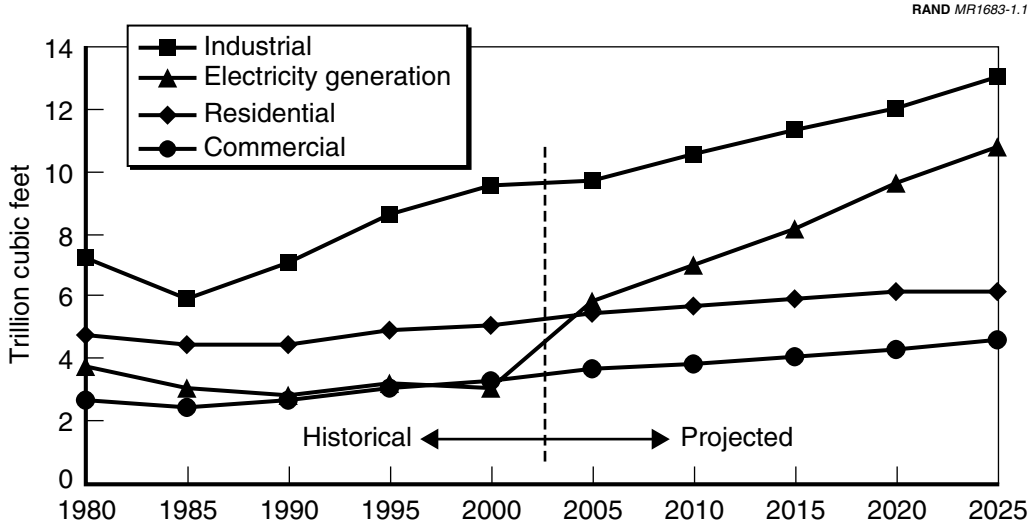
Chapter One

INTRODUCTION

GAS RESOURCES AND PRODUCTION IN THE ROCKY MOUNTAINS

Natural gas demand in the United States has been increasing for the last 15 years and is expected to increase substantially in the next 20 years (Energy Information Administration, 2003; National Petroleum Council, 1999). Demand is projected to increase in all sectors, especially electricity generation (Figure 1.1). In fact, 80 percent of projected electricity generation capacity additions through 2025 is expected to be fueled by natural gas (Energy Information Administration, 2003). Meeting this increasing demand will require an accompanying increase in supply. Imports, over 95 percent of which come from Canada, at present account for approximately 15 percent of the natural gas supply in the United States (Energy Information Administration, 2001a). Although imports are projected to increase, the fraction of total gas demand met



SOURCES: Historical data are from the Energy Information Administration (2001b). Projections are from the reference case of the Energy Information Administration (2003).

NOTE: Energy Information Administration reference case demand projections are made assuming no new legislation or regulation, such as that regarding CO_2 emissions or energy efficiency standards.

Figure 1.1—Historical and Projected Annual Natural Gas Demand

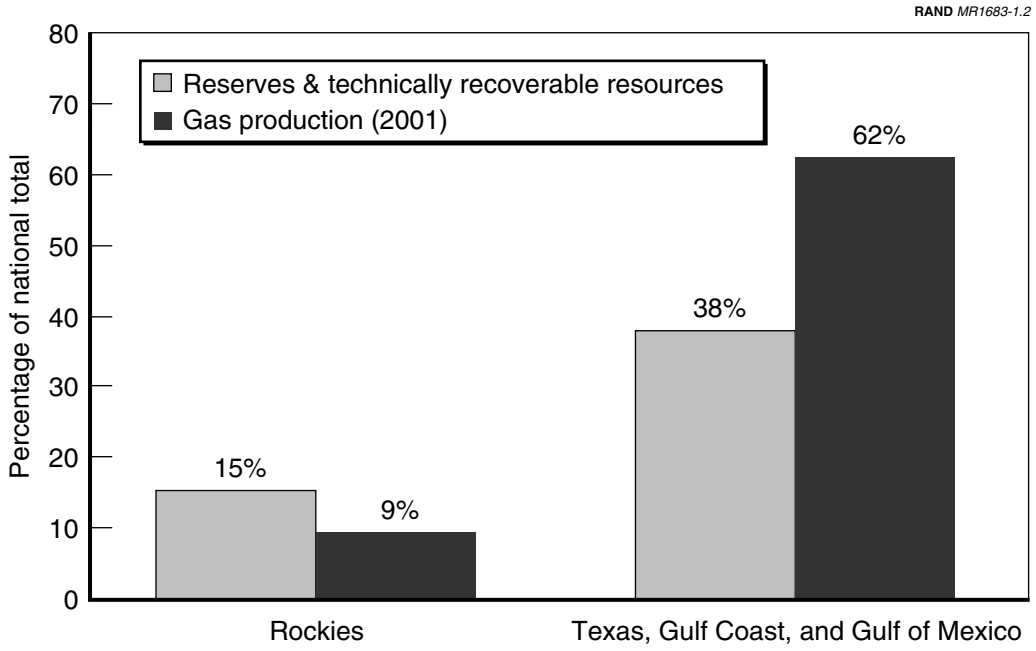
by imports is expected to reach only 22 percent by 2025 (Energy Information Administration, 2003). Thus, most of the increasing natural gas demand is expected to be met through increasing production in the United States.

The prospect of this production increase fuels ongoing efforts to both better assess our nation's natural gas resources and develop policies for developing those resources. Such efforts are drawing increasing attention to gas resources in the intermountain areas of the Rocky Mountains.

National resource assessments indicate that the Rocky Mountains are relatively rich in hydrocarbon resources, particularly natural gas (National Petroleum Council, 1999; U.S. Geological Survey National Oil and Gas Resource Assessment Team, 1995; Potential Gas Committee, 2001). These assessments indicate that the Rockies contain approximately 15 percent of the nation's proved reserves and technically recoverable (i.e., recoverable with current or anticipated future technology) natural gas supply (Figure 1.2). In 2001, production in this same region contributed approximately 9 percent of the natural gas produced in the United States. Thus, production in the region is lower than potential supply in terms of the fraction of the U.S. total.

In contrast, Texas, the Gulf Coast, and the Gulf of Mexico contain about 38 percent of the nation's future gas supplies, yet production in 2001 accounted for 62 percent of the nation's total (Figure 1.2). This suggests that production in the Rockies will grow as resources in the more established regions are depleted and production declines. Indeed, from 1997 through 2000, natural gas production in the Rockies increased by 15 percent whereas that in Texas, the Gulf Coast, and the Gulf of Mexico decreased by 5 percent (Energy Information Administration, 2001a). By most accounts, this trend of increasing production in the Intermountain West is expected to continue well into the future (National Petroleum Council, 1999; Energy Information Administration, 2003). Growing natural gas demand, particularly in California and the West, and the extent to which this demand may be met by increasing production in the Rockies, are important issues facing policymakers and the energy industry.

Accompanying the shift in production to the Rockies is a shift in land ownership and land use management responsibility. In the onshore parts of Texas, the Gulf Coast, and the Gulf of Mexico, which contain 60 percent of the reserves and technically recoverable resources in the entire region, 98 percent of the undiscovered gas underlies nonfederal land (Figure 1.3). Development decisions in this region involve primarily private landowners and states. In the Rockies, on the other hand, 60 percent of the undiscovered gas underlies federal land. Thus, an important implication of increasing natural gas production to the Rockies is that energy-related land use decisions are increasingly becoming the responsibility of federal land managers. Given the rapid increase in natural gas production occurring in the Rocky Mountains, demands upon federal land managers to open more lands for energy resource development will continue to mount. It is therefore important that these managers have access to any and all information that could potentially help inform the decisionmaking process.



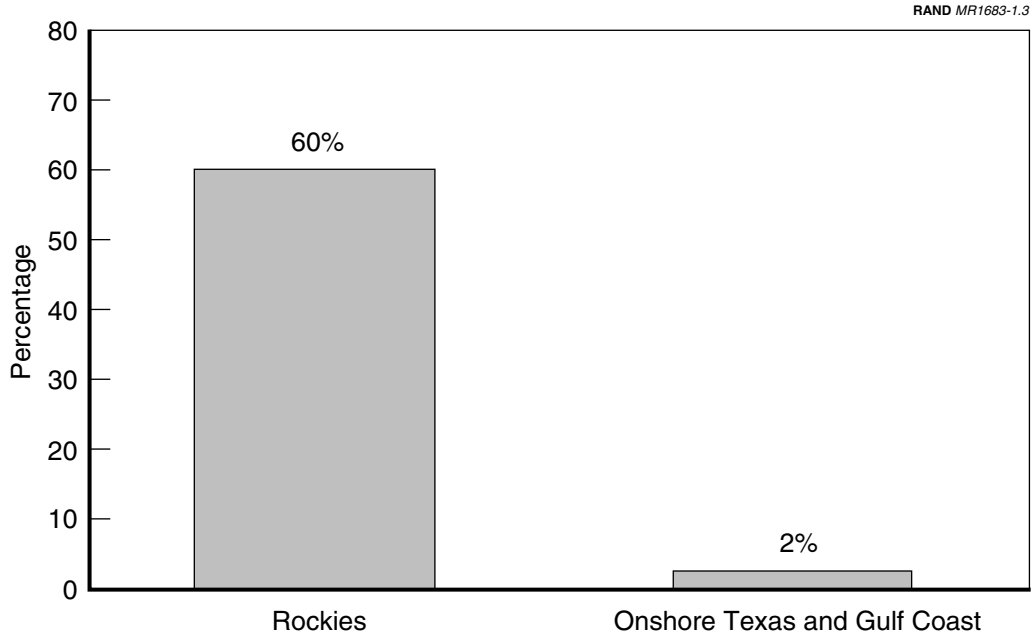
SOURCES: Data on reserves and production are from the Energy Information Administration (2002). Onshore data are provided by state and were allocated to U.S. Geological Survey (USGS) assessment regions as follows. Region four = MT + ND + SD + WY + CO/2. Regions five and six = NM/3 + TX + AR/3 + LA + AL/2 + MS/2 + FL. Technically recoverable resources include undiscovered conventional and nonconventional resources and reserve appreciation. Data on onshore and state offshore undiscovered resources are from the U.S. Geological Survey National Oil and Gas Resource Assessment Team (1995); onshore and state offshore reserve appreciation data are from Root et al. (1997); federal offshore undiscovered resources and reserve appreciation data are from the Minerals Management Service (2000).

NOTES: Rockies comprises USGS assessment region four; Texas, Gulf Coast, and Gulf of Mexico comprises USGS assessment region five and six plus the Gulf of Mexico. National total includes federal offshore.

Figure 1.2—Natural Gas Supply and Production in the Rockies, Texas, the Gulf Coast, and the Gulf of Mexico

RESOURCE ASSESSMENTS AND FEDERAL LAND MANAGEMENT

The federal government manages a vast array of natural resources in the nation, particularly in the western states. Much of this land management responsibility falls under the authority of the Bureau of Land Management (BLM) and the Forest Service. These and other agencies are responsible for deciding how federal lands are used, including the management of natural resources. This responsibility includes land use planning, leasing of federal land, and monitoring and evaluating land use activities. The Bureau of Land Management's land use planning process is governed primarily by the Federal Land Policy and Management Act as well as a number of



SOURCE: Data are from Gautier et al. (1998).

Figure 1.3—Percentage of Undiscovered Resources on Federal Land in the Rockies and in the Onshore and State Offshore Parts of Texas and the Gulf Coast

additional legal authorities reflecting environmental and resource management concerns. The process incorporates a variety of considerations and is guided by the general principles of multiple use and sustained yield (U.S. Bureau of Land Management, 2000).

Land use planning is a component of a comprehensive process that ultimately leads to the implementation of actions to carry out the plan. Although important for providing guidance for subsequent planning and approval activities, decisions made at the land use planning stage are strategic in nature and most actions that ultimately derive from these decisions are subject to more detailed examination in subsequent steps. For example, one outcome of land use planning may be the decision to open a particular area for gas or oil leasing; however, commencement of actual exploration and development activities is subject to additional permitting and approval. At the same time, however, in providing this strategic guidance, the land use plan clearly directs attention to specific areas for consideration for particular land uses. Land use planning thus establishes priorities for land use decisions.

In describing the land use planning process, the Federal Land Policy and Management Act refers to "resource value" as a consideration in assessing potential land uses. Resource is defined broadly to include the full range of potential commodities or uses that the land may provide. Resource values are determined in a variety of ways and in many cases are documented in the form of a quantitative or qualitative resource assessment. Such resource assessments play an important role in the land

use planning process. As described in the Bureau of Land Management's *Land Use Planning Manual,* "When making land use plan decisions, the BLM will consider information from all available sources, including scientific data gained from resource assessments, information regarding ecosystem protection and restoration needs, the reasonably foreseeable development of consumptive and nonconsumptive uses, and social and economic information" (U.S. Bureau of Land Management, 2000).

As a component of strategic land use planning, resource assessments are thus an important tool available to land managers in setting priorities for different land uses. Information regarding the potential value of a resource or activity helps land managers understand the possible implications of different land use decisions. Given the complex array of considerations involved in land use planning, the more information that land managers have available to them about different land use plan alternatives, the better able they will be to distinguish among plan strengths and weaknesses.

In the case of natural gas and oil, resource assessments historically focus on the amount of resource. The standard currency for gas and oil resources is the "technically recoverable" resource, which is the amount estimated to be recoverable given certain assumptions about current or anticipated future technical capabilities. In effect, the technically recoverable resource is an estimate of the amount that could conceivably be extracted. The amount of resource is a fundamental consideration, but additional attributes of energy resources affect the energy resource value of an area. A comprehensive assessment would include as much information about the resource as possible to help federal land managers distinguish among resources in different areas. Attributes of energy resources that influence their value include the following:

- How much resource might be recoverable,
- How much resource might be available at different costs, and
- How much resource is associated with lands having different values of key environmental measures.

In this report we describe a new approach for assessing natural gas and crude oil resources that incorporates these elements. We apply the approach to the Greater Green River Basin in southwestern Wyoming. Compared to current assessments, which focus primarily on the amount of resource, the more comprehensive assessment presented here expands the scope of energy resource assessments to include economic and environmental considerations.

Our primary objective is to help inform the land use planning process and improve federal land managers' ability to plan energy resource development. The potential benefits of our proposed resource assessment approach may reach beyond the formal federal land use planning process, however. It may also help inform national energy planning efforts; facilitate prioritization of permitting and approval processes within the context of existing land use plans; and help state planning agencies, utilities, gas and oil producers, and the associated investment community better plan future energy supplies and investment decisions. Before describing our approach in

more detail, we briefly outline some of the ways it may improve the utility of resource assessments and help inform policy decisions.

IMPROVING DECISIONMAKING WITH COMPREHENSIVE RESOURCE ASSESSMENTS

Federal Land Use Planning

As described above, the federal land use planning process provides strategic guidance for using federal lands taking numerous factors into consideration, including energy resource value. During this process, it would be helpful for land managers to have information on estimated production costs to help prioritize lands under consideration for energy resource exploration and development. Different areas with similar amounts of technically recoverable resource may have very different amounts of economically recoverable resource. Thus, estimates of production costs would provide useful information to help distinguish otherwise similar areas in terms of energy resource value.

Such an understanding would help land managers to more realistically consider energy resource development in the context of other land use considerations. For example, a choice to open land for gas or oil leasing might change the nature of the land, which could have significant implications for lands that currently have or are proposed for protected status. These decisions might be better informed if federal land managers could estimate the likelihood that the resource would be marketable within the next five to ten years. If the resource in a given area is expected to be too expensive, it might be prudent to focus attention on other areas where energy resources can be produced profitably.

Feedback from industry provides some guidance regarding the anticipated economics of different areas. However, a basin- or regionwide evaluation using a consistent and open methodology has the advantage of providing federal land managers with the best information for all areas, independent of proprietary information.

Our proposed approach is also intended to help inform the environmental protection aspects of federal land use planning. Environmental protection considerations are central to the land use planning process, which strives to balance the nation's need for domestic sources of minerals, food, timber, and fiber with the need to protect the quality of scientific, scenic, recreational, historical, ecological, and other environmental attributes (U.S. Bureau of Land Management, 2000). Because resource exploration and extraction may have adverse impacts on the environment, it may be important for federal land managers to know how much of the resource is on lands that are potentially vulnerable to these negative impacts. Our approach attempts to incorporate this information by providing a framework for identifying environmental attributes in the same spatial context as the energy resources. As with the cost considerations, such an environmental characterization could help inform the process of setting priorities for energy-related land use decisions. For example, managers might want to examine in more detail resource areas containing surface waters or wetlands because of the potential impacts of runoff or sedimentation; or,

they might need to consider more extensive mitigation efforts for processes or lands that may be associated with these potential impacts.

In including this environmental characterization, the intention is not to replace existing environmental impact analysis procedures, but rather to provide decisionmakers with an overview of how much resource is on lands that may require more detailed analysis before decisions are made or that might require increased mitigation efforts that could increase the costs of extraction.[1] This may also be important information for local communities who need to plan for future water needs, to plan for access to lands, and to understand the implications for ranchers, farmers, and others who might be affected by extraction activities.

Finally, the introduction of a systematic and transparent assessment methodology would provide a degree of consistency between separate land use plans. Traditional land use planning by federal land management agencies is conducted at the local (i.e., subfield office) level and can result in marked inconsistencies and discontinuities in planning consequences between adjacent areas. Such outcomes reflect a variety of factors, including differing assessment methodologies. Implementing our approach at a basin or regional scale may help minimize such problems.

National Energy Planning

For the purposes of energy planning and formulating national policies, it is important for the federal government to have a realistic view of how much gas and oil may be available as a function of cost in different areas. The relative merits of various options, such as increasing energy efficiency standards, investing in energy technologies, or pursuing expanded production in new areas such as Alaska or the Rockies, are difficult to compare without an understanding of the costs associated with each. Although it is common to discuss costs and savings associated with technology and efficiency initiatives, costs associated with production are much less clear.

In terms of meeting consumer demand, production costs have a strong influence on fuel choices as well as on the balance between imports and domestic production. Planning for future energy supplies thus depends strongly on estimates of energy resource production costs. The U.S. Department of Energy's Energy Information Administration (EIA) uses information like this in its forecasts, but the available data are uneven and incomplete. More accurate and detailed information would make its ability to forecast prices more reliable.

States, Utilities, and Producers

State planning agencies, utilities, gas and oil producers, and the associated investment community may also benefit from an improved understanding of gas and oil resource supplies, particularly estimates of the amount of resource expected to be

[1] As a requirement of the Energy Policy and Conservation Act of 2000, the federal government is involved in inventorying the natural gas resources in the Rocky Mountain region that are subject to various forms of access restrictions (see U.S. Departments of Interior, Agriculture, and Energy, 2003).

available as a function of price. As states become more dependent on natural gas for electricity generation, it is important that state planners who oversee their energy systems understand the resource potential. For example, it would be important to be able to estimate the price of gas if demand were to increase at a rapid rate. Price would be influenced by the amount of resource available at different production costs. California, for example, relies on natural gas supplied from a few western basins (Bernstein et al., 2002). For planning purposes, it would be useful to know how much gas is estimated to be available from those basins at different prices. Similarly, utilities, many of which are investing in gas-fired power plants with expectations of operating them for 30 or more years, could make better investment decisions with this type of information.

Economic Effects of Resource Extraction

A better assessment of the value of energy resources may also help stakeholders understand the positive and negative effects that resource extraction might have on the local, regional, and national economies. Increased extraction activities have positive economic elements but can sometimes replace economic activities that were previously on those lands. Positive economic benefits generally accrue locally, although property values and tourism can sometimes suffer. Estimates of the net economic effects of resource extraction are an important element in making land use decisions, in projecting revenues and jobs, and in other policy and forecasting issues. A realistic understanding of the economic effects at all scales depends on the amount of development and production activity that will actually occur. This is best estimated from the amount of resource that is expected to be profitable to produce.

GENERAL METHODOLOGY AND SCOPE

Our methodology for assessing natural gas and oil resources builds on existing technically recoverable resource assessments by incorporating economic and environmental considerations that further characterize energy resources. It is important to point out at the outset that the primary focus of this work is on the methodology used to make the assessment. Our results for the Greater Green River Basin reflect a reasonable range of assumptions regarding economic and environmental considerations. However, fine-tuning these assumptions to generate a precise resource estimate involves a number of stakeholder concerns and is beyond the scope of this work.

The general methodology is illustrated in Figure 1.4 and can be summarized in the following steps:

- Select a published technically recoverable resource estimate and allocate this resource among a defined set of individual analysis units,
- Evaluate the resource costs of each unit and generate cost-supply curves,
- Classify lands according to various environmental measures, and

- Evaluate, by means of geographic information system (GIS) overlays, the amount and distribution of resources that are economically recoverable at different costs and that underlie lands with differing values of environmental measures.

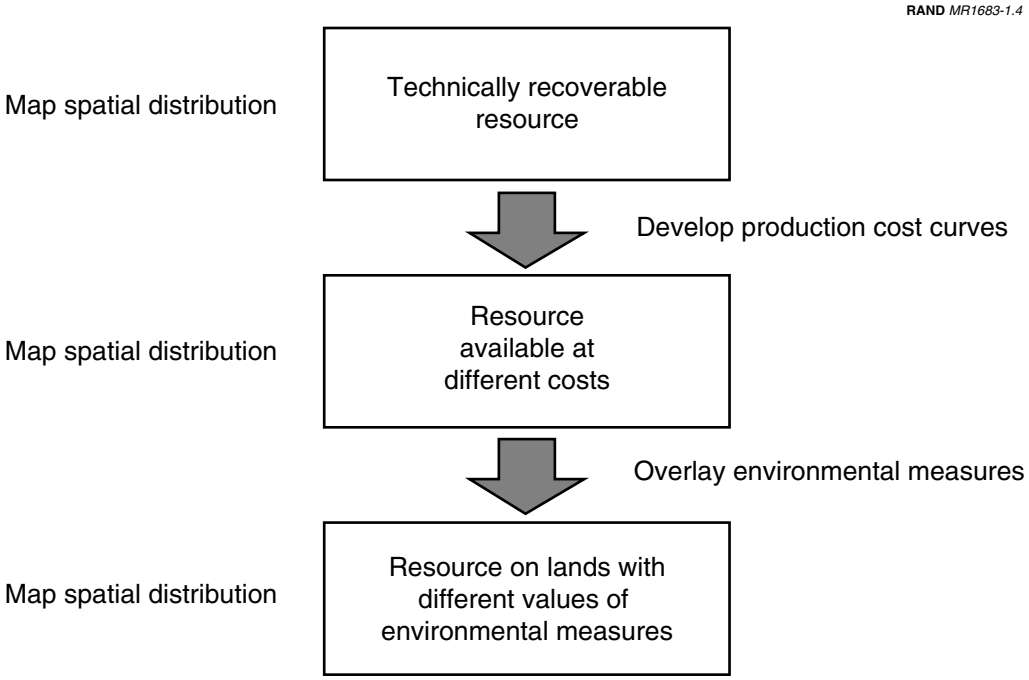
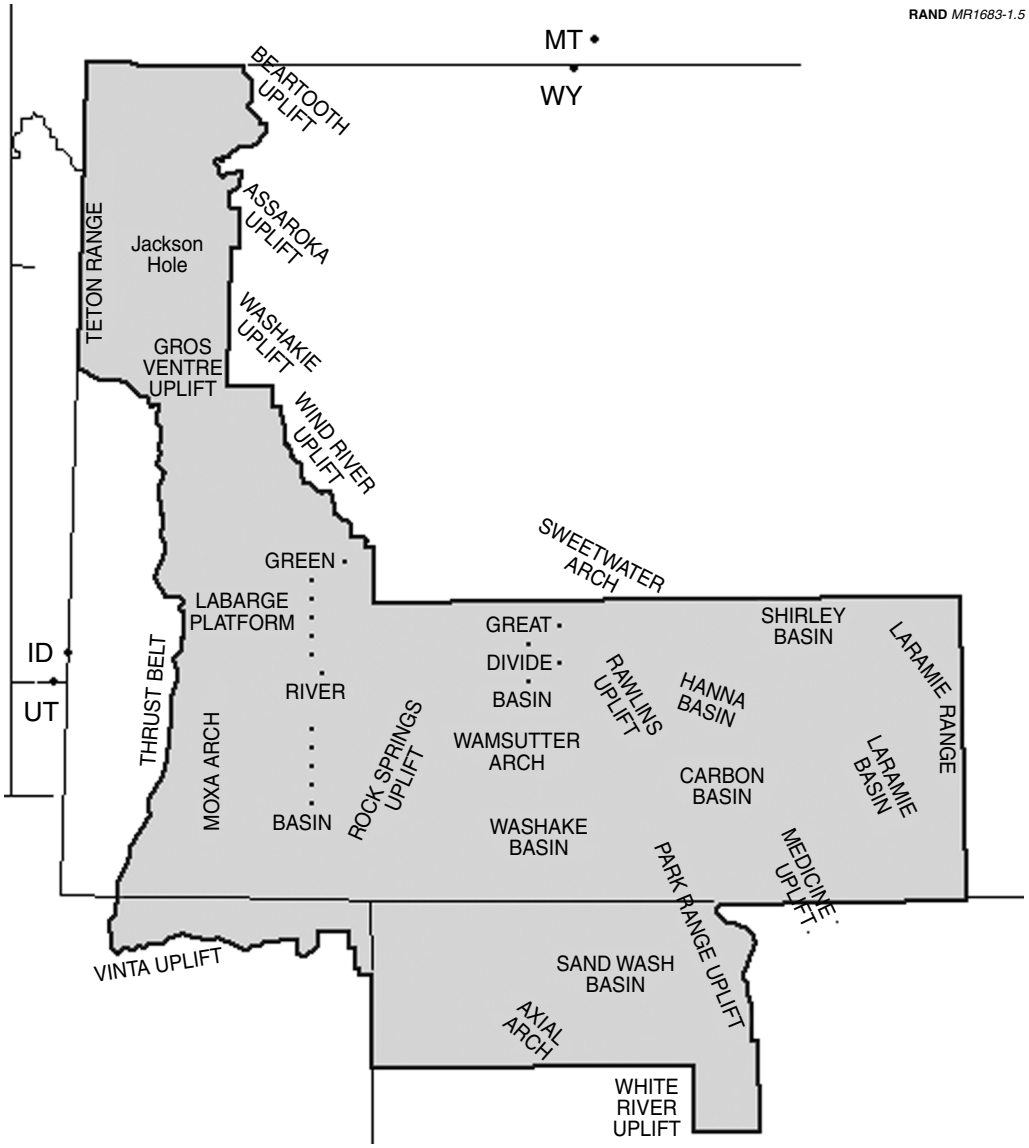


Figure 1.4—Summary of Approach

STUDY AREA

The methodology is being initially applied to the Greater Green River Basin because of the area's overall high resource potential and its diverse range of deposit types and depths, which results in a large range in development and production costs. The Greater Green River Basin is located primarily in southwestern Wyoming and includes a portion of northwestern Colorado and a small part of northeastern Utah. It comprises a number of individual structures including the LaBarge Platform, Moxa Arch, Rock Springs Uplift, Green River Basin, Great Divide Basin, Wamsutter Arch, Washakie Basin, Sandwash Basin, and others. Natural gas assessments for the Greater Green River Basin indicate that it may contain from 135 to 160 trillion cubic feet (Tcf), which represents approximately 50 percent of the remaining gas in the Rockies and 10 percent of the gas in the nation.

For our study area, we used U.S. Geological Survey (USGS) Province 37, Southwestern Wyoming (U.S. Geological Survey National Oil and Gas Resource Assessment Team, 1995; Figure 1.5). This area encompasses the entire Greater Green River Basin plus the Laramie and Shirley Basins to the east and extends northward through the Jackson Hole Basin to the Montana border on the west. Province 37 is



SOURCE: Beeman et al. (1996).

Figure 1.5—Study Area

larger than the Greater Green River Basin, although the vast majority of the gas and oil resources in the province lie within the Greater Green River Basin area. In this report, Greater Green River Basin refers to U.S. Geological Survey Province 37.

ORGANIZATION OF THIS REPORT

Chapter Two discusses the spatial analysis used to map the distribution of resources. The economic analysis methodology and results are presented in Chapter Three.

This is divided into wellhead costs[2] and infrastructure costs. The results are presented in terms of the spatial distribution of the amount of resource per unit area that is economically recoverable at different prices. Chapter Four discusses the environmental measures used in our analysis. These measures are associated with ecological and human resources that might be affected by gas or oil development. For each measure, we present the fraction of the gas resource underlying lands within the environmental study area having different values of the measure. The final chapter then presents our conclusions and the implications of our analysis for the Greater Green River Basin, the Rockies, and federal management of energy resources.

DATA AVAILABILITY AND DOCUMENTATION

We have endeavored to present our methodology in a transparent and reproducible way. Details of the spatial analysis, including data sources and descriptions, mapping procedures, and a description of the overlay analyses, are available on request. For the economic analysis, we have attempted to present a comprehensive discussion of the cost elements, data sources, and modeling procedure. This is supplemented with additional material available online.[3] Although all raw data are freely available, some details of the economic model are proprietary.

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[2]RAND obtained the services of Energy and Environmental Analysis, Inc., to conduct much of this analysis.

[3]Available at www.rand.org/publications/MR/MR1683.1.