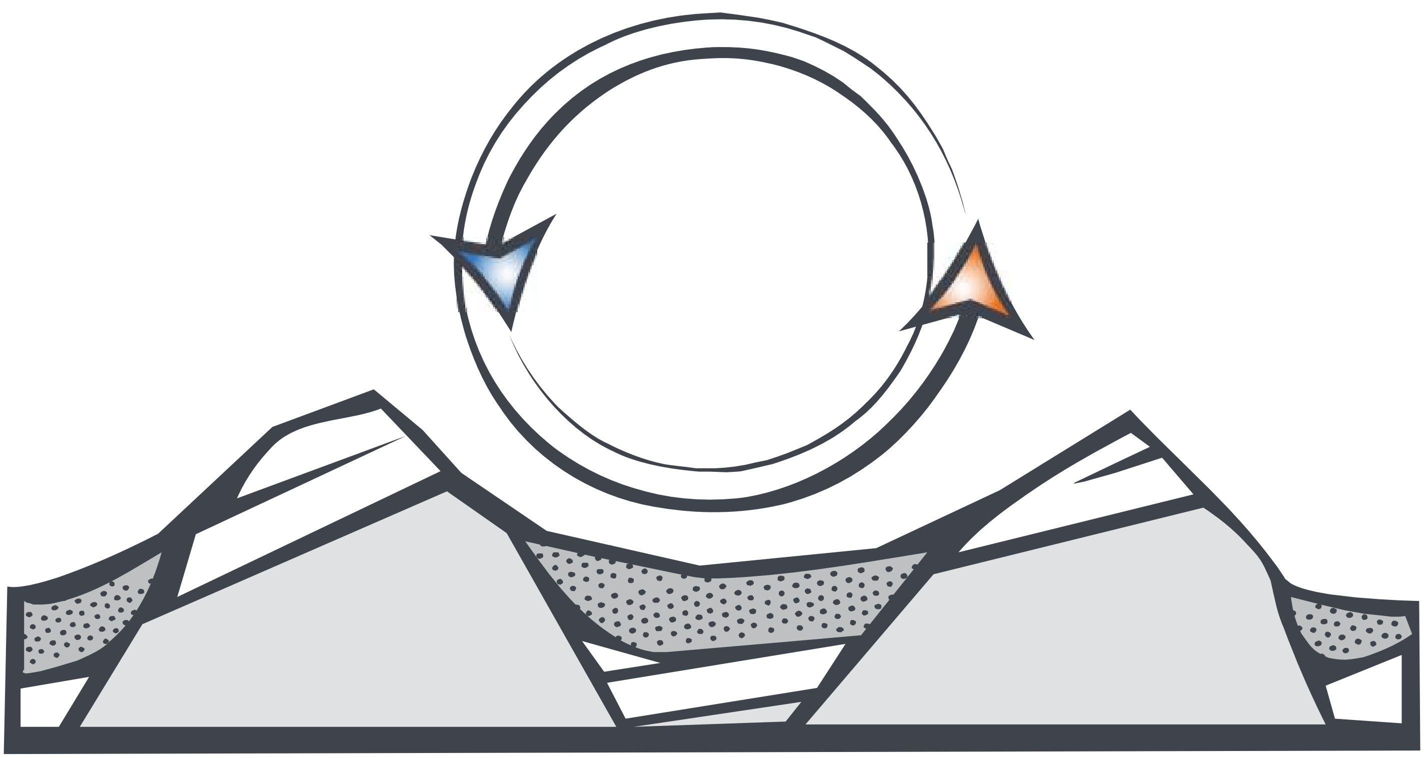

Chapter 3

Affected Environment

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CHAPTER 3
AFFECTED ENVIRONMENT

3.1 INTRODUCTION

This chapter provides a description of the biological, physical, and socioeconomic characteristics, including human uses, that could be affected by any future actions (including but not limited to any decisions to lease and/or develop geothermal resources) that may be taken consistent with implementing one of the alternatives considered in this PEIS, as described in Chapter 2. Information from broad-scale assessments were used to help set the context for the planning area. The information and direction for BLM resources has been further broken down into fine-scale assessments and information where possible. Specific aspects of each resource discussed in this section (e.g., water supply, air emissions, weeds, OHV use) were raised during the public and agency scoping process. The level of information presented in this chapter is commensurate with and sufficient to assess potential effects of any future actions (including but not limited to leasing and/or develop geothermal resources) that may be taken consistent with the alternatives in Chapter 4.

The planning area for the Geothermal PEIS is the area of geothermal potential in the western US states. The planning area includes BLM- and FS-administered surface lands with minerals under federal ownership that have geothermal potential and the subsurface federal geothermal mineral estate on other lands (see Section 1.9.1).

This section contains a description of the biological and physical resources of the planning area and follows the order of topics addressed as follows:

- Land Use, Recreation, and Special Designations;
- Geologic Resources and Seismic Setting;
- Energy and Minerals;
- Paleontological Resources;

- Soil Resources;
- Water Resources;
- Air Quality and Climate;
- Vegetation;
- Fish and Wildlife;
- Threatened and Endangered Species and Special Status Species;
- Wild Horse and Burros;
- Livestock Grazing;
- Cultural Resources;
- Tribal Interests and Traditional Cultural Resources;
- Natural Scenic and Historic Trails;
- Visual Resources;
- Socioeconomics and Environmental Justice;
- Health and Safety; and
- Noise
- Health and Safety

Table 3-1 lists identified critical resources and where they are addressed in this EIS.

Table 3-1
Critical Resources Identified Through Scoping

Resource	**Corresponding PEIS Section**
Air Quality	Air Quality and Climate
Areas of Critical Environmental Concern	Land Use, Recreation, and Special Designations
Cultural Resources	Cultural Resources and Tribal Interests and Traditional Cultural Resources
Hazardous Materials	Health and Safety
Invasive and Nonnative Species	Vegetation
Migratory Birds	Fish and Wildlife
Native American Religious Concerns	Tribal Interests and Traditional Cultural Resources
Threatened and Endangered Species	Threatened and Endangered Species and Special Status Species
Water Quality (Surface/Ground)	Water Resources
Wetlands/Riparian Zones	Vegetation
Wild and Scenic Rivers	Land Use, Recreation, and Special Designations
Wilderness	Land Use, Recreation, and Special Designations

3.2 LAND USE, SPECIAL DESIGNATIONS, AND RECREATION

3.2.1 Land Use

The western US is comprised of federally managed lands intermixed with private parcels. In some areas, federally managed lands dominate the landscape with small parcels of private lands (e.g., Nevada). However, in other instances, large tracts of private lands are interspersed with smaller tracts of federally managed lands (e.g., California). Federal lands are managed by federal agencies that have specific legislation guiding how their lands are to be used. The BLM and FS are two of the largest land management agencies mandated by national policies to administer their lands under the concept of multiple uses, while protecting long-term land health. Other federal land managers include the US Department of Defense, USNPS, USFWS, and US Bureau of Reclamation. Table 3-2, Acreage and Percentage of Federally Managed Lands in the Project Area as of Fiscal Year 2006, identifies the acreage of federal land within the project area (12 western states).

Table 3-2
Acreage and Percentage of Federally Managed Lands in the Project Area as of FY2006

State	Total State Acreage	Federal Land Acreage	Percent Land Federally Managed
Alaska	368,993,000	250,640,000	67.93
Arizona	72,777,000	51,084,000	70.19
California	100,977,000	52,879,000	52.37
Colorado	66,624,000	27,604,000	41.43
Idaho	53,339,000	36,413,000	68.27
Montana	94,234,000	37,940,000	40.26
Nevada	70,828,000	62,530,000	88.28
New Mexico	77,925,000	35,077,000	45.01
Oregon	62,126,000	34,840,000	56.08
Utah	54,318,000	39,018,000	71.83
Washington	43,064,000	16,825,000	39.07
Wyoming	62,593,000	31,633,000	50.54
Total	**1,127,798,000**	**676,483,000**	**59.98**

Source: BLM 2008c; FS 2008a

Federal Lands in the Planning Area

Within the planning area, or geothermal potential area, the BLM manages about 143 million acres and the FS manages about 104 million acres. These agencies are responsible for managing natural resources and resource uses, such as timber, minerals, livestock grazing, recreation, wildlife, and wilderness.

Table 3-3, Acreage of Public and NFS Lands in the Planning Area, identifies the amount of land managed by the BLM and FS in the planning area.

Table 3-3
Acreage of Public and NFS Lands in the Planning Area

State	BLM-Surface Acres	NFS- National Forest Acres	NFS- National Grasslands Acres[1]	Total Acreage
Alaska	5,860,536	2,732,322	-	8,592,858
Arizona	8,842,090	2,166,912	-	11,009,002
California	13,969,825	13,467,992	-	27,437,817
Colorado	6,288,740	15,092,198	786,000	22,166,938
Idaho	12,716,814	17,691,599	76,000	30,484,413
Montana	3,438,730	8,370,307	-	11,809,037
Nevada	45,991,073	6,221,008	-	52,212,081
New Mexico	9,507,142	8,314,108	-	17,821,250
Oregon	14,025,425	14,579,444	167,000	28,771,869
Utah	10,766,598	3,056,933	-	13,823,531
Washington[2]	--	6,430,898	-	6,430,898
Wyoming	11,747,232	2,863,442	1,566,000	16,176,674
Total	**143,154,205**	**100,987,163**	**2,595,000**	**246,736,368**

[2] Acreage calculations for Oregon and Washington are combined because states share one single BLM state-level office.
Source: BLM 2008c; FS2008a; [1]Olson 1997

United States Department of Agriculture, Forest Service
The National Forest Management Act of 1976 amended the Forest and Rangeland Renewable Resources Planning Act of 1974, which called for the management of renewable resources on NFS lands. The National Forest Management Act requires the Secretary of Agriculture to assess NFS lands, develop a management program based on multiple-use, sustained-yield principles, and implement a resource management plan for each unit of the NFS. The primary statues which authorize the disposal of renewable resources on NFS lands include the Organic Administration Act, Multiple-Use Sustained-Yield Act and the Bankhead-Jones Farm Tenant Act.

The FS is the federal agency responsible for the administration of the 191 million acres of land that comprise the NFS (Olson 1997). These lands consist of national forests and grasslands. The largest component of the NFS is the national forests. There are 155 national forests that contain more than 187 million acres. This amounts to almost 98 percent of the total acreage in the NFS.

The second largest component of the NFS is the national grasslands (Olson 1997). The FS currently administers 20 national grasslands consisting of

3,842,278 acres. National grasslands are located in 13 states. However, nine national grasslands consisting of 3,161,771 acres are in the Great Plains states of Colorado, North Dakota, South Dakota, and Wyoming. National grasslands in these four states alone contain more than 82 percent of the total national grassland acreage.

Bureau of Land Management

The BLM manages public lands under the authority of the Federal Land Policy and Management Act of 1976, Public Law 94-579, (43 USC 1714) (FLPMA). FLPMA provides direction for land use planning, administration, range management, rights-of-way, designated management areas (including specific locations and general designation of wilderness areas), and effects on existing rights (BLM 2008i).

The BLM is responsible for carrying out a variety of programs for the management and conservation of resources on 258 million surface acres, as well as 700 million acres of subsurface mineral estate (BLM 2008f). These surface acres comprise about 13 percent of the total US land surface and more than 40 percent of all land managed by the federal government.

Most of the public lands located in the western US, including Alaska, are characterized predominantly by extensive grassland, forest, high mountains, arctic tundra, and desert landscapes (BLM 2008j). The BLM manages multiple resources and uses, including energy and minerals; timber; forage; recreation; wild horse and burro herds; fish and wildlife habitat; wilderness areas; and archaeological, paleontological, and historical sites. In addition to its minerals management responsibilities, the BLM administers mineral leasing and oversees mineral operations on federal mineral estate underlying other state, private, or federally administered land, and manages most mineral operations on Indian lands.

The BLM administers approximately 57 million acres of commercial forests and woodlands through the Management of Lands and Resources and the Oregon and California Grant Lands appropriations (BLM 2008j). Under its multiple-use management mandate, the BLM administers more than 18,000 livestock grazing permits and leases and nearly 13 million authorized livestock AUMs on 160 million acres of public rangeland. The BLM also manages herd management areas and facilities for 57,000 wild horses and burros.

The BLM has an active program of soil and watershed management on 175 million acres in the lower 48 states and 86 million acres in Alaska (BLM 2008j). The 258 million acres of public lands include over 117,000 miles of fisheries habitat. Practices such as revegetation, protective fencing, and water development are designed to conserve and enhance public land, including soil and watershed resources.

Land Use Authorizations

Land use authorizations include various authorizations and agreements to use BLM-administered land, such as right-of-way (ROW) grants, road use agreements, and associated temporary use permits. Land use authorizations are issued for a variety of purposes, both short and long term. Short-term uses include agricultural leases, military training areas, and other uses involving minimal land improvements or disturbances. Long-term uses include rights-of-way grants for power lines, highways, roads, pipelines, fiber optics, communication sites, electric power generation sites, and irrigation.

Rights-of-way and Utility Corridors

As a general rule, a ROW is needed whenever a project is built on public lands (BLM 2008e). A ROW grant is an authorization to use a specific piece of public land for a certain project, such as roads, pipelines, transmission lines, and telephone lines. The grant authorizes rights and privileges for a specific use of the land for a specific period of time. Generally, a BLM or FS ROW is granted for a term commensurate with the life of the project. Typically, BLM grants are issued with 30-year terms, and most can be renewed. A more complete explanation of the BLM ROW program is found in Title 43 CFR 2800 and 2880. The BLM has also initiated efforts to streamline the application processing procedures (Instruction Memorandum No. 96-27 and Instruction Memorandum No. 97-18). A FS grant remains in effect unless terminated by mutual agreement or one agency giving the other 90 days prior written notice (FS 2003a). A more complete description to the FS ROW program is found in FS Manual 5460.

The EPAct of 2005 includes various initiatives directed at securing the nation's energy future, which include authorizing the US DOE in collaboration with federal land management agencies to designate corridors for energy transmission on federal lands within the 11 contiguous western states. The PEIS for Designation of Energy Corridors on Federal Land in the 11 Western States (US DOE and BLM 2007) considers 11 contiguous western states for the possible construction, operation, maintenance, and decommissioning and dismantling of energy infrastructure such as oil and gas pipelines and electric transmission lines; the states considered are Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. Geothermal resource development would use energy corridors to distribute electricity (US DOE and BLM 2007).

Land Use Permits and Leases

A lease is an authorization to possess and use public land for a fixed period of time. A lease is issued when there is going to be substantial construction, development, and improvement and there is an investment of large amounts of capital that will be amortized over time. Permits are authorized when uses of public lands will be short term and involve little or no land improvement, construction, or investment. Permits and leases are subject to process and monitoring fees and a fair market rental value.

Withdrawals

A land withdrawal is a real estate management tool to implement resource management planning prescriptions or to transfer administrative jurisdiction from one federal agency to another (BLM 2008c). A withdrawal creates a title encumbrance on the land, thereby restricting an agency's ability to manage its lands under multiple use management principles. The restrictions generally segregate the lands from some or all the public land laws and some or all of the mining and mineral leasing laws for a specific period of time, generally 20 years for post-FLPMA withdrawals. Withdrawn land can be closed to mining, mineral leasing, or mineral material disposal.

There are four major categories of formal withdrawals: administrative; Presidential Proclamations; Congressional; and Federal Power Act or Federal Energy Regulatory Commission Withdrawals (BLM 2008d). Withdrawals accomplish one or more of the following: transfer total or partial jurisdiction of federal land between federal agencies; close (segregate) federal land to operation of all or some of the public land laws and/or mineral laws; and dedicate federal land to a specific public purpose.

Split Mineral Estate

Public and NFS land ownership can involve split mineral estate situations, which involve separate surface ownership than subsurface ownership. For example, a parcel may contain private surface ownership and federal subsurface ownership, or it may contain federal surface ownership and private subsurface ownership. Through various acts, the federal government has retained mineral values, while encouraging settlement. As late as the 1980s, BLM policy concerning mineral estate was to reserve all oil and gas rights, as well as any other mineral values. Those lands on which the US reserved minerals and where they contain valuable mineral resources are generally kept in federal ownership. Many of the private surface owners have requested that the subsurface minerals be sold or transferred to their ownership.

3.2.2 Special Designations

The following section describes special management designations on public and NFS lands in the project and planning areas. These special areas have been designated to protect unique characteristics and contain resources that have been identified as scientifically, educationally, or recreationally important. Special management is administered with the intent to improve the manageability of the areas, allowing the BLM and FS to preserve, protect, and evaluate these significant components of national heritage. Special area designations on public and NFS lands can be established by Congress, Presidential Proclamation, or administratively. The BLM and FS have the authority to adopt special management designations through RMP or Forest Plan amendments or revisions.

Areas Designated by Congress or Presidential Proclamation

Congressional designations (Table 3-4) include Wilderness, National Conservation Areas, National Scenic Areas, National Recreation Areas, rivers in the National Wild and Scenic Rivers System, National Trails (discussed in detail under Section 3-16, National Scenic and Historic Trails) and Other Congressionally Designated Areas. The Steens Act Mineral Withdrawal Area is a Congressional designation specific to southeastern Oregon. National Monuments are designated by Presidential Proclamation or less commonly by Congressional designation. In instances where designations occur by an Act of Congress or Presidential Proclamation, the law or order designating each area provides specific objectives and guidelines for that area's management. Neither the BLM nor the FS has jurisdiction over lands other than public or NFS lands, respectively, within nationally designated areas.

Wilderness Areas

These areas are part of the National Wilderness Preservation System to ensure preservation and protection of their natural conditions. Nationwide, the FS manages more Wilderness areas (418) than any other agency, followed by the BLM (189). In the project area, there are a total of 408 Wilderness areas; California contains the most Wilderness areas (137), followed by Arizona (90), Nevada (68), and Alaska (48). In the planning area, there are 362 Wilderness areas. Activities and uses that do not support management objectives of these areas are prohibited. As such, subject to valid existing rights, Wilderness areas are withdrawn from all forms of mineral entry, location, and patent under the mining laws, and from disposition under all laws pertaining to mineral leasing.

National Conservation Areas

National Conservation Areas are designated mainly for the purpose of protecting natural or cultural resources. They may also be established to protect a variety of ecological, scenic, scientific, riparian, and recreation values. While most are managed for resource protection and recreation, activities such as grazing, logging, mining, and other commercial enterprises are often permitted. There is no single congressional act that guides the management of these areas. Instead, the particular Act that authorizes designation of each National Conservation Area identifies the unique values to be protected and any other specific management guidelines to be followed. In the project area, the BLM manages 17 National Conservation Areas, and the FS manages none. In the planning area, the BLM manages 15 National Conservation Areas, and the FS manages none.

Table 3-4
Congressional, Presidential, and Administrative Special Designation Areas on Public and NFS Lands in the Project and Planning Areas

Agency	Acreage									
	Congressional Designations							Administrative Designations		
	Wilderness Areas	National Conservation Areas	National Scenic Area	National Recreation Area	Wild and Scenic Rivers	Other Congressionally Designated Areas (FS)[1]	National Monuments	Wilderness Study Areas	Areas of Critical Environmental Concern (BLM)[2]	National Forest Inventoried Roadless Areas (FS)[3]
BLM (Project Area)	7,663,272	15,291,405	-	-	631,605	-	4,770,225	13,641,594	12,450,547	-
BLM (Planning Area)	6,441,930	2,223,694	-	-	333,254	-	1,288,035	10,050,923	8,243,565	-
FS (Project Area)	32,352,798	-	199,705	2,258,250	604,110	2,021,534	310,784	3,227,819	-	52,934,355
FS (Planning Area)	19,057,887	-	180,299	1,709,808	310,140	1,177,521	192,228	788,597	-	31,457,013
Total (Project Area)	**40,016,070**	**15,291,405**	**199,705**	**2,258,250**	**1,235,715**	**2,021,534**	**5,081,008**	**16,869,413**	**12,450,547**	**52,934,355**
Total (Planning Area)	**25,499,817**	**2,223,694**	**180,299**	**1,709,808**	**643,394**	**1,177,521**	**1,480,264**	**10,839,520**	**8,243,565**	**31,457,013**

1 Other Congressionally-Designated Areas are a FS-specific designation
2 Areas of Critical Environmental Concern are a BLM-specific designation
3 National Forest Inventoried Roadless Areas are a FS-specific designation
Source: BLM 2008c, FS 2008a

National Scenic Areas

These areas are designated to protect the scenic, cultural, historic, recreational, and natural resources in specific areas, while allowing compatible uses. The management policies for a specific National Scenic Area are set forth in the legislation designating it. In the project area the FS manages five National Scenic Areas. In the planning area, the FS manages three National Scenic Areas. No National Scenic Areas in the project or planning area are managed by the BLM.

National Recreation Areas

This designation was established primarily to protect important recreation, scenic, scientific, and natural values for the enjoyment of current and future generations. The activities center on water- and land-based activities associated with the natural environment. The uses and activities allowed within National Recreation Areas depend on the law designating the area and can vary widely. The FS manages 32 National Recreation Areas in the project area and nine in the planning area. No National Recreation Areas within the project or planning area are managed by the BLM.

Rivers in the National Wild and Scenic Rivers System

To effectively manage these special river segments, Congress established the National Wild and Scenic Rivers System. Rivers, or segments of rivers, must be free flowing and possess at least one outstandingly remarkable value, such as scenic, recreational, geologic, fish, wildlife, historic, cultural, or other features. The Bureau has many rivers not congressionally designated under the Act, but found to be eligible under the act. The outstandingly remarkable values of eligible rivers must be protected until superseded by Congress. Within the National Wild and Scenic Rivers System, three classifications define the general character of designated rivers: wild, scenic, or recreational. Classifications reflect levels of development and natural conditions along a stretch of river. These classifications are used to help develop management goals for the river.

There are approximately 1,235,715 acres of rivers in the National Wild and Scenic Rivers System in the project area and approximately 643,384 acres in the planning area. Nationwide, the northwestern states of Alaska, Washington, Oregon, Montana, and Idaho contribute well over half of the rivers to the National Wild and Scenic Rivers System, with Oregon leading the US with 48 designated rivers (National Wild and Scenic River System 2007). Four federal agencies cooperatively manage the congressionally designated rivers where rivers flow through federal lands. On federal lands, the National Park Service manages the most segments (29 percent), followed by FS (27 percent), BLM (22 percent), and USFWS (19 percent). The remaining river segments (less than 3 percent) are administered by a state.

National Monuments

These areas are designated to protect unique resources identified within the monument boundaries. National Monuments are managed by the BLM, FS, USFWS and NPS. Federal lands in National Monuments are generally closed to mineral development subject to valid existing rights. One exception is the Canyons of the Ancients National Monument in southwestern Colorado, which permits new leasing for oil and gas where a lessee makes a discovery on an existing lease and efficient recovery of the oil and gas resources requires drilling, or where necessary to protect oil and gas resources on federal lands against drainage.

Administrative Designations

At their discretion, both the BLM and FS may apply administrative designations (Table 3-4) in areas requiring special management. Administrative designations are not legislative. Special areas that are designated administratively by the BLM include Areas of Critical Environmental Concern (ACECs), Research Natural Areas, National Natural Landmarks, Backcountry Byways, and Watchable Wildlife Areas. Special areas designated by the FS include WSAs, Research Natural Areas, and Inventoried Roadless Areas. In addition, for the purposes of analysis in this PEIS, Wilderness Study Areas (WSAs) are also evaluated under administrative designation, however only Congress can provide additional direction for these areas.

Uses are permitted in the administratively designated areas to the extent that the uses are in harmony with the purpose for which the area was designated. All of the areas identified under this section would be closed to geothermal leasing or would be open with major constraints.

Wilderness Study Areas

The BLM and FS manage approximately 13,641,594 and 310,784 acres of WSAs in the project area, respectively. In the planning area, the BLM and FS manage approximately 10,050,923 and 788,597 acres of WSAs, respectively. The agencies are responsible for managing WSAs in such a manner to prevent impairment of their suitability for congressional designation as wilderness. The WSA designation remains until Congress makes a final decision on whether to designate the WSA as Wilderness, adding it to the National Wilderness Preservation System, or to release the lands from wilderness review. There are no time limitations on Congress, so it is uncertain when final decisions will be made on any WSA designation.

Areas of Environmental Concern

The FLPMA states that the BLM will give priority to the designation and protection of ACECs in the development and revision of land use plans. The ACEC designation is an administrative designation unique to the BLM; no other agency uses this form of designation. The ACEC designation indicates to the public that the BLM recognizes that an area has significant values and has established special management measures to protect those values. In addition, an ACEC designation also serves as a reminder that significant values(s) or resource(s) exist that must be accommodated when future management actions and land use proposals are considered near or within an ACEC. These ACECs differ from other special management designations, such as WSAs, in that designation by itself does not automatically prohibit or restrict other uses in the area. The one exception is that a mining plan of operation is required for any proposed mining activity within a designated ACEC. In the project area, the BLM manages 794 ACECs encompassing approximately 12,450,547 acres. In the planning area, the BLM manages 616 ACECs comprising approximately 8,243,565 acres. Appendix C identifies which ACECs are open or closed to fluid mineral leasing and what stipulations are required in areas open to leasing.

Inventoried Roadless Area

This FS-specific administrative designation represents some of the nation's most highly valued expanses of open space. Under this designation, approximately 58.5 million acres are conserved nationwide, or 31 percent of NFS lands, totaling about 2 percent of the total US land base. Nationwide, approximately 25 percent of the total acres of inventoried roadless areas are in Alaska. Another 72 percent of the nationwide total is in the remaining 11 states of the project area. The remaining 3 percent is outside the project area. In the project area, there are approximately 52,934,355 acres of inventoried roadless areas; and in the planning area, there are approximately 31,457,013 acres of inventoried roadless areas.

3.2.3 Recreation

Recreation opportunities on public and NFS lands range from dispersed uses, such as hiking and wildlife viewing, to developed recreation, including campgrounds and interpretive sites. Recreation is an important component of the multiple use management practices carried forth by both the BLM and FS. Recent surveys by these agencies demonstrate that recreational use on public and NFS lands is increasing annually. Steady population growth continues to increase the recreational demand on undeveloped public and NFS lands as visitors and nearby residents seek a diversity of recreational opportunities.

The Recreation Opportunity Spectrum is both a classification system and a prescriptive tool for recreation planning, management, and research (Clark and Stankey 1979). It is used by both the BLM and FS to illustrate the recreational setting by describing a combination of the physical, biological, social, and managerial conditions that give value to a place. The Recreation Opportunity Spectrum embodies six land classes: primitive; semiprimitive, nonmotorized; semiprimitive, motorized; roaded, natural; rural; and urban. Each setting prompts experiences that range from a sense of isolation and closeness to nature (at the primitive end of the spectrum) to social experiences in highly structured environments (at the urban end of the spectrum). The immense landscape of the project area contains a variety of recreation settings and opportunities allowing visitor to select the experiences most closely matching their reason for using public and NFS lands.

United States Department of Agriculture, Forest Service

Many people use NFS lands, waters, and recreation sites for physical exercise, nature exploration, and as an important means of relaxation (FS 2008a). The FS reports visitation estimates using standard definitions of national forest visits and national forest site visits. A national forest visit is defined as the entry of one person upon a national forest to participate in recreation activities for an unspecified period of time. A site visit is defined as the entry of one person upon a national forest site or area to participate in recreation activities for an unspecified period of time. In effect, a national forest visit is composed of one or more national forest site visits (FS 2008a).

According to the National Forest Visitor Use Monitoring Program, annual visitation to NFS lands nationwide is approximately 204.8 million national forest visits. Visitors averaged about 1.2 site visits for each national forest visit, or 245.9 million site visits. Included in the site visit total are 8.8 million site visits to designated Wilderness (FS 2008a).

Providing outdoor recreational opportunities is a primary goal identified in the FS Strategic Plan for Fiscal Years 2004 to 2008 (FS 2004a). More specifically, the FS recreational objectives are to:

- maximize opportunities for visitors to know and experience nature while engaging in outdoor recreation;
- develop and manage sites consistent with the available natural resources to provide a safe, healthful, esthetic, nonurban atmosphere; and
- provide a maximum contrast with urbanization at NFS sites (FS 2006a).

Many people visit NFS lands to camp, picnic, boat, or visit some other type of developed recreation facility. The top five activities pursued on NFS lands are viewing natural features, experiencing general relaxation, hiking, viewing wildlife, and pleasure driving (FS 2008a). Downhill skiing also is a popular activity in some regions.

Many of the facilities and services associated with FS recreation opportunities are free (FS 2008b). Some require fees or permits to help maintain, manage, and improve sites and facilities. Recreation permits may be required when extra measures are needed to protect natural or cultural resources. A Special Use Permit, which may include a fee, grants rights or privileges of occupancy and use to the holder. Examples include reserving a public site for a wedding party or holding a bicycle race on NFS lands. These permits contain specific terms and conditions that the holder must follow. Before Special Use Permits are issued, the FS must determine that the proposed use complies with all management plans and laws, that there is a demonstrated need for the activity, and that the use is appropriate on NFS lands. Special Use Permits are a temporary authority.

Bureau of Land Management

Public lands offer a number of diverse recreational opportunities. On more than 258 million acres of public lands, people enjoy several types of outdoor adventure, including camping, hunting, fishing, hiking, horseback riding, boating, whitewater rafting, hang gliding, off-highway vehicle driving, mountain biking, birding and wildlife viewing, taking photography, climbing, engaging in all types of winter sports, and visiting natural and cultural heritage sites. Recreational use on BLM-managed lands also helps support the economies of western communities and states. More than 22 million people now live within 25 miles of public lands, and two-thirds of public lands are within 50 miles of an urban area (BLM 2008g). Visits to recreation sites on public lands have significantly increased over the years, from just more than 51 million in 2001 to over 55 million in 2006, an almost 8-percent increase.

The BLM's outdoor recreation mission is to sustain healthy land and water resources while providing quality visitor services (BLM 2008f). The BLM's overall vision for outdoor recreation is "Visitors renewing their relationships with the land and respecting local cultures while enjoying quality recreation activities." The BLM provides resource-dependent recreational opportunities in a variety of settings that typify the vast western landscapes of the project area (BLM 2008f). These diverse settings range from Alaska's tundra to the deserts of the Southwest, and from the old growth forests of the Northwest to the plateaus and plains of the Rocky Mountain states. As a national provider of recreation, the BLM focuses on providing resource-based versus facilities-based recreation and tourism opportunities. Tourism generated by the recreation and leisure opportunities on public lands contributes significantly to the national economy, as well as to local economies (BLM 2008f). The BLM provides recreation opportunities in areas having national, regional, and local importance.

Recreational opportunities of regional and local importance are provided in a variety of settings on project area public lands: non-fee sites, rivers not in the National Wild and Scenic Rivers System (5,763 miles), and inventoried trails not in the National Trail System (7,468 miles) (BLM 2008f). While the BLM's focus is on providing resource-based recreation and tourism opportunities, the BLM provides facilities where necessary to protect resources and to serve as staging areas for resource-based recreation use. For the most part, however, facilities are not the attraction in and of themselves. In some areas, visitors are charged a recreation use fee or entrance fee to help cover the cost of facility maintenance and resource protection. The Federal Lands Recreation Enhancement Act (Public Law 108-447, Section 804) grants recreation fee authority to federal agencies including the BLM and FS to maintain and improve the quality of visitor amenities and services (BLM 2008h). It authorizes three fee categories: standard amenity fees, expanded amenity fees, and special recreation permits.

All public lands are allocated as a Special Recreation Management Area or an Extensive Recreation Management Area. A Special Recreation Management Area is a unit where specific recreation/tourism interests have expressed a desire for certain kind of activities, experiences, and other benefits. As such, these units are managed intensively for recreation, and the setting character in these units is a high priority. Areas with a Special Recreation Management Area allocation typically see investments in recreation facilities and visitor services. An Extensive Recreation Management Area is a unit with no identifiable market demand for structured recreation opportunities. Rather, an Extensive Recreation Management Area emphasizes the traditional dispersed recreation use of public lands. Extensive Management Areas are managed custodially; resources committed are generally limited and include provisions for visitor health and safety, and those aimed at reducing damage and mitigating user conflict. Visitors who want to avoid areas of intensive recreation activities generally prefer Extensive Recreation Management Areas. By default, anything not allocated as a Special Recreation Management Area becomes part of an Extensive Recreation Management Area.

Recreation Areas

The BLM and FS manage a diversity of recreation areas in the project area. These areas are managed and maintained for public use and offer a variety of opportunities such as camping, hiking, boating, interpretive programs, fishing, horseback riding, and wildlife viewing. Table 3-5, Number of BLM and FS Recreation Areas in the Project Area by State, lists the number of recreation areas managed by the BLM and FS in each state; these include campsites, trails not listed as nationally historic or scenic, sites at rivers and creeks not included in the National Wild and Scenic Rivers System, reservoirs, picnic sites, day-use areas, and certain multi-use recreational areas.

Table 3-5
Number of BLM and FS Recreation Areas in the Project Area by State[1]

State	Total # of BLM Recreation Areas in the Project Area	Total # of FS Recreation Areas in the Project Area[1]
Alaska	9	13
Arizona	38	49
California	41	298
Colorado	14	116
Idaho	50	103
Montana	4	55
Nevada	32	20
New Mexico	48	21
Oregon	49	107
Utah	83	153
Washington	11	98
Wyoming	38	52
Total	417	1,085

[1] Specially designated areas omitted from calculations include the following: Designated Critical Habitat, National Conservation Areas, National Game Refuge and Wildlife Preserves, National Historic Districts, National Historic and Scenic Trails, National Monuments, National Preserves, National Primitive Ares, National Protections Areas, National Recreation Areas, National Scenic Areas, National Scenic Research Areas, National Volcanic Monument Areas, National Wild and Scenic Rivers, (National) Wilderness Areas, Rental units (including cabins, lookouts, yurts, stations, kitchens, bunkhouses and A-frames), State Parks (Anasazi), Visitor, Discovery, and Information Centers, and Wilderness Study Areas.
Source: Recreation.gov (2008)

3.3 GEOLOGIC RESOURCES AND SEISMIC SETTING

The project area's geology is the result of large scale tectonic activity over hundreds of millions of years. The center of the North American continent, including central Canada and the central US, has been stable for over 600 million years. At the western edge, other pieces of crust have been added to the North American continent. The processes by which these pieces were added deformed the existing crust. The physiography (terrain texture, rock types, and geologic structure and history) of the western US is primarily a product of these additions and deformations.

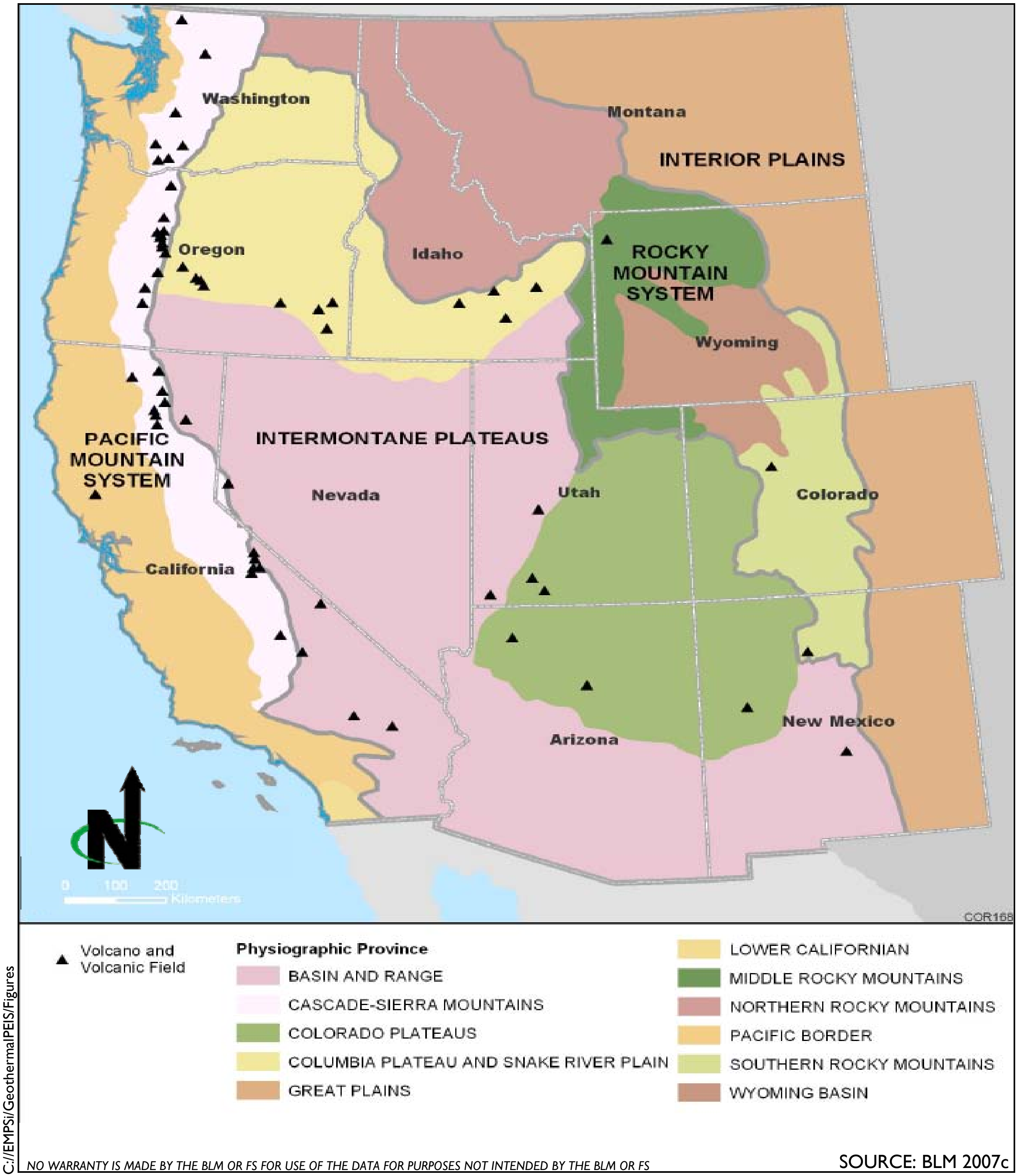
The western states are made up of several physiographic provinces with generally similar terrain and geologic characteristics. These physiographic provinces include the Great Plains, Southern Rocky Mountain, Wyoming Basin, Middle Rocky Mountain, Northern Rocky Mountain, Basin and Range, Colorado Plateau, Columbia Plateau, Cascade-Sierra Mountains, Pacific Border, and Lower California provinces. The characteristics of the physiographic provinces and Alaska are discussed below (Figure 3-1).

Regional Geologic History

During the last half of the Mesozoic Era, much of today's California, Oregon, and Washington were added to the North American continent. As slabs of ocean crust sank beneath the western edge of the continent, some pieces of continental crust were added to the continent, while other pieces were carried along with the sinking ocean slab (USGS 2004a). About 200 to 300 miles inland, magma generated above the sinking ocean slab rose into the North American continental crust erupting out of dozens of individual volcanoes. Volcanic mountain ranges grew as lava and ash erupted, and great masses of molten rock were injected and hardened in place beneath the surface (USGS 2004a).

For 100 million years, the effects of plate collisions were focused very near the edge of the North American continent. Three major mountain-building episodes reshaped the western US from about 170 to 40 million years ago (Jurassic to Cenozoic Periods). It was not until 70 million years ago that these effects began to reach the Rocky Mountains, resulting in raising mountains far inland from the western edge of the continent (USGS 2004a).

The southwestern US is beginning to be pulled apart by extensional forces. These forces are due to molten rock flowing in the earth's mantle beneath the solid crust. The extension results in a thinning of the crust over the mantle. The volcanism in the Basin and Range and the Rio Grand Rift is associated with this crustal extension and thinning. The crustal extension and associated volcanic activity, although slow, is ongoing and is the source of much geothermal heat (USGS 2003a).



C://EMPSi/GeothermalPEIS/Figures

There are 11 Physiographic Provinces in the 11 Western States

Physiographic Provinces of the 11 Western States

Figure 3-1

3.3.1 Characteristic by Physiographic Province

Great Plains

Physiography

The Great Plains physiographic province includes the west-central US, including eastern Montana, eastern Wyoming, eastern Colorado, and eastern New Mexico within the project area (Figure 3-1).The province is characterized by flat to rolling prairie with scattered hills and bluffs gradually rising westward to abruptly give way to the frontal ranges of the Rocky Mountains in the Southern Rocky Mountain and Basin and Range physiographic provinces (USGS 2002). With the exception of the Black Hills of South Dakota, with altitudes of 7,000 feet, the entire region has low relief (USGS 2002, USGS 2004b).

Geology

The Great Plains is a vast region that spreads across the stable core of North America. This area formed when several small continents collided and welded together over a billion years ago during the Precambrian. Precambrian metamorphic and igneous rocks form the basement of the Great Plains and make up the stable nucleus of North America. The province has experienced more than 500 million years of relative tectonic stability, remaining relatively unaffected by the mountain-building tectonic collisions suffered by the western and eastern margins of the continent (USGS 2004b).

During part of the Jurassic (208 to 144 million years ago), rising seas flooded the low-lying areas of the continent. Much of the Great Plains eventually lay submerged beneath shallow seas with sediments eroding from the rising Rocky Mountain deposited as layered wedges of fine debris. As sand, mud, and clays accumulated, the seas retreated northward. Once again, during the Cretaceous (144 to 65 million years ago), record high sea levels flooded the continental interior with shallow seas (USGS 2004b). The flatness of the Great Plains is a reflection of the platform of mostly flat-lying marine and stream deposits laid down in the Mesozoic and Cenozoic Eras (USGS 2004b). Uplifts, such as the Black Hills Uplift in eastern Wyoming and western South Dakota, are places where the Paleozoic and younger sedimentary rocks have been eroded away and crystalline rocks are exposed (USGS 2002).

Southern Rocky Mountains

The Southern Rocky Mountains are part of the Rocky Mountain System, a discontinuous series of mountain ranges that extend from central New Mexico northwest to the Canadian border (Figure 3-1). The system also includes the Middle Rocky Mountain, Northern Rocky Mountain, and Wyoming Basin provinces (USGS 2003a).

Physiography

West of the frontal ranges in Colorado and northern New Mexico are additional and higher mountain ranges generally oriented north-south but with many spurs and extensions oriented in other directions. These ranges are separated by valleys and high mountain parks. The ranges include 54 mountain peaks higher than 14,000 feet. Most of these high peaks are located near the Continental Divide, which extends approximately north-south through central Colorado and western New Mexico. The altitude of the divide decreases in southern New Mexico to less than 4,500 feet in some areas (USGS 2002).

Geology

The last major mountain-building event affecting the western US (about 70 to 40 million years ago) is responsible for raising the Rocky Mountains (USGS 2004a). Prior to the mountain-building uplifts, most of the area was covered by an extensive layer of sediments that had been deposited during the previous millions of years. These layers of sediment were gradually buried and altered to form layers of rock. The Great Plains province to the east of the Southern Rocky Mountains is still underlain by a relatively flat and undeformed sequence of these rocks (USGS 2002).

The uplift of the Rocky Mountains faulted, deformed, and elevated the land surface and the underlying ordered layers of rock. Faulting was prevalent, and a few faults developed more than 20,000 feet of vertical offset. As uplift continued, erosion removed the uppermost rocks and, in some areas, exposed the underlying crystalline-rock core of the mountains (USGS 2002). Many of the individual ranges that make up the Rocky Mountains are made up of a core of uplifted Precambrian granite surrounded by Paleozoic and Mesozoic sedimentary rocks that once overlay the uplifted blocks. Erosion throughout the Tertiary period exposed the uplifted blocks and filled valleys with deposits derived from both the Paleozoic and Mesozoic rocks and the Precambrian cores (USGS 2003a).

Rocks of various geologic age have a wide surficial distribution because of the depositional history and deformation of the area. Deformation caused extensive faulting, and faults commonly separate adjacent geologic units (USGS 2002).The Southern Rocky Mountains province is beginning to be pulled apart by extensional forces. The physiographic feature associated with this extension is the Rio Grande Rift, a long fault-bounded basin through which the upper Rio Grande River flows southward through New Mexico. Volcanism accompanies this extension. Inside the Rio Grande Rift, lava from a source deep in the mantle has periodically erupted. Among the larger volcanoes is the Valles Caldera in north-central New Mexico (USGS 2003a). The crustal extension and associated volcanic activity, although slow, is ongoing and is the source of much of the geothermal heat present in New Mexico and southern Colorado (USGS 2003a).

Wyoming Basin

Physiography

The Wyoming Basin is primarily in south-central Wyoming but also extends into northern Colorado (Figure 3-1). The Basin consists of a series of broad intermountain basins lying between isolated hills and low mountains between the Southern and Middle Rocky Mountains (BLM 2003a) The major basins within this province include the Greater Green River, Wind River, Laramie, and Hanna Basins. Within each of the major basins, there are numerous sub-basins.

Geology

During Paleozoic time, present-day Wyoming and much of the Rocky Mountain west were located along a fairly stable continental shelf with the land areas to the east. The area was generally inundated by shallow seas and fluctuations in sea level, which resulted in the deposition or erosion of sediments. Uplift and erosion of the Ancenstral Rocky Mountains during the Pennsylvanian resulted in the deposition of sandstones before a return of a shallow marine environment with repeated fluctuations in sea level (BLM 2003b).

Near the end of the Cretaceous, mountain building began again in the western Wyoming-eastern Idaho Thrust Belt. As the mountains were uplifted, erosion occurred and sediment was shed into the shallow seas to the east. At the end of the Cretaceous and the beginning of Tertiary time, another episode of mountain building (the Southern Rocky Mountains) was occurring to the east and southeast of the area involving the uplift of the Precambrian basement (BLM 2003b).

The uplifted blocks of basement rock were eroded and the sediment was deposited in the surrounding basins. In Oligocene and Miocene time, large volcanic eruptions occurred to the west and north of the area depositing thick layers of ash. Also in later Tertiary time, one more episode of uplift occurred, again resulting in the deposition of material in the basins. The late Tertiary deposits were subjected to erosion, and by the end of Tertiary time and the beginning of Quaternary time, the present-day topography began to emerge (BLM 2003b).

Middle Rocky Mountains

Physiography

The ranges of the Middle Rocky Mountain province cover most of northwestern Wyoming and extend north into Montana, west into Idaho, and southwest into Utah and Colorado (Figure 3-1). The province is separated from the Southern Rocky Mountains to the southeast by the Wyoming Basin. The ranges of this province are generally lower and less continuous than those to the south. The highest peaks of the Middle Rockies are Gannet Peak (13,785 feet) in the Wind River Range and Grand Teton (13,766 feet) in the Teton Range (Columbia Encyclopedia, 2007).

Geology

Before the Laramide mountain-building period, the Middle and Southern Rockies were part of a stable platform composed of Precambrian crystalline rocks. The platform received sediments that were transformed into sedimentary rocks, which were then uplifted and eroded during the mountain-building period. Later, volcanic activities produced mountains and high plateaus in many places (US DOE ad BLM 2007).

Tectonic forces that acted on the region produced large areas of subsidence and uplift. The smaller intermontane basins are less than 3,000 feet deep. The amount of uplift in the segment likewise varies considerably (USGS 2002).

Geologic structures, such as faults, anticlines, and synclines, are numerous and complex in the Middle Rocky Mountains in Wyoming. Older rocks have been lifted upward and shifted eastward over younger rocks along thrust faults in the Teton Range. The principal parts are the Wasatch and Teton ranges (which are both great tilted fault blocks); the Yellowstone Plateau and Absaroka Range (both developed on volcanic rocks); and the Bighorn, Beartooth, Owl Creek, and Uinta Mountains, and the Wind River Range (all broad folded mountains). All of these component sections have been eroded down to their Precambrian cores and are rimmed by Paleozoic and Mesozoic sedimentary rocks (Columbia Encyclopedia, 2007). Thick sequences of Paleozoic and younger sedimentary rocks have been downfolded into the numerous basins in the Wyoming Basin. Where these sedimentary rocks have been upfolded into anticlines that separate the basins, the rocks have been partly or completely removed by erosion, and older, mostly crystalline rocks are exposed along the axes of the uplifts or anticlines. In Yellowstone National Park, Quaternary volcanic rocks overlie the crystalline rocks (USGS 2002).

Northern Rocky Mountains

Physiography

The Northern Rocky Mountain province is located in western Montana and northern Idaho (Figure 3-1). The province is characterized by low mountains with summits between 6,900 and 7,874 feet above sea level (US DOE and BLM 2007).

Geology

The Rocky Mountains include fault-bounded uplifts, folded mountains, and highlands formed by volcanism resulting from the mountain-building period that occurred between the middle Cretaceous and late Eocene Periods. The uplift also set the stage for the geomorphic evolution of the Rocky Mountains, producing ridges and plateaus high enough to be glaciated, as well as many of the region's streams and canyons (US DOE and BLM 2007). Geologic structures, such as faults, anticlines, and synclines, are numerous and complex in the Northern Rocky Mountains. Older rocks have been lifted upward and shifted eastward over younger rocks along thrust faults near the Continental Divide and in the Teton Range (USGS 2002).

Precambrian rocks are exposed in western Montana and in Wyoming. Sedimentary rocks of Precambrian age crop out over a wide area in western Montana. In Wyoming and southwestern Montana, Precambrian rocks mostly are plutonic igneous rocks but also include several types of metamorphic rocks. (USGS 2002).

Paleozoic sedimentary rocks are exposed at the land surface mostly in mountainous areas where they flank uplifts or anticlines, or have been displaced upward along faults (USGS 2002a). Mesozoic (chiefly Cretaceous) sedimentary rocks are exposed over wide areas in Montana and Wyoming (USGS 2002). Mesozoic igneous intrusive rocks are common in central Idaho (US DOE and BLM 2007).

Large areas of Tertiary intrusive and volcanic rocks are present in northwestern Wyoming and western Montana (USGS 2002). Tertiary and Quaternary valley-fill deposits occur in western Montana and Wyoming, and Quaternary silicic volcanic rocks are in small areas in northwestern Wyoming and southwestern Montana.

Basin and Range

Physiography

Centered on Nevada and extending from eastern California to central Utah, and from southern Idaho into Sonora, Mexico, the Basin and Range province can be divided into the Great Basin in the north and the Salton Trough, Mojave-Sonoran Desert, Mexican Highlands, and Sacramento Mountains in the south (Figure 3-1) (USGS 2003a , US DOE and BLM 2007). The Basin and Range province has a characteristic topography, with more than 400 evenly spaced, nearly parallel mountain ranges and intervening basins. The mountain ranges are generally abrupt, steeply sloping, and deeply dissected with relief between 3,000 and 5,000 feet above the intermountain basins. The basins are typically broad, gently sloping, and largely undissected with altitudes from below sea level to about 5,000 feet above sea level (US DOE and BLM 2007).

Geology

The Basin and Range province was created about 20 million years ago as the earth's crust stretched, thinned, and then broke into some 400 mountain blocks that partly rotated from their originally horizontal positions (USGS 2003a). Along roughly north-south-trending faults, mountains were uplifted and valleys down-dropped, producing the province's distinctive alternating pattern of linear mountain ranges and valleys or basins (USGS 2002).

The mountain ranges consist of complexly deformed late Precambrian and Paleozoic rocks and some Mesozoic granitic rocks in the western part of the province. Cenozoic volcanic rocks are widespread throughout the province (US DOE and BLM 2007). These uplifted rocks erode and fill the intervening valleys and basins with fresh sediment (USGS 2003a). These basins generally contain an underlying, relatively undeformed sequence of rock that was deposited in the area prior to uplift and an overlying younger layer of rock and sediment that was derived from the erosion of nearby uplifted areas. Some of these basins contain older sedimentary rocks or volcanic rocks, and almost all contain a thick overlying sequence of Tertiary and Quaternary sediment derived from erosion of nearby uplifted blocks (USGS 2002).

Within the province, the earth's crust has been stretched up to 100 percent of its original width. The entire region has been subjected to extension that thinned and cracked the crust as it was pulled apart, creating large faults.

Colorado Plateau

Physiography

The Colorado Plateau includes the High Plateaus of Utah, Uinta Basin, Canyon Lands, Navajo section, Grand Canyon section, and Datil section (Figure 3-1) (USGS 2003a). The province is a vast region of plateaus, mesas, and deep canyons. Uplift of the Colorado Plateaus steepened stream gradients and accelerated the downcutting of the Colorado River and its principal tributaries. Downcutting of the Colorado River in the Grand Canyon has exposed thousands of feet of sedimentary rocks (USGS 2002).

Geology

Ancient Precambrian metamorphic rocks formed during continental collisions over a billion years ago make up the basement of the Colorado Plateau. Igneous rocks were injected millions of years later. These basement level rocks were uplifted and eroded until, by 600 million years ago, they had been beveled off to a smooth surface upon which younger rocks were deposited (USGS 2004a).

During the next 300 million years, the Colorado Plateau region was periodically inundated by tropical seas. Thick layers of limestone, sandstone, siltstone, and shale were laid down in the shallow marine waters. During times when the seas retreated, stream deposits and dune sands were deposited or older layers were removed by erosion (USGS 2004a). About 250 million years ago deposits of marine sediment waned and terrestrial deposits dominated. Eruptions from volcanic mountain ranges to the west buried vast regions beneath ashy debris. Short-lived rivers, lakes, and inland seas left sedimentary records of their passage. The Colorado Plateau is remarkable stable. Relatively little rock deformation (e.g., faulting and folding) has affected this high, thick crustal block within the last 600 million years (USGS 2004a).

Beginning about 20 million years ago, both the Basin and Range and Colorado Plateau regions were uplifted as much as almost two miles. Great tension developed in the crust, probably related to changing plate motions far to the west. As the crust stretched, the Basin and Range province broke up into a multitude of down-dropped valleys and elongate mountains. The neighboring Colorado Plateau preserved its structural integrity and remained a single tectonic block. Eventually, the great block of Colorado Plateau crust rose over one-half mile higher than the Basin and Range. As the land rose, the streams responded by cutting ever deeper stream channels, including the Grand Canyon (USGS 2004a).

Columbia Plateau

Physiography

The Columbia Plateau province includes southeastern Washington, northwestern Oregon, and most of southern Idaho (Figure 3-1). The province includes the Walla Walla Plateau, Blue Mountain section, Payette section, Snake River Plain, and the Harney section (USGS 2003a). The topography of the Columbia Plateau province is dominated by geologically young lava flows that inundated the countryside within the last 17 million years. The province is enveloped by one of the world's largest accumulations of lava (over 193,000 square miles). Over 220 million cubic yards of basaltic lava, known as the Columbia River basalts, covers the western part of the province. The Snake River Plain lies in a distinct depression (USGS 2004c). The Snake River Plain stretches across Oregon, through northern Nevada and southern Idaho, and ends at Wyoming's Yellowstone Plateau. Looking like a great spoon scooped out the earth's surface, the smooth topography of this province forms a striking contrast with the rugged mountainous fabric around it.

Geology

Between 14 and 16 million years ago, fissure volcanic eruptions in eastern Washington, eastern Oregon, and western Idaho produced enormous volumes of molten Columbia River lava that flowed west into eastern Washington and northeastern Oregon, with some lava continuing to flow as far west as the Pacific Ocean via the ancestral Columbia River valley. The lava eventually accumulated to a thickness of more than 6,000 feet. As the molten rock came to the surface, the earth's crust gradually sank into the space left by the rising lava. The subsidence of the crust produced a large, slightly depressed lava plain now known as the Columbia Basin (Plateau) (USGS 2003b). With the end of the outpouring of lava, tremendous forces deep within the earth began to warp the plateau in several places. A general uplift of the mountainous region in the north caused the entire plateau to tilt slightly to the south.

The Columbia River Basalt was created by tremendous eruptions between 17 and 6 million years ago, with most erupting in the first 1.5 million years. In the west, the Columbia River Basalts are almost exclusively black basalt (USGS 2004c).

The western end of the Snake River Plain is formed by a block down dropping between normal faults, known as a horst and graben structure. Although there is extensive faulting at the eastern end, the structure is not as clear. The earliest Snake River Plain eruptions began about 15 million years ago, just as the tremendous early eruptions that created Columbia River Basalt were ending.

But most of the Snake River Plain volcanic rock is less than a few million years old and younger. The Snake River Plain eruptions produced soupy black basaltic lava flows alternated with tremendous explosive eruptions of rhyolite, a light-colored volcanic rock (USGS 2004c).

Volcanic cinder cones dot the landscape of the Snake River Plain, along with calderas (great pits formed by explosive volcanism), low shield volcanoes, and rhyolite hills. Many of these features are obscured by later lava flows (USGS 2004c).

The volcanic activity is thought to be due to a concentrated heat source, or hot spot, that melted the rock beneath the Columbia Plateau province. Scientists have determined that the youngest volcanic rocks are clustered near the Yellowstone Plateau, and that the farther west they investigated, the older the lava rocks. This data led to the theory that an extremely hot plume of deep mantle material has risen and continues to rise to the surface beneath the Columbia Plateau province. It has caused and continues to cause eruptions as the North American plate is moving over it, leaving a record of plate motion rate and direction. The hot spot is thought to currently be under Yellowstone National Park. The steaming fumaroles and explosive geysers are ample evidence of a heat concentration beneath the surface (USGS 2004c). The Yellowstone Caldera is a large crater-like feature covering more than 1,300 square miles. It formed when an underground magma chamber collapsed after an eruption 630,000 years ago (USGS 2003a).

Cascade-Sierra

Physiography

The Cascade-Sierra province includes the Sierra Nevada in central California and Nevada in the south, and the Southern Cascade Mountains, Middle Cascade Mountains, and Northern Cascade Mountains in northern California, Oregon, and Washington (Figure 3-1)(USGS 2003a). The Cascade and Sierra Nevada ranges are part of the large mountain chain stretching more than 12,000 miles from Tierra del Fuego to the Alaskan Peninsula (USGS 2000). Extending from 14,494 feet (Mt. Whitney, the highest peak in the lower 48 states) in the east to near sea level in the west, the Sierra Nevada contains Yosemite and Sequoia National Parks (USGS 2003a).

The great length and strong north-south linearity of the Middle and Southern Cascade ranges, a narrow band extending from southern Washington to northern California (roughly parallel to the Pacific coastline), contrasts sharply with the varied directional trends of other mountain groups to the east and northeast. These mountain ranges contain 13 major volcanic centers with large and geologically recent active volcanoes that dominate the landscape (USGS 2000).

The North Cascade Range is steeper and wetter than most other continental US ranges. The peaks of the North Cascades reach elevations of 7,000 to 8,000 feet, with relatively large uninterrupted vertical distances from valley bottom to mountain top of 4,000 to 6,000 feet (USGS 2000). The deep canyons and sharp peaks are products of profound erosion from water and glaciers (USGS 2000).

Geology

Although the Sierra Nevada and Cascade Range are in a single province, the two ranges have been and continue to be formed by quite different geological forces and processes (USGS 2004d). The Sierra Nevada is a west-tilting 350-mile-long block of granite. The massive granite intruded the crust in Mesozoic time and was uplifted and faulted in the Tertiary during formation of the Basin and Range province to the east. The granitic rocks that underlie the fault blocks of the Sierra Nevada and the volcanic rocks of the southern Cascade Mountains join to form the eastern border of the low-lying California Trough, which contains the Central Valley. Eroded material from the Sierra Nevada has filled California's Central Valley (USGS 2003a).

The Cascade Mountains arose through the plate collisions that have enlarged the western portion of the continent in Tertiary to Quarternary time. The Cascade Mountains are comprised of a band of thousands of very small, short-lived volcanoes that have built a lava and volcanic debris platform. This mountain range contains large and geologically recent active volcanoes such as Rainier, Hood, and Shasta (USGS 2000). The few large volcanoes rise above this volcanic platform (USGS 2004e).

The northern Cascade Mountains includes rocks up to 400 millions years old. The range is a geologic mosaic made up of pieces of islands, ocean floor, and old continents that were carried along by the tectonic plates and added to the North American continent (USGS 2000). These assembled pieces were uplifted, eroded, and in some places buried again. Other pieces were forced deep into the earth to be heated and squeezed before being raised again (USGS 2000). About 35 million years ago volcanoes erupted to cover the older rocks, and large masses of molten rock invaded the older rocks from below. The volcanic arc is still active today (USGS 2000).

Pacific Border

Physiography

The Pacific Border province, also called the Pacific Uplands, consists of several mountain ranges along the Pacific Coast. These ranges are separated from the Cascade-Sierra Nevada province by troughs. The Pacific Border Province includes the Puget Trough, Olympic Mountains, Oregon Coast Range, Klamath Mountains, California Trough, California Coast Ranges, and Los Angeles Ranges (Figure 3-1) (USGS 2003a).

The Olympic Mountains in Washington are the northernmost of the coast ranges. The northwest-southeast trending Olympic-Wallowa Line across southern Washington is a structural zone that includes active earthquake faults (USGS 2003a).

Many volcanoes erupted throughout the region forming the Oregon Coast Range, but most individual craters are small. Among the larger volcanoes in the region is Crater Lake in southwest Oregon, which is part of the Cascade Range (USGS 2003a). The Klamath Mountains in southwestern Oregon and northwestern California include the Salmon and Trinity Mountains.

The California Trough (Central Valley, or Sacramento and San Joaquin Valleys) is a northwest-southeast trending elongate depression between the Sierra Nevada and Coast Ranges to the east and west, respectively (USGS 2003a). The valley is flat and full of material eroded from the surrounding mountains. These sediments contribute to the productive agricultural industry now in the region.

The California Coast Ranges consisting of the Diablo and Santa Lucia Ranges parallel the Pacific Coast in a complex series of ridges and valleys. The Transverse Ranges run perpendicular to the Coast Ranges north of Los Angeles.

Geology

The several mountain ranges underlain by severely folded, faulted, commonly metamorphosed marine and continental sediments form the Coastal Ranges (USGS 2002). Between 100 and 50 million years ago, subduction beneath the western edge of the North American continent resulted in the collision and buildup of belts of oceanic rock that gradually built the continental margin westward. During this subduction, magma rose up, causing the formation of chains of andesitic volcanoes at the surface and plutons of granitic magma beneath them. Plutonic rocks from this period are found in the Klamath Mountains, Sierra Nevada, Basin and Range, Mojave Desert, and Peninsular Ranges. During this time, the subducting plate was consumed beneath the North American plate and, by 100 million years ago, the subduction zone had shifted westward to the approximate position of today's Coast Ranges (Friedel, 2003).

The San Andreas transform fault system developed about 28 million years ago with the collision of the Pacific plate and the North American plate. This collision caused the subduction zone along the coast to cease, and the two plates began to slide past each other (Friedel, 2003). The topographic texture of western California is controlled by the San Andreas Fault system. Since the Tertiary, the shortening and wrinkling the crust due to this movement has created the parallel coastal northwest-southeast mountain ranges (USGS 2003a).

Lower California

Physiography

Several coastal mountain ranges underlain by severely folded, faulted, and commonly metamorphosed marine and continental sediments form the Lower California physiographic province (USGS 2002). The province is an extension of the Baja California peninsula. The province includes rolling mountain and valley terrain in southwestern California (Figure 3-1).

Geology

The Lower California province is comprised of the northern end of a granitic ridge forming the Baja California peninsula. The Lower California province is part of the Pacific plate and is sliding northward past the North American plate. These rocks are exposed on head lands at Point Loma and at La Jolla, California, with stretches of low estuaries filled with drifted sand and other deposits as in Mission Bay, California, and the enclosing sand spits there and along the Silver Strand which forms San Diego Bay California (NPS 2007).

Alaska

Physiography

In Alaska, a belt of mountains forms the South Central Alaska province, leading into the Alaska Peninsula and Aleutian Islands province.

Alaska is geologically and topographically diverse. Most of Alaska is on a large peninsula that forms the northwestern corner of the North American continent and separates the Arctic and Pacific Oceans. Large areas of high, rugged mountains in northern and southern Alaska are extensions of mountain systems in Canada. The Brooks Range in northern Alaska is the western terminus of the Rocky Mountain System. In southern Alaska, the Alaska and the Boundary Ranges, and the Talkeetna, Wrangell, Kenai-Chugach, and St. Elias Mountains are extensions of the Pacific Mountain System. The south peak of Mount McKinley in the Alaska Range is the highest point in the US with an altitude of 20,320 feet above sea level. The Aleutian Range that extends as a long peninsula southwestward from the Alaska mainland is an extension of the Alaska Range. Low mountains, plateaus, and highlands bound the high mountains and are, in turn, bounded by lowland areas (USGS 2002)

Geology

Alaska has a complex geology with a mosaic of geologic terranes (pieces of the Earth's crust), where each terrane's geologic history is different than that of adjacent terranes. All the terranes in Alaska represent blocks of the earth's crust that have moved large or small distances relative to each other. The movement might have been lateral movement with or without any rotation. Some of the terranes may have moved only a short distance, whereas others may have moved laterally for several hundreds of miles or rotated as much as 135 degrees. The pattern of Alaska terranes reflects the interactions of oceanic crustal plates with the North American plate. Large-scale lateral and rotational movements, rifting, and volcanic activity result from these interactions.

3.3.2 Geologic Hazards

Geologic hazards include earthquakes, volcanoes, landslides, and subsidence.

Seismic Risk. Earthquakes are the result of large masses of rock moving against each other along fractures called faults. The shaking due to earthquakes can be significant a dozen or more miles from the actual point where they occurred depending on type of earthquake and the type of rock and soils beneath a given location.

Crustal earthquakes, the most common, typically occur along faults, or breaks in the earth's crust, at shallow depths of 6 to 12 miles. Great subduction zone earthquakes occur around the world where the tectonic plates that make up the earth's surface collide. When these plates collide, one plate slides (subducts) beneath the other, where it is reabsorbed into the mantle of the earth. This dipping interface between the two plates is the site of some of the most powerful earthquakes ever recorded, often having magnitudes of eight to nine or larger. The 1964 Great Alaska (magnitude 9.2) earthquake was a subduction zone earthquake. Deeper intraplate earthquakes occur within the remains of the ocean floor that is being subducted beneath North America. The magnitude 6.8 intraplate earthquake that struck the Puget Sound area in 2001 was much less destructive than a crustal earthquake of the same magnitude would have been because of its great depth (33 miles). This type of earthquake could occur beneath much of the Northwest at depths of 25 to 37 miles (Oregon Department of Geology and Mineral Industries 2007).

The assessment of risk from earthquakes is complex and is usually expressed as zones of probability for given accelerations due to shaking. Figure 3-2 shows the peak accelerations with a 10-percent chance of being exceeded within the next 50 years for the western US.

Volcanoes. Volcanoes, like most earthquakes, are related to tectonic plate motion. Volcanoes cause a diversity of hazards to human culture, including clouds of hot gasses carrying rock and sand, blast effects, ash falls, and mud flows. However, unlike earthquakes, volcanoes generally give plenty of warning that they are awakening, although the actual moment of eruption may be a surprise (Oregon Department of Geology and Mineral Industries 2007). The presence of high geothermal heat flow is often associated with current and past volcanic activity. Volcanic risk is discussed below in terms of the location of volcanoes in the region. Figure 3-2 shows the location of volcanoes and volcanic fields within the western US.

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SOURCE: BLM 2007c

The assessment of risk from earthquakes is expressed as zones of probability for given accelerations due to shaking.

LEGEND:
Peak Ground Acceleration (g)
- 0-0.1
- >0.1-0.2
- >0.2-0.4
- >0.4-1.0

Peak Horizontal Ground Acceleration of the 11 Western States

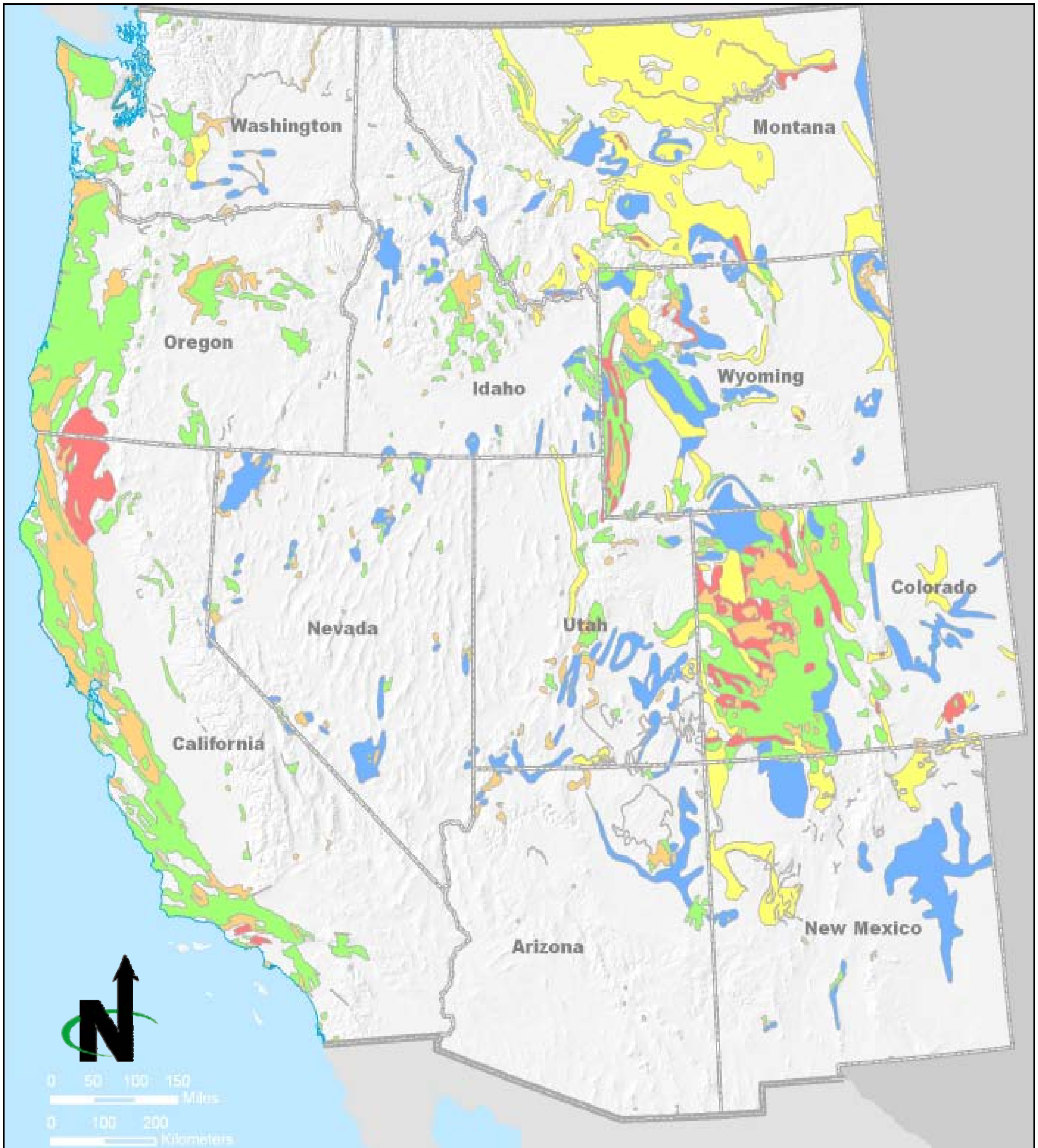
Lands with a 10% probability of exceedance within 50 years

Figure 3-2

Landslides. Landslides are the downslope movement of rock, soil, or related debris; however, the term generally implies a quick movement. Geologists use the term "mass movement" to describe a great variety of processes such as rock fall, creep, slump, mudflow, earth flow, debris flow, and debris avalanche regardless of the time scale. In most mass movement, water plays a pivotal role by assisting in the decomposition and loosening of rock, lubricating rock and soil surfaces to enhance the beginning of movement, adding weight to an incipient landslide, and imparting buoyancy to the individual particles.

Mass movements can be triggered by other natural geologic disasters or human activity. Volcanic eruptions and earthquakes can initiate earth movement on a grand scale. Lahars, debris flows made up of volcanic ash and water, are often the major hazard experienced in a volcanic episode. Although earthquakes can initiate debris flows, a major cause of mass movements is continuous rains that saturate soils. Mass movements are also frequently the direct consequence of human activity. Seemingly insignificant modifications of surface flow and drainage may induce mass movements (Oregon Department of Geology and Mineral Industries 2007). Areas at risk for mass movements include areas with steep slopes and areas with slighter slopes and unstable soils (Figure 3-3).

Subsidence. Subsidence is the slow, downward sinking of the land surface. It can occur naturally in areas that are tectonically active such as volcanic regions and fault zones. Subsidence can also occur in areas where sedimentary basins are filled with unconsolidated sands, silts, clays and gravels. Subsidence can also occur as a result of the extraction of subsurface fluids, including groundwater, hydrocarbons, and geothermal fluids. In these cases, a reduction in reservoir pore pressure reduces the support within the reservoir rock itself and for the rock overlying the reservoir, resulting in a copaction of the reservoir rock potentially leading to a slow, downward deformation of the land surface. Figure 3-8 shows the areas in the western US with major unconsolidated aquifers where pumping of groundwater could result in subsidence. In Alaska, subsidence is associated with soils rich in organic carbon when they are drained for agriculture or other purposes. Microbial decomposition, under drained conditions, readily converts the organic carbon to carbon dioxide gas and water causing a reduction in soil volume (Kagel et al. 2007).



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SOURCE: BLM 2007c

Areas at risk for mass movements include areas with steep slopes and areas with slighter slopes and unstable soils.

LEGEND:

Landslide Potential

- High Incidence and High Susceptibility
- High Incidence
- Moderate Incidence
- High Susceptibility
- Moderate Susceptibility

Landslide Hazard Potential of the 11 Western States

Figure 3-3

3.4 ENERGY AND MINERAL RESOURCES

Public and NFS lands are managed for recreation, timber harvesting, livestock grazing, oil and gas production, mining, wilderness protection and other purposes (US DOE and BLM 2007). In this section, energy and mineral resources are discussed, along with their association with geothermal resources.

On federal lands, mineral resources are governed by the General Mining Law of 1872, as amended; those portions of the Federal Land Policy and Management Act of 1976, as amended (FLPMA) that affect the General Mining Law; and the Surface Resources Act of 1955 and The Mining and Minerals Policy Act of 1970. Oil, Gas leasing is guided by the Energy Policy Act of 2005. Geothermal leasing is guided by the Geothermal Steam Act of 1970 (30 USC 1004), as amended by the Energy Policy Act of 2005.

The BLM manages Oil and Gas leases under Title 43 CFR part 3100, exploration under part 3150. Geothermal leasing is managed under Part 3200, mineral materials under 3600 regulations, mining claims for locatable minerals under 3800 regulations and solid leasable minerals other than coal or oil shale under Part 3500. The FS manages oil and gas operations on NFS lands under 36 CFR subpart E. Mineral leasing operations are guided by Forest Service Manual 2820 and mineral prospecting, including geophysical activities is guided by Forest service manual 2860. Locatable minerals and surface management regulations fall under 36 CFR 228 Subpart A and Forest Service Manual 2810. Mineral materials are regulated under 36 CFR 228 Subpart C and Forest Service Manual 2850.

Wind, solar, and biomass are considered renewable energy resources, along with geothermal energy resources. These resources all have different requirements related to economic development. However, some issues are common to all, including distance to existing power transmission facilities and compatibility with existing federal land use.

3.4.1 Solar Energy Resources

Solar energy is a renewable energy resource that has excellent potential for generating electricity in a large part of the western US. Installation of solar energy facilities on public and NFS lands requires a right-of-way permit instead of a lease. There are two basic types of solar energy installations that produce electrical power: photovoltaics systems and concentrating solar power. These can be combined with natural gas or other fossil fueled power systems to form hybrid systems.

Photovoltaic Systems

Photovoltaic systems use semiconductor materials similar to those used in computer chips to capture the energy in sunlight and convert it directly into electricity. Photovoltaic cells are connected into an array. The size of the array depends on the amount of sunlight and the needs of the customer. Large photovoltaic electrical generating systems have not generally been used for commercial utility applications due to the high upfront cost. Most photovoltaic applications are small, use little or no land, and have minimal or no environmental impact because electricity created is generally used on site or as part of an existing authorized use. They generally provide power to individual homes and small buildings. They are also found in rural areas on communication towers, water pumps, and road and traffic signs.

Concentrating Solar Power Systems

Concentrating solar power plants are generally large systems that use mirrors to focus sunlight to create high temperatures. The high temperatures generated by the focused sunlight are used to generate electricity either by a heat engine causing gas to expand moving a piston or a conventional power cycle using boiling water to create steam that turns a turbine.

There are currently three different types of centralized concentrating solar power systems: parabolic trough, solar "power tower," and solar dish. These systems require relatively flat land with slopes not exceeding three percent to accommodate the solar collectors. The area of land required depends on the type of plant, but is about five acres per produced megawatt. It is anticipated that a commercial scale concentrating solar power facility may be in the range of 100 megawatts or larger and will require in excess of 500 acres.

To work effectively, the solar installations require consistent levels of sunlight (solar insolation). Solar insolation is a measurement that has become increasingly more accurate in evaluating specific sites for solar energy installations. Solar insolation is the amount of sunlight hitting an area on the surface of the earth over a specific period of time. The higher the exposure of sun measured on an annual basis, the more electrical power that can be produced. Solar energy resources are classified based on the amount of solar radiation that contacts the ground surface in a specified area. Solar radiation is measured in units of watt-hours per square meter per day. The amount of solar energy resource available at a specific location varies with the latitude of that location, the season, and the time of day.

Solar energy resource maps were prepared by the US Department of Energy, National Renewable Energy Laboratory. In addition to varying by latitude, season, and time of day, the amount of solar radiation available at known occurrences of solar energy resources is dependent on the type of collector used. The two basic designs of solar collectors are flat-plate collectors and solar concentrators.

Flat-Plate Collectors

The flat-plate collector is a fixed panel containing photovoltaic cells or solar water heaters. The flat-plate panels collect sunlight and convert it to electricity or heat. The flat panel is installed where no obstructions will block sunlight from reaching the panel. A flat-plate collector generally receives the most sun when it is tilted towards the south at an angle equal to the latitude of the location.

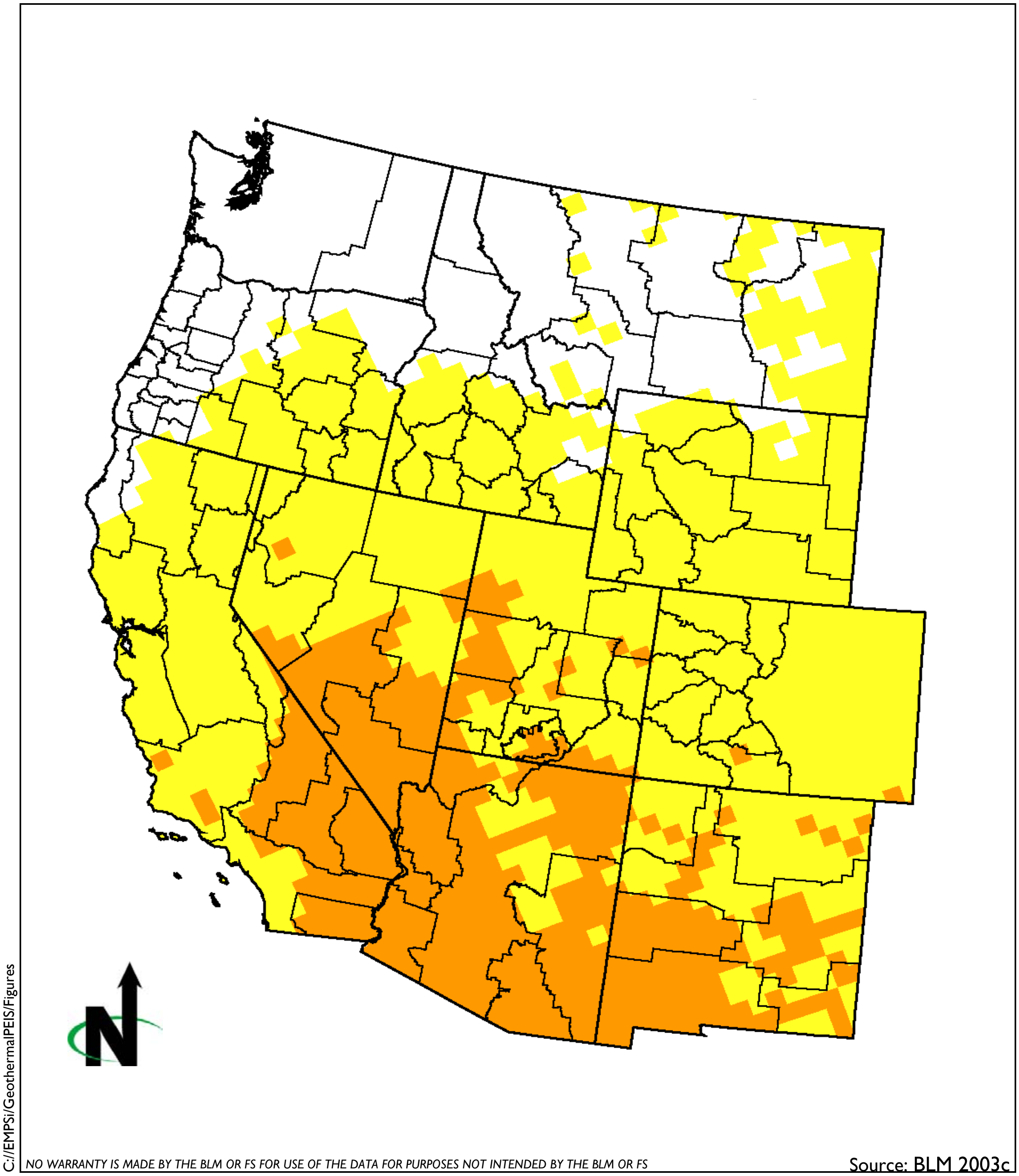
Solar Concentrators

The solar concentrator is a flat panel of photovoltaic cells or a concave arrangement of mirrors that concentrate sunlight onto a collector. The concentrator is attached to a motor-driven tracking mechanism. It is installed where no obstructions will block sunlight from reaching the concentrator, and uses the tracking mechanism to follow the sun as it crosses the sky each day. The tracking mechanism adjusts for seasonal variations in the Sun's azimuth and allows the solar concentrator to collect the maximum amount of direct sunlight. The flat-plate collector is more effective at collecting solar radiation than the solar concentrator.

Data concerning solar resources are collected for both concentrating solar power and photovoltaic systems. The US Department of Energy, National Renewable Energy Laboratory has developed a national solar resource assessment for the US at a resolution of approximately 25 by 25 miles. These data are updated periodically.

For photovoltaic systems, data for flat-plate collectors were used. This is typical for a photovoltaic panel oriented due south at an angle from horizontal equal to the latitude of the collector's location. Figure 3-4 shows the photovoltaic resources for the western US.

The concentrating solar power analysis used direct normal data. These data are pertinent to concentrating systems that track the sun throughout the day, such as trough collectors or dishes. Figure 3-5 shows the concentrating solar power resources in the western US.



The flat-plate collector is a fixed panel containing photovoltaic cells or solar water heaters. Solar resources are available for flat plate collectors through the 11 western states, but are highest in the southwest.

Yearly Average Solar Energy Resources available for flat-plate photovoltaic systems

Figure 3-4

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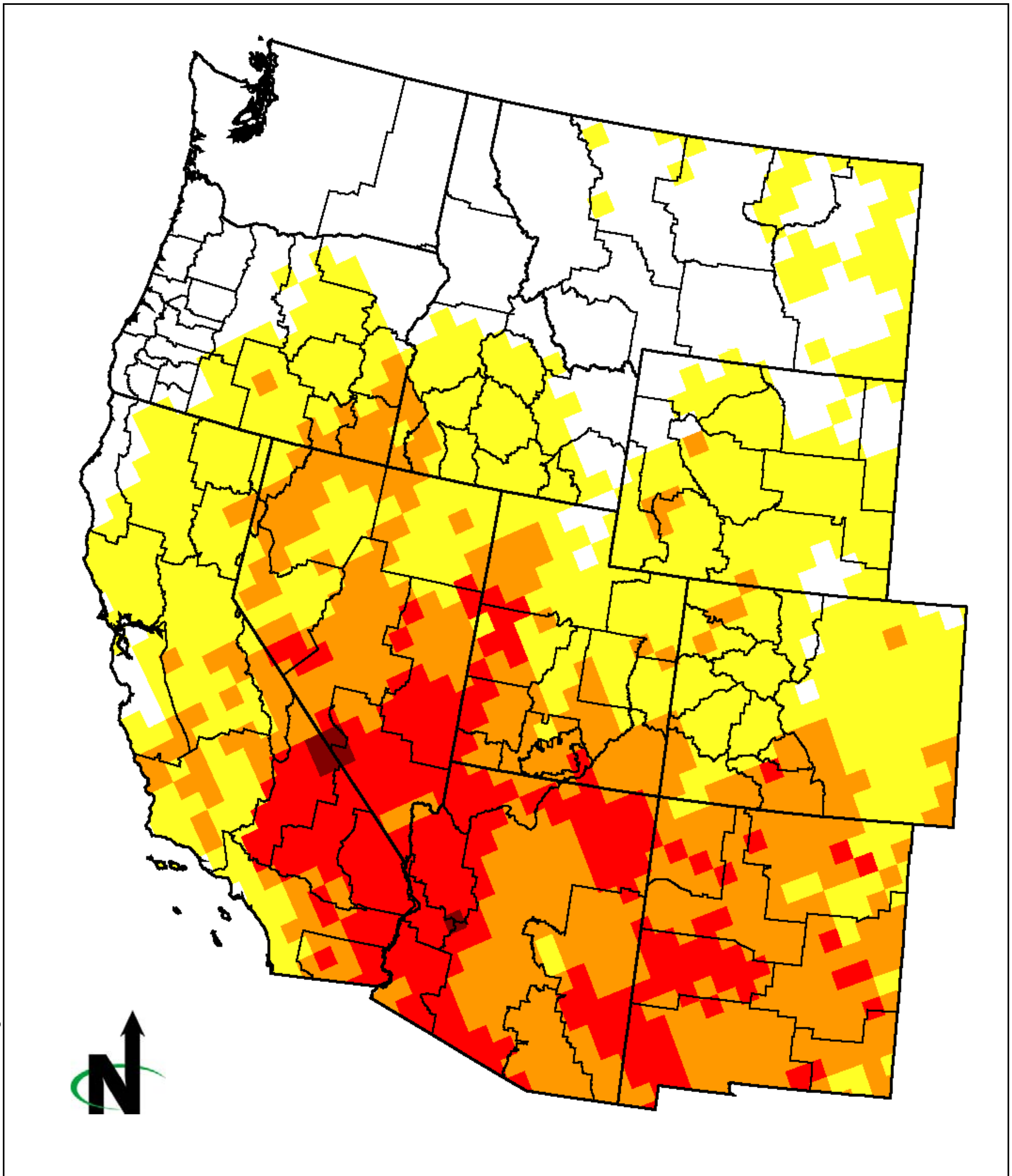

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SOURCE: BLM 2003c

These data are pertinent to concentrating systems that track the sun throughout the day, such as trough collectors or dishes. Solar resources are available for flat plate collectors through the 11 western states, but are highest in the southwest.

LEGEND:
Concentrating
Solar Resource
kWh/m²/day

5
6
7
8

Yearly Average Solar Energy Resources Available for Concentrating Solar Power Systems

Figure 3-5

3.4.2 Wind Resources

Wind energy is a renewable energy resource that has excellent potential for generating electricity. The BLM Wind Energy Programmatic EIS (BLM 2005a) has determined which areas on public lands have high, medium, or low potential for wind energy development based on the typical wind speed measured at a location. The wind power classification used in the EIS had seven wind classes based on the wind power density at a height of 164 feet (50 meters), measured in watts per square meter (Table 3-6).

Table 3-6
Wind Power Classification/Energy Development Potential

Wind Power Class	Energy Development Potential	Wind Power Density: Watts per square meter at 164 feet (50 meters) above Ground Level	Wind Speed[a]: Miles per hour at 164 feet (50 meters) above Ground Level
1	Low	0 – 200	0.0 – 12.5
2	Low	200 – 300	12.5 – 14.3
3	Medium	300 – 400	14.3 – 15.7
4	High	400 – 500	15.7 – 16.8
5	High	500 – 600	16.8 – 17.9
6	High	600 – 700	17.9 – 19.7
7	High	>800	>19.7

[a] Mean wind speed is estimated by assuming a sea level elevation and a Weibull distribution of wind speeds with a shape factor (k) of 2.0. The actual mean wind speed may differ from the estimated values shown here by as much as 20 percent, depending on the actual wind speed distribution (or Weibull k value) and elevation above sea level.
Source: BLM 2003c

Wind power is considered economic for large turbines (commercial utilities scale) at Class 3 and higher, although a small noncommercial turbine can be used at Class 1. Figure 3-6 shows public lands and FS lands wind resources greater than Class 3.

Installation of wind energy facilities on public lands and FS lands requires a right-of-way permit instead of a lease. Rental costs may be calculated by tower installation and/or permitted acreage.

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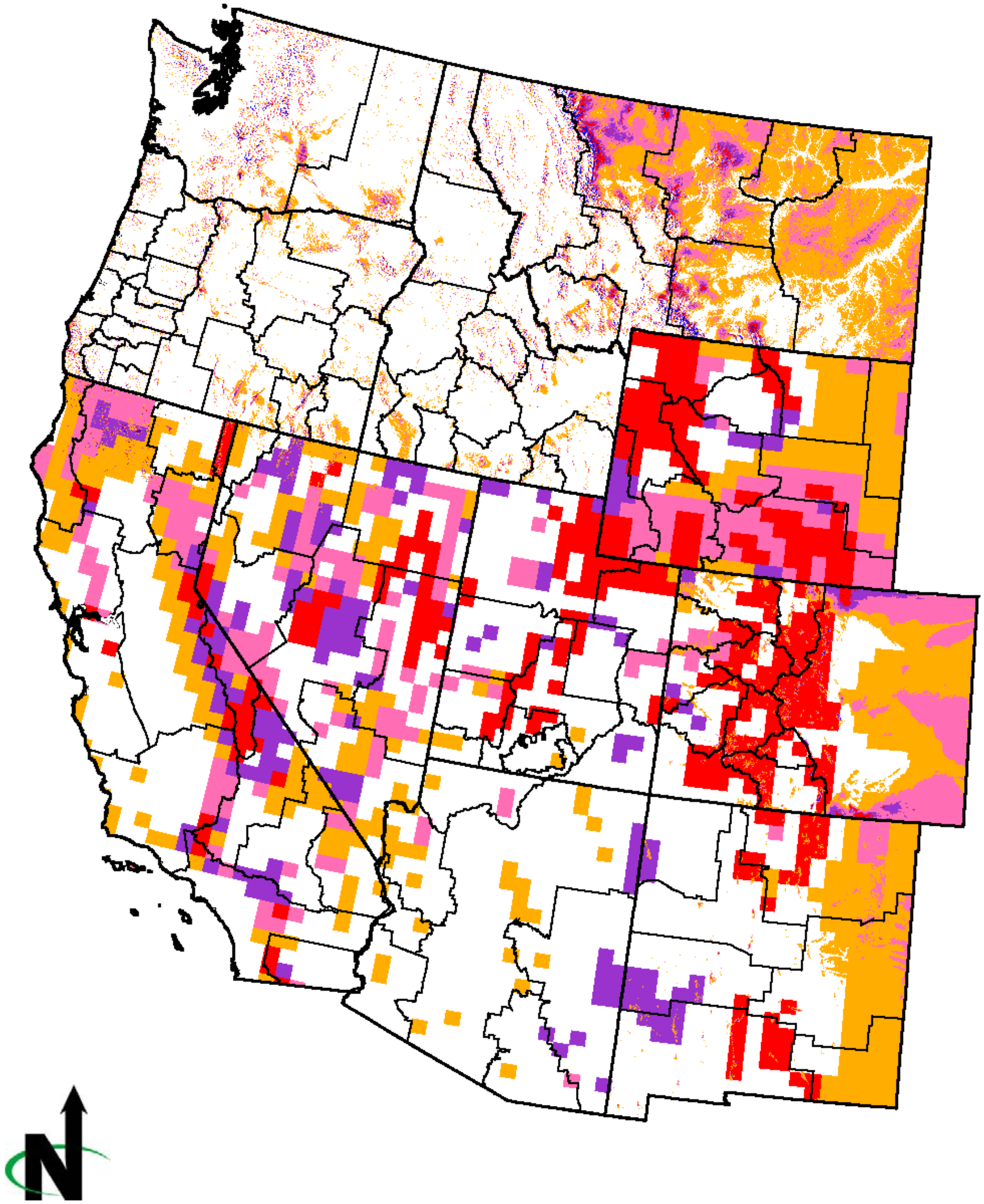

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SOURCE: : BLM 2003c

Wind power is considered economic for large turbines (commercial utilities scale) at Class 3 and higher. This map contains high (.4-1km) and low (25 km) resolution wind resource assessments.

LEGEND:

Wind Resource Power Class

3
4
5
6
7

Public Land and FS Wind Energy Resources

Wind Resource Power Class ≥ 3

Figure 3-6

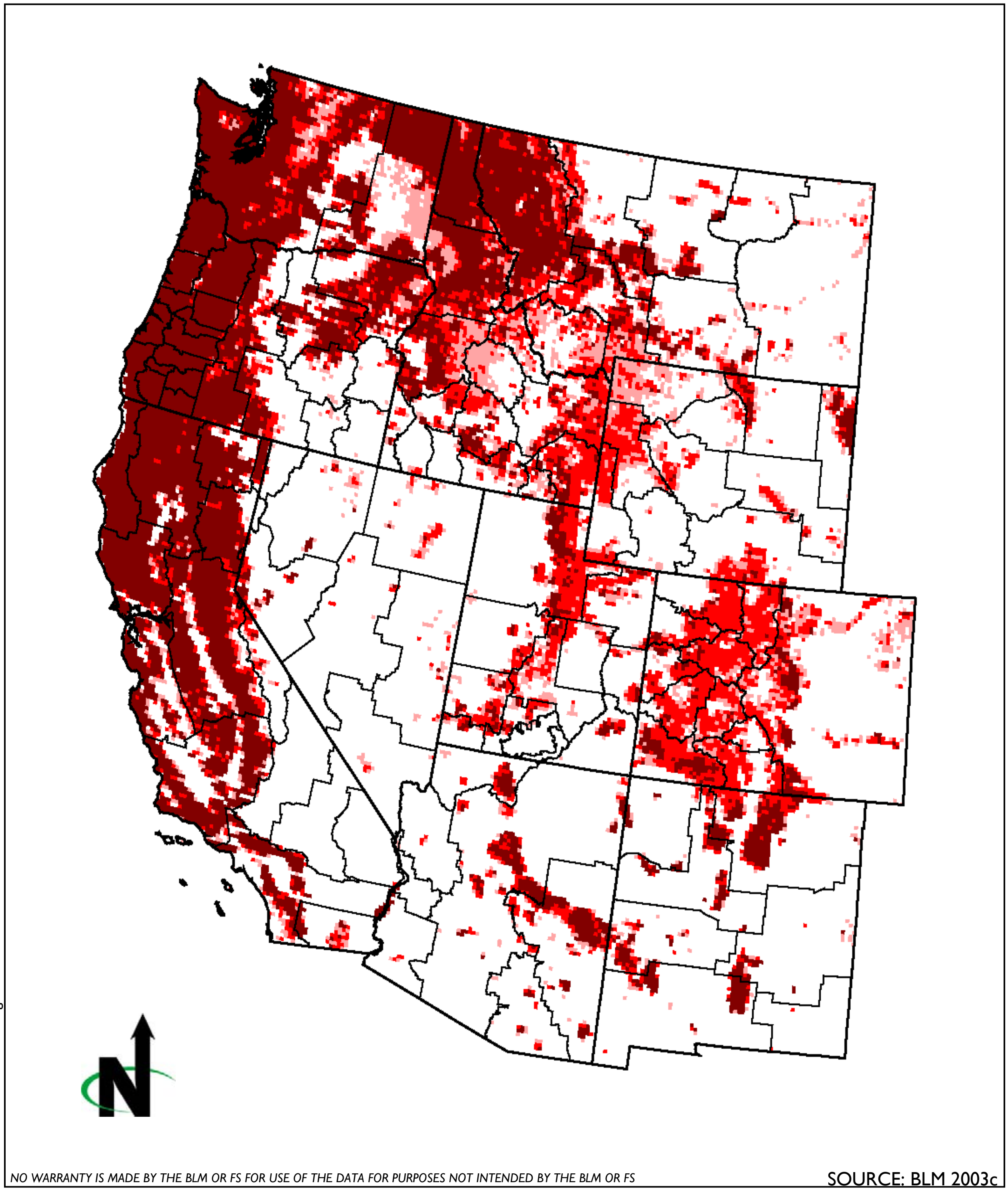
3.4.3 Biomass

Biomass power is power obtained from the energy in plants and plant-derived materials, such as food crops, grassy and woody plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes. Biomass can be used for direct heating (such as burning wood in a fireplace or wood stove), for generating electricity, or can be converted directly into liquid fuels to meet transportation energy needs (US DOI 2007).

Electricity generated from biomass is also called biopower. Biopower facilities use many different technologies; the most common is burning of wood or other biomass feed stocks to produce steam, which then is used to drive turbines and produce electricity. Some generators use a mix of biomass and fossil fuels to generate electricity, while others burn methane, a product of the natural decay of organic materials. In the US, the pulp and paper industries are major producers of biopower using residues from paper production to produce electricity for industrial plant use (US DOI 2007).

Wood has been used for energy longer than any other biomass source and remains the largest biomass energy resource. The largest source of energy from wood is pulping liquor or "black liquor," a waste product from processes of the pulp, paper, and paperboard industry. Biomass energy can also be derived from waste and from alcohol fuels. Biofuels are liquid fuels produced from plants. The two most common types of biofuels are ethanol and biodiesel. Ethanol is made by fermenting any biomass high in carbohydrates. The majority of ethanol produced in the US is made from corn. Biodiesel is made by processing vegetable oil, animal fat, or recycled cooking grease with alcohol or other chemicals. It can be used as an additive (typically 20 percent) or in its pure form as a renewable alternative fuel for diesel engines (US DOI 2007).

The availability of biomass materials was assessed using the monthly Normalized Difference Vegetation Index computed from the National Aeronautics and Space Administration's Advanced Very High Resolution Radiometer Land Pathfinder satellite program. The Normalized Difference Vegetation Index satellite data have a resolution of five by five miles. Figure 3-7 shows the availability of biomass on public and NFS lands in the Western US.



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Biomass power is obtained from the energy in plants and plant-derived materials. Biomass availability in the 11 Western States is highest in forested regions, including portions of California and the Pacific Northwest.

LEGEND:
Number of Months with NDVI ≥ .4
- 4
- 5
- 6

Biomass Availability

Assessed using monthly Normalized Difference Vegetation Index satellite data

Figure 3-7

3.4.4 Energy Minerals

Coal

Coal deposits can be found in all 12 project area western states; however, large deposits are only found within Alaska, Arizona, Colorado, Montana, New Mexico, Utah, and Wyoming (National Mining Association 2007). Together with North and South Dakota, the project area provides 45 percent of the nation's total production. The federal government is by far the largest owner of the nation's coal beds. In the west, the federal government owns 60 percent of the coal and indirectly controls another 20 percent. Coal companies must lease the land from the federal government in order to mine this coal (National Mining Association 2007).

The northern Rocky Mountain region and the Northern Great Plains of Wyoming, Montana, and North Dakota contain vast amounts of strippable coal. This region includes the 14 largest coal mines in the US, each having production of over 10 million short tons. More than 25 percent of US coal production is from 25 mines developing the Wyodak-Anderson, Anderson-Dietz, and Rosebud coal beds or zones in the Powder River Basin. These coals are relatively clean, containing less sulfur and ash than coals produced from other regions in the continuous US (USGS 1996).

Oil, Gas and Geothermal

The Northern Alaska physiographic province accounts for almost half of the oil and more than half of the undiscovered conventional gas assessed on onshore federal lands. Oil and gas resources extracted in Alaska are predominantly from the North Slope. As of 2005, Alaska accounted for 17 percent of the crude oil discovered in the US (BLM 2007c). Significant oil reserves are located throughout the Colorado Plateau. The Powder River Basin and the Wyoming Thrust Belt provinces of the Rocky Mountains and Northern Great Plains regions have the second-largest concentrations (behind Alaska) of undiscovered conventional oil and gas, respectively, assessed on federal lands (BLM 2007c). In California, oil and natural gas extraction is predominant in the San Joaquin, Ventura/Santa Barbara, Los Angeles, and Santa Maria regions. There are no significant oil, natural gas, or coal resources within the coastal areas and mountains of Washington and Oregon, in Nevada, or in Utah. There are limited oil and gas reserves in southern Arizona and southwest New Mexico (BLM 2007c).

BLM and FS consider geothermal resources to be a fluid mineral resource along with oil and natural gas. Therefore, while land closures or restrictions to fluid leasable minerals are primarily meant for oil and gas exploration and development, they apply to geothermal exploration and development as well.

Oil and gas drilling and development share other aspects with geothermal resources. Much of the data on geothermal resources comes from oil and gas well drilling. Also, there is consideration of using oil and gas infrastructure to enhance geothermal resources and vice versa (Western Governors' Association 2006).

The cost of drilling to develop geothermal resources is often the most decisive factor in determining the economic viability of proposed geothermal power plants. Yet, the thousands of oil and gas wells that are typically drilled to even greater depths (accessing even hotter zones) have scarcely been considered for use in geothermal systems. This potential applies to the deep sedimentary basins of the western US (Western Governors' Association 2006).

Many oil fields are nearing the end of the reserves that can be extracted economically. Higher oil prices and new technologies, such as enhanced oil recovery techniques and drilling microholes with less expensive rigs, can significantly increase the percentage of oil recovered profitably. The cost of electricity to operate oil fields is also an important factor in determining the economic life of those fields. Measures to reduce electrical costs, like utilizing renewable resources (wind, solar, and geothermal), can also increase the amount of profitable reserves (Western Governors' Association 2006).

Ideas being discussed in the industry include converting nearly-depleted oil and gas fields into geothermal assets using several proven technologies in unique combination. Initially, solar energy is transferred as heat to aging oil and gas reservoirs in a pattern designed to increase the recovery of remaining oil and gas, at the same time building up the heat content of the reservoir. Ultimately, the banked solar energy would be extracted using naturally occurring brines to drive geothermal power plants and local heating systems (Western Governors' Association 2006)

3.4.5 Non-Energy Minerals

Metallic Minerals

Major copper deposits are located throughout the project area, except for California and Oregon. United States copper production largely comes from deposits in southern Arizona, southern New Mexico, and Utah. Currently, most of the copper production in the US is derived from large, relatively low-grade hydrothermal mineral deposits that formed beneath composite volcanoes. Important, undeveloped hydrothermal copper deposits are hosted by sedimentary rocks in Montana; these deposits are also enriched in silver. Copper often occurs with other metals including cobalt and the platinum group elements: palladium, platinum, rhodium, ruthenium, iridium, and osmium. Major copper-cobalt deposits occur in central Idaho, and a major copper-nickel-platinum group elements deposit is located in Montana. The US ranks first in world production of molybdenum and has a large proportion of the world reserve base. Generally, molybdenum is produced as a byproduct of mining copper and, in particular, porphyry copper deposits. Therefore, the major deposits occur in essentially the same locations as copper, described above (Zientek and Orris 2005).

About 10 percent of total gold discovered in the world is in the US. Over 80 percent of the gold produced in the US in 2002 came from Nevada mines. These mines also produced approximately 30 percent of the US output of silver. Most of the major gold deposits are concentrated in Nevada, northern California, and southern Arizona. Significant deposits also occur throughout Alaska, Colorado, Idaho, Montana, New Mexico, Oregon, and Washington (Zientek and Orris 2005).

About 21 percent of total world silver discovered is in the US. More than two-thirds of the world's silver resources are associated with copper, lead, and zinc deposits. The remainder is associated with hydrothermal gold deposits. Over 40 percent of the significant and major deposits are in Nevada; significant deposits also occur in Alaska, Arizona, California, Colorado, Idaho, Montana, New Mexico, Oregon, Utah, and Washington (Zientek and Orris 2005).

Major lead and zinc deposits, sometimes with other metals, are located in Colorado and Utah, with some others in Alaska, Arizona, Nevada, Montana, Idaho, and Washington. Molybdenum deposits (Zientek and Orris, 2005).

3.4.6 Nonmetallic (Industrial) Minerals

The nonmetallic minerals include barite, garnet, bentonite, kaolinite, phosphates, diatomite, borax, gypsum, and potash. Most of the barite mined in the US comes from bedded barite deposits in Nevada. 95 percent of the world's high-quality abrasive-grade garnet, is found in the large North Creek, New York, deposit. Concentrations of garnet in Idaho and Montana are, however, great enough to form a placer garnet deposits than can be economically developed (Zientek and Orris 2005).

Bentonite is a rock consisting of clay minerals. Almost half of the world production of bentonites is from the US. Major sodium bentonite deposits are found in two districts in the western US: the Hardin district (Montana and Wyoming) and the Black Hills district (Montana, Wyoming, and South Dakota). Kaolin is a term for a group of clays that might best be described as kaolinite-bearing clays. Kaolin deposits are located in Utah, northern Nevada, and southern California. Major phosphorite deposits in the US are related to zones of oceanic upwelling that took place along the western coast of North America in the Permian (forming the western phosphate field in Wyoming, Idaho, Montana, and Utah). There is also a major phosphate deposit in northern Alaska. Diatomite is a sedimentary rock consisting chiefly of the fossilized, silica-rich skeletons of single-celled aquatic plants called diatoms. The largest production of high-purity diatomite comes from the extensive deposits near Lompoc, California. Numerous other deposits occur throughout the US, although most productive deposits are found in the west (Zientek and Orris 2005).

Borates are extracted primarily in California. The majority of boron production in California is from Kern County, California, with the balance from San Bernardino and Inyo Counties. Gypsum is mined primarily in southern Nevada, southern California, and central New Mexico. Potash refers to a group of water-soluble salts that contain the element potassium. Of the five sedimentary basins that host major potash deposits in the US, two are within the western US: the Gulf Coast Basin that covers parts of Alabama, Arkansas, Florida, Mississippi, eastern Texas, Louisiana, and extends into Mexico; and the Permian Basin that covers parts of Colorado, Kansas, New Mexico, Oklahoma, and western Texas. Most domestic production is from evaporite deposits in the Permian Basin near Carlsbad, New Mexico (Zientek and Orris 2005).

Aggregates are sand, gravel, stone, pumice, pumicite, cinders, and ordinary clay used for construction and decorative purposes. Each state in the western US develops its own aggregate resources areas, as transportation is a great part of the cost of the materials. Industrial minerals such as aggregate, limestone, and shale dominate mineral extraction throughout most of California. In southeastern California, southern Arizona, and southern New Mexico, the minerals predominantly extracted include construction aggregate including construction sand, gravel, and crushed stone. Raw, nonfuel minerals extracted throughout Nevada, southern Idaho, southwestern Oregon, and most of Utah include aggregate, gypsum, limestone, trona, shale, and stone. Construction aggregate (including crushed stone and common clay) is the dominant mineral extracted throughout Colorado (BLM 2007c).

3.5 PALEONTOLOGICAL RESOURCES

This analysis involved a review of scientific literature concerning the types and significance of paleontological resources known to occur on public and NFS lands in the project area (Baars 2000, BLM 2007d, Cooper et al. 1990, FS 1996, King 1977, Murphey and Daitch 2007, Peterson et al. 1973, and Reed et al. 2005). It also included a review of paleontological resource sections (if present) of 101 BLM RMPs for 62 BLM field offices in 12 states, which resulted in paleontological resources information for approximately half of the BLM field offices in the project area (Appendix E). Because of the large size of the project area, combined with the inherently discontinuous geographic distribution of geothermal resources, a list of potentially affected geologic units (formations and members thereof) was not compiled for this programmatic analysis. However, as appropriate, paleontological resources described in this section are discussed with reference to the Potential Fossil Yield Classification (PFYC) that was recently revised and adopted as policy by the BLM (BLM IM 2008-009) (Appendix E). The basis for the BLM's resource management classification scheme was the similar PFYC produced and still employed by the FS (FS 1996). Paleontological sensitivity maps based on the PFYC are available for only two of the affected states: Colorado and Utah. The BLM's preparation of additional PFYC maps for the other 10 states is ongoing.

The project area is known to contain some of the most fossiliferous sedimentary rock units in North America. Because of their fossil content, these rocks and correlative strata elsewhere in western North America have been the focus of continuous scientific interest and inquiry for approximately the last 135 years. The rich fossil record of the area ranges in age from the Archean Eon to the Upper Pleistocene Epoch, and represents a temporally discontinuous span of approximately 2.9 billion years. Collectively, these units (formations and members thereof) have produced an estimate of millions of scientifically significant fossil specimens from thousands of fossil localities.

Paleontologic and associated geologic fieldwork in the project area has produced an unprecedented amount of scientific data that continues to be used to study a wide variety of aspects of Phanerozoic biotas, including aspects of their evolution, biostratigraphy, paleobiogeography, paleoenvironments, taphonomy, and paleoecology. Fossils include highly diverse assemblages of vertebrates (fishes, amphibians, reptiles, birds, and mammals), invertebrates (mollusks, arthropods, insects, and many others), and plants (including algae), and include the holotypes of many presently recognized fossil taxa. Housed in museums throughout the US, fossils of western North America have been the subject of thousands of published scientific studies. Much knowledge of Paleozoic through Pleistocene climates, environments, and biotas of North America comes from studies of project area fossils and geology. In addition, individual fossils may also provide information on variation in the species and thereby provide insight on its evolution.

3.5.1 Definition and Significance of Paleontological Resources

Paleontology is a multidisciplinary science that combines elements of geology, biology, chemistry, and physics in an effort to understand the history of life on earth. Paleontological resources, or fossils, are the remains, imprints, or traces of once-living organisms preserved in rocks, sediments, and caves. These include mineralized, partially mineralized, or unmineralized bones and teeth, soft tissues, shells, wood, leaf impressions, footprints, burrows, and microscopic remains. The fossil record is the only evidence that life on earth has existed for more than 3.6 billion years. Fossils are considered nonrenewable resources because the organisms they represent no longer exist. Thus, once destroyed, a fossil can never be replaced. Fossils are important scientific and educational resources because they are used to:

- Study the phylogenetic relationships among extinct organisms, as well as their relationships to modern groups;
- Elucidate the taphonomic, behavioral, temporal, and diagenetic pathways responsible for fossil preservation, including the biases inherent in the fossil record;
- Reconstruct ancient environments, climate change, and paleoecological relationships;
- Provide a measure of relative geologic dating, which forms the basis for biochronology and biostratigraphy, and which is an independent and corroborating line of evidence for isotopic dating;
- Study the geographic distribution of organisms and tectonic movements of land masses and ocean basins through time;
- Study patterns and processes of evolution, extinction, and speciation; and
- Identify past and potential future human-caused impacts on global environments and climates (Murphey and Daitch 2007).

3.5.2 Paleontology and Geologic History of the Western United States

The geologic record of the history of earth, along with the associated history of life contained within the fossil record, has been subdivided into a series of eons, eras, periods, and epochs that define and encompass the entire 3.8 billion years of earth's history based on the geologic record. The following is a description of the paleontological and geologic history of western North America, including Alaska, with an emphasis on the project area. The discussion is divided into time periods from oldest to youngest, beginning with the Archean Eon of the Precambrian, from which the oldest known fossils in western North America date. It includes descriptions of the types of fossils present in western North America and their general provenance and scientific importance, major associated events in the history of life, the pale geography of western North America, and paleoenvironmental conditions of this region through time.

3.5.3 Archean and Proterozoic Eons of the Precambrian

Most of the history of life occurred during the vast stretch of time known as the Precambrian, which includes the older Archean Eon (3.8 to 2.5 billion years ago) and the younger Proterozoic Eon (2.5 billion to 543 million years ago). The oldest known fossils from western North America are of Archean age and consist of stromatolites that are approximately 2.8 billion years old. Stromatolites are lithified organosedimentary structures in which laminations are formed by communities of cyanobacteria trapping and binding sediments. Locally, these fossils form spectacular reefs in places such as the Medicine Bow Mountains in Wyoming. Stromatolites are also known from much younger rocks although modern forms are rare. Other fossils of Precambrian age in western North America consist of palynomorphs and algal filaments and globules known from 800 million year old sedimentary rocks of the Uinta Mountains in Utah. Precambrian (Archean and Proterozoic) life forms consisted of a diversity of unicellular prokaryotic (cells lacking nuclei) bacteria. The oldest known eukaryotic cells (cells with nuclei) have been reported from the Neoproterzoic of Australia, and are approximately 900 million years old. The close of the Precambrian is marked by the first appearance of multicellular life forms in the late Neoproterozoic. Known as the Ediacaran fauna, fossils of these enigmatic organisms include imprints of soft bodied forms and the first exoskeletons of marine invertebrates. Fossils of the Ediacaran fauna are now known from a number of localities around the world, although North American localities are known only from the east coast.

Fossils of Precambrian age are rare in western North America, although this is in large part because noncrystalline unmetamorphosed sedimentary rocks of this age are uncommon. The antiquity of Precambrian-age fossils and the information they provide about the origins of life makes them highly significant scientifically. In western North America, sedimentary rocks of this age occur in parts of Montana, Wyoming, Utah and Arizona, and are generally recommended for designation as PFYC Class 3 (Moderate or Unknown: Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence; or sedimentary units of unknown fossil potential) (Appendix E).

3.5.4 Paleoezoic Era

The Paleozoic Era lasted from approximately 543 to approximately 242 million years ago. It is subdivided into seven periods including, from oldest to youngest, the Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian.

A major adaptive radiation took place during the Cambrian Period that resulted in the evolution of most of the known phyla (broad groupings of organisms) as well as other phyla that have since become extinct. This geologically rapid appearance of diverse multicellular life is referred to as the Cambrian explosion, and is best documented in the fauna of the Burgess Shale (Middle Cambrian-age

Stephan Formation) of British Columbia. One of the most widespread and diverse groups of animals, the trilobites, first appeared at the beginning of the Cambrian, diversifying and evolving throughout most of the Paleozoic. Although the Cambrian fossil record is dominated by trilobites, other groups that evolved during this period include brachiopods, mollusks, echinoderms, porifera (sponges), and cnidaria (corals), as well as numerous extinct phyla.

At the beginning of the Cambrian Period, the landmass that would later become North America (referred to as Laurentia) was situated directly over the equator. East of Laurentia were several small continental masses that would eventually become Siberia, northern Europe, and Kazakhstan. Further east was the super-continent Gondwana, which included the combined land masses of South America, Africa, Antarctica, Australia, and China. During the Cambrian, the North American landmass was oriented at 90 degrees from its present orientation so that the paleoequator was on a line roughly from Texas to Hudson Bay, and the Canadian Shield formed highlands surrounded by ocean. Western North America was largely under water during this time, and was located north of the Canadian Shield between approximately 5 and 20 degrees north latitude. Sediments of Cambrian age in western North America include quartz-rich sandstone and limestone deposited in a shallow carbonate sea and muddy shale that was deposited in deeper waters. Cambrian-aged rocks are exposed in the Grand Canyon area, in parts of Colorado Utah and Idaho, in north-central Nevada, and in parts of California and the Pacific Northwest.

By the end of the early Ordovician Period, the uninterrupted sequence of carbonate deposition associated with the shallow seas of the Cambrian ended, and a period of craton-wide erosion lasted throughout much of the rest of the Ordovician. By the late Ordovician, the Laurentide landmass (that would later form North America) was centered just south of the paleoequator and was again almost completely covered with a shallow carbonate sea. This Late Ordovician marine transgression resulted in an explosive radiation and diversification of marine organisms shells of calcium carbonate. This fauna was dominated by brachiopods but also included crinoids, echinoderms, gastropods, trilobites, nautiloid cephalopods, and graptolites.

During the middle Ordovician, the earliest radiation of vertebrates was underway (modern vertebrates include animals with backbones including fishes, amphibians, reptiles, birds, and mammals). These early vertebrates are preserved in sandstone beds of the Harding Formation on public lands in south-central Colorado, and consist of scales and teeth of primitive jawless fishes called agnathans, a group that first appeared during the latest Cambrian.

During the middle Ordovician and early Silurian periods, a range of mountains was uplifted in the northern part of the Appalachian region of the eastern US, and shallow carbonate seas covered much of the cratonic interior of North America. Coral reefs were common and resulted in widespread deposition of limestone and dolomite. Silurian shallow-marine fossil faunas are dominated by articulate brachiopods, but also include bryozoans, cephalopods, crinoids, corals, ostracods, conodonts, and eurypterids (sea scorpions). The Silurian Period also saw the initial evolution of land plants. Rocks of Silurian age are more common in the eastern US but occur locally in the west with relatively widespread exposures in Nevada.

By the early Devonian Period, Laurentia had coalesced with Baltica (a slightly smaller landmass east of Laurentia that would later become western Europe), and the two were closely associated with the southern supercontinent Gondwana. Land that would later become western North America was located just south of the paleoequator, and was mostly covered by a shallow carbonate sea. A narrow chain of island mountains (the Antler Mountains) was present from what is today southern Nevada to northern Idaho. The area northwest of these mountains (the area that would later become the pacific coast of North America) was occupied by a deep, muddy ocean. Devonian seas contained reef systems and marine faunas similar to those of the Ordovician, and major radiations of both ammonoids and conodonts occurred during this time. A major diversification of vertebrate life was occurring simultaneously, with five classes of fish appearing by the Early Devonian (often referred to as the "age of fish"). This radiation of fishes included the agnathans (jawless fish that are represented today by the hagfish and lamprey), the Acanthodii (all extinct), the armored Placoderms (all extinct), the Chondrichthyes (sharks, skates and rays), and the Osteichthyes (bony fishes). The first land vertebrates (tetrapods) evolved during the Late Devonian and consisted of amphibians. This heralded what would be a dramatic evolutionary radiation and diversification of land vertebrates during the Carboniferous. The land plants that first appeared in the Silurian diversified and became abundant by the Early Devonian. Devonian-age rocks in western North America are present from New Mexico, Arizona, and Nevada north into Canada. Important fossil bearing rocks of Devonian age rocks in western North America are located in Nevada, Idaho, and southwestern Canada.

By the early Mississippian Period, Laurentia remained in an equatorial position and most of western North America remained under a shallow carbonate sea. The Appalachian Mountains extended from Georgia north into Labrador (their uplift having been a result of a continental collision with Gondwana along the southern margin of Laurentia), but land in western North America was limited to a small arc of highlands that developed from continued uplift of the Antler Mountains. These highlands consisted of a narrow swath of land that extended from southern California to northern Idaho. East of the Antler Highlands, a broad shallow carbonate sea extended east to the Great Lakes region, while west of the highlands were deeper ocean waters. The Antler Highlands provided a source material for thick deposits of Mississippian aged shale in Utah and deposits of sandstone and conglomerate in northern and eastern Nevada. Mississippian marine deposits now form extensive limestone deposits in

Montana, Wyoming, Utah, eastern Idaho, and Colorado, and comprise the red cliff limestone walls of Arizona's Grand Canyon. Fossil crinoids are abundant in Mississippian limestone, and the Mississippian Period has been referred to as the "age of crinoids." Other characteristic fossils include bryozoans, brachiopods, echinoderms, and foraminifera. Land plants of the Mississippian include forms that are transitional between those of the Silurian and Pennsylvanian Periods.

During the Pennsylvanian Period, all of the land masses on the globe were in the process of coalescing into a single massive supercontinent called Pangaea. The Appalachian mountain range and associated lowlands in the south and east provided source material for broad areas of sedimentation to the west. In the middle Pennsylvanian, the Ouachita Mountains formed in a narrow swath from central Texas to Louisiana. The end of uplift that had earlier produced the Antler Mountains coincided with the beginning of the Colorado Orogeny in the area of Colorado, Utah, and New Mexico. These new mountains, together with the Antler Mountains, formed isolated islands in a shallow sandy and muddy sea that covered most of the interior of North America, with a deep ocean on the western margin of the part of Pangaea that would later become North America. An island arc that extended from the location of northern California to southern Alaska, along what is now the Pacific coast, was the only land west of the Antler Mountains. Subsidence in areas adjacent to the ancestral Rocky Mountains resulted in thick sequences of Pennsylvanian-aged nonmarine shale, sandstone, and conglomerate in Colorado, and temporally equivalent sequences of marine limestone and sandstone in Colorado and Utah. Pennsylvanian-age rocks form extensive deposits throughout much of the central and western US from eastern Kansas to western Nevada and north to Montana.

The Pennsylvanian Period is associated with two major events in the history of life. The first was the development of vast cycads and tree fern forests including those along the western flank and adjacent lowlands of the Appalachian Mountains, resulting in a dramatic diversification of plant life that would ultimately be preserved as the rich coal beds of eastern and central North America. The second event was the evolution of reptiles during the lower Pennsylvanian which are first known from Nova Scotia. A large inland sea still covered much of the western US, and fossils from western North America are predominantly marine in origin.

The Permian Period marks the end of predominantly marine environments over much of North America, and is associated with both the regression of continental seas and the gradual emergence of the North American continent. By the late Permian, the Appalachian and Ouachita mountains had joined to form a single extensive range that extended from western Texas to Labrador roughly along a line that would become the Gulf and Atlantic coasts. However, western North America remained largely under shallow and deep seas. The volcanic island arc that had developed during the Pennsylvanian now extended from Baja California north to Alaska. Vast barrier reefs formed in the vicinity of west Texas. A broad phosphorite basin formed in an area that extended from northern Nevada to British Columbia, and these phosphate deposits are exposed today in Wyoming, Utah, Montana, and Idaho. Extensive deposits of Permian-age red sandstone and mudstone beds in the Rocky Mountain region indicates deposition on coastal mudflats and alluvial floodplains.

During the Permian Period, reptiles diversified and increased in abundance, assuming an ecological role as the dominant land vertebrates. The mammal-like reptiles, or therapsids, which included the ancestors of true mammals, were diversifying. The most dramatic paleontological event of the Permian was the massive global terminal Permian extinction event, the largest documented extinction event in the entire Phanerozoic. As many as 90 percent of all marine invertebrate families, including such dominant forms as the trilobites, went extinct by the end of the Permian. Large numbers of terrestrial animal and plant species also went extinct.

Sedimentary rocks of Cambrian, Ordovician, and Silurian age contain diverse fossil invertebrate assemblages but few vertebrate fossils. These are generally recommended for designation as PFYC Class 3 (Moderate or Unknown) (Appendix E). Sedimentary rocks of Devonian through Permian age have the potential to produce well-preserved and scientifically significant vertebrate fossils, although vertebrate occurrences are typically localized and uncommon. Locally abundant and well-preserved marine invertebrate fossils are also known. Sedimentary rocks of these time periods could range in sensitivity from PFYC Class 3 through 5 (Appendix E).

3.5.5 Mesozoic Era

The Mesozoic Era lasted from approximately 242 to 65.5 million years ago. It is subdivided from oldest to youngest into the Triassic, Jurassic, and Cretaceous periods. Generally, the Mesozoic Era is characterized by the evolution, diversification, and eventual extinction of dinosaurs, as well as the evolution of mammals, birds, and flowering plants.

During the Early Triassic, deposition of red beds similar to those of the Permian took place in much of North America. The North American continent remained near the equator in a similar orientation as during the Permian, and much of western North America was covered by seas. A sandy and muddy alluvial plain extended far west and north from the Ouachita-Appalachian Mountains, and a shallow muddy and sea with numerous barrier islands at its eastern margin extended from southern New Mexico north to Alaska. The Sonoma Orogeny resulted in a series of highlands and mountains that extended from northern Baja California to northern British Columbia. The Sonoma Mountains were surrounded by deep muddy waters and the extensive western volcanic arc remained to the west of the Sonoma range. Late Triassic-age sedimentary rocks of marine origin are present in southern Alaska and in the Brooks Range to the north.

The picturesque red and variegated beds of the Triassic-aged Moenkopi and Chinle formations are exposed throughout much of western North America, particularly on the Colorado Plateau. These rocks units are known to preserve a variety of vertebrate fossils such as terrestrial amphibians and reptiles, including primitive dinosaurs. They also yield locally abundant fossil plants and a variety of fossil trackways. The oldest mammal fossils are also known from the Triassic. Marine life during the Triassic was associated with a dramatic diversification of ammonoid cephalopods. These fossils are abundant in the marine fossil record and are biostratigraphically important. Triassic reefs were formed by new and more complex forms of reef building organisms that evolved in the wake of the late Permian extinctions. By the end of the Triassic Period, reptiles were not only abundant in terrestrial ecosystems, but had also evolved into aquatic forms such as plesiosaurs and ichthyosaurs.

By the beginning of the Jurassic, most of the North American continent was above water, and plate tectonics had caused a northward migration of the continent. The Appalachian Mountains and low-relief highlands extended west to roughly the present location of the Mississippi River. West of these highlands were alluvial lowlands and coastal plains that extended all the way west to Nevada. The Westernmost portion of North America including all of Alaska remained under waters of the Sundance Sea. Early Jurassic rocks in the western US typically consist of thick sequences of cross-bedded sandstone. The eolian sand dune deposits of the Navajo Sandstone are the best known example. In the westernmost portion of North America, Jurassic-age rocks consist of dark shale, bedded chert, graywacke, and conglomerate. By late Jurassic time, the volcanic island arc present along the western margin of North America had collided with the continent (the Nevadan Orogeny). Continued subduction along the western margin of the continent resulted in the deposition of Jurassic and Cretaceous aged marine rocks in the California Coast Ranges and to the east in the Great Valley of California. The Nevadan Orogeny marked the beginning of a protracted series of mountain building events known as the Cordilleran Orogeny that would continue throughout the remainder of the Mesozoic and into the Cenozoic. During the late Jurassic, the Sundance Sea east of the Cordilleran highlands experienced a major regression that coincided with deposition of the terrestrial highly fossiliferous Morrison Formation over a vast area of the western US.

The Morrison Formation contains abundant and diverse assemblages of fossil vertebrates, invertebrates, and plants, and characterizes the broad diversification of dinosaurs during the Jurassic. It also preserves smaller vertebrates including frogs, salamanders, lizards, crocodiles, and primitive fossil mammals, and is one of the most heavily researched formations in the world by paleontologists. During the Jurassic, vertebrates evolved the ability to fly as represented by the earliest birds and the reptilian pterosaurs. Marine reptiles such as plesiosaurs and ichthyosaurs were also more abundant than during the Triassic. Marine life during the Jurassic was dominated by mollusks and ammonoids with abundant crinoids and echinoids.

By the beginning of Cretaceous time, the rifting and break up of the supercontinent Pangaea was well underway. By the mid-Cretaceous, the North American continent had moved northward and was centered at near 40 degrees north latitude, with Alaska situated near the North Pole. Continued oceanic plate subduction along the western margin of the US during the Cretaceous resulted in a range of mountains and highlands that extended from Mexico to Alaska. A trangression of marine waters from both the Gulf of Mexico and the Arctic during early Cretaceous time resulted in the development of the broad (900-mile-wide) Cretaceous Interior Seaway that extended from Utah east to Ohio, and completely separated the western highlands from those to the east. By late Cretaceous time, the primarily marine sediments of the early and middle Cretaceous that covered much of the western interior were giving way to estuarine and coastal plain sediments as the seaway retreated. By latest Cretaceous time, the Laramide Orogeny, which resulted in the uplift of the Rocky Mountains, was underway. Terrestrial and marine rocks of Cretaceous-age are common throughout western North America.

Cretaceous marine deposits contain abundant and diverse invertebrate fossils typically including ammonoids, bivalves, gastropods, echinoderms, corals, and bryozoans. Marine vertebrates were also common and include giant fishes, mosasaurs (marine lizards), plesiosaurs, pliosaurs, and turtles as large as 13 feet long. Terrestrial vertebrate faunas were dominated by abundant and diverse dinosaurs such as *Triceratops*, *and Tyrannosaurus*. Pterosaurs attained wingspans of up to 30 feet. Birds diversified during the Cretaceous, as did mammals, although many mammals remained small and shrew-like in appearance. Plant evolution during the Cretaceous was marked by the appearance of angiosperms (flowering plants) that evolved during the early Cretaceous and coevolved with insects throughout this period, ultimately dominating plant communities by the end of the Cretaceous. The end of the Cretaceous Period is marked by the well known Cretaceous-Tertiary boundary event that resulted in the mass extinction of many animal and plant species 65.5 million years ago, and is widely accepted to have been caused largely by an asteroid impact. Included in the extinction were both marine and terrestrial organisms including dinosaurs (with the exception of birds), mosasaurs, plesiosaurs, pterosaurs, and many species of plants and invertebrates.

Sedimentary rocks of Triassic, Jurassic, and Cretaceous age may contain diverse and locally abundant assemblages of scientifically significant fossil vertebrates, invertebrates, and plants. These rock units generally could meet PFYC Class designations of 3, 4, or 5 (Appendix E).

3.5.6 Cenozoic Era

The Cenozoic Era lasted from 65.5 million years ago to the present and includes two periods, the Tertiary and Quaternary. The Tertiary Period is divided into the Paleogene and Neogene periods. The Paleogene includes the Paleocene, Eocene, and Oligocene epochs, and the Neogene includes the Miocene and Pliocene epochs. The Quaternary Period is divided into the Pleistocene and the Holocene. The Cenozoic Era is associated with the diversification of mammals following the extinction of nonavian dinosaurs and their dominance of terrestrial faunas, as well as the development of modern ecosystems and climatic regimes during the Quaternary. The youngest fossils are generally considered by paleontologists to date to the end of the Pleistocene Epoch, approximately 10,000 years ago. Accordingly, fossils are not considered to be present in sedimentary deposits of Holocene age, which contain only the unfossilized remains of modern species of animals and plants.

By the beginning of the Cenozoic Era, the North American continent was nearing its present geographic orientation and location. The Laramide Orogeny of the Late Cretaceous and early Cenozoic marked the final stages of the Cordilleran Orogeny. The Cordilleran Orogeny, which began during the Jurassic, had progressed eastward throughout the Mesozoic, resulting in the final uplift of the central Rocky Mountains by the end of the Cretaceous. This period also marked the end of marine environments within the western interior of North America. During the Laramide Orogeny, intermontane basins developed as a result of down-warping between Rocky Mountain uplifts, and surrounding highlands provided source material for thick sequences of Tertiary-aged fluvial and lacustrine sediments that accumulated in these basins. Also deposited in these basins were the organic remains of animals and plants that would eventually become the rich fossil record that documents the ecosystems of the early and middle part of the Cenozoic. In addition to extensive deposits of limestone, shale, mudstone, siltstone, and sandstone, significant amounts of volcaniclastic sediment were deposited throughout western North America during the Cenozoic. The west coast of North America is the leading edge of the North America continent and, as such, is tectonically more dynamic, resulting in a highly complex distribution of formations. A confusing array of deep marine, shallow marine, and nonmarine sediments of varying ages have been thrust, accreted, and shifted along the Pacific coast of North America. As a result, a wide variety of Cenozoic-aged sedimentary rocks with abundant fossils of both terrestrial and marine organisms are exposed along the Pacific Coast and in adjacent areas. Cooling and drying of global climates began during the Eocene and continued throughout the Oligocene, Miocene, Pliocene, and into the Pleistocene ice ages. The cool wet climates of the Pleistocene resulted in massive glacial expansion in the northern portion of the North American continent and in mountainous areas, while a vast lake system developed in the Midwest. Glacial till, eolian sand, alluvium, and colluvium are common types of Pleistocene-aged sedimentary deposits that occur in western North America.

The fossil record of the Cenozoic Era is extremely well preserved in rock units in western North America. Following the extinction of the dinosaurs at the end of the Cretaceous, mammals rapidly radiated and diversified into their respective modern groups, as well as several archaic groups that went extinct during the early part of the Tertiary. Eocene forests were inhabited by a host of mammals including insectivores, primates, marsupials, bats, rodents, small and large carnivores, tapirs, horses, rhinos, and many others. By the late Eocene, all the modern orders of mammals had evolved and were represented by species that were ancestral to the modern forms known today. As climates cooled, the tropical and subtropical forests of the Paleocene and early Eocene gave way to more open woodlands, and tropical species of animals including some types of fishes, turtles, alligators, crocodiles, and primate mammals, retreated south or went extinct in North America. Continued global cooling and drying led to the evolution of grassland ecosystems during the Miocene. General adaptive strategies for mammalian groups at this time included an increase in body size, the ability to digest grasses, and a trend towards greater cursoriality (skeletal modifications to become more effective runners). The diverse perissodactyls (odd-toed ungulates such as horses, rhinos, tapirs, brontotheres, and chalichotheres) of the early Tertiary steadily diminished in diversity as the artiodactyls (even-toed ungulates such as oreodonts, deer, bison, pronghorn, sheep, and goats) diversified throughout the Cenozoic. The first appearance of many modern mammal species can be traced back to the Pleistocene. However, many animals that were adapted to cooler climates went extinct as temperatures warmed at the end of the Pleistocene, although warmer temperatures were not necessarily the cause of the late Pleistocene extinctions. Extinct Pleistocene mammals include mammoth and mastodon, cave bear, North American lion, North American cheetah, saber tooth tiger, ground sloth, dire wolf, giant beaver, and the giant *Bison antiquus*.

Sedimentary rocks of Tertiary age are known to contain diverse and locally abundant assemblages of scientifically significant fossil vertebrates, invertebrates, and plants. As a result, these rock units are generally recommended for designation as PFYC Class designations of 3, 4, or 5 (Appendix E). Quaternary (Pleistocene) vertebrate, invertebrate, and plant fossils are typically uncommon and poorly preserved in most surficial sediments, although localized rich accumulations are known in western North America from cave deposits and other unusual settings such as tar pits. Pleistocene-age surficial deposits are generally recommended for designation as PFYC Class 2 (Low: Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils) (Appendix E) unless prior local discoveries warrant a higher class designation.

3.5.7 Review of BLM Resource Management Plans

A review of BLM RMPs for field offices in the project area was conducted to determine if paleontological resources had been previously addressed and, if so, if the paleontological sensitivity of the geologic units within each BLM field office could be estimated given the information provided. If sufficient information was available, an attempt was made to equate the information provided to the PFYC recently adopted as policy by the BLM (BLM Instruction Memorandum 2008-009) (BLM 2007d) (Appendix E). There was insufficient information to estimate PFYC subclasses a or b for PFYC Classes 3 through 5.

A total of 101 RMPs were reviewed from 62 BLM field offices in the 12-state project area (Appendix E) (Table 3-7). Resource Management Plans were not available for 57 of the BLM field offices within the project area. In cases where paleontological resources were not addressed, estimates of paleontological sensitivity could not be made. Of the 101 RMPs reviewed, 32 contained sufficient information on fossil occurrences or geologic formations to estimate sensitivity and tentatively assign PFYC classes for the geologic units within the field office (Table 3-7).

Table 3-7
Project Area BLM RMPs Reviewed & Tentative PFYC Classes

State	RMPs Reviewed	RMPs with Sufficient Information to Tentatively Assign PFYC Classes
Alaska	4	3
Arizona	5	4
California	11	1
Colorado	10	3
Idaho	13	4
Montana	10	8
New Mexico	9	3
Nevada	6	1
Oregon	4	0
Utah	13	5
Washington	3	0
Wyoming	13	0
Total	**101**	**32**

3.6 SOIL RESOURCES

Soil resources are categorized into *land resource units* that consider significant geographic differences in soils, climate, water resources, or land use. Land resource units are generally several thousand acres in size and typically coextensive with state general soil map units. Geographically associated land resource units are grouped into *major land resource areas*, which are in turn grouped into *land resource regions*. These large areas are used in statewide agricultural planning, as well as interstate, regional, and national planning (USDA Natural Resource Conservation Service 2006).

Soils in the project area are diverse and range from the arid, saline soils of the southwest, to the clayey glaciated soils of Montana, to the cold, wet permafrost soils of Alaska. Soils are the result of complex interactions between parent material (geology), climate, topography, organisms, and time. Soils are classified by the degree of development into distinct layers or horizons and their prevailing physical and chemical properties. Similar soil types are grouped together into soil orders based on defining characteristics, such as organic matter and clay content, amount of mineral weathering, water and temperature regimes, or other characteristics that give soil unique properties, such as the presence of volcanic ash or permafrost (BLM 2007c).

3.6.1 Description of Soil Orders and Classifications

Soil Orders

Alfisols can be found throughout the mountains of western Montana and Wyoming and in central Colorado and California. They are characterized by subsurface clay accumulations and nutrient-enriched subsoil. Alfisols commonly have a mixed vegetative cover and are productive for most crops, including commercial timber (BLM 2007c).

Andisols occur in Washington, Oregon, Idaho and along the Cascades in Northern California. In Alaska they are found in the southwest part of the Alaskan Peninsula and in the Aleutians (University of Idaho 2007). They are soils that have formed on volcanic ash deposits. They have high amounts of volcanic glass and organic matter, giving them a light, fluffy texture (BLM 2007c). As a group, Andisols tend to be highly productive soils (USDA Natural Resource Conservation Service 2006).

Aridisols occur across wide parts of the western US in Nevada, Arizona, New Mexico, central Wyoming, southern Idaho, and southern California. These soils are characterized by an extreme water deficiency. They are light colored, low in organic matter, and may have subsurface accumulations of soluble materials, such as calcium carbonate, silica, gypsum, soluble salts, and exchangeable sodium. Vegetation on these soils includes scattered desert shrubs and short bunchgrasses, which are important resources for livestock. Aridisols are generally not very productive without irrigation and may be prone to salinity buildup. Surface mineral deposits often form physical crusts that impede water infiltration (BLM 2007c).

Entisols occur extensively in eastern Montana and western Colorado, Wyoming, Utah, and central California. They are young, weakly developed mineral soils that lack significant profile development (soil horizons). They are often found in lower-elevation, arid, and semiarid environments supporting desert shrub and sagebrush communities. Entisols can include recent alluvium, sands, soils on steep slopes, and shallow soils. Soil productivity ranges from very low in soils forming in shifting sand or on steep rocky slopes to very high in certain soils formed in recent alluvium. Productivity is often limited by shallow soil depth, low water-holding capacity, or inadequate available moisture. However, these soils support rangeland vegetation and may support trees in areas of higher precipitation (BLM 2007c).

Gelisols occur almost exclusively in the tundra regions of Alaska. They are underlain by permanently frozen ground (permafrost). Some gelisols in wet environments have developed large accumulations of organic matter, particularly in areas of bogs and wetlands. Soil-forming processes take place very slowly above the permafrost in the active layer that thaws seasonally. These soils support tundra vegetation of lichens, grasses, and low shrubs that grow during brief summers. Plant productivity is low and limited by the northern latitudes' extremely short growing season, low levels of solar radiation, and poor water drainage. Bare rock is also common in Alaska, comprising nearly 8 million acres (BLM 2007c).

Histosols occur in limited areas in northern Washington, Central Colorado, and southwestern Alaska (University of Idaho 2007). They are organic soils that typically form in lowland areas with poor water drainage. Areas containing these soils are commonly called bogs, moors, peats, or mucks. The soils form in decomposed plant remains that accumulate in water, forest litter, or moss faster than they decay (USDA, Natural Resources Conservation Service 2006). While not extensive, Histosols are often associated with riparian or wetland resources and can be very important locally (BLM 2007c).

Inceptisols are found in northern Idaho and parts of Washington, Oregon, and Montana, as well as southwestern Alaska. They are generally young mineral soils but have had more time to develop profile characteristics than Entisols. They principally occur in very cool to warm, humid, and subhumid regions and in most physiographic conditions, and often support coniferous and deciduous forests, as well as rangeland vegetation. They may form in resistant rock or thin volcanic ash on steep mountain slopes or depressions, on top of mountain peaks, or next to rivers. Productivity is varied and may be high where moisture is adequate (BLM 2007c).

Mollisols in the project area are found in northern Montana, eastern Oregon, Washington, and Idaho, where they have developed from basalt and loess parent materials. These soils typically support grasslands and are mineral soils with thick, dark-colored surface horizons rich in organic matter from the dense root systems of prairie grasses. They are one of the most productive soils on public lands, and their high organic matter content helps reduce the risk of groundwater contamination by herbicides. Mollisols extend from upland areas to the prairie grasslands, where they are most abundant. Mollisols support a variety of plant communities, including grasslands, chaparral-mountain shrub, and forests. Since they have developed primarily under grassland vegetation, mollisols have been used extensively for livestock grazing (BLM 2007c).

Spodosols occur in northern Washington, central Colorado, and central Alaska (University of Idaho 2007). They are highly leached, acid**ic** soils that typically form on sandy soils under cold, humid conditions at high elevations (BLM 2007c). They are characterized by a subsurface accumulation of humus that is complexed with aluminum and iron (University of Idaho 2007). These soils commonly occur in areas of coarse textured deposits under coniferous forests of humid regions. They tend to be acid and infertile and require additions of lime in order to be productive agriculturally (USDA, Natural Resources Conservation Service 2006).

Ultisols occur in southwestern Washington, western Oregon and in the coastal mountains and the Cascade Range in California. They are formed through fairly intense weathering and leaching processes that result in a clay enriched subsoil. They are found primarily in humid temperate forest areas, typically on older, stable landscapes. These soils are low in nutrients, but, with soil additives, they are productive for row crops (University of Idaho 2007, USDA, Natural Resources Conservation Service 2006).

Vertisols occur in central and eastern Montana, and sporadically throughout the Western U.S. They have large amounts of expanding clay that causes them to have high shrinking and swelling characteristics (BLM 2007c). When wet, these soils swell, transmitting water very slowly, therefore, they have undergone little leaching and tend to be high in natural fertility (USDA, Natural Resources Conservation Service 2006).

Further soil classification includes suborder, great group, subgroup, family, and series. These classifications are based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Where further classification is discussed below, appropriate definitions have been included in the glossary.

Farmlands

The purpose of the Farmland Protection Policy Act (Public Law 97-98, 7 USC 4201) is to minimize the extent to which federal programs contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses, and to assure that federal programs are administered in a manner that, to the extent practicable, will be compatible with state and local government and private programs and policies to protect farmland. The term "farmland" includes all land defined as follows:

- Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion, as determined by the Secretary of Agriculture. Prime farmland includes land that possesses the above characteristics but is being used currently to produce livestock and timber. It does not include land already in or committed to urban development or water storage;
- Unique farmland is land other than prime farmland that is used for production of specific high-value food and fiber crops, as determined by the Secretary of Agriculture. It has the special combination of soil quality, location, growing season, and moisture supply needed to economically produce sustained high quality or high yields of specific crops when treated and managed according to acceptable farming methods; and
- Farmland, other than prime or unique farmland, that is of statewide or local importance for the production of food, feed, fiber, forage, or oilseed crops, as determined by the appropriate state or unit of local government agency or agencies, and that the Secretary of Agriculture determines should be considered as farmland for the purposes of the Farmland Protection Policy Act.

Cropland of statewide importance is land, in addition to prime farmlands, that is of statewide importance for the production of food, feed, fiber, forage and oilseed crops. Criteria for defining and delineating this land are to be determined by the appropriate State agency or agencies. Generally, additional farmlands of statewide importance include those that are nearly prime farmland and that economically produce high yields of crops when treated and managed according to acceptable farming methods.

Prime and unique farmlands, as well as farmlands of statewide importance are discussed for specific lease sites as farmlands soils are identified and managed by local soil conservation districts. The exception is where loss of farmland soils has been identified as a regional priority.

Biological Soil Crusts

Biological soil crusts (also known as cryptogamic, microbiotic, cryptobiotic, or microphytic crusts) are commonly found in semiarid and arid environments.

They provide important functions, such as improving soil stability and reducing erosion, fixing atmospheric nitrogen, contributing nutrients to plants, and assisting with plant growth (BLM 2007c).

Crusts are composed of a highly specialized nonvascular plant community consisting of cyanobacteria, green and brown algae, mosses, and lichens, as well as liverworts, fungi, and bacteria. Biological soil crusts occupy open spaces between the sparse vegetation of the Great Basin, Colorado Plateau, Sonoran Desert, and the inner Columbia Basin, and occur in agricultural areas, native prairies, and Alaska (BLM 2007c).

Biological soil crusts can reach up to several inches in thickness and vary in terms of color, surface topography, and surficial coverage. Crusts generally cover all soil spaces not occupied by vascular plants, which may be 70 percent or more in arid regions. They are well adapted to severe growing conditions but are influenced by physical disturbances, fire, and application of herbicides. Disturbance of biological crusts results in decreased soil organism diversity, nutrients, stability, and organic matter (BLM 2007c).

Soil Erosion and Compaction

Soil erosion is a concern throughout the project area, particularly in semiarid rangelands. The quantity of soil lost by water or wind erosion is influenced by climate, topography, soil properties, vegetative cover, and land use. While erosion occurs under natural conditions, rates of soil loss may be accelerated by human activities (BLM 2007c).

Tundra lands in Alaska are susceptible to erosion if the thick vegetative mat overlying permafrost is disturbed or removed. Trails quickly turn into widely braided ruts, especially in wetlands and at stream bank crossings. The resulting gully erosion can rapidly erode substantial quantities of previously frozen soils. Erosion from ice is also a concern due to spring-breakup flood events leaving disturbed stream channels. These events cause previously stable riparian areas to form a long-lasting sequence of extensively braided channels, especially in glacial soils (BLM 2007c).

Rangelands are affected by all four types of water erosion: sheet, rill, gully, and stream bank, as well as by wind erosion. Sheet erosion is relatively uniform erosion from the entire soil surface and is therefore often difficult to observe, while rill erosion is initiated when water concentrates in small channels as it runs off the soil. Sheet and rill erosion can reduce the productivity of rangeland soils but often go unnoticed. Gully and stream bank erosion is far more visible and may account for up to 75 percent of erosion in desert ecosystems. Changes in water flow patterns in arid areas resulting from thunderstorms and fire events can increase the size and frequency of runoff events and sediment yield to local water sources. Wind erosion is most common in arid and semiarid regions where lack of soil moisture greatly reduces soil's adhesive capability (BLM 2007c).

Soil compaction occurs when moist or wet soil aggregates are pressed together and the pore space between them is reduced. Compaction changes soil structure, reduces the size and continuity of pores, and increases soil density. Wheel traffic, large animals, vehicles, and people can cause soil compaction. Compaction becomes a problem when the increased soil density limits water infiltration, increases runoff and erosion, or limits plant growth or nutrient cycling (BLM 2007c).

3.6.2 Characteristics by Land Resource Region

Northwestern Forest, Forage, and Specialty Crop Region

In the project area, this region covers 90,165 square miles in parts of Oregon (42 percent), Washington (39 percent), and California (19 percent). It is comprised of the Northern Pacific Coast Range, Foothills, and Valleys, Willamette and Puget Sound Valleys, Olympic and Cascade Mountains, Sitka Spruce Belt, Coastal Redwood Belt, Siskiyou-Trinity Area, Cascade Mountains, and Eastern Slope major land resource areas (USDA, Natural Resources Conservation Service 2006). The dominant soil orders in this region are Alfisols, Andisols, Entisols, Inceptisols, Spodosols, and Ultisols. Soils on the hilly and steep uplands are mostly Andisols and Inceptisols. These soils are shallow to very deep and are well drained. Soils on the marine and glacial outwash terraces are dominantly Andisols and Spodosols. These soils are shallow or moderately deep to cemented materials or are deep or very deep. They are poorly drained to well drained. Entisols and Inceptisols are on floodplains and estuaries. These soils are very deep and typically are very poorly drained or poorly drained. Alfisols and Ultisols are on the mountains slopes. They are moderately deep or deep and are well drained. Mollisols are in the Willamette Valley. These soils are moderately deep to very deep and typically are moderately well drained. Most of the soils formed in colluvium or residuum weathered from siltstone and sandstone, but some formed in colluvium weathered from basalt or other volcanic rocks. The soils have a mixed mineralogy (USDA, Natural Resources Conservation Service 2006).

Northwestern Wheat and Range Region

This region covers 81,255 square miles in parts of Idaho (44 percent), Washington (29 percent), and Oregon (27 percent). A very small part is in Utah. It is comprised of the Columbia Basin, Columbia Plateau, Palouse and Nez Perce Prairies, Central Rocky and Blue Mountain Foothills, Snake River Plains, Lost River Valleys and Mountains, and Eastern Idaho Plateaus major land resource areas (USDA, Natural Resources Conservation Service 2006). The dominant soil orders in the region are Mollisols and Aridisols. Other soil orders that occur in the region are Alfisols, Andisols, Entisols, and Inceptisols. Mollisols and Aridisols formed in a deep mixture of loess and ash deposits overlying the basalt flows in this region. The other soil orders formed in alluvium on terraces and floodplains or in residuum and colluvium on foothills and mountain slopes. Most of the soils are deep or very deep, well drained, and loamy (USDA, Natural Resources Conservation Service 2006).

California Subtropical Fruit, Truck, and Specialty Crop Region

This region is entirely in California and covers 62,350 square miles (USDA, Natural Resources Conservation Service 2006). It is made up of the Central California Coastal Valleys, Central California Coast Range, California Delta, Sacramento and San Joaquin Valleys, Sierra Nevada Foothills, Southern California Coastal Plain, and Southern California Mountains major land resource areas (USDA, Natural Resources Conservation Service 2006). The soils in this region are dominantly Alfisols, Entisols, Mollisols, and Vertisols. Fluvents, Orthents, and Ochrepts on floodplains and alluvial fans are the most important soils used for agricultural purposes in this region. The soils in the region dominantly have mixed or smectitic mineralogy (USDA, Natural Resources Conservation Service 2006).

Many of the soils on floodplains and low terraces in the San Joaquin River valley are affected by salts and must be skillfully managed for good crop production. The agricultural drainage water in this valley commonly has a high salt load, and the salinity in receiving streams typically increases in a downstream direction. Soil resource concerns throughout this agriculturally rich region include controlling rainfall- and irrigation-caused water erosion and maintaining the soils' organic matter content. Wind erosion is a hazard in the San Joaquin River valley and in some of the coastal valleys. Irrigation water management is a priority in this populous region, where agriculture and urban areas compete for good-quality water. Salinity and the intrusion of saltwater into aquifers are management concerns in the coastal valleys (USDA, Natural Resources Conservation Service 2006).

Western Range and Irrigated Region

This region is the largest of all the land resource regions in land area, covering 549,725 square miles in parts of Arizona (21 percent), Nevada (20 percent), California (14 percent), New Mexico (13 percent), Utah (11 percent), Wyoming (7 percent), Texas (5 percent), Oregon (4 percent), Colorado (3 percent), Idaho (2 percent), and Montana (less than 1 percent) (USDA, Natural Resources Conservation Service 2006). It includes the following major land resource areas: Klamath and Shasta Valleys and Basins; Sierra Nevada Mountains; Southern Cascade Mountains; Malheur High Plateau; Humboldt Area; Owyhee High Plateau; Carson Basin and Mountains; Fallon-Lovelock Area; Great Salt Lake Area; Central Nevada Basin and Range; Southern Nevada Basin and Range; Mojave Desert; Lower Colorado Desert; Northern Intermountain Desertic Basins; Cool Central Desertic Basins and Plateaus; Warm Central Desertic Basins and Plateaus; Colorado Plateau; Southwestern Plateaus, Mesas, and Foothills; Mogollon Transition; Arizona and New Mexico Mountains; Sonoran

Basin and Range; Southeastern Arizona Basin and Range; and Southern Desertic Basins, Plains, and Mountains (USDA, Natural Resources Conservation Service 2006). The soils in this region are dominantly Aridisols, Entisols, and Mollisols. The dominant suborders are Argids and Calcids on plains and in basins; Orthents on plains, on plateaus, and in valleys throughout the region; and Xerolls and Ustolls on mountain slopes. The soils in the region dominantly have a mixed mineralogy (USDA, Natural Resources Conservation Service 2006).

Rocky Mountain Range and Forest Region

This region covers 236,510 square miles in parts of Montana (28 percent), Colorado (20 percent), Idaho (16 percent), Wyoming (13 percent), Utah (10 percent), Oregon (5 percent), Washington (4 percent), and New Mexico (3 percent). It includes the following major land resource areas: Northern Rocky Mountains, Central Rocky Mountains, Blue and Seven Devils Mountains, Northern Rocky Mountain Valleys, Northern Rocky Mountain Foothills, Wasatch and Uinta Mountains, Southern Rocky Mountains, Southern Rocky Mountain Parks, Southern Rocky Mountain Foothills, and High Intermountain Valleys (USDA, Natural Resources Conservation Service 2006). The soils in this region are dominantly Alfisols, Entisols, Inceptisols, and Mollisols. The dominant suborders are Ustepts, Ustolls, and Xerolls in valleys and on the lower mountain slopes, and Cryalfs and Orthents on the upper mountain slopes and crests. The soils in the region dominantly have a mixed mineralogy (USDA, Natural Resources Conservation Service 2006).

Northern Great Plains Spring Wheat Region

This region covers 142,225 square miles in the northern part of Montana and most of the Dakotas. Approximately 23 percent of this region lies within the project area in northern Montana. In Montana, the major land resource areas include Brown Glaciated Plain, Northern Dark Brown Glaciated Plains, and a small amount of Rolling Soft Shale Plain (USDA, Natural Resources Conservation Service 2006). Much of this region has been topographically smoothed by continental glaciation and is blanketed by undulating till and level to gently rolling lacustrine (lake) deposits. The surficial geology in the southwestern part of the region consists mainly of residual sediments weathered from sedimentary rocks. Alluvial deposits are along drainage ways (USDA, Natural Resources Conservation Service 2006). The soils in this region are dominantly Mollisols. Ustolls and Aquolls are the dominant suborders. Ustolls are on uplands, and Aquolls are in low wet areas and along streams. Aquolls are extensive in the Red River Valley. Some of the Ustolls have a high content of sodium, and some of the Aquolls have a high content of sodium and lime. Other important soils are Orthents on the steeper slopes. The soils in the region dominantly have mixed or smectitic mineralogy (USDA, Natural Resources Conservation Service 2006).

Western Great Plains Range and Irrigated Region

In the project area, this region covers 213,945 square miles in Montana (22 percent), New Mexico (16 percent), Colorado (15 percent), Nebraska (15 percent), and Wyoming (14 percent). The relevant major land resource areas in the southeastern part of Montana, eastern quarter of Wyoming , eastern part of Colorado, and central part of New Mexico include the following: Northern Rolling High Plains, Northern Part; Pierre Shale Plains; Pierre Shale Plains, Northern Part; Black Hills Foot Slopes; Black Hills; Mixed Sandy and Silty Tableland and Badlands; Central High Plains, Northern Part; Central High Plains, Southern Part; Upper Arkansas Valley Rolling Plains; Canadian River Plains and Valleys; Upper Pecos River Valley; Central New Mexico Highlands; and Southern Desert Foothills.

The soils in this region are dominantly Entisols and Mollisols. Other notable orders are Alfisols, Aridisols, Inceptisols, and some Vertisols. The dominant suborders are Ustorthents, Torriorthents, Haplustolls, and Argiustolls. Other notable suborders are Haplargids, Haplustalfs, and Haplustepts. Most have mixed or smectitic mineralogy, but some have carbonatic mineralogy (USDA, Natural Resources Conservation Service 2006). The major soil resource concerns in this region are overgrazing and the wind erosion and water erosion that occur where the ground cover has deteriorated. The invasion of undesirable plant species is a concern on rangeland. Wind erosion, water erosion, maintenance of the content of organic matter in the soils, and soil moisture management are major resource concerns on cropland. The quality of surface water also is a concern. Sediment, nutrients, pesticides, and organic material are the major nonpoint sources of surface and ground water pollution. Control of saline seeps on rangeland and salt management on irrigated land are needed in some areas (USDA, Natural Resources Conservation Service 2006).

The Denver, Fort Collins, Greeley, Fort Morgan, Limon, and Springfield, Colorado, urban areas are part of the Central High Plains, Southern Part major land resource area. A major soil resource concern in this major land resource area is the loss of prime farmland and cropland of statewide importance through conversion to urban use. Additional concerns are wind erosion, water erosion, surface compaction, increased salinization and overall degradation of soil quality caused by tillage and irrigation practices.

Central Great Plains Winter Wheat and Range Region

This region covers 219,740 square miles in Texas, Kansas, Oklahoma, Nebraska, New Mexico, and Colorado. Approximately 7 percent of this region lies inside the project area in far eastern New Mexico and Colorado, and a very small part of southeastern Wyoming. The relevant major land resource areas in the project area include the following: Central High Tableland; Southern High Plains, Northwestern Part; Southern High Plains, Southern Part; and Southern High Plains, Southwestern Part (USDA, Natural Resources Conservation Service 2006).The soils in this region are dominantly Mollisols, but significant acreages of

Alfisols, Entisols, and Inceptisols also occur. The dominant soil suborder is Argiustolls. Other notable suborders include Haplustolls, Ustipsamments, Calciustolls, Paleustolls, and Paleustalfs. Mineralogy is dominantly mixed but is smectitic or carbonatic in some soils (USDA, Natural Resources Conservation Service 2006).

The major resource concerns on the grassland in this region are overgrazing and invasive plants and noxious weed spread. The major resource concerns on cropland are wind erosion, water erosion, maintaining soils' organic matter content, and managing soil moisture. The quality of surface water also is a concern. Sediment, nutrients, pesticides, and salinity are the major nonpoint sources of surface and ground water pollution. Control of saline seeps on rangeland and salt management on irrigated land are concerns in some areas of the region (USDA, Natural Resources Conservation Service 2006).

Southern Alaska

This region covers 95,210 square miles in the southern part of Alaska. It includes the arc of coastal lowlands and mountains along the Gulf of Alaska from the Alexander Archipelago in the southeast to Kodiak Island and the southern portion of the Alaska Peninsula in the west. It also includes the lowlands and mountains of Cook Inlet. It is made up of the Alexander Archipelago-Gulf of Alaska Coast, Kodiak Archipelago, Southern Alaska Coastal Mountains, Cook Inlet Mountains, Cook Inlet Lowlands, and Southern Alaska Peninsula Mountains major land resource areas (USDA, Natural Resources Conservation Service 2006). The soils in this region dominantly have mixed or amorphic mineralogy. Gelepts and Cryepts occur on steep mountain slopes. Cryods, Cryands, Aquands, and Cryepts are on the lower slopes, foothills, and moraines. While Spodosols and Andisols intergrade in some areas, Andisols are dominant in the areas closer to volcanic sources. These areas include the Alaska Peninsula, Kodiak Island, the southern Kenai Peninsula, Kruzof Island, and Baranof Island. The Cryepts on the younger surfaces include Eutrocryepts and Dystrocryepts. Fluvents and Aquents are dominant on flood plains and low terraces. Histosols and Histic subgroups of other orders occur throughout the region. They are on level and depressional landforms and even on the steeper slopes along the coast and in the southeast. The Histosols include Fibrists, Hemists, Saprists, and Folists (USDA, Natural Resources Conservation Service 2006).

Aleutian Alaska

This region covers 10,670 square miles and includes the southwest part of the Alaska Peninsula, the Aleutian Islands, and the Pribilof Islands. The region includes the Aleutian Islands-Western Alaska Peninsula major land resource area (USDA, Natural Resources Conservation Service 2006). The dominant soils are Andisols, primarily Cryands that formed in volcanic ash or scoria. The soils in the area have an amorphic or mixed mineralogy. Soil textures grade from coarse scoria and cinders to fine sand with increasing distance from the volcanoes. Bare rock and rubble occur on the steep slopes of volcanic cones, peaks, and high ridges. Histosols, especially Fibrists, occur in depressions and on broad valley bottoms (USDA, Natural Resources Conservation Service 2006).

Interior Alaska

This region covers 259,260 square miles and includes the vast interior of Alaska, from the south slope of the Brooks Range to the north slope of the Alaska Range. It also includes the Copper River Basin and its surrounding mountains. It is made up of the following major land resource areas: Copper River Basin, Interior Alaska Mountains, Interior Alaska Lowlands, Yukon-Kuskokwim Highlands, Interior Alaska Highlands, Yukon Flats Lowlands, Upper Kobuk and Koyukuk Hills and Valleys, and Interior Brooks Range Mountains (USDA, Natural Resources Conservation Service 2006).

This region is in the zone of discontinuous permafrost. Not all of the soils have permafrost in their profile. With a temperature near 30 degrees F (-1 degree C), the permafrost in this region is warmer than that in the Northern Alaska Region (land resource region Y). Distribution of the permafrost-affected soils is determined by landform position, particle size, and moisture content of the soils. Much of the area on the flanks of the Brooks Range and Alaska Range is covered by rock, snow, and ice. Gelisols and Inceptisols are the dominant soils. The soils in the region have a dominantly mixed mineralogy. In areas on mountain slopes, Orthels and Turbels are intermixed with Gelepts and Gelolls. In these areas, the soils that are not affected by permafrost formed in the coarser textured materials on the steeper slopes. Orthels and Turbels are intermixed with Cryepts on low hills and mountains. An even mixture of Gelisols and Inceptisols dominates the basins. The Inceptisols have a more recent history of fire than the Gelisols. Wildfires disturb the insulating organic material at the surface, lowering the permafrost layer and eliminating perched water tables from these former Gelisols. Depending on the frequency of the fires, landform position, and particle size, these Inceptisols may or may not revert back to Gelisols. Histosols are in depressions throughout the region. Organic soils include Histels with permafrost and Hemists without permafrost. Spodosols and Andisols are of limited extent in the region. Cryods are in scattered areas in some of the mountainous parts of the region. Cryands are in parts of the Yukon-Kuskokwim Highlands (USDA, Natural Resources Conservation Service 2006).

Western Alaska

This region covers 91,300 square miles in the western part of Alaska. It is near the Bering Sea from the Alaska Peninsula and Bristol Bay lowlands to the southern Seward Peninsula. The region includes the northern Bering Sea islands. It is made up of the Northern Alaska Peninsula Mountains, Bristol Bay-Northern Alaska Peninsula Lowlands, Ahklun Mountains, Yukon-Kuskokwim Coastal Plain, Northern Bering Sea Islands, and Nulato Hills-Southern Seward Peninsula Highlands major land resource areas (USDA, Natural Resources Conservation Service 2006). Gelisols, which have permafrost in their profile, occur throughout the region and comprise about 45 percent of the soil types. Orthels and Turbels are on level to sloping coastal plains and terraces as well as on foot slopes and in swales in the hills and mountains. Mollorthels and Molliturbels are typical in the limestone uplands of the northern Bering Sea islands. Histels are in most of the depressions throughout the region. Coarse textured Gelepts and Gelolls are on steep slopes in the mountainous areas. Well-drained Cryepts and Cryolls are on moraines and outwash plains. Cryands are in areas where volcanic ash and loess mantle older landforms and in areas along the flanks of cinder cones. Well-drained Cryods are in scattered areas on uplands throughout the region. Fluvents are on floodplains and levees, and Psamments are in dune areas (USDA, Natural Resources Conservation Service 2006).

Northern Alaska

This region covers 125,550 square miles in the northern part of Alaska. It includes the northern slope of the Brooks Range, the western Brooks Range, and the northern and western Seward Peninsula. The region is made up of the Seward Peninsula Highlands, Northern Seward Peninsula-Selawik Lowlands, Western Brooks Range Mountains, Foothills, and Valleys, Northern Brooks Range Mountains, Arctic Foothills, and Arctic Coastal Plain major land resource areas (USDA, Natural Resources Conservation Service 2006). This area is in the zone of continuous permafrost. Permafrost is shallow or moderately deep, except on steep, coarse-textured soils in the high mountains. Most of the soils in the region are Gelisols, having permafrost within their soil profile. Orthels and Turbels, the dominant suborders, occur on all landforms in the region. Aquorthels and Histoturbels are on the gentler slopes and on poorly drained hillsides. Glacic subgroups occur near the coasts. Mollorthels are on some well-drained, south-facing slopes, and Psammorthels are on dunes. Fibristels formed in thick deposits of organic material in depressions throughout the region. Coarse textured Gelepts and Gelorthents are on some steep hill slopes and ridges. They have a mean annual soil temperature below 32 degrees F (0 degrees C) but do not have permafrost in their soil profile (USDA, Natural Resources Conservation Service 2006).

3.6.3 Climate Change

Some predicted effects of climate change include increased duration and frequency of droughts and an increase in extreme precipitation events. This combination can result in an increase in surface soil erosion and gullying beyond current levels. Continental scale shifts in precipitation may lead to areas where there are increases and decreases in soil moisture. Prolonged drought would also affect soil respiration, resulting in a decreased soil carbon pool (IPCC 2008).

3.7 WATER RESOURCES AND QUALITY

Geothermal resources primarily involve the presence and characteristics of available heat and groundwater. Groundwater is the primary water resource that is potentially affected by geothermal exploration and development. Potential effects to surface water are more limited in area and scope to the immediate vicinity of geothermal exploration and development activities; surface water effects are discussed in detail on a lease-by-lease basis.

Groundwater and surface water rights are not discussed in this section. Water rights are very specific to individual locations, aquifers, landowners, and local jurisdictions. Geothermal developers must obtain the appropriate water rights and state permits, in addition to the Federal lease for the resource.

There are about 26 major aquifer systems in the project area's 11 contiguous western states, excluding Alaska (Figure 3-8). There is little known about aquifers in Alaska except near the towns and cities. Each of these aquifers is unique in that the source, volume, and quality of water flowing through it depends on:

- its hydrogeological conditions (e.g., hydraulic conductivity, effective porosity, and hydraulic gradient);
- external factors (e.g., rates of precipitation, recharge, evaporation, and transpiration);
- the location and hydrologic connection with streams, rivers, springs, reservoirs, and wetlands; and
- overlaying human activities (BLM 2007c).

In general, the aquifers occur in six types of permeable geologic materials: unconsolidated deposits of sand and gravel, semiconsolidated sand, sandstone, carbonate rocks, interbedded sandstone and carbonate rocks, and basalt and other types of volcanic rocks. Rocks and deposits with minimal permeability, which are not considered aquifers, consist of intrusive igneous rocks, metamorphic rocks, shale, siltstone, evaporite deposits, silt, and clay. As such, there is a direct relationship between permeability and type of geologic material. For this reason, the aquifers are categorized according to their general geologic character (USGS 2002b).

In addition, sole-source aquifers are identified in this section. A sole-source aquifer is defined by the US EPA as supplying at least 50 percent of the drinking water consumed in the area overlying the aquifer, where the surrounding area has no alternative drinking water source(s) that could physically, legally, and economically supply all those who depend upon the aquifer for drinking water (US DOE and BLM 2007).

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SOURCE: BLM 2007c

There are about 26 major aquifer systems in the project area's 11 contiguous western states, excluding Alaska.

Principal Aquifers in the 11 Western States

Figure 3-8

Although the boundaries of groundwater and surface water resources do not always coincide, the discussion below is organized by surface water (hydrologic) regions. As shown on Figure 3-9, nine hydrologic regions have been identified in the project area: Alaska, Arkansas-White-Red, California, Great Basin, Lower Colorado, Missouri, Pacific Northwest, Rio Grande, and Upper Colorado (BLM 2007c). Within the project area hydrologic regions, the areas of greatest interest are public and NFS lands within the planning area. Most public and NFS lands occur in arid to semiarid environments in the Great Basin and Colorado drainage basins (BLM 2007c).

For this PEIS, a hot spring is defined as a spring with water temperatures above 50 °C (122 °F). Warm springs have temperatures between 20 to 50 °C (68 to 122 °F) and are not discussed. Hot and warm springs in the project area are detailed in Appendix F (US Department of Commerce, NOAA 2008).

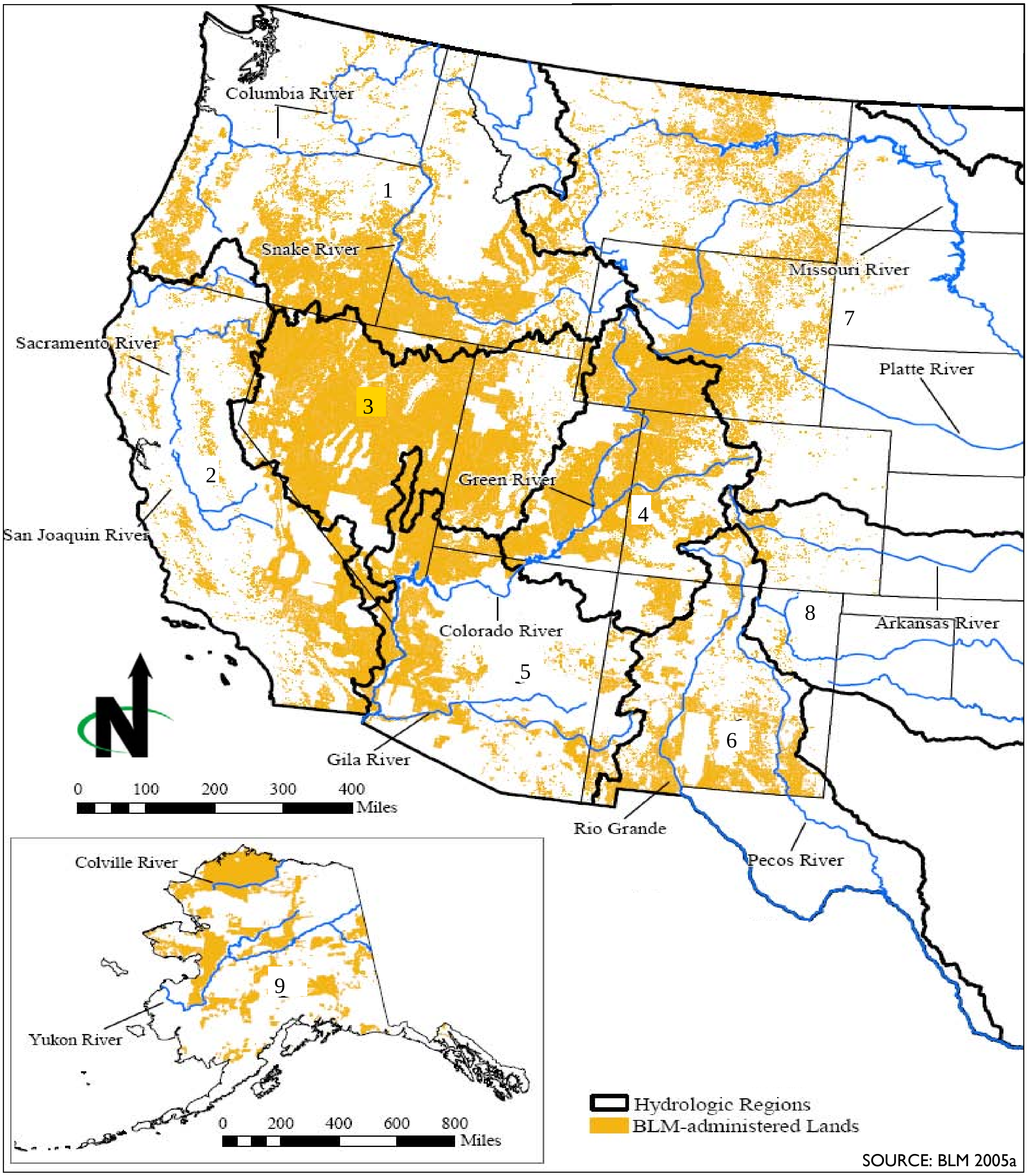
Characteristics by Hydrologic Region

Pacific Northwest Hydrologic Region

The Pacific Northwest Hydrologic Region includes the wet coastal areas of Oregon and Washington, as well as the semiarid Columbia Plateau in eastern Washington, Oregon, and southern Idaho (BLM 2007c). In this region, planning area public and NFS lands are along the Cascade Range, in central Washington, in all of Oregon except the coastal areas, and in all of Idaho except the panhandle. The Pacific Northwest Hydrologic Region encompasses the Puget-Willamette Lowland, Columbia Plateau, Northern Rocky Mountain Intermontane Basins, and the Snake River Plain regional aquifer systems. In addition, there are unconsolidated aquifers, Pliocene and younger basaltic rock aquifers, volcanic and sedimentary rock aquifers, Miocene basaltic rock aquifers, and aquifers in pre-Miocene rocks (USGS 2002b).

The area is geologically and topographically diverse and contains a wealth of ground and surface water resources that generally are suitable for all uses including drinking water (USGS 2002b). The southernmost portion of this hydrologic region extends down to the northern portion of the Great Basin. This area is geologically very new and contains extensive areas of lava and other volcanic rock. The rock substrata are very permeable; therefore, streams tend to lose much of their flow through percolation. (BLM 2007c).

Surface Water. Generally, streams that flow year-round east of the Cascade Range are fed by snowmelt from higher elevations or by groundwater discharge from aquifers recharged during periods of abundant precipitation (BLM 2007c). Tributary streams are short and have steep gradients, creating rapid surface water runoff with relatively short-term water storage, limiting recharge (BLM 2007c). Most of the region is drained by the Columbia River, its tributaries, and other streams that discharge to the Pacific Ocean.



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There are 9 total Hydrologic Regions within the 11 Western States and Alaska.

KEY HYDROLOGIC REGIONS

1. Pacific Northwest
2. California
3. Great Basin
4. Upper Colorado
5. Lower Colorado
6. Rio Grande
7. Missouri
8. Arkansas-White-Red
9. Alaska

Hydrologic Regions in the 11 Western States and Alaska

Figure 3-9

The Columbia River has 10 major tributaries—the Kootenay, Okanagan, Wenatchee, Spokane, Yakima, Snake, Deschutes, Willamette, Cowlitz, and Lewis Rivers (BLM 2007c). The Columbia River Basin extends roughly from the crest of the Coast Ranges of Oregon and Washington, east through Idaho, to the Continental Divide in the Rocky Mountains of Montana and Wyoming; and from the headwaters of the Columbia River in Canada to the high desert of northern Nevada and northwestern Utah. Its main stem, the Columbia River, originates in two lakes that lie between the Continental Divide and the Selkirk Mountain Range in British Columbia. After flowing a circuitous path for approximately 1,200 miles, it joins the Pacific Ocean near Astoria, Oregon (BLM 2007c).

Aridity progressively increases and precipitation decreases east of the Cascade Range because of rain-shadow effects caused by the mountains (BLM 2007c). Only large rivers that lie below the water table contain substantial flows year round. In most years, abundant precipitation along the western side of the Cascade Range produces abundant surface water flow in streams flowing off the Cascade Range to the Pacific Ocean (BLM 2007c). Those streams that do not flow to the Pacific flow to closed basins in southeastern Oregon (USGS 2002b). Many of these systems are rain driven and influenced primarily by winter rain storms (BLM 2007c).

Surface water is abundant in Idaho, Oregon, and Washington, though not always available when and where needed. In some places, surface water provides much of the water used for public-supply, domestic and commercial, agricultural (primarily irrigation and livestock watering), and industrial purposes. In arid parts of the region, however, surface water has long been fully appropriated, chiefly for irrigation. Most irrigation is on lowlands next to streams and on adjacent terraces. Generally, lowlands within a few miles of a main stream are irrigated with surface water diverted by gravity flow from the main stream or a reservoir and distributed through a system of canals and ditches. In some areas, water is pumped to irrigate lands farther from the stream at a higher altitude. (USGS 2002b). Groundwater is used when and where surface water supplies are lacking (USGS 2002b).

Aquifers and streams are in direct hydraulic connection in some places, particularly where the aquifers in the stream valleys consist of unconsolidated deposits. Water can move either from the aquifer to the stream or from the stream to the aquifer, depending on the altitude of the water level in the stream and the aquifer (USGS 2002b).

Groundwater. Groundwater is an important resource in this hydrologic region for domestic consumption and irrigation. It is generally contained in shallow alluvial aquifers along major streams and their valleys (BLM 2007c). Most of the groundwater is produced from aquifers in unconsolidated alluvial sand and gravel deposits that fill large to small basins in the region. These aquifers are virtually independent but share common hydrologic characteristics. These aquifers are important water sources for public-supply, domestic and commercial, agricultural, and industrial needs because of their location in generally flat lowlands where human activities are concentrated. Many large-yield public-supply and irrigation wells and thousands of domestic wells are completed in these types of aquifers, generally in areas of privately owned land (USGS 2002b).

All aquifers in this region were assigned to one of five general types depending on their geologic and hydrologic characteristics: unconsolidated aquifers, Pliocene and younger basaltic rock aquifers, volcanic and sedimentary rock aquifers, Miocene basaltic rock aquifers, and aquifers in pre-Miocene rocks (USGS 2002b).

Unconsolidated-deposit aquifers, which consist primarily of Holocene-, Pleistocene-, Pliocenene-, and Miocene- age sand and gravel, are the most productive and widespread aquifers in the region. These aquifers are prevalent along present and ancestral stream valleys and in lowlands are associated with structural or erosional basins. These unconsolidated-deposit aquifers provide freshwater for most public-supply, domestic, commercial, and industrial purposes. They also are important sources of water for agricultural (primarily irrigation) purposes. The unconsolidated deposits are mostly alluvial deposits, but in places, they consist of eolian, glacial, or volcanic deposits (USGS 2002b).

Pliocene and younger basaltic-rock aquifers consist primarily of thin, basaltic lava flows and beds of basaltic ash, cinders, and sand. The aquifers are most productive in the Snake River Plain of Idaho. These aquifers yield freshwater that is used mostly for agricultural (primarily irrigation) purposes (USGS 2002b).

Volcanic- and sedimentary-rock aquifers consist of a variety of volcanic and sedimentary rocks. These aquifers are not as productive as the aquifers described above. The volcanic rocks that compose the aquifers consist primarily of Pliocene and younger basaltic rocks on the eastern side of the Cascade Range in Oregon and Washington, and silicic volcanic rocks in southern Idaho and southeastern Oregon. Unconsolidated volcanic deposits included in the aquifers are ash and cinders. The sedimentary rocks that compose the aquifers consist primarily of semiconsolidated sand and gravel eroded mostly from volcanic rocks. The aquifers generally yield freshwater but locally yield saltwater. About 30 percent of the fresh groundwater withdrawals are used for public-supply, about 20 percent are used for domestic and commercial, and about 50 percent are used for agricultural (primarily irrigation) purposes (USGS 2002b).

Aquifers in pre-Miocene rocks consist of undifferentiated volcanic rocks, undifferentiated consolidated sedimentary rocks, and undifferentiated igneous and metamorphic rocks that are distributed throughout the region, principally in the mountainous areas. In some places, the thickness of the volcanic rocks might be as much as about 5,000 feet, and that of the consolidated sedimentary rocks might be as much as about 15,000 feet. East of the Cascade Range, the aquifers generally yield freshwater but locally yield saltwater. Within the Cascade Range and west of it, these aquifers commonly yield saltwater. Fresh groundwater withdrawals are used mostly for domestic and commercial purposes (USGS 2002b).

Miocene basaltic-rock aquifers consist primarily of thick basaltic lava flows underlying Pliocene and younger rocks in much of the intervening areas between outcrops. The aquifers are most productive in the Columbia Plateau of northeastern Oregon and southeastern Washington where the aquifers are thickest. The maximum thickness of the aquifers is estimated to be as much as about 15,000 feet in the southern part of the Columbia Plateau. These aquifers generally yield freshwater but locally yield saltwater. Most of the fresh groundwater withdrawals are used for agricultural (primarily irrigation) purposes (USGS 2002b).

The Puget-Willamette Lowland, Columbia Plateau, Northern Rocky Mountain Intermontane Basins, and the Snake River Plain regional aquifer systems are made up of the five types of aquifers discussed above. In southern Oregon and Idaho, these aquifers are part of the extensive basin-fill Basin and Range aquifers. These aquifers are described in more detail as part of the Great Basin Hydrologic Region, described below.

The Snake River Plain, the Columbia Plateau, and the Puget-Willamette Trough aquifer systems consist of extensive sets of aquifers and confining units that might locally be discontinuous but that function hydrologically as a single aquifer system on a regional scale. The major aquifers that compose the Puget-Williamette Trough regional aquifer system are unconsolidated-deposit and Miocene basaltic-rock aquifers in deep basins (USGS 2002b). The Columbia Plateau Regional Aquifer System consists of unconsolidated and Miocene basaltic rock aquifers in northeastern Oregon and southeastern Washington. Permeable zones are at the tops and the bottoms of the basaltic lava flows (USGS 2002b).

In the Snake River Plain of southern Idaho and southeastern Oregon, the aquifers consist of the unconsolidated and the Pliocene and younger basaltic rock aquifers. The layers of lava flows, beds of volcanic ash and tuff, basalt, silicic volcanic rocks, and semiconsolidated to consolidated sedimentary rocks that contain small to large quantities of volcanic material are complexly interbedded, and their permeability is extremely variable. Permeable zones at the tops and the bottoms of these flows yield large volumes of water to irrigation wells. These aquifers also discharge about one million gallons per day to springs in the walls of the Snake River Canyon (USGS 2002b).

The Northern Rocky Mountains Intermontane Basins aquifer systems consists of mainly aquifers in pre-Miocene rocks with some unconsolidated aquifers. They are present mostly in mountainous areas, and water from wells completed in these aquifers is used mostly for domestic and agricultural (livestock watering) supplies (USGS 2002b).

Groundwater Quality. Groundwater in Idaho, Oregon, and Washington generally is fresh (dissolved-solids concentration of 1,000 milligrams per liter or less) and chemically suitable for most uses. Because of sparse settlement in much of the area, little groundwater has been contaminated as the result of human activities, except locally. Measured concentrations of dissolved solids in groundwater exceed 1,000 milligrams per liter only in scattered areas throughout the region (USGS 2002b).

Dissolved-solids concentrations that exceed 500 milligrams per liter are common near coastal areas and in deep aquifers in Idaho, Oregon, and Washington. Most deep aquifers are overlain by shallower aquifers that contain water with smaller dissolved-solids concentrations. However, in some irrigated areas, water in shallow aquifers contains a large dissolved-solids concentration that resulted from percolation of the irrigation water. In central parts of closed basins, evaporation concentrates minerals in shallow groundwater (USGS 2002b).

Areas where dissolved-solids concentrations exceed 500 milligrams per liter reflect: irrigation, chiefly on the Snake River Plain and the Columbia Plateau; saltwater in underlying consolidated marine sedimentary rocks in Oregon and Washington; evaporation in closed basins in south-central Oregon; and geothermal water leaking into the cold freshwater system, chiefly in Idaho and Oregon (USGS 2002b). Table 3-8 identifies the sole-source aquifers in the Pacific Northwest Hydrologic Region as determined by the EPA.

Table 3-8
Pacific Northwest Hydrologic Region Sole-Source Aquifers

Sole-Source Aquifer	Location
Spokane Valley-Rathdrum Prairie Aquifer	WA, ID
Camano Island Aquifer	WA
Whidbey Island Aquifer	WA
Cross Valley Aquifer	WA
Newberg Area Aquifer	WA
Troutdale Aquifer System	WA
North Florence Dunal Aquifer	OR
Cedar Valley Aquifer	WA
Lewiston Basin Aquifer	WA, ID
Eastern Snake River Plain Aquifer	ID, WY
Central Pierce County Aquifer System	WA
Marrowstone Island Aquifer System	WA
Vashon-Maury Island Aquifer System	WA
Guemes Island Aquifer System	WA
Missoula Valley Aquifer	MT

Source: US EPA 2008a

Hot Springs. There are 179 hot springs within the Pacific Northwest Hydrologic Region. Most are in Idaho (3) and Oregon (40), with 14 in Washington, 7 in Montana, 5 in Nevada, and 2 in Wyoming (Appendix F) (US Department of Commerce, NOAA 2008).

California Hydrologic Region

The California Hydrologic Region includes nearly the entire state of California and parts of southern Oregon (BLM 2007c). In this region, the planning area public and NFS lands are in northeastern California and southern Oregon, along the eastern border of California, in scattered areas in southern California, and in a few small areas along the California coast. The California Hydrologic Region encompasses the Basin and Range basin-fill aquifers and carbonate rock aquifers, Central Valley aquifer system, Coastal Basin aquifers, Northern California basin-fill aquifers, and Northern California volcanic rock aquifers, (USGS 2002b). Water needs in California are very large, and the state leads the US in agricultural and municipal water use. The demand for water exceeds the natural water supply in many agricultural and nearly all urban areas. As a result, water is impounded by reservoirs in areas of surplus and transported to areas of scarcity by an extensive network of aqueducts (USGS 2002b).

Surface Water. The California region is drained by rivers such as the Sacramento and San Joaquin. Storms that bring moisture to the region are most frequent in winter. Surface water flow in streams is derived mainly from snowmelt in the mountainous areas during the spring months. Runoff is greater than 40 inches per year in many mountainous areas. During the remainder of the year, many streams have no flow or intermittent flow that follows major storms (BLM 2002).

In southern California, nearly all streams that head in the mountains are ephemeral and lose flow to alluvial aquifers within a short distance of where the streams leave the mountains and emerge onto the valley floors. The basins in the arid parts of southeastern California have virtually zero runoff because most precipitation that falls is evaporated almost immediately. However, high-intensity storms or rapid snowmelt in the mountains that border the basins may cause flash floods that reach the basin floors (USGS 2002b).

Before the inception of agriculture, the largest rivers in California's vast Central Valley overflowed their banks during periods of peak winter flows and formed extensive marshlands. An elaborate flood-control system and the lowering of the water table by withdrawals for irrigation now keep these rivers within their banks (USGS 2002b).

Groundwater. Groundwater in the mountainous areas is relatively deep and is contained in sedimentary units that continue under the intermountain basins and form a deep reservoir that is seldom tapped because of its depth. Shallow groundwater can be found in sands and gravels that fill the basins between the mountain ranges. This groundwater is fed by infiltration of surface water from streams that flow off the mountain ranges. Groundwater in southeastern California is the main source of water for domestic consumption and agricultural irrigation (BLM 2007c).

The Basin and Range aquifers are located in the southern California desert. The water-yielding materials in this area are in valleys and basins, and consist primarily of unconsolidated alluvial-fan deposits. However, locally, floodplain and lacustrine (lake) beach deposits may yield water to wells. Also, the consolidated volcanic and carbonate rocks that underlie the unconsolidated alluvium are a water source if the consolidated rocks are sufficiently fractured or have solution openings. Many of these valleys and basins are internally drained where water from precipitation that falls within the basin recharges the aquifer and ultimately discharges to the land surface and evaporates within the basin. Rarely, basins might be hydraulically connected in the subsurface by fractures or solution openings in the underlying bedrock. Also, several basins or valleys may develop surface-water drainage that hydraulically connects the basins, and groundwater flows between the basins, mostly through the unconsolidated alluvial stream/floodplain sediments (USGS 2002b).

The Central Valley aquifer system occupies most of a large basin in central California between the Sierra Nevada and the Coast Range Mountains. The Central Valley is the single-most important source of agricultural products in the US, and groundwater for irrigation has been essential in the industry's development. The basin contains a single, large, basin-fill aquifer system, the largest such system in the US. Although the valley is filled with tens of thousands of feet of unconsolidated sediments, most of the fresh groundwater is at depths of less than 2,500 feet (USGS 2002b).

The Coastal Basins aquifers occupy a number of basins in coastal areas from northern to southern California. These basins are in structural depressions formed by folding and faulting, filled with marine and alluvial sediments, and drained by streams that contain water at least part of the year. Nearly all the large population centers in California are located in these basins, and the available groundwater is used primarily for municipal supplies. In most of the basins, local groundwater supplies are no longer adequate, and surface water must be transported from distant sources. Seawater intrusion is a common problem in nearly all the Coastal Basins aquifers (USGS 2002b).

The most productive and highly-utilized aquifers in interior northern California are the northern California basin-fill aquifers. These aquifers are in unconsolidated alluvial sediments. However, in some basins, wells drilled into underlying volcanic rocks might produce large quantities of water. Most groundwater demand is for agricultural irrigation (USGS 2002b). The northern California volcanic-rock aquifers consist of volcanic rocks that yield water primarily from fractures and locally from intergranular spaces in porous tuffs.

Water-yielding zones in these rocks are unevenly distributed; however, in some areas, wells completed in the volcanic-rock aquifers yield large volumes of water. The northern California volcanic-rock aquifers are relatively unexplored and undeveloped (USGS 2002b). Table 3-9 identifies the sole source aquifers in the California Hydrologic Region as determined by the EPA.

Table 3-9
California Hydrologic Region Sole-Source Aquifers

Sole-source Aquifer	Location
Fresno County Aquifer	CA
Santa Margarita Aquifer, Scotts Valley	CA
Campo/Cottonwood Creek	CA
Ocotillo-Coyote Wells Aquifer	CA

Source: US EPA 2008b

Hot Springs. There are 75 hot springs within the California Hydrologic Region. Seventy of them are in California, and five are in Oregon (Appendix F) (US Department of Commerce, NOAA 2008).

Great Basin Hydrologic Region

The Great Basin Hydrologic Region includes the Great Basin and encompasses nearly the entire state of Nevada, as well as western Utah (BLM 2007c). In this region, the planning area public and NFS lands include almost the entire region. The Great Basin Hydrologic Region encompasses the Basin and Range basin-fill aquifers and carbonate rock aquifers, the southern Nevada volcanic rock aquifers, and a minor amount of the Colorado Plateau aquifers (USGS 2002b).

Surface Water. The Great Basin Hydrologic Region of Nevada and Utah is an arid region located in the rain-shadow of the Sierra Nevada Mountains. The region is characterized by northerly trending mountain ranges and intermountain valleys with closed drainage. None of the streams that originate within this basin have an outlet to the ocean. The Great Basin's internal drainage results from blockage of water movement by high fault-created mountains and lack of sufficient water flow to merge with larger drainages outside of the Great Basin. This internally drained area occupies approximately 200,000 square miles, including most of Nevada, a large part of Utah, and portions of Idaho, California, and Oregon (USGS 2004f).

This region's surface water sources evaporate or percolate before they can flow to the ocean (USGS 2004f). Precipitation generally falls as rain and mountain snowfall. Streams flowing from the mountains carry water to the basins, which infiltrates into the alluvial sediments and provides the only substantial recharge to basin groundwater. Surface water flow in the basins is derived almost entirely from the mountain streams (BLM 2007c). Any water that falls as rain or snow into this region does not leave (USGS 2004f).

Apart from major rivers (e.g., the Humboldt and Truckee Rivers), surface water flow in the basins of Utah and Nevada is intermittent along the mountain fronts and ephemeral in the basins themselves. Surface water flow in the mountainous areas is limited mainly to late spring snowmelt in the higher areas. Agricultural diversions of major streams exiting the mountains are common, and major rivers are used extensively for irrigation. Surface water flow in northern Nevada has been affected by groundwater pumping from mining areas into the rivers. The Humboldt River, from Battle Mountain to Winnemucca, Nevada, is dominated by mine discharge (BLM 2007c).

Groundwater. The water-yielding materials in the Basin and Range aquifers are in valleys and basins, consisting primarily of unconsolidated alluvial-fan deposits. Local floodplain and lacustrine (lake) beach deposits may also yield water to wells. Also, the consolidated volcanic and carbonate rocks that underlie the unconsolidated alluvium are a water source if the consolidated rocks are sufficiently fractured or have solution openings. Many of these valleys and basins are internally drained where water from precipitation that falls within the basin recharges the aquifer and ultimately evaporates within the basin. Rarely, basins might be hydraulically connected in the subsurface by fractures or solution openings in the underlying bedrock. Also, several basins or valleys may develop surface water drainage that hydraulically connects the basins, and groundwater flows between the basins, mostly through the unconsolidated alluvial stream/floodplain sediments (USGS 2002b).

Within the Basin and Range Province, aquifers are not continuous, or regional, because of the complex faulting in the region. Three principal aquifer types are collectively called the Basin and Range aquifers: volcanic-rock aquifers, carbonate-rock aquifers, and basin-fill aquifers. The volcanic-rock aquifers, located in south-central Nevada, are primarily tuff, rhyolite, or basalt of Tertiary age. The carbonate-rock aquifers, which are primarily limestones and dolomites of Mesozoic and Paleozoic age, underlie many of the alluvial basins in eastern Nevada, western Utah, and southeastern Idaho. Conditions indicate that the carbonate rock is cavernous. The basin-fill aquifers are primarily unconsolidated sand and gravel of Quaternary and Tertiary age. The most permeable basin-fill deposits are present in the depressions created by late Tertiary to Quaternary block faulting and can be classified by origin as alluvial-fan, lake-bed, or fluvial deposits. Any or all three aquifer types may be in, or underlie, a particular basin and constitute three separate sources of water; however, the aquifers may be hydraulically connected to form a single source. Other rock types within the region have low permeability and act as boundaries to the flow of fresh groundwater (USGS 2002b).

In the extreme eastern part of the region, in central Utah, the region encompasses a small part of the Colorado Plateau aquifers. These aquifers are described in the Upper Colorado Hydrologic Region section, below.

Shallow groundwater in the alluvium of the basins is the main source of water for domestic consumption, irrigation, and power plant cooling. Some areas of the Great Basin, particularly in northern Nevada, have geothermal reservoirs that underlie the shallow groundwater reservoirs. These geothermal waters have been tapped, often inadvertently, by open pit mining and dewatering of areas used for gold mining. The Great Basin contains many of the largest groundwater reservoirs in the US. These reservoirs are largely untapped at present, but major urban areas like Las Vegas, Nevada, are actively pursuing their development (BLM 2007c).

Groundwater Quality. The dissolved solids concentrations in the water in the basin-fill aquifers are generally less than 1,000 milligrams per liter but exceed 10,000 milligrams per liter in the Great Salt Lake Desert and near the Great Salt Lake. The Western Uinta Arch Paleozoic Aquifer System is the only sole-source aquifer identified by the EPA in the Great Basin Hydrologic Region (US EPA 2008b).

Hot Springs. There are 139 hot springs within the Great Basin Hydrologic Region. Most are in Nevada (115), with 12 in Utah, 8 in California, and 4 in Idaho (Appendix F) (US Department of Commerce, NOAA 2008).

Upper Colorado Hydrologic Region

The Upper Colorado Hydrologic Region includes southwestern Wyoming, eastern Utah, western Colorado, northeastern Arizona, and northwestern New Mexico (BLM 2007c). In this region, the planning area public and NFS lands include southwestern Wyoming, eastern Colorado, and northwestern New Mexico. The Upper Colorado Hydrologic Region encompasses the Colorado Plateau aquifer (USGS 2002b).

Surface Water. Perennial surface water flow occurs in major rivers (e.g., Green and Colorado Rivers). The upper reaches of the Colorado River and its tributaries drain this region. Precipitation varies greatly with elevation and occurs as winter snows and heavy autumn rainstorms. In southwestern Colorado, summer monsoonal flow produces ample rain. Major streams are fed by snowmelt in mountainous areas. The larger rivers in Colorado are perennial, but the smaller rivers and streams are either intermittent or ephemeral. Dams serve as flood control, domestic supply, and power generation for the major urban centers, as well as providing surface water for irrigation. Farming and ranching are usually limited to stream valleys, where irrigation water comes mostly from surface water (BLM 2007c).

Groundwater. Groundwater is found in most of the sedimentary rocks of the Colorado Plateau and is the major source of water for domestic and municipal use. Seeps and springs are an historic source of water for Native American tribes and a current source of water for smaller ranches (BLM 2007c). The distribution of aquifers in the Colorado Plateau is controlled in part by the structural deformation and erosion that has occurred since deposition of the sediments that compose the aquifers. The principal aquifers in younger rocks are present only in basins such as the Uinta, Piceance, and San Juan. In uplifted areas, younger rocks have been eroded away, and aquifers are present in older rocks that underlie more extensive parts of the Colorado Plateau area (USGS 2002b). Major aquifer systems are not present.

In general, the aquifers in the Colorado Plateau area are composed of permeable, moderately to well-consolidated sedimentary rocks. These rocks range in age from Permian to Tertiary and vary greatly in thickness, lithology, and hydraulic characteristics. Many water-yielding units in the area have been grouped into four principal aquifers for purposes of discussion. These include the Uinta-Animas aquifer, the Mesaverde aquifer, the Dakota-Glen Canyon aquifer system, and the Coconino-De Chelly aquifer. Most widespread and productive water-yielding units are included in these aquifers; however, there are some locally productive water-yielding units (USGS 2002b).

The Uinta-Animas aquifer primarily is composed of Lower Tertiary rocks in the Uinta Basin of northeastern Utah, the Piceance Basin of northwestern Colorado, and the San Juan Basin of northwestern New Mexico. Aquifers in each basin are present in different parts of the stratigraphic section. Some formations are considered to be an aquifer in more than one basin; however, some formations vary so much in their hydraulic characteristics that they are considered to be an aquifer in one basin and a confining unit in another (USGS 2002b).

The Mesaverde aquifer comprises water-yielding units in the Upper Cretaceous Mesaverde Group, its equivalents, and some adjacent Tertiary and Upper Cretaceous formations. The Mesaverde aquifer is at or near land surface in extensive areas of the Colorado Plateaus and underlies the Uinta-Animas aquifer. The aquifer is of regional importance in the Piceance, Uinta, Kaiparowits, Black Mesa, and San Juan Basins and is of lesser importance in the Wasatch Plateau and High Plateaus areas. Some of the rocks that form the Mesaverde aquifer contain coal beds, some of which have been mined for at least a century. The hydrologic effects of mining have been of increasing concern in the areas underlain by the aquifer. The quality of the water in the Mesaverde aquifer is extremely variable (USGS 2002b).

The Dakota-Glen Canyon aquifer system is defined here as those water-yielding rocks ranging in age from late Cretaceous to Triassic underlying most of the Colorado Plateau area. These rocks contain a series of aquifers and confining units. These aquifers are grouped together as an aquifer system because they are separated everywhere from overlying and underlying aquifers by thick confining units, and because some hydraulic connection exists between each of the aquifers in the system at some point in the Colorado Plateau area. In much of the area underlain by the aquifer system, the great depth to the aquifers or poor water quality makes the aquifers unsuitable for development. However, in areas where an aquifer is near land surface, the aquifer may be an important water source (USGS 2002b).

The rocks referred to as the Coconino-De Chelly aquifer are water-yielding rocks of Early Permian age underlying the southern part of the Colorado Plateau. The formations that comprise the Coconino-De Chelly aquifer are the Coconino, De Chelly, and Glorieta Sandstones; the San Andres Limestone; and the Yeso and Cutler Formations (USGS 2002b).

Relatively impermeable confining units separate each of the four principal aquifers in the Colorado Plateau. Thinner and less-extensive confining units separate some water-yielding zones within the principal aquifers; however, these units generally form less-effective barriers to groundwater movement. Where the intra-aquifer confining units are thin or absent, water can move between adjacent water-yielding zones within an aquifer (USGS 2002b).

Groundwater Quality. Although the quantity and chemical quality of water in the Colorado Plateau aquifers are extremely variable, much of the land in this sparsely populated region is underlain by rocks that contain aquifers capable of yielding usable quantities of water of a quality suitable for most agricultural or domestic use (USGS 2002b). Table 3-10 identifies the sole-source aquifers in the Upper Colorado Basin Hydrologic Region as determined by the EPA.

Table 3-10
Upper Colorado Hydrologic Region Sole-Source Aquifers

Sole-source Aquifer	Location
Glen Canyon Aquifer	UT
Castle Valley Aquifer	UT

Source: US EPA 2008c

Hot Springs. There are 14 hot springs within the Upper Colorado Hydrologic Region, 11 of which are in Colorado and 3 of which are in Utah (Appendix F) (US Department of Commerce, NOAA 2008).

Lower Colorado Hydrologic Region

The Lower Colorado Hydrologic Region includes almost all of Arizona, western New Mexico, and parts of southeastern Nevada, southeastern California, and southwestern Utah (BLM 2007c). In this region, planning area public and NFS lands are in southwestern Arizona, western New Mexico, and parts of southeastern Nevada, Southeastern California, and Southwestern Utah. The

Upper Colorado Hydrologic Region encompasses the Basin and Range basin-fill aquifers and carbonate rock aquifers, Colorado Plateau aquifers, and a minor portion of the Rio Grande Aquifer system (USGS 2002b).

Surface Water. This hydrologic region is comprised of the lower reaches of the Colorado River in the desert southwest of Arizona, New Mexico, and southern Nevada. In this region, public lands are mainly restricted to the arid valleys, while many of the upland areas are administered by the FS. The climate is arid, and precipitation is limited to the winter months and periods of heavy storms. Most precipitation during summer evaporates before it can infiltrate into the desert sands (BLM 2007c).

Surface water flow in the arid basins of the southwest is ephemeral to nonexistent most of the year. Spring snowmelt and periods of heavy winter rain result in surface water flow in the mountainous areas and along the intervening basins' mountain fronts. During the rest of the year, surface water flow is absent except after major storms, where flash floods are common along mountain fronts. Only major rivers draining the Colorado Plateau or the Mogollon Rim, such as the Gila and Bill Williams Rivers, have perennial flow. (BLM 2007c)

Groundwater. The Basin and Range basin-fill aquifers, Basin and Range carbonate rock aquifers, and the Colorado Plateau aquifers are described previously. The Rio Grande Aquifer is described as part of the Rio Grande Hydrologic Region section, described below.

Groundwater is found in the alluvium of basins and in the bedrock of mountainous areas (i.e., reservoirs to many thousands feet deep). Groundwater is recharged by precipitation in the mountains and infiltration of stream flow along the base of the mountains. The shallow groundwater reservoirs are used extensively for irrigation and domestic consumption. Irrigation demand and mine dewatering have substantially lowered the water levels in the shallow groundwater reservoirs of the Arizona basins. However, groundwater levels in the basins of southern New Mexico have not been substantially affected by irrigation. Many of the basins have shallow groundwater surfacing in playa lakes (BLM 2007c).

Groundwater Quality. The concentration of dissolved fluoride in groundwater in southern Arizona is close to or exceeds the US EPA Drinking Water Regulations Maximum Contaminant Level for dissolved fluoride (4 milligrams per liter) for drinking-water supplies in parts of some basins in Arizona. (USGS 2002b). Table 3-11 identifies the sole-source aquifers in the Lower Colorado Basin Hydrologic Region as determined by the EPA.

Table 3-11
Lower Colorado Hydrologic Region Sole-Source Aquifers

Sole-source Aquifer	Location
Upper Santa Cruz and Avra Basin Aquifer	AZ
Bisbee-Naco Aquifer	AZ

Source: US EPA 2008b

Hot Springs. There are 13 hot springs within the Lower Colorado Hydrologic Region, including 6 in New Mexico, 6 in Arizona, and 1 in Nevada (Appendix F) (US Department of Commerce, NOAA 2008).

Rio Grande Hydrologic Region

The Rio Grande Hydrologic Region includes almost all of New Mexico, as well as south-central Colorado (BLM 2007c). In this region, planning area public and NFS lands are in parts of south-central Colorado, north central New Mexico, and southern New Mexico. The Rio Grande Hydrologic Region encompasses the Rio Grande Aquifer system, the Pecos River Basin alluvial aquifer, the Roswell Basin Aquifer, the southeastern portion of the Colorado Plateau aquifers, and the northern extremes of the Pecos River Basin alluvial aquifer (USGS 2002b).

Surface Water. The Rio Grande and Pecos River are major surface water resources that derive their water from the mountainous regions of southern Colorado and flow through New Mexico and Texas to the Gulf of Mexico. The Rio Grande is the largest river in the area and has perennial flow through most of its length in Colorado and New Mexico. The river flows across the broad basin-fill deposits in Colorado, through deep canyon and small intermountain basins in northern New Mexico, and through a series of broad basins and narrow valleys to the state line in southern New Mexico (USGS 2002b). Most basins along the Rio Grande have surface drainage to the river and are topographically open basins. The northern end of the San Luis Valley and most other basins distant from the river have internal surface-water drainage and generally do not contribute stream flow to the Rio Grande (USGS 2002b).

Surface water flow is present year round in the Rio Grande. Much of the stream flow in the more-mountainous northern part of the Rio Grande is derived from mountain snowmelt runoff. Stream flow in the southern part of the river system is derived from upstream flow, groundwater discharge, and summer thunderstorm runoff (USGS 2002b). Agricultural diversions account for approximately 90 percent of surface water use and may result in practically no flow during the summer months (BLM 2007c).

Groundwater. The Rio Grande aquifer system is the principal aquifer in a 70,000-square-mile area of southern Colorado and central New Mexico. The aquifer system consists of a network of hydraulically interconnected aquifers in basin-fill deposits located along the Rio Grande Valley and nearby valleys (USGS 2002b). These aquifers are generally composed of unconsolidated sediment deposits present in intermountain basins between discontinuous mountain ranges in southern New Mexico and between mountains and tablelands in northern New Mexico. High mountains border the aquifers in southern Colorado (USGS 2002b). Groundwater recharge primarily originates as precipitation in the mountainous areas surrounding the basins, while most of the precipitation that falls in the valleys is lost to evaporation and transpiration (BLM 2007c).

Most groundwater withdrawal occurs as discharge from pumping wells, of which about 90 percent is used for irrigation of commercial crops. Most cities and communities in the area, such as Albuquerque, Las Cruces, and Santa Fe, New Mexico, rely on groundwater for municipal use. Groundwater withdrawals in closed basins have caused long-term water level declines, while withdrawals from wells located near the Rio Grande or its perennial tributaries generally do not cause long-term water level declines in the aquifer (BLM 2007c).

The Roswell Basin aquifer system consists of an underlying carbonate-rock aquifer and a hydraulically connected, overlying alluvial aquifer. The carbonate-rock aquifer primarily has been formed by solution openings in extensive limestone and dolomite formations of Permian age. The alluvial aquifer is in unconsolidated gravel, sand, silt, and clay that overlies the eastern part of the carbonate-rock aquifer. The alluvial aquifer hydraulically connects the carbonate-rock aquifer with surface flow in the Pecos River, which flows through the Roswell Basin (USGS 2002b).

Thick and extensive alluvial deposits of Cenozoic age compose the Pecos River Basin alluvial aquifer in extreme southeastern New Mexico and western Texas. The topography in the area consists mostly of flat to rolling plains that slope gently toward the Pecos River. Groundwater in the Cenozoic alluvium is of major importance in this area where average annual rainfall is less than 12 inches (USGS 2002b). The Espanola Basin Aquifer System is the only sole-source aquifer identified by the EPA in the Rio Grande Hydrologic Region (US EPA 2008d).

Hot Springs. There are 11 hot springs within the Rio Grande Hydrologic Region, of which 8 are in New Mexico and 3 are in Colorado (Appendix F) (US Department of Commerce, NOAA 2008).

Missouri Hydrologic Region

The Missouri Hydrologic Region includes most of Montana and Wyoming, as well as northwestern Colorado. In this region, planning area public and NFS lands are in parts of southwestern Montana, the basins of central Wyoming, and small parts of central Colorado. The Missouri Hydrologic Region encompasses the Northern Great Plains aquifer, the Central Midwest (Great Plains) aquifer system, the High Plains aquifer, and the Denver Basin aquifer. A small part of the western edge of the region (bordering Idaho) includes the Northern Rocky Mountains Intermontane Basin aquifer system. This aquifer system is described under the Pacific Northwest Hydrologic Region, as described previously (USGS 2002b).

Surface Water. This hydrologic region encompasses the eastern front of the Rocky Mountains stretching to the Great Plains, most of which is drained by the Missouri and Platte Rivers and their tributaries (BLM 2007c). The Missouri River system and the North Platte River drain eastward and southeastward to the Mississippi River, which discharges to the Gulf of Mexico (USGS 2002b). These rivers and their tributaries are an important source of water for public-supply, domestic and commercial, agricultural, and industrial uses. Much of the surface water has long been appropriated for agricultural use, primarily irrigation, and for compliance with downstream water pacts. Reservoirs store some of the surface water for flood control, irrigation, power generation, and recreational purposes (USGS 2002b). The demand for water is directly related to the distribution of people. The more densely populated areas are on lowlands near major streams. Many of the mountain, desert, and upland areas lack major population centers, particularly in Montana and Wyoming, where use of much of the land is controlled by the federal and withdrawal of groundwater is restricted (USGS 2002b).

Surface water resources are dominated by the major rivers and their tributaries. Average annual runoff in the region varies greatly (USGS 2002b). Precipitation is generally sparse in the summer and fall months, and surface water flow is generally dependent on snowmelt in the mountainous areas. Rivers flow mainly from late spring to early fall and can be dry in some parts of the region during the winter months (BLM 2007c). In arid and semiarid areas of the region, most precipitation replenishes soil moisture, evaporates, or is transpired by vegetation, and only a small part of the precipitation is left to maintain stream flow or recharge aquifers (USGS 2002b). Surface water is directly connected to groundwater through shallow alluvial aquifers that are found along all the major rivers and their tributaries (BLM 2007c). Runoff is affected in some areas by reservoirs that have been constructed on major streams to mitigate flooding and to store water for irrigation, electrical power generation, and recreation. Water stored in reservoirs during times when runoff is great is subsequently released during drier periods to maintain downstream flow (USGS 2002b).

Groundwater base flow supplies stream and river flow in the late summer and fall. Surface water is the main source of municipal and irrigation water in the Rocky Mountain region, and irrigation return flow is a major component of surface water flow (BLM 2007c).

Groundwater. Groundwater in Wyoming and western Montana is found both in the igneous rocks of the uplifts and the thick sedimentary fill in the basins, although groundwater in the uplifts is generally not used. Groundwater is used extensively for irrigation, much of it becoming irrigation return water that flows into major streams and their tributaries. In addition to irrigation, groundwater is also used for municipal and domestic water supplies. Recharge comes only from stream infiltration and spring snowmelt (BLM 2007c). The High Plains, Northern Great Plains, and Central Midwest aquifer systems in the region are extensive sequences of aquifers and confining units, which are usually, but not always, arranged as stacks of layers, that might be discontinuous locally but function regionally as a single aquifer systems (USGS 2002b).

High Plains. The High Plains aquifer underlies parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. The aquifer is the principal source of water in one of the major agricultural areas of the US. Most wells completed in the High Plains aquifer system obtain water from upper Tertiary aquifers that consist of the Ogallala Formation of Miocene age and the Arikaree Formation of Miocene and Oligocene age. The unconsolidated sand and gravel beds of the Ogallala Formation yield water much more readily than the sandstone beds of the Arikaree Formation. The consolidated siltstone and sandstone of the Brule Formation of Oligocene age yield highly variable volumes of water; yields are greatest where the beds have been fractured. Valley-fill and dune deposits of Quaternary age are hydraulically connected to the aquifers in Tertiary rocks and are included in the High Plains aquifer system. These permeable deposits are important recharge areas because they readily absorb and temporarily store precipitation before it percolates downward to recharge underlying permeable beds. Except for dune sands, which were deposited by wind, all the rocks and deposits that compose the High Plains aquifer system were deposited by streams. The streams probably were braided streams that flowed eastward from the Rocky Mountains and constantly shifted their channels across a broad plain that sloped gently to the east. Depth to water in the High Plains aquifer system ranges from less than 50 to almost 300 feet (USGS 2002b).

Water quality in the High Plains aquifer system in South Dakota and Wyoming is suitable for most uses practically everywhere. Locally, dissolved-solids concentrations in the water exceed the 500-milligram-per-liter secondary maximum contaminant level recommended for drinking water by the US EPA (USGS 2002b).

Northern Great Plains. The Northern Great Plains aquifer system underlies most of North Dakota and South Dakota, about one-half of Montana, and about one-third of Wyoming. The permeable rocks of the Northern Great Plains aquifer system have been grouped into five major aquifers. From shallowest to deepest, these are lower Tertiary, upper Cretaceous, lower Cretaceous, upper Paleozoic, and lower Paleozoic aquifers. All or parts of several geologic formations are included in each of the five major aquifers (USGS 2002b).

The aquifer system is mostly within the Williston Basin in eastern Montana and the western Dakotas, the Powder River Basin in northeastern Wyoming, and areas of structural uplifts that flank these basins. The major aquifers of the Northern Great Plains aquifer system are sandstones of Tertiary and Cretaceous age and carbonate rocks of Paleozoic age. These aquifers, along with regional confining units that separate some of them, form one of the largest confined aquifer systems in the US. In some places, local confining units separate the major aquifers into smaller, individual aquifers, but each major aquifer can be treated regionally as a single, large aquifer (USGS 2002b).

Regional movement of water in the Northern Great Plains aquifer system is from recharge areas at high altitudes, down the dip of the aquifers, and then upward to discharge into shallower aquifers or to the land surface. Much of the water moves into and through the Powder River and the Williston Basins. Much of the discharge from the aquifer system is by upward leakage of water into shallower aquifers where the hydraulic head in the shallower aquifer is less than that of a deeper aquifer. Some discharge from the Northern Great Plains aquifer system also is by withdrawals from wells or from flowing wells in places where artesian pressure is sufficient to allow water in confined aquifers to rise above the land surface (USGS 2002b).

Central Midwest. The Central Midwest aquifer system encompasses the eastern half of Colorado and small parts of northeastern New Mexico and southeastern Wyoming. The Central Midwest regional aquifer system includes the Great Plains aquifer subsystem. The Great Plains aquifer subsystem consists of two sandstone aquifers separated by a shale-confining unit, all of which are in Lower Cretaceous rocks. The aquifer system is overlain by a thick sequence of Upper Cretaceous shale beds that are part of several geologic formations but which function together as a single confining unit, the Great Plains confining system (USGS 2002b).

The upper aquifer, the Maha aquifer, consists chiefly of Dakota, Newcastle, or Muddy Sandstones or equivalent rocks. The lower aquifer, the Apishapa aquifer, consists mostly of the Cheyenne Sandstone or its equivalent, the Inyan Kara Group. The confining unit that separates the two aquifers is mostly the Skull Creek or the Thermopolis Shales or equivalent shale beds (USGS 2002b).

The Denver Basin aquifer system consists of a layered sequence of four aquifers in beds of permeable conglomerate, sandstone, and siltstone. Layers of relatively impermeable shale separate the aquifers and impede the vertical movement of groundwater between the aquifers. The northern part of this aquifer system underlies the surficial aquifer of the South Platte River. Although the Denver Basin aquifer system and the surficial aquifer are hydraulically connected in part of this area, they primarily function as separate aquifer systems (USGS 2002b). The Elk Mountain Aquifer in Wyoming is the only sole-source aquifer identified by the EPA in the Missouri Hydrologic Region (US EPA 2008c).

Hot Springs. There are over 100 hot springs within the Missouri Hydrologic Region. Most are in the Yellowstone National Park area, which has over 90 known hot springs. Three other hot springs are in Wyoming outside of Yellowstone National Park, and 13 others are in Montana (Appendix F) (US Department of Commerce, NOAA 2008).

Arkansas-White-Red Hydrologic Region

In the western US, the Arkansas-White-Red Hydrologic Region includes southeastern Colorado and northeastern New Mexico. In this region, there are only sporadic small parcels of planning area public and NFS lands. The region encompasses the High Plains aquifer system.

Surface Water. This hydrologic region occupies the drainage of the Arkansas, Canadian, and Red River basins above the points of the highest backwater effect of the Mississippi River. It includes all of Oklahoma and parts of Colorado, New Mexico, Texas, Kansas, Missouri, and Louisiana. Only a relatively small proportion of public and NFS lands are found in this region, primarily concentrated near the headwaters of the Arkansas River in central Colorado and near the headwaters of the Canadian River in northeastern New Mexico (BLM 2007c). Surface waters generally originate from precipitation falling in the eastern Rocky Mountains. Precipitation is relatively sparse in the summer and fall months, and surface water flow is typically dependent on snowmelt in the mountainous areas. Surface water resources are used extensively for agricultural irrigation (BLM 2007c).

Groundwater. The High Plains aquifer underlies the western edges of Colorado and New Mexico. The High Plains aquifer is described previously for the Missouri Hydrologic Region.

Surficial aquifers present in many parts of the region generally contain the shallowest groundwater in the area. These aquifers consist of Quaternary deposits of alluvial gravel, sand, silt, and clay or Quaternary deposits of eolian sand and silt. The alluvial and eolian deposits of the Arkansas River Valley are moderately thick and extensive and contain a major surficial aquifer (USGS 2002b). There are no sole-source aquifers identified by the EPA in the Arkansas-White-Red Hydrologic Region (US EPA 2008c, US EPA 2008d)

Hot Springs. There are two hot springs within this region, one in New Mexico and one in Colorado (Appendix F) (US Department of Commerce, NOAA 2008).

Alaska Hydrologic Region

The Alaska Hydrologic Region occupies the entire state of Alaska. In this region, planning area public and NFS lands are in an east-west band across the middle of the state, along the Aluetian Island mountain chain in the south, and on the southeastern coast.

Surface Water. This hydrologic region occupies all of Alaska and is characterized by abundant water resources. Major river systems, such as the Yukon, drain the mountain ranges, and extensive wetlands dot the low-lying plains and coastal regions (BLM 2007c). Alaska is geologically and topographically diverse and contains abundant natural resources, including groundwater and surface water of chemical quality that is generally suitable for most uses (USGS 2002b).

The Yukon and Kuskokwim River drainages are two of the dominant drainages in Alaska. Central Alaska is drained by the Yukon River, which drains an area of more than 330,000 square miles, making it the fourth-largest drainage basin in North America. Its main stem, the Yukon River, originates in northwestern Canada and extends through central Alaska, discharging into the Bering Sea. Major tributaries of the Yukon River include the Tanana, Nenana, Koyukuk, Tanana, and Chena Rivers (BLM 2007c).

The Kuskokwim River drains a large part of southwestern Alaska is the state's second-largest drainage. The glacially turbid main stem is approximately 900 miles long, originating from the interior headwaters of the Kuskokwim Mountains and the shadows of the Alaska Range. The Kuskokwim River flows in a southwest direction to the Bering Sea (BLM 2007c).

The Noatak River in northwestern Alaska discharges into the Chukchi Sea. Major rivers in southern Alaska include the Susitna and the Matanuska Rivers, which discharge into Cook Inlet, and the Copper River, which discharges into the Gulf of Alaska. North of the Brooks Range, the Colville and the Sagavanirktok Rivers and numerous smaller streams discharge into the Arctic Ocean (USGS 2002b).

Low mountains, plateaus, and highlands bound the high mountains and are, in turn, bounded by lowland areas. The lowlands are primarily along the courses of major streams and in coastal areas. Most of the population is concentrated in the cities of Anchorage, Fairbanks, and Juneau, all of which are located in lowland areas. The mountains, the frozen Arctic desert, the interior plateaus, and the areas covered with glaciers lack major population centers. Large parts of Alaska are uninhabited, and much of the state is federal land (BLM, National Park Service, and USFWS). Groundwater development has not occurred over most of these remote areas (USGS 2002b).

Groundwater. Information on subsurface geology, groundwater, and permafrost is sparse in Alaska. In large parts of the state, the surface geology is not well known. Local variations in geologic and permafrost conditions significantly affect the occurrence and movement of groundwater (USGS 2002b).

Hydrologic processes are strongly affected by the presence of permafrost, which may thaw seasonally or be continuous throughout the year, particularly on the

North Slope. In central Alaska, permafrost is discontinuous, and an active layer at the surface that thaws during the summer months can supply groundwater for domestic use. The major river valleys have alluvial aquifers with an active layer in the summer months that also supplies good-quality groundwater. During the winter, permafrost generally extends to the surface, impeding water infiltration and groundwater recharge (BLM 2007c).

The aquifers of Alaska have never been mapped, except in the immediate vicinity of some of the towns and cities such as Kenai, Anchorage, Juneau, and Fairbanks. In other places, data from widely scattered drill holes, combined with maps of the surficial geology, allow some inference about the availability of groundwater. In many areas, deposits of coarse-grained, unconsolidated alluvial and glacial-outwash deposits of Quaternary age, such as the Tanana River basin, comprise thick aquifers that yield large quantities of water to wells. In other areas, such as the Copper River basin, widespread Quaternary deposits consist mostly of lacustrine (lake) silt and clay that are underlain by saline water and do not comprise aquifers. In the coastal area between Norton Sound and Bristol Bay, Quaternary deposits extend over large areas but are generally too fine grained to yield significant amounts of water. However, sand and gravel deposits, such as those that provide the water supply for Bethel, locally form productive aquifers. From the Brooks Range northward to the Arctic Ocean, Quaternary deposits contain continuous permafrost and, therefore, are not aquifers. In the northern part of the discontinuous permafrost zone, the alluvial and outwash deposits are frozen during much of the year, and exploration for local sources of groundwater has generally not been conducted. In this region, however, scattered occurrences of large surface accumulations of ice during the winter indicate the presence of local aquifers (USGS 2002b).

Unconsolidated Quaternary deposits may locally be as thick as 1,000 feet in large basins such as the Yukon, Kuskokwim, Tanana, and Copper Rivers. The entire thickness, however, does not yield water. Igneous, metamorphic, and sedimentary rocks underlie about 70 percent of Alaska. Although these rocks generally yield smaller water amounts to wells than coarse-grained alluvial and outwash deposits, they are important aquifers in some parts of the state. In the Fairbanks area, approximately half the residents obtain water from wells completed in bedrock. Large springs issue from carbonate rocks in the eastern part of the Brooks Range. Carbonate bedrock on Admiralty Island in southeastern Alaska also yields large quantities of water from well-developed cave systems (USGS 2002b). There are no identified sole-source aquifers identified by the EPA in the Alaska Hydrologic Region (US EPA 2008a).

Hot Springs. There are 78 hot springs within the Alaska Hydrologic Region, approximately a third of which are located in the Aleutian Island mountain chain (Appendix F) (US Department of Commerce, NOAA 2008).

3.7.1 Climate Change

Some effects on water resources resulting from climate change include changes in stream systems, such as flow, temperature, and turbidity, as well as effects on glacial systems, which are advancing or receding, depending on local conditions (IPCC 2007).

3.8 Air Quality and Atmospheric Values

3.8.1 Applicable Plans, Policies and Regulations

The Clean Air Act was passed in 1970 (and amended in 1990) to reduce air pollution across the US. Specific air pollutants associated with harming human health were identified as criteria pollutants. The criteria pollutants were assigned acceptable airborne concentration levels, and collectively the list was named the National Ambient Air Quality Standards. Under the Clean Air Act, the US EPA is responsible for revising these standards when necessary as new air quality data and related impacts on the human environment become available. The Act also mandates the US EPA approve state implementation plans to ensure that local agencies comply with the Act.

More recently, the US EPA issued two new air quality regulations to control air pollution in the US. On March 15, 2006, they issued the Clean Air Mercury Rule to permanently cap and reduce mercury emissions from coal-fired power plants for the first time.

3.8.2 Criteria Pollutants

The US EPA established National Ambient Air Quality Standards for the following six criteria pollutants to protect public health and welfare: sulfur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO), ozone (O3), lead (Pb), and particulate matter (PM).

Particulate matter, or particulate pollution, is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. The size of particles is directly linked to their potential for causing health problems. The US EPA regulates particles that are 10 micrometers in diameter or smaller because those are the particles that generally pass through the throat and nose and enter the lungs. Once inhaled, these particles can affect the heart and lungs and cause serious health effects. The US EPA groups particulate pollution into two categories:

- Inhalable coarse particles, such as those found near roadways and dusty industries, are larger than 2.5 micrometers and smaller than 10 micrometers in diameter (PM10).
- Fine particles, such as those found in smoke and haze, are 2.5 micrometers in diameter and smaller (PM2.5). These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air.

The National Ambient Air Quality Standards (Table 3-12) and are divided into primary and secondary categories. Primary standards set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. Averaging periods vary by criteria pollutants based on potential health and welfare effects of each pollutant. The National Ambient Air Quality Standards are enforced by the states via local air pollution agencies. Some states have adopted their own air quality standards that are either as stringent as, or more stringent than, the National Ambient Air Quality Standards.

Table 3-12
National Ambient Air Quality Standards

Pollutant	Averaging Times	Ambient concentration standard[1]	Primary (P) or Secondary (S) standard[2]
Carbon monoxide	1 hour	35 ppm (40 mg/m^3)	P
	8 hours	9 ppm (10 mg/m^3)	P
Lead	Quarterly Average	1.5 µg/m^3	P,S
Nitrogen dioxide	Annual	0.053 ppm (100 µg/m^3)	P,S
PM_{10}	24 hours	150 µg/m^3	P
	Annual	Revoked	P
$PM_{2.5}$	24 hours	35 µg/m^3	P
	Annual	15 µg/m^3	P,S
Ozone	1 hour	0.12 ppm	P,S
	8 hours	0.08 ppm	P,S
Sulfur dioxide	3 hours	0.5 ppm	S
	24 hours	0.14 ppm	P
	Annual	0.03 ppm	P

[1] ppm = parts per million; mg/m3 = milligrams per cubic meter; µg/m^3 = micrograms per cubic meter
[2] P = primary standard (health-based); S = secondary standard (welfare-based)
Source: 40 CFR, Part 50

The US has been divided into air management units that have been classified based on their status in attaining the National Ambient Air Quality Standards. In an area where ambient concentrations of a particular pollutant are below the National Ambient Air Quality Standards, the US EPA designates that area as being in attainment. Likewise, areas are designated as being in nonattainment if criteria pollutant concentrations violate the National Ambient Air Quality Standards. Formerly nonattainment areas that are now in compliance with the National Ambient Air Quality Standards are designated as maintenance areas. Nonattainment areas must implement a plan to reduce ambient concentrations below the National Ambient Air Quality Standards. Areas where insufficient data are available to determine attainment status are designated as unclassified and are treated as attainment areas for regulatory purposes.

In addition to criteria pollutants, the US EPA, together with the states, also controls air toxics, or hazardous air pollutants. Such substances, if present in the surrounding air, are thought to have serious health impacts. Lists of substances identified as air toxics have been issued by the US EPA and some individual states. The details of the list and regulations applied to the hazardous air pollutants may vary among jurisdictions. Due to its minute emissions, an operating geothermal energy development would most likely be exempt from air toxics emissions regulations, depending on the types of technology and local attainment status.

3.8.3 Attainment Status in the Project and Planning Areas

Existing air quality conditions across the project and planning areas are described in terms of attainment status. Ambient pollutant levels are expected to be low in the undeveloped regions of public and NFS lands and negligible in remote areas. Project and planning areas with high pollutant levels are typically those with either large amounts of human development or high winds and dusty soil types with little vegetation.

Counties in the project and planning areas with public or NFS lands that are designated as nonattainment or maintenance areas for each criteria pollutant are listed in Table 3-13. Levels of PM_{10}, ozone, and nitrogen dioxide are expected to be higher near industrial areas and cities, which are associated with greater fossil fuel combustion. High sulfur dioxide concentrations are most commonly observed in areas with coal-fired power plants, smelters, and refineries.

Table 3-13
Project Area Counties that are Designated Nonattainment or Maintenance Areas for Criteria Pollutants

Pollutant	State	Nonattainment (Project Area)	Nonattainment (Planning Area)	Maintenance (Project Area)	Maintenance (Planning Area)
PM_{10}	AK	Anchorage Municipality[1], Juneau City and Borough[1]	None	None	None
	AZ	Pima[1], Gila[1], Pinal[1], Santa Cruz[1], Cochise[1], Maricopa[1], Yuma[1]	Pima[1], Gila[1], Pinal[1], Santa Cruz[1], Cochise[1], Maricopa[1], Yuma[1]	Mohave[1], Gila[1]	Mohave[1], Gila[1]
	CA	Riverside[1], Inyo[1], Imperial[1], Los Angeles[1], Orange, Riverside[1], San	Riverside[1], Inyo[1], Imperial[1], Los Angeles[1], Orange, Riverside[1], San	Kern[1]	Kern[1]

Table 3-13
Project Area Counties that are Designated Nonattainment or Maintenance Areas for Criteria Pollutants

Pollutant	State	Nonattainment (Project Area)	Nonattainment (Planning Area)	Maintenance (Project Area)	Maintenance (Planning Area)
		Bernardino[1], Mono[1], Inyo[1], Sacramento, Kern[1], Kings[1], Madera[1], San Joaquin[1], Stanislaus[1], Tulare[1],	Bernardino[1], Mono[1], Inyo[1], Sacramento, Kern[1], Kings[1], Madera[1], San Joaquin[1], Stanislaus[1], Tulare[1],		
	CO	None	None	Pitkin[1], Fremont[1], Adams[1], Araphoe[1], Boulder[1], Broomfield, Denver, Douglas, Jefferson, Prowers[1], Archuleta[1], Routt[1], San Miguel[1]	Pitkin[1], Fremont[1], Adams[1], Araphoe[1], Boulder[1], Denver, Douglas, Jefferson, Prowers[1], Archuleta[1], Routt[1], San Miguel[1]
	ID	Bonner[1], Bannock[1], Power[1], Shoshone[1]	Bannock[1], Power[1]	Ada[1], Bannock[1], Power[1]	Ada[1], Bannock[1], Power[1]
	MT	Silver Bow[1], Flathead[1], Rosebud[1], Lincoln[1], Missoula[1], Lake[1], Sanders[1]	Silver Bow[1], Rosebud[1], Lincoln[1], Missoula[1], Sanders[1]	None	None
	NV	Clark[1], Washoe[1],	Clark[1], Washoe[1]	None	None
	NM	Dona Ana[1]	Dona Ana[1]	None	None
	OR	Lane[1]	Lane[1]	Josephine[1], Klamath[1], Union[1], Lake[1], Jackson[1]	Klamath[1], Union[1], Lake[1], Jackson[1]
	UT	Weber[1], Salt Lake, Utah	Weber[1], Salt Lake, Utah	None	None
	WA	None	None	King[1], Thurston[1], Pierce[1], Spokane[1], Walla Walla[1], Yakima[1]	King[1], Thurston[1], Pierce[1], Walla Walla[1], Yakima[1]
	WY	Sheridan[1]	Sheridan[1]	None	None
Sulfur Dioxide	AZ	Pinal[1]	Pinal[1]	Pima[1], Cochise[1], Gila[1], Greenlee[1]	Pima[1], Cochise[1], Gila[1], Greenlee[1]
	MT	Lewis and Clark[1], Yellowstone[1]	Lewis and Clark[1], Yellowstone[1]	None	None
	NV	None	None	White Pine[1]	White Pine[1]
	NM	None	None	Grant[1]	Grant[1]
	UT	Salt Lake, Tooele[1]	Salt Lake, Tooele[1]	None	None

Table 3-13
Project Area Counties that are Designated Nonattainment or Maintenance Areas for Criteria Pollutants

Pollutant	State	Nonattainment (Project Area)	Nonattainment (Planning Area)	Maintenance (Project Area)	Maintenance (Planning Area)
Nitrous Dioxide	--	None	None	None	None
Carbon Monoxide	AK	None	None	Anchorage Municipality[1], Fairbanks North Star Borough[1]	Fairbanks North Star Borough[1]
	AZ	None	None	Maricopa[1], Pima[1]	Maricopa[1], Pima[1]
	CA	None	None	Kern[1], Butte[1], Fresno[1], Placer[1], El Dorado[1], Los Angeles[1], Orange, Riverside[1], San Bernardino[1], Stanislaus[1], Sacramento[1], Yolo[1], San Diego[1], Alameda[1], Contra Costa[1], Marin[1], Napa[1], San Francisco[1], San Mateo[1], Santa Clara[1], Solano[1], Sonoma[1], San Joaquin[1]	Kern[1], Butte[1], Fresno[1], Placer[1], El Dorado[1], Los Angeles[1], Orange, Riverside[1], San Bernardino[1], Stanislaus[1], Sacramento[1], Yolo[1], San Diego[1], Alameda[1], Contra Costa[1], Marin[1], Napa[1], San Francisco[1], San Mateo[1], Santa Clara[1], Solano[1], Sonoma[1], San Joaquin[1]
	CO	None	None	El Paso[1], Teller[1], Adams[1], Araphoe[1], Boulder[1], Broomfield, Denver, Douglas[1], Jefferson[1], Larimer[1], Weld[1], Boulder[1], Weld[1]	El Paso[1], Teller[1], Adams[1], Araphoe[1], Boulder[1], Denver, Douglas[1], Jefferson[1], Larimer[1], Weld[1]
	ID	None	None	Ada[1]	Ada[1]
	MT	Missoula[1]	Missoula[1]	Yellowstone[1], Cascade[1]	Yellowstone[1]
	NV	Clark[1], Washoe[1]	Clark[1], Washoe[1]	Carson City[1], Douglas[1], Washoe[1]	Carson City[1], Douglas[1], Washoe[1]

Table 3-13
Project Area Counties that are Designated Nonattainment or Maintenance Areas for Criteria Pollutants

Pollutant	State	Nonattainment (Project Area)	Nonattainment (Planning Area)	Maintenance (Project Area)	Maintenance (Planning Area)
	NM	None	None	Bernalillo	Bernalillo
	OR	Marion[1], Polk[1]	Marion[1], Polk[1]	Lane[1], Josephine[1], Klamath[1], Jackson[1], Clackamas[1], Multnomah[1], Washington[1]	Lane[1], Klamath[1], Jackson[1], Clackamas[1], Multnomah[1], Washington[1]
	UT	None	None	Weber[1], Utah[1], Salt Lake[1]	Weber[1], Utah[1], Salt Lake[1]
	WA	None	None	King[1], Pierce[1], Snohomish, Spokane[1], Clark[1], Yakima[1]	King[1], Pierce[1], Snohomish, Clark[1], Yakima[1]
Ozone	AZ	Maricopa[1], Pinal[1]	Maricopa[1], Pinal[1]	None	None
Ozone	CA	Amador, Calaveras, Butte[1], Imperial[1], Kern[1], Los Angeles[1], Orange[1], Riverside[1], San Bernardino[1], Mariposa, Tuolumne, Nevada, El Dorado[1], Placer[1], Sacramento[1], Solano[1], Sutter[1], Yolo[1], San Diego[1], Alameda[1], Contra Costa[1], Marin[1], Napa[1], San Francisco[1], San Mateo[1], Santa Clara[1], Solano[1], Sonoma[1], Fresno[1], Kings[1], Madera[1], Merced[1], San Joaquin[1], Stanislaus[1], Tulare[1], Sutter[1], Ventura[1]	Butte[1], Imperial[1], Kern[1], Los Angeles[1], Orange[1], Riverside[1], San Bernardino[1], Nevada, El Dorado[1], Placer[1], Sacramento[1], Solano[1], Yolo[1], San Diego[1], Alameda[1], Contra Costa[1], Marin[1], Napa[1], San Francisco[1], San Mateo[1], Santa Clara[1], Solano[1], Sonoma[1], Fresno[1], Kings[1], Madera[1], Merced[1], San Joaquin[1], Stanislaus[1], Tulare[1], Ventura[1]	None	None
Ozone	CO	Adams[1], Araphoe[1], Boulder[1], Broomfield[1], Denver[1], Douglas[1], Jefferson[1], Larimer[1], Weld[1]	Adams[1], Araphoe[1], Denver[1], Douglas[1], Jefferson[1], Larimer[1], Weld[1]	None	None
Ozone	NV	Clark[1]	Clark[1]	None	None
Lead	MT	Lewis and Clark[1]	Lewis and Clark[1]	None	None

[1] only a portion of the county is in nonattainment

Source: US EPA 2007b

3.8.4 National Air Quality and Emissions Trends

Air quality based on concentrations of the criteria pollutants has improved nationally since 1980. Such trends are observed by using measurements from air quality monitoring stations located across the country. The US EPA expects the long-term trend of air quality improvement to continue as the Clean Air Mercury Rule, state plans to attain national air quality standards, and other national programs and clean air requirements targeting mobile sources are implemented (US EPA 2007a).

The US EPA also estimates nationwide emissions of ambient air pollutants and the pollutants they are formed from (their precursors). Such estimates are based on actual monitoring data or engineering calculations of the amounts and types of pollutants emitted by vehicles, factories, and other sources. Many factors are taken into consideration when calculating emissions estimates, including levels of industrial activity, technological developments, fuel consumption, vehicle miles traveled, and other activities that cause air pollution (US EPA 2007a). While emissions are trending downwards, human-caused air pollutants are still directly connected a number of air quality issues. It is estimated that 137 million tons of pollution are emitted into the atmosphere each year nationwide. These emissions mostly contribute to the formation of ozone and particles, the deposition of acids, and visibility impairment (US EPA 2007a).

3.8.5 Climate Change

Ongoing scientific research has identified the potential impacts of anthropogenic (manmade) greenhouse gas (GHG) emissions and changes in biological carbon sequestration due to land management activities on global climate. Through complex interactions on a regional and global scale, these GHG emissions and net losses of biological carbon sinks cause a net warming effect of the atmosphere, primarily by decreasing the amount of heat energy radiated by the earth back into space. Although GHG levels have varied for millennia, recent industrialization and burning of fossil carbon sources have caused CO2(e) concentrations to increase dramatically and are likely to contribute to overall global climatic changes. The Intergovernmental Panel on Climate Change (IPCC) recently concluded that "warming of the climate system is unequivocal" and "most of the observed increase in globally average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."

Global mean surface temperatures have increased nearly 1.8°F from 1890 to 2006. Models indicate that average temperature changes are likely to be greater in the Northern Hemisphere. Northern latitudes (above 24° N) have exhibited temperature increases of nearly 2.1°F since 1900, with a nearly 1.8°F increase since 1970 alone. Without additional meteorological monitoring systems, it is difficult to determine the spatial and temporal variability and change of climatic conditions, but increasing concentrations of GHGs are likely to accelerate the rate of climate change.

In 2001, the IPCC indicated that by the year 2100, global average surface temperatures would increase 2.5 to 10.4°F above 1990 levels. The National Academy of Sciences has confirmed these findings, but also has indicated there are uncertainties regarding how climate change may affect different regions. Computer model predictions indicate that increases in temperature will not be equally distributed, but are likely to be accentuated at higher latitudes. Warming during the winter months is expected to be greater than during the summer, and increases in daily minimum temperatures is more likely than increases in daily maximum temperatures. Increases in temperatures would increase water vapor in the atmosphere and reduce soil moisture, increasing generalized drought conditions, while at the same time enhancing heavy storm events. Although large-scale spatial shifts in precipitation distribution may occur, these changes are more uncertain and difficult to predict.

As with any field of scientific study, there are uncertainties associated with the science of climate change. This does not imply that scientists do not have confidence in many aspects of climate change science. Some aspects of the science are known with virtual certainty, because they are based on well-known physical laws and documented trends (EPA 2008).

Several activities contribute to the phenomena of climate change, including emissions of GHGs (especially carbon dioxide and methane) from fossil fuel development, large wildfires, and activities using combustion engines; changes to the natural carbon cycle; and changes to radiative forces and reflectivity (albedo[1]). It is important to note that GHGs will have a sustained climatic impact over different temporal scales. For example, recent emissions of carbon dioxide can influence climate for 100 years.

Information is not available to reasonably discern whether global climate change is already affecting resources within the planning areas. Projected changes are likely to occur over several decades to a century; therefore, many of the projected changes associated with climate change described below may not be measurably discernable within the reasonably foreseeable future.

[1] Changes in reflectivity (albedo) and related effects on climate are not discussed beyond this point. This is in part due to the fact that understanding is limited as to the relationship between albedo and climate change. In addition, the great variability in existing albedo across the planning area renders a programmatic discussion useless; without site- and project-specific information, albedo impacts are not determinable. For example, only if one were to know that a particular geothermal project would result in deforestation of a densely vegetated area and would expose light-colored soil or gravel roads would one know that albedo would be likely to increase. Similarly, only where one knew that a project would involve the laying of black asphalt in a desert environment would one know that albedo would likely decrease.

Existing and anticipated effects of climate change on resources in the planning area are incorporated into the relevant sections below. The following resources have been or are anticipated to be affected by climate change:

- Soil resources;
- Water resources;
- Vegetation;
- Fish and wildlife;
- Threatened and endangered species;
- Wild horses and burros (through changes in vegetation and soil);
- Livestock grazing (through changes in vegetation and soil); and
- Tribal interests (through changes in vegetation and soil and their effects on availability of traditionally used plants).

3.8.6 Typical Emissions Associated with Geothermal Energy

Air emissions from geothermal power plants are very small compared to emissions from fossil fuel plants. Geothermal plants emit small amounts of nitrogen oxides and carbon dioxide and nearly no sulfur dioxide or particulate matter (Geothermal Energy Association 2007b). The primary pollutant of geothermal power plants is hydrogen sulfide, which is naturally present in most geothermal reservoirs. Hydrogen sulfide emissions are maintained below the most stringent standards with the use of sophisticated abatement equipment. Studies carried out in the past few decades estimating emissions from geothermal power plants have concluded that geothermal energy emissions are small and have been reduced by advanced technologies and energy-saving techniques.

Steam from a geothermal plant is condensed when passing through a turbine; however, noncondensable gases in the reservoir fluid such as carbon dioxide, hydrogen sulfide, sulfur dioxide, mercury, and several others pass through the turbine without condensing and are released into the atmosphere. The amount of noncondensable gases present and emitted depends on factors such reservoir fluid composition, temperature, method of power generation (flash, binary, or combined cycle), and equipment efficiency (Bloomfield et al. 2003).

Carbon Dioxide

Carbon dioxide is a noncondensable gas present in geothermal fluids. Of the five percent noncondensable gases present in geothermal steam, 75 percent or more of that volume is occupied by carbon dioxide. The amount of carbon dioxide in the geothermal fluid depends on the location of the reservoir, and the amount released into the atmosphere depends on the technology used by the power plant. For example, geothermal fluids in a closed-loop binary plant are never exposed to the atmosphere and emit no carbon dioxide. Additionally, improved and increased injection technologies have resulted in lower carbon dioxide emissions from geothermal power plants. Such variation in fluid composition and integrated technology makes it difficult to make generalizations about the amount of carbon dioxide released by geothermal plants but one estimate is at 0.20 pounds per kilowatt hour. This estimate weighted average values of all geothermal power plants, including binary plants, which represent 14 percent of the total capacity. This estimate is comparable to the value reported by the Executive Director of the International Geothermal Association, which is approximately 0.29 pounds per kilowatt hour for 85 geothermal plants operating in 11 countries (Bloomfield et al. 2003).

As shown in Table 3-14, geothermal energy production produces between 10 to 15 percent the carbon dioxide emissions that are realized from fossil fuel energy sources.

Table 3-14
Comparison of Geothermal and Fossil Fuel Carbon Dioxide Emissions for Electrical Generation

	Geothermal	Coal	Petroleum	Natural Gas
Emissions (pounds carbon dioxide per kilowatt hour)	0.20	2.095	1.969	1.321

Source: Bloomfield et al. 2003

Hydrogen Sulfide

Of all geothermal power plant emissions, hydrogen sulfide emissions are of greatest concern. Hydrogen sulfide is considered a nuisance pollutant and may be lethal in high doses. Because of such concerns, hydrogen sulfide emissions have been thoroughly studied, and abatement technology has been extensively researched and effectively employed. Abatement systems such as Streford and LO-CAT convert more than 99.9 percent of the hydrogen sulfide from geothermal gases to elemental sulfur, resulting in hydrogen sulfide being reduced to approximately 1 percent of noncondensable gases emitted by geothermal power plants. Binary geothermal power plants do not emit any hydrogen sulfide, while steam and flash power plants produce minimal hydrogen sulfide emissions. A study done by Tiangco et al. in 1995 compared emissions from all types of geothermal power plants, and reported an average hydrogen sulfide emission of 0.29 pounds per megawatt hour for dual-flash plants. In this report, the authors point out that hydrogen sulfide emission from California geothermal plants are measured below the limits set by the state's air pollutions control districts, which are often below federal standards. Considering all types of geothermal power plants, hydrogen sulfide emissions average was reported around 0.187 pounds per megawatt hour (Bloomfield et al. 2003).

Sulfur Dioxide

Geothermal plants do not emit sulfur dioxide directly, but hydrogen sulfide emissions eventually form sulfur dioxide in the atmosphere. These indirect sulfur dioxide emissions from flash geothermal plants are measured at 0.35 pounds per megawatt hour (Geothermal Energy Association 2007b).

Particulate Matter

Particulate matter is of little concern in geothermal plants, as emissions are measured well below federal limits. The Geothermal Energy Association (2007b) reviewed a 1995 study that reported PM_{10} emissions from California geothermal plants at zero. Small amounts of particulate matter are emitted from water-cooled geothermal plants, but these emissions are well below federal limits and are quite small compared to emissions from coal or oil plants (Geothermal Energy Association 2007b).

Nitrogen Oxides

Nitrogen oxides form from nitrogen oxidation in the air during high-temperature burning processes such as fuel burning. Geothermal power plants do not burn any fuel; therefore, they emit zero or low amounts of nitrogen oxides. Average nitrogen oxide emissions are reported at zero, yet some geothermal plants do emit small amounts of nitrogen oxides through combustion of hydrogen sulfide in hydrogen sulfide abatement systems.

3.9 VEGETATION

Vegetation is a general term for the plant life of a region; it refers to the ground cover provided by plants and is the most abundant biotic element of the biosphere. The term vegetation does not by itself imply anything regarding species composition, life forms, structure, spatial extent, or any other specific botanical or geographic characteristics. Old-growth redwood forests, sagebrush scrub, sphagnum bogs, desert soil crusts, roadside weed patches, and cultivated farmlands are all encompassed by the term vegetation.

Vegetation serves several critical ecological functions. Vegetation regulates the flow of water, carbon, and nitrogen. It is also of great importance in local and global energy cycles, the process by which energy from the sun is captured and redistributed among plants and animals and may be eventually stored as fossil fuels or released as heat energy. Such cycles are important not only for global vegetation patterns, but also for global climate patterns. Vegetation strongly affects soil characteristics, including soil volume, chemistry, and texture, which feed back to affect various vegetation characteristics, including productivity and structure. Also, vegetation serves as wildlife habitat and a food energy source for animal species (and, ultimately, to those that prey upon them). Vegetation is also critically important to the world economy in the global production of food, wood, fuel and other materials. Vegetation is the primary source of the earth's atmospheric oxygen.

Vegetation as discussed in this section includes everything from mosses and annual grasses to large trees. This section will introduce vegetation types across the western US and discuss vegetation type (tree, shrub, herb), life history (evergreen, deciduous, annual, perennial), percent canopy cover, and hydrologic and climactic requirements.

Vegetative communities occurring within the project area span a great variety of ecosystems, from arid deserts to coastal coniferous forests. Each vegetative community is unique in species composition, richness, diversity, and structure. A wide range of environmental factors influence the presence and development of various types of vegetation throughout the project area, including climate, elevation, aspect, precipitation, and soil type. Because of the great variety and complexity of project area vegetation, the project area can best be represented by ecoregions.

3.9.1 Ecoregions

Ecoregions are large areas of similar climate where ecosystems recur in predictable patterns. Each ecoregion contains a geographically distinct assemblage of natural vegetation and wildlife communities and species. Ecoregions are separated by a hierarchy that groups very large areas together based on climate, similarities in plant occurrence and abundance, soil type, climate, altitude, and precipitation, among other factors (Bailey 1988).

The largest ecosystems are domains. Domains are large areas of related climate differentiated based on precipitation and temperature. There are three domains in the project area: Polar, Dry, and Humid Temperate.

Divisions represent the climates within domains and are differentiated based on precipitation levels and patterns, as well as temperature (Figures 3-10 and 3-11). Ten divisions comprise the project area.

Divisions are subdivided into provinces, which are differentiated based on vegetation or other natural land covers. Provinces in each division are also divided into mountain and non-mountain provinces based on altitude. Twenty-nine provinces make up the project area (Figures 3-12 and 3-13). Table 3-15 lists the domains, divisions and respective provinces found in the project area. Ecoregions are further divided into sections and subsections. Appendix G provides more detail on ecoregions.

Table 3-15
Project Area Ecoregions and Subregions

Domain	Division	Province
Polar	Arctic	Arctic Tundra Brooks Range Tundra Bering Sea Tundra
	Subarctic	Yukon Intermountain Taiga Upper Yukon Taiga Alaska Range Taiga
Humid Temperate	Warm Continental	Alaska Mixed Forest
	Cold Oceanic	Aleutian Meadow
	Marine	Pacific Lowland Mixed Forest Cascade Mixed Forest Pacific Coastal Icefields Pacific Gulf Coast Forest
	Mediterranean	California Coastal Chaparral Forest Shrub California Dry Steppe California Coastal Steppe, Mixed Forest, and Redwood Forest Sierran Steppe—Mixed Forest—Coniferous Forest—Alpine Meadow California Coastal Range Open Woodland—Shrub—Coniferous Forest—Meadow

Table 3-15
Project Area Ecoregions and Subregions

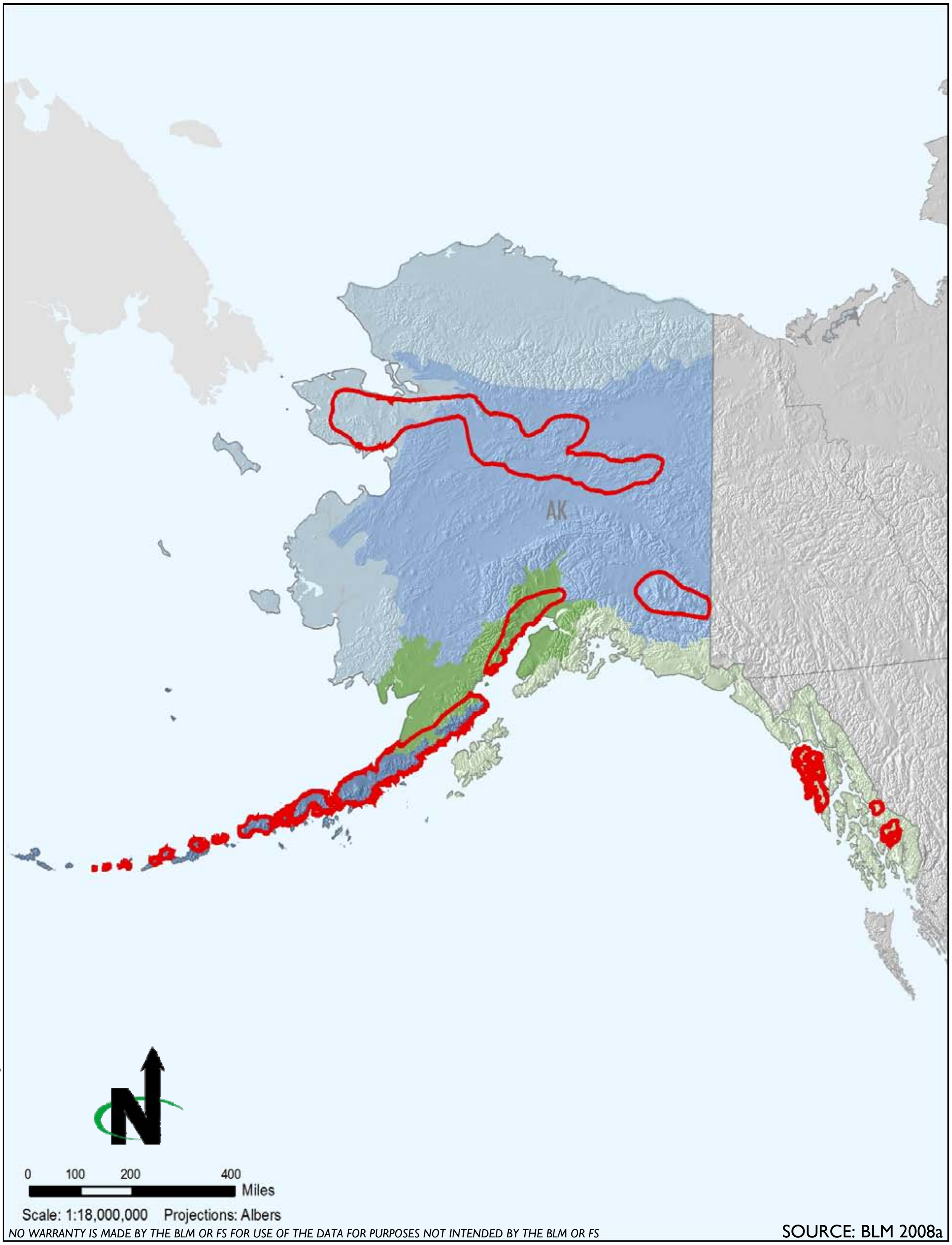
Domain	Division	Province
Dry	Tropical/Subtropical Steppe	Colorado Plateau Semidesert Southwest Plateau and Plains Dry Steppe and Shrub Arizona-New Mexico Mountains Semidesert—Open Woodland—Coniferous Forest—Alpine Meadow
	Tropical/Subtropical Desert	Chihuahuan Semidesert American Semidesert and Desert
	Temperate Steppe	Great Plains- Palouse Dry Steppe Southern Rocky Mountain Steppe—Open Woodland—Coniferous Forest—Alpine Meadow Middle Rocky Mountain Steppe—Coniferous Forest—Alpine Meadow Northern Rocky Mountain Forest-Steppe—Coniferous Forest—Alpine Meadow
	Temperate Desert	Intermountain Semidesert Nevada-Utah Mountains Semidesert—Coniferous Forest—Alpine Meadow Intermountain Semidesert and Desert

Source: Nowacki and Brock 1995, Bailey 1983,

Many federal agencies and private organizations, including the FS, BLM, US EPA, USGS, USFWS, Nature Conservancy, and Sierra Club, use a land classification system based on the ecoregion concept. Projects include biodiversity analysis and landscape- and regional-level forest and habitat planning. General vegetation trends are outlined below for each project area ecoregion division.

Arctic Division

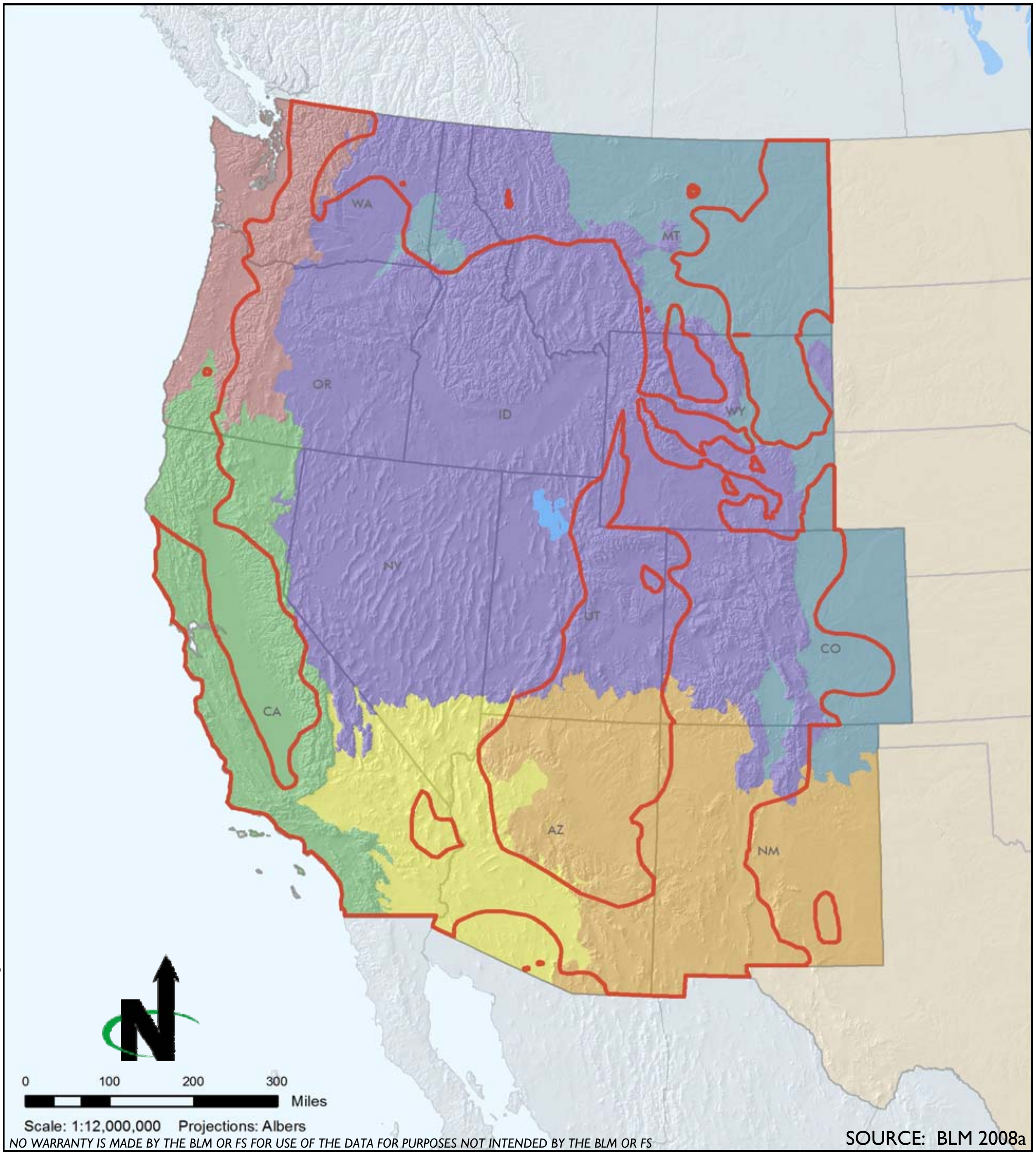
The Arctic Division occurs primarily in northern and western Alaska bordering the Bering Sea (Figure 3-10). The arctic division is best described as tundra. Vegetation consists of grasses, sedges, lichens, and willow shrubs. Moving south, the vegetation changes into birch-lichen woodland, and then into needleleaf forest. A distinct tree line separates forest from tundra in some places. This line coincides approximately with the 50 degrees F isotherm for the warmest month and is the boundary between tundra and subarctic climates (Bailey 1983). Moist and wet tundra communities provide the dominant vegetation. Standing water, mosses, sedges, and low-growing shrubs cover most of the area. Alder, willows, and scattered stands of stunted spruce and birch grow along the major rivers and streams.



The potential geothermal area contains areas within all five ecoregion divisions in Alaska.

Ecoregion Divisions in Alaska

Figure 3-10



Areas of geothermal potential are found in all six ecoregion divisions of the 11 western states.

LEGEND:

Potential Geothermal Area

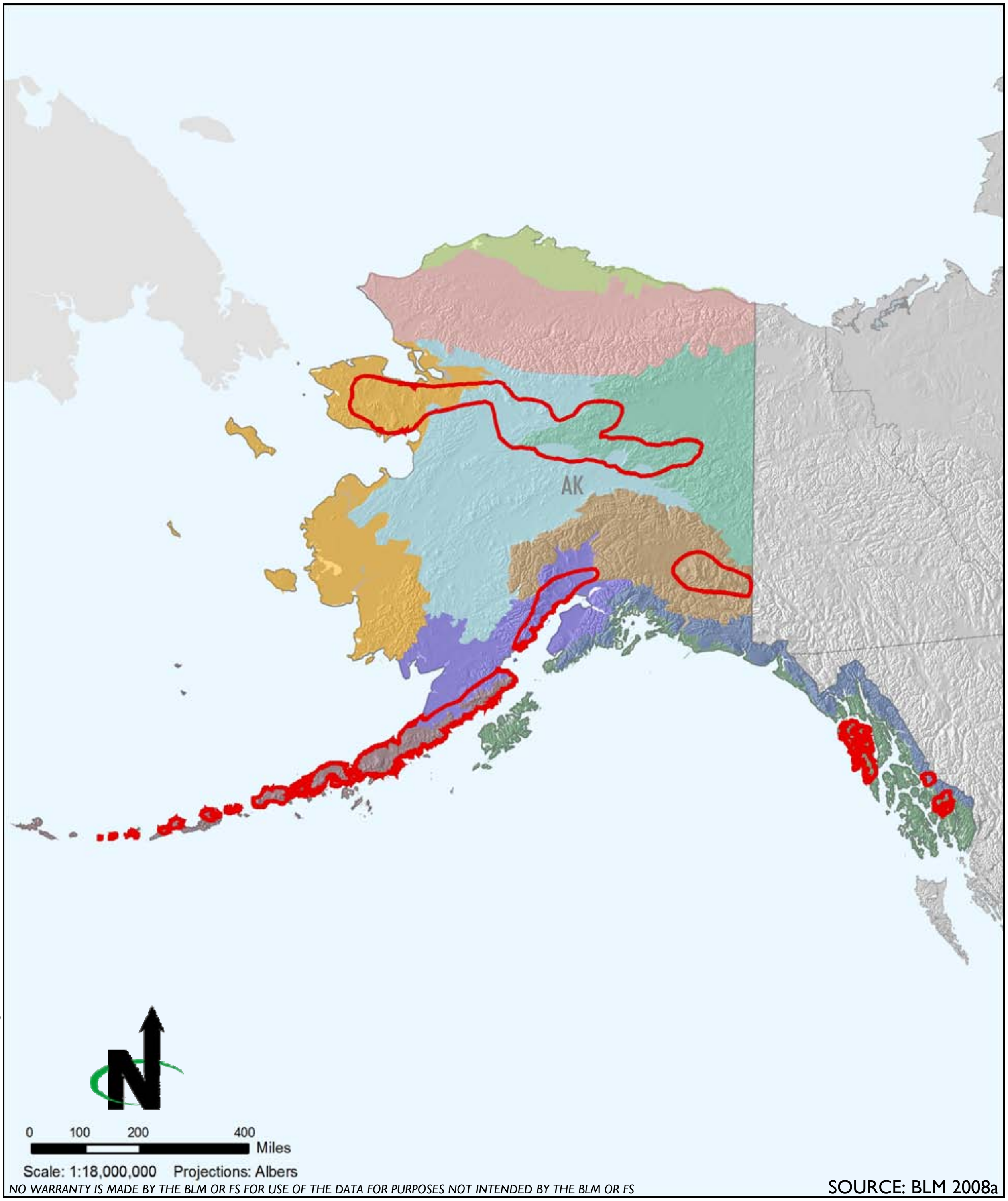
Ecoregions

- Marine
- Mediterranean
- Temperate Desert
- Temperate Steppe
- Tropical/Subtropical Desert
- Tropical/Subtropical Steppe

Ecoregion Divisions in the 11 Western States

Figure 3-11

C://EMPSi/GeothermalPEIS/Figures



Potential geothermal area is found within eight of the ten ecoregion provinces in Alaska.

LEGEND:

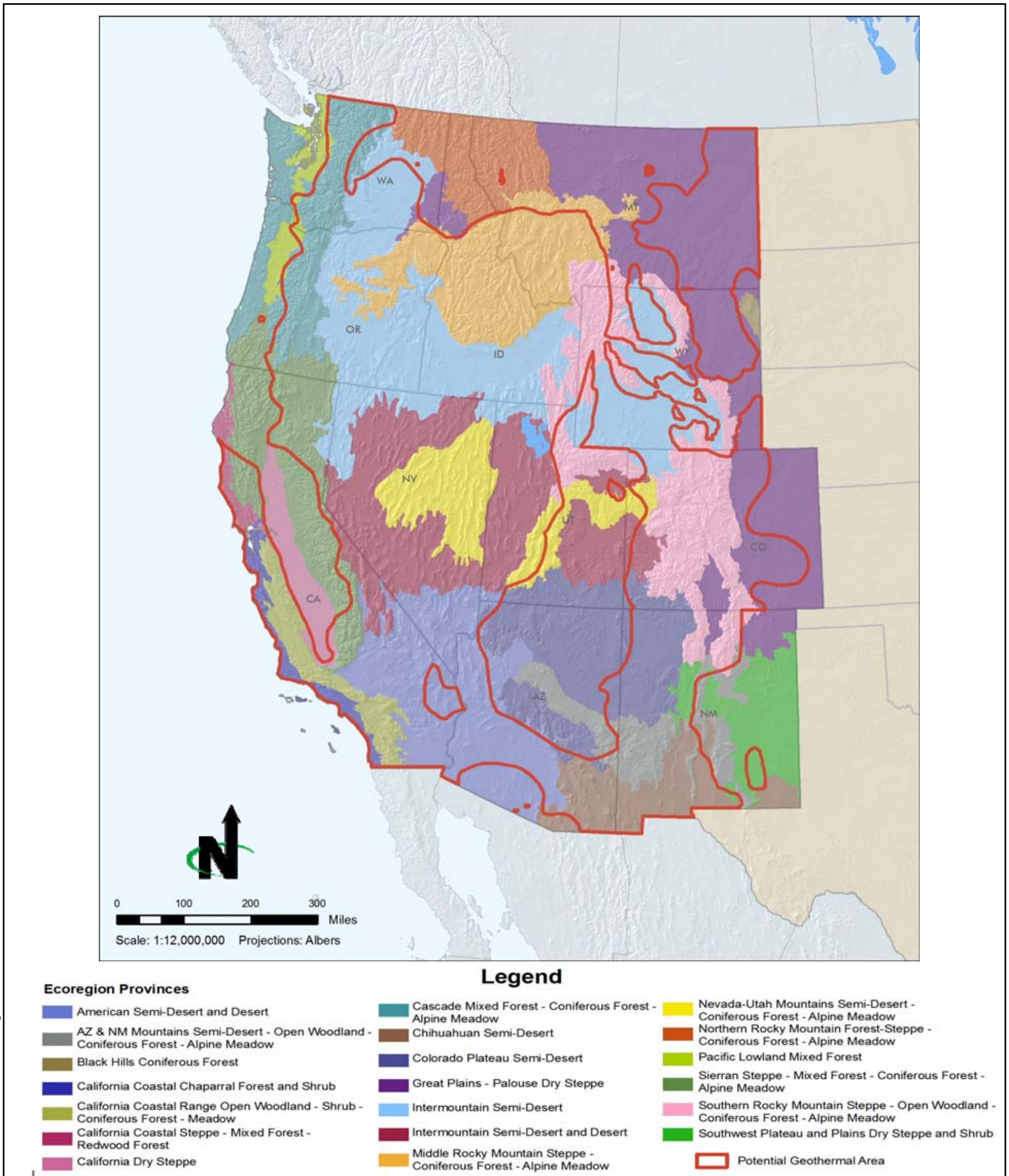
Potential Geothermal Area

Ecoregion Provinces

- Bering Sea Tundra Province
- Upper Yukon Taiga Province
- Alaska Range Taiga Province
- Yukon Intermountain Taiga Province
- Pacific Coastal Icefields Province
- Aleutian Meadow Province
- Pacific Gulf Coast Forest Province
- Alaska Mixed Forest Province
- Arctic Tundra Province
- Brooks Range Tundra Province

Ecoregion Provinces in Alaska

Figure 3-12



NO WARRANTY IS MADE BY THE BLM OR FS FOR USE OF THE DATA FOR PURPOSES NOT INTENDED BY THE BLM OR FS

SOURCE: BLM 2008a

C://EMPSi/GeothermalPEIS/Figures

The 11 Western States are divided into 20 ecoregion provinces.

Ecoregion Provinces in the 11 Western States

Figure 3-13

In the coldest area, permafrost limits the rooting depth of plants and forces surface water to drain by preventing it from seeping into the soil. Extensive marshes and lakes result. Cottongrass-tussock, the most widespread vegetation system in the Arctic, is associated with sedges, dwarf shrubs, lichens, mosses, dwarf birch, Labrador-tea, and cinquefoil. These highly productive systems produce 500 to 1,000 pounds of vegetation per acre and provide an important source of food for caribou and waterfowl. Several forbs flower brightly in the short summer.

Vegetation along the wet coastal areas is chiefly sedge and cottongrass; woody plants grow on higher sites. Birch-willow-alder thickets are extensive in transition zones between beach and forest. The lower Yukon and Kuskokwim Valleys are dominated by white spruce mixed with cottonwood and balsam poplar in tall, relatively dense stands, with a dense undergrowth of thinleaf alder, willow, rose, dogwood, and various species of berry bushes.

Subarctic Division

The Subarctic Division occurs primarily in central Alaska and includes much of the Brooks Range and the Yukon River watershed (Figure 3-10). The subarctic climate zone coincides with a great belt of needleleaf forest, often referred to as boreal forest, and with open lichen woodland known as tiaga. The tiaga forests are largely coniferous and are dominated by larch, spruce, fir, and pine. Although the taiga is dominated by coniferous forests, some broadleaf trees also occur, notably birch, aspen, willow, and rowan. Many smaller herbaceous plants grow closer to the ground.

The major river bottoms support dense white spruce-cottonwood-poplar forests on floodplains and south-facing slopes up to approximately 1,000 feet. The undergrowth is dense shrubbery formed by green and thinleaf alder, willow, dogwood, and berries. The outer valley edges support evergreen and coniferous forests, often with pure stands of black spruce. The undergrowth consists of willow, dwarf birch, crowberry, fern, blueberry, lichens, and mosses. Upland areas are generally covered by a rather dense white spruce-birch-aspen-poplar forest. Pure stands of white spruce grow near streams. Typical undergrowth includes willow, alder, fern, berries, grasses, and mosses. Root systems are shallow. Water balance is likely the factor limiting growth in most of these areas because of the hot, dry summer climate. Old river terraces, ponds, and sloughs contain scattered but extensive bogs where the vegetation is chiefly sphagnum and other mosses, sedges, bog rosemary, and Labrador-tea. Marginal areas may support willow and alder.

Cold Oceanic

The Cold Oceanic division includes much of the Alaska Peninsula and all of the Aleutian Islands. The islands that chiefly make up this province are mountainous, rising steeply from the sea. Trees are absent from the division and vegetation consists of low shrubs of willow, birch, and alder interspersed with lichen, and grass communities. At lower elevations, there is a luxuriant growth of tall grasses, flowering plants, and ferns, with thickets of low willows in some places. A little higher up, several types of heath cover vast areas. The boreal forest and coastal rainforest are slowly encroaching from the east on the area of this province. This is explained by the assumption that the distribution of the vegetation is not yet adjusted to the climatic conditions produced by retreat of the last continental glaciers Alpine tundra is found on mountainsides.

Warm Continental

The Warm Continental Division occurs in coastal areas of southwest Alaska, including part of the Kenai and Alaska peninsulas (Figure 3-10). Moist and wet tundra communities provide the dominant vegetation at the western edge near the coast. Standing water, mosses, sedges, and low-growing shrubs cover most of the area. Alder, willows, and scattered stands of stunted spruce and birch grow along the major rivers and streams. Further to the east and inland vertical vegetational zonation characterizes the Alaska Range and Wrangell Mountains, beginning with dense bottom-land stands of white spruce and cottonwood on the floodplains and low terraces of the Copper and Susitna Rivers. Above the terraces, poorly drained areas up to 1,000 feet support stands of black spruce. Upland spruce-hardwood forests of white spruce, birch, aspen, and poplar, with an undergrowth of moss, fern, grass, and berry, extend to timberline at about 2,500-3,500 feet. Tundra systems of low shrubs and herbaceous plants form discontinuous mats among the rocks and rubble above timberline. White mountain-avens may cover entire ridges in the Alaska Range, associated with moss campion, black oxytrope, arctic sandwort, lichens, grasses, and sedges. These tundra systems stop short of the permanent ice caps on the highest peaks.

Marine Division

The Marine Division occurs primarily in coastal areas from the Gulf of Alaska, including the Alaska panhandle, Kenai Peninsula, and Kodiak Island, to the Oregon border (Figures 3-10 and 3-11). Much of this division was heavily logged. Prior to extensive logging, dense coniferous forest dominated the vegetation. Principal trees are western redcedar, western hemlock, and Douglas-fir. The coniferous forest found further inland is less dense than along the coast and often contains deciduous trees, such as big-leaf maple, Oregon ash, and black cottonwood. Prairie areas support open stands of oaks or are broken by groves of Douglas-fir and other trees; principal indicator species are Oregon white oak and Pacific madrone. Poorly drained sites with swamp or bog communities are abundant.

The timberline is at low elevations, and much of the mountainous area above it is covered with nearly bare rocks, snowfields, and glaciers. Wherever soil has accumulated, however, there are grasses, herbs, and low shrubs. The timberline varies greatly in elevation, depending on slope exposure and other factors. Near

Prince William Sound, for example, the timberline is usually between 1,000 and 2,000 feet but can drop as low as 500 feet.

Mediterranean Division

The Mediterranean Division covers most of the state of California, with exception of the Mojave Desert and high Sierra Nevada mountains (Figure 3-11). The combination of wet winters and dry summers is unique among climate types. This region's montane vegetation consists of species with thick, hard evergreen leaves. The most important evergreen trees of the sclerophyll forest are California live oak, canyon live oak, interior live oak, tanoak, California laurel, Pacific madrone, golden chinkapin, and Pacific bayberry. The interior valleys have sagebrush and grassland communities. A riparian forest with many broadleaf species grows along streams. The coastal areas are wetter during the summer months and include coast redwoods, Douglas-fir, and other conifers. In the higher-altitude regions, the most important trees are ponderosa pine, Jeffrey pine, Douglas-fir, sugar pine, white fir, red fir, and incense cedar; but several other conifers are also present. The giant sequoia is one of the most spectacular species, but it grows only in a few groves on the western slope. Dense chaparral communities of manzanita, buckbrush, and buckthorn may appear after fire, sometimes persisting for years.

Tropical/Subtropical Steppe Division

The Tropical/Subtropical Steppe Division occurs primarily in the eastern half of Arizona and covers most of New Mexico (Figure 3-11). Steppes typically are grasslands of short grasses and other herbs and are present with locally developed shrub and woodland. On the Colorado Plateau, for example, there is pinyon-juniper woodland. To the east, in Texas, the grasslands grade into savanna woodland or semideserts composed of xerophytic shrubs and trees, and the climate becomes semiarid-subtropical. Cactus plants are present in some places. These areas are able to support limited livestock grazing but are not generally moist enough for crop cultivation without irrigation.

The foothill zone, which reaches as high as 7,000 feet, is characterized by mixed grasses, chaparral brush, oak-juniper woodland, and pinyon-juniper woodland. At about 7,000 feet, open forests of ponderosa pine are found, although pinyon and juniper occupy south-facing slopes. In Arizona, the pine forests of this zone are strongly infused with Mexican species, including Chihuahuan and Apache pine. Pine forest is replaced at about 8,000 feet on north-facing slopes by Douglas-fir. Aspen is common, and limber pine grows in places that are rockier and drier. The Douglas-fir zone merges into a zone of Engelmann spruce and corkbark fir at about 9,000 feet. Limber pines and bristlecone pines grow in rockier places. An alpine belt covers relatively small areas above 11,000 feet.

Tropical/Subtropical Desert Division

The Tropical/Subtropical Desert Division occurs primarily in western Arizona and southeast California and includes the Mojave Desert (Figure 3-11). The region is characterized by dry-desert vegetation, a class of xerophytic plants that are widely dispersed and provide negligible ground cover. In dry periods, visible vegetation is limited to small hard-leaved or spiny shrubs, cacti, or hard grasses. Many species of small annuals may be present, but they appear only after rare but heavy rains have saturated the soil.

In the Mojave-Sonoran Deserts (American Desert), plants are often so large that some places have a near-woodland appearance. Well known are the treelike saguaro cactus, the prickly pear cactus, the ocotillo, creosote bush, and smoke tree. But much of the desert of the southwestern US is in fact scrub, thorn scrub, savanna, or steppe grassland. Parts of this region have no visible plants; they are made up of shifting sand dunes or almost sterile salt flats.

A dominant pedogenic process is salinization, which produces areas of salt crust where only salt-loving (halophytic) plants can survive. Calcification is conspicuous on well-drained uplands, where encrustations and deposits of calcium carbonate (caliche) are common.

Temperate Steppe Division

The Temperate Steppe Division covers the high plains of Colorado, Wyoming, and Nevada (Figure 3-11). The vegetation is steppe, sometimes called shortgrass prairie, and semidesert. Typical steppe vegetation consists of numerous species of short grasses that usually grow in sparsely distributed bunches. Scattered shrubs and low trees sometimes grow in the steppe; all gradations of cover are present, from semidesert to woodland. Because ground cover is generally sparse, much soil is exposed. Many species of grasses and other herbs occur. Buffalo grass is typical of the American steppe; other typical plants are the sunflower and locoweed.

The semidesert cover is a xerophytic shrub vegetation accompanied by a poorly developed herbaceous layer. Trees are generally absent. An example of semidesert cover is the sagebrush vegetation of the middle and southern Rocky Mountain region and the Colorado Plateau.

A striking feature of the region is its pronounced vegetation zonation, controlled by a combination of altitude, latitude, direction of prevailing winds, and slope exposure. Generally, the various zones are at higher altitudes in the southern part of the province than in the northern, and they extend downward on east-facing and north-facing slopes and in narrow ravines and valleys subject to cold air drainage. The uppermost (alpine) zone is characterized by alpine tundra and the absence of trees. Directly below it is the subalpine zone, dominated in most places by Engelmann spruce and subalpine fir. Below this area lies the montane zone, characterized by ponderosa pine and Douglas-fir, which frequently alternate. Ponderosa pine dominates on lower, drier, more exposed slopes, and Douglas-fir is predominant in higher, moister, more-sheltered areas.

Temperate Desert Division

The Temperate Desert Division covers the largest portion of the project area and includes the western half of Colorado, Wyoming, and Montana, as well as most of Utah, Nevada, and portions of eastern Oregon and Washington (Figure 3-11). Sagebrush dominates at lower elevations. Other important plants in the sagebrush belt are shadscale, fourwing saltbush, rubber rabbitbrush, spiny hopsage, and horsebrush. All tolerate alkali to varying degrees, essential to their survival on the poorly drained soils widespread in the region. Where salt concentrations are very high, even these shrubs are unable to grow; they are replaced by plant communities dominated by greasewood or saltgrass.

The woodland belt above the sagebrush zone is similar to the corresponding belt on the Colorado Plateau, with juniper and pinyon occupying lower mountain slopes. The belt is frequently interrupted as mountains give way to plains.

In the montane zone above the woodland belt, ponderosa pine generally occupies the lower and more exposed slopes and Douglas-fir the higher and more sheltered ones. Typical species of the subalpine belt are alpine fir and Engelmann spruce. Great Basin bristlecone pine, with some individuals more than 1,000 years old, occupies widely scattered peaks. Only a few mountains in this province rise high enough to support an alpine meadow belt.

Noxious Weeds and Invasive Vegetation

Noxious weeds are invasive plants that are designated and regulated by state and federal laws, such as the Federal Noxious Weed Act, because they are detrimental to agriculture, commerce, and/or public health, and are recognized as a major threat to ecosystems. Noxious weeds are generally nonnative invasive plants that have been either accidentally or intentionally introduced.

Invasive plants and noxious weeds have biological traits that enable them to colonize new areas and successfully compete with native species. They can transform the structure and function of ecosystems through direct competition; changes in nutrient cycling, succession, and disturbance regimes; and shifts in evolutionary selection pressures (Mack and D'Antonio 1998). The spread of invasive plants threatens the structure and function of many ecosystems worldwide. Certain invasive plant species have the ability to spread over large areas or acutely threaten an ecosystem over its continental range (FS 2003a, Hobbs and Humphries 1995). There are estimated to be over 2,000 species of nonnative plants in the US, over half of which are considered invasive species (US Congress Office of Technology and Assessment 1993).

Invasive plants are introduced through a variety of pathways. Some nonnative species were intentionally introduced for beneficial reasons such as erosion control or as ornamental for gardens and later became invasive. Common methods of introduction and dispersal include contaminated seed, feed grain, hay, straw, and mulch; contaminated equipment movement across uncontaminated lands; contaminated animal fur and fleece; spreading of gravel, roadfill, and topsoil contaminated with noxious weed seed; and plants and seeds sold through nurseries as ornamentals (BLM 1996).

It is estimated that invasive plants already infest well over 40 million acres in the project area, and they continue to spread at an estimated rate of 3 million acres annually (BLM 1998). The estimated rate of weed spread on western NFS and public lands in 1996 was 2,300 acres per day (BLM 1996). A recent estimate of weed spread on all western federal lands is 10 to 15 percent annually (Asher and Dewey 2005). The states with the largest weed infestations on federal lands are Utah, Nevada, Arizona, and Oregon (Table 3-16). The most dominant invasive plants consist of grasses in the *Bromus* genus, which represent nearly 70 percent of the total infested area. The FS and BLM have recently adopted new strategies for managing noxious weeds and invasive vegetation (BLM 2007c, FS 2003b). Weed infestations are capable of destroying wildlife habitat; reducing opportunities for hunting, fishing, camping and other recreational activities; displacing many threatened and endangered species; reducing plant and animal diversity because of weed monocultures; increasing the risks of wildfire; and costing millions of dollars in controls and direct losses to land owners.

Table 3-16
Estimated Acres of Weed Infestation on NFS and Public Lands

State	Acres of Weed Infestations	Total Acreage	Percent Infested
Alaska	992	8,659,908	<0.01
Arizona	8,288,637	11,078,970	74.8
California	1,129,000	28,263,036	4.0
Colorado	3,084,000	22,167,004	13.9
Idaho	3,419,500	29,947,638	11.4
Montana	1,281,553	12,998,695	9.8
New Mexico	48,051	51,555,682	0.04
Nevada	9,257,394	17,758,678	52.1
Oregon and Washington	6,407,113	27,702,159	23.1
Utah	10,286,629	13,506,474	76.1
Wyoming	1,658,500	16,299,068	10.2

Source: Peterson 2006; BLM 1996, 2007c

3.9.2 Important Vegetation Communities

Riparian Areas and Wetlands

Riparian areas are the zones along water bodies that serve as interfaces between terrestrial and aquatic ecosystems. Riparian areas are most commonly associated with river and stream corridors, though riparian vegetation can also be found in marshes, wetlands, and along lakesides. The USDA, Natural Resources Conservation Service defines riparian areas in its General Manual (190-General Manual, Part 411) as "ecosystems that occur along watercourses and water bodies. They are distinctly different from the surrounding lands because of unique soil and vegetation characteristics that are strongly influenced by free or unbound water in the soil. Riparian ecosystems occupy the transitional area between the terrestrial and aquatic ecosystems. Typical examples would include floodplains, stream banks, and lakeshores." The USDA, Natural Resources Conservation Service's indicators of riparian areas include:

- Vegetation – The kinds and amounts of vegetation will reflect the influence of free or unbound water from an associated watercourse or water body and contrast with terrestrial vegetation.
- Soils – Soils in natural riparian areas consist of stratified sediments of varying textures that are subject to intermittent flooding or fluctuating water tables that may reach the surface. The duration of the soil-wetness feature is dependent upon the seasonal meteorological characteristics of the adjacent water body.
- Hydrology – Riparian areas are directly influenced by water from a watercourse or water body. Riparian areas occur along natural watercourses, such as perennial or intermittent streams and rivers, or adjacent to natural lakes. They may also occur along constructed watercourses or water bodies such as ditches, canals, ponds, and reservoirs.

Topography, relief, climate, flooding, and soil deposition most strongly influence the extent of water regimes and associated riparian zones. Likewise, a riparian area exerts considerable control on the flows in the landscape, especially on the movement of water, nutrients, sediments, and animal and plant species. Thus, the appearance and boundary of a riparian area vary from site to site. Riparian areas occur as complete ecosystems or as transition zones between aquatic and terrestrial ecosystems. They are more structurally diverse and more productive in plant and animal biomass than adjacent upland areas.

Riparian areas are critical ecosystem components because they provide wildlife cover, transportation corridors, and foraging and nesting habitat, as well as high plant and wildlife species diversity and density. Riparian areas are important in mitigating or controlling nonpoint source pollution. Riparian vegetation can be effective in removing excess nutrients and sediment from surface runoff and shallow ground water. They also can shade streams to optimize light and temperature conditions for aquatic plants and animals. Riparian vegetation, especially trees, is also effective in stabilizing stream banks and slowing flood flows, resulting in reduced downstream flood peaks (Montgomery 1996). Riparian areas are often important for their recreation and scenic values, such as hunting, fishing, boating, swimming, hiking, camping, picnicking, and bird watching.

Some riparian areas meet the criteria established for wetlands (Cowardin et al. 1979). Others do not because they do not possess the necessary hydrologic water regime, a predominance of hydric soils, or a prevalence of hydrophytic vegetation. Even non wetland riparian areas share many characteristics and functions with wetlands. Table 3-17 provides an estimate of the waterways that would be bordered by wetlands in each project area state.

Riparian ecosystems generally compose a small proportion of the landscape. No known comprehensive national inventory has been completed on the status, conditions, or trends of riparian areas. Local inventories have been conducted to provide information for specific needs. The FS and BLM routinely gather riparian information for activities on NFS and public lands, respectively (Montgomery 1996).

Table 3-17
Estimated Waters with Adjacent Riparian Habitat in the Project Area

State	Estimated River, Stream, and Creek (miles)	Estimated Lake, Pond, and Reservoir (acres)
Alaska	365,990	12,787,200
Arizona	90,375	335,590
California	211,513	2,086,230
Colorado	107,403	164,029
Idaho	115,595	Not available
Montana	176,750	844,802
Nevada	15,549	553,239
New Mexico	110,741	997,467
Oregon	114,823	618,934
Utah	85,916	481,638
Washington	69,204	Not available
Wyoming	108,767	325,048

Source: US EPA 2007a, Washington State Department of Environmental Quality 2002

Wetlands are generally defined as areas inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support vegetation that is typically adapted for life in saturated soil. Wetlands include bogs, marshes, shallows, muskegs, wet meadows, estuaries, and riparian areas. According to the US Army Corps of Engineers' Wetland Delineation Manual (Cowardin et al. 1979), an area must exhibit evidence of at least one positive wetland indicator from each of the following parameters to be defined as a wetland (Environmental Laboratory 1987):

- Hydrophytic Vegetation – The land supports predominately hydrophytes. Hydrophytes are macrophytic plants with the ability to grow in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content and depleted soil oxygen levels;
- Hydric Soils – A hydric soil is a soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation; and
- Hydrology – Encompasses all hydrologic characteristics of areas that are periodically inundated or have soils saturated to the surface at some time during the growing season. Such characteristics are usually present in areas that are inundated or have soils that are saturated to the surface for sufficient duration to develop hydric soils and support vegetation typically adapted for life in periodically anaerobic soil conditions.

Wetlands are often associated with perennial water sources, such as springs, perennial segments of streams, lakes, or ponds. Wetlands are considered a valuable ecological resource because of their important roles in providing fish and wildlife habitat, maintaining water quality, and flood control. Total wetland area present within any one of the project area states, on the basis of estimates from 1980, ranges from about 385,700 acres in Idaho to 175,000,000 acres in Alaska. (Table 3-18). As throughout the US, wetlands in the western states have experienced a major decline in abundance because of human disturbance; however, data show a recent net gain in wetland acreage (BLM 2006a).

Table 3-18
1980s Estimates of Project Area Wetlands

State	Wetland Area (acres)	Percent of Surface Area
Alaska	175,000,000	43.0
Arizona	600,000	0.8

Table 3-18
1980s Estimates of Project Area Wetlands

State	Wetland Area (acres)	Percent of Surface Area
California	454,000	0.4
Colorado	1,000,000	1.5
Idaho	385,700	0.7
Montana	840,300	0.9
Nevada	236,350	0.3
New Mexico	481,900	0.6
Oregon	1,393,900	2.2
Utah	558,000	1.0
Washington	938,000	2.1
Wyoming	1,250,000	2.0

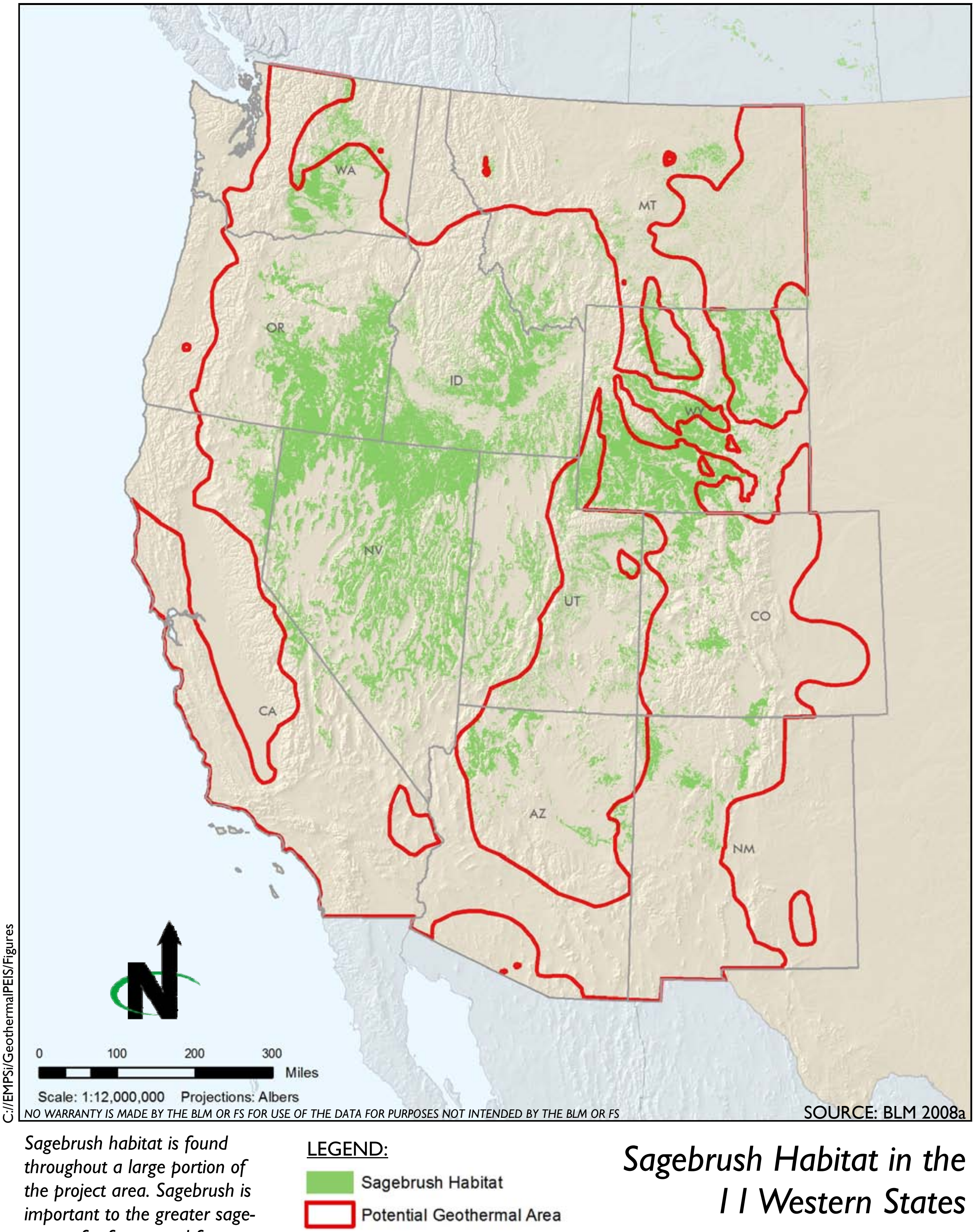
Source: US EPA 2007a, Dahl 1990

Sagebrush

Sagebrush habitats are declining rapidly across western North America. Over 350 associated plant and animal species are at risk of local or regional extirpation resulting from declining sagebrush habitat, including the sage-grouse. Broad concern over the future health of the remaining sagebrush lands has prompted the formation of cooperative partnerships among the BLM, FS, USFWS, and western state (except Alaska) wildlife agencies. (Alaska does not have sagebrush ecosystems.) Together, these partners plan and coordinate actions to conserve and manage sagebrush habitat for the benefit of sagebrush-dependent species, such as the sage-grouse.

Sagebrush ecosystems dominate approximately 118 million acres throughout western North America. Roughly 66 percent of the existing sagebrush habitats are publicly owned and managed by a federal agency. The BLM and FS are the primary agencies responsible for management of public and NFS lands containing sagebrush. The BLM has management authority for one-half of the sagebrush lands in the US. Within the project area states, the percent of sagebrush habitat managed by the BLM ranges from less than 5 percent to greater than 40 percent. The FS has stewardship of eight percent of the sagebrush habitats. Multiple use is the dominant management objective on almost all sagebrush habitats (Connelly et al 2004).

Sagebrush is distributed across every project area western state except Alaska (Figure 3-14). Sagebrush habitats cover approximately 93 million acres in the planning area. Nevada, Idaho, and Wyoming have the largest total area covered by sagebrush; all have over 20 percent of their area dominated by sagebrush.



Sagebrush habitat is found throughout a large portion of the project area. Sagebrush is important to the greater sage-grouse for forage and for roosting cover. The greater sage-grouse cannot survive where sagebrush does not exist.

Sagebrush Habitat in the 11 Western States

Figure 3-14

Approximately 12 percent of Washington and 17 percent of Utah is sagebrush habitat. All other states had less than 10 percent of their total area in sagebrush cover (Table 3-19).

Table 3-19
Sagebrush Cover

State	Total Acres	Project Area Sagebrush Cover (acres)	Percent of Total	Planning Area Sagebrush Cover (acres)	Percent of Total
Alaska	368,992,475	0	0	0	0
Arizona	72,776,537	3,740,960	5.1	356,363	0.5
California	100,976,703	3,210,153	3.2	3,162,519	3.1
Colorado	66,624,396	4,690,157	7.0	4,164,066	6.3
Idaho	53,338,876	13,942,093	26.1	12,468,337	23.4
Montana	94,234,060	5,753,029	6.1	3,618,861	3.8
Nevada	70,828,300	26,879,825	38.0	26,879,825	38.0
New Mexico	77,925,123	2,616,138	3.4	2,387,153	3.1
Oregon	62,125,940	14,012,905	22.6	14,009,018	22.5
Utah	54,317,654	9,173,616	16.9	4,478,491	8.2
Washington	43,064,444	4,957,259	11.5	3,388,208	7.9
Wyoming	62,593,028	23,616,814	37.7	16,579,909	26.5

Source: Meinke 2003

The sagebrush biome has changed considerably since European settlement. The current distribution, composition, and disturbance regimes of sagebrush ecosystems have been altered by disturbance, land use, and invasion of exotic plants. The areas where sagebrush habitat is most prevalent have been highly fragmented.

The number and intensity of fires has increased across much of the sagebrush biome. Cheatgrass *(Bromustectorum)* and other exotic plant species have invaded lower elevation sagebrush habitats across much of the western part of the biome, further exacerbating the role of fire in these systems. At higher elevations, juniper and pinyon woodland invasions into sagebrush habitats also have altered disturbance regimes.

Land conversion has fragmenting sagebrush habitats. Sagebrush habitats and dependent species that once were continuous now are separated by agriculture, urbanization, and development. Highly productive regions throughout the sagebrush biome that had deeper soils and higher precipitation have been converted to agriculture. Agriculture influences 49 percent of the sagebrush habitats by fragmenting the landscape or facilitating movements of potential predators and invasive species (Connelly et al. 2004).

Urbanization and increasing human populations have resulted in an extensive network of roads, power lines, railroads, and communications towers, with a resulting expanding influence on sagebrush habitats. Roads and other corridors promote the invasion of exotic plants, provide travel routes for predators, facilitate human access into sagebrush habitats, and increase the chance of human induced fires. Less than five percent of the existing sagebrush habitats are over 1.5 miles from a mapped road (Connelly et al 2004).

The BLM has adopted a National Sage-grouse Habitat Conservation Strategy to guide future actions for conserving sage-grouse and associated sagebrush habitats and to enhance the BLM's ongoing conservation efforts. Sage-grouse inhabit approximately 30 million acres on BLM lands, and another 10 million acres are considered suitable habitat. This strategy includes a partnership with the FS. It provides a framework for future conservation efforts by setting out broad goals and specific actions. The National Sage-grouse Habitat Conservation Strategy is meant to ensure that agencies successfully incorporate sage-grouse habitat conservation measures into all of their ongoing programs and activities, including geothermal leasing, land use planning, grazing, mineral leasing, and other programs (BLM 2007d). The sage-grouse is discussed in more detail below in Section 3.10, Fish and Wildlife.

Old-Growth Forests

Public and scientific interest in US' old-growth forests began in the Pacific Northwest and focused on coastal Douglas-fir and western hemlock forests that were the main habitat of the northern spotted owl. Old-growth forests are those forests that have accumulated specific characteristics related to tree size, canopy structure, snags and woody debris, and plant associations that can only occur over time. Ecological characteristics of old-growth forests emerge through the processes of succession. Old-growth forests support assemblages of plants and animals, environmental conditions, and ecological processes that are not found in younger forests (younger than 150 to 250 years) or in small patches of large, old trees. Old-growth forests often contain rich communities of plants and animals adapted because of long periods of forest stability. These varied species typically depend on the unique environmental conditions occurring exclusively in old-growth forests. Because of this, old-growth forests serve as biodiversity reservoirs for species that cannot thrive or easily regenerate in younger forest. Old-growth forests also sequester large amounts of carbon through photosynthesis, regulate hydrologic processes, and play a critical role in soil and nutrient cycling (Strittholt et al. 2006, Kaufmann et al. 2007).

Old-growth forests are often shaped over time by the natural competitive differences among species and individual trees and by small-scale disturbances affecting one or a few trees at a time. In other forests, plant succession processes are disrupted with some regularity by major biological disturbances, such as fire, insects, wind, or drought, that extend across larger areas (Marcot et al. 1997). There are many different types of old-growth forests for the diverse array of climates, soils, and topography in the western US.

Old-growth forest in the coastal Pacific Northwest and other areas where climates are wet are typical examples of forests driven largely by natural plant succession and small-scale disturbances. Such forests usually have an overstory dominated by large, old trees with multiple layers of younger, smaller trees beneath the overstory ready to replace the large, old trees when they die (Kaufmann et al. 2007).

In drier regions, forest types have evolved more in response to disturbance by fire than in response to successional processes. Old trees become a part of such forests because of adaptations that allow them to survive all but the most severe fires. In Arizona, Colorado, New Mexico, Utah, and drier parts of California, park-like forests with open canopies and grassy understories are typical. Thus, no single definition for old growth is adequate for the broad assortment of old-growth forests in the project area (Kaufmann et al. 2007).

Since the time of European settlement, approximately 72 percent of the original old-growth conifer forest has been lost, largely through logging and other developments. Of the remaining old growth, the central and southern Cascade and Klamath-Siskiyou Mountains account for nearly half. Large areas of old growth forest are also present in the Sierra Nevada, the Rocky Mountains and the Intermountain region. More than 78 percent of old-growth and 50 percent of mature forest are located on federal lands (Strittholt et al. 2006).

Since 1994, approximately 24 million acres of FS and BLM lands have been managed under the Northwest Forest Plan (FS and BLM 1994). The plan shifted federal lands management from predominantly resource extraction toward an ecosystem management approach (Thomas et al. 2006). Recent changes in NFS and public land management plans are intended to provide protection for old-growth forests throughout NFS and public lands in the west (Warbington and Beardsley 2002).

3.9.3 Climate Change

Climate change (warmer/drier summer conditions, warmer winters) may be one of the factors in recently observed changes in forest health involving large areas of tree mortality from a variety of insect agents. Many forest communities are resilient in responding to normal variations in weather and climate to which they are adapted. However, currently occurring increases in forest insect infestations and tree mortality throughout the planning area may be partially due to global climate change acting in concert with other variables such as long-term fire suppression, particularly in areas where stands are overstocked.

Due to changes in climate, grasslands and rangeland could expand into previously forested areas. Additionally, sagebrush habitats may decline sharply throughout the region and be replaced with grasslands. Increasing CO_2 concentrations also lead to preferential fertilization and growth of specific plant species, such as invaders like cheat grass. Climate change may favor certain shrub species, both native and exotic. Increased CO_2 in the atmosphere may favor growth of most woody plants and "cool season" grasses at the expense of "warm season" grasses. These and other differences among species could lead to changes in the composition of rangeland vegetation.

3.10 Fish and Wildlife

The BLM and FS have active wildlife management programs within each of their field or district offices. Wildlife management programs are largely aimed at habitat protection and improvement. The general objectives of wildlife management are to maintain, improve, or enhance wildlife species diversity, while ensuring healthy ecosystems; and to restore disturbed or altered habitat with the objective of obtaining desired native plant communities, while providing for wildlife needs and soil stability. The FS and BLM are primarily responsible for managing habitats, while state agencies (e.g., Colorado Department of Natural Resources, Utah Department of Wildlife Resources, Wyoming Game and Fish Department) have the responsibility for managing the big game, small game, and nongame fish and wildlife species in cooperation with BLM and FS. The USFWS has oversight of migratory bird species and of all federal threatened, endangered, proposed, or candidate species. The NMFS has responsibility for managing anadromous fish species such as salmon and steelhead.

The FS identifies and selects plant and animal species whose population changes are believed to reflect the effects of management activities. These species are referred to as management indicator species, and are identified in the Land and Resource Management Plans of each national forest. They are considered to represent a broader group of species or habitats that occur within each national forest and are considered sensitive to FS management activities. Impacts to these species would be considered in project-specific assessments prepared prior to project development.

The following discussions present general descriptions of the fish and wildlife species that may occur in the project area and planning area.

3.10.1 Fish and Other Aquatic Biota

Aquatic life is present throughout the rivers, streams, lakes, ponds, pools, and desert springs in the project area. The hydrologic regions described in Section 3.7, Water Resources, are used to define the regions of aquatic life found within the project area (Figure 3.-9). Essential fish species and populations are identified for each region. Species and populations presented represent the ecology of the region. They depend on the commonly occurring habitat types found in surface waters throughout each region, and the influence the aquatic and riparian community structure. Many species may occur in more that one region because of similarities in a region's ecology or as the result of human introduction.

Pacific Northwest and Alaska

The Pacific Northwest is best represented by members of the salmonid species that have a significant ecological, cultural, and commercial importance in the region. Salmonids include salmon *(Onchynchus)*, trout, char, grayling, and whitefish. All salmonids require relatively cold freshwater habitats with high water quality and diverse habitat to complete all stages of their life cycle. Thus, the conditions of surrounding forests and rangelands greatly influence salmonid survival (Quinn 2005).

Salmonids typically rely on large rivers and stream systems with direct ocean access because of their ecology. Many salmonids are anadromous, meaning the spend part of their life in freshwater (to spawn and for early development) and part of their life foraging in the ocean. Areas in Alaska within the planning area have several major river systems running through them, including the Yukon, Sustina, and Copper Rivers, as well as hundreds of smaller streams and tributaries. The most significant system in Pacific Northwest is the Columbia River Basin. With its headwaters in British Columbia, Canada, the Columbia River extends over 1,200 miles to the Pacific Ocean.

Salmonids migrate through several habitats while traveling from the ocean to breeding areas in freshwater and use all portions of the watershed, depending on the species. Chinook salmon spawn in larger faster waters, while sockeye and steelhead use headwater streams. Upon emerging from the gravel, individuals either start their migration to the sea within their first year (ocean type) or mature within rivers for two to three years before migrating to sea (stream type). In contrast, resident trout populations, such as rainbow, bull, and cutthroat, may spend their life (five to six years) in various freshwater systems, including small streams or lakes, and do not migrate to the sea (Quinn 2005).

Salmon, steelhead trout, and other native fish species support an active recreational and commercial fishery throughout the Pacific Northwest. However, sport fishing has been promoted in the Pacific Northwest, and to a lesser extent in Alaska, by introduction of various nonnative fish species. Introduced salmonids (such as brook, brown, lake, and hatchery-raised rainbow trout), centrarchids (such as bass and sunfish), and percids (such as walleye) now support much, if not most, of the nonnative sport fishing opportunities within these regions (Richter et al 1997).

A variety of aquatic invertebrates occur in northwest and Alaskan streams. These species can be quite susceptible to in-stream activity (e.g., removal of large woody debris) or disturbances in riparian zones. The diversity of aquatic insects is naturally low in glacier-fed streams. Streams flowing through conifer forest, however, support a diverse aquatic invertebrate fauna, including many mayflies, stoneflies, and caddisflies (Whittier et al. 1988). The diversity of freshwater mollusks is also usually highest in montane, spring-fed streams and pools (Forest Ecosystem Management Assessment Team 1993).

Essential Fish Habitat

Essential Fish Habitat (EFH) is defined in the Magnuson-Stevens Fishery Conservation and Management Act as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. The regulations (50 CFR 600.815[a][1][i]) specify the following requirements for EFH description:

- Fishery management plans must describe and identify EFH in text that clearly states the habitats or habitat types determined to be EFH for each life stage of the managed fish species;
- Fishery management plans should explain the physical, biological, and chemical characteristics of EFH and, if known, how these characteristics influence the use of EFH by the species/life stage;
- Fishery management plans must identify the specific geographic location or extent of habitats described as EFH; and
- Fishery management plans must include maps of the geographic locations of EFH or the geographic boundaries within which EFH for each species and life stage is found.

The mandate for federal agencies to evaluate potential effects on EFH applies to all species managed under a federal fishery management plan. Two fishery management plans for commercial and recreational salmon fisheries exist in the planning area (US Department of Commerce, National Oceanic and Atmospheric Administration 2007). These fishery management plans include Alaska, Washington, Oregon, California, and Idaho. The NMFS and Pacific Fisheries Management Council prepared an EIS to evaluate EFH for areas in Alaska. Appendix D of that EIS provides a description of all EFH for federally managed salmonid species in the Alaska region. Amendment 14 of the Pacific Coast Salmon Plan (Pacific Fishery Management Council 2000) contains a complete identification and description of EFH for the states of Washington, Oregon, California, and Idaho, along with an assessment of actions that could result in adverse impacts and actions to encourage conservation and enhancement of EFH.

The Pacific coast salmon fishery EFH includes those waters and substrate necessary for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem. In estuarine and marine areas, salmon EFH extends from the near-shore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (200 nautical miles). The EFH extends from Cape Prince of Wales in Alaska, on the western tip of the Seward peninsula, south to Point Conception in central California. The EFH for anadromous salmon also includes freshwater habitats such as streams, lakes, ponds, wetlands, and most historic habitat accessible to salmon (except above certain impassable natural barriers) in Alaska, Washington, Oregon, Idaho, and California.

Salmon typically use large stream and river systems with direct ocean access. However, they also are found in smaller coastal streams. Alaska has the greatest number of salmon-bearing streams and rivers with the large majority of them occurring in the southeast and throughout the southern gulf area. The most significant river system in Pacific Northwest (Washington, Oregon, and Idaho) is the Columbia River Basin. With its headwaters in British Columbia, the Columbia River extends over 1,200 miles to the Pacific Ocean. The Snake River is part of this system. The Sacramento River system is the largest system in California supporting salmon species. The Russian, Eel, and Klamath River systems are also important for salmon in California.

Salmon productivity is dependent on both ocean and freshwater conditions. Suitable habitat in freshwater generally is dictated by flow regime, water quality, habitat structure, and biotic interactions. All salmon require suitable habitat for spawning, incubation, and rearing. Generally, adult salmon require spawning gravel (less than two inches in diameter) and overhead stream bank or vegetative cover from predation and ultraviolet radiation, while eggs and newly hatched salmon (alevins) require stable gravel and cool (less than 57 degree F) water that is well oxygenated (Quinn 2005).

Lower Colorado River, Great Basin, and the Rio Grande

These regions cover most of Nevada, Arizona, New Mexico, and western Utah, as well as areas in eastern California. Grasses and shrubs cover large expanses and are critical for reducing runoff and erosion. Precipitation in these arid regions is extremely seasonal and arrives in intense pulses. Thus, the natural hydrology of the rivers and streams is highly variable and episodic. Native fish populations thrive on these pulsed intermittent flows and the natural flow regimes are considered optimum for sustaining native fish populations (Poff et al. 1997). However, many of the waterways in the southwest have been altered dramatically for water storage, flood abatement, and irrigation purposes.

Fish species distribution is limited because of a lack of habitat continuity. Streams often terminate in closed lakes, desiccate during dry periods, or go subterranean. Springs occur throughout the desert ecosystem, ranging from quiet pools or trickles to active aquifers. Many larger springs emit warm water, with temperatures above the mean annual air temperature, and range from fresh to highly mineralized, carrying large amounts of dissolved materials or extremely low dissolved oxygen levels (Naiman 1981). These pools often harbor endemic species that are found nowhere else.

Nonnative species have been introduced into many areas, and their presence can reduce numbers of native species through competition, hybridization, predation, and spread of pathogens to which they have developed resistance in their home waters, but to which native species have none (Marsh and Douglas 1997).

Many of the rivers in these regions have changed dramatically over the last hundred years. The Colorado River, which was once a warm, silted, swift river, is now a cold, clear series of artificial impoundments such as the Glen Canyon Dam that forms Lake Powell. The impoundments have altered aquatic habitats and species composition within most waterways in these regions. As a result, most native fish populations in many of the waterways have declined substantially. Overall, nonnative fish species in these hydrologic regions now outnumber native species in terms of numbers of species, population densities, and often biomass at many localities (Marsh and Douglas 1997).

The Colorado River is the primary river of the southwestern US, draining approximately 242,000 square miles from portions of Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, and California. The headwaters of the Colorado River are located in Rocky Mountain National Park in Colorado, from which the river flows southwest toward the Gulf of California. The Colorado River Basin is divided into two basins, the lower and upper, with a dividing line near Lee's Ferry, Arizona. The native fish community within the Lower Colorado River hydrologic region is dominated by fishes within the minnow and sucker families. Minnow species include the threatened Colorado pikeminnow and bonytail chub. The threatened razorback sucker is also found here.

Impoundments have had the greatest impacts on these fish communities (Minckley and Deacon 1991).

Bonytail chub was historically common, migrating throughout the main stem of the Colorado River and many of its tributaries, including the Green, Gunnison, Yampa, and Gila Rivers, before the construction of large dams (Kaeding et al. 1986). Although bonytail chub continues to be found in low numbers from several human-made lakes, including Lake Mohave, the temperature and physical and chemical composition of these lakes is very different from those in which the fish evolved (Minckley and Deacon 1991).

The headwaters of the Rio Grande originate in the Rocky Mountains of southwestern Colorado, and the river meanders approximately 1,900 miles across Colorado, New Mexico, and Texas before terminating at the Gulf of Mexico. NFS and public lands within the Rio Grande region are limited to the upper and middle reaches of this drainage. Historically, riparian woodlands in the Rio Grande valley were a mosaic of various-aged stands dominated by cottonwood and willow (Cassell 1998). However, conversion of much of this land to residential and agricultural uses has modified the floodplain, thereby significantly reducing the quantity and quality of aquatic habitat (Cassell 1998). These changes, combined with in-stream modifications, have reduced fish habitat considerably throughout the region.

Prior to the construction of dams like the Cochiti Dam, the Rio Grande had characteristics similar to the Colorado River and was considered a swift, warm, muddy river (Scurlock 1998). The settling effects of dam reservoirs have resulted in slower, clearer, colder water. This modification of water quality has had a debilitating effect on native fish species, such as the Rio Grande silvery minnow that was once wide spread.

Many nonnative fish species have adapted well to the in-stream modifications to both the Lower Colorado River and Rio Grande (Marsh and Douglas 1997). Usually more aggressive than native fish and able to outcompete them for resources, these nonnative species include walleye, bass (large and smallmouth), and rainbow, brook, and brown trout (Marsh and Douglas 1997).

The Great Basin covers an arid expanse of approximately 190,000 square miles and is bordered by the Sierra Nevada Range on the west, the Rocky Mountains on the east, the Columbia Plateau on the north, and the Mojave and Sonoran Deserts on the south. The Great Basin is the area of internal drainage between the Rocky Mountains and the Sierra Nevada Range. Streams in this area never reach the ocean, but are instead confined, draining to the base of the basin, and typically resulting in terminal lakes (such as Mono Lake and the Great Salt Lake), marshes, or sinks that are warm and saline (Moyle 1998).

Many Great Basin fish are adapted to extreme conditions. Trout are predominantly found in lakes and streams at higher elevations (Behnke 1992). Bonneville cutthroat trout have persisted in the isolated, cool mountain streams of the eastern Great Basin, while Lahontan cutthroat trout populations occupy small, isolated habitats throughout the basin. These trout species are unusually tolerant of high and fluctuating temperatures, high pH, and increased levels of dissolved solids.

Water diversions, subsistence harvest, and stocking with nonnative fish (particularly rainbow trout) have caused the extirpation of the Bonneville cutthroat trout from most of its range. Although Lahontan cutthroat trout were once common in desert lakes (including Pyramid, Walker, Summit, and Independence Lakes) and large rivers (such as the Humboldt, Truckee, and Walker Rivers), they have declined in numbers overall, disappearing in many areas (Hudson et al. 2000). The decline of Lahontan cutthroat trout abundance is a result of habitat loss, interbreeding with introduced rainbow trout, and competition with other species of trout. These factors continue to be the primary threats to this species (Coffin and Cowan 1995).

Minnows and pupfish are the dominant fish species at lower elevations and are found in thermal artesian springs and streams (Hubbs 1982). Various native and nonnative minnows, (e.g., dace, chubs, shiners) are common throughout streams and lakes of the basin. Pupfish, however, are very site specific and live, by choice, at the extreme upper limit of their zone of thermal tolerance (Naiman 1981). The most significant problem facing these fish are the limited water supply. Desert fishes have a tenuous hold on survival under natural conditions, occurring only in the few permanent springs, rivers, and lakes, and their existence has been placed in doubt by human activities (Hubbs 1982). Pumping groundwater for agriculture has threatened several pupfish populations, including the Devil's Hole pupfish (Naiman 1981).

The Upper Colorado River Basin

Three distinct aquatic zones have been identified in the Upper Colorado Basin (Joseph et al. 1977). The upper (headwater) zone is characterized by cold and clear water, a high gradient, and a rocky or gravel substrate. Resident salmonid populations are predominant in this zone. An intermediate zone occurs as the stream flows out of the upper zone. Within the intermediate zone, water discharge rates and temperature increase, and water is turbid during spring runoff and after heavy rainfall. The substrate is generally rocky with occasional expanses of sand. The lower (large-river) zone has warm water, meandering sections, and a low gradient in flat terrain. Minnows and suckers are the dominant fish communities of the intermediate and lower zones.

The construction of reservoirs, such as Fontenelle and Flaming Gorge, has had profound effects on water flow and quality throughout the upper basin region; lower summer water temperatures have resulted, and spawning of native fish has virtually ceased (Wullschleger 2000). The humpback chub, for example, prefers deep, fast-moving, turbid waters often associated with canyon bound segments of the rivers (Douglas and Marsh). Historically, this species occurred in great numbers throughout the Colorado River system from the Green River in Wyoming to the Gulf of California in Mexico. Today, due to lower water temperature and migration routes blocked by dams, this species can only be found in limited deep, canyon-bound portions of the Colorado River (Douglas and Marsh 1996).

Native salmonids in the upper zone of the Upper Colorado River Basin, including the Gila and Apache trout, are disappearing with the introduction of rainbow, brook, and cutthroat trout for sport fishing (Behnke 1992). The habitat immediately downstream of constructed reservoirs favors these nonnative salmonids (Platania 2003). Nonnative species are highly competitive for available resources and interbreed with native species causing hybridization. Both actions adversely affect native species (USFWS 1994, Minckley and Deacon 1991). Populations of native species within lakes are also declining as a result of competition with, and predation by, introduced nonnative species, such as carp, northern pike, and red shiner (Rinne 2003).

California

California has two distinct fish habitat regions: northern and southern California. The northern region extends from the Oregon border south to Sacramento (the most southern reaches of salmon distribution in North America). This region includes rain-fed coastal streams, snow-fed streams of western Sierra Nevada and the Central and San Joaquin Valleys. Habitat characteristics are very similar to those observed in the western Pacific Northwest, with a dominance of evergreen forests throughout the area. Streams in the coastal region usually have steep drainages and are characterized by extreme seasonal flow, flooding in the winter and becoming intermittent in summer (Moyle 1976). Water flow in snow-fed streams is more constant than in coastal streams, a condition to which native fish are adapted.

Freshwater fish habitats within southern California are located predominantly within the arid southeast region of the state and include numerous rivers and lakes. Native fish communities, such as pupfish and minnows in the lower elevations and cutthroat trout in the mountainous regions, and their aquatic habitats exhibit characteristics similar to those seen in the Lower Colorado and Great Basin regions.

Missouri River Basin

The Missouri River historically carried a heavy silt load collected from tributaries in the northern part of its drainage. Its wide and diverging channel created shifting sandy islands, spits, and pools, resulting in fish species suited to its turbid and dynamic conditions. Many of the fish communities within the upper reaches of the Missouri River are considered benthic fishes and include sturgeon and minnows (Scarnecchia et al. 2002).

NFS and public lands in Montana occur predominantly in the northeastern portion of the state in the Milk River Basin subsection of the Missouri River Basin. This area has relatively high densities of depressional wetlands, often called prairie potholes, as they are dominated by shortgrass prairies. The upper reaches of the Missouri River and its major tributaries maintain the healthiest fish populations in the basin (Scarnecchia et al. 2002). However, dams built along the main stem of the Missouri River in Montana, such as the Fort Peck Dam, have altered flows and sediment transport and impede fish migration patterns. These changes have contributed to the decline of many native main stem species, including, sturgeon, and several species of chub (family Cyprinidae).

Introduced species, such as rainbow trout, have been stocked throughout Montana. Rainbow trout have adapted well to the wide range of habitats available within the basin. The species has successfully integrated into this aquatic system and has caused a severe reduction in the range of native cutthroat trout through hybridization and competition. Other introduced species that have adapted well to the modifications of the Missouri River drainage in Montana include smallmouth bass, walleye, and white crappi.

Portions of Wyoming east of the Continental Divide are drained by the Missouri River Basin, while southwest portions of the state drain into the Upper Colorado River Basin. Native and introduced salmonids such as rainbow, brook, and cutthroat trout dominate fish communities within these areas. Streams flowing through the arid desert plains of Wyoming are characterized by low gradients and meandering or braided channels with sand and gravel substrates. Riparian vegetation in this area is dominated by cottonwoods, willows, shrubs, and grasses. Central and northern Wyoming are considered high cold desert. Native and nonnative minnows and suckers dominate fish communities in these areas.

Arkansas-White-Red Region

This hydrologic region occupies the drainage of the Arkansas, Canadian, and Red River basins above the points of the highest backwater effect of the Mississippi River. It includes all of Oklahoma and parts of Colorado, New Mexico, Texas, Kansas, Missouri, and Louisiana. Only a relatively small proportion of NFS and public lands are found in this region, primarily concentrated near the headwaters of the Arkansas River in central Colorado and near the headwaters of the Canadian River in northeastern New Mexico. Surface waters generally originate from precipitation falling in the eastern Rocky Mountains. Precipitation is relatively sparse in the summer and fall months, and surface water flow is typically dependent on snowmelt in the mountainous areas. Surface water resources are used extensively for agricultural irrigation.

Fish species in the upper headwaters of these rivers are similar to those in the Upper Colorado, supporting trout and other cold-water species (Behnke 1992). At lower elevations, the species assemblage is comprised primarily of warm-water species, both introduced and native, such as and several species of chub (family Cyprinidae), perches and darters (family Percidae), largemouth bass, black crappie, catfish, and common carp (Lohr and Fausch 1997).

Amphibians and Reptiles

Public and NFS lands in the planning area support a wide variety of amphibians and reptiles. The number of amphibian species reported in these states ranges from as few as 8 species reported in Alaska to 68 species reported in California. The number of reptile species reported from these states ranges from four species (zero terrestrial) in Alaska to 112 species in Arizona (Table 3-20). The amphibians reported from these states include frogs, toads, and salamanders that occupy a variety of habitats that include forested headwater streams in mountain regions, marshes, and wetlands, and xeric habitats in the desert areas of the Southwest. The reptile species include a wide variety of turtles, snakes, and lizards. Amphibian and reptile species that are threatened or endangered are listed in Appendix H.

Table 3-20

Number of Wildlife Species in the Project Area[1]

State	Amphibian	Reptiles	Mammals[2]	Birds
Alaska	8	4[3]	83	445
Arizona	29	112	169	533
California	68	90	182	626
Colorado	18	56	131	478
Idaho	15	24	111	402
Montana	18	17	110	417
Nevada	15	54	125	472
New Mexico	25	96	156	510
Oregon	31	29	137	492
Utah	17	57	136	428
Washington	27	22	116	468
Wyoming	12	27	121	420

[1] Excludes marine species, native species that have been extirpated, and feral domestic species

[2] Includes wild horse and burros

[3] The four (4) reptile species found in Alaska are sea turtles with limited or no terrestrial presence.

Source: Adapted from DOE and DOI 2007 (Table 3.8-2) with additional data provided from Sage 1986, FS 1995a, Igl 1996

Birds

Birds are the most prolific animal family found in the project area (Table 3-20). The number of bird species ranges from 402 in Idaho to 626 in California (Igl

1996). The coastal states (Alaska, California, Oregon, and Washington) include oceanic species such as puffin, frigatebird, and albatross that would not occur in the planning area. Bird species that are threatened or endangered are listed in Appendix H.

Birds of Conservation Concern 2002 is the most recent USFWS effort to accurately identify the migratory and nonmigratory bird species (beyond those already designated as federally threatened or endangered) that represent the highest conservation priorities and draw attention to species in need of conservation action. Birds of Conservation Concern 2002 includes 276 species that are primarily derived from assessment scores from three major bird conservation plans: Partners in Flight, the US Shorebird Conservation Plan, and the North American Waterbird Conservation Plan. Bird species considered for inclusion on lists in this report include nongame birds, game birds without hunting seasons, subsistence-hunted nongame birds in Alaska, and ESA candidate, proposed endangered or threatened, and recently delisted species.

Within the project area, a number of important bird areas have been identified by the National Audubon Society. Important bird areas are locations that provide essential habitats for breeding, wintering, or migrating birds. While these sites can vary in size, they are discrete areas that stand out from the surrounding landscapes. Important bird areas must support one or more of the following:

Species of conservation concern (e.g., threatened or endangered species);

- Species with restricted ranges;
- Species that are vulnerable because their populations are concentrated into one general habitat type or ecosystem; or
- Species or groups of similar species (e.g., waterfowl or shorebirds) that are vulnerable because they congregate in high densities.

The important bird areas program has become a key component of many bird conservation efforts and efforts to identify and recognize important bird areas are ongoing throughout the project area. The current number of important bird areas ranges from 9 in Wyoming to 147 in California. Identification of important bird areas is continuing, and these numbers are expected in increase (National Audubon Society 2007).

Migratory Birds

Many of the bird species in the project area are seasonal residents within individual states and exhibit seasonal migrations. These birds include waterfowl, shorebirds, raptors, and neotropical songbirds. The USFWS has the legal mandate and the trust responsibility to maintain healthy migratory bird populations (USFWS 2004c). The regulatory framework organized to protect the migratory birds includes:

- *Migratory Bird Treaty Act.* The Migratory Bird Treaty Act implements a variety of treaties and conventions between the US, Canada, Mexico, Japan, and Russia. This treaty makes it unlawful to take, kill, or possess migratory birds, as well as their eggs or nests. Most of the bird species reported from the project area are classified as migratory under this Act.
- *Executive Order 13186: Responsibilities of Federal Agencies to Protect Migratory Birds*. Under this Executive Order, each federal agency taking an action that could have, or is likely to have, negative impacts on migratory bird populations must work with the USFWS to develop a memorandum of understanding to conserve those birds. The memorandums of understanding developed by this consultation are intended to guide future agency regulatory actions and policy decisions.

The USFWS has outlined a plan to conserve and protect migratory birds in its Migratory Bird Strategic Plan 2004-2014. The strategy includes direct collaboration with both the FS and BLM in making land use and planning decisions. The protection of migratory bird species of conservation concern is the primary goal of the plan.

The planning area falls within two of the four major North American migration flyways (Lincoln et al. 1998): the Central Flyway and the Pacific Flyway. These pathways are used in spring by birds migrating north from wintering areas to breeding areas, and in fall by birds migrating southward to wintering areas.

The Central Flyway includes the Great Plains–Rocky Mountain routes. These routes extend from the northwest Arctic coast southward between the Mississippi River and the eastern base of the Rocky Mountains and encompass all or most of the states of Wyoming, Colorado, and New Mexico, and portions of Montana, Idaho, and Utah. In western Montana, this flyway crosses the Continental Divide and passes through Utah's Great Salt Lake Valley before turning eastward. The majority of birds make using the central flyway make relatively direct north and south migrations between northern breeding grounds and southern wintering areas (Birdnature.com 2007, Lincoln et al. 1998).

The Pacific Flyway includes the Pacific Coast Route, which occurs between the eastern base of the Rocky Mountains and the Pacific coast of the US. This flyway encompasses Alaska, California, Nevada, Oregon, and Washington, and portions of Montana, Idaho, Utah, Wyoming, and Arizona. Birds migrating from the Alaskan Peninsula follow the coastline to near the mouth of the Columbia River, then travel inland to the Willamette River Valley before continuing southward through interior California (Lincoln et al. 1998). Birds migrating south from Canada pass through portions of Montana and Idaho and then migrate either eastward to enter the Central Flyway, or turn southwest along the Snake and Columbia River Valleys and then continue south across central Oregon and the interior valleys of California (Birdnature.com 2007). This route is not as heavily used as some of the other migratory routes in North America (Lincoln et al. 1998).

Waterfowl, Wading Birds, and Shorebirds

Waterfowl (ducks, geese, and swans), wading birds (herons and cranes), and shorebirds (plovers, sandpipers, and similar birds) are among the more abundant bird groups in the project area. Many of these species exhibit extensive migrations from breeding areas in Alaska and Canada to wintering grounds in Mexico and southward (Lincoln et al. 1998). Most are ground-level nesters, and many sometimes forage in relatively large flocks on the ground or water. Within the region, migration routes for these birds are often associated with riparian corridors and wetland or lake stopover areas (Lincoln et al. 1998).

Waterfowl species are popular game species and are hunted throughout the project area. Ducks, geese, teal, and cranes are all commonly hunted and are managed primarily by state fish and wildlife agencies in conjunction with USFWS. Various conservation and management plans exist for waterfowl, shorebirds, and water birds.

Neotropical Migrants

Songbirds of the order *Passeriformes* represent the most diverse category of birds, with the warblers and sparrows representing the two most diverse groups of passerines. Passerines exhibit a wide range of seasonal movements, with some species remaining as year-round residents and others undergoing migrations of hundreds of miles or more (Lincoln et al. 1998). As the largest and most diverse category of birds, breeding, nesting, and feeding habits vary greatly (Lincoln et al. 1998).

Birds of Prey

The birds of prey include the raptors (hawks, falcons, eagles, kites, and osprey), owls, and vultures. The largest of these birds are the premier avian predators in their respective ecosystems. Raptors and owls species vary considerably with regard to their seasonal migrations. Some species are virtually nonmigratory, and others migrate only in the northern portion of their range while remaining nonmigratory their southern range. Finally, other species migrate throughout their ranges.

The bald eagle and golden eagle are protected under the Bald and Golden Eagle Protection Act (16 USC 668– 668d, 54 Stat. 250, as amended), which prohibits the taking or possession of, or commerce in, bald and golden eagles, with limited exceptions for permitted scientific research and Native American religious purposes. The 1978 amendment authorizes the Secretary of the Interior to permit the taking of golden eagle nests that interfere with resource development or recovery operations. The BLM and FS field or district offices also have specific management guidelines for raptors, including golden eagles.

Raptors forage on a variety of prey, including small mammals, reptiles, other birds, fish, invertebrates, and, at times, carrion. Hunting and foraging varies significantly among species, with some being very active hunters, pursuing prey on the wing, and others foraging from a perch, All forage during the day. Owls forage in a similar manner, although most hunting occurs at night, though some owl species may be active during the day (Sovern et al 1994).

The vultures are represented by three species: the turkey vulture, which occurs in each of the western states; the black vulture, which is reported from Arizona, California, and New Mexico; and the endangered California condor, reported from Arizona and California. These birds are large soaring scavengers that feed on carrion.

Upland Game Birds

Upland game birds that are native to the project area include several native species of grouse, including the greater sage-grouse and Gunnison sage-grouse, and mourning doves. Ring-necked pheasant, chukar, gray partridge, and wild turkey are all nonnative species that have been introduced but are managed as game species. All of the upland game bird species within the project area are year-round residents. Ring-necked pheasants and greater sage-grouse have experienced long-term declines due to the degradation and loss of important sagebrush-steppe and grassland habitats (BLM 2005b).

Most concerns about upland game birds in the project area have focused on the greater sage-grouse. Greater sage-grouse require contiguous, undisturbed areas of high-quality habitat during their four distinct seasonal periods of breeding, summer-late brooding and rearing, fall, and winter (Connelly et al. 2004). Figure 3.10-1 shows the current and historical distribution of sage grouse in the project area.

Sagebrush is important to the greater sage-grouse for forage and for roosting cover, and the greater sage-grouse cannot survive where sagebrush does not exist (Connelly et al 2004). Sagebrush is found throughout and almost exclusively in the temperate desert ecoregion division, although the eastern portions of the sagebrush biome do extend into the temperate steppe ecoregion division. The distance between leks (strutting grounds) and nesting sites can exceed 12 miles (Connelly et al. 2000, Bird and Schenk 2005). The annual movements of migratory populations can exceed 60 miles, and migratory populations can have home ranges that exceed 580 square miles (Bird and Schenk 2005). However, the greater sage-grouse has a high fidelity to a seasonal range. They also return to the same nesting areas annually (Connelly et al. 2000, 2004). Leks are generally areas supported by low, sparse vegetation or open areas surrounded by sagebrush that provide escape, feeding, and cover. They can range in size from small areas of 0.1 to 10 acres to areas of 100 acres or more (Connelly et al. 2000). Nesting generally occurs 1 to 4 miles from lek sites, although it may range up to 12 miles (Connelly et al 2004). Suitable winter habitat requires sagebrush 10 to 14 inches above snow level with a canopy cover ranging from 10 to 30 percent. Wintering areas are potentially the most limiting seasonal habitat for greater sage-grouse (Connelly et al 2004).

While no single or combination of factors have been proven to have caused the decline in greater sage-grouse numbers over the past half-century, the decline in greater sage-grouse populations is thought to be due to a number of factors including drought, oil and gas wells and their associated infrastructure, power lines, predators, and a decline in the quality and quantity of sagebrush habitat (due to livestock grazing, range management treatments, and development activities) (Connelly et al. 2004, Crawford et al. 2004). West Nile virus is also a significant stressor of greater sage-grouse (Naugle et al. 2004). The BLM manages more habitats for greater sage-grouse than any other entity. It has developed a National Sage-Grouse Habitat Conservation Strategy to manage public lands in chorus with the FS and other agencies in a manner that will maintain, enhance, and restore greater sage-grouse habitat while providing for multiple use (Connelly et al 2004). The strategy is consistent with the individual state sage-grouse conservation planning efforts. The purpose of this strategy is to set goals and objectives, assemble guidance and resource materials, and provide more uniform management directions to the multiple federal and state sage grouse conservation effort being led by state wildlife agencies (BLM 2004b). More on sage grouse and sagebrush compatibility with geothermal development can be found in text box 4.10-1.

Big Game

The following presents a generalized overview of the big games species. Table 3-21 presents the conservation status (i.e., whether a species is thriving or is rare or declining) for the big games species within the project area.

Elk (Cervus canadensis). Elk are generally migratory between their summer and winter ranges, although some herds do not migrate (i.e., occur within the same area year-round) (BLM 2004a). Their summer range occurs at higher elevations. Aspen and conifer woodlands provide security and thermal cover, while upland meadows, sagebrush/mixed grass, and mountain shrub habitats are used for forage. Their winter range occurs at mid to lower elevations where they forage in sagebrush/mixed grass, big sagebrush and rabbitbrush, and mountain shrub habitats (BLM 2004b). They are highly mobile within both summer and winter ranges in order to find the best forage conditions. In winter, they congregate into large herds of 50 to more than 200 individuals (BLM 2004a). The crucial winter range is considered to be the part of the local elk

Table 3-21
State Conservation Status Ranks for the Big Game Species in the Project Area

	State Conservation Status Rank											
Species	**AK**	**AZ**	**CA**	**CO**	**ID**	**MT**	**NM**	**NV**	**OR**	**UT**	**WA**	**WY**
Elk (*Cervus canadensis*)	-	NR	AS	S	S	S	V	S	S	AS	S	S
Mule deer (*Odocoileus hemionus*)	NR	S	S	S	S	S	S	S	AS	S	S	S
White-tailed deer (*Odocoileus virginianus*)	-	S	-	S	S	S	AS	-	NR	CI	S	S
Proghorn antelope (*Antilocapra americana*)	-	S	AS	AS	S	S	S	S	AS	AS	PE	S
Bighorn sheep (*Ovis canadensis*)	-	AS	V	AS	V	AS	CI	V	I	V	V	V
Moose (*Alces americanus*)	NR	-	-	E	S	S	-	-	-	V	I	S
American bison *(Bos bison)*	-	E	U	PE	CI	I	NR	PE	PE	I	PE	CI
Caribou (*Rangifer tarandus*)	NR	-	-	-	NR	NR	-	-	-	-	CI	-
Black bear (*Ursus americanus*)	NR	S	S	S	S	S	AS	AS	AS	V	S	S
Grizzly bear (*Ursus arctos*)	NR	PE	PE	PE	CI	I	PE	PE	PE	PE	CI	CI
Cougar (*Puma concolor*)	-	AS	S	AS	S	AS	V	S	AS	AS	AS	AS

– = the state is not within the species' range
U (unranked) – conservation status not yet assessed
AS (apparently secure) – uncommon but not rare, some cause for long-term concern due to declines or other factors
S (secure) – common, widespread, and abundant
V (vulnerable) – vulnerable due to a restricted range, relatively few populations (often 80 or fewer), recent or widespread declines, or other
CI (critically imperiled) – critically imperiled because of extreme rarity (often 5 or fewer occurrences) or because some factors such as very steep declines make it especially vulnerable to extirpation
PE (presumed extirpated) – assumed that a wild population no longer occurs

I (imperiled) – imperiled because of rarity due to a very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it vulnerable to extirpation
E (exotic) – nonnative, present due to direct or indirect human interaction
NR (not ranked)- Nation or state/province conservation status not yet assessed.
Source: NatureServe 2007

range where about 90 percent of the local population is located during an average of five winters out of ten from the first heavy snowfall to spring green-up (BLM 2005b). Elk calving generally occurs in aspen-sagebrush parkland vegetation and habitat zones during late spring and early summer (BLM 2004a). Calving areas are mostly located where cover, forage, and water are in close proximity (BLM 2005b). They may migrate up to 60 miles annually (NatureServe 2007). Elk are susceptible to chronic wasting disease (BLM 2004a).

Mule Deer (Odocoileus hemionus). Mule deer occur within most ecosystems within the region, but attain their highest densities in shrub lands characterized by rough, broken terrain with abundant browse and cover (BLM 2005). Home range size can vary from 74 to 593 acres or more, depending on the availability of food, water, and cover (NatureServe 2007). Some populations of mule deer are resident (particularly those that inhabit plains), but those in mountainous areas are generally migratory between their summer and winter ranges (BLM 2004b; NatureServe 2007). In arid regions, they may migrate in response to rainfall patterns (NatureServe 2007). In mountainous regions, they may migrate more than 62 miles between high summer and lower winter ranges (NatureServe 2007). In western Wyoming, mule deer migrate 12 to 98 miles (Sawyer and Whirter 2005). Their summer range occurs at higher elevations that contain aspen and conifers and mountain browse vegetation. Fawning occurs during the spring while they are migrating to their summer range. This normally occurs in aspen-mountain browse intermixed vegetation (BLM 2004a).

Mule deer have a high fidelity to specific winter ranges where they congregate within a small area at a high density. Their winter range occurs at lower elevations within sagebrush and pinyon-juniper vegetation. Winter forage is primarily sagebrush, with true mountain mahogany, fourwing saltbush, and antelope bitterbrush also being important. Pinyon-juniper provides emergency forage during severe winters (BLM 2004a). Overall, mule deer habitat is characterized by areas of thick brush or trees (used for cover) interspersed with small openings (for forage and feeding areas); they do best in habitats that are in the early stage of succession (Utah Division of Wildlife Resources 2007). Prolonged drought and other factors can limit mule deer populations. Several years of drought can limit forage production, which can substantially reduce animal condition and fawn production and survival. Severe drought conditions were responsible for declines in the population size of mule deer in the 1980s and early 1990s (BLM 2004a). In arid regions, they are seldom found more than 1.0 to 1.5 miles from water (BLM 2004a). Mule deer are also susceptible to chronic wasting disease. When present, up to three percent of a herd's population can be affected by this disease. Some deer herds in Colorado and Wyoming have experienced significant outbreaks of chronic wasting disease (BLM 2004a).

Wintering Areas

Ungulates (such as deer, elk, and caribou) become energetically challenged during the late fall and winter season, especially at higher elevations and latitudes. This is the result of lower-quality and less-accessible food resources combined with harsher environmental conditions, such as cold temperatures, high winds, minimal water, and deep or crusted snow. A reprieve comes in spring when new plant growth becomes available (Eastland et al. 1989, Patterson and Messier 2001).

Survival during the winter season is accomplished by minimizing energy expenditures and utilizing stored body fat reserves as a supplemental energy source. Behavioral adaptations are critical for winter survival. Ungulates will migrate to wintering areas where relatively high-quality and abundant winter food resources are in close proximity to protection from harsh weather and cover from predators. Ungulates also reduce their movement and minimize body heat loss and energy expenditure as much as possible. Finally, they typically congregate in larger winter groups that facilitate trail development in deep snow conditions and improve predator detection and defense (Christianson and Creel 2007).

Winter range is often found in river valleys and riparian areas. These areas possess topographic variation and vegetative productivity that provides adequate cover and good winter browse conditions. South-facing valley slopes have relatively lower snow accumulations and warmer resting sites. Valleys provide protection from high wind chills (Christianson and Creel 2007). However, myriad factors (such as temperature, precipitation, and winter severity) can change from year to year. This can have a direct effect on flora and fauna in and around wintering areas. Thus, winter ranges are subject to boundary changes from year to year, as well as relative use by wintering ungulates (Christianson and Creel 2007).

Key ungulate winter ranges play a disproportionately large role, given their localized size and distribution, in maintaining the overall productivity of regional ungulate populations. These ranges ensure that a significant proportion of the breeding population survives to the next year (Christianson and Creel 2007).

Development, recreation, and resource-extraction activity within and adjacent to key wintering areas adds stress and increases energy drain for animals. They may be forced to move about more than normal and even relocate to less favorable habitat. This becomes an increasingly significant factor as winter progresses. Industrial activity may also create temporary and permanent access that exposes animals to additional non-industrial disturbances and to greater pressure from predators (FS 2001).

Because of the importance of winter ranges, USFWS, FS, BLM, and state fish and game departments manage these areas carefully to ensure proper game management and healthy ecosystems on lands they manage. Traditional high-use and high-quality winter ranges have been identified and mapped by various agencies. Mapping is based of several decades of winter aerial population surveys, supplemented by habitat assessments using air photo interpretation and ground surveys (FS 2001, USFWS 2007a).

White-tailed Deer (Odocoileus virginianus). White-tailed deer inhabit a variety of habitats, but are often associated with woodlands and agricultural lands (Colorado Division of Wildlife 2007). Within arid areas, they are mostly associated with riparian zones and montane woodlands that have more mesic conditions. They can also occur within suburban areas.

Urban areas and very rugged mountain terrain are unsuitable habitats (NatureServe 2007). White-tailed deer occur in two social groups: adult females and young; and adult and occasionally yearling males. However, adult males are generally solitary during the breeding season except when with females (NatureServe 2007). The annual home range of sedentary populations can average as high as 1,285 acres, while some populations can undergo annual migrations of up to 31 miles. In some areas, the density of white-tailed deer may exceed 129 per square mile (NatureServe 2007).

Snow accumulation can have a major controlling effect on populations (NatureServe 2007). They mostly feed upon agricultural crops, browse, grasses, and forbs, but also consume mushrooms, acorns, fruits, and nuts (Colorado Division of Wildlife 2007, Utah Division of Wildlife Resources 2007). They often cause damage when browsing in winter on ornamental plants around homes (NatureServe 2007).

Pronghorn (Antilocapra americana). Pronghorn inhabit non-forested areas such as desert, grassland, and sagebrush habitats (BLM 2005b). Herd size can commonly exceed 100 individuals, especially during winter (BLM 2004a). They consume a variety of forbs, shrubs, and grasses, with shrubs being of most importance in winter (BLM 2004a). Some pronghorn are year-long residents and do not have seasonal ranges. Fawning occurs throughout the species range. However, some seasonal movement within their range occurs in response to factors such as extreme winter conditions and water or forage availability (BLM 2004a). Other pronghorn are migratory. Most herds range within an area 5 miles or more in diameter, although the separation between summer and winter ranges has been reported to be as much as 99 miles or more (NatureServe 2007). For example, in western Wyoming, pronghorn migrate 72 to 160 miles between seasonal ranges (Sawyer et al. 2005). Pronghorn populations have been adversely impacted in some areas by historic range degradation and habitat loss and by periodic drought conditions (BLM 2005b).

Bighorn Sheep (Ovis canadensis). Rocky Mountain bighorn sheep *(Ovis c. canadensis)* and desert bighorn sheep *(O. canadensis nelsoni)* are considered to be year-long residents within their ranges; they do not make seasonal migrations like elk and mule deer (BLM 2004a). However, they do make vertical migrations in response to an increasing abundance of vegetative growth at higher elevations in the spring and summer and when snow accumulation occurs in high-elevation summer ranges (NatureServe 2007).

Also, ewes move to reliable watercourses or water sources during the lambing season, with lambing occurring on steep talus slopes within one to two miles of water (BLM 2004a). Bighorn sheep prefer open vegetation such as low shrub, grassland, and other treeless areas with steep talus and rubble slopes (BLM 2004b). Unsuitable habitats include open water, wetlands, dense forests, and other areas without grass understory (NatureServe 2007).

The distribution of the bighorn sheep within the project area is mostly within the central north-to-south band of states. Their diet consists of shrubs, forbs, and grasses (BLM 2004a). In the early 1900s, bighorn sheep experienced significant declines due to disease, habitat degradation, and hunting (BLM 2005b). Threats to bighorn sheep include habitat changes due to fire suppression, interactions with feral and domestic animals, and human encroachment (NatureServe 2007). Bighorn sheep are very vulnerable to viral and bacterial diseases carried by livestock, particularly domestic sheep. Therefore, BLM has adopted specific guidelines regarding domestic sheep grazing in or near bighorn sheep habitat (BLM 2004a). In appropriate habitats, reintroduction efforts, coupled with water and vegetation improvements, have been conducted to restore bighorn sheep to their native habitat (BLM 2005b).

Moose (Alces americanus). Although moose range widely among habitat types, they prefer forest habitats where there is a mixture of wooded and open areas near wetlands and lakes (Utah Division of Wildlife Resources 2007). They are primarily browsers upon trees and shrubs such as willow, fir, and quaking aspen, although grasses, forbs, and aquatic vegetation are also consumed during spring, summer, and fall (BLM 2005b, Colorado Division of Wildlife, 2007). They generally occur singly or in small groups. Moose are active throughout day and night, but the peak periods of activity are near dawn and dusk (Utah Division of Wildlife Resources 2007). Some moose make short elevational or horizontal migrations between summer and winter habitats (NatureServe 2007).

Moose breed in late summer to early fall, with calving occurring in late spring (Utah Division of Wildlife Resources 2007). Moose habitat is thought to be improved by annual flooding and habitat management techniques such as prescribed burning (BLM 2005b). In addition to predation by wolves and bears, snow accumulation may have a controlling effect on moose populations. Habitat degradation due to high numbers of moose can lead to population crashes (NatureServe 2007).

American Bison (Bos bison). The American bison inhabits grasslands, semidesert shrublands, pinyon-juniper woodlands, and alpine tundra (Colorado Division of Wildlife 2007). They are grazers with grasses, sedges, and rushes comprising most of their diet (Colorado Division of Wildlife 2007). American bison are diurnal, being especially active during early morning and late afternoon. They have several grazing periods that are interspersed with periods of loafing and ruminating (NatureServe 2007). Within the project area, American bison are often found in managed herds that are often closely confined (Colorado Division of Wildlife 2007). Only a few remnant wild populations occur in US and Canadian national parks (NatureServe 2007). Pre-1900 herds migrated up to several hundred miles between summer and winter ranges, but herds that currently exist either make short migrations or do not migrate (Utah Division of Wildlife Resources 2007).

***Caribou (Rangifer tarandus*).** Caribou inhabit arctic tundra, subarctic taiga, mature coniferous forest, semi-open and open bogs, rocky ridges with jack pine, and riparian zones throughout all habitats. Migratory herds in Alaska winter in boreal forest and summer in tundra. Caribou are gregarious and in tundra form loose herds of about 1,000. Tundra caribou may travel extensively in summer in attempt to avoid bothersome insects (Eastland et al. 1989).

Caribou often incur high calf loss, mostly due to predation by wolves (Bergerud et al. 1984). The Porcupine Herd of northeastern Alaska give birth on patches of bare ground within snowfields (Eastland et al. 1989) and cows select areas north of the foothills (snow conditions permitting), thereby reducing exposure of calves to predators. In northeastern Alaska and adjacent Canada, first-year survival of calves was 51 percent; mean annual survival rate was 84 percent for adult females and 83 percent for adult males; and hunting mortality for the herd averaged 2 to 3 percent annually (NatureServe 2007).

American Black Bear (Ursus americanus). American black bear is found mostly within forested or brushy mountain environments and woody riparian corridors (Utah Division of Wildlife Resources 2007). They are omnivorous. Depending upon seasonal availability, they will feed on forbs and grasses, fruits and acorns, insects, small vertebrates, and carrion (Colorado Division of Wildlife 2007). Breeding occurs in June or July, with young born in January or February (Utah Division of Wildlife Resources 2007). American black bears are generally nocturnal, and have a period of winter dormancy (Utah Division of Wildlife Resources 2007). They are locally threatened by habitat loss and disturbance by humans (NatureServe 2007). The home range size of American black bears varies depending on area and gender and has been reported to be from about 1,250 to nearly 32,200 acres (NatureServe 2007).

Grizzly Bear (Ursus arctos). Brown bear are found mostly in arctic tundra, alpine tundra, and subalpine mountain forests. They were once found in a wide variety of habitats, including open prairie, brushlands, riparian woodlands, and semidesert scrub, but have since been extirpated these areas. Sustainable populations require huge areas of suitable habitat (Craighead 1976). Diet is highly variable and consists of fruits, nuts, large and small mammals, fish, insects, and tuberous roots. Grizzly bears are common only where food is abundant and concentrated (e.g., salmon runs, caribou calving grounds). Grizzly bears become dormant during the winter. Young are born in the den and emerge in spring (NatureServe 2007).

Cougar (Puma concolor). Cougars (also known as mountain lions) inhabit most ecosystems in the project area, but are most common in the rough, broken terrain of foothills and canyons, often in association with montane forests, shrublands, and pinyon-juniper woodlands (Colorado Division of Wildlife 2007). They mostly occur in remote and inaccessible areas (NatureServe 2007). Their annual home range can be more than 560 square miles, while densities are usually not more than 10 adults per 100 square miles (NatureServe 2007). The mountain lion is generally found where its prey species (especially mule deer) are located. In addition to deer, they prey upon most other mammals (which sometimes include domestic livestock) and some insects, birds, fishes, and berries (Colorado Division of Wildlife 2007). They are active year round. Their peak periods of activity are within two hours of sunset and sunrise, although their activity peaks after sunset when they are near humans (NatureServe 2007, Utah Division of Wildlife Resources 2007). They are hunted on a limited and closely monitored basis in some states (BLM 2004a, NatureServe 2007).

3.10.2 Climate Change

Changes in climate can influence the timing and length of seasons, which in turn can have a direct effect on plants and animals. This includes changes in ranges, abundances, phenology (timing of an event such as breeding), morphology and physiology, and community composition, biotic interactions, and behavior. Changes are being seen in all different types of taxa, from insects to mammals, in North America as well as on many other continents.

3.11 THREATENED, ENDANGERED AND SPECIAL STATUS SPECIES

In the project area, there are over 2,000 species considered threatened, endangered, or of special concern at national, regional or state level (all referred to as special status) occurring on or near public and NFS lands (Table 3-22), Plants, Invertebrates, Fish, and Wildlife Listed under the Endangered Species Act Occurring on or near Public and NFS Lands in the Project Area). Species considered special status are either federally listed as threatened or endangered under the Endangered Species Act (see below), are proposed for future listing, or considered special status by the BLM, FS, or individual states programs. The number of species considered for special status is dynamic and could change throughout the time period considered by the PEIS. The number of special status species occurring in the planning area cannot be accurately accessed because species occurrences are not always reported or known, species can be rare, location and accurate range are not always well defined, and habitats may change over time. For the purposes of this analysis, it is assumed that all special status species that occur in the project area would have the potential to occur in the planning area.

Table 3-22
Plants, Invertebrates, Fish, and Wildlife Listed under the Endangered Species Act Occurring on or near Public and NFS Lands in the Project Area

State	Plants	Invertebrates	Fish	Amphibians	Reptiles	Mammals	Birds
Endangered							
Alaska	1	-	-	-	1	4	2
Arizona	11	1	8	1	-	8	6
California	134	26	15	6	3	29	11
Colorado	6	1	4	-	-	2	4
Idaho	-	4	2	-	-	3	1
Montana	-	-	2	-	-	2	3
Nevada	2	1	17	-	-	1	1
New Mexico	7	7	6	-	-	4	4
Oregon	9	1	4	-	1	6	4
Utah	11	1	7	-	-	2	2
Washington	3	-	1	-	1	7	3
Wyoming	-	-	5	1	-	2	1
Threatened							
Alaska	-	-	-	-	-	3	2
Arizona	6	-	8	1	1	1	1
California	45	6	15	2	8	4	6
Colorado	7	1	1	-	-	3	2

Table 3-22
Plants, Invertebrates, Fish, and Wildlife Listed under the Endangered Species Act Occurring on or near Public and NFS Lands in the Project Area

State	Plants	Invertebrates	Fish	Amphibians	Reptiles	Mammals	Birds
Idaho	4	1	4	-	-	3	-
Montana	3	-	1	-	-	2	1
Nevada	7	1	5	-	1	1	-
New Mexico	6	-	7	1	1	1	1
Oregon	6	2	15	-	2	4	3
Utah	13	-	1	-	1	3	1
Washington	6	1	14	-	-	4	3
Wyoming	3	-	-	-	-	3	-
Candidate							
Alaska	1	-	-	-	-	-	1
Arizona	3	4	2	1	1	-	1
California	10	3	-	3	-	2	2
Colorado	6	-	1	-	-	-	2
Idaho	2	-	-	-	-	1	1
Montana	1	1	-	-	-	-	1
Nevada	4	1	-	3	-	-	1
New Mexico	-	4	2	-	1	-	2
Oregon	2	2	-	1	-	2	3
Utah	1	3	-	1	-	-	1
Washington	5	2	-	1	-	10	3
Wyoming	1	-	-	-	-	-	1

Source: USFWS 2008

Special status aquatic animal species are found on public lands throughout the US. A number of listed salmon populations are found in rivers in the Pacific Coast states. In arid habitats, many special status fish species are found in the rare and fragile desert wetlands and springs, as well as in major rivers such as the Colorado and the Rio Grande. In the deserts of the Great Basin and Colorado Plateau, terminal lakes, marshes, and sinks provide important habitats for special status fish species that are adapted to their warm, saline conditions. Special status mollusk species occur predominantly in the Snake River of Idaho and in thermal habitats and small springs and wetlands in New Mexico, Arizona, and Utah. Aquatic arthropods of special status occur predominantly in the vernal pools of California. Special status terrestrial arthropods are largely butterflies that occur mostly in open habitats. Special status amphibians occur in wetland habitats throughout the west, and special status reptiles occur in warm habitats of California and the southwest. Special status birds and mammals use a wide range of habitats found on public and NFS lands throughout the project area.

3.11.1 Endangered Species Act

The Endangered Species Act (ESA) was passed in 1973 to address the decline of fish, wildlife, and plant species in the US and throughout the world. The purpose of the ESA is to conserve "the ecosystems upon which endangered and threatened species depend" and to conserve and recover listed species (ESA 1973, Section 2). The law is administered by USFWS and the US Department of Commerce, National Marine Fisheries Service (NMFS). The USFWS has primary responsibility for terrestrial and freshwater organisms, while the NMFS is primarily responsible for marine species such as salmon and whales.

Under the ESA, species may be listed as either endangered or threatened. The ESA defines an endangered species as any species that is in danger of extinction throughout all or a significant portion of its range (ESA 1973, Section 3[6]). A threatened species is one that is likely to become an endangered species within the foreseeable future throughout all or a significant part of its range (ESA 1973, Section 3[20]). All species of plants and animals, except pest insects, are eligible for listing as endangered or threatened. The ESA also affords protection to critical habitat for threatened and endangered species. Critical habitat is defined as the specific areas within the geographical area occupied by the species at the time it is listed, on which are found physical or biological features essential to the conservation of the species and which may require special management considerations or protection (ESA 1973, Section 3[5][A and B]). Except when designated by the Secretary of the Interior, critical habitat does not include the entire geographical area that can be occupied by the threatened or endangered species (ESA 1973, Section 3[5][C]).

Species may also be candidates for listing (ESA 1973, Section 6[d][1] and Section 4[b][3]). The USFWS defines proposed species as any species that is proposed in the *Federal Register* to be listed under Section 4 of the ESA. Candidate species are those for which USFWS has sufficient information on their biological status and threats to propose them for listing as endangered or threatened under the ESA, but for which development of a listing regulation is precluded by other higher priority listing activities (USFWS 2004a). The NMFS defines candidate species as those proposed for listing as either threatened or endangered or whose status is of concern, but for which more information is needed before they can be proposed for listing. Candidate species receive no statutory protection under the ESA, but by definition these species may warrant future protection under the ESA.

Federally listed species that could occur in the project area are included in Appendix H.

BLM Special Status Species Policy

On public lands, the BLM is required to manage plant and wildlife species that are listed or proposed under the ESA, which has nine sections containing requirements or authorizations that apply to the BLM (ESA Sections 2, 4, 5, 6, 7, 9, 10, 11, and 18). These are addressed in BLM Manual 6840 — Special Status Species Management (BLM 2001), which establishes special status species policy for plant and animal species and the habitats on which they depend. The policy refers not only to species listed under the ESA, but also to those designated by the BLM State Director as sensitive. BLM Manual 6840 defines a sensitive species as a species that could easily become endangered or extinct in the state. Criteria in BLM Manual 6840 for designating a species as sensitive are as follows:

- The species is under ESA status review by the USFWS or NMFS;
- The numbers of individuals of the species are declining so rapidly that federal (ESA) listing may become necessary;
- The species has typically small or widely dispersed populations; or
- The species inhabits an ecological refugium or other specialized or unique habitat.

Under BLM Manual 6840, the BLM is required to use other agencies' lists (such as threatened and endangered lists, watch lists, and species of concern lists issued by various state and federal agencies) (Table 3-23, Plant, Invertebrate, and Fish and Wildlife Considered BLM Special Status in the Project Area). For example, the BLM Utah State Office currently uses the Utah Division of Wildlife Resources' sensitive animals list as the BLM list. The number of sensitive species varies across the project area BLM State Offices (Table 3-23, Plant, Invertebrate, and Fish and Wildlife Considered BLM Special Status in the Project Area). Similarly, which species may occur at a geothermal energy development project in the planning area would depend on the particular state in which the project is located, the species list for that state, and the specific location (and associated habitats) of the proposed project, and would need to be addressed in the site-specific environmental analysis.

Forest Service Threatened, Endangered & Sensitive Species Program

The Threatened, Endangered & Sensitive Species Program is the Forest Service's dedicated initiative to conserve and recover plant and animal species that need special management attention and depend on National Forest and Grassland habitats. In addition to contributing to the recovery of threatened and endangered species, the Forest Service management also conserves habitat for some 3,250 sensitive species. These are species listed by the FS as needing special management to maintain and improve their status on National Forest and Grasslands, and prevent a need for listing under the ESA.

Table 3-23
Plant, Invertebrate, and Fish and Wildlife Considered BLM Special Status in the Project Area

State	Plants	Invertebrates	Fish	Amphibians	Reptiles	Mammals	Birds
Alaska	33	-	6	-	-	2	26
Arizona	44	24	7	-	13	9	2
California	497	13	4	8	11	21	9
Colorado	79	1	4	5	6	4	11
Idaho	161	21	21	8	7	29	50
Montana	98	-	10	6	5	15	29
Nevada	116	74	46	3	7	33	34
New Mexico	179	27	23	6	15	22	32
Oregon	457	59	38	12	2	20	36
Utah	101	28	22	4	13	19	19
Washington	196	2	8	2	4	20	20
Wyoming	37	-	8	4	1	9	13

Source: Alaska Natural Heritage Program 2007; Arizona Game and Fish Department 2007; BLM 2002, 2004a, 2004b, 2006b, 2007c, 2007d, 2007e; Colorado Natural Heritage Program 2007; Keinath et al. 2003; Montana Natural Heritage Program 2006, 2007; New Mexico Department of Game and Fish, Conservation Services Division 2006; New Mexico Rare Plant Technical Council 2005; Nevada Natural Heritage Program 2007; Utah Department of Natural Resources, Division of Wildlife Resources 2006.

The FS Threatened, Endangered & Sensitive program involves a variety of activities conducted by the FS and government, educational, and private organization partners. These include inventory and monitoring, habitat assessments, habitat improvements through land treatments and structure installation, species reintroductions, development of conservation strategies, research, and information and education (FS 2007a). Table 3-24, US Forest Service Special Status Species by Project Area State, provides the numbers of FS plant and wildlife species listed under the program.

State-listed Species

Each of the project area states also has species identified that are of state concern. Some species are listed per a specific definition and afforded protection and/or management under a state regulation. Other species are on some form of watch list; these species are tracked with regard to their abundance and distribution within a state by organizations, such as the state Natural Heritage Program. The species that occur on public or NFS lands in the planning area and that may be affected by a specific geothermal energy development project would depend upon the location of that particular project, and would need to be addressed in the site-specific environmental analysis.

Table 3-24
US Forest Service Special Status Species by Project Area State

State	Plants	Invertebrates	Fish	Amphibians	Reptiles	Mammals	Birds
Alaska	19	-	3	-	-	1	5
Arizona	129	30	10	8	14	47	36
California	377	14	23	20	13	14	9
Colorado	61	5	9	4	1	9	21
Idaho	75	-	5	3	1	5	10
Montana	104	-	6	5	3	14	14
Nevada	96	3	7	2	1	5	7
New Mexico	65	41	14	8	10	54	38
Oregon[1]	428	61	12	12	7	12	25
Utah							
Washington[1]	288	43	13	10	7	13	23
Wyoming	63	-	12	5	1	13	26

[1]For USFS areas spanning more than one state, species are counted under both states when not indicated by USFS which specific state they are found.

Source: Colorado Natural Heritage Program 2007; Keinath *et al.* 2003; Martin 2007; Montana Natural Heritage Program 2006; FS 2000, 2001, 2004b, 2007a, 2007b, 2007c, 2007d, 2007e

3.11.2 Threats to Special Status Species

A variety of factors affect endangered, threatened, and special status species. Some threats are greater for certain taxa or ecosystems, while others, including habitat loss from urbanization and agricultural development, have a wide-spread potential effect. Habitat loss is a primary threat to species and reason for their decline. The loss of suitable habitat is the result of one or more factors, including both direct human impact through urbanization and land and water use and global and regional climate change (McKinney 2002). Invasive species and genetic hybridization can also adversely affect sensitive species.

Land use is also a primary influence on species decline. Urbanization, logging, mining, water diversion, agriculture, and recreation have all historically affected populations of native plants and animals. Land use can reduce and fragment habitat (Donovan and Flather 2002, NatureServe 2008, Newlon 2005). Fragmentation of forests results in reduced habitat for territorial species such as the brown bear *(Ursus arctos)*, which require large home ranges (Campbell 1999). Indirect effects of various land uses include road construction and erosion, which can increase the effect on waterways and riparian habitats and can fragment terrestrial habitats. Land use can result in the introduction of nonnative species and the need for diversion of water for irrigation, and efforts to control potential threats to crops and livestock with the use of chemicals can affect species. Endangered native bunchgrass and sagebrush communities have been diminished by the invasion of introduced species and historical clearing of land for agricultural use. Species that are obligate to these communities, such as the state-listed Gunnison sage grouse *(Centrocercus minimus)*, have consequently experienced population decreases (Johnson, Jr. 2007, NatureServe 2008, USFWS 2004b). In drier ecoregions, such as temperate and sub-tropical desert and steppe, federally endangered Devil's Hole pupfish *(Cyprinodon diabolis)* and other desert organisms endemic to isolated permanent aquatic habitats have historically been threatened by the diversion of water (NVDCNR 2007).

Climate change has a disproportionate effect on special status species. Based on analysis of temperature and precipitation data from the 20th century and models on continued climate change patterns, it is anticipated that global temperatures will continue to rise and weather patterns will become increasingly erratic. This trend is anticipated to result in ongoing increases in precipitation in historically wetter ecoregions and further reduced precipitation in historically drier ecoregions. The broad implications of these changes affect all species but are specifically detrimental to highly specialized species (Diaz 2004, Joyce et al. 2007).

As climate change continues, wetter ecoregions, such as the subarctic and marine, will experience increased levels of precipitation. The increased moisture in these habitat areas will result in greater vegetative biomass and reduced desert habitat. This has the potential to encourage distribution and heighten population levels of invasive plant species, particularly in historical desert areas where native species may be less tolerant of increased precipitation. Desertification has already contributed to the decline of sagebrush and bunchgrass habitat and associated species.

Invasive species are those that are not historically native to a habitat or region. Often they are introduced purposefully for agricultural use, hunting, pest control, or aesthetic purposes. Other times they are unintentionally introduced, traveling in the bilge water of transoceanic ships, shipping containers, or on the wheels and insides of cars. Or they may arrive through accidental release from captivity. The three major threats from nonnative species are competition, predation, and hybridization.

Plant communities may be dramatically altered by the invasion of nonnative species. Sagebrush habitat has been overcome by cheatgrass *(Bromus spp.)*, an invasive plant found in every US state (Chambers et al. 2005, Pendleton et al. 2007, USFWS 2004b). Competition for nonnative species also impacts wildlife. Accidental release of brown trout into federally threatened native bull trout habitat has created competition for food sources (Epifanio et al. 2003).

Predation by non-native species is a common threat to sensitive species of birds, aquatic invertebrates, amphibians and small mammals that have evolved defensive tactics against certain types of predation. Frequently the threat of predation by non-native species is compounded by threats from urbanization and other land use activities.

The threat of hybridization, the process of cross-breeding two closely-related species, is the dilution of the sensitive population's gene pool to the point at which the sensitive species is no longer distinct. Hybridization is not always successful in producing a viable mixed-gene population. The progeny of two distinct species can be sterile, increasing the rate of population decline in the sensitive species (USFWS 2007b).

3.11.3 Climate Change

Changes in climate can influence the timing and length of seasons, which in turn can have a direct effect on threatened and endangered species and their habitat. This may include changes in ranges, abundances, phenology (timing of an event such as reproduction), morphology and physiology, and community composition, biotic interactions, and behavior. Changes are being seen in all different types of taxa, from insects to mammals, in North America as well as on many other continents.

3.12 WILD HORSES AND BURROS

The BLM, in conjunction with the FS, manages wild horses and burros on BLM- and FS-administered lands through the Wild Free Roaming Horse and Burro Act of 1971. Animals are managed within 199 herd management areas with the goals of maintaining the natural ecological balance of public lands and the ability to support multiple herds (BLM 2007h). Herd population management is important for balancing herd numbers with forage resources and other uses of public and adjacent private lands (BLM 2004c, d). Wild horses that are found outside of herd management areas are considered excess and are subject to annual removal. Removed animals are made available for adoption. Unadoptable individuals are destroyed in the most humane manner possible (BLM 2004c). On average, a herd of 10 wild horses or burros uses about 3,600 acres, with most herd management areas occupying 10,000 to 100,000 acres or more (BLM 2007h). Annual home range (the area habitually occupied by a herd over the course of a year) is usually less than 6,178 acres but may be as large as 74,132 acres (NatureServe 2007). As wild horse numbers within a herd can increase up to 25 percent annually, they can affect the condition of their range and increase competitive pressure among wild horses, livestock, and wildlife. Therefore, wild horse and burro herd size is maintained through gathers that are performed every three to five years. A gather is a roundup of wild horses and burros, usually conducted by helicopter. Once gathered, a specialist loads the animals onto trucks for transport to a holding area at the gather site where determinations are made about which animals will be returned to the range and which will be sent to a BLM preparation facility. Gathered horses and burros sent to a BLM preparation facility are placed for adoption through the Wild Horse and Burro Adoption Program or otherwise placed in long-term holding facilities. The BLM is currently researching the use of immuno-contraceptives to slow the reproductive rate of wild horses and burros (BLM 2004d). Issues that make wild horse and burro management difficult include:

- Competition between large game animals (elk, deer, antelope) and horses;
- Herd management areas located within areas where critical soils (i.e., soils that pose salinity problems and/or are very susceptible to erosion) make up more than 50 percent of the area;
- Competition with livestock; and
- Illegal chasing, capturing, and harassment (BLM 2004d).

Wild horses generally occur in common social groups of several females that are led by a dominant male. Young males are expelled from the social group when they are one to three years old and form bachelor groups (NatureServe 2007). They feed on grass and grass-like plants and browse on shrubs in winter. They visit watering holes daily and may dig to water in dry river beds (NatureServe 2007). Wild horses also tend to dominate water sources, driving wildlife away

(BLM 2004b). They are sometimes regarded as a pest because they can foul water, compete with livestock, or displace native ungulates such as pronghorn and bighorn sheep (NatureServe 2007).

Table 3-25 summarizes the wild horse and burro statistics for the project area for fiscal year 2007. Ten of the 12 western states (there are no herds in Alaska or Washington) have a total of 28,563 wild horses and burros, although the appropriate management level (i.e., the maximum number of animals sustainable on a year-long basis) is considered only 27,492 animals (BLM 2007h).

3.12.1 Climate Change

As discussed in Section 3.6 Soils and Section 3.9 Vegetation, climate change can affect both the soils and vegetation that wild horses and burros depend upon for food and habitat. As mentioned above, changes in soil stability increase the challenges with the management of wild horses and burros, particularly when more than 50 percent of the areas on which they are located already have soil issues. Changes in vegetation can pose either advantages or challenges for wild horses and burros in meeting their nutritional requirements, depending on what changes in vegetation occur.

Table 3-25
Project Area Wild Horse and Burro Statistics (Fiscal Year 2007)

State	Herd Areas			Herd Management Areas				Populations			
	BLM Acres	Other Acres	Total Acres	No. Herd Management Areas	BLM Acres	Other Acres	Total Acres	Horses	Burros	Total	Total Appropriate Management Level
Alaska[1]	-	-	-	-	-	-	-	-	-	-	-
Arizona	2,019,932	1,617,998	3,637,930	7	1,756,086	1,327,777	3,083,863	215	1,501	1,716	1,600
California	5,112,778	1,851,661	6,964,439	22	1,946,590	471,855	2,418,445	2,478	635	3,113	2,199
Colorado	658,119	76,572	366,098	4	366,098	38,656	404,754	771	0	771	812
Idaho	428,421	49,235	477,656	6	377,907	40,287	418,194	803	0	803	617
Montana	104,361	119,242	223,603	1	28,282	8,865	37,147	154	0	154	105
Nevada	19,593,299	3,088,027	22,681,326	102	15,778,284	1,695,925	17,474,209	12,467	528	12,995	13,485
New Mexico	88,653	37,874	126,527	2	24,505	4,107	28,612	89	0	89	83
Oregon	3,559,935	785,250	4,345,185	18	2,703,409	259,726	2,963,135	2,092	15	2,107	2,715
Utah	3,236,178	689,176	3,925,354	21	2,462,726	374,614	2,837,340	2,543	195	2,738	2,151
Washington[1]	-	-	-	-	-	-	-	-	-	-	-
Wyoming	7,297,778	3,030,010	10,327,788	16	3,638,330	1,137,121	4,775,451	4,077	0	4,077	3,725
Total	42,099,454	11,345,045	53,444,499	199	29,082,217	5,358,933	34,441,150	25,689	2,874	28,563	27,492

[1] No horse or burro herds are present in Alaska or Washington.

Source: BLM 2007H

3.13 LIVESTOCK GRAZING

The primary laws that govern grazing on public lands are the Taylor Grazing Act of 1934, the FLPMA, and Public Rangelands Improvement Act of 1978. The three enabling statutes that govern grazing on NFS lands are the Organic Administration Act, the Bankhead-Jones Farm Tenant Act, and the Multiple-Use Sustained-Yield Act.

The Taylor Grazing Act directs that occupation and use of the range be regulated to preserve the land and its resources from destruction or unnecessary injury, and to provide for the orderly use, improvement, and development of the range. FLPMA provides authority and direction for managing federal lands on the basis of multiple use and sustained yield and mandates land use planning principles and procedures for federal lands. The Public Rangelands Improvement Act does the following:

- Defines rangelands as public lands on which there is domestic livestock grazing or that are suitable for livestock grazing;
- Establishes a national policy to improve the condition of public rangelands so they will become as productive as feasible for all rangeland values;
- Requires a national inventory of public rangeland conditions and trends; and
- Authorizes funding for range improvement projects.

The BLM manages rangelands on public lands under 43 CFR Part 4100 and BLM Handbooks 4100 to 4180. The BLM conducts grazing management practices through BLM Manual H-4120-1 (BLM 1984). The FS primarily manages grazing and management on NFS lands under 36 CFR 222, Forest Service Manuals (FSM 2200 – Range Management), and Forest Service Handbooks (FSH 2200 – Range Management) (FS 2007f). Under this management, ranchers may obtain a grazing permit for an allotment of public or NFS land on which a specified number of livestock may graze. An allotment is an area of land designated and managed for livestock grazing. The number of permitted livestock on a particular allotment on public land is determined by how many animal unit months that land will support. An animal unit month is the quantity of forage required by one mature cow and her calf (or the equivalent in sheep or horses) for one month. Upper and special limits governing the total number of livestock for which a person is entitled to hold a grazing permit on NFS lands is determined by the Chief of the Forest Service based factor identified in 36 CFR 222.

Approximately 154,897,988 acres of public and 103,129,814 acres of NFS lands are grazed in the project area. Approximately 125,131,307 acres of public and 70,187,293 acres of NFS lands are grazed in the planning area. Table 3-26 lists

Table 3-26
Livestock Grazing Permits, Leases, and Active Animal Unit Months on Public Lands in the Project Area (Fiscal Year 2006)

State	Leases and Permits	Active AUMs	Receipts form Leases, Licenses and Permits
Alaska*	0	0	$0
Arizona	757	660,007	$693,917
California	548	355,726	$318,202
Colorado	1,591	650,168	$649,238
Idaho	1,890	1,348,526	$1,619,808
Montana	3,755	1,281,144	$2,027,960
Nevada	644	2,137,635	$2,277,130
New Mexico	2,275	1,856,795	$2,104,970
Oregon	1,277	1,026463	$1,332,862
Utah	1,499	1,239,786	$1,236,951
Washington	283	33,603	$49,166
Wyoming	2,792	1,960956	$2,332,290
Total	**17,311**	**12,550,809**	**$14,642,494**

* Data does not include reindeer grazing permits. There are approximately 11 case files with open permits issued by the BLM . There are approximately 7.134 animals currently grazing.
Source: BLM 2006c

Table 3-27
Authorized Livestock Permits and Active Animal Unit Months on National Forest System Lands[1] in the Project Area (Fiscal Year 2005)

State	Permits	Active AUMs
Alaska	0	0
Arizona	392	592,856
California	413	381,047
Colorado	710	774,533
Idaho	765	703,784
Montana	802	458,890
Nevada	134	226,066
New Mexico	672	522,065
Oregon	294	341,193
Utah	815	543,670
Washington	108	81,135
Wyoming	463	616,871
Total	**5,568**	**5,242,110**

[1] Forest Service System Lands include National Forests, National Grasslands, Land Utilization Projects, and other federal lands for which the FS has administrative jurisdiction.
Source: FS 2006b

grazing statistics on public lands within the project area. The total number of grazing permits/leases on public lands in the project area was 17,311, with a total of 12.6 million animal unit months authorized. These grazing authorizations produced approximately $14.7 million in grazing fees (BLM 2006c).

Within the planning area approximately 10,138,925 AUMs are available within 125,131,307 acres of public land, and approximately 3,303,980 AUMs are available within 70,187,293 acres of NFS lands.

3.13.1 Climate Change

The consequences of weather and climate change on livestock grazing and grassland use can be subtle and complex. The projected changes in climate–increases in temperature, reductions in soil moisture, and more intense rainfall events–may require changes in livestock management. The availability of feed and water for livestock grazing is extremely vulnerable to drought; hence, the carrying capacity of land may influence livestock management.

3.14 CULTURAL RESOURCES

Cultural resources are past and present expressions of human culture and history in the physical environment and include prehistoric and historic archaeological sites, structures, natural features, and biota that are considered important to a culture, subculture, or community. Cultural resources also include aspects of the physical environment that are a part of traditional lifeways and practices and are associated with community values and institutions. These traditional cultural resources are addressed in a separate chapter on ethnographic resources and tribal trust assets (Chapter 3.15). Cultural resources addressed in this section include the physical remains of prehistoric and historic cultures and activities, such as archaeological sites, historic trails, and boom towns. Historic properties are a subset of these kinds of cultural resources that meet specific eligibility criteria found at 36 CFR 60.4 for listing on the National Register of Historic Places (NRHP).

In this chapter, cultural resources are discussed according to established culture regions: Alaska (Arctic and Subarctic), California, Great Basin, Great Plains, Northwest Coast, Plateau, and Southwest. These are regions where there is continuity across the landscape in cultural adaptations, traditions, environment, and habitats. For consistency, maps defining these regions and the cultural groups within them are derived from the respective volumes of the Smithsonian Handbook of the American Indian and reflect the choices of the authors and editors of this series. These maps generally depict territorial assumptions existing at the approximate time of Native contact with Euro-Americans and may not encompass territorial ranges or ancestral lands as recognized by tribes or archaeologists. For example, important Ancestral Puebloan occupations in Southwestern Colorado are found outside of the tribal ranges for the Southwest region. This is a programmatic level overview and should not be considered a detailed source for the extent of regional cultural influence or tribal interest.

Culture resources of these regions have been organized into prehistoric and historic resources. Prehistoric resources refer to any material remains, structures, and items used or modified by people before Euro-Americans established a presence in the region. Historic resources include material remains and the landscape alterations that have occurred since the arrival of Euro-Americans.

Appendix I provides detailed discussions of the prehistoric and historic cultural resources and patterns of these regions. Within each region's discussion, a table is provided to indicate the languages spoken by ethnographically recorded tribes. Discussions of prehistory within each region are focused on chronological periods that have been established based on the region's prehistoric archaeology. It should be noted that for many of these regions, there are area-specific culture chronologies that have been developed where cultural practices were unique within the larger region. Discussion of such specific time periods is avoided given the programmatic nature of this document and for ease of discussion. Although the culture regions are most appropriately applied to prehistoric populations, historic period resources are also organized by these culture regions for the ease of discussion. Discussions of the history within each region are organized by overall themes of the region. This includes such things as westward expansion, transportation, and mineral development. Because this approach leads to a very general discussion of the culture regions, an effort was made to coordinate with the BLM and FS field, regional, and district offices within the planning area to identify areas sensitive for cultural resources. The discussions in this section are based on the larger overview provided in Appendix I.

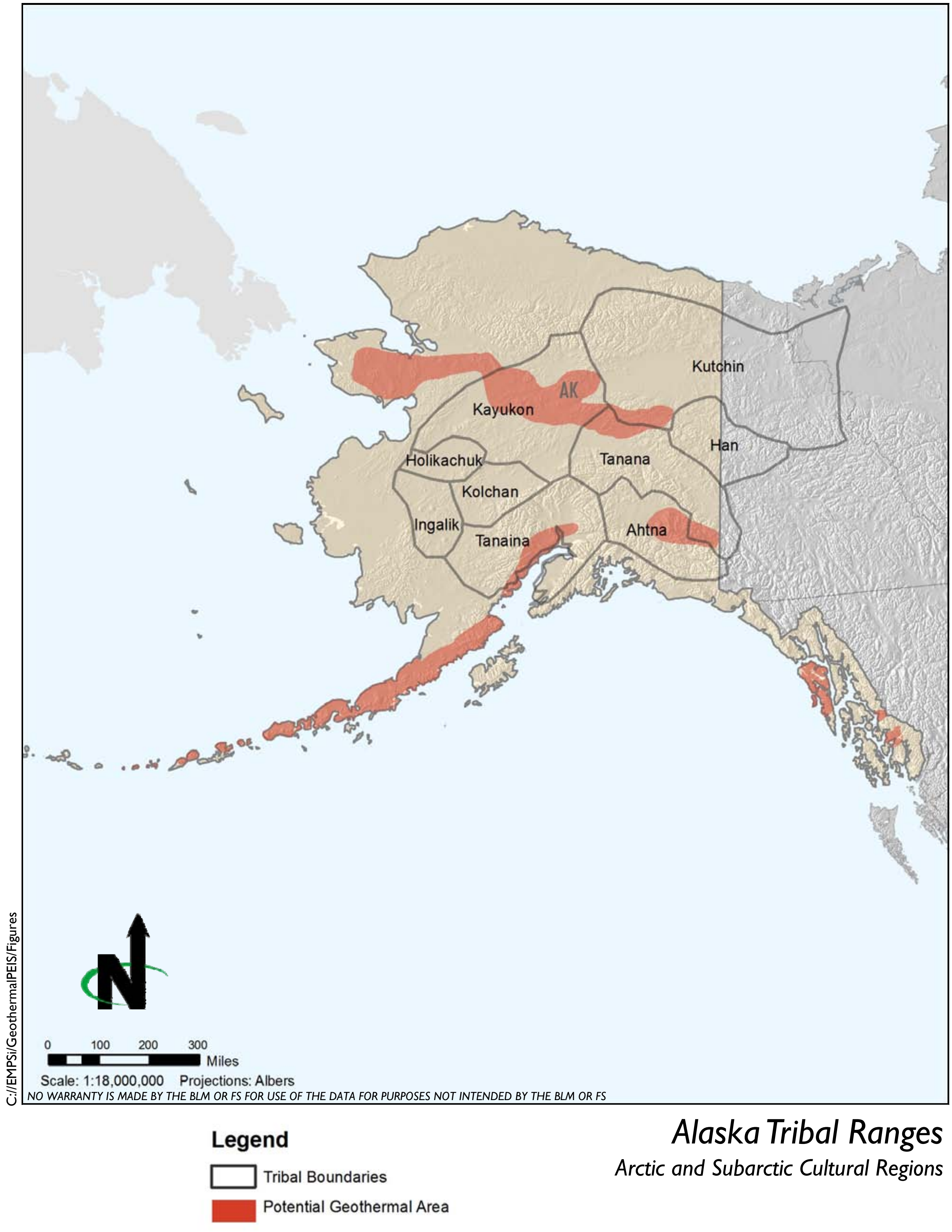
3.14.1 Alaska (Arctic and Subarctic)

Alaska is divided into two culture regions, the Arctic and Subarctic, which are combined into the Alaska culture region for purposes of this discussion (Figure 3-15 – Alaska [Arctic and Subarctic Culture Regions] Tribal Ranges). Within the project area, the Alaska culture region includes most of FS Region 10 and all or portions of the western BLM Field Offices.

Much of Alaska was ice free during the last glacial period, and the archaeology of the area is considered likely to provide important information pertaining to early North American human settlement. However, Pre-Clovis evidence for occupation of Alaska is debatable, and the early coastline has been greatly altered from rising sea levels. The earliest agreed-upon evidence is for a microblade tradition in the Paleoindian Subarctic, similar to that of the Archaic Northwest Coast (Neusius and Gross 2007).

Many of the later prehistoric cultural traditions outlined in Appendix I still occur in modern times within contemporary populations of Alaska. Based on the discussed prehistoric patterns, expected prehistoric sites of the region include isolated fluted points, lithic scatters, shell middens, burials, village sites, camp sites, and resource procurement sites. Most are expected to be situated along the coastline to facilitate marine mammal hunting, rivers to facilitate fishing, and inland in areas that produce game and plants. There are exceptions to this distribution pattern given regional variability.

Historic Alaska witnessed early Russian, Spanish, and English exploration and fur trading, bringing early contact with Native Alaskans. Other historic period activities include commercial whaling and fishing, missionization, gold mining, oil development, railroad construction, and development of other transportation-related routes. Historic-era sites expected within the region include early exploration settlements and camps; trading posts; whaling and salmon fishing facilities and communities; mineral mining, mineral development sites, and transport appurtenances such as pipelines, railroad tracks, and associated boom towns; and trails and associated towns.



Alaska Tribal Ranges

Arctic and Subarctic Cultural Regions

Figure 3-15

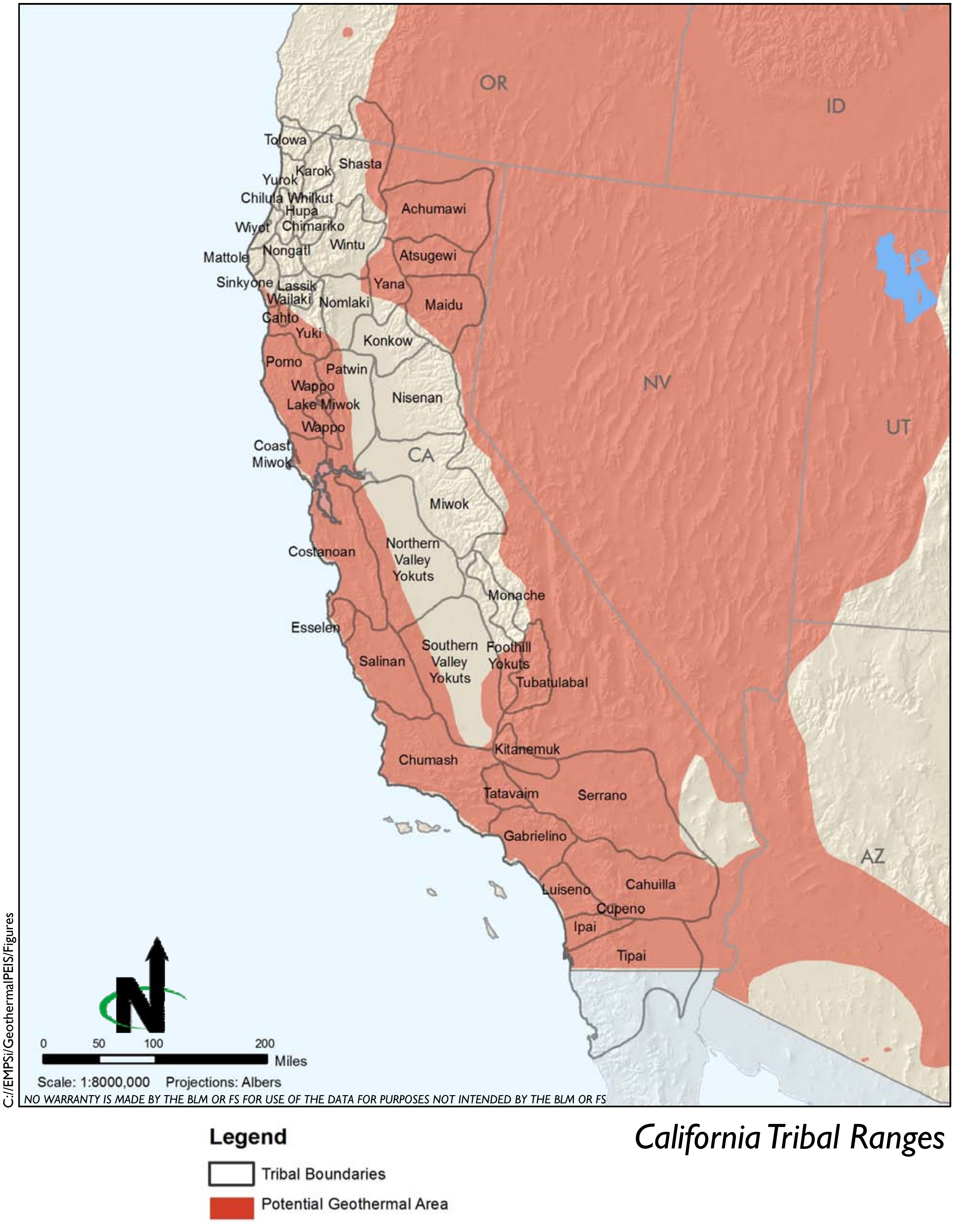
3.14.2 California

The California culture region resembles the modern state; however, it excludes parts of the northwest and northeast corners of the state (Northwest Coast and Plateau culture regions, respectively), as well as the Mojave Desert and areas east of the Sierra Nevada (Great Basin culture region) (Figure 3-16 – California Tribal Ranges). Within the project area, the California culture region includes all of FS Region 5 and a small southern portion of FS Region 6 in Oregon and all or portions of the western BLM Field Offices.

The early prehistory of California has been dramatically affected by post-glacial sea level rise, resulting in coastline inundation and coastal environment alteration. Consequently, any sites formed during the Paleoindian period along the now-submerged coastline would also be submerged or eroded. Additionally, the coastal environments would have been different than what they are today, making it difficult to assign sensitivity for cultural resources based solely on modern coastal environments.

Some of the earliest sites of the California culture region are isolated lithics and lithic scatters found on ground surfaces. A series of such sites have been found along the coastline and associated with coastal rivers, lagoons, and estuaries; a pattern for sites that continued through later periods. Other site types expected in the California region include shell middens, permanent village sites with pithouses, large and small seasonal base camps, smaller seasonal camps, specialized resource procurement sites (such as quarries, rock art, petroglyphs, pictographs, and bedrock milling stations), and cemeteries. Site occurrence can be most expected along the coast on higher ground, such as bluffs and marine terraces, at lagoons and estuaries, along the open coast at permanent bays and wetlands, along creeks and rivers, and in the foothills and mountains.

The largest effect on the Native American populations of California was missionization by the Spanish, who established missions, presidios, and pueblos (towns), primarily along coast and adjacent inland valleys. This affected social organization and subsistence activities of prehistoric populations. Early Euro-American exploration of the California culture region was done not only by the Spanish, but also by Britons, Russians, Mexicans, and later, Americans. Large numbers of Chinese later emigrated to the region, often establishing separate camps and small enclaves across the region. Major historic industries of the region included mining, agriculture, ranching, and railroad construction. Trails and transportation routes were also established and used by the early explorers, emigrants, and industries. Site types to be expected based on these activities include exploration camps, early settlements, Chinese camps and towns, missions, presidios, pueblos, ranches, farms, mines, mining camps, and railroads and trails with their associated boom towns.



California Tribal Ranges

Figure 3-16

3.14.3 Great Basin

The cultural region of the Great Basin is based on the hydrographic region of the same name, but is extended to include the area between the Sierra Nevada and the Rocky Mountains (Figure 3-17 – Great Basin Tribal Ranges). Within the project area, the Great Basin culture region includes portions of FS Regions 1 through 6 and all or portions of the western BLM Field Offices.

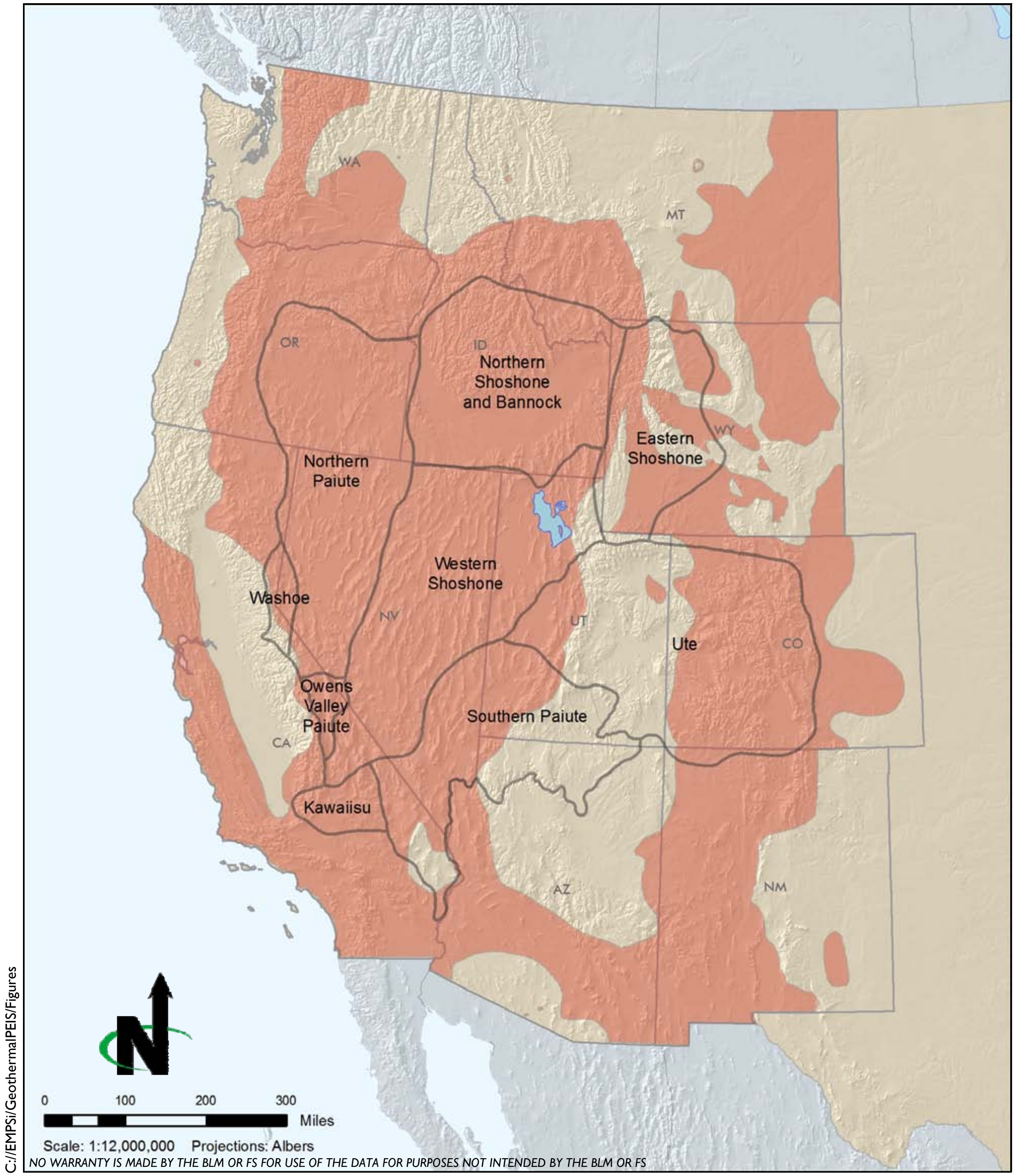
The Great Basin region exemplifies an Archaic stage for nearly all of prehistory. It is varied in landform and climate. These different environments within the region require a variety of adaptations that have resulted in diverse cultural traditions.

Based on prehistoric patterns discussed in Appendix I, expected prehistoric sites of the Great Basin region are as varied as the region. Isolated Paleoindian fluted points could occur throughout the region, particularly in Utah and the western Great Basin. Other site types found in the region include village sites with pithouses and later architecture, seasonal sites, temporary camps, burials, caches, rock art, turquoise mines, and agricultural features such as irrigation ditches. A number of areas and geographic features have been identified as particularly sensitive for one or several of these site types depending on time period and setting. These are discussed in Appendix I. A select few examples include caves, valley floors, and margins of pluvial lakes.

Spanish and Mexican exploration resulted in some early intermittent contact with Native populations of the Great Basin. This was followed by migration of peoples across and through the region but little settlement until after the mid-nineteenth century. Historic period activities include mining, ranching, farming, western expansion, railroad construction, and trail establishment. Historic-era cultural resources expected within the region include early exploration settlements and camps, mineral exploration and mining locales, mining camps, historic farms and ranches, railroad tracks and associated boom towns, and historic trail routes and associated towns.

3.14.4 Great Plains

The area between the Saskatchewan River in the north, the Rio Grande in the south, the foothills of the Rocky Mountains in the west, and the upper Mississippi River valley in the east makes up the Great Plains culture region (Figure 3-18 – Great Plains Tribal Ranges). The majority of this culture region is east of the project (and planning) area; project (and planning) area states within the Great Plains culture region include eastern Montana, Wyoming, and Colorado (the easternmost portion of the project (and planning) area in New Mexico is included in the Southwest culture area). Within the project area, the Great Plains culture region includes portions of FS Regions 1 and 2 and all or portions of the western BLM Field Offices.



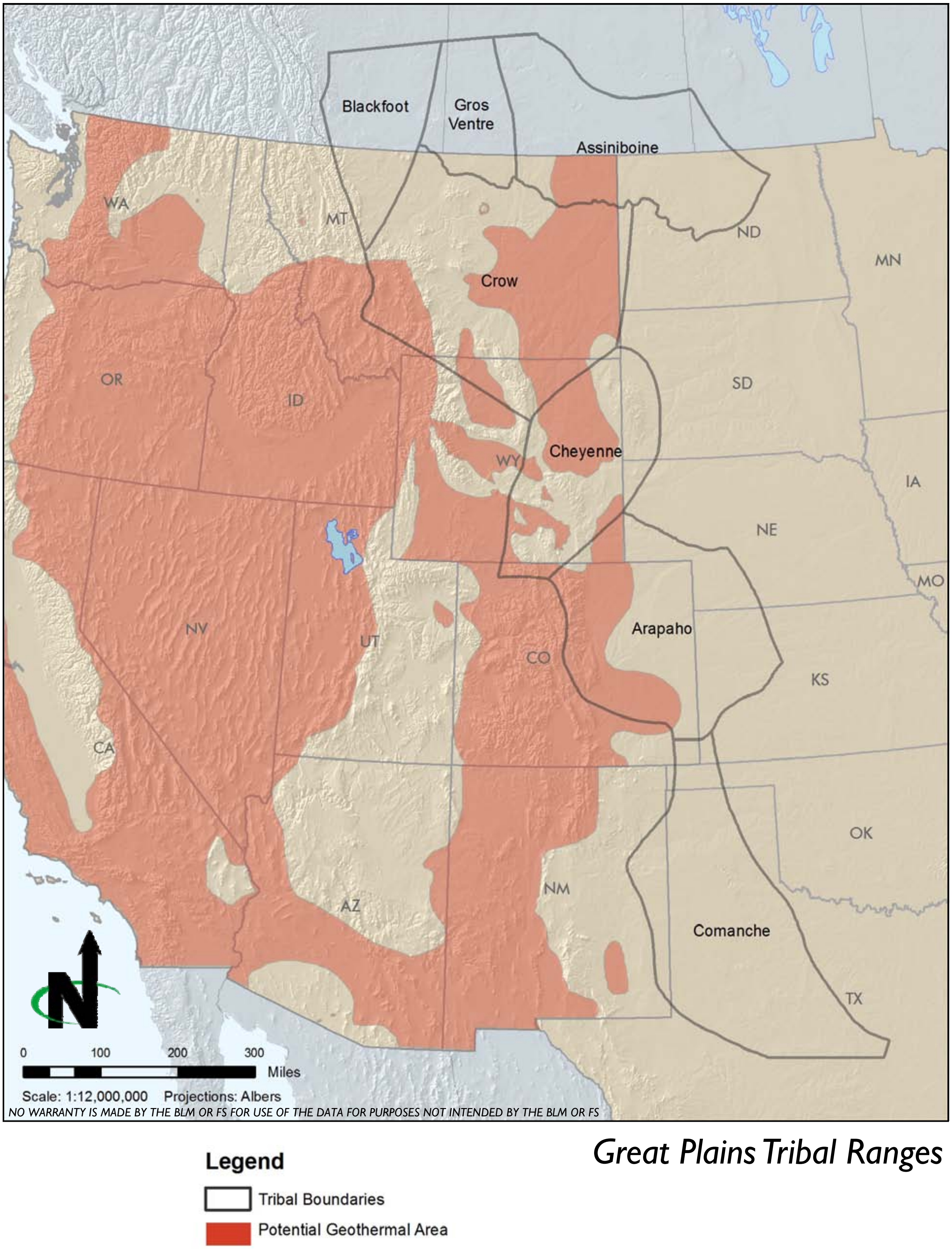
Great Basin Tribal Ranges

Legend

Tribal Boundaries

Potential Geothermal Area

Figure 3-17



Great Plains Tribal Ranges

Figure 3-18

The cultures of the Great Plains region are quite varied, primarily due to the diverse environs it covers. Different environments require unique adaptations by the occupants. However, all cultures of the Great Plains regions have at least one trait in common: bison hunting.

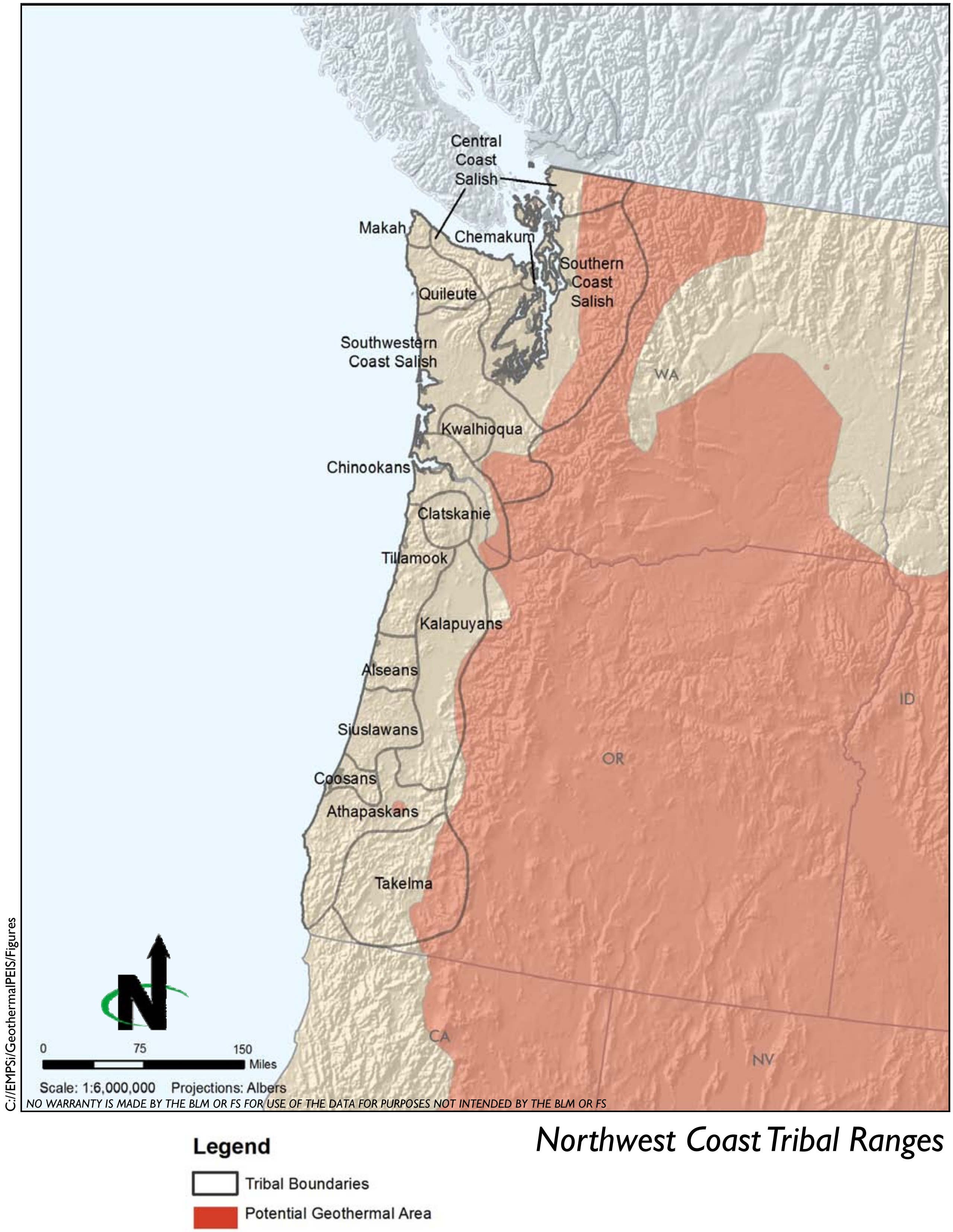
Site types expected to occur within the Great Plains culture region include surface lithic scatters, quarries, blade and biface caches, burials, large game kill sites (such as bison drives, traps, and jump sites), artificial corrals for collecting and killing large game, horticultural areas (particularly in the eastern Great Plains), occupational sites with housepits and associated storage and fire pits, stone rings, petroglyphs, pictographs, and stone cairns and lines. Additionally, horticultural features can be expected to occur in the river valleys of the region, with the exception of the northwest and western-central Great Plains. Great Plains sites can often occur in caves and rockshelters, especially in northern Wyoming and Montana, in mountainous regions, in the high plains, in arroyos, in sand dunes, on steep bluffs, along prehistoric lakeshores created by retreating glaciers, in intermontane basin interiors, in foothills, on butte tops, on barren ridges, on stream terraces, and on raised topographic features in the interior basins and plains.

The Great Plains region of the project area continued to support mobile bison hunters during the historic period, while further east, several migrations and relocations occurred, creating a tangled history of movement in those areas. One of the most significant historic occurrences in the culture region was the introduction of the horse by early Spanish explorers, which affected intertribal relations, social structures within tribes, and economies. The Spanish were followed by other Euro-Americans who developed fur and hide trading in the region. Additionally, ranching, mining, and westward expansion via railroad and trail became notable activities. Based on the discussed activities, historic-era cultural resources that can be expected within this part of the project area include exploration campsites, trading posts, ranches, mines, mining camps, early European and American settlements, and railroads and trails with their associated boom towns.

3.14.5 Northwest Coast

The Northwest Coast culture region covers areas between the crest of the Cascades and the Pacific Ocean from the Copper River delta and Yakutat Bay in Alaska, south to the Winchuck River and Cape Mendocino in California (Figure 3-19 – Northwest Coast Tribal Ranges). Within the project area, the Northwest Coast culture region includes portions of FS Regions 5, 6, and 10 and all or portions of the western BLM Field Offices.

The Northwest Coast culture region is highly varied and divided. Similar to other coastal regions, the early prehistory of the Northwest Coast has been dramatically affected by post-glacial sea level rise, resulting in inundation of the



Northwest Coast Tribal Ranges

Figure 3-19

coastline and altering coastal environments. The entirety of the Northwest Coast was ice free as of 12,000 years ago, although lands immediately adjacent to the Pacific Ocean were never glaciated. The region is unique in that its moist nature has led to excellent preservation in many saturated sites.

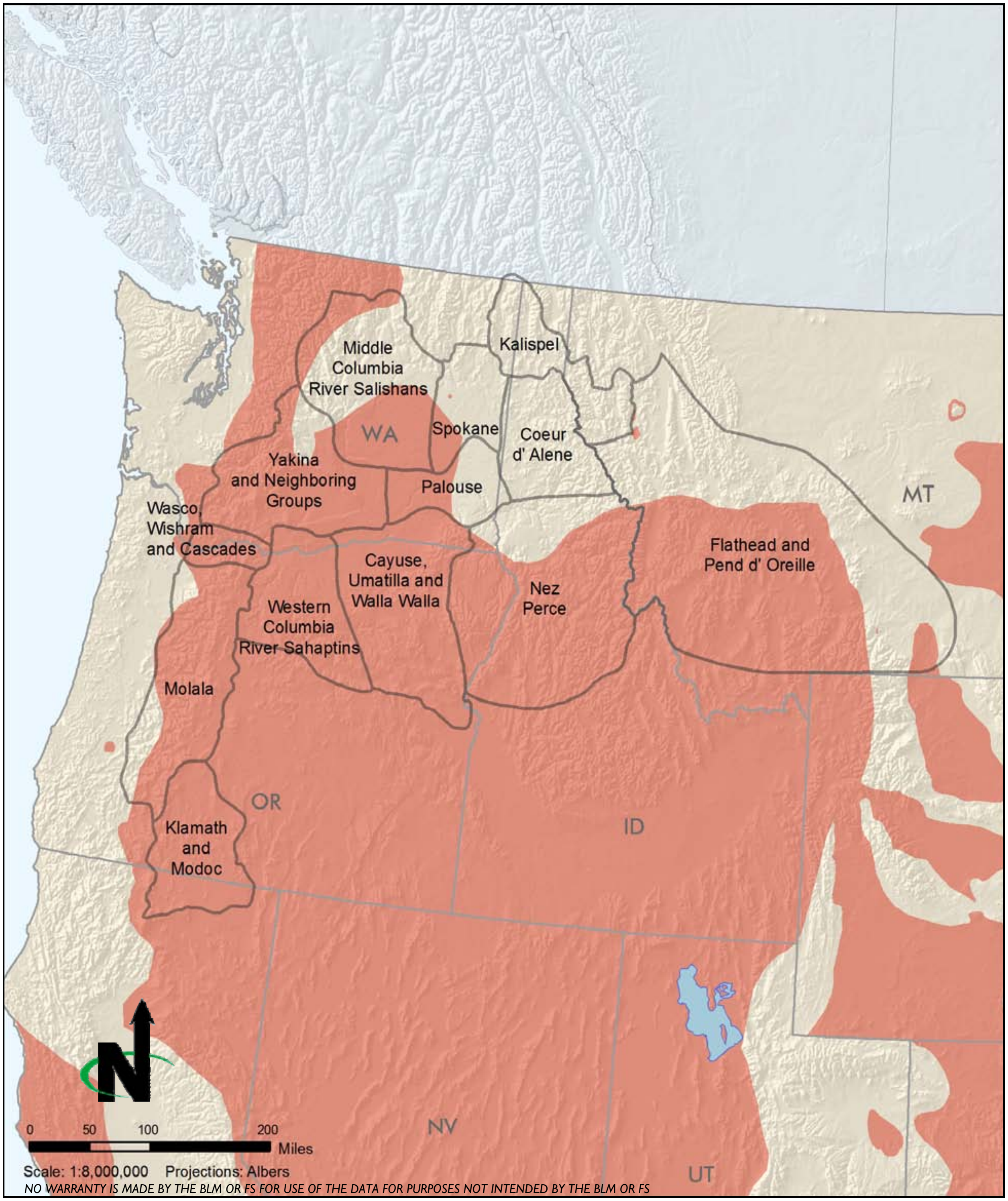
Based on the prehistoric patterns of the Northwest Coast culture region discussed in Appendix I and the environmental conditions discussed above, there is likelihood for submerged sites along coastlines and rivers. Additionally, research has suggested that many early archaeological sites may be ephemeral. Isolated Clovis fluted points could occur throughout the region as surface finds. Other site types include caches, temporary campsites, fishing sites/locales, large and dense middens, villages possibly with pithouses or preserved plank houses, cemeteries, and built fortifications. These are most likely to exist along the coast and rivers, especially the Columbia River; the eastern boundary with the Plateau culture region; and on bluff tops and other defensible locations.

Early explorers from Spain, England, and Russia brought the fur trade to the Northwest Coast culture region. Other historic industries within the region included mining of gold, silver, copper, coal, and other minerals; fishing; timber; and agriculture. A number of trails were established to facilitate exploration, trade, and migration, including the Oregon, Applegate, Cowlitz, and Lewis and Clark Trails. Additionally, railroads, along with rivers and ports, developed in the region to allow for travel and movement of goods. Site types to be expected with these activities include campsites, trading posts, trails and railroads with their associated towns, timber mills, mining camps, farms, and port cities.

3.14.6 Plateau

The Plateau culture region comprises the area drained by the Columbia and Fraser Rivers and includes portions of Oregon, Washington, Idaho, Montana, and northern California, with the exception of some areas within the Great Basin (Figure 3-20– Plateau Tribal Ranges). In general, the area covers parts of British Columbia, eastern Washington, western and northern Oregon, the Idaho panhandle, and western Montana. Within the project area, the Plateau culture region includes portions of FS Regions 1, 4, 5, and 6 and all or portions of the western BLM Field Offices.

The Plateau culture region is highly varied and has established several subregional chronologies to deal with the variety. However, researchers have identified several characteristics that are common throughout the region. These include a subsistence base of fish, game, and roots; use of complex fishing technologies; intermarriage and cooperative use of subsistence resources among groups; relatively uniform mythology, art styles, and religious practices; village and band levels of social organization; institutionalized trade; and linear settlement patterns.



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Plateau Tribal Ranges

Legend

Tribal Boundaries

Potential Geothermal Area

Figure 3-20

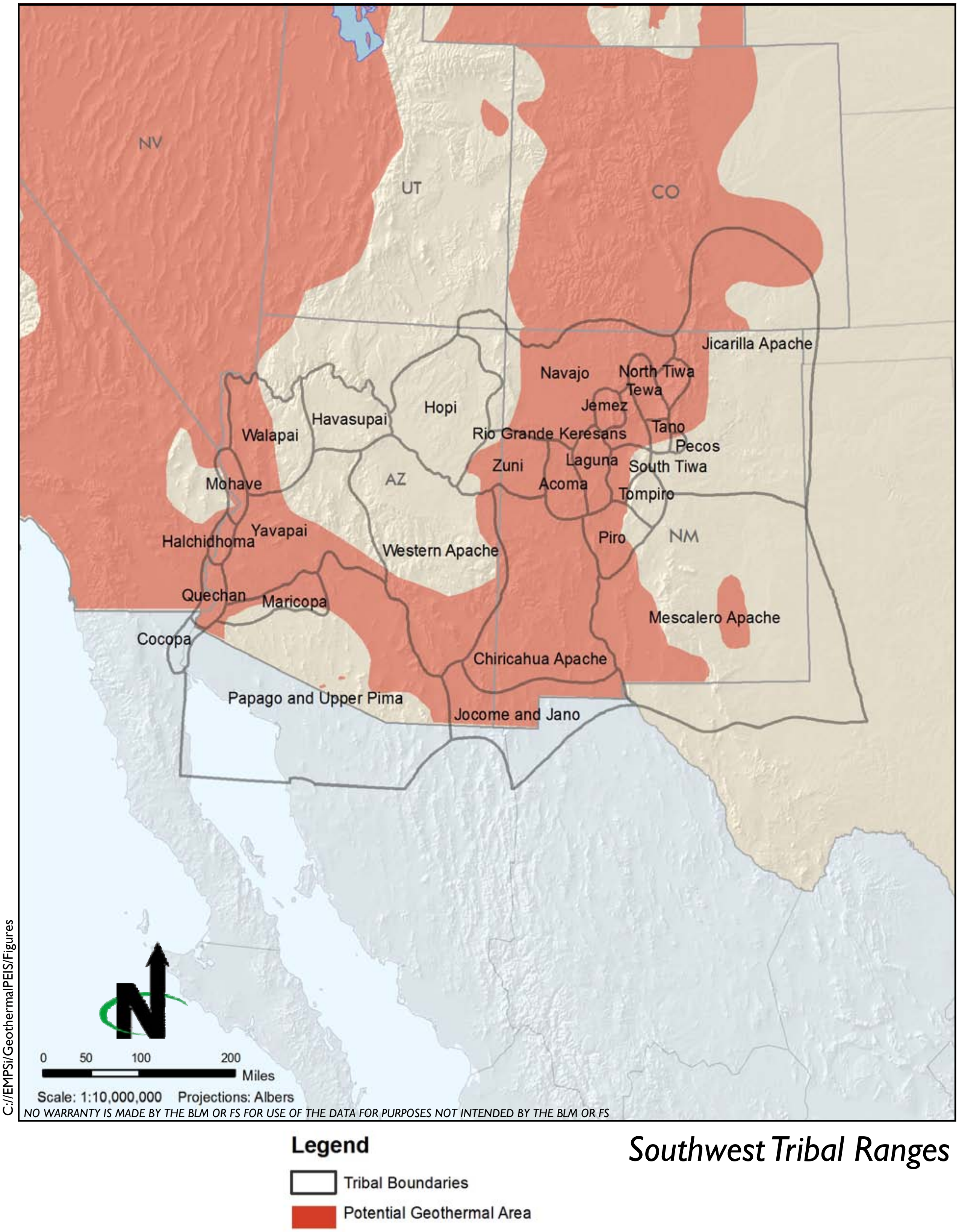
Paleoindian evidence in the Plateau culture region is represented by a single developed site and various scattered surface artifacts across the region. Early sites also indicate a disparity between the north and south, where sites in the north are often ephemeral lithic scatters and sites in the south tend to be short-term occupation sites. Often, permanent habitation sites are found near the steppe-forest margins of the lowlands. Later, village sites with large numbers of pithouses are found in the lower reaches of large rivers. Other site types expected in the region include semi-permanent villages, temporary subsistence camps, burials (sometimes with multiple internments), and bison kill sites. The likelihood of sites to occur within a specific region or topographic area depends on the time period. Sites range from high to low elevations across prehistory, often being located along main rivers.

Russian and Spanish explorers were the first to have contact with Native Americans of the Plateau culture region. Later, the Lewis and Clark expedition crossed the region and Presbyterian, Jesuit, Mormon, and Catholic missionaries settled there. Industries that developed in the region as Euro-Americans became established include the fur trade, mining, agriculture, ranching, logging, and fishing. Exploration and migration into the Plateau culture region was facilitated by the railroad and historic trails that crossed the area. Site types to be expected based on these major historic themes of the Plateau culture region include camps of early explorers, mission establishments, mines, mining camps, trading posts, farms and ranches with associated irrigation features, fisheries and canneries along major rivers, timber mills, trails (such as the Oregon and Lewis and Clark Trails), railroads, and boom towns.

3.14.7 Southwest

The Southwest culture region covers all of Arizona, the western majority of New Mexico, the southern tip of Nevada, southern Utah, extreme southern and western Texas, and parts of southwest Colorado (Figure 3.21 – Southwest Tribal Ranges). Important Ancestral Puebloan occupations in Southwestern Colorado are found outside of the tribal ranges depicted at the time of contact for the Southwest region. The region does include parts of northern Mexico, but since this part of the region is not included in the project area, it is not discussed here. USFS regions included in the Southwest region include portions of Regions 2 and 4 and all of Region 3. BLM field offices in the region include all or portions of all field offices in New Mexico and Nevada, with the exception of the Arizona Strip Office. In addition, the southwestern cultural region includes portions of field offices in southern Colorado.

This is a highly varied region culturally that is rich in cultural resources. Many of the tribes and pueblos may have more in common with neighboring cultural regions because of their shared environmental contexts. As a whole, the Southwest culture region is demanding of its inhabitants and requires extensive adaptations to its environments for survival. This is recognized in the



Southwest Tribal Ranges

Figure 3-21

development of agriculture, domestication, stone and masonry architecture, and irrigation systems, as well as mysterious abandonments in some areas. A wide array of other traditions, some having been adopted from Mesoamerican cultures, also characterizes the cultures of the region. However, because of the diversity of the environments, these adaptations vary among the area's subregions.

Evidence of the earliest human occupation in the Southwest culture region is found throughout in the form of isolated big game kill and butchering sites. More common sites expected include temporary sites with simple houses, seasonal camps, crop fields with associated irrigation features, villages with advanced architecture, pithouses, pueblos, kivas, and cliff dwellings. Sites are most expected to occur in the foothill and mountain areas; in the floors, caves, and rockshelters of valley floors formed by permanent rivers; in dry lake basins; along rivers and drainages; and on river terraces, hilltops, mesas, and other defensible locations; and in arroyo mouths. Important sites were largely abandoned in many areas prior to contact, including the four corners area north into Colorado and Utah. Later populations aggregated in the Rio Grande valley, west-central and eastern New Mexico, and eastern Arizona, making these areas particularly sensitive for later sites.

Spanish explorers entered the Southwest culture region by following the Rio Grande north from Mexico. Early cities and towns were established mostly in river valleys and associated with established Native American communities. Here, missions and military outposts were founded. New Mexico, Arizona, and Texas are particularly sensitive for these resources. Once the area was passed to Mexico and ultimately ceded to the US, development of the region continued with more military posts, stage routes, ranches, mines, and new American settlements. Other activities and site types expected to occur in the culture region include ranches and farms, trading posts, mines, mining camps, ghost towns, trails, railroads, and roads.

3.15 TRIBAL INTERESTS AND TRADITIONAL CULTURAL RESOURCES

This section is an overview of separate but related resource considerations primarily involving Native America Indian tribes and Native Alaskans. Tribal interests include economic rights such as Indian trust assets and resource uses and access guaranteed by treaty rights. Traditional cultural resources or properties include areas of cultural importance to contemporary communities, such as sacred sites or resource gathering areas. While most commonly considered in the context of Native Americans and Native Alaskans, there are traditional cultural resources associated with other ethnic or socially linked groups, such as Hispanics in the Southwest. Although Indian reservations and restricted lands are explicitly excluded from geothermal leasing under this PEIS, there are tribal and Native Alaskan interests and traditional use of public and NFS lands that could be impacted by geothermal leasing and development. Geothermal leasing and development could also impact adjacent or nearby reservations, trust lands, restricted Indian allotments, and federally tribal-dependent Indian communities.

3.15.1 Tribal Interests

The trust responsibility is the US Government's permanent legal obligation to exercise statutory and other legal authorities to protect tribal lands, assets, resources, and treaty rights, as well as a duty to carry out the mandates of federal law with respect to American Indian and Alaska Native Tribes. Federal Indian policy and trust responsibilities have developed from court decisions, congressional laws, and policies articulated by the President. Different departments, branches of government, and agencies have defined responsibilities. The Secretary of the Interior has specific trust responsibilities not delegated to any other department or agency, including holding land in trust and maintaining monetary accounts for tribes and individual tribal members.

For the BLM and FS, trust responsibilities are essentially those duties that relate to the reserved rights and privileges of federally recognized tribes as found in treaties, executive orders, laws, and court decisions that apply to public and NFS lands. Trust responsibilities for the BLM are found in DOI Secretarial Order No. 3215 (US DOI 2000), 512 Department Manual Chapter 2 (US DOI 1995), and BLM Manual H-8160-1 (BLM 1994). For FS activities, trust responsibilities are defined primarily by the authorities listed Forest Service Manual 1563.01 and by treaties that may apply to specific areas of the National Forest System. As federal land managing agencies, the BLM and FS have the responsibility to identify and consider potential impacts of plans, projects, programs, or activities on Indian lands, trust resources, and treaty rights. When planning any proposed project or action, the agencies must ensure that all anticipated effects on Indian lands, trust resources, and treaty rights are addressed in the planning, decision, and operational documents prepared for each project. Federal agencies must ensure that meaningful consultation and coordination are conducted on a government-to-government basis with federally recognized tribes.

Much of the public domain land in the lower 48 states was originally obtained by treaties made with Indian tribes. Approximately 60 tribes have treaties that contain some rights to off-reservation lands and resources. Other laws define the subsistence rights of Alaskan Natives to use natural resources on federal land (FS 1997). Treaties are negotiated contracts made pursuant to the US Constitution and take precedence over any conflicting state laws because of the Constitution's supremacy clause (Article 6, Clause 2). Treaty rights are not gifts or grants from the US, but are bargained-for concessions from sovereign governments. Other sources of defined reciprocal rights and obligations assumed by the federal government and Indian tribes include congressional and executive branch actions to acquire Indian lands, establish reservations, provide federal recognition of tribes, and remove Indian peoples to reservations or rancherias. Rights on federal lands are interpreted and applied by the federal courts. Some federal statutes, congressional acts, and executive orders do not distinguish between federally and non-federally recognized tribes and bands.

Indian tribes and Native Alaskans often view these rights and resource uses as holistically interconnected with culture, tradition, and spiritual practice. Among many groups, land, water, geologic features, landscapes, and other seemingly inanimate objects are considered sacred. Federal land policy and legal precedents, however, make distinctions between economic rights and resource uses and those that are cultural or spiritual.

Indian trust assets are legal interests in assets held in trust by the federal government for federally recognized Indian tribes or nations or for individual Indians. Assets are anything owned that has monetary value. A legal interest refers to a property interest for which a legal remedy, such as compensation or injunction, may be obtained if there is improper interference. A trust has three components, including the trustee, the beneficiary, and the trust asset. The beneficiary is also sometimes referred to as the beneficial owner of the trust asset. In the Indian trust relationship, the US is the trustee and holds title to these assets for the benefit of an Indian tribe or nation or for individuals.

These assets can be real property, physical assets, or intangible property rights. Examples include lands, minerals, water rights, gathering rights, hunting and fishing rights, rights to other natural resources and forest products, money, or claims. They need not be owned outright, but can include other types of property interest, such as a lease or a right to use something. Some treaties express a priority right for a resource; others express a proportional, or in common, right. Indian trust assets cannot be sold, leased, or otherwise alienated without federal approval.

Indian trust assets do not include things in which a tribe has no legal interest. Without a treaty or act of Congress specifying otherwise, land ownership can affect the determination of whether or not a resource is an Indian trust asset. For example, an off-reservation resource-gathering area in which a tribe has no legal property interest would generally not be considered an Indian trust asset. In this case, if religious or cultural resources could be affected by the federal action, these interests would be addressed as part of the cultural resources or social impact assessment because of the lack of legal property interest. The same resource on a reservation, trust, or ceded land may be an Indian trust asset, as determined on a case-by-case basis.

The DOI's Departmental Manual Part 303, Indian Trust Assets, defines general DOI policy and principles for managing Indian trust assets. Department of the Interior agencies are required to protect and preserve Indian trust assets; ensure their use promotes the interests of the beneficial owner; enforce leases; promote tribal control; manage and distribute income; maintain good records; and protect treaty-based fishing, hunting, gathering, and similar rights of access and resource use on traditional tribal lands.

Several tribes are also interested in recovering ownership of lands that were part of their original land base and, therefore, would be concerned about committing lands to other uses. The federal government has the authority to convey land to federally recognized tribes under different authorities. The FS exchanges land, BLM transfers land, and Congress may legislatively restore or create tribal land out of federal land. Land has been conveyed in recent years through these means.

Some tribes that were parties to unratified treaties did not surrender any land or resources to the US. Although these cases were settled, some individuals and tribes did not accept the land settlement money. The DOI, through the Bureau of Indian Affairs, holds accounts for those who have not extinguished their aboriginal claims to land and who continue to reserve the right to pursue further legal action.

Other tribal interests include general concerns about ecosystem management, maintaining healthy lands and water, and restoring the natural resource base. Tribal and Native Alaskan communities and regional entities often request that their local knowledge be included in resource management decisions.

3.15.2 Traditional Cultural Resources

Traditional cultural resources or properties are places associated with the cultural practices or beliefs of a living community. They can be considered a subset of the broader category of cultural resources, which are discussed in Section 3.14. Traditional cultural properties are rooted in the community's history and are important in maintaining cultural identity. Examples of traditional cultural properties include natural landscape features, ceremonial and worship places, plant gathering locations, traditional hunting and fishing locations, ancestral archaeological sites, artisan material locations, rock art and communal resources such as community-maintained irrigation systems. The boundaries of these resources and impact areas are often difficult to assess. Resources tied to particular locations and that meet the criteria for eligibility can be listed on the National Register of Historic Places. Some traditional cultural resources have values that do not have a direct property referent and may not manifest themselves by distinguishable physical remains, but still are subject to consideration in planning. It is the continuity of their significance and importance to the maintenance of contemporary traditions that is important.

While many traditional cultural resources are well known, some locations or resources may be privileged information that is restricted to specific practitioners or clans. For tribes, maintaining confidentiality and customs regarding traditional knowledge may take precedence over identifying and evaluating these resources, unless they are in imminent danger of damage or destruction. In some cases, the connections of contemporary communities with a particular location or an ancestral site may have been lost, but are rediscovered or recognized during the planning process. A person with traditional knowledge may associate a place or site with a tradition, practice, oral history, ancestral use, or belief important to the community's cultural life. For identification of traditional cultural resources, field visits are usually required. Systematic field survey could be needed to locate resources, such as ancestral archaeological sites. Ethnographic studies could be necessary to ensure issue identification. Multiple tribes may have interests potentially affected in a particular lease area. Agencies must be flexible in making a good-faith effort to consult with tribes when their actions could affect these resources. Consultation must be conducted in a manner that is sensitive to different world views, time frames, communication modes, and information confidentiality.

3.15.3 Tribal Interests and Traditional Cultural Resources

Project Area

Tribal Interests and traditional cultural resources are identified primarily through consultations with federally recognized Indian tribes on a government-to-government basis (Executive Order 13084 and Executive Memorandum of April 29, 1994, on Government-to-government Relations with Native American Tribal Governments). In the case of non-federally recognized tribes and other potentially affected communities, direct consultations are also necessary to identify traditional cultural resources.

Typically the tribal government is the primary point of contact for identifying Indian trust and treaty rights, but the US Bureau of Indian Affairs and the Interior Office of the Special Trustee are also often consulted. In the lower 48 states, there are 46.2 million acres of Indian trust land and 8.9 million acres of individual trust allotments (FS 1997). There is no comprehensive list of all Indian trust assets for tribes and individual Indians. If needed, further information on the nature of the trust asset is determined by examining government documents, such as treaties, court decisions, water rights adjudication proceedings, and reservation-establishing proclamations. Since trust and treaty rights are often subject to interpretation and are often contested, agency legal counsel is usually consulted.

For the purposes of this PEIS, in September 2007, an initial contact letter was sent via certified US Mail by the Deputy Director of the BLM and Deputy Chief of the FS to over 400 tribes and Alaskan Native groups in the project area. The letter described the PEIS process and pending lease locations and invited recipients to consult on the project. Previously, in June 2007, these groups were also sent a newsletter announcing the project. To date, responses have been received from seven tribal representatives. Four respondents requested that their groups be consulted on the project if lease areas fall within their areas of interest. Two respondents requested consultation and to participate in the PEIS process. One respondent noted that no lease applications were in their area of interest. Additional contact efforts are planned, and agency consultation will be conducted with those tribes and Native Alaskan groups who have requested inclusion. Consultation and coordination efforts are described further in Chapter 6.

Planning Area

In the planning area, there is extensive geographic, environmental, historic, economic, social, ethnic, and religious diversity that is reflected in the tribal interests and traditional cultural resources that may be valued by Native American, Native Alaskans, and other potentially affected communities. There is no comprehensive way to define all of the resources on this broad scale, especially where confidentiality is often required. There is also considerable overlap between what an outsider or another group might define as economic interests and natural resource issues, and ones that have religious and cultural meaning to a group. Throughout the western US, the BLM and FS have established programs and relationships with tribes that provide the means to further engage tribes on their interests, values, concerns, and priorities on a more-local level and project-specific basis. Continued consultations and ethnographic studies would be necessary to identify issues specific to locations considered for geothermal leasing in the planning area. Some common categories of these interests and resources are presented here.

The planning area includes Indian trust or restricted lands in which the title is held by the US in trust for an Indian or an Indian tribe, or lands in which the title is held by Indians or an Indian tribe but is subject to restriction by the US against transfer. These lands can be on or off reservations. The BLM is prohibited from issuing leases on these properties, but trust assets need to be identified. There may be conflicts with agencies about existing trust assets, tribal treaty rights, or ownership claims. Tribes may have interests in converting public and FS land to trust land or in reestablishing portions of their ancestral land base.

There are tribal interests and traditional cultural resources associated with water rights and the uses of water sources, such as rivers, lakes, and springs.

Although Indian-reserved water rights are not expressed in treaties, they are inherent or implied rights. The reserved water right as applied to Indians is derived from Winters v. US 1908. This Supreme Court case held that, "sufficient water was implicitly reserved to fulfill the purposes for which the reservation was established." The Winters Doctrine provides that tribes have senior water rights. Recent court cases have found that Indian reservations have priority water rights on federal lands, including public and NFS lands. Water rights and priority claims for reservation and off-reservation uses are likely to occur in the planning area. Additionally, these rights and claims often are in the same geographic area where tribes could have concerns about enhancing flows for fish, maintaining plant and wildlife riparian habitat, and preserving cultural locations' use and setting (FS 1997). Among many tribes, all water and water sources are associated with power and essential life forces. Water sources are considered sacred, and hot springs are especially important. Springs are places where prayers are said, ceremonies are held, and offerings are made. The hot mineral water and mud from hot springs are often used for healing (Bengston 2003).

Resource-gathering areas are a broad category that can include trust assets; treaty and subsistence rights and resources; and culturally significant plants, animals, fish, and minerals. Plant resources can include foods that were established as part of a traditional seasonal round. Examples include traditions of gathering acorns in California, pine nuts in Nevada, camas roots in the Pacific Northwest, berries in the Plateau region, mesquite pods in the Southwest, and a variety of seed plants west-wide. Other examples of plant resources include fibers used for basketry and weaving in the eastern Sierra, and wood for building, carving, and fuels. Many plants are gathered for medicinal and religious use. Plant gathering is often a communal activity with cultural and religious significance. Loss of access to these plants or gathering locations, or losing the ability to maintain their habitats, can affect religious and ceremonial uses.

Hunting and fishing rights are often guaranteed by treaties, and many traditionally used locations and habitats are prized. Wildlife and fish are also important in the cosmology of many Native American groups and in exercising traditional lifeways. In Alaska, for example, some hunting and butchering is often a community-based traditional activity as well as a subsistence right. In the Pacific Northwest, salmon continues to be a large part of most Columbia River tribes' culture and is connected to sustaining life and culture. For some groups, animal species are considered ancestors or spiritual beings, which are treated with respect and taken for food or fur only after the hunter establishes a relationship through rituals and offerings. Traditionally used fishing and hunting locations can be important, as can be the lands and waters that support wildlife and fish habitat. Other interests include tribal grazing rights that could be included in treaties or agreements, as well as gathering locations for rocks, minerals, and soils. For example, in the Southwest and elsewhere, clays for pottery and minerals for glazes and pigments are gathered from public and NFS lands.

Most American Indian tribes and individual tribal members conceive of spirituality, or sacred sites and daily activities, as interconnected. The spiritual and natural worlds are not separate from everyday life (FS 1997). Many of the resource uses and use areas described above also have a spiritual or sacred dimension. Sacred sites can also include places that are an expression of belief systems in the land or nature. For some sacred areas, there may be no observable cultural function to an outsider or even to tribal members who have not been entrusted with the information. Indian people determine what is of spiritual importance to them. Locations such as landscape features, mountain tops, trails, water courses, springs, caves, offering areas, shrines, and rock art sites often figure in these groups' oral traditions concerning their origins, mythology, and the nature of the world. There are frequently active or ancestral ceremonial locations that are treasured. Archaeological sites, burials, and historic sites are often seen as important ties to ancestors and traditions that are not to be disturbed (Bengston 2003).

Based on comments on the Draft PEIS, in addition to the physical components of the environment described above, the quality of the natural environment, such as clean water and a pure, untainted airshed are basic Tribal cultural values.

3.15.4 Climate Change

The status of the local ecosystem, including but not limited to vegetation composition and any wildlife, is integral to many native cultures. Potential changes in local ecosystems associated with effects of climate change may alter the availability of plants, wildlife, or other natural resources for traditional uses.

3.16 National Scenic and Historic Trails

3.16.1 Background

The National Trails System Act of 1968 (16 USC 1241-51) established the framework for the National Trails System. The purpose of this Act is to accommodate the outdoor recreation needs of an increasing population, while preserving the environment, history, and natural aesthetics of open areas (BLM 2006d). National Scenic Trails and National Historic Trails are congressional designations given to protected areas in the US that contain trails and surrounding areas of particular natural beauty and historic significance. National trails are officially established under the authorities of the National Trails System Act (16 USC 1241-51). The National Trails System is made up of National Scenic Trails, National Historic Trails, and National Recreation Trails.

National Scenic Trails are 100 miles or longer, continuous, primarily nonmotorized routes of outstanding recreation opportunity. National Historic Trails commemorate historic and prehistoric routes of travel that are of significance to the entire nation. National Historic Trails have as their purpose the identification and protection of the historic route and its historic remnants and artifacts for public use and enjoyment (US DOI, National Park Service 2006a). They must meet three criteria listed in Section 5(b)(11) of the National Trails System Act:

- They must follow actual documented route of historic use;
- They must be of national significance; and
- They must possess significant potential for public recreation and/or interpretation.

National Scenic Trails and National Historic Trails may only be authorized by Congress. National Recreation Trails, also authorized in the National Trails System Act, are existing regional and local trails recognized by either the Secretary of Agriculture or the Secretary of the Interior upon application.

Administration of each trail is officially assigned to or shared among the US DOI, National Park Service, BLM, and/or the FS. Subject to available funding, the administering agencies exercise trail-wide responsibilities under the Act for that specific trail. Such responsibilities include coordination among and between agencies and partner organizations in planning, marking, certifying, preserving and protecting resources, interpreting, establishing cooperative / interagency agreements, and offering financial assistance to other cooperating government agencies, landowners, interest groups, and individuals.

National trails cross numerous jurisdictions, with various segments managed by a variety of landowners or agencies. On-site management responsibilities often include inventorying of resources and mapping, planning and developing trail segments or sites, ensuring compliance, making provisions of appropriate public access, offering site interpretation, maintaining trails, marking trails, preserving or protecting resources, protecting viewsheds, and managing visitor use.

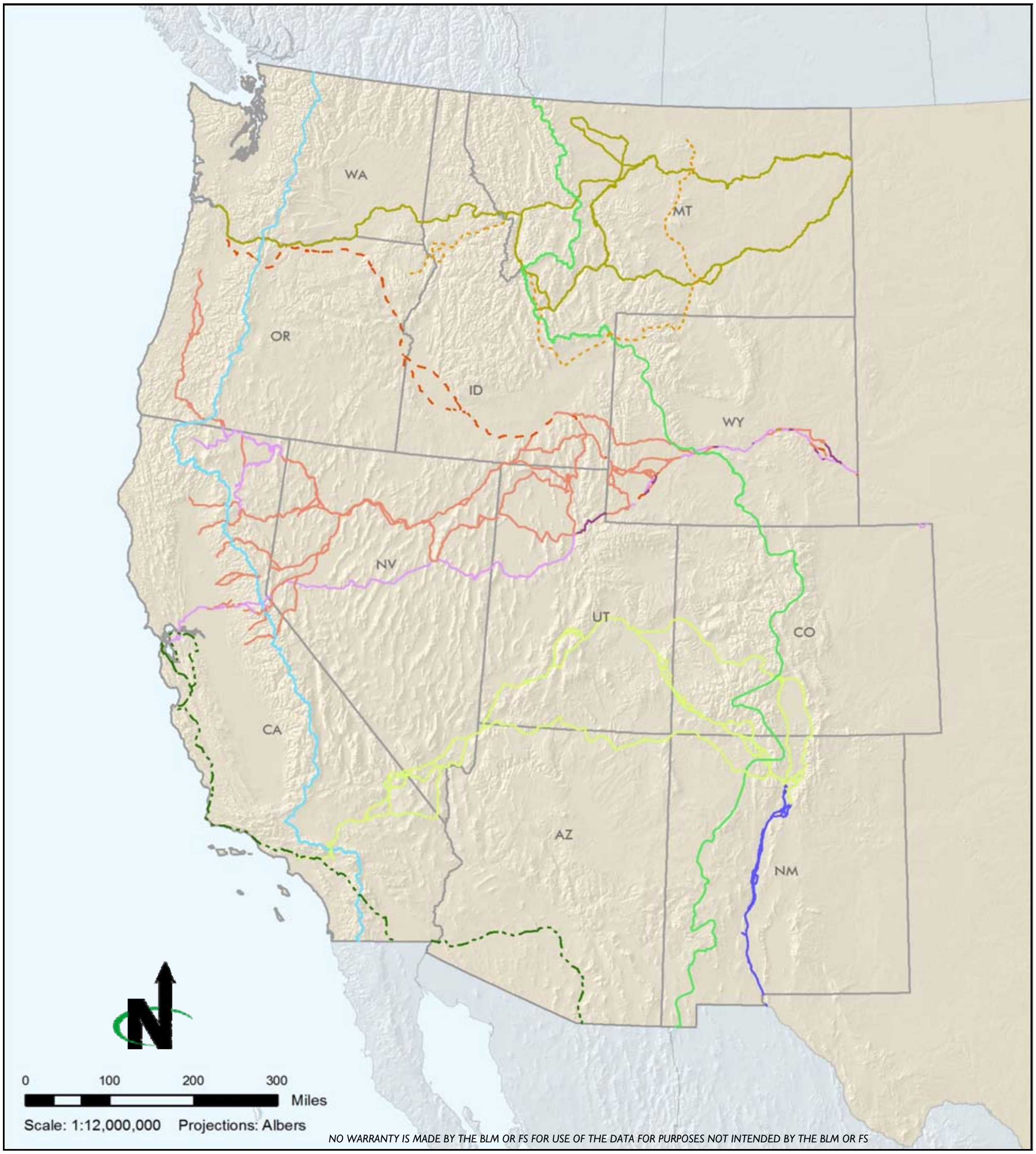
In the project area, the BLM manages public lands in 10 western states that include 2 National Scenic Trails and 11 National Historic Trails (Table 3-28). In the project area, the FS manages NFS lands that include portions of one National Historic Trail and two National Scenic Trails (Table 3-28). Figure 3-22 shows the distribution of National Scenic and Historic Trails throughout the project area, identifying each trail by name. There are approximately 15,280 miles of National Historic Trails and National Scenic Trails within the project area. Within the planning area, National Scenic Trails and National Historic Trails traverse approximately 3,005 miles of public land and approximately 3,168 miles of NFS land.

Table 3-28
Project Area National Trails

Trail Name	Type	Project Area (approx. miles)	Planning Area (approx. miles)	Public (BLM) or NFS (FS) Lands Affected	Administering Agency (if BLM or FS)
California	National Historic Trail	3,296	1,844	Public lands	other
Continental Divide	National Scenic Trail	1,775	1,453	Public lands; NFS lands	FS
El Camino Real de Tierra Adentro	National Historic Trail	645	249	Public lands	BLM (with US DOI, National Park Service)
Iditarod	National Historic Trail	78	1.5	Public lands	BLM
Juan Bautista de Anza	National Historic Trail	1,039	218	Public lands	other
Lewis and Clark	National Historic Trail	1,321	420	Public lands	other
Mormon Pioneer	National Historic Trail	57	99	Public lands	other
Nez Perce	National Historic Trail	539	421	Public lands; NFS lands	FS
Old Spanish	National Historic Trail	2,615	1566	Public lands	BLM (with US DOI, National Park Service)
Oregon	National Historic Trail	1,133	436	Public lands	other
Pacific Crest	National Scenic Trail	1,598	1,394	Public lands; NFS lands	other
Pony Express	National Historic Trail	1,263	617	Public lands	other
Santa Fe	National Historic Trail	unknown	unknown	Public lands	other

Source: BLM 2006d; US DOI, National Park Service 2006a, 2006b.

C://EMPSi/GeothermalPEIS/Figures



11 National Scenic and Historic Trails are located in the project area. Alaska has one trail in the planning area.

Legend

National Scenic and Historic Trails

- California
- Continental Divide
- El Camino Real de Tierra Adentro
- Juan Bautista de Anza
- Lewis and Clark
- Mormon Pioneer
- Nez Perce
- Old Spanish
- Oregon
- Pacific Crest
- Pony Express

National Scenic and Historic Trails in the 11 Western States

Figure 3-22

3.16.2 National Historic Trails

California Trail

The trail was used by over 250,000 farmers and gold seekers during the 1840s and 1850s. The route starts along the Missouri River and then converges on the Great Platte River Road, overlaps with the Oregon Trail, and continues through the Rocky Mountains. After crossing the Rockies, many routes were used to get to and cross the Sierra Nevada. The total system of trails that make up the California Trail is approximately 5,664 miles (US DOI, National Park Service 2007c). Within the project area, there are approximately 3,296 miles of the California Trail. The California Trail crosses approximately 1,039 miles of public land and approximately 261 miles of NFS land within the planning area.

El Camino Real de Tierra Adentro

This trail dates back to the Spanish Colonial era of the sixteenth to nineteenth centuries when it was the primary route between Mexico City, the capital of New Spain, and other Spanish provincial capitals (National Park Service, 2006c). From Mexico, the trail crosses briefly into west Texas and then north through New Mexico to Santa Fe. The trail was used for trade and interaction among Europeans, Spaniards, Mexicans, and Native Americans and affected settlement and development within the southwest (National Park Service, 2006c). Within the project area, there are approximately 645 miles of the El Camino Real de Tierra Adentro Trail. The trail crosses approximately 66 miles of public land and approximately 8 miles of NFS land within the planning area.

Iditarod Trail

The Iditarod Trail, located in Alaska, was a path originally used by Native American hunters and Russian explorers. In the twentieth century, gold seekers used the trail to reach the mines, and the trail was improved. Several towns, such as Seward, Iditarod, and Nome, grew up around the mining districts, where miners would buy supplies from local stores and markets and would stay overnight in tents before going to the mines. The trail begins in two places, Seward and Nome, and the two legs eventually met at the Iditarod Mining District. It was officially surveyed by the US Army's Alaska Road Commission in 1908 and was heavily used until 1924, when the airplane became common for travel. The trail was not well used again until the 1960s, when dog sledding became an interest; the first dog sled race took place in 1967. The total length of the Iditarod trail in the project area is approximately 938 miles. Within the planning area, there are approximately 1.5 miles of the Iditarod Trail. Overall trail administration has been delegated by the US DOI to the BLM, and the trail includes approximately 85 miles of BLM lands and an additional 52 miles of State and Native Lands that the BLM is currently administering (Krantz 2008). The route includes no NFS land.

Nez Perce (Nee Me Poo)

This trail extends from Wallowa Lake in Oregon to Bear Paw Mountain in Montana. It is named for the Nez Perce Tribe of Native Americans who were forced to leave their lands and move to a reservation. During the travels, fighting occurred between the Nez Perce and white settlers. The US Army was called, and the Nez Perce attempted to flee to Canada. Approximately 750 Nez Perce men, women, and children traveled over 1,170 miles through the mountains on a journey that lasted from June to October of 1877 (FS 2007h). From Wallowa Lake, the trail extends east through the Snake River at Dug Bar, entering Idaho at Lewiston, and then entering north-central Idaho at Bannock Pass. The trail then travels back to the east into Montana at Targhee Pass to cross the Continental Divide. It bisects Yellowstone National Park in Wyoming, and then follows the Clark Fork River out of Wyoming into Montana. The trail then heads north into Bearpaw Mountains and ends forty miles from the Canadian border (FS 2007h). Approximately 539 miles of the Nez Perce Trail traverses the project area. Within the planning area, this trail crosses approximately 74 miles of public land and approximately 183 miles of NFS land.

Juan Bautista de Anza

This trail was used by a party of 300 Spanish colonists, led by Colonel San Juan Bautista, from Mexico to California in 1775. The party intended to establish a mission and presidio (military post) in Alta, California, to secure the area from the Russians and British, who also had claimed the land. It was the first overland trail that connected New Spain with Alta, California (US DOI, National Park Service 2007b). The party contained 30 families, a dozen soldiers, cattle, mules, and horses. The trail is over 1,200 miles long, and it took the party three months to follow the trail through the southwest desert before reaching the California coast. It took another three months to travel from the southern coast up the northern coast to present-day San Francisco (FS 2007i). There are approximately 1,039 miles of the Juan Bautista de Anza Trail within the project area. Within the planning area, the trail crosses approximately 84 miles of public land and 11 miles of NFS land.

Lewis and Clark

This trail runs along the early explorations of Meriwether Lewis and William Clark on behalf of the US. The trail follows the Missouri River upstream, eventually reaching the Pacific Ocean at the mouth of the Columbia River. The route goes through Idaho and western Montana for a total of approximately 1,321 miles within the project area. There are approximately 28 miles on public land and 49 miles on NFS land within the planning area.

Mormon Pioneer Trail

One of the major forces of settlement in the West was Mormon emigration. Sixteen hundred Mormons left Illinois in February 1846, crossing into Iowa to escape religious persecution (Billington 1963). Their leader, Brigham Young, opted not to follow the Oregon Trail but instead forged a new route just north of the Platte River. This was because the route was better suited to wagon travel and he wished to avoid other travelers from Missouri who frequented the Oregon Trail (Billington 1963). The Mormons crossed Mississippi and established temporary headquarters there, then went on to Missouri, and through the Great Plains, where they spent an icy winter and lost 600 people from their party (Billington 1963). They reached the Valley of the Great Salt Lake, where they settled, in June 1847. There are approximately 57 miles of the Mormon Pioneer Trail within the project area. Within the planning area, the trail crosses public land for approximately 8 miles. It does not cross any NFS lands within the planning area.

Old Spanish

Before there was the Old Spanish Trail, an overland southern route to California from New Mexico did not exist. This trail was first established by a Mexican trader, Antonio Armijo, in 1829. He traveled from Santa Fe, New Mexico, to Los Angeles, California, on a commercial caravan, carrying Mexican woolen goods and planning to bring horses back from California (US DOI, National Park Service 2007c). Portions of the trail had been used as a Native American footpath, an early trade route, and a horse and mule trail. The trail runs through present-day Colorado, Utah, Arizona, Nevada, and California (Cultures and Histories of the American Southwest 2007). There are approximately 2,615 miles of the Old Spanish Trail within the project area. Within the planning area, it crosses public land for approximately 750 miles and NFS land for 275 miles.

Oregon Trail

Fur trappers and traders used this trail to access the Northwest Coast. The Oregon Trail was used by settlers traveling to the Plateau Region or to pass through en route to more westerly points. The trail began as an unconnected series of trails used by Native Americans. Fur traders expanded the route to bring pelts to trading posts in the early 1800s. The route extends roughly 2,000 miles west, from Missouri toward the Rocky Mountains to the Willamette Valley; a trail to California digressed from the route in Idaho (BLM 2008k). Several groups followed the route over time, including large populations of settlers, moving from the eastern portion of the US to settle the west between 1800 and the 1880s (BLM 2008k).

Missionaries used the trail during the 1830s, traveling along the Platte and Snake Rivers to settle churches in the Northwest. Mormons, headed toward the Great Salt Lake in Utah, used the trail beginning in 1847, and the discovery of gold in California caused many gold miners to use the trail in 1849. It is estimated that 4,000 emigrants followed the trail west in 1847 (Schwantes 1989), many in small caravans of wagons. Military posts and spur roads were established off the Oregon Trail. The trail was the major connection between the east and western portions of the US. It was used as a cattle driving trail eastward for a brief time as well. The construction of the Central Pacific Railroad, connecting California to the rest of the continent in 1869, decreased use of the Oregon Trail. By the early twentieth century, railroad lines paralleled the trail, and it was no longer used as a major transportation corridor (BLM 2008k and Schwantes 1989). There are approximately 1,133 miles of the Oregon Trail within the project area. Within the planning area, it crosses approximately 176 miles of public land and approximately 46 miles of NFS land.

Pony Express National Historic Trail

This began in 1860 as a mail route connecting the eastern US with California. It was privately financed and was used only for 18 months before the telegraph system was constructed and replaced the Pony Express. Riders on horseback transported mail from Missouri to California in ten days, traveling over 1,800 miles. The transcontinental railroad later followed much of this route (US DOI, National Park Service 2007b). Within the project area, there are approximately 1,263 miles of the Pong Express Trail. Within the planning area, it crosses approximately 448 miles of public land and approximately 187 miles of NFS land.

Santa Fe Trail (Kansas to Santa Fe)

This trail was used for trade and commerce between 1821 and 1880 (US DOI, National Park Service 2008). It extended from Missouri to New Mexico, branching into the Mountain Route and the Cimarron Route (Santa Fe 2008). Except for a short hiatus during the Mexican-American War between 1846 and 1848, the trail provided international passage of goods and travelers. Both during and after the war, the Santa Fe Trail was used heavily for freighting of military supplies to forts in the southwest. Once the railroad extended into the southwest territory, the trail was no longer used. The 1,203 miles of trail are managed by the NPS (US DOI, National Park Service 2006b) and do not cross public or NFS lands.

3.16.3 National Scenic Trails

Continental Divide

Congress designated this 3,100-mile scenic trail in 1978, extending from Canada to Mexico, crossing Montana, Idaho, Wyoming, Colorado, and New Mexico (Continental Trail Alliance 2005). The trail runs along the Continental Divide of the North America. There are approximately 1,775 miles of the trail within the project area. It crosses approximately 191 miles of public land and approximately 1,099 miles of NFS land within the planning area.

Pacific Crest

This trail runs from the Cascade and Sierra Nevada Mountains, from Canada to Mexico. It was inspired by the 1930s idea of a long-distance mountain trail and passes through 25 National Forests and 7 National Parks. It was completed in Oregon and Washington in 1987 (FS 2007i). Within the project area, it runs for approximately 1,598 miles. It traverses approximately 141 miles of public land and 1,049 miles of NFS land within the planning area.

3.17 VISUAL RESOURCES

This section describes visual resources in the project area and planning area, as well as regulations associated with visual resources.

General Visual Setting

The project area encompasses a wide variety of landscape types that can be categorized into ecological regions (or ecoregions). Attributes used to characterize an ecoregion include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology, all of which influence visual resources (US EPA 2007d). Visual resources are generally homogenous within an ecoregion. The coverage of an ecoregion within any one state varies greatly. A description and figure of the project and planning area ecoregions is provided in Section 3.9, Vegetation, and Appendix G.

Although the population is not evenly distributed across the project area or planning area, human influences have altered much of the visual landscape, especially with respect to land use and land cover. In some places, intensive human activities, such as mineral extraction and energy development, have significantly altered the natural visual landscape. Large, fast-growing cities also contain heavily altered landscapes, with urban sprawl spreading into what were recently relatively undisturbed landscapes.

3.17.1 US Department of the Interior, Bureau of Land Management Visual Resources

In accordance with FLPMA, the BLM is entrusted with the multiple-use management of natural resources on public land, which contain many outstanding qualities, including scenic landscapes. In managing public lands for multiple uses, the BLM is constrained by the legal mandate to "protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archaeological values…and provide for…human occupancy and use" (BLM 2008j).

The BLM's Visual Resource Management (VRM) system guides visual resources management on public lands (BLM 2007j). Visual resources are defined as the visible physical features on a landscape (e.g., land, water, vegetation, animals, structures, and other features). There are three stages of the VRM system: inventory (visual resource inventory), assigning VRM Management Classes, and analysis (visual resource contrast rating).

The visual resource inventory process provides BLM managers with a means for determining visual values. The process involves a scenic quality evaluation, sensitivity level analysis, and a delineation of distance zones. The process is described in detail in BLM Handbook H-8410-1, Visual Resource Inventory. Based on these three factors, BLM-administered lands are placed into one of four visual resource inventory classes. These inventory classes represent the relative value of the visual resources. Classes I and II being the most valued, Class III representing a moderate value, and Class IV being of least value. The inventory classes provide the basis for considering visual values in the resource management planning (RMP) process. Visual Resource Management classes are established through the RMP process for all BLM-administered lands. During the RMP process, the class boundaries are adjusted as necessary to reflect the resource allocation decisions made in RMP's.

Visual management objectives are established for each class. The VRM class objectives for visual resources on public lands are:

- VRM Class I Objective: To preserve the existing character of the landscape. The level of change to the characteristic landscape should be very low and must not attract attention.
- VRM Class II Objective: To retain the existing character of the landscape. The level of change to the characteristic landscape should be low.
- VRM Class III Objective: To partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate.
- VRM Class IV Objective: To provide for management activities which require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high.

Where a project is proposed and there are no RMP-approved VRM objectives, interim visual management classes are established (BLM 2007k). Interim classes are developed using the guidelines in Section I to V of BLM Handbook H-8410-1, Visual Resource Inventory, and must conform with the land-use allocations set forth in the RMP which covers the project area. The establishment of interim VRM classes will not require a RMP amendment, unless the project that is driving the evaluation requires one. The analysis stage (visual resource contrast rating) involves determining whether the potential visual impacts from proposed surface-disturbing activities or developments will meet the management objectives established for the area, or whether design adjustments will be required (BLM 2007j). A visual contrast rating process is used for this analysis, which involves comparing the project features with the major features in the existing landscape using the basic design elements of form, line, color, and texture. The analysis is also influenced by the number of and proximity of receptors sensitive to visual resources. This process is described in BLM Handbook H-8431-1, Visual Resource Contrast Rating. The analysis can then be used as a guide for resolving visual impacts. Once every attempt is made to reduce visual impacts, BLM managers can decide whether to accept or deny project proposals; attaching additional mitigation stipulations to bring the proposal into compliance; or change the VRM management classification through an RMP amendment.

General Description of Visual Resources by VRM Class

Visual Resource Management Class I

VRM Class I is assigned to those areas where a management decision has been made previously to maintain a natural landscape (BLM 2007k). This includes areas such as national wilderness areas, the wild section of rivers in the National Wild and Scenic Rivers System, and other congressionally and administratively designated areas where decisions have been made to preserve a natural landscape. Class I provides for natural ecological changes; however, it does not preclude very limited management activity. VRM Class I areas are typically more remote and unaltered by human disturbances than VRM Class II, III, and IV areas.

Areas with special designations (such as rivers in the National Wild and Scenic Rivers System, wilderness areas, wilderness study areas, scenic roadways, and National Park System lands) have valuable scenic resources. These areas are typically minimally developed and have greater restrictions on the types of allowable activities in order to, for example, preserve the area's visual resources. Section 3.2, Land Use, Recreation, and Special Designations describes these areas and their management.

Visual Resource Management Classes II, III, and IV

VRM Classes II, III, and IV are assigned based on a combination of scenic quality, sensitivity level, and distance zones (BLM 2007k). In VRM Class II areas, management activities may be seen but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape. In VRM Class III areas, management activities may attract attention but should not dominate the view of the casual observer. Changes should also repeat the basic elements found in the predominant natural features of the characteristic landscape. In VRM Class IV areas, management activities may dominate the view and be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements. Typically, VRM Class IV areas are noticeably modified by surface disturbances (such as highways and wildland-urban interface areas) or involve land-intensive activities (such as cross-country, or open, off-highway vehicle use).

3.17.2 US Department of Agriculture, Forest Service Visual Resources

The Scenery Management System, described in FS Agriculture Handbook 701, outlines the process for inventorying and analyzing aesthetic values on NFS lands (FS 1995b). Scenic resources are defined as attributes, characteristics, and features of landscapes that provide varying responses from, and varying degrees of benefits to, humans.

Scenic integrity is the state of naturalness or, conversely, the state of disturbance created by human activities or alteration (FS 1995b). Integrity is stated in degrees of deviation from the existing landscape character in a National Forest. Scenic integrity is a continuum ranging over the following five scenic integrity levels:

- Very high (unaltered): Refers to landscapes where the valued landscape character is intact with only minute, if any, deviations. The existing landscape character and sense of place is expressed at the highest possible level.
- High (appears unaltered): Refers to landscapes where the valued landscape character appears intact. Deviations may be present but must repeat the form, line, color, texture, and pattern common to the landscape character so completely and at such scale that they are not evident.
- Moderate (slightly altered): Refers to landscapes where the valued landscape character appears slightly altered. Noticeable deviations must remain visually subordinate to the landscape character being viewed.
- Low (moderately altered): Refers to landscapes where the valued landscape character appears moderately altered. Deviations begin to dominate the valued landscape character being viewed, but they borrow valued attributes such as size, shape, edge effect, and pattern of natural openings; vegetative type changes; or architectural styles outside the landscape being viewed. They should not only appear as valued character outside the landscape being viewed but compatible or complimentary to the character within.
- Very low (heavily altered): Refers to landscapes where the valued landscape character appears heavily altered. Deviations may strongly dominate the valued landscape character. They may not borrow from valued attributes such as size, shape, edge effect, and pattern of natural openings; vegetative type changes; or architectural styles within or outside the landscape being viewed. However, deviations must by shaped and blended with the natural terrain (landforms) so that elements such as unnatural edges, roads, landings, and structures do not dominate the composition.

There is also an unacceptably low scenic integrity level. It refers to landscapes where the valued landscape character being viewed appears extremely altered. Deviations are extremely dominant and borrow little, if any, form, line, color, texture, pattern, or scale from the landscape character. Landscapes at this level of integrity need rehabilitation. This level should only be used to inventory existing integrity and should not be used as a management objective.

General Description of Scenic Resources by Scenic Integrity Level

Both very high and high scenic integrity levels are for areas where primitive scenic resources are found. Typically, the foreground, middleground, and background distance zones have an undisturbed appearance. These areas are more remote and are used for low impact activities, such as hiking.

Moderate scenic integrity level areas are for areas where relatively natural scenic resources are found. Typically, the distant middleground and background distance zones have alterations to scenic resources that are visible but difficult to identify. Some effort is needed to access these areas.

Both low and very low scenic integrity levels are for areas where scenic resources are altered by human activities and structures. Typically, the foreground, middleground, and background distance zones have disturbances to scenic resources that are readily noticeable. These areas are readily accessible due to the presence of roads and are used for high-impact activities, such as OHV recreation.

Scenic integrity level objectives outlined in forest plans identify how scenic resources are to be managed. The objectives vary depending on the location, quality, uniqueness, sensitivity, and desired use of the scenic resources.

3.17.3 Other Visual Resources

Management of visual resources on non-BLM and non-FS lands is likely to be influenced by local planning documents. For example, county general plans typically contain elements that address, for example, conservation of natural resources or open space. In areas with hilltops and ridgelines, general plans can include actions that restrict development that would result in skylining (or silhouetting) of structures on hilltops and ridgelines. In areas with scenic roadways, general plans can include actions intended to maintain the attractiveness of the roadway. Also, in areas with valleys or expansive vistas, general plans can include actions to protect structures from blocking or altering these views. Furthermore, local planning documents have recently begun addressing nighttime lighting in order to minimize light pollution, as well as to conserve energy. Light pollution can be defined as any adverse effect of artificial light, including sky glow, glare, light trespass, light clutter, and decreased visibility at night.

3.18 SOCIOECONOMICS AND ENVIRONMENTAL JUSTICE

3.18.1 Socioeconomic Influences of Geothermal Development and Operation

The construction and operation of geothermal power plants contributes to local, state, and national economies through the creation of jobs, generation of property taxes, payments of revenues, and voluntary contributions to local communities. The construction of direct-use facilities also contributes to economies through job creation and property tax generation. While estimates on the economic impacts of direct-use facilities are not available, a description of the impacts of geothermal electrical generation on economies is described below.

Jobs

Areas of high geothermal potential are often located in rural areas, which typically have chronic, high unemployment rates. The development of geothermal resources in such rural areas can improve local socioeconomic conditions. The construction of a 50-megawatt geothermal power plant could create several hundred temporary construction and related development jobs that would last from two to three years. Between 30 and 50 permanent, high-skilled, full-time jobs at the facility would pay well above minimum wage. Such a development project should provide approximately 90 to 150 new full-time jobs in the community after considering the economic multiplier effect; the idea that a single expenditure in an economy can have repercussions throughout the entire economy The long lifetime of geothermal plants means that they can become a stable, reliable part of a community's economic base (National Geothermal Collaborative 2007).

Property Tax

The development of a geothermal power plant represents a large capital investment in the county in which it is constructed. These plants can generate substantial property taxes for the local county, and considering that many geothermal development locations are in rural areas, the additional revenue stream can result in a substantial increase in the county's tax base (National Geothermal Collaborative 2007). Property taxes are based on the estimated value of the company assets. In 2003, the Geysers, the largest complex geothermal power plant in the world (located north of San Francisco), paid property taxes to two counties totaling more than $11 million. At the geothermal power plants in Inyo County, California, plant owners pay approximately $6 million annually, of which roughly two-thirds is used to fund schools (Kagel 2006). The 10 geothermal power plants installed in Imperial County, California, have a capacity of 330 megawatts and generate approximately $10 million annually in property tax, which represents 20 percent of the county's total property tax revenue (National Geothermal Collaborative 2007).

Revenue Payments

Revenues are monies paid by a geothermal developer to the owner of the leased land on which a power plant operates. Revenues include lease sales and rental fees, bonus bids, and royalties or direct use fees. Royalties are based on a percentage of a developer's revenues, currently set at 1.75 percent of gross revenue from electricity sales for the first 10 years of a lease, and 3 percent thereafter for federal lands for competitive geothermal leases issued under the Energy Policy Act of 2005 and non-producing leases that elect to convert to the new royalties. Producing leases and those noncompetitive lease applications that were grandfathered and those producing leases that do not convert to the new royalty rate will continue to pay a royalty of 10 percent of net proceeds. The 1970 Geothermal Steam Act mandates that in states where the federal government collects geothermal revenues, 50 percent of the total shall be returned to the state in which the resource is located. Based on 2005 amendments, the remaining 50 percent will be equally divided between the county and federal government (Federal Register 2007). As an example of the scale of revenues being generated, in fiscal year 2007, Nevada had approximately 235 megawatts of geothermal electric-generating capacity on government lands, which provided 5.5 percent of the state's power. In that year alone, Nevada received $8.8 million in revenues (competitive lease sales = $5.7 million, royalties = $2.5 million, and lease rentals = $623.8 thousand) of which the counties received $4.4 million (US DOI MMS 2007, BLM 2007a).

Voluntary Payments

Geothermal companies often donate funds to the communities in which they are located. In California, the Mammoth Pacific power plant has been designated a "good neighbor" by many locals for its financial contributions to local groups and for building a new community center from the power plant's proceeds (Kagel 2006).

3.18.2 Socioeconomic Influences of Existing Geothermal Power Plants

As of 2004, geothermal represented approximately one percent of the electricity-generating capacity in the project area, excluding Alaska, equating to approximately 3,195 megawatts (Western Governors' Association 2006). By using the relationships described above between the size of power plants and produced economic stimulus, the following are estimates of the existing contribution of geothermal power plants to economies in the project area:

- Jobs: between 1,917 and 3,195 permanent, full-time jobs that pay above minimum wage, using the ratio of approximately 30 to 50 full-time jobs for a 50-megawatt power plant, as described above;
- Property taxes: approximately $96.8 million annually at the rate generated in Imperial County, California, as described above; and
- Revenue Payments: approximately $230 million annually at the rate generated in Nevada, as described above.

3.18.3 Existing Project Area Socioeconomic Conditions

The use of project area public and NFS lands for geothermal energy development affects the demographic characteristics and economies of the project area. Additionally, social structure and values within the project area shape the demand and opportunities created by public and NFS lands. For these reasons, demographic, economic, and social data for the project area are presented in this section.

Socioeconomic resources include historic, current, and forecasted population statistics, race/ethnicity, age distribution, housing, and poverty. Such data provide background on population growth, distribution of racial/ethnic minorities and low-income groups, and population aging. These factors are reflected in the project area's economics and social values. Economic development is measured through employment, personal income, tax revenues (sales and state income), gross state product, and government revenues and expenditures. For each development measure, data is presented for a selection of years with available data between 1990 and 2006 to provide historical trends for the project area. Forecasts for each measure provide future expectancy of each measure. It should be noted that the forecasts presented are estimates based on past annual rates only and do not attempt to factor in the variety of economic and social factors that are likely to influence future growth in each development measure. In addition, dollar amounts presented are not adjusted for inflation.

Due to the nature of Census data, economic statistics could not be obtained specifically for the planning area; trends for the planning area are assumed to reflect the same general trends seen in the project area.

Population

Total project area population was estimated at 68.3 million in 2006 and is expected to reach over 80 million by 2015 and 95 million by 2025. California had the highest population concentration in the project area with more than 53 percent of the project area's total population in 2006. Table 3-29, Total Project Area Population (in millions), displays population trends from 1990 to 2006, as well as population forecasts for 2015 and 2025.

The project area's population grew at an annual average rate of 2 percent between 1990 and 2006. The largest population growth occurred in Nevada with a 6.7-percent increase, while the lowest growth occurred in Montana and Wyoming, with .7 and .8 percent increases, respectively. Relatively high growth rates in the remaining states were estimated for Arizona (3.3 percent), Utah (2.6 percent), Idaho (2.6 percent), and Colorado (2.4 percent). Close-to-average growth occurred in New Mexico (1.8 percent), Oregon (1.8 percent), and Washington (1.7 percent), with lower-than-average growth rates in the remaining states.

Table 3-29
Total Project Area Population (in millions)

State	1990	2006	Average Annual Growth Rate 1990-2006 (%)	2015 (Projected)	2025 (Projected)
Alaska	0.6	0.7	1.0	0.7	0.8
Arizona	3.7	6.2	3.3	7.5	9.5
California	29.8	36.5	1.3	40.0	44.3
Colorado	3.3	4.8	2.4	5.0	5.5
Idaho	1.0	1.5	2.6	1.6	1.9
Montana	0.8	0.9	0.7	1.0	1.1
Nevada	1.2	2.5	4.7	3.1	3.9
New Mexico	1.5	2.0	1.8	2.0	2.1
Oregon	2.8	3.7	1.8	4.0	4.5
Utah	1.7	2.6	2.7	2.8	3.2
Washington	4.9	6.4	1.7	7.0	8.0
Wyoming	0.5	0.5	0.8	0.5	0.6
Project Area	**51.5**	**68.3**	**1.8**	**80.0**	**95.0**

Source: US Bureau of the Census 2007a

Age Distribution

As illustrated in Table 3-30, Project Area Age Distribution (2006), the project area's median age in 2006 was 32.4 years, with Montana (39.2 years) and Utah (28.3 years) having the highest and lowest median ages, respectively. Approximately 24 percent of the project area's population was children (under 18 years of age), while slightly over 10 percent of the project area's population were older than 65 years. Utah, at 31.1 percent, possessed the highest percentage of children in 2006, followed by Idaho (26.9 percent), Alaska (26.8 percent), Arizona (26.4 percent), California (26.1 percent), and New Mexico (26.1 percent). The number of children in the remaining states was close to the project area average (within 2 percentage points). Alaska and Utah, at 6.8 percent and 8.8 percent, respectively, contributed to the smallest population percentage whose age was over 65 years, while Montana (at 13.8 percent) had the highest number of elderly in the project area. The remaining states had an elderly population near the project area's average.

Table 3-30
Project Area Age Distribution (2006)

State	Median Age	Percent Children (under 18 Years of Age)	Percent Elderly (over 65 Years of Age)
Alaska	33.4	26.8	6.8
Arizona	34.6	26.4	12.8
California	34.4	26.1	10.8
Colorado	35.4	24.6	10.0
Idaho	34.2	26.9	11.5
Montana	39.2	23.1	13.8
Nevada	35.5	25.4	11.1
New Mexico	35.3	26.1	12.4
Oregon	37.5	23.2	12.9
Utah	28.3	31.1	8.8
Washington	36.7	23.9	11.5
Wyoming	37.1	23.5	12.2
Project Area	**35.13**	**25.59**	**11.22**

Source: US Bureau of Census 2007a

Vacant Housing

Table 3-31, Project Area Available Housing Units (in thousands), shows the number of vacant housing units in 1990 and 2000, with the percent change over the 10-year period, as well as the projected vacant housing of the project area in 2010. The number of total vacant housing units in the project area was estimated at 1.9 million in 2000; vacant housing units are expected to drop off to 1.8 million by 2010. California, with the largest population in the project area, also had the largest number of available housing units. Vacant housing units in California were estimated at 711,700 in 2000 (almost 40 percent of the project area's total), but are expected to decrease to 633,500 by 2010. Arizona, with 288,000 units, and Washington, with 180,000 units, had the next-largest numbers of vacant units after California.

There was a slight decline in the number of vacant housing units between 1990 and 2000, with a total annual growth rate of -0.26 percent for the project area. Most states experienced a decline in available housing units between 1990 and 2000. States with higher-than-average annual drops in vacant units were Colorado (-2.6 percent), Wyoming (-1.4 percent), California (-1.2 percent), and Alaska (-1.0 percent), while states such as Nevada (3.8 percent), Oregon (2.8 percent), and New Mexico (1.4 percent) experienced fairly large increases in vacant housing units.

Table 3-31
Project Area Available Housing Units (in thousands)

State	1990	2000	Average Annual Growth Rate 1990-2000 (%)	2010 (Projected)
Alaska	43.7	39.4	-1.0	35.5
Arizona	290.6	287.9	-0.1	285.2
California	801.7	711.7	-1.1	631.8
Colorado	194.9	149.8	-2.3	114.9
Idaho	52.6	58.2	1.1	64.6
Montana	55.0	54.0	-0.1	53.0
Nevada	52.6	76.3	4.5	110.6
New Mexico	89.3	102.6	1.4	117.9
Oregon	90.3	119.0	3.2	157.0
Utah	61.1	67.3	1.0	74.1
Washington	160.0	179.7	1.2	201.8
Wyoming	34.6	30.2	-1.3	26.3
Total	**1926.4**	**1876.1**	**-0.26**	**1,827.8**

Source: US Bureau of Census 2007a

Employment

Between 1990 and 2006, project area labor force and employment grew by 1.7 percent, while unemployment dropped slightly. Tables 3-32, Project Area State Labor Force and Employment (in millions), and 3-33 Project Area State Unemployment (in millions), show employment and unemployment data for the project area, between 1990 and 2006. Employment growth rates were highest in Nevada (4.4 percent) and Arizona (3.2 percent) than the rest of the project area. Growth rates in Montana (1.4 percent) and California (1.1 percent) were less than the project area's average growth.

Almost 53 percent (16.9 million) of all project area (32.2 million) employment was concentrated in California. Employment in Washington, Arizona, and Colorado in 2006 stood at 3.1 million, 2.8 million, and 2.1 million respectively; the remaining states supported less than 7 million jobs. Employment in the project area as a whole is projected to increase to 37 million in 2014; California is expected to provide 50 percent (18.4 million) of project area employment by 2014. Unemployment rates dropped for all states except Oregon; the highest drop in unemployment rates occurred in Wyoming and Montana.

Table 3-32
Project Area State Labor Force and Employment (in millions)

State	Labor Force 1990	Labor Force 2006	Labor Force Average Annual Growth Rate 1990-2006 (%)	Employment 1990	Employment 2006	Employment Average Annual Growth Rate 1990-2006 (%)	Employment 2014 (Projected)
Alaska	0.27	0.35	1.6	0.25	0.32	1.5	0.4
Arizona	1.8	2.9	3.8	1.7	2.8	3.1	3.6
California	15.0	17.8	1.1	14.2	16.9	1.1	18.4
Colorado	1.7	2.6	2.7	1.7	2.5	2.4	3.0
Idaho	0.5	0.7	2.1	0.5	0.7	2.1	0.8
Montana	0.4	0.5	1.4	0.4	0.5	1.4	0.6
Nevada	0.6	1.3	5.0	0.6	1.2	4.3	1.7
New Mexico	0.7	0.9	1.6	0.7	0.9	1.6	1.0
Oregon	1.5	1.9	1.5	1.4	1.8	1.6	2.0
Utah	0.8	1.3	3.1	0.8	1.2	2.5	1.5
Washington	2.5	3.3	1.8	2.4	3.1	1.6	3.5
Wyoming	0.2	0.3	2.6	0.2	0.3	2.5	0.4
Total	**26.0**	**33.9**	**1.7**	**24.9**	**32.2**	**1.6**	**36.9**

Source: US Department of Labor 2007a, 2007b

Table 3-33
Project Area State Unemployment (in millions)

State	1990 Unemployment	1990 Unemployment Rate	2006 Unemployment	2006 Unemployment Rate
Alaska	0.02	7.2	0.02	7.0
Arizona	0.09	5.1	0.10	4.4
California	0.80	5.1	0.90	5.1
Colorado	0.01	5.2	0.10	4.7
Idaho	0.03	5.3	0.03	3.7
Montana	0.02	6.0	0.02	3.5
Nevada	0.03	4.7	0.05	4.1
New Mexico	0.05	6.7	0.04	4.7
Oregon	0.08	4.9	0.10	5.5
Utah	0.03	4.3	0.04	3.4
Washington	0.10	5.1	0.20	4.9
Wyoming	0.01	5.7	0.01	3.0
Total	**1.3**	**5.0**	**1.61**	**4.9**

Source: US Department of Labor 2007a, 2007b

Personal Income

Table 3-34, Project Area State Personal Income indicates that personal income in the project area grew by 5.9 percent between 1996 and 2006. Growth rates in personal income were highest in Nevada (8.4 percent) over the 10-year period; growth rates in the remaining 11 states were within 1.7 percent of the project area's average rate of 5.9 percent.

California, with a personal income growth rate at 5.9 percent in the 10-year period, generated almost 60 percent of the project area's personal income, producing almost $1.4 trillion in 2006. Personal income in California is expected to reach $1.8 trillion by 2010. For the project area as a whole, personal income is expected to increase from $2.5 trillion in 2006 to $3.2 trillion in 2010.

Table 3-34
Project Area State Personal Income (in billions of dollars*)

State	1996	2006	Average Annual Growth Rate 1996-2006 (%)	2010 (Projected)
Alaska	15.7	25.9	5.1	31.6
Arizona	95.5	197.0	7.5	263.2
California	810.4	1,434.9	5.9	1,803.3
Colorado	100.2	188.2	6.5	242.2
Idaho	24.4	43.9	6.1	55.5
Montana	16.9	29.2	5.6	36.3
Nevada	43.5	97.4	8.4	134.5
New Mexico	33.3	58.1	5.7	72.6
Oregon	76.0	123.1	4.9	149.3
Utah	40.4	75.9	6.5	97.7
Washington	139.7	243.5	5.7	304.1
Wyoming	10.7	20.9	6.9	27.3
Total	**1406.5**	**2,538.0**	**5.9**	**3186.07**

* not adjusted for inflation
Source: US Department of Commerce 2007b

Gross State Domestic Product

The total value of goods and services produced in each state, or gross state product, was estimated at $3,080 billion for the project area in 2006 and is expected to reach $3,866 billion by 2010 (Table 3-35, Project Area Total Gross Domestic Product). More than 56 percent ($1,727 billion) of total gross state product was produced in California in 2006.

Table 3-35
Project Area Total Gross Domestic Product (in billions of dollars*)

State	1990	2006	Growth Rate 1990-2006 (%)	2010 (Projected)
Alaska	24.9	41.1	3.2	47.0
Arizona	69.3	232.5	7.9	314.7
California	788.3	1,727.4	5.0	2,101.7
Colorado	74.2	230.5	7.3	306.0
Idaho	17.8	49.9	6.7	64.6
Montana	13.4	32.3	5.7	40.2
Nevada	31.8	118.4	8.7	164.4
New Mexico	26.9	75.9	6.7	98.3
Oregon	57.3	151.3	6.3	192.9
Utah	31.4	97.7	7.4	129.8
Washington	115.6	293.5	6.0	370.5
Wyoming	13.1	29.6	5.2	36.3
Total	**1264.0**	**3080.1**	**5.57**	**3,866.0**

* not adjusted for inflation
Source: US Department of Commerce 2007a

Total project area production grew at a rate of 5.57 percent between 1990 and 2006. The gross state product growth rate was uneven across the project area states, with higher-than-average rates for Nevada (8.7 percent), Arizona (7.9 percent), Utah (7.4 percent), and Colorado (7.3 percent). Below-average growth rates occurred in Wyoming (5.2 percent), California (5.0 percent), and Alaska (3.2 percent).

State Income Tax Revenues

As shown in Table 3-36, Project Area State Income Tax Revenues, the majority of the project area experienced moderately large annual increases in income tax revenues between 1996 and 2006. Increases in California (13.3 percent) were higher than the project area average (12.2 percent); whereas Idaho (7.5 percent) and Montana (8 percent) experienced relatively slow increases in income tax revenues. While increases in Alaska were high at, 16.6 percent, it should be noted that Alaska has no personal tax income, therefore this data reflects only corporate tax income data.

In 2006, California produced $61.5 billion in income taxes, generating 74 percent of total state income tax revenues in the project area. Oregon was the second-largest state income tax producer with $5.9 billion in 2006. Revenues for the entire project area are projected to increase from $83.4 billion in 2006

Table 3-36
Project Area State Income Tax Revenues (in billions of dollars*)

Including Personal and Corporation Income tax unless otherwise noted

State	1996	2006	Average Annual Growth Rate 1996-2006 (%)	2010 (Projected)
Alaska[1]	0.3	0.8	16.6	1.2
Arizona	1.9	4.1	8.0	5.6
California	26.6	61.5	13.1	86.0
Colorado	2.5	4.7	8.8	6.1
Idaho	0.8	1.4	7.5	1.8
Montana	0.5	0.9	8.0	1.1
Nevada[2]	-	-	-	-
New Mexico	0.8	1.5	8.7	1.9
Oregon	3.1	5.9	9.0	7.6
Utah	1.3	2.6	10.0	3.4
Washington[2]	- [a]	-	-	-
Wyoming[2]	- [a]	-	-	-
Total	**37.8**	**83.4**	**12.1**	**114.5**

* Not adjusted for inflation

[1]There are no personal or corporate state income taxes in Nevada, Washington, Wyoming.

[2]There are no personal state income taxes in Alaska, data reflects corporation net income tax only.

Source: US Bureau of Census 2007b

to $114.5 billion in 2010. Revenues in California are expected to reach $86 billion in 2010.

Sales Tax Revenues

Total sales tax revenues for the project area are projected to grow from $57.7 billion in 2006 to $74.8 billion in 2010 (Table 3-37, Project Area State Sales Tax Revenues)Between 2002 and 2010, sales tax revenues are expected to grow for each individual state, with revenues in the largest generating state, California, projected to reach $40 billion in 2010.

During the period from 1997 to 2002, higher-than-average annual growth in sales tax revenues occurred in Arizona (9.6 percent), Wyoming (10.0 percent), Nevada (10 percent), and California (6.9 percent). The average annual growth rate for the project area as a whole during this period was 6.7 percent.

Table 3-37
Project Area General State Sales Tax Revenues (in billions of dollars*)

State	1996	2006	Growth Rate 1997-2006 (%)	2010 (Projected)
Alaska[1]	-	-	-	-
Arizona	2.7	5.3	9.6	7.20
California	19.0	32.1	6.9	40.0
Colorado	1.3	2.1	6.1	3.3
Idaho	0.9	1.1	5.1	1.5
Montana[1]	-	-	-	-
Nevada	1.6	3.2	10.0	4.7
New Mexico	1.3	1.7	3.1	1.9
Oregon	-	-	-	-
Utah	1.2	1.9	5.8	2.4
Washington	6.2	10.0	6.1	12.7
Wyoming	0.3	0.6	10.0	.88
Total	**34.5**	**57.7**	**6.7**	**74.8**

* not adjusted for inflation
[1]There are no general state sales taxes in Alaska, Montana or Oregon.
Source: US Bureau of Census 2007b

State and Local Government Expenditures

Funding for state and local government services for the project area in 2002 was concentrated in California at $293.3 billion, 60 percent of the total amount of $504.9 billion for the project area (Table 3-38, Project Area Total State and Local Government Expenditures). Other states with relatively large state and local government expenditure are Washington ($50.4 billion), Colorado ($32.4 billion), Arizona ($31.9 billion), and Oregon ($27.7 billion).

Annual growth rates in state and local government expenditures have increased fairly rapidly throughout the project area, with an overall annual average rate of 8.0 percent over the period of 1997 to 2002. Colorado's growth rate at 9.5 percent was more than one percentage point higher than the project area average, while growth rates in Alaska (4.6 percent) and Montana (5.0 percent) were relatively low during the period.

Table 3-38
Project Area Total State and Local Government Expenditures (in billions of dollars*)

State	1997	2002	Average Annual Growth Rate 1997-2002 (%)	2010 (Projected)
Alaska	7.5	9.4	4.6	13.5
Arizona	21.2	31.9	8.5	61.3
California	196.0	293.3	8.4	559.0
Colorado	20.6	32.4	9.5	66.9
Idaho	5.4	7.6	7.1	13.1
Montana	4.4	5.6	5.0	8.2
Nevada	9.2	14.0	8.8	27.4
New Mexico	9.3	12.7	6.4	20.9
Oregon	19.9	27.7	6.8	47.0
Utah	10.8	15.5	7.5	27.6
Washington	36.1	50.4	6.9	86.0
Wyoming	3.2	4.3	6.1	6.9
Total	**343.6**	**504.9**	**9.3**	**934.2**

* not adjusted for inflation
Source: US Bureau of Census 2007c

Alternative Economic Values

In addition to traditional development that provides employment and income to the rural west, an economic value can be attributed to the project area for its amenities. Likewise, some cost can be attributed for the protection of these values. Amenities are those features, either developed or undeveloped, that attract visitors to an area (e.g., recreation opportunities, wildlife viewing, solitude, etc.). Recreation (both individual and commercial) and tourism support local and niche businesses throughout public and FS lands. This type of income is dependant on the open space to support the amenities that attract recreationists and others in search of this locale.

State and Local Government Employment

State and local government employment data for 1995 and 2006 have been recorded in Table 3-39, Project Area Total State and Local Government Employment (in thousands). As shown in the table, growth in government employment in the project area has been varied over the 11-year period. The overall annual employment growth for the project area stood at 1.8 percent over the period, while states such as Nevada increased their employment by 3.1 percent, with a slightly smaller but still large increase in Arizona (2.4 percent).

Table 3-39
Project Area Total State and Local Government Employment (in thousands)

State	1995	2006	Average Annual Growth Rate 1995-2006 (%)	2010 (Projected)
Alaska	45.6	52.6	1.4	55.4
Arizona	218.8	285.1	2.4	313.9
California	1,479.6	1,818.7	1.9	1,960.4
Colorado	204.9	255.0	2.0	276.1
Idaho	67.1	79.4	1.5	84.4
Montana	56.3	54.2	-.3	53.5
Nevada	73.5	103.3	3.1	116.9
New Mexico	110.7	127.9	1.3	134.8
Oregon	166.1	181.7	.8	187.7
Utah	104.8	128.8	1.9	138.8
Washington	283.2	333.2	1.5	353.5
Wyoming	37.9	45.8	1.7	49.1
Total	**2,848.5**	**3,465.7**	**1.8**	**3,721.9**

Source: US Bureau of Census 2007c

The majority of the states were within half a percentage point of the total project area growth, while Oregon (.8 percent) saw slower growth and Montana (-.3 percent) experienced a decline in government employment.

California's government employment stood at 1.8 million in 2006, holding 52 percent of project area's total, and is expected to reach 2.0 million in 2010. Other states with relatively large totals of government employees in 2006 were Washington (333,200), Arizona (285,100), and Colorado (255,000). Total employment in the project area was more than 3.4 million in 2006 and is expected to exceed 3.7 million in 2010.

Environmental Justice

As required by NEPA, and specifically in accordance with Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations, federal agencies must incorporate environmental justice as part of their missions. This section addresses topics related to environmental justice, providing specific information on economic, racial, and demographics in and around the project area to identify areas of low-income and high-minority populations.

A summary of the geographic distribution of low-income and minority populations, based on the demographic data from the 2006 American Community Survey (US Bureau of the Census 2007a) for each project area state is presented in Table 3-40, Project Area Minority and Low-income Population Composition. For the data presented in this table, the following definitions describe low-income and minority population categories:

- Minority: The minority category includes persons who classify themselves as belonging to any of the following racial groups: Hispanic or Latino, Black or African American, American Indian or Alaskan Native, Asian, Native Hawaiian or Other Pacific Islander, and some other race (non-White). The term minority includes all persons classifying themselves in various racial categories, except those identifying themselves as not of Hispanic origin and as White or Other Race (US Bureau of Census 2007a).
- Low-Income: The Bureau of Census determines which families or individuals are poor using a set of money income thresholds, taking into account family size and composition. Those families or individuals that fall below their relevant poverty threshold are considered low income.

In 2006, the project area minority population was estimated at 30 million (44.3 percent of total project area population). Some individual states hosted a relatively large number of minority individuals. Of total population in New Mexico, 57.6 percent were considered minority, followed by 57.2 percent in California, 41.4 percent in Nevada, and 40.5 percent in Arizona. In each of the above states, as well as the project area as a whole, the Hispanic population dominated the minority ethnic groups. Of all the states, New Mexico and California have minority populations that exceed the project area minority population, as well as exceeding half of the total population of each state. Montana (11.4 percent), Wyoming (12.0 percent), Idaho (13.7 percent), Utah (17.2 percent), and Oregon (19.2 percent) have minority populations well (more than 20 percentage points) below the project area average.

The project area poverty (low-income) rate is estimated at 12.9 percent, exceeding the poverty rates of more than half of the project area states. States with poverty rates higher than the average for the project area are New Mexico (18.5 percent), Arizona (14.2 percent), Oregon (13.3 percent), Montana (13.6 percent), and California (13.1 percent). Out of all the project area states, New Mexico (at 18.5 percent) holds the highest poverty rate, while Wyoming has the lowest poverty rate (9.4 percent).

Table 3-40
Project Area Minority and Low-income Population Composition

Parameter	Alaska	Arizona	California	Colorado	Idaho	Montana
Total Population	670,053	6,166,318	36,457,549	4,753,377	1,466,465	944,632
White, Non-Hispanic	443,944	3,668,571	15,600,175	3,400,011	1,265,241	836,541
Hispanic or Latino	37,498	1,803,377	13,074,155	934,410	138,871	20,513
Non-Hispanic or Latino Minorities	188,611	694,370	7,783,219	418,956	62,353	87,578
One race	140,871	610,190	7,065,079	340,937	37,384	70,035
Black or African American	20,419	198,854	2,201,043	170,995	6,105	4,327
American Indian or Alaskan Native	86,688	252,214	168,486	29,223	13,708	58,034
Asian	29,622	139,386	4,424,529	127,082	14,884	5,509
Native Hawaiian or Other Pacific Islander	3,526	9,326	120,837	3,700	2,021	763
Some other race	616	10,410	150,184	9,937	666	1,402
Two or more races	47,740	84,180	718,140	78,019	24,969	17,543
Total minority	226,109	2,497,747	20,857,374	1,353,366	201,224	108,091
Low-income	73,036	875,617	4,775,939	570,405	184,774	128,470
Percent minority	33.7	40.5	57.2	28.5	13.7	11.4
Percent low-income	10.9	14.2	13.1	12.0	12.6	13.6

Table 3-40
Project Area Minority and Low-income Population Composition

Parameter	Nevada	New Mexico	Oregon	Utah	Washington	Wyoming	Project Area
Total Population	2,495,529	1,954,599	3,700,758	2,550,063	6,395,798	515,004	*68,070,145*
White, Non-Hispanic	1,463,452	828,965	2,989,235	2,112,440	4,886,203	453,251	*37,948,029*
Hispanic or Latino	610,051	860,687	379,034	286,113	580,027	35,732	*18,760,468*
Non-Hispanic or Latino Minorities	422,026	264,947	332,489	151,510	929,568	26,021	*11,361,648*
One race	366,233	243,503	244,073	118,698	752,915	19,189	*10,009,107*
Black or African American	178,999	35,849	60,985	21,303	211,333	3,269	*3,113,481*
American Indian or Alaskan Native	26,393	176,968	36,631	27,061	83,313	10,497	*969,216*
Asian	146,075	23,557	134,601	47,871	418,886	4,311	*5,516,313*
Native Hawaiian or Other Pacific Islander	9,871	1,053	7,934	18,958	26,691	350	*205,030*
Some other race	4,895	6,076	3,922	3,505	12,692	762	*205,067*
Two or more races	55,793	21,444	88,416	32,812	176,653	6,832	*1,352,541*
Total minority	1,032,077	1,125,634	711,523	437,623	1,509,595	61,753	*30,122,116*
Low-income	257,040	361,601	492,201	270,307	754,704	48,410	*8,792,504*
Percent minority	41.4	57.6	19.2	17.2	23.6	12.0	*44.3*
Percent low-income	10.3	18.5	13.3	10.6	11.8	9.4	*12.9*

Source: US Bureau of Census 2007a

3.19 Health and Safety

This section describes health and safety concerns associated with geothermal energy development. Also discussed is the regulatory framework around health and safety of workers involved with geothermal energy development.

3.19.1 Applicable Plans, Policies and Regulations

Occupational health and safety issues pertaining to geothermal resource development include exposure to geothermal gases, confined spaces, heat, and noise. Occupational health and safety rights for individuals are protected through the federal Occupational Safety and Health Act (29 USC 651 et seq.). Under this act, Congress created the Occupational Safety and Health Administration (OSHA), an agency of the US Department of Labor. The OSHA's mission is to assure the safety and health of America's workers by setting and enforcing standards; providing training, outreach, and education; establishing partnerships; and encouraging continual improvement in workplace safety and health. States may have additional laws and regulations that build on the Occupational Safety and Health Act.

Hazardous and toxic substances would be used and generated during the various phases of geothermal resource development. These substances have hazardous physical and chemical properties (e.g., ignitability, corrosivity, reactivity) and may also have high toxicity. There are numerous federal laws that regulate hazardous and toxic substances. Of these laws, the most far reaching are discussed below. States may also have additional laws that regulate the management of hazardous and toxic substances.

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), a hazardous substance is any material the US EPA has designated for special consideration under the Clean Air Act, Clean Water Act, Toxic Substances Control Act, or Resource Conservation and Recovery Act (US EPA 2007e). The US EPA also may designate additional substances as being hazardous under CERCLA. Hazardous wastes or substances can be hazardous to human health or the environment when they are improperly managed and possess at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity) or appear on other EPA lists of substances deemed to be hazardous in some way.

The Resource Conservation and Recovery Act is a federal law enacted in 1976. Three primary goals of the Act are to protect human health and the environment from the potential hazards of waste disposal, to reduce the amount of waste generated, and to ensure that wastes are managed in an environmentally sound manner (US EPA 2006). In 1984, Congress enacted the Hazardous and Solid Waste Amendments, which expanded the scope of the Act by implementing management for hazardous wastes from their manufacture all the way through to their final disposal.

3.19.2 Typical Hazards of the Geothermal Industry

There are physical hazards associated with all phases of geothermal development: exploration, development, operation, and close out. Many of the hazards associated with geothermal energy development are shared by other energy industries. Existing hazards are usually associated with site excavation, road building, exploration drilling, flow testing, well venting, power plant construction, power plant operation, and transmission line construction. Thermal hazards are also present whenever working with heated fluids. Adherence to safety standards and use of protective equipment can reduce occupational hazards and the chance of burns from geothermal fluids, but work-related injuries and fatalities can still occur.

Chemical hazards associated with naturally occurring contaminants may also be present in geothermal fluids. Human exposure may occur during the exploration, development, operation, or close out phases of a geothermal project. Health effects may be acute or chronic, and exposure may be via inhalation of geothermal steam or ingestion of geothermal fluids (drinking contaminated water). Watson and Etnier (1981) report that the most frequent and severe of reported injuries to geothermal workers is dermal exposure to caustic sludges produced by H_2S abatement systems.

Inhalation of Noncondensable Gases

The primary human health issue within the geothermal energy working environment is the inhalation of noncondensable gases that form when geothermal fluids turn to steam. Steam is produced during drilling, flow testing, well venting, and cooling of geothermal fluids as part of standard power plant operations. The primary gas of concern is hydrogen sulfide, while others such as mercury, radon, and benzene are also present but are typically not at levels considered hazardous to human health.

Total noncondensable gas emissions from geothermal resources typically comprise less than five percent of the total steam emitted (Reed and Renner 1995). Binary power plants reinject all geothermal fluids into the reservoir, thereby eliminating emissions concerns; however, emissions do occur during flow testing and well venting.

Hydrogen Sulfide

Hydrogen sulfide emissions have resulted in complaints of odor annoyance and health impairment. The OSHA has established an acceptable maximum concentration of 20 parts per million (ppm) for hydrogen sulfide in the workplace, with a maximum level of 50 ppm allowed for 10 minutes maximum if no other measurable exposure occurs. The National Institute for Occupational Safety and Health has set a maximum recommended exposure limit ceiling value of 10 ppm for 10 minutes maximum (Agency for Toxic Substances and Disease Registry 2006).

Anspaugh and Hahn (1979) evaluated occupational hazards at the Geysers in California. While this information is nearly 30 years old, the more significant hazards at that time were exposure to toxic chemicals, hazardous materials, and noise. The most significant cause of illness was exposure to the chemicals and wastes associated with hydrogen sulfide abatement. Anspaugh and Hahn concluded that, on a comparative basis, geothermal energy is a relatively benign source of energy. The chemical exposure issues mentioned above are shared by many other energy technologies including oil and gas, oil shale, and nuclear.

Anspaugh and Hahn (1979) also reviewed public health concerns related to the Geysers Geothermal Power Plant. Residents of communities near the Geysers filed public health complaints, most of which were related to annoyance effects, particularly to odor annoyance from hydrogen sulfide. Some residents appeared at hearings held by the California Public Utilities Commission and voiced complaints of headaches, nausea, and sinus congestion. The concentrations of hydrogen sulfide that appear to be responsible for these complaints were about 0.1 ppm, or 100 times lower than the recommended standard for occupational exposure. Whether such low concentrations of hydrogen sulfide can produce actual health effects remains to be proven, but the possibility does exist that some individuals are particularly sensitive.

While abatement systems can reduce levels of hydrogen sulfide, some abatement systems have their own suite of chemicals and wastes, exposure to which can also result in occupational illness. Chemicals used in hydrogen sulfide abatement systems include hydrogen peroxide, caustic soda, and catalytic compounds containing iron and nickel. Waste is primarily sludge made of noncommercial quality sulfur with lesser amounts of other chemicals (Anspaugh and Hahn 1979).

Mercury

Mercury levels vary between geothermal resources and are not present in all geothermal fluids. In those resources containing mercury, power production could result in mercury emissions, depending upon the type of plant. Binary plants do not emit any mercury because all geothermal fluids are reinjected into the geothermal reservoir. Mercury abatement technology is available for power plants using resources with elevated mercury content. State and local governments have introduced measures to reduce mercury emissions from a variety of sources and have resulted in the presence of mercury abatement measures at most geothermal facilities currently in production (Geothermal Energy Association 2007b).

Radon

Radon is a toxic radioactive gas with no color, odor, or taste that forms from the normal decay process of uranium, which is present in most rocks and soil. Radon is present in geothermal fluids and is released to the air from cooling towers. It is generally only a concern in indoor areas where concentrations can build up over time. A study of radon levels at the Geysers concluded that the cooling towers had no discernible effect on ambient radon levels in either nearby communities or in the plant environment itself (Layton and Anspaugh 1981).

Benzene

Benzene is a known carcinogen that is present in some geothermal fluids, but levels are generally within acceptable ranges. The Heber geothermal facility in southern California was required to conduct quarterly benzene cooling tower analysis as a permit condition; however, levels have never been high enough to trigger risk assessments under the California Environmental Protection Agency exposure level standards (Geothermal Energy Association 2007b).

Drilling Hazards

Due to limited research of the geothermal industry, extensive hazard data for geothermal drilling activities are not available. However, drilling hazards associated with the geothermal industry are generally similar to hazards experienced with the well-documented hazards of drilling for the oil and gas industry. Table 3-41 provides a description of the common types of hazards associated with oil and gas drilling.

Table 3-41
Oil and Gas Industry Drilling Hazards that May be Present in the Geothermal Industry

Hazard	Source
Struck by	Falling/moving pipe; tongs and/or spinning chain, kelly, rotary table, etc.; high-pressure hose connection failure causing employees to be struck by whipping hose; tools/debris dropped from elevated location in rig; vehicles
Caught in/between	Collars and tongs, spinning chain, and pipe; clothing gets caught in rotary table/drill string
Fire/Explosion/High pressure release	Well blowout, drilling/tripping out/swabbing etc. results in release of gas that may be ignited if not controlled at the surface; welding/cutting near combustible materials, uncontrolled ignition sources near the well head, e.g., heater in the doghouse, unapproved or poorly maintained electrical equipment; aboveground detonation of perforating gun
Rig collapse	Overloading beyond the rated capacity of the rig; improper anchoring/guying; improper raising and lowering the rig; existing maintenance issues with the rig structure that impacts the integrity

Table 3-41
Oil and Gas Industry Drilling Hazards that May be Present in the Geothermal Industry

Hazard	Source
Falls	Fall from elevated areas of the rig, i.e., stabbing boar, monkey board, ladder, etc.; fall from rig floor to grade
Hydrogen sulfide exposure	Hydrogen sulfide release during drilling, swabbing, perforating operations, etc. resulting in employee exposures; production tank gauging operations, gaugers sometimes exposed to hydrogen sulfide

Source: OSHA 2007

Contamination of Drinking Water Supplies

Another human health concern related to geothermal projects is the potential contamination of underground and surface drinking water supplies with geothermal fluids. The common contaminants in geothermal fluids that are of concern to public health through consumption in drinking water are arsenic, boron, and mercury.

Most geothermal reservoirs are found deep underground, well below groundwater reservoirs. Drilling activities can result in the pollution of shallower water aquifers with drilling fluids as wells are bored through them, although this effect is limited to the duration of drilling. Well casing is used upon well completion, which separates geothermal fluids from any shallower aquifers that a drilled well may pass through. Groundwater contamination can occur in rare situations involving a well casing break or the percolation of surface-discharged geothermal fluids.

Surface water bodies can be contaminated from either surface discharges or spills of geothermal fluids, or underground contamination of springs that feed a surface water body. Surface discharges are regulated through state and local permits, and abatement technologies are installed as necessary to reduce contaminants to acceptable levels.

Construction, Operation, and Maintenance Plan

Construction, operation, and maintenance plans are used to establish procedures and protocols for the safe construction, operation, and maintenance of geothermal resource developments. These plans typically address worker and site safety, emergency response protocols, and procedures for managing hazardous and toxic substances. A construction, operation, and maintenance plan is prepared by the operator of the geothermal energy operation prior to any geothermal resource development. Furthermore, a plan is also used to identify procedures for safely abandoning and properly reclaiming a site during close out.

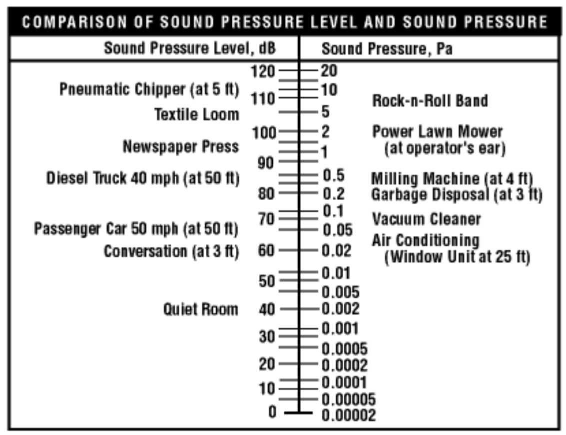
3.20 Noise

This section describes the environmental noise fundamentals, background noise levels, noise propagation, and noise standards and guidelines related to geothermal resource development.

3.20.1 Fundamentals

Noise is defined as any undesirable sound. Sound is any pressure variation that the ear can detect. Sound pressure levels are measured in units of decibels. Any time a sound level (or sound pressure level) is referred to, a decibel notation is implied.

Figure 3-23
Comparison of Sound Pressure Level and Sound Pressure[1]



[1] dB = decibel
Source: Canada's National Occupational Health and Safety Resource 2008.

Audible sounds range from 0 decibel, considered the quietest sound that can be heard by an average person, called the "threshold of hearing," to about 130 decibels, which is considered so loud that it causes pain, and is called the "threshold of pain" (Figure 3-23), Comparison of Sound Pressure Level and Sound Pressure). The perceived pitch of a sound, which characterizes the sound as being high or low when heard, is determined by its frequency. Low-pitched or bass sounds have low frequencies, and high-pitched or treble sounds have high frequencies. A healthy, young person can hear sounds with frequencies ranging from approximately 20 to 20,000 cycles per second (hertz). The sound of human speech is typically in the range 300 to 3,000 hertz (Canada's National Occupational Health and Safety Resource 2008).

The A-weighted decibel scale estimates the range of human hearing by filtering out lower frequency noises, which are not as damaging as high frequencies. This scale is widely used in noise standards, guidelines, and ordinances, and is widely accepted in analyzing noise and its impacts on humans. Table 3-42, Comparison between Noise Source and Sound Level, provides a comparison between sound pressure levels associated with some familiar sources and geothermal operations.

Table 3-42
Comparison between Noise Source and Sound Level

Noise Source	Sound Level (A-weighted decibel scale)
Near leaves rustling from breeze	25
Whisper at six feet	35
Inside average suburban residence	40
Near a refrigerator	40
Inside average office, without nearby telephone ringing	55
Speech at 3 feet, normal voice level	60
Automobile (60 miles per hour) at 100 feet	65
Vacuum cleaner at 10 feet	70
Garbage disposal at 3 feet	80
Electric lawn mower at 3 feet	85
Food blender at 3 feet	90
Auto horn at 10 feet	100

Source: Geothermal Energy Association 2007a

Although an A-weighted sound may adequately indicate the level of sound at a given instant, it does not account for the duration of the sound or that sound levels can vary with time. To assess these variations, two descriptors are often used, L_{dn} and L_{EQ}. The day-night average sound level (L_{DN} or DNL) is the average A-weighted sound level during a 24-hour period with 10 decibels added to nighttime levels (between 10:00 p.m. and 7:00 a.m.). This adjustment is added to account for the fact that human sensitivity increases during the nighttime hours when people are involved in more noise-sensitive activities (e.g., sleeping). The equivalent continuous sound pressure level (L_{EQ}) is a sound level that, if maintained continuously during a specific time period, would contain the same total energy as sound that varied over that time. Statistical values of noise levels are also frequently used to describe time-varying characteristics of environmental noise measured in A-weighted decibel scale. The L_{eq} values typically used are L_{10}, L_{50}, and L_{90}, representing noise levels that are exceeded at 10, 50, and 90 percent of the time, respectively. L_{10} represents a sound level considered intrusive, L_{50} is the median noise level, and L_{90} corresponds to background noise.

Noise effects on humans fall into three categories:

- Subjective effects such as annoyance, nuisance, and dissatisfaction;
- Interference with activities such as speech, sleep, and learning; and
- Physiological effects such as anxiety, tinnitus, or hearing loss.

Determining if a noise is objectionable depends on the type of noise (tonal, broadband, low frequency, or impulsive), in addition to the circumstance and individual sensitivity of the person who hears it. Typically, the levels associated with environmental noise only produce effects in the first two categories. However, workers subjected to noise in environments such as industrial plants or airports may experience noise effects similar to those described under the third category. Table 3-43, Subjective Response to Changes in Sound Level, illustrates how differences in sound magnitudes are perceived by humans.

Table 3-43
Subjective Response to Changes in Sound Level

Change in Sound Level	Perceived Change in Loudness
±1 decibel	Requires close attention to noise
±3 decibels	Barely perceptible
±5 decibels	Quite noticeable
±10 decibels	Dramatic; sounds nearly twice or half as loud
±20 decibels	Striking; fourfold change in loudness

Source: Berendt, Corliss, and Ojalvo 2000

3.20.2 Background Noise Levels

Background noise is the noise from all other sources than the source of interest (e.g., geothermal operations). The background noise level can vary considerably depending on the location. There is currently no available information defining existing noise levels in areas of geothermal potential on public and NFS lands, which would be recorded as background noise levels at any given project site. Natural background noises expected to exist in such areas include agricultural activities, recreation activities (including mechanized and motorized uses), oil and gas development, and aircraft over flights.

3.20.3 Noise Propagation

Predicting the noise level at a receptor location depends on a complex combination of source characteristics and site-specific factors (Anderson and Kurze 1992) that include:

- Source characteristics such as sound power, directivity, and configuration;
- Geometric spreading (geometric divergence) as the sound moves away from the source to the receptor;
- Atmospheric air absorption, which depends strongly on the sound frequency and relative humidity, less strongly on temperature, and slightly on pressure;
- Ground effects due to sound reflected by ground surfaces interfering with the sound propagating directly from the source to the receptor;

- The topography, structures, and other natural or human-made barriers between the source and the receptor; and
- Meteorological factors such as turbulence and variations in vertical wind speed and temperature.

Most screening applications only consider geometric spreading when predicting noise levels. A detailed analysis of noise levels would require a sound propagation model that integrates most of the sound attenuation mechanisms identified above; however, this type of analysis would require detailed source characteristics and site-specific data (e.g., as vegetation types, topography, and meteorological data). Moreover, the effects of variables such as vertical wind and temperature gradients can also have considerable impacts on such an analysis.

At short distances (less than 160 feet), the wind has a minor effect on the sound level. For locations at greater distances from a given source, wind can cause considerable differences in sound levels. Wind speed typically increases with height, and this variation focuses it in the downwind direction and creates a shadow in the upwind direction. Therefore, upwind sound levels will be lower, and downwind levels higher, than if there were no wind.

Changes in temperature with height also play a major role in sound propagation. During the day, air temperature decreases with height. In contrast, on a clear night, the temperature often increases with height (a condition known as a temperature inversion). The speed of sound varies with temperature so that generally sound bends (refract) upward during the day, leading to reduced sound levels on the ground, and bends downward during inversions, leading to higher sound levels on the ground. Such temperature effects are uniform in all directions, differing from those of wind that affect mostly upwind and downwind direction.

3.20.4 Noise Standards and Guidelines

The federal law that directly affects noise control is the Noise Control Act of 1972, as amended by the Quiet Communities Act of 1978 (42 USC 4901-4918). This Act delegates to the states the authority to regulate environmental noise. It also directs government agencies to comply with local community noise statutes and regulations, and to conduct their programs to promote an environment free of any noise that could jeopardize public health or welfare. More specifically, BLM regulations mandate that noise at one-half mile—or at the lease boundary, if closer—from a major geothermal operation shall not exceed 65 A-weighted decibels (43 CFR 3200.4[b]).

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