CHAPTER 3

PUBLIC LAND RESOURCES

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CHAPTER 3

PUBLIC LAND RESOURCES

Introduction and Study Area

This chapter describes the natural and socioeconomic environment of public lands in the western U.S., including Alaska, which would be affected by the alternatives under consideration. It focuses on the resources that were identified in Chapter 1, and is useful in understanding the environmental, cultural, and social consequences of the proposed program.

Land Use and Ecoregions

Land Use

The BLM manages nearly 261 million acres in the western U.S. and Alaska. Public lands represent from less than 0.1% of the total land area in some western states to over 67% of lands in Nevada (Table 3-1).

Approximately 164 million acres of public lands are upland rangeland, of which approximately 161 million acres are open to livestock grazing. Other public uses on rangeland include recreation, and oil, gas, and mineral development.

Another 55 million acres are forestland and woodland. Forestlands and woodlands are a source of timber and other forest products, and are used for livestock grazing, recreational, and cultural purposes.

Wetland and riparian areas total about 23 million acres and are primarily used for recreation and grazing. The remaining 19 million acres consist of barren mountains, mountaintops, glaciers, sand dunes, and playas. These areas are primarily used for recreation.

Ecoregions

Because this PER addresses a broad geographic region with a diverse range of biophysical characteristics, it is useful to subdivide this region into smaller, homogeneous areas for analysis. Where possible, information on resources has been organized by ecoregions rather than by state boundaries. Ecoregions are geographic areas that are delineated and defined by similar climatic conditions, geomorphology, and soils (Bailey 1997, 2002). Since these factors are relatively constant over time and strongly influence the ecology of vegetative communities, ecoregions may have similar potentials and responses to disturbance (Clarke and Bryce 1997; Jensen et al. 1997). Ecoregions, therefore, provide a useful framework for organizing, interpreting, and predicting changes to vegetation following management treatments.

TABLE 3-1
Acres of Public Lands in 17 Western States and Percent of Lands in the State Administered by the BLM

State	Acres of BLM Land	Percent of State Lands Administered by the BLM
Alaska	85,468,616	23.5
Arizona	12,218,180	16.8
California	15,230,638	15.1
Colorado	8,363,916	12.6
Idaho	12,001,817	22.5
Montana	7,963,511	8.5
Nebraska	6,354	<0.1
Nevada	47,824,624	67.6
New Mexico	13,371,737	17.2
North Dakota	58,837	0.1
Oklahoma	2,136	<0.1
Oregon	16,135,761	26.0
South Dakota	274,437	0.6
Texas	11,833	<0.1
Utah	22,858,179	42.1
Washington	408,580	0.9
Wyoming	18,366,584	29.3
Total	260,565,740	23.5

Source: USDI BLM (2006c, d). Acreages are approximate and subject to change in response to land transfers.

The public lands addressed in this PER lie within eight major physiographic regions, or ecoregion divisions: Tundra, Subarctic, Subtropical Steppe, Subtropical Desert, Temperate Steppe, Temperate Desert, Mediterranean, and Marine, including Mountain Provinces (Map 3-1).

Climate

Climate is the statistical distribution of atmospheric conditions, as determined by the weather patterns that result from long-term fluctuations in global atmospheric and hydrologic cycles. Climatic patterns describe the annual distribution of energy and moisture, thus affecting the amount and seasonal distribution of temperature, precipitation, and winds. These factors influence the composition and distribution of rangeland vegetation, as well as the formation and erosion of rangeland soils, and hydrological conditions. These factors also influence the distribution of wind-borne air pollutants, such as smoke from wildfires and prescribed fires.

The western U.S. experiences several broad climatic groups: polar, boreal, temperate, Mediterranean highland, and dry. Polar and boreal climates dominate in Alaska, while a humid temperate climate is characteristic of the coastal areas of Washington, Oregon, and northern California. The southern California coast has a Mediterranean climate, while mountainous areas have a highland climate. The rest of the western states east of the Cascade, Sierra Nevada, and Rocky mountains are characterized by a dry climate. On a regional scale, temperature and precipitation vary with latitude, elevation, distance from the oceans, and the position of mountain ranges with respect to prevailing winds. The eight ecoregions found in the treatment area are based on the seasonality of precipitation, and on the degree of dryness or cold, and depend largely on latitude and continental position.

Tundra Ecoregion

The climate of the westernmost and northernmost portion of Alaska (including the Alaska Peninsula and Aleutian Islands), is typified by cold Arctic air masses. The tundra climate has a very short, cool summer and a long, severe winter, with the warmest average monthly temperature between 50 °F and 32 °F (freezing). Between 55 and 188 days per year typically have a daily mean temperature above freezing. Annual precipitation is often less than 8 inches, but the climate is humid because of the low potential evaporation.

Subarctic Ecoregion

The moist, boreal climate type demonstrates a large seasonal temperature range. Winters dominate, with cool, short summers. Because average monthly temperatures are below freezing for up to 7 consecutive months, soil moisture freezes solidly to depths up to 14 feet. Only a single month has an average temperature above 50 °F. The limited precipitation (10 to 20 inches annually) falls mainly during the short summer months, although thunderstorms are uncommon.

Subtropical Steppe Ecoregion

The western subtropical steppe borders deserts on both the north and south, with the temperate steppe to the north and east. This ecoregion division has a hot semiarid climate where potential evaporation exceeds precipitation, and where all months have average temperatures above freezing. Bright sunny days with cool clear nights are typical. Precipitation ranges from 10 to 20 inches per year, with a summertime peak due to thunderstorm activity.

Subtropical Desert Ecoregion

South and west of the Arizona-New Mexico Mountains is the subtropical desert climate. This region is not only very dry, but also has extreme maximum summer temperatures. In addition, both daytime solar and nocturnal radiation are high, leading to extreme daily temperature variations. Annual precipitation is less than 8 inches.

Temperate Steppe Ecoregion

Temperate steppes are areas with a semiarid continental climatic regime, where evaporation usually exceeds precipitation. Seven or less months have an average temperature above 50 °F. Winters are cold and dry, and summers are warm to hot, with at least 1 month's average temperature below freezing.

Temperate Desert Ecoregion

Temperate deserts are generally dry with wide temperature differences between summer and winter. In the intermountain region between the Pacific coast and Rocky Mountains, the temperate desert has a very pronounced drought season and a short humid season. Most precipitation falls in winter, despite a small peak in late spring. Eight or more months have an average temperature above 50 °F. Winter is relatively short, but with at least 1 month's average temperature below freezing.

Mediterranean Ecoregion

Most of California west of the Sierra Nevada Mountains and Mojave Desert is typified by alternate wet winters and dry summers, within a strong transition zone between the dry desert and the wet coast. Mild temperatures dominate, with the coldest average monthly temperature between 65 °F and 27 °F. Most precipitation occurs in winter, with the wettest month receiving nearly 3 times the precipitation of the driest summer month.

Marine Ecoregion

The temperate oceanic climate extends from southeast Alaska down the Pacific Coast to southwestern Oregon. This climate receives abundant rainfall from maritime air masses, with average temperatures moderated by the ocean. Although the warmest average monthly temperature is below 72 °F for at least 4 months, the average temperature is above 50 °F; the coldest month averages just above 32 °F. Annual precipitation is high (40 to 80 inches per year), but significantly lower in summer. The relatively low temperatures reduce evaporation, producing a very damp, humid climate with substantial cloud cover. Mild winters and cool summers are typical.

Mountain Provinces

The mountainous portions of all eight ecoregion divisions exhibit a highland climate, where site-specific conditions vary greatly, depending on altitude and exposure. Windward slopes typically have greater precipitation (and leeward slopes less precipitation) than the ecoregion division as a whole. Southern exposures also tend to be warmer than slopes with northern exposures. Finally, the occurrence of mountain winds (up slope during the day, down slope at night) and diurnal temperature inversions is greatest near mountains.

Air Quality

Because air pollution can directly pose health risks and cause significant welfare impacts to humans, improvement of air quality in the U.S. is an important regulatory goal. The Clean Air Act (originally passed in 1955 and amended several times since), establishes a mandate to reduce emissions of specific pollutants via uniform federal standards. Under the Act, the USEPA is responsible for setting standards and approving state implementation plans (SIPs) to ensure that local agencies comply with the Act.

The standards set by the USEPA include primary and secondary NAAQS for six pollutants, referred to as criteria pollutants, to protect public health and welfare. The criteria pollutants are sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), lead (Pb), and particulate matter (PM).

Particulate matter is a generic term for a broad class of chemically and physically diverse substances that exist as discrete particles over a wide range of sizes. For regulatory purposes, PM is sub-classified by the particle's aerodynamic diameter. PM_{10} includes all PM with an aerodynamic diameter of 10 microns or less and is referred to as inhalable PM. $PM_{2.5}$ includes all PM with an aerodynamic diameter of 2.5 microns or less, called fine PM, and is by definition a subset of PM_{10}. Studies have shown more serious health effects associated with $PM_{2.5}$; therefore, the USEPA promulgated more stringent standards for this class of PM.

The NAAQS are listed in Table 3-2. The primary NAAQS protect the health of sensitive individuals, and the secondary NAAQS protect the general welfare of the public. Different averaging periods are established for the criteria pollutants based on their potential health and welfare effects. The NAAQS are enforced by states, which in some cases have adopted additional or more stringent standards.

All areas of the nation have been classified based on their status with regard to attaining the NAAQS. An area is designated by the USEPA as being in attainment for a criteria pollutant if ambient concentrations of that pollutant are below the NAAQS, or being in nonattainment if criteria pollutant concentrations violate the NAAQS. Once nonattainment areas comply with the NAAQS, they are designated as maintenance areas. Areas that are classified as nonattainment must implement a plan to reduce ambient concentrations below the NAAQS. Areas where insufficient data are available to determine attainment status are designated as unclassified, and are treated as attainment areas for regulatory purposes.

The Clean Air Act also provides for the prevention of significant deterioration (PSD) of air quality, especially in areas of the country where the air quality is much better than standards. In Class I areas, only a

TABLE 3-2
National Ambient Air Quality Impact Significance Criteria (μg/m³)

Pollutant	Averaging Period[1]	NAAQS		PSD Increments[2]	
		Primary	Secondary	Class I	Class II
NO_2	Annual	100	100	2.5	25
CO	1-hour	40,000	NA	NA	NA
	8-hour	10,000	NA	NA	NA
PM_{10}	24-hour	150	150	8	30
	Annual	NA	NA	4	17
$PM_{2.5}$	24-hour	35	35	NA	NA
	Annual	15	15	NA	NA
SO_2	3-hour	NA	1,300	25	512
	24-hour	365	NA	5	91
	Annual	80	NA	2	20
Lead	Quarter	1.5	1.5	NA	NA
O_3	1-hour[3]	235	235	NA	NA
	8-hour[3]	157	157	NA	NA

[1] Annual standards are never to be exceeded. Short-term standards (those other than annual or quarterly) are not to be exceeded more than once per year, except for O_3, PM_{10}, and $PM_{2.5}$ standards. For O_3, the expected number of days with ozone levels above the standard is not to be exceeded more than once per calendar year. For PM_{10}, the standard is attained when the 99th percentile concentration for the year is less than the standard. For $PM_{2.5}$, the standard is attained when the 98th percentile concentration for the year is less than the standard.
[2] Prevention of significant deterioration (PSD) increments are the maximum amounts of pollutants allowed above a specified baseline concentration. Class I areas are predominantly large national parks and wilderness areas as of August 7, 1977.
[3] The 1-hour NAAQS will no longer apply to an area 1 year after the effective date of the designation of that area for the 8-hour ozone NAAQS. The effective designation date for most areas is June 15, 2004.
NA = Not applicable.

very small amount or increment of air quality deterioration is permissible. Class I areas include specified national parks, wilderness areas, and certain Indian reservations (Map 3-2). Mandatory Class I areas, which include large national parks and wilderness areas that were in existence on August 7, 1977, are a subset of Class I areas that may not be redesignated, and are subject to visibility protection regulations. All areas that have not been designated Class I are considered Class II areas. The PSD permit provisions of the Clean Air Act only apply to stationary sources of air pollution and do not include prescribed fire, which is defined as a temporary source. Some states, however, have regulations to restrict intrusions of smoke from prescribed burning that might adversely impact visibility within mandatory federal Class I and other smoke-sensitive areas.

Detailed knowledge of the existing air quality for the area covered by this PER is limited to available monitoring sites for criteria pollutants. In the undeveloped regions of public lands, ambient pollutant levels are expected to be low, and probably negligible in remote areas. In general, locations experiencing high ambient pollutant levels in the treatment area are areas with commercial and industrial land use (areas with mills, power plants, etc.), and local population centers (areas with automobile exhaust, residential heating, etc.).

Table 3-3 lists counties with public lands that are designated as nonattainment or maintenance areas for each criteria pollutant. PM_{10}, O_3, and NO_2 concentrations are expected to be higher near industrial areas and cities where there are significant combustion sources and vehicles. High SO_2 concentrations occur primarily near coal-fired power plants, smelters, and refineries.

Visibility Protection in Mandatory Federal Class I Areas

Under the Clean Air Act, Congress created the Grand Canyon Visibility and Transport Commission (GCVTC). The GCVTC was comprised of eight western states, six tribal agencies, and four federal land management agencies, and was charged with assessing the current scientific information on

TABLE 3-3
Counties within the Treatment Area that are Designated Nonattainment or Maintenance Areas for Various Pollutants

Pollutant	State	Nonattainment	Maintenance
PM_{10}	Arizona	Cochise*, Gila*, Maricopa*, Pima*, Pinal*, Santa Cruz*, Yuma*	Gila*, Mohave*
	California	Fresno*, Imperial*, Inyo*, Kern*, Kings*, Madera*, Mono*, Riverside*, San Bernardino, Stanislaus*, Tulare*	Kern*, Mono*
	Colorado	Prowers*	Adams*, Arapahoe*, Archuleta*, Boulder*, Broomfield, Denver, Douglas, Freemont*, Jefferson, Pitkin*, Routt*, San Miguel*
	Idaho	Bannock*, Bonner, Power*, Shoshone*	Ada*
	Montana	Missoula*, Rosebud*, Silver Bow*	None
	Nevada	Clark*, Washoe*	None
	New Mexico	Dona Ana*	None
	Oregon	Jackson*, Lake*, Lane*	Josephine*, Klamath*
	Utah	Salt Lake, Utah	None
	Washington	Yakima*	None
	Wyoming	Sheridan*	None
SO_2	Arizona	Cochise*, Gila*, Pinal*	Greenlee*, Pima*
	Montana	Lewis and Clark*, Yellowstone*	None
	Nevada	None	White Pine*
	New Mexico	None	Grant*
	Utah	Salt Lake*, Tooele*	None
NO_2	None	None	None
CO	Alaska	None	Fairbanks North Star*
	Arizona	Maricopa*	Pima*
	California	Los Angeles*, Riverside*, San Bernardino*	Butte*, El Dorado*, Fresno*, Kern*, Napa*, Placer*, San Diego*, Solano*, Sonoma*, Stanislaus*, Yolo*
	Colorado	None	Boulder*, El Paso*, Jefferson*, Larimer*, Teller*
	Idaho	None	Ada*
	Montana	Missoula*	Cascade*, Yellowstone*
	Nevada	None	Carson City*, Douglas*, Washoe*
	New Mexico	None	Bernalillo
	Oregon	Marion*, Polk*	Clackamas*, Jackson*, Josephine*, Klamath*, Lane*, Washington*
	Utah	Utah*	Salt Lake
	Washington	Spokane*	Yakima*
Ozone	Arizona	Maricopa*	None
	California	Butte, El Dorado*, Fresno*, Imperial, Kern*, Kings, Napa*, Placer*, Riverside*, San Bernardino*, San Diego*, Solano*, Sonoma*, Stanislaus, Tulare, Yolo	Kern*, Monterey, San Benito, San Diego
	Colorado	None	Boulder*, Jefferson
	Nevada	Washoe	Clark*, King*, Pierce*, Snohomish*, Yakima*
	New Mexico	Dona Ana*	None
	Oregon	Marion*, Polk*	Clackamas*, Washington*
	Utah	None	Salt Lake
Lead	Montana	Lewis and Clark*	None

* Only a portion of the county is in nonattainment or maintenance for the pollutant.
Notes: States that are not listed for a particular pollutant do not have counties within the treatment area that are also within nonattainment or maintenance areas for that pollutant.
Source: USEPA Green Book available at http://www.epa.gov/oar/oaqps/greenbk/.

visibility impacts and making recommendations for addressing regional haze in the western U.S (GCVTC 1996). The GCVTC signed and submitted more than 70 recommendations to the USEPA indicating that visibility impairment was caused by a wide variety of sources and pollutants, and that a comprehensive strategy was needed to remedy regional haze (Western Governors' Association 1996). Based on the findings and recommendations from the GCVTC, the USEPA established regional haze regulations, and encouraged states to coordinate their implementation efforts through regional planning organizations.

The Western Regional Air Partnership (WRAP) was established in 1997 as a successor to the GCVTC. The WRAP is a voluntary organization comprised of 13 western governors (Alaska, Arizona, California, Colorado, Idaho, Montana, North Dakota, New Mexico, Oregon, South Dakota, Utah, Washington, and Wyoming), 11 tribal leaders, and 2 federal departments (USDA and USDI).

In the 1990 amendments to the Clean Air Act, the U.S. Congress directed the USEPA to develop regional haze regulations to achieve the national visibility goal of "the prevention of any future, and the remedying of any existing impairment of visibility in mandatory Class I federal areas, which impairment results from manmade air pollution."

The USEPA promulgated the Regional Haze Rule in 1999 to improve visibility in 156 mandatory federal Class I national parks and wilderness areas where visibility is an important value (USEPA 1999a). Improvement in visibility must be made every 10 years for the 20% most impaired (haziest) days, and there must be no degradation for the 20% best (clearest) days, until the national visibility goal is reached in 2064. State implementation plans and tribal implementation plans (TIPs) outline how reasonable progress towards this goal will be achieved and demonstrated. Section 308 of the Regional Haze Rule provides nationally applicable provisions of the rule in the development of SIPs and TIPs, which address regional haze.

Smoke Management Policies and Regulations

In 1998, in cooperation with several federal land management agencies, the USEPA issued the Interim Air Quality Policy on Wildland and Prescribed Fires, a national policy on how best to achieve national clean air goals (including the PM NAAQS) while improving the quality of natural ecosystems through the increased use of wildland and prescribed fire (USEPA 1998a). It provides guidance to federal land management agencies on how best to manage fires on wildlands, and provides incentives to state and tribal entities to implement programs to minimize smoke impacts and meet air quality goals.

According to a survey of over 100 government agencies in the western states and Alaska, most state and local agencies require that a prescribed burning project be pre-registered with the state agency (USDI BLM 2003a). In most locations, no open burning activities may be undertaken without first obtaining a proper permit from the appropriate regulatory agency, unless specifically exempted by law. Applications for open burning permits usually require submitting information on the amount and type of material to be burned, burn location and dates, reasons for the burn and alternative treatment options, potential impacts, contact information, predicted weather conditions, contingency actions, and smoke management methods.

Once a prescribed burn permit application is submitted to the applicable permitting agency (including payment of any required fees), the application is reviewed and discussed with the permittee. An agency will issue or deny the permit, usually with restrictions or conditions. A preliminary burn date is established, and frequent communication with the agency up to the burn day is usually required. On the scheduled day of the burn, the regulatory agency will issue the burn forecast and authorization to burn. If approved, the burn then commences until the objectives of the burn are met, after which time the fire is extinguished. Land managers conducting prescribed burning must implement actions to reduce and disperse smoke emissions. These actions can include using mass ignition (aerial) techniques, conducting burns under favorable weather conditions, spreading impacts over a broad time period and geographical area, and using predictive modeling.

The BLM prepares prescribed fire plans for prescribed burning activities, following guidance in the *Interagency Prescribed Fire Planning and Implementation Procedures Reference Guide* (USDA and USDI 2006b) and the BLM Supplement to this guide. This guidance provides information on how to use prescribed fire in a safe, controlled, and cost-effective manner to achieve the management objectives defined in applicable resource and fire management plans. It also specifies that compliance with federal, state, and local air quality regulations is mandatory, coordination with applicable air regulatory agencies is necessary, and staff should participate in state and local rule making and periodic reviews.

In addition, an evaluation of smoke dispersal conditions, including meteorological information, is often conducted to determine the potential impacts of the smoke plume. Contingency plans may also be developed to identify actions to be taken if the requirements of the fire plan are exceeded.

Wildland Fires, Prescribed Fire, and Wildland Fire Use

Since 1990, approximately 9 acres of public lands have been burned by wildfires for every acre burned by prescribed fire. Wildfire events require a Wildland Fire Situation Analysis to determine the appropriate management response. Prescribed fires are management-ignited wildland fires that burn under specified conditions and in predetermined areas, and that produce the fire behavior and fire characteristics required to achieve resource management objectives. A written, approved prescribed fire plan must exist, and NEPA requirements must be met prior to ignition. Wildland fire use is the application of the appropriate management response to naturally-ignited wildland fires to accomplish specific resource management objectives in predefined designated areas outlined in Fire Management Plans. Wildand fire use requires a Wildland Fire Implementation Plan that assesses, analyzes, and selects an appropriate management response. For all three types of wildland fire, impacts to air quality are considered in determining the strategy and tactics for management.

Carefully planned and implemented prescribed fire should produce far less smoke impact to air quality than uncontrolled wildfires. Unlike wildfire, the impacts of smoke from prescribed fire are managed. Where smoke impacts from prescribed fire are of concern, fuel accumulations can be reduced through manual, mechanical, or chemical treatments prior to, or instead of, prescribed burning. Smoke impacts can also be reduced through scheduling burning when the wind is blowing away from smoke-sensitive areas and during good dispersion conditions (Hardy et al. 2001). Scheduling prescribed burns before new fuels accumulate can reduce the amount of emissions produced. Fire managers can also reduce the amount of area burned, increase the combustion efficiency of a burn, and increase the plume height in order to reduce smoke impacts to air quality.

Standard Operating Procedures for Managing Prescribed Burning

As discussed in *The Smoke Management Guide for Prescribed and Wildland Fire 2001 Edition*, the BLM and other agencies that use fire focus on two different approaches to managing smoke: 1) reduction of emissions, and 2) redistribution of emissions through a knowledge of climate and associated meteorological conditions (National Wildfire Coordinating Group 2001). The techniques used to reduce emissions are to: 1) reduce the area burned, 2) reduce the amount of fuels burned (total fuel loading), 3) reduce biomass (fuel) production, 4) reduce the amount of fuel consumed (refers to fuel moisture), 5) burn before new biomass appears, and 6) increase the combustion efficiency. The techniques used to redistribute the emissions focus on 1) burning when dispersion is good, 2) scheduling burns to minimize cumulative impacts, 3) avoiding sensitive areas, 4) burning smaller areas, and 5) burning more frequently. Typically, a combination of these methods is implemented over time to increase effectiveness. It should be noted that several of these techniques are specifically targeted for forest ecosystems and would be less effective in rangeland conditions.

Herbicide Drift

Aerial and ground application of herbicides may transport herbicides through drift, allowing airborne herbicides to move beyond the intended target. The primary factors that influence drift are droplet size, wind speed, humidity, formulation of the herbicide, height of emission, equipment and application techniques, and the size of the area treated with the herbicide. The factor that has the greatest influence on downwind movement is droplet size. Procedures that can be employed to reduce drift include: 1) using a lower spray nozzle height, 2) using the lower end of the pressure range, 3) increasing the spray nozzle size, 4) using drift-reducing nozzles, 5) using drift control additives, and 6) using sprayer shields (Hofman and Solseng 2001). Additionally, several university extension service agencies provide assistance regarding SOPs to minimize herbicide spray drift (Dexter 1993, Hofman and Solseng 2001).

Topography, Geology, Minerals, Oil, and Gas

The diversity in the landscape of the treatment areas reflects differences in geologic processes and the effects of climate, which have been shaping the land over a long period of time.

In 2005, on-shore public lands produced about 40% of the nation's coal, about 11% of its natural gas, and about 5% of its oil (USDI BLM 2006b). In FY 2005, the BLM administered over 54,000 oil and gas leases, of which approximately 21,000 leases were producing. BLM geothermal resources produced over 34 megawatt-hours of electric power. Information pertaining to mineral, oil, and gas resources, presented below, was gathered from the Mineral Resources Program, a section of the U.S. Geological Survey (USGS).

Tundra Ecoregion

The Tundra Ecoregion is rich in minerals, oil, and gas. Metallic minerals including silver, lead, and zinc are found throughout the North Slope region of Alaska. To the south, along the western coast of Alaska, are significant concentrations of gold. 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 coal resources extracted in Alaska are predominantly from the Tundra Ecoregion (i.e., North Slope). As of 2005, Alaska accounted for 17% of the crude oil discovered in the U.S. (Energy Information Administration 2006).

Subarctic Ecoregion

Gold is the most dominant mineral extracted in this ecoregion. Other mineral operations include copper mining, and production of aggregate (e.g., construction sand, gravel, and crushed stone). There are limited discoveries of coal, gas, and oil resources in the central portion of Alaska.

Temperate Desert Ecoregion

Raw, non-fuel minerals extracted throughout this ecoregion include aggregate, gypsum, limestone, trona, shale, and stone. Metallic minerals, predominantly silver and gold, are extracted in the southern portions of this ecoregion. There is very little oil and gas found in this ecoregion. However, coalfields located in the Temperate Steppe Ecoregion extend into this ecoregion, and are found throughout southwest Wyoming and central and southwest Utah.

Subtropical Desert Ecoregion

Minerals predominantly extracted from the western portion of this ecoregion are construction aggregate including construction sand, gravel, and crushed stone. Metallic minerals (e.g., gold, silver, and copper) dominate the central and eastern portion of this region. Gypsum is prominent in southern Nevada. Limited oil and gas reserves are located in southern Arizona and southwest New Mexico. No coalfields are found in this ecoregion.

Temperate Steppe Ecoregion

Construction aggregate (including crushed stone and common clay) is the dominant mineral extracted throughout the southern and central sections of this ecoregion. While industrial minerals within this region are predominantly extracted for construction purposes, Wyoming contains the world's largest source of trona. Trona is the principal ore from which soda ash is produced. Metallic minerals and precious stones (i.e., gems) are extracted throughout the northern and northeastern portions of the ecoregion.

There are significant deposits of coal concentrated throughout the Colorado Plateau extending into the Rocky Mountains and Great Plains. Significant oil reserves are located throughout the region (Map 3-3). 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 (Gautier et al. 1998; U.S. Departments of Interior, Agriculture, and Energy 2003).

Subtropical Steppe Ecoregion

Construction aggregate and metallic minerals dominate the nonfuel minerals extracted in this ecoregion. In addition, potash accounts for a significant portion of minerals mined in New Mexico. The Carlsbad Potash District (in New Mexico) is the largest potash-producing area in the U.S. (Energy Information Administration 2001). There are extensive coalfields throughout northern Arizona and New Mexico. These fields extend up into the Colorado Plateau. No oil or natural gas reserves have been located in this ecoregion.

Mediterranean Ecoregion

Industrial minerals such as aggregate, limestone, and shale dominate mineral extraction throughout this ecoregion. There is no coal mining within this ecoregion, although oil and natural gas extraction is predominant in the San Joaquin, Ventura/Santa Barbara, Los Angeles, and Santa Maria regions.

Marine Ecoregion

Metallic minerals such as gold, silver, aluminum, lead, and zinc are mined in southeast Alaska and in Washington. In western Oregon, aggregate is the most dominant mineral extracted. There are no significant oil, natural gas, or coal resources within this region.

Soil Resources

Soils in the treatment 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 (Brady and Weil 1999). Soils are classified by the degree of development into distinct layers or horizons and their prevailing physical and chemical properties (Fanning and Fanning 1989). 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 (Jenny 1980).

Eleven soil orders are represented on public lands in the western U.S. and Alaska (Map 3-4). Because soils develop under local conditions of climate, parent material, and vegetation, each ecoregion may contain several or all of the soil orders as a result of various combinations of local soil forming factors. Soils are organized here by soil order rather than by ecoregion.

Aridisols are found on over 40% of public lands (105 million acres). They occur across wide parts of the western U.S. 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 soils, are 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.

Gelisols occur on over 27% of public lands (71 million acres), 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 the brief summers. Plant productivity is low and limited by the extremely short growing season of the northern latitudes, low levels of solar radiation, and poor water drainage. Bare rock is also common in Alaska, comprising nearly 8 million acres.

Mollisols occur on about 15% of public lands (40 million acres). They are found in much of North and South Dakota and northern Montana, as well as in 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.

Entisols occur on about 9% of public lands (23 million acres). Entisols occur extensively in eastern Montana, western Colorado, South Dakota, Wyoming, Utah, and central California. They are young, weakly developed mineral soils that lack significant profile development (soil horizons) and 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, but these soils do support rangeland vegetation and may support trees in areas of higher precipitation.

Alfisols occur on less than 2% of public lands (4 million acres). They 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.

Inceptisols also occur on less than 2% of public lands (4 million acres). Inceptisols are found in northern Idaho and parts of Washington, Oregon, and Montana, as well as southwest 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.

The other soil orders represent less than 1% of public lands each (1 million acres or less), and therefore, will not be discussed in detail. **Andisols** 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. **Histosols** are organic soils that typically form in lowland areas with poor water drainage. While not extensive, Histosols are often associated with riparian or wetland resources and can be very important locally.

Spodosols are highly leached, acid soils that typically form on sandy soils under cold, humid conditions at high elevations. **Ultisols** are strongly acid mineral soils associated with advanced soil weathering and are low in nutrients. **Vertisols** have large amounts of expanding clay that causes them to have high shrinking and swelling characteristics.

The concept of soil quality encompasses a soil's capacity to function and to sustain plant and animal productivity, air and water quality, and human health (Soil Quality Institute 2001). It is a function of each soil's inherited properties (texture, type of minerals, depth) as well as more dynamic properties that can change with management (porosity, infiltration, effective ground cover, and aggregate stability). The ability of a soil to filter, buffer, degrade, immobilize, and detoxify herbicides is a function of the soil quality.

Management activities can result in changes in certain soil properties such as soil porosity, organic matter, biological activity, and susceptibility to erosion. These changes in turn affect the fate of herbicides in soils. For example, disturbances that result in increased susceptibility to erosion will affect the off-site movement of certain herbicides that are designed to bind to soil particles. Herbicides can alter soil organism diversity and composition. Compaction or surface disturbance may affect soil activated herbicides from reaching the root zone of target plants.

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 and contributing nutrients to plants, and assisting with plant growth (Belnap and Gardner 1993, Evans and Ehleringer 1993, Eldridge and Greene 1994, Belnap and Giliette 1998, Harper and Belnap 2001). 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 (Belnap and Phillips 2001). Biological soil crusts occupy open spaces between the sparse vegetation of the Great Basin, Colorado Plateau, Sonoran Desert, and the inner Columbia Basin, and also occur in agricultural areas and native prairies, and in Alaska.

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% or more in arid regions (Belnap 1994). They are well adapted to severe growing conditions, but are influenced by disturbances such as compression from domestic livestock grazing, tourist activities (hiking, biking, and OHVs), mechanical treatment and agricultural practices (extensive tillage and planting), application of herbicides, and military activities (Peterjohn and Schlesinger 1990, Belnap 1995, USGS 2004a). Disturbance of biological crusts results in decreased soil organism diversity, nutrients, stability, and organic matter. Trampling may reduce the number of crust organisms found on the surface and increase runoff and the rate of soil loss without apparent damage to vegetation (Eldridge 1996). Burial of crusts by sediments kills non-mobile photosynthetic components (mosses, lichens, and green algae) of the crust (Campbell 1979). Fires can cause severe damage to biological crusts, but recovery is possible, depending on fire size and intensity. Shrub presence (particularly sagebrush) may increase fire intensity, thereby decreasing the likelihood of early vegetative or crust recovery after a burn (USGS 2003).

Micro and Macroorganisms

Microorganisms help to break down and convert organic remains into forms that can be used by plants. Microorganisms, such as mycorrhizal fungi, nitrogen-fixing organisms, and certain types of bacteria assist plant growth, suppress plant pathogens, and build soil structure. One of the main benefits of mycorrhizal fungi is the improved uptake of nutrients (predominantly phosphorous) and water by plants (Allen 1991). Soil microorganisms are also important in the breakdown of certain types of herbicides.

Macroorganisms, such as insects, earthworms, and small burrowing mammals, mix the soil and allow organic matter on the surface to become incorporated into the soil. These organisms are part of a food chain that is essential to the cycling of nutrients within the soil. Soil microorganisms are also important in the breakdown of certain types of pesticides.

Soil Erosion

Soil erosion is a concern throughout the western U.S. and Alaska, 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 if human activities are not carefully managed.

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 streambank crossings. The resulting gully erosion can rapidly erode substantial quantities of previously frozen soils. Erosion from aufeis (thick ice that builds ups as a result of repeated overflow) and anchor ice is also a concern due to spring breakup flood events leaving disturbed streamchannels. These events cause previously stable riparian areas to form a long-lasting sequence of extensively braided channels, especially in glacial soils.

Rangelands are affected by all four types of water erosion—sheet, rill, gully, and streambank. 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 are capable of reducing the productivity of rangeland soils, but often go unnoticed. Gully and streambank erosion is far more visible, and may account for up to 75% of erosion in desert ecosystems (Hein 2002). Changes in water flow patterns in arid areas resulting from thunderstorms and fire events can cause an increase in the size and frequency of runoff events and sediment yield to local water sources (Water Science and Technology Board and Board on Environmental Studies and Toxicology 2002).

It is possible to control rates of soil erosion by managing vegetation, plant residues, and soil disturbance. Vegetative cover is the most significant factor in controlling erosion because it intercepts precipitation, reduces rainfall impact, restricts overland flow, and improves infiltration. Biological soil crusts are particularly important for protecting the soil and controlling erosion in desert regions, but are easily disturbed by grazing and human activities.

With a decrease in vegetative cover, the potential risk of herbicides entering surface water and groundwater can increase (Purdue Pesticide Program 2001). Herbicides can be transported by surface water runoff, potentially increasing the risk of direct injury to nontarget species, harming aquatic organisms in streams and ponds, and leading to groundwater contamination (University of Missouri Extension 1997).

Differences in chemical solubility, adsorptive characteristics, volatility, and degradability, plus soil properties that affect water movement, biological activity, and chemical retention, affect the amount of a herbicide that may leach to groundwater. The speed at which leaching of chemicals through soil occurs is dependent on the soil characteristics. Soil texture (sand, silt, and clay) affects the movement of water and herbicides through soil. The coarser the soil, the faster the movement of percolating water and the lower the opportunity for adsorption of dissolved chemicals. Soils with more clay and organic matter tend to hold water and dissolved chemicals longer. These soils also have far more surface area onto which herbicides can be adsorbed (LaPrade 1992).

Wind erosion is most common in arid and semiarid regions where lack of soil moisture greatly reduces the adhesive capability of soil (Brady and Weil 2002). In addition to moisture content, soil particle size (texture), mechanical stability of aggregates and clods, and presence of vegetation also affect the ability of wind to move soil. While wind erosion on rangelands is difficult to quantify, the presence of natural vegetation on most rangelands is generally sufficient to keep wind erosion from becoming a serious problem. Most wind erosion problems result from bare, exposed soils with weak or degraded soil structure, such as along trails or on sand dunes or disturbed surfaces. Herbicides can be potentially transported by blowing soils after application. Herbicides bound to soil particles may be moved offsite by wind erosion events.

Soil Compaction

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. Generally, soils made up of particles of about the same size compact less than soil with a variety of particle sizes. Numerous rock fragments can create bridges that reduce compaction. Plant litter and roots, and soil organic matter, structure, moisture, and texture all affect a soil's ability to resist compaction. In areas of rangeland where compaction exists, compacted soil extends generally less than 6 inches below the soil surface, although it can be as deep as 2 feet under heavily used tracks and roads (USDA Natural Resource Conservation Service 1996). Compaction becomes a problem when the increased soil density limits water infiltration, increases runoff and erosion, or limits plant growth or nutrient cycling (Soil Quality Institute 2001).

Water Resources and Quality

Water Resources

Water resources in the western U.S. and Alaska are important for fish and wildlife habitat and a variety of human needs, such as domestic consumption, industrial activities, crop irrigation, livestock watering, and recreation. Numerous legal and policy requirements have been established to manage water resources for these multiple needs, including the Clean Water Act, the Colorado River Basin Salinity Control Act, and EO 11988 (*Floodplain Management*).

Water resources are classified as surface water or groundwater. Surface water resources include rivers, streams, lakes, ponds, reservoirs, and wetlands. Major river systems (e.g., Colorado, Columbia, Snake, Missouri, Arkansas, Rio Grande, and Yukon rivers) and their tributaries are important sources of water in the western U.S and Alaska.

The quantity and quality of surface water resources are affected by precipitation, topography, soil type, vegetation, agricultural practices, urbanization, and general land use practices, especially for large tracts of public land. The alteration of vegetative cover from land use practices can have significant impacts on water infiltration, soil erosion, and stream sedimentation.

The largest quantities of useable freshwater occur as groundwater, which provides drinking water for more than 97% of the rural population without access to public-water supplies, and between 30 and 40% of the water used for agriculture (Alley et al. 1999). Groundwater is obtained primarily from wells that tap into aquifers. Aquifers are layers of permeable rocks that are recharged with freshwater from precipitation that percolates through the unsaturated zone to the water table, typically in upland, mountainous areas. Recharge rates generally range from a tiny fraction to about one-half of the average annual precipitation. Streams are commonly a significant source of recharge to groundwater downstream from mountain fronts and steep hillslopes in arid and semiarid areas.

As shown on Map 3-5, nine hydrologic regions have been identified in the treatment area: Alaska, Pacific Northwest, California, Upper Colorado, Lower Colorado, Rio Grande, Missouri, Great Basin, and Arkansas-White-Red (Seaber et al. 1987). Most public lands occur in arid to semiarid environments in the Great Basin and Colorado drainage basins.

Alaska Hydrologic Region

The BLM administers approximately 143,000 miles of riparian habitat and nearly 12.6 million acres of wetlands in Alaska (USDI BLM 2006d). This hydrologic region occupies the entire state of Alaska, and is characterized by an abundance of water resources. Major river systems, such as the Yukon, drain the mountain ranges, and extensive wetlands dot the low-lying plains and coastal regions.

The Yukon and Kuskokwim river drainages are two of the dominant drainages in Alaska. The Yukon River drains an area of more than 330,000 square miles (mi^2), making it the fourth largest drainage basin in North America. Its mainstem, the Yukon River, originates in northwestern Canada and extends through central Alaska, discharging into the Bering Sea (Brabets et al. 2000). Major tributaries of the Yukon River include the Tanana, Nenana, and Chena rivers.

The Kuskokwim River is the second largest drainage in Alaska. The glacially turbid mainstem 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.

Hydrologic processes are strongly affected by the presence of permafrost, which may thaw seasonally or be continuous throughout the year, particularly in 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 valleys of major rivers have alluvial aquifers with an active layer in the summer months that also supply good quality groundwater. During the winter, permafrost generally extends to the surface, impeding water infiltration and groundwater recharge.

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. The region is drained by the Columbia, Willamette, and Snake River systems, which are important sources of hydroelectric power and irrigation for agriculture.

The coastal areas of Oregon and Washington are influenced by medium to high rainfall levels due to the interaction between marine weather systems and the mountainous nature of the region. Mountains within this area are generally rugged with steep canyons. Tributary streams are short and have steep gradients, creating rapid surface water runoff with relatively short-term water storage, limiting recharge.

The Columbia River Basin drains approximately 259,000 mi^2. The 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 mainstem, 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.

The Columbia River has 10 major tributaries—the Kootenay, Okanagan, Wenatchee, Spokane, Yakima, Snake, Deschutes, Willamette, Cowlitz, and Lewis rivers.

The Pacific Northwest Hydrologic Region includes a network of coastal streams and rivers. Many are rain-driven systems that are hydrologically flashy and influenced primarily by rain storms during the winter. Streams west of the Cascade Range typically discharge directly into the Pacific Ocean.

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. 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. Aridity progressively increases and precipitation decreases east of the Cascade Range because of rainshadow effects caused by the mountains.

Timing of precipitation east of the Cascade Range coincides with periods of relatively high solar radiation; thus, precipitation is rapidly evaporated, limiting the amount of surface water available to streams in this portion of the region (Spence et al. 1996). 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.

Groundwater is an important resource in this hydrologic region for domestic consumption and irrigation, particularly when surface water supplies are insufficient. It is generally contained in shallow alluvial aquifers along major streams and their valleys.

California Hydrologic Region

This hydrologic region includes nearly the entire state of California, as well as parts of southern Oregon. The region is characterized by a Mediterranean climate with winter precipitation, and a prolonged summer period with little precipitation.

The California region is drained by rivers such as the Sacramento and San Joaquin. Surface water flow in streams is derived mainly from snowmelt in the mountainous areas during the spring months. During the remainder of the year, many streams have no flow or intermittent flow that follows major storms.

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.

Upper Colorado Hydrologic Region

This hydrologic region includes the Colorado Plateau, which encompasses parts of southern Wyoming, western Colorado, eastern Utah, and northern Arizona and New Mexico. 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 fall rainstorms.

Perennial surface water flow occurs in major rivers (e.g., the Green River and Colorado River). Major streams are fed by snowmelt in the mountainous areas. Dams serve as flood control, domestic supply, and power generation for the major urban centers, as well as provide surface water for irrigation. Intermittent flow occurs in tributaries to the major rivers, and ephemeral flow occurs in small canyons. Surface water runoff or groundwater baseflow are the major processes that deliver precipitation and snowmelt to streams. In Colorado, the annual hydrograph for most streams is dominated by snowmelt in the mountains; however, there is also a rain component, which varies by region. For instance, in the southwest portion of Colorado, summer monsoonal flow produces ample rain. The larger rivers in Colorado are perennial, but the smaller rivers and streams are either intermittent or ephemeral.

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. Major aquifer systems are not present; groundwater is localized and can be abundant in some areas and absent in others. Farming and ranching are usually limited to stream valleys, where irrigation water comes mostly from surface water. Groundwater baseflow is the major source of water for perennial flows in the late summer and early fall. Seeps and springs are an historic source of water for Native American tribes and a current source of water for smaller ranches.

Lower Colorado Hydrologic Region

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 Forest Service. 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.

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

Groundwater is found in the alluvium of the basins and in the bedrock of the mountainous areas (i.e., deep reservoirs to depths of many thousands of feet). 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.

Rio Grande Hydrologic Region

This region occupies central New Mexico and western Texas. The Rio Grande and Pecos rivers are major surface water resources that derive their water from the mountainous regions of southern Colorado and flow through New Mexico to the Gulf of Mexico. Surface water flow is present year-round in the Rio Grande and is caused by spring snowmelt and summer monsoon thunderstorms. Agricultural diversions account for approximately 90% of surface water use and may result in practically no flow during the summer months (Levings et al. 1998).

The Rio Grande aquifer system covers a 70,000-mi^2 area of southern Colorado, central New Mexico, and western Texas. It consists of a network of hydrologically interconnected aquifers in basin-fill deposits located along the valleys of the Rio Grande and nearby rivers. These aquifers are generally composed of unconsolidated sediment deposits present in intermountain basins. Groundwater recharge primarily originates as precipitation in the mountainous areas that surround the basins, while most of the precipitation that falls in the valleys is lost to evaporation and transpiration. Potential evaporation may exceed 100 inches per year, while precipitation is frequently less than 8 inches per year (Levings et al. 1998).

Most groundwater withdrawal occurs as discharge from pumping wells, of which about 90% 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.

Missouri Hydrologic Region

This hydrologic region covers the largest geographic area of the nine regions, including much of Montana, Wyoming, northeastern Colorado, North Dakota, South Dakota, and Nebraska. This region represents 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.

Surface water resources are dominated by the major rivers and their tributaries. 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. Surface water is directly connected to groundwater through shallow alluvial aquifers that are found along all the major rivers and their tributaries. Groundwater baseflow 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.

Groundwater in Wyoming and western Montana is found both in the igneous rocks of the uplifts and 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. Major aquifers in the Great Plains are the Ogallala Aquifer of eastern Wyoming, Nebraska, and Kansas, and the Dakota Aquifer of North and South Dakota. These aquifers are overdrawn and the water table has been declining for decades. Recharge comes only from stream infiltration and spring snowmelt.

Great Basin Hydrologic Region

The Great Basin of Nevada and Utah is an arid region located in the rainshadow of the Sierra Nevada Mountains. The Great Basin is characterized by northerly trending mountain ranges and intermountain valleys with closed drainage. Precipitation generally falls as rain and snowfall in the mountains. Streams flowing down from the mountains carry water to the basins, which infiltrates into the alluvial sediments and provides the only substantial recharge to groundwater in the basins. Surface water flow in the basins is derived almost entirely from the mountain streams.

Apart from major rivers (e.g., the Humbolt 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 of the ranges. 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.

Groundwater is found in the alluvium of the basins and in the deeper rocks that underlie the alluvial basins. 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 United States. These reservoirs are largely untapped at present, but major urban areas like Las Vegas are actively pursuing their development.

Arkansas-White-Red Hydrologic 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 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.

Groundwater resources, which are extensive in this region, and consist primarily of the Ogallala Aquifer and alluvial aquifers associated with the river valleys. The Ogallala Aquifer underlies much of this region, and water withdrawals are used almost exclusively for irrigation (Robson and Banta 1995).

Water Quality

Water quality is defined in relation to its specified and/or beneficial uses, such as human consumption, irrigation, fisheries, livestock, industry, or recreation. The quality of surface water is determined by interactions with soil, transported solids (organics and sediments), rocks, groundwater, and the atmosphere. The Clean Water Act established the basic structure for regulating discharges of pollutants into the waters of the U.S., and is responsible for setting water quality standards for all contaminants in surface waters. Section 313 of the Clean Water Act requires all federal agencies to comply with state water quality standards "...to the same extent as any nongovernmental entity." Thus, the BLM has a responsibility to fulfill its obligations under the Clean Water Act and Safe Drinking Water Act, to maintain waters that meet or surpass designated beneficial uses, to restore impaired water resources in support of their designated beneficial uses, and to provide water for public consumption and use (USEPA 2003e).

Section 303(d) of the Clean Water Act requires that water bodies violating state water quality standards and failing to protect beneficial uses be identified and placed on a 303(d) list (USEPA 2003e). The delisting of 303(d) listed streams is a priority of the BLM.

Nonpoint source pollution, the largest source of water quality problems, comes from diffuse or scattered sources rather than from an outlet, such as a pipe that constitutes a point source. Sediment is a nonpoint source of pollution that results from activities such as livestock grazing and timber harvest. Erosion and delivery of eroded soil to streams is the primary nonpoint source pollution problem of concern to the BLM (USDI BLM 1980).

The most important factors affecting water quality include sediments, microbes, pesticides, nutrients, metals, and radionuclides (Nash 1993). Sedimentation and nutrient loading affect surface waters, while agricultural runoff and industrial wastes can also leach into groundwater. Surface water quality is also affected by solar loading and shade producing vegetation that affect water temperature, flow, total suspended solids (TSS), total dissolved solids (TDS), turbidity, changes in dissolved oxygen, salinity, and acidity.

The susceptibility of aquifers to groundwater contamination relates to geology, depth to groundwater, infiltration rates, and solubility of contaminants. Deep aquifers are often too deep to be affected by surface alteration or shallow waste disposal. However, shallow aquifers may be directly affected by surface alternation and by waste and wastewater disposal. Shallow, unconfined aquifers with rapid recharge rates are generally the most vulnerable to contamination because of the rapid infiltration of groundwater from the surface to the water table.

Water quality data for the surface and groundwater resources of the western states are available from the USGS National Water Information System (NWIS) database (USGS 2002b), the USGS National Water

Quality Assessment (NAWQA) Program (USGS 2002c), the USEPA's Index of Watershed Indicators (USEPA 1999b), the USEPA's National Water Quality Inventory (USEPA 2000a), the USGS Groundwater Atlas of the United States (USGS 2000), and from state water quality databases. These sources have been used to develop a general assessment of water quality in the hydrologic regions of the western states (including Alaska), where the BLM has substantial land management responsibility. Data from the USEPA's Index of Watershed Indicators characterizes the condition and vulnerability of each of the 2,262 subbasins in the U.S. (Map 3-6). Information on general groundwater quality (based on concentration of TDS) was compiled from the USEPA's National Water Quality Inventory (USEPA 2000a; Map 3-7).

Alaska Hydrologic Region

Surface and groundwater resources in Alaska are of relatively good quality. The lack of industrial and agricultural development reduces the risk of contamination of water resources. Human activities, such as mining, oil drilling, and waste disposal in small villages contribute to localized surface and groundwater pollution. Oil drilling adds petrochemicals to both surface water and groundwater, and waste disposal adds nitrates and colliform bacteria. Public lands have localized surface water and groundwater contamination from oil drilling.

Pacific Northwest Hydrologic Region

Surface water quality has been degraded in the agricultural areas of eastern Washington and Oregon and in southern Idaho by contamination resulting from agricultural and grazing practices. Elevated levels of nitrates, phosphates, and other nutrients are found in these waters. In Montana, agricultural practices in the Bitterroot Valley have added nutrients to surface water. Fish farming has also contributed to elevated nutrient levels in these streams and rivers of Washington. Irrigation return waters in the Snake River Basin are contributing nutrients and pesticides to surface waters (Clark et al. 1998). Herbicide use results in elevated levels of these chemicals in surface waters during the growing season; however, these levels typically decline after the growing season.

Groundwater is generally of good quality for most uses across the Pacific Northwest. Rivers and streams with lower water quality are primarily the result of thermal modifications, pathogens, habitat alteration, and concentrated agricultural activities in areas such as the Willamette Valley and the Columbia Plateau (Wentz et al. 1998; Williamson et al. 1998; USEPA 2000a). Elevated levels of nitrates and pesticides have been detected in the groundwater in the Snake River Basin and the Columbia Plateau.

California Hydrologic Region

Surface water resources in California show elevated concentrations of TDS from high salinity, particularly in the southern portion of the region. Groundwater and surface water diversions are used for agricultural irrigation in California. Because of the arid nature of the climate, much of this irrigation water evaporates, leading to irrigation return waters that flow back into streams with elevated levels of salt, nutrients, and pesticides. In the agricultural areas of the Central Valley of California (San Joaquin and Sacramento River basins), nutrient loadings to streams and accumulation of pesticides in aquatic organisms and streambed sediments are a problem (Dubrovsky et al. 1998; Domagalski et al. 2000). Nitrate concentrations in streams generally meet USEPA drinking water standards, but at levels that can pose a problem for aquatic life.

Groundwater in southern California has naturally high concentrations of TDS from the presence of evaporite beds in the sedimentary rocks that underlie the desert areas. In agricultural areas, extensive fertilizer use, combined with heavy irrigation to overcome the high evaporation rates, have resulted in elevated concentrations of nitrates in shallow groundwater reservoirs. Pesticides are present in shallow groundwater reservoirs, but at concentrations generally below USEPA drinking water standards. In agricultural areas, groundwater is used for irrigation, leading to substantial declines in shallow groundwater tables and contamination of groundwater resources by agricultural practices. In the desert areas administered by the BLM, groundwater is generally not affected by pesticides. The low recharge rate for groundwater in these areas means that any application of herbicides is unlikely to enter and affect groundwater resources.

Upper Colorado Hydrologic Region

In this hydrologic region, surface waters generally flow out of the southern Rocky Mountains and work their way to major rivers. Water quality in the southern Rocky Mountains is generally good, except in historic mining areas. As the surface waters pass through the Colorado Plateau country, quality declines due to agricultural practices, evaporation, a change in the nature of the bedrock, and urban wastewater disposal practices (Spahr et al. 2000). Concentrations of nutrients and pesticides increase as the waters pass through this area. Groundwater quality in this region appears to be influenced mainly by the nature of the bedrock. In areas of sedimentary rock, concentrations of TDS, along with radon, uranium, and metals, can be high. Mesozoic rocks in this region may host uranium, selenium, evaporite, and copper deposits. In areas of the Colorado Plateau administered by the BLM, grazing and mining are the main activities, often leading to local groundwater contamination from metals, especially the uranium-rich areas of the Colorado Plateau.

Lower Colorado Hydrologic Region

High surface water temperatures in this hydrologic region affect water quality. Total dissolved solids concentrations can be elevated, especially along major rivers with extensive agriculture in their river valleys, such as the Salt and Gila rivers of Arizona. Agricultural land use practices and mining have been the major contributors to surface water degradation in this region. Public lands in this region are used mainly for grazing and mining, resulting in localized impacts to surface waters. These impacts include increases in turbidity, sedimentation, salinity, and possible chemical contamination. High erosion rates can be expected wherever there is a large percentage of exposed soil, a very common result of grazing by domestic animals in this region (Bogan et al. 2003).

Groundwater quality in this region is dependent on the rocks that host the groundwater reservoir. Shallow groundwater reservoirs are mainly in alluvium or Late Tertiary sedimentary beds dominated by lakebeds and evaporites, causing saline groundwater with elevated concentrations of TDS. In mining districts, concentrations of metals are elevated in the groundwater, and in areas of extensive grazing, shallow alluvial groundwater may have elevated concentrations of nitrates and bacteria. Deep groundwater reservoirs are usually contained in carbonate rocks, leading to groundwater of good quality and low concentrations of TDS.

Rio Grande Hydrologic Region

Elevated levels of TDS associated with agriculture in the Rio Grande River valley can pose a problem for surface water quality. Agricultural practices along the Rio Grande River have also contributed nutrients and pesticides to surface waters (Levings et al. 1998). The upper reaches of the Rio Grande River in Colorado and the tributaries to the Rio Grande River in southern Colorado have shown elevated metal concentrations, primarily due to the Creede, Colorado, mining district.

Most of the groundwater resources utilized in the Rio Grande River basin are used for irrigation and livestock watering, although drinking water is also an important use. Nitrate concentrations may exceed USEPA standards, particularly in agricultural areas such as the San Luis and Rincon valleys. Pesticides have been detected in the groundwater in both agricultural and urban areas, but generally do not exceed USEPA standards. Volatile organic compounds (VOCs) may be present in shallow groundwater in urban areas such as Albuquerque and Santa Fe (Levings et al. 1998).

Missouri Hydrologic Region

In the high Rocky Mountains of this hydrologic region, surface water has low concentrations of dissolved solids and meets all aquatic and drinking water standards, except in areas of historic mining. As surface water leaves the mountains and enters the plains and valleys surrounding the mountainous area, the water quality changes. In Colorado, agricultural land use practices and urban wastewater disposal degrade the water quality by adding nutrients and pesticides (Dennehy et al. 1998). In Wyoming, dewatering from mining and petroleum extraction has resulted in localized increases in concentrations of dissolved solids and metals in surface waters. Grazing activities in the Great Plains affect surface water quality by contributing sediments and nutrients. Bacterial contamination of surface water by domestic livestock is considered a significant non-point source of water pollution (Bohn and Buckhouse 1985, George 1996). Areas of extensive agriculture often have elevated nutrients and pesticides in the surface water. Agricultural practices have contributed nutrients and pesticides to surface waters in basins along major rivers in this region.

Groundwater in this region is generally of good quality and low in TDS, except in areas of historic and present-day mining, where there are elevated concentrations of sulfate and metals in the groundwater. In areas of the Rocky Mountains administered by the BLM, mining is the principal source of groundwater contamination. A secondary source of contamination is the geology of the bedrock, where rocks rich in uranium and radon contribute to groundwater. This is particularly evident in Wyoming and in the South Platte River basin of Colorado (Dennehy et al. 1998). Shallow alluvial groundwater in agricultural areas has elevated concentrations of nutrients and pesticides. Shallow groundwater along the Colorado Front Range and in large urban areas of the Rocky Mountains shows local evidence of contamination by wastewater, petroleum by-products, and nutrients and/or pesticides used on lawns and golf courses. In the Great Plains, groundwater has nitrate concentrations that often exceed the USEPA limit of 10 parts per million (ppm) and also has elevated concentrations of pesticides.

Great Basin Hydrologic Region

Water quality in the rivers and streams of this hydrologic region has been affected by agricultural land use along the major rivers, urban waste disposal practices, the chemical composition of rocks in the river basins, and past mining activity. Public lands in the Great Basin generally exclude urban and agricultural areas, but include most of the areas of past mining. Agricultural practices have contributed nutrients and pesticides to surface waters in basins along major rivers. Urban areas, such as Reno, Las Vegas, and Salt Lake City, have added nutrients and synthetic organic compounds to surface waters as well. Past mining activity has added metals to surface waters in localized areas throughout the Great Basin. The chemical makeup of near-surface rocks has contributed arsenic, uranium, and radon to surface waters (Bevans et al. 1998).

Groundwater quality in the Great Basin is determined mainly by the chemistry of the rocks that host the groundwater reservoir. Groundwater in reservoirs made of carbonate rocks and sandstones has relatively low concentrations of TDS and is of good quality. Groundwater in the central parts of basins with playa lakes, and in areas with evaporite beds, generally has elevated concentrations of salts and TDS. Groundwater in mining areas often has high localized concentrations of mercury, arsenic, and other metals. In areas of extensive agriculture, shallow alluvial aquifers are often contaminated with nitrates and pesticides.

Arkansas-White-Red Hydrologic Region

Surface water quality is typically moderate in this hydrologic region, and poor in areas with extensive agricultural or livestock production. The upper reaches of the Arkansas River, where most public lands are located, rely primarily on spring snowmelt for recharge and are generally of better water quality than other portions of the region.

Groundwater quality is relatively good in this region. The TDS concentration of water in the aquifers in eastern Colorado and eastern New Mexico is generally less than 500 milligrams per liter (mg/L), but may exceed 1,000 mg/L in small areas of Colorado. Concentrations less than 250 mg/L are found in northeastern Colorado and are the result of relatively high recharge rates in areas of sandy soil that contains few soluble minerals (Robson and Banta 1995).

Wetland and Riparian Areas

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 (USDI BLM 1998b). Wetlands include bogs, marshes, shallows, muskegs, wet meadows, estuaries, and riparian areas. According to the 1987 Corps of Engineers Wetland Delineation Manual, 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):

- **Soils -** The substrate is predominately undrained hydric soil, or the soils posses characteristics that are associated with reducing soil conditions;
- **Hydrology -** The area is inundated either permanently or periodically at a mean water depth of less than 6.6 feet or the soil is saturated to the surface at some time during the growing season of the prevalent vegetation; and
- **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.

The BLM administers approximately 12.8 million acres of wetlands. Of these, approximately 12.6 million acres are found in Alaska (USDI BLM 2006d).

Riparian and wetland areas comprise approximately 9% of public lands (USDI BLM 2006c). The benefits of these vital areas, however, far exceed their relatively small acreage. The functions of wetland and riparian areas include water purification, stream shading, flood attenuation, shoreline stabilization, groundwater recharge, and habitat for aquatic, semiaquatic, and terrestrial plants and animals (USEPA 2001b).

The BLM has surveyed 89% of the wetland acreage in the lower 48 states. Only a small fraction of the wetlands in Alaska have been surveyed due to their pristine nature and lack of immediate development pressure. Sixty-seven percent of wetlands in the lower 48 states evaluated were judged to be functioning properly (USDI BLM 2006d). Ninety-eight percent of Alaska wetlands are assumed to be functioning properly. The remaining Alaska wetlands have been placed in the "Unknown" category because some questions have been raised about development impacts.

The BLM defines properly functioning wetlands as those that: 1) support adequate vegetation, landform, or debris to dissipate energies associated with wind action, wave action, and overland flow from adjacent sites, thereby reducing erosion and improving water quality; 2) filter sediment and aid floodplain development; 3) improve floodwater retention and groundwater recharge; 4) develop root masses that stabilize islands and shoreline features against cutting action; 5) restrict water percolation; 6) develop diverse ponding characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterbird breeding, and other uses; and 7) support greater biodiversity (Prichard et al. 2003). This assessment does not take into consideration the habitat value of the wetland to fish and wildlife.

About 20% of wetlands are considered to be functional, but at risk, and 2% are non-functional, in terms of their ability to dissipate energy associated with high-flow events (USDI BLM 2006d). Public lands with poorly functioning wetlands tend to be located in the southwestern U.S.

Riparian areas, according to the BLM, are green zones along flowing-water features such as rivers, streams, and creeks (Gebhardt et al. 1990). These areas exclude streams where water flows for only brief periods during storm runoff events (ephemeral streams). The BLM administers approximately 143,000 miles of riparian habitat in the treatment area. Of this, approximately 107,565 miles are found in Alaska (USDI BLM 2006d).

It is estimated by the BLM that 46% of surveyed riparian areas in the lower 48 states and 100% of riparian areas in Alaska are properly functioning in terms of having adequate vegetation, landform, or large woody debris present to dissipate stream energy associated with high waterflows (USDI BLM 2006c). Eight percent of riparian areas in the lower 48 states are considered non-functional, and 38% are functioning but at risk (USDI BLM 2006c). Poorest functioning riparian areas are found in the southwest and Montana, while most riparian areas in Alaska, Colorado, and Utah function properly.

Vegetation

The composition and distribution of plant communities in the western U.S. have been influenced by many factors, including climate, drought, insects, diseases, wind, domestic livestock grazing, cultivation, browsing by wildlife, and fire (Gruell 1983). Other activities that have a direct and/or indirect effect on plant communities include logging, minerals extraction and reclamation activities, recreational activities, and ROW development including road construction and maintenance. In addition, competition with non-native invasive plant species has resulted in the loss of native plant communities in portions of the western states.

Before European settlement, naturally occurring fire was an important influence on the landscape of the West, and plant communities are adapted to the occasional intense fires that burned over the landscape (Gruell 1983). The exclusion of fire following European settlement has caused significant changes in plant species composition in the western U.S., especially in areas adapted to fire (Swetnam 1990). Where fire-adapted communities previously limited the expansion of juniper, sagebrush, and other less fire-tolerant species, exclusion of fire has resulted in invasion of these species into the surrounding ecosystems (Gruell 1983). The circumstance has also contributed to accumulation of hazardous fuels.

Ecological Processes that Underlie the Effects of Fire on Flora

The following section presents an overview of ecological principals related to the effects of fire on vegetation, followed by a discussion of the fire ecology and vegetation in each ecoregion. The following documents were the source of information provided in this assessment: *Final EIS Vegetation Treatment on BLM Lands in Thirteen Western States* (USDI BLM 1991a); *Wildland Fire in Ecosystems Effects of Fire on Flora* (USDA Forest Service 2000b); *Proceedings of the Invasive Species Workshop: The Role of Fire in the Control and Spread of Invasive Species* (Tall Timbers Research Station 2001); and *Fire as a Tool for Controlling Nonnative Invasive Plants* (Rice 2004). The reader is encouraged to consult these documents, and the references cited therein, for a more detailed assessment of fire-vegetation relationships; website links to several of these documents are provided in the References section of the PER.

Fire Recurrence

Fire has shaped plant communities for as long as vegetation and lightning have existed on earth (Pyne 1982). Approximately 8 million lightning strikes per day occur globally that can start fires. During the past 20,000 years, humans have also been a major source of ignition, and the intentional burning of vegetation by Native Americans has occurred for several centuries (Gruell 1985, Denevan 1991).

Historically, fire has occurred over large areas covering more than half of the U.S. at intervals of 1 to 12 years, and at longer intervals over the remainder of the country (Frost 1998). The frequency of historical fire varied widely depending on climate. Fire return intervals in the western U.S. typically ranged from 2 to 5 years in ecosystems that supported abundant cured or dead fine fuels such as ponderosa pine and oak savanna in the Southwest; 5 to 35 years for dry site conifers, shrublands such as California chaparral, and most grasslands; 35 to 200 years for mesic site western conifers; 200 to 500 years for some wetter site conifers; and 500 to 1,000 years for extremely cold or wet ecosystems, such as alpine tundra and Pacific Northwest coastal spruce-hemlock forests.

Historically, fires have occurred at irregular intervals, largely determined by climate (Johnson and Larsen 1991, Swetnam 1993). However, temperature was the most important influence on fire frequency over periods of decades to centuries. In both cases, fuel moisture content was probably the fuel property most influenced by climatic trends in precipitation and temperature.

Biodiversity

Biodiversity is the variety of life and associated ecological processes that occur in an area. Fire regime, which is defined as the nature of fire occurring over long periods and the prominent immediate effects of fire that generally characterize an ecosystem, influences biodiversity in various ways (Duchesne 1994). The official definition of fire regime is the patterns of fire occurrences, frequency, size, severity, and sometimes vegetation and fire effects, in a given area or ecosystem (National Wildfire Coordinating Group 2007). In forest ecosystems, understory fire (i.e., fires that tend to occur in the understory and are nonlethal to the dominant vegetation) regimes have the greatest influence on biodiversity within plant communities because the understory vegetation is more affected by fire than the overstory. Stand-replacement fire (i.e., fire kills aboveground parts of the dominant vegetation and changes the aboveground structure substantially) regimes influence biodiversity across the landscape by affecting the size, shape, and distribution of vegetation patches. Mixed fire (i.e., causes selective mortality in dominant vegetation or varies between understory fires and stand-replacement fires) regimes have a substantial effect on biodiversity within plant communities. Fire frequency and timing largely determine biodiversity in grassland systems (Brown and Smith 2000).

Biodiversity can be increased by fire and reduced by eliminating fire. Variability of fire regimes in time and space creates the most diverse complexes of species. Thus, landscapes having fires with high variability in timing, intensity, pattern, and frequency tend to have the greatest diversity in ecosystem components (Swanson et al. 1990). However, biodiversity can be reduced when fires occur much more frequently than they did under the historical fire regime.

Plant Response to Fire

Many species depend on fire to continue their existence. Many species have adaptive traits that allow species to survive fire. Thick bark, fire resistant foliage, and adventitious buds allow plants to survive low to moderate intensity fires of short duration, while traits such as fire-stimulated germination and belowground sprouting parts allow plants to survive high intensity fires (Brown and Smith 2000). Fire severity and intensity have a large influence on the composition and structure of the initial plant community following fire.

As a general rule, burned areas tend to return to the same flora that was there before fire (Lyon and Stickney 1976, Christensen 1985). However, fires of high severity create opportunities for new plants to establish from off-site seed. Large, high severity burns can be slow to recover, depending on available seed sources. Fires of low severity are followed by a strong sprouting response, except where annuals are the dominant vegetation.

The timing of fire, including seasonality and frequency, is important in determining fire severity and species survival. Seasonal timing of fire affects reproduction of herbaceous plants and shrubs. For example, spring and summer fires may produce abundant postfire flowering, while fall fires may produce little. Fire frequency is especially important for short fire-return interval species. Frequent fire regimes that allow control of shrubs are important for maintaining grassland ecosystems (Brown and Smith 2000). Many rare and threatened plant species depend on short-return fire intervals to survive (Greenlee 1997).

Community and Landscape Responses to Fire

Species diversity within a plant community depends on species composition, the adaptive traits of plants, the timing of fire, and the nature of fire as it moves through the community. The spatial arrangement of fuels and individual plants can be important to survival, particularly where fuels are unevenly distributed. Concentrations of live or dead fuels can generate high fire intensities and severities on relatively small sites, which can enhance or reduce diversity depending on the community. For example, in a Douglas-fir forest, localized fuel concentrations may result in fire-created gaps or holes in the canopy, creating structural diversity and stimulating understory vegetation, a typical response to fire in a mixed fire regime. However, in a ponderosa pine forest, excessive mortality to highly valued old growth trees might be a consequence (Brown and Smith 2000).

Ecosystems and plant communities are considered to be fire dependent when their continued existence depends on recurrent fire. Where fires occur regularly and frequently, such as in open pine communities and Mediterranean shrublands, plant communities may remain stable for millennia (Chandler et al. 1983). Repeated fires in fire-dependent communities maintain a dynamic process that creates diversity across the landscape. If fire is excluded, however, biodiversity likely diminishes (Chang 1996).

Fires create patches on the landscape of different dominant vegetation and stand structure. Patches can vary in size and shape depending on the biophysical features of the landscape. Winds of variable speed and direction can cause fire to create a variety of burn shapes. Terrain and landforms primarily determine patch characteristics in heavily dissected landscapes. For example, historical fires were typically large (> 10,000 acres) in boreal forests on moderate terrain, but medium to large (100 to 10,000 acres) in conifer forests in mountainous terrain (Heinselman 1981, Brown and Smith 2000).

As time since the last fire increases, stands become similar and structural diversity is reduced. The likelihood of larger fires increases as the fire-free period becomes longer, resulting in larger fires and less patch diversity (Heinselman 1981, Bonnickson and Stone 1982, Swetnam 1993).

Ecological Processes

Fire is an ecological process that triggers other processes and associated conditions. Plant mortality, regeneration, and growth are obvious effects of fire. Secondary effects include plant succession, decomposition of dead material, and accumulation of fuel needed for a fire to start.

Successional Pathways

Succession is viewed as a dynamic process that can move in different directions under the influence of periodic disturbance and may never reach a stable end point (Christensen 1988). Successional classes (e.g., mature forest) are described by vegetation type and structural stage. Time is a key element in understanding succession (Wright and Heinselman 1973). Some grassland plant communities regain their former composition and structure within 1 to 2 years after a disturbance, while forest communities could take decades to centuries to recover to a mature condition. Fire severity influences the length of time until plant communities recover to their pre-burn state. Large, severe burns have a longer recovery time then less severe fires. Periodic fires at short intervals can prevent the development of later successional vegetation stages, and can sometimes alter successional pathways if frequent fires eliminate propagules of later successional species, as in the case of frequent fires in sagebrush sites dominated by downy brome.

Decomposition

Fire, insects, and pathogens are responsible for the decomposition of dead organic matter and the recycling of nutrients (Olson 1963, Stoszek 1988). Burning directly recycles the carbon found in living and dead vegetation. The relative importance of fire and biological decomposition depends on site and climate (Harvey 1994). In cold and dry environments biological decay is limited, which allows accumulation of plant debris. Fire plays a major role in recycling organic matter in these environments. Without fire, nutrients are tied up in dead woody vegetation. In forests, increased tree density results in increased competition and moisture stress, and increased likelihood of mortality from insects and diseases. Increased mortality leads to increased dead fuels and increased fire. In grassland ecosystems where both fire and grazing are excluded, thatch or dead herbaceous litter accumulates, reducing plant productivity and plant species richness (Wright and Bailey 1982). Fire can help control encroaching shrubs and trees; increase productivity, utilization of coarse grasses, and availability of forage; and improve habitat for wildlife.

Fuel Accumulation

Fuel accumulation is a term that is often used to indicate an increasing potential for fire to start, spread, and intensify as the time since the last fire increases. Fuel accumulation and associated fire potential depend on fuel quantity as well as other important fuel properties such as compactness and continuity (vertical and horizontal). Generally, the greatest amount of fuel accumulation is on highly productive sites in grassland, shrubland, and forest ecosystems (Brown and See 1981, Wright and Bailey 1982). In forest ecosystems, much of the dead fuel exists as coarse woody debris.

Fuel continuity is important because it partially controls where a fire can go and how fast it travels. In grasslands and open shrublands, heavily grazed areas and areas of low productivity form discontinuous fuels that limit the spread of fire and can be a critical obstacle to use of prescribed fire. In forests, existence of ladder fuels from understory vegetation allows surface fires to reach into the crown canopy. If the canopy is mostly closed, crown fire can readily develop under adequate wind speeds. Open canopies do not support crown fires. Increased fuel continuity can account for changes in fire severity from understory to stand replacement.

Live and dead fuels, as well as small and large diameter fuels, can follow different patterns of accumulation in forests. Typically, live herbaceous and shrub fuels increase following fire during early stages of stand development. Then, as tree canopies close, fuel quantities tend to decrease on mesic sites (Habeck 1976, Lyon and Stickney 1976). However, the decrease in fuels may not occur where understories contain shade tolerant species, which tend to have more foliar biomass than shade intolerant species due to their longer needle retention and higher crown densities (Brown 1978). Because of their shade tolerance, they can fill in crown canopy gaps and develop into understory ladder fuels.

On many grasslands, grazing eliminates some of the annual production, so fuel accumulation is minor. In the absence of grazing, fuel quantities depend primarily on annual production, which varies substantially by site potential and annual precipitation (Wright and Bailey 1982). In shrub and shrub/grass ecosystems, young communities generally have a low dead-to-live ratio. Flammability depends largely on grass and sedge fuels. As shrubs become senescent or undergo mortality, dead stemwood accumulates, which significantly increases potential flammability.

Human Influences

People are part of ecosystems and as such have exerted a major, far-reaching influence on fire across the landscape. Burning by Native Americans was common throughout the United States, although its extent varied considerably, depending on locale and population movements (Pyne 1982, Boyd 1999).

Efforts to suppress fires were modest at first, relying on wet blankets and buckets of water around dwellings and campsites. Suppression capabilities now rely on sophisticated communications, rapid attack, specialized equipment, and many fire fighters. Fire protection has reduced the extent of fire and increased fire intervals. Then, more protection is needed to keep burned acreage down.

Shifting Fire Regimes

Across most of the U.S., fire regimes have shifted from what they were historically. In a comprehensive assessment of burning in the contiguous United States, Leenhouts (1998) estimated that approximately 10 times more area must be burned than at present to restore historical fire regimes to nonurban and nonagricultural lands. The greatest departure from historical fire regimes is in the Rocky Mountains, where only a small fraction of the pre-1900 annual average fire acreage is being burned today (Barrett et al. 1997). Extensive grazing by domestic stock that reduces fuels, and fragmentation by agriculture and urbanization, have also contributed to shifting fire regimes. Lengthened fire return intervals have resulted in changes to vegetation and fuels by increasing wildfire severity and decreasing species and structural diversity. A recent comparison of historical and current fire regimes in the Interior Columbia River Basin showed that fires have become more severe over 24% of the area (Morgan et al. 1998).

Forests and Woodlands

Changes in forest composition and structure due to shifting fire regimes have been widely documented. Generally, shade-intolerant species are being replaced with shade-tolerant species. Stand densities are increasing with the development of multiple layer canopies. Outbreaks of insects and occurrence of root diseases appear to be worsening (Stewart 1988). The greatest impacts have occurred in the understory fire regime types typified by ponderosa pine and longleaf pine ecosystems. Although these two ecosystems experience widely different climates, they share the same end results of fire exclusion, which is made worse in some locations by selective harvesting of old growth trees. Where fire regimes have shifted, growth and vigor of trees are reduced, insect and disease mortality is increased, and understory fuel loadings and continuity are increased so that wildfires tend to be of high intensity, killing most or all of the overstory. Diversity of understory herbs and shrubs is decreased.

Under mixed fire regimes, there is considerably less nonlethal understory fire than in the past (Brown et al. 1994). The mixed fire regime is shifting toward a stand-replacement fire regime that favors more shade tolerant species and less landscape diversity. In stand-replacement fire regimes, fire intervals have generally lengthened; however, the effects of this change vary widely depending largely on presettlement fire return intervals and accessibility for fire suppression efforts. For example, in a lodgepole pine/subalpine fir forest in Idaho, presettlement stand-replacement fire was 1.5 times more prevalent than during the recent period (Brown et al. 1994). In the same forest type in Yellowstone National Park, however, the area burned probably has not changed substantially from presettlement to recent periods (Romme and Despain 1989).

The age distribution of marginally commercial and noncommercial forests, such as those in wilderness areas and parks, is shifting to an abundance of older stands (Brown and Arno 1991). Succession is increasing the shade tolerant component of stands, making a major species shift likely if fire continues to be excluded. In the case of aspen, more than half of the aspen forest type has been lost, much of it due to successional replacement by conifers (Bartos et al. 1983; Bartos 1998). Fire protection policies have resulted in the fire cycle in aspen shifting from about 100 years to 11,000 years.

Grasslands and Shrublands

Grassland fire regimes have shifted dramatically from the presettlement period. Many ecologists consider the reduced frequency and extent of fires on rangelands due to fire protection to be among the most pervasive influences in the United States by non-indigenous peoples (Pieper 1994). The shift to woody plant domination has been substantial during the past hundred years. Grazing and possibly climate changes have acted with reduced fire to give a competitive advantage to woody plant species. Some woody plants, such as honey mesquite, become resistant to fire, develop fuel discontinuities, and reduce the spread of fire. In time, recovery following fire favors shrubs over perennial herbaceous species, which can alter the composition of ecosystems to the point that a return to the grassland type becomes nearly impossible or impractical (Archer 1994, Brown 1995).

Fire regimes have shifted to increased fire in the drier portions of the sagebrush-steppe ecosystem that occupies over 100 million acres in the western U.S. Fire frequency has increased in many areas due to invasion of downy brome, medusahead, and other introduced annuals that cure early and remain flammable during a long fire season. Increased fire frequency exerts strong selective pressure against many native plants. A contrasting situation exists for the more mesic mountain big sagebrush type, in which decreased fire frequency and encroachment by conifers is causing a reduction in herbaceous and shrub vegetation.

Managing Fire

Fire is an integral component of ecosystems that can affect all aspects of ecosystem management. Fire regimes have shifted as a result of human influences, and may continue to shift with clearly detrimental results in some ecosystems. Land managers need to know how to plan and carry out fire management strategies that successfully incorporate the ecological role of fire. Constraints on managing prescribed fire and smoke make it difficult to achieve resource goals, while protection against wildland fires allows development of undesirable ecological consequences (Brown and Arno 1991).

Historical Range of Variability

The historical range of variability (also called natural range of variability) in ecosystem components can be used to help set desired future conditions and fire management objectives. It can serve as a basis for designing disturbance prescriptions at varying spatial scales and help establish reference points for evaluating ecosystem management (Morgan et al. 1994). Historical fire regimes of forest ecosystems are often characterized by determining age distribution and aerial extent of seral classes across a large landscape, and dating fire scars to determine fire return intervals. A strong argument can be made that knowledge of historical fire should be used as a guide for understanding landscape patterns, conditions, and dynamics, but not necessarily for creating historical landscapes. Knowledge of historical variability provides a basis for bringing the range of existing conditions in a landscape within the historical range (Swanson et al. 1993).

Restoration of Fire

The need for restoration is most evident in high fire frequency regimes, such as understory fire regime types and some grasslands and shrublands, where fire has been excluded for several times longer than the average fire return interval. Although considerable knowledge supports the need for restoration of fire into wildland ecosystems, constraints and obstacles confront land managers (Brown and Arno 1991, Mutch 1994). Limited funding, air quality restrictions, concerns over escape fire, and inadequate public support can pose difficulties. Some breakthroughs in managing emissions and obtaining support have provided more latitude for prescribed fire programs (Mutch and Cook 1996).

Restoration of fire in grasslands, shrublands, and savannas requires careful consideration of seasonal timing and frequency to assure that prescribed fires will spread at appropriate severities. Once woody plants have encroached to a point of dominating a site, it becomes difficult to get fire to spread with sufficient heat to kill aboveground stems, such as oak in savannas (Huffman and Blanchard 1991) and juniper in sagebrush/grass communities. Perhaps the greatest obstacle to success lies in areas that have successionally lost the native mix of species and lack sufficient grass fuel to carry fire. In these areas, seeding of native species following fire may be necessary to restore a semblance of former plant species composition. Where conifers such as pinyon-juniper and inland Douglas-fir invade grasslands, successful spread of surface fire may require fuel enhancement work, such as cutting numerous trees to create adequate surface fuels (Gruell et al. 1986). Otherwise, crown fire may be required, which will necessitate a more flammable, narrow fire prescription that can limit burning opportunities.

Fire Ecology and Vegetation by Ecoregion

Vegetation within the treatment area has been classified into 14 subclasses that are consistent with the National Vegetation Classification Standard (Federal Geographic Data Committee 1997; Table 3-4). The subclasses differentiate vegetation on the basis of growth form (tree, shrub, or herb), life history strategy (evergreen or deciduous, annual or perennial), and percent of canopy closure (forest or woodland) or hydrologic influences. The following sections discuss important vegetation subclasses for each ecoregion and their fire ecology.

Tundra Ecoregion

Located at high latitudes in northern and western Alaska, plant communities in the Tundra Ecoregion are adapted to withstand an extremely short growing season, continuous permafrost, and limited rooting depths. Slow-growing dwarf shrubs, grasses and sedges, and cryptogams (lichens) are the dominant vegetation types in this region. Approximately 39 million acres of public lands occur within this ecoregion.

Perennial graminoid communities are found on over 13 million acres (Map 3-8). Along Alaska's coastal regions to the north, west, and southwest, cottongrass-tussock communities are the most widespread plant systems. Cottongrass occurs as the dominant species in extensive patches in flat, poorly drained areas, and is associated with other sedges, dwarf shrubs, lichens, mosses, dwarf birch, Labrador tea, and cinquefoil. Similar plant communities are also found at low elevations in the mountainous North Slope and Alaska Peninsula regions.

Deciduous shrublands (both dwarf and non-dwarf) are found in many of the same areas as perennial graminoid communities, as well as higher elevation alpine areas. Deciduous dwarf-shrubland occurs on over 10 million acres and is characterized by shrubs that are less than 2 feet tall, a reduced stature that is attributable to extremely harsh growing conditions. Characteristic plant species include dwarf birch, willow, blueberry, and Labrador tea and other shrubs. A variety of forbs and graminoids are found in the understory, and lichen species may be an important component. At high elevations in mountainous areas, dwarf Arctic birch, crowberry, and dwarf blueberry are also common.

Deciduous shrubland species occur on over 6 million acres and are generally the same as those found in deciduous dwarf-shrublands, but are taller because of slightly better growing conditions. Willow, dwarf birch, alder, huckleberry, Labrador tea, and heath species are common. These communities may be successional to forest or woodland, or may be the climax vegetation where frozen and poorly drained permafrost soils limit tree growth. Stunted black spruce and other tree species are occasionally scattered throughout shrub communities.

In areas underlain by permafrost, nearly 3 million acres of sedge-dominated wet meadows, bogs, and wetlands are scattered among the shrublands. Along major rivers and streams, riparian communities composed of alder, willows, and stunted stands of spruce and birch can be found. In shrublands, pure stands of stunted alder shrubs are found in wet drainages, at the head of streams, along river terraces, or on slopes. Some evergreen spruce woodlands, spruce hardwood forests composed of white spruce, paper birch, and alder, and black spruce forests also occur, in low amounts, in the Tundra Ecoregion.

Fire Ecology

In general, distribution of vegetation over the tundra biome is characterized by a patchy occurrence of dense vegetation, sparse vegetation, and bare ground offering an interrupted fuel bed (Payette et al. 1989). However, in the sedge tussock-mixed shrub tundra, the fuel layer, made up mostly of tussock cottongrass, is dense and continuous, leading to large, fast spreading fire conflagrations (Racine et al. 1987).

The transition zone between the upper limit of the boreal forest and the tundra, which has been distinguished as forest-tundra, is characterized by a fragmented cover of scattered forest stands of lichen-spruce and lichen-heath communities on well-drained sites. In Alaska, the forest-tundra is commonly termed taiga. The forest-tundra is further delineated into the forest subzone and shrub subzone (Payette et al. 1989; Sirois and Payette 1991). In both the forest-tundra and tundra, the ground vegetation is the primary carrier of fire. Lichens resemble dead tissue more than live tissue in their susceptibility to fire and often serve as the initial point of ignition. The low shrub component can provide a high percentage of fine, dry fuel with a low temperature of ignition (Auclair 1983).

Burning patterns of tundra ecosystems generally are characterized by moderate intensity surface fires that may kill all aboveground plant parts, but seldom destroy underground parts (Bliss and Wein 1972, Viereck and Schandelmeier 1980, Van Wagner 1983). Although the fire cycle may be as short as 100 years, it is usually much longer (Viereck and Schandelmeier 1980).

The tussocksedge tundra of Alaska may be a fire-dominated ecosystem, although the fire interval has yet to be determined (Racine et al. 1987). The long fire rotations in the tundra are probably related to the prevalence of cold, humid summers, saturated peat profiles, and the absence of continuous plant cover. These features serve to restrict fire spread over a large area (Payette et al. 1989).

Subarctic Ecoregion

Located within the central continental region of Alaska, the Subarctic Ecoregion primarily consists of evergreen forests and open lichen woodlands collectively known as the boreal forest, or taiga. The climate in this region is characterized by low precipitation (10 to 20 inches average annual precipitation), extreme ranges of temperature, low humidity, and high evaporation rates. However, as it is a diverse area, large portions of this region are semiarid as well. Approximately 43 million acres of public lands occur in this ecoregion.

Over 20 million acres of evergreen woodlands and mixed evergreen-deciduous woodlands can be found throughout this region. Within the lowland areas of interior central Alaska, evergreen woodlands are often composed of pure stands of black spruce, with an understory of willow, dwarf birch, crowberry, blueberry, lichens, and mosses. Within the mountainous regions of central and south-central Alaska, woodlands are also common, typically supporting a number of boreal tree species: white spruce, black spruce, tamarack, balsam poplar, paper birch, and aspen.

Deciduous shrubland occurs on 10 million acres, predominantly at higher elevations in the mountainous areas of this region. These shrublands are composed of a wide variety of low growing shrubs, herbs, grasses, and sedges, rooted in mosses and lichens. Mountain avens, low growing willows, dwarf birch, Labrador tea, blueberry, green alder, moss campion, and blackish oxytrope are all common species. Along riparian areas, deciduous tree species are prevalent. Paper birch, aspen, and balsam poplar are all found in these deciduous forest riparian communities. Extensive sphagnum bogs occur in old river terraces, ponds, and sloughs. These scattered wetlands are composed of sphagnum and other mosses, sedges, bog rosemary, Labrador tea, rose, birches, willow, bog cranberry, soapberry, and blueberry. About 2 million acres of forested communities also occur in the Subarctic Ecoregion. Mixed evergreen-deciduous forests, supporting many of the same species as woodlands, can be found in mountainous areas between elevations of about 1,000 and 3,000 feet (timberline). Spruce-hardwood forests, consisting of white spruce, birch, aspen, and poplar, with an undergrowth of mosses and berries, are common.

TABLE 3-4
Vegetation Classification System

Order	Class	Subclass
Tree dominated	Closed tree canopy	1. Evergreen forest
		2. Deciduous forest
		3. Mixed evergreen-deciduous forest
	Open tree canopy	4. Evergreen woodland
		5. Deciduous woodland
		6. Mixed evergreen-deciduous woodland
Shrub dominated	Shrubland	7. Evergreen shrubland
		8. Deciduous shrubland
	Dwarf-shrubland	9. Evergreen dwarf-shrubland
		10. Deciduous dwarf-shrubland
Herb dominated	Herbaceous vegetation	11. Perennial graminoid
		12. Annual graminoid or forb
		13. Perennial forb
		14. Riparian/wetland

Source: Developed by the BLM based on the Federal Geographic Data Committee Vegetation Subcommittee's National Vegetation Classification Standard (Federal Geographic Data Committee 1997).

Fire Ecology

Because of its structure, the black spruce forest in Alaska is highly flammable and burns readily. Most fires in black spruce associations are either crown fires or surface fires intense enough to kill the overstory trees (Viereck and Shandelmeier 1980). Because the base of most black spruce crowns is close to or in contact with the moss-lichen layer, surface fire readily spreads into the crowns of trees and ignites most of the black spruce and tamarack trees as it passes (Viereck and Shandelmeier 1980). Associated understory shrubs are top-killed and the moss-lichen layer is usually consumed. Small patches of exposed mineral soil are common, intermixed with less severely burned microsites (Foote 1983). Fires under extremely dry conditions may burn off this entire layer and completely expose the mineral soil, although this is not common. In less extreme conditions, the lichen-dominated black spruce forest burns while the moister and older feather moss dominated stands or deciduous mixed wood areas remain unburned (Foster 1983). In general, fire on black spruce sites is a common occurrence, and most stands burn before they are 100 years old (Foote 1983).

Because mature white spruce forests accumulate large amounts of organic matter consisting of feather mosses, woody fuels, flaky barks, and shrubs, they are highly susceptible to fire. Also, the crown and canopy structure (i.e., tree crowns extending nearly to the ground) is ideal for ignition and propagation of crown fires (Rowe and Scotter 1973, Van Wagner 1983). In the boreal forest, the fire regime is characterized by crown fires or severe surface fires with a return interval averaging 50 to 150 years. In Alaska, white spruce stands commonly are greater than 100 years old (Foote 1983).

In general, aspen stands are most flammable in the spring, late summer, and fall when they are leafless due to the drying effect of sun and wind on the leaf litter. Furthermore, in the fall the herbaceous plant and shrub component of the understory is dead and dried out, forming a continuous layer of loosely organized fine fuel. In general, flammability depends largely on the amount of herbaceous, shrub, and coniferous fuels present in the stand. Stands with a fair conifer component can burn when aspen leaves are still present.

Temperate Desert Ecoregion

The Temperate Desert Ecoregion is composed of arid lands in the rain shadow of the Pacific mountain ranges, including the Great Basin, Columbia Plateau, and Wyoming Basin. Plant communities, which are adapted to pronounced summer drought and cold winters, are composed primarily of xerophytic semidesert shrubs. Approximately 105 million acres of public lands occur in this ecoregion.

Evergreen shrublands in the form of sagebrush communities occur on nearly 74 million acres (Map 3-9). These shrublands typically consist of fairly dense to open vegetation, with shrubs that are 2 to 6 feet high and an understory of perennial and annual grasses and forbs (Cronquist et al. 1972). On the drier sites, shrub density is generally high, while on more mesic sites individuals are more robust and widely spaced, with greater coverage of herbaceous species.

In the plains and tablelands of the Columbia River and Snake River plateaus and the Wyoming Basin, representative shrubs in sagebrush communities include big sagebrush, black sagebrush, low sagebrush, Mormon tea, and bitterbrush (Cronquist et al. 1972). Important perennial grasses include bluebunch and western wheatgrass, Sandberg bluegrass, Idaho fescue, and basin wildrye. Medusahead and downy brome are introduced annual grasses that have become abundant in these communities where the native herbaceous understory has been depleted, particularly in lower precipitation zones. They have an adaptive advantage over seedlings of most existing grass species in their ability to take advantage of limited moisture early, short lifespans, and prolific seed production. Where repeated fire or grazing have removed the native vegetation, these invasives, as well as invasive forbs, will dominate the site, taking advantage of what moisture exists and outcompeting the native vegetation. They then dry out and become fuel, burning very intensely and carrying fire into previously unburned areas, thus repeating and expanding the cycle.

In the Great Basin and northern Colorado Plateau, common shrubs in salt desert shrub communities are shadscale, fourwing saltbush, spiny hopsage, and greasewood. These communities occur from valley bottoms to mid-elevations in areas with shallow water tables and accumulated salts. Understory vegetation is generally sparse, with a large amount of bare soil or desert pavement exposed (MacMahon 1988). Species such as saltgrass, Indian ricegrass, squirreltail, fescues, and James' galleta may be found in this understory layer. Fires are generally absent due to the sparse fuels, and efforts to reestablish native plant communities are complicated by the dry conditions.

In the mountainous regions, sagebrush communities can be found scattered throughout the forested areas, and sagebrush communities dominate the foothills adjacent to the forested habitat. These higher elevation sagebrush communities are dominated by big sagebrush and other shrubs including antelope bitterbrush, mountain mahogany, and snowberry. The herbaceous component of these plant communities often contains Idaho fescue, bluebunch wheatgrass, various needlegrass and bluegrass species, and a variety of forbs.

Pinyon-juniper (evergreen) woodlands occur on nearly 14 million acres. These communities can be found in small areas in central Oregon, and at elevation zones above sagebrush communities throughout the rest of the ecoregion. Young pinyon-juniper trees are easily killed by fire, which historically limited their expansion into sagebrush communities (West and Van Pelt 1987). Stands of pinyon-juniper have established in many locations, and form dense canopies that cause the loss of understory plants. These closed-canopy pinyon-juniper stands generally do not have enough understory shrubs to carry a surface fire, and do not burn until conditions are met to carry a crown fire.

Deciduous shrublands typically occur at similar elevations as sagebrush, on arid, saline soils on nearly 3 million acres. Dropping leaves during times of drought enable plants such as greasewood, hopsage, catclaw acacia, and European smoketree to survive the harsh conditions. Many of these species are fairly tolerant of alkaline and saline conditions, and occur as lesser members of sagebrush and pinyon-juniper communities.

Other vegetation classes include the perennial bunchgrass grasslands of Oregon, Washington, and Idaho (6 million acres), and the evergreen forests that occur at elevations above woodlands (over 1 million acres). Dominant tree species in these forests include ponderosa pine and Douglas-fir. In a few areas, mountains are high enough to support subalpine fir and Engelmann spruce. Aspen commonly occurs in mountainous areas and is frequently mixed with young conifers.

Fire Ecology

During the era of Euroamerican settlement, fire frequencies initially increased in the Temperate Desert Ecoregion. Newspaper records between 1859 and 1890 report that settlers engaged in active fire suppression, including deliberate overgrazing of rangeland to reduce fuels. Woody species were favored by the reduction of grass and forb competition caused by overgrazing (Wright 1986). Grazing altered the role of fire in desert areas once dominated by grasses. The consequent reduction of major fires was followed by shrub invasion into desert grasslands. Early 1900s wildland management policies continued to promote historical fire suppression and rangeland use in desert landscapes. A new management strategy was initiated when managers recognized that continued shrub encroachment was associated with overgrazing and fire reduction (Leopold 1924, Komarek 1969). Shifts in land management resulted in reduced grazing, and increased fuels, and thus changed the fire dynamics. Currently, burning of thousands of acres is becoming more common, and fire has become a serious management issue in some shrubland areas (Blaisdell et al. 1982; Bunting et al. 1987; Wilson et al. 1995a). Desert shrubland management traditionally focused on shrub eradication in favor of grasses. The objective was to improve forage for livestock and increase efficient management of range by increasing livestock and wildlife visibility. Fire, disking, herbicides, and heavy grazing were all commonly used. Often, the end result of this heavy range management was to decrease the amount of annual biomass and actually reduce the productivity of these ranges.

Historical accounts of sagebrush habitat are sketchy, but fires in big sagebrush were set both by lightning and humans. The many species and subspecies of sagebrush are quite susceptible to fire. Typical succession after fire would begin with grass/forb dominance, and eventually lead to sagebrush recovery in 30 or more years. In the late 1800s, overstocked free ranging cattle led to a depletion of perennial grasses and other palatable forage. The subsequent introduction and spread of downy brome in the early 1900s corresponds with increased fire frequency and the reduction of big sagebrush. This, in turn, increased erosion and further damaged perennial native grass and forb components (MacMahon 1992).

Since 1900, the cultivation and abandonment of marginal land, abusive grazing, and widespread recurrent prescribed burning of sagebrush has resulted in an imbalance between the numbers and sizes of shrubs, and associated native grasses and forbs (Blaisdell et al. 1982). Thus, much of the resource potential of the sagebrush range has been depleted. By 1936, 85% of sagebrush lands were considered depleted (Tisdale et al. 1969). Prescribed fire was used to remove shrubs and replace them with native perennial grass forage (Pechanec and Stewart 1944; Pechanec et al. 1954; Cornelius and Talbot 1955; Reynolds et al. 1968). This ecosystem readily burns, particularly where there is a contiguous understory of grasses. Habitat changes coincident with increased fire have included plant community composition changes (Blaisdell 1949, Hassan and West 1986), altered soil seed banks (Blank et al. 1995), and increased soil repellency (Salih et al. 1973). The absence of sagebrush is often an indicator of past burns (Humphrey 1974). Secondary consequences of wildfires in sagebrush can include range deterioration, flooding, erosion, lowered grazing capacity, and reduction in the amount and quality of wildlife habitat. Extensive research has focused on rangeland degradation (Young et al. 1979) and loss of productivity (Beetle 1960; Harniss et al. 1981).

Big sagebrush can gain dominance over the herbaceous layer in 5 to 30 years after a burn. The season in which a burn takes place affects the resulting species dominance (White and Currie 1983) and postfire sagebrush productivity (Mueggler and Blaisdell 1958). For example, silver sagebrush mortality is higher and regrowth is less after a dry fall burn (White and Currie 1983). After fires, sagebrush mortality is proportional to fuel reduction. Although many sagebrush species are readily killed by fire, at least three species (threetip sagebrush, silver sagebrush, and coastal sagebrush) are known to resprout (Tisdale and Hironaka 1981, Malanson and O'Leary 1985). Most sagebrush species reseed after fire, but may require fire intervals of up to 50 years to regain their dominance (Bunting et al. 1987). Frequent fires can cause conversion from sagebrush species to rabbitbrush, horsebrush, and snakeweed. Where downy brome occurs, the burn season is extended and wildfires are reported to consume more area per burn. Introduced downy brome can outcompete indigenous herbaceous species. Downy brome is undependable as forage because of its large fluctuations in yield from year to year. After two to three reburns, sagebrush sites can be converted to stable downy brome; fire return intervals of 5.5 years maintain downy brome dominance.

Downy brome is often accompanied by other invasive, noxious, and undesirable species. Together these pose a serious fire hazard, particularly following wet springs.

Planning prescribed fires in sagebrush should include specific objectives and consider many factors such as species and subspecies of sagebrush, soils, fuel loading, fuel moisture content, and windspeed (Salih et al. 1973; Britton and Ralphs 1979; J.K. Brown 1982; Simanton et al. 1990). Early spring or late summer burns can be used to promote native perennial grasses. There is little postfire recruitment for 3 to 5 years following a fire in perennial grasses, yet surviving grasses and accompanying forbs increase biomass production. Often, forbs will dominate an area for several years postburn. Harniss and Murray (1973) found increases in herbage production for 20 years after a burn.

Attempts at restoring sagebrush rangeland to achieve higher biomass yields are being investigated (Downs et al. 1995). In general, shrublands that have been converted to grasses by large wildfires are difficult to restore. Fire negatively impacts soil seedbeds important for sagebrush regeneration (Blank et al. 1995). Sagebrush seed can be viable for up to 4 years. Sagebrush can be restored through reseeding. Downy brome seed banks present on sagebrush sites may negatively influence reestablishment of native bunchgrasses and shrubs (Hassan and West 1986). If sagebrush is in good condition, an initial postfire influx of downy brome will occur if some plants are present on these sites. Given adequate precipitation, however, perennial native grasses and shrubs can outcompete downy brome by the second year (West and Hassan 1985). Postfire rehabilitation efforts can be unsuccessful if other measures, such as grazing management, are not incorporated (Evans and Young 1978).

Fire was an important natural disturbance in the pinyon-juniper biome before the introduction of livestock in the 19th century (Gottfried et al. 1995). It is estimated that small surface fires historically occurred every 10 to 30 years (Leopold 1924), and large stand-replacing fires occurred every 100 to 300 years (Miller and Rose 1999). Fires apparently restricted the junipers to shallow, rocky soils and rough topography (Arend 1950, Burkhardt and Tisdale 1969, O'Rourke and Ogden 1969). Under natural fire cycles, the successional stages following fire are typically annuals; mixed annuals and perennials; perennial forb; grass and shrub; shrub and pinyon-juniper; and climax pinyon-juniper. Young pinyon and juniper trees are readily killed by fires, but older trees may be less susceptible due to thicker bark and more open crowns.

The major human influence on pinyon-juniper woodlands and fire's role in these ecosystems has been ranching. Most of the western rangelands were overgrazed, especially in the period following the 1880s. Overgrazing has had an important effect on the role of fire in the woodlands. The reduction of cover of herbaceous species resulted in insufficient fuels for fires to spread and to control tree establishment. In woodlands, tree density has increased. In many rangelands, juniper woodlands have established, replacing shrub communities. Fires ignited by lightning or humans tend to be restricted in space. Fire suppression activities by land management agencies also reduced the occurrence of fires. Woodland and savanna stand densities have increased throughout most of the West.

Climatic fluctuations, such as the drought in the Southwest in the early 1950s and global climate change, also have affected the distribution of woodlands in the West. In the Intermountain West, Miller and Rose (1999) quantitatively established that the co-occurrence of wet climatic conditions, introduction of livestock, and reduced role of fire contributed to the postsettlement expansion of western juniper. Prior to 1880, fire was probably the major limitation to juniper encroachment.

During the 1950s and 1960s, large operations were conducted to eliminate the pinyon-juniper cover in the hope of increasing forage production for livestock (Gottfried and Severson 1993; Gottfried et al. 1995). Other objectives were to improve watershed condition and wildlife habitat. Mechanical methods, such as chaining and cabling, were used, and the resulting slash was piled and burned. Burning these large fuel concentrations generated high heat levels that damaged soil and site productivity (Tiedemann 1987). Many of these piled areas were sterilized and remain free of vegetation after over 20 years. Individual tree burning was used on some woodland areas. Most of the control operations failed to meet their objectives. Many areas failed to develop sufficient herbaceous cover to support renewed periodic surface fires. Prescribed fire, sometimes in association with the felling of trees, is used to restore areas where pinyon-juniper has encroached into shrublands.

Subtropical Desert Ecoregion

The Subtropical Desert Ecoregion occupies southeast California, southern Nevada, Arizona, New Mexico, and western Texas, and includes the Chihuahuan, Sonoran, and Mojave deserts. Vegetation is adapted to dry conditions, and includes numerous xerophytic plants, such as small, hard-leaved or spiny shrubs, cacti, or hard grasses, which are widely spaced and provide little ground cover. Large portions of these hot deserts have no visible plants and are made of shifting sand dunes or nearly sterile salt flats. Approximately 29 million acres of public lands occur in this ecoregion.

Although major fires were not historically common in this region due to the wide spacing between plants and sparse fuels, the invasion of fire-prone species (e.g., red brome, downy brome, and buffelgrass) has shortened the fire interval in some areas, resulting in significant changes in plant communities.

Evergreen shrub communities are prevalent in desert habitats on over 23 million acres of public lands. On the plains of the Sonoran Desert, shrublands of creosote bush and saltbush species cover extensive areas in nearly pure stands. Individual shrubs are typically widely spaced, with large amounts of bare ground in between.

Large plants, such as the treelike saguaro cactus, prickly pear cactus, ocotillo, creosote bush, and smoke tree often form communities with a near-woodland appearance. They are commonly associated with blue paloverde, bursage, mesquite, desert ironwood, crown of thorns, jojoba, acacia, and many species of cactus, yucca, and agave.

In the Mojave Desert, Joshua tree shrublands are widespread. Other common shrubs in this region include creosotebush, bursage, thornbush, shadscale, all scale, spiny hopsage, and greasewood. The Mojave Desert is especially rich in annual plants, which are abundant during the rainy season in winter and spring (Brown 1982).

Shrublands occurring adjacent to shallow playa lakes and desert washes, and in other moist habitats, have a unique species composition. Greasewood and catclaw acacia, which occur as scattered individuals in many plant communities throughout the ecoregion, often form pure stands in desert washes. Mesquite is another shrub species that may be found growing along washes and watercourses. Shrubs associated with alkaline soils near playas include mesquites, whitethorn acacia, blue paloverde, ironwood, desert willow, and canyon ragweed.

Evergreen shrublands in the Chihuahuan Desert include such species as mesquite, American tarwort, acacia, and creosotebush. Shrubs have recently increased in density in the Chihuahuan Desert, which is thought to have historically existed as open grassland or grassland scattered with shrubs (Buffington and Herbel 1965). Evergreen shrublands grade into grasslands, with the relative abundance of each plant community determined by such factors as fire, grazing, climate change, and seed dissemination (Holechek et al. 1995).

Perennial grasslands occur on nearly 4 million acres in the high plains of southeast Arizona (in the Chihuahuan Desert), where they are best developed on deep, well-drained soils on level sites (Brown 1982). Black grama and tobosagrass grasses are characteristic, along with sideoats grama and hairy grama, bush muhly, vine and curly mesquite, pappusgrass, tanglehead, and threeawn. Shrubs and succulents characteristic of this grassland include yucca, bear grass, agaves, sumac, ocotillo, acacias, mimosas, and cacti.

Deciduous and evergreen woodlands occur in select areas on over 1 million acres, predominantly on higher elevation slopes (pinyon-juniper woodlands) and in eastern New Mexico (oak and mesquite woodlands).

Fire Ecology

Prior to Euroamerican settlement, fires in desert habitats were set by lightning and Native Americans (Komarek 1969, Humphrey 1974). European settlers, however, suppressed fires and deliberately overgrazed rangelands to reduce fuels and use most of the grassland resources (Smith 2000). The reduction of major fires, together with the grazing of native grasses and the accompanying soil erosion, has caused shrubs to invade desert grasslands, thereby expanding in area and converting the structure of grasslands to shrublands (Bahre 1985). Wildfire risk varies from low in sparsely vegetated habitats (e.g., saltflats) to high in areas with heavy fuel loadings (e.g., mesquite shrublands). Introduced grasses such as red brome and lovegrasses provide herbaceous-level fuels that significantly increase the risk of a damaging wildfire in these habitats.

In many areas of the Mojave and Sonoran deserts, plant communities are too sparse during most years to adequately carry a prescribed burn. Therefore, this type of treatment would not be suitable for these areas. In areas that have increased fuel loading as a result of invasive annuals like red brome, prescribed fire would negatively affect plant communities by encouraging the further spread of these invasive species. In the denser desert shrublands, where there is an adequate amount of fuel to support a fire, many shrubs, trees, and cacti could be severely affected by burning, as these species are not adapted to fire. Paloverde, burroweed, bursage, broom snakeweed, ocotillo, and creosote bush are examples of desert species that can suffer high mortality rates from burning (Wright and Bailey 1980; Paysen et al. 2000).

Mesquite density and distribution increased prior to 1900 with fire suppression and seed dispersal by livestock. After 1900, mesquite continued to increase even though numerous eradication practices such as biological control, herbicides, mechanical removal, and prescribed burning were used to limit its density and spread (Glendening 1952, Wright and Bailey 1982, Wright 1990, Jacoby and Ansley 1991).

Fire as a management tool for controlling mesquite has its limitations. Mesquite may become more prevalent 5 years following a burn than it was before fire (Martin 1983). Mesquite can root sprout and top-killed individuals may resprout from dormant buds found in upper branches or from the base of the trunk below the ground surface. Mesquite seedlings can survive fire (Cable 1961), but on a burned site mesquite is sometimes reduced (Wright 1980). Fire may kill a good proportion of mature mesquite, particularly the smaller trees (>2 inch diameter; Cable 1949, 1973). It is most susceptible to fire during the hottest and driest part of the year (Cable 1973). Drought years may increase mortality of mesquite if eradication is attempted. If managers wish to open dense mesquite stands, then roots as well as aboveground biomass must be killed. Fire can be used to reduce the density of young mesquite populations, particularly during dry seasons that follow 1 to 2 years of above normal summer precipitation (Wright 1980). Adequate precipitation, no grazing, and using fire about every 10 years allow grasses to successfully compete with mesquite. Rehabilitation of mesquite-invaded grasslands requires removal of livestock before burning, otherwise the shrubs outcompete the grasses (Cox et al. 1990). Shrub reinvasion depends on grazing management combined with continued use of fire at the desired frequency (Wright 1986).

In managing for mesquite savanna, shaded rangeland may be a preferred condition, rather than complete eradication of mesquite (Ansley et al. 1995, 1996). Low-intensity fire may allow mesquite to retain apical dominance on upper branches while reducing overall foliage. Season, air temperature, relative humidity, and duration and temperature of fire are factors that appear to affect the response of mesquite to fire (Paysen et al. 2000). Mesquite topkill is related to heat in the canopy, not at the stem bases. Single and repeated summer burns kill mesquite aboveground, but do not kill roots (Ansley et al. 1995). Prescribed burning may be used to kill mesquite seedlings, while leaving tree-sized individuals alive.

Prior to 1900, fires in paloverde-cactus shrub were not considered to be important and occurred mainly in the restricted desert grasslands (Humphrey 1963). Conversion of desert shrubland to grassland to enhance forage for livestock and wildlife was the primary land-use goal during the 1800s (Phillips 1962; Martin and Turner 1977).

Since 1900, increases in ignitions and fire size are evidence of changing land management practices in the paloverde-cactus shrub. Exotic grass invasion now supplies a contiguous fuel source in many areas so that the historical small and infrequent fires have been replaced by more frequent and larger fires (Narog et al. 1995). Rogers (1986) speculated that finer fuels and higher rates of spread may allow desert fires to become larger than nondesert fires before being controlled. Although many of the species in this vegetation type can resprout (Wilson et al. 1995b), postfire communities generally experience changes in species composition, particularly with an increase in the grass component, at the expense of cacti and succulents (Rogers and Steele 1980, McLaughlin and Bowers 1982, Cave and Patten 1984).

The increase in fire frequency and size may have serious consequences, particularly for plant and wildlife species of special interest, such as the giant saguaro (Thomas 1991) and the desert tortoise; both may be fire intolerant.

Temperate Steppe Ecoregion

The Temperate Steppe Ecoregion, which is typified by a semiarid continental climate, includes the Rocky Mountains and the Great Plains. Vegetation communities adapted to this climate include steppe, or shortgrass prairie, and semidesert, as well as the evergreen and deciduous forests and woodlands of the Rocky Mountains. Approximately 19 million acres of public lands occur in this ecoregion.

Perennial grassland communities are widespread in this ecoregion (over 4 million acres), which includes the prairie grasslands of the Great Plains, the Palouse grasslands of Oregon, Washington, and Idaho, and the mountain grasslands of the Rocky Mountains.

Prairie grasslands, which occur on the broad, flat belt of land that slopes eastward from the foothills of the Rocky Mountains, vary in height in response to precipitation. Dominant grasses in the shortgrass communities are buffalograss and blue grama, which occur with other herbs, as well as some woody species, including mesquite, sagebrush, and yucca.

Mixed grass communities include both warm-season (e.g., blue grama) and cool season species, such as needlegrasses, wheatgrasses, and fescues grass species. Shrubs, including juniper, sagebrush, rabbitbrush, and forbs are also important components of mixed grass communities (Brown 1982).

The Palouse grasslands, or northwest bunchgrass prairies, are dominated by bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass, and rough fescue. Many of the introduced species are Mediterranean annuals that are well adapted to grazing and the predominantly winter precipitation regime.

Perennial mountain grasslands are scattered throughout areas at elevations from 3,000 to over 9,000 feet in the

Rocky Mountains, particularly in western Montana. These grasslands are part of the vegetation mosaic created by the highly complex environment of the Rocky Mountains. Important grasses in these communities include bromes, bluegrasses, oatgrasses, sedges, wheatgrasses, fescues, needlegrasses, hairgrasses, reedgrasses, bentgrasses, and junegrass. Forb components vary with site, latitude, and management. Shrubs include several species of sagebrush, rabbitbrush, snakeweed, shrubby cinquefoil, rose, horsebrush, and prickly pear cactus (Mueggler and Stewart 1980).

Evergreen forests occur on over 2 million acres in the mountain regions, with species composition that varies by altitude. Subalpine forests are composed of Engelmann spruce, subalpine fir, and mountain hemlock. Below this zone, Douglas-fir, western white pine, grand fir, western larch, lodgepole pine, and ponderosa pine are common. Lodgepole pine or ponderosa pine forests may occur at the lowest elevations, and often grade into grasslands or evergreen shrubland. Fire is an important component of all of these forests, with the highest natural frequency on the lowest elevation sites. Lodgepole pine is specifically adapted to regenerate after fire.

Deciduous forests may occur along streams and rivers in the eastern portion of this ecoregion. Eastern species such as ash, hackberry, elm, birch, and bur oak may be found. Deciduous forests composed of quaking aspen are prevalent throughout the Rocky Mountains up into Alaska (DeByle and Winokur 1985). Aspen may form extensive pure stands or exist as a minor component of other forest types.

The most common type of shrubland in this ecoregion is sagebrush steppe. Sagebrush-dominated communities occur on the plains and lower mountain slopes on nearly 8 million acres. Chaparral shrublands and pinyon-juniper woodlands (2 million acres) are also found in some of the lower elevation areas on warm, dry sites.

Fire Ecology

Perennial Graminoid – Grasslands. Fire was not a predominant force in delimiting the extent of the Plains grasslands. However, given their existence and their flammability characteristics, the presence of fire must have had an impact on the character of the grasslands and their species composition and distribution. Modifications of climate and soil development led to invasion of some grassland areas by woody species. Under these circumstances, fire probably played a distinct role in the maintenance, or loss, of these grassland areas. Working in concert with grazing animals, fire could check the advance of more fire-sensitive, woody species, provided enough grass fuel was available. It could also encourage the advance of woody species that were adapted to disturbance and harsh climate conditions. Where invasion by woody species was not an issue, fires could maintain highly productive grasslands, and cause shifts in grassland species composition in others. Under conditions of drought, fire could result in severe site damage (Paysen et al. 2000).

Clearly, fire was a common element in presettlement times, and frequency might have increased with the arrival of Euroamerican settlers (Jackson 1965). For years, attempts to suppress fires in the Plains were either nonexistent or ineffective. As late as the 1890s, from the Dakotas to the Texas Panhandle, fires would run unchecked for days. During this period, fire, drought, and grazing played a role in maintaining, and at times debilitating, the grassland character. When fire or any other phenomenon that reduced the vegetative cover occurred during periods of serious drought, wind erosion often retarded the processes of succession (Paysen et al. 2000).

Perennial Graminoid – Mountain/Palouse Grasslands. Although bunchgrass species vary in their individual susceptibility to fire damage, repeated fires at intervals of about 5 to 40 years historically maintained the bunchgrass community (Gruell et al. 1986). The abundance of individual species varied by site conditions and the actual frequency and seasonal timing of fire. A successional process of major importance was the continual checking and reduction of woody plant encroachment.

Grazing by livestock, elimination of Native American ignitions, and fire control efforts greatly reduced the amount of fire in these grasslands. As a result, species such as ponderosa pine, Douglas-fir, lodgepole pine, and sagebrush have increased substantially along ecotonal boundaries. In some areas, dense Douglas-fir forests now dominate sites to such an extent that evidence of former grasslands is lost except by soil analysis (Bakeman and Nimlos 1985). Elimination of periodic burning has apparently reduced diversity of herbaceous species in some areas (Wright and Bailey 1982).

A study of fire regimes in the Interior Columbia River Basin involving grasslands and other vegetation types suggests that human influences have had a variable effect on the nature of fire regimes (Morgan et al. 1994). Fires tend to be less frequent, but not always more severe than they were in historic fire regimes. For example, where exotic annuals have invaded sagebrush steppe vegetation, fires have become so frequent that sagebrush does not have time to reestablish, and the annuals return quickly.

Evergreen Forests. Evergreen forests of the Rocky Mountains have historically had variable fire regimes, ranging from frequent, low severity understory burns in ponderosa pine forests to infrequent, stand replacing fires in lodgepole pine forests (Arno 2000).

A broad range of mid-elevation mountain forests dominated by interior Douglas-fir, western larch, or Rocky Mountain lodgepole pine were characterized by mixed fire regimes. They were abundant and diverse in western and central Montana (Arno 1980; Arno and Gruell 1983; Barrett et al. 1991). Mixed fire regimes allowed an open overstory of mature Douglas-fir and larch to survive many fires. Small trees and associated less fire-resistant species were heavily thinned by moderate-intensity burning. Additionally, some nonlethal underburns occurred in lodgepole pine stands having light fuels.

Effects of these variable fires often included maintaining a mosaic of small stands dominated by various age structures of seral coniferous species and seral hardwoods such as Scouler's willow and aspen. Some stands experienced nonlethal underburns that maintained open understories by killing saplings and fire sensitive species. Others experienced patchy fire mortality that gave rise to patchy tree regeneration, including that of seral species. Occasional large stand-replacement fires may have reduced spatial diversity, but the varying distribution of seed sources and sprouting shrubs in the preburn mosaic probably enhanced variability in postburn vegetation.

With a reduction in fire activity due to livestock grazing (removing fine fuels) and fire exclusion policies, young conifer stands have invaded former grasslands within or below the forest zone. The trees are densely stocked and subject to extreme drought stress. They often have poor vigor and are susceptible to western spruce budworm or other insect or disease attacks and to stand replacing fires. Productivity of seral herbs, shrubs, and aspen also declines dramatically in the continuing absence of fire. Stands within the forest zone may have undergone significant changes in recent decades. As a result of fire exclusion, the trees in most stands within the landscape mosaic have become older, and often have a buildup of down woody or ladder fuels. Recent wildfires have burned as larger stand-replacement fires than those detected in fire history studies (Barrett et al. 1991; Arno et al. 1993).

Deciduous Forests. Before settlement by Euroamericans, large expanses of aspen parkland existed in the western U.S. Aspen regenerates well after fire, suckering prolifically from roots. In the aspen parkland, these stands were often perpetuated as a shrublike cover by light- to moderate-intensity fires that swept across the prairie grasslands and ignited the aspen stands on a regular 3- to 15-year basis. In the Rocky Mountains, low-intensity fires caused thinning and encouraged all-aged stands, whereas high-intensity fires resulted in new even-aged stands.

Settlement of the West in the late 1800s and early 1900s increased fire frequency because of land-clearing fires, slash burning, and railway traffic (Murphy 1985). In more recent times, following the implementation of rigorous fire protection programs, lack of fire has threatened the continued existence of aspen in the West (Brown and DeByle 1987, 1989; Peterson and Peterson 1992). Fire suppression since the 19th century has altered dynamics in aspen stands in the mountainous western United States, changing fire frequencies from as little as 10 years (Meinecke 1929 *in* DeByle et al. 1987) to approximately 12,000 years (DeByle et al. 1987). Without the occurrence of disturbance, aspen clones mature in about 80 to 100 years (Schier 1975) and regeneration of this species is threatened. The dying back of those stands is now favoring shade-tolerant conifers or in some case grasses, forbs, or shrubs, depending on the availability of seed sources (Krebill 1972; Beetle 1974; Schier 1975; DeByle 1976; DeByle et al. 1987; Bergeron and Danserau 1993). Aspen stands are being replaced by conifers. Conversion to conifer stands may require the absence of moderate to high intensity fire for as little as one aspen generation to as long as 200 or more years in the southern boreal forest or in the Rocky Mountains (J. K. Brown 1985; Brown and Simmerman 1986; Bergeron and Dubuc 1989; Perala 1990).

Subtropical Steppe Ecoregion

The Subtropical Steppe Ecoregion, located in northern Arizona, New Mexico, and Texas, is composed of plateaus and high plains. Because of its altitude, the climate is semiarid, rather than arid. This region is composed primarily of grassland vegetation, with locally found shrubs and woodlands. Pinyon-juniper woodlands are common on the Colorado Plateau. To the east, in New Mexico and Texas, grasslands grade into savanna woodlands or semideserts composed of xerophytic shrubs and trees. Approximately 13 million acres of public lands occur in this ecoregion.

The perennial graminoid communities in this region are composed of xerophytic grasses, with shrubs and low trees growing singly or in clumps, and occupy over 4 million acres. Common grass species include blue and hairy grama, buffalograss, threeawn species, sideoats grama, bluestem, and bristly wolfstail. Shrubs and trees, such as mesquite, oaks, and junipers, often grow in open stands among the grasses. The perennial grasslands grade into evergreen woodlands, with the respective coverage of each vegetation class dependent on the amount and type of disturbance to which a particular area is subjected.

Evergreen woodlands of drought-tolerant juniper and pinyon pines consist of a relatively open canopy on dry sites at mid-elevations on nearly 4 million acres. Plant composition in pinyon-juniper woodlands exhibits wide geographic variation. In the Colorado Plateau and the central and southern Rockies, doubleleaf pinyon replaces singleleaf pinyon and is associated with Rocky Mountain juniper, Utah juniper, and oneseed juniper (Cronquist et al. 1972). In the dry mountains of southern New Mexico and Arizona, alligator juniper, Emory oak, gray oak, and Mexican pinyon dominate (Brown 1982). The understory layer of shrubs, grasses, and forbs in these communities is composed of representatives from adjacent sites above and below the woodland zone. Important understory species include big sagebrush, western and bluebunch wheatgrass, blue grama, cliffrose, bitterbrush, Indian ricegrass, mountain mahogany, rubber rabbitbrush, and Mormon tea (Garrison et al. 1977).

It is estimated that small surface fires historically occurred every 10 to 30 years (Leopold 1924), and large stand-replacing fires occurred every 100 to 300 years (Miller and Rose 1999). Fires easily kill young trees and frequent fires maintain the sagebrush-grassland communities (West and Van Pelt 1987). Drought and competition from grasses probably helped slow the invasion of juniper into adjacent shrublands, particularly at lower elevations. Many pinyon-juniper sites may have historically cycled between grass-shrub and pinyon-juniper communities, with fire as the chief driving force (West and Van Pelt 1987).

At higher elevations (up to 7,000 feet), chaparral is a common type of evergreen shrubland on over 4 million acres, with pinyon-juniper and oak-juniper woodlands also occurring. Plant communities consist of dense to moderately open stands of evergreen and sclerophyllous shrubs of relatively uniform height. Most chaparral shrubs are deep-rooted, sprout readily from the root crown, and regenerate quickly after burning (Brown 1982). Shrub live oak is common, and associated with mountain mahogany, yellowleaf silktassel, sumac, hollyleaf buckthorn, pointleaf and Pringle manzanita, desert ceonothus, and other oak species. Grass species may include sideoats grama and hairy grama, cane bluestem, plains lovegrass, threeawn, and bristly wolfstail. Forbs are not particularly abundant, except during a brief period after burns (Brown 1982).

Evergreen forests occur at the highest elevations in this region. Over 7,000 feet, forests of ponderosa pine, Douglas-fir, lodgepole pine, limber pine, and aspen may be found. Engelmann spruce, corkbark fir, limber pine, and bristlecone pine occur in subalpine forests.

Fire Ecology

Perennial Graminoid. Grazing by livestock, elimination of Native American ignitions, and fire control efforts have greatly reduced the amount of fire in these grasslands. These and other human influences are similar to those described earlier for Perennial Graminoid – Mountain/Palouse Grasslands. Changes in fire regimes differ depending on whether active fire suppression results in the buildup of fuel, or if livestock grazing and other activities break up fuel continuity (Paysen et al. 2000).

Although bunchgrass species vary in their individual susceptibility to fire damage, repeated fires at intervals of 5 to 40 years historically maintained the bunchgrass community (Gruell et al. 1986). Encroachment into grasslands by woody species was an ongoing process kept in check by repeated fires.

Evergreen Shrubland (Chaparral). Chaparral shrub species in the Subtropical Steppe Ecoregion are fire-dependent, comprised of highly flammable species, and grow rapidly after fire, taking about 25 years to mature (Smith 2000). The production of dead fuels in chaparral stands is not well understood, but probably increases with age and after a drought. Fuels in chaparral communities are not as easily ignited as grass fuels, but will burn readily under hot, dry conditions.

Prescribed burns in chaparral communities would be expected to benefit these communities, provided fires were not too frequent or too hot, by reducing fuel accumulations and increasing structural diversity

(Paysen et al. 2000). Prescribed fire can be used to remove dead fuel for hazard reduction, increase structural diversity for wildlife habitat purposes, and increase the proportion of young biomass in a stand—for both fire hazard reduction and wildlife habitat improvement. In some areas, but not all, prescribed fire can be used to maintain stands of chaparral in their current state (that is, to maintain a fire climax).

Evergreen Woodland (Pinyon-juniper). The general effects of fire on pinyon-juniper woodlands in this ecoregion are largely the same as those on pinyon-juniper woodlands in the Temperate Desert Ecoregion. Surrounding communities that have been invaded by pinyon and juniper trees tend to benefit from fire, while communities with a large component of non-native species, or dense pinyon-juniper stands that have little understory vegetation, tend to be adversely affected.

Mediterranean Ecoregion

The Mediterranean Ecoregion occupies most of California (excluding deserts in the southeastern portion of the state) and a portion of southern Oregon. This region supports a distinctive assemblage of hard-leaved evergreen trees and shrubs, commonly known as chaparral, which are adapted to withstand severe summer droughts and frequent fires. Coniferous forests and oak woodlands are also characteristic of the region. Approximately 6 million acres of public lands occur in this ecoregion.

Evergreen shrubland occurs on over 2 million acres. Along coastal areas a type of chaparral known as maritime chaparral is common. Inland evergreen shrublands are found in the low hills of mountainous regions, often forming a mosaic pattern with deciduous (oak) woodlands, grasslands, or evergreen forests. Important chaparral species include manzanita, wedgeleaf ceanothus, hollyleaf buckthorn, poison oak, chamise, Christmasberry, mountain mahogany, California scrub oak, blue oak, and interior live oak (Holechek et al. 1995). Chaparral shrubs are adapted to recurrent fire, and the ecosystem depends on periodic fires for its persistence. Herbaceous vegetation is generally lacking in chaparral communities, except after fire.

Nearly 1 million acres of deciduous woodlands and evergreen woodlands also occur in foothills throughout California, typically on sites that are more mesic than those occupied by chaparral. Deciduous oak woodlands include stands of Oregon white oak, California black oak, blue oak, valley oak, and various other oaks. On cooler, moister sites in the Coast Ranges, oak woodlands merge with mixed hardwood forests in which tanoak, California laurel, and Pacific madrone are common. Evergreen live oaks are common associates, and conifer species such as Coulter pine, digger pine, Douglas-fir, and grand fir may also be present. Understory vegetation varies by location and may include poison oak, snowberry, serviceberry, blackberry, wild oats, bromes, bluegrass, ryegrass, and needlegrass.

Evergreen woodland communities composed of live oaks occur in moist, frost-free areas such as the coastal hills from San Francisco into southern California, where adequate moisture and mild temperatures allow them to carry out photosynthesis through the winter. Evergreen oak woodlands are composed of species such as canyon live oak, interior live oak, coast live oak, and Engelmann oak. Oak woodlands may exist as open, park-like savannas, occupying a transition zone between grasslands and denser woodlands. Shrubs are generally absent because they cannot compete with trees for moisture on drier sites. Evergreen woodlands also include some endemic tree species such as Monterey cypress, Torrey pine, Monterey pine, and Bishop pine.

In the mountains of California and southern Oregon, evergreen forests are the dominant vegetation type, occupying nearly 2 million acres of public lands. These forests are a diverse assemblage of many conifer species, and are adapted to a long, warm growing season, relatively mild winters, and periods of summer drought. Tree species include ponderosa pine, Douglas-fir, white fir, sugar pine, incense cedar, Jeffrey pine, California red fir, and giant sequoia (Szaro 1995). At elevations between 6,500 and 9,500 feet, subalpine forests composed of mountain hemlock, California red fir, lodgepole pine, western white pine, and whitebark pine occur.

Evergreen forests also occur along coastal northwestern California as redwood-dominated communities. Other common tree species forests include Douglas-fir, western hemlock, and western red cedar. The understories are dominated by Pacific rhododendron, western azalea, salal, California huckleberry, western swordfern, and redwood sorrel. Pine-cypress forests also occur along the coast, while mixed forests of tanoak, coast live oak, madrone, and Douglas-fir occur further inland.

For the most part, annual and perennial graminoid communities are located in the valleys and plains of the Mediterranean Ecoregion. While it is generally believed that the Central Valley, the largest grassland expanse in California, was historically dominated by perennial grassland communities, other plant communities (e.g., oak woodlands, chaparral, annual grasslands, and desert scrub) may have also been present (Blumler 1992, Hamilton 1997). Large portions of the native vegetation have been replaced by annual grasses, however, as a result of introduced species, fires, and overgrazing by livestock of early Spanish settlers (Sims 1988). Annual grasses include introduced species such as wild oat, slender oat, soft chess, ripgut brome, red brome, and wild barley. Common forbs include redstem filaree, broadstem filaree, turkey mullein, true clovers, and burclover. Perennial grasses, which are found in moist, lightly grazed or relict areas, include Idaho fescue and purple needlegrass (Garrison et al. 1977). With the development of irrigation, the California grassland ecosystem has become intensively utilized for agriculture.

Fire Ecology

Evergreen Forest. Evergreen forests in this region historically had an understory fire regime or a mixed severity fire regime, and are presently at risk for high-intensity, stand-replacing crown fires due to large fuel accumulations. Suppression of the mixed patchy fires in high elevation forests may eventually result in a landscape mosaic consisting largely of contiguous stands with comparatively heavy loadings of dead trees (standing and fallen) and canopy fuels.

Evergreen Woodland (Oak Woodlands). In recent centuries, fire regimes in western oak forests were characterized by frequent, low intensity fires. This was probably due to use of these types by Native Americans, who likely carried out programs of frequent underburning. Frequent, low intensity fires, helped to maintain open stands with a grassy understory. In the last half of the 20th century, higher intensity fires at longer intervals were more common. Such fires can kill a stand of oaks outright (Smith 2000), although most oaks will resprout after fire if the underground portions of the plant are still alive (Plumb 1980). The introduction of annual grasses into oak woodlands has increased the seasonal period during which fires can occur, enabling them to burn and spread earlier in the season (USDA Forest Service 2002b). Because conditions in oak woodlands have changed significantly since historic fire regimes, there are many concerns surrounding the use of prescribed fire in these systems.

Evergreen Shrubland (Chaparral). Chaparral succeeds many forest types after a major disturbance, whether from fire or logging. It is often seral, especially at elevations where we currently consider chaparral as a montane understory type. Given a reasonable number of disturbance free years, the forest type will regain dominance. Chaparral often succeeds chaparral after fire, especially at elevations where chaparral is the dominant vegetation type. Species composition can shift drastically, probably depending on whether the fire occurred before or after seed set for a given species. Fire frequency and timing can cause chaparral to be overtaken by herbaceous vegetation types, such as annual grasses.

Marine Ecoregion

The Marine Ecoregion Division occupies the Cascade and Coast Ranges of western Washington and Oregon, and the Coast Mountains of southeastern Alaska, along the Pacific Coast. The mild, rainy climate produces conditions that are hospitable for dense forest communities, which are characteristic of this region. Approximately 4 million acres of public lands occur in this ecoregion.

In the Cascade and Coast Ranges, complex, multi-storied evergreen forests occupy over 1 million acres, with species composition varying by altitude and climate. At lower elevations, Douglas-fir, western red cedar, western hemlock, grand fir, silver fir, Sitka spruce, and Alaska cedar are the dominant tree species. Subalpine forests composed of mountain hemlock, subalpine fir, whitebark pine, and Alaska cedar extend to timberline, which varies from 7,700 to 10,000 feet. In the drier climates of the eastern Cascade Range, forests dominated by ponderosa pine are common. Evergreen forests are often associated with understory plants such as vine maple, huckleberry, elderberry, salal, Oregon grape, twinflower, and western swordfern (Franklin 1988).

The area between the Cascade and Coast ranges is also characterized by dense evergreen forests. Much of the land in this intermountain region once existed as Douglas-fir, western redcedar, and western hemlock forests, but has since been developed for agricultural and urban uses.

Evergreen forests are also the predominant vegetation type found in the Coast Mountains of southeastern Alaska. Forests in this region are restricted to low elevation, coastal rainforests dominated by Sitka spruce and western hemlock. Associated species include Alaska cedar and mountain hemlock.

Along the major river channels, deciduous riparian forests composed of broadleaf trees such as black cottonwood, red alder, willow, and birch are common. In poorly drained areas, wetlands characterized by sphagnum moss, sedges, and willows occur.

Vegetation types with minor coverage in the Marine Ecoregion include Oregon white oak woodlands, which occur as scattered stands at low elevations, and prairies (perennial graminoid communities), which now occur only as remnant patches in the Willamette Valley and Puget Sound lowlands. Both of these community types are being lost as a result of succession by evergreen forests and development.

Fire Ecology

Evergreen Woodland (Oak Woodlands). Open woodlands dominated by Oregon white oak once occupied the driest climatic areas throughout the Puget Sound-Willamette Valley lowlands and southward in dry valleys behind the coastal mountains to the California border. Oregon white oak dominated in open woodlands and savannas associated with valley grasslands, and isolated small prairies that were surrounded by the extensive coast Douglas-fir forest. Oak woodlands also were associated with droughty sites such as bedrock with shallow soils on the southeast coast of Vancouver Island and in the San Juan archipelago, in the rain shadow of the Olympic Mountains.

Journal accounts and archeological sources show that extensive oak woodlands of the Willamette and other major valleys persisted as a "fire climax" maintained by frequent aboriginal burning (Habeck 1961; Boyd 1986, 1999; Agee 1993). Prior to the influx of Euroamerican settlers in the mid-1840s, the Kalapuyan Indians and other tribes typically set fire to large areas of Oregon oak woodlands to aid hunting and food plant harvest, and for other purposes (Boyd 1986). Burning was commonly done in September, and many areas were burned at short intervals, perhaps annually in some areas. Similar patterns of frequent burning to maintain valley grasslands, isolated prairies, and open oak woodlands are described from northwestern Washington southward to central California (Lewis 1973; Boyd 1986, 1999), but these practices are well documented only in the Willamette Valley of northwestern Oregon. Most of these fires must have been characterized by short duration flaming as they quickly consumed grass and litter that had accumulated since the previous burn. The thick-barked oaks survived, but regeneration of all shrubs and trees would have been heavily thinned by frequent burning.

In former oak savannas, fire exclusion has led to an increased density of shrubs and oaks, transforming them into woodlands (Agee 1993). In former oak woodlands, shrubs, Douglas-fir, and other tree species are replacing oaks. Livestock grazing and fire exclusion have been major factors in the successional change that has occurred in Oregon oak woodlands since Euroamerican settlement. Logging, clearing, and firewood harvest also have changed many woodlands. Additionally, large areas of oak woodlands have been displaced by agriculture and urbanization.

Evergreen Forest. These humid maritime forests are extensive at lower and middle elevations west of the Cascades and British Columbia Coast Range. The cooler, wetter, and more northerly portions of the coastal Douglas-fir type (generally associated with the mountains of western Washington and southwestern British Columbia) burned in stand-replacement fires at long intervals, averaging 200 to several hundred years (Agee 1993). The range of pre-1900 fire intervals on a given site is unknown because in most cases only the most recent interval can be calculated due to decay of the previous stand. Long et al. (1998) described fire intervals over the last 9,000 years, and Impara (1997) reports on the spatial patterns of historical fires in the Oregon Coast Range.

Western hemlock is the potential climax dominant tree in most of this type, but seral Douglas-fir, which arose after replacement fires during the last several hundred years, is the actual dominant. The greater size and longevity of Douglas-fir allows it to persist in considerable quantities for 700 to 1,000 years between major stand-opening disturbances such as fire or severe blowdowns (Agee 1993). Scattered individual Douglas-fir survived fires and served as seed sources in the burn. Seeds of this species may also survive and mature in the crowns of some trees whose foliage was killed (but not consumed) by a late-summer fire. The seeds are also wind-dispersed from unburned stands. Douglas-fir seedlings grow readily on burned seedbeds and outcompete other conifers in the postburn environment.

Often red alder becomes abundant and temporarily outgrows Douglas-fir in a recent burn. However, the fir grows up beneath and displaces alder within a few decades, benefiting from soil nitrogen fixed by symbiotic organisms associated with alder roots. Numerous other seral conifers (e.g., western white pine, shore pine, grand fir, Sitka spruce) and hardwood species (e.g., bigleaf maple, American mountain ash, cascara buckthorn), as well as seral shrubs (salmonberry, huckleberries) and herbaceous plants, appear in the postburn environment (Fonda and Bliss 1969, Franklin and Dyrness 1973, Hemstrom and Franklin 1982, Huff 1984, Yamaguchi 1986).

Large areas of these forests have been clearcut in recent decades, sometimes followed by broadcast burning. This has given rise to large areas of early seral communities dominated by native flora, often with planted Douglas-fir, which might offset a shortage of early seral communities resulting from natural fires. However, natural burns and clearcuts differ ecologically, for example in seedbed preparation, in providing residual large woody debris, and in having an overstory of dead trees (Kauffman 1990).

Vegetation Condition and Fire Regimes

In support of national-level fire planning and ecological assessment, the Fire Regime Condition Class (FRCC) concept was devised. The BLM uses the FRCC concept to describe ecological departure. It is a measure that helps to describe common issues on public lands, such as altered disturbance regimes, invasive species, or highly altered plant communities. Generally, FRCC is one piece of information used to describe the health of public lands.

The first national FRCC assessment was completed in the late 1990s and published in *Development of Coarse-scale Spatial Data for Wildland Fire and Fuel Management* (Coarse Scale; Schmidt et al. 2002). This analysis was used in the Draft PER. This assessment excluded public lands in Alaska (86 million acres), as well as 25.5 million acres of agricultural, barren, and urban/developed lands in the lower 48 states. Three condition classes were established to represent qualitative measures describing the degree of departure from historical fire regimes. Departure from historical fire regimes may result from activities, such as fire exclusion, timber harvesting, livestock grazing, introduction and establishment of exotic plant species, introduced insects or disease, and/or other management activities, that alter key ecosystem components such as species composition, structural stage, stand age, canopy closure, and fuel loadings.

While the intent of the Coarse Scale analysis was regional and national characterization, USDI agencies found the analysis to be of limited utility, especially for public lands in the western U.S. The condition classes in the Coarse Scale analysis were assigned based on successional stages for potential natural vegetation groups. Public lands were poorly represented in this effort for two reasons. First, some vegetation types, such as annual grasses or woodlands, could not be discerned in the vegetation classification used (Kuchler's Potential Natural Vegetation Groups; Kuchler 1964). Second, condition class assignments relied heavily on forest canopy cover thresholds, which have limited applicability to the majority of public lands.

Because of these shortfalls, a second national FRCC analysis was conducted as part of the Rapid Assessment Phase of the Landscape Fire and Resource Management Planning Tools Project (LANDFIRE). The Rapid Assessment Phase is intended as an interim product while further refinement of LANDFIRE continues. LANDFIRE is a 5-year, multi-partner project producing consistent and comprehensive maps and data describing vegetation, wildland fuel, and fire regimes across the United States. It is a shared project between the wildland fire management programs of the USDA and USDI.

Intended to better represent USDI-administered lands, the Rapid Assessment Phase mapped FRCC based on potential natural vegetation groups (historic vegetation), S-class (current seral stages), and historic fire regimes of the coterminous United States. Despite some localized inaccuracies, the Rapid Assessment Phase layer is the most accurate FRCC summary map for lands managed by the BLM, to date. Like the first national FRCC assessment, the second national FRCC assessment also excluded lands in Alaska as well as agricultural, barren, and urban/undeveloped lands in the lower 48 states.

The Rapid Assessment Phase is primarily intended for use at the national, regional, or state level, but not the local level. As a result, the Rapid Assessment Phase, like the Coarse Scale Analysis, is not intended to portray district or field office site conditions. FRCC can be assessed at the local level using a variety of tools (besides the national map), such as the FRCC software or GIS mapping tools. For this Final PER, departures from historical fire regimes are based on the Rapid Assessment Phase analysis, and have been grouped into three classes, as shown on Map 3-10. **Condition Class 1** lands (27.2 million acres of public lands; acres are approximate as federal agencies are updating and refining acreage estimates) are characterized by fire regimes that are within their historical range of vegetation variability characteristics, fuel composition, and fire frequency, severity, and pattern. Fire behavior, effects, and other associated disturbances are comparable to those that took place prior to management practices that do not mimic the normal fire regime. The structure and composition of vegetation and fuels are similar to the historical regime, and the risk of losing key ecosystem components to fire is low. These areas can generally be maintained within the historical fire regime with treatments such as prescribed fire. Wildland fire use for resource benefit may also be used to maintain these areas.

Condition Class 2 lands (79.5 million acres) have fire regimes that have been moderately altered from their historical conditions. They experience either an increased or decreased fire frequency of one or more return intervals, resulting in changes to fire size, intensity, and severity, and/or landscape patterns. Vegetation composition and structure and fuels have been moderately altered from their historical range, and have a moderate risk of losing key ecosystem components due to fire or other causes. These lands may need moderate levels of restoration treatments, such as prescribed fire and hand or mechanical treatments, to be restored to the historical fire regime.

Condition Class 3 lands (54.7 million acres) have fire regimes that have a high departure from the historical condition, and the associated risk of losing key ecosystem components to fire or other causes is high. Vegetation composition, structure, and diversity, as well as fuels, have been significantly altered from their historical range. Due to these alterations, Condition Class 3 areas are especially susceptible to severe and intense wildland fires. These areas often require high levels of restoration treatments, such as hand or mechanical treatments, before prescribed fire can be used to restore the historical fire regime (Schmidt et al. 2002). Almost 41% (21.2 million acres) of the Class 3 lands occur in the Temperate Desert Ecoregion. 15.5 million acres occur in the Subtropical Desert Ecoregion, 8.2 million acres occur in the Temperate Steppe Ecoregion, and 5.4 million acres occur in the Subtropical Steppe Ecoregion. An additional 1.5 million acres of Class 3 lands occur in evergreen forests of the Mediterranean Ecoregion.

A comparison by acreage shows that the acreage of FRCC Condition Class 3 lands increased substantially between the Coarse Scale and Rapid Assessment Phase analysis. The Rapid Assessment Phase analysis further supports the need for treatment of large numbers of acres in the West to improve condition class.

Further information and methods can be found at the FRCC website and in the Interagency FRCC Guidebook (www.frcc.gov).

Noxious Weeds and other Invasive Vegetation

Invasive plants are undesirable plants that infest land or deplete water resources, and may cause physical and economic damage or have other adverse effects on humans. Invasive plants are increasingly recognized as a major threat to ecosystems. Many invasive taxa have transformed both the structure and function of ecosystems by changing nutrient cycling or disturbance regimes (D'Antonio et al. 1999; Rejmanek et al. 2005). The spread of invasive plants threatens the structure and function of many ecosystems worldwide (Higgens et al. 1996; Drake et al. 1989). Certain invasive plant species have the ability to spread over large areas or acutely threaten an ecosystem over its continental range (Hobbs and Humphries 1995). There are estimated to be over 2,000 species of non-native plants in the U.S. (U.S. Congress Office of Technology and Assessment 1993), over 1,000 of which are invasive (Rejmanek et al. 2005). Approximately 10% of invasive species have profound effects on biodiversity, and clearly demand a major allocation of resources for containment, control, and/or eradication.

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. Noxious weeds are generally non-native invasive plants that have been either accidentally or intentionally introduced.

The Extent of the Problem

It is estimated that invasive plants already infest well over 100 million acres in the U.S., and they continue to spread at an estimated rate of 3 million acres annually (USDI BLM 1998a). 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; and costing millions of dollars in treatments and loss of productivity to land owners.

Besides ecological changes, invasive plants can cause impacts to public safety. While the spread of downy brome has increased the frequency and severity of fires, to the detriment of native plants and animals, as well as property and human safety, other species have caused unforeseen disasters as well. In 1936, for example, the town of Bandon, Oregon, was destroyed and 11 citizens killed by a fire propagated by gorse, a highly flammable plant introduced 70 years earlier (Simberloff 1996). This species is still being battled along the Oregon and California coasts.

Traits of Invasive Plants

Invasive plants and noxious weeds have biological traits that enable them to colonize new areas and successfully compete with native species. While not all invasive species share many of these traits, most species have one or more that allow them to compete successfully. These traits may include deep tap root systems and very little surface foliage (allowing the plants to grow later in the summer than most native rangeland plants); earlier growth and reproduction than most natives; long-lived seeds in a viable seedbank; adaptations for spreading long and short distances; production of many seeds from one plant; long lifespan; ability to delay flowering; ability to reproduce vegetatively; tolerance for a wide range of physical conditions; rapid growth; self pollination; ability to compete intensively for nutrients; and production of toxic compounds that negatively affect neighboring plants (adapted from USDA Forest Service 2005).

Some plant communities and ecosystems are more susceptible to plant invasion than others. Very few invaders are successful in successionally advanced plant communities. Open and disturbed communities are more invaded, while undisturbed forests are less invaded (Rejmanek et al. 2005).

Mechanisms of Invasion

Invasive plants have been introduced into the U.S. through a variety of pathways. Some non-native species were intentionally introduced for beneficial reasons and later became invasive. Purple loosestrife, which was originally introduced in ballast water dumped from ships coming from Europe, is still sold as an ornamental plant in garden centers in many states. Dalmatian toadflax is another introduced ornamental that can still be found in garden seed mixes. Saltcedar was introduced for erosion control, as was European beachgrass along the West Coast. Many other invasive plants have been introduced unintentionally via air, water, rail, or road transportation pathways. Common methods of introduction include contaminated seed, feed grain, hay, straw, and mulch; movement of contaminated equipment across uncontaminated lands; animal fur and fleece; spreading of gravel, roadfill, and topsoil contaminated with noxious weed seed; and plants and seeds sold through nurseries as ornamentals (USDI BLM 1996).

Once introduced, invasive plants are spread primarily by vehicles, humans, wild horses, livestock, wind, water, and wildlife. Initially, invasive weeds may become established in disturbed sites such as trailheads, along roads and trails, firebreaks, landing pads, oil and gas development sites, wildlife and/or livestock concentration areas, and campgrounds, but may also invade relatively undisturbed sites.

The plant invasion process occurs in three phases: introduction, establishment, and spread. Once an introduction occurs, a delay or lag phase often takes place while an invasive plant becomes established. The length of this initial phase varies, but it can last for up to 100 years (Hobbs and Humphries 1995). This phase is followed by a period of rapid growth that continues until the invasive species reaches the bounds of its new range (Figure 3-1; Mack et al. 2000).

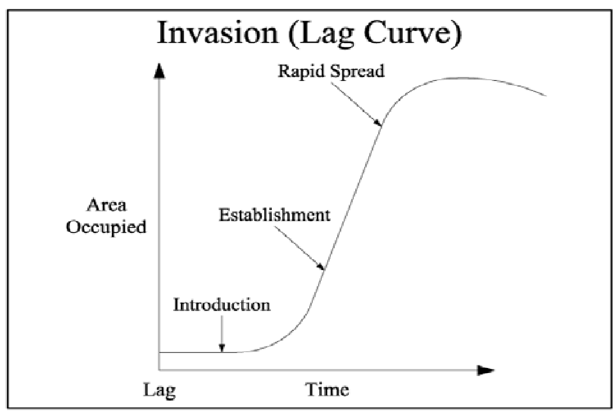

Figure 3-1. Relationship between Area Occupied by Invasive Species and Time.

Understanding this process is critical for making timely and appropriate decisions for managing invasive plants. Preventing the spread of species during the lag phase should be a priority for managers. The establishment phase, while enough residual desired vegetation remains, should be another crucial time for controlling infestations (USDA Forest Service 2005).

Sleeper weeds, a relatively new concept, are invasive plant species with populations that are known to have increased significantly more than 50 years after becoming naturalized (Groves 2006). Common reed, for example, has been identified as a sleeper weed in Quebec, Canada. While the species has been present in Quebec since 1916, it did not spread on a large scale until the 1960's, most likely after the development of the highway network (Lelong et al 2007). Controlling newly introduced populations of non-native species should help to alleviate the development of sleeper weeds.

Maintaining cover of native plant species on public lands may be critical to halting the spread of noxious weeds. In a 45-year study of a sagebrush steppe landscape in Idaho, areas with the highest cover of native species exhibited the greatest resistance to invasion by downy brome (Anderson and Inouye 2001).

BLM Infestations

In 2006, the BLM estimated that nearly 45 million acres of public lands were infested with weeds (Table 3-5). The estimated rate of weed spread on western public lands in 1996 was 2,300 acres per day (USDI BLM 1996). A recent estimate of weed spread on all western federal lands is 10% to 15% annually (Asher and Dewey 2005). The states with the largest weed infestations on public lands are Utah, Nevada, Arizona, and Oregon (Table 3-5). The most dominant invasive plants consist of grasses in the *Bromus* genus, which represent nearly 70% of the total infested area. A single species, downy brome, occupies an estimated 10 million acres alone. Another grass, red brome, has invaded portions of the Southwest. Other important weed species that occupy over 100,000 acres include halogeton, common Mediterranean grass, medusahead, houndstongue, leafy spurge, Canada thistle, saltcedar, spotted knapweed, rush skeletonweed, Russian knapweed, diffuse knapweed, yellow star-thistle, and hoary cress.

The BLM treated approximately 50,000 to 320,000 acres of noxious weeds during 1997 through 2006. Treatments included a combination of chemical, mechanical, manual, biological, and cultural controls, and herbicides have been used to create firebreaks in shrublands as well as improve forage for livestock and wildlife. Each year, over half of the treatment acres were in Montana, and over 35,000 treatment acres were in Idaho. In 2005, the BLM inventoried nearly 6.4 million acres for weeds, and evaluated weed treatments on over 278,000 acres of treatment lands (USDI BLM 2006c).

Non-timber forest products include all plant materials other than timber that are extracted from forests for human use (National Network of Forest Practitioners 2005). They consist of medicinal plants (e.g., ginseng, goldenseal), wild foods (e.g., mushrooms, berries, roots, syrups), decoratives and floral greens (e.g., salal, ferns, boughs), flavors and fragrances (e.g., sassafras, balsam fir), fibers (e.g., cedar bark, sweet grass, lichens), wild native seeds and transplants for restoration and nursery stock, plant dyes, arts and crafts materials, and resins and saps. These forest products are harvested for a variety of reasons, including subsistence, cultural, spiritual, commercial, recreational, and educational purposes.

Native American tribes and Alaska Natives traditionally used forest products for tools, food, construction materials, medicine, and religious ceremonies. Forest products used included bark for housing, branches and stems for utensils and tools, and wood for containers (Chamberlain et al. 1998). Much of the knowledge gained from Native American tribes and Alaska Native groups has influenced the development of the U.S. herbal medicinal industry. A discussion of Native American and Alaska Native plant uses is provided in the Cultural Resources section of this chapter, and in Appendix D of the PER.

During FY 2005, approximately $194,000 worth of non-timber forest products was sold by the BLM. The actual value of non-timber forest products harvested on public lands is substantially greater (USDI BLM 2006c). Over 40% of non-timber forest product sales on public lands were in western Oregon, and about 13% were in Nevada. Other important states for non-timber forest product sales are Colorado and Utah.

Special Status Species

There are over 150 plant species occurring on or near public lands in the treatment area that are federally-listed as threatened or endangered, or proposed for listing. The number may change over time depending on future evaluations of each species' status. BLM policy states that BLM actions must not adversely impact special status species, which include species that are listed under the ESA, given some form of special designation to denote rarity by the state, or are listed as sensitive by the BLM. Special status species, other than those already listed under the ESA, are in potential danger of becoming listed under the ESA. Special status plant species are distributed throughout the western

TABLE 3-5
Estimated Acres of Weed Infestations on Public Lands in 2000

State	Bromus species[1]	Halogeton	Mediter-ranean grass[2]	Medusa head	Centaurea spp.[3]	Hounds-tongue	Other	Total
Alaska[4]	--	--	--	--	--	--	992	992
Arizona	5,007,000	5,000	3,190,600	0	150	0	86,000	8,288,637
California	517,000	4,000	243,000	261,000	35,000	0	69,000	1,129,000
Colorado	1,952,000	372,000	0	0	23,000	408,000	329,000	3,084,000
Idaho	2,814,000	--[4]	0	15,000	214,000	500	376,000	3,419,500
Montana	933,018	300	0	0	157,726	9,580	180,929	1,281,553
Nebraska[4]	--	--	--	--	--	--	--	--
North Dakota	0	0	0	0	0	0	2,196	2,196
New Mexico	30	21	0	0	7,000	0	41,000	48,051
Nevada	6,564,244[5]	1,050,000	1,500,000	5,000	18,100	50	120,000	9,257,394
Oklahoma[4]	--	--	--	--	--	--	--	--
Oregon and Washington	5,139,000	151,000	0	676,000	48,000	113	393,000	6,407,113
South Dakota	208	0	0	0	3	66	2,111	2,388
Texas[4]	--	--	--	--	--	--	--	--
Utah	6,948,000	3,063,000	94,000	25	51,000	604	130,000	10,286,629
Wyoming	1,395,000	1,500	0	0	47,000	27,000	188,000	1,658,500
Total	31,269,500	4,646,821	5,027,600	957,025	600,979	445,913	1,918,228	44,865,953

[1] Includes downy, rigput, Japanese, and red bromes.
[2] This refers to *Schismus barbatus*.
[3] Includes spotted, Russian, diffuse, squarrose, and Tyrol knapweeds and yellow and malta starthistles.
[4] No data were reported for this state.
[5] Acres calculated through GIS based on 10% cover estimate derived from remote sensing data sources. Acreage includes undifferentiated *Bromus* and other invasive annual grass species.
Source: Peterson (2006).

U.S., including Alaska. A list of these species can be found in Appendix J.

For this PER, the BLM has consulted with the USFWS and NMFS since 2001 on listed species and species proposed for listing, and their critical habitats, that could be affected by the proposed treatments. As part of the consultation process, the BLM prepared a *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Biological Assessment*, which provides a description of the distribution, life history, and current threats for each species (USDI BLM 2007a). Information contained in the BA will be used as a guideline by BLM field offices when developing local projects.

Fish and Other Aquatic Organisms

The BLM administers lands directly affecting almost 155,000 miles of fish-bearing streams and 4 million acres of reservoirs and natural lakes (USDI BLM 2006d). These habitats range from isolated desert springs of the Southwest to large interior rivers and their numerous tributaries.

For this section, the eight geographic regions that were used to describe water resources in the treatment area are used to describe associated aquatic organisms and their habitats (Map 3-5). Key fish species have been identified for each region. These species are ecologically representative of the region(s), use major habitat types within the region, and strongly influence the aquatic community structure. As a result of species distributions and ecological similarities between regions, some key species may occur in more than one geographic region.

Alaska and the Pacific Northwest

The most significant group of native fishes found in Alaska and the Pacific Northwest, in terms of their ecological, cultural, and commercial importance, is the salmonid family. All members of this group, which include salmon, trout, char, and whitefish, require relatively pristine, cold freshwater habitats during part or all of their life cycles, and as such, depend greatly on the conditions of the surrounding forests and rangelands to ensure their survival (Meehan 1991).

Most salmonids use large stream and river systems with direct ocean access. In Alaska, significant streams within public lands include the Colville River and Yukon River systems. The most significant system in Pacific Northwest is the Columbia River Basin. With its headwaters in British Columbia, the Columbia River extends over 1,200 miles to the Pacific Ocean.

Salmonid productivity within a freshwater system is dependent on the underlying stream productivity and the period of use by salmonids during their life cycle. Five general factors determine the suitability of aquatic habitat for salmonids: flow regime, water quality, habitat structure, food (energy) source, and biotic interactions. All salmonids require suitable habitat for spawning, incubation, and rearing. Generally, adults require spawning gravel (less than 2 inches in diameter) and overhead streambank or vegetative cover from predation, while eggs and newly hatched salmon (alevins) require stable gravel and cool (less than 57 °F) and highly oxygenated water (Meehan 1991). Bull trout, which tend to spend most, if not all of their life in inland waters, require water less than 42 °F for spawning and rearing of newly hatched young. Because salmonids prefer cold water, temperatures above 77 °F are lethal to most species in this family (Meehan and Bjornn 1991).

Migrant salmonids pass through several distinct habitats while traveling to and from feeding or breeding habitats, utilizing the full extent of the watershed. The importance of each habitat type differs by species. Chinook salmon, for example, spawn in the mainstem of a river. Upon emerging from the gravel, individuals either start their migration to the sea within their first year (ocean-type) or mature within rivers for 2 to 3 years before migrating to sea (stream-type). In contrast, resident trout populations, such as rainbow, bull, and cutthroat trout, may spend their life (5 to 6 years) in various freshwater systems, including small streams or lakes, and do not migrate to the sea (Meehan and Bjornn 1991).

Various fish species have been introduced into aquatic systems throughout Alaska and the Pacific Northwest. Most of the non-native species have been introduced to promote sportfishing opportunities. Some have escaped from fish farms. 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 many, if not most, of the non-native sport fishing opportunities within these regions (Mills 1994).

A variety of aquatic invertebrates occur in Northwest and Alaskan streams. These species can be quite susceptible to instream 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).

The Arid Environment

In arid regions, hydrologic inputs that drive aquatic systems come in pulses of short duration. Although rain may trigger biological processes, such as reproduction, after long dry periods, a severe rainfall that creates flash flooding can exert considerable pressure on fish species and community structure (Naiman 1981). The natural hydrology of southwestern desert rivers and streams is highly variable and episodic (Rinne and Stefferud 1997). Natural flow regimes have been considered optimum for sustaining native fish populations (Poff et al. 1997). Although many streams of the U.S. deserts have been highly modified, reducing the impacts of flash floods on fish communities, these sudden rain inputs may still be detrimental. Carrying heavy silt, flash floods may remove or destroy habitat features such as shoreline vegetation, leaving fish species susceptible to rising water temperatures (Naiman 1981).

Because there is limited hydrological connection among water bodies within the desert, fish distribution is also limited. Some streams continually flow through the humid desert regions, terminating in closed lakes or dissipating in the sand, while other streams originate from subterranean sources, emerging as springs. 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). Although each spring or pool is species-poor, most aquatic inhabitants of each pool are short-lived (1-2 years) and native to only a single locality (Naiman 1981, Page and Burr 1991).

Aquatic species have been introduced into this ecosystem, either on purpose or accidentally, changing the ecological balance to favor many of the non-native species. Invasive fish reduce numbers of native species through competition, hybridization, predation, and the spread of pathogens to which they have developed resistance in their home waters, but to which native species have not (Rinne 1995, 2003). Overall, non-native fish species now outnumber natives in number of species, population density, and often biomass at many localities (Platania and Bestgen 1988; Griffith and Tiersch 1989; Douglas et al. 1994).

Large reservoirs and diversions have been constructed on various rivers and streams, at least partially to deliver irrigation water for agricultural purposes. Additionally, domestic livestock grazing has impacted some rangelands, and historical grazing pressures in riparian areas have reduced the function of some aquatic habitats.

Lower Colorado River and the Rio Grande

These regions cover portions of Nevada, Arizona, New Mexico, and Texas. Grasses and shrubs cover large expanses of the southwest region. This vegetation helps to reduce runoff and erosion during the rainy season. During the dry seasons, dormant vegetation and vegetative litter serve a similar function and are critical for the overall health of these rangeland systems. Livestock grazing in the region has reduced the quality of plant communities, resulting in increased runoff into streams during heavy rainfall, and localized lowering of water tables (Naiman 1981, Rinne and Minckley 1991). These impacts, combined with upper basin modifications, including dams, have impacted fish habitat throughout the lower Colorado and Rio Grande rivers.

The Colorado River, which was once a warm, silted, swift river, is now a cold, clear series of artificial impoundments. These impoundments are a significant threat to desert waterways, and in some instances can end a stream's existence, as has occurred in the lower reaches of the Salt and Gila rivers in Arizona (Cole 1981). The Glen Canyon Dam on the Colorado River, upstream of Lee's Ferry, eliminated the seasonal variation in the river's discharge, ionic composition, temperature, and sediment load in the gorge of the Grand Canyon. The impoundment has altered both the flow of the river and the river's potential for fish habitat downstream. As a consequence, most native fish populations in the Colorado River Basin have declined substantially throughout much of the species' ranges.

The Family Cyprinidae is the most dominant native fish group within the lower basin region, followed by the Family Catostomidae. The Cyprinidae family is composed mainly of minnow species, including the threatened Colorado pikeminnow and bonytail chub, while the Catostomidae family includes the threatened razorback sucker (Starnes 1995). Impoundments have had the greatest impacts on these fish communities (Minckley and Deacon 1991).

Bonytail chubs were historically common, migrating throughout the mainstem 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 bonytails continue to be found in low numbers in several man-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 1973, Minckley and Deacon 1991).

The headwaters of the Rio Grande River 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. Public lands within the Rio Grande region are limited to the upper and middle reaches of this drainage. Most precipitation in the basin falls as snow near its headwaters or as rain near its mouth, while little water is contributed to the system along the middle reaches of this river, particularly within the Chihuahuan Desert.

Historically, riparian woodlands in the Rio Grande River 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 this floodplain area, significantly reducing the quantity and quality of wetland and riparian habitat (Cassell 1998; Levings et al. 1998). These changes, combined with instream modifications, have reduced fish habitat considerably throughout the region.

Prior to the construction of dams like the Cochiti Dam, the Rio Grande River 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 the range of the Rio Grande silvery minnow, a species that once extended from Española, New Mexico, in the Rio Grande River Valley to the Gulf of Mexico; and in the Pescos River from Santa Rosa, New Mexico, to the confluence with the Rio Grande River in south Texas (Federal Register 1994). Currently, it is found only in a 170-mile reach of the middle Rio Grande River in New Mexico. Much of its decline may be attributed to modification of stream habitat by impoundments, water diversion for agriculture, and stream channelization.

Many non-native fish species have adapted well to the instream modifications to the Lower Colorado and Rio Grande rivers (Maddux et al. 1993; Douglas et al. 1994). Usually more aggressive than native fish and able to outcompete them for resources, these non-native species include walleye, bass (large and smallmouth), and rainbow, brook, and brown trout (Douglas et al. 1994).

Great Basin

The Great Basin covers an arid expanse of approximately 190,000 mi^2 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 1976).

Many Great Basin fish are adapted to extreme conditions. Trout are predominantly found in lakes and streams at higher elevations within the basin (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 both high temperatures (>80 °F) and large daily fluctuations in temperature (up to 68 °F). They are also quite tolerant of high alkalinity (>3,000 mg/L) and dissolved solids (>10,000 mg/L; Behnke 1992).

Water diversions, subsistence harvest, and stocking with non-native 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 the species (Coffin and Cowan 1995, Dunham 1998).

Minnows and pupfish are the dominant fish species at lower elevations and are found in thermal artesian springs and streams (Cole 1981, Feldmeth 1981). Various native and non-native 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 (Feldmeth 1981).

Pupfish are able to survive extreme environmental conditions, tolerating water temperatures as high as 115 °F, salinity as high as 142 parts per thousand (ppt; ocean water is typically 33 ppt), and oxygen concentrations as low as 0.13 mg/L (Page and Burr 1991). Because of the high water temperatures, pupfish have developed behavioral traits to regulate body temperature. They have been observed migrating to shallow pools in the morning and remaining there throughout the day, returning to deep water at night. While some pupfish populations are isolated in extremely variable environments (i.e., rapidly fluctuating water levels and temperature gradients), others are isolated in stable springs with constant temperatures (Biological Resource Research Center 2001, NatureServe Explorer 2001).

The most significant problem facing desert 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 (Deacon and Williams 1991). Pumping groundwater for agriculture has threatened several pupfish populations, including the Devil's Hole pupfish (Deacon and Williams 1991).

Aquatic invertebrates are probably diverse within the Great Basin region, though relatively little is known about them (Hershler and Pratt 1990). Streams flowing within mountainous forest region support diverse aquatic invertebrate fauna including mayflies, stoneflies, and caddisflies. Small springs contain diverse molluscan fauna (Hershler and Sada 1987). Spring biotic communities are usually less diverse than stream communities, and springs are often habitat for endemic species because they are predictable, benign habitats that have served as refugia during dry periods.

The Upper Colorado River Basin

The Colorado River is the primary river of the southwestern U.S., draining approximately 242,000 mi^2 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 basins, with a dividing line near Lee's Ferry, Arizona. 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 (Carlson and Carlson 1982, Wullschleger 2000). The humpback chub, for example, prefers deep, fast-moving, turbid waters often associated with canyon-bound segments of the rivers (Valdez and Clemmer 1982). 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 are disappearing with the introduction of rainbow, brook, and cutthroat trout for sport fishing (Miller et al. 1982). The habitat immediately downstream of constructed reservoirs favors these non-native salmonids (Platania 2003). In addition, non-native species effectively outcompete native species for available resources, and interbreed with native species (Joseph et al. 1977; Rinne and Minckley 1991). Populations of native species within lakes are also declining as a result of competition with and predation by, introduced non-native species, such as carp, northern pike, and red shiner (Rinne and Minckley 1991).

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.

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 those comprised of 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 Basin encompasses 529,350 mi^2 and flows for over 2,340 miles, from its headwaters at the confluence of the Gallatin, Madison, and Jefferson rivers in the Rocky Mountains at Three Forks, Montana, to its confluence with the Mississippi River at St. Louis, Missouri.

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 species within the upper reaches of the Missouri River are considered benthic fishes, such as sturgeon and minnows (Duffy et al. 1996; Scarnecchia et al. 2002).

Public lands in Montana occur predominantly in the northeastern portion of the state. The surrounding habitat, referred to as the Milk River Basin, has relatively high densities of depressional wetlands dominated by shortgrass prairies. The upper reaches of the Missouri River and its major tributaries maintain the healthiest fish populations in the basin (White and Bramblett 1993). However, dams built along the mainstem of the Missouri River, such as the Fort Peck Dam in Montana, have limited fish migration patterns and water flow, as well as the movement of silt downstream, resulting in declining fish numbers and reduced quality spawning and rearing habitat (Hesse et al. 1989). This combination of habitat loss and poor dam management has contributed to the decline of many native mainstem species including paddlefish, sturgeon, and several species of chub.

Native species such as the sicklefin chub, sturgeon chub, and pallid sturgeon prefer silty rivers with a diversity of depths and velocities forming braided channels, sand bars, sand flats, and gravel bars, all of which were historically common along the Missouri River (Gilbraith et al. 1998; Scarnecchia et al. 2002). All three species have been affected by changes in the Missouri River. Although the chub species have managed to effectively reproduce where habitat conditions allow, the pallid sturgeon has been unable to adapt well to the present river conditions, resulting in a significant decline in its abundance (Duffy et al. 1996). The endangered pallid sturgeon, a bottom feeder, may become extinct, as changes in water flows continue to affect food sources, spawning habitat, and the timing of reproduction (USFWS 1990).

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 (Walleyes Unlimited 2002). Other introduced species that have adapted well to the modifications of the Missouri River drainage in Montana include smallmouth bass, walleye, and white crappie.

The Missouri River drainage includes all of Wyoming east of the Continental Divide, and represents 74% of the state's surface area. Typically, streams along the southern boundary of Wyoming originate from the mountainous region of northern Colorado and are characterized by high gradients, cobble and boulder substrates, and riparian areas dominated by conifers and willows. This area of Wyoming drains into the North Platte River drainage, comprising 24% of the surface area of Wyoming. Native and introduced salmonids such as rainbow, brook, and cutthroat trout dominate fish communities within this region.

As streams flow onto the arid, desert plains, they are characterized by low gradients, meandering or braided channels, and silt, sand, and gravel substrates, with riparian areas dominated by cottonwoods, willows, shrubs, and grasses. Central and northern Wyoming are considered high cold desert. Native and non-native minnows and suckers dominate fish communities.

Special Status Species

There are over 100 aquatic animal species occurring on or near public lands that are federally listed as threatened or endangered, or are proposed for future listing. Included in the total number are 59 species/subspecies of fish, 13 species of mollusk, and 6 aquatic arthropods. A complete list of these special status species may be found in Appendix J. Please note that this list is dynamic, and will likely change throughout the time period considered by this PER.

Special status aquatic animal species are found on public lands throughout the United States. A number of listed salmon populations are found in rivers of 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 the 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 mollusks 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 concern occur predominantly in the vernal pools of California.

Wildlife Resources

Public lands sustain an abundance and diversity of wildlife and wildlife habitat. Public lands provide a permanent or seasonal home for more than 3,000 species of amphibians, reptiles, birds, and mammals.

Wildlife populations are found in areas where their basic needs—food, shelter, water, reproduction, and movement—are met. The area in which the needs of a particular population are met is its habitat. Many animals have special behaviors and physical traits that allow them to successfully compete with other animals in only one or a few habitats; many threatened and endangered species fall into this category. Other animals, such as mule deer, coyote, and American robin are less specialized and can use a wider range of habitats.

Several features make some habitats better for wildlife than others. In turn, the more of these features that are present, the greater the diversity of wildlife species that is likely to be present. These features include:

- Structure – shape, height, density, and diversity of the vegetation and other general features of the terrain.
- Vertical layers – layers of vegetation (e.g., herbaceous, shrub, and forest canopy).
- Horizontal zones – vegetation and other habitat features that vary across an area.
- Complexity – an integration of vertical layers and horizontal zones.
- Edge – the area where two types of vegetative communities meet, such as a forest and shrub community.
- Special features – unique habitat features needed for survival or reproduction, including snags (dead trees), water, and rock outcrops.

Of the 164 million acres of rangeland administered by the BLM within the western states, 52% have been inventoried for habitat quality. Of those acres, 42% are rated as excellent or good, 42% are rated as fair, and 16% are rated as poor based on the departure of vegetation composition from a reference condition (USDI BLM 2006d). The BLM also administers 55 million acres of forestlands and woodlands. Of these acres, 16% have been rated as healthy and providing good habitat for wildlife, while 25% are in need of restoration, including mechanical thinning, fuels reduction, and prescribed fire. The condition of the remaining acres is unknown (USDI BLM 2004a).

An important activity of the BLM is to manage vegetation to improve wildlife habitat. Plants, which are an important component of habitat, provide food and cover. Food is a source of nutrients and energy, while cover reduces the loss of energy by providing shelter from extremes in wind and temperature, and also affords protection from predators. The following section describes the important characteristics of wildlife and habitat in the eight ecoregions that comprise the treatment area, focusing primarily on the vegetative characteristics of habitat and how wildlife use this vegetation.

Tundra Ecoregion

Because of the short growing seasons and low summer temperatures, vegetation in tundra areas exhibits simple structure, few layers, limited complexity, low primary productivity, low decomposition rates, low stress tolerance, and high susceptibility to physical disturbance. Thus, on an annual basis, the tundra supports fewer wildlife species and numbers than other ecoregions, although it does support large populations of some wildlife, such as shorebirds and waterfowl, during summer.

Wildlife species in tundra habitats fall into three categories: 1) resident species that remain active year-round, 2) resident species hibernating in winter, and 3) migratory species present for only a portion of the year (Lent 1986). Resident species that remain active year-round include the willow ptarmigan, common raven, snowy owl, Arctic fox, brown lemming, muskox, and caribou. Hibernating species include the

Arctic ground squirrel, and hoary marmot. The great majority of the 97 or so bird species using the tundra are migratory (Pitelka 1979).

Except for the wood frog, there are no amphibians or reptiles in the Tundra Ecoregion. Because they are cold-blooded animals, the climate is too cold for these groups. Wood frogs are unique in that they partially freeze in winter; up to one-third of the water in a wood frog's body may turn to ice for a period of several weeks (Behler 1995).

The tundra has low species diversity; tundra insect fauna, for example, is only 1% to 5% as rich in species as the insect fauna found at temperate latitudes (Bolen 1998). Wildlife populations are also constrained by the low plant productivity, and can fluctuate greatly in response to annual changes in plant productivity. Animal population peaks can markedly alter vegetation and other habitat features in some instances, leading to sharp declines in population numbers. The brown lemming is the classic example of a cyclic species, with extreme fluctuations in numbers. Lemmings clip and consume large amounts of dormant vegetation under the snow during winter. During periods with large populations of lemming, lemmings remove much of the vegetation during winter, resulting in limited food during summer, and also limited protective cover against predators. As lemming populations decline due to starvation and predation, species that prey upon lemmings, such as the snowy owl and Arctic fox, also show marked population declines.

The widespread occurrence of shallow lakes and wetlands during the summer creates ideal conditions for insects, especially mosquitoes. Mosquitoes have adapted to the harsh winter by overwintering in an egg stage that is resistant to drying, hatching as larvae when warmer weather and moisture returns in the spring. Plant-eating insects are rare in the Tundra Ecoregion, likely due to the low growth rate of the vegetation. Nearly all insects prey on animals, biting the animal or burrowing into its skin or flesh.

Insect fauna provides an important prey base for migratory shorebirds and waterfowl. To cope with the short summer and limited food supplies, migratory birds tend to nest almost immediately upon arriving on the breeding grounds, and young hatch when insects and vegetation are most abundant. Waterfowl, other small birds, and small mammals are preyed upon by Arctic fox, snowy owl, gyrfalcons, peregrine falcons, and rough-legged hawks (World Wildlife Fund 2002).

Even resident populations of the tundra can be quite mobile in their search for suitable food and cover. Arctic foxes may travel hundreds of miles in search of new denning areas, while caribou may go years without using certain winter ranges. Ptarmigan congregate by the thousands in favorable winter valleys in winter, but disperse widely during the summer.

Suitable habitat for denning or burrowing species may be limited in areas with continuous or near-continuous permafrost. Burrowing species must select areas where the permafrost is not near the surface. The presence of deep snowdrifts is important for denning wolverines, polar bears, and brown bears. Talus slopes and cut banks are important habitat features used by denning Arctic foxes. Raptors tend to nest along river and coastal bluffs because of the generally flat, treeless character of the Arctic tundra.

Subarctic Ecoregion

The Subarctic Ecoregion, or boreal forest, is the largest ecoregion in North America. The vegetation is similar in structure and dominated by relatively few species of spruce, firs, larch, and other conifers, and some hardwoods such as birch and aspen. Boreal forests are structurally more complex than tundra, and thus support a greater diversity of wildlife species. These forests provide habitat for large mammals, such as grizzly bear, black bear, wolf, moose, and wolverine; small mammals, such as red fox, American beaver, American marten, and weasels; birds, such as spruce and ruffed grouse, owls, and raven; and the amphibian, wood frog.

Many species have unique adaptations to survive in subarctic forests. Herbivores typically graze on herbaceous and shrubby vegetation during the summer, but shift to a high fiber diet of conifer needles and woody shrub browse during winter.

White-winged crossbills are an example of a species that have adapted to the abundant cone seeds in boreal forests. These birds move in large flocks when cone supplies are abundant, but are nomadic when cone supplies are limited. White-winged crossbills also breed opportunistically, when cone supplies are most abundant.

Bog vegetation occurs widely throughout the Subarctic Ecoregion. Bogs are characterized by a spongy underfoot of peat that provides a rooting layer for most vegetation, and is often overlain by sphagnum moss. In Interior Alaska, bogs are often underlain by permafrost. Bogs tend to have limited structural complexity, as trees and shrubs are often sparse in bogs. Thus, fewer wildlife species are found in bogs than upland forests. The high water table of bogs also discourages burrowing species.

Fires, which are normal, recurring events in boreal forest ecosystems, help maintain ecosystem productivity and biodiversity (Rowe et al. 1974; Adams et al. 2000). Large area fires are common due to the uniformity of the vegetation and presence of a continuous layer of surface fuels, the moss and lichen layer. Fires can also destroy the rich growth of lichens found in the northern portions of the boreal forest. These lichens are an important food source for barren-ground caribou, comprising 60 to 80% of the winter diet of caribou (Boertje and Garner 1998, Bolen 1998). Fire may be necessary to maintain lichen ranges in the long term, because in old stands, competition from sphagnum moss, shade from trees, or the old age of lichens may limit lichen productivity (Andreev 1954, Viereck 1973, Zoltai 1974, Maikawa and Kershaw 1976).

After a fire of adequate severity, birch, aspen, and willow can revegetate the area, either sprouting from surviving roots or establishing from seed where adjacent seed sources exist. Willow, in particular, is the mainstay of the moose's winter diet, and moose populations thrive in such burned areas. However, because lichens are slow growing, it can take decades before the biomass of lichens for winter caribou grazing reaches its preburn levels (Joly et al. 2002). Schaefer and Pruitt (1991) observed that burned areas did not provide suitable winter habitat for caribou, but that fires could enhance the quality and abundance of summer forage.

Temperate Desert Ecoregion

Vegetation structure in the Temperate Desert Ecoregion tends to reflect the area's precipitation pattern and temperature regimes (Jones 1986). Sagebrush is co-dominant with perennial bunchgrasses in the wetter, northern part of the ecoregion, but sagebrush dominates in the southern, drier portion (Paige and Ritter 1999). Trees are mostly limited to the pinyon-juniper woodlands found at higher elevations, and along watercourses.

Northern, cooler desert regions, such as the Great Basin Desert, support far fewer wildlife species than southern, warmer deserts found in the Subtropical Desert Ecoregion (Bender 1982, Brown 1982). The shorter growing season of the northern deserts results in lower plant productivity and a lower diversity and abundance of animal prey. Thermal regimes in northern deserts also limit the activity of wildlife, especially cold-blooded animals such as amphibians and reptiles, to short periods each year.

The Great Basin Desert, which is the largest desert in North America, is dominated by two structurally and floristically simple plant communities—sagebrush and saltbush. Because most precipitation in the region falls during the winter when plants are dormant, there is insufficient moisture during the growing season for the development of plant structure and diversity needed to support an abundance of wildlife species. This desert supports large populations of pronghorn antelope, and also provides critical habitat for sage-grouse species that use sagebrush for food and cover.

Desert habitats have some of the most unusual wildlife in the treatment area. Desert animals are adapted to survive under extreme environmental conditions, including low, erratic rainfall, and highly variable temperatures. Many small desert mammals require no free water, but survive on their own metabolic water and through water conservation measures, such as being active only at night and excreting uric acid rather than urea. Spadefoot toads have a special appendage on their hind foot that allows them to burrow into the soil to avoid daytime heat, and breeding activities are timed to occur during periods with summer thunderstorms.

Special features, such as water and rock outcrops, are critical habitat components in desert environments. Permanent and temporary water sources are scarce in this ecoregion, but their importance cannot be overstated. Riparian areas are especially important in the desert. For example, of the 148 species of breeding birds in the Great Basin Desert, 131 are dependent upon riparian areas for all or part of their life requisites.

Talus slopes, cliffs, and rock outcrops provide nesting and feeding habitat, thermal and escape cover, and resting sites for wildlife. Common reptiles that use these features include the common garter snake, western rattlesnake, and sagebrush lizard. Rodents and other small mammals use rock features to hide from predators, and to avoid temperature extremes. Bats use caves and rock outcrops as roost and nursery sites. Deep, rugged cliffs are used by desert bighorn sheep for lambing, escape, and thermal cover. Raptors, including golden eagles and several species of hawks use cliffs and rock outcrops as nest and perch sites. The canyon walls of the Snake River provide nesting habitat for one of the highest densities of predatory birds in the world (USDA Forest Service and USDI BLM 1997).

Soil characteristics determine the number of subsurface sites available to wildlife in the desert. Lack of vegetative structure in deserts is often offset by subsurface space created by deep and diverse soils. Subsurface sites provide shelter from daytime heat, protection from predators, and sources of food for predator, such as snakes.

Wildlife habitat in this ecoregion has undergone great change during the past century, usually to the detriment of native species. For example, cool-season bunchgrasses once dominated large areas of the Columbia Plateau. Much of the grassland community has since been lost with the conversion of lands to agricultural and urban uses. Changes in fire regimes and grazing by domestic livestock have modified significant portions of the remaining grassland habitat. Species associated with native perennial bunchgrass communities, including the Columbian sharp-tailed grouse, kit fox, and Idaho ground squirrel, have declined in numbers more than other species' groups in the region. These species rely on grassland vegetation for plant and insect forage, nesting and brood-rearing habitat, and hiding cover.

Much of the sagebrush habitat in the Temperate Desert Ecoregion has been lost or modified during the past several decades, resulting in habitat fragmentation. This loss is a result of conversion to agricultural and urban uses, grazing, altered fire regimes, and the encroachment of downy brome, other weeds, and woody species such as juniper and Douglas-fir (USDA Forest Service and USDI BLM 1997). The best sagebrush habitat occurs where there is a mix of multi-age sagebrush with associated perennial bunchgrasses and forbs, interspersed with open wet meadows or riparian areas. These are key habitat components for sage-grouse and other wildlife. During winter, sage-grouse feed almost exclusively on the leaves of sagebrush (Patterson 1952; Wallestad et al. 1975).

Subtropical Desert Ecoregion

The Subtropical Desert Ecoregion is composed of the Mohave, Sonoran, and Chihuahuan deserts. In contrast to the cooler deserts of the Temperate Desert Ecoregion, the hotter deserts of the Subtropical Desert Ecoregion tend to have a more diverse flora and fauna. The northern limits of many species common in Mexico are found in this ecoregion, such as brown-crested flycatcher, vermilion flycatcher, black-tailed gnatcatcher, hooded skunk, pocketed free-tail bat, coatimundi, and jaguar. The Sonoran Desert is the most floristically diverse of the three deserts, and as a result, has the greatest diversity of wildlife. The desert tortoise, which is federally listed as a threatened species (in the Mojave Desert only), is found in this ecoregion. Long-lived and once common, desert tortoises have suffered population declines due to adverse impacts associated with human activities (USFWS 1994a).

The ecoregion is characterized by widely dispersed desert plants that provide little ground cover for wildlife. Canopy cover rarely exceeds 50%, and there is usually extensive bare ground between plants. In the Mojave and Sonoran deserts, several species of cacti, ocotillo, yucca, and other woody species provide areas of near-woodland habitat that support a greater diversity of wildlife than other areas with less plant structure.

Like species in the Temperate Desert, wildlife in the Subtropical Desert have evolved numerous means to deal with water scarcity and other rigors of the hot desert. Presence of standing water in winter and new herbaceous growth in spring provide water and forage for most wildlife (Laudenslayer and Boggs 1988). During summer and fall, some species, such as the desert kangaroo rat and other rodents, derive water from the seeds in their diet. Saguaro, as well as most other species of cactus, has spines for protection from many grazing animals. However, collared peccaries and many desert rodents can avoid or digest cactus spines and obtain water from the plants' succulent tissues.

Black-throated sparrows secrete highly-concentrated urine and dry feces, and thus need little drinking water. In contrast, most other desert-living bird species show few adaptations for coping with water scarcity and simply fly to water sources to meet their needs. Reptiles and small mammals are active mostly at night and retreat to cool burrows, or seek shelter under vegetation or in rock outcrops to avoid the midday sun and reduce water loss. The yucca night lizard, for example, is restricted to desert regions with downed litter of yucca and agave plants (Jones 1986).

Salt balance is an important physiological function in desert animals. Chuckwallas, desert lizards, eat the fleshy tissue of cacti, and are able to excrete salt from their nostrils by sneezing, without losing much water. Many other lizard species also have salt glands for excreting salt.

The structure of live vegetation is probably the most important habitat feature in these deserts. Shrubs and tall cacti are used by lizards for feeding and breeding, and lizards climb onto creosote bushes during the day to avoid hot ground temperatures. Vertical structure provides nesting, feeding, and breeding niches for birds. Cacti provide roosting and breeding habitats for bats that small shrubs do not provide. Horizontal vegetation structure is also important, as some species of birds prefer either open or closed habitats, and many species of lizards require more open areas for foraging, but closed habitat the rest of the time to avoid the heat and predators (Pianka 1966, Rottenberry and Wiens 1980).

The extensive root systems of certain desert plants, such as creosotebush, provide access to subsurface openings for toads, salamanders, lizards, snakes, and small mammals. Creosotebush areas found in the Chihuahuan and Sonoran deserts have little vegetative structure, but have a rich diversity of wildlife because of favorable soils that allow access to subsurface space.

Desert wildlife have evolved characteristics that are adaptive to the attributes of certain plant species. Desert iguanas feed heavily on creosotebush buds, especially during the spring, and their distribution is closely related to the distribution of creosotebush (Norris 1953). Several birds rely on the saguaro and other cacti for roosting and nesting, including elf owl, cactus wren, and gilded flicker. Cavity-nesting birds often select vegetation with spines, perhaps to discourage nest predation by small mammals and reptiles. The Gila woodpecker and gilded flicker both excavate nest cavities in saguaro cacti, but due to differences in bill structure, the gilded flicker must excavate its cavity near the top of the cactus, while the Gila woodpecker can excavate cavities near the base of the trunk.

Temperate Steppe Ecoregion

The Temperate Steppe Ecoregion is comprised of prairie grasslands, evergreen and deciduous forests, and sagebrush and chaparral shrublands. Prairie grasslands occur in an environment with irregularities in weather patterns, including wet and dry spells, which occur often enough to impose severe stresses on wildlife. In a drought year, for example, reduced moisture and higher temperatures can greatly affect the abundance and quality of vegetation used for food and cover, often leading to substantial population declines in some species, especially birds.

The characteristics and habitats of grassland animals differ from those of animals that inhabit shrublands and forests. Many grassland species live in burrows, including burrowing owls, prairie dogs, ground squirrels, pocket gophers, black-footed ferrets, and American badgers. Burrows provide a place to hide from predators, a more stable microclimate during hot summers and cold winters, and shelter from grassland fires (Brown 1982).

If an animal cannot hide in a burrow, it must be a fast runner to avoid predation. The swift fox can travel at 25 miles per hour (mph), while the pronghorn can run at 70 mph. Even quail and grouse often run instead of flying to escape predation, staying close to the ground and using the vegetation as cover.

Grassland animals tend to occur in large social groups. For example, millions of American bison occurred on the Great Plains in presettlement days and millions of prairie dogs have been found in a single prairie dog town. Wildlife species living in grasslands tend to be more social than their forestland counterparts. Prairie dogs live in large, highly organized social units, while their eastern woodland counterpart, the woodchuck, rarely interacts with its own species. Flocking species are also more prevalent in grasslands than in forestlands. Socialization enables the members of a flock to more readily detect predators, but also to convey other information, such as mating status, which is difficult to ascertain in open grassland where sound is muffled and perches are few. Raptors are also more common in grasslands than other habitats, as open spaces favor animals with good vision and provide an abundance of prey items.

Compared with other habitats, grasslands tend to have low bird species diversity and abundance (Wiens and Dyer 1975). Although grasslands are highly productive, they are structurally simple and less complex than other habitat types, and thus provide birds with few niches to exploit. Bird species tend to differentiate themselves based on the cover and height of the grassland vegetation, with the horned lark and burrowing owl selecting areas with low, scattered vegetation, and the savanna sparrow and bobolink selecting high, dense herbaceous cover.

Grasslands found in the proposed treatment area include the Great Plains, shortgrass prairie, intermountain grasslands, and the Palouse grasslands. The mixed prairie of the Great Plains constitutes the eastern range for many grassland animals, including the prairie dog, pronghorn, swift fox, and desert cottontail. It was also the home of the American bison. The shortgrass prairie to the west of the Great Plains, and east of the Rocky Mountains, is where true grassland animals are found. Many of the species found here cannot survive in the tallgrass and mixed prairies because they are less able to see and flee from predators.

Wildlife found in the intermountain grasslands associated with the Rocky Mountains are similar to those found in grasslands to the east, except species that need a year-round supply of green grass do not occur. Deer, elk, and pronghorn survive in the intermountain grasslands by foraging upon shrubs and other woody vegetation during winter. Ground squirrel diversity is especially high in the intermountain grasslands, with 19 of the 22 species of ground squirrels in North America found in this region. Much of the Palouse grasslands have been converted to agriculture or lost to shrubland encroachment, greatly reducing their value to sharp-tailed grouse and other wildlife that were once common.

Evergreen and deciduous forests are found at higher elevations and along streams and other aquatic areas. The plant species composition of coniferous forest stands, and the types of wildlife that use them, varies with altitude. Aspen is an important component of many deciduous forests. Aspen typically is found in moist areas and becomes established after fire or other disturbance has cleared a suitable area. American beaver use aspen limbs and foliage for food and to build dams and lodges. Snowshoe hare feed on aspen twigs and bark during winter, and aspen buds are important in the winter diet of ruffed grouse. American badger, ground squirrels, and other burrowing animals provide bare ground needed by aspen seeds to germinate.

Subtropical Steppe Ecoregion

The Subtropical Steppe Ecoregion is composed primarily of grassland vegetation, with local occurrences of shrubs and woodlands. Grassland wildlife species found in the Temperate Steppe Ecoregion are also found here, such as pronghorn, mule deer, white-tailed deer, coyote, American badger, and black-tailed jackrabbit. The northern limit of distribution of several mammals, including the Mexican ground squirrel and gray fox, occurs in the grasslands of this ecoregion (Bailey 1997).

Woodlands formed of pinyon and several species of juniper (pinyon-juniper woodlands) are found on about 4 million acres, and are also found in other ecoregions. The canopy of these woodlands is generally open, and the trees are far apart. Open stands of pinyon-juniper with abundant vegetation below the trees provide the best wildlife habitat. These woodlands generally do not have the structure and complexity to support a large diversity of wildlife as compared to other forest types, although a study in Utah showed that avian species diversity in pinyon-juniper woodlands is similar to species diversity in other woodland and forest types (Paulin et al. 1999).

Reptiles are not common in pinyon-juniper woodlands. Birds feed on pinyon and juniper seeds and berries, find nesting cavities within juniper trunks, and use the stringy and fibrous juniper bark for nesting material. The pinyon jay, plain titmouse, and bushtit are obligate to these woodlands, and 144 different species of birds have been observed in pinyon-juniper woodlands in New Mexico (Short and McCulloch 1977). Avian species diversity is usually greater in pinyon-juniper woodlands than in adjacent grasslands (Sieg 1991).

Abert's squirrel, pinyon mouse, wood rat, gray fox, and other small mammals eat berries, seeds, and the inner twigs from pinyon-junipers. Mule deer, white-tailed deer, elk, pronghorn, and desert bighorn sheep may occur throughout the year in pinyon-juniper woodlands. Leaves and berries of pinyon pine and juniper trees are eaten by large mammals.

Most food habit studies have shown that the value of pinyon-juniper woodlands to wildlife is usually related to the quantity and composition of the vegetation growing in association with pinyon-juniper. As pinyon-juniper stands mature, the trend is toward increased tree density and finally, dense canopy cover.

The dense canopy cover shades out plants found below pinyon-junipers, reducing the variety of plant types that can provide food and cover for wildlife. Small mammals, deer, and elk use of pinyon-juniper woodlands declines as tree canopies become more dense, although some species, like pinyon mice and pinyon jays, may favor denser stands (Short and McCulloch 1977, Willis and Miller 1999).

Mediterranean Ecoregion

The vegetation of the Mediterranean Ecoregion is dominated by grassland, shrubland, and forestland habitats. Many shrub (chaparral) and forest/woodland plant species have thick, hard, evergreen leaves. The number of wildlife species using shrub habitats is limited by the lack of trees in shrublands. However, wildlife species diversity can also be limited in evergreen woodlands due to the paucity of shrubs in these communities, as shrubs are often unable to compete with trees for the limited moisture.

Because of their tough, leathery texture, the leaves of vegetation in chaparral communities are resistant to wilting, and thus provide cover for wildlife even during the frequent droughts typical of the region. Wildlife found in chaparral tend to be species that nest on the ground or in shrubs, such as ground- and shrub-nesting birds and rodents, or that prey upon ground- and shrub-dwelling species, including coyote, striped skunk, and bobcat.

Although this ecoregion supports a diverse vertebrate fauna, including numerous species of reptiles and rodents, only a limited number of species are closely tied to the chaparral. These include the mountain quail, California thrasher, wrentit, brush rabbit, California mouse, and dusky-footed woodrat.

Mountain quail favor slopes covered with chaparral. They feed on acorn mast, fruits, and seeds in the fall, leafy foods during winter, and bulbs in the spring and summer. Thrashers and wrentits find good food and cover in the chaparral, and are more often seen than heard in the dense vegetation. The brush rabbit does not use burrows regularly like most other species of rabbits, perhaps because of the dense chaparral cover. Woodrats construct stick dens that are also used by the California mouse. Since homes are constructed of sticks, woodrats are vulnerable to fires in chaparral communities.

Chaparral communities are adapted to fire, and wildlife respond by retreating to burrows, hiding in rock crevices, or escaping from the area. After a fire, seed-eating birds, such as mourning doves, move into the area to feed on seeds exposed by fire. Mule deer seek out the temporary community of herbaceous plants that develop during the first year or two after the fire. Many of these plants produce bright flowers that attract nectar-feeding insects and birds.

Deciduous and evergreen woodlands provide vegetation structure and complexity that benefits a variety of wildlife species. The habitat often occurs in a mosaic-like pattern of conifer stands intermixed with deciduous tree stands. The shrub and herbaceous strata are often poorly developed in these woodlands. Mature woodlands are important to cavity nesting birds, and oak mast crops are an important food source for birds and mammals, such as scrub and Steller's jays, acorn woodpecker, wild turkey, mountain quail, California ground squirrel, western gray squirrel, black bear, and mule deer (Anderson 1988). Amphibians that reside in the forest detritus layers include Mount Lyell salamander, ensatina, and relictual slender salamander (McDonald 1988).

Oak woodlands serve as important wildlife habitat, supporting over 300 vertebrate species, many of which are special status species such as the California spotted owl and willow flycatcher (Thomas 1997). Oak trees provide nesting sites for both canopy- and cavity-nesting birds, and the acorns they produce are an autumn food source relied upon by many bird and mammal species (Almeda County Agriculture Advisory Committee 2005).

Annual and perennial grasslands are found in central and coastal California. Annual grassland habitats consist largely of non-native annuals that have displaced native perennials (Kie 1988). Habitat structure and wildlife abundance are dependent on a mix of plant species at a site. Sites with western brackenfern exhibit a taller, more diverse structure than sites with shorter grasses. Many wildlife species use grassland habitats, but some require special habitat features, such as cliffs, caves, ponds, or shrubby areas for breeding, resting, and escape cover.

Marine Ecoregion

The Marine Ecoregion is dominated by evergreen and, to a lesser extent, deciduous forests located along the Pacific Coast. These forests are managed by the BLM primarily for timber production and wildlife habitat.

Temperate forests are among the most productive habitats in the world (Whittaker 1975). The energy available to wildlife from temperate forests vegetation, along with their structure and complexity, provide habitat for a diversity of wildlife. Temperate forests are also routinely subject to disturbances that increase variability in the environment and create edge habitat. In turn, the succession of vegetation types that follow a disturbance provide habitats for a succession of wildlife species.

In general, deciduous trees support more wildlife than evergreen trees (Glenn-Lewin 1977). Conifer forage is less palatable than deciduous forage, which means that there are fewer animals that can consume the foliage, and in turn, be consumed by predators. Conifer foliage is also relatively unpalatable to decomposing organisms, such as fungi and bacteria, so the decomposition of coniferous matter is often a slow process (Hunter 1990). Deciduous trees generally have more structural complexity than conifers, providing more places for animals to feed and seek shelter.

Conifers do possess characteristics that are critical to the survival of many wildlife species. Spruce grouse are dependent on conifer foliage to survive the winter. Conifer stands also provide crucial winter cover to elk, deer, and other wildlife by blocking wind and keeping snow from reaching the ground, covering browse, and restricting animal movements. However, the foliage that captures snowfall also intercepts light in the spring, reducing the amount of light that can reach the forest floor, warm the soil, and stimulate the growth of herbaceous vegetation and shrubs used by these wildlife.

Since this ecoregion is characterized by abundant rainfall, there is an abundance of moisture on the forest floor, as well as in ponds and streams, to support a diversity of amphibians. All frogs and toads in this region lay their eggs in water. Most salamanders lay their eggs in or near water, while others lay their eggs on land under logs (Ensatina), in rock outcrops (western red-backed salamander), or both (clouded salamander). Many of these amphibians spend a portion or most of their lives out of water, living under moist logs, dead wood, or forest litter, or in burrows or root or rock crevasses.

Few reptiles are found in this ecoregion. The alligator lizard is the only widely distributed species found in forested habitats, and the painted turtle and western pond turtle are the only turtles common in the area. The most common snake is the northwestern garter snake.

Birds have adapted to exploit the different layers of vegetation in the forest. Ruffed grouse, winter wren, American robin, spotted towhee, and dark-eyed junco are often found near the forest floor or in shrubs. Woodpeckers and brown creepers are seen moving up and down the trunks of trees in search of insects. Nuthatches and chickadees exploit the cone seeds, while warblers and kinglets glean insects from the upper deciduous forest canopy.

Like birds, mammals exploit the vegetation types and strata found in the forest. Shrews, mice, and moles are fossorial or live near the forest floor. Rabbits and hares reside near the ground and seek shelter in dense herbaceous or shrub vegetation. Wide-roaming species that live near the ground include black-tailed deer, elk, black bear, mountain lion, and bobcat. Deer and elk tend to remain in dense forest stands during the day to seek shelter, but move to more open shrublands and grasslands at night to feed, and thus favor forest habitat interspersed with shrubland/grassland habitats. Bears favor large stands of contiguous forest, but also use shrublands with abundant berries and other forage.

Several special habitat features have been identified in forests that are important to wildlife. Snags, which are dead or dying trees, are critical to many species of wildlife. Cavities in snags provide shelter and nesting sites for woodpeckers, owls, and other cavity-using wildlife, while dead and dying bark often harbors large numbers of insect prey for birds. Edges are places where different plant communities or successional stages meet, such as between a forest clearing and dense forest stand. A large number of species are found at edges, and some species reach their maximum population densities there (Hunter 1990). For some species of birds, however, nest predation is higher for individuals nesting near edges than for those nesting in the forest interior.

A number of species rely on old-growth forests for most or all of their life requisites. Old-growth forests in the Marine Ecoregion generally consist of conifer trees with a diameter of more than 3 feet at the base of the tree, and that are more than 200 years old (Bolen 1998). These forests also contain a multilayered canopy and numerous snags and logs. Vaux’s swifts depend on large, hollow snags for nesting and roosting habitat. Marbled murrelets use the stout branches of old-growth trees for nest platforms. Northern spotted owl nest in tree cavities and feed on northern flying squirrels. Banana slugs, Pacific giant salamander, Olympic salamander, and Oregon slender salamander are other species that prefer the rotting logs and moist soil conditions found in old-growth habitats.

Special Status Species

There are over 75 terrestrial animal species occurring on or near public lands in the treatment area that are federally listed as threatened or endangered, or proposed for listing. Included in the total number are 10 species of arthropod, 7 species of amphibian, 5 species of reptile, 20 species of bird, and 27 species of mammal. A complete list of special status animal species may be found in Appendix J. Please note that this list is dynamic, and will likely change throughout the time period considered by this PER.

Special status animal species are found on public lands throughout the U.S. Special status 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 lands throughout the western U.S.

Livestock

Approximately 161 million acres of public lands are open to livestock grazing, with use levels established by the Secretary of the Interior and administered through the issuance of grazing permits/leases. The majority of the grazing permits issued by the BLM involve grazing by cattle, with fewer and smaller grazing permits for other kinds of livestock (primarily sheep and horses).

The BLM administers grazing lands under 43 CFR Part 4100 and BLM Handbooks 4100 to 4180, and conducts grazing management practices through BLM Manual Handbook H-4120-1 (*Grazing Management*; USDI BLM 1984a). Management of livestock grazing is authorized and enforced through both permits and leases, and is commonly carried out through the development and implementation of allotment management plans (AMPs) and/or terms and conditions of the grazing permit or lease. The grazing permit establishes the allotment(s) to be used, the total amount of use, the number and kind of livestock, and the season of use. The grazing permit may also contain terms and conditions as appropriate to achieve management and resource condition objectives. Allotment management plans further outline how livestock grazing is managed to meet multiple-use, sustained-yield, and other needs and objectives, as determined through land use plans.

Geographically specific rangeland health standards and guidelines are identified for each state to help direct the grazing program for those states. Each year the BLM conducts reviews of land within its jurisdiction to determine the level of compliance with rangeland health standards. At a minimum, grazing is managed to ensure that 1) watersheds are in or making significant progress towards properly functioning physical condition; 2) ecological processes including the hydrologic cycle, nutrient cycle, and energy flow are maintained; 3) water quality complies with state water quality standards; and 4) significant progress is being made toward restoring or maintaining habitats for all special status species, including federally-listed threatened or endangered species. Reviews of rangeland health standards are often conducted when grazing permits or leases expire, particularly when those permits or leases are within high priority watersheds.

Public lands provide an important source of forage for many ranches and help to support the agricultural component of many communities scattered throughout the west. As of October 2005, the total number of grazing permits/leases in force was 17,940, with a total of 12.7 million Animal Use Months (AUMs) authorized (Table 3-6; USDI BLM 2006d). Grazing authorizations produced approximately $14.5 million in annual revenues in FY 2005 (USDI BLM 2006c).

Wild Horses and Burros

The BLM, in conjunction with the Forest Service, manages wild horses and burros on BLM- and Forest Service-administered lands through the *Wild Free-Roaming Horse and Burro Act of 1971*. In FY 2005, wild horse and burro populations on public lands totaled over 31,760 animals, with nearly half of these animals living in Nevada (Table 3-7). Another 25,000 animals are held in holding pens. The population of wild horses and burros is approximately 4,000 animals above the Appropriate Management Level (AML) of 27,500. The AML is an estimate of the number of wild horses and burros that public lands can support while maintaining a thriving natural ecological balance (USDI BLM 2006c, d).

TABLE 3-6
Grazing Permits and Leases in Force and Active Animal Unit Months during Fiscal Year 2005

State	Leases and Permits	Active AUMs
Arizona	757	660,511
California	573	421,843
Colorado	1,588	662,920
Idaho	1,889	1,351,806
Montana, North Dakota, and South Dakota	4,289	1,366,331
Nevada	644	2,130,112
New Mexico, Oklahoma, and Texas	2,290	1,861,369
Oregon and Washington	1,579	1,058,756
Utah	1,525	1,237,117
Wyoming and Nebraska	2,806	1,950,312
Total	17,940	12,701,077

Source: BLM Public Land Statistics (USDI BLM 2006d).

Animals are managed within 201 Wild Horse and Burro Herd Management Areas (HMAs; USDI BLM 2006c). Wild horse herds grow at an average rate of 20% annually. Management is accomplished by carefully controlling horse and burro populations so that their numbers do not exceed the carrying capacity of the land. This is done primarily by gathering animals periodically so that numbers are near the AML. Fertility control is being used in some HMAs as a means to reduce the population growth rate. It has shown to be effective thus far and will likely be used on a larger scale in future years.

When horse and burro populations begin to exceed the AML, excess animals are gathered and offered to the public through periodic adoption. In FY 2005, 5,700 wild horses and burros were adopted in the U.S. Thirty-two percent of these were adopted in the eastern U.S. Nearly 209,000 animals have been adopted since 1971 (USDI BLM 2006d). In 2001, the BLM implemented a program to further reduce the wild horse and burro population to approximately 27,500 animals. Public lands inhabited by wild horses or burros are closed to grazing under permit or lease by domestic horses and burros. *The Wild Free-Roaming Horse and Burro Act* mandates that wild horses and burros can only be managed in areas where they were found in 1971. Those that stray onto non-designated public and/or private lands are removed.

Paleontological and Cultural Resources

Paleontological Resources

The BLM is responsible for managing the public lands and their various resources so that they are utilized in a manner that will best meet the present and future needs of this Nation. The western U.S. has a fossil record that includes almost all of the geologic periods from the Cambrian (500+ million years ago) to the Holocene (Recent; the last 10,000 years), and nearly every imaginable ancient environment. Many fossil deposits are of national and international importance, and many thousands of different kinds of fossils were originally made known to the scientific world from specimens first found in the west.

The BLM manages fossils as a natural heritage resource on the lands it administers under the general guidance of the FLPMA and NEPA. Fossils are managed to promote their use in research, education, and recreation, and paleontological localities are an important consideration in developing land use management decisions. More than 200 properties, totaling more than 5 million acres, are managed either wholly or in part for paleontological values or contain paleontological values that may require special management strategies in the future. Significant paleontological resources can also be found on other public lands estimated to total over 20 million acres. Because of the increasing interest and activity related to fossils over the past 3 decades, it is estimated that there are more than 50,000 fossil sites documented on public lands. Table 3-8 lists the localities that include many of these sites.

Cultural Resources

Cultural resources include archaeological, historic, or architectural sites, structures, or places with important public or scientific uses, and may include definite locations (sites or places) of traditional cultural or religious importance to specific social or cultural groups. Cultural resources are concrete, material places and things that the BLM locates, classifies, and ranks. The BLM manages cultural resources according to their relative importance, to protect significant cultural resources from inadvertent loss, destruction, or impairment, and to encourage and accommodate.

TABLE 3-7
Wild Horses and Burros on Public Lands in Fiscal Year 2005

State	Wild Horses			Wild Burros		
	Free-Roaming Population	Adopted	Removed	Free-Roaming Population	Adopted	Removed
Arizona	230	218	1	1,542	91	53
California	3,079	705	992	1,228	231	252
Colorado	800	292	357	0	17	0
Idaho	704	110	360	0	0	0
Montana, North Dakota, and South Dakota	142	4	0	0	0	0
Nevada	13,251	54	5,805	1,464	0	68
New Mexico, Oklahoma, and Texas	82	916	23	0	69	0
Oregon and Washington	2,670	313	891	15	6	0
Utah	2,420	173	248	142	20	0
Wyoming and Nebraska	3,991	420	1,973	0	1	0
Total	27,369	3,205	10,650	4,391	435	373

Source: BLM Public Land Statistics (USDI BLM 2006c).

the appropriate uses of these resources through planning and public participation

The cultural heritage for public lands administered by the BLM in 17 western states extends back 11,000 to 13,000 years before the present (BP). As one moves forward in time, the number and variety of sites increases mainly as a result of the increase in Native populations and, after 1500 AD or so, European and Euroamerican immigration.

Table 3-9 summarizes the number of acres of public lands inventoried for cultural resources, the number of properties found on public lands, and the number of properties listed in the NRHP.

American Indian and Alaska Native Cultural Resources

This review uses the culture area approach as defined in the *Handbook of North American Indians* (Sturtevant 1978-2001). See Map 3-11 for the location of these areas. These regions represent areas within which specific cultural groups shared certain cultural characteristics and histories. Each culture area section provides a brief review of the archaeology and ethnography of that area. Table 3-10, summarizing examples of major types of archaeological sites likely to be in each culture area, follows this section.

Arctic and Subarctic (Alaska)

Archaeological research suggests that the earliest human migrants crossed into the New World via the Bering Land Bridge, likely following large herbivorous Pleistocene animals, such as mastodon, woolly mammoth, horse, and American bison. In this culture area, typical artifacts from the period 13,000 to 9,000 Before Present (BP) include lanceolate projectile points, bifacial knives and scrapers, and retouched flake tools (Ames and Maschner 1999, Dixon 1999). Cultural resource sites from this time period include open campsites, habitations or campsites located in caves or rockshelters, and sites where game animals were killed and/or processed.

As the post-glacial climate in Alaska warmed, prehistoric cultures became more established. Early aboriginal groups, with a subsistence strategy similar to that of the Paleoindians, used tool assemblages dominated by microblades, small wedge-shaped cores, and burins.

Cultures from 9,000 to 6,000 BP often are referred to as the Microblade Tradition (Dumond 1987). In addition to open campsites and sites with skin-covered tents, semi-subterranean houses are documented for this period (Anderson 1984). By 6,000 BP, the Northern Archaic Tradition had arisen in the boreal forests of the interior,

TABLE 3-8
Interpreted Paleontological Sites on Public Lands

State	Interpreted Locations
Colorado	• Dinosaur Diamond Byway • Gard Park Fossil Area • Kremmling Cretaceous Ammonitie Locality • Rabbit Valley Trail Through Time • Fruita Paleontology Area
Idaho	• Malm Gulch Area of Critical Environmental Concern (ACEC)
Utah	• Cleveland Lloyd Dinosaur Quarry • Copper Ridge Sauropod Dinosaur Tracks • Mill Canyon Dinosaur Trail • Warner Valley Dinosaur Track Site
Wyoming	• Red Gulch Track Site ACEC • Big Cedar Ridge Fossil Plant Area ACEC • Dry Creek Petrified Tree Environmental Education Area

represented by small, seasonal campsites and tool assemblages composed of lanceolate and side-notched projectile points and scrapers (Dumond 1987). Technological advances during the period 6,000 to 250 BP led to the development of several distinct cultures. Tool kits of the widespread Arctic Small Tool Tradition included small stone endblades and sideblades inserted into the shafts of arrows or spears (Dumond 1987). Populations of Arctic Small Tool Tradition people developed highly specialized maritime technologies (kayaks, umiaks, dogsleds, toggling harpoons, bow and arrows, and ground slate tools). Habitations, in the form of semisubterranean houses, often were clustered in villages (McCartney 1984, Dumond 1987).

At present, the Alaska Natives and Indians are the dominant native groups of Alaska. In general, the Inuit (Eskimo and Aleut) inhabit the coastal areas and adjacent tundra, while Indians (Athabaskan or Tlingit) inhabit the interior forests and southeast Alaska, though both groups have tremendous intra-cultural diversity and overlapping resource exploitation areas. Terrestrial and marine mammals and fish are the primary source of food for both groups; plants being of lesser importance, given the short growing season.

Kelp and berries are the principal plant foods, with mushroom, wild parsnip, wild rhubarb, and lupine roots also gathered. Dune grass is used to weave baskets and mats (Kehoe 1992). Alaskan Indians have focused their subsistence activities on marine whales and seals, seasonal fish runs, and inland caribou herds and a variety of other land mammals.

Edible plant resources of the interior include a wide variety of berries, fern roots, lily bulbs, mushrooms, wild onions, wild rhubarb, rose hips, and various roots (Kehoe 1992). Birch bark continues to be used for the manufacture of many utilitarian objects, including baskets, shelters, cooking pots, and canoes. The wood of birch, spruce, and willow has been used for bows, arrows, snowshoe frames, wooden tools, and house and canoe frames. Ropes and fishing nets have been made from willow bast, nettle fibers, and spruce roots. Additional uses of spruce roots include containers, basketry, sewing thread, and twine (McClellan and Deniston 1981).

Northwest Coast

Archaeological evidence for occupation of this culture area dates back to about 11,000 BP, though faunal remains from the Olympic Peninsula suggest human presence earlier than 12,000 BP (Lyman 1991). Early peoples’ subsistence systems focused on maritime resources, and typical artifacts consist of large chipped stone projectile points, microblades, compound harpoons, and grinding stones (Ames and Maschner 1999). Due to the damp climate and acidic soils in this region, faunal remains and tools made from perishable items dating to this period are rarely preserved. In addition, the changing sea levels over the last 10,000 years have inundated many of the older occupation or processing sites.

TABLE 3-9
Cultural Resources on Public Lands

State	Number of Acres (in millions)	Number of Acres Surveyed	Percent of Acres Surveyed	Number of Properties Recorded
Alaska	85.5	109,872	0.1	3,205
Arizona	12.2	822,100	6.7	11,858
California	15.2	1,813,118	11.9	28,454
Colorado	8.4	1,493,770	17.9	39,232
Idaho	12.0	2,020,017	16.8	14,604
Montana, North Dakota, and South Dakota	8.3	1,340,862	16.2	10,224
Nevada	47.8	2,183,973	4.6	44,851
New Mexico, Oklahoma, and Texas	13.4	1,441,183	10.8	34,931
Oregon and Washington	16.5	1,585,580	9.6	12,623
Utah	22.9	1,801,321	7.9	38,526
Wyoming and Nebraska	18.4	2,590,769	14.1	40,157
Total	260.6	17,202,565	6.6	278,665
Source: BLM Public Land Statistics (USDI BLM 2006f).				

By about 5,000 BP, sea levels rose and stabilized, and distinctive cultural patterns emerged. Bone and ground stone tools were prevalent from Southeast Alaska to Puget Sound, as were large settlements and specialized maritime subsistence strategies. There is evidence of sedentism (pithouses and shell middens in western Washington) from 3,500 BP, and it appears that by 3,000 BP, trade networks with Plateau cultures were well established (Nelson 1990). Petroglyph sites begin during this period (Boreson 1998, Ames and Maschner 1999).

By 1,000 BP, most Northwest Coast groups occupied village sites on a year-round basis. Many village sites were located for defensive purposes and included fortifications, suggesting the presence of warfare, social complexity, and competition for resources (Ames and Maschner 1999). Typical artifacts include composite woodworking tools, netsinkers, bone and antler tools, and copper and iron tools. Archaeological sites in the Northwest Coast region are generally difficult to locate because of dense vegetation and poor preservation (Nelson 1990).

A handful of "wet sites" occurring in the Pacific Northwest have been systematically studied, with excellent preservation of organic components, such as acorns, wood, and basketry items, from prehistoric sites on the Olympic Peninsula of Washington, including Ozette, the Hoko River, and Mud Bay, and also the "Sunken Village" on the Willamette River in Oregon (Croes 2007).

Food resources currently used by native Northwest groups include salmon, halibut, cod, candlefish (an important source of dietary oil), clams, whales, elk, deer, mountain sheep, and bear. Plant food sources, which are numerous in this culture area, include edible ferns and lilies, the tuber of the wapato, over 40 fruits and berries, edible nuts, leaves, and shoots, and certain types of algae, seaweed and kelp. Many groups used controlled burning to maintain prairies, and berry, root, and nut-producing areas along the coast from California to British Columbia (Suttles 1990, Ames and Maschner 1999).

Forest resources are used extensively, particularly western red cedar and Alaska cedar, for canoes, for plank house construction, and for specialized ritual purposes such as totem poles and masks. Sitka spruce has often been used for houses and canoes, and western hemlock and Douglas-fir saplings have been used to construct fish weirs. Red alder, Rocky Mountain maple, and Alaska cedar have been used for spoons, bowls, masks, and dishes; and western yew has been used for bows, wedges, clubs, and digging sticks. Plant materials used to make rope and cordage include the limbs of western red cedar, the stipes of bull kelp, the roots of cedar and spruce, and the fibers of stinging nettle and Indianhemp. Materials used in basketry include cedar

TABLE 3-10
Culture Areas, Prehistoric Occupation Periods, and Selected Common Site Types

Culture Area	Paleoindian	Middle Period or Archaic	Late or Sedentary Period
Arctic and Subarctic	*13,000+ to 9,000 B.P.* Open campsites Cave or rockshelter occupation sites Animal kill and lithic processing sites	*9,000 to 6,000 B.P.* Semi-subterranean houses Open campsites and tent camps	*6,000 to 250 B.P.* Semi-subterranean house villages Open campsites and tent camps
Northwest Coast	*12,500+ to 6,000 B.P.* Open campsites Cave or rockshelter occupation sites		*6,000 to 250 B.P.* Large, cedar plank pithouse villages Fortified sites Seafood capture or processing sites Pictograph and petroglyph sites
California	*11,000(?) to 8,000 B.P.* Open campsites Animal kill or processing sites	*8,000 to 5,000 B.P.* Open campsites and coastal villages Plant or seafood processing sites	*5,000 to 250 B.P.* Large coastal villages Burial mounds Extensive seafood, sea mammal, and plant processing sites Pictograph and petroglyph sites
Great Basin	*11,500+ to 8,000 B.P.* Open campsites Cave occupation sites Lithic processing sites	*8,000 to 4,000 B.P.* Cave or rockshelter occupation sites Pithouse villages Plant and lithic processing sites Fishing sites	*4,000 to 250 B.P.* Cave or rockshelter occupation sites Small pithouse villages Plant and lithic processing sites Storage pits Pictograph and petroglyph sites
Southwest	*11,500 to 8,000 B.P.* Open campsites Animal kill and lithic processing sites Cave occupation sites	*8,000 to 2,000 B.P.* Open campsites Cave or rockshelter occupation sites Pithouses and storage pits Waddle and daub structures Lithic processing sites Pictograph and petroglyph sites	*2,000 to 250 B.P.* Pithouse villages Storage pits Above-ground structures (Pueblos) Below-ground structures (Kivas) Irrigation ditches and roads Navajo hogans and pueblitos Pictograph and petroglyph sites
Plains	*12,000 to 8,000 B.P.* Open campsites Cave or rockshelter occupation sites Animal kill and lithic processing sites	*8,000 to 2,000 B.P.* Open campsites Cave or rockshelter occupation sites Pithouses and storage pits Tipi ring sites Cairns and cairn lines Animal kill, lithic, and plant processing sites	*2,000 to 250 B.P.* Open campsites and tipi ring sites Waddle and daub structures Earthlodge villages Burial mounds Storage pits Cave or rockshelter occupation sites Small pithouse villages Cairns and cairn lines Animal kill, lithic, and plant processing sites Pictograph and petroglyph sites
Plateau	*12,500 to 8,000 B.P.* Open campsites Cave or rockshelter occupation sites Fishing sites Lithic processing sites	*8,000 to 4,000 B.P.* Open campsites Small pithouse villages Cave occupation sites Animal or fish processing sites Lithic processing sites Plant processing sites	*4,000 to 250 B.P.* Pithouse and longhouse villages, often with burials Open campsites Cave occupation sites Storage pits Animal or fish processing sites Lithic and plant processing sites Pictograph and petroglyph sites

roots, cattail, tule, beargrass, and various sedges and grasses. The inner bark of western red cedar and Alaska cedar is used for baskets, mats, skirts, capes, towels, and diapers. There are numerous medicinal plants in the Northwest region, including devil's club, kinnikinnick, hogfennel, and tobacco (Suttles 1990).

Southwest

Between 11,500 and 8,000 BP, human groups practiced a highly mobile hunting and gathering subsistence strategy. In general, the oldest archaeological sites in this culture area are located near now extinct springs, large and small Pleistocene lakes (playas), or major drainages, and consist of open camps, animal kill sites, animal processing sites, or caves.

Archaeological sites dating from 8,000 to 2,000 BP are either open campsites located near water sources, containing chipped and ground stone tools, or are in rockshelters or caves, where well-preserved twined sandals, wood artifacts, and basketry are often recovered (Kehoe 1992). Horticulture was introduced into the southwest as early as 4,500 BP, although domestic crops did not substantially contribute to the diet until later (Woodbury and Zubrow 1979). Typical artifacts of the period include stemmed projectile points used with atlatls, basketry, scrapers, grinding slabs, and cobble tools. Remains of surface structures, made of posts and brush or other material, are documented beginning midway through the period in the West (Irwin-Williams 1979). The first pit house sites and storage pits are documented late in this period (Woodbury and Zubrow 1979). Petroglyphs and pictographs are first produced during this time period (Schaafsma 1980).

Researchers have subdivided the Southwest, starting from about 2,000 BP, into the Anasazi, Mogollon, Hohokam, and Hakataya geographical-cultural areas. The Anasazi occupied variable topography during the generally cooler and moister climates; the Mogollon inhabited well-watered, forested and mountainous regions; the Hohokam were located in low, dry deserts; and the Hakataya occupied the hot desert regions bordering the lower Colorado River (Woodbury 1979). Parts of the region were intensively occupied and socially and economically linked to the civilizations of the Mexican Classic Period, when sedentary cultures began to emerge (Irwin-Williams 1979).

Maize was cultivated in earnest by about 2,200 BP, and was soon followed by beans, squash, cotton, and other crops (Irwin-Williams 1979; Woodbury and Zubrow 1979). By 1,700 BP, some inhabitants of the region had developed sophisticated irrigation, pottery, storage pits, and pit house villages. Eventually, small to large permanent towns of multi-story, aboveground structures (pueblos) were developed. Sites dating to this period may include features such as irrigation canals, wells, storage pits, and roads. Typical artifacts consist of pottery (used for the storage of crops), basketry, and small corner-notched projectile points indicating the adoption of the bow and arrow by 1,500 BP (Woodbury and Zubrow 1979).

The Pueblo Indians are best known for their agricultural development of corn, beans, and squash. In addition, wild plants (e.g., amaranth, chenopods, wild onion, wild celery, sage, grass seeds, juniper berries, pine nuts, acorns, walnuts, agave, prickly pear, and tree cholla) were eaten (Bodine 1979, Plog 1979). Other plants are used for clothing, shelter, and medicine. Baskets are made from yucca fibers, cotton is used for weaving, blankets are made from small palms, yucca roots are used for hair washing, and gourds are used as containers (Bodine 1979, Kennard 1979, Plog 1979, Schroeder 1979).

The Yuman groups (Colorado River Tribes) living along the Colorado and Middle Gila rivers have traditionally cultivated corn, squash, pumpkins, melons, beans, and cotton (Maxwell 1978). Important animal foods include small game and fish, and important plant resources include prickly pear, saguaro, mesquite, and numerous nuts and berries (Maxwell 1978, Jorgensen 1980). Yuman groups living on or near the Colorado Plateau practiced agriculture in the canyons in summer, then hunted deer, antelope, bighorn sheep, and rabbits in the fall. They also gathered pinyon nuts, juniper berries, various cacti, and other plants for both subsistence and domestic purposes (Khera and Mariella 1983, McGuire 1983, Schwartz 1983).

Southern Athapaskan or Apachean-speaking tribes occupied much of eastern Arizona, portions of New Mexico around the Pueblos, southeastern Colorado, western Oklahoma, and parts of western and southern Texas beginning about 700 BP. Following contact with the indigenous Pueblo peoples, the Navajo readily adopted maize, bean, and squash agriculture. The Western Apache, Jicarilla, and Lipan cultivated crops less intensively, and the remaining groups did not adopt any agricultural practices. With arrival of the Spanish, the Navajo readily adopted the raising of horses, sheep, goats, and cattle, and cultivated orchards and other introduced crops (Basso 1983, Opler 1983, Tiller 1983, Witherspoon 1983).

Traditional plants gathered by the Apacheans include agave crowns, saguaro cactus fruit, yucca, prickly pear, mesquite beans, acorns, pinyon nuts, numerous berries, grass seeds, wild root crops, and various greens or young plants. Yucca has been used to make shampoo, and the sap of Spanish bayonet and other plants has been used to make dyes. Common basketry plants include sourberry, willow, martinia, and bata mota. At least 29 species of plants have been used for medicinal purposes. Various large and small game animals were hunted for food and hides.

Great Basin

Two of the oldest archaeological sites in this culture area are the Tule Springs campsite (11,000 BP) and Danger Cave (9,000 BP; Aikens 1983). Typical artifacts of the period from 11,000 to 8,000 BP include lanceolate-shaped and long-stemmed projectile points, occasional fluted points, specialized scrapers, chipped stone crescents, and drills (Warren and Crabtree 1986). This period also includes the earliest evidence of basket making (Adovasio 1986). Inhabitants of the region likely were highly mobile hunter-gatherers with a generalized big game hunting and collecting economy.

The warm and dry climatic conditions during 8,000 to 7,000 BP limited human subsistence activities. Sites dating to this period are rare, and include caves (Aikens 1983) and rockshelters in drier areas, or pithouse villages located in valley bottoms near permanent streams and springs (Elston 1986). During this period, generalized hunting and collecting remained the major subsistence practices, although seed collecting and processing activities gained importance, as indicated by bedrock mortars and milling stones. Root collecting and fishing also gained importance during this period (Mehringer 1986). Typical artifacts include projectile points used with atlatls, basketry, twined sandals, and various wooden implements (Aikens and Madsen 1986).

By about 4,000 BP, subsistence systems were broad-based and resource-rich areas were heavily exploited seasonally. The shift in styles of projectile points over time indicates the adoption of the bow and arrow. While caves continued to be occupied (Aikens 1983), many locations along major rivers contained small pithouse villages with associated storage facilities (Butler 1986). Horticulture was introduced in the eastern Great Basin and Owens Valley by Southwest cultures around 1,500 BP. Outside of these areas, hunting and gathering remained the primary form of subsistence. An expanded reliance on pinyon nut gathering, as evidenced by mortars and pestles, also occurred during this period (Aikens and Madsen 1986, Elston 1986). Petroglyphs were common by 3,000 BP and pictographs by 1,000 BP (Schaafsma 1986).

Prior to the acquisition of the horse in the late 1700s, Shoshone and Northern Paiute in the High Desert region and western Wyoming fished for salmon in the spring and dug camas roots in the summer. These groups traveled to the mountains of southeastern Idaho and northern Utah to hunt deer and elk in the fall. After the development of equestrian culture, ranges and territories extended into present-day Wyoming and Montana, in seasonal pursuit of buffalo.

In the high desert, the single-leaf pinyon nut was an important staple, along with plant resources such as chenopod, blazingstar, grass seeds, mesquite, salvia, various cacti, and gourds (Egan 1917; Steward 1939, 1997; Thomas et al. 1986). The Western Shoshone wore hats made from twined sage bark or willow and clothing made from bark, grass, or fur. A large number of plants have also been used for basketry in this region (Adovasio 1986; Fowler 1986; Thomas et al. 1986). The Eastern Shoshone pursued game more extensively, while fish were a substantial part of the Northern Paiute diet (Liljeblad and Fowler 1986, Murphy and Murphy 1986, Shimkin 1986).

The aboriginal groups of the low desert, such as the Ute, Southern Paiute, Kawaiisu, Owens Valley Paiute, and Panamint, exhibited seasonal migration by traveling into the deserts and valleys in the winter and mountains in the summer. With the introduction of horses, these groups ranged onto the Plains, and adopted a Plains pattern, such as buffalo hunting and use of long-pole tepees (Conetah 1982, Janestki 1991, Kehoe 1992).

Plants utilized within the low desert region included berries, roots of sego lily and bulrush, some cacti, pinyon, and mesquite beans. Low desert tribes also hunted large and small animals (Kelly 1964, 1976; Kroeber 1976; Kelly and Fowler 1986). Plant materials used to make cordage included sagebrush bark, juniper bark, dogbane, yucca, and nettle. Tule reeds had multiple uses, in such items as balsa rafts, mats, and blankets (Callaway et al. 1986). Present day Moapa Paiutes still use desert fan palms for making baskets, food, and shelter (Moapa Memories 2002). Jimson weed, tobacco, nettle, and red ants are some of the traditional medicines used by Native groups in this region (Zigmond 1986).

Plateau

Because of the arid climate during the period from 12,500 to 8,000 BP, resources in this culture area were concentrated along the margins of rivers and major tributaries. Archaeological sites dating to this period include caves, rock shelters, and open camps. The low frequency of early sites is generally attributed to the low population densities of the highly mobile hunter-gatherers who occupied the Plateau. Stemmed and unstemmed lanceolate projectile points, microblades, cobble tools, scrapers, gravers, and bifaces are common artifacts associated with the period. Although groups engaged in fishing, intensive utilization of riverine resources did not occur until later, when climatic conditions stabilized (Ames et al. 1998; Ames and Maschner 1999).

A gradual increase in moisture from 8,000 to 4,000 BP helped expand the range of sagebrush steppe and stimulate the productivity of root crops across the region. Human groups continued to practice highly mobile subsistence strategies with an increasing reliance on salmon (Chatters and Pokotylo 1998). Other than the addition of large side-notched points, and a decrease in the overall size of projectile points, evidence of atlatl use, the tool kit is similar to that of the preceding period. The appearance of individual or small numbers of pit houses along major drainages signified the rise of semi-sedentary settlement strategies, and hopper mortars and milling stones provide evidence for the increased importance of roots and other plant resources in the diet. Other site types include large open sites lacking evidence of habitations, caves, short-term camps, resource extraction sites, and resource processing sites, generally located farther from the major drainages (Ames et al. 1998).

A cooling climate around 4,000 BP helped to stabilize salmon productivity by restricting the seasonality of the salmon migrations (Butler and Schalk 1986). In response, inhabitants of the Plateau intensified their use of salmon, storing it for year-round consumption, and structuring their subsistence strategies to coincide with seasonal salmon migrations. Semi-permanent villages of various-sized pit houses, and longhouses appearing about 1,500 BP, were located mainly along rivers and major tributaries and occupied during the winter months. Some of the habitations were eventually used for human burials. Camps positioned at strategic resource locales in the uplands and mountains were used on a seasonal basis. Cave sites produce well-preserved wood and fiber artifacts. The adoption of the bow and arrow; specialized fishing technologies including nets, harpoons, and barbed bone points; and the continued presence of grinding and pounding tools are evidence of increasingly complicated subsistence strategies (Ames et al. 1998). Petroglyphs and pictographs, dating as early as 3,500 BP, are most common near the larger settlements on major rivers (Boreson 1998).

The hallmark of northern and southern Plateau cultures is still salmon fishing. For many Plateau groups, plant resources also constitute a large portion of the diet. Significant plant resources utilized by these groups include root crops of camas, bitter root, lomatium, balsamroot, and yellowbells, and various berries. These plant resources have not only provided food, but have also been used for such functions as shelter, clothing, basketry, and medicine. Some Plateau groups traditionally burned habitats to enhance the production of usable plant material, including berries (Chatters 1998, Ross 1998).

In the southern Plateau, traditional dwellings were semi-subterranean and constructed from wood and large mats made of tule bulrushes or cattail reeds, sewn together with Indianhemp (Schuster 1998). The main firewoods of the region are Douglas-fir and ponderosa pine, with alder wood preferred for cooking or smoking salmon. Douglas-fir saplings have been used for fish net poles, greasewood twigs for sewing needles, Indianhemp for fishing nets and other weaving purposes, and cattail leaves for weaving bags. Rosewood has been used in cradleboards, and has been hung in homes to repel ghosts. Medicinal and religious plants include mullein, willow bark, and tobacco (Hunn 1990, Hunn and French 1998).

In the northern Plateau, tule reeds and cedar bark were used for covering structures, and tule was also used for matting and bedding, and to shroud corpses. Sources of baskets and bags included birch bark, cedar bark, cedar and spruce roots, and Indianhemp (for cordage). Underground storage casks were made from cottonwood bark, canoes were made from white pine bark, snowshoe frames were made from maple boughs, and mats used to dry salmon were made from willow shoots. Sources of dye included huckleberries and the inner bark of Oregon grape, and sunflower root was used to make shampoo (Kennedy and Bouchard 1998, Miller 1998).

California

The Lake Mojave sites, dating to over 10,000 BP, represent some of the oldest archaeological materials in this culture area. These sites include evidence of big game hunting and gradual expansion into the use of plant resources. Open camp and processing sites suggest that there were few early occupants of the region who maintained a highly mobile subsistence strategy. Artifacts include large, fluted projectile points, lanceolate-shaped points, shouldered points, chipped stone crescents, scrapers, knives, and choppers (Wallace 1978).

Between 8,000 and 7,000 BP, an arid environment caused lakes and marshes to dry, forcing people to adapt to new environments (Moratto 1984). Based on the presence of milling stones, a shift from big game hunting to plant and seed collecting occurred between 8,000 and 5,000 BP. Artifact assemblages are surprisingly homogeneous, consisting mostly of heavy, deep-basined milling and hand stones, with occasional projectile points that were likely used with atlatls (Wallace 1978).

About 5,000 BP, transition began toward a more diversified subsistence economy that included the exploitation of marine and terrestrial resources. Inland sites show evidence of intensive plant processing indicated by the presence of mortars and pestles. Archaeological and climatic evidence from the last 2,000 years indicates that subsistence and settlement patterns in California remained quite stable. Coastal groups relied on marine resources; northern groups relied on riverine resources, especially salmon; central and southern groups relied on lake and marsh resources; and groups throughout the state relied on deer and acorns. The presence of bedrock mortars in the Sierra Nevada foothills indicates continuous use of the same areas. There is also evidence that widespread burning of forests was conducted to stimulate plant growth and provide forage for deer, a universal food source (Driver and Massey 1957, Lewis 1973, Bendix 2002). The earliest petroglyphs appear to correlate with similar ones from the Great Basin dating 3,000 BP, while very elaborate, perhaps ceremonial, pictographs are thought to be no more than 1,000 years old (Clelow 1978).

Coastal groups have long exploited coastal marine and inland oak forest resources, where they collect acorns and hunt large and small game. A variety of plants provide building materials, basketry materials, clothing, and medicine. The redwood tree was used to construct permanent dwellings and large canoes, as well as clothing made from its bark. Juniper and tule were also used to make shelters. Tule reeds are used in basketry (in addition to numerous other plants), boats, clothing, and matting. Materials used to make dyes include green oak galls, burned pepperwood berries, tan oak bark, and alder bark. Medicinal plants include tobacco, angelica, and pepperwood leaf (Loeb 1926, Maxwell 1978).

In the valleys between the Sierra Nevada and coastal ranges, riparian corridors and foothills rich in oak groves provide acorns, a staple diet of many California tribes. Migrating salmon are an important food source, as are berries, bulbs, tubers, and roots. Native groups of the Central Valley and Sierra region hunted waterfowl using snares, nets, arrows, and decoys. Tule growing in wetlands has been an important component of baskets, matting, dwellings, and watercraft. Plants used for cordage and rope include milkweed, Indianhemp, dogbane, and inner willow bark. Medicinal plants include tobacco and horehound (Levy 1978, Wallace 1978).

In the desert region of southeast California, important tribal resources included fish, shellfish, deer, rabbit, rodents, and insects. Additional dietary staples, still used, include wild grass, mescal beans, pinyon seeds and nuts, and mesquite beans, which are ground into flour and made into cakes (Barrows 1900, Kelly 1964, Kroeber 1976).

In the desert region, dwellings were constructed from a wide variety of plants, including juniper, manzanita, greasewood, mountain oak, and mesquite, with tule, carrizo, ferns, bark, or reeds often used for thatching. Plants used for basketry include tule, sumac, squawbrush, and a variety of rushes and grasses. Yucca has been used for cordage. A number of plants were used for clothing and sandals, including the inner bark of willow and cottonwood trees, mescal and yucca fibers, and mesquite bark. Creosote bush and milkweed were used as adhesives, and yucca root has been used to make soap. Among the wide variety of medicinal plants are tobacco, jimson weed, wormwood, creosote, and sumac (Bean and Saubel 1972).

Plains

Human occupation of this culture area dates to at least 11,500 BP. Highly mobile hunters occupied sites on a short-term basis or repeatedly over varying lengths of time. These sites, which were frequently located near water sources, often include finely manufactured fluted, stemmed, or lanceolate points in association with skeletons of extinct game species.

American bison hunting has played a significant role in the subsistence economy of Plains groups throughout prehistory. Additional utilized fauna included elk, mountain sheep, deer, antelope, bear, and various small mammals, as well as fish, freshwater mussels, reptiles, and amphibians. Archaeological evidence indicates that roots, bulbs, berries, fruits, and seeds were collected and often processed using a variety of grinding stones (Frison 2001, Vehik 2001).

Typical artifacts of the period from 8,000 to 2,000 BP include medium-sized lanceolate to large, side-notched projectile points, corner-notched dart points, hide scrapers, milling or grinding stones, coiled basketry, and pottery. Although open campsites (often with fire pits), cave or rockshelter sites, and American bison kill and processing sites are the most common sites, burials, as well as sites containing housepits and/or food cache pits are also documented throughout this period. In addition, the use of teepees, based on the presence of stone circles at cultural resources sites, is evident (Frison 2001, Vehik 2001).

Petroglyphs and pictographs (rock art) date from this period (2,000 to 250 BP), occurring on rock outcrops in the northern and northwestern Plains and southeastern Colorado (Frison 2001, Gunnerson 2001). With the appearance of the bow and arrow in the northwestern Plains about 1,900 BP, hunting became more efficient. The use of teepees by the more nomadic western and northwestern Plains dwellers became very common throughout the period, to the point where some multiple stone circle sites are labeled villages (Frison 2001). By 1,500 BP, farming of maize, beans, squash, and sunflowers was established in the eastern Plains and spread to sedentary groups living in earth lodge villages along the Missouri River (Maxwell 1978; Kehoe 1992; Wedel 1961, 1983; Wedel and Frison 2001; Wood and Irwin 2001).

At the time of European contact, plants used for subsistence by Plains groups included prairie turnip, groundnut, ground bean, sunflower, Jerusalem artichoke, serviceberries, mesquite beans, cacti, camas, and grass seeds. Maize, beans, and squash were also cultivated (Maxwell 1978, Wedel 1983, Wedel and Frison 2001). Following the introduction of horses by the Spanish in the 16th century, subsistence patterns of many Plains groups shifted from sedentary, part-time farming and hunting to mounted hunting heavily focused on the migratory herds of American bison. During the 1700s, pressure from the Europeans generated movements of woodland groups, such as the Sioux, onto the Plains. By the late 1700s, the dependence on plants for subsistence by these groups waned (Maxwell 1978).

Plains groups have used plants for a variety of purposes, in addition to subsistence. Tobacco has been used in religious ceremonies. Cottonwood and willow were used to provide fuel and building materials, and willow has been used for boat frames. Oak, elm, and huckleberry are also high quality building materials, and poles made from pine have been used for teepee frames. Willow, box elder bark, and nettles have been used to make baskets, which are often colored with a black dye derived from walnuts. Medicinal plants of the Plains include mescal beans and sweetgrass. Bowls were made from box elder, and bows from cedar, ash, and hickory. Sage was used to help whiten hides (Brown and Irwin 2001, Voget 2001, Wedel and Frison 2001, Wood and Irwin 2001).

European Settlement Resources

Euro-American contacts with the western U.S and Alaska generally began with exploration or trading, with missionary activities soon following in some of the areas. The earliest exploration occurred in the Southwest and in California in the 1500s, with settlements by the military, missionaries, and colonists in the 1600s in the Southwest, and in the later 1700s in California. In the late 1700s, Spanish, Russian, British, and American exploration and trade extended up and down the West Coast of North America. By the late 1700s and early 1800s, explorers such as Lewis and Clark and fur traders traversed the interior of what is now the western U.S. Table 3-11 shows the types of European settlement resources typically present in the cultural areas.

The discovery and the promise of precious metals first inspired conquest of Native People through treaty and force, then created the market for the development of agriculture, timber, and fisheries, and finally motivated the construction of a transportation system sufficient to transport people and goods. Although furs and precious metals drew the first adventurers, a more permanent settlement of the West in the late 19th and early 20th centuries was related to agriculture. In most of the arid regions of the West agriculture primarily consisted of ranching. During this time, the Homestead Act and other similar programs transferred most of the irrigable land to private ownership, and the adjacent public land was used for grazing livestock by the ranchers who had either homesteaded or purchased those private lands. Beginning about the turn of the 20th century, the federal government reserved tracts of land in the West for management by agencies such as the Forest Service and National Park Service, and, after its formation in the middle of the century, by the BLM. These lands remain in the public domain.

The history of the rural western U.S. encompasses several broad themes and periods including exploration, discovery of the region's mineral wealth, conflict, and settlement, and includes the growth of communities dependent upon resource extraction—farming, ranching, logging, fishing, and mining. These communities were in turn linked to local, regional, and national markets through a complex and evolving system of trails, military roads, wagon roads, rail lines, and navigable river corridors, a trend that continues into the modern period. By the mid-20th century, with the region secured and transportation assured, recreation and tourism increasingly comprised the economic base of western communities, and military training use escalated in response to the training needs of the modern military.

Public lands in the West contain cultural resources representing all major periods and events in the broad sweep of western history. The most common rural manifestations of these dominant themes include transportation resources such as ferry sites, railroads, trails, and roads; military sites (training grounds and battlefields); and mining resources related to exploration (prospect pits), extraction (adits, hydraulic cuts, and quarries), and processing (smelters and mills). Other resources include homesteading, ranching and farming resources (human and animal shelter and irrigation development); fishery resources (boats, fish traps, and weirs); and logging resources (stumpage, sawmills, and human and animal shelter). Evidence of community development includes rural schools, stores, churches, and community centers. Recreation and leisure sites include cabins, resorts, and trail systems.

Important Plant Uses and Species Used by American Indians and Alaska Natives

Although universally important, plant use by Native American and Alaska Native groups is extremely varied, both by region and by group. Subsistence use of such plant products as roots and tubers, stalks, leaves, berries, and nuts is essential to native people. Vegetation also provides habitat for important wildlife species.

Most Native American and Alaska Native groups constructed a variety of residential shelters and other buildings such as ceremonial lodges and sweat houses using a combination of materials, usually employing a locally derived hardwood as part of the structural frame. The frames were then covered with other readily available materials, such as planks, mats, brush, and other materials. Wood has been burned to cook food, warm dwellings, and facilitate toolmaking. Trees have been fashioned into various types of watercraft and terrestrial hauling devices. Various woods have been carved or used to produce utilitarian implements like bowls and spoons, and also ceremonial items, such as pipes and totems, and many other items of material culture.

The use of plants for medicinal purposes is widespread, as is the use of tobacco. Plants such as tobacco, sweet grass, cedar, and sage, have seen important religious and other ceremonial uses. The use of grasses and other plant resources for basket, box, and tool making also can be observed in the cultures of numerous Native American and Alaska Native groups. Plant products also have been used to make textiles, cordage, and matting, as well as to tan hides. The use of plant dyes, paints, and soaps is widespread.

Visual Resources

The public lands administered by the BLM contain many outstanding scenic landscapes. Visual resources in these landscapes consist of land, water, vegetation, wildlife, and other natural or man-made features visible on public lands. Vast areas of grassland, shrubland, canyonland and mountain ranges on public lands provide scenic views to recreationists, visitors, adjacent landowners, and those just passing through. Roads, rivers, and trails on public lands pass through a variety of characteristic landscapes where natural attractions can be seen and where cultural modifications exist. Activities occurring on these lands, such as recreation, mining, timber harvesting, grazing, or road development, for example, have the potential to disturb the surface of the landscape and impact scenic values.

Public lands have a variety of visual (scenic) values which warrant different levels of management. The BLM uses a system called VRM (visual resource management; Manual 8400) to systematically identify and evaluate these values to determine the appropriate level of scenery management (USDI BLM 1984b). The VRM process involves 1) identifying scenic values, 2) establishing management objectives for those values through the land use planning process, and 3) then designing and evaluating proposed activities to analyze

TABLE 3-11
European Settlement Resource Types

Site Type	Examples	Culture Region
Transportation		
River navigation	Fords, cable ferries, and shipwrecks	All
Overland navigation (both railroad and non-railroad)	Trails, wagon roads, truck trails (public and private), engineered features (bridges, trestles, ballast, track, and ties), and construction camps	All
Exploration and Overland Migration		
Trails (most often at topographic restrictions, such as canyons)	Trail ruts (rock) and trail ruts (earth)	All
Geological landmarks with cultural and historical value	Rock promontories, springs, passes, and meadows	All
Inscriptions	Petroglyphs (chiseled inscriptions), pictographs, and carvings on trees	All
Missions	Schools, churches, agricultural plots, orchards, and housing	All
Military		
Battlefields (Indian wars)	Not applicable	All except Alaska
Training grounds	World War I, World War II, Korean War, and Cold War eras	Great Basin and Plateau
Transportation routes	Trails and wagon roads	All
Agriculture		
Ranching and farming	Home ranch facilities (including foundations), outlying buildings and structures, cultural landscape elements (including fences, stock ponds and trails, dams, and river fords), irrigation structures, and archaeological sites	All
Commerce/Urban Development		
Urban settlement	Civic, commercial, and domestic	All
Mining		
Resources associated with extraction	Resources associated with prospecting (locating ore) and development (accessing and removing ore), resources associated with placer mining (sluicing), and lode mining (adits, waste rock, and interior tramways)	All
Resources associated with beneficiation and refining	Mills (various types), smelters, tailing piles, tailing ponds, power plants, and refineries	All
Support facilities	Bunkhouses, mess halls, livestock shelters, and trash dumps	All
Transportation systems	Trails, two-track roads, truck trails, rail lines, and construction debris	All
Logging		
Extraction	Stumps, skid lines, and sky-line cables	All
Processing	Lumber mills and power plants	All
Support facilities	Shingle camps, logging camps, and livestock facilities	All
Transportation	Roads, donkey engines, big wheels, rail lines, and flumes	All
Fisheries		
Extraction (except processing-related and support facilities)	Weirs, fish traps, natural features (falls, eddies), and boats	All
BLM Administration and Development		
Administrative facilities	Buildings (administrative, maintenance, and warehouse) and livestock facilities	All
Interpretation	Museums and interpretive signs	All
Recreation (pre-1934)	Camp sites, developed natural features, summer homes, interpretive signs, roads, and trails	All
Recreation (post-1934)	Campground, developed water source, and roads and trails	All

effects and develop mitigations to meet the established VRM objectives.

The BLM Visual Resource Inventory Handbook (Handbook 8410-1; USDI BLM 1986b) sets forth the procedures for inventorying scenic values and establishing VRM objectives, referred to as Management Classes. A visual resource inventory is informational in nature and does not set forth management direction. A visual resource inventory is based on an analysis of three primary criteria influencing visual values: 1) inherent scenic quality, 2) public sensitivity to landscape change, and 3) distance zones from primary travel ways or special areas. These three criteria are ranked for all acres of public land and a final VRM inventory rating is identified.

These ratings are then used during the land use planning process and considered along with other resource objectives to determine final VRM objectives, or classes. BLM policy requires that every acre of BLM land be inventoried and assigned a VRM class ranging from Class I to Class IV. After VRM classes have been established, Bureau policy requires all management activities to be designed to meet the assigned classes. Class IV allows for the most visual change to the existing landscape, while Class I allows the least (Table 3-12).

The Visual Contrast Rating Handbook (Handbook 8431-1; USDI BLM 1986c) is used to provide an objective and consistent method for describing landscape character, evaluating visual effects of activities, and developing mitigation to meet VRM objectives. The contrast rating process involves describing the landscape in the context of the basic environmental design elements and features that comprise it. The elements of form, line, color, and texture are used when describing and evaluating landscapes. Activities or modifications in a landscape that repeat these elements are thought to be in harmony with their surroundings. Modifications that do not harmonize are said to be in contrast with their surroundings. Visual resource design techniques and best management practices (BMPs) are then used in project development to minimize contrast in order to meet the VRM Class objectives established in the LUP.

Wilderness and Other Special Areas

The BLM manages certain lands under its jurisdiction that possess unique and important historical, anthropological, ecological, biological, geological, and paleontological features. These features include undisturbed wilderness tracts, critical habitat, natural environments, open spaces, scenic landscapes, historic locations, cultural landmarks, and paleontologically rich regions. Special management is administered with the intent to preserve, protect, and evaluate these significant components of our national heritage. Most special areas are either designated by an Act of Congress or by Presidential Proclamation, or are created under BLM administrative procedures.

The National Landscape Conservation System is the primary management framework for these specially designated lands. The NLCS was created in June 2000 by the BLM to bring into a single system some of the agency's premier areas. Of the nearly 261 million acres administered by the BLM, nearly 43 million acres on 867 BLM units are managed under the NLCS program (Map 3-12 and Table 3-13). The NLCS designations include National Monuments, National Conservation Areas, Designated Wilderness and WSAs, National Scenic and Historic Trails, and Wild, Scenic, and Recreational Rivers (USDI BLM 2006d).

Fourteen of the 15 BLM-administered National Monuments are areas designated by the President, under the authority of the Antiquities Act of 1906, for the protection of objects of scientific and historical interest that are located on federal lands. Congress has also created a BLM National Monument on which to conserve, protect, enhance and manage public lands. National Conservation Areas, Cooperative Management and Protections Areas, Outstanding Natural Areas, National Recreation Areas, and Forest Reserves are designated by Congress to conserve, protect, enhance, and manage public land areas for the benefit and enjoyment of present and future generations. These 13 areas, totaling 14 million acres, feature exceptional natural, recreational, cultural, wildlife, aquatic, archeological, paleontological, historical, educational, and scientific resources. Additionally, the White Mountains National Recreation Area in Alaska is approximately 1 million acres and was designated by the Alaska National Interest Lands Conservation Act of 1980. The White Mountains National Recreation Area

TABLE 3-12
Visual Resource Management (VRM) Classes, Objectives, and Appropriate Management Activities

VRM CLASS	Visual Resource Objective	Change Allowed (Relative Level)	Relationship to the Casual Observer
Class I	Preserve the existing character of the landscape. Manage for natural ecological changes.	Very Low	Activities should not be visible and must not attract attention.
Class II	Retain the existing character of the landscape.	Low	Activities may be visible, but should not attract attention.
Class III	Partially retain the existing character of the landscape.	Moderate	Activities may attract attention but should not dominate the view.
Class IV	Provide for management activities which require major modification of the existing character of the landscape.	High	Activities may attract attention, may dominate the view, but are still mitigated.

is managed for multiple uses with an emphasis on recreational uses (USDI BLM 2006c).

National Wilderness Areas, designated by Congress, are defined by the Wilderness Act of 1964 as places "where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain." Designation is aimed at ensuring that these lands are preserved and protected in their natural condition. Wilderness Areas, which are generally 5,000 acres or more in size, offer outstanding opportunities for solitude or a primitive and unconfined type of recreation; such areas may also contain ecological, geological, or other features that have scientific, scenic, or historical value. The BLM manages 175 Wilderness Areas encompassing nearly 7.2 million acres (USDI BLM 2006d).

Wilderness Study Areas have been designated by the BLM as having wilderness characteristics, thus making them worthy of consideration by Congress for wilderness designation. Currently, the BLM manages 610 WSAs encompassing 14.3 million acres. While Congress considers whether to designate a WSA as permanent wilderness, the BLM manages the area to prevent impairment of its suitability for wilderness designation.

National Wild and Scenic Rivers (WSRs) are rivers (or river sections) designated by Congress or the Secretary of the Interior, under the authority of the Wild and Scenic Rivers Act (WSRA) of 1968, to protect remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values and to preserve the river in its free-flowing condition. The law recognizes three classes of rivers—wild, scenic, and recreational. Wild rivers are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and water unpolluted. Scenic rivers are free of impoundments with shorelines or watersheds largely undeveloped, but accessible in places by roads. Recreational rivers are readily accessible by road or railroad, may have some development along their shoreline, and/or may have undergone some impoundment or diversion in the past. The BLM manages all or portions of 38 rivers totaling 2,052 miles as part of the National WSR System (USDI BLM 2006d).

Congress, under the National Trails System Act of 1968, designates areas as National Scenic and Historic Trails. National Scenic Trails offer maximum outdoor recreation potential and provide enjoyment of the various qualities (scenic, historical, natural, and cultural) of the areas through which these trails pass. National Historic Trails are extended trails that follow as closely as possible, on federal land, the original trails or routes of travel with national historical significance. Designation identifies and protects historic routes and their historic remnants and artifacts for public use and enjoyment. A designated trail must meet certain criteria, including having a significant potential for public recreational use or interest based on historical interpretation and appreciation.

The NLCS differs from the National Park System and the National Wildlife Refuge System in several ways. Visitor facilities are often located in adjacent communities, providing local economic opportunities and minimizing new development in the special areas. Traditional land uses, such as livestock grazing, are often permitted in these areas, and the local communities and interested public are encouraged to participate in the planning and management of them. Other special areas managed by the BLM outside of the NLCS framework include Areas of Critical

Environmental Concern (ACEC), Research Natural Areas, National Natural Landmarks, National Recreation Trails, and a variety of other area designations.

The BLM uses the ACEC designation to highlight public land areas where special management attention is necessary to protect and prevent irreparable damage to important historical, cultural, and scenic values; fish or wildlife resources; or other natural systems or processes.

The ACEC designation may also be used to protect human life and safety from natural hazards. The BLM identifies, evaluates, and designates ACECs through its resource management planning process. Allowable management practices and uses, mitigation, and use limitations, if any, are described in the planning document.

Under current guidelines, ACEC procedures also are used to designate Research Natural Areas, Outstanding Natural Areas, and other natural areas requiring special management attention. The National Natural Landmarks Program recognizes and encourages the conservation of outstanding examples of natural history. National Natural Landmarks are designated by the Secretary of the Interior and are the best examples of biological and geological features in both public and private ownership within the U.S. The Recreational Trails Program provides funds to the states to develop and maintain recreational trails and trail-related facilities for both non-motorized and motorized recreational trail uses.

Among these groups, 903 areas comprising nearly 13 million acres are designated as ACECs; 45 areas comprising over 417,000 acres are designated as National Natural Landmarks; and 164 areas comprising over 323,000 acres are designated as Research Natural Areas. An additional 30 million acres fall under various other designations, such as the Lake Todatonten Special Management Area, the Santa Rosa Mountains National Scenic Area, Herd Management Areas, and Globally Important Bird Areas. In addition, there are over 2,950 miles of vehicle routes and trails designated as National Backcountry Byways and National Recreation Trails (USDI BLM 2006b, c).

The BLM also cooperates with the National Park Service in implementing the National Natural Landmark Program as it applies to public lands. The National Park Service, through the National Natural Landmark Program, designates significant examples of the Nation's ecological and geological heritage.

Recreation

Public lands provide visitors with a wide range of recreational opportunities, including hunting, fishing, camping, hiking, dog mushing, cross-country skiing, boating, hang gliding, OHV driving, mountain biking, birding, viewing scenery, and visiting natural and cultural heritage sites. In addition to the recreational opportunities afforded the public by wilderness and other special areas discussed earlier, the BLM administers 205,498 miles of fishable streams, 2.2 million acres of lakes and reservoirs, 6,600 miles of floatable rivers, over 500 boating access points, 300 Watchable Wildlife sites, 55 National Back Country Byways, 5,500 miles of National Scenic, Historic, and Recreational Trails, and thousands of miles of multiple use trails used by motorcyclists, hikers, equestrians, and mountain bikers (USDI BLM 2006c).

The BLM's long-term goal is to provide opportunities to the public for environmentally responsible recreation. Over 4,000 communities with a combined population of 23 million people are located within 25 miles of public lands, and approximately 40% of public lands are located within a day's drive of a major urban area (USDI BLM 2006c).

Most BLM lands are managed as Extensive Recreation Management Areas (ERMAs), where management consists primarily of providing basic information and access. Dispersed recreation occurs in ERMAs, and visitors have the freedom of recreational choice with minimal regulatory constraints. Significant public recreation issues or management concerns are limited in these areas, and nominal management suffices.

Special Recreation Management Areas (SRMAs) are places where special or intensive recreation management is needed. SRMAs include congressionally recognized areas, such as WSRs, parts of the National Trail System, National Recreation Areas, and Wilderness Areas. In addition, administratively recognized areas where issues or management concerns may require special or intensive management are also designated. Areas where visitor use may cause user conflicts, visitor safety problems, or resource damage are also included. These more intensively used areas require direct supervision of recreational activities and of commercial and BLM-regulated recreation operations. Most SRMAs require selective vegetation treatments to protect visitors from hazards and/or adverse effects associated with certain plants, and

TABLE 3-13
National Landscape Conservation System and Other Special Designation Areas on Public Lands as of September 2005

State	National Landscape Conservation System Area														Non-NLCS Area	
	Outstanding Natural Areas, Forest Reserve Cooperative Management and Protection Areas, and National Recreation Areas		National Monuments		National Conservation Areas		Wilderness Areas		Wilderness Study Areas		Wild, Scenic, and Recreational Rivers		National, Historic, and Scenic Trails		Acres of Critical Environmental Concern	
	# of Sites	Acres	# of Sites	Acres	# of Sites[1]	Acres[2]	# of Sites[1]	Acres	# of Sites[1]	Acres	# of Sites	Acres/Miles	# of Sites[1]	Mi[2]	# of Sites	Acres
Alaska	1	998,772	-	-	1	1,208,624	-	-	1	784,238	6	609,280/952	1	418	41	4,545,920
Arizona			5	1,775,017	3	121,277	47	1,396,466	2	63,930	-	-	2	1,003	50	638,110
California	1	7,400	3	291,390	3	10,729,231	76	3,552,665	77	974,769	6	24,800/78	4	1,690	147	3,441,407
Colorado			1	163,892	2	185,773	4	139,524	54	621,737	-	-	-	-	68	648,166
Idaho			1	274,800	1	484,034	1	802	66	1,341,709	-	-	4	1,472	95	580,973
Montana			2	375,027	-	-	1	6,000	40	450,823	1	89,300/149	3	-	43	248,576
Nebraska			-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nevada			-	-	3	1,043,422	38	1,758,613	71	2,877,917	-	-	1	711	36	1,358,234
New Mexico			1	4,124	1	227,100	3	139,281	60	970,532	2	22,720/71	3	60	151	595,001
North Dakota			-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oklahoma			-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oregon	2	428,156	1	52,947	-	-	4	186,723	97	2,337,762	23	254,438/803	3	-	200	894,135
South Dakota			-	-	-	-	-	-	-	-	-	-	-	-	-	-
Texas			-	-	-	-	-	-	-	-	-	-	1	-	-	-
Utah			1	1,870,800	1	-	3	27,720	99	3,260,120	-	-	3	-	59	1,267,389
Washington			-	-	-	-	1	7,140	1	5,518	-	-	-	-	-	-
Wyoming			-	-	-	-	-	-	42	575,841	-	-	6	213	38	696,894
Total	4	1,434,328	15	4,807,997	13	13,999,461	175	7,214,934	610	14,264,896	38	1,005,538/2,052	12	5,567	928	14,914,805

[1] Figures in the number column do not add up to the total shown at the bottom since areas may cross state lines and are reported in the count for each state.
[2] Acreages/miles for multi-state sites are provided only for the state in which the majority of site is located.
Source: BLM Public Land Statistics (USDI BLM 2006d).

replanting of vegetation in highly disturbed areas to improve appearance.

BLM field offices reported 56 million recreational visits to BLM public lands and waters in FY 2005, an increase of nearly 4% from the previous year. The total amount of time spent on public lands, reported as visitor days, was estimated at 66.2 million visitor days, down 5% from the previous year (Table 3-14; USDI BLM 2006d). The greatest number of visitor days occurred in Arizona and California. Overall, developed recreational sites were used about as frequently as non-developed dispersed areas. Recreational use of public lands consists predominately of camping and picnicking, which represented 43% of all visitor days in 2005. Other important recreational activities include non-motorized travel, such as hiking, horseback riding, and mountain biking (10%); off-highway travel (10%); hunting (8%); and viewing public land resources and interpretation and education (6%). The remaining visitor days were associated with driving for pleasure, special events, sports and activities, power and non-power boating, fishing, and swimming. Snow- and ice-based activities, such as cross-country skiing, snowmobiling, and snowshoeing, represented less than 1% of visitor days (USDI BLM 2006c).

Commercial revenues generated by recreation on BLM lands are discussed in the Social and Economic Values section of this chapter.

TABLE 3-14
Estimated Recreation Use of Public Lands during Fiscal Year 2005

State	Number of Visitor Days[1] (thousands)		
	Recreation Sites	Dispersed Areas	Total[2]
Alaska	297	921	1,218
Arizona	7,541	1,776	13,958
California	8,426	8,776	17,246
Colorado	1,637	3,021	4,776
Idaho	1,234	2,847	4,102
Montana, North Dakota, and South Dakota	920	2,528	3,448
Nevada	915	4,644	5,560
New Mexico, Oklahoma, and Texas	581	1,416	1,997
Oregon and Washington	2,015	3,712	5,727
Utah	1,912	3,883	6,226
Wyoming and Nebraska	630	1,258	1,890
Total	26,108	34,782	66,178

[1] One visitor day equals 12 visitor hours.
[2] Includes visitor days for recreation lease sites and recreation partnership sites.
Source: BLM Public Land Statistics (USDI BLM 2006d).

Rights-of-way, Facilities, and Roads

Rights-of-way

Rights-of-way Under FLPMA and the Mineral Leasing Act provisions, the BLM issues ROW grants to authorize the construction, operation, and maintenance of a wide range of projects on public lands. These include petroleum pipelines, electrical transmission lines, telecommunications lines, energy development and distribution facilities, water facilities, communication sites, and roads. Rights-of way for roads, trails, and other infrastructure needs are appropriated for use by the BLM and other federal agencies (e.g., Forest Service, Federal Highway Administration, and Bonneville Power Administration) under Section 507 of FLPMA.

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The length and width of an ROW (and the resulting acreage of public lands) is dependant on a variety of physical and operational factors, including topography, geology, safety, type of use or uses proposed within the ROW, current technology, and access needs. Rights-of-way may also be subject to controls or limitations prescribed by law or identified within BLM land use plans. The BLM encourages the utilization of ROWs in common, where practical, in order to minimize adverse environmental impacts. The BLM land use plans identify ROW corridors for existing and future ROW development.

Rights-of-way are issued for short-term use of public lands or in perpetuity. Right-of-way grants generally include provisions that authorize the holder to manage vegetation within and adjacent to the ROW using methods approved by the BLM. The scope and intensity of vegetation management treatments within ROWs are operationally specific and highly variable. Inspections are conducted at periodic intervals to assess vegetation treatment needs within the ROW. Several techniques are used to manage vegetation in ROW. Preeemergence or postemergence herbicides can be applied to prevent or control young emerging and existing vegetation. Mechanical methods, such as mowing, are also used to eliminate undesirable vegetation. In certain situations, livestock have been used to selectively remove undesirable plant species, in a targeted approach. Vegetation can interfere with ROW site access and facility maintenance, interfere with electric power flow, and pose safety problems for workers and other users of ROW. The development and maintenance of ROW has significant impacts on vegetation. The removal of the existing vegetation during construction activities results in increases in bare ground that can facilitate the introduction and spread of non-native and invasive plant species. The relatively open nature of ROW makes them attractive to many recreationists, including OHV enthusiasts, horseback riders, and hikers. However these activities can also facilitate the spread of invasive species that are present on ROW.

Facilities and Roads

The BLM operates or oversees operation on numerous facilities on public lands. These include oil, gas, geothermal, and mineral exploration and production sites, including over 21,000 production sites; 510 campgrounds, 87 interpretive centers, and other recreational facilities; over 4,300 buildings and 713 administrative sites; over 76,000 miles of roads; and communication facilities (USDI BLM 2006c).

Construction and operations disturbance can often introduce noxious weeds and other invasive vegetation to facility sites and roads. In general, vegetation management at facilities focuses on controlling vegetation that can pose a safety or fire hazard, or is not aesthetically pleasing. In such situations the vegetation is managed using several methods, which can be integrated into an effective management process. Residual herbicides, applied to vegetation before or after emergence, offer extended management in areas where bare ground is required for safety purposes. Mechanical methods, such as mowing, and manual control by hand pulling have been used to manage vegetation along roads, as well as in sensitive areas.

Social and Economic Values

Social/Demographic Environment

The western U.S., including Alaska, is more sparsely populated than the rest of the U.S., containing about 32% of the total U.S. population, but comprising approximately 65% of the total land area. In 2000, over 89 million people lived in this region, with over 50 million in California and Texas, alone (Table 3-15). Population density is relatively low, averaging about 40 people per mi^2, which is half of the national average of nearly 80 people per mi^2. Density ranges from about 1 person per mi^2 in Alaska to over 217 persons per mi^2 in California. Based on 2000 census data, population growth between 1990 and 2000 averaged over 16%, which was slightly higher than the national average. Many of the western states, however, exceeded the national average, with growth rates of 20% or higher during this time period.

Within regions of the western states, mobility patterns of the population were evident. Population declined in rural areas and increased in urban areas. Growth of the western states during this time occurred predominantly in WUI areas, due to expansion of urban population areas into previously rural areas.

The western U.S. contains a large percentage of the nation’s minority populations, including over 60% of the nation’s Hispanics and American Indians, and over 50% of the nation’s Asian/Pacific Islanders. In particular, Arizona, California, New Mexico, and Texas contain large Hispanic populations, which comprise from 25 to over 40% of the total population in each of these states. Over 15% of Alaska’s population is comprised of American Indians.

The age distribution of the population of the western U.S. is similar to the nationwide distribution.

Approximately 27% of the population is under 18 years of age, while about 11% is over 65. Alaska and Utah are slight exceptions, with a higher percentage of people under 18 (over 30%) and a lower percentage of people over 65 (5% and 8%, respectively).

Economic Environment

Employment

Between 1990 and 2000, employment growth in the western U.S. averaged 21%, which slightly exceeded the national average of about 18%. Nevada and Arizona had the most employment growth overall (60% and 42%, respectively) while California and Alaska had below-average employment growth of less than 15%. Most employment growth during this time occurred in the management, professional, and related occupations (26%) and in the service sector (15%), while negligible growth occurred in the manufacturing sector.

In December 2006, the nationwide unemployment rate was 4.5% (Table 3-16). Unemployment rates in the western U.S. exceeded the national average, with the greatest unemployment in Alaska (6.7%), Oregon (5.4%), and Washington (5.0%). The unemployment rate was lowest in Utah (2.6%) and Montana (2.9%; U.S. Department of Labor Bureau of Labor Statistics 2007). Unemployment rates were generally higher for African Americans and Hispanics than other races.

Over 23% of the nation's employment opportunities, amounting to over 40 million jobs, are located in the western U.S. (Table 3-17). Employment in the trade and services industries accounts for over half of the total jobs. Industries related to natural resources, such as agriculture and mining, are important sources of employment and represent nearly one third of the nation's agricultural services, forestry, and fishing jobs. Employment in the government and military sector is higher in Alaska than in other states, accounting for 27% of total jobs versus about 17% overall in the western U.S.

Income

In 2000, the per capita income in the western U.S. was $20,215, which was similar to the national average of $21,690. Per capita income was greatest in Colorado, Washington, Alaska, and California, and lowest in Montana, Idaho, and Utah. In 1999, approximately 12% of the population of the western U.S. lived below the poverty level, which was consistent with the national average. The highest poverty rates occurred in Montana, California, and Arizona, while the lowest rates occurred in Alaska, Colorado, and Utah (U.S. Department of Commerce Bureau of the Census 2004).

In 1999, the highest mean annual income in the western U.S. was paid to individuals employed by the federal government ($63,048), followed by the mining ($57,458), transportation and public utilities ($50,397), and manufacturing ($50,201) sectors. The lowest average income was realized by those working in the agricultural services, forestry, and fishing ($18,845) and retail trade ($20,332) industries (U.S. Department of Commerce Bureau of the Census 2004).

Revenues Generated by BLM Lands

The BLM allows land use for authorized private commercial activities such as energy and mineral commodity extraction, timber harvesting, livestock grazing, recreation, and the development of ROW on public land. Income generated by public land is used to assist state and local governments, support the General Fund of the U.S. Treasury, and offset charges for program operations where certain fees collected can be retained by the BLM. During FY 2005, the BLM collected nearly $1.6 billion from a variety of land uses in the western U.S. (Table 3-18).

Operating revenues from mineral leases and permits totaled $178.3 million in FY 2005 (USDI BLM 2006c). These receipts include rental collections from oil and gas ROW, revenues from developed lands within the Naval Oil Shale Reserve in Colorado, lease rentals and bonus bids from the National Petroleum Reserve in Alaska, and fees related to mining claims, holding fees, and non-operating revenues.

Woodland products are an important commodity and source of revenue generated on public lands. These products include timber; other wood products, such as fuelwood, posts, and poles; and non-wood forest products, such as Christmas trees, cactus, seed, yucca, pinyon nuts, mushrooms, and yew bark. During FY 1997 to 2005, an average of approximately $35 million was generated annually from woodland products harvested from public lands, the majority of which came from timber sales. The average volume of timber harvested annually between 1997 and 2005 was approximately 30 million cubic feet. The revenue generated from timber sales has generally decreased over the past 8 years, from $83.6 million in 1997 to $36.1 million in 2005 (USDI BLM Public Land Statistics 1997-2006).

TABLE 3-15
Population, Age Distribution, and Race in the Western States and Alaska

State	Population 2000 (thousands)	Percent Change from 1990	Density (per mi^2)	Age Distribution		Percent of Hispanic Origin	Percent of Both Hispanic and Non-Hispanic Origin					
				Percent Under 18	Percent Over 65		Caucasian	African American	American Indian	Asian/Pacific Islander	Other	More than 1 Race
Alaska	627	12.3	1.1	30.2	5.4	4.1	69.3	3.5	15.6	4.5	1.6	5.4
Arizona	5,131	28.6	45.2	26.5	12.6	25.3	75.5	3.1	5.0	1.9	11.6	2.9
California	33,877	12.1	217.2	27.2	10.1	32.4	59.5	6.7	1.0	11.2	16.8	4.7
Colorado	4,301	23.4	41.5	25.5	9.2	17.1	82.8	3.8	1.0	2.3	7.2	2.8
Idaho	1,294	22.2	15.6	28.4	10.7	7.9	91.0	0.4	1.4	1.0	4.2	2.0
Montana	902	11.4	6.2	25.3	12.5	2.0	90.6	0.3	6.2	0.6	0.6	1.7
Nebraska	1,711	8.4	22.3	26.3	13.6	5.5	89.6	4.0	0.9	1.3	2.8	1.4
Nevada	1,998	39.9	18.2	25.5	10.6	19.7	75.2	6.8	1.3	4.9	8.0	3.8
New Mexico	1,819	16.7	15.0	27.8	11.2	42.1	66.8	1.9	9.5	1.2	17.0	3.6
North Dakota	642	0.5	9.3	24.9	13.5	1.2	92.4	0.6	4.9	0.6	0.4	1.2
Oklahoma	3,460	9.7	50.3	25.9	13.2	5.2	76.2	7.6	7.9	1.5	2.4	4.5
Oregon	3,421	16.9	35.6	24.6	12.2	8.0	86.6	4.6	1.3	3.2	4.2	3.1
South Dakota	755	7.8	9.9	26.5	13.1	1.4	88.7	0.6	8.3	0.6	0.5	1.3
Texas	20,852	22.8	79.6	28.2	9.9	32.0	71.0	11.5	0.6	2.8	11.7	2.5
Utah	2,233	22.9	27.2	32.0	8.2	9.0	89.2	0.8	1.3	2.4	4.2	2.1
Washington	5,894	17.4	88.6	25.6	10.6	7.5	81.8	3.2	1.6	5.9	3.9	3.6
Wyoming	494	8.1	5.1	25.9	11.0	6.4	92.1	0.8	2.3	0.7	2.5	1.8
United States	281,422	11.6	76.6	25.6	11.7	12.5	75.1	12.3	0.9	3.7	5.5	2.4
Western States	89,406	16.5	40.5	27.1	10.5	24.9	70.7	6.5	1.9	6.0	11.4	3.6
Percentage of Total U.S.	31.8	-	-	33.7	28.5	63.2	29.9	16.7	68.3	50.3	66.3	46.7

Source: U.S. Department of Commerce Bureau of the Census (2004).

TABLE 3-16
Percent Unemployment for Western U.S. and Alaska

State	Year		
	1990	2000	December 2005
Alaska	7.0	6.6	6.7
Arizona	5.5	3.9	4.1
California	5.8	4.9	4.8
Colorado	5.0	2.7	4.0
Idaho	5.9	4.9	3.2
Montana	6.0	4.9	2.9
Nebraska	2.2	3.0	3.1
Nevada	4.9	4.1	4.4
New Mexico	6.5	4.9	3.8
North Dakota	4.0	3.0	3.2
Oklahoma	5.7	3.1	3.8
Oregon	5.6	4.9	5.4
South Dakota	3.9	2.3	3.2
Texas	6.3	4.2	4.5
Utah	4.3	3.2	2.6
Washington	4.9	5.2	5.0
Wyoming	5.5	3.9	3.0
United States	5.6	4.0	4.5

Source: U.S. Department of Labor Bureau of Labor Statistics (2007).

Ninety percent of income from the sale of timber and other vegetative materials is derived from Oregon and California and Coos Bay (Oregon) Wagon Road Grant Lands. Timber harvest levels on these lands are guided by the direction of the Northwest Forest Plan. Timber sales on other public lands include sales from salvage timber and forest health projects.

Grazing fees are derived using a formula established in the *Public Rangelands Improvement Act of 1978*, which is based on several index factors, including private land lease rates, beef cattle prices, and the cost of production. In 2006, the fee was $1.56 per AUM, down from $1.79 in 2005 (USDI BLM 2006c). Approximately $14.5 million was collected in grazing receipts in 2005. Half of the grazing fees are used by the BLM for rangeland improvements (USDI BLM 2006d).

Fees are charged at many public recreation sites to provide for maintenance and improvement, and include access fees for Entrance Permits, Special Area Permits, Daily Use Permits, Commercial, Competitive, and Group Permits, Leases, and Passports. At other locations, generally those without public facilities, no fees are charged. In FY 2005, nearly 79% of recreational use on public lands, in terms of visitor days, occurred in non-fee areas (USDI BLM 2006d). The BLM also issues special recreation permits to qualified commercial companies and organized groups such as outfitters, guides, vendors, and commercial competitive event organizers who conduct activities on both fee and non-fee lands. Nearly $13.3 million were collected in recreation fees in 2005 (USDI BLM 2006d).

In FY 2005, sales of public land and material, including receipts from the sale of public land, and the sale of vegetative and mineral materials, totaled nearly $1.5 billion, of which nearly $1.2 billion were from the sale of certain public lands in Clark County, Nevada, near the city of Las Vegas, under the *Southern Nevada Public Land Management Act* (USDI BLM 2006c).

In addition to providing revenue for the BLM, all of the major public land activity categories generate economic benefits to the communities and states in which they occur. For example, there are nearly 18,000 grazing leases in force on public lands, supporting over 12.7 million AUMs (Table 3-6). Alaska and Texas have no grazing permits in force. The value of these grazing permits and the acreage they entail vary widely depending on the location, soil characteristics, and precipitation. The availability of public land grazing leases is highly beneficial, if not crucial, to some ranching operations, however, and consequently is very important to many rural communities throughout the West.

Similarly, mineral development is an economic mainstay of many western communities. Table 3-17 illustrates the relative importance to the employment base of mineral extraction, particularly in Arizona, Wyoming and Nevada. Each of these states, plus Alaska, has a much higher percentage of employment in mining/natural resource industry than the average for the West as a whole. This industry sector includes oil and gas, coal, aggregates, and hard rock minerals such as gold and copper. Alaska's oil industry not only supports ongoing employment, it contributes toward minimizing taxes for all state residents and has provided a substantial cash rebate to residents over the years.

The BLM estimated the benefits to local economies from recreation on public lands. These estimates serve as one example of the economic activity that depends on the public land base. Recreational activity provides revenue for local economies through expenditures associated with activities such as hunting, fishing, and wildlife viewing (Table 3-19). In FY 2005, an estimated $3 billion was injected into local economies through these recreation-associated expenditures (USDI BLM 2006c, d). These activities produce indirect financial

TABLE 3-17
Percent Employment by Industry in 2004

State	Agriculture	Mining and Natural Resources	Construction	Manufacturing	Transportation and Public Utilities	Trade (wholesale and retail)	Finance, Insurance, and Real Estate	Services	Government	Other	Total Number (thousands)
Alaska	0.3	3.5	6.5	3.5	20.6	13.8	4.8	7.7	27.4	3.6	301
Arizona	2.7	8.6	8.4	7.2	19.0	15.8	6.8	14.0	17.6	3.7	2,379
California	3.1	0.2	5.8	10.5	18.9	15.5	0.6	15.1	16.4	3.4	14,633
Colorado	2.0	0.7	7.0	7.0	18.7	15.3	7.1	13.9	16.7	4.0	2,186
Idaho	6.5	0.8	7.3	10.3	19.8	16.5	4.6	12.9	19.7	3.1	600
Montana	6.5	1.7	6.5	4.6	20.8	17.0	5.2	8.4	21.4	4.0	410
Nebraska	6.9	0.1	5.3	11.0	21.6	16.1	6.9	10.3	17.8	3.8	917
Nevada	1.4	7.8	10.2	4.0	17.0	14.1	5.4	8.1	14.0	3.0	1,165
New Mexico	2.5	1.9	6.4	4.6	17.3	14.4	4.4	11.4	25.3	3.6	799
North Dakota	8.8	1.1	5.4	7.0	21.3	17.4	5.6	7.1	23.0	4.6	341
Oklahoma	3.3	2.2	4.3	9.7	18.8	15.2	5.7	10.8	20.5	5.0	1,472
Oregon	4.3	0.6	5.3	12.6	19.9	16.4	6.1	11.1	17.0	3.6	1,624
South Dakota	9.2	0.2	5.4	9.9	20.3	17.2	7.2	6.2	19.7	4.2	385
Texas	2.9	1.6	5.9	9.3	20.6	16.4	6.2	11.3	17.7	3.8	9,519
Utah	2.4	0.7	6.8	10.3	19.8	15.7	5.8	12.6	18.0	2.9	1,119
Washington	2.9	0.3	6.3	9.6	19.2	15.8	5.8	11.2	19.3	3.7	2,752
Wyoming	5.5	8.1	8.2	3.8	19.1	14.4	4.1	6.0	25.4	3.7	259
Western U.S.	3.2	0.8	5.8	9.3	19.5	15.8	6.1	12.8	17.6	3.6	40,861

Source: U.S. Department of Labor Bureau of Labor Statistics (2004).

benefits to community businesses providing food, lodging, equipment sales, transportation, and other services. State fish and wildlife management agencies also benefit from spending associated with these activities from sources such as state tax revenue and state administered fishing and hunting license programs.

Expenditures by the BLM

The budget for the BLM was $1.78 billion in FY 2006, and is projected to be $1.8 billion in FY 2007 (USDI BLM 2006c). In FY 2006, $848 million was allocated to management of lands and resources (Table 3-20). These expenditures included integrated management of public land, renewable and cultural resources, fish and wildlife, threatened and endangered species, recreation, and energy and minerals.

Wildland Fire Management

While the amount budgeted for wildland fire management may be relatively consistent from year to year, the cost of fighting fires has varied substantially. The USDI allocated $800 million to wildland fire management for FY 2006 for all USDI fire efforts (USDI BLM 2006c).

Table 3-21 shows the BLM's fire suppression expenditures for recent years. The variability often results from changing weather, but terrain, vegetation, and proximity to populated areas all contribute to the cost of fighting a fire.

The cost of fire suppression also depends on the number and size of fires. Approximately 95% of wildland fires are controlled in the initial attack, when they are relatively small and not yet seriously out of control. Table 3-22 illustrates the acreage lost to large fires (greater than 10,000 acres) in recent years. Notably, there were relatively few large fires in 2001 and 2003, which likely contributed to reduced suppression expenditures in those years. 2004 was an anomaly in that costs remained relatively low despite an extremely large acreage lost to fire. The most likely reason is that

TABLE 3-18
Revenues Generated from Public Lands by Source for Fiscal Year 2005

State	Mineral Leases	Timber Sales	Land and Material Sales	Grazing Fees	Recreation Fees	Other[1]	Total
Alaska	$64,139,369	$17,490	$202,736	$0	$260,115	$801,390	$65,421,100
Arizona	91,485	2,675	2,509,213	769,358	1,217,641	1,828,752	6,419,124
California	220,665	1,605,477	1,388,651	267,679	3,347,666	2,815,390	9,645,528
Colorado	15,499,973	38,502	640,191	617,622	424,138	667,176	17,887,602
Idaho	31,700	558,581	218,056	1,622,749	579,963	828,918	3,839,967
Montana	2,517,912	610,113	139,909	2,039,872	307,467	221,436	5,836,709[2]
Nebraska	0	0	0	1,510	0	0	1,510
Nevada	130,948	6,441	1,240,628,540	2,101,628	2,140,736	4,838,503	1,249,846,796
New Mexico	957,739	14	3,739,748	2,174,496	396,957	721,915	7,990,869
North Dakota	2,172	0	1,573	18,731	0	2,460	24,936
Oklahoma	13,834	0	0	236	0	0	14,070
Oregon	14,861	23,507,514	271,822	1,278,627	1,980,602	1,322,489	28,375,915
South Dakota	201	33,428	1,018	174,142	0	4,601	213,390
Texas	634	0	0	0	0	0	634
Utah	129,034	25	586,121	1,136,093	2,155,660	656,863	4,663,796
Washington	84	10,455	28,165	51,906	0	18,028	108,638
Wyoming	851,335	23,070	1,622,279	2,285,227	218,650	1,026,460	6,027,021
Other	93,700,388[3]	0	0	0	0	0	93,700,388
Total	178,302,334	26,413,785	1,252,024,986	14,539,876	13,029,595	115,754,381	1,498,906,604

[1] Includes fees and commissions, ROW rents, rent of land, and other sources.
[2] Includes Land Utilization Project land purchased by the federal government under Title III of the Bankhead-Jones Farm Tenant Act and subsequently transferred to the USDI.
[3] Includes mining claim and holding fees and non-operating revenue.
Source: BLM Public Land Statistics (USDI BLM 2006d).

TABLE 3-19
Estimated Benefits to Local Economies by Recreation on Public Lands during Fiscal Year 2005

State[1]	Fishing Expenditures	Hunting Expenditures	Wildlife Viewing Expenditures	Total
Alaska	$116,425,359	$22,158,084	$80,372,999	$218,956,442
Arizona	17,251,493	45,326,644	154,080,147	216,658,284
California	54,815,364	82,363,747	411,761,577	548,940,688
Colorado	74,107,778	154,416,602	98,545,120	327,069,500
Idaho	44,282,994	72,746,698	66,800,278	183,829,970
Montana	13,377,194	23,635,550	33,670,436	70,683,180
Nevada	43,973,306	101,344,319	193,650,554	338,968,179
New Mexico	21,802,203	27,218,884	106,404,864	155,425,951
Oregon	60,958,338	140,939,262	219,081,863	420,979,463
Utah	46,208,009	92,412,855	245,410,668	384,031,532
Washington	1,876,536	2,044,106	5,274,085	9,194,727
Wyoming	10,459,904	39,947,204	85,394,947	135,802,055
Total	505,538,478	804,553,955	1,700,447,538	3,010,539,971

[1]Estimates include only states with more than 75,000 acres of public lands. No estimates were made for Nebraska, North Dakota, Oklahoma, South Dakota, and Texas.
Source: BLM Public Lands Statistics (USDI BLM 2006d).

TABLE 3-20
Summary of BLM Jobs and Expenditures for the Management of Lands and Resources Program by Activity and Subactivity (dollars in thousands)

Activity/Subactivity	2005 (Actual)		2006 (Enacted)	
	FTE[1]	Amount	FTE[1]	Amount
Management of Lands and Resources	6,287	$836,826	6,138	$847,632
Land Resources	1,493	188,014	1,456	187,613
Soil, Water, Air	246	34,738	240	33,838
Range Management	6,880	69,183	658	69,870
Forest Management	72	8,895	75	10,404
Riparian Management	195	21,228	190	22,124
Cultural Resources	130	14,925	127	15,015
Wild Horse and Burros	170	39,045	166	36,362
Wildlife and Fisheries	298	36,947	302	40,480
Wildlife Management	197	25,063	202	28,166
Fisheries Management	101	11,884	100	12,314
Threatened and Endangered Species	176	21,144	171	21,254
Recreation	553	60,589	548	65,131
Wilderness Management	145	16,431	141	16,559
Recreation Resource Management	408	44,158	407	48,752
Resource Protection	536	81,501	527	84,358
Energy and Minerals	1,009	106,631	993	108,157
Realty and Ownership	731	92,624	710	88,978
Transportation Facilities and Maintenance	426	77,813	395	76,646
Workforce Organization and Support	626	142,161	611	144,446
Alaska Minerals	15	3,944	11	2,263
Other[2]	663	25,458	639	27,306

[1] Full Time Equivalent.
[2] Includes Communications Sites Management, Mining Law Administration, Land Resources Information Systems, Challenge Cost Share, and Reimbursable programs.
Source: USDI BLM (2006c).

nearly all of the large fires that year were in Alaska, and several were sufficiently remote, or in such rugged terrain, that they were allowed to burn without a major effort to control them.

Hazardous Fuels Reduction

Reducing the hazardous fuels available to sustain a wildland fire can be costly. The USDI treated 542,568 acres in the WUI during 2005 at an average cost of $244 per acre. Treatment can cost up to $5,000 per acre for labor-intensive, small, mechanical treatments in forested WUI areas. During the same year, the USDI treated 726,835 acres in non-WUI areas at a cost of about $104 per acre (USDI BLM 2006c).

Weed Management

Herbicides and other vegetation management methods are employed to control invasive plant species, which have caused a variety of problems on public lands. The Vegetation section of this chapter addresses several major types of weed infestations on public lands. As Duncan and Clark (2005) noted, "The economic impact of most (weed) species is poorly documented. This is generally due to the lack of quantitative information on ecosystem impacts and the challenge of assessing non-market cost such as those to society and the environment (e.g., changes in fire frequency, wildlife habitat, aesthetics, loss of biodiversity)."

Expenditures for herbicides used on BLM land are a relatively small part of the agency's budget, accounting for only a little more than $2.7 million in FY 2005 (Table 3-23). Table 3-23 includes only the cost of the chemicals; labor and equipment costs for herbicide application are in addition to the costs shown. The BLM estimated it spent $9.6 million to treat approximately 205,000 acres ($47 per acre) to treat weeds during FY 2005; These costs included herbicide, labor, and equipment costs. The cost of herbicides can vary dramatically, depending on the type selected and the method of application. Costs can also vary significantly by geographic region, vendor, type of chemical (generic versus branded), and size and terrain of the application target area. The Forest Service estimated the average cost per acre at $100 for ground applications and $25 for aerial applications (USDA Forest Service 2005). The BLM's range of estimated application costs is even broader. For ground applications, BLM's estimates range from $50 to $300 per acre for backpack or ATV applications and $25 to $75 per acre for boom sprayer applications. Aerial applications are estimated at $6 to $40 per acre for fixed-wing aircraft and $25 to $200 per acre for helicopter applications.

TABLE 3-21
BLM Wildland Fire Suppression Expenditures Fiscal Year 1998 through Fiscal Year 2005

Fiscal Year	Expenditure	Percent Change from Prior Year
1998	$ 63,470,000	NA
1999	85,724,000	35.1
2000	228,394,000	166.4
2001	192,115,000	-15.9
2002	204,666,000	6.5
2003	151,994,000	-25.8
2004	158,626,000	4.4
2005	218,445,000	39.7

NA = Not applicable
Source: USDI BLM (2006c).

It is estimated that downy brome infests over 56 million acres in the 17 western states and that the infestation is growing at 14% per year (Duncan and Clark 2005). As indicated in Table 3-5, more than 90 million acres of public lands are infested with downy brome and other brome species. Downy brome can increase the frequency and intensity of wildfire and destroy the structure of the native plant communities, particularly sagebrush habitats. Because of its widespread dominance, downy brome has become the most important forage grass in the western U.S. However, it is highly unreliable as a forage base for both cattle and wildlife because it can exhibit "tenfold differences (300-3,500 lbs/acre) from year to year" in productivity, depending on precipitation.

Once a treatment is accomplished, it is then costly to rehabilitate the land. Cost per acre to stabilize and rehabilitate disturbed land is estimated at $17. During 1991, however, it cost $100,000 to rehabilitate the 1,700 acres burned in the Snake River Birds of Prey Area, Idaho, or almost $59 per acre. During 2004, it cost the BLM $1,640 per acre to restore 12,000 acres of forestland and woodlands. The unit cost ranged from $295 per acre in New Mexico to $2,730 per acre in Oregon (USDI BLM 2005a).

TABLE 3-22
BLM Action Fires Larger than 10,000 Acres[1] during 1999 to 2005

Calendar Year	Number of Fires	Average Size (acres)	Total Acreage
1999	64	44,990	2,879,351
2000	66	34,851	2,300,187
2001	28	40,524	1,134,662
2002	46	55,484	2,552,265
2003	23	55,940	1,286,612
2004	51	122,805	6,263,059
2005	98	68,277	6,691,137
Total	376	61,455	23,107,273

[1] Fire Type 1 - All protection types.
Source: USDI BLM (2007c).

Payments to State and Local Governments

Where the federal government maintains public land, it makes payments to state and local governments for a variety of purposes. Receipts from coal leases and bonus payments, for example, are shared. Payments in lieu of taxes help address the loss of potential local tax income that could have been generated from those public lands if they were in private ownership. Payments in lieu of taxes, as well as other forms of transfer payments, are generally set by law and provided according to a formula. Payments in lieu of taxes, for example, are computed based on the number of acres of public lands within each county and multiplied by a dollar amount per acre. Over $2 billion in payments have been made since 1976. Table 3-24 shows the BLM payments to states and local governments for FY 2004.

Human Health and Safety

Background Health Risks

This section discusses background information on human health risks of injuries, and cancer and other diseases for people living in the states in which the BLM is planning to implement vegetation treatments. People living in these states are exposed to a variety of risks common to the U.S. as a whole, including

TABLE 3-23
Herbicide Uses and Costs for Vegetation Treatments on Public Lands during 2005

Herbicide	Type of Application	Acres Treated[1]	Total Herbicide Expenditure[2]	Cost per Acre for Herbicide[2]
2,4-D	Aerial Ground	1,689 40,133	$5,474 186,515	$3.24 4.65
Bromacil	Aerial Ground	0 2,999	0 379,763	NA 126.63
Chlorsulfuron	Aerial Ground	374 2,667	35,572 51,836	95.11 19.44
Clopyralid	Aerial Ground	5,168 6,277	169,510 268,032	32.80 42.70
Dicamba	Aerial Ground	48 7,664	945 150,245	19.69 19.60
Diuron	Aerial Ground	0 4,427	0 72,340	NA 16.34
Fosamine	Aerial Ground	0 0	0 0	NA NA
Glyphosate	Aerial Ground	11,032 8,309	25,648 56,487	2.32 6.80
Hexazinone	Aerial Ground	0 4,952	0 3,138	NA 0.63
Imazapic	Aerial Ground	0 45	0 1,309	NA 29.10
Imazapyr	Aerial Ground	1,203 1,788	151,340 105,619	125.80 59.07
Metsulfuron methyl	Aerial Ground	663 14,129	5,529 178,208	8.34 12.61
Picloram	Aerial Ground	4,158 28,385	67,497 629,897	16.23 22.19
Sulfometuron methyl	Aerial Ground	0 304	0 7,741	NA 25.46
Tebuthiuron	Aerial Ground	40,755 0	47,427 0	1.16 NA
Triclopyr	Aerial Ground	4,000 3,170	23,750 85,966	5.94 27.12

[1] Acres treated do not take into account whether the aerial application was by helicopter or airplane, nor do they distinguish between ground application methods. Costs would vary depending on the application method.
[2] Total herbicide expenditure and cost per acre do not include costs for labor, equipment, and application, and represent an average cost for use throughout the BLM.
NA = Not available or not applicable.

automobile accidents and other injuries; contaminants in the air, water, soil, and food; and various diseases. Risks to workers may differ from those facing the general public, depending on the nature of a person's work. Some of these risks may be quantified, but a lack of data allows for only a qualitative description of certain risks. Where data are only available for the U.S. as a whole, it is assumed that these data apply to the treatment states. Information for this section was obtained from the Centers for Disease Control and Prevention (CDC), the National Center for Injury Prevention and Control (NCIPC), the National Center for Health Statistics (NCHS), the National Institute for Occupational Safety and Health (NIOSH), and the Bureau of Labor Statistics.

TABLE 3-24
BLM Payments to States and Local Governments during Fiscal Year 2005

State	Payments in Lieu of Taxes	Mineral Leasing Act	Taylor Grazing Act[1]			Proceeds of Sales	Other	Total Payments
			Section 3	Section 15	Other			
Alaska	$15,785,027	$29,559	$0	$0	$0	$5,412	$31,594,5953[3]	$47,414,593
Arizona	19,233,774	45,743	43,124	79,669	0	107,081	0	19,509,331
California	19,002,175	122,757	14,012	55,755	0	45,359	0	19,240,058
Colorado	16,839,759	129,557	53,520	30,062	43,068	29,640	0	17,125,606
Idaho	15,871,144	15,850	167,896	22,898	0	18,051	0	16,095,839
Montana	17,188,322	18,056	128,785	95,678	0	20,175	649,745[4]	18,100,761
Nebraska	676,604	0	0	664	0	0	0	677,268
Nevada	13,732,723	65,445	233,458	705	0	824,000	204,497,479[5]	219,353,810
New Mexico	22,386,899	475,204	170,502	135,900	14	88,389	8,269[4]	23,265,177
North Dakota	950,280	1,086	0	7,921	0	67	0	959,354
Oklahoma	1,600,788	13	0	68	0	0	11,946[6]	1,612,815
Oregon	6,428,257	7,678	131,630	23,405	0	46,661	113,338,900[7]	119,976,531
South Dakota	2,566,411	100	0	67,435	0	2,600	0	2,636,546
Texas	2,595,410	317	0	0	0	0	0	2,595,727
Utah	19,622,224	55,319	104,868	0	0	15,337	0	19,797,748
Washington	6,322,087	42	0	22,367	0	5,378	0	6,349,874
Wyoming	14,810,769	413,269	145,697	327,446	6,924	78,040	0	15,782,145
Western States	195,612,593	1,379,995	1,193,49	869,973	50,006	1,286,190	350,100,934	550,493,183
All States	226,356,675	1,379,995	1,193,49	869,973	50,006	1,286,458	350,100,934	581,237,533

[1] Payments in lieu of taxes are made by the USDI, Office of the Secretary, for tax-exempt federal lands administered by the BLM, National Park Service, USFWS, and Forest Service, as well as for federal water projects and some military installations.
[2] Including payments for FY 2004 that were processed in FY 2005.
[3] National Petroleum Reserve – Alaska lands.
[4] Land utilization lands under the Bankhead-Jones Farm Tenant Act (7 U.S.C. 1012).
[5] Land utilization sales under the Southern Nevada Public Land Management Act resulted in direct payments at the time of sale totaling $193,566,000. Calendar year payments to Clark County and the State of Nevada under the Santini-Burton Act totaled $3,784,080.
[6] Oklahoma royalties.
[7] Payments from Oregon and California grant lands and Coos Bay Wagon Road grant land counties.
Source: USDI BLM (2006c).

Risks from Diseases

Disease Incidence

Despite the difficulties in establishing correlations between work conditions and disease, certain illnesses have been linked to occupational hazards. For example, asbestosis and lung cancer among insulation and shipyard workers has been linked to their exposure to asbestos (NIOSH 2002). Pneumoconiosis among coal miners has been correlated with the inhalation of coal dust. Occupational exposures to some metals, dusts, and trace elements, as well as CO, carbon disulfide, halogenated hydrocarbons, nitroglycerin, and nitrates, can result in increased incidence of cardiovascular disease. Neurotoxic disorders can arise from exposure to a wide range of chemicals, including some pesticides. Dermatological conditions like contact dermatitis, infection, trauma, cancer, vitiligo, uticaria, and chloracne have a high occurrence in the agricultural, forestry, and fishing industries.

Disease Mortality

Mortality rates for states in the BLM treatment area are listed in Table 3-25. The five most common causes of death in the U.S., as well as in the treatment states, are heart disease, cancer, stroke, respiratory disease, and accidents (Minino et al. 2002). Counties in the western U.S. that have the highest mortality rates are located in central Nevada, north and south-central California, and western Montana. Mortality rates are generally lowest in counties in western Utah, central Idaho, and northwest Wyoming (NCHS 2007). Mortality rates for males are nearly one and a half times those as for females, and mortality rates for African Americans are nearly one and a half times those of Caucasians (NCHS 2007).

TABLE 3-25
Mortality Rates (per 100,000 population) and Causes of Death by State 2002-2003

State	Cause of Death				
	All[1]	Diseases		Cancer	Accidents
		Cerebrovascular and Cardiovascular Disease	Chronic Respiratory Disease		
Alaska	825.8[2]	245.1	23.2	108.7	54.4
Arizona	787.4	252.7	47.1	172.3	46.6
California	775.1	291.6	37.5	155.8	23.5
Colorado	787.8	234.9	41.4	138.7	38.8
Idaho	798.0	269.8	44.0	158.5	43.3
Montana	840.3	255.5	64.4	216.0	51.7
Nebraska	793.5	298.6	51.3	197.0	36.8
Nevada	922.6	312.2	54.2	181.9	35.2
New Mexico	825.4	253.0	42.3	158.4	55.7
North Dakota	775.9	271.3	48.4	218.5	37.4
Oklahoma	959.7	363.7	55.4	213.6	49.0
Oregon	825.6	261.1	49.7	203.2	37.8
South Dakota	784.8	270.6	51.2	212.7	47.1
Texas	877.8	318.9	23.0	101.5	28.2
Utah	776.8	241.6	49.8	203.8	37.5
Washington	792.9	268.4	70.7	260.1	46.3
Wyoming	851.7	265.6	54.7	186.9	55.1
United States	864.8	305.7	43.2	194.4	35.7

[1]Age-adjusted death rate per 100,000 population, which accounts for changes in the age distribution of the population.
Source: NCHS (2007).

Risks from Injuries

Injury Incidence

In 2005, more than 29.3 million nonfatal injuries were reported in the United States, 4.4 million of which were transportation related (CDC 2007). Injuries accounted for 26% of emergency department visits during 2004 (NCHS 2007).

The rate of hospitalizations for injury is significantly higher among elderly persons than among all other age groups (CDC 2005). The NIOSH estimates that approximately 10 million traumatic work-related injuries occur annually. Some chronic injuries may be directly linked to the nature of the work performed. For example, vibration syndrome affects a large proportion of workers using chippers, grinders, chainsaws, jackhammers, or other handheld power tools, causing blanching and reduced sensitivity in the fingers. The Bureau of Labor Statistics reported that in 1995, an estimated 62% of all work-related illness cases were due to musculoskeletal disorders associated with repeated trauma, such as that associated with the use of power tools (NIOSH 1997). Noise-induced hearing loss may also affect production workers who are exposed to noise levels of 80 decibels or more on a daily basis.

Acute trauma at work remains a leading cause of death and disability among U.S. workers. During the period from 1980 through 1995, at least 93,338 workers in the U.S. died as a result of trauma suffered on the job, with an average of about 16 deaths per day (NIOSH 2001). The *Census of Fatal Occupational Injuries Summary* by the BLS (U.S. Department of Labor Bureau of Labor Statistics 2004) identified 5,559 workplace deaths from acute traumatic injury in 2003. Occupational fatalities resulted from a number of causes, including motor vehicle accidents, machines, falls, homicide, electrocution, and being struck by falling objects (NIOSH 2002).

The occupational fatality rate in 2005 was approximately 4.0 fatalities per 100,000 employed. Fatality rates were highest for the agriculture, forestry, fishing, and hunting; mining; transportation; and construction industries. The fatality rate for the agriculture, forestry, fishing, and hunting sector was the highest, at 32.5 fatal industries per 100,000 workers. The mining sector had the second highest rate, at 25.6

fatalities per 100,000 employed. In the transportation and construction industries the rates were 17.6 and 11.0 fatalities per 100,000 employed, respectively. The largest number of fatal work injuries resulted from construction-related incidents, which accounting for 21% of workplace fatalities in 2003 (U.S. Department of Labor Bureau of Labor Statistics 2004).

Injury Mortality

Over 167,000 Americans died from injuries nationwide in 2004. About 26% of these resulted from motor vehicle accidents, while other accidental deaths occurred from unintentional falls, drowning, and poisoning (CDC 2007). Injury is the leading cause of death and disability among children and young adults.

Risks from Cancer

Cancer Incidence

Nationwide, the chance of developing some form of cancer during one's lifetime is estimated to be about one in four (Calabrese and Dorsey 1984). There are many causes of cancer development, including occupational exposure to carcinogens, environmental contaminants, and substances in food. In the U.S., one-third of all cancers are attributed to tobacco smoking (Chu and Kamely 1988). Work-related cancers are estimated to account for 4% to 20% of all malignancies. It is difficult to quantify the information because of the long time intervals between exposure and diagnosis, personal behavior patterns, job changes, and exposure to other carcinogens. The NIOSH has reported that approximately 20,000 cancer deaths and 40,000 new cases of cancer each year in the U.S. are attributable to occupational hazards. Millions of U.S. workers are exposed to substances that have tested as carcinogens in animal studies (NIOSH 2002).

Cancer Mortality. Based on the data shown in Table 3-25, cancer accounted for between 13 and 33% of all deaths in the treatment states in 2002-2003. Nationwide, cancer account for approximately 23% of all fatalities (NCHS 2007). Cancer mortality rates are generally highest in counties in western and southern Nevada and northern California and lowest in counties in Utah, central Colorado, and northern New Mexico (Devesa et al. 1999), and differ depending on race and sex. Generally, males have higher rates of cancer mortality than females, and African Americans have higher rates than Caucasians.

Risk from Using Herbicides on Public Lands

Based on the BLM's injury breakout report (USDI BLM 2005b), only one minor injury from use of herbicides was recorded during FY 2005.

Risk from Wildfire Control on Public Lands

During FY 2005, 24,683 fires totaling 6,691,137 acres were suppressed on public lands. Over three out of every four fires were caused by lightning, while the remainder were caused by humans. Approximately 56% of fires occurred on forestlands, the remainder on rangelands and other land types (USDI BLM 2006d).

Wildfires cause the loss of life and property. According to the National Interagency Fire Center (2005), 12 people died from wildland fire-related accidents in 2005. From 1999 to 2005, the leading cause of firefighter deaths nationally, which include federal, state, and local firefighters and volunteers, as well as private individuals who were involved in direct support of wildland fire operations are: vehicle accidents (23.8%), heart attacks (22.7%), aircraft accidents (22.3%), and burnovers/entrapments (20.2%).

During FYs 2002 to 2005, 49 USDI personnel were injured conducting fire operations. During 2005, wildland fires resulted in the loss of 240 primary residences and 750 total structures on lands near BLM- or Forest Service-administered lands (USDI BLM 2006c).