water, and noise pollution decrease quality of life for local residents and decrease quality of recreation experiences for downstream and downwind visitors. Haze and drilling rigs in viewsheds reduce quality of scenic landscapes, driving for pleasure, and other recreation activities and negatively impact adjacent property values. Groundwater discharge can negatively impact adjacent habitat, property, and crop yields, while depleting aquifers and wells.	Contingent valuation surveys, hedonic pricing analysis of property values, preventive expenditures, well replacement costs, restoration and environmental mitigation costs, direct impact analysis of the change in crop yields and revenues.
Biodiversity	Air, water, and noise pollution can negatively impact fish and wildlife species. Groundwater discharge changes hydrological regimes with negative impacts on riparian areas and species. Road and drill site construction displaces and fragments wildlife habitat.	Replacement costs, restoration and environmental mitigation costs.
Ecosystem services	Discharging ground water negatively impacts aquifer recharge and wetland water filtration services. Road and drill site construction increases erosion, causing a decline in watershed protection services.	Change in productivity, replacement costs, increased water treatment costs, preventive expenditures.
Passive use	Roads, drilling rigs, and pipelines in roadless areas result in fewer passive use benefits for natural environments.	Contingent valuation surveys, opportunity costs of not utilizing future information about the health, safety, and environmental impacts of oil and gas drilling.

Source: Morton 2001b

Include private and public lands in resource assessments. The BLM's assessments should also incorporate all private lands, including those with federal subsurface resources, because those lands hold the majority of economically recoverable undiscovered gas.

Take into account access that is available through directional drilling. According to the National Petroleum Council (1999) directional drilling allows "access to resources 5 to 6 miles from the drill site." We recommend that the assessments use a reasonable three- to four-mile directional drilling distance when examining access to gas and oil resources.[18] The BLM and Forest Service should also analyze the use of directional drilling for all new gas and oil development projects in the American West.

Take into account the positive effect of emerging technology on access. Advances in technology may, for example, make directional drilling feasible from six to 10 miles away from the drill site. Advances in drill bit technology will continue to reduce drill times, removing most concerns about seasonal wildlife stipulations. Technological advances should, in general, reduce the quantity of gas and oil that is estimated to be inaccessible.

Include an analysis of drilling opportunities in resource assessments. The results from the DOE drilling opportunity analysis show that industry has access to a majority of the landscape in the Upper Green River study area. Such analyses of drilling opportunities in other Rocky Mountain basins may reach similar conclusions.

Collect baseline data and fund long-term monitoring. We recommend that public agencies and private companies immediately begin to collect baseline data and to monitor and analyze the cumulative impacts of energy development across the landscape, including both public and private lands. To be most useful, baseline data must be collected before drilling begins.

This information is vital if the public is to fully understand the potentially irreversible, cumulative environmental impacts from energy development in the Rocky Mountains—impacts on aquifers, air and water quality, wildlife species, and cropland productivity—before any increases in the scale of gas production through piecemeal phases is allowed. Such information is also essential to complete economic analyses that correctly account for the environmental costs associated with gas and oil drilling.

Increase assurance bonding requirements. We recommend that the BLM increase the assurance bonding requirements for companies that extract energy resources from public lands. History has shown that the costs of restoring abandoned drill sites have been greater than the posted bonds. Increased bonding requirements will provide taxpayers with assurance that there will be sufficient money to pay for damage to public land that is caused by gas and oil extraction.

Increased assurance bonding requirements can reduce the need for regulation and can be a cost-effective method for including environmental costs in energy production decisions. If damages are minimal, companies will get their bonds back.

To be most useful, baseline data must be collected before drilling begins.

[18] While it is technically feasible to use directional drilling for gas or oil six or more miles from the drill site, it may not be economically feasible. To compensate, we adjusted the drilling distance cited by NPC downward to the three- to four-mile recommended distance.

Increased assurance bonding is needed to help pay the future costs of maintaining the energy infrastructure (roads, water holding ponds, gas pipelines, and so forth) if and when an economic "bust" comes. Currently, there are more than 134,000 abandoned and orphaned wells (Thomas 2001) that scar the American landscape and create potential threats to water quality and human health and safety.

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Increasing the amount of assurance bonds is a cost effective way to include environmental costs in energy production decisions.

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APPENDIX

Estimates of economically recoverable gas and oil on national forest roadless areas in six western states

Resource	Economically recoverable quantity	Economically recoverable as % of technically recoverable	Economically recoverable in relation to total U.S. consumption
WYOMING			
Conventional gas	2,899 - 3,200 billion cubic feet	80% - 88%	47 - 51 days
Tight sands gas	0.9 - 36.0 billion cubic feet	0.1% - 3%	0.01 - 0.58 days
Coal bed methane gas	0.3 - 0.5 billion cubic feet	28% - 47%	0.004 - 0.007 days
Total Gas	**2,900 - 3,237 billion cubic feet**	**60% - 66%**	**47 - 52.0 days**
Oil and natural gas liquids	388 - 438 million barrels	76% - 86%	20 - 22 days
COLORADO			
Conventional gas	50 - 89 billion cubic feet	33% - 59%	0.8 - 1.4 days
Tight sands gas	147 - 181 billion cubic feet	14% - 17%	2.4 - 2.9 days
Coal bed methane gas	430 - 801 billion cubic feet	41% - 77%	6.9 - 12.9 days
Total Gas	**626 - 1,072 billion cubic feet**	**28% - 47%**	**10.1 - 17.2 days**
Oil and natural gas liquids	3.2 - 8.3 million barrels	12% - 32%	0.2 - 0.4 days
UTAH			
Conventional gas	103 - 138 billion cubic feet	48% - 65%	1.6 - 2.2 days
Tight sands gas	9.2 - 16.5 billion cubic feet	10% - 18%	0.1 - 0.3 days
Coal bed methane gas	70.1 - 141 billion cubic feet	40% - 79%	1.1 - 2.3 days
Total Gas	**182 - 295 billion cubic feet**	**38% - 62%**	**2.9 - 4.7 days**
Oil and natural gas liquids	15.8 - 28.1 million barrels	41% - 74%	0.8 - 1.4 days

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Estimates of economically recoverable gas and oil on national forest roadless areas in six western states

Resource	Economically recoverable quantity	Economically recoverable as % of technically recoverable	Economically recoverable in relation to total U.S. consumption
MONTANA			
Conventional gas	169 - 234 billion cubic feet	46% - 63%	2.7 - 3.8 days
Tight sands gas	3.0 - 3.2 billion cubic feet	12% - 13%	0.049 - 0.051 days
Coal bed methane gas	0.0 - 0.0 billion cubic feet	0% - 0%	0.0 - 0.0 days
Total Gas	**172 - 237 billion cubic feet**	**43% - 60%**	**2.8 - 3.8 days**
Oil and natural gas liquids	1.1 - 2.0 million barrels	14% - 25%	0.06 - 0.10 days
NEW MEXICO			
Conventional gas	1.4 - 2.3 billion cubic feet	30% - 48%	0.02 - 0.04 days
Tight sands gas	25.8 - 34.3 billion cubic feet	42% - 56%	0.4 - 0.6 days
Coal bed methane gas	0.10 - 0.13 billion cubic feet	79% - 96%	0.0 - 0.0 days
Total Gas	**27.3 - 36.7 billion cubic feet**	**41% - 55%**	**0.4 - 0.6 days**
Oil and natural gas liquids	0.9 - 1.1 million barrels	55% - 70%	0.05 - 0.06 days
NORTH DAKOTA			
Conventional gas	1.5 - 3.4 billion cubic feet	25% - 55%	0.02 - 0.06 days
Tight sands gas	12.9 - 13.5 billion cubic feet	11% - 12%	0.21 - 0.22 days
Coal bed methane gas	0.0 - 0.0 billion cubic feet	0% - 0%	0.0 - 0.0 days
Total Gas	**14.5 - 17.0 billion cubic feet**	**12% - 14%**	**0.2 - 0.3 days**
Oil and natural gas liquids	0.6 - 1.5 million barrels	4% - 12%	0.03 - 0.07 days

COVER PHOTOS:
Rocky Mountain Front by Bill Cunningham

Drilling rig on Upper Green River Basin, Wyoming by Lloyd Dorsey/ Wyoming Wildlife Federation

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