Contents

Appendix F: Methodologies and Supplemental Materials for Analysis of Affected Environment and Environmental Effects of Solar Energy Development on Resources

This appendix provides detailed information on the methodologies and data sources used to assess the potential environmental impacts of solar energy development in this Programmatic environmental impact statement (PEIS). The assessments of the affected environment and potential impacts of utility-scale solar energy development on resources present in the 11-state planning area were conducted for photovoltaic (PV) solar technologies and for development of related infrastructure. The assessments were conducted at a general level (i.e., not site-specific) and were intended to describe the resources present and the broadest possible range of impacts for individual PV solar energy facilities, associated transmission facilities, and other offsite infrastructure related to the different phases of development. The assessments are presented in Chapters 4 and 5, while proposed design features to avoid, minimize, or compensate for impacts are presented in Appendix B. The impact analyses presented in Chapter 5 provided a basis for the design features.[1]

Assumptions on the capacities and areas of solar facilities were based on the BLM's updated definition of utility-scale (any facility greater than or equal to 5 MW nameplate capacity). The range of capacities in megawatts (MW) analyzed for solar energy facilities was 5 to 750 MW (see discussion in Section 3.1.2). The BLM occasionally has received applications for facilities with even higher capacities. Because of the modular nature of PV facilities the land and water use of larger facilities is proportional to their capacities, so impacts for facilities larger than 750 MW can be estimated using values given in Table 3.1-2 on a per-megawatt basis. On the basis of these assumptions, and assuming that 8 acres/MW of land would be required, the maximum area of land disturbance for single facilities would be about 6,000 acres for a 750-MW facility.

Construction and operation of transmission lines to tie solar energy facilities into the main power grid would be required for most new solar energy facilities. The location of the tie-in to the transmission grid would likely be the nearest existing transmission line with sufficient uncommitted capacity to accept power from the facility (or with the ability to be upgraded to sufficient capacity). Analysis of the impacts of transmission line construction and of line upgrades is included in Chapter 5 of this PEIS.

Other offsite infrastructure that might be needed to support solar facility development could include water pipelines (if water for construction and/or operations were being obtained from an offsite source) and natural gas pipelines (if natural gas were required at the facility in large quantities). For water pipelines, the impacts of construction with respect to land disturbance were not assessed in the Programmatic EIS because, if offsite water sources would be used, the locations of these sources are unknown at this time. Similarly, the impacts of pipeline construction for natural gas were not assessed,

[1] The BLM also evaluated comments received during scoping process (summarized in Chapter 6) in developing the alternatives and design features.

because such pipelines are not expected to be needed for most solar facility development (solar facilities are not expected to use natural gas in significant quantities), and because locations and lengths of pipelines are not predictable at the programmatic level. Thus, if new water or gas pipelines are needed for solar facility development, the impacts of construction and operation of these pipelines will need to be assessed at the project-specific level.

In the following sections, the methods used for evaluation, supplemental information for Affected Environment analyses, and supplemental information for Environmental Effects analyses are presented for each resource and concern area (i.e., acoustic environment, hazardous materials and wastes, health and safety, military and civilian aviation, wildland fire).

F.1 Acoustic Environment

F.1.1 Methods Used for Evaluation

The information presented in the affected environment section was derived from standard references, such as the Acoustical Society of America, the U.S. Environmental Protection Agency, the National Wind Coordinating Committee for noise, and the Federal Transit Administration for vibration.

No site-specific information is available because the location of a PV facility site is not known at the Programmatic EIS level, so screening-level analysis was performed based on available and widely-used information. Noise and vibration analyses were done for site preparation, which is typically the noisiest phase over the life of a PV project.

For noise impact assessment, it was conservatively assumed that the noise level at 50 ft (15 m) from the noise sources (e.g., construction site) would be about 95 dBA, which is the same as the level if either ten dozers or ten pieces of various heavy construction equipment are operating simultaneously, for example. Considering geometric spreading and ground effects, as explained Section F.1.2.1, two distances from the noise sources are estimated using the formula in Section F.1.3: 1) attenuated to 40 dBA, typical of daytime rural background levels; and 2) attenuated to the EPA guideline level of 55 dBA L_{dn} for residential areas, assuming a 10-hour daytime work schedule.

Ground-borne vibration related to human annoyance is related to root mean square (rms) velocity levels, expressed in VdB as described in Section F.1.3. For vibration impact analysis, vibration source levels for typical and upper-range sonic pile drivers of 93 and 105 VdB were conservatively assumed. In fact, vibratory pile drivers have become a preferred choice in the construction industry due to low noise and vibration outputs. To assess the vibration-related impacts, the distance at which the vibration level from a piece of equipment diminishes below the threshold of perception of 65 VdB for humans was estimated.

F.1.2 Supplemental Material for Affected Environment

F.1.2.1 Noise Propagation Analysis

Several important factors affect the propagation of sound in the outdoor environment (Anderson and Kurze 1992):

- *Source characteristics,* such as sound power, directivity, and configuration;
- *Geometric spreading* as the sound moves away from the source, which does not depend on frequency. Specifically, 6- and 3-dB reductions are observed per doubling of distance for point (e.g., fixed equipment) and line (e.g., road traffic) sources, respectively;
- *Atmospheric absorption,* which depends strongly on frequency and relative humidity, somewhat on temperature, and slightly on pressure;
- *Ground effects,* which are the result of interference between sound traveling directly from source to receiver and sound reflected from the ground when both source and receiver are close to the ground;
- *Meteorological effects* due to turbulence and variations in vertical wind speed and temperature; and
- *Screening effects* by topography, structures, dense vegetation, and other natural or man-made barriers.

Among the factors listed above, meteorological effects due to vertical wind speed and temperature profiles are likely the most important in noise propagation over longer distances (say, beyond several hundred meters from the noise sources). Because of surface friction, wind speed typically increases with height, which will bend the path of sound downward to “focus” it on the downwind side and upward to make a “shadow” on the upwind side of the source (“wind gradient effect”).[2] Also, on a typical clear, sunny day, temperature tends to decrease with height due to solar heating on the ground, the condition known as “temperature lapse.” Similar to the wind gradient effect, upward refraction of sound creates a “temperature gradient effect” shadow zone. Conversely, on a clear night with calm or low winds, temperature increases with height due to radiative cooling of surface air. This nocturnal temperature inversion is the strongest in winter months due to a longer nighttime period. Temperature inversions can cause downward refraction to create enhanced sound fields near a noise source, particularly because there would be little, if any, shadow zone within 1 or 2 mi (1.6 or 3.2 km) of the source in the presence of a strong temperature inversion (Beranek 1988). Temperature gradient effects are exerted omnidirectionally from the source, in contrast to wind gradient effects, which are limited to mostly upwind and downwind areas.

A refined noise analysis would employ a sound propagation model that integrates most of the sound attenuation mechanisms noted above along with detailed source-, receptor-, and site-specific data, such as land use, topography, and meteorology. However, in many screening-level applications, only geometric spreading or geometric spreading combined with ground effects is considered when predicting noise levels.

[2] A shadow zone is defined as the region where direct sound does not penetrate because of upward diffraction.

This method assumes a simplified uniform (isothermal) atmosphere with no wind, which is unusual for typically changing atmospheric conditions. For a temperature lapse condition typical of daytime, sound levels would be about 5 dB lower than those for the uniform condition (Saurenman et al. 2005). For a temperature inversion condition typical of nighttime, sound levels would be about 5 to 10 dB higher than those for the uniform condition. Around sunrise, when temperature inversion is the strongest, sound levels would be about 10 to 15 dB higher (but noise-producing operations at solar energy facilities are anticipated to occur only rarely at this time of day).

F.1.2.2 Noise Regulations/Ordinances

In general, quantitative noise-level regulations are specified in one of the following ways (Alberts 2006):

- Specifying a single all-encompassing maximum limit;
- Determining preexisting ambient noise levels and specifying that a new noise source may not increase the ambient noise by more than a particular amount;
- Setting a base limit, with adjustments for district types and time of day or night; or
- Specifying maximum sound levels for each octave range.

Table F.1.2-1 lists the maximum permissible noise levels for Colorado by land use zone and by time of day, similarly to those for Oregon and Washington. None of the other states have statewide quantitative noise standards (NPC 2023). In California, however, the state requires each municipality and county to have a Noise Element of the General Plan, a substantial noise database and a blueprint for making land use decisions in that jurisdiction (State of California 2017). State land use compatibility criteria for the community noise environment presented in terms of L_{dn} or CNEL are used to identify the noise levels that are compatible with various types of land uses. The Noise Element of the General Plan contains goals and policies to support land use planning that will allow the jurisdiction to ensure that these criteria are met for various land uses. Note that state rules and regulations and city/county ordinances can be found in NPC 2023 or their respective web sites.

Table F.1.2-1. Colorado Limits on Maximum Permissible Noise Levels

Zone	Maximum Permissible Noise Level (dBA)[a]	
	7 am to 7 pm[b]	7 pm to 7 am
Residential	55	50
Commercial	60	55
Light industrial	70	65
Industrial	80	75

[a] At a distance of 25 ft or more from the property line. Periodic, impulsive, or shrill noises are considered a public nuisance at a level 5 dBA less than those tabulated.
[b] The tabulated noise levels may be exceeded by 10 dBA for a period not to exceed 15 minutes in any 1-hour period.
Source: 2020 Colorado Revised Statutes, Title 25 “Public Health and Environment,” Article 12 “Noise Abatement,” Section 25-12-103 “Maximum Permissible Noise Levels.”

F.1.2.3 Countywide Noise Levels

To provide noise levels associated with general community activities over the 11 western states, countywide day-night average sound levels (L_{dn} or DNL) are estimated based on population density (Miller 2002):

$$L_{dn} \text{ (dBA)} = 22 + 10 \log_{10}(\rho)$$

where ρ = population density (people per mi^2)

Estimated L_{dn} levels based on 2021 U.S. Census Bureau population data (USCB 2021) are presented for the 11-state planning area in Figure F.1.2-1. In the 11-state planning area, about 59% of wilderness natural background areas and 29% of counties in rural areas have day-night average sound levels less than 35 and 35 to 45 dBA, respectively (Cavanaugh and Tocci 1998). As might be expected, higher sound levels greater than 55 dBA occur in the counties with significant urban/suburban populations, such as Denver, Los Angeles, and San Francisco.

F.1.3 Supplemental Material for Impacts Assessment

There are various mechanisms of sound attenuation in ambient air, as presented in Section F.1.2.1. For a screening-level noise impact analysis, only geometric spreading and ground effects are considered. Sound pressure level (L_p) at a receiver location is estimated using the following formula (Quagliata et al. 2018):

$$L_p = L_{pref} - (20 + 10\ G) \log_{10}(D/D_{ref})$$

where:

- L_p = sound pressure level at a given distance, dBA;
- L_{pref} = sound pressure level at a reference distance, dBA;
- G = ground factor, unitless (see below);
- D = distance from the equipment to the receiver, ft; and
- D_{ref} = reference distance, ft; typically 50 ft.

G value depends on ground type (acoustically soft or hard) and effective path height, which is the average of source height and receptor height. For acoustically hard ground conditions (e.g., asphalt), G should be assumed to be zero. For acoustically soft ground conditions (e.g., vegetation-covered ground), G value ranges from 0 to 0.66, depending on the effective path height. Note that larger ground factor means larger amounts of ground attenuation with increasing distance from the source.

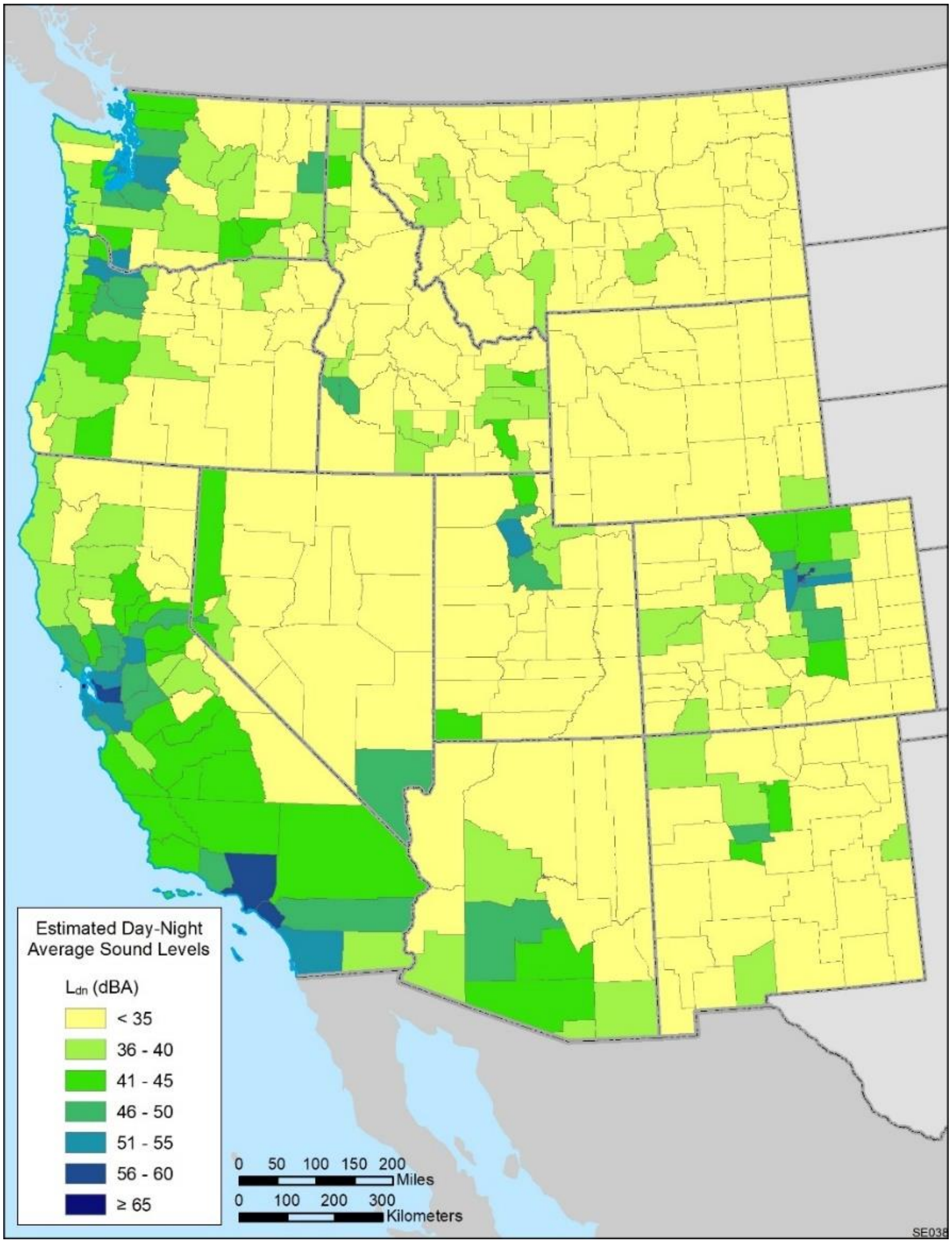


Figure F.1.2-1. Day-Night Average Sound Level (L_{dn}) by County, Estimated on the Basis of Population Density (L_{dn} data based on the formula in Miller 2002; population data from USCB 2021)

For vibration impact analysis, annoyance assessment is made for each piece of equipment individually. Ground-borne vibration related to human annoyance is related to root mean square (rms) velocity levels (L_v), expressed in vibration decibels (VdB), similar to airborne sound in dB. Along with source reference vibration level, the vibration level (L_v) at a receiver location is estimated using the following formula (Quagliata et al. 2018):

$$L_v = L_{vref} - 30 \log_{10}(D/25)$$

where:

L_v = the rms velocity level adjusted for distance, VdB;
L_{vref} = the source reference vibration level at 25 ft, VdB; and
D = distance from the equipment to the receiver, ft.

F.2 Air Quality and Climate Change

F.2.1 Methods Used for Evaluation

The information presented in the affected environment section was derived from the federal, state, or international agencies' reports/references: the National Centers for Environmental Information (NCEI), the National Renewable Energy Laboratory (NREL), and the Western Regional Climate Center (WRCC) for meteorology; the U.S. Environmental Protection Agency (EPA) and 11-state environmental agencies for air quality; and the EPA, the Intergovernmental Panel on Climate Change (IPCC), the International Energy Agency (IEA), the NCEI, the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Global Change Research Program (USGCRP) for climate change. The affected environment description included climate by state, solar energy resource map, and meteorological data summaries (percent of possible sunshine, temperatures, precipitation) and wind roses at selected locations for meteorology; statewide air emissions for criteria pollutants and VOCs, the National/State Ambient Air Quality Standards (NAAQS/SAAQS), nonattainment area maps, and general conformity for air quality; and recent IPCC findings, historic climate change at the national and state levels, and statewide GHG emissions for climate change. No site-specific information is available because the specific locations of future PV facilities on BLM-administered lands is not known at the Programmatic EIS level. Thus, air quality modeling related to both construction and operation of a PV facility was not performed because the site-specific information such as soil conditions, topography, and meteorological conditions is not known. Site-specific assessments would be made during the ROW application process to assess the potential severity of these impacts and develop appropriate mitigation measures.

The reduction or displacement of electricity generation in fossil fuel–fired power plants by electricity from PV facilities could reduce overall emissions of combustion-related pollutants. During operations, air pollutant emissions displaced by operation of a hypothetical PV facility were estimated for both criteria pollutants (NO_X and SO_X) and GHG (CO_2, CH_4, and NO_2 along with CO_2e). To gain some perspective on the potential for reductions, these emissions were compared with total emissions from electricity generation and from all sources over the 11-state study area.

Per CEQ guidance, to provide accessible comparisons or equivalents, GHG emissions displaced by PV electricity generation are contextualized in more familiar terms. Techniques may include placing a proposed action's GHG emissions in more familiar metrics such as household emissions per year, annual average emissions from a certain number of cars on the road, or gallons of gasoline burned. In addition, monetized benefits estimates using social cost of GHG (SC–GHG) values were also presented.

For cumulative impacts analysis, GHG emissions associated with all stages of the solar life cycle (including manufacturing, materials transportation, construction, installation, maintenance, and decommissioning and dismantlement) were compared with those for other energy technologies, such as natural gas- and coal-fired electricity generation. In addition, these life cycle emissions were compared with displacement of fossil fuel GHG emissions by PV electricity generation to see the monetary benefits from operations of PV facilities.

F.2.2 Supplemental Material for Affected Environment

F.2.2.1 Meteorology

General meteorological conditions for each state, extracted from historic climatic information issued by the Western Regional Climate Center (WRCC 2023), are briefly described below, followed by a summary of percent of possible sunshine, temperature, precipitation, and wind patterns across the 11-state area.

F.2.2.1.1 Description of Climate by State

Arizona. Arizona has three main topographic areas: (1) a mountainous region oriented southeast to northwest; (2) a high plateau in the northeast; and (3) lower mountain ranges and desert valleys in the southwest. A large portion of Arizona is classified as desert or semiarid. The air is generally dry and clear, with low relative humidity (annual averages ranging from 55% at Flagstaff to 33% at Yuma) and a high percentage of sunshine (annual averages ranging from 86 to 92%). Sometimes, cold air masses from Canada penetrate into the state and bring temperatures well below zero (a lowest record of –35°F [–37°C]) in the high plateau and mountainous regions of central and northern Arizona. High temperatures are common throughout the summer months at the lower elevations, and the highest temperature of 125°F (52°C) was observed in the desert area. Great temperature extremes occur between day and night throughout Arizona with daily ranges as large as 50 to 60°F (28 to 33°C). The mountainous region averages 25 to 30 in (64 to 76 cm) of precipitation per year, while the desert southwest averages as low as 3 or 4 in (8 or 10 cm) per year. The plateau area receives about 10 in (25 cm) of precipitation per year.

California. Because of the size of California, a latitude span of almost 10 degrees, and complex topography, substantial spatial and temporal variations in climate exist within the state. The easternmost mountain chains form a barrier that protects much of the state from the extremely cold air of the Great Basin in winter. The ranges of mountains to the west offer some protection to the interior from the strong flow of air off the Pacific Ocean. Thus, precipitation is heavy (in excess of 50 in. [127 cm] per year) on the coastal or western side of both the Coast Range and the Sierra Nevada and lighter on the eastern slopes (under 8 in [20 cm] in some areas). Between the two mountain chains and over much of the desert area, hot summers and moderate to cold winters are the rule. Along the coast, the climate is subject to wide variations within short distances because of the influence of topography on the circulation of marine air.

Depending to some extent on the amount of marine influence experienced, temperature ranges become wider. On the coast, temperature ranges are small from day to night and from winter to summer. Higher elevations in the mountains experience large temperature variations. Extreme temperatures have been recorded, from as low as –45°F (–43°C) to as high as 134°F (57°C). Annual precipitation at one station has exceeded 161 in (409 cm), while other locations have gone for more than a year with no measurable rain.

Colorado. Colorado lies astride the highest mountains of the Continental Divide. Colorado has an inland continental location in the middle latitudes, which is characterized by rugged mountain ranges in the west and level-to-rolling prairie in the east. Most of the state experiences a cool and invigorating mountain climate. In the western portion of the state, rugged topography causes large variations in climate within short distances and precludes climatic generalizations. The highest temperature can reach 90 to 95°F (32 to 35°C) in the summer, and temperatures on snow-covered mountain peaks and valleys can be as low as –50°F (–46°C). In the eastern plains, the climate is fairly uniform, with characteristic features of low relative humidity, abundant sunshine, light rainfall, moderate to high winds, and a large daily range in temperature. Summer daily maximum temperatures of 95 to 100°F (35 to 38°C) have been recorded, and the highest temperature, exceeding 115°F (46°C), occurred in the northeastern plains. Usual winter extremes are from 0 to –15°F (–18 to –26°C). Precipitation west of the Continental Divide is more evenly distributed throughout the year than in the eastern plains. For most of western Colorado, the greatest monthly precipitation occurs in the winter, while June is the driest month. In contrast, June is one of the wetter months in most of the eastern portions of the state.

Idaho. Located some 300 mi (480 km) from the Pacific Ocean, Idaho is, nevertheless, influenced by maritime air borne eastward on the prevailing westerly winds. Particularly in winter, the maritime influence is noticeable in greater average cloudiness, greater frequency of precipitation, and mean temperatures. Eastern Idaho's climate has a more continental character, a fact quite evident not only in the somewhat greater range between winter and summer temperatures, but also in the dry winter-wet summer pattern (more typical of a continental climate). The pattern of average annual temperatures in Idaho shows the effect of both latitude and altitude. The highest annual averages occur at lower elevations in river basins. At Swan Falls located about 25 mi (40 km) south of Boise, the annual mean temperature is 55°F (13°C), highest in the state. In contrast, at Obsidian located in the central part of Idaho at an elevation of 6,780 ft (2,070 m), the annual mean is 35.4°F (1.9°C), lowest in the state. Temperature extremes can range from –60°F (–51°C) to 118°F (48°C). To a large extent the source of moisture for precipitation in Idaho is the Pacific Ocean. Precipitation patterns are complex and generally heavier in the north than in the south. Sizeable areas receive an average of 40 to 50 in (102 to 127 cm) annually with a few points or small areas receiving in excess of 60 in (152 cm), while other large areas receive less than 10 in (25 cm) annually. Snowfall distribution is affected both by availability of moisture and by elevation. Annual snowfall totals in Shoshone County, which lies on the eastern side of Idaho's northern panhandle, have reached nearly 500 in (1,270 cm).

Montana. The Continental Divide cuts through the western half of Montana in a north-south direction and exerts a strong influence on the climates of adjacent areas. To the west of the Divide, the climate is similar to that on the north Pacific Coast; in the east, the climate is markedly continental. On the west side of the mountain barrier, winters are milder, precipitation is more evenly distributed throughout the year, summers are cooler, and winds lighter than on the eastern side. The west also has more cloudiness and higher humidity. On average, cold waves mostly hit the northeastern parts of the state six to 12 times per winter. In small areas ideally situated for radiation cooling, low temperatures can fall to –50°F (–46°C) or lower, with a record of –70°F (–57°C). Summers can be hot in the eastern part of the state with a record of 117°F (47°C). Temperatures of over 100°F (38°C) sometimes occur at lower elevations west of the Divide during the summer. However, summer nights are generally cool. Precipitation varies widely and is largely influenced by topography. Areas near mountains tend to be wettest, but there are exceptions where the rain shadow effect appears. The western part of the state tends to be wettest, and the north-central area the driest. The average precipitation ranges from 6.6 in (17 cm) to 34.7 in (88 cm). Annual snowfall varies from 20 in (51 cm) in the two northern Divisions east of the Continental Divide to quite heavy, 300 in (762 cm), in some parts of the mountains in the western half of the state.

Nevada. Nevada is predominantly a plateau and lies on the eastern, lee side of the Sierra Nevada Range, a massive mountain barrier that causes air from the west to be warm and dry along with the prevailing westerlies. Prolonged cold weather is rare because mountains east and north of the state act as a barrier to prevent intrusions of extremely cold continental arctic air masses. Nevada has great climatic diversity, ranging from scorching lowland desert in the south to cool mountain forest in the north. Wide daily temperature ranges are caused by strong daytime surface heating and rapid nighttime cooling because of the dry air. The average daily temperature range between the highest and the lowest daily temperatures is about 30 to 35°F (17 to 19°C). The mean annual temperatures range from the middle 40s°F in the northeast to middle 60s°F in the south. Summer temperatures above 100°F (38°C) occur rather frequently in the south, and temperature extremes have ranged from –50 to 120°F (–46 to 49°C). Variation in precipitation is due primarily to differences in elevation and exposure to precipitation-bearing storms. Precipitation is lightest in the lower portions of the western plateau, opposite California's Death Valley and northward to the Idaho border. In valleys in this area, annual precipitation is less than 5 in (13 cm), but reaches about 40 in (102 cm) in the Sierra Nevada. Snowfall is usually heavy in the mountains, particularly in the north, but amounts to near zero in the south.

New Mexico. New Mexico is divided into three major areas by mountain ranges and highlands, running generally in a north-south direction and merging in the north. It has a mild, arid, or semiarid continental climate characterized by light precipitation, abundant sunshine, low relative humidity, and relatively large annual and diurnal temperature ranges. Mean annual temperatures range from 64°F (18°C) in the extreme southeast to 40°F (4°C) or lower in high mountains and valleys of the north. During the summer, daytime temperatures often exceed 100°F (38°C) at elevations below 5,000 ft (1,500 m), but average monthly maximum temperatures range from the upper 70s°F at higher elevations to above 90°F (32°C) at lower elevations. During the winter, minimum temperatures below freezing are common throughout the state; subzero temperatures, however, are rare except in the mountains. The lowest recorded temperature was –50°F (–46°C) and the highest was 116°F (47°C). Average annual precipitation ranges from less than 10 in (25 cm) over much of the southern desert and the Rio Grande and San Juan Valleys to more than 20 in (51 cm) at higher elevations. Arid and semiarid climates are characterized by a wide variation in annual precipitation, as illustrated by annual extremes ranging from 3 to 34 in (8 to 86 cm) at Carlsbad. Average annual snowfall ranges from about 3 in (8 cm) at the Southern Desert and Southeastern Plains stations to well over 100 in (254 cm) at Northern Mountain stations. It may exceed 300 in (762 cm) in the highest mountains of the north.

Oregon. The most important geographic feature affecting Oregon’s climate is the Pacific Ocean on its western border. Temperatures are moderated by the presence of the ocean, which also provides abundant moisture for heavy rainfall in western Oregon and the higher elevations of the western portion of the state because of the normal movement of air masses from west to east. Mountain ranges such as the Coast Range and Cascades also exert a strong influence on the climate. Few states have greater temperature extremes than Oregon where, despite moderating influences, temperature extremes have ranged from –54 to 119°F (–48 to 48°C). However, these extremes are seldom approached. In half of the years studied, no temperatures above 110°F (43°C) were recorded. Here, in January, the average temperature is 45°F (7°C), only 15°F (8°C) below that of July. The normal mean January temperature in southeast Oregon is 25 to 28°F (–4 to –2°C) and in the northeast is 29 to 33°F (–2 to 1°C); July normal means range between 65 and 70°F (18 to 21°C) in the central valleys and plateau regions and 70 to 78°F (21 to 26°C) along the eastern border. Average annual rainfall varies from less than 8 in (20 cm) in drier Plateau Regions to as much as 200 in (508 cm) at places along the western slopes of the Coast Range. Annual average snowfall ranges from 1 to 3 in (3 to 8 cm) along the coast to 40 to 75 in (102 to 191 cm) in the valleys in the northeast.

Utah. The topography of Utah is extremely varied, with most of the state being mountainous. Along with prevailing westerly air masses, a large portion of the original moisture of the Pacific storms falls as precipitation while passing over the mountain ranges in the western United States, such as the Sierra Nevada and Cascade Ranges and the Rocky Mountains. Thus air masses reaching Utah are relatively dry, resulting in light precipitation over most of the state. Utah features a dry, semi-arid to desert climate, although its many mountains feature a large variety of climates. Temperatures vary with altitude and latitude. Temperatures below zero are uncommon in most of the state, and prolonged periods of extremely cold weather are rare. This is primarily because the mountains in the eastern and northern parts of the state act as barriers to intensely cold continental arctic air masses. The lowest temperature on record is –50°F (–46°C). Daily temperature ranges vary widely due to relatively strong daytime insolation and rapid nocturnal cooling. Annual precipitation varies greatly, from less than 5 in (13 cm) over the Great Salt Lake Desert (west of Great Salt Lake) to more than 40 in (102 cm) in some parts of the Wasatch Mountains, which run north-south in the middle of Utah. Snowfall is moderately heavy in the mountains, especially over the northern part of the state. While the principal population centers along the base of the mountains receive a considerable amount snow, a deep snow cover seldom remains long on the ground.

Washington. Washington’s location on the windward coast produces a predominantly marine climate west of the Cascade Mountains, while east of the Cascades, the climate possesses a mix of continental and marine characteristics. There are two eastward orographic liftings of the air: one from the Pacific Ocean to the Cascades and the other from the Inland Basin toward the Rocky Mountains.[3] Warming and drying of air as it descends along the lee (eastern) slopes of the Cascade Range results in near-desert conditions in the lowest section of the Columbia Basin. West of the Cascade Mountains, summers are cool and comparatively dry, and winters are mild, wet, and cloudy. The highest summer and lowest winter temperatures are usually recorded during periods of easterly winds. Measurable rainfall is recorded on 150 days each year with 190 days in the mountains and along the coast. The annual precipitation ranges from approximately 20 in (51 cm) in an area northeast of the Olympic Mountains to 150 in (381 cm) along the southwestern slopes of these mountains. Eastern Washington is part of the large inland basin between the Cascade and Rocky Mountains. East of the Cascades, summers are warmer, winters cooler, and precipitation less than in western Washington. The area experiences a “chinook” wind a few times each winter, which produces a rapid rise in temperature. Annual precipitation ranges from 7 to 9 in (18 to 23 cm) near the confluence of the Snake and Columbia Rivers to 75 to 90 in (178 to 229 cm) near the summit of the Cascades.

Wyoming. The Continental Divide splits Wyoming from near its northwest corner to the center of its southern border. The state’s outstanding topographic features are mountains and high plains. The mountain ranges in the west generally run in a north-south direction, perpendicular to the prevailing westerlies, which provides effective barriers for humid air currents moving in from the Pacific Ocean; the state is semiarid east of the mountains. Because of its average elevation of 6,700 ft (2,000 m), Wyoming has a relatively cool climate. Above 6,000 ft (1,800 m), temperatures rarely exceed 100°F (38°C). The warmest portions of the state are at lower elevations. The highest recorded temperature in the Big Horn Basin is 114°F (46°C), while for most of the state, the mean maximum temperatures in July range between 85 and 95°F (29 and 35°C). However, with increasing elevation, average values drop rapidly. In January, minimum temperatures range mostly from 5 to 10°F (–15 to –12°F) with the record low of –66°F (–54°F) at Yellowstone National Park. Precipitation varies greatly and is greater over the mountain ranges and at higher elevations. In the southwest, annual averages are 7 to 10 in (18 to 25 cm). At lower elevations along the eastern border, annual averages are from 12 to 16 in (30 to 41 cm). The driest portion of the state at the Big Horn Basin has an annual mean precipitation of 5 to 8 in (10 to 20 cm), and only a few locations receive as much as 40 in (102 cm) of precipitation per year. Total annual snowfall varies considerably. At lower elevations in the east, the range is from 60 to 70 in (152 to 178 cm). Over the drier southwest portion, amounts vary from 45 to 55 in (114 to 140 cm) Snow is very light in the Big Horn Basin with annual averages from 15 to 40 in (38 to 102 cm). The higher ranges receive snowfall well over 200 in (508 cm), e.g., about 262 in (665 cm) in the southwest corner of Yellowstone.

---

[3] Orographic lifting occurs when air is forced to rise and cool due to terrain features such as hills or mountains. If the cooling is sufficient, water vapor in the air can condense and cause extensive cloudiness or precipitation in higher terrain.

F.2.2.1.2 Overview Across the Study Area

Sunshine, temperature, and precipitation in the 11-state study area vary widely with elevation, latitude, season, and time of day. Table F.2.2-1 presents historical percentages of possible sunshine, temperatures, and precipitation at selected locations throughout the 11-state study area (NCEI 2023a).[4] The percentage of possible sunshine ranges from upper 40s in humid northwestern states to upper 80s in arid southern states. Annual average temperatures range from low 40s°F to mid-70s°F. Monthly temperature extremes range from a low of –1.1°F (–18.4°C) in Alamosa, Colorado, to a high of 106.5°F (41.4°C) in Phoenix, Arizona. Las Vegas, Nevada, averages only 4.2 in (11 cm) of precipitation each year, compared with 39.3 in (100 cm) in Seattle, Washington. Some cities in Arizona and California, including Phoenix and Los Angeles, have no recorded snowfall, while Flagstaff, Arizona (which is about 120 mi [190 km] north of and 5,700 ft [1,700 m] higher than Phoenix), has about 7.5 ft of snowfall (230 cm) a year.

The predominant prevailing wind aloft in the study area is from the west, as in most of the United States. However, surface winds are greatly modified by topographic features, vegetation, and large water bodies. The wind roses presented for selected locations in Figure F.2.2-1 demonstrate the variation in surface winds over the 11-state study area (NCEI 2023b). As shown in the figure, the prevailing wind directions vary from site to site, and the distribution of wind frequencies between the various directions is also highly site-dependent. The figure also shows substantial variation in wind speeds, ranging from 6.1 mph (2.7 m/s) in Phoenix to 11.4 mph (5.1 m/s) in Cheyenne. Low wind speeds or calms are associated with conditions of poor atmospheric dispersion. Of the 12 stations shown, four—Helena, Las Vegas, Phoenix, and Portland —have calms more than 20% of the time. On the other hand, Cheyenne, Wyoming, and Denver, Colorado, have calms less than 10% of the time.

Wind Rose

A *wind rose* summarizes wind speed and direction graphically as a series of bars pointing in different directions. The direction of each bar shows the direction *from* which the wind blows. Each bar is divided into segments, which represent wind speeds in a given range—for example, 1.1 to 4.7 mph (0.5 to 2.1 m/s). The length of a segment represents the percentage of the summarized hours that winds blew from the indicated direction with a speed in the given range.

[4] Defined as the percentage of time between sunrise and sunset that sunshine reaches the ground.

Table F.2.2-1. Percentage of Possible Sunshine, Temperature, and Precipitation at Selected Meteorological Stations in the 11-State Study Area

State	Station	Percent Possible Sunshine (%)[a]	Temperature (°F)[b,c]			Annual Precipitation	
			Daily Minimum[e]	Daily Maximum[e]	Mean	Water Equivalent (in)[b,d]	Snowfall (in)[b,d]
Arizona	Flagstaff	78 (15)	16.9	82.0	46.8	20.52	90.1
	Phoenix	86 (11)	45.3	106.5	75.6	7.22	0.0
	Tucson	85 (52)	40.5	101.2	70.6	10.61	0.1
California	Bakersfield	NA[f]	39.6	98.3	66.2	6.36	0.1
	Bishop	NA	22.1	99.7	57.3	4.84	6.8
	Los Angeles	NA	49.1	76.7	63.6	12.33	0.0
	Redding	88 (10)	37.2	99.9	63.4	33.52	2.6
	Sacramento	78 (47)	38.5	92.6	61.8	18.14	0.0
	San Diego	68 (56)	49.8	77.3	64.7	9.79	0.0
	San Francisco	NA	44.5	74.8	58.7	19.64	0.0
Colorado	Alamosa	NA	-1.1	83.3	42.3	7.39	27.6
	Denver	NA	18.4	89.9	51.2	14.48	50.8[g]
	Grand Junction	71 (56)	17.3	94.5	53.2	9.06	17.7
Idaho	Boise	64 (60)	25.4	92.7	53.2	11.51	17.6
	Lewiston	NA	29.5	90.8	53.8	12.87	12.7
	Pocatello	64 (54)	17.1	89.3	47.0	11.82	38.5
Montana	Billings	60 (56)	17.9	87.3	48.2	14.31	57.4
	Great Falls	61 (46)	15.0	84.3	44.6	14.76	66.1
	Helena	60 (55)	13.5	86.1	45.5	11.40	37.2
New Mexico	Albuquerque	76 (63)	26.4	91.2	57.9	8.84	7.9
	Clayton	NA	21.4	90.0	54.3	16.12	22.3
	Roswell	74 (7)	28.1	96.5	63.2	11.63	9.6
Nevada	Elko	NA	15.4	91.8	47.8	9.99	41.2
	Las Vegas	85 (47)	39.6	104.5	70.1	4.18	0.2
	Reno	79 (45)	25.7	93.9	55.0	7.35	20.9
Oregon	Burns	NA	15.5	88.7	46.0	10.41	34.0
	Medford	NA	32.5	91.6	55.9	18.43	3.4
	Portland	48 (46)	36.2	82.3	55.1	36.91	4.3
Utah	Salt Lake City	66 (64)	24.2	94.0	54.7	15.52	51.9
Washington	Seattle	47 (30)	37.1	77.6	53.7	39.34	6.3
	Spokane	52 (48)	24.3	84.4	48.6	16.45	45.4
	Yakima	NA	23.1	89.9	50.8	8.01	20.3
Wyoming	Cheyenne	66 (64)	18.1	84.1	46.9	15.41	62.9
	Lander	68 (50)	9.8	87.7	45.1	13.23	87.6
	Sheridan	63 (55)	11.7	87.8	45.4	14.93	71.4

[a] Numbers in parentheses represent period of record in years.

[b] Based on climate normals as 30-year averages (1991–2020).

[c] To convert °F to °C, use the following formula: °C = (°F – 32) ´ 5/9.

[d] To convert in to cm, multiply by 2.54.

[e] "Daily Minimum" denotes lowest monthly average of the daily minimum, which normally occurs in either January or December. "Daily Maximum" denotes the highest monthly average of the daily maximum, which normally occurs in July.

[f] NA = data not available.

[g] Based on 2006–2022 data; Snowfall data are unavailable for Denver for the period of 1991–2020.

Source: NCEI (2023a).

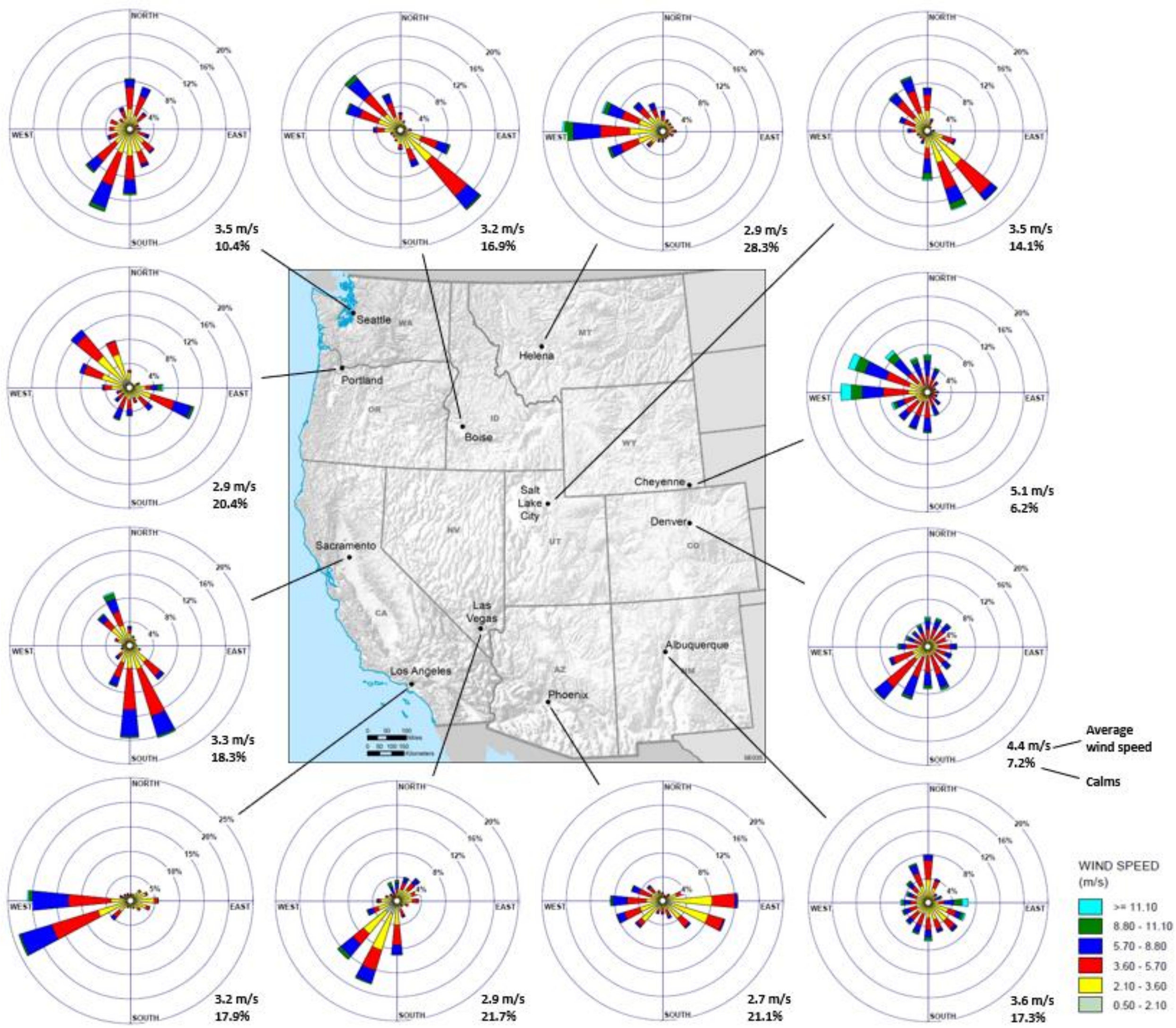


Figure F.2.2-1. Wind Roses for Selected Meteorological Stations in the 11-State Study Area, 2018 to 2022 (Source: NCEI 2023b)

F.2.2.2 National and State Ambient Air Quality Standards

National Ambient Air Quality Standards (NAAQS) and State Ambient Air Quality Standards (SAAQS) are shown in Table F.2.2-2. Note that Arizona, Idaho, and Utah have no SAAQS for six criteria pollutants, although Idaho has standards for fluorides.

Table F.2.2-2. National Ambient Air Quality Standards (NAAQS) and State Ambient Air Quality Standards (SAAQS) for Criteria Pollutants in the 11-State Study Area[a,b]

Pollutant[c]	Averaging Time	NAAQS[d]		California[e]	Colorado	Montana[f]	Nevada[g]	New Mexico[h]	Oregon[i]	Washington	Wyoming
		Primary	Secondary								
CO	1-hour	35 ppm	–[j]	20 ppm (23 mg/m^3)	–	23 ppm	35 ppm (40,500 μg/m^3)	13.1 ppm	35 ppm	35 ppm (40 mg/m^3)	35 ppm
	8-hour	9 ppm	–	9.0 ppm (10 mg/m^3) 6 ppm (7 mg/m^3)[k]	–	9 ppm	9 ppm (10,500 μg/m^3)[l] 6 ppm (7,000 μg/m^3)[m]	8.7 ppm	9 ppm	9 ppm (10 mg/m^3)	9 ppm
Pb	30-day	–	–	1.5 μg/m^3	–	–	–	–	–	–	–
	Calendar quarter	–	–	–	–	1.5 μg/m^3	–	–	0.15 μg/m^3	–	–
	Rolling 3-month	0.15 μg/m^3 [n]	0.15 μg/m^3 [n]	–	–	–	0.15 μg/m^3	–	–	0.15 μg/m^3	–
NO_2	1-hour	100 ppb	–	0.18 ppm (339 μg/m^3)	–	0.30 ppm	100 ppb	–	0.100 ppm	100 ppb	100 ppb
	24-hour	–	–	–	–	–	–	0.10 ppm	–	–	–
	Annual	53 ppb	53 ppb	0.030 ppm (57 μg/m^3)	–	0.05 ppm	0.053 ppm (100 μg/m^3)	0.05 ppm	0.053 ppm	53 ppb (100 μg/m^3)	53 ppb
O_3	1-hour	–	–	0.09 ppm (180 μg/m^3)	–	0.10 ppm	0.10 ppm (195 μg/m^3)[p]	–	–	–	–
	8-hour	0.070 ppm [o]	0.070 ppm [o]	0.070 ppm (137 μg/m^3)	–	–	0.070 ppm	–	0.070 ppm	0.070 ppm	70 ppb
$PM_{2.5}$	24-hour	35 μg/m^3	35 μg/m^3	–	–	–	35 μg/m^3	–	35 μg/m^3	35 μg/m^3	35 μg/m^3
	Annual	12.0 μg/m^3	15.0 μg/m^3	12 μg/m^3	–	–	12.0 μg/m^3	–	12 μg/m^3	12.0 μg/m^3	12 μg/m^3/ 15 μg/m^3 [q]
PM_{10}	24-hour	150 μg/m^3	150 μg/m^3	50 μg/m^3	–	150 μg/m^3	150 μg/m^3	–	150 μg/m^3	150 μg/m^3	150 μg/m^3
	Annual	–	–	20 μg/m^3	–	50 μg/m^3	–	–	–	–	50 μg/m^3
SO_2	1-hour	75 ppb[r]	–	0.25 ppm (655 μg/m^3)	–	0.50 ppm	75 ppb	–	0.075 ppm	75 ppb	75 ppb
	3-hour	–	0.5 ppm	–	700 μg/m^3 (0.267 ppm)	–	0.5 ppm (1,300 μg/m^3)	0.50 ppm[s]	0.50 ppm	0.5 ppm	–
	24-hour	–	–	0.04 ppm (105 μg/m^3)	–	0.10 ppm	0.14 ppm (365 μg/m^3)	0.10 ppm 0.14 ppm[s]	0.10 ppm	0.14 ppm	–
	Annual	–	–	–	–	0.02 ppm	0.030 ppm (80 μg/m^3)	0.02 ppm 0.03 ppm[s]	0.02 ppm	0.02 ppm	–

[a] States with no SAAQS for criteria pollutants, e.g., Arizona, Idaho, and Utah, are not listed in this table. However, the State of Idaho has standards for fluorides; also refer to IDEQ (2023) for fluorides.

[b] Detailed information on attainment determination criteria for NAAQS/SAAQS and reference method for monitoring is available in the references listed below.

[c] CO = carbon monoxide; NO_2 = nitrogen dioxide; O_3 = ozone; Pb = lead; $PM_{2.5}$ = particulate matter ≤2.5 μm; PM_{10} = particulate matter ≤10 μm; SO_2 = sulfur dioxide.

[d] Primary standards provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly; Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

[e] The State of California has standards for additional pollutants such as visibility-reducing particles, sulfates, hydrogen sulfide, and vinyl chloride, which are not presented in this table; also refer to CARB (2016) for additional pollutants.

[f] The State of Montana has standards for additional pollutants such as fluoride in forage, hydrogen sulfide, settleable PM, and visibility, which are not presented in this table; also refer to MDEQ (2021) for additional pollutants.

[g] The State of Nevada has standard for additional pollutant, such as hydrogen sulfide, which is not presented in this table; also refer to NDEP (2023) for additional pollutant.

[h] The State of New Mexico has standards for additional pollutants such as hydrogen sulfide and total reduced sulfur, which are not presented in this table; also refer to NMED (2023) for additional pollutants.

[i] The State of Oregon has standards for additional pollutants such as particle fallout, which is not presented in this table; also refer to ODEQ (2022) for additional pollutant.

[j] A dash indicates that no standard exists.

[k] Lake Tahoe.

[l] Below 5,000 ft (1,500 m) above mean sea level.

[m] Above 5,000 ft (1,500 m) above mean sea level.

[n] In areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous (1978) standards (1.5 $\mu g/m^3$ as a calendar quarter average) also remain in effect.

[o] Final rule signed October 1, 2015, and effective December 28, 2015. The previous 8-hour (2008) O_3 standards of 0.075 ppm are not revoked and remain in effect for designated areas. Additionally, some areas may have certain continuing implementation obligations under the prior revoked 1-hour (1979) standards of 0.12 ppm and 8-hour (1997) O_3 standards of 0.08 ppm.

[p] Lake Tahoe Basin, #90.

[q] First value is primary standard and second value is secondary standard; see footnote d.

[r] The previous SO_2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2) any area for which an implementation plan providing for attainment of the current (2010) standard has not been submitted and approved and which is designated nonattainment under the previous SO_2 standards or is not meeting the requirements of a State Implementation Plan (SIP) call under the previous SO_2 standards (40 CFR 50.4(3)). A SIP call is an EPA action requiring a state to resubmit all or part of its SIP to demonstrate attainment of the required NAAQS.

[s] Different standards apply within 3.5 mi (5.6 km) of the Chino Mines Company smelter furnace stack at Hurley.

Sources: ADEQ (2019); CARB (2016); CDPHE (2023); EPA (2023a); IDEQ (2023); MDEQ (2021); NDEP (2023); NMED (2023); ODEQ (2022); UDEQ (2021); WDEQ (2023); WDOE (2023).

F.2.2.3 Historic Climate Change by State

The following subsections briefly summarize changes in temperature, precipitation, snowpack, and glaciers by study area state.[5]

Arizona. Through 2015, data showed that Arizona has warmed about 2°F (1.1°C), since the beginning of the twentieth century (EPA 2016a); including the years 2016–2020 showed the temperature increase over the century to be about 2.5°F (1.4°C) (NCEI 2022). The first 21 years of this century have been the warmest period on record for the state. Since the 1950s, the snowpack has been decreasing in Arizona as well as in most mountainous areas in the Colorado River Basin. Annual precipitation has decreased in Arizona during the last century. Unlike many areas of the United States, Arizona and other southwestern states have not experienced an upward trend in the frequency of 1-inch (2.5-cm) extreme precipitation events.

California. Through 2015, data showed that California has warmed about 1-3.5°F (0.6–1.9°C), with an increase of over 3°F (1.7°C) in Southern California, which is one of the largest temperature increases in the United States (EPA 2016b; NCEI 2022). Since the 1950s, the snowpack has declined in California and the nearby states that drain into the Colorado River. Warming is causing snow to melt earlier in spring, and mountain glaciers are retreating. Annual precipitation shows wide variability but has been below average since 2000. There is no long-term trend in winter precipitation. Two-inch (5.1-cm) extreme precipitation events also show no overall trend.

Colorado. Through 2015, data showed that southeastern Colorado has warmed by 1-1.5°F (0.6-0.8°C) and the rest of the state has warmed by 2-2.5°F (1.1-1.4°C) (EPA 2016c). Based on NCEI data, temperatures in Colorado have risen about 2.5°F (1.4°C) since the beginning of the twentieth century and have remained consistently higher than the long-term (1895–2020) average since 1998 (NCEI 2022). The amount of snowpack measured in April has declined by 20 to 60% at most monitoring sites in Colorado. Since 2000, annual precipitation totals have been generally below average and the number of 1-inch (2.5-cm) precipitation events has been near or below average.

Idaho. Through 2015, Idaho had warmed 1-2°F (0.6-1.1°C), which was similar to the average warming nationwide (EPA 2016d). Including data for 2016–2020 shows state temperatures to have risen by almost 2°F (1.1°C) since the beginning of the twentieth century (NCEI 2022). Since the 1950s, Idaho's snowpack has been decreasing in most locations. Statewide, there is substantial variability but no overall trend in total annual precipitation for the 126-year period of record. The number of 1-inch (2.5-cm) extreme precipitation events has been above average since 2005, with an overall upward trend since 1900.

Montana. Through 2015, Montana had warmed about 2°F (1.1°C), ranging from 1.5 to 2.5°F (0.8 to 1.4°C) (EPA 2016e). Including data for 2016–2020 shows that temperatures in Montana have risen by almost 2.5°F (1.4°C) since the beginning of the

[5] Summary data for precipitation from NCEI (2022); for temperature, snowpack, and glaciers from EPA (2016a-k). Note that descriptions between EPA (2016a-k) and NCEI (2022), which are based on the data up to 2015 and 2020, respectively, can differ somewhat because the latter include more recent years that are the warmest period on record.

twentieth century, higher than the warming for the contiguous United States as a whole (NCEI 2022). The first 21 years of this century represent the warmest period on record for Montana. Since the 1950s, the snowpack in Montana has been decreasing. More than 1,000 glaciers cover about 26 square miles of mountains in Montana, but that area is decreasing in response to rising temperatures. Glacier National Park's glaciers receded rapidly during the last century. Areas that are no longer covered by glaciers may still accumulate snowpack, but the snow no longer remains year-round. Annual precipitation varies widely and shows no overall trend. The number of 1-inch (2.5-cm) extreme precipitation events has generally been near average since 1970.

Nevada. Nevada had warmed about 2°F (1.1°C) in the last century before 2015, ranging from 1 to 3°F (0.6 to 1.7°C) (EPA 2016f). Including data for 2016–2020 shows that temperatures in the state have risen almost 2.4°F (1.3°C) since the beginning of the twentieth century (NCEI 2022). Since the 1950s, snowpack has declined in Nevada as well as in the other states in the Colorado River Basin. After wet conditions in the late 1990s, total annual precipitation has been near or below average since 2000 but shows no overall trend across the 126-year period of record.

New Mexico. New Mexico had warmed at least 1°F (0.6°C), in the last century before 2016, ranging from 0.5 to 2.5°F (0.3 to 1.4°C) (EPA 2016g). Including data for 2016–2020 shows temperatures in the state have risen more than 2°F (1.1°C) since the beginning of the twentieth century (NCEI 2022). Since the 1950s, the snowpack has been decreasing in New Mexico as well as in Colorado, Utah, and Wyoming, which matters because the headwaters of the Rio Grande, San Juan, Colorado, and Navajo rivers are in those states. Annual precipitation is highly variable from year to year but was below or near average since 2000. Unlike many areas of the United States, New Mexico has not experienced an upward trend in the frequency of 1-inch (2.5-cm) extreme precipitation events.

Oregon. Over the past century before 2016, Oregon had warmed about 2°F (1.1°C), ranging from 1 to2.5°F (0.6 to 1.4°C), which was similar to the average warming nationwide (EPA 2016h). Including data for 2016–2020 shows that temperatures in Oregon have now risen about 2.5°F (1.4°C) since the beginning of the twentieth century, and temperatures in the 1990s and 2000s were higher than in any other historical period (NCEI 2022). Warmer winters have reduced average snowpack in the Cascades by 20% since 1950 and the snowpack is now melting a few weeks earlier than during the twentieth century. Warming is causing snow to melt earlier in spring, and mountain glaciers are retreating. Annual precipitation varies widely and was below average during the 2015–2020 period. The number of 2-inch (5.1-cm) extreme precipitation events has been highly variable over the historical record (since 1900) and mostly below normal since 2000.

Utah. Over the past century before 2016, most of the state of Utah had warmed about 2°F (1.1°C), either 1.5 to 2°F (0.8 to 1.1°C) in western Utah or 2.5 to 3°F (1.4 to 1.7°C) in eastern Utah (EPA 2016i). Including data for 2016–2020 shows that temperatures across the state have risen more than 2.5°F (1.4°C) since the beginning of the twentieth century, with the period since 2012 including eight of the ten warmest recorded years (NCEI 2022). Since the 1950s, the snowpack has been decreasing in Utah as well as in Wyoming and Colorado, which contribute snowmelt to the Green and Colorado rivers. Annual precipitation during the most recent 16 years (2005–2020) has been near the long-term average, but 2020 was the driest year on record. There is no long-term trend in the number of 1-inch (2.5-cm) extreme precipitation events.

Washington. Over the past century before 2016, Washington has warmed 1 - 2°F (0.6–1.1°C), which has been similar to the average warming nationwide (EPA 2016j). Since 1986, all but five years have been above the long-term (1895–2020) average (NCEI 2022). Three thousand glaciers cover about 170 mi^2 (440 km^2) of mountains in Washington, but that area is decreasing in response to warmer temperatures. Warmer winters have reduced average snowpack in Washington by 20% since 1950 (EPA 2016j). Both annual precipitation and the number of extreme precipitation events have varied widely since the beginning of the twentieth century.

Wyoming. Over the past century before 2016, most of Wyoming had warmed by 1 to 3°F (0.6 to 1.7°C), which is higher warming than most of the contiguous United States (EPA 2016k). Including data for 2016–2020 shows that temperatures in the state have risen about 2.5°F (1.4°C) since the beginning of the twentieth century, and nearly every year of this century has been above the long-term average (NCEI 2022). Since the 1950s, the snowpack in Wyoming has been decreasing. Wyoming's mountain ranges also contain 1,500 glaciers. As the climate warms, most of these glaciers will retreat and some could disappear altogether. Areas that are no longer covered by glaciers may still accumulate snowpack, but the snow will no longer remain yearround. Total annual precipitation and the number of 1-inch (2.5-cm) extreme precipitation events have been trending upward since 2000.

F.2.3 Supplemental Material for Impacts Assessment

F.2.3.1 Emission Factors

Table F.2.3-1 presents emission factors by state and composite emission factors over the 11-state study area for both criteria pollutants (SO_2 and NO_X) and GHG related to combustion-related power generation in 2021.

Table F.2.3-1. Combustion-related Composite Emission Factors Over 11-State Study Area with Annual Emission Factors and Power Generation by State,2021

State		Combustion Emission Factor (lb/MWh)						Combustion Power Generation (MWh)
		SO_2	NO_X	CO_2	CH_4	N_2O	CO_2e	
Arizona		0.24	0.61	1,258	0.07	0.010	1,263	62,496,165
California		0.03	0.82	899	0.05	0.006	902	104,951,097
Colorado		0.54	0.94	1,800	0.17	0.024	1,811	38,420,016
Idaho		0.18	0.50	830	0.03	0.004	832	5,501,167
Montana		2.20	1.74	2,140	0.24	0.035	2,156	12,183,468
Nevada		0.19	0.71	1,030	0.04	0.005	1,033	28,967,727
New Mexico		0.26	1.12	1,762	0.15	0.021	1,773	22,572,720
Oregon		0.04	1.23	890	0.04	0.005	892	22,337,648
Utah		0.74	1.87	1,779	0.18	0.026	1,791	37,342,587
Washington		0.20	0.67	1,037	0.09	0.012	1,043	21,567,806
Wyoming		1.48	1.54	2,341	0.25	0.037	2,358	34,043,367
Total								**390,383,768**
Composite[a]	(lb/MWh)	0.41	1.01	1,360	0.11	0.01	1,367	
	(kg/MWh)	0.19	0.46	617	0.05	0.01	620	

[a] Estimated by dividing the sum of products of emission factors by state and power generation by state by total power generation over 11-state study area.

Source: EPA (2023b).

F.2.3.2 SO_2 and NO_X Emissions Avoided Under the Reasonable Foreseeable Development Scenario

Table F.2.3-2 presents estimated emissions displaced for criteria pollutants (SO_2 and NO_X) related to combustion-related power generation in 2021 under the reasonable foreseeable development scenario (RFDS).

F.2.3.3 Greenhouse Gas Emissions Avoided for a Hypothetical PV Solar Energy Facility

Table F.2.3-3 presents GHG emissions avoided by solar energy production from hypothetical 5- and 750-MW PV facilities along with percentage of emissions from electric power generation by state.

Table F.2.3-2. SO_2 and NO_X Emissions Avoided from Displacement of Combustion-related Power Generation by State Under the Reasonably Foreseeable Development Scenario (RFDS)

State	Capacity (MW)[a]	Capacity Factor (%)[b]	Annual Generation (GWh/yr)	Emission Factors (lb/MWh)[c]		Emissions Displaced (tons/yr)	
				SO_2	NO_X	SO_2	NO_X
Arizona	26,428	28.3	65,591	0.24	0.61	8,002	19,907
California	14,663	27.6	35,389	0.03	0.82	513	14,456
Colorado	6,028	24.6	12,986	0.54	0.94	3,526	6,110
Idaho	11,943	26.6	27,878	0.18	0.50	2,509	7,011
Montana	718	22.5	1,413	2.20	1.74	1,551	1,231
Nevada	6,416	27.7	15,590	0.19	0.71	1,442	5,566
New Mexico	1,483	27.2	3,540	0.26	1.12	460	1,981
Oregon	6,852	24.1	14,494	0.04	1.23	297	8,928
Utah	5,306	29.3	13,598	0.74	1.87	5,038	12,694
Washington	9,571	24.7	20,750	0.20	0.67	2,096	6,993
Wyoming	3,634	22.2%	7,073	1.48	1.54	5,238	5,429
Total/Average	**93,041**	**27.5%**	**218,301**	**0.41**	**1.01**	**30,672[d]**	**90,305[e]**

[a] Estimated RFDS generation capacity.

[b] Statewide capacity factors are estimated based on electricity generation capacity and annual generation.

[c] Statewide emission factors are taken from the EPA's *eGrid* database.

[d] Equates to 38% of total emissions from 11-state electric power systems in 2021 (EPA 2023b) and to 8.9% of total emissions from 11-state all source categories in 2020 (see Table 4.2-1).

[e] Equates to 46% of total emissions from 11-state electric power systems in 2021 (EPA 2023b) and to 5.4% of total emissions from 11-state all source categories in 2020 (see Table 4.2-1).

Sources: EIA (2023a,b); EPA (2023b).

Table F.2.3-3. Greenhouse Gas Emissions Avoided for Individual PV Solar Energy Facilities from Displacement of Combustion-related Power Generation by State

State	Capacity (MW)[a]	Capacity Factor (%)[b]	Annual Generation (GWh/yr)	Emission Factors (kg CO_2e / MWh)[c]	Emissions Displaced (MT CO_2e/yr)	% of total emissions from electric power generation for 2021[c]
Arizona	5 – 750	28.3	12.4 – 1,861	573	7,111 – 1,066,582	0.02 – 3.0
California	5 – 750	27.6	12.1 – 1,810	409	4,935 – 740,310	0.01 – 1.7
Colorado	5 – 750	24.6	10.8 – 1,616	822	8,851 – 1,327,621	0.03 – 4.2
Idaho	5 – 750	26.6	11.7 – 1,751	377	4,406 – 660,855	0.21 – 31.8
Montana	5 – 750	22.5	9.8 – 1,475	978	9,619 – 1,442,787	0.08 – 12.1
Nevada	5 – 750	27.7	12.1 – 1,822	468	5,690 – 853,524	0.04 – 6.3
New Mexico	5 – 750	27.2	11.9 – 1,790	804	9,597 – 1,439,477	0.05 – 7.9
Oregon	5 – 750	24.1	10.6 – 1,587	405	4,282 – 642,246	0.05 – 7.1
Utah	5 – 750	29.3	12.8 – 1,922	812	10,409 – 1,561,336	0.03 – 5.1
Washington	5 – 750	24.7	10.8 – 1,626	473	5,127 – 769,054	0.05 – 7.5
Wyoming	5 – 750	22.2	9.7 – 1,460	1,070	10,411 – 1,561,698	0.03 – 4.3
Average		27.5		620		

[a] See assumptions provided in Section 3.1-2. The range of facility capacities is based on the capacities of approved facilities on BLM-administered lands through 2022. BLM has received ROW applications for larger facilities up to 4,000 MW; air quality impacts can be scaled on a per-megawatt basis.

[b] Statewide capacity factors are estimated based on electricity generation capacity and annual generation.

[c] Statewide emission factors and total emissions from electricity generation are taken from the EPA's *eGrid* database.

Sources: EIA (2023a,b); EPA (2023b).

F.2.3.4 GHG Emissions Avoided Under the Reasonably Foreseeable Development Scenario

Table F.2.3-4 presents GHG emissions avoided by solar energy production under the reasonably foreseeable development scenario (RFDS) by state.

Table F.2.3-4. Greenhouse Gas Emissions Avoided from Displacement of Combustion-related Power Generation by State Under the Reasonably Foreseeable Development Scenario (RFDS)

State	Capacity (MW)[a]	Capacity Factor (%)[b]	Annual Generation (GWh/yr)	Emission Factors (kg CO_2e/MWh)[c]	Emissions Displaced (MMT CO_2e/yr)
Arizona	26,428	28.3	65,591	573	37.6
California	14,663	27.6	35,389	409	14.5
Colorado	6,028	24.6	12,986	822	10.7
Idaho	11,943	26.6	27,878	377	10.5
Montana	718	22.5	1,413	978	1.4
Nevada	6,416	27.7	15,590	468	12.5
New Mexico	1,483	27.2	3,540	804	1.7
Oregon	6,852	24.1	14,494	405	5.9
Utah	5,306	29.3	13,598	812	11.0
Washington	9,571	24.7	20,750	473	9.8
Wyoming	3,634	22.2	7,073	1,070	7.6
Total/Average	**93,041**	**27.5**	**218,301**	**620**	**123.1**[d]

[a] Estimated RFDS generation capacity.

[b] Statewide capacity factors are estimated based on electricity generation capacity and annual generation.

[c] Statewide emission factors are taken from the EPA's *eGrid* database.

[d] This emission equates to 51% of total emissions from 11-state electric power systems in 2021 (EPA 2023b) and to 11% of total emissions from 11-state all source categories in 2020 (Table 4.2-2).

Source: EIA (2023a,b); EPA (2023b).

Figure F.2.3-1 summarize the estimates of social costs of CO_2, CH_4, and N_2O (in 2020 dollars per metric ton) in five-year increments from 2020 to 2050.

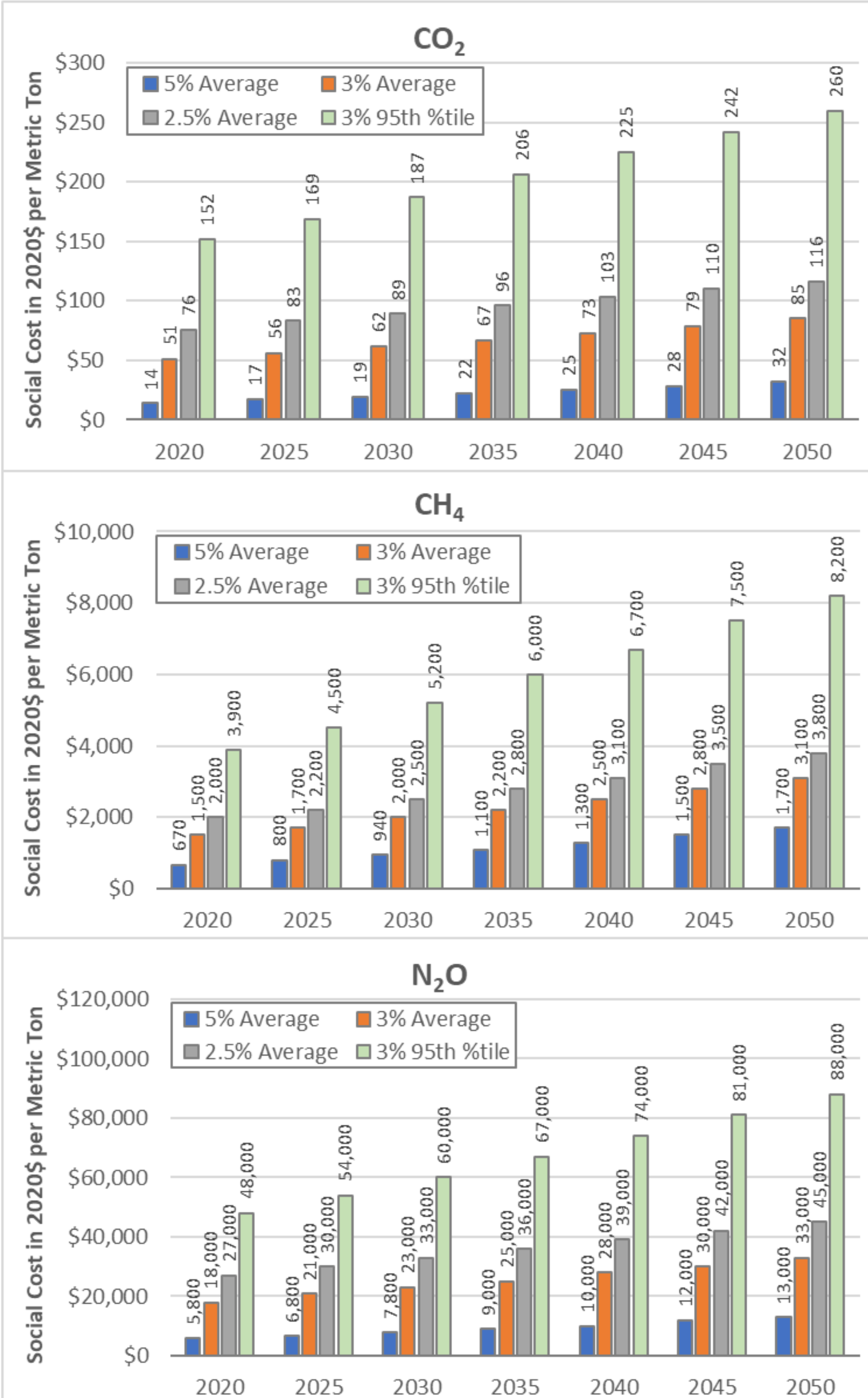


Figure F.2.3-1. Social Costs of CO_2, CH_4, and N_2O in 2020 Dollars per Metric Ton, 2020–2050 (Data Source: IWG 2021)

F.2.3.5 Albedo Effects of PV Technology

The deployment of PV panels would effect a change in the albedo, or the fraction of solar radiation reflected back into space by an area of the Earth's surface. On a large scale, such a change could conceivably affect the radiative balance of the Earth's surface, and thus contribute to global warming by slightly reducing the amount of sunlight reflected back to outer space as the panels absorb more and reflect less solar energy than the underlying ground. Historical changes in Earth-surface albedo, both positive and negative, have occurred from a number of other human-induced changes, for example, from the conversion of forests to farmland or from the construction of roads and buildings. The size of the effect from deployment of PV technologies, however, would be small compared to these historical effects and, with respect to global warming, would be more than compensated for by displaced fossil fuel CO_2 emissions, as discussed in the following paragraphs.

Typical surface albedo values range from 0.05 for asphalt to 0.95 for fresh snow, with a global mean planetary albedo of about 0.3 (Jacobson 1999). An albedo for desert, where many PV facilities are located, ranges from 0.2 to 0.4, meaning that 20 to 40% of incident radiation is reflected back into space. Dark-colored sunlight-absorbing PV panels, by comparison, typically reflect less than 10% of incident solar radiation (albedo <0.1).

A study discussed potential impacts of the Earth's albedo modification on climate change associated with widespread deployment of PV technology (Nemet 2009). By 2100, radiative forcing of the albedo effect due to PV panels is predicted to range from about 0.003 to 0.029 W/m^2.[6] At the same time, solar energy, including that from PV, would displace a considerable amount of GHG emissions, mainly CO_2 from avoided fossil fuel combustion, such as coal or natural gas. Negative radiative forcing from avoided fossil fuel combustion due to PV solar energy generation is estimated to range from −0.102 to −1.031 W/m^2 (negative values indicate a cooling effect). For comparison, radiative forcing caused by anthropogenic GHG emissions since preindustrial times is about 2.6 W/m^2, and the albedo effect from previous land use changes is estimated at about −0.2 W/m^2. Therefore, climatic benefits resulting from widespread deployment of PVs for fossil fuels far outweigh (that is, are more than 30 times larger than) the unfavorable effects due to the small change in the Earth's albedo.

F.2.3.6 Impacts of PV Facilities on Loss of Soil Carbon Storage

Research indicates that the carbon storage capacity of desert plants and soils could be comparable to that of temperate forests and grasslands (Wohlfahrt et al. 2008). These researchers quantified the net CO_2 stored by an ecosystem's biomass (i.e., from shrubs and from microscopic organisms living in the soil). In addition to CO_2 storage in desert plants, they accounted for the significant amount of CO_2 that is stored in soil biological crusts, such as in blue-green algae, lichens, and mosses, which cover some desert

[6] Radiative forcing is defined as the radiative imbalance (expressed in watts per square meters, or W/m^2) in the climate system at the top of the atmosphere caused by the addition of a GHG (or other change). A positive radiative frequency tends to warm the Earth's surface, while a negative radiative frequency tends to cool the surface.

soils. This analysis is presented as an indicator of potential impacts from loss of soil carbon storage, although desert ecosystems are only a portion of the planning area.

Wohlfahrt et al. calculated the annual removal of GHGs from the atmosphere attributed to soil carbon storage as about 100 g/m^2 of carbon, with the majority being removed during spring months. These results suggest that arid biomes covering more than 30% of the Earth's land surface may be playing a much larger role in global carbon cycling and in modulating atmospheric CO_2 levels than previously thought.

On the basis of this research, an assessment was performed of the potential adverse effect of CO_2 added to the atmosphere due to loss of desert plants and crustal matter associated with utility-scale solar facilities, compared with the benefit of avoided CO_2 emissions. Potential loss of CO_2 storage capacity associated with clearing of desert lands for a solar facility was estimated. A land area of about 8 acres (0.032 km^2) per MW was assumed to be cleared, and a capacity factor of 27.5% for the solar facilities was assumed (EIA 2023a,b). The resulting loss of CO_2 storage capacity (assuming soil carbon storage of 100 g/m^2 of carbon) was estimated to be about 1.6 ton/acre/yr (0.37 kg/m^2/yr). This storage loss would be about 0.8% of CO_2 emissions avoided by operation of a PV facility, based on a combustion-related composite CO_2 emission factor averaged over the 11-state planning area. As a consequence, CO_2 removal from operation of a solar facility would be expected to be far more beneficial than the CO_2 storage capacity lost by clearing of vegetation from the desert, from the standpoint of GHG emission reductions. Additionally, as the BLM continues to require that construction of PV facilities avoid and minimize soil and vegetation disturbance (BLM 2020; BLM 2022), less CO_2 storage capacity will be lost in the construction of these facilities.

F.3 Cultural Resources

F.3.1 Methods Used for Evaluation

Information on cultural resources for the affected environment was derived from multiple federal, state, local, and Tribal resources as provided by pertinent agencies and governments of the 11-state planning area. Discussion of current regulatory and legal frameworks relating to cultural resources and their protection and management was derived from the various applicable laws, orders, acts, and guidance handbooks provided by the associated governing bodies and agencies (See Tables F.3.2-1 and F.3.2-2 below). Federal sources of data included the National Register of Historic Places (NRHP), National Historic Landmarks (NHL), National Monuments (NM), and National Historic Trails (NHT). These resources are provided in Tables F.3.2-3, F.3.2-7, F.3.2-8, and F.3.2-9. Several of these sources were accompanied by GIS data of variable resolution and used to visualize the cultural resource setting at a broad level. These data are shown in Figure F.3.2-1. Broad prehistoric and historic contexts were derived from publicly available literature. The BLM provided spatial and tabular data of Areas of Critical Environmental Concern (ACEC). State-level resource inventories were provided by the BLM's National Cultural Resource Information Management System (NCRIMS). This system provided quantitatively high-resolution tabular data for resources on BLM-administered lands in terms of resource counts, temporal affinity, and NRHP eligibility status for each state. Additionally, these data provided state-level Class II and III survey coverage. Traditional Cultural Properties within BLM-administered lands are part of ongoing consultation with Tribal Nations due to the sensitivity of their locations, thus specific Tribal resource inventories were not included.

The general evaluation of impacts on cultural resources mainly follows the 2012 Western Solar Plan where the nature and vulnerability of the resource is defined with potential direct and indirect impacts indicated. Discussion included general impacts originating during various stages of project construction, maintenance, decommissioning, and indirect impacts. At the State level, NCRIMS provided quantifiable counts and types of resources that would be impacted for each alternative on both excluded lands and BLM-administered lands available for application. These are provided in Tables F.3.3-1 through F.3.3-9. Due to the sensitive nature of resource locations, they have not been reproduced in map form. Potentially applicable design features are indicated in Appendix B and are intended to extend beyond regulatory requirements and BLM policy and were derived from the literature on best management practices, communications from the Tribes, and information in past NEPA documents.

F.3.2 Supplemental Material for Affected Environment

Table F.3.2-1. Cultural Resource Laws and Regulations

Law or Order Name	Intent
Antiquities Act of 1906	This law makes it illegal to remove cultural resources from federal land without permission and establishes a permitting process for conducting archaeological fieldwork on federal land. It also allows the President to establish historical monuments and landmarks.
Bald and Golden Eagle Protection Act of 1940, as amended	Section 668a of this act allows the Secretary of the Interior to permit the taking, possession, and transportation of bald eagle or golden eagle specimens for the religious purposes of Indian tribes as well as other scientific or exhibition purposes. Otherwise, the act prohibits the take, possession, sale, purchase, or transportation of any bald eagle or golden eagle (alive or dead), or any part, nest, or egg thereof.
National Historic Preservation Act of 1966, as amended (NHPA)	The NHPA creates the framework within which cultural resources are managed in the United States. The law requires that each state appoint a State Historic Preservation Officer (SHPO) to direct and conduct a comprehensive statewide survey of historic properties and maintain an inventory of such properties, and it created the Advisory Council on Historic Preservation, which provides national oversight and dispute resolution. Section 106 of the NHPA defines the process for identifying and evaluating cultural resources and determining whether a project will result in an adverse effect on the resource. It also addresses the appropriate process for resolving (mitigating) adverse effects to historic properties. Section 110 of the NHPA directs the heads of all federal agencies to assume responsibility for the preservation of listed or eligible historic properties owned or controlled by their agency. Federal agencies are directed to locate, inventory, and nominate properties to the NRHP, to exercise caution to protect such properties, and to use such properties to the maximum extent feasible. Additional provisions of Section 110 include documentation of properties adversely affected by federal undertakings, the establishment of trained federal preservation officers in each agency, and the inclusion of the costs of preservation activities as eligible agency project costs. The NHPA also establishes the processes for consultation among interested parties, the lead agency, and the SHPO, and for government-to-government consultation between U.S. government agencies and Native American Tribal governments

Table F.3.2-1. Cultural Resource Laws and Regulations *(Cont.)*

Law or Order Name	Intent
Executive Order (E.O.) 11593, Protection and Enhancement of the Cultural Environment (Federal Register 36:8921, May 13, 1971)	E.O. 11593 requires federal agencies to inventory their cultural resources and to record, to professional standards, any cultural resource that may be altered or destroyed.
Archaeological and Historic Preservation Act of 1974 (AHPA)	The AHPA directly addresses impacts on cultural resources resulting from federal activities that would significantly alter the landscape. The focus of the law is data recovery and salvage of scientific, prehistoric, historic, and archaeological resources that could be damaged during the creation of dams and the impacts resulting from flooding, worker housing, creation of access roads, etc.; however, its requirements are applicable to any federal action.
Federal Land and Policy Management Act of 1976 (FLPMA)	The FLPMA requires the BLM to manage its lands for multiple use and sustained yield in a manner that will protect the quality of its environmental values, such as cultural resources
American Indian Religious Freedom Act of 1978 (AIRFA)	The AIRFA protects the right of Native Americans to have access to their sacred places. It requires consultation with Native American organizations if an agency action will affect a sacred site on federal lands.
Archaeological Resources Protection Act of 1979, as amended (ARPA)	The ARPA establishes civil and criminal penalties for the destruction or alteration of cultural resources and establishes professional standards for excavation.
Native American Graves Protection and Repatriation Act of 1990 (NAGPRA)	The NAGPRA requires federal agencies to consult with the appropriate Native American Tribes prior to the intentional excavation of human remains and funerary objects. It requires the repatriation of human remains found on the agencies' land.
E.O. 13006, Locating Federal Facilities on Historic Properties in our Nation's Central Cities (Federal Register 61:26071, May 21, 1996)	E.O. 13006 encourages the reuse of historic downtown areas by federal agencies.
E.O. 13007, Indian Sacred Sites (Federal Register 61:26771, May 24, 1996)	E.O. 13007 requires that an agency allow Native Americans to worship at sacred sites located on federal property.
E.O. 13175, Consultation and Coordination with Indian Tribal Governments (Federal Register 65:67249, Nov. 9, 2000)	E.O. 13175 requires federal agencies to ensure meaningful and timely input by Tribal officials in the development of federal policies that have Tribal implications.
E.O. 13287, Preserve America (Federal Register 68:10635, March 5, 2003)	E.O. 13287 encourages the promotion and improvement of historic structures and properties to encourage tourism.

Table F.3.2-2. BLM Guidance Regarding Cultural Resource Management

BLM 8100 Series Manuals and Handbooks
8100 Manual: *The Foundations for Managing Cultural Resources*
8110 Manual: *Identifying and Evaluating Cultural Resources*
8130 Manual: *Planning for Uses of Cultural Resources*
8140 Manual: *Protecting Cultural Resources*
8150 Manual: *Permitting Uses of Cultural Resources*
8170 Manual: *Interpreting Cultural Resources for the Public*

Table F.3.2-3. ACECs Designated for Protection of Cultural Resource Values (excludes DRECP, California)

ACEC	State	BLM Field Office / RMP	ACEC Values
Johnson Spring	Arizona	Arizona Strip	Cultural
Kanab Creek	Arizona	Arizona Strip	Cultural
Little Black Mountain	Arizona	Arizona Strip	Cultural
Lost Spring Mountain	Arizona	Arizona Strip	Cultural, Wildlife
Marble Canyon	Arizona	Arizona Strip	Cultural, Wildlife
Moonshine Ridge	Arizona	Arizona Strip	Cultural, Wildlife
Virgin River Corridor	Arizona	Arizona Strip	Cultural, Riparian, T&E
Black Butte	Arizona	Bradshaw-Harquahala	Cultural, Geologic, Wildlife
Harquahala Mountains	Arizona	Bradshaw-Harquahala	Cultural, Wildlife
Tule Creek	Arizona	Bradshaw-Harquahala	Cultural, Wildlife
Vulture Mountains	Arizona	Bradshaw-Harquahala	Cultural, Wildlife
Black Mountains Ecosystem Management	Arizona	Kingman	Cultural, Wildlife
Burro Creek Riparian and Cultural	Arizona	Kingman	Cultural, Wildlife
Carrow-Stephens Ranches	Arizona	Kingman	Cultural, Paleontology
Joshua Tree Forest-Grand Wash Cliffs	Arizona	Kingman	Cultural, Wildlife
Wright-Cottonwood Creeks Riparian and Cultural	Arizona	Kingman	Cultural
Beale Slough Riparian & Cultural	Arizona	Lake Havasu	Cultural, Wildlife
Bullhead Bajada Natural & Cultural	Arizona	Lake Havasu	Cultural, Wildlife
Crossman Peak Scenic	Arizona	Lake Havasu	Cultural, Wildlife
Swansea Historic District	Arizona	Lake Havasu	Cultural, Wildlife
Cuerda De Lena	Arizona	Lower Sonoran	Cultural, Wildlife
Lower Gila Terraces and Historic Trails	Arizona	Lower Sonoran	Cultural
Saddle Mountain	Arizona	Lower Sonoran	Cultural, Wildlife
Baboquivari Peak	Arizona	Phoenix	Cultural, Wildlife
White Canyon	Arizona	Phoenix	Cultural, Wildlife
Bowie Mountain Scenic	Arizona	Safford	Cultural, Wildlife
Dos Cabezas Peaks	Arizona	Safford	Cultural

Table F.3.2-3. ACECs Designated for Protection of Cultural Resource Values (excludes DRECP, California) ***(Cont.)***

Swamp Springs-Hot Springs Watershed	Arizona	Safford	Riparian, T&E Species
Dripping Springs	Arizona	Yuma	Cultural, Wildlife
Dripping Springs Core	Arizona	Yuma	Cultural, Wildlife, Geologic
Sears Point	Arizona	Yuma	Cultural
Sears Point Core	Arizona	Yuma	Cultural
Big Marias	Arizona/ California	Yuma	Cultural
Calico Early Man Site	California	Barstow	Cultural
Clark Mountain	California	Barstow	Cultural, Wildlife, Scenery
Cronese Basin	California	Barstow	Cultural, Wildlife
Dead Mountains	California	Barstow	Cultural
Manix	California	Barstow	Cultural, Paleontology
Mountain Pass Dinosaur Trackway	California	Barstow	Cultural, Paleontology
Rainbow Basin/Owl Canyon	California	Barstow	Cultural, Geology, Paleontology
Rodman Mountains Cultural Areas	California	Barstow	Cultural
Salt Creek Hills	California	Barstow	Cultural, Wildlife
Bodie Bowl	California	Bishop	Cultural
Cerro Gordo	California	Bishop	Cultural
Travertine Hot Springs	California	Bishop	Cultural, Geologic
East Mesa	California	El Centro	Cultural, Wildlife
Gold Basin/Rand Intaglios	California	El Centro	Cultural
Indian Pass	California	El Centro	Cultural
Lake Cahuilla A	California	El Centro	Cultural
Lake Cahuilla B	California	El Centro	Cultural
Lake Cahuilla C	California	El Centro	Cultural
Lake Cahuilla D	California	El Centro	Cultural
Pilot Knob	California	El Centro	Cultural
Plank Road	California	El Centro	Cultural
San Sebastian Marsh/San Fellipe Creek	California	El Centro	Cultural, Riparian, Wildlife
West Mesa	California	El Centro	Cultural, Wildlife
Mesquite Hills/Crucero	California	Needles	Cultural

Table F.3.2-3. ACECs Designated for Protection of Cultural Resource Values (excludes DRECP, California) *(Cont.)*

Mopah Spring	California	Needles	Cultural, Scenery
ACEC	State	BLM Field Office / RMP	ACEC Values
Patton's Iron Mountain Division Camp	California	Needles	Cultural
Haloran Wash	California	Needles	Cultural
Whipple Mountains	California	Needles	Cultural
Alligator Rock	California	Palm Springs / South Coast	Cultural
Corn Springs	California	Palm Springs / South Coast	Cultural, Wildlife, Scenery
Mule Mountain	California	Palm Springs / South Coast	Cultural
Palen Dry Lake	California	Palm Springs / South Coast	Cultural
Blue Hill	Colorado	Colorado River Valley	Cultural
Grand Hogback	Colorado	Colorado River Valley	Cultural, Geologic
Thompson Creek	Colorado	Colorado River Valley	Cultural, Geologic
Atwell Gulch	Colorado	Grand Junction	Cultural, Wildlife
Indian Creek	Colorado	Grand Junction	Cultural
Pyramid Rock	Colorado	Grand Junction	Cultural, Wildlife
Rough Canyon	Colorado	Grand Junction	Cultural, Wildlife, Geologic
Sinbad Valley	Colorado	Grand Junction	Cultural
Barger Gulch Heritage Area	Colorado	Kremmling	Cultural
Cucharas Canyon	Colorado	Royal Gorge	Cultural
Garden Park	Colorado	Royal Gorge	Cultural
Blanca Wetlands	Colorado	San Luis Valley	Cultural, Wildlife
Cumbres And Toltec Railroad	Colorado	San Luis Valley	Cultural
Paradox Rock Art	Colorado	Uncompahgre	Cultural
Duck Creek	Colorado	White River	Cultural, Wildlife
Moosehead Mountains	Colorado	White River	Cultural, Wildlife
Lone Bird	Idaho	Challis	Cultural
Pulaski Tunnel	Idaho	Coeur d'Alene	Cultural
American River Historic Sites District	Idaho	Cottonwood	Cultural
Lower Salmon River	Idaho	Cottonwood	Cultural
Upper Lolo Creek	Idaho	Cottonwood	Cultural

Table F.3.2-3. ACECs Designated for Protection of Cultural Resource Values (excludes DRECP, California) *(Cont.)*

ACEC	State	BLM Field Office / RMP	ACEC Values
Upper Salmon River	Idaho	Cottonwood	Cultural
Sand Point	Idaho	Jarbidge	Cultural
Indian Rocks	Idaho	Pocatello	Cultural
Juniper Canyon	Idaho	Pocatello	Cultural
Castle Butte	Montana	Billings and Pompeys Pillar	Cultural, Historic, Tribal
East Pryor Mountain	Montana	Billings and Pompeys Pillar	Cultural, Wildlife
Four Dances	Montana	Billings and Pompeys Pillar	Cultural, Wildlife
Grove Creek	Montana	Billings and Pompeys Pillar	Archaeological, Tribal
Petroglyph Canyon	Montana	Billings and Pompeys Pillar	Cultural, Historic
Pompeys Pillar	Montana	Billings and Pompeys Pillar	Cultural
Pryor Foothills	Montana	Billings and Pompeys Pillar	Cultural, Wildlife
Stark Sites	Montana	Billings and Pompeys Pillar	Cultural
Weatherman Draw	Montana	Billings and Pompeys Pillar	Tribal, Cultural, Historic
Elkhorn Mountains	Montana	Butte	Cultural, Wildlife
Beaverhead Rock	Montana	Dillon	Cultural
Everson Creek	Montana	Dillon	Cultural
Muddy Creek/Big Sheep Creek	Montana	Dillon	Cultural
Virginia City Historic District	Montana	Dillon	Cultural
Kevin Rim	Montana	Havre	Cultural, Fish, Wildlife
Sweetgrass Hills	Montana	Havre	Cultural, T&E Species, Wildlife
Battle Butte Battlefield	Montana	Miles City	Cultural, Historic, Scenic
Big Sheep Mountain	Montana	Miles City	Historic, Cultural, Paleontological
Jordan Bison Kill	Montana	Miles City	Cultural, Historic
Powder River Depot	Montana	Miles City	Special Status Plants, Rare Plant Communities, Cultural
Reynolds Battlefield	Montana	Miles City	Cultural
Seline	Montana	Miles City	Cultural
Cedar Creek Battlefield	Montana	Miles City	Cultural, Historic
Long Medicine Wheel	Montana	Miles City	Cultural, Historic, Paleontological
Walstein	Montana	Miles City	Cultural, Historic, Paleontological

Table F.3.2-3. ACECs Designated for Protection of Cultural Resource Values (excludes DRECP, California) *(Cont.)*

ACEC	State	BLM Field Office / RMP	ACEC Values
Swamp Cedar	Nevada	Ely	Cultural, Wildlife
Arden Historic Sites	Nevada	Las Vegas	Cultural
Arrow Canyon	Nevada	Las Vegas	Cultural
Crescent Townsite	Nevada	Las Vegas	Cultural
Gold Butte Part B	Nevada	Las Vegas	Cultural, Wildlife
Gold Butte Part C	Nevada	Las Vegas	Cultural, Wildlife
Gold Butte Townsite	Nevada	Las Vegas	Cultural, Wildlife
Hidden Valley	Nevada	Las Vegas	Cultural
Keyhole Canyon	Nevada	Las Vegas	Cultural
Rainbow Gardens	Nevada	Las Vegas	Cultural, Wildlife
Red Rock Springs	Nevada	Las Vegas	Cultural, Wildlife
Stump Spring	Nevada	Las Vegas	Cultural
Virgin River	Nevada	Las Vegas	Cultural, Wildlife
Whitney Pocket	Nevada	Las Vegas	Cultural, Wildlife
Pah Rah High Basin Petroglyph	Nevada	Sierra Front	Cultural
Pecos River\Canyons Complex	New Mexico	Carlsbad	Cultural
Arden Adams Canyon	New Mexico	Farmington	Cultural
Ah-Shi-Sle-Pah Road	New Mexico	Farmington	Cultural
Albert Mesa	New Mexico	Farmington	Cultural
Andrews Ranch	New Mexico	Farmington	Cultural
Ashii Nala’a’ (Salt Point)	New Mexico	Farmington	Cultural
Bee Burrow	New Mexico	Farmington	Cultural
Bis Sa'Ani	New Mexico	Farmington	Cultural
Bi Yaazh	New Mexico	Farmington	Cultural
Blanco Mesa	New Mexico	Farmington	Cultural
Blanco Star Panel	New Mexico	Farmington	Cultural
Cagle’s Site	New Mexico	Farmington	Cultural
Canyon View	New Mexico	Farmington	Cultural
Casa del Rio	New Mexico	Farmington	Cultural
Casamero Community	New Mexico	Farmington	Cultural

Table F.3.2-3. ACECs Designated for Protection of Cultural Resource Values (excludes DRECP, California) *(Cont.)*

ACEC	State	BLM Field Office / RMP	ACEC Values
Cedar Hill	New Mexico	Farmington	Cultural
Chacra Mesa	New Mexico	Farmington	Cultural
Cho’li’; Gobernador Knob	New Mexico	Farmington	Cultural
Christmas Tree Ruin	New Mexico	Farmington	Cultural
Church Rock Outlier	New Mexico	Farmington	Cultural
Cottonwood Divide	New Mexico	Farmington	Cultural
Crow Canyon	New Mexico	Farmington	Cultural
Crow Point Steps and Herrudura	New Mexico	Farmington	Cultural
Deer House	New Mexico	Farmington	Cultural
Delgadita / Pueblo Canyons	New Mexico	Farmington	Cultural
Devil Springs Mesa	New Mexico	Farmington	Cultural
Dogie Canyon School	New Mexico	Farmington	Cultural
Dzil'Na'Oodlii (Huerfano Mesa)	New Mexico	Farmington	Cultural
East Rincon	New Mexico	Farmington	Cultural
Encierro Canyon	New Mexico	Farmington	Cultural
Encinada Mesa-Carrizo Canyon	New Mexico	Farmington	Cultural
Farmer’s Arroyo	New Mexico	Farmington	Cultural
Four Ye’i	New Mexico	Farmington	Cultural
Frances Mesa	New Mexico	Farmington	Cultural
Gonzalez Canyon-Senon S. Vigil Homestead	New Mexico	Farmington	Cultural
Gould Pass Camp	New Mexico	Farmington	Cultural
Halfway House	New Mexico	Farmington	Cultural
Haynes Trading Post	New Mexico	Farmington	Cultural
Holmes Group	New Mexico	Farmington	Cultural
Hummingbird	New Mexico	Farmington	Cultural
Hummingbird Canyon	New Mexico	Farmington	Cultural
Jaquez (Aka 'Jacques') Chacoan Community Caps	New Mexico	Farmington	Cultural
Lacjoma <asl	New Mexico	Farmington	Cultural

Table F.3.2-3. ACECs Designated for Protection of Cultural Resource Values (excludes DRECP, California) *(Cont.)*

Kin Nizhoni	New Mexico	Farmington	Cultural
Kin Yazhi	New Mexico	Farmington	Cultural
Kiva	New Mexico	Farmington	Cultural
Lake Valle	New Mexico	Farmington	Cultural
Largo Canyon Star Ceiling	New Mexico	Farmington	Cultural
Margarita Martinez Homestead	New Mexico	Farmington	Cultural
Martin Apodaco Homestead	New Mexico	Farmington	Cultural
Martinez Canyon	New Mexico	Farmington	Cultural
Morris 40	New Mexico	Farmington	Cultural
MossTrail	New Mexico	Farmington	Cultural
Munoz Canyon	New Mexico	Farmington	Cultural
North Road	New Mexico	Farmington	Cultural
Pierre's Site	New Mexico	Farmington	Cultural
Pointed Butte	New Mexico	Farmington	Cultural
Pork Chop Pass	New Mexico	Farmington	Cultural
Pregnant Basketmaker	New Mexico	Farmington	Cultural
Pretty Woman	New Mexico	Farmington	Cultural
Rincon Largo District	New Mexico	Farmington	Cultural
Rock House-Nestor Martin Homestead	New Mexico	Farmington	Cultural
San Rafael Canyon	New Mexico	Farmington	Cultural
Santos Peak	New Mexico	Farmington	Cultural
Shield Bearer	New Mexico	Farmington	Cultural
Simon Canyon	New Mexico	Farmington	Cultural, Wildlife, Scenic
Star Rock	New Mexico	Farmington	Cultural
Star Spring–Jesus Canyon	New Mexico	Farmington	Cultural
String House	New Mexico	Farmington	Cultural
Superior Mesa Community	New Mexico	Farmington	Cultural
Tapacito And Split Rock District	New Mexico	Farmington	Cultural
Truby’s Tower	New Mexico	Farmington	Cultural
Twin Angels	New Mexico	Farmington	Cultural

Table F.3.2-3. ACECs Designated for Protection of Cultural Resource Values (excludes DRECP, California) *(Cont.)*

ACEC	State	BLM Field Office / RMP	ACEC Values
Alamo Hueco Mountains	New Mexico	Las Cruces	Cultural, Biological, Paleontological
Apache Box	New Mexico	Las Cruces	Cultural, Biological, Scenic
Cooke’s Range	New Mexico	Las Cruces	Cultural, Biological, Scenic
Cornudas Mountain	New Mexico	Las Cruces	Cultural, Biological, Scenic
Dona Ana Mountains	New Mexico	Las Cruces	Cultural, Biological, Scenic
Los Tules	New Mexico	Las Cruces	Cultural
Old Town	New Mexico	Las Cruces	Cultural, Recreation
Organ;/Franklin Mountains	New Mexico	Las Cruces	Cultural, Biological, Scenic, Riparian
Rincon	New Mexico	Las Cruces	Cultural
San Diego Mountains	New Mexico	Las Cruces	Cultural
Three Rivers Petroglyph	New Mexico	Las Cruces	Cultural
Wind Mountain	New Mexico	Las Cruces	Cultural, Wildlife, Scenic
Cabezon Peak	New Mexico	Rio Puerco	Cultural
Casamero Community	New Mexico	Rio Puerco	Cultural
Jones Canyon	New Mexico	Rio Puerco	Cultural
Ojito	New Mexico	Rio Puerco	Cultural
Arden Historic Sites	New Mexico	Roswell	Cultural
Arrow Canyon	New Mexico	Roswell	Cultural
Crescent Townsite	New Mexico	Roswell	Cultural
Gold Butte Part B	New Mexico	Roswell	Cultural, Biological
Gold Butte Part C	New Mexico	Roswell	Cultural, Biological
Gold Butte Townsite	New Mexico	Roswell	Cultural, Biological
Hidden Valley	New Mexico	Roswell	Cultural
Keyhole Canyon	New Mexico	Roswell	Cultural
Mescalero Sands	New Mexico	Roswell	Cultural
Rainbow Gardens	New Mexico	Roswell	Cultural, Biological
Red Rock Springs	New Mexico	Roswell	Cultural, Biological
Stump Spring	New Mexico	Roswell	Cultural
Virgin River	New Mexico	Roswell	Cultural, Biological
Whitney Pocket	New Mexico	Roswell	Cultural, Biological

Table F.3.2-3. ACECs Designated for Protection of Cultural Resource Values (excludes DRECP, California) ***(Cont.)***

ACEC	State	BLM Field Office / RMP	ACEC Values
Copper Hill	New Mexico	Taos	Cultural
Agua Fria	New Mexico	Socorro	Cultural, Biological, Geological, Scenic
Tinjas	New Mexico	Socorro	Cultural, Scenic, Recreation
La Cienega, New Mexico, Taos,	New Mexico	Taos	Cultural, Wildlife
Sombrillo	New Mexico	Taos	Cultural, Paleontological
Cornudas Mountain	New Mexico	White Sands	Cultural
Three Rivers Petroglyph	New Mexico	White Sands	Cultural
Wind Mountain	New Mexico	White Sands	Cultural
Dakubetede	Oregon	Ashland	Cultural
Sterling Mine Ditch	Oregon	Ashland	Cultural
Biscuitroot	Oregon	Burns	Cultural
Ojito	Oregon	Burns	Cultural, Geology, Paleontology, Wildlife, Rare Plants
Baker Cypress	Oregon	Butte Falls	Cultural, Scenic, Fish and Wildlife
Cobleigh Road	Oregon	Butte Falls	Cultural
Table Rocks	Oregon	Butte Falls	Cultural, Scenic, Fish and Wildlife
Middle Santiam Terrace	Oregon	Cascades	Cultural
Sandy River ONA	Oregon	Cascades	Cultural
Waldo-Takilma	Oregon	Grants Pass Interagency Office	Cultural
Bumpheads	Oregon	Klamath Falls	Cultural
Upper Klamath River	Oregon	Klamath Falls	Cultural
Upper Klamath River Addition	Oregon	Klamath Falls	Cultural
Yainax Butte	Oregon	Klamath Falls	Cultural
Grass Mountain RNA	Oregon	Mary's Peak	Cultural, Visual
Ten Mile Wash	Utah	Moab	Cultural
Alkali Ridge	Utah	Monticello	Cultural
Cedar Mesa	Utah	Monticello	Cultural, Scenic
Hovenweep	Utah	Monticello	Cultural
San Juan River Benm	Utah	Monticello	Cultural

Table F.3.2-3. ACECs Designated for Protection of Cultural Resource Values (excludes DRECP, California) *(Cont.)*

ACEC	State	BLM Field Office / RMP	ACEC Values
Shay Canyon	Utah	Monticello	Cultural
Big Hole	Utah	Price	Cultural
Copper Globe	Utah	Price	Cultural
Cottonwood Canyon	Utah	Price	Cultural
Dry Lake Archaeological District	Utah	Price	Cultural
Dry Wash	Utah	Price	Cultural
Grassy Trail	Utah	Price	Cultural
Hunt Cabin	Utah	Price	Cultural
Kings Crown	Utah	Price	Cultural
Molen Seep	Utah	Price	Cultural
Muddy Creek	Utah	Price	Cultural
North Salt Wash	Utah	Price	Cultural
Pictographs	Utah	Price	Cultural
Sand Cove	Utah	Price	Cultural
Shepards End	Utah	Price	Cultural
Short Creek	Utah	Price	Cultural
Smith Cabin	Utah	Price	Cultural
Swaseys Cabin	Utah	Price	Cultural
Temple Mountain	Utah	Price	Cultural
Wild Horse Canyon	Utah	Price	Cultural
Wilsonville	Utah	Price	Cultural
Canaan Mountain	Utah	St George	Cultural
Little Creek Mountain	Utah	St George	Cultural
Lower Virgin River	Utah	St George	Cultural
Santa Clara / Gunlock	Utah	St George	Cultural
Pumpkin Buttes	Wyoming	Buffalo	Cultural
Little Mountain	Wyoming	Cody	Cultural, Wildlife, Paleontological
Upper Owl Creek	Wyoming	Grass Creek	Cultural, Wildlife
Cedar Canyon	Wyoming	Green River	Cultural, Wildlife
Natural Corrals	Wyoming	Green River	Cultural, Wildlife
Oregon Buttes	Wyoming	Green River	Cultural, Wildlife
Pine Springs	Wyoming	Green River	Cultural

Table F.3.2-3. ACECs Designated for Protection of Cultural Resource Values (excludes DRECP, California) *(Cont.)*

ACEC	State	BLM Field Office / RMP	ACEC Values
South Pass Historic Landscape	Wyoming	Green River	Cultural, Wildlife
White Mountain Petroglyphs	Wyoming	Green River	Cultural, Wildlife
Bridger Butte	Wyoming	Kemmerer	Cultural, Wildlife
Beaver Rim	Wyoming	Lander	Cultural, Wildlife, Geologic
Green Mountain	Wyoming	Lander	Cultural, Wildlife
South Pass Historical Landscape	Wyoming	Lander	Cultural
Twin Creek	Wyoming	Lander	Cultural, Wildlife
Trapper'S Point	Wyoming	Pinedale	Cultural, Wildlife
Sand Hills/Jo Ranch	Wyoming	Rawlins	Cultural, Wildlife

Figure F.3.2-1. Major Culture Areas, Congressionally Designated National Historic Trails, ACECs with Cultural Values, and National Historic Landmarks within the 11-State Study Area

Table F.3.2-4. Time Periods and Examples of Characteristic Cultural Resources for Culture Areas in the 11-State Study Area

Culture Area	Paleoindian	Middle Period or Archaic	Late or Sedentary Period
California	9000 (?) to 6000 BC • Open campsites • Animal kill or processing sites	*6000 to 3000 BC* • Open campsites • Coastal villages • Plant and seafood processing sites	*3000 BC to AD 1750* • Large coastal villages • Burial mounds • Extensive seafood and sea mammal processing sites • Intensive plant processing sites Prehistoric trails • Geoglyphs/Intaglios
Great Basin	*9500 + to 6000 BC* • Open campsites • Cave occupation sites Lithic processing sites • Animal kill or processing sites • Isolated projectile points	*6000 to 2000 BC* • Cave or rockshelter occupation sites • Pithouse villages • Plant processing sites Fishing sites • Lithic processing sites Animal kill or processing sites	*2000 BC to AD 1750* • Cave or rockshelter occupation sites • Stone circles • Cave burials • Cairns and cairn lines • Small pithouse villages • Plant processing sites • Storage pits • Lithic processing sites • Pictograph and petroglyph sites • Animal kill or processing sites • Prehistoric roads
Southwest	*12,000 to 6000 BC* • Open campsites • Animal kill or processing sites • Cave occupation sites • Lithic processing sites Isolated projectile points	*6000 to 1 BC* • Open campsites • Cave or rockshelter occupation sites • Pithouses and storage pits • Wattle-and-daub structures • Lithic processing sites • Pictograph and petroglyph sites	*AD 1 to 1750* • Pithouse villages • Storage pits • Aboveground structures (pueblos) • Belowground structures (kivas) Irrigation ditches • Roads • Navajo hogans and pueblitos Pictograph and petroglyph sites Intaglios • Prehistoric roads or trails
Northwest	*>10,500 to 6500 BC* • Rare presence • Marine and riverine-related travel and fishing gear (traps, hooks, net weights) • Lithic processing areas	*6500 to 4400 BC* • Marine and riverine-related travel and fishing gear (traps, hooks, net weights) • Shell middens • Potentially small huts • Lithic processing areas	*4400 BC to AD 1775* • Semi-subterranean houses, pithouses, fortifications • Storage pits • Boats and tackle • Bone/antler tools including harpoon heads, lances • Nets/net weights • Groundstone and shell for woodworking • Basketry • Shell middens and midden cemeteries • Burial mounds

Table F.3.2-4. Time Periods and Examples of Characteristic Cultural Resources for Culture Areas in the 11-State Study Area *(Cont.)*

Culture Area	Paleoindian	Middle Period or Archaic	Late or Sedentary Period
Plains	*10,000 to 6000 BC* • Open campsites • Cave or rockshelter occupation sites • Animal kill or processing sites • Lithic processing sites • Isolated projectile points	*6000 to 1 BC* • Open campsites • Cave or rockshelter occupation sites • Pithouses and storage pits • Tipi ring sites • Cairns and cairn lines • Animal kill or processing sites • Lithic processing sites • Plant processing sites	*AD 1 to 1750* • Open campsites • Stone circles • Wattle-and-daub structures • Earthlodge villages • Burial mounds • Storage pits • Cave or rockshelter occupation sites • Small pithouse villages • Cairns and cairn lines • Animal kill and processing sites • Lithic processing sites • Plant processing sites Pictograph and petroglyph Sites • Prehistoric trails
Plateau	*9000-6000 BC* • Rare isolated sites • Circular dwellings • Fishing-related gear • Lithic processing	*6000 to 2000 BC* • Semi-subterranean dwellings • Storage pits • Fishing and hunting-related implements • Groundstone	*3000 BC to AD 1800* • Pithouses, camps, cemeteries, cremations, cache pits • Animal kill/processing areas, hunting camps • Lithic processing areas, groundstone, bone and antler tools • Root processing areas • Riverine fishing gear

Modified from BLM 2007.
Northwest: Ames 2003.
Plateau: DOE 2008, Prentiss et al. 2005.

Table F.3.2-5. Major Culture Areas and Historic Period Site Types (AD 1550 to present) Listed by State

State	Culture Areas	Range of Historic Resources
Arizona	Southwest, Great Basin	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military camps and outposts, missions, Civilian Conservation Corps (CCC) camps, and railroads
California	California, Great Basin, Plateau	Historic trails, missions, buildings, structures, towns, forts, mining-related sites, logging-related sites, agricultural sites, railroads, CCC camps, and military camps and outposts
Colorado	Great Basin, Plains, Southwest	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military outposts, CCC camps, and railroads
Idaho	Great Basin, Plateau	Historic trails, fur trapping sites, agricultural settlements, canals, ranches, structures, mining-related sites, railroads, dendroglyphs, WWII POW camp(s)
Montana	Plains, Plateau, Great Basin	Historic trails, fur trapping sites, trading posts, forts, buildings, structures, agricultural sites, mining-related sites, ranching sites, railroads
Nevada	Great Basin	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military outposts, missions, and railroads
New Mexico	Southwest, Plains	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military outposts, and railroads
Oregon	Northwest, Plateau, Great Basin	Fur trade sites, maritime trade sites, agricultural sites, historic trail, timber-related sites, mining sites, fisheries-related sites, ranching sites, railroads, structures, settlements
Utah	Great Basin, Southwest	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military outposts, and railroads
Washington	Northwest, Plateau	Fur trade sites, maritime trade sites, agricultural sites, historic trails, timber-related sites, mining sites, fisheries-related sites, ranching sites, railroads, structures, settlements
Wyoming	Plains, Great Basin	Historic trails, fur trapping sites, trading posts, forts, buildings, structures, agricultural sites, mining-related sites, ranching sites, railroads

Table F.3.2-6. Reportable Inventory Data for BLM-administered Lands by Time Period and NRHP Eligibility Status

State	Total Known Cultural Resources	Prehistoric	Historic	Multi-component	Ethnohistoric	Time Period Unknown	NRHP Elig. Yes*	NRHP Elig. No	NRHP Elig. Undetermined	NRHP Elig. Unknown**
Arizona	10,304	6,115	733	380	15	3,061	3,198	2,162	4,944	0
California	11,772	5,843	3,271	698	0	1,960	1,137	1,789	8,754	92
Colorado	56,593	42,834	8,469	1,909	0	3,381	9,591	34,702	11,717	583
Idaho	20,845	12,924	5,859	1,591	5	466	5,538	7,494	7,813	0
Montana	11,544	2,254	3,282	192	2	5,814	908	2,036	8,600	0
Nevada	35,694	18,542	10,396	2,721	14	4,021	5,265	20,451	9,978	0
New Mexico	41,730	17,308	7,171	1,964	0	15,287	3	0	41,727	0
Oregon	14,234	7,746	3,035	593	27	2,832	515	1,542	12,176	0
Utah	52,911	25,402	5,139	1,047	51	21,272	18,906	15,459	18,546	0
Washington	31	12	10	4	0	5	3	0	28	0
Wyoming	52,590	34,080	5,207	3,499	0	9,804	11,144	26,026	15,420	0

Source: National Cultural Resources Information System (NCRIMS). Best available data are from 2020. Updated data are anticipated to be available in January 2024 and will be incorporated between draft and final EIS.

* Includes term "Contributing" where present.

** Includes term "Unevaluated" where present.

Table F.3.2-7. Reportable Resource Survey Investigations and Areal Coverage on BLM-administered Lands

State	Investigations Total	Total Acres Surveyed*	Class II Surveys	Class II Acres	Class II/III Surveys	Class II/III Acres	Class III Surveys	Class III Acres	Other Investigations**	Other Acres	Unknown Survey Class	Unknown Acres
Arizona	3,317	977,867	131	405,744	5	723	1,732	259,108	97	11,393	1,352	300,900
California	5,112	997,767	118	58,606	0	0	4,156	766,267	756	156,433	82	16,462
Colorado	14,158	1,717,933	226	118,629	3	2,745	13,218	1,324,016	187	98,237	524	174,306
Idaho	1,993	1,038,221	6	49,567	1	3	1,885	926,678	14	6,177	87	55,795
Montana	3,904	703,869	0	0	0	0	11	15,409	32	24,924	3,862	663,536
Nevada	11,594	7,969,604	128	1,285,203	55	204,904	3,767	2,190,061	7,415	3,986,629	229	302,806
New Mexico	49,999	2,588,772	0	0	0	0	0	0	0	0	49,999	2,588,772
Oregon	1,447	1,795,079	103	206,940	0	0	676	934,261	65	367,899	603	285,980
Utah	17,890	4,122,517	11	1,742	1	1	17,632	3,053,444	201	1,026,077	45	41,254
Washington	2	65,477	0	0	0	0	1	129	1	65,348	0	0
Wyoming	11,858	1,526,343	2	720	6	141	1,709	263,897	70	4,053	10,071	1,257,532

Source: National Cultural Resources Information System (NCRIMS). Best available data are from 2020. Updated data are anticipated to be available in January 2024 and will be incorporated between draft and final EIS.

* Includes both Class II and Class III surveys and are likely over-calculated due to survey area overlap.

** Includes non-survey activities such as monitoring, excavation, etc.

Table F.3.2-8. National Historic Landmarks Within the 11-State Study Area

Arizona	County
Casa Malpais Site	Apache
Hubbell Trading Post National Historic Site	Apache
Klagetoh (Leegito) Chapter House	Apache
Navajo Nation Council Chamber	Apache
Painted Desert Community Complex Historic District	Apache
Painted Desert Inn	Apache
Sage Memorial Hospital School of Nursing, Ganado Mission	Apache
Double Adobe Site	Cochise
Fort Bowie National Historic Site	Cochise
Fort Huachuca	Cochise
Lehner Mammoth-Kill Site	Cochise
Murray Springs Clovis Site	Cochise
Phelps Dodge General Office Building	Cochise
San Bernardino Ranch	Cochise
Tombstone Historic District	Cochise
1956 Grand Canyon TWA-United Airlines Aviation Accident Site	Coconino
El Tovar Hotel	Coconino
Grand Canyon Lodge	Coconino
Grand Canyon Park Operations Building	Coconino
Grand Canyon Power House	Coconino
Grand Canyon Railroad Station	Coconino
Grand Canyon Village Historic District	Coconino
Grand Canyon Village Historic District (Boundary Increase)	Coconino
Lowell Observatory	Coconino
Mary Jane Colter Buildings (Hopi House, The Lookout, Hermit's Rest, and the Desert View Watchtower)	Coconino
Merriam, C. Hart, Base Camp Site	Coconino
Winona	Coconino
Kinishba Ruins	Gila
Point of Pines	Graham
Sierra Bonita Ranch	Graham
Poston Elementary School, Unit 1, Colorado River Relocation Center	La Paz
Gatlin Site	Maricopa
Hohokam-Pima Irrigation Sites	Maricopa
Pueblo Grande Ruin	Maricopa
Taliesin West	Maricopa
Awatovi Ruins	Navajo
Fort Apache Historic District	Navajo
Old Oraibi	Navajo
Air Force Facility Missile Site 8 (571-7) Military Reservation	Pima
Desert Laboratory	Pima
San Xavier del Bac	Pima
Ventana Cave	Pima
Calabasas	Santa Cruz

Table F.3.2-8. National Historic Landmarks Within the 11-State Study Area *(Cont.)*

Arizona (Cont.)	County
Guevavi Mission Ruins	Santa Cruz
Tumacacori Museum	Santa Cruz
Jerome Historic District	Yavapai
Yuma Crossing and Associated Sites	Yuma
California	**County**
Abbey, The-Joaquin Miller House	Alameda
First Church of Christ, Scientist	Alameda
Lake Merritt Wild Duck Refuge	Alameda
Lightship WAL-605, RELIEF	Alameda
Paramount Theatre	Alameda
Room 307, Gilman Hall, University of California	Alameda
Uss Potomac (Yacht)	Alameda
John Muir National Historic Site	Contra Costa
Tao House	Contra Costa
Coloma	El Dorado
Fresno Sanitary Landfill	Fresno
Gunther Island Site 67	Humboldt
Coso Rock Art District	Inyo
Coso Rock District	Inyo
Manzanar War Relocation Center, National Historic Site	Inyo
Nuestra Senora Reina de la Paz	Kern
Rogers Dry Lake	Kern
The Forty Acres	Kern
Walker Pass	Kern
Borax Lake-Hodges Archeological Site	Lake
Angelus Temple	Los Angeles
Baldwin Hills Village	Los Angeles
Barnsdall, Aline, Complex	Los Angeles
Bradbury Building	Los Angeles
Eames House	Los Angeles
Gamble House	Los Angeles
Hale Solar Laboratory	Los Angeles
Hubble, Edwin, House	Los Angeles
Lane Victory	Los Angeles
Little Tokyo Historic District	Los Angeles
Los Angeles Memorial Coliseum	Los Angeles
Los Cerritos Ranch House	Los Angeles
Neutra, Richard and Dion, VDL Research Houses and Studio	Los Angeles
Ralph J. Scott	Los Angeles
Rose Bowl, The	Los Angeles
Saddle Rock Ranch Pictograph Site	Los Angeles
Santa Monica Looff Hippodrome	Los Angeles
Sinclair, Upton, House	Los Angeles
Space Flight Operations Facility	Los Angeles
Twenty-Five Foot Space Simulator	Los Angeles
US Court House and Post Office	Los Angeles

Table F.3.2-8. National Historic Landmarks Within the 11-State Study Area *(Cont.)*

California *(Cont.)*	County
Watts Towers of Simon Rodia	Los Angeles
Well No. 4, Pico Canyon Oil Field	Los Angeles
Angel Island, U.S. Immigration Station	Marin
Drakes Bay Historic and Archeological District	Marin
Marin County Civic Center	Marin
Point Reyes Lifeboat Rescue Station, 1927	Marin
Ahwahnee Hotel	Mariposa
LeConte Memorial Lodge	Mariposa
Rangers' Club	Mariposa
Wawona Hotel and Pavilion	Mariposa
Mendocino Woodlands Recreational Demonstration Area	Mendocino
Tule Lake Segregation Center	Modoc
Bodie Historic District	Mono
Asilomar Conference Grounds	Monterey
Asilomar Conference Grounds Warnecke Historic District	Monterey
Carmel Mission	Monterey
Larkin House	Monterey
Monterey Old Town Historic District	Monterey
Royal Presidio Chapel	Monterey
U.S. Customhouse	Monterey
Elmshaven	Napa
Donner Camp	Nevada
Modjeska House	Orange
Nixon, Richard, Birthplace	Orange
Harada House	Riverside
Mission Inn	Riverside
"Big Four" House	Sacramento
Folsom Powerhouse	Sacramento
Locke Historic District	Sacramento
Old Sacramento Historic District	Sacramento
Pony Express Terminal	Sacramento
Stanford-Lathrop House	Sacramento
Sutter's Fort	Sacramento
Anza House	San Benito
Castro, Jose, House	San Benito
San Juan Bautista Plaza Historic District	San Benito
Balboa Park	San Diego
Bancroft, Hubert H., Ranchhouse	San Diego
Berkeley	San Diego
Chicano Park	San Diego
Estudillo House	San Diego
Hotel Del Coronado	San Diego
Las Flores Adobe	San Diego
Mission Beach Roller Coaster	San Diego

Table F.3.2-8. National Historic Landmarks Within the 11-State Study Area *(Cont.)*

California *(Cont.)*	County
Oak Grove Butterfield Stage Station	San Diego
Old Mission Dam	San Diego
Rancho Guajome Adobe	San Diego
San Diego Mission Church	San Diego
San Diego Presidio	San Diego
San Luis Rey Mission Church	San Diego
Scripps, George H., Memorial Marine Biological Laboratory	San Diego
Star Of India	San Diego
Warner's Ranch	San Diego
Alcatraz	San Francisco
Alma (Scow Schooner)	San Francisco
Aquatic Park Historic District	San Francisco
Balclutha	San Francisco
Bank of Italy	San Francisco
C.A. Thayer	San Francisco
Eureka	San Francisco
Flood, James C., Mansion	San Francisco
Hercules (Tugboat)	San Francisco
Old U.S. Mint	San Francisco
Presidio	San Francisco
San Francisco Cable Cars	San Francisco
San Francisco Civic Center Historic District	San Francisco
San Francisco Port of Embarkation, US Army	San Francisco
Ss Jeremiah O'Brien	San Francisco
Swedenborgian Church	San Francisco
U.S. Post Office And Courthouse	San Francisco
USS Pampanito (Submarine)	San Francisco
Wapama	San Francisco
Carrizo Plain Rock Art Discontiguous District	San Luis Obispo
Hearst San Simeon Estate	San Luis Obispo
Mission San Miguel Arcangel	San Luis Obispo
Ralston, William C., House	San Mateo
Rock Magnetics Laboratory	San Mateo
San Francisco Bay Discovery Site	San Mateo
Gonzalez, Rafael, House	Santa Barbara
La Purisima Mission	Santa Barbara
Los Alamos Ranch House	Santa Barbara
Mission Santa Ines	Santa Barbara
Santa Barbara County Courthouse	Santa Barbara
Santa Barbara Mission	Santa Barbara
Space Launch Complex 10	Santa Barbara
Steedman Estate	Santa Barbara
Hanna-Honeycomb House	Santa Clara
Hoover, Lou Henry, House	Santa Clara

Table F.3.2-8. National Historic Landmarks Within the 11-State Study Area *(Cont.)*

California *(Cont.)*	County
New Almaden	Santa Clara
Norris, Frank, Cabin	Santa Clara
Our Lady of Guadalupe Mission Chapel (1953-1960)	Santa Clara
Unitary Plan Wind Tunnel	Santa Clara
California Powder Works Bridge	Santa Cruz
Looff Carousel and Roller Coaster on the Santa Cruz Beach Boardwalk	Santa Cruz
Lower Klamath National Wildlife Refuge	Siskiyou
Mare Island Naval Shipyard	Solano
Burbank, Luther, House and Garden	Sonoma
Fort Ross	Sonoma
Fort Ross Commander's House	Sonoma
London, Jack, Ranch	Sonoma
Petaluma Adobe	Sonoma
Sonoma Plaza	Sonoma
Knight's Ferry Bridge	Stanislaus
Columbia Historic District	Tuolumne
Parsons Memorial Lodge	Tuolumne
Rancho Camulos	Ventura
Trujillo Homesteads	Alamosa
Denver & Rio Grande Railroad San Juan Extension	Archuleta
Colorado Chautauqua	Boulder
Georgetown-Silver Plume Historic District	Clear Creek
Pike's Stockade	Conejos
Denver Civic Center	Denver
Pikes Peak	El Paso
United States Air Force Academy, Cadet Area	El Paso
Central City-Black Hawk Historic District	Gilpin
Red Rocks Park and Mount Morrison Civilian Conservation Corps Camp	Jefferson
Elitch Gardens Carousel	Kit Carson
Durango-Silverton Narrow-Gauge Railroad	La Plata
Leadville Historic District	Lake
Lindenmeier Site	Larimer
Rocky Mountain National Park Administration Building	Larimer
Ludlow Tent Colony Site	Las Animas
Lowry Ruin	Montezuma
Mesa Verde Administrative District	Montezuma
Bent's Old Fort National Historic Site	Otero
Granada Relocation Center	Prowers
Colorado Fuel and Iron Company Administrative Complex	Pueblo
Shenandoah-Dives Mill	San Juan
Silverton Historic District	San Juan
Telluride Historic District	San Miguel
Cripple Creek Historic District	Teller

Table F.3.2-8. National Historic Landmarks Within the 11-State Study Area *(Cont.)*

Idaho	County
Assay Office	Ada
Fort Hall	Bannock
Experimental Breeder Reactor No. 1	Butte
City of Rocks	Cassia
Camas Meadow Camp and Battle Sites	Clark
Lolo Trail	Clearwater
Weippe Prairie	Clearwater
Bear River Battleground	Franklin
Cataldo Mission	Kootenai
Lemhi Pass	Lemhi
Montana	**County**
Bannack Historic District	Beaverhead
Lemhi Pass	Beaverhead
Chief Plenty Coups (Alek-Chea-Ahoosh) House	Big Horn
Rosebud Battlefield-Where the Girl Saved Her Brother	Big Horn
Chief Joseph Battleground of the Bear's Paw	Blaine
Rankin Ranch	Broadwater
First Peoples Buffalo Jump	Cascade
Great Falls Portage	Cascade
Russell, Charles M., House and Studio	Cascade
Fort Benton	Chouteau
Hagen Site	Dawson
Going-to-the-Sun Road	Flathead
Granite Park Chalet	Flathead
Great Northern Railway Buildings	Flathead
Lake McDonald Lodge	Flathead
Sperry Chalets	Flathead
Two Medicine General Store	Flathead
Three Forks of the Missouri	Gallatin
Camp Disappointment	Glacier
Many Glacier Hotel Historic District	Glacier
Virginia City Historic District	Madison
Traveler's Rest	Missoula
Northeast Entrance Station	Park
Grant-Kohrs Ranch National Historic Site	Powell
Deer Medicine Rocks	Rosebud
Wolf Mountains Battlefield-Where Big Crow walked Back and Forth	Rosebud
Butte-Anaconda Historic District (Additional Documentation)	Silver Bow
Wheeler, Burton K., House	Silver Bow
Pictograph Cave	Yellowstone
Pompey’s Pillar	Yellowstone

Table F.3.2-8. National Historic Landmarks Within the 11-State Study Area *(Cont.)*

Nevada	County
McKeen Motor Car #70	Carson City
Hoover Dam	Clark
Applegate-Lassen Trail	Humboldt
Fort Churchill	Lyon
Leonard Rock Shelter	Pershing
Virginia City Historic District	Storey
Newlands, Senator Francis G., House	Washoe
East Ely Depot	White Pine
Fort Ruby	White Pine
Nevada Northern Rail Routes	White Pine
Nevada Northern Railway East Ely Yards and Shops	White Pine
Village of Columbus and Camp Furlong	Luna
Manuelito Complex	McKinley
Wagon Mound	Mora
Watrous	Mora
O'Keeffe, Georgia, Home and Studio	Rio Arriba
Puye Ruins	Rio Arriba
San Gabriel de Yungue-Ouinge	Rio Arriba
Anderson Basin	Roosevelt
Glorieta Pass Battlefield	San Miguel
Pecos National Monument	San Miguel
Big Bead Mesa	Sandoval
San Jose de los Jemez Mission and Giusewa Pueblo Site	Sandoval
Sandia Cave	Sandoval
Barrio de Analco Historic District	Santa Fe
El Santuario de Chimayo	Santa Fe
National Park Service Southwest Regional Office	Santa Fe
Palace of the Governors	Santa Fe
San Lazaro	Santa Fe
Santa Fe Plaza	Santa Fe
Seton Village	Santa Fe
Trinity Site	Socorro
Blumenschein, Ernest L., House	Taos
Carson, Kit, House	Taos
Las Trampas Historic District	Taos
Luhan, Mabel Dodge, House	Taos
San Francisco de Assisi Mission Church	Taos
San Jose de Gracia Church	Taos
Taos Pueblo	Taos
Abo	Torrance
Quarai	Torrance
Rabbit Ears	Union
Acoma	Valencia
Hawikuh	Valencia
San Estevan del Rey Mission Church	Valencia
Zuni-Cibola Complex	Valencia

Table F.3.2-8. National Historic Landmarks Within the 11-State Study Area *(Cont.)*

Oregon	County
Timberline Lodge	Clackamas
Elmore, Samuel, Cannery	Clatsop
Fort Astoria	Clatsop
Lightship Wal-604, Columbia	Clatsop
Kam Wah Chung Company Building	Grant
Jacksonville Historic District	Jackson
Oregon Caves Chateau	Josephine
Crater Lake Superintendent's Residence	Klamath
Fort Rock Cave	Lake
Deady Hall	Lane
Villard Hall	Lane
Bonneville Dam Historic District	Multnomah
Bonneville Dam Historic District (Boundary Increase)	Multnomah
Columbia River Highway Historic District	Multnomah
Pioneer Courthouse	Multnomah
Portland Skidmore/Old Town Historic District	Multnomah
Sunken Village Archeological Site (35MU4)	Multnomah
Watzek, Aubrey R., House	Multnomah
Nez Perce Traditional Site, Wallowa Lake	Wallowa
Utah	**County**
Desolation Canyon	Carbon
Bryce Canyon Lodge and Deluxe Cabins	Garfield
Central Utah Relocation Center (Topaz) Site	Millard
Bingham Canyon Open Pit Copper Mine	Salt Lake
Council Hall	Salt Lake
Emigration Canyon	Salt Lake
Fort Douglas	Salt Lake
Temple Square	Salt Lake
Young, Brigham, Complex	Salt Lake
Alkali Ridge	San Juan
Danger Cave	Tooele
Quarry Visitor Center	Uintah
Smoot, Reed, House	Utah
Mountain Meadows Massacre Site	Washington
Washington	**County**
Hanford B Reactor	Benton
Marmes Rockshelter	Franklin
Fort Worden	Jefferson
Port Townsend Historic District	Jefferson
Adventuress	King
Arthur Foss (Tugboat)	King
Duwamish	King
Panama Hotel	King
Pioneer Building, Pergola, And Totem Pole	King
Relief (Lightship)	King
Seattle Electric Company Georgetown Steam Plant	King

Table F.3.2-8. National Historic Landmarks Within the 11-State Study Area *(Cont.)*

Washington *(Cont.)*	County
Uscgc Fir	King
Virginia V	King
Navy Yard Puget Sound	Kitsap
Port Gamble Historic District	Kitsap
USS Hornet	Kitsap
Chinook Point	Pacific
Fireboat No.1	Pierce
Fort Nisqually Granary and Factor's House	Pierce
Longmire Buildings	Pierce
Mount Rainier National Park	Pierce
Paradise Inn	Pierce
Yakima Park Stockade Group	Pierce
American and English Camps, San Juan Island	San Juan
San Juan Island National Historic Site	San Juan
W. T. Preston (Snagboat)	Skagit
Wyoming	**County**
Ames Monument	Albany
Medicine Wheel-Medicine Mountain	Big Horn
Sun, Tom, Ranch	Carbon
South Pass	Fremont
South Pass City Historic District	Fremont
Hell Gap Paleoindian Site (48GO305)	Goshen
Fort Phil Kearny and Associated Sites	Johnson
Fort David A. Russell	Laramie
Union Pacific Railroad Depot	Laramie
Wyoming State Capitol and Grounds	Laramie
Penney, J. C., Historic District	Lincoln
Independence Rock	Natrona
Fort Yellowstone	Park
Heart Mountain Relocation Center	Park
Horner Site	Park
Norris Museum/Norris Comfort Station	Park
Norris, Madison, and Fishing Bridge Museums	Park
Obsidian Cliff	Park
Wapiti Ranger Station	Park
Lake Guernsey State Park	Platte
Oregon Trail Ruts	Platte
Swan Land and Cattle Company Headquarters	Platte
Sheridan Inn	Sheridan
Upper Green River Rendezvous Site	Sublette
Expedition Island	Sweetwater
Jackson Lake Lodge	Teton
Lake Hotel	Teton
Madison Museum	Teton
Murie Ranch Historic District	Teton
Old Faithful Inn	Teton

Table F.3.2-9. Congressionally Designated National Historic Trails Within the 11-State Study Area (administering agency assumed to be NPS unless otherwise noted)

State	Congressionally Designated National Historic Trails
Arizona	• Butterfield Overland Trail • Juan Bautista de Anza National Historic Trail • Old Spanish National Historic Trail (co-administered by BLM and NPS)
California	• Butterfield Overland Trail • Oregon–California National Historic Trail • Juan Bautista de Anza National Historic Trail • Old Spanish National Historic Trail (co-administered by BLM and NPS) • Pony Express National Historic Trail
Colorado	• Oregon–California National Historic Trail • Old Spanish National Historic Trail (co-administered by BLM and NPS) • Pony Express National Historic Trail • Santa Fe National Historic Trail
Idaho	• Oregon–California National Historic Trail • Lewis and Clark National Historic Trail • Nez Perce Nee Me Poo National Historic Trail • Oregon National Historic Trail
Montana	• Lewis and Clark National Historic Trail • Nez Perce Nee Me Poo National Historic Trail
Nevada	• Oregon–California National Historic Trail • Old Spanish National Historic Trail (co-administered by BLM and NPS) • Pony Express National Historic Trail
New Mexico	• Butterfield Overland Trail • El Camino Real de Tierra Adentro National Historic Trail (co-administered by BLM and NPS) • Old Spanish National Historic Trail (co-administered by BLM and NPS) • Santa Fe National Historic Trail
Oregon	• Oregon–California National Historic Trail • Lewis and Clark National Historic Trail • Nez Perce Nee Me Poo National Historic Trail • Oregon National Historic Trail
Utah	• Oregon–California National Historic Trail • Mormon Pioneer National Historic Trail • Old Spanish National Historic Trail (co-administered by BLM and NPS) • Pony Express National Historic Trail
Washington	• Lewis and Clark National Historic Trail • Oregon–California National Historic Trail
Wyoming	• Oregon–California National Historic Trail • Mormon Pioneer National Historic Trail • Nez Perce Nee Me Poo National Historic Trail • Oregon National Historic Trail • Pony Express National Historic Trail

Table F.3.2-10. Congressionally and Presidentially Designated National Monuments and Parks with Cultural Components Within the 11-State Study Area

National Monument Name	State	Administering Agency
Agua Fria National Monument	Arizona	BLM
Baaj Nwaavjo I’tah Kukveni – Ancestral Footprints of the Grand Canyon National Monument	Arizona	BLM
Casa Grande National Monument	Arizona	NPS
Chiricahua National Monument	Arizona	NPS
Grand Canyon National Park	Arizona	NPS
Grand Canyon–Parashant National Monument	Arizona	NPS and BLM
Ironwood Forest National Monument	Arizona	BLM
Montezuma Castle National Monument	Arizona	NPS
Navajo National Monument	Arizona	NPS
Organ Pipe Cactus National Monument	Arizona	NPS
Petrified Forest National Park	Arizona	NPS
Pipe Springs National Monument	Arizona	NPS
Saguaro National Park	Arizona	NPS
Sonoran Desert National Monument	Arizona	BLM
Sunset Crater Volcano National Monument	Arizona	NPS
Tonto National Monument	Arizona	NPS
Tumacacori National Historical Park	Arizona	NPS
Tuzigoot National Monument	Arizona	NPS
Vermillion Cliffs National Monument	Arizona	BLM
Walnut Canyon National Monument	Arizona	NPS
Wupatki National Monument	Arizona	NPS
Berryessa Snow Mountain National Monument	California	BLM and FS
Cabrillo National Monument	California	NPS
California Coastal National Monument	California	BLM
Carrizo Plain National Monument	California	BLM
Castle Mountain National Monument	California	NPS
César E. Chávez National Monument	California	NPS
Channel Islands National Park	California	NPS
Devils Postpile National Monument	California	NPS
Fort Ord National Monument	California	BLM
Giant Sequoia National Monument	California	FS
Joshua Tree National Park	California	NPS
Lassen Volcanic National Park	California	NPS
Lava Beds National Monument	California	NPS
Mojave Trails National Monument	California	BLM
Muir Woods National Monument	California	NPS
Pinnacles National Park	California	NPS
San Gabriel Mountains National Monument	California	FS
Sand to Snow National Monument	California	BLM & FS
Death Valley National Park	California & Nevada	NPS
Black Canyon of the Gunnison National Park	Colorado	NPS

Table F.3.2-10. Congressionally and Presidentially Designated National Monuments and Parks with Cultural Components Within the 11-State Study Area (Cont.)

National Monument Name	State	Administering Agency
Browns Canyon National Monument	Colorado	BLM
Camp Hale-Continental Divide	Colorado	FS
Canyons of the Ancients National Monument	Colorado	BLM
Chimney Rock National Monument	Colorado	FS
Colorado National Monument	Colorado	NPS
Great Sand Dunes National Park & Preserve	Colorado	NPS
Mesa Verde National Park	Colorado	NPS
Rio Grande National Forest	Colorado	FS
White River National Forest	Colorado	FS
Yucca House National Monument	Colorado	NPS
Dinosaur National Monument	Colorado & Utah	NPS
Hovenweep National Monument	Colorado & Utah	NPS
Craters of the Moon National Monument and Preserve	Idaho	NPS and BLM
Minidoka National Historic Site	Idaho	NPS
Big Hole National Battlefield	Montana	NPS
Lewis and Clark Caverns State Park	Montana	MT
Little Bighorn	Montana	NPS
Pompeys Pillar National Monument	Montana	BLM
Upper Missouri River Breaks National Monument	Montana	BLM
Aztec Ruin National Monument	New Mexico	NPS
Bandelier National Monument	New Mexico	NPS
Browns Canyon National Monument	New Mexico	BLM and FS
Capulin Volcano National Monument	New Mexico	NPS
Carlsbad Cave National Park	New Mexico	NPS
Chaco Culture National Historical Park	New Mexico	NPS
El Morro National Monument	New Mexico	NPS
Gila Cliff Dwellings National Monument	New Mexico	NPS
Kasha–Katuwe Tent Rocks National Monument	New Mexico	BLM
Organ Mountains-Desert Peaks National Monument	New Mexico	BLM
Rio Grande del Norte National Monument	New Mexico	BLM
Salinas Pueblo Missions National Monument	New Mexico	NPS
White Sands National Park	New Mexico	NPS
Avi Kwa Ame	Nevada	BLM and NPS
Basin and Range National Monument	Nevada	BLM
Gold Butte National Monument	Nevada	BLM
Cascade-Siskiyou National Monument	Oregon	BLM
Oregon Caves National Monument and Preserve	Oregon	NPS
San Juan Islands National Monument	Washington	NPS and BLM
Arches National Park	Utah	NPS
Bears Ears National Monument	Utah	BLM and FS
Bryce Canyon National Park	Utah	NPS
Capitol Reef National Park	Utah	NPS

Table F.3.2-10. Congressionally and Presidentially Designated National Monuments and Parks with Cultural Components Within the 11-State Study Area (Cont.)

National Monument Name	State	Administering Agency
Cedar Breaks National Monument	Utah	NPS
Grand Staircase–Escalante National Monument	Utah	BLM
Natural Bridges National Monument	Utah	NPS
Rainbow Bridge National Monument	Utah	NPS
Timpanogos Cave National Monument	Utah	NPS
Zion National Park	Utah	NPS
Hanford Reach National Monument	Washington	FWS
Olympic National Park	Washington	NPS
Devils Tower National Monument	Wyoming	NPS
Fort Laramie National Historical Site	Wyoming	NPS
Grand Teton National Park	Wyoming	NPS
Spirit Mountain Cave	Wyoming	BLM

F.3.3 Supplemental Material for Impacts Assessment

Table F.3.3-1. Cultural Resources on Available Lands in Arizona for the No Action Alternative and Five Action Alternatives

Arizona	No Action	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Known Cultural Resources in Alternative	2,088	2,222	1,855	1,176	574	506
Prehistoric	1,023	1,157	970	499	148	133
Historic	224	243	208	159	127	110
Multi-component	76	82	64	40	21	20
Ethnohistoric	8	7	6	6	4	4
Time Period Unknown	757	733	607	472	274	239
NRHP Elig. Yes*	421	431	378	225	103	89
NRHP Elig. No	597	668	576	268	98	81
NRHP Elig. Undetermined	1,070	1,123	901	683	373	336
NRHP Elig. Unknown**	0	0	0	0	0	0

Source: National Cultural Resources Information System (NCRIMS). Best available data are from 2020. Updated data are anticipated to be available in January 2024 and will be incorporated between draft and final EIS.

* Includes term "Contributing," where present.

** Includes term ”Unevaluated," where present.

Table F.3.3-2. Cultural Resources on Available Lands in California for the No Action Alternative and Five Action Alternatives

California	No Action	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Known Cultural Resources in Alternative	1,888	5,559	1,780	1,324	1,255	1,004
Prehistoric	441	1,640	648	370	353	215
Historic	967	2,819	713	645	659	605
Multi-component	257	567	167	117	93	65
Ethnohistoric	0	0	0	0	0	0
Time Period Unkown	223	533	252	192	150	119
NRHP Elig. Yes*	186	437	133	48	48	30
NRHP Elig. No	233	756	262	210	209	187
NRHP Elig. Undetermined	1,455	4,333	1,376	1,063	991	784
NRHP Elig. Unknown**	14	33	9	3	7	3

Source: National Cultural Resources Information System (NCRIMS). Best available data are from 2020. Updated data are anticipated to be available in January 2024 and will be incorporated between draft and final EIS.

* Includes term "Contributing," where present.

** Includes term "Unevaluated," where present.

Table F.3.3-3. Cultural Resources on Available Lands in Colorado for the No Action Alternative and Five Action Alternatives

COLORADO	No Action	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Known Cultural Resources in Alternative	1,651	16,605	8,283	5,866	4,260	3,079
Prehistoric	604	11,745	5,846	4,247	2,812	1,991
Historic	811	3,010	1,567	1,036	987	769
Multi-component	82	589	341	233	167	111
Ethnohistoric	0	0	0	0	0	0
Time Period Unknown	154	1,261	529	350	294	208
NRHP Elig. Yes*	346	1,997	1,135	804	662	500
NRHP Elig. No	935	11,342	5,524	3,897	2,710	1,949
NRHP Elig. Undetermined	341	3,011	1,503	1,104	841	613
NRHP Elig. Unknown**	29	255	121	61	47	17

Source: National Cultural Resources Information System (NCRIMS). Best available data are from 2020. Updated data are anticipated to be available in January 2024 and will be incorporated between draft and final EIS.

* Includes term "Contributing," where present.

** Includes term "Unevaluated," where present.

Table F.3.3-4. Cultural Resources on Available Lands in Idaho for the No Action Alternative and Five Action Alternatives

IDAHO	No Action	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Known Cultural Resources in Alternative	14,395	5,105	3,912	2,986	1,770	1,656
Prehistoric	8,020	2,623	1,999	1,592	872	826
Historic	5,015	2,070	1,616	1,157	758	697
Multi-component	1,065	326	244	191	109	103
Ethnohistoric	5	0	0	0	0	0
Unknown	290	86	53	46	31	30
NRHP Elig. Yes*	3,685	1,125	800	668	395	375
NRHP Elig. No	5,718	2,316	1,921	1,619	971	910
NRHP Elig. Undetermined	4,990	1,664	1,191	699	404	371
NRHP Elig. Unknown**	2	0	0	0	0	0

Source: National Cultural Resources Information System (NCRIMS). Best available data are from 2020. Updated data are anticipated to be available in January 2024 and will be incorporated between draft and final EIS.

* Includes term "Contributing," where present.

** Includes term "Unevaluated," where present.

Table F.3.3-5. Cultural Resources on Available Lands in Montana for the No Action Alternative and Five Action Alternatives

Montana	No Action	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Known Cultural Resources in Alternative	7,417	3,174	2,090	431	1,651	311
Prehistoric	1,184	380	284	57	207	41
Historic	2,362	920	371	127	299	107
Multi-component	78	25	18	3	12	2
Ethnohistoric	0	0	0	0	0	0
Time Period Unknown	3,793	1,849	1,417	244	1,133	161
NRHP Elig. Yes*	505	128	54	23	46	18
NRHP Elig. No	1,206	456	199	61	123	32
NRHP Elig. Undetermined	5,706	2,590	1,837	347	1,482	261
NRHP Elig. Unknown**	0	0	0	0	0	0

Source: National Cultural Resources Information System (NCRIMS). Best available data are from 2020. Updated data are anticipated to be available in January 2024 and will be incorporated between draft and final EIS.

* Includes term "Contributing," where present.

** Includes term "Unevaluated," where present.

Table F.3.3-6. Cultural Resources on Available Lands in Nevada for the No Action Alternative and Five Action Alternatives

NEVADA	No Action	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Known Cultural Resources in Alternative	13,339	26,113	19,150	12,265	9,054	6,681
Prehistoric	4,935	10,167	7,951	5,073	3,059	2,081
Historic	3,453	7,552	4,904	3,671	3,213	2,594
Multi-component	701	1,451	1,023	621	520	391
Ethnohistoric	0	3	0	0	0	0
Time Period Unknown	4,250	6,940	5,272	2,900	2,262	1,615
NRHP Elig. Yes*	1,001	2,051	1,509	900	790	480
NRHP Elig. No	4,792	10,314	7,387	4,977	3,854	2,875
NRHP Elig. Undetermined	7,545	13,747	10,253	6,388	4,409	3,326
NRHP Elig. Unknown**	1	1	1	0	1	0

Source: National Cultural Resources Information System (NCRIMS). Best available data are from 2020. Updated data are anticipated to be available in January 2024 and will be incorporated between draft and final EIS.

* Includes term "Contributing," where present.

** Includes term "Unevaluated," where present.

Table F.3.3-7. Cultural Resources on Available Lands in New Mexico for the No Action Alternative and Five Action Alternatives

New Mexico	No Action	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Known Cultural Resources in Alternative	10,460	15,460	13,000	9,587	9,301	7,216
Prehistoric	3,858	5,898	5,151	3,818	3,441	2,729
Historic	1,905	2,476	1,745	1,205	1,448	1,001
Multi-component	560	690	500	339	373	267
Ethnohistoric	0	0	0	0	0	0
Time Period Unknown	4,137	6,396	5,604	4,225	4,039	3,219
NRHP Elig. Yes*	3	3	3	3	3	3
NRHP Elig. No	0	0	0	0	0	0
NRHP Elig. Undetermined	10,457	15,457	12,997	9,584	9,298	7,213
NRHP Elig. Unknown**	0	0	0	0	0	0

Source: National Cultural Resources Information System (NCRIMS). Best available data are from 2020. Updated data are anticipated to be available in January 2024 and will be incorporated between draft and final EIS.

* Includes term "Contributing," where present.

** Includes term "Unevaluated," where present.

Table F.3.3-8. Cultural Resources on Available Lands in Oregon for the No Action Alternative and Five Action Alternatives

Oregon	No Action	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Known Cultural Resources in Alternative	10,961	3,419	1,944	1,270	846	719
Prehistoric	6,098	1,790	1,179	709	438	346
Historic	2,560	892	348	277	226	215
Multi-component	449	110	64	49	36	31
Ethnohistoric	20	11	6	3	1	1
Time Period Unknown	1,834	616	347	232	145	126
NRHP Elig. Yes*	379	112	67	48	35	28
NRHP Elig. No	1,301	323	146	86	80	56
NRHP Elig. Undetermined	9,281	2,984	1,731	1,136	731	635
NRHP Elig. Unknown**	0	0	0	0	0	0

Source: National Cultural Resources Information System (NCRIMS). Best available data are from 2020. Updated data are anticipated to be available in January 2024 and will be incorporated between draft and final EIS.

* Includes term "Contributing," where present.

** Includes term "Unevaluated," where present.

Table F.3.3-9. Cultural Resources on Available Lands in Utah for the No Action Alternative and Five Action Alternatives

Utah	No Action	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Known Cultural Resources in Alternative	3,976	17,398	12,362	9,469	8,295	6,992
Prehistoric	1,532	7,057	5,035	4,028	3,312	2,822
Historic	540	2,909	1,959	1,616	1,512	1,346
Multi-component	96	399	298	250	215	193
Ethnohistoric	2	44	40	36	36	36
Time Period Unknown	1,806	6,989	5,030	3,539	3,220	2,595
NRHP Elig. Yes*	1,591	5,867	4,332	3,241	2,898	2,280
NRHP Elig. No	1,244	6,941	5,001	4,031	3,646	3,185
NRHP Elig. Undetermined	1,141	4,590	3,029	2,197	1,751	1,527
NRHP Elig. Unknown**	0	0	0	0	0	0

Source: National Cultural Resources Information System (NCRIMS). Best available data are from 2020. Updated data are anticipated to be available in January 2024 and will be incorporated between draft and final EIS.

* Includes term "Contributing," where present.

** Includes term "Unevaluated," where present.

Table F.3.3-10. Cultural Resources on Available Lands in Washington for the No Action Alternative and Five Action Alternatives

Washington	No Action	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Known Cultural Resources in Alternative	19	3	0	0	0	0
Prehistoric	8	1	0	0	0	0
Historic	5	0	0	0	0	0
Multi-component	4	0	0	0	0	0
Ethnohistoric	0	0	0	0	0	0
Time Period Unknown	2	2	0	0	0	0
NRHP Elig. Yes*	2	1	0	0	0	0
NRHP Elig. No	0	0	0	0	0	0
NRHP Elig. Undetermined	17	0	0	0	0	0
NRHP Elig. Unknown**	0	2	0	0	0	0

Source: National Cultural Resources Information System (NCRIMS). Best available data are from 2020. Updated data are anticipated to be available in January 2024 and will be incorporated between draft and final EIS.

* Includes term "Contributing," where present.

** Includes term "Unevaluated," where present.

Table F.3.3-11. Cultural Resources on Available Lands in Wyoming for the No Action Alternative and Five Action Alternatives

Wyoming	No Action	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Known Cultural Resources in Alternative	37,325	25,279	22,261	18,649	14,590	12,865
Prehistoric	24,889	17,405	15,578	13,181	10,083	8,950
Historic	3,609	2,242	1,767	1,491	1,311	1,133
Multi-component	2,336	1,656	1,467	1,250	974	864
Ethnohistoric	0	0	0	0	0	0
Time Period Unknown	6,491	3,976	3,449	2,727	2,222	1,918
NRHP Elig. Yes*	7,789	5,049	4,569	3,799	3,223	2,868
NRHP Elig. No	19,567	13,478	11,797	9,768	8,030	6,958
NRHP Elig. Undetermined	9,969	6,752	5,895	5,082	3,337	3,039
NRHP Elig. Unknown**	0	0	0	0	0	0

Source: National Cultural Resources Information System (NCRIMS). Best available data are from 2020. Updated data are anticipated to be available in January 2024 and will be incorporated between draft and final EIS.

* Includes term "Contributing," where present.

** Includes term "Unevaluated," where present.

F.4 Ecological Resources

F.4.1 Vegetation

F.4.1.1 Methods Used for Evaluation

The vegetation impact assessment included quantitative analyses using GIS to evaluate potential impacts within the planning area of the Programmatic EIS. The intersections of BLM-administered land boundaries and the 35 ecoregion boundaries were calculated using two approaches:

- V1 calculated the percentage of each of the alternatives intersected relative to the total amount of the ecoregion area in the 11-state planning area (Table 4.1.3-2).
- V2 calculated each ecoregion intersection as a percentage of the total land available for application under each of the alternatives (Table 4.1.3-3).

Vegetation included plant communities and land cover types that were associated with the ecoregions that resulted in the highest percentages in these two analyses. (See Appendix E for a description of plant communities and land cover types for all 35 ecoregions.)

The methodology for the overall impacts on vegetation presented in Table F.4.1.3-1 is described in the table footnotes.

F.4.1.2 Supplemental Material for Affected Environment

The ecoregion discussions presented in this Programmatic EIS follow the Level III ecoregion classification, with 35 ecoregions covering the 11-state planning area. (See also Appendix E, Figure E-1, Level III Ecoregions in the 11-state Planning Area.) Table F.4.1.2-1 lists the number of acres of BLM-administered land in each ecoregion.

Table F.4.1.2-1. Level III Ecoregion Acreage on BLM-administered Land by State (Source: EPA 2022b)

State	Level III Ecoregion	Acres
Arizona	Arizona/New Mexico Mountains	610,890
	Arizona/New Mexico Plateau	1,652,964
	Chihuahuan Deserts	325,115
	Colorado Plateaus	1,054,592
	Madrean Archipelago	1,012,925
	Mojave Basin and Range	1,679,150
	Sonoran Basin and Range	5,773,692
California*	Cascades	72,297
	Central Basin and Range	685,226
	Central California Foothills and Coastal Mountains	1,099,563
	Central California Valley	33,575
	Coast Range	122,695
	Eastern Cascades Slopes and Foothills	728,608
	Klamath Mountains/California High North Coast Range	228,967
	Mojave Basin and Range	3,453
	Northern Basin and Range	555,601
	Sierra Nevada	377,312
	Sonoran Basin and Range	62,878
	Southern California Mountains	85,990
	Southern California/Northern Baja Coast	94,149
Colorado	Arizona/New Mexico Plateau	299,188
	Colorado Plateaus	4,512,891
	High Plains	7,089
	Southern Rockies	2,440,948
	Southwestern Tablelands	51,504
	Wyoming Basin	1,042,675
Idaho	Blue Mountains	188,178
	Central Basin and Range	71,372
	Columbia Plateau	788
	Idaho Batholith	453,088
	Middle Rockies	1,925,913
	Northern Basin and Range	4,464,154
	Northern Rockies	109,192

Table F.4.1.2-1. Level III Ecoregion Acreage on BLM-administered Land by State (Source: EPA 2022b) *(Cont.)*

State	Level III Ecoregion	Acres
Idaho *(Cont.)*	Snake River Plain	4,502,584
	Wasatch and Uinta Mountains	12,890
	Wyoming Basin	46,674
Montana	Canadian Rockies	20,659
	Idaho Batholith	270
	Middle Rockies	1,536,566
	Northern Rockies	207
	Northwestern Glaciated Plains	1,963,030
	Northwestern Great Plains	4,374,161
	Wyoming Basin	148,120
Nevada	Arizona/New Mexico Plateau	27,293
	Central Basin and Range	36,539,462
	Mojave Basin and Range	4,539,803
	Northern Basin and Range	6,165,570
New Mexico	Arizona/New Mexico Mountains	885,806
	Arizona/New Mexico Plateau	2,856,268
	Chihuahuan Deserts	7,040,953
	Colorado Plateaus	420,133
	High Plains	517,804
	Madrean Archipelago	333,717
	Southern Rockies	135,410
	Southwestern Tablelands	1,303,262
Oregon	Blue Mountains	2,029,856
	Cascades	527,070
	Coast Range	751,515
	Columbia Plateau	187,029
	Eastern Cascades Slopes and Foothills	325,943
	Klamath Mountains/California High North Coast Range	919,063
	Northern Basin and Range	10,691,251
	Snake River Plain	189,745
	Willamette Valley	96,700
Utah	Central Basin and Range	9,625,415
	Colorado Plateaus	11,600,824
	Mojave Basin and Range	285,220
	Northern Basin and Range	172,711
	Southern Rockies	1,330
	Wasatch and Uinta Mountains	863,446
	Wyoming Basin	218,950
Washington	Blue Mountains	14,796
	Cascades	841

Table F.4.1.2-1. Level III Ecoregion Acreage on BLM-administered Land by State (Source: EPA 2022b) *(Cont.)*

State	Level III Ecoregion	Acres
Washington *(cont.)*	Coast Range	175
	Columbia Plateau	338,217
	Eastern Cascades Slopes and Foothills	10,585
	North Cascades	35,794
	Northern Rockies	35,749
	Puget Lowland	803
	Willamette Valley	28
Wyoming	High Plains	74,903
	Middle Rockies	505,949
	Northwestern Great Plains	1,847,665
	Snake River Plain	417
	Southern Rockies	397,605
	Wasatch and Uinta Mountains	22,506
	Wyoming Basin	15,198,439

* Acreage in California excludes area in DRECP.

Figure F.4.1.2-1 highlights current vegetation composition with canopy cover. Successional classes are a combination of succession stage (early, mid, and late), together with canopy cover (all, open, and closed) shown as A through E. Two additional categories are uncharacteristic native vegetation cover (UN) and uncharacteristic exotic vegetation (UE).

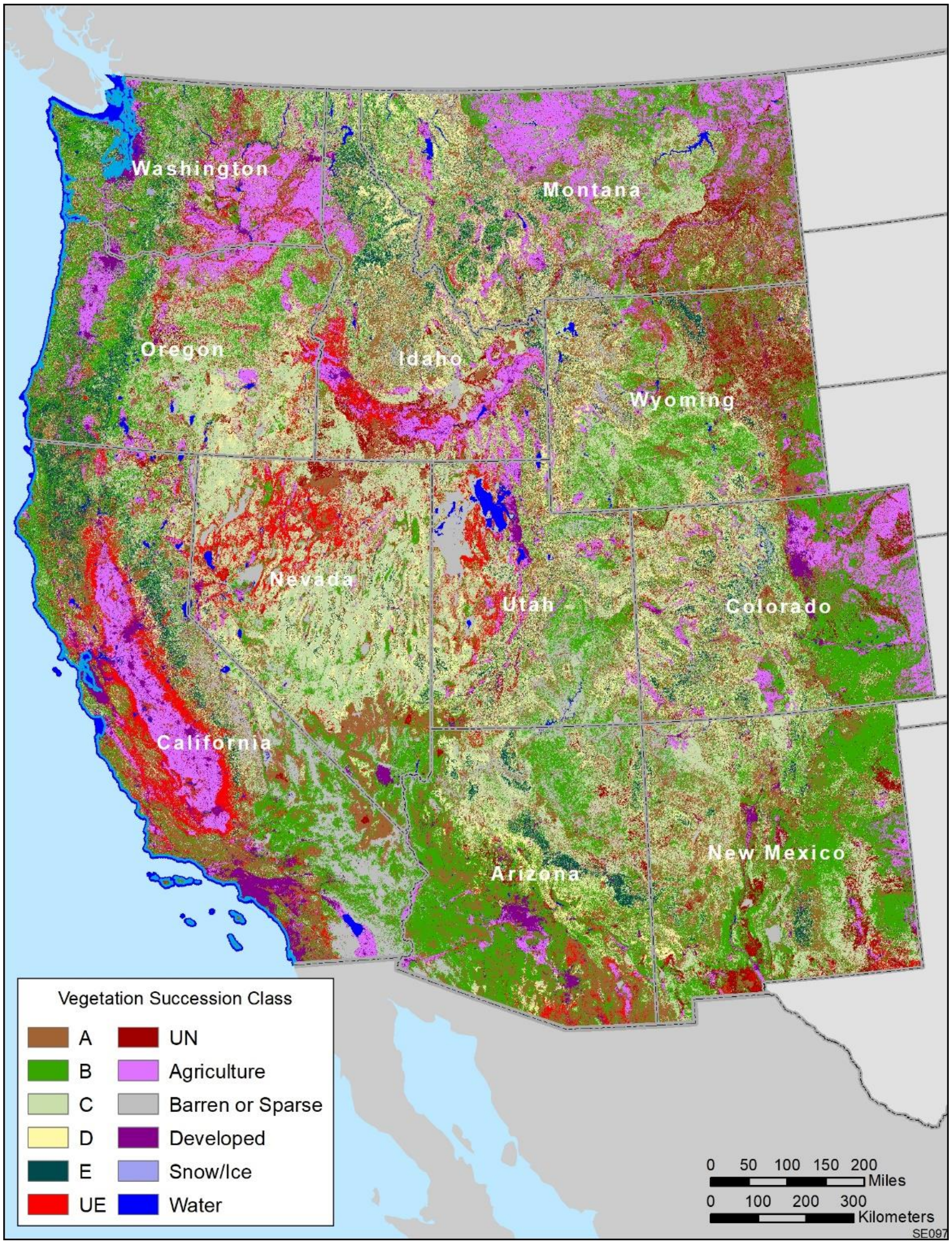


Figure F.4.1.2-1. Current Vegetation Composition and Structure (Source: USGS 2022a)

Figure F.4.1.2-2 demonstrates the departure of current vegetation conditions from estimated historical (prior to European settlement) conditions. Vegetation Departure uses a percentage from 0 to 100 to represent how vegetation has departed from historical vegetation reference conditions.

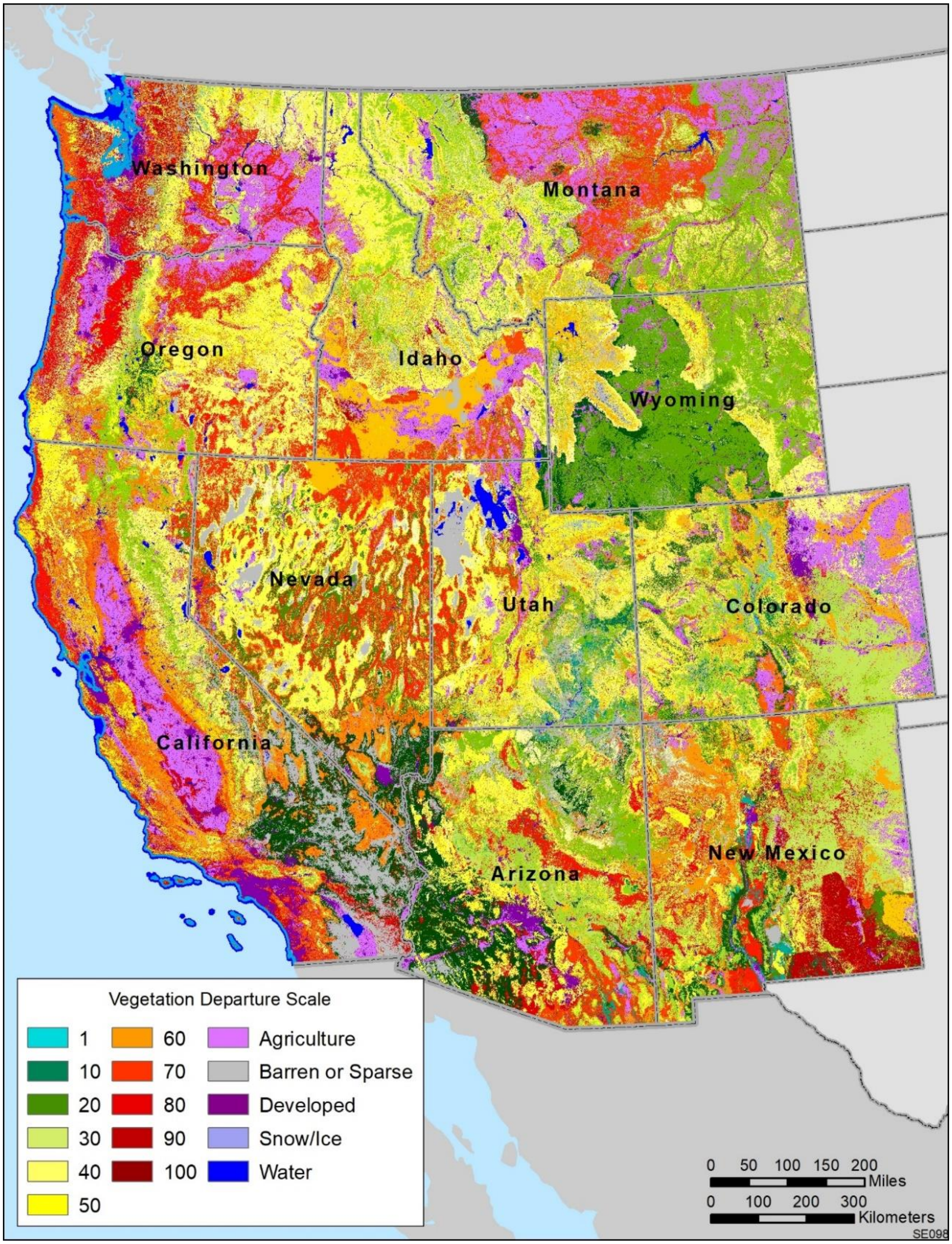


Figure F.4.1.2-2. Vegetation Departure (Source: USGS 2022b)

BLM has adopted a landscape approach to natural resource management, using a set of concepts and principles when multiple stakeholders are involved to help achieve sustainable social, environmental, and economic outcomes. A multiscale index of landscape intactness, defined as a quantifiable estimate of naturalness on a gradient of anthropogenic influence over broad landscapes or ecoregions, provides a standardized approach to natural resource status and condition. USGS, in cooperation with BLM, created the index for landscape intactness by quantifying the surface disturbance footprint from development and deriving a terrestrial development index. Levels of landscape intactness vary within ecoregions and correspond to land ownership, jurisdiction, and land use. More than 20 percent of the Mojave Basin and Range, Central Basin and Range, Middle Rockies, Northern Great Basin, Colorado Plateau, and Sonoran Desert ecoregions are classified at the highest level of landscape intactness. The ecoregions with the lowest level of intactness are dominated by agriculture as a land use. BLM-administered lands with the highest level of intactness include those in the Northern Basin and Range, Central Basin and Range, and Mojave Basin and Range. These are predominantly arid shrublands. Although the level of intactness is high, the index does not include information on invasive species such as cheatgrass (*Bromus tectorum*). Cheatgrass and associated alterations of fire regime is more widespread in arid shrublands of the Great Basin than in others with a lower level of intactness, such as the Wyoming Basin (Carter Carr Miller Wood 2017). Cheatgrass creates a monoculture, is very flammable, and can cause more intense and frequent wildfires. It is able to outcompete native plants by beginning growth early in the season and also reestablishing quickly after a fire (NPS 2020). Figure F.4.1.2-3 shows areas of low landscape intactness across the ecoregions in the 11-state planning area, and Figure F.4.1.2-4 highlights areas of low level of landscape intactness on BLM-administered lands. Additional information at the local level on invasive species, shrublands, and fire regime will more accurately determine ecological integrity (Carter Carr Miller Wood 2017).

F.4.1.3 Supplemental Material for Impacts Assessment

Potential impacts on terrestrial and wetland plant communities and habitats from the development of utility-scale solar energy projects would include direct impacts from habitat loss and fragmentation as well as a wide variety of indirect impacts, as listed in Table F.4.1.3-1. Impacts would be incurred during all phases of the project, including site characterization and initial site preparation and would continue throughout the operational life of the facility, typically extending over several decades.

Supplemental discussion of noxious weeds and invasive species, impacts on wetlands, impacts of altered hydrology, restoration of vegetation, and impacts specific to transmission lines and roads follows.

Figure F.4.1.2-3. Areas with Low Landscape Intactness and Ecoregions of the 11 states (Carr Leinwand Wood 2016)

Figure F.4.1.2-4. Areas with Low Landscape Intactness on BLM-administered Lands Within the 11 States (Carr Leinwand Wood 2016)

Table F.4.1.3-1. Potential Impacts on Plant Communities Associated with Utility-Scale Solar Energy Facilities, Including Associated Access Roads and Transmission Line Corridors

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
***Individual Impacting Factor*[d]**							
Alteration of topography and drainage patterns	Construction, operations, decommissioning	Changes in surface temperature, soil moisture, and hydrologic regimes, and distribution and extent of aquatic, wetland, and riparian habitats; erosion; changes in groundwater recharge; spread of invasive species; decrease in pollinators, changes in community structure and function.	None	None	Terrestrial	Aquatic, wetland, and riparian	Can be mitigated by avoiding development of drainages and using appropriate stormwater management strategies.
Erosion	Construction operations, decommissioning	Habitat degradation; loss of plants; sedimentation of adjacent areas especially aquatic, wetland, and riparian habitats, loss of productivity; spread of invasive species; changes in community structure and function.	None	Terrestrial	Aquatic, wetland, and riparian	None	Can be mitigated with standard erosion control practices.
Fugitive dust	Site characterization, construction, operations, decommissioning	Decrease in photosynthesis, reduction in productivity, increase in turbidity and sedimentation in aquatic habitat, spread of invasive species, decrease in pollinators, changes in community structure and function.	None	None	All plant communities	None	Can be mitigated by retaining vegetative cover, soil covers, or soil-stabilizing agents.
Groundwater withdrawal	Construction, operations	Change in hydrologic regime, reduction in surface water, surface subsidence, reduction in soil moisture, reduction in productivity, decrease in pollinators, changes in community structure and function.	None	Terrestrial (other than phreatophytic)	Aquatic, wetland, riparian, and phreatophytic	None	Can be mitigated by reducing water consumption requirements.

Table F.4.1.3-1. Potential Impacts on Plant Communities Associated with Utility-Scale Solar Energy Facilities, Including Associated Access Roads and Transmission Line Corridors *(Cont.)*

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Habitat fragmentation	Construction, operations	Genetic isolation, loss of access to important habitats, reduction in diversity, spread of invasive species, decrease in pollinators, changes in community structure and function.	None	None	All plant communities	None	Difficult to mitigate; requires minimizing disruption of intact communities, especially by linear features such as transmission lines and roads.
Increased human access	Construction, operations	Collection, mortality.	None	All plant communities	None	None	Can be mitigated by reducing the number of new transmission lines and roads in important habitats.
Oil and contaminant spills	Site characterization, construction, operations, decommissioning	Death of directly affected individuals, uptake of toxic materials, reproductive impairment, decrease in pollinators, changes in community structure and function.	None	None	Terrestrial	Aquatic, wetland, and riparian	Can be mitigated by using project mitigation measures and spill prevention and response planning.
Restoration of topography and drainage patterns	Decommissioning	Changes in temperature, soil moisture, and hydrologic regimes; changes in community structure and function, introduction of invasive plants.	None	None	All plant communities	None	Mostly beneficial; adverse impacts can be mitigated by using standard erosion and runoff control measures.
Restoration of topsoil	Decommissioning	Beneficial changes in soil moisture, increased productivity, changes in community structure and function.	None	None	All plant communities	None	Mostly beneficial; adverse impacts can be mitigated by using standard erosion and runoff control measures.

Table F.4.1.3-1. Potential Impacts on Plant Communities Associated with Utility-Scale Solar Energy Facilities, Including Associated Access Roads and Transmission Line Corridors *(Cont.)*

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Restoration of native vegetation	Decommissioning	Beneficial changes in soil moisture, increased productivity, increased diversity, increase in pollinators, changes in community structure and function.	None	None	All plant communities	None	Mostly beneficial; adverse impacts can be mitigated by ensuring species mix used includes a diverse weed-free mix of hardy native species.
Soil compaction	Site characterization, construction, operations, decommissioning	Reduction in productivity, reduction in diversity, increased runoff and erosion, spread of invasive species, changes in community structure and function.	None	All plant communities	None	None	Can be mitigated by aerating soil after being compacted.
Topsoil removal	Construction, operations	Reduction in productivity, reduction in diversity, direct mortality of individuals, increased sedimentation in aquatic habitat, spread of invasive species, decrease in pollinators, changes in community structure and function.	None	None	All plant communities	None	Readily mitigated by stockpiling soils to maintain seed viability, vegetating to reduce erosion, and replacing at appropriate depths when other site activities are complete.
Vegetation clearing	Construction, operations	Elimination of habitat, habitat fragmentation, direct mortality of individuals, changes in temperature and moisture regimes, erosion, increased fugitive dust emissions, reduction in productivity, reduction in diversity, spread of invasive species, decrease in pollinators, changes in community structure and function, use of herbicides	None	None	None	All plant communities	Difficult to mitigate; most project areas are likely to require clearing. Restoration of a vegetative cover consistent with the intended land use would reduce some impacts.

Table F.4.1.3-1. Potential Impacts on Plant Communities Associated with Utility-Scale Solar Energy Facilities, Including Associated Access Roads and Transmission Line Corridors *(Cont.)*

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Vegetation maintenance	Operations	Reduction in vegetation cover or vegetation maintained in early successional stage or low-stature, habitat fragmentation, direct mortality of individuals, reduction in diversity, spread of invasive species, decrease in pollinators, changes in community structure and function.	None	None	All plant communities	None	Can be mitigated by managing for low-maintenance vegetation (e.g., native shrubs, grasses, and forbs), mowing or hand trimming, invasive species control, minimizing the use of herbicides near sensitive habitats (e.g., aquatic and wetland habitats), and using only BLM approved herbicides consistent with manufacturer's label of safe application guidelines.
Vehicle and equipment emissions	Construction, operations	Reduced productivity.	None	All plant communities	None	None	Readily mitigated by maintaining equipment in proper operating condition.
Vehicle and foot traffic	Site characterization, construction, operations, decommissioning	Direct mortality of individuals through crushing, soil compaction, increased fugitive dust emissions, and introduction of invasive species.	None	All plant communities	None	None	Can be mitigated by using worker education programs, signage, and traffic restrictions, and ensure that all equipment entering the site is free of vegetation or soil.

Table F.4.1.3-1. Potential Impacts on Plant Communities Associated with Utility-Scale Solar Energy Facilities, Including Associated Access Roads and Transmission Line Corridors *(Cont.)*

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
All Impacting Factors Combined							
	Site characterization	Direct mortality of individuals, habitat loss, soil compaction, increased fugitive dust emissions, increased runoff and erosion, spread of invasive species, changes in community structure and function.	None	All plant communities	None	None	Relatively easy.
	Construction	Direct mortality of individuals, habitat loss, reduced productivity and diversity, habitat fragmentation, soil compaction, increased fugitive dust emissions, spread of invasive species, changes in temperature and moisture regimes, increased sedimentation in aquatic habitat, increased runoff and erosion, changes in groundwater recharge, changes in community structure and function.	None	None	None	All plant communities	Relatively difficult; residual impact mostly dependent on the size of area developed.

Table F.4.1.3-1. Potential Impacts on Plant Communities Associated with Utility-Scale Solar Energy Facilities, Including Associated Access Roads and Transmission Line Corridors *(Cont.)*

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
All Impacting Factors Combined (Cont.)							
	Operations	Direct mortality of individuals, habitat loss, reduction in vegetation cover or vegetation maintained in early successional stage or low-stature, reduced productivity and diversity, habitat fragmentation, soil compaction, increased fugitive dust emissions, changes in temperature and moisture regimes, increased sedimentation in aquatic habitat, increased runoff and erosion, changes in groundwater recharge, changes in community structure and function.	None	None	None	All plant commun ities	Relatively difficult; residual impact mostly dependent on the size of area developed.
	Decommissioning	Beneficial changes in soil moisture, temperature, and hydrologic regimes, increased productivity, increased diversity, direct mortality of individuals, habitat loss, soil compaction, increased fugitive dust emissions, changes in community structure and function.	None	None	All plant communities (benefits)	None	Relatively easy to mitigate adverse impacts of decommissioning. May be difficult to achieve restoration objectives.

Table F.4.1.3-1. Potential Impacts on Plant Communities Associated with Utility-Scale Solar Energy Facilities, Including Associated Access Roads and Transmission Line Corridors *(Cont.)*

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
All Impacting Factors Combined (Cont.)							
	Overall project	Direct mortality of individuals, habitat loss, reduced productivity and diversity, habitat fragmentation, soil compaction, increased fugitive dust emissions, changes in temperature and moisture regimes, increased sedimentation in aquatic habitat, increased runoff and erosion, changes in groundwater recharge, surface subsidence, changes in community structure and function.	None	None	None	All plant communities	Relatively difficult; residual impact mostly dependent on the size of area developed and the success of restoration activities.

[a] Relative impact magnitude categories were based on professional judgment utilizing CEQ regulations for implementing NEPA (40 CFR 1508.27) by defining significance of impacts based on context and intensity. Similar impact magnitude categories and definitions were used in BLM (2008a,b) and assume no mitigation. Impact categories were as follows: (1) none—no impact would occur; (2) *small*—effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource (e.g., <1% of a population or community would be lost in the region); (3) *moderate*—effects are sufficient to alter noticeably but not to destabilize important attributes of the resource (e.g., >1 but <10% of a population or community would be lost in the region); and (4) *large*—effects are clearly noticeable and are sufficient to destabilize important attributes of the resource (e.g., >10% of a population or community would be lost in the region). Actual impact magnitudes on plant communities would depend on the location of projects, project-specific design, application of mitigation measures (including avoidance, minimization, and compensation) and the status of communities in project areas.

[b] Plant communities are placed into groups based on ecological system (aquatic, wetland, riparian, and terrestrial) when the category is relevant to impact magnitude.

[c] Actual ability to mitigate impacts will depend on site-specific conditions and the communities present in the project area. Design Features are presented in Appendix B.

[d] Impacting factors are presented in alphabetical order.

Table F.4.1.3-2. Intersection of Level III Ecoregions with Each Alternative (V1)

Level III Ecoregion Name	Total Acres in the 11-State Planning Area	No Action Alternative		Percentage of Total Ecoregion Area Intersected Under Each Alternative				
		Priority Areas	Variance Lands	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Central Basin and Range	76,303,734	0.1	10.0	31.0	20.7	11.1	4.4	3.0
Northwestern Great Plains	49,869,515	-	6.7	2.1	1.1	0.6	0.6	0.4
Middle Rockies	38,667,391	-	5.7	1.0	0.1	0.1	0.1	0.1
Arizona/New Mexico Plateau	36,289,720	0.1	3.4	4.8	3.4	2.0	1.0	0.8
Southern Rockies	36,003,642	-	0.7	1.6	0.3	0.2	0.1	0.1
Northern Basin and Range	34,643,702	-	25.7	6.4	4.8	2.7	1.5	1.1
Colorado Plateaus	33,748,531	0.0	1.4	12.1	5.2	3.4	2.2	1.8
Wyoming Basin	32,786,525	-	22.4	14.3	10.8	7.9	4.4	3.6
Mojave Basin and Range	31,552,809	0.3	4.5	8.0	5.2	4.6	1.6	1.4
Southwestern Tablelands	29,673,559	-	2.6	3.8	3.0	0.9	0.4	0.2
Sonoran Basin and Range	29,248,205	0.4	4.2	6.8	4.6	3.5	1.4	1.1
High Plains	28,130,798	-	0.4	0.5	0.4	0.3	0.3	0.2
Arizona/New Mexico Mountains	27,353,929	0.0	0.4	2.2	0.4	0.3	0.0	0.0
Northwestern Glaciated Plains	23,701,889	-	3.7	2.9	2.2	0.6	1.7	0.4
Columbia Plateau	20,542,146	-	2.2	1.7	0.6	0.5	0.4	0.4
Northern Rockies	20,252,896	-	0.6	0.5	0.0	0.0	0.0	0.0
Central California Foothills and Coastal Mountains	18,946,607	-	0.2	2.6	0.1	0.1	0.1	0.1
Chihuahuan Deserts	17,907,555	0.2	12.8	20.9	17.7	11.9	7.1	5.3
Blue Mountains	17,522,603	-	10.0	2.3	0.4	0.2	0.1	0.1
Idaho Batholith	14,896,340	-	2.3	0.9	0.0	0.0	0.0	0.0
Cascades	14,543,149	-	3.5	1.9	0.2	0.1	0.1	0.1
Coast Range	13,400,720	-	5.5	1.4	0.0	0.0	0.0	0.0
Snake River Plain	13,251,404	-	24.9	11.5	9.5	8.7	5.5	5.1
Eastern Cascades Slopes and Foothills	13,160,143	-	2.4	1.6	0.9	0.4	0.3	0.2
Sierra Nevada	13,121,963	-	0.1	1.3	0.0	0.0	0.0	0.0
Klamath Mountains/California High North Coast Range	11,949,581	-	7.2	3.6	0.0	0.0	0.0	0.0

Table F.4.1.3-2. Intersection of Level III Ecoregions with Each Alternative (V1) *(Cont.)*

Level III Ecoregion Name	Total Acres in the 11-State Planning Area	No Action Alternative		Percentage of Total Ecoregion Area Intersected Under Each Alternative				
		Priority Areas	Variance Lands	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Central California Valley	11,487,979	-	0.0	0.2	0.2	0.2	0.2	0.2
Wasatch and Uinta Mountains	11,291,082	-	0.3	2.7	0.4	0.3	0.2	0.2
Madrean Archipelago	9,796,929	0.0	4.5	8.9	4.7	3.8	1.8	1.3
North Cascades	7,510,766	-	0.4	0.4	0.0	0.0	0.0	0.0
Southern California/Northern Baja Coast	5,174,478	-	0.1	0.9	0.1	0.1	0.1	0.1
Canadian Rockies	4,665,251	-	0.4	0.4	0.0		0.0	
Puget Lowland	4,189,406	-	0.0	0.0	0.0	0.0	0.0	0.0
Southern California Mountains	3,913,616	-	0.1	1.1	0.1	0.0	0.0	0.0
Willamette Valley	3,678,079	-	2.6	1.6	0.1	0.1	0.1	0.1

Table F.4.1.3-3. Intersection of Level III Ecoregions with the Total Area of Each Alternative (V2)

Level III Ecoregion Name	Total Acres in the 11-State Planning Area	No Action Alternative		Percentage of Ecoregion Area Intersected Under the Total Area of Each Alternative				
		Priority Areas	Variance lands	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Central Basin and Range	76,303,734	19.3	16.2	43.0	45.6	39.8	31.2	28.5
Northwestern Great Plains	49,869,515	-	7.1	1.9	1.5	1.5	2.7	2.4
Middle Rockies	38,667,391	-	4.7	0.7	0.1	0.2	0.3	0.3
Arizona/New Mexico Plateau	36,289,720	7.5	2.6	3.2	3.6	3.4	3.3	3.4
Southern Rockies	36,003,642	-	0.5	1.0	0.3	0.3	0.4	0.4
Northern Basin and Range	34,643,702	-	18.8	4.1	4.8	4.4	4.8	4.9
Colorado Plateaus	33,748,531	2.7	1.0	7.4	5.1	5.4	6.9	7.6
Wyoming Basin	32,786,525	-	15.6	8.6	10.2	12.2	13.5	14.9
Mojave Basin and Range	31,552,809	27.3	3.0	4.6	4.7	6.8	4.7	5.7
Southwestern Tablelands	29,673,559	-	1.6	2.0	2.6	1.2	1.2	0.7
Sonoran Basin and Range	29,248,205	32.8	2.6	3.6	3.9	4.8	3.8	4.2
High Plains	28,130,798	-	0.2	0.3	0.3	0.4	0.7	0.9

Table F.4.1.3-3. Intersection of Level III Ecoregions with the Total Area of Each Alternative (V2) *(Cont.)*

Level III Ecoregion Name	Total Acres in the 11-State Planning Area	No Action Alternative		Percentage of Ecoregion Area Intersected Under the Total Area of Each Alternative				
		Priority Areas	Variance lands	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Arizona/New Mexico Mountains	27,353,929	0.3	0.2	1.1	0.3	0.4	0.1	0.1
Northwestern Glaciated Plains	23,701,889	-	1.8	1.2	1.5	0.6	3.9	1.3
Columbia Plateau	20,542,146	-	0.9	0.6	0.3	0.5	0.8	0.9
Northern Rockies	20,252,896	-	0.3	0.2	0.0	0.0	0.0	0.0
Central California Foothills and Coastal Mountains	18,946,607	-	0.1	0.9	0.1	0.1	0.1	0.1
Chihuahuan Deserts	17,907,555	9.3	4.8	6.8	9.2	10.1	11.8	12.0
Blue Mountains	17,522,603	-	3.7	0.7	0.2	0.2	0.2	0.2
Idaho Batholith	14,896,340	-	0.7	0.3	0.0	0.0	0.0	0.0
Cascades	14,543,149	-	1.1	0.5	0.1	0.1	0.1	0.1
Coast Range	13,400,720	-	1.6	0.3	0.0	0.0	0.0	0.0
Snake River Plain	13,251,404	-	7.0	2.8	3.7	5.5	6.9	8.5
Eastern Cascades Slopes and Foothills	13,160,143	-	0.7	0.4	0.3	0.2	0.4	0.4
Sierra Nevada	13,121,963	-	0.0	0.3	0.0	0.0	0.0	0.0
Klamath Mountains/California High North Coast Range	11,949,581	-	1.8	0.8	0.0	0.0	0.0	0.0
Central California Valley	11,487,979	-	0.0	0.0	0.1	0.1	0.2	0.2
Wasatch and Uinta Mountains	11,291,082	-	0.1	0.6	0.1	0.2	0.3	0.3
Madrean Archipelago	9,796,929	0.7	0.9	1.6	1.3	1.8	1.7	1.6
North Cascades	7,510,766	-	0.1	0.1	0.0	0.0	0.0	0.0
Southern California/Northern Baja Coast	5,174,478	-	0.0	0.1	0.0	0.0	0.0	0.0
Canadian Rockies	4,665,251	-	0.0	0.0	0.0		0.0	
Puget Lowland	4,189,406	-	0.0	0.0	0.0	0.0	0.0	0.0
Southern California Mountains	3,913,616	-	0.0	0.1	0.0	0.0	0.0	0.0
Willamette Valley	3,678,079	-	0.2	0.1	0.0	0.0	0.0	0.0

Table F.4.1.3-2 percentage of each of the alternatives intersected relative to the total amount of the ecoregion area in the 11-state planning area Table F.4.1.3-3 shows the percentage each ecoregion intersection as a percentage of the total land available or preferred under each of the alternatives. The results in F.4.1.3-3 illustrate the ecoregions that may see the most solar development.

Noxious Weeds and Invasive Species

The prevention of the spread or introduction of noxious weeds and invasive plant species is a high priority to federal, state, and county agencies. Ground disturbance from construction may make vegetation communities more susceptible to infestations of noxious weeds or invasive plants. These species are most prevalent in areas of surface disturbance, such as roadsides, existing utility ROWs, and within the urban-wildland interface.

Legally, a noxious weed is any plant officially designated by a federal, state, or county government as injurious to public health, agriculture, recreation, wildlife, or property (Sheley and Petroff 1999). Under the Federal Plant Protection Act of 2000 (formerly the Noxious Weed Act of 1974 [7 USC 2801–2814]), a noxious weed is defined as "any plant or plant product that can directly or indirectly injure or cause damage to crops, livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment." Some of the worst wildland weeds may not be listed as noxious; for example, cheatgrass (*Bromus tectorum*), a highly invasive species, is not listed as noxious in states such as Montana, where it occurs in large populations in rangelands (Seipel 2018). Other species, such as buffelgrass (*Pennisetum ciliare*) are recognized as noxious too late to prevent widespread establishment, as in southern Arizona. Noxious weeds are opportunistic plant species that readily flourish in disturbed areas, thereby preventing native plant species from establishing successive communities.

Invasive species are generally tolerant of disturbed conditions, and disturbed soils at project sites may provide an opportunity for the introduction and establishment of non-native invasive species. Seeds or other propagules of invasive species may be transported to a project site from infested areas by heavy equipment or other vehicles used at the site, or on recreational vehicles operated by the public and non-project personnel that can now access the area. Weed seeds can also be transported via footwear or clothing of workers and visitors. Invasive species may also spread from established populations near a project site and colonize soils disturbed by project activities. Edge effects from surrounding traditional development could increase the opportunities for noxious and non-native weeds in the project area. The time periods required for the re-establishment of plant communities may create an increased potential for the establishment and spread of invasive species. Invasive plant species typically develop high population densities and tend to exclude most other plant species, thereby reducing species diversity and potentially resulting in long-term effects. The establishment of invasive species may greatly reduce the success of native plant community restoration efforts in project areas and create a source of future colonization and degradation of adjacent undisturbed areas. The establishment of invasive grass species, particularly annual grasses, such as cheatgrass or buffelgrass, which produce large amounts of easily ignitable fuel over large contiguous areas, may also alter fire regimes. This situation may result in an increase in the frequency and intensity of wildfires, and in some areas, such as in some desert-scrub communities, an altered fire regime may become established where fire was previously infrequent. In plant communities not adapted to frequent or intense fires, native species, particularly shrubs and trees, may be adversely affected, and their populations may be greatly reduced, creating opportunities for greater increases in invasive species populations (Brooks and Pyke 2001). Increases in fire frequency or severity may thus result in a reduction of biodiversity and may promote the conversion of some habitats (such as shrubland or shrub-steppe) to other types, prolonging or preventing the development of mature native habitats (BLM 2007).

Trends in vegetation composition and the spread of invasive species are tracked using satellite imagery combined with collection of vegetation data on the ground. Data available on annual herbaceous cover from the Multi-Resolution Land Characteristics (MRLC) consortium was used to develop Alternatives 4 and 5. BLM utilizes an Assessment, Inventory and Monitoring (AIM) strategy to monitor and manage invasive species. Through this program, the vegetation trends in BLM rangelands from 1991 to 2020 show an increase in annual herbaceous cover with a decline in perennial herbaceous cover, and an increase in trees. AIM data showed that cheatgrass (*Bromus tectorum*) and Japanese brome (*Bromus japonicus*) were common in several of the ecoregions in this assessment. (Kleinhesselink 2022).

Impacts on Wetlands

It is expected that direct impacts on sensitive habitats, many of which are water-dependent, located within a project site could be avoided. On May 24, 1977, the President signed E.O. 11990, “Protection of Wetlands” (*Federal Register*, Volume 42, page 26961, May 24, 1977), which requires all federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands. Therefore, direct and indirect impacts on wetlands would be avoided or minimized. Compliance with CWA Section 404 would be required. Impacts on waters of the United States, including jurisdictional wetlands (those under the regulatory jurisdiction of the CWA, Section 404) on or near the project site or near the locations of ancillary facilities would be avoided or minimized and mitigated as required by Section 404. Preconstruction surveys would identify wetland locations and boundaries, and the permitting process would be initiated with the USACE for unavoidable impacts. Under the “no net loss” wetland policy, wetlands destroyed are compensated for by the development of new wetland areas, generally located offsite, and compensatory mitigation may be required for unavoidable impacts of solar project development.

Changes in Hydrology During Construction

Reduced infiltration and altered surface runoff and drainage characteristics could result in changes in soil moisture, reduced recharge of shallow groundwater systems, and changes in the hydrologic regimes of streams and associated wetlands and riparian areas located downstream of a project site. Hydrologic changes could also result from the elimination of ephemeral or intermittent streams on a project site. Soils on steep slopes could be particularly susceptible to increased erosion resulting from changes in stormwater flow patterns. Erosion and reductions in soil moisture could alter terrestrial plant communities near a project site, resulting in reduced growth and reproduction and changes in species composition. Altered hydrologic regimes, such as reductions in the duration, frequency, or extent of inundation or soil saturation, could result in changes in plant species composition in wetlands or riparian communities, changes in community distribution, or reductions in community extent. If new drainage areas are developed, however, new riparian habitats could be created, depending on the timing and duration of soil saturation. Increased volumes or velocities of flows could affect wetland and riparian habitats, removing fine soil particles, organic materials, and shallow-rooted plants. Large-scale reductions in infiltration may increase flow fluctuations, reduce base flows, and increase flood flows, resulting in impacts on wetland and riparian community composition and extent.

Wetlands that collect surface water may be affected by soil disturbances. For example, the hydrology of playas, which are ephemeral lakes intermittently inundated because of impermeable soils, may be adversely affected by trenching activities or other soil disturbances that disrupt the storage of surface water, potentially reducing the frequency or duration of inundation.

Impacts of Altered Hydrology During Operations

Upland habitats contribute to the hydrologic inflow to wetlands within their watershed through groundwater recharge or surface drainage. Depending on soil type, soils in some areas may have altered drainage and infiltration characteristics due to compaction, resulting in greater runoff. Increases in surface runoff and reductions in infiltration rates over large land areas as a result of soil compaction or constructed surfaces could contribute to a localized lowering of the groundwater table. Springs, seeps, and streamflows that are supported by groundwater discharge could be reduced if a large portion of the recharge area is affected, resulting in impacts on associated wetlands and riparian areas outside the solar energy facility site. Terrestrial plant species that access groundwater, such as phreatophytic species, could also be adversely affected by changes in groundwater levels. In addition, surface flows (i.e., sheet flows) provide important water resources to upland species occupying alluvial fans where perennial water sources are rare.

Restoration of Vegetation Following Construction

While restoration would focus on the planting of native species to restore locally native plant communities, in some areas, restoration may potentially include species that are not locally native. Although the replanting of disturbed soils may successfully establish vegetation in some locations (i.e., with a biomass and species richness similar to those of local native communities), the resulting plant community may be somewhat different from native communities in terms of species composition and representation of particular vegetation types, such as shrubs (Newman and Redente 2001). The community composition of replanted areas would likely be greatly influenced by the species that are initially seeded, and colonization by species from nearby native communities may be slow (Paschke et al. 2005; Newman and Redente 2001).
In addition, although the inclusion of invasive species would be prohibited, the planting of non-native species may result in the introduction of those species into nearby natural areas. The establishment of mature native plant communities may require decades, and

some community types may never fully recover from disturbance. Successful re-establishment of some habitat types, such as some shrubland communities, may be difficult and may require considerably greater periods of time. Restoration of plant communities in areas with arid climates (e.g., averaging less than 9 in [20 cm] of annual precipitation) would be especially difficult (Monsen et al. 2004) and may be unsuccessful in some areas. These would include such communities as the saltbush-greasewood communities of the Central Basin and Range ecoregion or the creosotebush communities, and unique habitat types, such as microphyll woodlands and desert washes of the Mojave Basin and Range and Sonoran Basin and Range ecoregions. The loss of intact native plant communities could result in increased habitat fragmentation, even with the restoration of affected areas.

Restoration of Vegetation Following Decommissioning

Plant communities may be difficult to restore following decommissioning. In some locations, such as deserts and other arid regions, the re-establishment of plant communities may require considerable periods of time. In Wyoming, for example, typically shrub-dominated communities would require approximately 10 to 15 years for successful re-establishment, and 20 to 40 or more years for shrubs of pre-construction stature to re-establish in the area (BLM 2018). In some locations, permanent differences between restored plant communities and nearby undisturbed areas would likely remain, particularly if any infrastructure is left and/or buried

Transmission Lines and Roads

Direct impacts on plant communities during construction of transmission line ROWs or during upgrades to existing lines would primarily include habitat losses resulting from the placement of towers and construction of access roads, as well as habitat modification by tree removal in forest or woodland communities. Site preparation activities may include the grading of soils to provide a level working area for equipment installation. Additional areas may be cleared for construction laydown areas and staging areas. Damage to plants may also occur from equipment operation near land-clearing and construction areas.

Indirect impacts on terrestrial and wetland habitats could result from erosion, sedimentation, altered drainage patterns, fugitive dust, tree cutting, herbicide use, and ROW maintenance. Indirect impacts could include the degradation of adjacent habitat or, in the case of wetlands, habitat within the watershed.

The operation of heavy equipment within transmission line ROWs may result in loss or destruction of existing vegetation and biological soil crusts and in the compaction and disturbance of soils. Soil aeration, infiltration rates, moisture content, and erosion rates could be affected. These factors could affect the rate or success of vegetation recovery or re-establishment.

Habitats adjacent to a ROW may become fragmented or isolated as a result of construction. Biodiversity may subsequently be reduced in fragmented or isolated habitats. The fragmentation of large, undisturbed habitats of high quality by ROW construction would be considered a greater impact than that of previously disturbed or fragmented habitat.

Maintenance programs for transmission line ROWs may result in the establishment of plant communities different from those in adjacent undisturbed areas and may prevent the development of mature habitat types. Herbicides used in ROW maintenance could be carried to wetland and riparian areas by surface runoff or could be carried by air currents to nearby nontarget terrestrial communities. The presence of a ROW may increase access to adjacent lands that previously had limited access. Disturbances resulting from increased access may include trampling, erosion, increased frequency of fires, unauthorized OHV use, illegal dumping, and illegal collection of plants from these areas (PBS&J 2002). The spread of invasive plant species may also be promoted by increased access along ROWs. These impacts could lead to changes in the abundance and distribution of plant species and changes in community composition within and adjacent to ROWs.

The effects of water withdrawals on groundwater or surface water sources depend on facility location. Wetland or riparian habitats supported by these water sources would potentially be affected by altered hydrologic regimes. If localized lowering of groundwater levels occurs, terrestrial plant species that access groundwater, such as phreatophytic species, may be adversely affected. In addition, changes in surface flows may affect upland species and habitats.

F.4.2 Aquatic Biota

F.4.2.1 Methods Used for Evaluation

The information presented in the Affected Environment and Impacts sections were derived from books; scientific literature; environmental assessments for various solar energy projects; and BLM manuals, handbooks, databases, and websites.

The primary potential impacts on aquatic ecosystems from solar energy development are those that may alter the extent, quantity, and quality of aquatic habitats and that could affect the abundance, diversity, and survival of aquatic biota. It is not possible to quantitatively analyze impacts on aquatic ecology in the Programmatic EIS due to the broad scope of the Programmatic EIS and the wide regional and local variety of aquatic species and habitats that occur within the 11-state planning area. In general, the action alternatives are similar in the application of design features intended to protect aquatic ecosystems and in the exclusion of development from areas containing sensitive aquatic habitats and protected species. Alternatives with larger land areas open to application may have a greater potential to impact aquatic ecosystems compared to alternatives with smaller areas open to application. Actual impact magnitudes on aquatic resources would depend on the location of proposed solar projects, the extent and types of aquatic habitats and the biota present at proposed sites, the regional uniqueness and protection status of habitats and species present, project-specific design, and application of design features and other mitigation measures that avoid, minimize, and compensate for potential impacts on aquatic ecosystems.

F.4.2.2 Supplemental Material for Affected Environment

No supplemental material to the aquatic biota affected environment (Section 4.4.2).

F.4.2.3 Supplemental Material for Impacts Assessment

Impacts on aquatic biota and habitats from solar energy projects could occur in a number of ways, including (1) habitat loss, alteration, or fragmentation; (2) disturbance and displacement of aquatic organisms; (3) mortality; (4) introduction of non-native aquatic organisms; and (5) increase in human access. Aquatic biota and habitats may also be affected by human activities not directly associated with a solar energy project or its workforce, but associated with the potentially increased access by the public to areas that had previously received little use. These impacts are discussed below, by project development phase, and summarized in Table 5.4.2-1.

F.4.2.3.1 Site Characterization

Before a solar energy project and its ancillary facilities (e.g., transmission line and gas and water pipeline ROWs) can be constructed, the potential project site areas must be characterized. Typical activities associated with site characterization are summarized in Section 3.2.1.1. Some site characterization activities would assist developers in designing a specific project to avoid or minimize impacts on aquatic resources during future phases of the project.

Potential impacts on aquatic habitats and aquatic biota from site characterization activities would primarily be associated with ground disturbance, because it increases soil erosion that can increase sedimentation and turbidity in downgradient surface water habitats, and because it can promote formation of gullies or down-cutting of water pathways that can lead to impacts on riparian and wetland habitats. As described in Section 3.2.1.1, many of the site characterization activities would involve minimal or no site disturbance. Ground-disturbance activities such as installation of meteorological towers, installation of groundwater sampling wells, would generally affect only small areas including the footprint of installed structures or equipment, the area disturbed by vehicles or other equipment needed for the installation, and, in some cases, the development of minimum-specification access roads needed to reach the installation or sampling sites. It is anticipated that characterization facilities (e.g., meteorological towers, drill rigs, and temporary impoundments for drilling fluids or cutting) and most of the associated characterization activities would be located in upland areas and not directly within aquatic habitats. In such cases, direct impacts on aquatic habitats and biota would be minimal. Because the amount of ground disturbance would be small, the resulting effects of erosion and sedimentation on aquatic habitats and biota from these impacting factors should also be small. Other than discrete water sampling of groundwater and surface water, no water depletions would be expected during the characterization phase of a project and aquatic habitats would not be significantly affected. If drilling activities were required as part of site characterization, accidental releases of drilling wastes could affect downstream habitats because of sedimentation or the introduction of contaminants during storm runoff events.

In some cases, vehicles would be driven through portions of the site in order to transport workers or equipment. If vehicles are driven through aquatic habitats or if workers walk through those habitats, some aquatic biota could be crushed and killed. Vehicular traffic can result in rutting and accumulation of cobbles in some stream crossings, which can interfere with fish passage in streams during periods of low flows. If such changes prevent fish and other aquatic species from leaving stream areas that periodically dry out and entering portions of streams that contain adequate water, mortality of trapped individuals would be expected. The significance of such impacts would depend on the types of aquatic communities present, with greater impacts anticipated in regionally unique habitats that support rare or endemic species. Such impacts can be avoided or minimized by constructing temporary bridges for vehicles or personnel.

F.4.2.3.2 Construction

Impacts on aquatic resources from the construction of utility-scale solar energy projects and associated transmission facilities could result from (1) direct disturbance of aquatic habitats within the footprint of construction or operation activities, (2) sedimentation of nearby aquatic habitats as a consequence of soil erosion from construction areas, or (3) changes in water quantity or water quality as a result of grading that affects surface runoff patterns, depletions or discharges of water into nearby aquatic habitats, or releases of chemical contaminants into nearby aquatic systems.

As described in Section F.4.2.3.1, vehicles or machinery used in aquatic habitats and worker foot traffic through aquatic habitats could crush and kill aquatic organisms; such impacts can be avoided or minimized by constructing temporary or permanent bridges for vehicles or personnel. Draining and filling of aquatic habitats within the construction footprint for the solar energy facility or within associated transmission corridors would result in direct loss of any aquatic habitats or organisms within the construction footprint. Such direct impacts on aquatic habitats within a general project area would require additional permitting (e.g., under Section 404 of the Clean Water Act) and would be avoided or minimized by restricting placement of solar energy structures and the associated infrastructure to upland areas (see design features in Appendix B). However, surface grading and other surface disturbances in upland areas could still affect ephemeral streams and runoff channels that provide conveyance to more perennial stream habitats. Ephemeral and intermittent aquatic habitats also provide important seasonal habitat for a variety of organisms, such as insects with aquatic life stages, amphibians, and brachiopod crustaceans (Grippo et al. 2015). Such habitats are especially important in arid environments. (Grippo et al. 2015; Steward et al 2022). The sensitivity of ephemeral streams to land disturbance varies depending upon a variety of factors, including ecological region, topography, soil characteristics, and the presence of rare or unique organisms (O’Connor et al. 2015, Steward et al. 2022). Based upon representative projects identified in Section 3.1.1, it is anticipated water needed during construction of solar PV facilities would range from 0.12 ac-ft per MW to 2.9 ac-ft per MW. If water for construction activities needed to be withdrawn from waterways on or near the site, the resulting depletions could reduce the amount of aquatic habitat available, depending upon the proportion of the available water being withdrawn. Using groundwater during construction could also reduce the quantity of surface water habitat. Water needs for construction activities could be met by trucking in water from offsite.

Turbidity and sedimentation from erosion are part of the natural cycle of physical processes in water bodies, and most populations of aquatic organisms have adapted to short-term changes in these parameters. However, sediment inputs can adversely affect aquatic biota, depending on the species present and the geochemical composition, particle size, concentration, and duration of exposure to the suspended material compared to natural conditions (Waters 1995; Bilotta and Brazier 2008). Increased sediment loads can suffocate aquatic vegetation, invertebrates, and fish; decrease the rate of photosynthesis in plants and phytoplankton and lead to trophic shifts; decrease fish feeding efficiency; decrease the levels of invertebrate prey; reduce fish spawning success; and adversely affect the survival of incubating fish eggs, larvae, and fry as well as invertebrate and amphibian eggs. In addition, some migratory fishes may avoid streams that contain excessive levels of suspended sediments (Waters 1995; Bilotta and Brazier 2008).

The potential for soil erosion and sediment loading of nearby aquatic habitats is, in part, proportional to the amount of surface disturbance and the proximity to aquatic habitats. However, several additional factors, such as topography, wind speeds, particle size, soil moisture, and plant cover, are also important (Field et al. 2010). Removal of riparian vegetation may also result in greater levels of sediment entering the aquatic habitat with which the vegetation is associated. Implementation of design features identified in Appendix B would avoid or minimize such impacts by restricting removal of riparian vegetation for specific projects. It is anticipated that upland areas disturbed during construction of solar energy projects would have a higher erosion potential than undisturbed areas because of site grading and removal of vegetated cover. Fugitive dust from disturbed areas could also contribute turbidity and sedimentation if it settles in aquatic habitats in sufficient quantity (Field et al. 2010). In addition to areas directly affected by the construction of solar energy facilities, surface disturbance could occur outside of the project areas as a result of the development of access roads, transmission lines, utility corridors, and similar infrastructure elements. Implementation of measures to control erosion and runoff into aquatic habitats (e.g., silt fences, retention ponds, runoff-control structures, and earthen berms) would reduce the potential for impacts from increased sedimentation. Plans of Development for past solar energy projects on BLM-administered lands have identified procedures and mitigation measures to limit the potential for impacts from erosion, sedimentation, fugitive dust, and runoff into aquatic habitats during construction and operation (e.g., BLM 2018; BLM 2019; BLM 2021).

In addition to potentially resulting in increased sediment loads, the removal of riparian vegetation, especially taller trees, could potentially affect the temperature regime in aquatic systems by altering the amount of solar radiation that reaches the water surface. This thermal effect may be most pronounced in small stream habitats, where a substantial portion of the stream channel may be shaded by vegetation. The level of thermal impact associated with the clearing of riparian vegetation would be expected to increase as the amount of affected shoreline increases, although several studies indicate local vegetative stream cover may only weakly influence stream temperature (Ice et al. 2010). Regional or upstream canopy cover, hyporheic exchange, and in-stream debris are other primary determinants of stream temperature that need to be considered (Ice et al. 2010). If water temperature increases, the level of dissolved oxygen in the water generally decreases. Consequently, changes in temperature regimes of aquatic habitats can affect the ability of some species to survive within the affected areas, especially during periods of elevated temperatures. Water temperatures during some periods in many aquatic habitats in the desert southwest (where solar insolation regimes may be most conducive to development of utility-scale solar energy projects) may sometimes approach levels lethal to resident species under existing conditions. Consequently, alterations to the environment that increase water temperatures in such areas by even a few degrees could result in mortality to aquatic organisms during such periods. Fish exposed to stressful temperatures generally move along the temperature gradient until acceptable temperatures are encountered (Hazel 1993). Fish typically avoid elevated temperatures by swimming to areas of groundwater inflow, deep holes, or shaded areas. If thermal refuge is unavailable, fish exposed to excessive temperatures may die. Amphibians, reptiles, and some other aquatic organisms that are mobile enough to move, even temporarily, to areas where temperatures are more suitable are less likely to be adversely affected by altered temperatures.

Contaminants could be introduced into aquatic habitats as a result of the accidental release of fuels, lubricants, or pesticides/herbicides used during the construction of solar energy projects. Because the concentrations of accidentally introduced contaminants in aquatic habitats will depend largely on the dilution capability and therefore the flow of the receiving waters, impacts would be more likely if contaminated runoff from project areas drains into small perennial streams rather than larger streams. The level of impacts from releases of toxicants would depend on the type and volume of chemicals entering the waterway, the location of the release, the nature of the water body (e.g., size, volume, and flow rates), and the types and life stages of aquatic organisms present in the receiving waterway. However, introduced contaminants can result in direct mortality or sublethal effects resulting in changes in behavior, reproduction, or endocrine functions. In general, lubricants and fuel would not be expected to enter waterways in appreciable quantities as long as heavy machinery is not used in or near waterways, fueling locations for construction equipment are situated away from the waterway, and design measures (such as use of berms, booms, and spill containment kits) are implemented to control spills that do occur.

In areas where access roads, pipelines, or utility corridors cross streams, obstructions to fish movement can occur if culverts, low-water crossings, or buried pipelines are not properly installed, sized, or maintained. During periods of low water, vehicular traffic can result in rutting and accumulation of cobbles in some crossings that can interfere with fish movements. In streams with low flows, flow could become discontinuous if disturbance of the streambed during construction activities results in increased porosity or if alteration of the channel spreads flow across a wider area than usual. Restrictions to fish movement would likely be most significant if they occur in streams supporting species that need to move to specific areas in order to reproduce, or in smaller streams where aquatic organisms may need to move to avoid desiccation or heat stress during low-flow periods. Other types of organisms, such as amphibians and reptiles that can cross low water barriers by temporarily utilizing non-flowing areas would be less affected. Proper installation, periodic inspections, and maintenance of stream crossings would avoid or minimize such impacts.

In addition to the potential for the direct impacts identified above, indirect impacts on fisheries could occur as a result of increased public access to remote areas via newly constructed access roads and transmission lines. Access to the solar energy project area would likely be restricted by the construction of fences in order to prevent unauthorized access to the site, potentially reducing public access to some waterways. Fishing pressure in surface waters with recreation species could increase if there is greater road access, and other human activities (e.g., OHV use) could disturb riparian vegetation and soils, resulting in erosion and sediment-related impacts on water bodies, as discussed above. In areas where perennial surface waters or intermittent streams connected to perennial surface waters are present, non-native aquatic species may become established because of the new road access either as a result of the use of live bait or unauthorized efforts to stock the waterway with desirable recreational species. Such impacts would be smaller in locations where existing access roads or utility corridors that already provide access to waterways are utilized. In addition, there is the potential for introducing non-native aquatic species (e.g., fish and mussels) or harmful microbes (e.g., chytrid fungus) via construction or maintenance equipment. Using water from safe sources and decontaminating equipment as appropriate, especially equipment used to convey water (i.e., water pumps), would reduce the risk of introducing harmful aquatic organisms. Design features such as equipment inspections and cleaning and screens for water pumps would be implemented for specific projects, as appropriate, to limit the potential for introducing non-native aquatic species and other potentially harmful organisms (see Appendix B).

F.4.2.3.3 Operations

During the operations and maintenance phase of a utility-scale solar energy facility, aquatic habitats and aquatic biota may be affected by water withdrawn from aquatic habitats for cleaning PV panels, drinking water for support staff, or other operational purposes, continued erosion and sedimentation due to altered land surfaces, exposure to contaminants, and continued increases in public access.

Recently, concern has been expressed about the impacts of polarized light on insects that have aquatic life stages and deposit eggs in aquatic habitats. Water bodies have the ability to polarize light. Consequently, light that has been polarized by reflecting off smooth dark surfaces, such as solar panels, can act as an “ecological trap” in which aquatic insects mistake solar panels for open water and lay eggs on the surface of the panel (Horváth et al. 2010). In fact, insects can be more attracted to the highly polarized light reflected off solar panels than they are to natural water bodies (Horváth et al. 2010). Although high numbers of insects may be killed in this way, the significance of the resulting waste of reproductive effort on insect populations is unknown, as is the potential for adverse impacts on higher trophic levels that depend on these insects as food sources. In addition, technological advancements in PV panel design, such as the development of matte solar panels, may reduce the amount of polarized light reflected from solar panels and minimize these impacts on aquatic biota (Száz et al. 2016).

If the project utilizes water from nearby water bodies or groundwater sources during operation for cleaning PV panels or for other facility purposes, there is a potential for water depletion impacts on aquatic habitats within the vicinity. Based on representative projects identified in Section 3.1.1, water needed during the operation phase of solar PV facilities would range from 0.01 ac-ft/yr per MW to 0.13 ac-ft/yr per MW. As described in Section 4.4.2, maintaining connectivity among aquatic habitats is an important concern. Changes in the flow patterns of seeps, springs, or streams and the depletion of surface water resulting from surface or groundwater withdrawal could alter the connectivity among stream networks that serve as important corridors for aquatic biota and can affect the quality of aquatic habitats and the survival of populations of aquatic organisms within affected bodies of water. For example, prolonged or frequent drying can reduce species diversity (McCluney and Sabo 2011; Datry 2011; Steward et al. 2022) and ultimately alter or eliminate species through physiological stress or habitat loss (Stanley et al. 1994; Sponsellor et al. 2010). Miller et al. (2007) noted indirect effects of lowered base flows on aquatic insects through increased temperature and specific conductance and Miller et al. (2012) observed reduced growth rates, biomass, and subsequent fecundity of stream insects to elevated stream temperatures resulting from water withdrawals during drought years. In the case of aquatic invertebrates, the most sensitive species (e.g., Hydrosychidae) could be replaced by more tolerant species such as Chironomidae (e.g., midges) and Oligochaetae (e.g., worms) (Stanley et al. 1994; Sponseller et al. 2010). Sensitive and tolerant species will be different in different geographic regions. A reduction in water depths can also increase the susceptibility of some aquatic organisms to predation from avian and terrestrial predators. As with perennial aquatic habitats, springs, seeps, intermittent water bodies and ephemeral streams are also important habitats for providing ecosystem services and maintaining biotic diversity (Vander Vorste et al. 2019; Steward et al. 2022). In intermittent habitats, water withdrawal (including withdrawal of groundwater) could reduce the frequency and duration of wet periods, which could ultimately increase fragmentation and reduce connectivity of stream networks and decrease the richness and abundance of aquatic species as streams become pools connected by dry reaches (Steward et al. 2022).

In addition to a spatial and temporal reduction in available aquatic habitat, the water quality of the remaining habitat could decrease as temperature and solute concentrations increase and dissolved oxygen levels decrease. With regard to water quality, aquatic organisms have specific physiological tolerances within which survival is possible. Under natural conditions, many aquatic species in arid aquatic habitats may be at their physiological limit and an increase in stressful water quality conditions could significantly alter species composition (Stanley et al. 1994; Lake 2003; Archer and Predick 2008). In addition to stress or mortality at the level of the individual, water withdrawals could reduce genetic diversity as populations were eliminated by habitat loss or were reproductively isolated by habit fragmentation (Larned 2010; McCluney and Sabo 2011). Extinction of local populations under natural conditions can take longer than 5 years to naturally recover if connected populations are nearby (Lake 2003) or may require reintroduction efforts.

Water depletions are of particular concern if unique habitats (e.g., springs and seeps in arid regions) or protected species would be affected because the potential for negative population-level effects for rare organisms would be greater than for common and widespread organisms. Thus, water withdrawal concerns are particularly relevant in aquifers supporting endangered species. Many endangered aquatic biota exist in relatively few populations or are naturally endemic to a particular water body. For example, the Devils Hole pupfish (*Cyprinodon diabolis*) is endemic to Devils Hole, a spring-fed pool in Death Valley NP. Populations of the Devils Hole pupfish underwent significant declines beginning in the 1960s in response to water withdrawals for irrigation (Riggs and Deacon 2002). Water depletion impacts on aquatic resources would depend on the proportion of water withdrawn from a particular water body, the direct and indirect impacts of water withdrawals, and the types of organisms present. If a water source supports unique or rare organisms, the potential for negative population-level effects would be greater than if the types of organisms present were common and widespread. If groundwater were used as the water source, there could still be depletion impacts on aquatic habitats such as wetlands, springs, or spring-fed streams that rely on the groundwater source for recharge or the maintenance of baseflow. If water is withdrawn from a surface water source, there is also a potential for impingement and entrainment of aquatic organisms at the water intake and, depending on the numbers of individuals of particular species that are killed, population-level impacts could result. Overall, it is anticipated the use of water for PV solar facilities during the operation phase would be relatively small. Depletion impacts on nearby aquatic habitats could be reduced or avoided through the use of alternate water sources, such as piping in municipal water or trucking water to the site. Design features requiring projects to avoid water withdrawals and implement specific measures in sensitive aquatic habitats (see Appendix B) would avoid or minimize the potential for impacts on such areas during operation of solar energy facilities.

As identified in Section F.4.2.3.1, the potential for soil erosion and sediment loading of nearby aquatic habitats is in part proportional to the amount of surface disturbance and the proximity to aquatic habitats. During the operation phase, some level of vegetation clearing (e.g., regularly within the solar energy project area and every 3 or more years within ROWs) would be required to maintain the site and any associated ROWs for transmission lines. Although the potential for erosion at a given project site and the resulting levels of turbidity and sedimentation in nearby aquatic habitats would likely be less during the operations phase than during the construction phase because of the establishment of some level of ground cover, the levels would be greater than those that occurred preconstruction and would continue throughout the operational life of the project.

The potential exists for toxic materials (e.g., fuel, lubricants, cleaning solutions, and herbicides) to be accidentally introduced into waterways during operation and maintenance of solar energy facilities. The level of impacts from releases of toxicants would depend on the type and volume of chemicals entering the waterway, the location of the release, the nature of the water body (e.g., size, volume, and flow rates), and the types and life stages of organisms present in the waterway. Because the amounts of most fuels and other hazardous materials utilized at PV facilities are expected to be small, an uncontained spill would probably affect only a limited area. In general, lubricants and fuel would not be expected to enter waterways as long as heavy machinery is not used near waterways, fueling locations for maintenance equipment are situated away from waterways, and measures are taken to control potential spills. Mitigation measures for maintenance of transmission line corridors generally restrict the use of machinery near waterways and require the availability of spill containment kits. Similarly, restrictions are generally placed on the application methods, quantities, and types of herbicides used in the vicinity of waterways in order to limit the potential for impacts on aquatic ecosystems. Plans of Development for past solar energy projects on BLM-administered lands have identified procedures and mitigation measures to limit the potential for impacts from spills and herbicide applications during operation (e.g., BLM 2018; BLM 2019; BLM 2021). Appendix B includes design features that would require development and implementation of stormwater runoff and spill protection plans to address the potential for contaminants to enter aquatic ecosystems.

F.4.2.3.4 Decommissioning/Reclamation

Decommissioning (including reclamation) of a utility-scale solar energy project would reduce or eliminate impacts that occurred from construction and operation to the extent practicable by re-establishing affected habitat. The effectiveness of any reclamation activity would depend on the specific actions taken; the best results, however, would occur where original site topography, hydrology, soils, and vegetation patterns could be re-established. However, full restoration of site features may not be possible under all situations. Impacts on aquatic habitats and biota during decommissioning activities would be similar to those from construction but may be of more limited scale and shorter duration. This would depend, in part, on whether decommissioning would involve full removal of facilities, partial removal of key components, or abandonment. For example, leaving buried components in place would reduce the amount of trenching and soil disturbance required and therefore result in lower levels of sediments being introduced into nearby aquatic habitats.

Water withdrawals associated with site operations would be discontinued following decommissioning. Depending on the water source used for site operations, impacts may cease immediately or last years to decades. For especially sensitive aquatic habitats, such as seeps and springs, ecosystem impacts of depletion may be irreversible. There could be temporary increases in the use of vehicles or machinery and in worker foot traffic through aquatic habitats that could crush and kill aquatic organisms. Recreational use of the decommissioned project site might also increase after aboveground structures were removed, which could lead to increased pressure on adjacent fishery resources if present. Fencing may remain for a short period of time after reclamation and would reduce access in the short term. Most public land management agencies do not allow off-road travel, and signage can be posted to keep travelers on authorized roads and trails. Thus, if access is kept limited, it is anticipated that the increase in fishing pressure would be small.

Other potential environmental concerns resulting from decommissioning would include disposal of wastes, hazardous materials, and remediation of any contaminated soils. Some fuel and chemical spills could also occur; generally, these would be confined to access roads and project site areas. As described previously, the level of impacts from releases of toxicants would depend on the type and volume of chemicals entering a waterway, the location of the release, the nature of the water body (e.g., size, volume, and flow rates), and the types and life stages of organisms present in the waterway.

The potential for impacts from chemical spills would be minimized through the use of design features identified in Appendix B. After decommissioning activities were complete, there would be no fuel or chemical spills associated with the solar energy facility.

Whether aquatic habitats would recover from impacts following decommissioning and how long such recovery would take depends on the type and magnitude of potential impacts, the types of habitats that had been affected, and also on the ability of affected populations of organisms to become re-established in restored areas.

F.4.2.3.5 Transmission Lines and Roads

In general, many of the potential impacts on aquatic habitats and biota identified in Sections F.4.2.3.1 through F.4.2.3.4 are also applicable to the design, construction, operation, and decommissioning of transmission lines, and to upgrades to existing lines. Potential construction impacts of transmission corridor development on aquatic biota would result primarily from ground disturbance, vegetation removal, and excavation during clearing of the ROWs and from installation of access roads and structures (e.g., transmission line towers, substations, or pipelines) near or in water bodies. Potential impacts could include changes in surface water flow patterns, deposition of sediment in surface water bodies, changes in water quality or temperature regimes, loss of riparian vegetation, introduction of toxic materials, restrictions to fish movements, and changes in human access to water bodies. The severity of impacts would depend upon such factors as the type of aquatic habitat and the types of organisms present, season of construction, size of the aquatic habitat, the length and width of the area to be cleared, construction procedures used, and the quality of the existing habitat.

During the construction of transmission corridors, ground disturbance, removal of vegetation (especially riparian vegetation), and direct disturbance of stream bottoms could result in increased suspended sediment loads both during construction activities and for a limited period of time after construction activities cease. These suspended sediments typically settle to the bottom within some distance downstream of the construction area; that distance depends on factors such as the size of sediment particles and water velocity in the receiving body of water. The overall area of aquatic habitat affected by sediment from a particular construction activity would then include the footprint of the disturbed area plus an area downstream of the activity. In most cases, transmission line towers can be located to minimize the need to place structures directly within aquatic habitats as long as the span between adjacent towers is not too great.

The level of effects from increased sediment loads depends on the natural condition of the receiving waters, the biota present, and the timing of sediment inputs. Whereas most aquatic systems might be expected to be affected by large increases in levels of suspended and deposited sediments, aquatic habitats in which waters are normally turbid may be less sensitive to small to moderate increases in suspended sediment loads than habitats that normally have clear waters. Similarly, increased sedimentation during periods of the year in which sediment levels might naturally be elevated (e.g., during wet parts of the year) may have smaller impacts than during periods in which natural sediment levels would be expected to be lower.

Characteristics of surface water runoff, such as flow direction and flow rates following rain events, are controlled, in part, by local topography and vegetation cover. Consequently, construction activities that affect the terrain and vegetation during corridor development could alter the water flow patterns. Impacts on aquatic ecosystems could result if these alterations affect the amount, timing, or flashiness of runoff entering a particular water body. In general, attempts are made to control or reduce such impacts on aquatic ecosystems by ensuring that the overall grade of a corridor remains similar to the grade present prior to construction by maintaining some vegetative cover in corridors and by maintaining a relatively unaltered buffer of vegetation along the margins of water bodies. As described in Section F.4.2.3.2, the removal of riparian vegetation, especially taller trees, can affect, but will not necessarily affect, the temperature regime in aquatic habitat. If local riparian habitat is a significant influence on stream temperature, the thermal impact associated with the clearing of riparian vegetation for transmission corridors would increase as the amount of affected shoreline increases.

During the operational phase of a project, aquatic systems could be adversely affected by maintenance activities along transmission corridors, especially vegetation control. For most transmission line corridors, vegetation control in a particular area is relatively infrequent (generally no more often than once every 3 to 4 years), and the amount of vegetation disturbed is much less than that which would occur during construction. Selected trees might be removed or trimmed if they are considered likely to pose a risk to the transmission system. If control of vegetation along shorelines can be accomplished by using manual techniques, the erosion of stream banks from maintenance activities would be expected to be relatively minor.

The mechanisms by which toxic materials (e.g., fuel, lubricants, and herbicides) could be accidentally introduced into waterways during construction and maintenance activities for transmission corridors would be similar to those described in Sections F.4.2.3.2 and F.4.2.3.3. The level of impacts from releases of toxicants would depend on the type and volume of chemicals entering the waterway, the location of the release, the nature of the water body (e.g., size, volume, and flow rates), and the types and life stages of organisms present in the receiving waterway.

Low-water crossings used to accommodate vehicular traffic during construction or maintenance of transmission lines could interfere with fish passage in some cases, as identified in Section F.4.2.3.2. Potential impacts could be avoided or minimized by installing bridges at water crossings.

In addition to the potential for the direct impacts identified above, indirect impacts on fisheries could occur as a result of increased public access to remote areas via transmission line ROWs and associated access roads. Fishing pressure in surface waters with recreation species could increase if there is greater road access, and other human activities (e.g., OHV) use) could disturb vegetation and soils, resulting in erosion and sediment-related impacts on water bodies, as discussed above. Also, because of the new road access, wherever perennial surface waters or intermittent streams connected to perennial surface waters are present, non-native aquatic species may become established either as a result of their use as bait or in an effort to stock the waterway with desirable recreational species. Such impacts would likely be smaller in locations where corridors could be co-located with roads or existing ROWs or where they would be located close to existing features (e.g., trails or logging roads) that already provide access to waterways. In addition, there is the potential for introducing non-native aquatic species via construction or maintenance equipment. Use of safe water sources and decontaminating equipment as appropriate, especially equipment used to convey water (i.e., water pumps), would reduce the risk of non-native species introductions.

Decommissioning of transmission corridors would also result in impacts on aquatic habitats and associated biota. Decommissioning activities would be expected to include the dismantling and removal of structures such as electricity transmission towers. The types of impacts resulting from decommissioning would be similar to those associated with energy project construction, including increased erosion and sedimentation, potential changes to surface water hydrology, potential establishment of invasive species, and potential spills of oil or other toxic materials associated with the operation of heavy machinery.

Decommissioning would generally result in soil disturbance, potentially including regrading of areas within the ROWs. Establishment and use of temporary work areas and storage areas would also result in some surface disturbance. Vegetation adjacent to aquatic habitats at stream crossings could be removed or damaged during decommissioning, thereby increasing the potential for erosion and subsequent sedimentation in nearby aquatic habitats.

Decommissioning activities would generally affect habitat previously disturbed by initial project construction. Depending on the time since initial construction was completed, the type of construction activities that occurred, and the type of aquatic habitat present, the aquatic communities present at the time of decommissioning may closely resemble nearby undisturbed areas. Some aquatic habitats would again recover from the disturbance associated with decommissioning after a period of time. Recovery time could range from months to many years, depending on the nature of the disturbance and the type of aquatic habitats present. Within some ROWs, permanent differences between aquatic communities in disturbed areas and nearby undisturbed areas may remain.

Recreational use of the decommissioned transmission corridors (e.g., as a travel corridor by OHVs) might also increase after aboveground structures were removed, which could increase fishing pressure in surface waters with recreation species. However, it is anticipated that the resulting impacts would be small.

F.4.3 Wildlife

F.4.3.1 Methods Used for Evaluation

F.4.3.1.1 Wildlife Species Included in the Assessment

Wildlife species considered in the assessment included representative amphibian, reptile, bird, insect, and mammal species. Representative species were selected among those species known to occur, or for which potentially suitable habitat occurs, within the 11-state planning area. To a large extent, selection of representative species was based on whether a species (1) has important habitat within the 11-state planning area, (2) is important to humans (e.g., big game, small game, and furbearer species), (3) is representative of other species that share important habitats (e.g., desert focal bird species), or (4) has some type of regulatory protection (e.g., Migratory Bird Treaty Act or Bald and Golden Eagle Protection Act).

F.4.3.1.2 Data Sources

The types of data used to determine the known or potential presence of wildlife species in the 11-state planning area, and life history information for the species, were collected from various sources and at different geographical and organizational levels. The most current, location-specific data at the highest resolution were used whenever available. Sources of information included, but were not limited to, the following:

- State game or natural resource agencies - Arizona Game and Fish Department (AZGFD 2012), California Department of Fish and Wildlife (CDFW 2015 & CDFW 2023), Colorado Parks & Wildlife (CPW 2022), Idaho Fish & Game (IDFG 2023a & IDFG 2023b), Montana Natural Heritage Program (MNHP 2023), Nevada Department of Wildlife (NDOW 2013 & NDOW 2023), Oregon Department of Fish & Wildlife (ODFW 2021 & ODFW 2023); Oregon State University (OSU 2023), Utah Division of Wildlife Resources (UDWR 2023a & UDWR 2023b), Washington State Department of Natural Resources (WDNR 2019), Wyoming Game & Fish Department (WGFD 2023), and Wyoming Natural Diversity Database (WYNDD 2023);
- Bureau of Land Management (BLM 2023);
- NatureServe (2023); and
- United States Geological Survey (USGS 2022 & USGS 2023)

F.4.3.1.3 Analysis Approach

It is not possible to quantitatively analyze all wildlife species by Programmatic EIS alternative due to the broad scope of the Programmatic EIS and the numerous species and habitat that could occur within the 11-state planning area. Big game migration corridors and winter habitat were selected as example analyses but other species would need to be analyzed at the project level. Big game migration corridor and winter habitat spatial data obtained from state game or natural resource agencies and USGS were intersected with alternatives to determine the acreage of that habitat that could be impacted under each alternative. Alternatives with larger areas of intersection may have a greater impact compared to those alternatives with smaller intersection areas. Actual impact magnitudes on wildlife species would depend on the location of proposed solar projects, project-specific design, application of design features and other mitigation measures (including avoidance, minimization, and compensation), and the status of the species and their habitats in project areas.

F.4.3.2 Supplemental Material for Affected Environment

F.4.3.2.1 Migratory Routes

Figure F.4.3.2-1 shows the USFWS administrative waterfowl flyway boundaries.

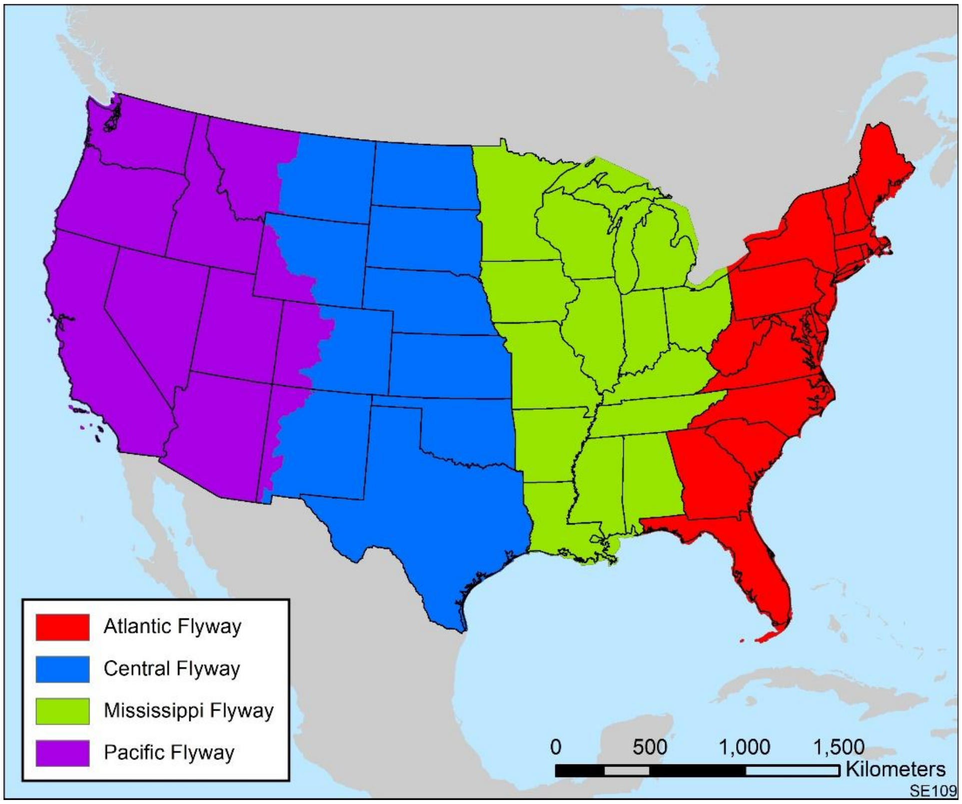


Figure F.4.3.2-1. USFWS Administrative Waterfowl Flyway Boundaries (Data Source: USFWS 2023)

F.4.3.2.2 Big Game Species

Big game migration corridors and winter ranges, as mapped by state and federal natural resource agencies, are shown in Figures F.4.3.2-2 and F.4.3.2-3. The acreage of these areas intersecting BLM-administered lands in each state are summarized in Table F.4.3.2-1. Variation may occur between state agencies and how they define big game winter ranges. Permitting decisions relevant to big game will be determined at the project level in collaboration with state agencies. Table F.4.3.2-2 presents the conservation status for the primary big game species within the 11-state planning area. The following paragraphs present a generalized overview of the primary big game species.

Figure F.4.3.2-2. Big Game Migration Corridors as Mapped by State and Federal Natural Resource Agencies (Data Sources: USGS 2022; USGS 2023; CDFW 2023; CPW 2022; IDFG 2023b; NDOW 2023; ODFW 2021; UDWR 2023a; WGFD 2023. Additional sources of big game data may be available.)

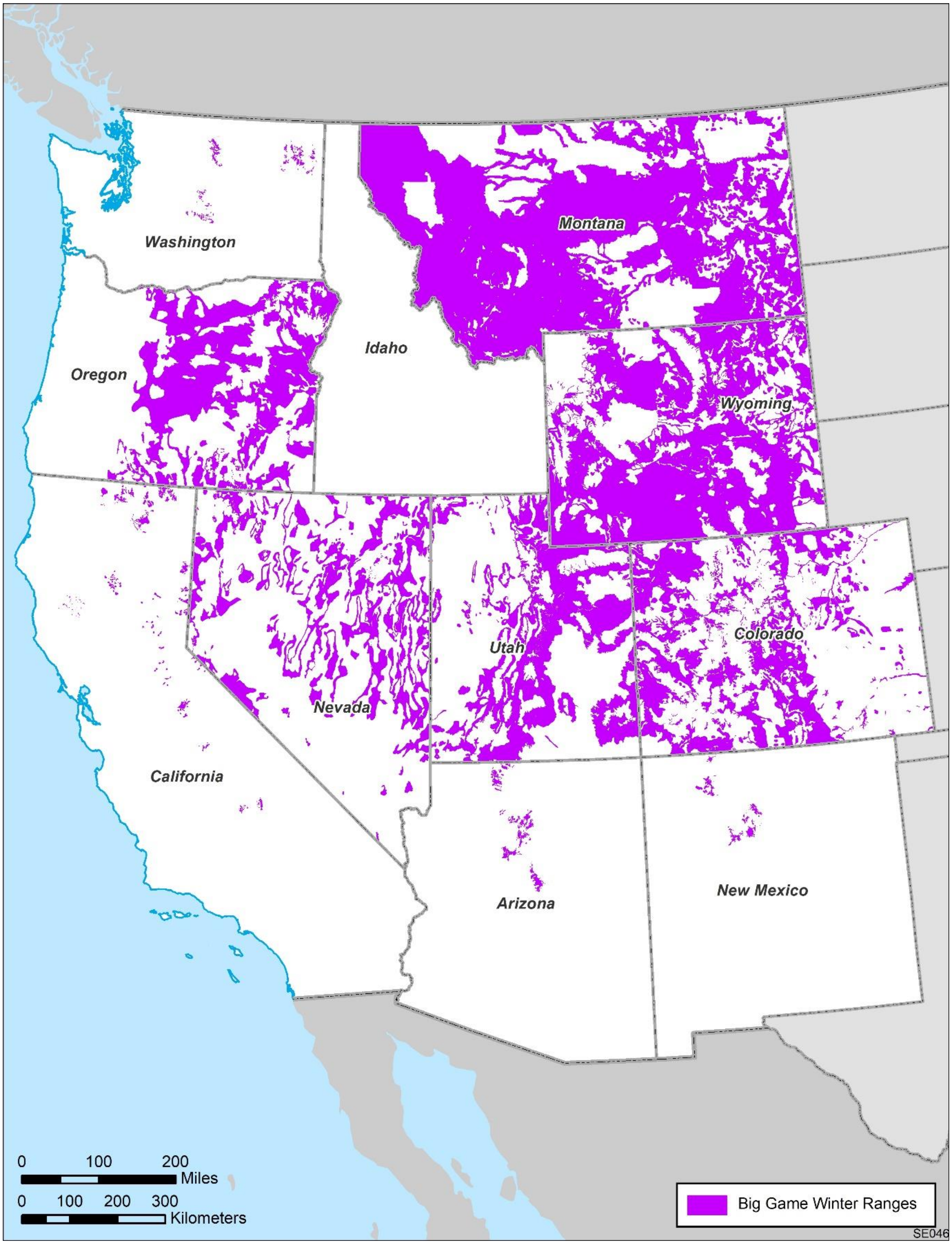


Figure F.4.3.2-3. Big Game Winter Ranges as Mapped by State and Federal Natural Resource Agencies (Data Sources: USGS 2022; USGS 2023; CDFW 2023; CPW 2022; MFWP 2023a; NDOW 2023; ODFW 2021; UDWR 2023a; WGFD 2023. Additional sources of big game data may be available.)

Table F.4.3.2-1. Acreage of Big Game Migration Corridors and Winter Ranges Intersecting BLM-administered Lands[a]

State	Big Game Migration Corridors (acres)	Big Game Winter Ranges (acres)
Arizona	41,787	74,652
California	730,103	95,188
Colorado	1,844,294	5,523,555
Idaho	3,582,494	1,406
Montana	-	6,370,992
Nevada	15,116,356	12,253,534
New Mexico	42,515	102,397
Oregon	2,578,870	6,765,372
Utah	2,525,666	7,813,711
Washington	12,314	8,227
Wyoming	566,258	13,609,409

[a] Does not include areas within the DRECP.
Sources: USGS 2023; CDFW 2023; CPW 2022; IDFG 2023b; MFWP 2023a; NDOW 2023; ODFW 2021; UDWR 2023a; WGFD 2023

F.4.3.2.2.1 Elk. Elk are highly migratory animals, but the timing and distance of migration varies (UDWR 2022). Their summer range occurs at higher elevations. Aspen and conifer woodlands provide security and thermal cover while upland meadows, sagebrush/mixed grass, and mountain shrub habitats are used for forage. Their winter range occurs at mid to lower elevations, where they forage in sagebrush/mixed grass, big sagebrush/rabbitbrush, and mountain shrub habitats. They are highly mobile within both summer and winter ranges to find the best forage conditions. In winter, they congregate into large herds of 50 to more than 200 individuals. The crucial winter range is considered to be the part of the local elk range where about 90% of the local population is located during an average of 5 winters out of 10 from the first heavy snowfall to spring. Elk calving generally occurs in aspen-sagebrush parkland vegetation and habitat zones during late spring and early summer. Calving areas are mostly located where cover, forage, and water are nearby. They may migrate up to 60 mi (97 km) annually (NatureServe 2023). Elk are susceptible to chronic wasting disease.

F.4.3.2.2.2 Mule Deer. Mule deer occur within most ecosystems in the 11-state planning area but attain their highest densities in shrublands characterized by rough, broken terrain with abundant browse and cover. The size of home ranges can vary from 74 to 593 acres (0.3 to 2.4 km^2) or more, depending on the availability of food, water, and cover (NatureServe 2023). Some populations of mule deer are resident (particularly those that inhabit plains), but those in mountainous areas are generally migratory between their summer and winter ranges (NatureServe 2023). In arid regions, they may migrate in response to rainfall patterns (NatureServe 2023). In mountainous regions, they may migrate more than 62 mi (100 km) between high summer and lower winter ranges (NatureServe 2023). Their summer range occurs at higher elevations that contain aspen and conifers and mountain browse vegetation. Fawning occurs during the spring while the mule deer are migrating to their summer range. This normally occurs in aspen-mountain browse intermixed vegetation.

Table F.4.3.2-2. State Conservation Status Ranks for Big Game Species in the 11-state Planning Area

Species	State Conservation Status Rank[a]										
	Arizona	California	Colorado	Idaho	Montana	New Mexico	Nevada	Oregon	Utah	Washington	Wyoming
Elk (*Cervus canadensis*)	SNA	SNR	S5	S5	S5	S3	S5	S5	S4	S5	S5
Mountain goat (*Oreamnos americanus*)	-	-	SNA	S3	S3	-	SNA	SNA	SNA	S2	SNA
Mule deer (*Odocoileus hemionus*)	S5	SNR	S4	S4	S5	S5	S5	S5	S5	S5	S5
White-tailed deer (*Odocoileus virginianus*)	S5	–	S5	S5	S5	S4	–	S3S4	S1	S5	S5
Pronghorn (*Antilocapra americana*)	S5	S3	S4	S3	S5	S5	S5	S4	S4	SX	S5
Bighorn sheep (*Ovis canadensis*)[b]	S3S4	SNR	S4	S2	S4	S1	S4	S3	S3	S2S3	S2S3
American black bear (*Ursus americanus*)	S5	SNR	S5	S4	S5	S4	S4	S4	S3	S5	S5
Moose (*Alces alces*)	-	-	SNA	SNR	S4	-	SNR	SNR	S3S4	S3S4	S4
American bison (*Bison bison*)	SNA	SNR	SX	SNA	S2	SX	SX	SX	S2	SX	S1
Cougar (*Puma concolor*)	S4	SNR	S4	S5	S4	S3	S5	S4	S4	S4S5	S4

[a] – = the state is not within the species' range;); S1 = critically imperiled (at very high risk of extirpation in the jurisdiction due to very restricted range, very few populations or occurrences, very steep declines, severe threats, or other factors); S2 = Imperiled (at high risk of extirpation in the jurisdiction due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors); S3 = vulnerable (at moderate risk of extirpation in the jurisdiction due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors); S4 = apparently secure (At a fairly low risk of extirpation in the jurisdiction due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.); S5 = secure (at very low or no risk of extirpation in the jurisdiction due to a very extensive range, abundant populations or occurrences, with little to no concern from declines or threats); SNA = Not Applicable (a conservation status rank is not applicable because the species or ecosystem is not a suitable target for conservation activities); SNR = unranked (national or subnational conservation status not yet assessed); SX= Presumed Extirpated (species or ecosystem is believed to be extirpated from the jurisdiction (i.e., nation, or state/province). Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.)

[b] The peninsular bighorn sheep (*Ovis Canadensis nelsoni*) and the Sierra Nevada bighorn sheep (*Ovis Canadensis sierrae*) in California are federally endangered.

Source: NatureServe (2023).

Mule deer have a high fidelity to specific winter ranges where they congregate within a small area at a high density. Their winter range occurs at lower elevations within sagebrush and pinyon-juniper woodlands. Winter forage is primarily sagebrush, but mountain-mahogany (*Cercocarpus*), fourwing saltbush (*Atriplex canescens*), and antelope bitterbrush (*Purshia tridentata*) are also important. Pinyon-juniper woodlands provide emergency forage during severe winters. Overall, mule deer habitat is characterized by areas of thick brush or trees (used for cover) interspersed with small openings (for forage and feeding areas) (UDWR 2019). Prolonged drought and other factors can limit mule deer populations. Several years of drought can limit forage production, which can substantially reduce animal condition and fawn production and survival. Severe drought conditions were responsible for declines in the population of mule deer in the 1980s and early 1990s. In arid regions, they are seldom found more than 1.0 to 1.5 mi (1.6 to 2.4 km) from water. Mule deer are also susceptible to chronic wasting disease. When the disease is present, up to 3% of a herd's population can be affected. Some deer herds in Colorado and Wyoming have experienced significant outbreaks of chronic wasting disease.

F.4.3.2.2.3 White-Tailed Deer. White-tailed deer inhabit a variety of habitats but are often associated with woodlands and agricultural lands. Within arid areas, they are mostly associated with riparian zones and montane woodlands that have more mesic conditions. They can also occur within suburban areas. Urban areas and very rugged mountain terrain are unsuitable habitats (NatureServe 2023).

White-tailed deer occur in two social groups: (1) adult females and young and (2) adult and occasionally yearling males, although adult males are generally solitary during the breeding season except when with females (NatureServe 2023). The annual home range of sedentary populations can average as much as 1,285 acres (5 km^2), while some populations can undergo annual migrations of up to 31 mi (50 km). In some areas, the density of white-tailed deer may exceed 129/mi^2 (50/km^2) (NatureServe 2023). Snow accumulation can have a major controlling effect on populations (Mech et al. 1987). White-tailed deer feed mostly on leafy green browse, grasses, and forbs but also consume mushrooms, acorns, fruits, and nuts (McCullough 1985).

F.4.3.2.2.4 Pronghorn. Pronghorn inhabit nonforested areas such as desert, grassland, and sagebrush habitats. Herd size can commonly exceed 100 individuals, especially during winter. Pronghorn consume a variety of forbs, shrubs, and grasses, with shrubs being most important in winter. Some pronghorn are year-long residents and do not have seasonal ranges. Fawning occurs throughout the species range. However, some seasonal movement within their range occurs in response to factors such as extreme winter conditions and water or forage availability. Other pronghorn are migratory. Most herds range within an area 5 mi (8 km) or more in diameter, although the separation between summer and winter ranges has been reported to be as much as 99 mi (159 km) or more (NatureServe 2023). Pronghorn populations have been adversely affected in some areas by historic range degradation and habitat loss and by periodic drought conditions.

F.4.3.2.2.5 Bighorn Sheep. The taxonomy of bighorn sheep has been reevaluated in recent years but some researchers currently recognize five subspecies of bighorn sheep: Rocky Mountain (*O. c. canadensis*), Sierra Nevada (*O. c. sierrae*), Desert (or Nelson) (*O. c. nelsoni*), Mexican (*O. c. mexicana*), and Peninsular (*O. c. cremnobates*) (Barbosa et al. 2021). The Rocky Mountain subspecies is the most abundant and widespread but all five subspecies can be found in at least one of the 11- state planning area. The bighorn sheep is considered to be a year-long resident; it does not make seasonal migrations as do elk and mule deer. However, it does make vertical migrations in response to an increasing abundance of vegetative growth at higher elevations in the spring and summer and, when snow accumulation occurs, in high-elevation summer ranges (NatureServe 2023). Also, ewes move to reliable watercourses or water sources during the lambing season, with lambing occurring on steep talus slopes within 1 to 2 mi (1.6 to 3.2 km) of water. Bighorn sheep prefer open vegetation such as low shrub, grassland, and other treeless areas with steep talus and rubble slopes. Unsuitable habitats include open water, wetlands, dense forests, and other areas without grass understory (NatureServe 2023).

The diet of the bighorn sheep consists of shrubs, forbs, and grasses. In the early 1900s, bighorn sheep experienced significant declines due to disease, habitat degradation, and hunting. Threats to bighorn sheep include habitat changes resulting from fire suppression, interactions with feral and domestic animals, and human encroachment (NatureServe 2023). Bighorn sheep are very vulnerable to viral and bacterial diseases carried by livestock, particularly domestic sheep. Therefore, the BLM has adopted specific guidelines regarding domestic sheep grazing in or near bighorn sheep habitat. In appropriate locations, reintroduction efforts, coupled with water and vegetation improvements, have been conducted to restore bighorn sheep to their native habitat.

F.4.3.2.2.6 American Black Bear. American black bears are found mostly within forested or brushy mountain environments and woody riparian corridors (UDWR 2008). They are omnivorous. Depending on seasonal availability, they will feed on plants, fruits, insects, small vertebrates, and carrion (NatureServe 2023). Breeding occurs in June or July, with young born in January or February (UDWR 2008). American black bears are generally nocturnal and have a period of winter dormancy (UDWR 2008). They are locally threatened by habitat loss and disturbance by humans (NatureServe 2023). The home range size of American black bears varies depending on area and gender and has been reported to be from about 1,250 to nearly 32,200 acres (5 to 53 km^2) (NatureServe 2023).

F.4.3.2.2.7 Cougar. Cougars (also known as mountain lions or puma) inhabit most ecosystems in the 11-state planning area but are most common in mountainous or remote, undisturbed areas. They skirt open areas and take advantage of available cover (NatureServe 2023; MLF 2023). They are mostly found in remote and inaccessible areas (NatureServe 2023). Their annual home range can be more than 560 mi^2 (1,450 km^2), while densities are usually not more than 10 adults/100 mi^2 (10 adults/259 km^2) (NatureServe 2023). The cougar is generally found where its prey species are located (MLF 2023). In addition to preying on deer, cougars prey upon most other mammals (which sometimes include domestic livestock) and some insects and reptiles (NatureServe 2023). They are active year-round. Their peak periods of activity are at dusk and dawn (Jones et al. 1983; MLF 2023).

F.4.3.2.2.8 Mountain Goat. The mountain goat is a big game species in several states within the 11-state planning area but is native only to Washington, Idaho, and Montana (Natureserve 2023). They live in isolated, high-elevation areas with harsh weather conditions (IDFG 2019). They shift altitude seasonally and will seek shelter in timbered areas to avoid deep snow (ODFW 2023). They primarily feed on grass and alpine shrubs during summer and autumn and will switch to a diet of browse when grasses are covered by snow (IDFG 2019). Males are often solitary and join female groups in the fall. Adult females and young may form small groups during the summer (NatureServe 2023). Most threats to mountain goats are direct threats to their habitat, such as habitat alteration due to road building, mining, or changing climate. They are also susceptible to disturbance by recreational activities and may abandon high-quality areas (IDFG 2019).

F.4.3.2.2.9 Moose. Moose are found mostly in forested marshy areas and meadows during spring and summer but can also be found in upland areas (IDFG 2020). During winter, some prefer heavily timbered areas while others are found in sagebrush steppe (IDFG 2020). They are comfortable in water and can swim for miles (MFWP 2023). Moose browse on a wide variety of vegetation including leaves, twigs, bark, and buds of hardwood and softwood trees and shrubs. They will also eat aquatic vegetation and willows. They are known to adapt to a variety of available forage as the seasons change (IDFG 2020 & WDFW 2023). They are usually solitary but may congregate during rutting season or on excellent winter ranges (MFWP 2023). The home range of the moose is approximately 3-6 mi^2 but they are known to wander much farther (WDFW 2023). Survival studies have found that most mortality was attributed to disease and malnutrition with other causes being predation or human-related causes (IDFG 2020).

F.4.3.3 Supplemental Material for Impacts Assessment

F.4.3.3.1 Construction

F.4.3.3.1.1 Habitat Disturbance. Habitat disturbance could result in major impacts on wildlife (e.g., a large loss of important habitat attributes such as crucial winter range or migration corridors) from the construction of a solar energy project. Habitats within the construction footprint would be reduced or altered. The construction of a solar energy project could also make movement between habitat fragments more difficult. Habitat fragmentation could cause loss of genetic interchange among populations (Mills et al. 2000; Wang and Schreiber 2001; Willyard et al. 2004; Epps et al. 2005; Dixon et al. 2007; BLM 2021).

A solar energy project (particularly its associated transmission line and pipeline ROWs) could establish edge habitat. Edge habitat could (1) increase predation and parasitism of vulnerable animals in the vicinity of edges; (2) have negative consequences on wildlife by modifying their distribution and dispersal patterns; (3) be detrimental to species requiring large undisturbed areas, because increases in edges are generally associated with concomitant reductions in habitat size and possible isolation of habitat patches and corridors (habitat fragmentation); (4) change local wildlife composition and abundance in such areas; and (5) cause habitat degradation outside of facilities in the vicinity of edges. The ecological importance of edge habitat largely depends on how different it is from the regional landscape. For example, the influence of the edge is less ecologically important where the landscape has a high degree of heterogeneity.

Landscapes with a patchy composition (e.g., tree-, shrub-, and grass-dominated cover) may already contain edge-adapted species that make the influence of a newly created edge less likely (Harper et al. 2005).

Development of a solar energy project site would represent a loss of habitat (including loss of foraging habitats, breeding and nesting habitats, migratory stopover habitats, and prey base for predators), which could result in a long-term reduction in wildlife abundance and richness within the project area overall. For example, golden eagles may be especially sensitive to solar energy development because of their sensitivity to land use changes. Loss of foraging habitat and changes to prey availability would be the primary risks to golden eagles. A reduction in prey availability is expected to result in significant declines in population size of the golden eagle (Wiens et al. 2017). A species affected by habitat disturbance might be able to shift its habitat use for a short period. For example, the density of several forest-dwelling bird species has been found to increase within a forest stand soon after the onset of fragmentation as a result of displaced individuals moving into remaining habitat (Hagan et al. 1996). However, it is generally presumed that the habitat into which displaced individuals move is already occupied and would be unable to sustain the same level of use over the long term. The subsequent competition for resources in adjacent habitats would likely preclude the incorporation of the displaced individuals into the resident populations. If it is assumed that areas used by wildlife before development were preferred habitat, then an observed shift in distribution because of development would be toward less preferred and presumably less suitable habitats (Sawyer et al. 2006).

The direct loss of habitat due to construction of solar energy facilities may be reduced for some species through mitigation measures. For example, recent attention has been placed on solar energy developments that integrate measures to conserve habitat and maintain ecosystem function. One example of these measures is the planting of seed mixes of regional native plants either within the solar infrastructure footprint or in offsite areas adjacent to the solar energy facility. These native plantings attract and support native insect pollinators by providing food sources, refugia, and nesting habitat (Walston et al. 2018).

In addition to a direct loss of habitat, the construction of solar energy facilities may also cause an indirect loss of habitat. Although habitats adjacent to solar energy projects (including ancillary facilities) might not be directly disturbed, wildlife might make less use of these areas (primarily because of the disturbance and noise that would occur within the project site). This impact could be considered indirect habitat loss, and it could be of greater consequence than direct habitat loss (Sawyer et al. 2006). For example, the proportion of high-use pronghorn (*Antilocapra americana*) habitat up to 2 km beyond a utility-scale solar energy facility declined by 40% following construction (Sawyer et al. 2022). Similarly, the density of sagebrush obligates, particularly Brewer's sparrow (*Spizella breweri*) and sage sparrow (*Amphispiza belli*), was reduced by 39 to 60% within a 328-ft (100-m) buffer around dirt roads (Ingelfinger and Anderson 2004). The loss of effective habitat (amount of habitat actually available to wildlife) due to roads was reported to be 2.5 to 3.5 times as great as the actual habitat loss (Reed et al. 1996). Many of the individuals that make use of areas adjacent to a road or other development could be subjected to increased physiological stress as a result of complications from overcrowding (e.g., increased competition for space and food, increased vulnerability to predators, and increased potential for the propagation of diseases and parasites). Overcrowding of species such as mule deer in winter ranges could cause density-dependent effects, such as increased fawn mortality (Sawyer et al. 2006). This combination of avoidance and stress would reduce the capability of wildlife to use habitat effectively (WGFD 2004). Overall, direct and indirect habitat losses could potentially reduce the carrying capacity within the species range and result in population-level effects, such as reduced survival or reproduction (Sawyer et al. 2006). Direct habitat loss may affect raptors through the loss of breeding, wintering, and foraging areas. Some raptors may shift the center of their territories to make use of transmission towers, but unless prey increases, raptor abundance would most likely remain the same.

However, some species, such as the common raven (*Corvus corax*), might become more abundant along roads, because of vehicle-generated carrion; also, common ravens might become more common along transmission lines because of the presence of perch and nest sites (Coates et al. 2014). Similarly, raven populations may increase on and around solar energy projects due to human subsidies such as garbage, water, and perch sites. The increased presence of common ravens can exert higher predation pressure on other species like the threatened desert tortoise (Chock et al. 2021) and can decrease sage-grouse nest success through nest predation (Harju et al. 2018). The presence of mesopredators, such as mice, chipmunks, and ground squirrels, has been found to increase with surface disturbance due to energy development (Sanders and Chalfoun 2019). Mesopredators are known to prey on songbird nests and their presence has been associated with a decrease in songbird nest survival (Sanders and Chalfoun 2019).

Wildlife migration corridors for big game, birds, bats, and pollinators would also be vulnerable to project development. Migratory birds may experience higher mortality from solar energy facilities located along migration routes (Chock et al. 2021). Migratory water birds may also be attracted to solar energy facilities if PV panels are perceived as waterbodies (lake effect hypothesis) leading to increased collisions for those species (Chock et al. 2021). Construction of solar energy facilities may alter pollinator movements; however, decreasing mowing and revegetating between panel rows with diverse plant species may benefit pollinator species (Guiller et al. 2017). Big game would be most impacted if construction occurs at pinch points where physiographic constrictions force herds through relatively narrow corridors (Berger 2004). One study tracking pronghorn migration before and after a solar energy facility was constructed found that 86% of pronghorn migrated through the facility location before construction. Post-construction, some pronghorn followed the fence line of the facility and ended up on a highway causing hazards to the pronghorn as well as motorists (Sawyer et al. 2022). Loss of habitat continuity along migration routes would severely restrict the seasonal movements necessary to maintain healthy big game populations (Sawyer and Lindzey 2001; Thomson et al. 2005). As summarized by Rytwinski and Fahrig (2015), roads can impede the movements of various animal species, including reptiles and small and large mammals.

Habitat disturbance could facilitate the spread and introduction of invasive plant species (Section 5.4.1). Roads (and other linear corridors) could facilitate the dispersal of invasive plant species by altering existing habitat conditions, stressing or removing native plant species, and allowing easier movement by wildlife or human vectors (Trombulak and Frissell 2000). Wildlife habitat could also be adversely affected if invasive vegetation became established in the construction-disturbed areas and adjacent offsite habitats.

Construction activities might result in increased erosion and runoff from freshly cleared and graded sites. Ground-disturbing activities can result in increased turbidity and increased concentrations of dissolved solids, salts, and metals which could potentially impact aquatic wildlife species (Grippo et al. 2015a). The potential impacts of construction activities on aquatic species are discussed further in Section 5.4.2.

Little information is available regarding the effects of fugitive dust on wildlife; however, if exposure was of sufficient magnitude and duration, the effects could be similar to those on humans (e.g., breathing and respiratory symptoms, including dust pneumonia). A more probable effect would be the dusting of plants, which could make forage less palatable. Dust suppressants have been correlated with a higher frequency of plant damage, which could affect wildlife habitat (Lovich and Ennen 2011). In addition, pollinator species could be affected by fugitive dust, potentially reducing pollinator populations in the vicinity. This localized effect would be short term and generally coincide with the displacement of and stress to wildlife from human activity. Fugitive dust is not expected to result in any long-term individual or population-level effects. Dusting impacts could be potentially more pervasive along unpaved access roads.

Overall, the effects of habitat disturbance would be related to the type and abundance of the habitats affected and to the wildlife that occurred in those habitats. For example, on large project sites, habitat disturbance could represent a significant impact on local wildlife, especially species whose affected habitats were uncommon and not well represented in the surrounding landscape. In contrast, fewer impacts would be expected from smaller solar energy projects located on currently disturbed lands.

F.4.3.3.1.2 Wildlife Disturbance. Activities associated with the construction of a utility-scale solar energy project could cause wildlife disturbance, including interference with behavioral activities. The response of wildlife to disturbances caused by noise and human presence would be highly variable and species-specific. Intraspecific responses could also be affected by the physiological or reproductive condition of individuals; distance from the disturbance; and type, intensity, and duration of the disturbance. Wildlife could respond to a disturbance in various ways, including attraction, habituation, and avoidance (Geffroy et al. 2015; Lackey et al. 2012; May et al. 2017). All three behaviors are considered adverse. For example, wildlife might cease foraging, mating, or nesting near areas where construction was occurring. In contrast, wildlife like bears, foxes, and squirrels would readily habituate and might even be attracted to human activities, primarily when a food source was accidentally or deliberately made available.

Disturbance could reduce the relative value of the habitat to wildlife such as mule deer, especially during periods of heavy snow and cold temperatures. Under adverse weather conditions, wildlife experience increased physiological stress and require higher levels of energy for survival and reproductive success. Increased human presence can further increase energy expenditures, which can lead to reduced survival or reproductive outcome. Furthermore, disturbance could prevent access to the amount of forage needed to sustain individuals. Hobbs (1989) determined that mule deer doe mortality during a severe winter period could double if the does were disturbed twice a day and caused to move a minimum of 1,500 ft (457 m) per disturbance.

Raptor flush response varies among species, between populations, and between seasons and depends on the type of disturbance (Holmes et al. 1993; Keeley and Bechard 2011; Spail and Heath 2017). One study conducted in New Mexico found that a distance of 650 m prevented 95% of nest-attending ferruginous hawks from flushing in response to humans walking (Keeley and Bechard 2011). Another study of golden eagles found that they were 60 times more likely to flush in response to recreationists that stopped a motor vehicle and transitioned to walking. They also found that flushing distance declined throughout the breeding season (Spaul and Heath 2017). Bighorn sheep (*Ovis canadensis*) have been reported to respond at a distance of 1,640 ft (500 m) from roads with more than one vehicle per day, while deer and elk (*Cervus canadensis*) respond at a distance of 3,280 ft (1,000 m) or more (Gaines et al. 2003).

Noise levels from construction would vary with the level of activity, number of pieces of equipment operating, and the location and type of activity. For typical construction projects, noise levels would be highest during the site preparation phase, that is, the early phase of construction when most of the noisy and heavy equipment would be used for land clearing, grading, and road construction over a short time period (see Section 5.1 for a more detailed discussion on the impacts of noise). Excessive construction noise levels can alter wildlife habitat use, communication, and activity patterns resulting in impacts on mating, feeding behavior and protection of young, nest abandonment, energy loss, decreased food intake, habitat avoidance and abandonment, and reproductive losses (BLM 2018). Anthropogenic noise can impact amphibian behavior (interfering with vocalizations and causing frogs to leave burrows) and physiology (elevating stress hormones and inducing immunosuppressive effects) (Dutta 2018). Anthropogenic noise has also been found to impact male reproductive investment in insects (Bowen et al. 2020). The response of wildlife to noise would vary by species; physiological or reproductive condition; distance; and the type, intensity, and duration of the disturbance. Regular or periodic noise could cause adjacent areas to be less attractive to wildlife and result in a long-term reduction in use by wildlife in those areas.

Some wildlife can habituate to noise (Krausman et al. 2004). However, this is likely to occur only with frequently repeated, predictable exposures, and acclimation can be lost if enough time passes between repeat exposure (Wright et al. 2007). Also, it could be the visual element of the event rather than, or in addition to, the auditory component that causes the observed reaction in wildlife (AMEC Americas Limited 2005). Acclimation to a noise stimulus does not prevent other effects such as hearing loss. The apparent tolerance to noise stress could be the result of the animal or population having to remain in the area because of the absence of alternative habitats, high energetic costs associated with avoidance, or even reduced hearing from the frequency of the noise stimulus (Wright et al. 2007). Also, acclimation could cause possible sensitization, such that the animal may demonstrate an enhanced stress response when exposed to a different new stressor (Wright et al. 2007).

Responses of birds to disturbance often involve activities that are energetically costly (e.g., flying) or affect their behavior in a way that might reduce food intake (e.g., shift away from a preferred feeding site) (Tätte et al. 2018). A variety of adverse effects of noise on raptors have been demonstrated, but for some species, the effects were temporary and the raptors became habituated to the noise (Delaney et al. 1999). A review of the literature by Hockin et al. (1992) showed that the effects of disturbance on bird breeding and breeding success include reduced nest attendance, nest failures, reduced nest building, increased predation on eggs and nestlings, nest abandonment, inhibition of laying, increased absence from nest, reduced feeding and brooding, exposure of eggs and nestlings to heat or cold, retarded chick development, and lengthening of the incubation period. The most adverse impacts associated with noise could occur if critical life-cycle activities (e.g., mating and nesting) were disrupted. For instance, disturbance of birds during the nesting season could result in nest or brood abandonment. The eggs and young of displaced birds would be more susceptible to heat, cold, or predators.

Brattstrom and Bondello (1983) reported that peak sound pressure levels reaching 95 dB resulted in a temporary shift in the hearing sensitivity of kangaroo rats (*Dipodomys* spp.) and that at least three weeks was required for the recovery of hearing thresholds. The authors postulated that such hearing shifts could affect the ability of the kangaroo rat to avoid approaching predators. Krausman et al. (2004) reported that desert ungulates do not hear sound pressure levels generated by military jet aircraft as well as humans do (i.e., 14 to 19 dB lower).

More recently, concerns are beginning to focus on the impacts of chronic anthropogenic noise exposure on wildlife (Barber et al. 2010; Bayne et al. 2008). Noise exposure can cause physiological stress either directly (as described above) or indirectly through secondary stressors such as annoyance. These secondary stressors can increase the ambiguity in received signals or cause animals to leave a preferred resource area (Wright et al. 2007). Increased noise levels can also reduce the distance and area over which an animal perceives natural acoustic signals (Barber et al. 2010). Chronic noise can reduce habitat quality, especially for species that rely on acoustic signals for communication (Bayne et al. 2008). Bayne et al. (2008) found total passerine abundance was 33% lower near noise-producing energy sites (sites with compressor stations) than near noiseless energy sites (natural gas well pads). Overall, chronic noise exposure can result in changes in foraging and anti-predator behavior, reproductive success, and density and community structure (Barber et al. 2010).

F.4.3.3.1.3 Wildlife Injury or Mortality. Clearing, grading, and trenching activities could result in the direct injury or death of wildlife species not mobile enough to avoid construction operations (e.g., insects, reptiles, small mammals) or those that used burrows (e.g., desert tortoise [*Gopherus agassizii*], ground squirrels, and burrowing owls [*Athene cunicularia*]) (BLM 2015; Murphy-Mariscal et al. 2018; Lovich and Ennen 2011). If clearing or other construction activities occurred during the spring and summer, bird nests and eggs or nestlings could be destroyed. Although more mobile wildlife species, such as deer and adult birds, might avoid the initial clearing activity by moving into habitats in adjacent areas, it is conservatively assumed that adjacent habitats are at carrying capacity for the species that live there and could not support additional biota from the construction areas. The subsequent competition for resources in adjacent habitats would likely preclude the incorporation of the displaced individuals into the resident populations.

The abundance of the affected species on the site and in the surrounding areas would have a direct influence on population-level effects. Impacts on common and abundant species would probably be less than impacts on uncommon species. The greater the size of the project site, the greater the potential for more individual wildlife to be injured or killed. Also, the timing of construction activities could directly affect the number of individual wildlife injured or killed. For example, construction during the reproductive period of ground-nesting birds, such as sage-grouse, would have a greater potential to kill or injure birds than construction at a different time.

Direct mortality from vehicle collisions would be expected to occur along access roads, especially in wildlife concentration areas or travel corridors. In the United States, an estimated 89 million to 340 million birds are killed on roads annually (Hallisey et al. 2022). When access roads cut across migration corridors, the effects can be dangerous for both animals and humans (Sawyer et al. 2019). Amphibians and reptiles are attracted to roads to bask and thermoregulate making them more susceptible to road mortality (Hallisey et al. 2022) Amphibians are also more susceptible to road mortality due to their inconspicuous size and relatively slow movements (Hallisey et al. 2022). Golden eagles and other raptors can also incur vehicle collisions because of their reliance on scavenging (Lonsdorf et al. 2018).

ROW and access road development increases the use of public lands for recreation and other activities; increasing the amount of human presence increases the potential for harassment and legal or illegal taking of wildlife. This might include the collection of live animals, particularly reptiles and amphibians, for pets. Direct mortality of small mammals might increase due to the use of snowmobiles and OHVs because the animals that occupy subnivean spaces could be crushed or suffocated and predators' access to them would increase when they move over compacted vehicular trails (Gaines et al. 2003). Direct mortality also occurs when OHV users carry firearms into areas not normally accessed by people or vehicles. Rabbits, squirrels, and raptors are often used as "targets."

F.4.3.3.1.4 Exposure to Contaminants or Fires. Wildlife could be exposed to accidental fuel spills or releases of other hazardous materials. Pesticides, lead, and other contaminants already are background stressors. Additive effects may increase stress. Potential impacts on wildlife would vary according to the material spilled, volume of the spill, location of the spill, length and intensity of exposure (i.e., chronic versus acute exposure), and the exposed species. A spill would be expected to have a population-level adverse impact only if it were very large (or in the case of a small spill if the substance was highly toxic) or if it contaminated a crucial habitat area where a large number of individual animals were concentrated. The potential for either event is very unlikely. In addition, use of the project area by wildlife during construction would be limited, since there would be construction-related disturbances, thus greatly reducing the potential for contaminant exposure.

Increased human activity could increase the potential for fires. In general, the effects of fire on wildlife would be related to the impacts on vegetation which, in turn, would affect habitat quality and quantity, including the availability of forage and shelter (Hedlund and Rickard 1981; Groves and Steenhof 1988; Sharpe and Van Horne 1998; Lyon et al. 2000b). Wildfires have been found to impact sage-grouse population growth due to loss of sagebrush habitat (Dudley et al. 2021). While individuals caught in a fire could incur increased mortality, most wildlife would be expected to escape by either outrunning the fire or seeking underground or aboveground refuge within the fire (Ford et al. 1999; Lyon et al. 2000a). However, some mortality of burrowing animals from asphyxiation in their burrows during fire has been reported (Sanderfoot et al. 2021). Impacts from wildlife include injury, direct mortality, predation due to lack of cover, and starvation from lack of food. An individual's ability to survive a wildfire depends on several factors including mobility, behavior, food availability, and cover. Species like coyotes and great horned owls who are generalists are usually less impacted than specialist species who rely on a single resource for food (Ketcham and Koprowski 2013). Smoke inhalation has also been found to contribute to negative health outcomes in mammals, birds, reptiles, and insects (Sanderfoot et al. 2021).

F.4.3.3.2 Operations

F.4.3.3.2.1 Habitat Disturbance. In general, the solar energy development could result in areas that were once considered areas with a high probability of being used by wildlife becoming areas of low or no use (e.g., the presence of the solar energy infrastructure, lack of vegetation, and fencing around the facility would result in the long-term loss of habitat for some species such as large mammals), while other areas with a low probability of use could be used more frequently. This change might cause a shift of wildlife use to presumably less-suitable habitat (Sawyer et al. 2006). Because solar energy projects would be fenced, big game and many other mammal species would be excluded from the project area. Potentially, herd animals such as elk, deer, and pronghorn (*Antilocapra americana*) could be forced to travel longer distances if a large solar energy project transected the migration paths between their winter and summer ranges or were located in crucial habitats, such as calving areas. Pronghorn movements were studied at a 2.3 km^2 solar energy facility constructed in Wyoming in 2018 in an area designated as crucial pronghorn winter range. 69% of monitored resident pronghorn and 86% of migratory pronghorn used the site prior to construction. These pronghorn were completely excluded from the site due to fencing and were forced to alter their movements post construction (Sawyer et al. 2022). Movement patterns of other species could also be affected. Fencing around arrays has been found to create a barrier for some ground gleaning insectivorous bat species (Johnston et al. 2014). A recent acoustic study found that bat activity of most species analyzed was negatively affected by solar PV panels (Tinsley et al. 2023). Furthermore, a solar energy development could alter habitats and connectivity among habitats for species existing as a metapopulation such as bighorn sheep.

F.4.3.3.2.2 Wildlife Disturbance. During the operation and maintenance of solar energy projects, wildlife could be disturbed by noise and the presence of workers. The activities associated with solar energy facility operations that could generate noise include transmission lines (corona), vehicles, maintenance equipment, and actual plant operations. In general, the noise-generating activities in the solar field area are minimal. The sound level from transformers would be about 51 dBA at 492 ft (150 m) and 40 dBA (typical background for rural areas) at 1,800 ft (550 m). No major equipment that can cause ground vibration would be used during operations (see Section 5.1.1.3). The response of wildlife to these disturbances would be highly variable and depend on the species; distance; and the type, intensity, and duration of the disturbance. Disturbance impacts on wildlife during operation and maintenance of a solar energy project would be similar to those discussed for the construction phase (Section 5.4.3.1.2). For example, some individual wildlife might temporarily or permanently move from the project area. Wildlife permanently moving from the area might incur high mortality rates if the surrounding habitats were at or near carrying capacity or if the surrounding areas lacked habitat capable of supporting the displaced individuals.

Recent solar energy development projects have implemented alternatives to traditional vegetation clearing for the construction and operation phases. The Yellow Pine Solar Project allows vegetation to be maintained at 18-24 inches to help preserve soils, biological soil crusts, soil seed banks, native perennial vegetation diversity and structure, and cacti and yucca species, and to resist weed invasions, dust, and erosion (BLM 2020a). By maintaining vegetation within the solar energy facility, wildlife is expected to remain within the solar energy facility to some extent (BLM 2020b).

During the operations phase, the panels on the PV arrays would have to be routinely cleaned. This would generally be done with high-pressure water sprayed from trucks during evening hours. The panel cleaning operations would cause a minor, localized disturbance to wildlife. Water that did not evaporate from the washing operations would collect on the ground around the PV arrays. This could benefit vegetation growth near the PV arrays, which could enhance habitat or forage for wildlife species that inhabit the project site. This may attract raptors and increase the likelihood of them colliding with solar energy facilities.

Artificial light at night (ALAN) could also disturb wildlife in the solar energy project area. ALAN has been shown to affect basic responses and functions related to orientation in space (phototaxis, phototropism) and time (circadian rhythms) (Falcón et al. 2020). In invertebrates, ALAN can impact reproductive success and growth of moths and spiders and can interfere with the production and perception of courtship messages by fireflies (Falcón et al. 2020). In amphibians, ALAN can affect the nocturnal distribution and choice of preferred substrate in salamanders, can reduce larvae metamorphosis duration and juvenile growth in toads, can reduce hatching success in frogs, and can reduce activity and alter metabolism in toads (Falcón et al. 2020). Little information is known concerning ALAN’s impact on terrestrial reptiles as most studies have focused on sea turtles, but increased activity has been observed in anole primarily due to the increase in arthropods attracted by lights (Falcón et al. 2020). ALAN impacts on birds have been well studied and include disruptions of circadian systems in both sedentary and migratory birds; impacts on reproduction and the annual breeding rate; developmental delays in the visual system of young birds; disorientation; and collision with structures resulting in death of hundreds to thousands of individuals. ALAN also impacts stopover habitat use of inland migrating birds who avoid bright areas (Falcón et al. 2020). Studies on the impacts of ALAN on mammals are limited and do not include many different species. The most documentation relates to the impacts of night lighting on bats. The impacts vary by species but include a delay to leave the nest, decreased mating activity, changes in flight speed and paths, and increases in collisions (Falcón et al. 2020).

F.4.3.3.2.3 Collisions. The presence of solar energy facilities would create a physical hazard to some wildlife. In particular, birds or bats could collide with solar energy facilities, while mammals and ground-nesting birds could collide with project fencing. Little to no available data exist regarding bat mortalities from collision with PV solar panels (BLM 2019). Hypotheses regarding the cause of bat collisions with PV panels include confused echolocation feedback, failure to detect angled panels because of reduced echolocation output, or misinterpretation of echolocation-detected flat panels as water bodies (Smallwood 2022). Estimated bat fatalities at solar energy facilities can be high. One study estimated an average of 0.06 bat fatalities/MW/year at PV facilities (Smallwood 2022). Hypotheses regarding the cause of avian collisions with PV panels include the lake effect, polarized light from PV panels attracting prey of insectivorous birds, reflected self-images eliciting aggressive responses, or high-speed predator-prey encounters resulting in accidental collisions (Smallwood 2022). Several recent studies have estimated bird fatalities at utility-scale solar energy facilities on a regional and national scale; however, estimates vary greatly due to regional variation in fatality rates, different survey designs across solar energy facilities, and different analytical approaches to fatality estimates (Walston et al. 2016, Kosciuch et al. 2020, Smallwood 2022). One estimate ranged from 2.7 to 9.9 birds/MW/year or 37,800-138,600 birds per year in the United States across PV and CSP facilities (Walston et al. 2016). Another study calculated an average annual fatality rate of 1.82 birds/MW/year or 30,976 birds/year for PV utility-scale solar energy facilities in the Southwestern United States (Kosciuch et al. 2020). Yet another study calculated an average fatality rate of 11.61 birds/MW/year at utility-scale solar PV projects resulting in a total annual fatality estimate of 141,811 in the state of California (Smallwood 2022). Mitigation measures to avoid and minimize collisions would help decrease the level of impact on bird and bat species (Appendix A.4.1.11).

F.4.3.3.2.4 Exposure to Contaminants or Fires. During operation of the solar energy project, wildlife might be exposed to herbicides (see Section 5.4.3.1.5), fuel, or other hazardous materials (e.g., lubricating oils). Potential exposure to hazardous materials would be most likely from a spill. A spill could result in direct contamination of individual animals, contamination of habitats, and contamination of food resources. Acute (short-term) effects generally occur from direct contamination; chronic (long-term) effects usually occur from factors such as the accumulation of contaminants from food items and environmental media (Irons et al. 2000). Acute exposure is most often fatal or causes severe biological harm. Chronic exposure can reduce reproduction, hatching success, and growth and cause a variety of pathological conditions. Contaminant ingestion during preening or feeding might impair endocrine and liver functions, reduce breeding success, and reduce growth of offspring.

The impacts on wildlife from a spill would depend on factors such as the time of year, volume of the spill, type and extent of habitat affected, and home range and density of the wildlife species. A population-level adverse impact would be expected only if the spill was very large or if it contaminated a crucial habitat area where a large number of individual animals were concentrated. The potential for either event would be unlikely. Because the amounts of most fuels and other hazardous materials are expected to be small, an uncontained spill would affect only a limited area. Also, the avoidance of contaminated areas by wildlife during spill response activities (due to disturbance from human presence) would minimize the potential for wildlife exposure. Furthermore, given the limited quantity and quality of wildlife habitat within the boundaries of a solar energy project, few individual animals would be exposed to contaminants.

Impacts on wildlife from fires during the operations phase would be similar to those described for the construction phase (Section 5.4.3.1.2).

F.4.3.3.3 Decommissioning/Reclamation

Decommissioning activities could affect wildlife by altering existing habitat characteristics and the species supported by those habitats. These activities would vary among locations, depending on the extent of infrastructure that would need to be removed, projected future land use, and the amount of site restoration (e.g., type of revegetation) required. Decommissioning activities that could affect wildlife include the following:

- The dismantling process;
- Purging and cleaning of structures left in place;
- Generation of waste materials;
- Regrading of project areas;
- Revegetation activities; and
- Accidental releases (spills) of potentially hazardous materials.

During decommissioning activities, localized obstruction of wildlife movement could occur in the areas where the solar energy facilities and transmission lines were being dismantled. However, seasonal stipulations for the protection of wildlife contained in the solar energy facility and related ROWs would also apply to the decommissioning phase. There would also be an increase in noise and visual disturbance associated with removal of project facilities and site restoration. Increased traffic levels during decommissioning would result in increased roadkill, but injury and mortality rates of wildlife would probably be lower than during construction.

Most wildlife would avoid areas while decommissioning activities were taking place. Avoidance would have a short-term impact. However, animal feeding and nuisance animal issues might become problematic because of the increased number of workers who might have a shorter-term view of the consequences of their actions. A problematic animal (e.g., a bear or mountain lion) might have to be deliberately displaced to protect lives and property, either through harassment or live-trapping and release to another part of its range.

Other potential environmental concerns resulting from decommissioning would include the disposal of solid wastes and hazardous materials and the remediation of contaminated soils. Some fuel and chemical spills could also occur, but these generally would be confined to access roads and project site areas. The probability that wildlife would be exposed to such spills would be small and limited to a few individuals. After decommissioning activities were complete, there would be no fuel or chemical spills associated with the utility-scale solar energy facility or water pipelines or, if the lines were not maintained as part of the energy grid, transmission lines.

Removal of aboveground facilities would reduce potential nesting, perching, and resting habitats for several bird species, particularly raptors and common ravens. However, this could benefit species such as small mammals and greater sage-grouse that are preyed upon by those species. Removal of aboveground facilities would also reduce bird collisions. In addition, the removal of aboveground facilities would ensure free passage of wildlife. The revegetation of decommissioned solar energy facilities and associated ROWs would increase wildlife habitat diversity, since control of vegetation (including cutting of woody vegetation) would cease, allowing native shrubs and trees to grow and increase in density. As disturbed areas would become revegetated, any impacts from fragmentation that existed during the lifetime of the project would diminish. Habitats that had been avoided by wildlife because of the proximity of facilities and humans could become re-inhabited.

How soon wildlife resources in the solar energy facility site area could return to pre-project conditions would depend partly on the habitat and vegetation conditions that existed prior to construction. In the extreme, natural recovery to pre-disturbance plant cover and biomass in desert ecosystems may take 50 to 300 years, with complete ecosystem recovery potentially requiring more than 3,000 years (Lovich and Bainbridge 1999). In the long term, decommissioning and reclamation would increase species diversity and habitat quality within the project area.

F.4.3.3.4 Transmission Lines and Roads

Transmission lines could fragment existing habitat, establish altered habitat within the ROW, and establish edge habitat at the borders of the ROW and the existing habitat. Construction of transmission lines in a forest has been found to decrease the habitat available for forest interior species (Biasotto and Kindel 2018). Line construction would thus reduce the density and diversity of forest interior species in an area larger than that of the actual cleared ROW segment. Conversely, species that prefer open habitats, such as the red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), brown-headed cowbird (*Molothrus ater*), common raven (*Corvus corax*), and yellow warbler (*Dendroica petechia*), might increase in numbers. An increase in brown-headed cowbird populations could adversely affect other bird species, since the cowbird is a brood parasite, laying its eggs in the nests of other species, especially warblers, vireos, and sparrows.

Nests along the forest edge could also be more vulnerable to predators, such as raccoons (*Procyon lotor*) and jays. Predators such as coyotes (*Canis latrans*) and foxes commonly use ROWs for hunting, because there are more small mammals that prefer open areas there. The cleared ROW segments might also encourage increases in the populations of invasive bird species, such as the house sparrow (*Passer domesticus*) and European starling (*Sturnus vulgaris*), which compete with many native species.

Although most fragmentation research has focused on forested areas, similar ecological impacts have been reported for the more arid and semiarid landscapes of the western United States, particularly shrub-steppe habitats that are dominated by sagebrush or salt desert scrub communities. For example, habitat fragmentation, combined with habitat degradation, has been shown to be largely responsible for the declines in populations and distributions of sage-grouse species (Davis et al. 2015).

The transmission line ROW could function as:

- A specialized habitat for some species;
- A travel lane that would enhance species movement, predation, and spread of non-native, invasive plant species;
- A barrier to the movement of species, energy, or nutrients (because it would fragment existing habitat);
- Sources of biotic and abiotic effects on the adjacent ecosystem matrix; and
- A sink—wildlife would enter the corridor and die (e.g., by colliding with transmission lines).

Similar impacts could occur from water pipeline ROWs. The degree to which a ROW would carry out these functions would depend on the wildlife species, the width and length of the ROW, and the habitat contrast between the ROW and adjacent areas (Williams 1995; Jalkotzy et al. 1997).

Transmission lines and other project structures could provide perch sites for raptors and corvids (e.g., ravens, crows, and magpies), thereby increasing predatory levels on other wildlife (e.g., small mammals, birds). The lines and structures would enable birds, such as the golden eagle (*Aquila chrysaetos*), great-horned owl (*Bubo virginianus*), red-tailed hawk, ferruginous hawk (*Buteo regalis*), common raven, prairie falcon (*Falco mexicanus*), American kestrel, and osprey, to nest or perch in otherwise treeless landscapes (BirdLife International 2003; Fernie and Reynolds 2005). Transmission support structures could also protect some bird species from mammalian predators, range fires, and heat (Steenhof et al. 1993). However, high winds could cause the nests of birds that use transmission line support structures to fall apart. Entanglement in tower support structures might be another hazard (Steenhof et al. 1993). A transmission line might also lead to a functional loss of habitat for those species that avoid the proximity of these facilities (BirdLife International 2003) resulting in indirect habitat loss that can be substantially more expansive than the direct loss of habitats associated with transmission lines. For example, the lesser prairie-chicken (*Tympanuchus pallidicinctus*) seldom nests within 1,300 ft (396 m) of transmission lines (Pitman et al. 2005).

Bird mortality due to collision and electrocution at U.S. power lines constitutes a major source of anthropogenic mortality with collision rates (8 million to 57 million birds/year) far exceeding those of electrocution (0.9 million to 11.6 million birds/year) (Loss et al. 2014). Raptors and owls represent the most frequently electrocuted species. Other species such as herons, storks, corvids, and pigeons are also known to be electrocuted (Pérez-García et al. 2017). In the Western United States, the most electrocuted eagle, hawk, and owl are the golden eagle (*Aquila chrysaetos*), red-tailed hawk (*Buteo jamaicensis*), and great horned owl (*Bubo virginianus*) (Eccleston and Harness 2018). Although electrocution of raptors or other birds does occur, it would be expected to be rare because the spacing between the conductors or between a conductor and ground wire or other grounding structure would exceed the wing span of the California condor (*Gymnogyps californianus*), the largest bird to occur in the 11-state planning area. Electrocution can occur during current arcing when flocks of small birds cross a line or when several roosting birds take off simultaneously. This is most likely to occur in humid weather conditions (Demerdzhiev 2014; BirdLife International 2003). Arcing can also occur from the waste streamers of large birds roosting on the crossarms above insulators (BirdLife International 2003). The electrocution of other wildlife from contact with electrical transmission lines is even less common. Nonavian wildlife species that have been electrocuted include snakes, mice, squirrels, raccoons, bobcat (*Lynx rufus*), and American black bear (*Ursus americanus*) (Edison Electric Institute 1980; Williams 1990). Among the mammals, squirrels are among the most commonly reported species to be electrocuted because of their penchant for chewing on electrical wires. Because of the relatively rare nature of electrocutions, they are not expected to adversely affect populations of wildlife species in the vicinity of a utility-scale solar energy project.

The potential effects of electric and magnetic field (EMF) exposure on animal behavior, physiology, endocrine systems, reproduction, and immune functions have been found to be negative, very minor, or inconclusive (WHO 2007). In general, these results are for exposures much higher and longer than would be encountered by wildlife under actual field conditions. Also, there is no evidence that EMF exposure alone causes cancer in animals, and the evidence that EMF exposure in combination with known carcinogens can enhance cancer development is inadequate (WHO 2007).

Electrical discharge by transmission lines can create a crackling or hissing noise and wind can cause vibrations of the tower structures, resulting in noise. These noises may be audible to some wildlife species (Bartzke et al. 2014). Noise will also occur if helicopters are used for the construction or maintenance surveys of transmission lines. Wildlife behavior could be impacted by the presence of helicopters but surveys would be infrequent and would not be expected to result in long-term impacts (Dyal et al. 2021).

The potential for bird collisions with transmission lines depends on variables such as habitat, season, relation of the line to migratory flyways, feeding flight patterns, and topographic features, migratory and resident bird species, and structural characteristics of the lines (Loss et al. 2014). Birds that migrate at night, fly in flocks, and/or are large and heavy with limited maneuverability are at particular risk (BirdLife International 2003). Waterfowl, grebes, shorebirds, and cranes are most vulnerable to colliding with transmission lines (Rioux et al. 2013). Of highest concern with regard to bird collisions are locations where lines span flight paths; these include river valleys, wetland areas, lakes, areas between waterfowl feeding and roosting areas, and narrow corridors (e.g., passes that connect two valleys). A disturbance that would lead to a panic flight could increase the risk of collision with transmission lines (BirdLife International 2003).

The shield wire is often the cause of bird losses associated with higher voltage lines, because birds fly over the more visible conductor bundles, only to collide with the relatively invisible, thin shield wire (Rioux et al. 2013). Young, inexperienced birds as well as migrants in unfamiliar terrain appear to be more vulnerable to wire strikes than resident breeders. Collision risk is also dependent on environmental and site attributes like weather, lighting, topography, and line placement (Rioux et al. 2013).

Rioux et al. (2013) concluded that although waterfowl were the most commonly detected birds colliding with transmission lines, no adverse population or ecological results occurred because waterfowl populations are continuing to increase. The potential for waterfowl and wading birds to collide with transmission lines could be assumed to be related to the extent of the preferred habitats that are crossed by the lines and the extent of other waterfowl and wading bird habitats within the immediate area. Power line collision estimates tend to be biased towards water birds because most of the available studies were conducted at or near bodies of water (Loss et al. 2014).

While not immune to collisions, raptors have several attributes that decrease their susceptibility to collisions with transmission lines: (1) they have keen eyesight; (2) they soar or fly by using relatively slow, flapping motions; (3) they can generally maneuver while in flight; (4) they learn to use utility poles and structures as hunting perches or nests and become conditioned to the presence of lines; and (5) they do not fly in groups (like waterfowl), so their position and altitude are not determined by other birds. Despite these advantages, birds of prey are at an increased risk of collision during intraspecific and interspecific interactions during flight when they can be distracted and less likely to recognize flight hazards (Eccleston and Harness 2018). Mitigation measures to avoid and minimize collisions with transmission would help decrease the level of impact on bird species (Appendix B.4.1.4).

Periodic maintenance of transmission line ROWs in forested areas would maintain the ROW in an early stage of plant community succession, which could benefit small mammals and their predators. Regrowth of willows and other trees following maintenance could benefit ungulates that use browse. Conversely, habitat maintenance would have localized adverse effects on certain species, such as the red squirrel (*Tamiasciurus hudsonicus*), southern red-backed vole (*Myodes gapperi*), and American marten (*Martes americana*), which prefer late-successional or forested habitats. ROW vegetation maintenance would not be expected to occur more often than once every three years, lessening impacts on migratory birds and other wildlife species that might use the ROWs.

Most herbicides used on BLM-administered lands would pose little or no risk to wildlife unless the animals were exposed to accidental spills or direct spray or drift or unless they consumed herbicide-treated vegetation. Herbicide applications would be conducted by following label directions and applicable permits and licenses. Thus, any adverse toxicological threat from herbicides on wildlife would be unlikely. The response of wildlife to herbicide use would be attributable primarily to habitat changes resulting from treatment rather than to toxic effects of the applied herbicide. However, accidental spills or releases of these materials could affect exposed wildlife. Contact with herbicides or ingestion of treated materials can result in death, damage to vital organs, decrease in body weight, decrease in healthy offspring, and increased susceptibility to predation (BLM 2019). Overall, most commonly used herbicides degrade quickly once they enter the environment; thus, they are not persistent, nor do they bioaccumulate (Tatum 2004).

Following decommissioning activities (e.g., removal of aboveground structures), the recreational use of ROWs (e.g., as a travel corridor by OHVs) might increase, which could lead to increased wildlife disturbance and mortality. However, removal of aboveground facilities would reduce the potential for bird collisions.

F.4.4 Special Status Species

F.4.4.1 Methods Used for Evaluation

Special status species (SSS) were defined as 1) species listed as threatened, endangered, proposed under review, or candidates under the Endangered Species Act (ESA), 2) species for which the U.S. Fish and Wildlife Service (USFWS) made a positive 90-day finding 3) delisted species throughout the post-delisting monitoring period (minimum five years; ESA §4(g)), 4) BLM-sensitive species as designated on a national level by BLM headquarters in coordination with the BLM State Director, and five) state-listed species. This Programmatic EIS does not provide a detailed impact analysis for individual species because it is not possible to quantitatively analyze impacts on SSS in this report due to its broad scope and the lack of project-specific information. The primary potential impacts on special status species from solar energy development are similar to those discussed for wildlife, vegetation, and aquatic biota. However, because of their small population sizes and often specialized habitat needs or dependence on rare habitats, SSS may be more vulnerable to impacts than common and widespread species. Small population size makes them more vulnerable to the effects of habitat fragmentation, habitat alteration, habitat degradation, human disturbance and harassment, mortality of individuals, and the loss of genetic diversity.

A GIS-based analysis was used to compare potential impacts on special status species by alternative. For ESA-listed species, the ranges of listed species from USFWS (https://ecos.fws.gov/ecp/) were compared to the boundaries of each alternative. All species whose ranges overlap the alternative boundary were considered to be potentially affected by solar energy development. In addition, alternatives that overlap with the greatest number and area of ESA species ranges may have the greatest potential to impact listed species. However, actual impacts would depend on the siting and design features of the project and the characteristics of the SSS potentially affected. CH has been excluded from all alternatives; therefore, direct effects to CH are not anticipated and CH was not used in the impact analysis.

Consultation with the USFWS under Section 7 of the ESA is required for those species currently listed under the ESA; coordination with the USFWS should be conducted for those species that are candidates, proposed, or under review for listing under the ESA. The consultation process includes the development of a biological assessment (BA), a document prepared to determine whether the proposed federal action is likely to adversely affect listed species, proposed species, or designated critical habitat. As a result of the BA and the consultation process, the USFWS will form a biological opinion formally stating whether or not the federal action is likely to jeopardize the continued existence of listed or proposed species or result in the destruction of adverse modification of critical habitat.

Unlike ESA-listed species, range maps were not available for most BLM-sensitive species and state-listed species. Therefore, county level occurrence data, when available, was used to assess these species' distributions in relation to the alternative boundaries. Species found in counties that overlap with the boundaries under each alternative were considered to be potentially impacted by solar energy development. As with ESA-listed species, this GIS-based approach provides a general assessment of species potentially affected by solar energy development. Project-specific species assessments will be required for future solar energy development projects.

F.4.4.2 Supplemental Material for Affected Environment

No supplemental material to the special status species affected environment (Section 4.4.4).

F.4.4.3 Supplemental Material for Impacts Assessment

No supplemental material to the special status species impacts assessment (Section 5.4.4).

F.5 Environmental Justice

F.5.1 Methods Used for Evaluation

In September 2022, the Bureau of Land Management (2022) published an Instruction Memorandum (IM2022-059, Attachment 1) on environmental justice implementation, which suggests the following thresholds that are used in this analysis to provide an initial identification of geographies with potential minority populations of concern:

1. Threshold Analysis: the minority population (population other than “White alone, not Hispanic or Latino”) is 50% or more of the population in a geography; and
2. Meaningfully Greater Analysis: the population of a geography is 110% of the geographic reference area for one or all minority populations (i.e., if the percentage in the geographic reference area is 20%, the study area must be 22% or greater to be identified).

Using the following thresholds, as suggested in the IM2022-59, attachment 1 (and applying to populations of people who are living at or below 200% of the federal poverty threshold, per BLM IM2022-59, Attachment 1 recommendation), this analysis provides an initial identification of geographies with potential low-income populations of concern:

1. With populations initially identified as living at or below 200% of the poverty line, potential concern is determined using the 50% Threshold Analysis, which identifies whether those populations are equal to or greater than 50% or more of total residents in a study area are low-income; and
2. Low-Income Threshold Analysis, in which the percentage of identified low-income population is equal to or greater than 100% of the geographic reference area (i.e., if the percentage in the geographic reference area minority population is 20%, the study area percentage of minority population must be 20% or greater to be identified).

Based on the CEQ Guidance (1997) and BLM (2022) IM, the following six major steps were carried out to identify minority and low-income populations with potential environmental justice concern for the 11-state planning area. (Refer to Section 4.18 for information specific to Tribal populations.)

Step 1: Recognize key thresholds used to determine initial minority and low-income population numbers and percentages.

(1) Minority population percentage within proximity lands available for development;

(2) Minority population percentage of the reference area for the block groups;

(3) Low-income population percentage within proximity of lands available for development;

(4) Low-income percentage of the reference area for the block groups; and

Step 2: Identify a data source for annual socioeconomic datasets that provide sub-indicators for calculating the key indicators listed in Step 1. The analysis used the most recent 2017–2021 American Community Survey (ACS) 5-Year Estimates from the U.S. Census Bureau (USCB 2022b) and U.S. Current Population Reports detailed in P60-280 data tables (USCB 2023).

Step 3: Specify a geographic or statistical area that will be most inclusive in identifying potentially impacted populations, provide data at a scale appropriate to the 11-state planning area, and be clear and understandable to a broad audience. Specify a geographic or statistical area that represents its reference area (that is, “the general population or other appropriate unit of geographic analysis” in the CEQ guidance). For identifying environmental justice communities for the 11-state planning area, the suitable geographic or statistic areas for a community and its reference area are “block group” (within or intersecting with lands available for development) and “state,” respectively, as the scope of these datasets is standard for regional programmatic demographic analysis. Note that Table 4.5.1 state-level data used national averages from Census P60 and DP05 tables to determine whether threshold values met or exceeded reference values.

Step 4: Identify minority and low-income populations (for information about Tribal populations, see 4.18). For each county of each of the 11 states:

- Use census data (P60) to determine low-income population (using equal to or less than 200% of poverty threshold); and
- Use census data (ACSDP05) to identify total county population and total population of “white, not Hispanic or Latino” population. Subtract “white, not Hispanic or Latino” population total from county total to get total number of minority population.

Step 5: Identify potential minority populations of concern using 50% Threshold analysis, meaning that if a minority population percentage is equal to or greater than 50%, it is identified as a potential minority population of concern. If a minority population does not meet the 50% Threshold Analysis and the block group minority population is also less than 50%, then the Meaningfully Greater Threshold Analysis was applied. To do this, the block group minority population total was multiplied by 110% to obtain the “meaningfully greater” threshold. If a block group minority population was equal to or greater than the “meaningfully greater” percentage, it was identified as a potential minority population of concern.

Step 6: Identify potential low-income populations of concern using 50% Threshold analysis, meaning that if the percentage of block group population (whose income is equal to or below 200% of the federal poverty level) is equal to or more than 50% of the total block group population, it qualifies as a potential low-income population of concern. If a low-income population was not equal to or greater than 50%, the Low-Income Threshold analysis was used, meaning that if the study area (block group) population percentage (whose income is equal to or below 200% of the federal poverty level) is equal to or more than the reference area total population percentage (whose income is equal to or below 200% of the federal poverty level), it qualified as a potential low-income population of concern.

F.5.2 Supplemental Material for Affected Environment

Table F.5.2-1 provides a broad block group comparison within the 11-state planning area to identify minority and low-income populations that may have environmental justice concerns. The table is arranged in alphabetical order by state describing the number of block groups in each state and within each Alternative or No Action area, and further identifies the number of low-income and minority block groups and population members in proximity to each Alternative or No Action area.

Note that this analysis is representative of populations in these block groups and is meant as an initial screening. This does not preclude consideration of minority and/or low-income populations residing within surrounding or distant block groups that may be impacted by utility-scale PV solar development. Future project-level NEPA review would include a more comprehensive analysis that includes local input from potentially affected/impacted low-income, minority, and Tribal populations.

Table F.5.2-1. Identified Low-Income and Minority Population Residing in Block Groups Located Within or Intersecting With Lands Available for Development (Alternatives 1-5 and No-Action) in the 11-State Planning Area

ALTERNATIVE 1							
State	Total # of block group in each state	Total # of block groups in Alternative 1	# of low - income block groups	# of minority block groups	Total block group population in Alternative 1	Low-income block group population in Alternative 1	Minority block group population in Alternative 1
Arizona	4,773	317	207	83	445,049	119,161	100,012
California	25,607	545	323	84	733,178	162,185	103,248
Colorado	4,058	223	154	37	252,488	57,762	22,337
Idaho	1,284	245	199	67	297,858	88,843	33,761
Montana	900	148	108	23	162,386	40,253	12,105
Nevada	1,963	234	109	45	381,100	57,169	68,577
New Mexico	1,614	259	167	153	338,380	120,058	165,572
Oregon	2,970	360	265	32	425,608	108,423	18,844
Utah	2,020	179	138	22	266,876	62,435	13,615
Washington	5,311	182	149	43	220,021	60,757	30,432
Wyoming	457	130	87	39	155,262	29,741	12,741

ALTERNATIVE 2							
State	Total # of block group in each state	Total # of block groups in Alternative 2	# of low - income block groups	# of minority block groups	Total block group population in Alternative 2	Low-income block group population in Alternative 2	Minority block group population in Alternative 2
Arizona	4,773	287	189	75	409,425	109,958	90,656
California	25,607	200	136	34	234,185	66,928	33,169
Colorado	4,058	149	111	30	161,264	42,948	18,436
Idaho	1,284	145	121	57	183,360	56,144	27,729
Montana	900	105	77	19	112,858	29,200	9,881
Nevada	1,963	205	97	38	328,473	50,504	62,581
New Mexico	1,614	243	157	143	315,669	113,283	154,503
Oregon	2,970	186	132	19	219,983	56,668	13,342
Utah	2,020	134	111	18	185,463	49,298	10,247
Washington	5,311	76	60	20	94,110	25,486	14,191
Wyoming	457	120	82	35	141,091	27,725	11,719

ALTERNATIVE 3							
State	Total # of block group in each state	Total # of block groups in Alternative 3	# of low - income block groups	# of minority block groups	Total block group population in Alternative 3	Low-income block group population in Alternative 3	Minority block group population in Alternative 3
Arizona	4,773	275	180	72	398,718	105,237	87,263
California	25,607	156	103	30	191,744	53,493	31,164
Colorado	4,058	142	104	26	153,643	39,656	15,990
Idaho	1,284	142	118	57	179,508	54,563	27,729
Montana	900	85	65	16	92,122	25,409	8,156
Nevada	1,963	196	92	36	316,332	47,920	60,953
New Mexico	1,614	223	142	133	295,059	103,819	144,595
Oregon	2,970	180	127	19	213,481	55,015	13,342
Utah	2,020	127	106	17	175,805	47,331	10,089
Washington	5,311	72	57	20	89,905	24,381	14,191
Wyoming	457	114	76	35	136,272	26,301	11,719

ALTERNATIVE 4							
State	Total # of block group in each state	Total # of block groups in Alternative 4	# of low - income block groups	# of minority block groups	Total block group population in Alternative 4	Low-income block group population in Alternative 4	Minority block group population in Alternative 4
Arizona	4,773	263	171	64	380,724	98,702	76,903
California	25,607	176	117	31	207,617	59,498	30,197
Colorado	4,058	132	98	27	143,870	37,594	15,747
Idaho	1,284	141	117	57	178,950	54,911	27,729
Montana	900	98	74	19	105,797	28,225	9,881
Nevada	1,963	204	96	37	327,552	50,102	61,676
New Mexico	1,614	216	141	130	285,846	103,536	139,980
Oregon	2,970	177	129	18	210,371	55,413	13,014
Utah	2,020	133	111	18	182,258	49,298	10,247
Washington	5,311	70	54	17	88,236	23,315	12,602
Wyoming	457	117	79	34	136,364	25,884	11,244

ALTERNATIVE 5							
State	Total # of block group in each state	Total # of block groups in Alternative 5	# of low - income block groups	# of minority block groups	Total block group population in Alternative 5	Low-income block group population in Alternative 5	Minority block group population in Alternative 5
Arizona	4,773	254	165	63	374,487	96,012	76,005
California	25,607	139	89	27	173,328	47,998	28,192
Colorado	4,058	125	91	23	136,790	34,365	13,301
Idaho	1,284	140	116	57	177,605	54,105	27,729
Montana	900	79	61	16	85,393	23,986	8,156
Nevada	1,963	195	91	35	315,411	47,518	60,048
New Mexico	1,614	201	131	124	272,080	97,868	134,999
Oregon	2,970	170	123	18	203,060	53,364	13,014
Utah	2,020	125	104	17	173,954	46,703	10,089
Washington	5,311	67	52	17	85,420	22,624	12,602
Wyoming	457	111	74	34	131,902	24,734	11,244

NO-ACTION ALTERNATIVE							
State	Total # of block group in each state	Total # of block groups in Variance No-Action	# of low - income block groups	# of minority block groups	Total block group population in Variance No-Action	Low-income block group population in Variance No-Action	Minority block group population in Variance No-Action
Arizona	4,773	317	207	83	445,049	119,161	100,012
California	25,607	545	323	84	733,178	162,185	103,248
Colorado	4,058	223	154	37	252,488	57,762	22,337
Idaho	1,284	245	199	67	297,858	88,843	33,761
Montana	900	148	108	23	162,386	40,253	12,105
Nevada	1,963	234	109	45	381,100	57,169	68,577
New Mexico	1,614	259	167	153	338,380	120,058	165,572
Oregon	2,970	360	265	32	425,608	108,423	18,844
Utah	2,020	179	138	22	266,876	62,435	13,615
Washington	5,311	182	149	43	220,021	60,757	30,432
Wyoming	457	130	87	39	155,262	29,741	12,741

An additional data set can be found at https://blmsolar.anl.gov/documents/2023peis/ej-table.pdf. It is derived from the U.S. Census, American Community Survey, using "Places" as the geographic scale to identify minority, low-income, and Tribal populations with potential environmental justice concerns. The data tables are provided as an additional resource to supplement local, project-level data collection and analysis by listing population centers (e.g., cities, towns) in the 11-state planning area that were identified as having minority, low-income, and/or Tribal communities that met or exceeded minority and/or low-income population thresholds. Note that rural communities with small populations may be missed using this scale of analysis; this data is meant as a supplement to a more comprehensive approach to identify local populations with potential environmental justice concerns.

F.5.3 Supplemental Material for Impacts Assessment

Table F.5.3-1. Counties (# and %) with Identified Minority and Low-income Populations and Numbers Located Within Each Alternative

Arizona Summary: 15 counties analyzed; 12 counties with identified minority and/or low-income populations of potential concern; 3 counties with no identified minority or low-income populations meeting or exceeding threshold.	**Minority**	**Low-Income**	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**No Action Alt.**
Total number of counties located in each Alternative Action area			14	14	14	14	14	15
Category totals (minority, low-income, Alt. 1,2,3,4,5, and No Action) of counties with identified minority and/or low-income populations	5	11	11	11	11	11	11	12
Percent of counties, in each Alternative, with minority and/or low-income population (with potential environmental justice concern)			78%	78%	78%	78%	78%	80%
California Summary: 58 counties analyzed; 43 counties with identified minority and/or low-income populations of potential concern;15 counties with no identified minority or low-income populations meeting or exceeding threshold.	**Minority**	**Low-Income**	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**No Action Alt.**
Total number of counties located in each Alternative Action area			48	38	37	36	35	53
Category totals (minority, low-income, Alt. 1,2,3,4,5, and No Action) of counties with identified minority and/or low-income populations	29	32	35	27	26	24	24	39
Percent of counties, in each Alternative, with minority and/or low-income population (with potential environmental justice concern)			73%	71%	68%	67%	69%	74%
Colorado summary: 64 analyzed; 47 counties with identified minority and/or low-income populations of potential concern; 17 counties with no identified minority or low-income populations meeting or exceeding thresholds.	**Minority**	**Low-Income**	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**No Action Alt.**
Total number of counties located in each Alternative Action area			52	46	42	42	38	54
Category totals (minority, low-income, Alt. 1,2,3,4,5, and No Action) of counties with identified minority and/or low-income populations	17	43	39	38	34	35	31	40
Percent of counties, in each Alternative, with minority and/or low-income population (with potential environmental justice concern)			75%	83%	81%	83%	82%	74%

Table F.5.3-1. Counties (# and %) with Identified Minority and Low-income Populations and Numbers Located Within Each Alternative *(Cont.)*

Idaho summary: 44 counties analyzed; 36 counties with identified minority and/or low-income populations of potential concern; 8 counties with no identified minority or low-income populations meeting or exceeding thresholds.	**Minority**	**Low-Income**	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**No Action Alt.**
Total number of counties located in each Alternative Action area			43	36	36	36	36	43
Category totals (minority, low-income, Alt. 1,2,3,4,5, and No Action) of counties with identified minority and/or low-income populations	15	21	36	31	31	31	31	36
Percent of counties, in each Alternative, with minority and/or low-income population (with potential environmental justice concern)			84%	86%	86%	86%	86%	84%

Montana summary: 56 counties analyzed; 37 counties with identified minority and/or low-income populations of potential concern; 19 counties with no identified minority or low-income populations meeting or exceeding thresholds (illustrated in gray font above).	**Minority**	**Low-Income**	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**No Action Alt.**
Total number of counties located in each Alternative Action area	**11**	**26**	**52**	**49**	**42**	**49**	**41**	**54**
Category totals (minority, low-income, Alt. 1,2,3,4,5, and No Action) of counties with identified minority and/or low-income populations			34	31	28	31	27	36
Percent of counties, in each Alternative, with minority and/or low-income population (with potential environmental justice concern)			65%	63%	67%	63%	66%	67%

Nevada summary: 17 counties analyzed; 6 counties with identified minority and/or low-income populations of potential concern; 11 counties with no identified minority or low-income populations meeting or exceeding thresholds.	**Minority**	**Low-Income**	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**No Action Alt.**
Total number of counties located in each Alternative Action area	**1**	**6**	**17**	**17**	**17**	**17**	**17**	**17**
Category totals (minority, low-income, Alt. 1,2,3,4,5, and No Action) of counties with identified minority and/or low-income populations			6	6	6	6	6	6
Percent of counties, in each Alternative, with minority and/or low-income population (with potential environmental justice concern)			35%	35%	35%	35%	35%	35%

New Mexico Summary: 33 counties analyzed; 31 counties with identified minority and/or low-income populations of potential concern;2 counties with no identified minority or low-income populations meeting or exceeding thresholds.	**Minority**	**Low-Income**	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**No Action Alt.**
Total number of counties located in each Alternative Action area	**28**	**25**	**31**	**31**	**29**	**27**	**22**	**32**
Category totals (minority, low-income, Alt. 1,2,3,4,5, and No Action) of counties with identified minority and/or low-income populations			30	30	28	26	22	31
Percent of counties, in each Alternative, with minority and/or low-income population (with potential environmental justice concern)			97%	97%	97%	96%	100%	97%

Table F.5.3-1. Counties (# and %) with Identified Minority and Low-income Populations and Numbers Located Within Each Alternative *(Cont.)*

Oregon Summary: 36 counties analyzed; 31 counties with identified minority and/or low-income populations of potential concern; 5 counties with no identified minority or low-income populations meeting or exceeding thresholds (illustrated in gray font above).	**Minority**	**Low-Income**	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**No Action Alt.**
Total number of counties located in each Alternative Action area	**8**	**28**	**36**	**32**	**32**	**31**	**29**	**36**
Category totals (minority, low-income, Alt. 1,2,3,4,5, and No Action) of counties with identified minority and/or low-income populations			31	27	27	26	24	31
Percent of counties, in each Alternative, with minority and/or low-income population (with potential environmental justice concern)			86%	84%	84%	84%	83%	86%
Utah Summary: 29 counties analyzed; 22 counties with identified minority and/or low-income populations of potential concern; 7 counties with no identified minority or low-income populations meeting or exceeding thresholds.	**Minority**	**Low-Income**	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**No Action Alt.**
Total number of counties located in each Alternative Action area	**2**	**21**	**29**	**23**	**22**	**22**	**21**	**29**
Category totals (minority, low-income, Alt. 1,2,3,4,5, and No Action) of counties with identified minority and/or low-income populations			22	19	19	19	18	22
Percent of counties, in each Alternative, with minority and/or low-income population (with potential environmental justice concern)			76%	83%	86%	86%	86%	76%
Washington summary: 39 counties analyzed; 32 counties with identified minority and/or low-income populations of potential concern; 7 counties with no identified minority or low-income populations meeting or exceeding.	**Minority**	**Low-Income**	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**No Action Alt.**
Total number of counties located in each Alternative Action area	6	31	32	22	21	22	21	37
Category totals (minority, low-income, Alt. 1,2,3,4,5, and No Action) of counties with identified minority and/or low-income populations			22	19	19	19	18	22
Percent of counties, in each Alternative, with minority and/or low-income population (with potential environmental justice concern)			67%	86%	90%	86%	86%	59%
Wyoming summary: 23 counties analyzed; 13 counties with identified minority and/or low-income populations of potential concern; 10 counties with no identified minority or low-income populations meeting or exceeding thresholds (illustrated in gray font above).	**Minority**	**Low-Income**	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**No Action Alt.**
Total number of counties located in each Alternative Action area			**23**	**23**	**23**	**23**	**23**	**23**
Category totals of counties with identified minority and/or low-income populations	5	10	13	13	13	13	13	13
Percent of counties, in each Alternative, with minority and/or low-income population (with potential environmental justice concern)			57%	57%	57%	57%	57%	57%

F.6 Geology and Soil Resources

F.6.1 Methods Used for Evaluation

The geologic setting and soil resources description was based on a review of aerial maps, topographic maps, geologic maps, and the scientific literature. The affected environment description focused mainly on surface features (e.g., terrain, water bodies, land forms, and geologic materials) with some attention to the underlying structural aspects (e.g., horsts and grabens). Detailed geologic history and descriptions of stratigraphic units with depth were not considered, to limit the discussion to the geologic context most relevant to the development of a solar project on the ground surface. Geologic map data was obtained from the U.S. Geological Survey (USGS).

The geologic hazards assessment considered the types of geologic hazards relevant to the affected area including seismic, volcanic, soil settlement and subsidence, slope instability, and flooding. Findings published in academic and professional articles and reports as well as federal and state sources were considered. Figures showing Quaternary faults, peak ground accelerations, volcano hazard areas, and landslide hazard areas were prepared using recent information (e.g., the latest seismic hazard estimates).

Soil conditions were characterized using data from the U.S. Department of Agriculture's National Resources Conservation Service (NRCS). Information such as soil texture and composition, parent material, land forms on which the soils developed, drainage class, soil permeability, surface runoff potential, soil hydric rating, compaction, fugitive dust, rutting potential, soil erosion factors, land classification, or primary land use data were considered to gain a general understanding of a soil's susceptibility to impacts as a result of ground-disturbing activities. Descriptions of soil resources included discussion of soils designated as prime farmland and soils of statewide importance.

The impact assessment for soil resources relied on academic and professional literature reviews to characterize soil conditions. The main elements in assessing relative impacts on soil resources are the geographic location and temporal/spatial extent of ground-disturbing activities, including vegetation clearing and grubbing, excavation and backfilling, construction of project structures and ancillary facilities, trenching, drilling, stockpiling of soils, construction of road beds, drainage and wetland crossings, heavy truck and equipment traffic, and increased foot traffic.

F.6.2 Supplemental Material for Affected Environment

F.6.2.1 Geology

The 11-state planning area physiographic provinces are shown in Figure F.6.2-1. The characteristics of these physiographic provinces are summarized in Table F.6.2-1.

The occurrence of Quaternary faults in the 11-state planning area is shown in Figure F.6.2-2. The peak horizontal acceleration as a percentage of gravitational acceleration (g) is shown in Figure F.6.2-3 for the 11-state planning area. The acceleration shown has a 10% probability of being exceeded over a 50-year period.

Table F.6.2-2 provides a scale that relates peak horizontal acceleration to perceived shaking and potential damage to structures on the ground.

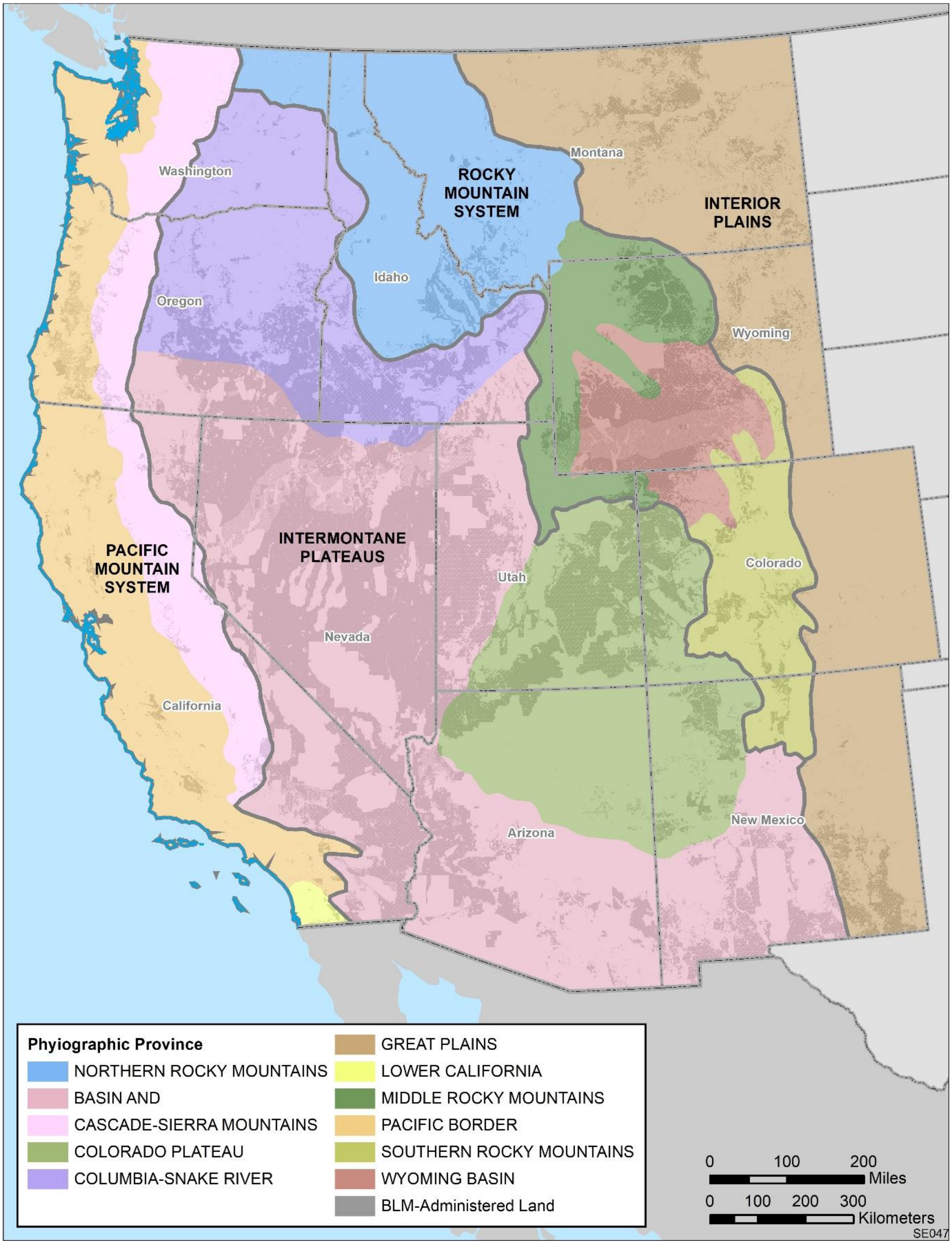


Figure F.6.2-1. Physiographic Provinces of the 11-state Planning Area (Sources: Modified from USGS 2004; National Map 2023.)

Table F.6.2-1. Physiographic Provinces in the 11-State Planning Area

Physiographic Province	Section	Geographic Location	General Terrain	Rock Types
Pacific Border	Olympic Mountains	Northwestern Washington, between the coast and the Cascade Mountains	High ridges with bluffs at the coast and long beaches. Historic large subduction zone earthquakes.	Mountains of folded and faulted sediments and volcanic rock scraped off the Juan de Fuca plate as it subducted beneath North America. Metamorphic rocks are common in the inner peninsula core.
	Oregon Coast Ranges	Oregon and Washington, running parallel to the coast	High ridges with bluffs at the coast	Mountains of folded and faulted sediments and volcanic rock
	California Coast Ranges	California, running parallel to the coast	A series of ridges and valleys with a northwest trend. One of the main faults controlling the Coast Ranges is the San Andreas Fault. Elevations range from sea level to more than 11,483 ft (3,500 m). Earth flows and complex landslides are active in mountainous areas.	Folded and faulted formations of sedimentary, igneous, and metamorphic bedrock are common
	Transverse Ranges	California, between the Coast Ranges to the north and the Lower California Province to the south	Consists of ranges and basins trending nearly east and transverse to the southeasterly trend of adjoining areas (e.g., the Sierra Nevada, the Great Valley, and the Coast Ranges at the north, and the Lower California province at the south). Highest ranges reach elevations greater than 10,000 ft (3,048 m).	Mountains consist of marine formations; those to the east consist mostly of older rocks, including granite, and metamorphosed sedimentary and volcanic rocks. Basins are filled with thick terrestrial deposits buried under marine fill.
	Klamath Mountains	Situated between the Coast Ranges of California and Oregon	Similar rock structures as the Sierra Nevada (see below).	Deformed and metamorphosed sediments intruded by granite.
	Great Valley of California	Situated between the Sierra Nevada and the Coast Ranges (and south of the Klamath Mountains) in central California	A flat geological trough with elevations ranging from below sea level to more than 1,000 ft (305 m). Alluvial fans slope westward along the foot of the Sierra.	Thick sequence of sedimentary deposits derived from erosion of the Sierra Nevada
Lower California		Situated between the Salton Trough and the coast on the northern end of Baja California	The province is a westward-dipping plateau. Elevations range from 11,000 ft (3,353 m) at San Jacinto Peak on the north end to below sea level at the Salton Sea trough. Terraces along the coast are as high as 1,300 ft (396 m) above sea level.	Granitic batholith forms the plateau

Table F.6.2-1. Physiographic Provinces in the 11-State Planning Area *(Cont.)*

Physiographic Province	Section	Geographic Location	General Terrain	Rock Types
Cascade-Sierra Mountains	Cascade Mountains	Washington, Oregon, and northern California	Best known for their high, snow-capped volcanoes. The mountains are part of the circum-Pacific volcanic belt characterized by younger, active volcanoes (such as Mount St. Helens, Mount Rainer, and Glacier Peak). Overlooks the Columbia-Snake River Plateau.	Volcanic, sedimentary, and metamorphic rocks
	Sierra Nevada Mountains	Eastern California, east of California's Great Central Valley	Uplifted by faulting along the east, tilting westward exposing granitic and metamorphosed sedimentary formations. About 350 mi (563 km) long and 60 mi (97 km) wide with a maximum elevation of about 9,000 ft (2,743 m) along the east fault scarp and overall maximum elevation of 14,505 ft (4,421 m) at Mount Whitney. Lava flows.	Primarily granitic rocks with some older metamorphic rock; volcanic rocks along the eastern scarp
Basin and Range		South of the Columbia Plateau, extending from southern Idaho and Oregon through most of Nevada and parts of western Utah, eastern California, western and southern Arizona, and southwestern New Mexico	Consists of more than 400 evenly spaced, nearly parallel block-faulted mountain ranges and intervening basins. Jagged crests are generally abrupt, steeply sloping, and deeply dissected with elevations from 3,000 to 5,000 ft (914 to 1,524 m) above the intermountain basins. Basins are typically broad, gently sloping, and largely undissected with elevations ranging from below sea level to about 5,000 ft (1,524 m). Basins in the north are internally drained.	Mountain ranges composed of complexly deformed Precambrian and Paleozoic rocks. Mesozoic granitic rocks are found in the western province. Cenozoicvolcanic rocks are widespread. Intermontane basins filled with Tertiary rocks overlain by Quaternary sediments (e.g., alluvium, dune sand, and playa deposits).
Columbia-Snake River Plateau	Columbia Plateau	Southeastern Washington, northeastern Oregon	A flat and geomorphically featureless area surrounded by mountains and highlands	The western part of the plateau, which is a basin filled with sedimentary deposits over a thick slab of basalt
	Snake River Plain	Southeastern Oregon, southern Idaho, extending into northern Nevada	A flat and geomorphically featureless area surrounded by mountains and highlands	The south-eastern part of the plateau and characterized by rhyolitic volcanic rocks covered by basaltic lava

Table F.6.2-1. Physiographic Provinces in the 11-State Planning Area *(Cont.)*

Physiographic Province	Section	Geographic Location	General Terrain	Rock Types
Colorado Plateau		At the intersection of Colorado, Utah, Arizona, and New Mexico, covering 130,000 mi^2 (336,698 km^2) between the Rocky Mountain and Basin and Range provinces	The plateau is an uplifted surface greater than 5,000 ft (1,524 m) in elevation, with peaks reaching to 11,000 ft (3,353 m). Extensive areas of horizontal sedimentary formations with structural upwarps and igneous structures (e.g., volcanoes, cinder cones and volcanic necks, lava-capped plateaus and mesas, and dome mountains caused by intrusion of stocks and laccoliths).	Mostly sedimentary rocks. Volcanic rocks and volcanic plugs are common in some areas
Northern, Middle, and Southern Rockies		Northeastern Washington, western Montana, northwestern Wyoming, Colorado, and northwestern New Mexico	Before the Laramide mountain-building period, the Northern, Middle and Southern Rockies were part of a stable platform composed of Precambrian crystalline rocks. The platform received sediments that were transformed into sedimentary rocks, which were then uplifted and eroded during the mountain-building period. Later, volcanic activities produced mountains and high plateaus in many places. Separated from the Middle Rockies by the Wyoming Basin in Wyoming, the Southern Rockies have summits between 10,827 and 14,436 ft (3,300 and 4,400 m).	Sedimentary, metamorphic, and volcanic rocks
Wyoming Basin		Located in northwestern Colorado and southwestern Wyoming, the basin provides a connection between the Colorado Plateau and the Great Plains (through a “break” in the Rocky Mountain range)	Consists of elevated semiarid basins and isolated low mountains with elevations ranging from 6,000 to 8,000 ft (1,829 to 2,438 m). Basins have a bowl-like structure with sedimentary deposits resting unconformably on older sedimentary formations. Cuestas and hogbacks formed around the rims of basins create topographic relief in those areas.	Sedimentary formations, with volcanic and intrusive rocks
Great Plains		Located east of the Rocky Mountains and the Basin and Range province in the eastern parts of Montana, Wyoming, Colorado, and New Mexico	A large region of generally low relief, sloping eastward from about 5,500 ft (1,676 m) at the foot of the Rocky Mountains to about 2,000 ft (610 m) at the eastern boundary of the province	Marine sediments covered with more recent sedimentary deposits derived from the Rocky Mountains

Sources: Rau (1973); Burchfiel et al. (1992); Dohrenwend (1987); Madole et al. (1987); DOGAMI (2023); Wayne et al. (1991).

Figure F.6.2-2. Quaternary Faults in the 11-state Planning Area (Source: USGS 2020.)

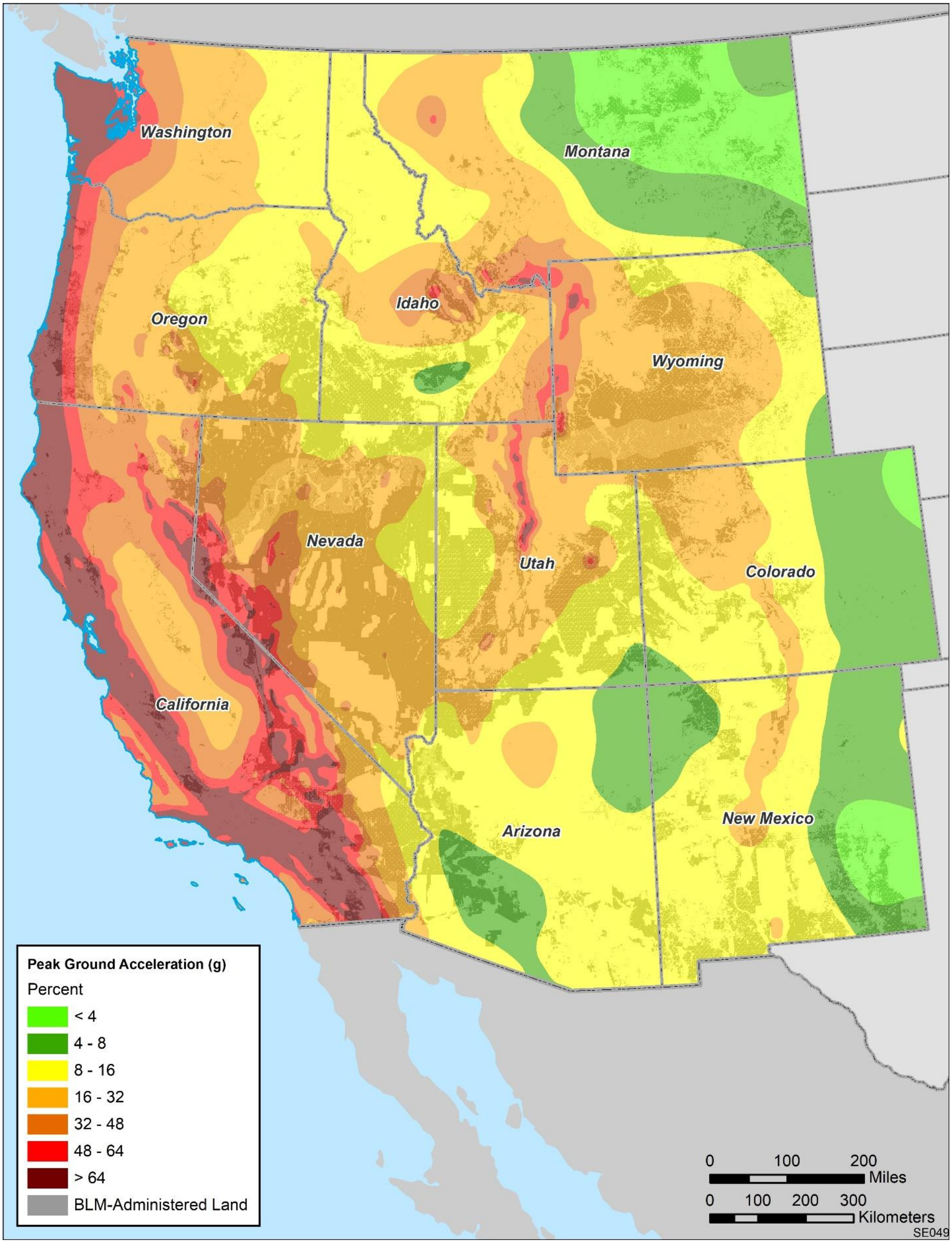


Figure F.6.2-3. Peak Horizontal Ground Acceleration Within the 11-tate Planning Area with a 10% Probability of Exceedance in 50 Years (Source: USGS 2018.)

Table F.6.2-2. Relationship Between Peak Horizontal Acceleration, Perceived Shaking, and Potential Structural Damage

Peak Horizontal Acceleration (%g)	Perceived Shaking	Potential Damage
<0.17	Not felt	None
0.17 to 1.4	Weak	None
1.4 to 3.9	Light	None
3.9 to 9.2	Moderate	Very light
9.2 to 18	Strong	Light
18 to 34	Very strong	Moderate
34 to 65	Severe	Moderate to heavy
65 to 124	Violent	Heavy
>124	Extreme	Very heavy

Source: Wald (2000).

Major volcanoes or volcanic fields in the 11-state planning area are shown in Figure F.6.2-4. Landslide-prone areas are shown in Figure F.6.2-5. Table F.6.2-3 shows reported land subsidence due to groundwater withdrawals for the 11-state planning area.

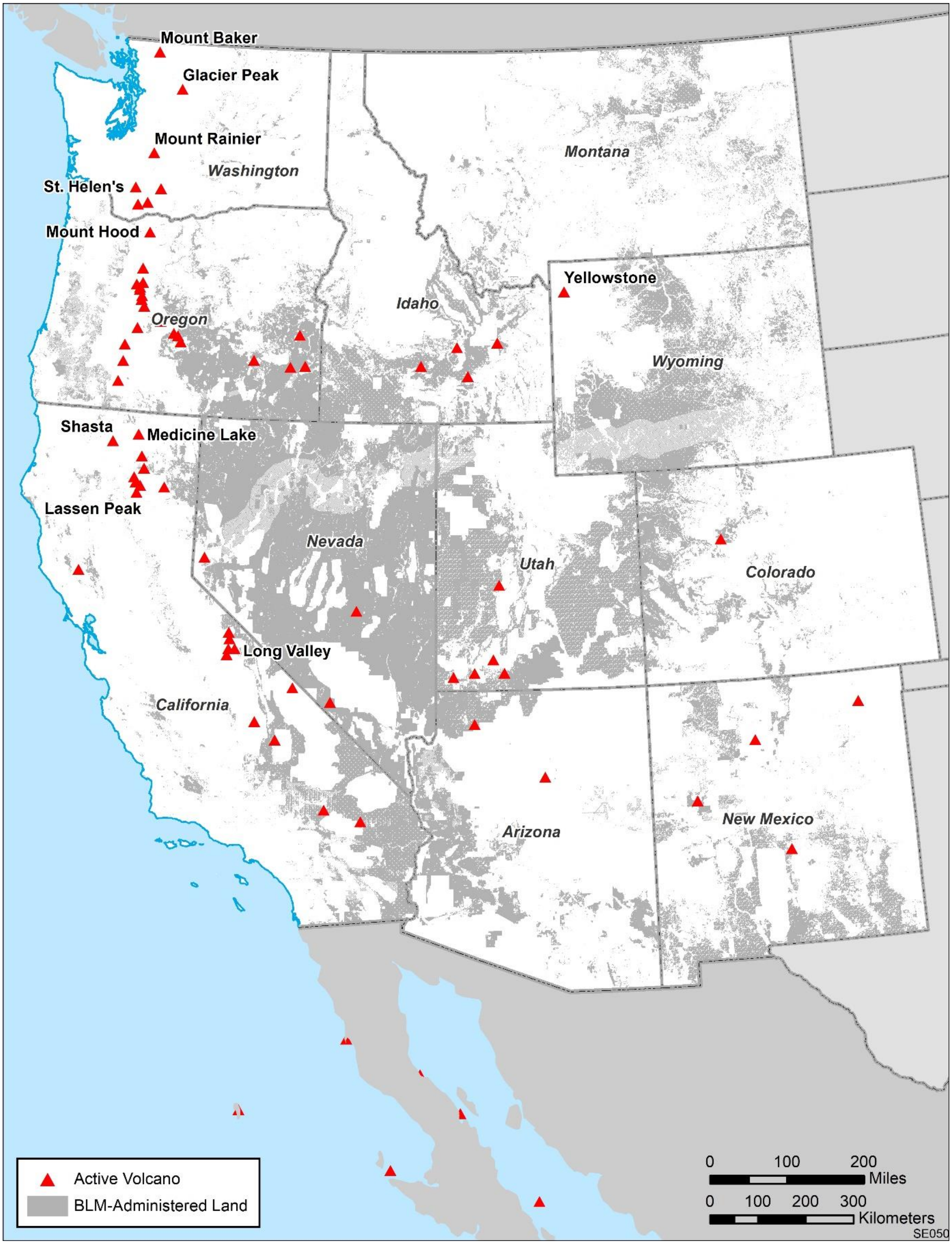


Figure F.6.2-4. Active Volcanoes and Areas of Unrest Potentially Affecting the 11-state Planning Area (Source: USGS 2023.)

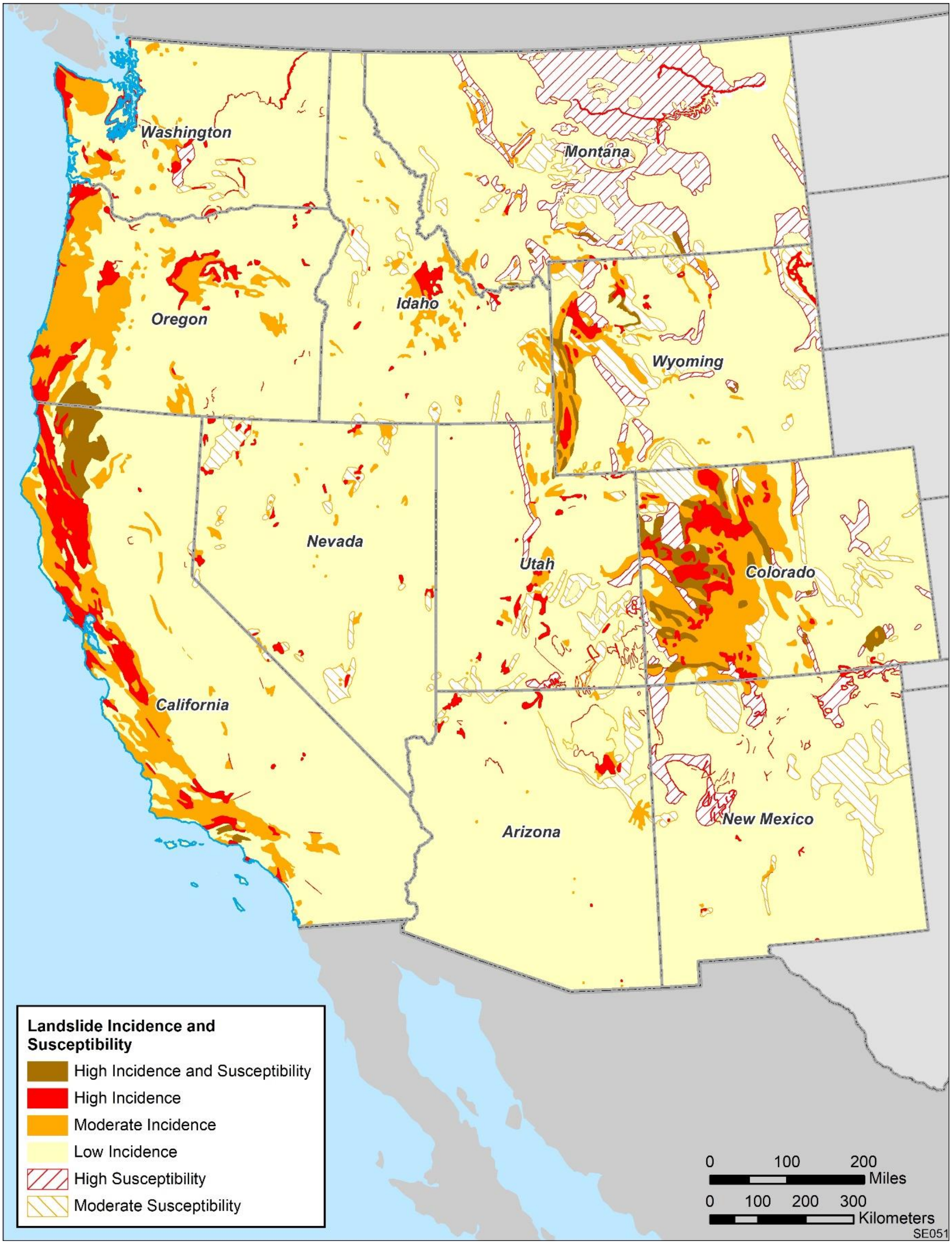


Figure F.6.2-5. Landslide Hazard Potential Map of the 11-state Planning Area (Source: USGS 1997.)

Table F.6.2-3. Areas of Subsidence in the Western United States Due to Groundwater Withdrawal

State	Area of Subsidence
California	• Antelope Valley • Coachella Valley • Elsinore Valley • La Verne area • Lucerne Valley • Mojave River Basin • Oxnard Plain • Pomona Basin • Sacramento Valley • Salinas Valley • San Benito Valley • San Bernardino area • San Gabriel Valley • San Jacinto Valley • San Luis Obispo area • Santa Clara Valley • Temecula Valley • Wolf Valley
Nevada	• Las Vegas Valley
Idaho	• Raft River Area
Arizona	• Avra Valley • East Salt River Valley • Eloy Basin • Gila Bend area • Harquahala Plain • San Simon Valley • Stanfield Basin • Tucson Basin • West Salt River Valley • Wilcox Basin
Colorado	• Denver Area
New Mexico	• Albuquerque Basin • Mimbres Basin

Source: Galloway et al. (1999).

F.6.2.2 Soil Resources

Table F.6.2-4 describes the nine soil orders within the planning area, their distribution, and general characteristics in order of decreasing predominance. A map of the dominant soil orders within the planning area is provided in Figure F.6.2-6.

The susceptibility of surface soils in the 11-state planning area to erosion by water and by wind are shown in Figure F.6.2-7. Larger numbers indicate soils that are more susceptible to erosion.

Figure F.6.2-8 displays a map of the farmland classification for the 11-state planning area.

Table F.6.2-4. Soil Orders in the 11-state Planning Area, in Order of Decreasing Predominance

Soil Order	Principal Geographic Extent	Characteristics
Mollisols	Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming	Commonly occur between aridisols of very dry areas and soils of more humid environments. Thick, dark-colored, organic-rich, highly fertile, mineral soils. Typically develop under grasslands, although some have formed under a forest ecosystem, in subhumid to subarid climates having a moderate to pronounced seasonal moisture deficit. Support cropland and pasture or rangeland.
Entisols	Arizona, California, Colorado, Montana, Nevada, New Mexico, Utah, and Wyoming	Common in lower elevation arid and semiarid environments. Characterized by minimal degree of soil development. Include recent alluvium, sands, soils on steep slopes, and shallow soils. Also formed in recently deposited sediments on floodplains, dunes, fans, and deltas along rivers and small streams. Support wildlife habitat and pasture or rangeland, but can support trees in areas of high precipitation.
Aridisols	Arizona, southern California, Colorado, Idaho, Nevada, New Mexico, Utah, central Washington, and Wyoming	Occur in desert environments where evaporation greatly exceeds precipitation. Light in color, low in organic material, and commonly with a thin surface physical or biological crust. Subsurface accumulations of salts and other soluble materials result in hardpans that impede water infiltration. Support desert rangeland; generally, not productive without irrigation.
Inceptisols	Arizona, northern California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming	Occur in a wide range of climates, from semiarid to humid, but are excluded from most deserts. Generally young mineral soils showing only moderate degrees of soil development and weathering (more than entisols). Develop where the native vegetation is grass, but some support trees. Can support pasture or cropland, rangeland, forest, or wildlife habitat.
Alfisols	Arizona, California, Colorado, Idaho, Montana, New Mexico, Oregon, Utah, Washington, and Wyoming	Occur primarily in moderately dry soil moisture regimes and in cold soil temperature regimes. Characterized by subsurface clay accumulations leached from surface layer and nutrient-rich subsoils. Formed under primarily forest vegetation. Can support cropland and commercial timberland.
Andisols	Limited areas in northern California, northern Idaho, western Montana, Oregon, and Washington	Occur primarily in cool areas with moderate to high precipitation. Mostly formed from weathering of volcanic ejecta (e.g., ash, lava) that results in minerals with little orderly crystalline structure. Generally considered highly productive soils.
Vertisols	Scattered in Arizona, California, Idaho, Montana, New Mexico, and Oregon	Occur in a range of environments but require a climate in which seasonal drying occurs. High content of expanding clay that swells when wet and exhibits deep, wide cracks when dry. Low water transmission results in little leaching and poor drainage when wet. Support natural vegetation that is predominantly forest, grass, or savannah. High in natural fertility.
Ultisols	Scattered in northern California and in the western valleys of Oregon and Washington	Occur in humid environments. Strongly acidic mineral soils, low in nutrients. Show intensive leaching of clay minerals and other constituents, resulting in a clay-enriched subsoil dominated by quartz, kaolinite, and iron oxides. Formed under forest vegetation.
Spodosols	Cascade Mountains region of Oregon and Washington	Form under coniferous forest vegetation from sandy or loamy materials. Organic acids from decaying leaf litter form (iron and aluminum) complexes that accumulate in the subsoil as a reddish or brownish horizon. Highly acidic soils with low fertility.

Sources: NRCS (2015, 2023).

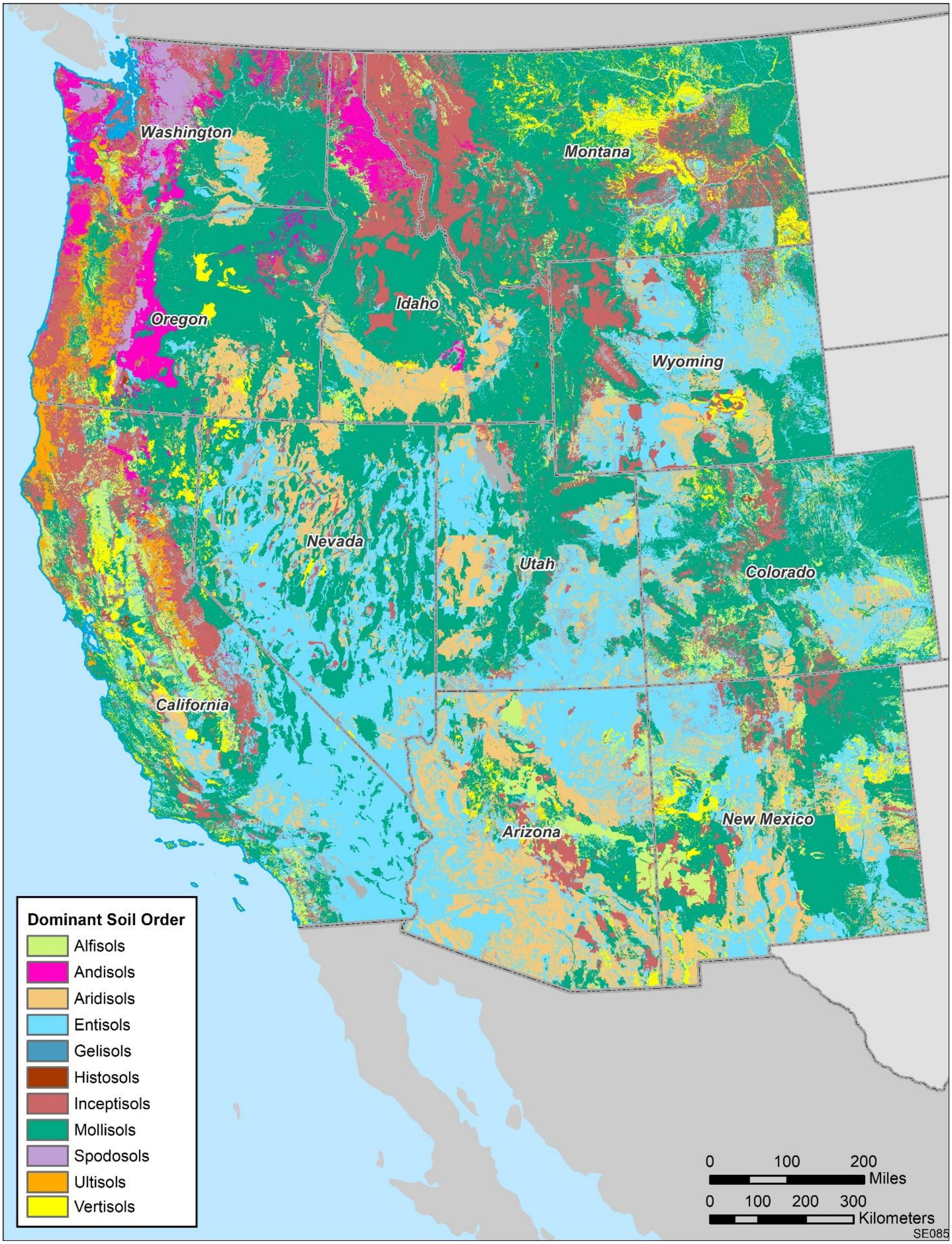


Figure F.6.2-6. Dominant Soil Orders of the 11-state Planning Area (Source: USDA 2021.)

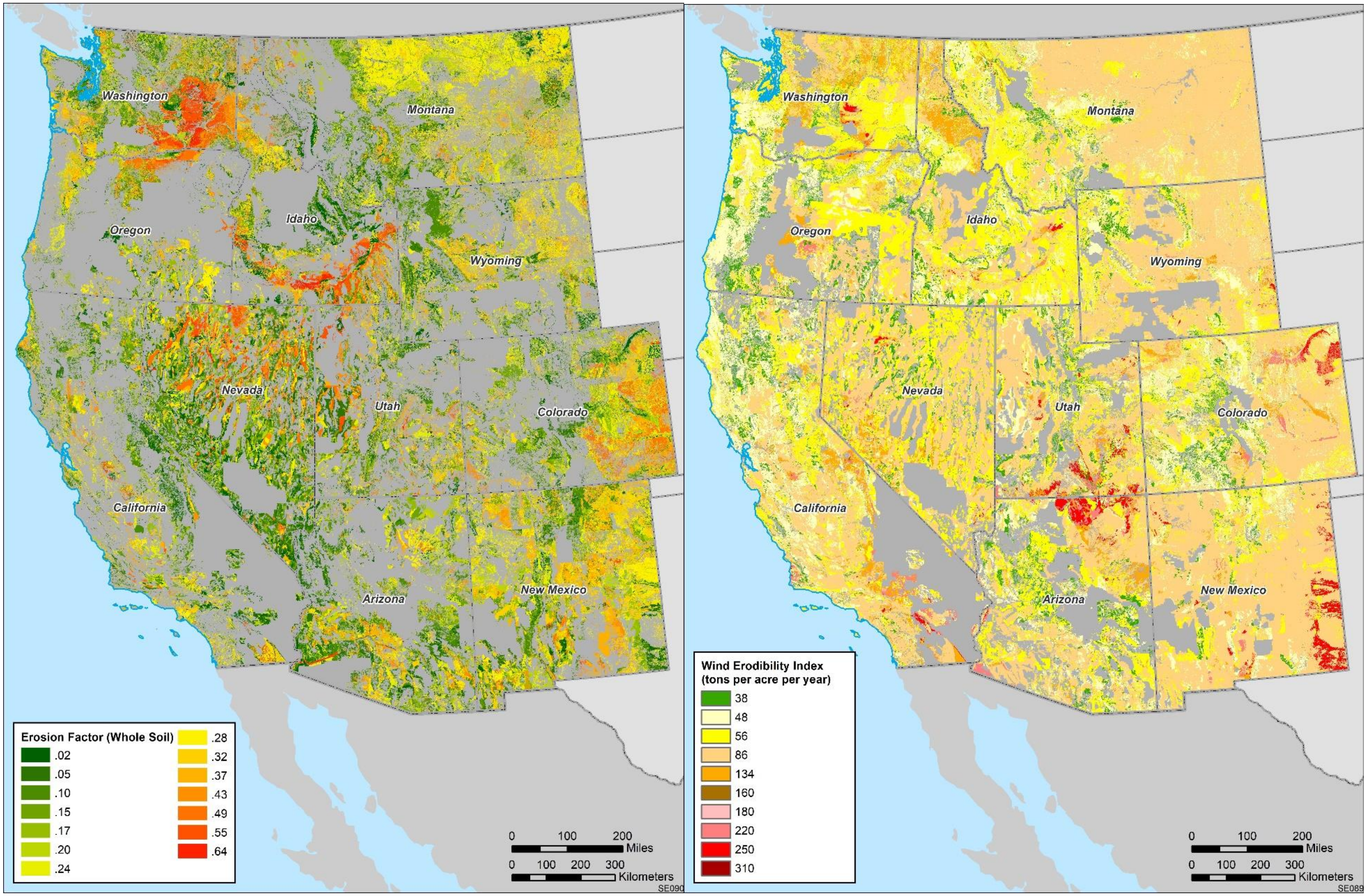


Figure F.6.2-7. Erodibility of Surface Soils by Water *(left)* and Wind *(right)* in the 11-state Planning Area (Source: USDA 2021)

Figure F.6.2-8. Farmland Classification for Soils in the 11-state Planning Area (Source: USDA 2021)

F.6.3 Supplemental Material for Impacts Assessment

There are no supplemental materials for the geology and soil resources impacts assessment (Section 5.6).

F.7 Hazardous Materials and Waste

F.7.1 Methods Used for Evaluation

The information presented in the Affected Environment and Impacts sections were derived from scientific literature, official publications, and the opinions of subject matter experts.

F.7.2 Supplemental Material for Affected Environment

Table F.7.2-1. Hazardous Materials Used During Construction of PV Solar Energy Facilities

Material	Purpose	Remarks
Compressed gases: oxygen, acetylene, and nitrogen	Welding, cutting, brazing, and purging	• Expected to be removed after completion of the construction phase.
Vehicle and equipment fuels: diesel, gasoline, kerosene, and propane	Fuel for off-road construction vehicles and various construction equipment	• Diesel fuel and gasoline are expected to be stored in manufactured aboveground storage tanks with capacities of 2,000 gal (7,600 L) or less. • Propane stored in aboveground pressure tanks, 2,000 gal (7,600 L) or less. • Removed after completion of the construction phase.
Propane	Comfort heating of temporary buildings and trailers	• Expected to be stored in aboveground pressure tanks of 2,000 gal (7,600 L) or less • Excess removed after completion of the construction phase
Vehicle and equipment fluids, including lubricating oils, hydraulic fluids, brake fluids, glycol-based coolants, battery electrolyte, and dielectric fluids	Maintenance and support of construction vehicles and equipment, including compressors and emergency/ standby generators	• Expected to be present in minimal quantities only sufficient to maintain fluid levels of construction vehicles and equipment, primarily in container sizes of 55 gal (210 L) or less • Excess removed after completion of the construction phase
Solvents, chemical cleaning agents	Cleaning of equipment after assembly, preparation of surfaces for application of paints or other corrosion control coatings	• Expected to be present in minimally necessary quantities only, primarily in container sizes of 55 gal (210 L) or less
Paints, primers, thinners, and corrosion control coatings; sealants and adhesives	Weatherproofing equipment and structures; component assembly	• Expected to be used throughout the construction phase; likely to be present in container sizes of 55 gal (210 L) or less • Components are expected to arrive onsite with final coatings applied; only field dressing after assembly will likely be necessary • Excess hazardous materials removed after completion of the construction phase • Some materials may exhibit hazardous characteristics (e.g., flammability) or contain toxic ingredients (e.g., chromium in certain paints and primers)
Herbicides and Pesticides	Vegetation and insect control	• Expected to be limited to EPA- and state-approved commercial products, present only in minimally necessary quantities • Wholesale applications (e.g., for vegetation control over the active construction zone) may be performed by a contractor, with no pesticides stored onsite • Pesticide use is uncommon, and in some cases prohibited by permitting authorities (Semararo et al. 2018)

Table F.7-2. Hazardous Materials Associated with Operation of PV Solar Energy Facilities

Material	Purpose	Remarks
Compressed gases	Instrument and equipment purge, calibration gases; equipment repair (welding, brazing, and soldering), comfort heating, fire control	• Nitrogen, air, oxygen, and argon for instrument purge and calibration • Acetylene, MAPP gas for welding, heating, cutting, brazing, soldering, etc. • Propane for comfort heating. • CO2 for portable and installed fire extinguishers
Vehicle and equipment fuels: diesel, gasoline, kerosene, and propane	Fuel for emergency generators, emergency fire-water pumps, air compressors, and other equipment containing internal combustion engines, and onsite vehicles	• Fuel is likely to be stored in and dispensed from aboveground tanks with capacities in the range of 500 to 2,000 gal (1,900 to 7,600 L)
Vehicle and equipment fluids, including lubricating oils, hydraulic fluids, brake fluids, glycol-based coolants, and transmission oil	Preventive maintenance of diesel engine(s) on emergency generator(s) and other equipment using internal combustion engines	• Amounts onsite only sufficient to maintain fluid levels and perform preventive maintenance
Battery electrolytes	Contained in vehicle and equipment batteries and in batteries that compose the backup power source for DC loads	• Majority contained in lead-acid batteries that are in service • Only sufficient quantities of electrolyte will be on hand to maintain fluid levels in lead acid storage batteries
Solvents, chemical cleaning agents	Equipment cleaning and maintenance, scale control on heat exchangers and cooling systems.	• Minimal quantities would be present onsite. • Work may be performed periodically by an outside contractor, with no cleaning agents stored onsite
Paints, primers, thinners, and corrosion control coatings	Protection of equipment and structures against corrosion	• Expected to be used throughout the operations phase on an as-needed basis; likely to be present in container sizes of 55 gal (210 L) or less • Some materials may exhibit hazardous characteristics (e.g., flammability) or contain toxic ingredients (e.g., chromium in certain paints and primers)
Pesticides and herbicides, fertilizers	Vegetation and insect control	• Expected to be limited to EPA- and state-approved commercial products, present only in minimally necessary quantities. • Wholesale applications of pesticides (e.g., for vegetation control over the active industrial zone) may be performed by a contractor, with no pesticides stored onsite
Water treatment chemicals	Demineralize water used for panel washing	• Most probably ion-exchange resins.
Dielectric fluids	Electrical insulating fluid for electrical devices such as transformers, switches, capacitors, and bushings	• Large transformers may contain >1,000 gal (>3,800 L) of dielectric fluid. • Depending on power conditioning equipment present and facility power production capacity, >100,000 gal (>380,000 L) of dielectric fluid may be present. • Dielectric fluids will be PCB-free. • Dielectric fluids typically last the life of the electrical device but may need to be replaced if electrical arcing occurs to a significant degree inside the device due to a malfunction or failure.

F.7.3 Supplemental Material for Impacts Assessment

No supplemental material to the hazardous materials and waste impacts assessment (Section 5.7).

F.8 Health and Safety

F.8.1 Methods Used for Evaluation

The information presented in the Affected Environment and Impacts sections was derived from scientific literature, other solar environmental assessments, and BLM manuals and handbooks. The literature reviews focused on the hazards associated with the construction, operation, and decommissioning of utility-scale solar energy facilities, with particular emphasis on projects in the western United States.

F.8.2 Supplemental Material for Affected Environment

No supplemental material for the health and safety affected environment (Section 4.8).

F.8.3 Supplemental Material for Impacts Assessment

No supplemental material for the health and safety impacts assessment (Section 5.8).

F.9 Lands and Realty

F.9.1 Methods Used for Evaluation

The information presented in the Affected Environment and Impacts sections was derived from scientific literature, other solar environmental assessments, BLM manuals and handbooks, and spatial analyses conducted using GIS. The source of information for lands and realty also included BLM's Public Land Statistics (BLM 2023). General information on, and management of, lands and realty included an overview of the acreage of lands administered by BLM in the 11-state planning area.

Potential lands and realty effects may occur from conflicts with existing or authorized land uses or conflicts with applicable land use plans, policies, or regulations. It is not possible to quantitatively analyze impacts on lands and realty in this Solar Programmatic EIS due to the broad scope of the Solar Programmatic EIS and the extent and types of BLM-administered lands that occur within the 11-state planning area. Alternatives with larger land areas open to application may have a greater potential impact compared to those alternatives with smaller areas open to application . Actual impact magnitudes on lands and realty would depend on the location of proposed solar projects, project-specific design, and application of design features and other mitigation measures.

F.9.2 Supplemental Material for Affected Environment

No supplemental material for the lands and realty affected environment (Section 4.9).

F.9.3 Supplemental Material for Impacts Assessment

No supplemental material for the lands and realty impacts assessment (Section 5.9).

F.10 Military and Civilian Aviation

F.10.1 Methods Used for Evaluation

The locations of airfields in relation to potential locations of solar energy facilities were considered in the analysis. Also, the analysis for military aviation focused on military airspace, particularly low-level flight paths, immediately above areas where solar energy facilities and related transmission lines could be located. A qualitative approach was taken to assess aviation impacts from solar energy facilities and associated transmission lines, which primarily considered the location of military flight paths. Potential impacts on military and civilian aviation would occur from air space conflicts and glare.

It is not possible to quantitatively analyze impacts on aviation in this Solar Programmatic EIS due to the broad scope of this report and the numerous airports and military flight paths that could occur within the 11-state planning area. Alternatives with larger areas of intersection with airports and, particularly, military training routes, may have a greater impact compared to those alternatives with smaller intersection areas. Actual impact magnitudes on civilian and military aviation would depend on the location of projects, project-specific design, and application of design features and other mitigation measures.

F.10.2 Supplemental Material for Affected Environment

Figures F.10.2-1 through F.10.2-4 show the locations of special use airspace (SUA) and military training routes (MTRs) with floors under 1,000 ft within the 11 -state planning area.

F.10.3 Supplemental Material for Impacts Assessment

No supplemental material for the military and civilian aviation impacts assessment (Section 5.10).

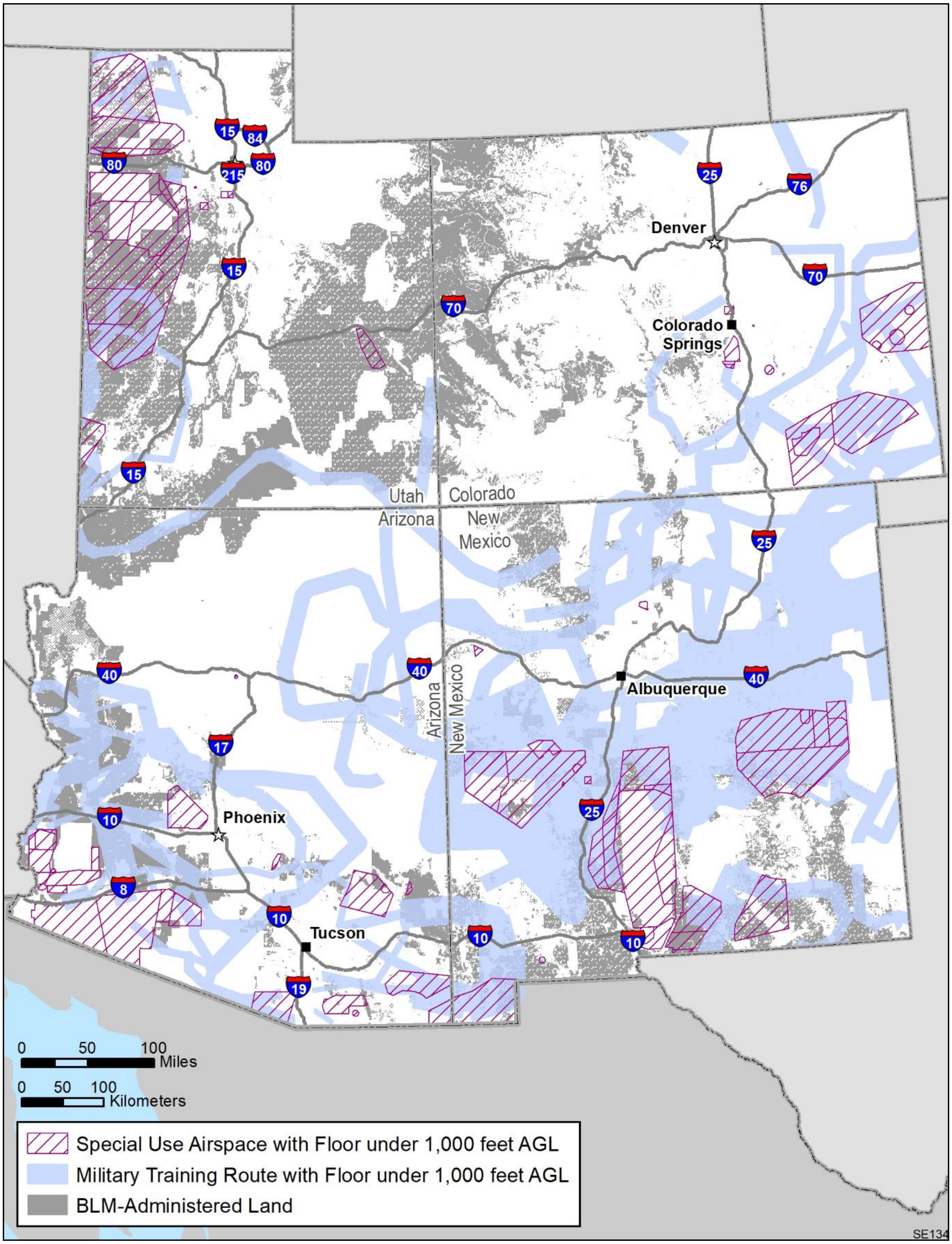


Figure F.10.2-1. Special-use Airspace and Military Training Routes with Floors Under 1,000 Feet: Arizona, Colorado, New Mexico, and Utah

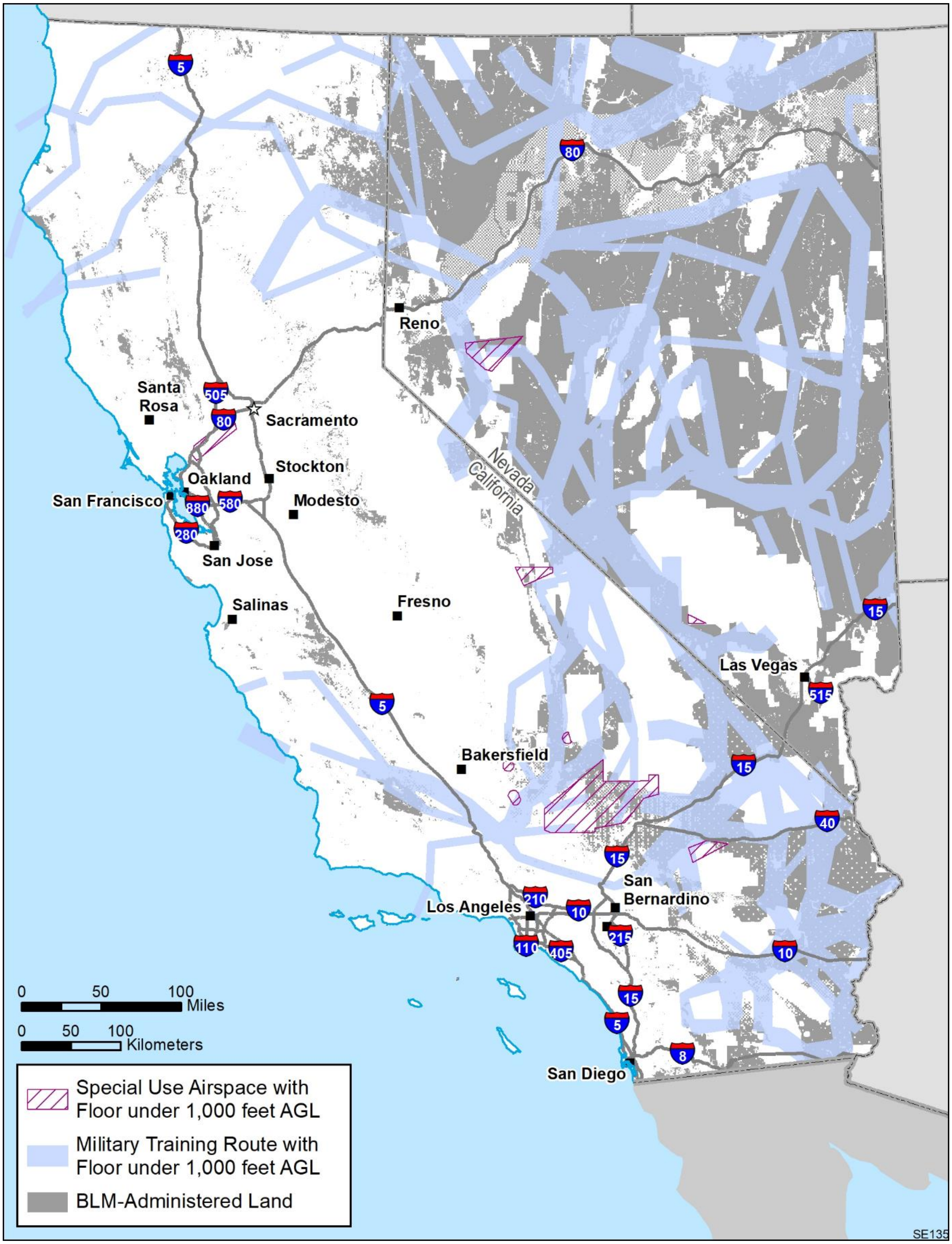


Figure F.10.2-2. Special-use Airspace and Military Training Routes with Floors Under 1,000 Feet: California and Nevada

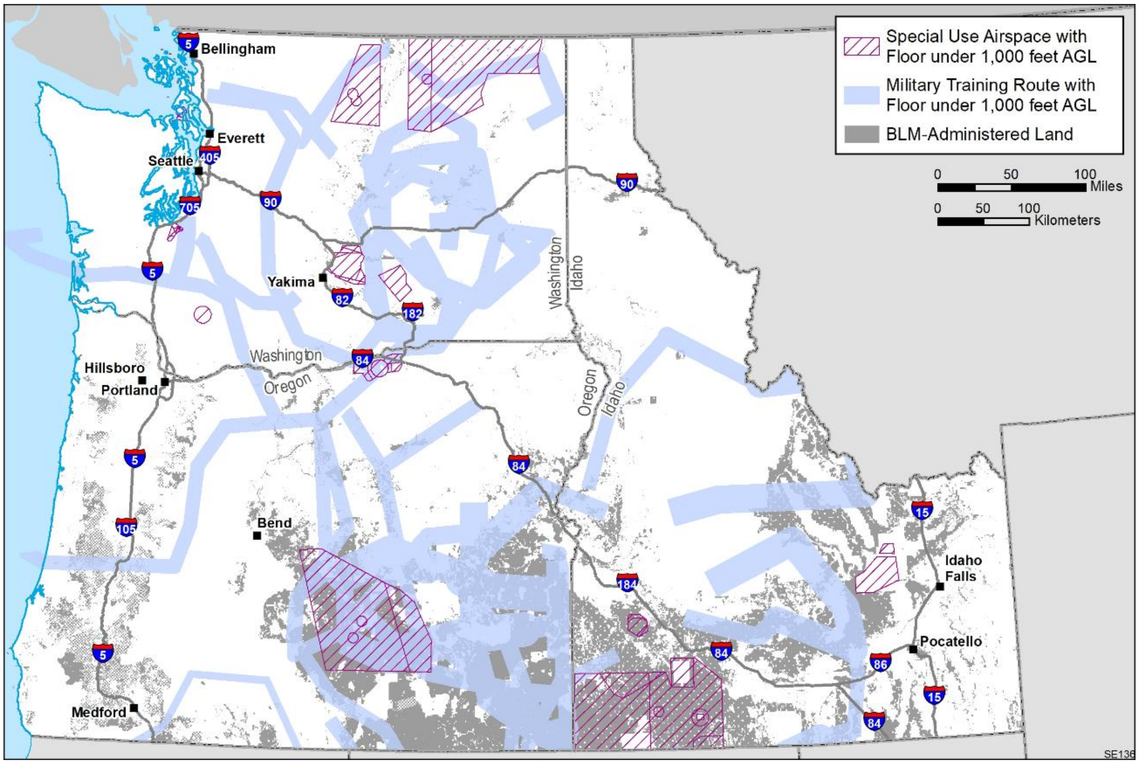


Figure F.10.2-3. Special Use Airspace and Military Training Routes with Floors under 1,000 Feet in Idaho, Oregon, and Washington

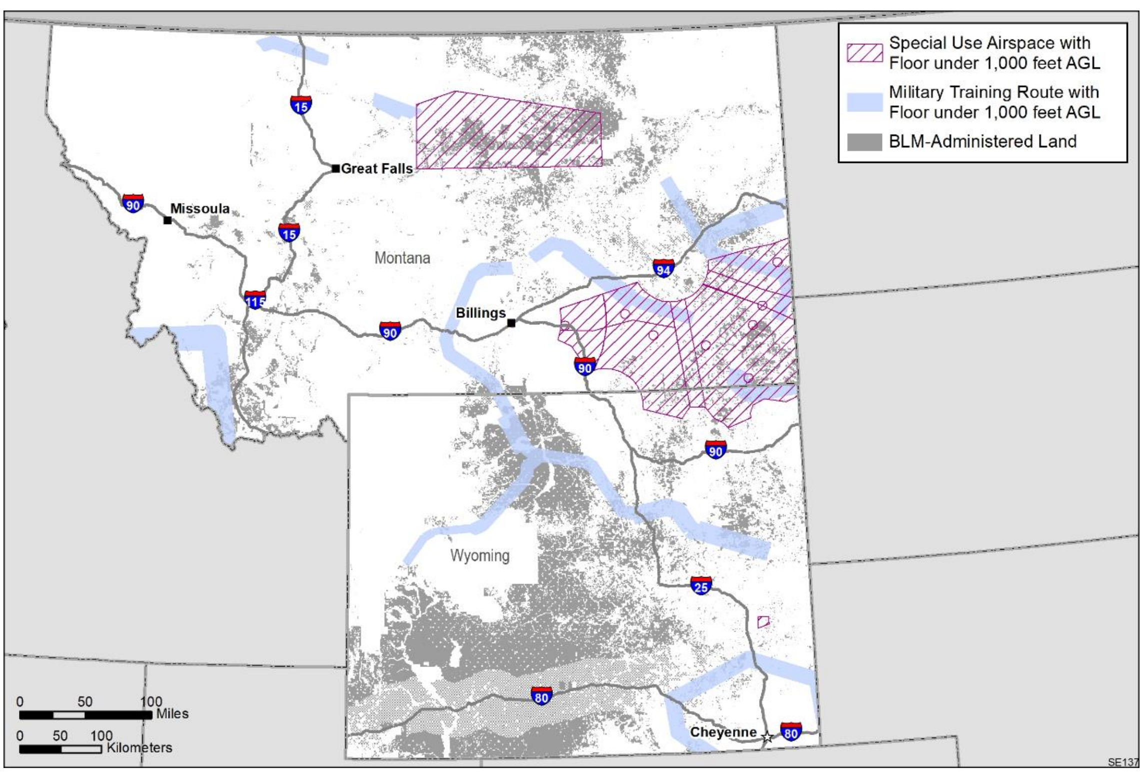


Figure F.10.2-4. Special-use Airspace and Military Training Routes with Floors under 1,000 Feet: Montana and Wyoming

F.11 Minerals

F.11.1 Methods Used for Evaluation

The information presented in the Affected Environment and Impacts sections was derived from scientific literature, other solar environmental assessments, BLM manuals and handbooks, and spatial analyses conducted using GIS. The source of information for minerals included BLM's Public Land Statistics (BLM 2023). Information included a description of mineral types (saleable, leasable, and locatable) and BLM's policies related to minerals.

The primary potential impacts on minerals from solar energy development are those that may reduce the current or future availability of mineral resources. It is not possible to quantitatively analyze impacts on minerals in this Solar Programmatic EIS due to the broad scope of this report and the extent and types of minerals that occur within the 11-state planning area. Alternatives with larger areas of intersection with mineral resources may have a greater impact compared to those alternatives with smaller intersection areas. Actual impact magnitudes on mineral resources would depend on the location of solar projects, project-specific design, and application of design features and other mitigation measures.

F.11.2 Supplemental Material for Affected Environment

Table F.11.2-1 provides the acreage of minerals administered by the BLM. Table F.11.2-2 provides information on oil and gas production; while Table F.11.2-3 provides information on oil and gas activities. Table F.11.2-4 provides information on geothermal leases. Table F.11.2-5 summarizes coal production. Table F.11.2-6 summarizes solid mineral leases. Table F.11.2-7 summarizes saleable mineral production. Table F.11.2-8 summarizes hardrock leases.

Table F.11.2-1. Mineral Acres Administered by BLM[a]

State	Federal Minerals[b]	Federal Surface Lands[c]	Split Estate Federal Minerals[d]
Arizona	33.6	30.6	3.0
California	50.9	48.4	2.5
Colorado	29.4	24.2	5.2
Idaho	37.0	33.6	3.4
Montana	39.5	27.8	11.7
Nevada	60.3	60.0	0.3
New Mexico	35.9	26.4	9.5
Oregon	33.9	32.4	1.5
Utah	36.2	35.0	1.2
Washington	12.9	12.6	0.3
Wyoming	41.4	29.5	11.6
Total:	**411.0**	**360.5**	**50.2**

[a] Millions of acres. Values are rounded, so Federal surface and split estate values do not exactly match the federal minerals total.

[b] Federal minerals refers to onshore federal minerals that are part of BLM's responsibilities, and is the sum of federal surface lands and split-estate federal minerals.

[c] Federal surface lands include both the public domain and acquired lands of all federal agencies. Bureau of Indian Affairs mineral estate is not included in federal surface lands.

[d] The term *split estate federal minerals* refers to federal mineral rights under private surface lands. These are patented lands with minerals reserved to the United States and may be for single, multiple, or all minerals.

Source: BLM (2023).

Table F.11.2-2. Oil and Gas Production in the 11-State Planning Area

State	Oil Production FY 2022 (tbbl)[a]	Gas Production FY 2021 (mcf)[b]
Arizona	6	229
California	122,421	133,136
Colorado	157,532	1,686,523
Idaho	37	1,312
Montana	20,576	37,453
Nevada	229	4
New Mexico	574,327	2,041,715
Oregon	0	320
Utah	46,429	230,767
Washington	0	0
Wyoming	90,939	1,055,521
Total:	**1,012,496**	**5,186,980**

[a] tbbl = thousand barrels. To convert bbl to L, multiply by 159.

[b] mcf = million cubic feet. To convert cf to m^3, multiply by 0.02832.

Sources: EIA (2023a,b).

Table F.11.2-3. Oil and Gas Activities on Public Lands in the 11-State Planning Area, FY 2022

State	Producible Leases	Acres in Producing Status[a]
Arizona	0	0
California	312	78,926
Colorado	2,125	1,452,441
Idaho	2	2,333
Montana	1,350	639,113
Nevada	38	29,122
New Mexico	6,780	3,830,186
Oregon	0	0
Utah	1,433	1,037,975
Washington	0	0
Wyoming	7,326	3,870,736
Total:	**19,366**	**10,940,832**

[a] To convert to hectares, multiply by 0.4.

Source: BLM (2023).

Table F.11.2-4. Geothermal Leases in the 11-State Planning Area, FY 2022

State	Pre-EPAct Competitive Leases[a]		EPAct Competitive Leases[b]		Noncompetitive Leases[c]		Geothermal Private Leases[d]		Total	
	# Leases	Acres[e]	# Leases	Acres[e]	# Leases	Acres[e]	# Leases	Acres[e]	# Leases	Acres[e]
Arizona	0	0	0	0	0	0	0	0	0	0
California	31	42,607	25	28,414	13	10,858	0	0	69	81,879
Colorado	0	0	2	1,204	0	0	0	0	2	1,204
Idaho	0	0	2	2,379	0	0	0	0	2	2,379
Montana	0	0	0	0	0	0	0	0	0	0
Nevada	31	26,558	215	513,519	144	343,837	1	48	391	883,952
New Mexico	1	280	4	11,870	0	0	0	0	5	12,150
Oregon	0	0	0	0	14	10,401	0	0	14	10,401
Utah	6	5,128	25	58,363	20	50,776	0	0	51	114,267
Washington	0	0	0	0	2	7,364	0	0	2	7,364
Wyoming	0	0	0	0	0	0	0	0	0	0
Total:	**69**	**74,573**	**273**	**615,749**	**193**	**423,236**	**1**	**48**	**536**	**1,113,606**

[a] Leases issued under the Geothermal Steam Act.

[b] Leases issued under the Geothermal Steam Act, as amended by the Energy Policy Act of 2005.

[c] Includes direct use leasing and lands offered for competitive leases that received no bids.

[d] An existing geothermal lease between private parties that are now managed by the federal government when the mineral estate was purchased as part of a federal government land acquisition.

[e] To convert to km^2, multiply by 0.004047.

Source: BLM (2023).

Table F.11.2-5. Coal Production in the 11-State Planning Area, FY 2021

State	No. Mines	Production[a]
Arizona	0	0
California	0	0
Colorado	8	11,875
Underground	5	7,130
Surface	3	4,745
Idaho	0	0
Montana	6	28,580
Underground	1	7,247
Surface	5	21,333
Nevada	0	0
New Mexico	3	9,265
Underground	1	1,572
Surface	2	7,693
Oregon	0	0
Utah	6	12,434
Underground	5	12,000
Surface	1	434
Washington	0	0
Wyoming	16	238,773
Underground	1	3,195
Surface	15	235,578
Total:	**39**	**300,927**
Underground	**13**	**31,144**

[a] Thousand short tons.
Source: EIA (2021).

Table F.11.2-6. Solid Mineral Leases on BLM Public Lands, FY 2022

State	Sodium		Potassium		Phosphate		Gilsonite	
	# Leases	Acres[a]	# Leases	Acres[a]	# Leases	Acres[a]	# Leases	Acres[a]
Arizona	1	4	0	0	0	0	0	0
California	13	20,847	6	10,286	0	0	0	0
Colorado	7	14,644	0	0	0	0	0	0
Idaho	0	0	0	0	88	45,746	0	0
Montana	0	0	0	0	1	1,409	0	0
Nevada	0	0	1	2,500	0	0	0	0
New Mexico	0	0	144	185,473	0	0	0	0
Oregon	0	0	0	0	0	0	0	0
Utah	0	0	178	153,697	4	8,118	14	3,680
Washington	0	0	0	0	0	0	0	0
Wyoming	61	68,875	0	0	0	0	0	0
Total:	**82**	**104,370**	**329**	**351,956**	**93**	**55,273**	**14**	**3,680**

[a] To convert to km^2, multiply by 0.004047
Source: BLM (2023).

Table F.11.2-7. Saleable Mineral Production (yd^3) for All Existing Contracts and Permits, FY 2022[a]

State	Non-Exclusive Sales		Exclusive Sales		Free-Use Permits		Total	
	#	Quantity	#	Quantity	#	Quantity	#	Quantity
Arizona	80	19,489	216	1,483,184	12	114,929	**308**	**1,617,602**
California	15	2,111	102	523,286	0	0	**117**	**525,397**
Colorado	67	115	85	500,176	27	49,294	**179**	**549,585**
Idaho	185	45,244	10	3,147	73	113,759	**268**	**162,150**
Montana[b]	2	151	10	1	12	33,409	**24**	**33,561**
Nevada	120	32,246	382	3,892,210	138	210,754	**640**	**4,135,210**
New Mexico[c]	168	302,351	269	956,952	18	203,201	**455**	**1,462,504**
Oregon/Washington	31	24,270	2	125,021	14	39,424	**47**	**188,715**
Utah	260	103,391	70	340,490	13	23,625	**343**	**467,506**
Wyoming[d]	53	4,635	231	950,381	75	43,192	**359**	**998,208**
Total:	**981**	**534,003**	**1,377**	**8,774,848**	**382**	**831,587**	**2,740**	**10,140,438**

[a] To convert to m^3, multiply by 0.764555. Saleable production includes sand, gravel, soil, stone, calcium, pumice, and/or clay.
[b] Includes North Dakota and South Dakota.
[c] Includes Kansas, Oklahoma, and Texas.
[d] Includes Nebraska.
Source: BLM (2023).

Table F.11.2-8. Hardrock Leases, FY 2022

State	No. Leases	Acres
Arizona	0	0
California	1	41
Colorado	0	0
Idaho	1	41
Montana	0	0
Nevada	0	0
New Mexico	0	0
Oregon	0	0
Utah	2	314
Washington	0	0
Wyoming	0	0
Total:	**4**	**396**

[a] These minerals include copper, nickel, lead, zinc, cadmium, cobalt, gold, silver, garnet, uncommon-variety limestone or clay, platinum, palladium, quartz crystals, semiprecious gemstones, uranium, or other minerals.
Source: BLM (2023).

F.11.3 Supplemental Material for Impacts Assessment

No supplemental material for the minerals impacts assessment (Section 5.11).

F.12 Paleontological Resources

F.12.1 Methods Used for Evaluation

Different geological units (formations) contain varying and predictable levels of paleontological resources based on the type of unit. The BLM's adoption of the PFYC system provides baseline guidance for assessing the relative occurrence of important paleontological resources and the need for mitigation (BLM 2022). Specifically, the system is used to classify geologic units at the formation or member level according to the probability of vertebrate fossils or uncommon invertebrate or plant fossils and their sensitivity to adverse impacts. A higher classification number indicates a higher fossil yield potential and greater sensitivity to adverse impacts. The classifications are described in detail below and displayed in Figure 4.12.2-1 in the 11-state planning area.

The first class of the PFYC system is "*Class 1* – Very Low," which consists of geologic units unlikely to contain recognizable paleontological resources. Units in this class are usually igneous or metamorphic rock and can be dated to the Precambrian era. These units are of negligible concern with paleontological mitigation being unlikely. Overall, the impact on potential paleontological resources is unlikely, though standard stipulations should be in place prior to the authorization of any land use to accommodate unanticipated discoveries (BLM 2022).

The second class of the PFYC system is "*Class 2* – Low" and consists of geologic units that are not likely to contain paleontological resources and typically have been surveyed for paleontological resources and found lacking, were younger than 10,000 years before present (BP), are recent aeolian deposits, or sediments exhibiting significant physical or chemical changes that make fossil preservation unlikely to occur. Unless paleontological resources are found, the likelihood of these resources is generally low with further assessment deem unnecessary aside from isolated cases. The probability of impact on paleontological resources in this category is considered low, with localities of these resources managed on a case-by-case basis due to their rarity. This classification does not trigger any analysis prior to land use. However, should paleontological resources be discovered, standard stipulations for unanticipated discoveries should be observed (BLM 2022).

The third class of the PFYC system is "*Class 3* – Moderate." Geologic units belonging to this class are sedimentary units where fossil content varies in scientific importance, abundance, and predictable occurrence. These units are usually marine in origin with sporadic, though often low, occurrences of paleontological resources. Due to the variability in resource concentrations, there remains a possibility of important paleontological resources in these units, resulting in a low-to-moderate impact on potential resources. Management considerations are often equally as broad as the dispersal of paleontological resources. Some of these considerations may include records review, pre-disturbance surveys, monitoring, mitigation, or avoidance. A qualified paleontologist may be required to determine whether the resource potential in the area is significant and merits mitigative action.

The fourth class of the PFYC system is "*Class 4* – High" and contains geologic units known to have a high occurrence of paleontological resources. These units' resources have been documented as scientifically important, often bearing rare or uncommon fossils including nonvertebrate or unusual plant fossils though their occurrences and predictability vary. Mitigation strategies of units in this class will vary depending on the proposed activity, but field assessment by a qualified paleontologist is usually required to assess the condition of the units. These strategies must consider the nature of the disturbance, such as the removal or digging through of soils, potential for accelerated erosion as a result of the action, or increased ease of access for looting. Field assessment is normally required with a possibility for onsite monitoring during land disturbing activities or overall avoidance of paleontological resources.

The fifth class of the PFYC system is "*Class 5* – Very High," with units consistently and predictably producing scientifically important paleontological resources. These units have documented resources that are highly susceptible to adverse impacts from surface-disturbing activities. These units are also regularly the focus of illegal collecting activities. The management concerns for this class of geologic unit is high to very high and requires field survey by a qualified paleontologist in almost every instance. Paleontological mitigation may also be necessary prior to surface-disturbing activities. Avoidance or preservation through controlled access should be considered for geologic units on this class.

Three other classifications within the framework of the PFYC system do not fit into any of the other categories. The first of these is known as "*Class U* – Unknown Potential," where units unable to receive a distinct PFYC assignment are listed. These units geologically exhibit features indicative of those that possess significant paleontological resources. However, there is little to no information about any resources in the geological unit or surrounding units. Overall, this classification consists of areas that are understudied, have unverified reports of paleontological resources, or have not yet been assessed by BLM staff. These units are considered to have a classification of medium to high management concerns until provisional assignments are made to the geological unit. These units often require field surveys due to the lack of information, prior to any ground-disturbing activities. In some cases, literature review or professional consultation may allow for a provisional classification of Class U units, but the unit should undergo formal survey and research to make an informed determination.

The second of these classifications is "*Class W* – Water," which includes any surface area mapped as water (lakes, rivers, oceans, etc.). Though bodies of water do not regularly contain paleontological resource, shorelines should be properly surveyed for the possibility of uncovered or transported paleontological materials. Sinkholes and cenotes may trap animals which are then fossilized, and reservoirs may reveal paleontological resources at lower water intervals. Care should be taken when any kind of disturbance is planned for Class W areas, as ground-disturbance activities, such as dredging a river, may disturb sediments containing paleontological resources.

The third and final of these outlier classifications is "*Class I* – Ice." This classification includes any areas mapped as ice or snow, including glaciers. Receding glaciers should be considered for their potential to reveal paleontological resources as well as melting snow fields that may contain possible soft-tissue preservation.

F.12.2 Supplemental Material for Affected Environment

Tables F.12-.2-1 and F.12.2-2 list the paleontologically significant parks, monuments, and ACECs. Figure F.12.2-1 also shows the locations of PFYC classes within the area. Table F.12.2-3 lists the typical age of geological units, examples of those units, and their current PFYC status in the 11-state planning area;

Table F.12.2-1. National Monuments and Parks with Paleontological Components

National Monument or Park	State	Current Land Manager
Agua Fria National Monument	Arizona	BLM
Casa Grande National Monument	Arizona	NPS
Chiricahua National Monument	Arizona	NPS
Grand Canyon National Park	Arizona	NPS
Grand Canyon-Parashant National Monument	Arizona	NPS and BLM
Ironwood Forest National Monument	Arizona	BLM
Montezuma Castle National Monument	Arizona	NPS
Navajo National Monument	Arizona	NPS
Organ Pipe Cactus National Monument	Arizona	NPS
Papago Park	Arizona	AZ
Petrified Forest National Park	Arizona	NPS
Pipe Springs National Monument	Arizona	NPS
Saguaro National Park	Arizona	NPS
Sonoran Desert National Monument	Arizona	BLM
Sunset Crater Volcano National Monument	Arizona	NPS
Tonto National Monument	Arizona	NPS
Tumacacori National Historical Park	Arizona	NPS
Tuzigoot National Monument	Arizona	NPS
Vermillion Cliffs National Monument	Arizona	BLM
Walnut Canyon National Monument	Arizona	NPS
Wupatki National Monument	Arizona	NPS
Berryessa Snow Mountain National Monument	California	BLM and FS
Cabrillo National Monument	California	NPS
California Coastal National Monument	California	BLM
Carrizo Plain National Monument	California	BLM
Castle Mountain National Monument	California	NPS
César E. Chávez National Monument	California	NPS
Channel Islands National Park	California	NPS
Devils Postpile National Monument	California	NPS
Fort Ord National Monument	California	BLM
Giant Sequoia National Monument	California	FS
Joshua Tree National Park	California	NPS
Lassen Volcanic National Park	California	NPS
Lava Beds National Monument	California	NPS

Table F.12.2-1. National Monuments and Parks with Paleontological Components *(Cont.)*

National Monument or Park	State	Current Land Manager
Mojave Trails National Monument	California	BLM
Muir Woods National Monument	California	NPS
Pinnacles National Park	California	NPS
San Gabriel Mountains National Monument	California	FS
Sand to Snow National Monument	California	BLM and FS
Death Valley National Park	California and Nevada	NPS
Black Canyon of the Gunnison National Park	Colorado	NPS
Camp Hale-Continental Divide	Colorado	FS
Canyons of the Ancients National Monument	Colorado	BLM
Chimney Rock National Monument	Colorado	FS
Colorado National Monument	Colorado	NPS
Florissant Fossil Beds National Monument	Colorado	NPS
Great Sand Dunes National Park & Preserve	Colorado	NPS
Rio Grande National Forest	Colorado	FS
White River National Forest	Colorado	FS
Yucca House National Monument	Colorado	NPS
Hovenweep National Monument	Colorado, Utah	NPS
Dinosaur National Monument	Colorado and Utah	NPS
Craters of the Moon National Monument & Preserve	Idaho	NPS and BLM
Hagerman Fossil Beds National Monument	Idaho	NPS
Minidoka National Historic Site	Idaho	NPS
Big Hole National Battlefield	Montana	NPS
Lewis and Clark Caverns State Park	Montana	MT
Pompeys Pillar National Monument	Montana	BLM
Upper Missouri River Breaks National Monument	Montana	BLM
Aztec Ruin National Monument	New Mexico	NPS
Bandelier National Monument	New Mexico	NPS
Browns Canyon National Monument	New Mexico	BLM and FS
Capulin Volcano National Monument	New Mexico	NPS
Carlsbad Cave National Park	New Mexico	NPS
Chaco Culture National Historical Park	New Mexico	NPS
El Morro National Monument	New Mexico	NPS
Gila Cliff Dwellings National Monument	New Mexico	NPS
Kasha-Katuwe Tent Rocks National Monument	New Mexico	BLM
Organ Mountains-Desert Peaks National Monument	New Mexico	BLM
Prehistoric Trackways National Monument	New Mexico	BLM
Rio Grande del Norte National Monument	New Mexico	BLM
Salinas Pueblo Missions National Monument	New Mexico	NPS
White Sands National Park	New Mexico	NPS
Avi Kwa Ame	Nevada	BLM and NPS
Basin and Range National Monument	Nevada	BLM
Gold Butte National Monument	Nevada	BLM
Cascade-Siskiyou National Monument	Oregon	BLM

Table F.12.2-1. National Monuments and Parks with Paleontological Components *(Cont.)*

National Monument or Park	State	Current Land Manager
John Day Fossil Beds National Monument	Oregon	NPS
Tule Springs Fossil Beds National Monument	Nevada	NPS
Oregon Caves National Monument & Preserve	Oregon	NPS
Arches National Park	Utah	NPS
Bryce Canyon National Park	Utah	NPS
Capitol Reef National Park	Utah	NPS
Cedar Breaks National Monument	Utah	NPS
Grand Staircase-Escalante National Monument	Utah	BLM
Jurassic National Monument	Utah	BLM
Natural Bridges National Monument	Utah	NPS
Rainbow Bridge National Monument	Utah	NPS
Timpanogos Cave National Monument	Utah	NPS
Zion National Park	Utah	NPS
Bears Ears National Monument	Utah	BLM, Manti La Sal National Forest, and the Bears Ears Commission
Hanford Reach National Monument	Washington	FWS
Olympic National Park	Washington	NPS
San Juan Islands National Monument	Washington	BLM
San Juan Island National Historical Park	Washington	NPS
Devils Tower National Monument	Wyoming	NPS
Fort Laramie National Historical Site	Wyoming	NPS
Fossil Butte National Monument	Wyoming	NPS
Grand Teton National Park	Wyoming	NPS
Spirit Mountain Cave	Wyoming	BLM

Table F.12.2-2. ACECs Designated for Protection of Paleontological Resource Values

ACEC	State	BLM Field Office	ACEC Values
Carrow Stephens Ranches	Arizona	Kingman	Historic sites and paleontological resources
Bear Springs Badlands	Arizona	Safford	Paleontological resources; scenic
111 Ranch RNA	Arizona	Safford	Paleontological
Manix	California	Barstow	Paleontological and cultural
Mountain Pass Dinosaur Trackway	California	Barstow	Historic and paleontological values
Rainbow Basin/Owl Canyon	California	Barstow	Outstanding scenery; unique geology and paleontology; prehistoric archaeology
Marble Mountain Fossil Bed	California	Needles	Paleontological
Mountain Pass Dinosaur Trackway	California	Needles	Paleontological
Fossil Falls	California	DRECP	ACEC Estimated Acres field calculations are BLM acres only using the PCS: NAD 1983 California Teale Albers projection. Calculation completed on September 2, 2022.
Coyote Mountains Fossil Site	California	DRECP	ACEC Estimated Acres field calculations are BLM acres only using the PCS: NAD 1983 California Teale Albers projection. Calculation completed on September 2, 2022.
Garden Park	Colorado	Royal Gorge	Paleontological; historical
Coal Draw	Colorado	White River	Paleontological values
Blacks Gulch	Colorado	White River	Paleontological values
McCoy Fan Delta	Colorado	Colorado River Valley	Geologic and Paleontological values associated with Fluvial and marine depositional events
River Rims	Colorado	Dominguez-Escalante NCA	Unique and sensitive rare plants and paleontological resources on the benches and slopes above Gunnison River
Dolores River Riparian	Colorado	Grand Junction	To protect riparian, hydrology, scenic and paleontological resources
Gibbler Mountain	Colorado	Dominguez-Escalante NCA	Unique and sensitive paleontological and rare plant resources.
Raven Ridge	Colorado	White River	Candidate T/E plants, sensitive plants and RVAs, paleontological values
Kremmling Cretaceous Ammonite RNA	Colorado	Kremmling	Managed to protect significant marine invertebrate fossils and for research and preservation.
Bug Creek	Montana	Miles City	Paleontological
Hell Creek	Montana	Miles City	Paleontological
Sand Arroyo	Montana	Miles City	Paleontological
Ash Creek Divide	Montana	Miles City	Paleontological
East Pryor Mountain	Montana	Billings and Pompeys Pillar	Wild Horse, Historic, Cultural, Paleontological, Special Status Plants/Animals
Flat Creek	Montana	Miles city	Paleontological
Powderville	Montana	Miles City	Paleontological
Malta Geologic	Montana	HiLine	Paleontological
Stewart Valley	Nevada	Carson City	Paleontological
Arrow Canyon	Nevada	Las Vegas	Paleontological; geological; cultural

Table F.12.2-2. ACECs Designated for Protection of Paleontological Resource Values *(Cont.)*

ACEC	State	BLM Field Office	ACEC Values
Alamo Hueco Mountains	New Mexico	Las Cruces	Biological; scenic; cultural; paleontological; special status species
Robledo Mountains	New Mexico	Las Cruces	Paleontological, cultural, and scenic values; endangered plant species
Ball Ranch	New Mexico	Rio Puerco	Special status plant habitat; paleontological
Ojito	New Mexico	Rio Puerco	Geological; paleontological; cultural; wildlife; rare plant habitat; geologic hazard
Pronoun Cave	New Mexico	Rio Puerco	Paleontological; cultural
Torreon Fossil Fauna East	New Mexico	Rio Puerco	Paleontological; natural system
Torreon Fossil Fauna West	New Mexico	Rio Puerco	Paleontological; natural system
Fossil Forest	New Mexico	Farmington	WDL-BLM Wilderness Designation NMNMAA - 026026 per PL 86-603 as amended by PL 104-333, Section 1022.
Lost Forest-Sand Dunes-Fossil Lake	Oregon	Lakeview Resource Area	
Fossil Mountain	Utah	Fillmore	Prehistoric life form
Alcova Fossil Area	Wyoming	Casper	Paleontological resources known to exist/site includes Alcova Pterodactyl Trackway-only 4 trackway known worldwide/outcrops of Morrison & Sundance formations contain fossilized remains from the Triassic & Jurassic periods.
Paleocene-Eocene Thermal Maximum (PETM)	Wyoming	Cody	Protect and enhance paleontological, wildlife, recreation, and scenic resources
Little Mountain	Wyoming	Cody	Protect and manage important cave, cultural, and paleontological resources, maintain scenic values; Carried forward in 2015 Cody RMP
Big Cedar Ridge	Wyoming	Washakie	Fossil plant area; Carried forward in 2015 Worland RMP
Brown/Howe Dinosaur	Wyoming	Cody	Protection of fossil resources for scientific research and education; Carried forward in 2015 Cody RMP
Red Gulch Dinosaur Tracksite	Wyoming	Washakie	Paleontological; Carried forward in 2015 Worland RMP

Table F.12.2-3. Age of Geologic Units and Potential Fossil Yield

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Cenozoic	Quaternary (0–1.8)	Holocene (0–0.01)		• Alluvium and colluvium (3) • Dune sand (3) • Eolian deposits (loess) (3) • Lacustrine and playa deposits (3) • Mud and salt flats (3) • Terrace and flood gravels (3)
		Pleistocene (0.01–1.8)	• Mammoths • Bison and cows • Horses • Deer • Squirrels and rabbits • Invertebrates	• Alluvium and colluvium (3) • Dune sand (3) • Eolian deposits (loess) (3) • Glaciofluvial deposits (3) • Lacustrine and playa deposits (3) • Mud and salt flats (3) • Terrace and flood gravels (3)
	Tertiary (1.8–65.0)	Pliocene (1.8–5.3)	• Mammals • Birds (eggs) • Warm climate plankton (marine) • Invertebrates	• Ogallala Formation (5) Colorado • Hagerman Fossil Beds (5) Idaho • Andesite (1) Idaho • Dalles Group (4) Oregon
		Miocene (5.3–23.8)	• Mammals (rodents) • Birds (eggs) • Invertebrates	• Browns Park Formation (4) Utah • Dry Union Formation (5) Colorado • Muddy Creek Formation (3) Arizona, California, Utah, Nevada • Ogallala Formation (3) New Mexico • Wagontongue Formation (3) Colorado • Rhyolite (1) • Lake Owyhee Volcanic Field (2) Oregon
		Oligocene (23.8–33.7)	• Mammals (early horses, primates, marsupials, carnivores) • Crocodilians, alligators • Lizards and turtles • Amphibians and fish • Invertebrates • Birds (eggs) • Plants and pollen	• Bishop Conglomerate (2) Colorado • Duchesne River Formation (5) Utah • Little Butte Volcanics (3) Oregon • Fort Logan Formation (5) Montana

Table F.12.2-3. Age of Geologic Units and Potential Fossil Yield *(Cont.)*

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Cenozoic *(Cont.)*	Tertiary (1.8–65.0) *(Cont.)*	Eocene (33.7–54.8)	• Mammals (early horses, primates, marsupials, carnivores, grazers) • Crocodilians, alligators • Lizards and turtles • Amphibians and fish • Invertebrates • Birds (eggs) • Plants and pollen	• Bridger Formation (5) Colorado, Wyoming • Duchesne River Formation (4/5) Colorado, Utah • Green River Formation (4/5) Colorado, Utah • Uinta Formation (5) Colorado • Wasatch Formation (4 in Utah; 5 in Colorado) Colorado, Utah • Climbing Arrow Formation (5) Montana • John Day/Clarno Group (5) Oregon
		Paleocene (54.8–65.0)	• Small mammals • Reptiles • Amphibians and fish • Birds (eggs) • Insects • Plants and pollen	• Currant Creek Formation (4) Utah • Fort Union Formation (4) Montana, Wyoming • Nacimiento Formation (5) Colorado, New Mexico • Ojo Alamo Formation (3) New Mexico • Wasatch Formation (3 in Montana; 5 in Wyoming) Montana, Wyoming • Paleocene Fort Union Formation (4) Wyoming • Tullock Member (4) Montana
Mesozoic	Cretaceous (65.0–144)		• Terrestrial flora and fauna: – Dinosaurs – Birds – Early mammals – Diverse insects – Flowering plants – Freshwater fish and invertebrates • Marine flora and fauna: – Plankton and diatoms – Cephalopods (ammonites, belemnites) – Marine reptiles – Fish • – Sharks and rays	• Burro Canyon Formation (4 in Colorado; 3 in New Mexico and Utah) Colorado, Utah, New Mexico • Castlegate Formation (3) Colorado, Utah • Cliff House Sandstone (2 in New Mexico; 4 in Colorado) Colorado, New Mexico • Lewis Shale (3) Wyoming • Mowry Shale (3 in Wyoming; 4 in Colorado) Colorado, Wyoming • Niobrara Formation (3 in Montana; 4 in Colorado/Wyoming) Colorado, Montana, Wyoming • Various volcanic units (1) • Greenhorn Formation (3) Montana • Snow Camp Terrane (1) Oregon • Lance Formation (5) Wyoming

Table F.12.2-3. Age of Geologic Units and Potential Fossil Yield *(Cont.)*

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Mesozoic *(Cont.)*	Jurassic (144–206)		• Terrestrial flora and fauna: – Dinosaurs – Early mammals – Seed plants – Ferns • Marine flora and fauna: – Plankton – Cephalopods (ammonites) – Marine reptiles – Fish – Sharks and rays	• Kayenta Formation (3 and 4 in Nevada; 4 in Utah and Arizona; 5 in Colorado) Arizona, Colorado, Nevada, Utah • Moenave Formation (4) Arizona, Utah • Morrison Formation (5) Arizona, Colorado, Montana, New Mexico, Utah • Navajo Sandstone (4 in Arizona and U; /5 in Colorado) Arizona, Colorado, Utah • Summerville Formation (2 in New Mexico; 4 in Utah;5 in Colorado) Colorado, New Mexico, Utah • Piper Formation (3) Montana • Sundance and Gypsum Springs Formations (5) Wyoming • Hurwal Formation (3) Idaho
	Triassic (206–248)		• Terrestrial flora and fauna: – Dinosaurs – Early mammals – Seed plants – Conifers	• Chinle Formation (4 in Nevada; 5 in Arizona, Colorado, and Utah) Arizona, Colorado, Nevada, New Mexico, Utah • Chugwater Formation (3 and U in Montana) Colorado, Montana, Wyoming • Moenkopi Formation (3 in Colorado, New Mexico, and Nevada; 4 in Arizona, California, New Mexico and Utah) Arizona, California, Colorado, Nevada, New Mexico, Utah • Thaynes Limestone (3) Utah • Wingate Formation (3 in Utah; 5 in Colorado) Colorado, Utah • Red Peak Member (3) Wyoming • Sedimentary Rocks (5) Idaho
Paleozoic	Permian (248–290)		• Terrestrial flora and fauna dominate: – Anapsids (turtles) – Diapsids – Archosaurs – Gymnosperms (conifers)	• Coconino Sandstone (3) Arizona • Kaibab Formation (3) Arizona, Nevada, Utah • San Andres Formation (3) New Mexico • Satanka Shale (3) Wyoming • Toroweap Formation (2 in Utah; and 3 in Arizona and Nevada) Arizona, Nevada, Utah • Phosphoria Formation (3/4) Montana, Wyoming

Table F.12.2-3. Age of Geologic Units and Potential Fossil Yield *(Cont.)*

Era		Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Paleozoic *(Cont.)*	Carboniferous *(Cont.)*	Pennsylvanian (290–323)		• Terrestrial flora and fauna dominate: – Freshwater clams – Seedless plants – Ferns – Winged insects (dragonflies) – Amniote species (lizards) – Diapsids (reptiles, snakes) • – Archosaurs (crocodiles, dinosaurs, birds)	• Belden Formation (3) Colorado • Hermit Shale (4) Arizona • Minturn Formation (3) Colorado • Morgan Formation (3) Colorado, Utah • Oquirrh Formation (3) Idaho, Utah • Alaska Bench Formation (3) Montana • Challis Volcanic Group (3) Idaho • Amsden Formation (3) Wyoming
		Mississippian (323–354)		• Marine invertebrates • (e.g., bryozoans and rachiopods) dominate: – Foraminifera – Modern fish fauna	• Deseret Limestone (3 or 4) Utah • Humbug Formation (3) Colorado, Idaho, Utah • Madison Formation (3) Colorado, Utah • Redwall Limestone (3) Arizona, California, New Mexico, Nevada, Utah • Deep Creek Formation (2) Idaho • Kibbey Formation (3) Montana

Table F.12.2-3. Age of Geologic Units and Potential Fossil Yield *(Cont.)*

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Paleozoic *(Cont.)*	Devonian (354–417)		• Terrestrial plants (ferns, seed plants, trees) • Terrestrial insects and spiders • Diverse freshwater fish • Marine vertebrates and invertebrates (see below)	• Jefferson Limestone (2) Utah, Colorado, New Mexico • Madison Formation (3) Colorado, Utah • Temple Butte Formation (3) Arizona, Idaho • Beirdneau Formation (2) Idaho • Darby Formation (2) Wyoming
	Silurian (417–443)		• Coral reefs • Marine invertebrates (see below) • Marine fish • Freshwater fish • Terrestrial plants	• Trail Creek Formation (2) Idaho • Saturday Mountain Formation (3) Idaho • Laketown Dolomite (2) Wyoming
	Ordovician (443–490)		• Marine invertebrates: – Red and green algae – Bryozoans – Crinoids, blastoids – Corals – Graptolites – Trilobites – Brachiopods, snails, clams – Cephalopods – Archaeocyathids (sponges) • Marine vertebrates: – Ostraderms (jawless, armored fish) • Conodonts (early vertebrates) • Terrestrial plants	• Fishhaven Dolomite (2) Utah • Garden City Limestone (2) Utah • Garden City Formation (3) Idaho • Bighorn Dolomite (2) Wyoming
	Cambrian (490–543)		• Marine invertebrates: – Red and green algae – Trilobites – Brachiopods – Echinoderms – Archaeocyathids (sponges)	• Bright Angel Shale (2) Arizona, Utah • Tapeats Sandstone (2 in Arizona; 3 in California; 5 in Nevada) Arizona, California, Nevada • St. Charles Formation (3) Idaho • Sedimentary Rocks (5) Montana • White River Formation (5) Wyoming
	Proterozoic (543–2,500)		• Soft bodied fauna • Carbon film • Microbial mats (stromatolites)	Various igneous and metamorphic units (1)
	Archean (2,500–3,800?)		None	Various igneous and metamorphic units (1)

[a] Ma = millions of years before the present.
[b] Distinctive fossils are those characteristic of the geologic period listed and may or may not be present in the geologic units (formations) in the study area.
Sources: Adapted from Palmer and Geissman (1999); University of California Museum of Paleontology (2007).

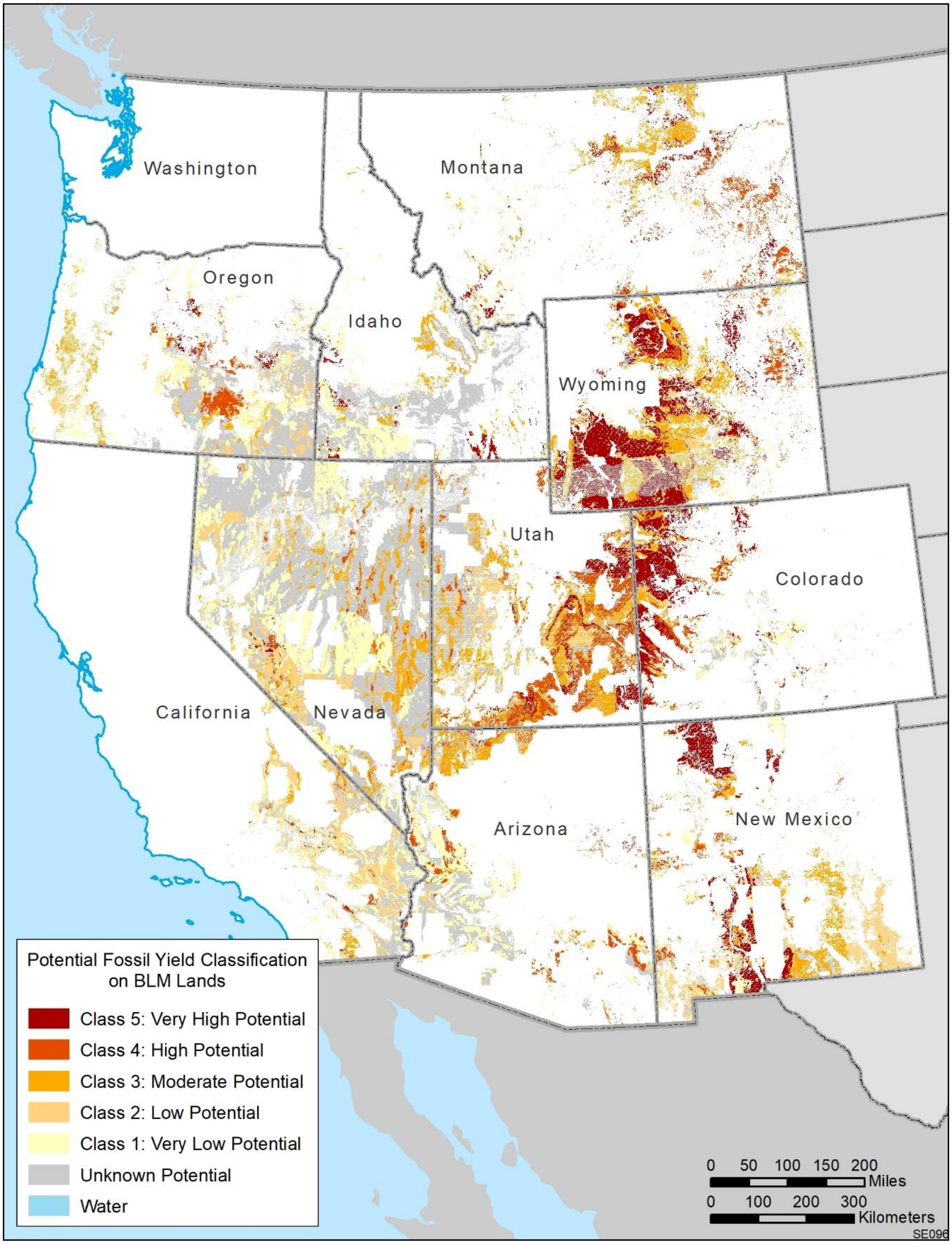


Figure F.12.2-1. Potential Fossil Yield Classifications (PFYCs) in the 11-State Planning Area. Note: California and Washington PFYC mapping was still in progress at the time of this figure's development.

F.12.3 Supplemental Material for Impacts Assessment

No supplemental material for the minerals impacts assessment (Section 5.12.3).

F.13 Rangeland Resources

F.13.1 Livestock Grazing

F.13.1.1 Methods for Evaluation

The information presented in the Affected Environment and Impacts sections were derived from scientific literature, official publications, and the opinions of subject matter experts.

Table F.12.3-1. Acreage Overlap of PFYC Classes and Lands Available for Solar Application for the Alternatives

State	All BLM-Administered Land Intersecting PFYC (Minus DRECP/CDCA)	No Action Alternative: Intersection of PFYC with SEZs (acres)	No Action Alternative: Intersection of PFYC with Variance Lands (acres)	Alternative 1: Intersection of PFYC with BLM-administered lands available for application (acres)	Alternative 2: Intersection of PFYC with BLM-administered lands available for application (acres)	Alternative 3: Intersection of PFYC with BLM-administered lands available for application (acres)	Alternative 4: Intersection of PFYC with BLM-administered lands available for application (acres)	Alternative 5: Intersection of PFYC with BLM-administered lands available for application (acres)
PFYC Class 1	26,516,589	41,721 (0.15%)	8,086,462 (30%)	9,381,748 (35%)	4,661,229 (18%)	2,210,051 (8%)	904,564 (3%)	596,889 (2%)
PFYC Class 2	20,237,376	43,731 (0.22/%)	6,841,370 (33%)	8,846,389 (44%)	7,038,135 (35%)	4,584,352 (23%)	2,488,632 (12%)	1,870,831 (9%)
PFYC Class 3	25,672,356	17,670 (0.07%)	7,279,857 (28%)	8,698,096 (34%)	4,523,214 (18%)	2,346,269 (9%)	1,414,597 (6%)	925,792 (4%)
PFYC Class 4	13,861,414	5,787 (0.04%)	4,167,712 (30%)	3,581,944 (26%)	1,704,140 (12%)	1,037,930 (7%)	443,325 (3%)	320,708 (2%)
PFYC Class 5	19,312,657	34,024 (0.17%)	7,097,566 (37%)	6,848,944 (35%)	4,178,150 (22%)	3,095,148 (16%)	1,880,308 (10%)	1,518,061 (8%)
Other (U, W, &I)	52,786,331	186,158 (0.35%)	13,115,273 (25%)	18,558,885 (35%)	13,924,797 (26%)	7,636,944 (14%)	3,858,756 (7%)	2,900,945 (5%)

F.13.1.2 Supplemental Material for Affected Environment

Table F.13.1.2-1. Grazing Permits and Leases in Force as of January 2022

State	Number[a]	Active AUMs[b]
Arizona	778	636,433
California	529	233,903
Colorado	1,497	582,982
Idaho	1,872	1,301,993
Montana	3,802	1,138,440
New Mexico	2,187	1,825,679
Nevada	772	2,181,490
Oregon	1,255	1,012,460
Utah	1,494	1,180,099
Washington	270	34,276
Wyoming	2,911	1,870,312
Total	**17,367**	**11,998,067**

[a] Not including authorizations for non-use.

[b] An AUM is the amount of forage needed to sustain one cow and her calf, one horse, or five sheep or goats for one month.

Source: BLM 2023a p. 79.

F.13.1.3 Supplemental Material for Impacts Assessment

No supplemental material to the livestock grazing impacts assessment (Section 5.13.1).

F.13.2 Wild Horse and Burro

F.13.2.1 Methods Used for Evaluation

The information presented in the Affected Environment and Impacts sections was derived from scientific literature, other solar environmental assessments, and spatial analyses conducted using GIS. The primary source of information for wild horse and burro (WH&B) herd management areas (HMAs) was from BLM (2023). The primary potential impacts on WH&B from solar energy development are those that may affect resource features (i.e., forage, water, cover, and space), individuals, and populations.

A landscape-level analysis was used to determine potential impacts by quantifying the total acreage of HMAs within the acreage of those areas open for solar energy development applications under each alternative.

Impact analyses focused on acreage of HMAs within the various alternative areas; and how solar energy development may affect continued management of WH&B within those areas. It is not possible to quantitatively analyze impacts on WH&B HMAs in this Solar Programmatic EIS due to the broad scope of the report and the numerous HMAs that occur within the 11-state planning area. Alternatives with larger areas of intersection with HMAs may have a greater impact compared to those alternatives with smaller intersection areas. Actual impact magnitudes on WH&B would depend on the location of the HMAs, project-specific design, application of design features and other mitigation measures, and the status of the WH&B and their habitats in the project area.

F.13.2.2 Supplemental Material for Affected Environment

Table F.13.2.2-1 summarizes the WH&B statistics in the 11-state planning area; while Figures F.13.2.2-1 shows the locations of HMAs within the area.

F.13.2.3 Supplemental Material for Impacts Assessment

No supplemental material for the WH&B impacts assessment (Section 5.13.2).

Table F.13.2.2-1. Wild Horse and Burro Statistics for the 11-state Planning Area as of March 1, 2023

State	Herd Area		Herd Management Area		Estimated Population and High AML			
	BLM Acres	Total Acres	BLM Acres	Total Acres	Horse Pop.	Horse High AML	Burro Pop.	Burro High AML
Arizona	2,019,027	3,643,197	1,498,207	2,296,269	465	240	6,205	1,436
California	5,170,931	7,021,651	2,053,082	2,533,722	4,007	1,735	3,013	465
Colorado	723,095	851,275	365,988	404,013	1,527	827	0	0
Idaho	420,783	477,300	383,894	418,268	651	617	0	0
Montana	103,844	230,073	27,094	35,640	205	120	0	0
Nevada	19,778,204	23,028,911	14,032,947	15,668,201	44,786	11,967	4,482	824
New Mexico	88,655	126,530	24,506	28,613	385	83	0	0
Oregon	3,608,660	4,312,356	2,733,577	2,978,751	4,519	2,676	54	24
Utah	3,224,891	3,915,687	2,154,458	2,451,227	3,555	1,786	201	170
Washington	--	--	--	--	--	--	--	--
Wyoming	7,301,975	10,344,424	3,644,013	4,779,373	8,828	3,795	0	0
TOTAL	**42,440,065**	**53,951,404**	**26,917,766**	**31,594,077**	**68,928**	**23,866**	**13,955**	**2,919**

Source: BLM (2023)

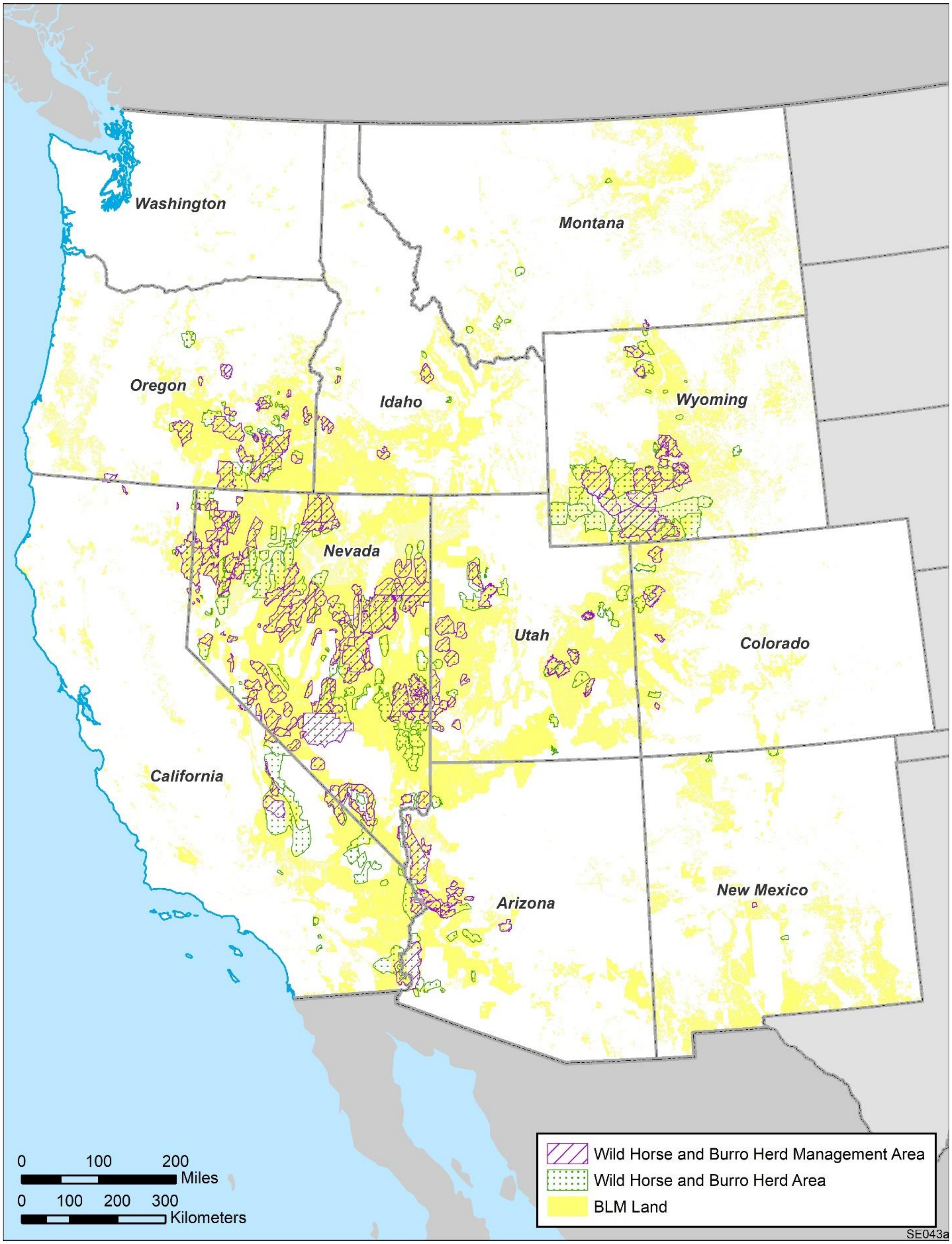


Figure F.13.2.2-1. Wild Horse and Burro Herd Areas (HA) and Herd Management Areas (HMA) in 11-state Planning Area

F.14 Recreation

F.14.1 Methods Used for Evaluation

The information presented in the Affected Environment and Impacts sections were derived from scientific literature, official publications, and the opinions of subject matter experts.

F.14.2 Supplemental Material for Affected Environment

Table F.14.2-1. Estimated Recreational Use of Public Lands Administered by the BLM, Fiscal Year 2022

	Recreation Sites[b]		Dispersed Areas[c]		Recreation Partnership Sites[d]		Totals[e]	
Admin State[a]	**Visits[f]**	**Visitor Days[g]**	**Visits[f]**	**Visitor Days[g]**	**Visits[f]**	**Visitor Days[g]**	**Visits[f]**	**Visitor Days[g]**
Arizona	2,672	4,879	1,905	2,069	1,741	2,973	**6,318**	**9,921**
California	6,796	10,748	6,690	6,661	213	94	**13,699**	**17,503**
Colorado	5,582	2,811	3,975	5,872	816	293	**10,373**	**8,976**
Idaho	3,745	2,543	3,447	4,405	0	0	**7,192**	**6,948**
Montana	3,266	2,752	1,820	2,644	3	1	**5,089**	**5,397**
Nevada	7,152	1,916	1,768	2,577	0	0	**8,920**	**4,493**
New Mexico	1,695	1,121	1,939	2,907	< 1	< 1	**3,634**	**4,028**
Oregon	5,069	4,562	4,310	4,210	514	159	**9,893**	**8,931**
Utah	6,449	3,608	5,098	5,565	176	125	**11,723**	**9,298**
Wyoming	1,715	952	1,351	1,386	17	3	**3,083**	**2,341**
Total	**44,894**	**36,242**	**32,737**	**38,776**	**3,490**	**3,650**	**81,121**	**78,668**

[a] The Arizona State Office also administers BLM public lands in California along the Colorado River; the California State Office also administers BLM public lands in northwestern Nevada; the Montana State Office also administers BLM public lands in North Dakota and South Dakota; the New Mexico State Office also administers BLM public lands in Kansas, Oklahoma, and Texas; the Oregon State Office also administers BLM public lands in Washington; and the Wyoming State Office also administers BLM public lands in Nebraska.

[b] These are recreation sites and other specific areas on public lands directly managed by the BLM that are recognized as “managerially significant,” where management actions are required to provide specific recreation setting or activity opportunities, to protect resource values, or to enhance visitor safety. Visitation estimates at these sites and areas are based on a variety of methods, including sampling, fee receipts, registrations, traffic counts, observations, or estimates based on local knowledge.

[c] Dispersed areas are the remaining public lands that are open to recreational use but may not contain developed or “managerially significant” recreation sites. Visitation estimates in dispersed areas are made using information gained from staff field patrols, data from adjacent land management agencies, or data gathered using social crowd-sourced methods.

[d] Recreation partnership sites are recreation sites managed primarily by another public entity under the authority of the Recreation and Public Purposes Act and similar agreements; the BLM has a significant presence on the leased parcel (e.g., ranger patrols, signs, brochures). Visitation estimates for partnership sites are based on a variety of methods.

[e] In FY 2022, total recreational use of public lands increased slightly from the previous record setting year. Dramatically increased recreational use, the post COVID-19 pandemic, and catastrophic wildfires continued to affect recreational sites in certain locations. Many visitor centers and indoor facilities reopened but with limited capacities. Many sites and areas showed gradual increases as more visitors continued seeking outdoor experiences following several years of limited travel.

[f] A visit is the entry of any person onto lands and related waters administered by the BLM for the pursuit of recreational experiences, regardless of duration.

[g] A visitor day is a common unit of measure of recreational use among federal agencies. One visitor day represents an aggregate of 12 visitor hours to a site or area.

Source: BLM 2023, Table 4-1.

Table F.14.2-2. Estimated Recreational Use of BLM-administered Public Lands for Recreational Activities, Fiscal Year 2022

Recreational Activities	Participants (in Thousands)[a]			
	Fee Sites and Areas[b]	Special Recreation Permitted Activities[c]	Areas Without Permits or Fees[d]	Total
Land-Based Activities				
Camping and Picnicking	3,383	366	16,536	**20,285**
Nonmotorized Travel	1,817	407	27,158	**29,382**
Off-Highway Travel	445	419	18,981	**19,845**
Driving for Pleasure	1,975	78	9,733	**11,786**
Viewing Public Land Resources	2,779	510	23,158	**26,447**
Interpretation and Education	1,388	104	8,993	**10,485**
Hunting	183	48	7,597	**7,828**
Specialized Sports, Events, and Activities	1,627	701	18,592	**20,920**
Water-based Activities				
Boating (Motorized)	906	40	2,947	**3,893**
Boating (Row/Float/Paddle)	614	362	4,869	**5,845**
Fishing	1,244	285	5,326	**6,855**
Swimming and Other Water Activities	639	70	2,618	**3,327**
Snow and Ice-based Activities				
Snowmobile/Motorized Travel	16	7	405	**428**
Other Winter Activities	42	430	734	**1,206**
Total	**17,058**	**3,827**	**147,647**	**168,532**

[a] A participant is a visitor on a single visit who engages in one or more recreational activities on public land. A single visitor can participate in several activities during a single visit and is counted as a participant in each activity.

[b] Activity participation occurring at designated fee sites and areas with entrance permits, recreational use permits, and special area permits, usually with fee collection at the site.

[c] Activity participation on public lands that is subject to authorization under special recreation permit regulations, including the activities of private parties, commercial outfitters and guides, competitive events, organized groups, and other events.

[d] Activity participation at nonfee sites and dispersed areas when neither permits nor fees are required.

Source: BLM 2023, Table 4-2.

F.14.3 Supplemental Material for Impacts Assessment

No supplemental material to the recreation impacts assessment (Section 5.14).

F.15 Socioeconomics

F.15.1 Methods Used for Evaluation

Analysis of the socioeconomic impacts of solar energy developments in the 11-state planning area estimated the economic impacts on employment and income, and the impact on state sales and income taxes. Because of the relative economic importance of solar energy developments in small rural economies in many of the states and the consequent lack of local economic and community infrastructure, the analysis also estimates the impact of solar energy development on population in-migration, housing, and community service finances and employment.

Impacts on State-level Employment and Income

Impacts of solar energy developments on state employment and income are assessed using regional economic multipliers, together with available project expenditure and schedule data for construction and operations, using the JEDI model developed by National Renewable Energy Laboratory (NREL). Multipliers capture the indirect (offsite) effects of onsite activities associated with construction and operation of solar energy developments. Multipliers are derived by the JEDI model from IMPLAN input-output economic accounts for each state, which show the flow of commodities to industries from producers and institutional consumers. The accounts also show consumption activities by workers, owners of capital and imports from outside the region. The IMPLAN model contains sectors representing industries in agriculture, mining, construction, manufacturing, wholesale and retail trade, utilities, finance, insurance and real estate, and consumer and business services. The model also includes information for each sector on employee compensation, proprietary and property income, personal consumption expenditures, federal, state and local expenditures, inventory and capital formation, imports and exports.

Expenditure data associated with the construction and operation of solar energy developments in the JEDI model was derived from project expenditure data for both construction and operation and for labor and materials in various general cost categories. Information on the expected pattern of procurement within each state for the various materials and subcontracts in each cost category was used by the JEDI model in the calculation of impacts to adjust total procurement expenditures. The JEDI model was used to estimate impacts on state employment and income. Impacts on employment are described in terms of the total number of jobs created in the region in a single year of construction and in the first year of operation. The relative impact of the increase in employment in each state is calculated by comparing total solar energy development construction employment in a single year with state employment in 2021.

Sales and Income Tax Impacts

The analysis estimated direct sales tax revenues by multiplying the value of capital project expenditures and materials and supplies expenditures in each state by the current sales tax rate in each state. State income tax revenues were estimated by multiplying the value of direct personal income generated by solar activities by state tax rates for taxpayer income categories.

Although energy developments on public land are often exempt from property taxes, some utility-scale solar energy developments on public land pay property taxes. Other state and local revenues include those from user fees, permit fees and payments in lieu of taxes (PILOT) used to support local and state public services provided in communities in the vicinity of these facilities. The size and combination of taxes and payments made by solar energy facilities on federal lands to local communities would be the result of negotiation between solar energy developers and local jurisdictions, and state and federal agencies.

Impacts on Population

An important consideration in the assessment of impacts of solar energy developments is the number of workers, families and children that would in-migrate into each state during construction. The capacity of regional labor markets to produce workers in the appropriate occupations required for development construction in sufficient numbers is closely related to the occupational profile of each state and occupational unemployment rates. To estimate the in-migration that would occur, the analysis used construction labor and material cost factors, together with estimates of the extent of local procurement of construction materials and labor, to develop estimates of available labor in each direct labor category based on state unemployment rates applied to each occupational category. The national average household size was used to calculate the number of additional family members that might accompany direct in-migrating workers.

Impacts on population are described in terms of the total number of in-migrants arriving in the region in a single year of construction and in the first year of operation. The relative impact of the increase in population in each state is calculated by comparing total solar energy development construction in-migration in a single construction year with state population in 2020.

Impacts on Local Housing Markets

The in-migration of workers into each state during construction has the potential to substantially affect the state’s housing market. The impacts on solar-related in-migration on housing were described in terms of the number of rental units required in a single year of construction. The relative impact on the existing housing in each state was estimated by calculating the impact of solar-related housing demand in a single year of construction on the number of vacant rental housing units in 2021.

Impacts on Community Services and Employment

In-migration associated with construction of solar energy developments would translate into increased demand for educational services and for public services (police, fire protection, health services, etc.) in each state. Impacts were estimated by multiplying the total number of in-migrating workers and their families by existing local and state public service expenditures, and the number of employees in each public service, per 1,000 population in each state. Relative impacts were calculated by comparing employment and financial data in a single year of construction and in the first year of operations with state employment and expenditure data for local and state jurisdictions in 2021.

F.15.2 Supplemental Material for Affected Environment

Table F.15.2-1. Population and Population Growth, 11-state Planning Area

State	2010	2020	Annual Average Growth Rate (%)	Rural Population, 2020 (%)	2030 Forecast
Arizona	6,392,017	7,151,502	1.1	10.2	8,313,814
California	37,253,956	39,538,223	0.6	5.0	41,860,549
Colorado	5,029,196	5,773,714	1.4	13.8	6,416,217
Idaho	1,567,582	1,839,106	1.6	29.4	2,116,413[1]
Montana	989,415	1,084,225	0.9	44.1	1,171,659
Nevada	2,700,551	3,104,614	1.4	5.8	3,525,793
New Mexico	2,059,179	2,117,522	0.3	22.6	2,136,414
Oregon	3,831,074	4,237,256	1.0	19.0	4,721,060
Utah	2,763,885	3,271,616	1.7	9.4	3,879,161
Washington	6,724,540	7,705,281	1.4	16.0	8,512,446
Wyoming	563,626	576,851	0.2	35.2	597,260
Total	**69,875,626**	**76,399,910**	**0.9**	**10.0**	**83,250,786**

[1] 2031 data

Sources: Arizona Commerce Authority (2023), California Department of Finance (2023), Colorado Department of Local Affairs (2023), Idaho Department of Labor (2023), Montana Department of Commerce (2023), Nevada Department of Taxation (2023), University of New Mexico (2023), Portland State University (2023), U.S. Census Bureau (2023a,b,c), University of Utah (2023), Washington Office of Financial Management (2023), Wyoming Department of Administration and Information (2023).

Table F.15.2-2. Civilian Labor Force Statistics, 2021

State	Civilian Labor Force	Employed	Unemployed	Unemployment Rate (%)
Arizona	3,401,906	3,210,791	191,115	5.6
California	19,980,462	18,676,721	1,303,741	6.5
Colorado	3,120,868	2,975,830	145,038	4.6
Idaho	883,059	847,426	35,633	4.0
Montana	548,944	526,641	22,303	4.1
Nevada	1,538,959	1,429,447	109,512	7.1
New Mexico	952,564	889,428	63,136	6.6
Oregon	2,146,693	2,026,107	120,586	5.6
Utah	1,648,313	1,590,143	58,170	3.5
Washington	3,899,915	3,701,656	198,259	5.1
Wyoming	297,398	284,934	12,464	4.2
Total	**38,419,081**	**36,159,124**	**2,259,957**	**5.9**

Source: U.S. Census Bureau (2023d).

Table F.15.2-3. Wage and Salary Employment by Industry, by State, 2021

Sector	Arizona	California	Colorado	Idaho	Montana	Nevada	New Mexico	Oregon	Utah	Washington	Wyoming
Agriculture, forestry, fishing and hunting	25,558	372,203	35,371	34,772	25,250	5,540	16,462	57,078	11,510	85,475	9,141
Mining, quarrying, and O&G extraction	14,490	22,678	27,871	3,616	7,579	14,330	19,156	1,577	11,542	3,691	19,765
Utilities	30,309	140,812	25,471	8,545	4,923	9,693	9,646	16,014	10,651	28,857	4,982
Construction	234,633	1,235,586	241,173	73,007	44,526	106,802	64,942	134,188	120,843	264,308	23,675
Manufacturing	231,395	1,676,715	206,005	82,213	25,547	71,225	36,095	223,581	162,392	348,181	11,895
Wholesale and retail trade	456,253	2,420,891	379,955	121,265	75,284	192,455	113,857	288,085	220,916	526,720	37,237
Transportation and warehousing	150,012	930,369	122,572	34,173	22,774	84,221	30,935	76,852	72,443	179,449	12,616
Finance, insurance, and real estate services (FIRE)	278,873	1,107,961	216,069	48,525	27,542	82,334	42,853	111,713	114,823	195,068	13,159
Services, not incl. FIRE	1,634,121	9,905,030	1,582,702	399,132	262,904	801,411	486,691	1,022,278	790,318	1,886,028	134,595
Public administration	155,167	864,476	138,641	42,178	30,312	61,436	68,791	94,741	74,705	183,879	17,869
Total	**3,210,791**	**18,676,721**	**2,975,830**	**847,426**	**526,641**	**1,429,447**	**889,428**	**2,026,107**	**1,590,143**	**3,701,656**	**284,934**

Source: U.S. Census Bureau (2023e).

Table F.15.2-4. Personal and Median Household Income, by State

State	Total Personal Income ($m, 2022)	Median Household Income (2021)
Arizona	417,021	65,913
California	3,018,471	84,097
Colorado	433,128	80,184
Idaho	105,748	63,377
Montana	64,811	60,560
Nevada	194,741	65,686
New Mexico	108,836	54,020
Oregon	266,139	70,084
Utah	195,834	79,133
Washington	589,368	82,400
Wyoming	41,465	68,002
Total	**5,435,564**	**--**

Source: U.S. Department of Commerce (2023).

Table F.15.2-5. Low-income Communities, by State, 2020

State	Communities with More Than 50% Low-income Population	Communities with :ow-income Population Greater Than 100% of County Level
Arizona	184	255
California	288	716
Colorado	66	241
Idaho	56	138
Montana	121	251
Nevada	17	55
New Mexico	199	266
Oregon	65	216
Utah	30	138
Washington	71	288
Wyoming	25	98
Total	**1,122**	**2,662**

Table F.15.2-6. Housing Characteristics, by State, 2021

	Housing Units			Vacancy Rate	
State	Owner-occupied	Renter-occupied	Vacant	Homeowner	Rental
Arizona	1,765,658	917,899	373,333	1.3	5.0
California	7,335,247	5,882,339	1,110,953	1.0	3.9
Colorado	1,473,449	754,483	226,941	9.0	5.1
Idaho	471,036	186,065	85,044	9.0	4.0
Montana	301,421	135,060	76,072	1.2	6.3
Nevada	659,671	482,281	127,894	1.4	6.9
New Mexico	543,834	253,762	139,801	1.5	7.3
Oregon	1,047,165	610,926	140,773	0.9	3.6
Utah	729,074	304,577	99,907	0.7	5.7
Washington	1,864,897	1,066,944	238,834	0.8	3.9
Wyoming	165,359	65,294	41,165	1.3	10.8
Total	**16,356,811**	**10,659,630**	**2,660,737**	**--**	**--**

Source: U.S. Census Bureau (2023f).

Table F.15.2-7. Sales and Income Taxes, by State, 2021 ($ in millions)

State	Sales Tax	Individual Income Tax	Corporate Income Tax
Arizona	12.0	5.4	0.5
California	57.8	100.1	13.8
Colorado	8.2	8.2	0.8
Idaho	1.9	17.0	0.3
Montana	0.7	1.4	0.2
Nevada	6.3	0.0	0.0
New Mexico	4.2	1.6	0.2
Oregon	2.5	9.8	1.0
Utah	4.0	5.0	0.5
Washington	21.7	0.0	0.0
Wyoming	0.9	0.0	0.0
Total	**120.2**	**148.5**	**17.3**

Sources: U.S Bureau of the Census (2023g).

Table F.15.2-8. State and Local Government Revenues and Expenditures, 2019 ($ in millions)

State	Revenues	Expenditures
Arizona	58.5	66.6
California	530.1	644.2
Colorado	58.5	66.6
Idaho	13.6	15.3
Montana	10.3	11.3
Nevada	26.5	29.9
New Mexico	25.6	25.8
Oregon	50.0	60.0
Utah	31.5	35.3
Washington	85.4	100.7
Wyoming	8.8	10.0
Total	**898.8**	**1,065.7**

Source: U.S Bureau of the Census (2023g).

Table F.15.2-9. State and Local Government Employment, 2021

State	Total Employment	Level of Service	Uniformed Police Officers	Level of Service[1]
Arizona	279,186	39.4	14,467	2.0
California	1,833,630	46.5	26,056	0.7
Colorado	310,490	54.3	11,756	2.1
Idaho	86,373	47.7	3,086	1.7
Montana	59,524	55.2	1,901	1.8
Nevada	113,899	37.2	5,774	1.9
New Mexico	120,044	56.9	4,307	2.0
Oregon	207,693	49.4	6,177	1.5
Utah	163,762	50.7	4,699	1.5
Washington	386,327	50.7	10,525	1.4
Wyoming	49,937	86.6	1,472	2.6
Total	**3,610,865**	**47.6**	**90,220**	**1.2**
State	**Firefighters**	**Level of Service**	**Teachers**	**Level of Service**
Arizona	8,430	1.2	67,834	9.6
California	37,876	1.0	405,595	10.3
Colorado	7,196	1.3	76,385	13.3
Idaho	1,447	0.8	24,167	13.3
Montana	673	0.6	16,524	15.3
Nevada	2,433	0.8	33,639	11.0
New Mexico	2,325	1.1	30,338	14.4
Oregon	3,827	0.9	48,752	11.6
Utah	2,714	0.8	39,155	12.1
Washington	8,875	1.2	78,512	10.3
Wyoming	426	0.7	12,859	22.2
Total	**76,222**	**1.0**	**833,760**	**11.0**

[1] Level of service is the number of employees per 1,000 population in each state in 2021.

Source: U.S. Census Bureau (2023g).

F.15.3 Supplemental Material for Impacts Assessment

No supplemental material to the socioeconomics impacts assessment (Section 5.15).

F.16 Specially Designated Areas and Lands with Wilderness Characteristics

F.16.1 Methods Used for Evaluation

The information presented in the Affected Environment and Impacts sections was derived from scientific literature, other solar environmental assessments, BLM data, BLM manuals and handbooks, and spatial analyses conducted using GIS. Information provided included the number, acreage, or miles of specially designated areas and Lands with Wilderness Characteristics (LWCs – those for which an applicable land use plans have designated for protection) in the 11-state planning area. As these areas are excluded from solar energy development; potential impacts would occur from indirect impacts on visitor experience resulting from fugitive dust, visual disturbance, noise, and lighting, which could reduce opportunities for solitude or outstanding opportunities for primitive and unconfined types of recreation.

General information on, and management of, specially designated areas and LWCs are provided. Tables summarizing acres and/or miles of specially designated areas and LWCs within BLM-administered lands within each of the states are provided below (Section F.16.2). Figures showing their locations are also included in Section F.16.2. The impact analysis focuses on whether construction, operation, maintenance, and decommissioning solar projects would conflict with the status or management goals of the specially designated areas or LWCs. The analysis reviews solar energy development relative to the specific legislation and agency guidance documents that pertain to the designation and management of special designation areas and LWCs. These include FLPMA, the Wilderness Act of 1964, National Trails System Act, and relevant BLM policies.

In general, depending on the resources and resource values present, the closer a solar energy facility is to specially designated areas or LWCs, the more likely inadvertent encroachment on the area, and a higher probability that its resource values would be adversely affected by solar energy development. While there is an inherent subjectivity in this type of analysis, impact assessments of these special areas draw heavily on the visual analysis completed and recorded in the Visual Resource sections in this Solar Programmatic EIS (Section 5.19) and on the professional judgment of the analysis team with respect to the potential sensitivity of the area to the presence of solar energy development.

It is not possible to quantitatively analyze impacts in this Solar Programmatic EIS due to the broad scope of the report and the numerous specially designated areas and LWCs that occur within the 11-state planning area. Alternatives with larger areas of intersection with specially designated areas and LWCs may have a greater impact compared to those alternatives with smaller intersection areas. Actual impact magnitudes on specially designated areas and LWCs would depend on the location of projects, project-specific design, and application of design features and other mitigation measures.

F.16.2 Supplemental Material for Affected Environment

The following tables summarize the specially designated areas and LWCs within the 11-state planning area; while Figures F.16.2-1 through F.16.2-4 show their locations within BLM-administered lands.

Table F.16.2-1. National Conservation Areas (NCAs)

State	Number	BLM Acreage
Arizona	3	120,170
California	3[a]	88,644
Colorado	3	396,810
Idaho	1	483,700
Montana	0	0
Nevada	5	1,208,438
New Mexico	2	251,976
Oregon	1[b]	428,440
Utah	3	138,205
Washington	0	0
Wyoming	0	0
Total	**23**	**4,325,188**

[a] The Piedras Blancas Historic Light Station Outstanding Natural Area is not included based on its coastal location and as it is a component of the California Coastal National Monument. The Alabama Hills National Scenic Area, mostly located within the DRECP, is included.

[b] Steens Mountain Cooperative Management and Protection Area in Oregon is included. However, the Yaquina Head Outstanding Natural Area in Oregon is not included as it is in an urban area and is located mostly in Pacific coastal waters.

Source: BLM (2023a).

Table F.16.2-2. National Monuments (NMs), 11-state Planning Area

State	Number	BLM Acreage
Arizona[a]	6	2,307,790
California	7	2,142,662
Colorado	2	185,793
Idaho	1	275,076
Montana	2	377,397
Nevada	2	1,000,522
New Mexico	4	749,166
Oregon	1	112,928
Utah	3	2,945,758
Washington	1	970
Wyoming	0	0
Total:	**29**	**10,098,062**

[a] The Baaj Nwaavjo I'tah Kukveni – Ancestral Footprints of the Grand Canyon National Monument area is included in the total area of National Monuments for Arizona. Its acreage was determined from GIS data.

Source: BLM (2022a).

Table F.16.2-3. Wilderness Areas (WAs)

State	Number	BLM Acreage
Arizona	47	1,396,966
California	92	4,125,676
Colorado	5	205,814
Idaho	9	557,644
Montana	1	6,347
Nevada	49	2, 262,411
New Mexico	18	455,794
Oregon	9	254,060
Utah	35	914,079
Washington	1	7,140
Wyoming	0	0
Total:	**263[a]**	**10,185,931**

[a] Some wildernesses areas are in more than one state. These are listed under each state, but are only counted once in the total acreage tallies.

Source: BLM (2022b).

Table F.16.2-4. Wilderness Study Areas (WSAs)

State	Number	BLM Acreage
Arizona	2	59,118
California	59	503,539
Colorado	53	546,969
Idaho	40	554,619
Montana	35	435,084
Nevada	60	2,018,717
New Mexico	48	725,006
Oregon	87	2,645,103
Utah	77	2,795,574
Washington	1	5,554
Wyoming	42	574,401
Total:	**487[a]**	**10,858,496**

[a] Some WSAs are in more than one state. These are listed under each state, but are only counted once in the total tallies.

Source: BLM (2023e).

Table F.16.2-5. National Historic and Scenic Trails (NHTs and NSTs)

State	No. NHT	BLM (mi)	No. NST	BLM (mi)
Arizona	2	76	1	46
California	3	423	1	189
Colorado	1	85	1	1
Idaho	5	582	1	13
Montana	2	347	1	11
Nevada	3	1,147	0	0
New Mexico	2	156	1	192
Oregon	2	24	1	44
Utah	3	583	0	0
Washington	0	0	1	12
Wyoming	5	1,644	1	172
Total:	**9[a]**	**5,024**	**5[a]**	**680**

[a] Because trails cross state lines, the miles of each trail are counted once toward each state it is in and only once toward the overall total.

Source: BLM (2020a).

Table F.16.2-6. Wild and Scenic Rivers (WSRs)

State	Number	BLM Acreage (interim)	Wild (mi)	Scenic (mi)	Recreation (mi)	Total (mi)
Arizona	0	0	0.0	0.0	0.0	0.0
California	10	38,583	55.3	17.2	47.9	120.4
Colorado	0	0	0.0	0.0	0.0	0.0
Idaho	16	100,096	307.9	0.0	4.9	312.8
Montana	1	89,300	64.0	26.0	59.0	149.0
Nevada	0	0	0.0	0.0	0.0	0.0
New Mexico	2	22,851	57.7	12.0	2.5	72.2
Oregon	34	321,388	429.1	122.0	459.3	1,010.4
Utah	12	26,246	24.2	49.3	8.5	82.0
Washington	0	0	0.0	0.0	0.0	0.0
Wyoming	0	0	0.0	0.0	0.0	0.0
Total	**75**	**598,464**	**938.2**	**226.5**	**582.4**	**1,747.1**

Source: BLM (2023f)

Table F.16.2-7. Areas of Critical Environmental Concern (ACECs)

State	Number	BLM (acres)
Arizona	59	992,317
California	189	4,040,071
Colorado	88	739,766
Idaho	99	637,754
Montana	66	454,412
Nevada	54	1,427,980
New Mexico	160	1,125,708
Oregon	187	833,384
Utah	59	753,490
Washington	16	24,483
Wyoming	48	64,529
Total:	**1,025**	**11,093,894**

Source: BLM (2023b)

Table F.16.2-8. Lands with Wilderness Characteristics (LWCs)

State	Number[a]	BLM (acres)
Arizona	89	718,731
California	12	93,677
Colorado	61	481,558
Idaho	0	0
Montana	13	35,210
Nevada	7	239,860
New Mexico	4	53,609
Oregon	21	108,201
Utah	143	455,225
Washington	0	0
Wyoming	2	11,878
Total:	**352**	**2,197,950**

[a] Number of uniquely named areas that are managed for wilderness characteristics. LWCs within DRECP in California are excluded.

Source: BLM (Perfors 2023).

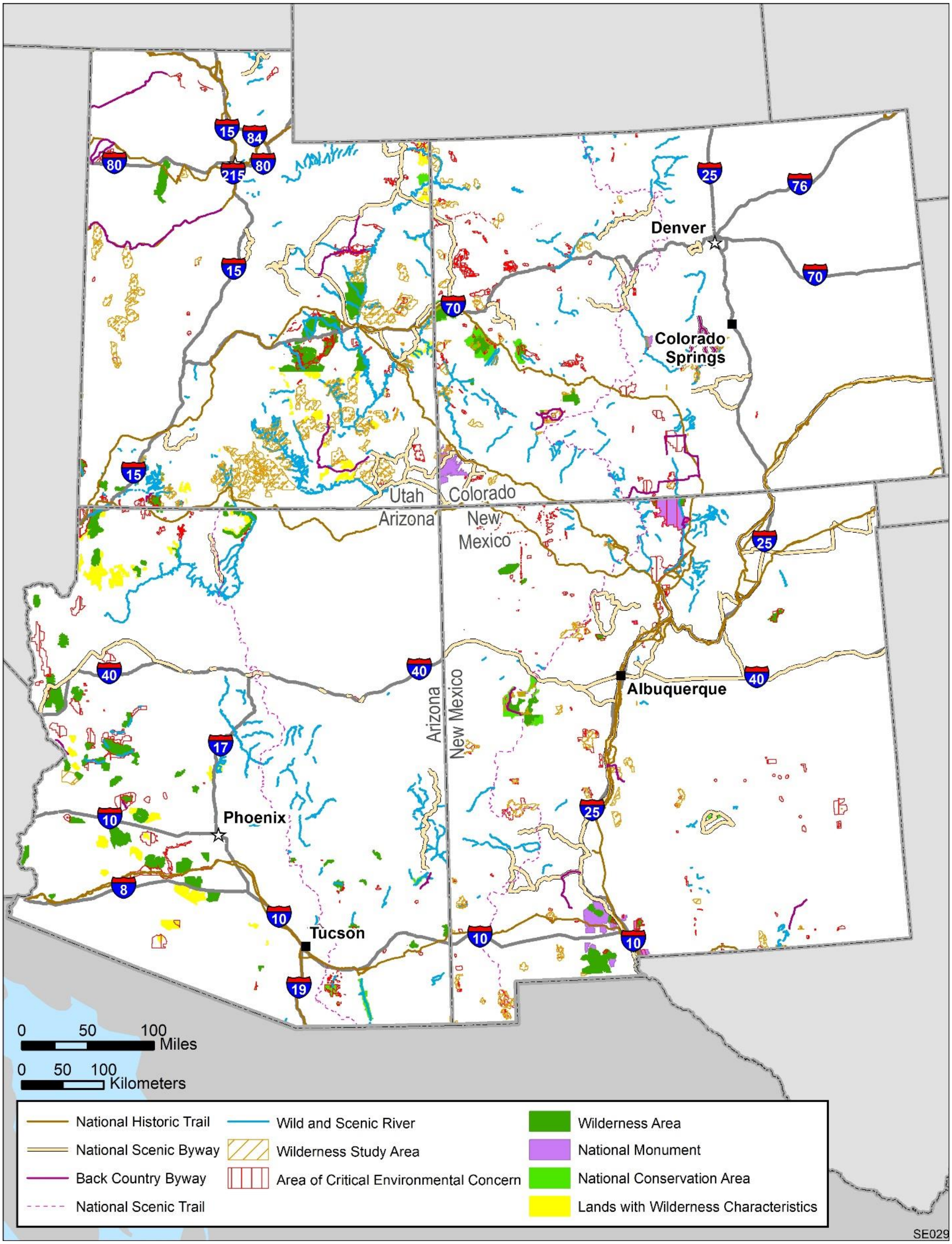


Figure F.16.2-1. Specially Designated Areas and Lands with Wilderness Characteristics: Arizona, Colorado, New Mexico, and Utah

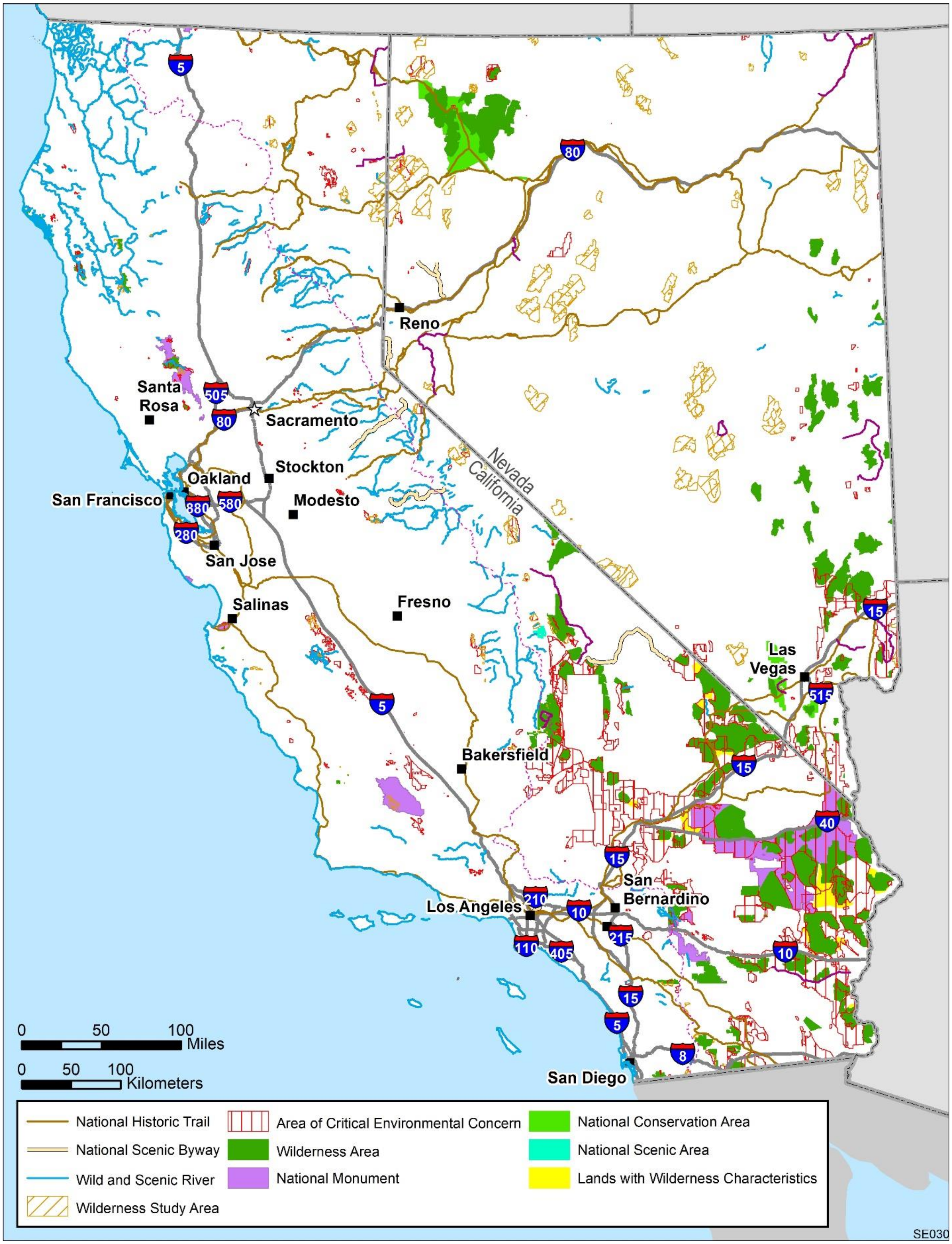


Figure F.16.2-2. Specially Designated Areas and Lands with Wilderness Characteristics: California and Nevada

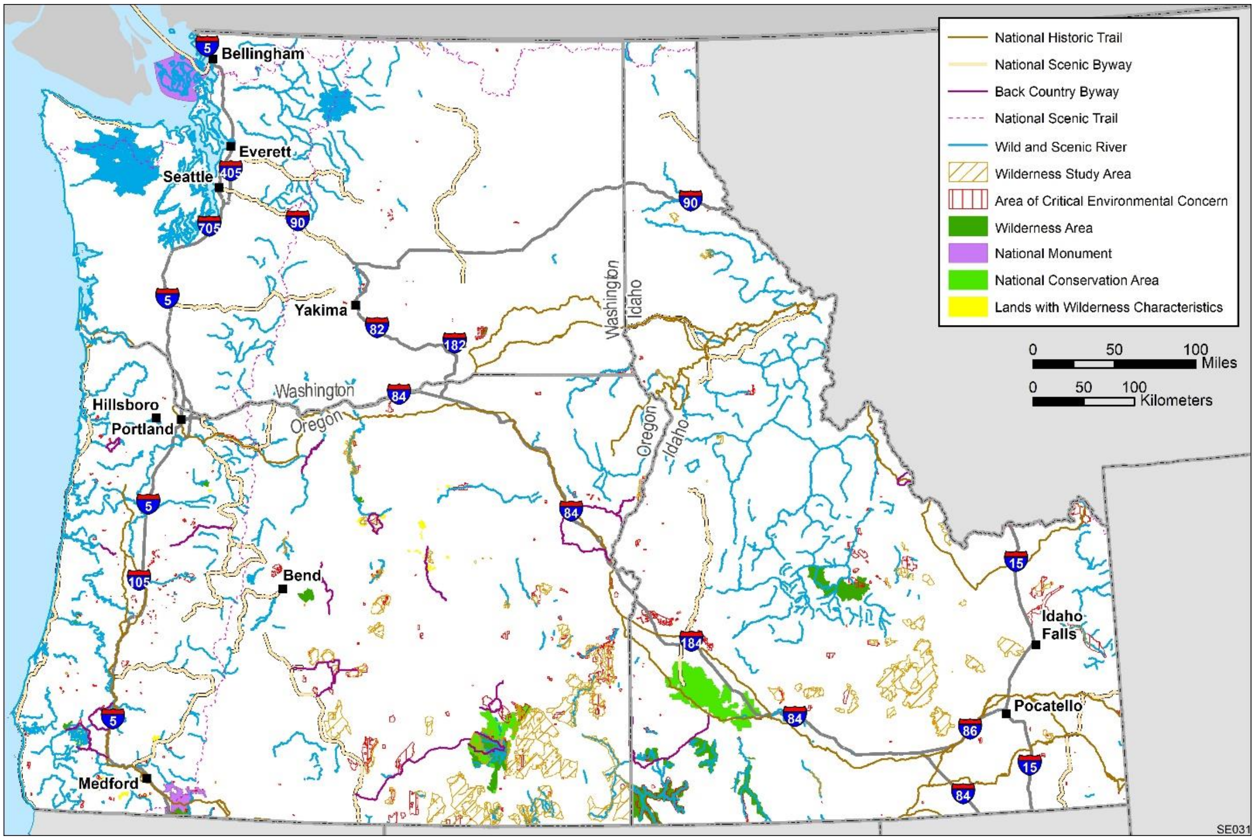


Figure F.16.2-3. Specially Designated Areas and Lands with Wilderness Characteristics: Idaho, Oregon, and Washington

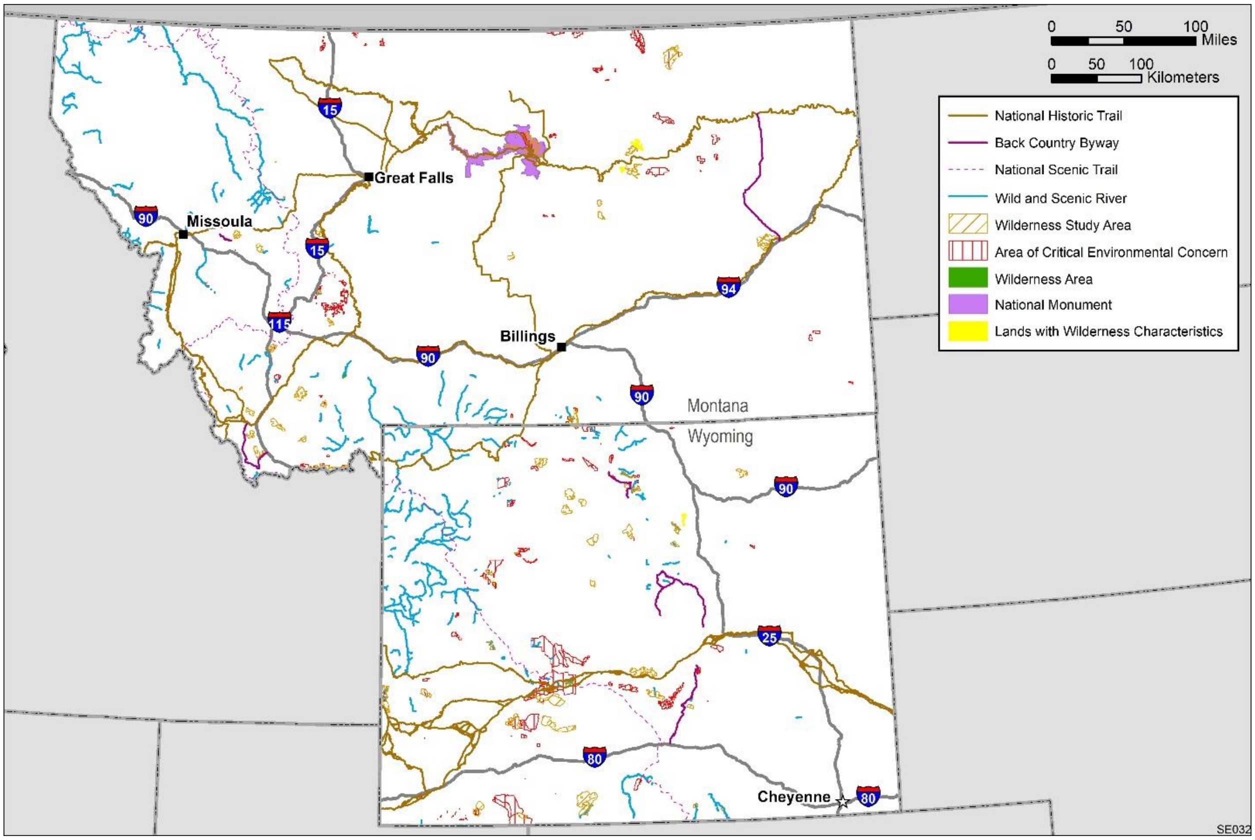


Figure F.16.2-4. Specially Designated Areas and Lands with Wilderness Characteristics: Montana and Wyoming

F.16.3 Supplemental Material for Impacts Assessment

No supplemental material for the specially designated areas and LWCs impacts assessment (Section 5.16).

F.17 Transportation

F.17.1 Methods Used for Evaluation

The information presented in the Affected Environment and Impacts sections was derived from scientific literature, other solar environmental assessments, data available from the Federal Highway Administration and U.S. Bureau of Transportation Statistics, and spatial analyses conducted using GIS. Information provided includes miles of public roads in rural areas and miles of freight railroads in the 11-state planning area. Primary impacts on transportation are expected on local road networks near a solar energy facility, potentially resulting in degradation in the level of service. Project-related traffic on busier transportation corridors, such as interstates or arterial roads would have no notable impact on transportation and are therefore not of concern. Additionally, newly created roads internal to the project area would not be open to the public and are therefore not of concern. Temporary impacts are considered those that would occur during construction or decommissioning; while long-term impacts are those that would occur during the operations period. Effects may occur from physical changes to roads, construction activities, introduction of construction- or operations-related traffic on local roads, or changes in traffic volumes created by either direct or indirect workforce changes in the area.

It is not possible to quantitatively analyze transportation impacts in this Solar Programmatic EIS due to the broad scope of the Solar Programmatic EIS and the numerous roads and railroads that occur within the 11-state planning area. Alternatives with larger areas of intersection with transportation routes may have a greater impact compared to those alternatives with smaller intersection areas. Actual impact magnitudes on transportation would depend on the location of projects, project-specific design, and application of design features and other mitigation measures.

F.17.2 Supplemental Material for Affected Environment

No supplemental material for the transportation affected environment section (Section 4.17).

F.17.3 Supplemental Material for Impacts Assessment

No supplemental material for the transportation impacts assessment (Section 5.17).

F.18 Tribal Interests

F.18.1 Methods Used for Evaluation

Methods used in the assessment of Tribal resources focused on identifying resources that are generally of Tribal concern and include trust assets and resources, traditional cultural properties, burial remains, sacred sites or landscapes, ecological balance and environmental protection, water quality and use, human health and safety, economic development and employment, rights to hunting, fishing, and gathering of specific resources for traditional purposes and use, and access to energy resources (see Section 4.18). A GIS based analysis was used to determine the acreages of Tribal Lands by state and within BLM territory. Previously raised Tribal concerns can be found in Appendix K of the 2012 Western Solar Plan however, this Programmatic EIS does not provide a detailed impact analysis for Tribal Interests because formal consultation needs to occur to identify all Tribal concerns. Consultation for this effort is still ongoing and will be documented in Appendix D of this Programmatic EIS. As discussed in Section 4.18, these issues and concerns shall be viewed and evaluated collectively and concurrently with Tribes using a holistic approach.

BLM identified Affiliated Tribes in the 11-state planning area by contacting BLM Field Offices to determine which Tribes they communicate with regularly for projects in their jurisdiction. Tribes were also found through the 2012 Western Solar Plan that identified Tribes using the National Park Service *Native American Consultation Database* and available information in the records of the Indian Claims Commission and California’s Native American Heritage Commission. A full list of Tribes that may have affiliation with lands within solar-suitable areas is in Appendix D. Any additional Tribes not listed require identification through continuous formal outreach and consultation.

Several disciplines provided data relevant to the evaluation of impacts on potential resources of concern to Tribes. The susceptibility of physical features and landscapes to adverse effects from construction and operation was determined in conjunction with parallel studies of noise, air quality, visual resources (viewsheds), geology, hydrology, and so on. For ecological resources, species important to Tribes were compared with the descriptions of plants and wildlife in the area availble for solar applications to determine whether such species had been observed or were likely in those locations. Additional mitigation measures were suggested by BLM Field Offices and were incorporated. Formal consultation with Tribes shall occur to determine any other concerns regarding impacts to Tribal Interests.

Design Features identified in Appendix B.18 were derived from previous communications with the Tribes, ethnographic studies, and previous NEPA documents used in the 2012 Western Solar Plan. Those documents were examined to determine what forms of mitigation had been acceptable in the past or were suggested as acceptable for the current study. However, further mitigation measures need to be developed following formal consultation with federally recognized Tribes.

F.18.2 Supplemental Material for Affected Environment

No supplemental material for the health and safety affected environment (Section 4.18).

F.18.3 Supplemental Material for Impact Assessment

No supplemental material for the health and safety impacts assessment (Section 5.18).

F.19 Visual Resources

F.19.1 Methods Used for Evaluation

The visual impact assessment used GIS to identify 1) BLM-administered lands available for application under the alternatives, where solar energy development might be located, and 2) those lands and sensitive visual resource areas (SVRAs) outside of the lands available for application from which solar energy development might visible. All lands identified in the analysis would be subject to visual impacts from the development, if, and only if, the solar energy development was actually visible from within these areas, and visually prominent enough to cause a non-negligible impact. The determination of visibility and visual prominence would be undertaken as part of a project-specific environmental assessment where the details of the project’s location, size, and its setting would be available, as would information about specific viewpoints and views of concern.

The analysis identified the BLM-administered lands available for application for each alternative classified by scenic quality rating (A, B, or C). Scenic quality assessment is a component of the BLM's VRI process, as described in BLM's Visual Resource Inventory Manual H8410-1 (BLM 1986a). Available scenic quality data were obtained from BLM, and GIS was used to overlay the footprint of the lands available for application under each alternative onto the scenic quality data. This process resulted in maps showing the distribution of scenic quality rating classes within the lands available for application for each alternative, and a table of the acreages of each rating class value where solar energy development might actually be located.

F.19.2 Supplemental Material for Affected Environment

Figures F.19.2-1 through F.19.2-11 are individual state maps showing scenic quality ratings (derived from VRIs) and SVRAs for the 11-state planning area . The scenic quality factor of the VRI is the direct measure of the quality and quantity of the scenic resource, and so in this Programmatic EIS serves as the primary basis for analysis and discussion of visual impacts. Scenic quality is rated as A, B, or C where an "A" rating reflects the highest scenic quality, a "C" rating reflects the lowest scenic quality, and a "B" rating reflects an intermediate level scenic quality. Also shown are sensitive visual resource areas (SVRAs) both within and outside BLM-administered lands. SVRAs close to the lands available for application could be subject to visual impacts from the development, if, and only if, the solar energy development was actually visible from withing these areas, and visually prominent enough to cause a non-negligible impact.

Figures F.19.2-12 through F.19.2-22 are individual state maps of artificial night sky brightness for the 11-state planning area. These maps were derived from the New World Atlas of Artificial Sky Brightness (Cinzano et al., 2001). For all figures, the first column in the figure inset table gives the ratio between observed artificial brightness and the natural background sky brightness (assumed to be 174 μcd/m^2). For example, areas shown in red on the map have night sky brightness values approximately 5-10 times brighter than completely unlit natural areas. The second column gives the brightness contributed by artificial light sources (μcd/m2); the third column gives the approximate total brightness (mcd/m^2). Units of brightness are microcandellas/square meter, and millicandellas/square meter. The candela is a measure of visual intensity of light sources as perceived by humans.

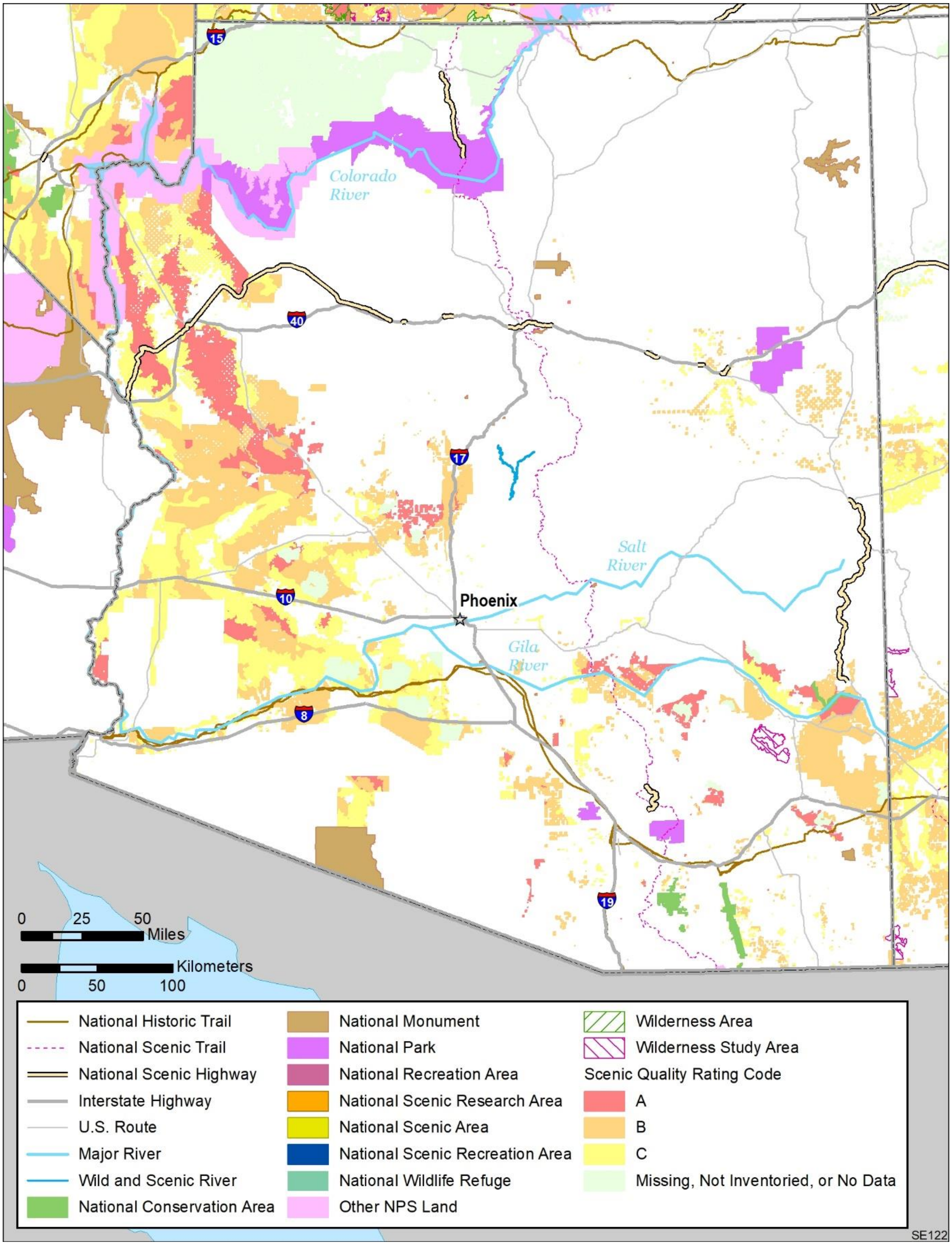


Figure F.19.2-1. Scenic Quality Ratings on BLM-administered Lands and SVRAs in Arizona (Sources: BLM and Argonne National Laboratory)

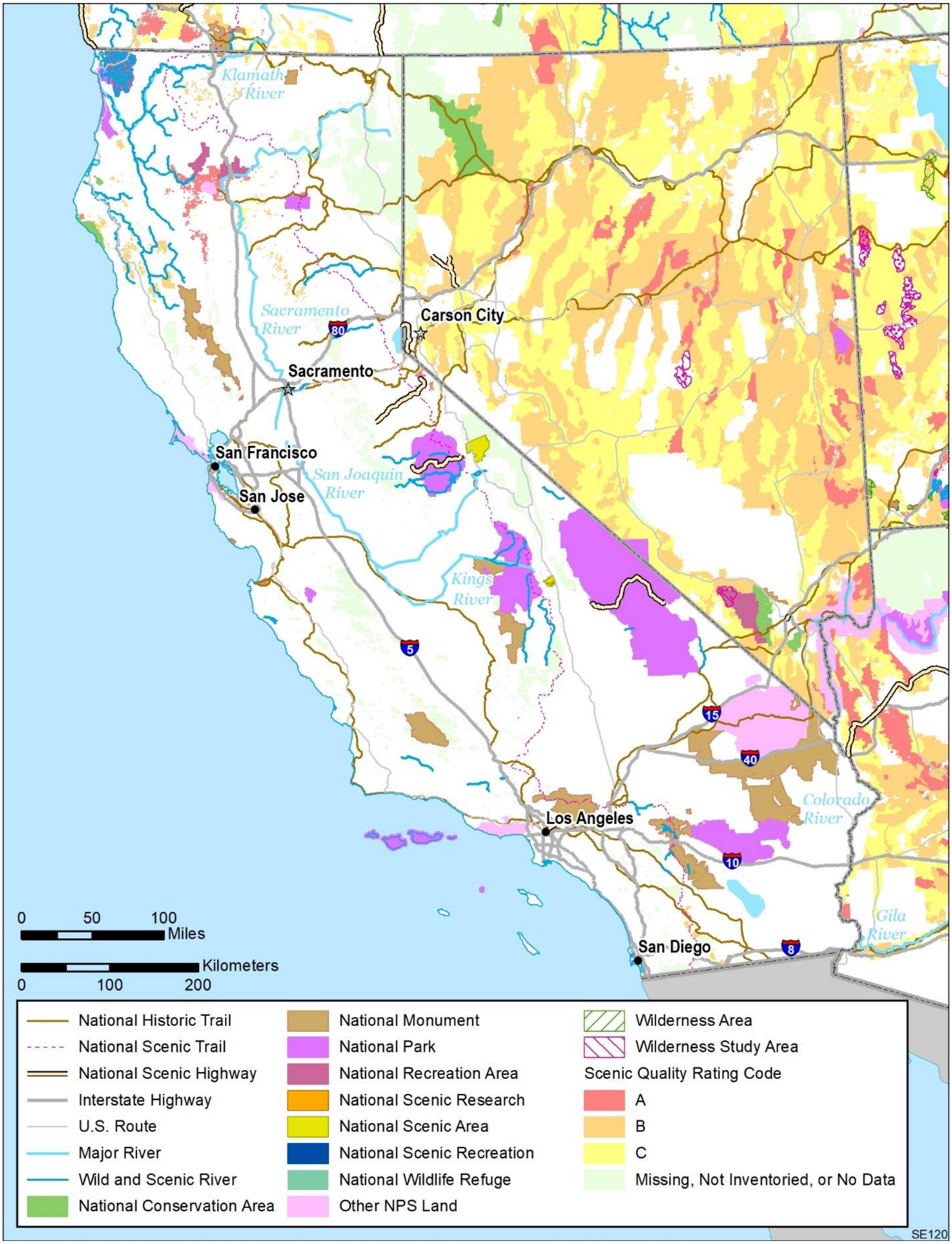


Figure F.19.2-2. Scenic Quality Ratings on BLM-administered Lands and SVRAs in California (Sources: BLM and Argonne National Laboratory)

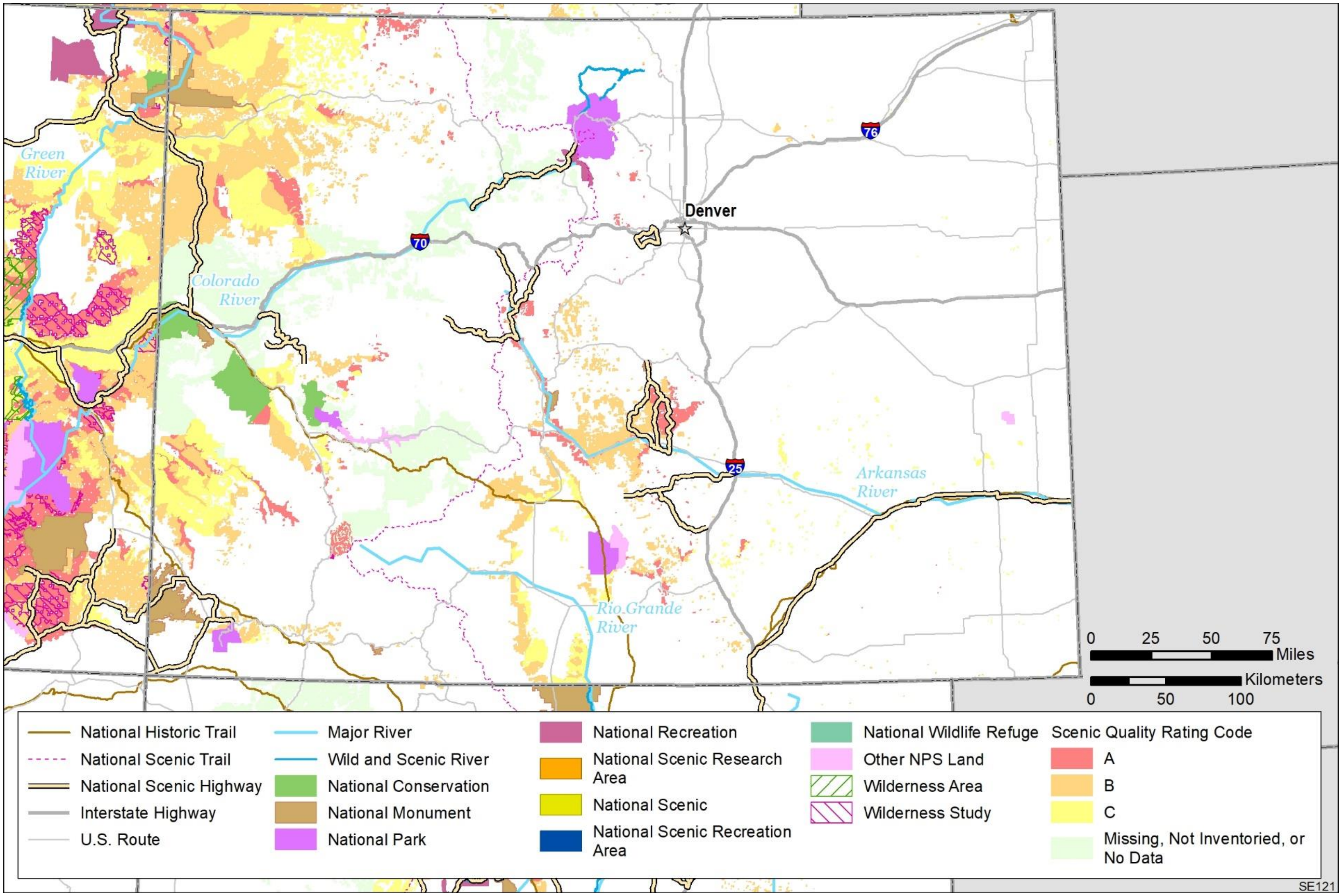


Figure F.19.2-3. Scenic Quality Ratings on BLM-administered Lands and SVRAs in Colorado (Sources: BLM and Argonne National Laboratory)

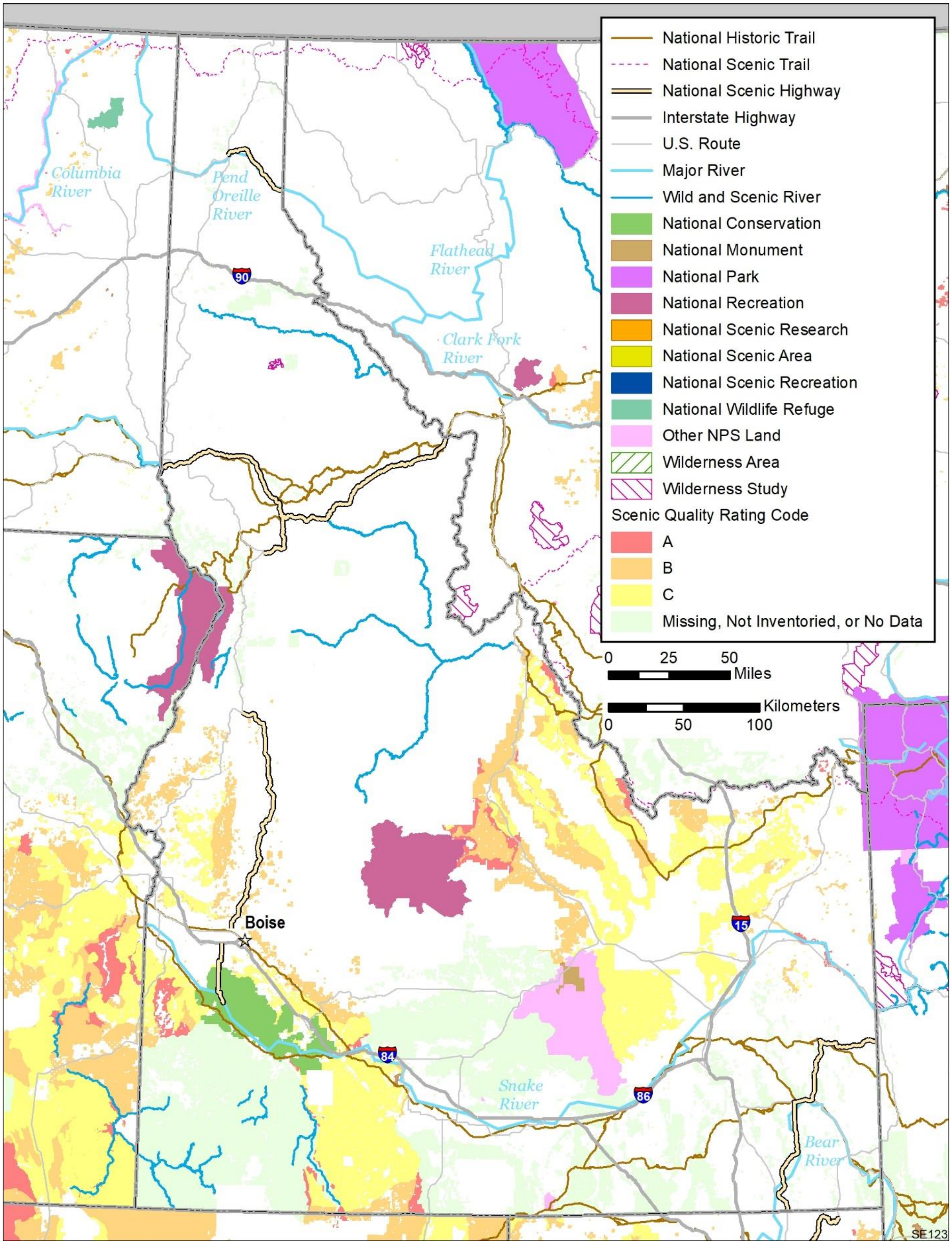


Figure F.19.2-4. Scenic Quality Ratings on BLM-administered Lands and SVRAS in Idaho (Sources: BLM and Argonne National Laboratory)

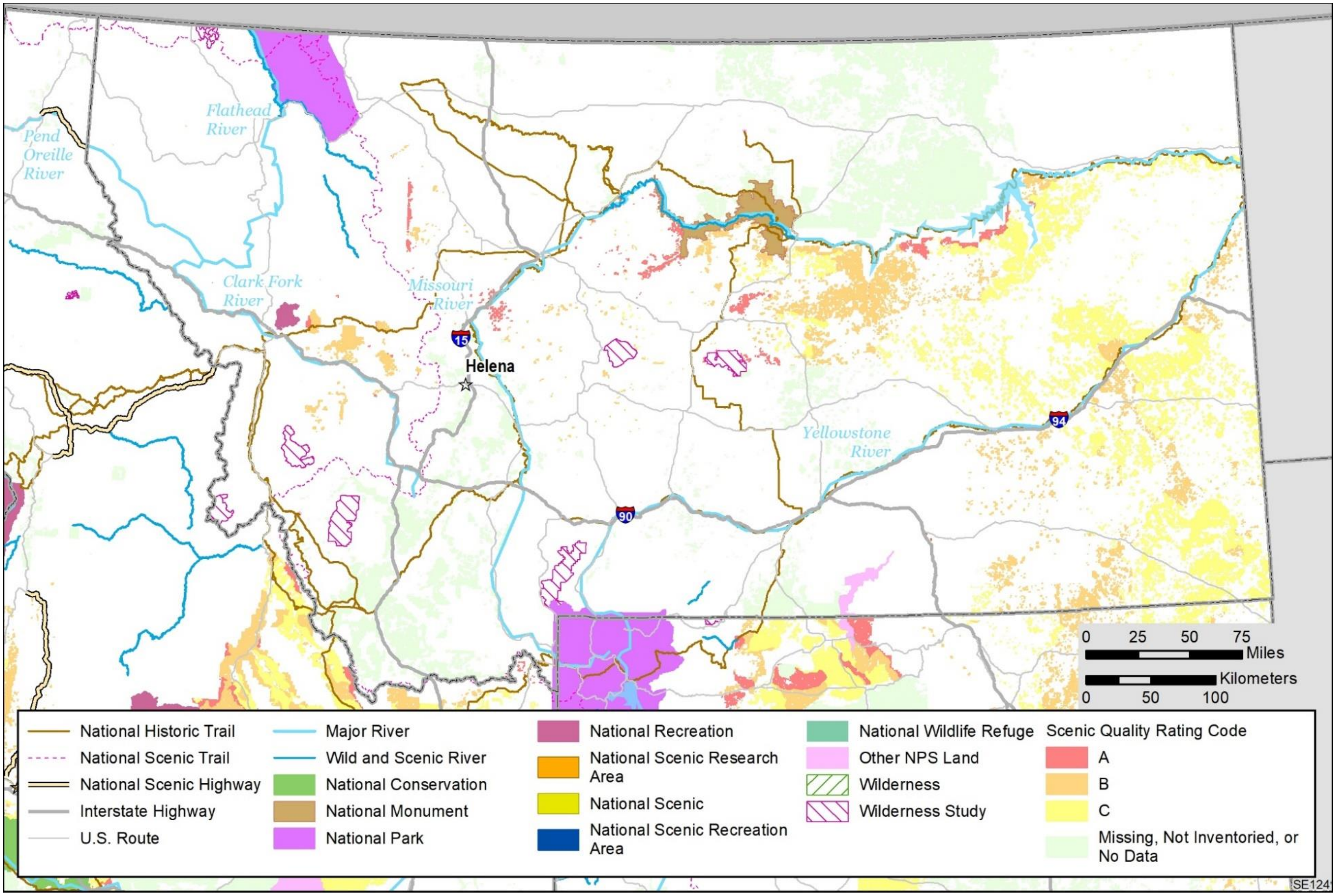


Figure F.19.2-5. Scenic Quality Ratings on BLM-administered Lands and SVRAs in Montana (Sources: BLM and Argonne National Laboratory)

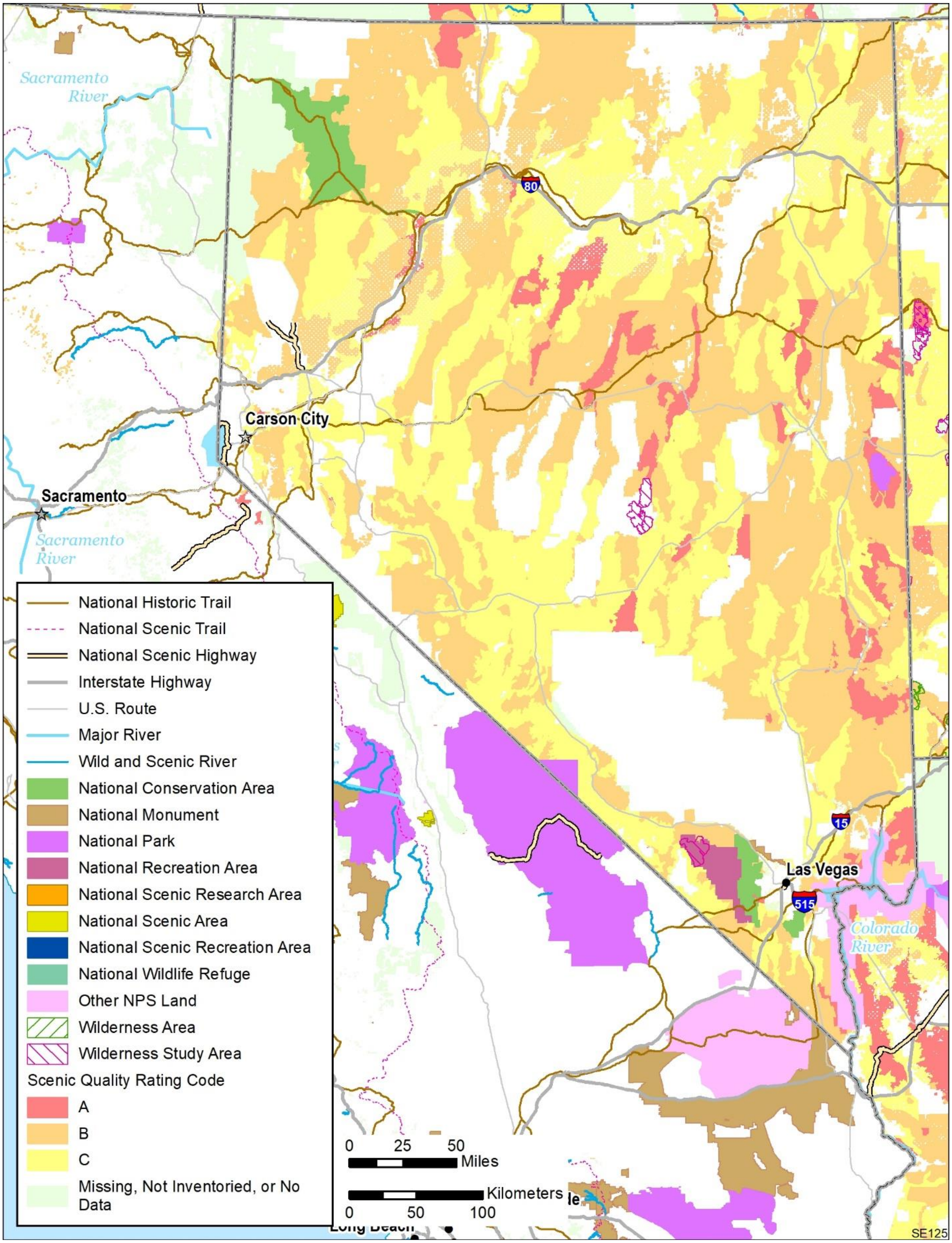


Figure F.19.2-6. Scenic Quality Ratings on BLM-administered Lands and SVRAs in Nevada (Sources: BLM and Argonne National Laboratory)

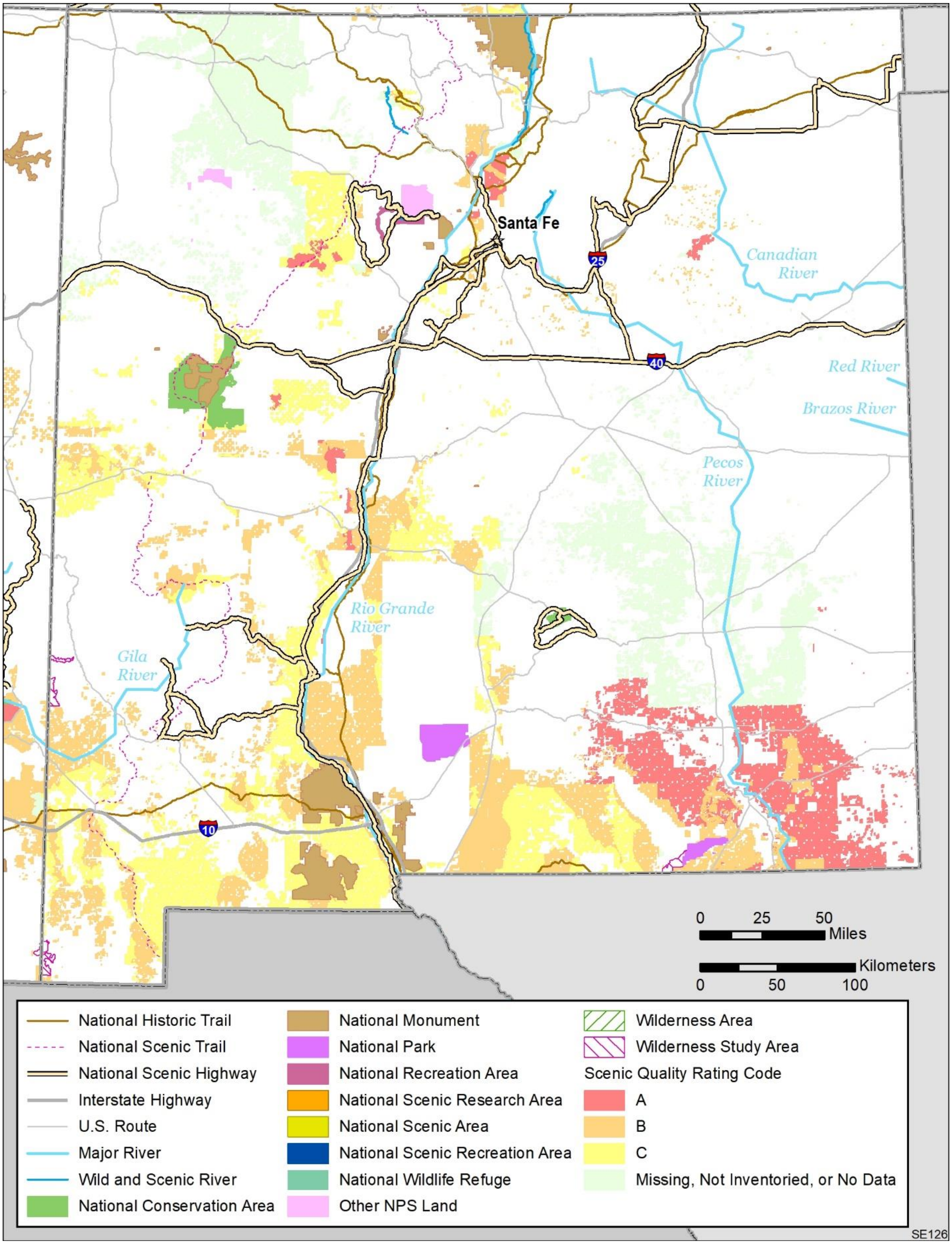


Figure F.19.2-7. Scenic Quality Ratings on BLM-administered Lands and SVRAs in New Mexico (Sources: BLM and Argonne National Laboratory)

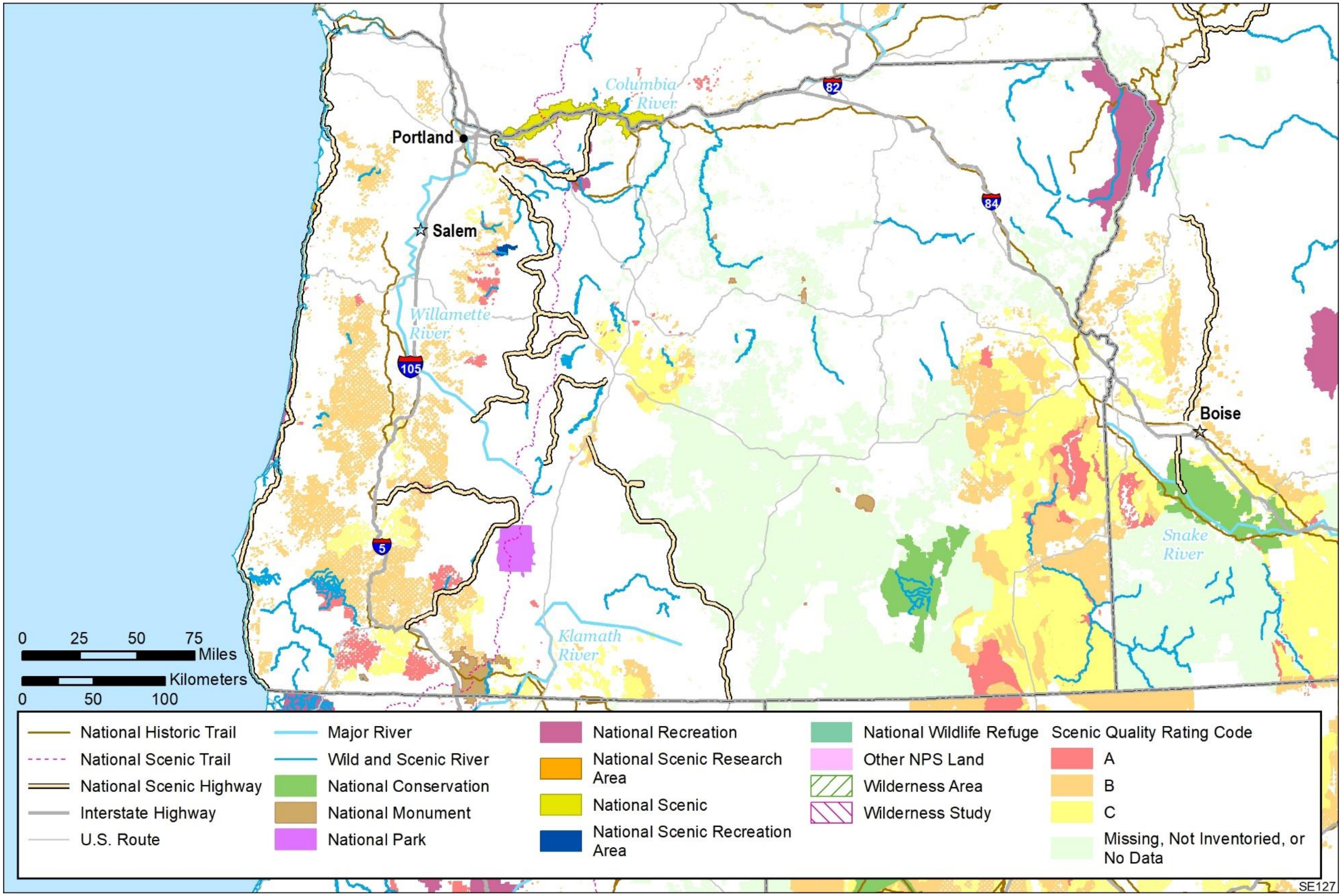


Figure F.19.2-8. Scenic Quality Ratings on BLM-administered Lands and SVRAs in Oregon (Sources: BLM and Argonne National Laboratory)

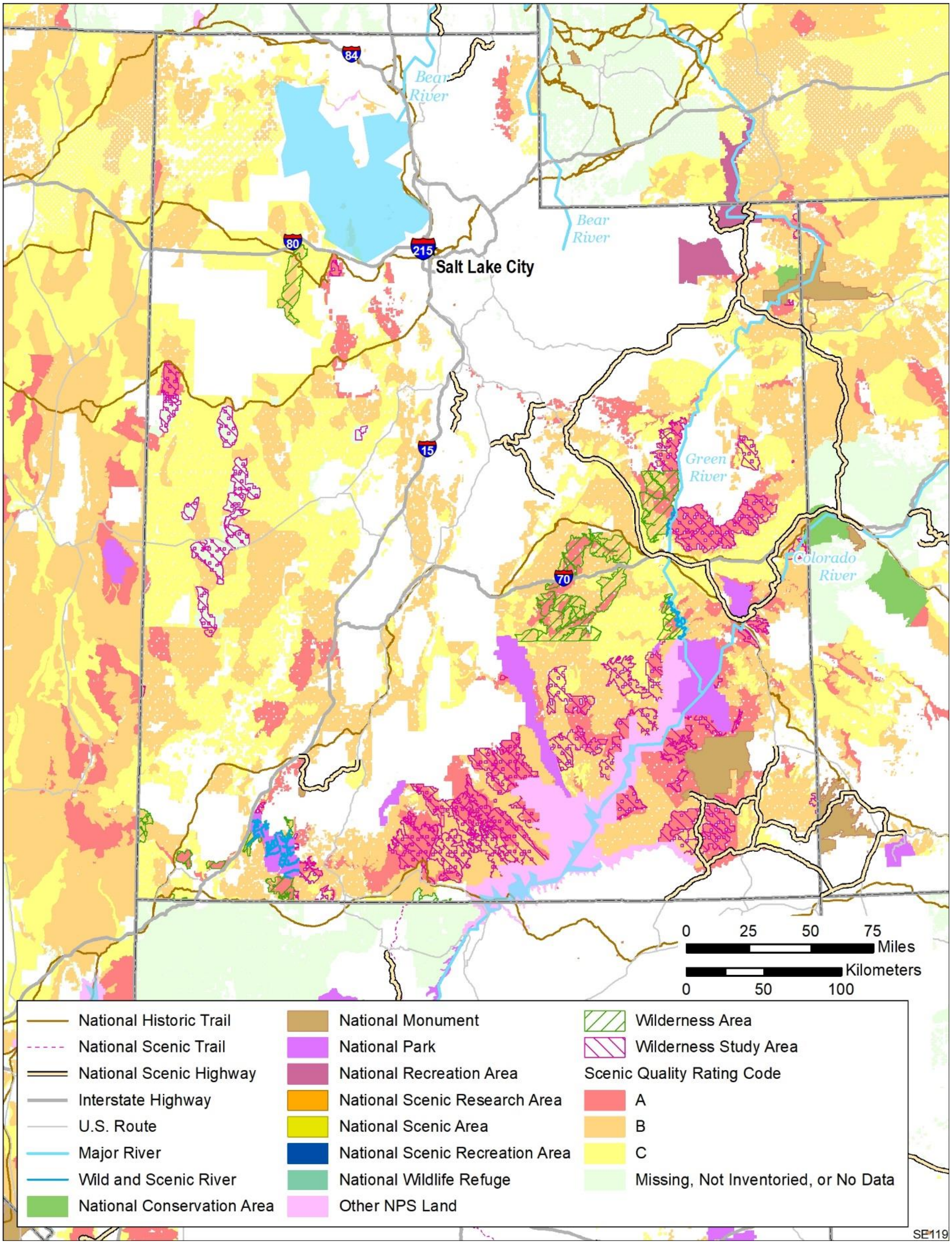


Figure F.19.2-9. Scenic Quality Ratings on BLM-administered Lands and SVRAs in Utah (Source: BLM and Argonne National Laboratory.)

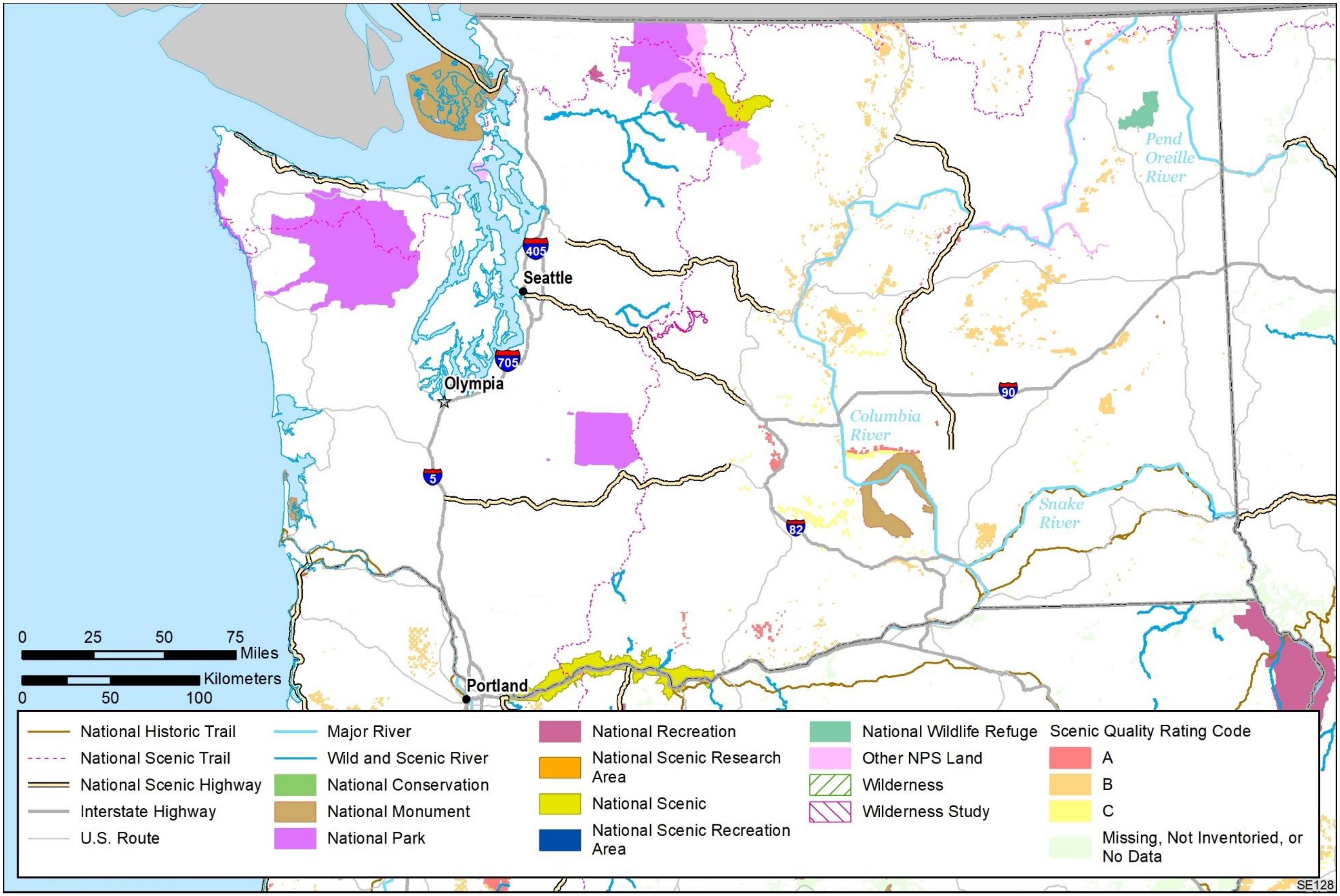


Figure F.19.2-10. Scenic Quality Ratings on BLM-administered Lands and SVRAs in Washington (Source: BLM and Argonne National Laboratory.)

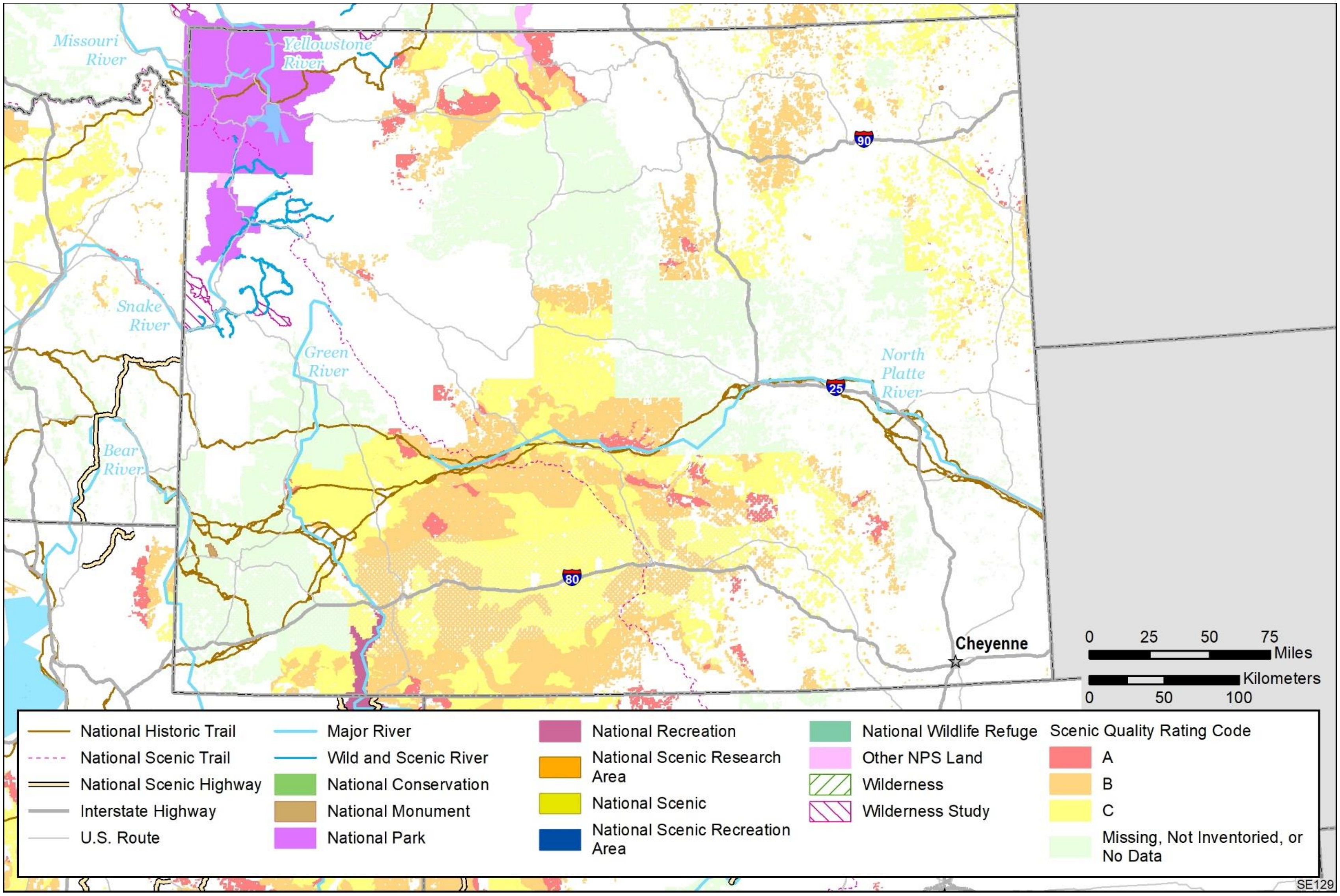
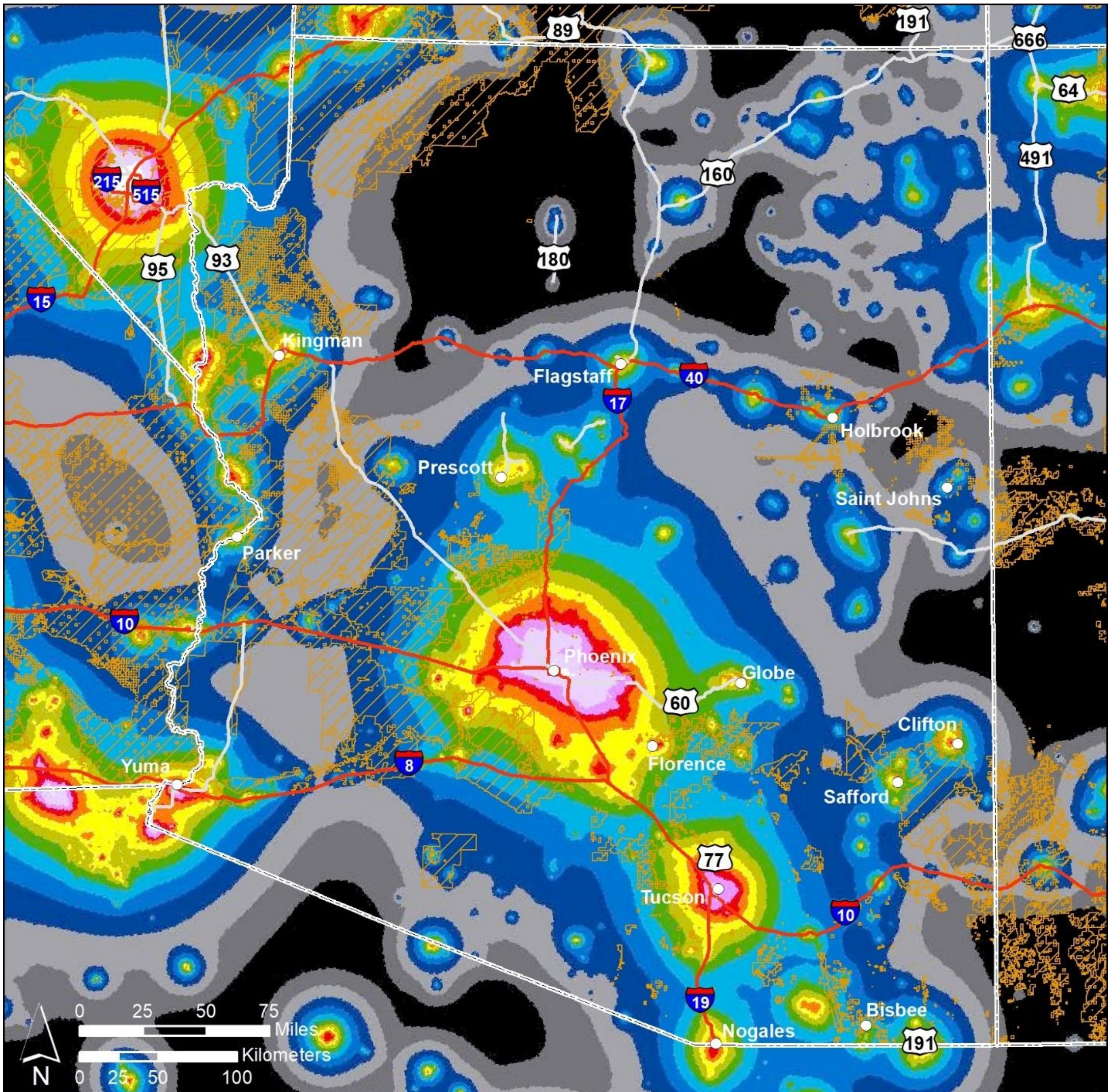


Figure F.19.2-11. Scenic Quality Ratings on BLM-administered Lands and SVRAs in Wyoming (Source: BLM and Argonne National Laboratory.)



	Ratio to Natural Brightness	Artificial Brightness (µcd/m2)	Approximate Total Brightness (mcd/m2)		Ratio to Natural Brightness	Artificial Brightness (µcd/m2)	Approximate Total Brightness (mcd/m2)
	<0.01	<1.74	<0.176		0.64–1.28	111–223	0.285–0.397
	0.01–0.02	1.74–3.48	0.176–0.177		1.28–2.56	223–445	0.397–0.619
	0.02–0.04	3.48–6.96	0.177–0.181		2.56–5.12	445–890	0.619–1.065
	0.04–0.08	6.96–13.9	0.181–0.188		5.12–10.2	890–1,780	1.07–1.96
	0.08–0.16	13.9–27.8	0.188–0.202		10.2–20.5	1,780–3,560	1.96–3.74
	0.16–0.32	27.8–55.7	0.202–0.230		20.5–41	3,560–7,130	3.74–7.30
	0.32–0.64	55.7–111	0.230–0.285		>41	>7,130	>7.30

SE052

Figure F.19.2-12. Artificial Night Sky Brightness and BLM-administered lands (hatched areas) in Arizona (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)

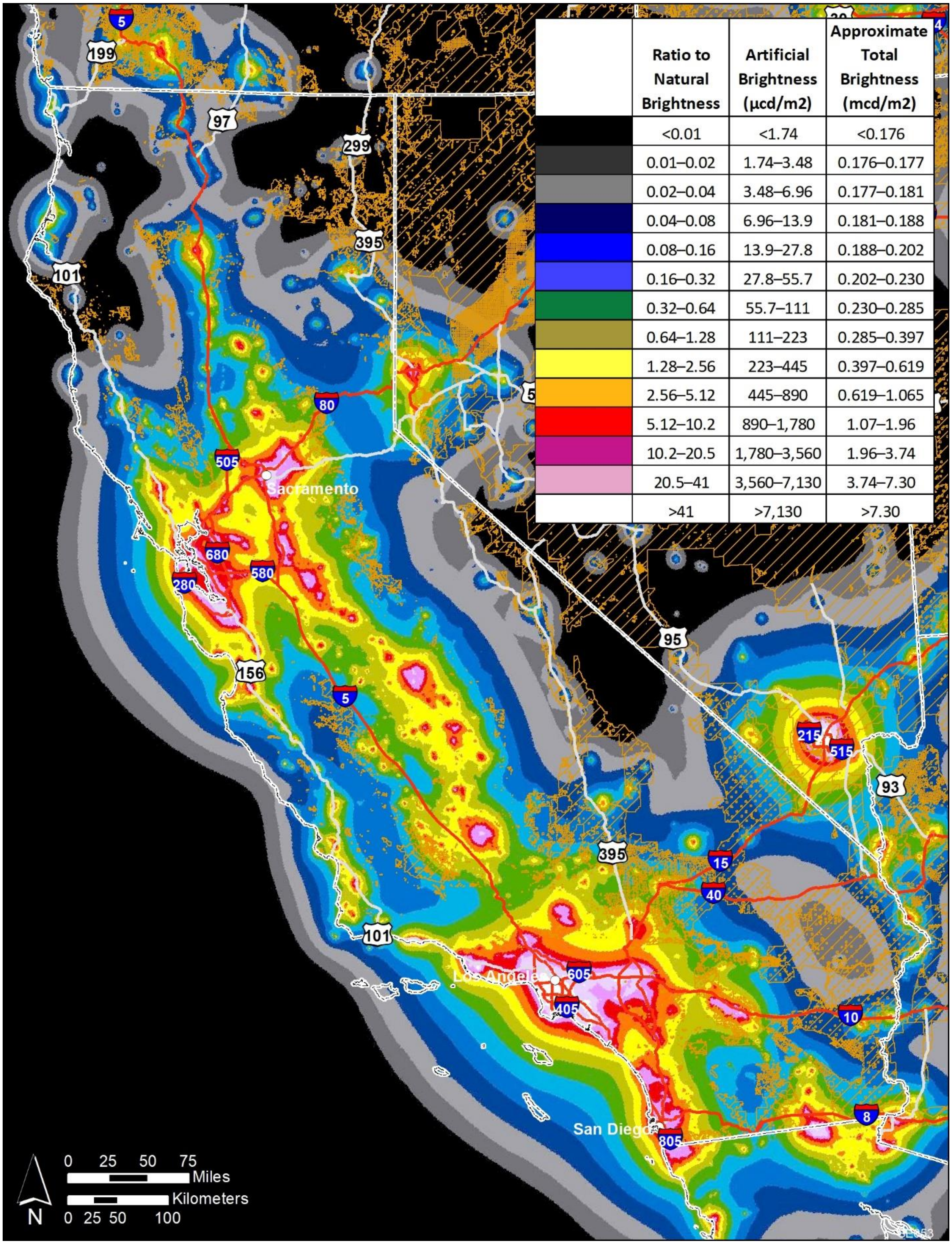
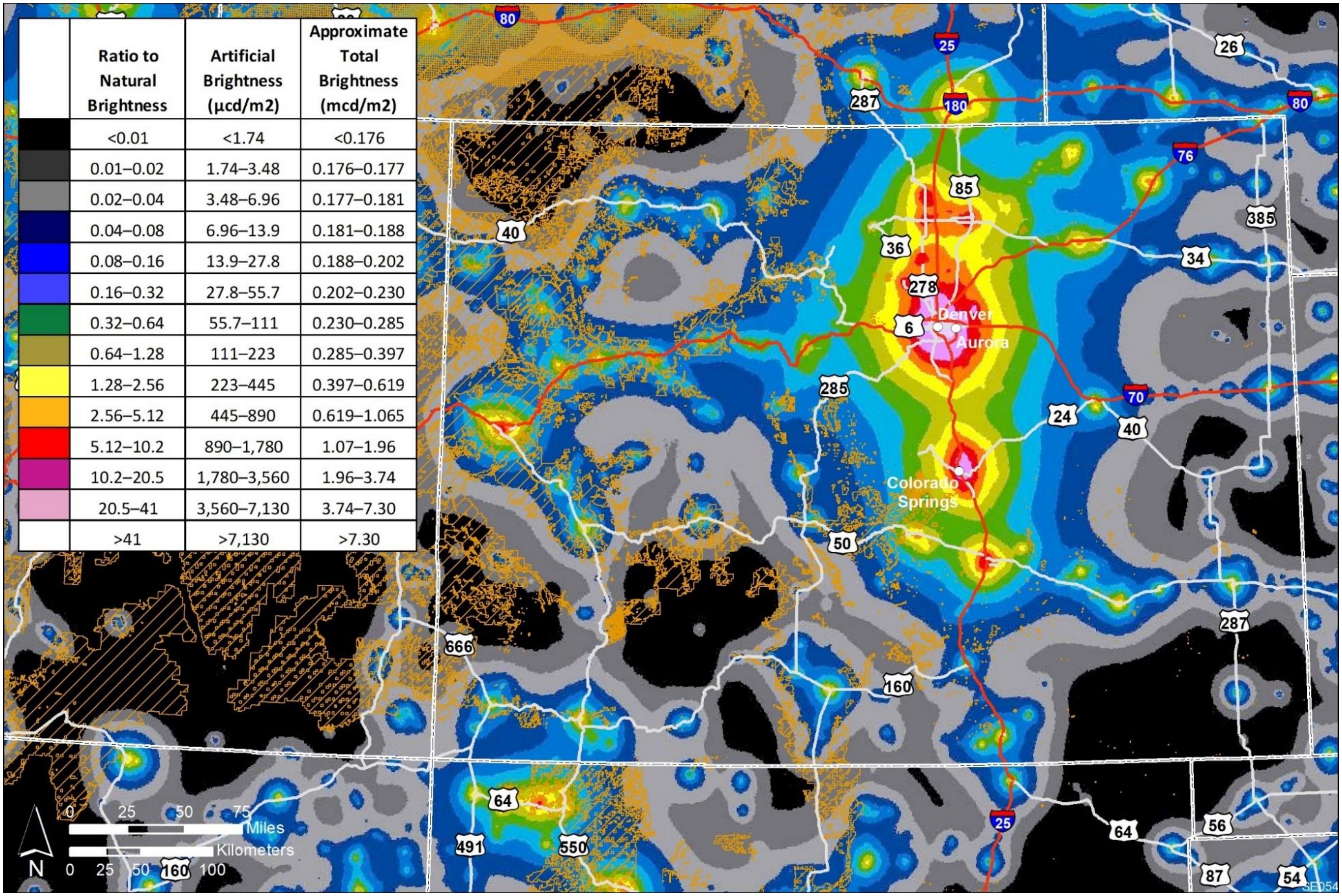


Figure F.19.2-13. Artificial Night Sky Brightness and BLM-administered lands (hatched areas) in California (Sources: New World Atlas of Artificial Sky Brightness Cinzano et al. 2001 and Argonne National Laboratory.)



	Ratio to Natural Brightness	Artificial Brightness (µcd/m2)	Approximate Total Brightness (mcd/m2)
(black)	<0.01	<1.74	<0.176
(dark gray)	0.01–0.02	1.74–3.48	0.176–0.177
(gray)	0.02–0.04	3.48–6.96	0.177–0.181
(dark blue)	0.04–0.08	6.96–13.9	0.181–0.188
(blue)	0.08–0.16	13.9–27.8	0.188–0.202
(light blue)	0.16–0.32	27.8–55.7	0.202–0.230
(green)	0.32–0.64	55.7–111	0.230–0.285
(olive)	0.64–1.28	111–223	0.285–0.397
(yellow)	1.28–2.56	223–445	0.397–0.619
(orange)	2.56–5.12	445–890	0.619–1.065
(red)	5.12–10.2	890–1,780	1.07–1.96
(magenta)	10.2–20.5	1,780–3,560	1.96–3.74
(pink)	20.5–41	3,560–7,130	3.74–7.30
(white)	>41	>7,130	>7.30

Figure F.19.2-14. Artificial Night Sky Brightness and BLM-administered lands (hatched areas) in Colorado (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)

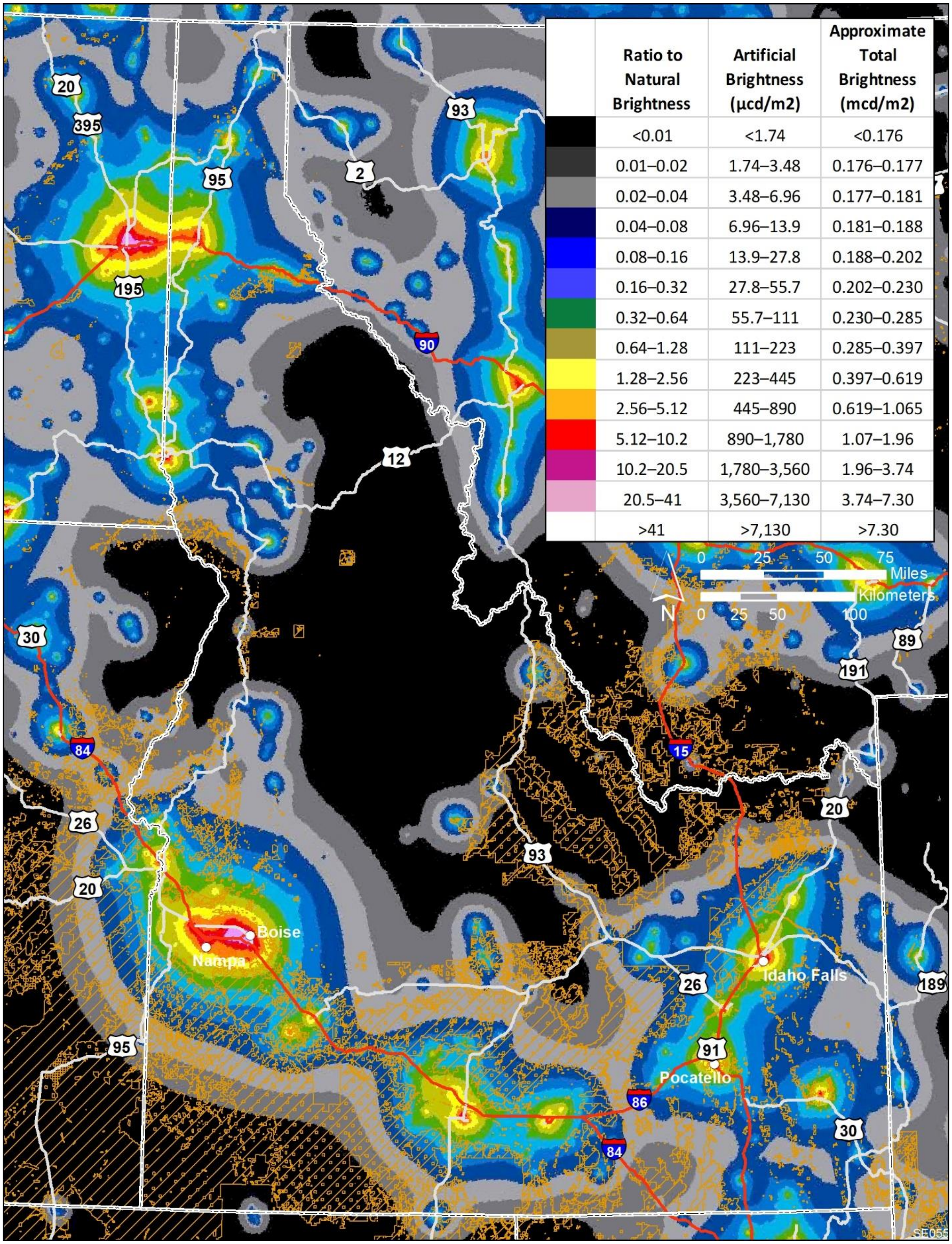
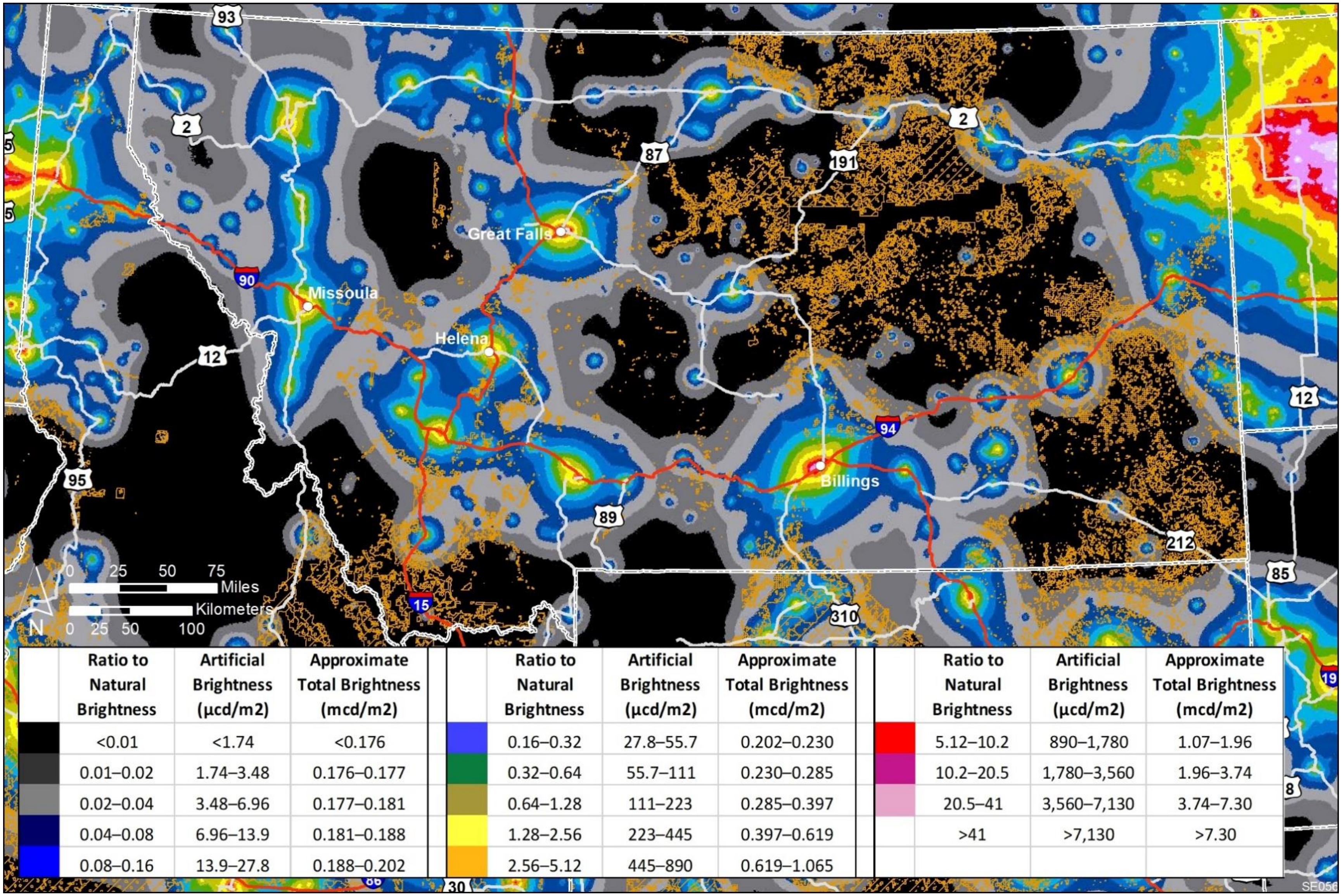


Figure F.19.2-15. Artificial Night Sky Brightness and BLM-administered lands (hatched areas) in Idaho (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)



Ratio to Natural Brightness	Artificial Brightness (μcd/m2)	Approximate Total Brightness (mcd/m2)
<0.01	<1.74	<0.176
0.01–0.02	1.74–3.48	0.176–0.177
0.02–0.04	3.48–6.96	0.177–0.181
0.04–0.08	6.96–13.9	0.181–0.188
0.08–0.16	13.9–27.8	0.188–0.202
0.16–0.32	27.8–55.7	0.202–0.230
0.32–0.64	55.7–111	0.230–0.285
0.64–1.28	111–223	0.285–0.397
1.28–2.56	223–445	0.397–0.619
2.56–5.12	445–890	0.619–1.065
5.12–10.2	890–1,780	1.07–1.96
10.2–20.5	1,780–3,560	1.96–3.74
20.5–41	3,560–7,130	3.74–7.30
>41	>7,130	>7.30

Figure F.19.2-16. Artificial Night Sky Brightness and BLM-administered lands (hatched areas) in Montana (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)

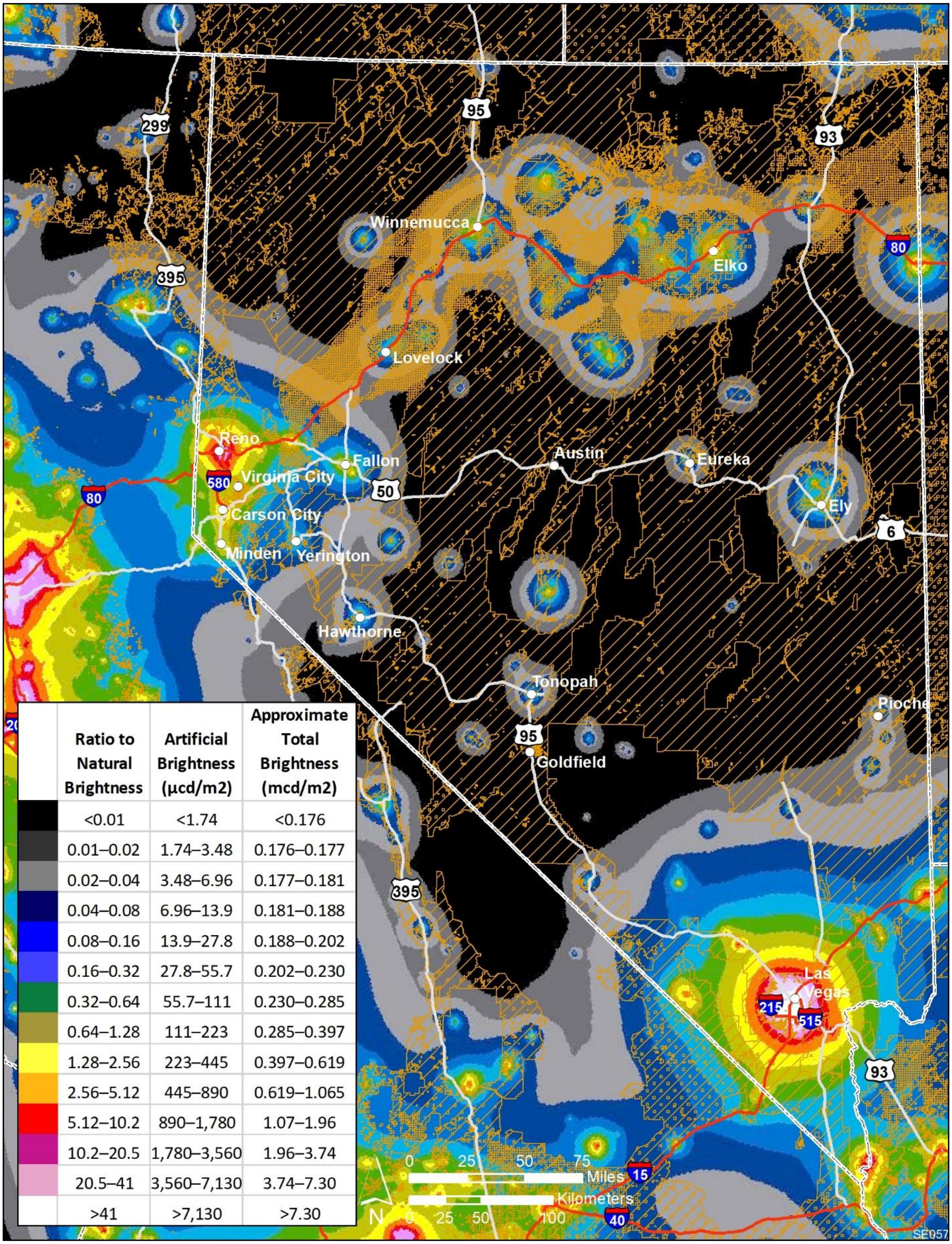
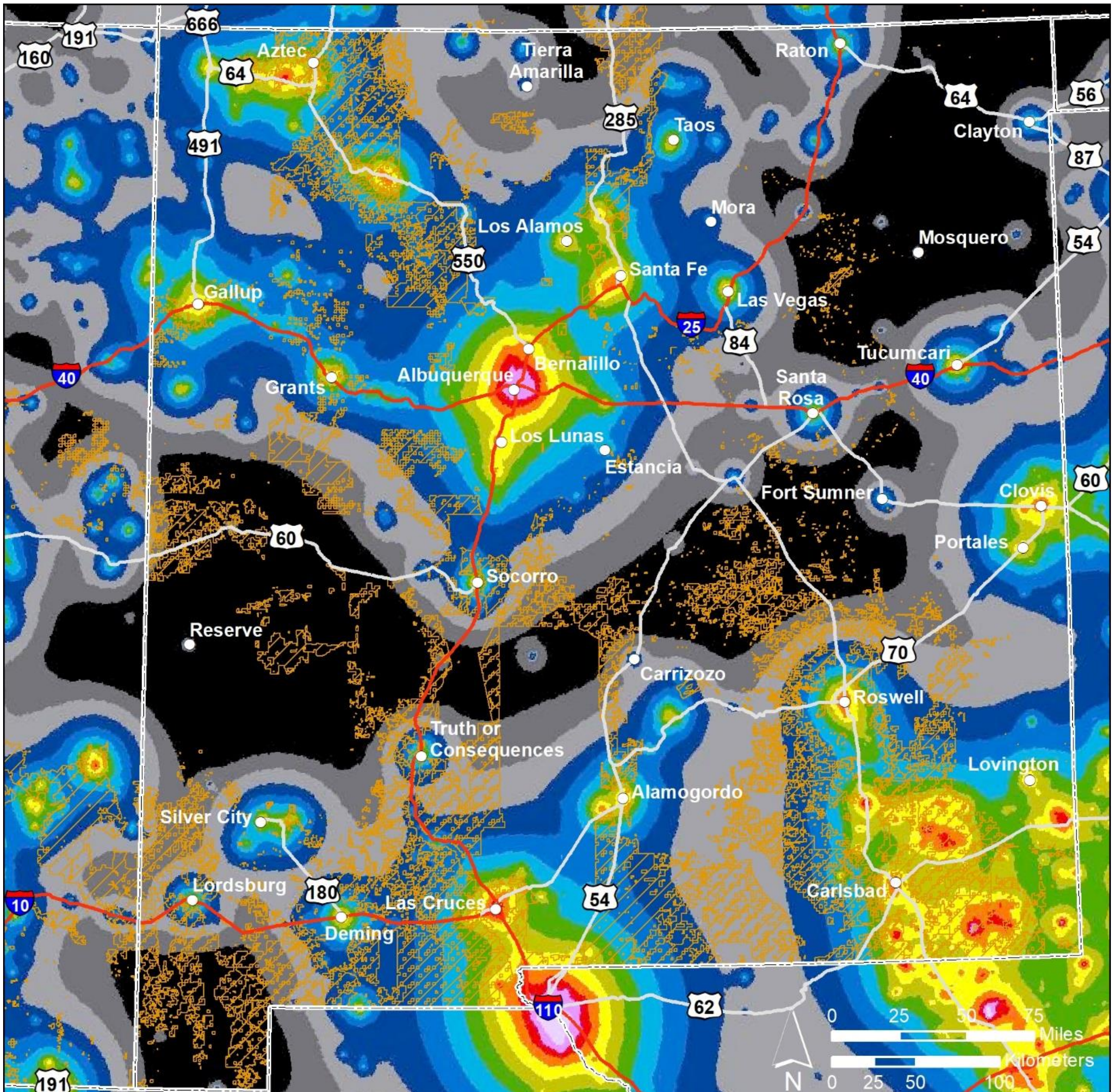


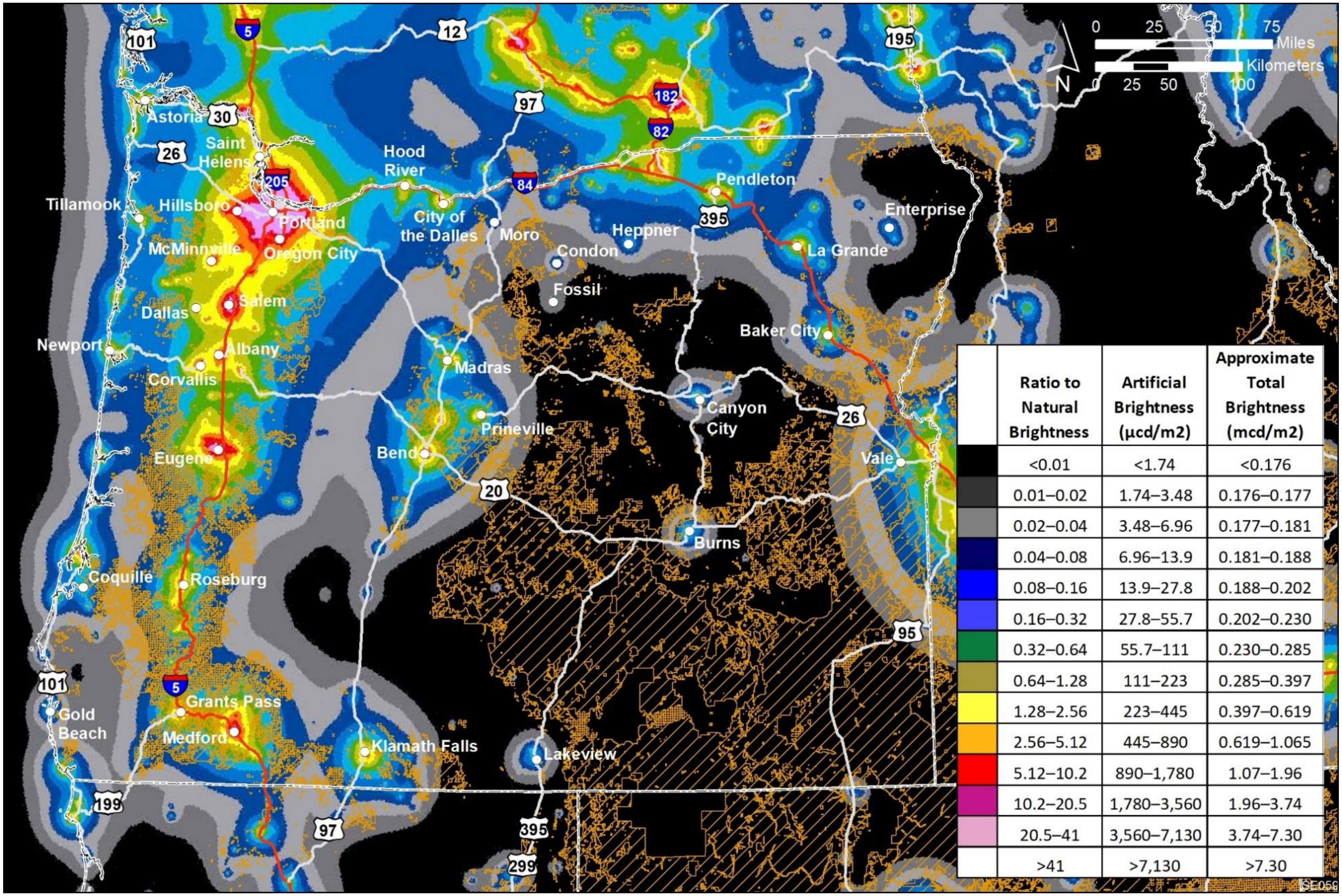
Figure F.19.2-17. Artificial Night Sky Brightness and BLM-administered lands (hatched areas) in Nevada (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)



Ratio to Natural Brightness	Artificial Brightness (μcd/m2)	Approximate Total Brightness (mcd/m2)	Ratio to Natural Brightness	Artificial Brightness (μcd/m2)	Approximate Total Brightness (mcd/m2)
<0.01	<1.74	<0.176	0.64–1.28	111–223	0.285–0.397
0.01–0.02	1.74–3.48	0.176–0.177	1.28–2.56	223–445	0.397–0.619
0.02–0.04	3.48–6.96	0.177–0.181	2.56–5.12	445–890	0.619–1.065
0.04–0.08	6.96–13.9	0.181–0.188	5.12–10.2	890–1,780	1.07–1.96
0.08–0.16	13.9–27.8	0.188–0.202	10.2–20.5	1,780–3,560	1.96–3.74
0.16–0.32	27.8–55.7	0.202–0.230	20.5–41	3,560–7,130	3.74–7.30
0.32–0.64	55.7–111	0.230–0.285	>41	>7,130	>7.30

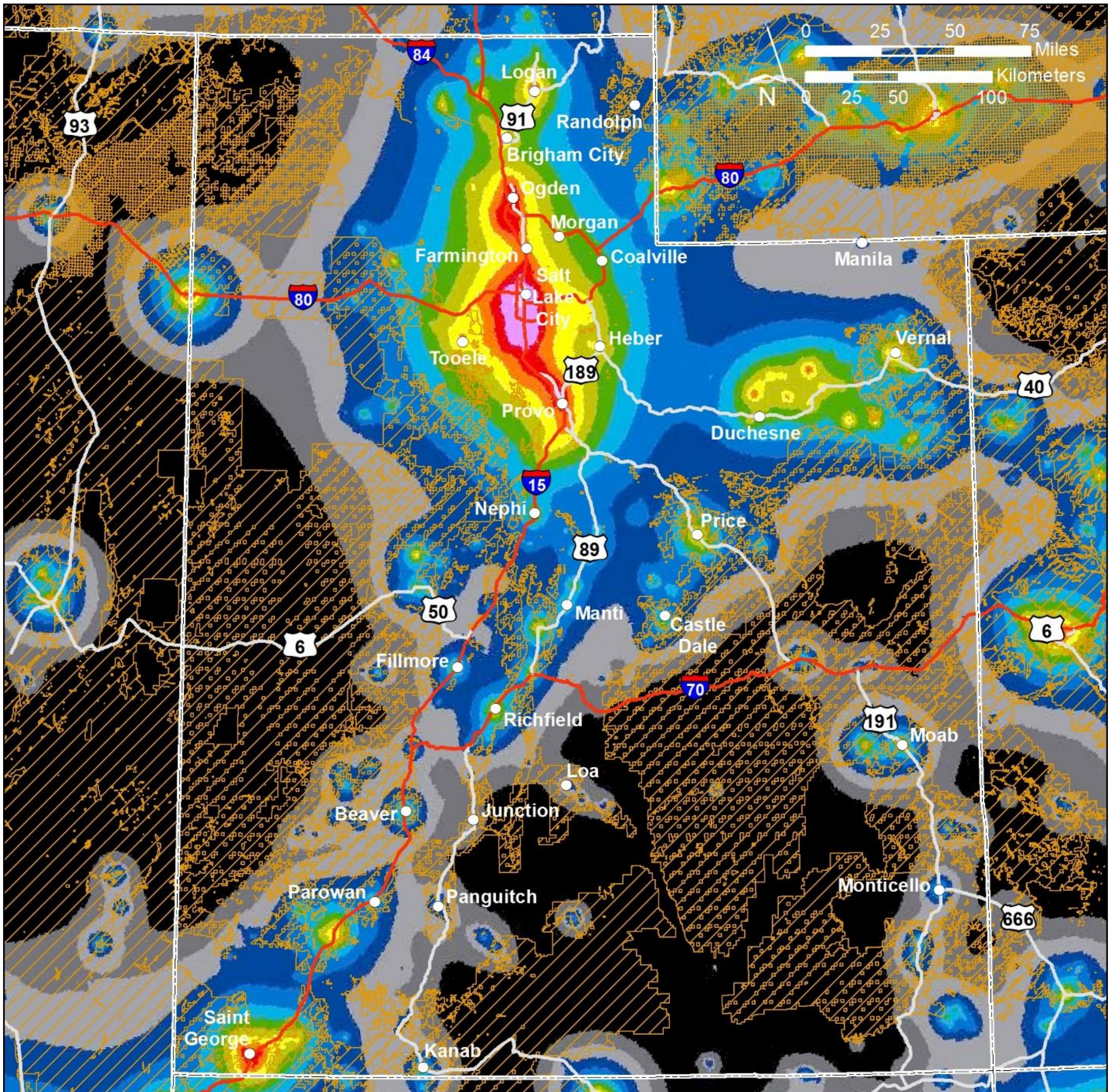
SE058

Figure F.19.2-18. Artificial Night Sky Brightness and BLM-administered lands (hatched areas) in New Mexico (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)



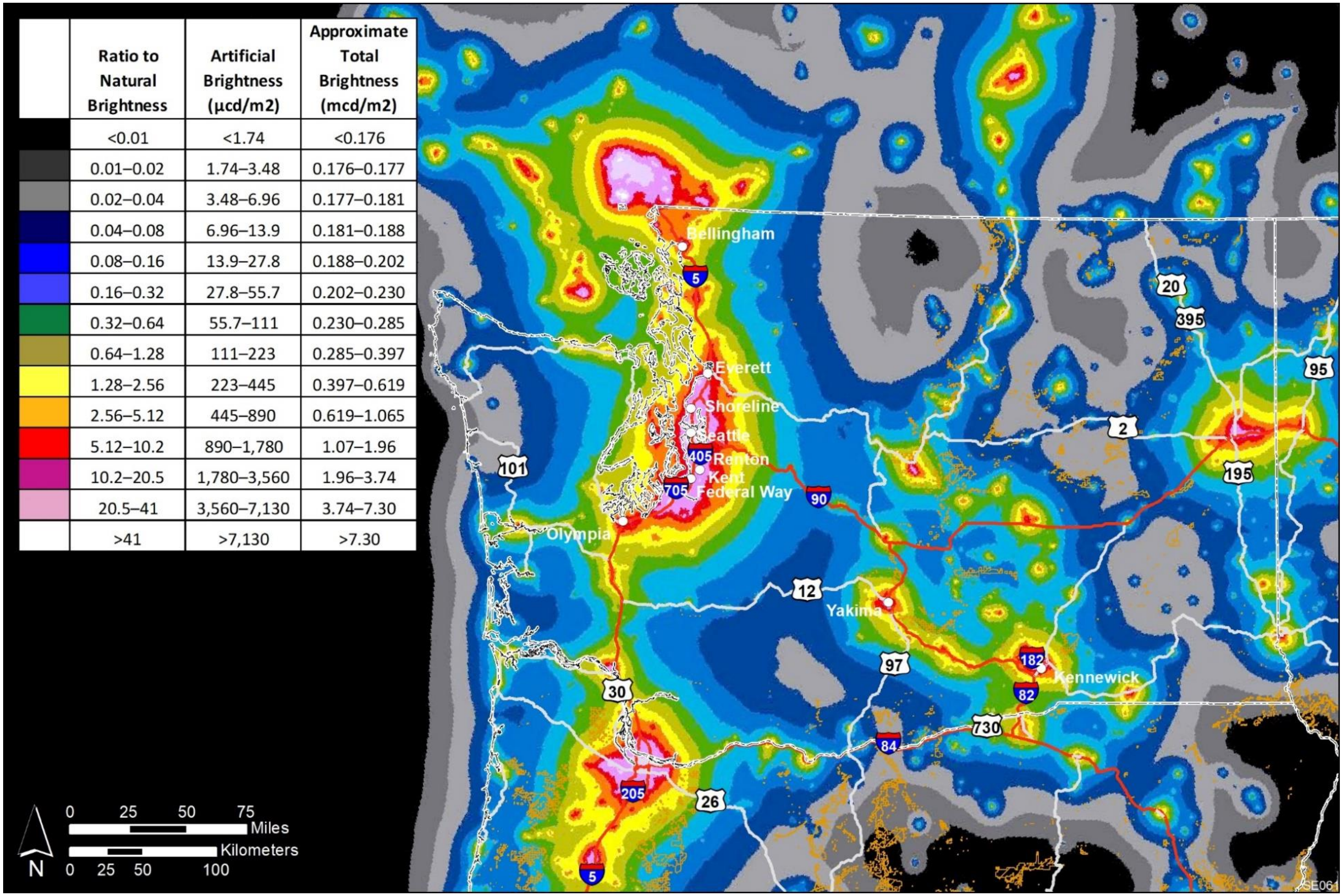
	Ratio to Natural Brightness	Artificial Brightness (μcd/m2)	Approximate Total Brightness (mcd/m2)
	<0.01	<1.74	<0.176
	0.01–0.02	1.74–3.48	0.176–0.177
	0.02–0.04	3.48–6.96	0.177–0.181
	0.04–0.08	6.96–13.9	0.181–0.188
	0.08–0.16	13.9–27.8	0.188–0.202
	0.16–0.32	27.8–55.7	0.202–0.230
	0.32–0.64	55.7–111	0.230–0.285
	0.64–1.28	111–223	0.285–0.397
	1.28–2.56	223–445	0.397–0.619
	2.56–5.12	445–890	0.619–1.065
	5.12–10.2	890–1,780	1.07–1.96
	10.2–20.5	1,780–3,560	1.96–3.74
	20.5–41	3,560–7,130	3.74–7.30
	>41	>7,130	>7.30

Figure F.19.2-19. Artificial Night Sky Brightness and BLM-administered lands (hatched areas) in Oregon (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)



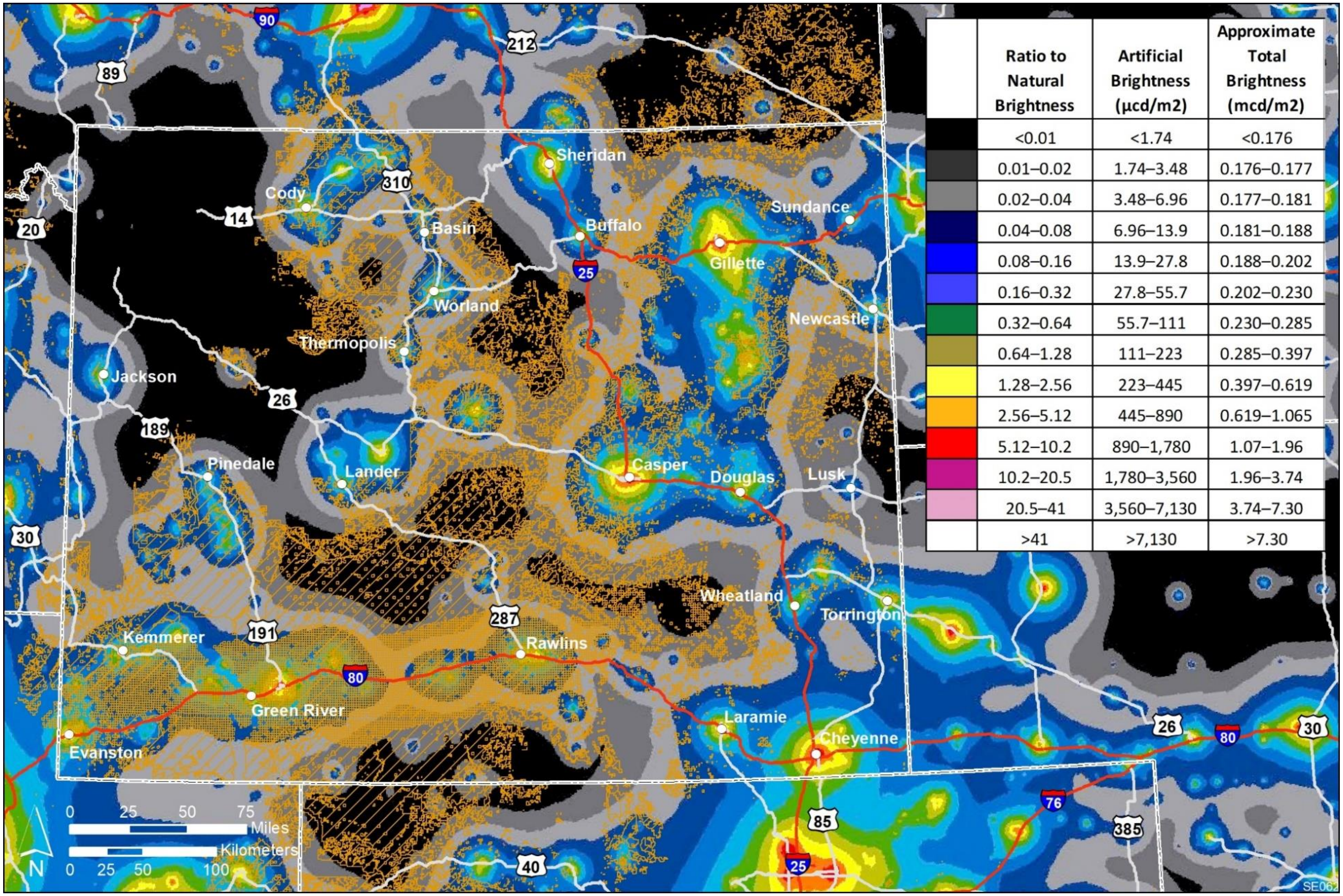
	Ratio to Natural Brightness	Artificial Brightness (µcd/m2)	Approximate Total Brightness (mcd/m2)			Ratio to Natural Brightness	Artificial Brightness (µcd/m2)	Approximate Total Brightness (mcd/m2)
	<0.01	<1.74	<0.176			0.64–1.28	111–223	0.285–0.397
	0.01–0.02	1.74–3.48	0.176–0.177			1.28–2.56	223–445	0.397–0.619
	0.02–0.04	3.48–6.96	0.177–0.181			2.56–5.12	445–890	0.619–1.065
	0.04–0.08	6.96–13.9	0.181–0.188			5.12–10.2	890–1,780	1.07–1.96
	0.08–0.16	13.9–27.8	0.188–0.202			10.2–20.5	1,780–3,560	1.96–3.74
	0.16–0.32	27.8–55.7	0.202–0.230			20.5–41	3,560–7,130	3.74–7.30
	0.32–0.64	55.7–111	0.230–0.285			>41	>7,130	>7.30

Figure F.19.2-20. Artificial Night Sky Brightness and BLM-administered lands (hatched areas) in Utah (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)



	Ratio to Natural Brightness	Artificial Brightness (μcd/m2)	Approximate Total Brightness (mcd/m2)
	<0.01	<1.74	<0.176
	0.01–0.02	1.74–3.48	0.176–0.177
	0.02–0.04	3.48–6.96	0.177–0.181
	0.04–0.08	6.96–13.9	0.181–0.188
	0.08–0.16	13.9–27.8	0.188–0.202
	0.16–0.32	27.8–55.7	0.202–0.230
	0.32–0.64	55.7–111	0.230–0.285
	0.64–1.28	111–223	0.285–0.397
	1.28–2.56	223–445	0.397–0.619
	2.56–5.12	445–890	0.619–1.065
	5.12–10.2	890–1,780	1.07–1.96
	10.2–20.5	1,780–3,560	1.96–3.74
	20.5–41	3,560–7,130	3.74–7.30
	>41	>7,130	>7.30

Figure F.19.2-21. Artificial Night Sky Brightness and BLM-administered lands (hatched areas) in Washington (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)



	Ratio to Natural Brightness	Artificial Brightness (µcd/m2)	Approximate Total Brightness (mcd/m2)
	<0.01	<1.74	<0.176
	0.01–0.02	1.74–3.48	0.176–0.177
	0.02–0.04	3.48–6.96	0.177–0.181
	0.04–0.08	6.96–13.9	0.181–0.188
	0.08–0.16	13.9–27.8	0.188–0.202
	0.16–0.32	27.8–55.7	0.202–0.230
	0.32–0.64	55.7–111	0.230–0.285
	0.64–1.28	111–223	0.285–0.397
	1.28–2.56	223–445	0.397–0.619
	2.56–5.12	445–890	0.619–1.065
	5.12–10.2	890–1,780	1.07–1.96
	10.2–20.5	1,780–3,560	1.96–3.74
	20.5–41	3,560–7,130	3.74–7.30
	>41	>7,130	>7.30

Figure F.19.2-22. Artificial Night Sky Brightness and BLM-administered lands (hatched areas) in Wyoming (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)

F.19.3 Supplemental Material for Impacts Assessment

F.19.3.1 BLM Visual Resource Management (VRM) System

Because of the experiential nature of visual resources, the human response to visual changes in the landscape cannot be precisely quantified, even though the visual changes associated with a proposed utility-scale solar energy development can be described (Hankinson 1999). There is, however, some commonality in individuals' experiences of visual resources, and while it may not be possible to quantify subjective experience and values, it is possible to systematically examine and characterize commonly held visual values and to reach consensus about visual impacts and their trade-offs. The BLM's Visual Resource Management (VRM) program provides a means of describing visual impacts that may be created by proposed projects or activities on BLM-administered public lands so that defensible decisions about the disposition and public concern about maintaining scenic values of public lands relative to competing resource demands can be made (BLM 1984). (See the text box *Factors That Influence the Degree of Visual Contrast* for factors that influence individuals' perceptions of visual contrasts considered within the BLM's VRM system.)

The BLM is responsible for ensuring that public lands are managed in a manner that will protect the quality of scenic values (43 U.S.C. 1701 (a)(8)). Each program within the BLM is responsible for ensuring scenic values are considered in all management activities on BLM-administered lands (BLM 1984). BLM accomplishes this through its VRM system. The VRM system includes systematic processes for inventorying scenic [visual] values on BLM-administered lands, establishing visual resource management objectives for those values through the Resource Management Plan (RMP) process, and evaluating proposed projects or activities to determine whether they conform with the management objectives. The primary components of BLM's VRM system include visual resource inventory (VRI), VRM class allocations, and visual contrast rating.

- *VRI.* BLM's VRI process provides BLM managers with a means for determining visual values for a tract of land. The VRI does not direct management; instead, it describes existing scenic resources at the time the inventory is conducted, much like the presence of a particular plant or wildlife habitat. The inventory includes the following three components: scenic quality evaluation (what it looks like), sensitivity level analysis (importance to the public), and delineation of distance zones (where and how landscapes are viewed by the public). Based on the inventory results, BLM-administered lands are placed into one of three visual resource inventory classes (VRI Class II-IV). VRI Class I is not based on the inventory and is assigned to areas where a decision has been made previously to maintain a natural landscape such as a wilderness area or other Congressional or administrative decision. The inventory classes represent the scenic value(s) for a planning area. Class II has high visual value based on the inventory; Class III has a moderate value based on the inventory; and Class IV are areas typically with lower scenic quality and are in the Background or Seldom Seen Distance Zones based on the inventory. Understanding the VRI and the underlying factors is important for disclosing the effects to scenic resources from management decisions and proposed projects or activities on BLM-administered lands. More information about VRI methodology is available in *Visual Resource Inventory*, BLM Manual Handbook 8410-1 (BLM 1986a).

- *VRM class allocations* are the product of the land use planning process. Allocations are used to describe allowable resource uses in an RMP and are identified for every acre of BLM-administered lands within the decision area. VRM Class allocations are used to retain or achieve the desired visual character, and the VRM management class objectives specify the level of allowable change (e.g., visual contrast) to the visual character. The results of the VRI provide the basis for considering visual values in the RMP. The VRM Class allocations do not have to be the same as the VRI classes, e.g., an area with a VRI Class III value may have a VRM Class IV objective. Proposed projects or activities on BLM-administered lands must conform to the VRM Class objectives that apply to the project or activity area as established in the RMP. The management objectives for the VRM classes are as follows:
  - Class I objective is to preserve the existing character of the landscape. The level of change to the characteristic landscape should be very low and must not attract attention.
  - Class II objective is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen but must not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural landscape features.
  - Class III objective is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements of form, line, color, and texture found in the predominant natural landscape features.
  - Class IV objective is to provide for management activities that require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high.

    More information about the BLM VRM program is available in *Visual Resource Management*, BLM Manual Handbook 8400 (BLM 1984).

- *Visual contrast rating.* The BLM's VRM system defines visual impact as the visual contrast observers perceive between existing landscapes and proposed projects and activities. (See text box for factors that influence the degree of visual contrast and are considered within the BLM's VRM system.) The BLM's contrast rating system (BLM 1986b) specifies a systematic process for determining the nature and extent of visual contrast that may result from a proposed land use activity and for determining whether those levels of contrast are in conformance with the VRM class objective for the area. Contrasts between an existing landscape and a proposed project or activity are expressed in terms of the landscape elements of form, line, color, and texture. These basic design elements are routinely used by landscape designers to describe and evaluate landscape aesthetics. They have been incorporated into the BLM's VRM system to lend objectivity and consistency to the process of assessing visual impacts of proposed projects and activities on BLM-administered lands.

Visual impacts may include both changes to visual values (e.g., scenic quality) and the existing landscape character both as a result of visual contrasts created by the facilities and public perception of the changes. Visual impacts can be either positive or negative, depending on the type and degree of visual contrasts introduced to an existing landscape. Under the BLM's VRM system approach, where modifications repeat the general forms, lines, colors, and textures of the existing landscape, the degree of visual contrast is lower, and the impacts are generally perceived less negatively. Where modification introduces pronounced changes in form, line, color, and texture, the degree of contrast is greater and impacts are often perceived more negatively. On the other hand, modifications (such as visual restoration) that enhance scenic quality may be perceived more positively.

Site-specific analysis is needed to thoroughly assess the potential impacts from a particular project or activity to visual resources. Without precise project or activity information such as location and complete description, only the general nature of potential impacts on visual resources or other sensitive resources can be described.

Factors That Influence the Degree of Visual Contrast and Impact

Distance and Angle of Observation: Viewer distance from a proposed project or activity affects the perceived level of visual contrast. The contrast created by a proposed project or activity is usually less as viewing distance increases because details become less discernible. Scale also is important because the observed scale relationship of a proposed project or activity and the characteristic landscape may also change with increasing distance from viewer (BLM 1986b). Viewer angle relative to a proposed project or activity may also affect perceived visual contrast; the apparent size of a proposed project or activity is directly related to the angle between the viewer's line-of-sight and location of the proposed project or activity. At angles approaching 90° (e.g., views of canyon walls or steep mountain slopes), the landscapes may be scrutinized more closely than those viewed from lower angles (e.g., views of plains and other low-relief areas). An elevated viewpoint, such as when viewing a project located on a valley floor from nearby mountains, can also lead to increased visual contrast because more of the project's surface area is visible from the elevated viewer position. As a viewer shifts from an elevated (superior) position to a lower (inferior) position, the apparent shape or form of a proposed project or activity may change even more than its apparent size.

Seasonal Variation and Lighting Conditions: Seasonal variation and lighting conditions may affect perceived visual contrast. The presence of snow cover, fall-winter coloration of foliage, and leaf drop may alter line, color, and texture properties of vegetation and soil, thereby creating more visual contrasts between a proposed project and the landscape. The change in the angle of the sun by season and time of day affects shadow casting and color saturation which, in turn, may affect both perceived details in the landscape and visual contrast.

Visibility: Circumstances or activities that reduce or eliminate visibility views of a proposed project or activity will reduce the level of perceived visual contrast. The visibility of a proposed project or activity may be affected by atmospheric conditions such as smoke from wildfires, air pollution, or haze. Intervening topography, vegetation, or structures that effectively screen views can greatly reduce visual contrast of even large visual changes. Conversely, projects placed at higher elevations relative to viewers, particularly along ridgelines, may be conspicuously visible over larger areas and thus may have greater visual contrast.

Recovery Time: Vegetative recovery can vary by ecological and geographical area, which may contribute to a longer period of visual contrast in some locations than others, until successful vegetation establishment from restoration.

Motion: Motion of an object within the visual field draws visual attention. Moving vehicles, workers, smoke, vapor, and dust plumes, and project components, e.g., wind turbine blades will have greater perceived visual contrast than stationary objects.

Duration of Observation: Proposed projects or activities that are viewed for a long period of time may be perceived as having greater visual impact than those viewed briefly. For example, a transmission line that closely parallels a hiking trail may be in continuous view of hikers for several hours and may have greater perceived visual impact than the same transmission line crossed by a perpendicular trail, which would be viewed relatively briefly by hikers.

Other Contributing Factors: The type of activity a viewer is engaged in when viewing a proposed project or activity may affect his or her perception of visual impact; for example, persons engaged in nature photography might perceive a project as having greater visual impact than they would if they were motocross racing. Some individuals and groups may be inherently more sensitive to visual impacts in a valued landscape because of educational orsocial background, life experiences, and other cultural factors.

Continued on next page.

Factors That Influence the Degree of Visual Contrast and Impact *(continued)*

The landscape setting provides the context for evaluating the degree of visual contrast in form, line, color, and texture between a proposed project or activity and the existing landscape as well as the perceived appropriateness of the project or activity to a landscape setting. Because of their physical properties, some landscapes may be perceived by most viewers to have intrinsically higher scenic value than other landscapes.

Scenic integrity describes the degree of "intactness" of a landscape, which is related to the existing amount of visual disturbance present. Landscapes with higher scenic integrity are generally regarded as more sensitive to visual disturbances. A project or activity proposed in a pristine, high-scenic value landscape may be more conspicuous and may be perceived as having greater visual impact than if that same project or activity were proposed in an industrialized landscape of low scenic value where similar projects already exist. Some landscapes have special meanings to some viewers because of unique scenic, cultural, or ecological values and are therefore perceived as being more sensitive to visual disturbances. Other landscapes are regarded as more sensitive to visual disturbances because they are near or adjacent to high-resource value landscapes, such as national parks, national monuments, wildlife refuges, or scenic/historic trails. Landscape settings that are relatively rare within a given region may be of greater public concern than landscape settings that are regionally very common.

Sources: BLM (1984, 1986a,b); USFS (1995).

F.19.3.2 Scenic Quality Ratings on BLM-Administered Lands Across Alternatives

The following maps show inventoried scenic quality on BLM-administered lands available for application under the No Action and Action Alternatives.

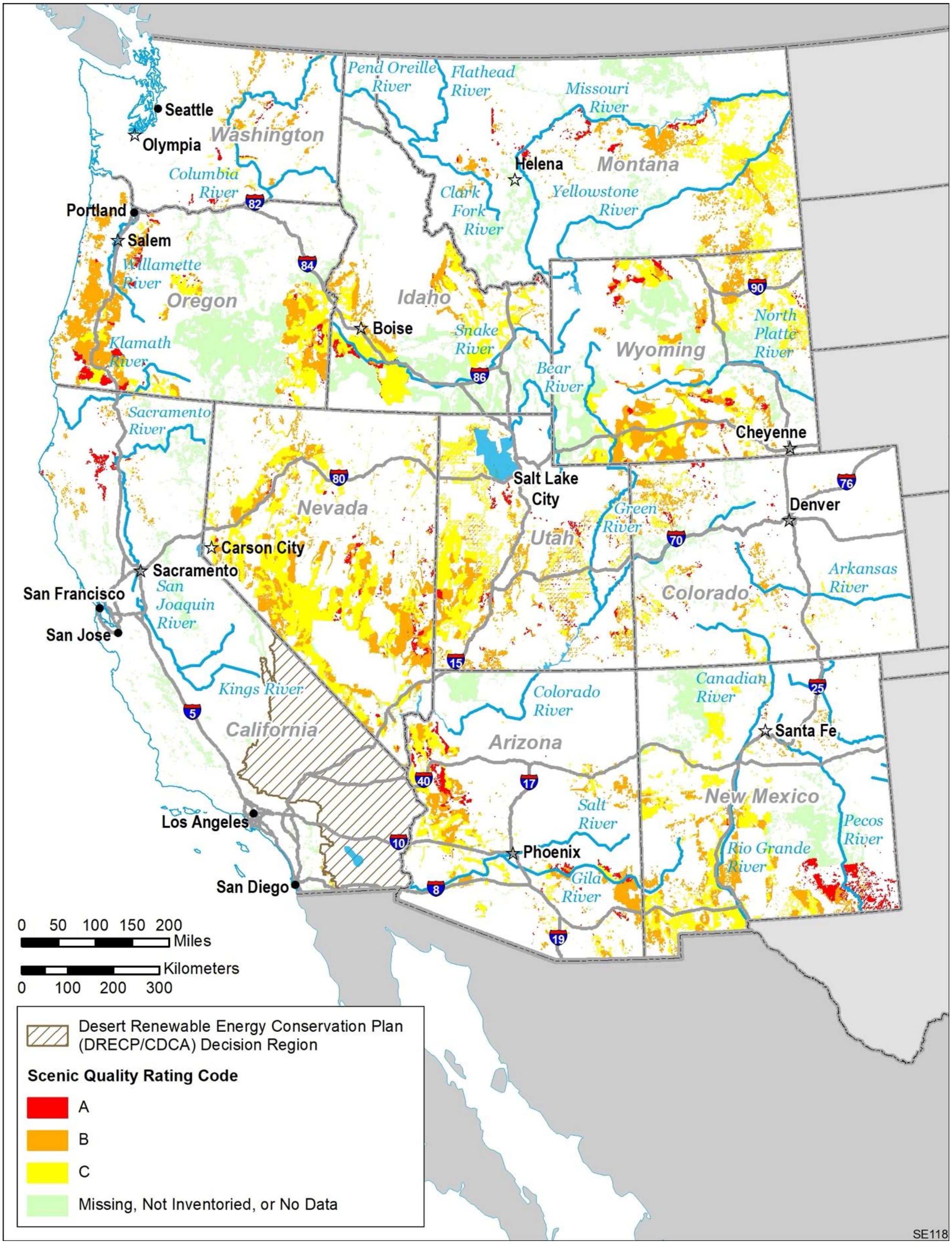


Figure F.19.3-1. Scenic Quality Ratings on BLM-administered Lands Available for Application under the No Action Alternative (Source: BLM and Argonne National Laboratory.)

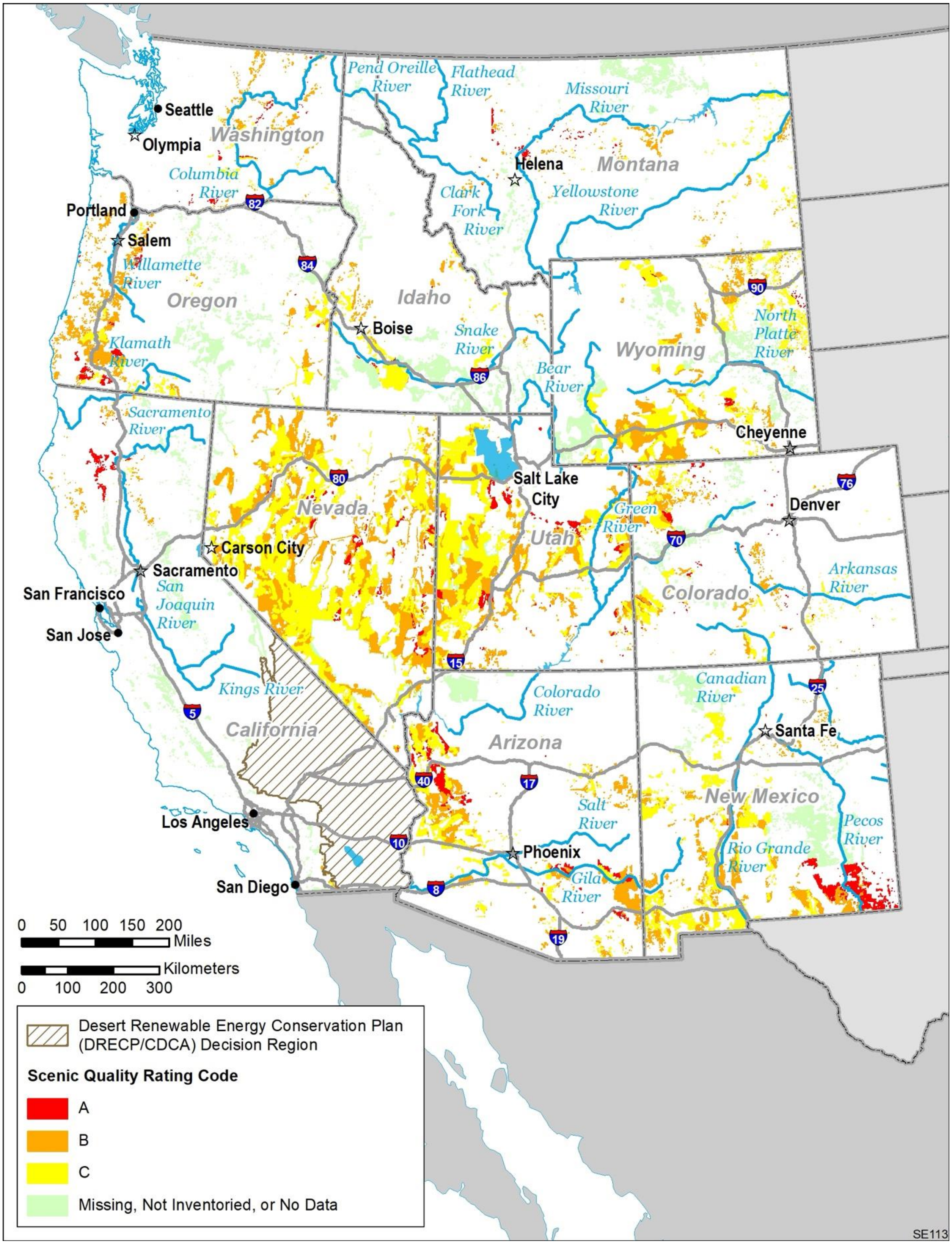


Figure F.19.3-2. Scenic Quality Ratings on BLM-administered Lands Available for Application under Alternative 1 (Source: BLM and Argonne National Laboratory.)

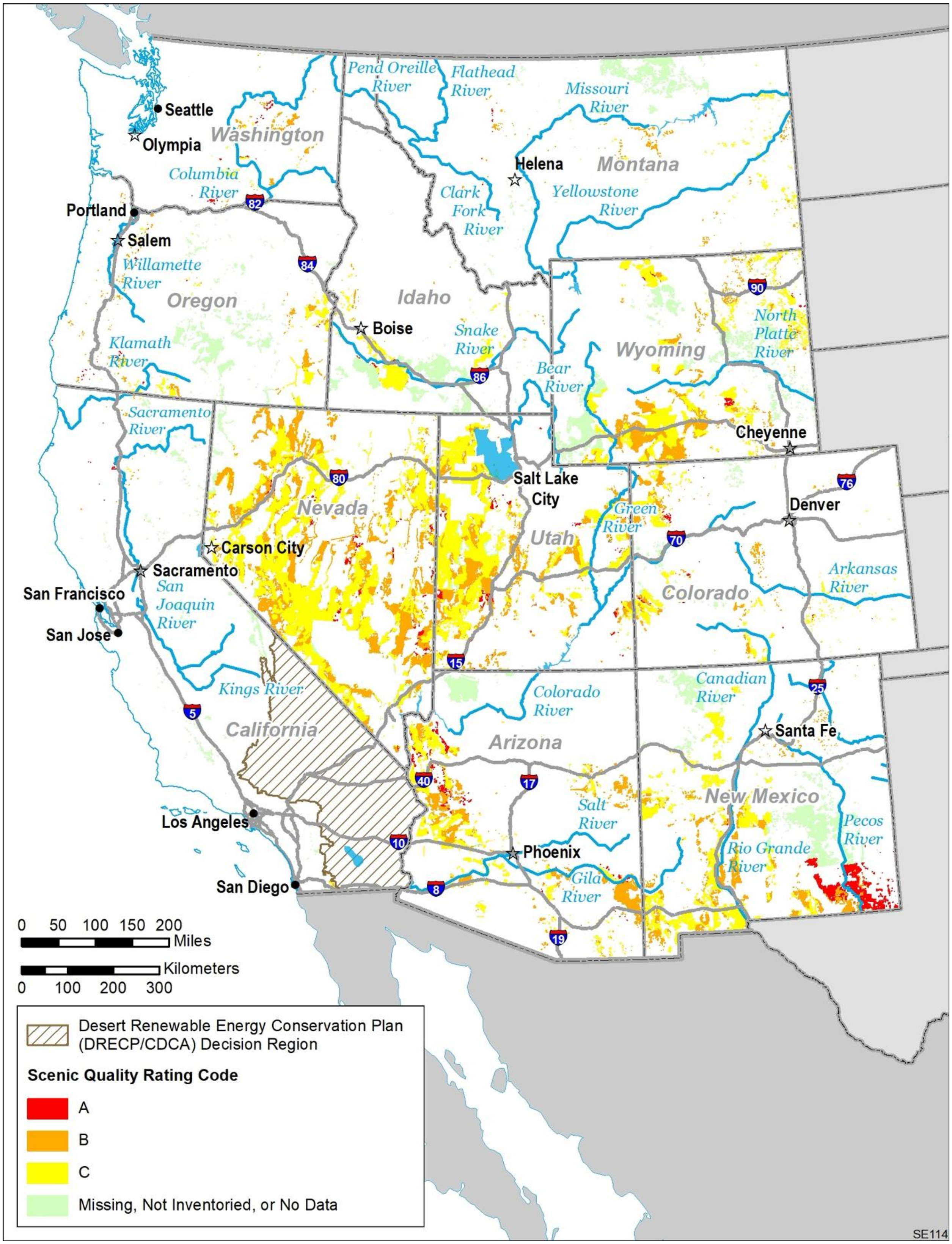


Figure F.19.3-3. Scenic Quality Ratings on BLM-administered Lands Available for Application under Alternative 2 (Source: BLM and Argonne National Laboratory.)

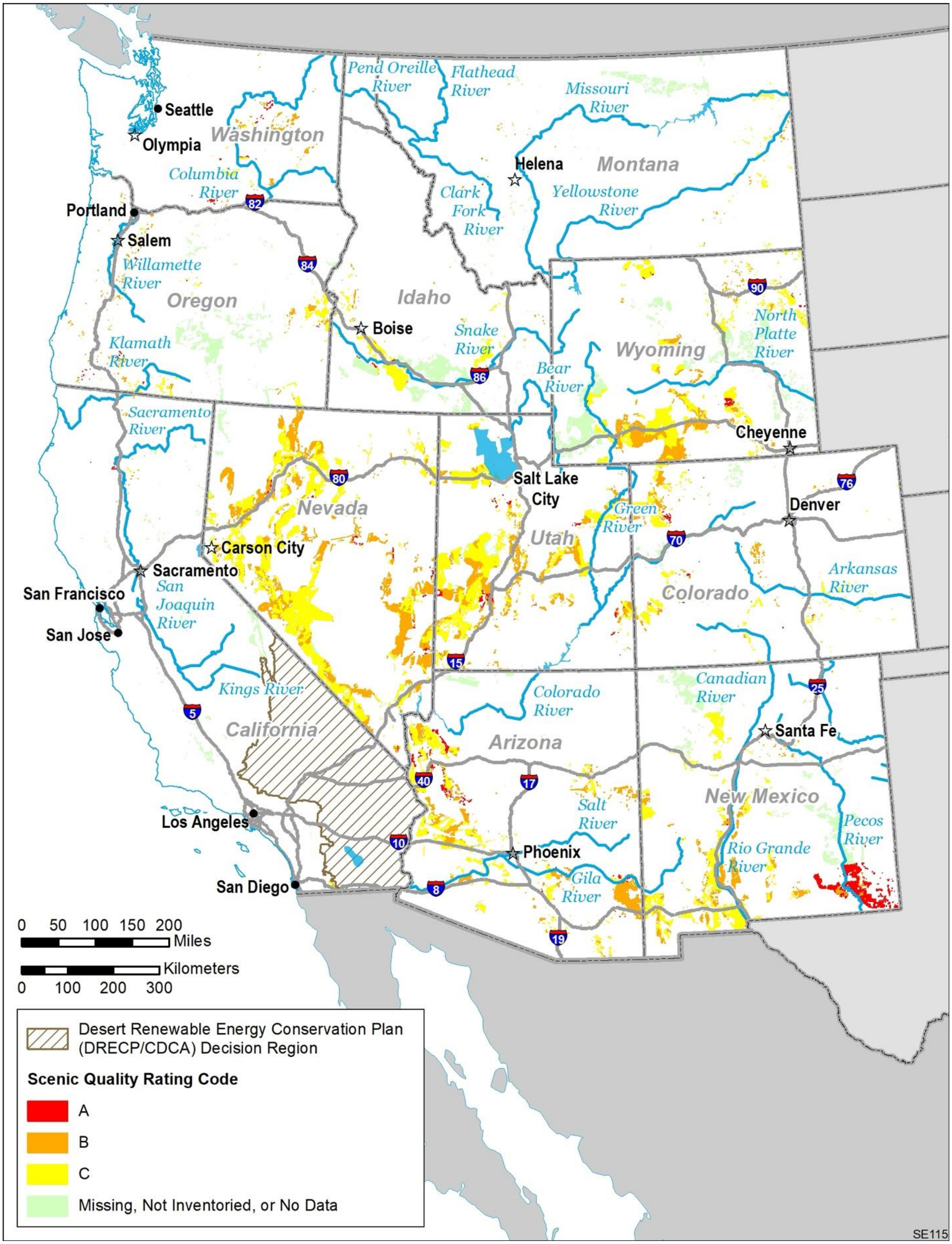


Figure F.19.3-4. Scenic Quality Ratings on BLM-administered Lands Available for Application under Alternative 3 (Source: BLM and Argonne National Laboratory.)

Figure F.19.3-5. Scenic Quality Ratings on BLM-administered Lands Available for Application under Alternative 4 (Source: BLM and Argonne National Laboratory.)

Figure F.19.3-6. Scenic Quality Ratings on BLM-administered Lands Available for Application under Alternative 5 (Source: BLM and Argonne National Laboratory.)

F.19.3.3 Artificial Sky Brightness on BLM-Administered Lands Across Alternatives

The following maps show artificial sky brightness for BLM-administered lands available for application under the No Action and Action Alternatives.

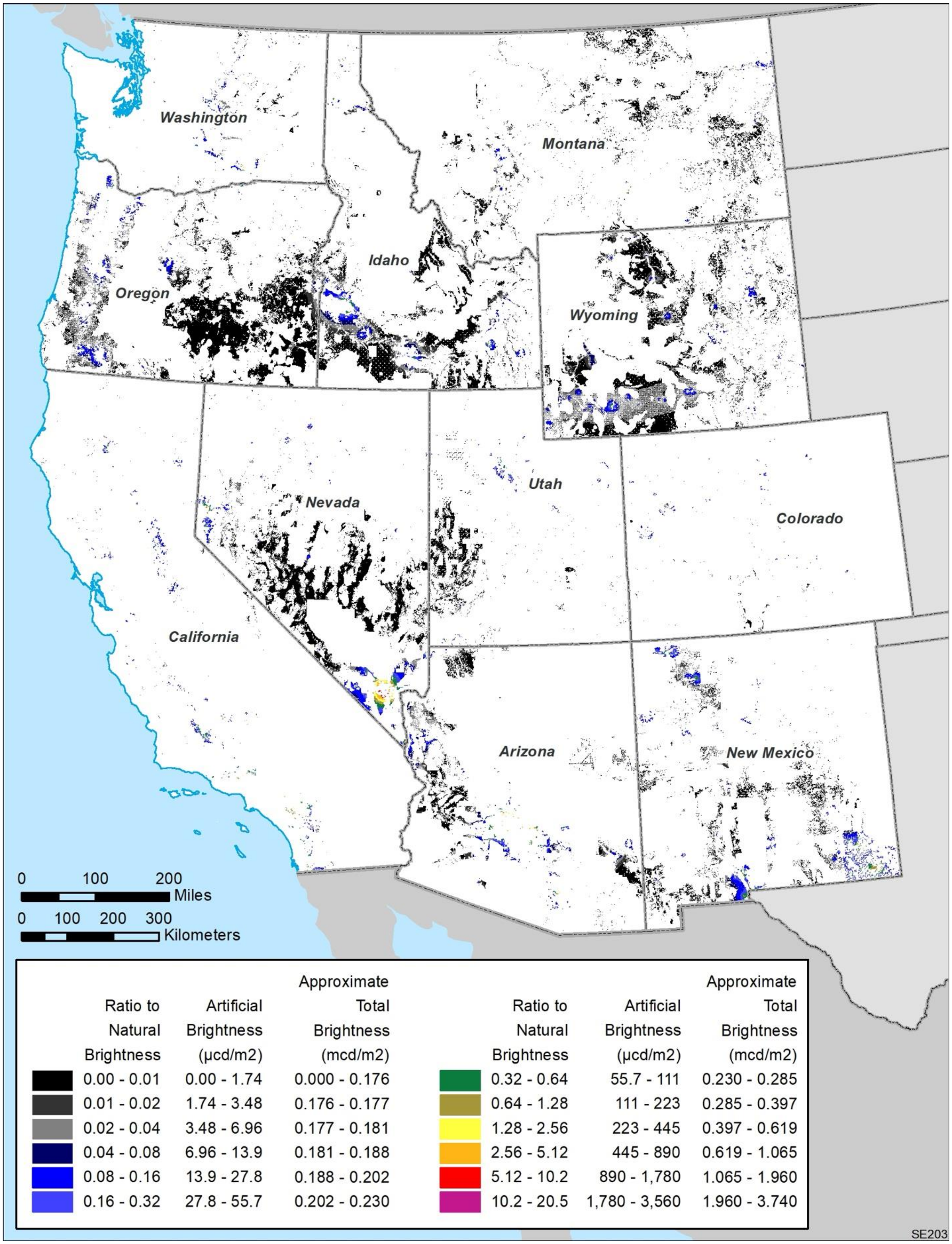
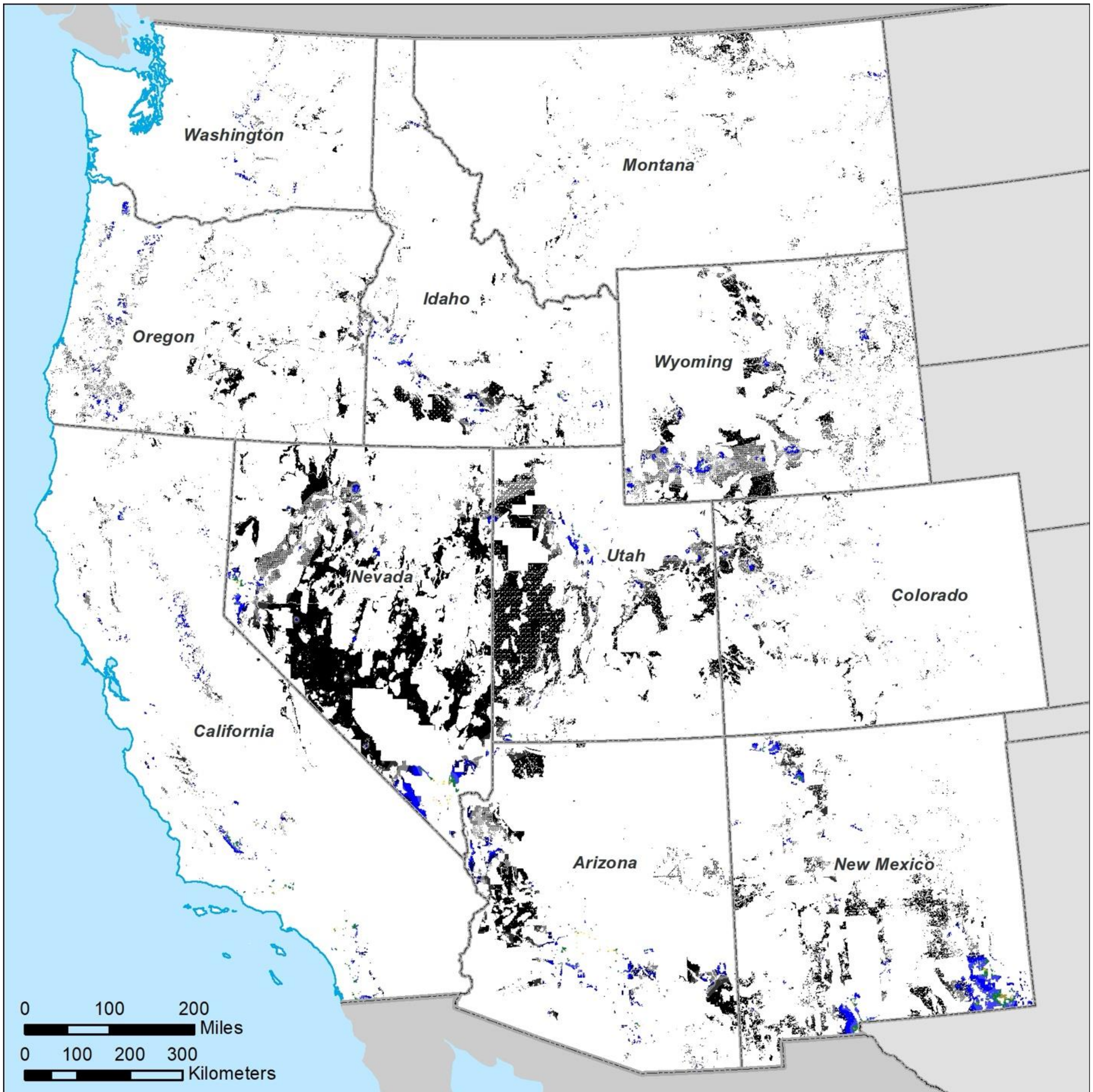


Figure F.19.3-7. Artificial Night Sky Brightness for BLM-Administered Lands Available for Application under the No Action Alternative (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)



Ratio to Natural Brightness	Artificial Brightness (µcd/m2)	Approximate Total Brightness (mcd/m2)	Ratio to Natural Brightness	Artificial Brightness (µcd/m2)	Approximate Total Brightness (mcd/m2)
0.00 - 0.01	0.00 - 1.74	0.000 - 0.176	0.32 - 0.64	55.7 - 111	0.230 - 0.285
0.01 - 0.02	1.74 - 3.48	0.176 - 0.177	0.64 - 1.28	111 - 223	0.285 - 0.397
0.02 - 0.04	3.48 - 6.96	0.177 - 0.181	1.28 - 2.56	223 - 445	0.397 - 0.619
0.04 - 0.08	6.96 - 13.9	0.181 - 0.188	2.56 - 5.12	445 - 890	0.619 - 1.065
0.08 - 0.16	13.9 - 27.8	0.188 - 0.202	5.12 - 10.2	890 - 1,780	1.065 - 1.960
0.16 - 0.32	27.8 - 55.7	0.202 - 0.230	10.2 - 20.5	1,780 - 3,560	1.960 - 3.740

Figure F.19.3-8. Artificial Night Sky Brightness for BLM-Administered Lands Available for Application under Alternative 1 (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)

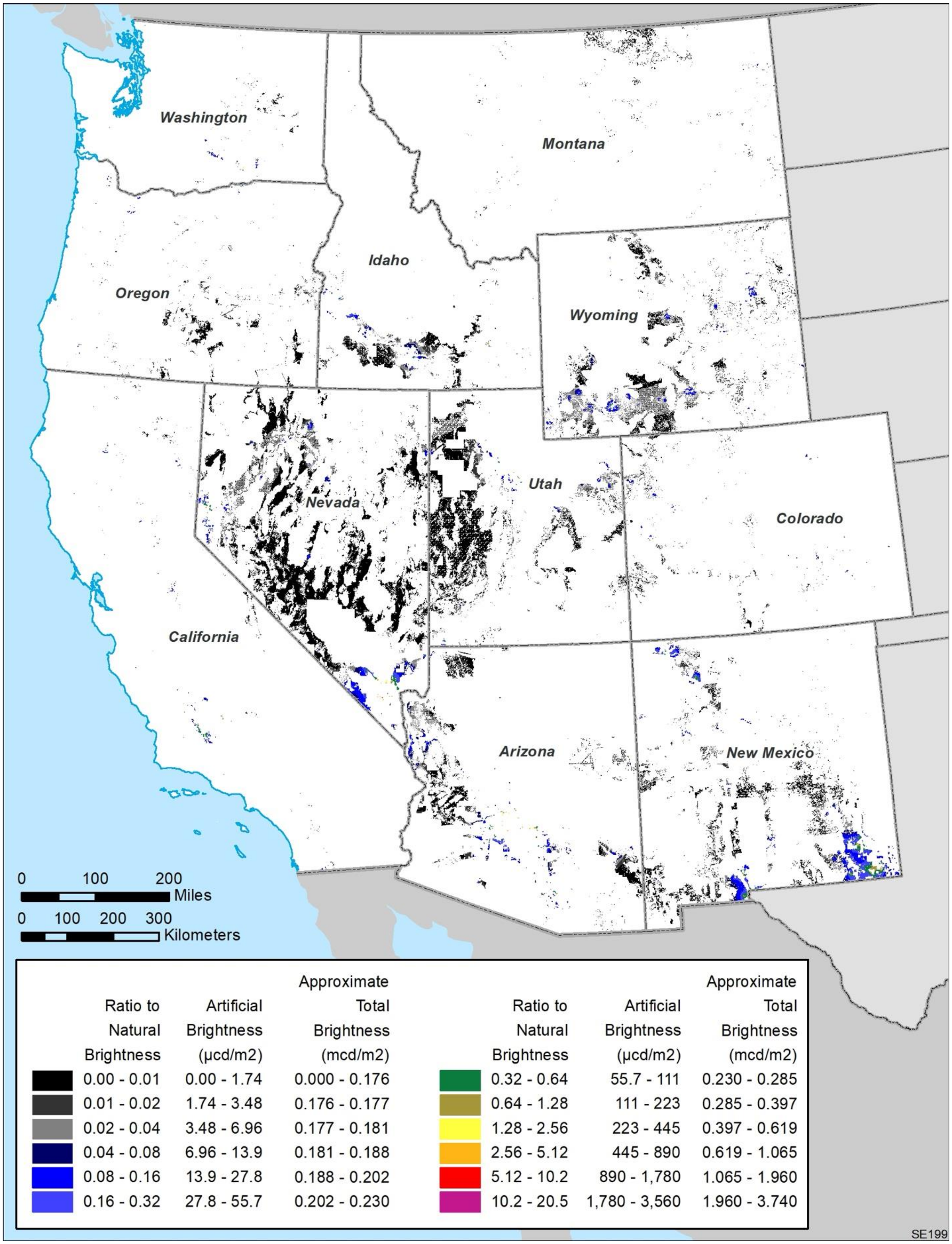


Figure F.19.3-9. Artificial Night Sky Brightness for BLM-Administered Lands Available for Application under Alternative 2 (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)

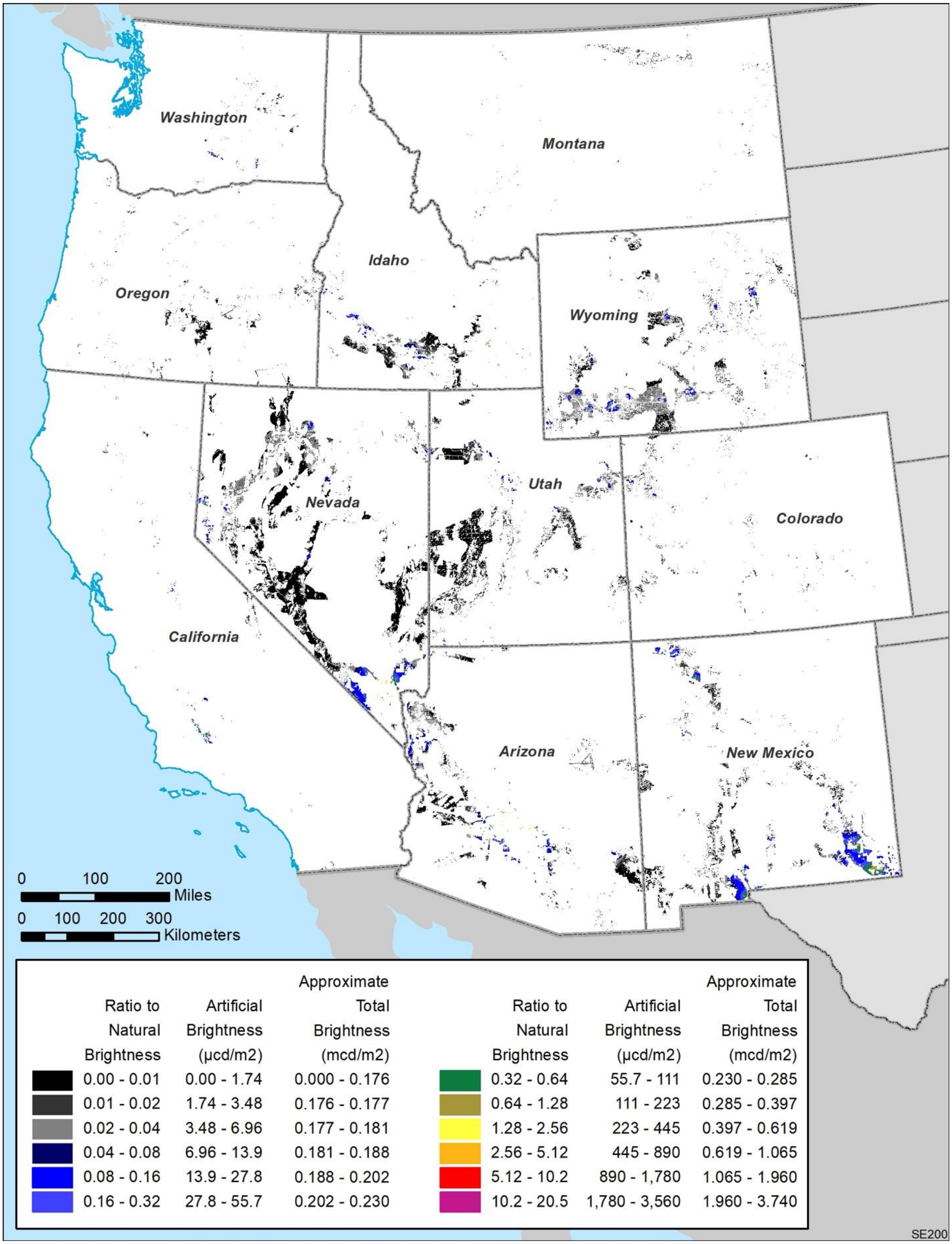


Figure F.19.3-10. Artificial Night Sky Brightness for BLM-Administered Lands Available for Application under Alternative 3 (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)

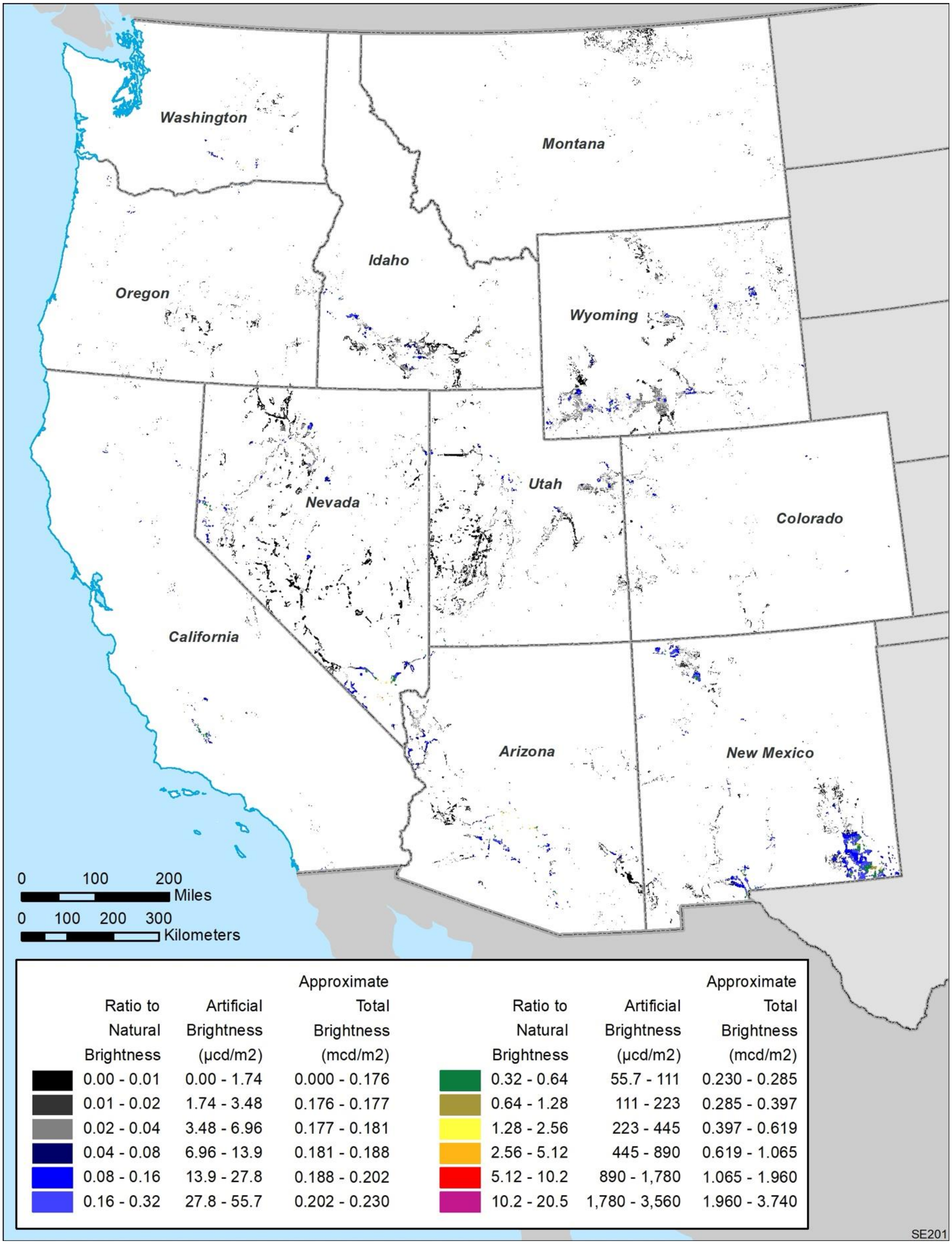


Figure F.19.3-11. Artificial Night Sky Brightness for BLM-Administered Lands Available for Application under Alternative 4 (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)

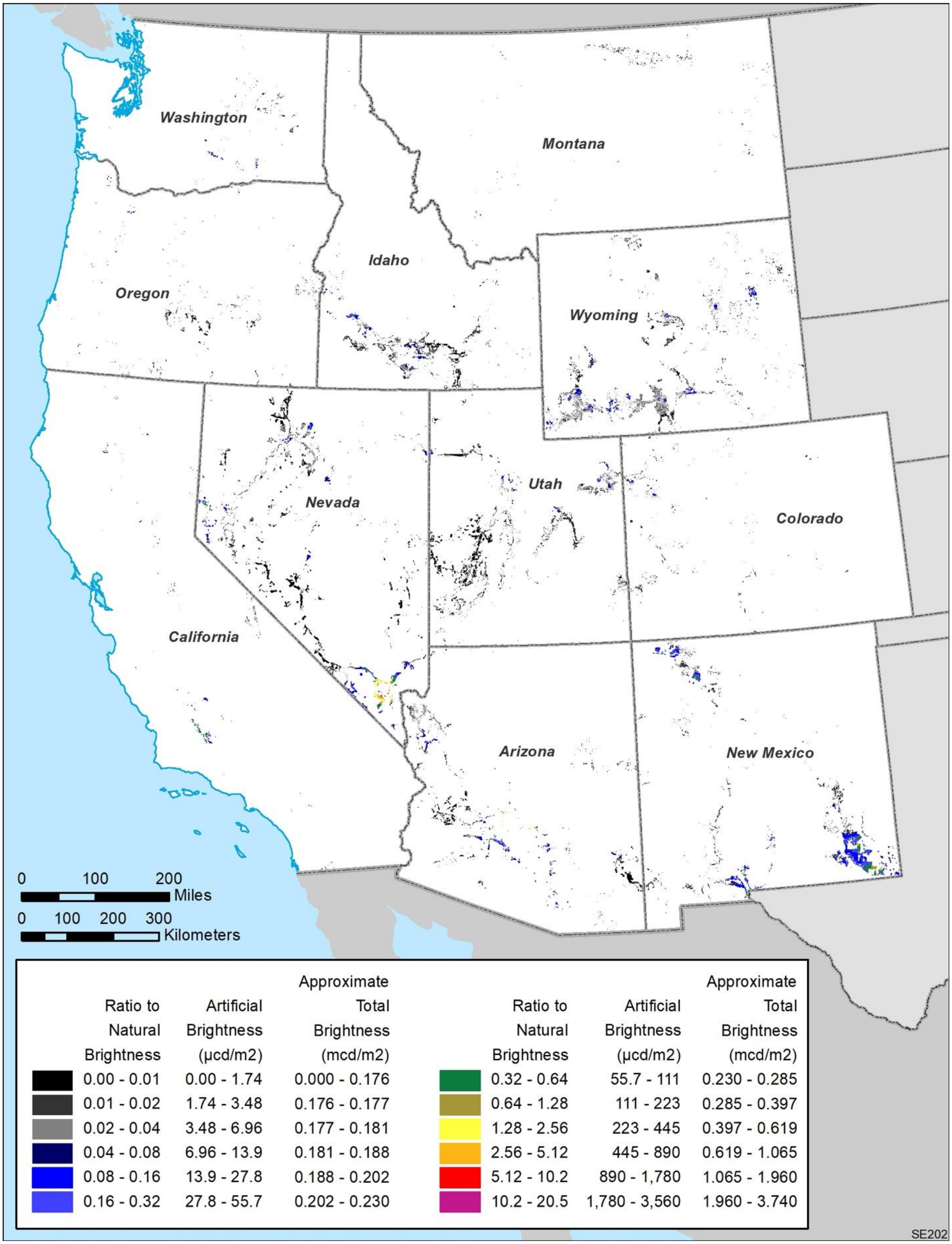


Figure F.19.3-12. Artificial Night Sky Brightness for BLM-Administered Lands Available for Application under Alternative 5 (Sources: New World Atlas of Artificial Sky Brightness [Cinzano et al. 2001] and Argonne National Laboratory.)

F.20 Water Resources

F.20.1 Methods Used for Evaluation

The water resources description was based on a review of aerial maps, topographic maps, digital hydrographic maps, federal agency reports, and scientific literature. The affected environment description includes surface water features (e.g., drainage basins, water bodies, rivers, streams, floodplains, and wetlands) and groundwater resources (e.g., regional aquifers including sole-source aquifers). Both water use and water quality were described based on available information.

Water rights, allocation, and use policies in the 11-state planning area were described. Because states have the primary authority and responsibility to manage water resources within their borders, a description of various state policies was included. In the generally water-scarce western United States, beneficial use of water resources is permitted under the framework defined by water rights laws, management practices that promote sustainability of the water resources, and the protection of riparian, wetlands, and aquatic habitats. Various sole-source aquifers in the 11-state planning area are described as they are subject to EPA review from potentially adverse effects of a federally funded project.

The impacts assessment for use of water resources used water availability on a regional and statewide scale. Water use for both construction and operation of a PV power plant have the potential to affect other beneficial uses in the area. During construction, ground-disturbing activities, including vegetation clearing and grubbing, excavation and backfilling, construction of project structures and ancillary facilities, trenching, drilling, stockpiling of soils, construction of road beds, drainage and wetland crossings, heavy truck and equipment traffic, and increased foot traffic have the potential to affect water quality of nearby surface water bodies and groundwater aquifers. Appropriate water use and water quality permits and associated monitoring, mitigation, and remediation requirements would be in effect. Under applicable water quality permits, a plant owner and/or operator is generally required to implement best management practices that reduce the effects of construction and operation on water resources.

F.20.2 Supplemental Material for Affected Environment

F.20.2.1 Surface Water Resources

F.20.2.1.1 Hydrologic Regions

Ten major hydrologic regions have been identified in the 11-state planning area based on the USGS classification system (see Figure 4.20-1): (1) Pacific Northwest, (2) California, (3) Upper Colorado, (4) Lower Colorado, (5) Rio Grande, (6) Missouri, (7) Great Basin, (8) Arkansas-White-Red, (9) Souris-Red-Rainy, and (10) Texas-Gulf. Each hydrologic region encompasses either the drainage area of a major river or the combined drainage areas of a series of rivers (USGS 2008a). The 11-state planning area has considerable climatic variability. The Pacific Northwest coastal regions generally have mild climate with cool and wet winters and warm dry summers. However, the interior areas can be more extreme with relatively little precipitation and hot summers. The mountains support water storage in the snowpack and cause the topographic lift for the western coastal sides and the rainshadow effect on eastern slopes, resulting in climactic variation from temperate rainforests to semi-arid and desert regions. Table F.20.2-1 lists the hydrologic regions in the 11-state planning area and their major river systems and provides a brief description of precipitation patterns and principal uses of surface water within each region.

Table F.20.2-1. Hydrologic Regions and Surface Water Conditions in the 11-state Planning Area

Hydrologic Region	Geographic Area	Major River Systems	Precipitation	General Surface Water Quality
Pacific Northwest	All of Washington State, a large portion of Oregon, a large portion of Idaho, a small portion of western Montana, a small portion of western Wyoming, and a small region in northern Nevada and northern Utah	Columbia, Snake, Yakima	Precipitation decreases east of the Cascades, and stream flow is driven primarily by snowmelt or groundwater discharge	Agricultural areas degraded by nutrients (nitrates and phosphates) and pesticides from agricultural and grazing practices
California	Most of California, a very small portion of western Nevada, and a portion of south-central Oregon	Sacramento, San Joaquin	Precipitation occurs primarily in winter, with prolonged summer periods of little rainfall. Streamflow derived primarily from spring snowmelt	Elevated TDS[a] levels from high salinity because of irrigation practices and arid climate. Agricultural practices in central California have resulted in elevated nutrients and pesticides.
Upper Colorado	Colorado Plateau in western Colorado, eastern Utah, southwestern Wyoming, northern Arizona, and northwestern New Mexico	Upper Colorado	Precipitation varies with elevation and includes winter snow storms and heavy fall rainstorms, with most streamflow dominated by snowmelt in the mountains	Generally good water quality except in historic mining areas and in agricultural areas. Areas of sedimentary rock may have high levels of TDS, radon, uranium, and other metals.
Lower Colorado	Most of Arizona and portions of western New Mexico, southern Nevada, and southeastern California	Lower Colorado	This region is arid, with precipitation limited to winter months and periods of heavy storms. Streamflow is largely absent except in winter or after major storms. High erosion rates common in areas with grazing livestock.	Elevated TDS in areas with agriculture and grazing, and metals in mining areas
Rio Grande	Central New Mexico and south-central Colorado	Rio Grande, Pecos	An arid region with precipitation limited to winter months and periods of heavy storms. Streamflow derived from spring snowmelt and summer thunderstorms.	Elevated TDS and nutrient and pesticide contamination in agriculture areas. Upper reaches of the Rio Grande have elevated levels of metals in mining areas attributed to the Creede mining district of southern Colorado.

Hydrologic Region	Geographic Area	Major River Systems	Precipitation	General Surface Water Quality
Missouri	Northeastern Colorado	Platte	Precipitation generally sparse in summer and fall, with streamflow derived from snowmelt in mountainous areas, and in summer and fall from groundwater discharge	Good water quality in high Rocky Mountains. Quality degrades as streams enter plains and valleys, where agricultural practices and urban runoff impact water quality. Mining and oil extraction cause locally increased TDS and metals concentrations, while grazing contributes sediments and nutrients.
Great Basin	Central and northern Nevada and western Utah, a very small portion of southwestern Wyoming, and a very small portion of northeastern California	Humboldt, Truckee	Arid region located in rain shadow of the Sierra Nevada Mountains. Surface water flow in basins derived from rain and snow falling in mountain areas.	Poor water quality in areas near urban centers; elevated metal concentrations in historic mining areas. Near-surface rocks naturally contribute arsenic, uranium, and radon to surface waters.
Arkansas-White-Red	Southeastern Colorado and northeastern New Mexico	Arkansas, Canadian, Red	Precipitation sparse in summer and fall. Streamflow derived from snowmelt in the mountainous areas.	Surface water quality is typically moderate in this region except poor in areas with extensive agricultural or livestock production.
Souris-Red-Rainy	A very small region of the Souris-Red-Rainy (U.S. name) or Hudson Bay ocean watershed (Canadian name) located in northwestern Montana bordering Canada	St. Mary and Belly Rivers (both flow from Montana into Canada)	A relatively wet part of the state with relatively dependable summer streamflow fed by snowmelt and rainfall in the Glacier National Park	Surface water quality is good near the Glacier National Park and degrades downstream; generally suitable for drinking and food processing after conventional treatment
Texas-Gulf	A small region in eastern New Mexico	Running Water Draw, Black Water Draw, Yellow House Draw, Lost Draw, Sulphur Springs Draw, Mustang Draw, Monument-Seminole Draw[b]	An arid region with precipitation limited to winter months and periods of heavy storms. Streamflow derived from spring snowmelt and summer thunderstorms.	For part of this region within the planning area, available data indicate some designated uses are supported. For other parts, insufficient data exist to make a support determination.[c]

[a] TDS = total dissolved solids; a measurement of water quality.
[b] Source: New Mexico State University (2008).
[c] New Mexico Environment Department 2022.

Stream discharge in the 11-state planning area is affected by precipitation (which varies with season) and the regional topography. For example, moist air masses from the Pacific Ocean rise and cool as they approach the various mountain ranges in the western states. This condition causes increased precipitation with elevation on the western slopes of the ranges, thereby stripping moisture from the air masses as they move eastward and reducing the moisture available for precipitation on the eastern slopes of the ranges (creating a rainshadow effect). Seasonally, spring snowmelt causes higher streamflow during the spring months. High streamflows also occur during summer thunderstorms. Most perennial streams, especially those in arid basins, rely on groundwater discharge to sustain their flow. Decrease of natural streamflow may occur due to consumptive use of surface water and/or groundwater in a basin, such as use for irrigation and public drinking water supply, or the withdrawal and/or consumption of water for energy-related operations (Healy et al. 2015 [USGS Circular 1407]). Water withdrawals for energy production are mostly associated with thermoelectric plants that use water for cooling. Many rivers in the 11-state planning area are regulated by dams and other flow control structures, so stream discharge is also controlled by release schedules from reservoirs.

The quality of surface water varies by stream segment and is related to the volume of streamflow, the nature of local bedrock and soils, and human activities (e.g., mining, wastewater discharges, and agriculture). Generally, the quality of surface water in mountainous areas is considered good. However, as the water flows downstream to arid and semiarid valleys, the quality is reduced as tributaries pick up dissolved solids and sediments from bedrock and soils. Evaporation also increases the dissolved solids content of waters. During the spring, meltwater may dilute these constituents, but by summer the dilution effect disappears. The quality of groundwater discharge also contributes to the quality of surface water. The return flows from agricultural irrigation commonly carry elevated levels of nutrients, salts, and metals leached from the soils. As return flows eventually discharge to surface water bodies, they could degrade the quality of surface water. Impaired waters are identified in the U.S. EPA’s Total Maximum Daily Load program (EPA 2023a). The 11-state planning area includes all of EPA Regions 8, 9, and 10, and a portion of EPA Region 6; the EPA provides a listing of all impaired waters for each of these regions.

F.20.2.1.2 Floodplains, Ephemeral Streams, and Wetlands

Surface water resources of the affected environment include lakes and rivers as well as numerous floodplains, ephemeral streams (i.e., streams that carry water only briefly in direct response to precipitation), and wetlands. The Clean Water Act (33 USC §1251–1387) is the primary law protecting water quality in surface waters by means of regulatory and nonregulatory methods to limit pollution discharges by point and non-point sources. Additional protections to floodplains, ephemeral streams, and wetlands are provided by Executive Orders 11988 and 11990 (“Floodplain Management” [*Federal Register*, Volume 42, page 26951, May 24, 1977] and “Protection of Wetlands” [*Federal Register*, Volume 42, page 26961, May 24, 1977]). Appendix H provides further information on laws and regulations governing surface waters at the state and local levels for the 11-state planning area.

Floodplain maps are usually prepared for populated areas that could experience flooding. These maps are generally prepared by the Federal Emergency Management Agency (FEMA) for floods that statistically have a 1% and 0.2% chance of occurring each year (i.e., 100-year and 500-year flood events). Such maps are used for property insurance purposes (FEMA 2023). Because the 11-state planning area has large areas that have not been evaluated for 100-year flood potential, affected environments and future project-specific impacts would need to be addressed during site-specific project planning.

Stream channels for ephemeral and intermittent streams are often incorporated in the National Hydrography Dataset from the USGS, but drainages and washes often are not. Again, for site-specific project work, planners would need to identify these drainages during assessment of affected environments and future project-specific impacts (e.g., using aerial photographs, field surveys). The 11-state planning area contains many mountain valley regions with low-relief alluvial fans. Surface water flows over alluvial fans and drainages can be significant during large storm events, resulting in localized flooding and severe erosion.

Wetlands in the 11-state planning area are often associated with perennial water sources such as springs, streams, lakes, or ponds. Given the arid climate of the Southwest, wetlands in this region are often inundated from seasonal to intermittent portions of the year. In wetter parts of the Pacific Northwest and the Rockies, wetlands are expected to have longer hydroperiods. However, even when wetlands are not inundated, shallow groundwater depths are typical, which often support vegetation important to ecological habitats (see Section 4.4.1 and Appendix F.4 for further discussion of wetlands).

F.20.2.2 Groundwater Resources

Twenty-eight major aquifer systems occur in the 11-state planning area (see Figure 4.20-2). Groundwater occurs primarily in unconsolidated and semi-consolidated sand and gravel aquifers, sandstone aquifers, carbonate-rock aquifers, aquifers in interbedded sandstone and carbonate rocks, and igneous (volcanic) and metamorphic rock aquifers. The most widely distributed systems are the basin-fill aquifers of the Basin and Range Region in Nevada, southeastern California, western Utah, the Pacific Northwest, the Willamette, Columbia Plateau, and the Snake River Plain (Whitehead 1994); the Lower Tertiary aquifers in central and northeast Wyoming and eastern Montana (Whitehead 1996); and the aquifers within the Colorado Plateau that occupy western Colorado, eastern Utah, northeastern Arizona, and northwestern New Mexico (Robson and Banta 1995). Other major aquifer systems include the Central Valley aquifer system in California, the Rio Grande aquifer system in New Mexico, and the High Plains aquifer system east of the Rocky Mountains (Planert and Williams 1995; Robson and Banta 1995). In addition, aquifers of alluvial and glacial origin occur in the northern regions of Montana (Whitehead 1996).

Shallow groundwater is typically found near the surface in the vicinity of large surface water bodies (i.e., lakes and streams) and near the areas with lowest elevation in a basin. Deeper groundwater may occur at great depths in bedrock aquifers. Recharge of these aquifer systems occurs mainly through precipitation, especially in mountainous areas where snow precipitation is significant and evaporation is relatively low. Groundwater discharges to local streams and rivers and to springs in valleys of low-lying areas and in alluvial fans. During the summer, groundwater discharges contribute significantly to streamflows in low-lying arid and semiarid regions. Groundwater quality is significantly affected by the host bedrock. Recharge of aquifers can be of critical importance to the appropriate management of groundwater resources. Overdraft conditions occur when more water is discharged (including groundwater withdrawals) from an aquifer than is recharged to the aquifer. Groundwater extraction can lead to reduction in discharge to springs, streams, wetlands, and riparian zones. By lowering the groundwater levels, pumping can also lead to saltwater intrusion, subsidence, water-quality degradation, reduction in instream and ecologically needed flows, and surface fissures. Evaluated using site-specific conditions, the water budget of a specific local basin is an important tool for proper, sustainable management of the groundwater resource. Table F.20-2-2 lists the potentially affected aquifer systems within the ten hydrologic regions covered by the 11-state planning area and summarizes their principal uses and general water quality.

Within the 11-state planning area, some aquifers provide the major water supply for local communities and are federally designated as sole source aquifers (Table F.20.2-3). The EPA defines a sole source (or principal source) aquifer as one that supplies at least 50% of the drinking water consumed in the area overlying the aquifer (EPA 2023a). The EPA's criteria for sole source aquifer designation also require that the area have no alternative drinking water sources that could physically, legally, and economically supply all those who depend upon the aquifer for drinking water (EPA 2023a). Proposed federally funded projects that have the potential to contaminate a designated sole source aquifer are subject to EPA review.

Table F.20.2-2. Characteristics of Major Aquifer Systems in the 11-State Planning Area

Geographic Area	Major Aquifer Systems	Aquifer Types	Principal Water Uses	General Groundwater Quality
All of Washington State, a large portion of Oregon, a large portion of Idaho, a small portion of western Montana, a small portion of western Wyoming, and a small region in northern Nevada and northern Utah	Pacific Northwest basaltic-rock aquifers, unconsolidated-deposit aquifers, volcanic and sedimentary-rock aquifers	Bedrock, unconsolidated-deposit aquifers, semi-consolidated and consolidated rock aquifers	Irrigation, public and domestic water supplies	Generally good water quality (TDS <1000 mg/L)
Most of California and a very small portion of western Nevada	Pacific Northwest basin-fill aquifers, Pacific Northwest basaltic-rock aquifers, Basin and Range carbonate-rock aquifers, Basin and Range basin-fill aquifers, California Coastal Basin aquifers, and Central Valley aquifer system	Sedimentary rocks (including carbonate rock) and basin sediments	Main source of water for public supply, domestic consumption, and agricultural irrigation	Elevated TDS levels from evaporative beds in southern California. Agricultural practices in central California combined with a high evaporation rate have resulted in elevated nitrates and pesticides in shallow groundwater systems and substantial declines in shallow groundwater tables.
Colorado Plateau in western Colorado, eastern Utah, northern Arizona, and New Mexico	Colorado Plateau aquifers	Sedimentary rocks	Major source of water for municipal and domestic uses	Groundwater quality is influenced by the nature of the bedrock. Elevated levels of TDS in areas of sedimentary rock. Mining may cause metal contamination in local groundwater.
Most of Arizona and portions of western New Mexico, southern Nevada, and southeastern California	Southern Nevada volcanic-rock aquifers, Rio Grande aquifer system, Basin and Range basin-fill aquifers, and the Colorado Plateau aquifers	Basin sediments and bedrock	Main source of water for domestic consumption and agricultural irrigation	Groundwater quality is influenced by the nature of the bedrock. Elevated TDS and salinity in alluvium or in areas with Late Tertiary sedimentary bedrock. Elevated metals in groundwater in mining areas. Good water quality in deep, carbonate aquifers. Irrigation and mine dewatering lowered the water levels in shallow groundwater in Arizona.
Central New Mexico and south central Colorado	Rio Grande aquifer system, Colorado Plateau aquifers, Roswell Basin aquifer system, and the High Plains aquifer	Basin sediments	Irrigation, livestock watering, and domestic uses	Elevated nitrate in agricultural areas such as the San Luis and Rincon Valleys. Pesticides detected in agricultural and urban areas.
Northeastern Colorado	Denver Basin aquifer system and the High Plains aquifer	Basin sediments	Primarily for irrigation. Other uses include municipal and domestic water supplies	Generally good water quality. Elevated levels of sulfate and metals in local groundwater near mining areas. Elevated concentrations of nutrients and pesticides in shallow alluvial groundwater near agricultural areas.

Table F.20.2-2. Characteristics of Major Aquifer Systems in the 11-State Planning Area (Cont.)

Geographic Area	Major Aquifer Systems	Aquifer Types	Principal Water Uses	General Groundwater Quality
Central and northern Nevada and western Utah	Basin and Range basin-fill and carbonate-rock aquifers and the southern Nevada volcanic-rock aquifers	Basin sediments and bedrock	Domestic consumption, public water supply, irrigation, and power plant cooling	Groundwater quality is influenced by the nature of the bedrock. Good water quality in carbonate rock and sandstone aquifers. Elevated levels of salts and TDS in the central parts of basins, elevated metal concentrations in historic mining areas, and elevated nitrate and pesticide concentrations in shallow groundwater in agricultural areas.
Southeastern Colorado and northeastern New Mexico	High Plains	Basin sediments	Irrigation	Generally good quality. Dissolved solid concentrations less than 250 mg/L are found in northeastern Colorado and are the result of relatively large recharge rates in areas of sandy soil that contains few soluble minerals.
A small region in eastern New Mexico	High Plains	Basin sediments	Irrigation	Groundwater quality is influenced by the nature of the bedrock. TDS is generally good (<500 mg/L) with some areas exceeding 1000 mg/L.

Sources: BLM (2007a); Hutson et al. (2004).

Table F.20.2-3. Sole Source Aquifers in the 11State Planning Area

Location	Sole Source Aquifer
Arizona	Upper Santa Cruz and Avra Basin Aquifer
Arizona	Bisbee-Naco Aquifer
California	Fresno County Aquifer
California	Santa Margarita Aquifer, Scotts Valley
California	Campo/Cottonwood Creek
California	Ocotillo-Coyote Wells Aquifer
Idaho	Eastern Snake River Plain Aquifer
Idaho	Lewiston Basin Aquifer
Idaho	Spokane Valley-Rathdrum Prairie Aquifer
Montana	Missoula Valley Aquifer
New Mexico	Española Basin Aquifer System
Oregon	North Florence Dunal Aquifer
Utah	Glen Canyon Aquifer
Utah	Castle Valley Aquifer
Utah	Western Unita Arch Paleozoic Aquifer System
Washington	Lewiston Basin Aquifer
Washington	Spokane Valley-Rathdrum Prairie Aquifer
Washington	Troutdale Aquifer System
Washington	Central Pierce County Aquifer
Washington	Vashon-Maury Island Aquifer
Washington	Cedar Valley Aquifer
Washington	Bainbridge Island Aquifer
Washington	Cross Valley Aquifer
Washington	Newburg Area Aquifer
Washington	Marrowstone Island Aquifer
Washington	Whidbey Island Aquifer
Washington	Camano Island Aquifer
Washington	Guemes Island Aquifer
Wyoming	Elk Mountain Aquifer
Wyoming	Eastern Snake River Plain Aquifer

Source: EPA (2023c).

The EPA's Sole Source Aquifer Protection Program is authorized by Section 1424(e) of the U.S. Safe Drinking Water Act (SDWA). Proposed federally funded projects that have the potential to contaminate a designated sole source aquifer are subject to EPA review. In many cases, Memoranda of Understanding (MOUs) have been developed by the EPA with federal funding agencies (e.g., the Federal Highway Administration and the Department of Housing and Urban Development) to establish a review of responsibilities under the Sole Source Aquifer Protection Program and to list categories of projects that should or should not be referred to the EPA for review. MOUs help ensure that projects that pose serious threats to groundwater quality are referred to the EPA (EPA 2023a).

Most projects referred to the EPA for review meet all federal, state, and local groundwater protection standards and are approved without imposing additional conditions. Occasionally, site- or project-specific concerns for groundwater quality protection lead to specific recommendations or additional pollution prevention requirements as a condition of funding. In rare cases, federal funding has been denied when the applicant either has been unwilling or unable to modify the project.

Special agency stipulations may apply to lands that have been designated with sole source aquifers. For example, no surface-disturbing activities would be allowed within sole source aquifer designated areas on BLM-administered lands, unless an exception was granted for activities for which it can be demonstrated that the proposed action would not result in a negative impact on the aquifer. Under the Safe Drinking Water Act, all states are required to develop source water assessment programs for determining risks of polluting sources of drinking water. All states within the planning area have programs to identify and protect groundwater supply and/or quality issues. Washington State established critical aquifer recharge areas to protect drinking water supplies. Oregon identified three groundwater management areas because of elevated nitrate concentrations. Idaho identified the Spokane Valley-Rathdrum Prairie Aquifer as sensitive, which requires the strongest level of the state's protection. Montana has a source water delineation and assessment program to identify recharge areas for groundwater and potential contaminant sources within these areas. Wyoming has a groundwater pollution control program that evaluate the potential impacts on groundwaters from activities permitted at local, state, or federal level. California defines groundwater protection areas that are vulnerable to movement of pesticides to groundwater. In California, the State Water Resources Control Board and nine Regional Water Quality Control Boards protect groundwater through regulatory and planning processes to identify beneficial use and water quality objectives, regulate activities that may potentially impact beneficial use, and manage future impacts. Nevada has a Source Water Protection Program to help prevent contaminants from entering public drinking water sources including groundwater sources. Utah has adopted rules regarding protection of public drinking water resources. It identifies various protection zones within which certain activities may be restricted that have the potential to impact a drinking water source. Colorado regulates the discharge of pollutants to the state's groundwater such that the types and amounts of pollutants discharged do not violate the state water quality standards. Arizona monitors groundwater quality throughout the state and identifies agricultural-use pesticides that may pose a threat to groundwater quality. New Mexico Ground Water Quality Bureau issues groundwater discharge permits to prevent contamination of groundwater resources as specified in the state's groundwater and surface water protection regulations.

F.20.2.3 Water Rights, Supply, and Use

The arid climate and scarcity of water resources throughout the 11-state planning area make water rights and management of extreme importance in achieving beneficial uses of water resources while maintaining healthy aquatic ecosystems. States have primary authority and responsibility for the allocation and management of water resources within their borders, except as otherwise specified by Congress. The BLM cooperates with state governments and complies with applicable state laws to the extent consistent with federal law to acquire, perfect, protect, and manage water rights to protect water uses identified for public land management purposes. The BLM ensures that land use authorizations granted to third parties contain appropriate terms and conditions to protect BLM-administered water rights and uses. Third-party uses of appropriated water on BLM-administered lands that operate under BLM permitting authority shall comply with applicable state laws, federal laws, and executive orders.

Water rights and management activity varies by state. Beneficial uses of water resources vary by state, but typically include irrigation, domestic, recreational, and industrial uses. Balancing beneficial uses with scarce water resources, in combination with complex water rights and management practices, can make obtaining water supplies for solar energy development difficult. A significant component to any solar energy development plan will be a project level water availability assessment to determine if water is physically and legally available to meet the necessary water requirements. The myriad of applicable laws and agencies regulating water resources in any one location is complex and often needs to be assessed on a case-by-case basis. There are varying water management doctrines and approaches among the states, and sometimes surface water resources are managed differently than groundwater resources. Variation of management among the states stems from quantity and types of available resources, the climate and terrain of a state, and historical development. However, the states' water management strategies accommodate many water needs and uses (human and ecological), while maintaining the sustainability of those resources. The following sections provide descriptions of general water management concepts and of the various agencies involved in water management and water rights issues, and a summary of state-by-state water management.

The rest of this section describes the general availability and use of water resources in the 11-state planning area. The description uses long-term water supply as a baseline. Any long-term trends in water supplies, including those from effects of climate change at the regional scale, should be considered. Water resources planning in various states considers long-term trends to assure balance between water demand and availability. Drought conditions, which have occurred in the region since early 2000, may reduce the water supply substantially from time to time, thus affecting the pattern of water use. Park et al. (2022) concluded that the 2000-2021 period was the driest 22-year period since 800. During July-October 2021, more than 68% of the western United States was under extreme or exceptional drought. However, in May 2023, the total area of the western United States (the 11-state planning area) that is under drought is nearly 50% less than that portion at the beginning of October 2022 (NIDIS 2023), noting that this reduction in drought area is the result of a wet 2023 winter. Wet years are not uncommon within the multidecadal drought.

Water use may also be legally restricted because of water right issues and various interstate compacts. As water rights can be transferred or traded, the use of water among various sectors could also change with time. Such transfer of water rights is affected by national and local economies. Regional population growth and weather patterns related to climate change may also contribute to the variation of water supply and use. Finally, conservation measures implemented in different states change water use behaviors. All in all, water supply and use are dynamic and interdependent in nature. The information on water supply and use described below provides a general picture of existing conditions by state. Whether the supply can meet the demand varies among different hydrologic basins and water management areas, districts, or hydrologic regions within each state. Therefore, local hydrologic and climatic conditions and policies, designations, or declarations issued by federal, Tribal, and state water management agencies in response to drought and water shortages must be considered when impacts are evaluated at the project level.

Water Rights Doctrines. A water right is the right to divert and use a certain quantity of water for a specified use. Two water rights doctrines form the basis of water laws in the United States: the riparian doctrine and the doctrine of prior appropriation. The right to use water that is present or passes through a piece of property is termed a riparian water right. The riparian doctrine is based on the principle of "reasonable use." A property owner is allowed to divert or consume water that physically touches their property, but may not unreasonably detain or divert water. The definition of reasonable use of riparian water rights varies among states, and the definition is subject to change. Riparian water rights are tied to the land adjacent to the water body and are generally not transferrable to non-adjacent areas. Most of the eastern United States follows the riparian doctrine. Some states such as California, Oregon, and Washington use aspects of both the riparian doctrine and the doctrine of prior appropriation. Water law in all other states in the 11-state planning area is based on the principles of prior appropriation and beneficial use.

Under the doctrine of prior appropriation, the first person (or entity) to divert water from a source has the most senior right to use that water right and subsequent junior water right holders use the remaining water. Owners of appropriative water rights do not need to be adjacent to the water body, as under the riparian doctrine, but can divert water for use where it is needed. Most of the western states rely upon the prior appropriation doctrine to manage the allocation of water resources. Under the system of prior appropriation, junior water rights are fulfilled after all senior water rights holders have obtained their allocation of water. Thus, in times of drought or other water shortage, water rights may be curtailed and junior water rights holders may not receive their share of the resource. Some states allow water rights to be bought, sold, or transferred separately from the land, while other states forbid such transfers. State-based appropriative water rights may be lost through abandonment or forfeiture if not used for a certain period of time. For example, in Arizona, if a water right is not used for five consecutive years, the water right is considered forfeited and the water becomes available for appropriation again (Hockaday and Ormerod 2020).

Beneficial Use of Water Resources. In some states, the priority of a water right can be based solely on the first date of use, and in others the priority can also depend on the specific use of the water. Priority "beneficial uses" of water can be specified, including for example, domestic, municipal, irrigation, livestock (stock water), industrial, wildlife, or recreation. Each state has its own system for defining priorities regarding beneficial uses of water, from different sources and in different basins. For example, water rights in Utah are based on the concept of beneficial use, and any water right granted in the state has a specified beneficial use associated with it (Hockaday and Ormerod 2020).

Non-consumptive water use to support wildlife or recreation within a stream system can be considered a beneficial use in some states and is sometimes termed an "instream flow." This use can be given a priority in times of drought to support wildlife by maintaining a minimum streamflow that has been demonstrated to support wildlife. In Utah, instream flows were defined as a beneficial use in 1986 through passage of legislation. The instream flow water rights in Utah can be held only by the Utah Division of Wildlife Resources or the Division of Parks and Recreation and can only be obtained through legislative approval. Some states do not recognize instream flows, recreation uses, or maintenance of wildlife, riparian, or fish habitat as beneficial uses of water. New Mexico has no state laws governing instream flows, and they are not recognized as a beneficial use in the state. However, ongoing litigation in New Mexico is working toward defining instream flows as a beneficial use (Hockaday and Ormerod 2020).

Federal Reserved Water Rights. Where Congress or the Executive Branch has withdrawn lands from the public domain for a specific federal purpose, such reservation may create a federal reserved water right to unappropriated water in the amount necessary to fulfill the primary purpose of the reservation. The purposes of federal reservations of land are specified in Congressional legislation and Presidential executive orders that create the reservations. Federal reserved water rights, unlike state appropriative water rights, are not lost by nonuse and may provide for future needs. The priority date of the federal reserved water right is the date of the withdrawal of the lands within the reservation by legislation or Executive Order. Examples of reservations that create federal reserved water rights on BLM-administered lands include national conservation areas, national monuments, wild and scenic rivers, wilderness areas, and public water reserves. Federal reserved water rights are also created when certain lands are reserved for federally recognized Indian Tribes, national parks, national forests, and national wildlife refuges. Pueblo water rights apply to lands that were recognized by Spanish law as Spanish or Mexican pueblos (cities) and have been designated in California and New Mexico. A pueblo water right specifies that water flowing through or contained within the original pueblo can be used for municipal purposes within the modern city limits.

Federal, State, and Local Legislation and Adjudications. Water use is primarily governed through state and/or local regulations, but a few federal laws (such as the Clean Water Act, the Endangered Species Act, the Wild and Scenic Rivers Act, and the Wilderness Act) play an important role in determining the availability of water.

All states in the 11-state planning area have passed legislation concerning the use and supply of water. For example, California has a suite of water laws that fall under the *California Code of Regulations,* Title 23. Colorado also has enacted statewide water laws in the *Colorado Revised Statutes.* Additionally, Colorado has a system of water courts that handle all water rights applications. Many of the states also provide specific regulations on standards for the reuse or recharge of municipal wastewater. The state water laws establish the rules and agencies/parties responsible for enforcing those rules. Additionally, some counties in the southwestern United States have additional laws or ordinances that govern the water supplies within that county. For example, 27 county-level ordinances have been established in California to manage groundwater resources. Local and municipal ordinances relating to water use or regulations within an irrigation district may also apply to certain areas.

States can also establish judicial or quasi-judicial procedures termed adjudications, to confirm and determine the priority of water rights not obtained or confirmed through the state's permitting system. Adjudications have been necessary in many states to resolve complex water rights claims, including those claimed under the federal reserved rights doctrine (including Tribal rights) that had previously not been included in a state's accounting of water rights for a basin (Gerlak and Thorson 2006). The McCarran Amendment of 1952 assigned the state court systems responsibility for determining the federal and Tribal water rights for a basin (Hobbs 2006). The adjudications involve all water users in a basin, so the process can be long and complex. In New Mexico, the adjudication of the Pecos River basin began in 1956 and is still ongoing (NMOSE 2023). Each state handles water rights adjudications in different ways. In New Mexico and Utah, the state engineer initiates the adjudications. In Nevada, the state engineer can initiate adjudications or water rights can be directly adjudicated in courts. In California, the State Water Board has only initiated two out of 20 adjudications; the rest are conducted by the state or federal court system or by the court system with the State Water Board as a referee (CADWR 2010a). The results of adjudications are often a complex set of new rules and regulations for a basin that are enforced by state or regional water officials (Gerlak and Thorson 2006; Hobbs 2006). The water rights decisions can sometimes include a settlement of both money and water (Gerlak and Thorson 2006).

Federal, State, and Local Agencies and Water Resources Managed. A myriad of agencies are involved in protecting water quality and quantity. At the federal level, the EPA and the U.S. Army Corps of Engineers (USACE) enforce many programs to protect water bodies, for example, from contamination or physical alteration. The EPA also has set standards and regulations for the reuse of wastewater treatment plant effluent. The National Park Service (NPS), the U.S. Fish and Wildlife Service (USFWS), the BLM, and other federal agencies are responsible for maintaining federal reserved water rights that accompany the land holdings of these agencies. Often, these agencies are interested in preserving instream flows or maintaining groundwater-fed springs to protect wildlife habitat. The BOR and the USACE are responsible for managing hydropower and other types of dams; however, the flows from these dams are often regulated by state laws or international treaties. The U.S. Section of the IBWC is the agency responsible for managing the water at the United States–Mexico border.

Water management at the state level is typically performed by a division of water resources or an office of the state engineer, and a combination of agencies is responsible for water management in some cases. In Utah, there are two agencies: the Division of Water Resources, responsible for planning within the surface water basins, and the Division of Water Rights, responsible for appropriating available water resources within basins. In California, the State Water Resources Control Board holds primary responsibility for issuing and regulating surface water rights, while groundwater resources are typically managed at a local level. The California Department of Water Resources is responsible for planning for the future of California's water resources and is a repository of information on those resources. For example, all wells drilled in the state must be registered with the Department of Water Resources, and water levels for 35,000 wells are available from their Web site (CADWR 2010b). Additionally, each state has a department of environmental quality or equivalent agency that regulates the quality of water and maintains drinking water standards within the state.

Another layer of management often exists at a regional, county, or local level. In New Mexico, the Office of the State Engineer has identified priority regions within the state, each of which has an appointed "water master" to help track water use and enforce water law within that region. New Mexico also has a system of acequias, or community ditches, that have been in existence since the Spanish colonized the area starting in the seventeenth century (NMOSE 2010c). Acequia associations are in charge of distributing surface water in certain areas of New Mexico. In California, water masters are often appointed to enforce an adjudication of a basin. Colorado water rights are established through seven regional water court systems throughout the state and enforced by regional water commissioners. Before a water right is approved, it must be approved by both the water court system and the local Division Engineer Office (CDWR 2008). Additionally, in many regions of the southwestern United States, water conservation agencies and irrigation districts are responsible for the local management of water resources, and can also act as the water master for adjudicated basins (e.g. Imperial Irrigation District, Mojave Water Agency, Palo Verde Irrigation District, and Metropolitan Water Agency, operating in California).

There are many different approaches to managing water resources. In some states, surface water and groundwater are managed differently, and in others all water resources are managed conjunctively. Also, in some regions, the beneficial uses of water within a basin are stipulated by water management agencies. For example, in Nevada the groundwater in some basins is designated as having preferred beneficial uses, and all other uses are not allowed within the basin. As is the case with many basins in Nevada, new agricultural irrigation is not allowed as a groundwater use in the Las Vegas Valley basin. Other uses are specified as preferred within the basin. Various beneficial uses are recognized in the 11-state planning area. Arizona recognizes the following beneficial uses: domestic, municipal, irrigation, stock watering, power, mining, recreation, wildlife and fish, and groundwater recharge. California recognizes several more beneficial uses, including aquaculture, fire protection, frost protection, heat control, industrial use, and water quality control (Hockaday and Ormerod 2020).

To obtain water rights in most states, users must submit to the appropriate state (or local) agency an application that, in most cases, must identify the source of the water, the location of the proposed diversion (or well), the proposed place of use, the beneficial use, and the proposed quantity of use. Surface water is almost universally acquired using a process similar to that described here, but the process of obtaining groundwater varies from state to state. Permits to withdraw groundwater are not required to be obtained through a state agency in California, but may be required through a county or local agency. In Arizona, permits to withdraw groundwater are only required in certain areas. In Nevada, vested water rights are those for which a user initiated work for beneficial use of surface waters prior to March 1, 1905 (date of adoption of Nevada's water law), of artesian groundwater prior to March 22, 1913, and for percolating groundwater prior to March 25, 1939. New water rights are obtained using the adjudication process of the Nevada Division of Water Resources (NDWR 2018).

Many groundwater basins in the 11-state planning area have been over-appropriated and are experiencing groundwater level declines and depletions in streamflow and springflow. Declines in groundwater levels can occur even when pumping rates are lower than aquifer recharge rates and can lead to streamflow depletion. The effects depend on local conditions inkling aquifer properties, pumping rates, and location of wells in relation to surface water bodies. Declining water levels also have the potential to cause land subsidence and saltwater intrusion and reduce drought resilience. Many of the over-appropriated basins are closed to new applications for groundwater use, and any future groundwater use within the basins must be transferred from other uses. Each state handles these groundwater overdrafts differently. Most of the states in the 11-state planning area have started artificially recharging some overdrawn aquifers by either diverting surface waters to infiltration basins and allowing water to percolate from the surface into an aquifer or by injecting water into wells to replenish aquifer storage. In most cases, excess surface water during wet periods is diverted for these artificial recharge activities. Usually, the water is considered available for use later, during times of water shortage. Special permits may be required to use artificially recharged water.

Another strategy for optimizing water use has been the rise of the reuse of wastewater treatment plant effluent for irrigation, energy production, artificial recharge, industrial purposes, or other uses. Most western states are encouraging the reuse of treated water to optimize water use, especially within heavily populated areas. In Arizona, 80,000 ac-ft/yr (99 million m^3/yr) of effluent from the Phoenix metro area is allocated to the Palo Verde Nuclear Generating Station for cooling, allowing the existence of the only nuclear power plant not located on a major body of water (Azcentral 2010).

Many states have a process for designating basins or regions as special management areas to impose additional regulation of water resources. The Nevada Division of Water Resources (NDWR) designates groundwater basins when they are deemed to need a higher level of oversight and management (NDCNR 2022). As of 2005, the New Mexico Office of the State Engineer (NMOSE) had “declared” every basin within the state as being in need of management (NMOSE 2010e). Prior to that time, basins that had not been declared were not subject to regulation by the NMOSE. Additionally, New Mexico has instituted a program called Active Water Resource Management that is currently being employed in the seven “priority” basins within New Mexico (NMOSE 2004). This initiative is developing tools to perform detailed accounting of water use, implementing new or existing regulations, creating water districts for management, and assigning water masters to those districts (NMOSE 2004).

Most states allow interbasin transfers of water if water is available in one place but needed in another. States handle these interbasin transfers in different ways. Nevada uses a formal process by which the NDWR approves interbasin transfers. However, In Utah, for example, interbasin transfers are allowed, but there is no formal process for evaluating and approving them in the state. In Colorado, interbasin transfers are necessary to support the half of the population that lives on the eastern side of the state that receives only 20% of the precipitation (CLCS 2009). Twenty-five of the 39 interbasin transfers in Colorado originate from the Colorado River Basin (CLCS 2009).

In addition to managing surface water and groundwater resources, water managers also consider the health of springs and seeps, the quality of water, and instream flow needs for wildlife. Water supports life, and clean, flowing water is needed to support wildlife and the economic and resource values of public lands. The need to support wildlife can often lead to court cases to establish the amount of water deemed sustainable to withdrawal from a stream or aquifer in order to maintain healthy ecosystems in a basin.

F.20.2.3 Water Management: Interstate Compacts and International Treaties

Several international compacts pertain to the governing of water rights in the 11-state planning area for both surface waters and groundwater. The International Boundary and Water Commission (IBWC) was established in 1889 to implement water treaties between the United States and Mexico (IBWC 2023a). The commission has sections representing each country that consist of an engineer-commissioner, a team of engineers, and legal staff. The main goals of the IBWC relate to boundary demarcation, national ownership of waters, sanitation, water quality, flood control, and resource management of water bodies shared along the United States–Mexico border. Two major river systems cross several western states and Mexico—the Colorado River and the Rio Grande River—along with several smaller water bodies. Transboundary aquifers also underlie the boundary between the United States and Mexico. In 2006, the United States and Mexico signed the Transboundary Assessment Aquifer Act (P.L. 109-448), which promotes the assessment of transboundary aquifer systems that underlie Arizona, New Mexico, and Texas along the United States–Mexico border. The program aims to identify and better understand the properties of priority transboundary aquifers. Ongoing projects represent a collaboration among federal agencies and universities of the two nations (USGS 2023a). The act does not impact water rights, laws, or international treaties.

The Boundary Waters Treaty of 1909 between the United States and Canada prevents and resolves disputes involving the shared waters between the two nations. The International Joint Commission (IJC) was created by the treaty (IJC 2023). The treaty established the IJC as the approver of new project and the authority to resolve disputes involving shared waters. The treaty also established an order of precedence of new use of the shared waters with priority given to domestic and sanitary use followed by navigation, and finally for power generation and irrigation.

Columbia River. The Columbia River Basin covers an area of 165 million acres (668,000 km^2) across the states of Washington, Oregon, Idaho, Montana, Wyoming, Utah, and Nevada and the Canadian province of British Columbia. The Columbia River originates in British Columbia and flows approximately 1,200 mi (1,940 km) through Canada and United States before flowing into the Pacific Ocean near Astoria, Oregon. Major tributaries of the Columbia River include the Kootenai, Flathead, Pend Oreille, Yakima, Spokane, Okanogan, Wenatchee, Methow, Snake, John Day, Deschutes, and Willamette Rivers. Following the creating of the IJC, the United States and Canada requested that the IJC determine the feasibility of developing the Columbia River System.

The Columbia River Treaty, signed in 1961, is an agreement between the two nations for cooperative development and operation of the Columbia River system to provide flood control and power generation. Under the treaty, Canada built three dams—Mica, Duncan, and Keenleyside Dams—and the United States built the Libby Dam. The two nations began negotiations to modernize the treaty regime in 2018. As part of these negotiations, an ecosystem-based approach to managing the water resources of the Columbia River Basin is also being considered.

The Columbia River Compact is a partnership between the states of Washington and Oregon under which commercial fishing on the lower Columbia River is regulated. The United States Congress ratified the interstate compact in 1918. Under the compact, five fishing zones were created between the mouth of the river and the Bonneville Dam and a sixth zone between the Bonneville and McNary dams, which is designated exclusively for Native American fisheries.

Colorado River. The Colorado River Basin covers an area of 156 million acres (632,000 km^2) across seven states: Colorado, Wyoming, Utah, New Mexico, Nevada, Arizona, and California. The Colorado River headwaters are located in the Colorado Rocky Mountains and the river historically flowed 1,440 mi (2,300 km) to Mexico's Gulf of California, but currently its waters are consumed before reaching the Gulf. The use and management of the Colorado River among the seven states and Mexico is managed by international treaties, interstate compacts, federal laws, court decisions and decrees, contracts, and regulatory guidelines that are collectively referred to as the "Law of the River." The major components of the Law of the River are described in Table F.20-4. In light of prolonged drought, low runoff conditions, and low water levels in Lake Powell and Lake Mead, the Department of the Interior declared the first-ever Colorado River Basin water shortage on August 16, 2021.

Most of the components of the Law of the River pertain to allocation of Colorado River water, but the Colorado River Basin Salinity Control Act of 1974 addresses water quality. The Colorado River System is naturally very saline (BLM 2017). Salinity in the Colorado River increases as it flows downstream. The sources of salinity in the Colorado River Basin were estimated to be 47% from natural sources, 37% from irrigation, 12% from reservoir leaching, and 4% from municipal and industrial activities. Between 1940 and 1980, the river carried an average salt load of about 9.3 million tons (8.4 million metric tons) annually past the Hoover Dam (BLM 2017). Between 2005 and 2015, the annual average salt load has decreased to approximately 7.5 million tons (6.8 million metric tons). The decreasing salinity trend in the Colorado River Basin is also analyzed by Rumsey et al. (2021). The Colorado River Basin Salinity Control Act, as amended in 1984 (P.L. 106-459), directed the Secretary of the Interior to enhance and protect the quality of water in the Colorado River and to develop a comprehensive program for minimizing salt contributions to the Colorado River from BLM-administered lands. The BLM implements its Colorado River Basin Salinity Control Program and coordinates with the Colorado River Basin Salinity Control Forum to achieve the act's objectives. Surface disturbance leading to erosion of naturally saline soils and subsequent runoff have the potential to increase the salt load on the Colorado River. The effects may vary by location, amount of area disturbed, and erosion control practices.

Rio Grande. The Rio Grande originates in the San Juan Mountains in southern Colorado and flows 1,865 mi (3,000 km) south through New Mexico before forming the border between Texas and Mexico enroute to the Gulf of Mexico. Disputes over Rio Grande water resources have led to three major water compacts—the 1905 Rio Grande Project (RGP) compact between Texas and New Mexico; the 1906 United States–Mexico treaty; and the 1938 Rio Grande Compact between Colorado, Texas, and New Mexico (Littlefield 1999). These treaties are overseen and enforced cooperatively by the New Mexico Office of the State Engineer (NMOSE), New Mexico's Elephant Butte

Irrigation District, Texas' El Paso County Water Improvement District No. 1, and the U.S. Bureau of Reclamation (BOR). The Rio Grande Compact establishes appropriations of Rio Grande water between Colorado, New Mexico, and Texas by setting downstream delivery schedules for each state based on the natural supply. The Mexican Water Treaty of 1944 allocated water to Mexico, including 1.5 million ac-ft/yr (1.9 billion m^3/yr) of Colorado River water (Table F.20.2-4) and two-thirds of the flows that originate from tributaries originating in Mexico, which averages to 350,000 ac-ft/yr (432 million m^3/yr) over a five-year period (CRS 2005).

Table F.20.2-4. Summary of Components to the Law of the River

Year	Agreement	Components
1909	The Boundary Waters Treaty of 1909	• Defined boundary waters shared between the two nations, established free and open navigation of the boundary waters, established jurisdiction and control of shared waters, established the International Joint Commission (IJC) as the approval authority for new projects involving boundary waters, provided for equal sharing of the waters of St. Marys and Milk Rivers, established order of precedence for new use of boundary waters, and established the IJC as the authority to resolve disputes.
1918	Columbia River Compact	• Regulated the commercial fisheries in the Columbia River by ratifying the compact between the states of Washington and Oregon.
1922	Colorado River Compact	• Defined Upper Colorado River Basin and Lower Colorado River Basin and allotted to each 7.5 million ac-ft/yr (9.3 billion m3/yr) of water for beneficial use.
1928	Boulder Canyon Project Act	• Ratified the 1922 compact. • Authorized the construction of Hoover Dam and related facilities. • Apportioned the Lower Colorado River Basin's 7.5 million ac-ft/yr (9.3 billion m3/yr) to Arizona (2.8 million ac-ft/yr [3.5 billion m3/yr]), California (4.4 million ac-ft/yr [5.4 billion m3/yr]), and Nevada (0.3 million ac-ft/yr [370 million m3/yr]). • Authorized the Secretary of the Interior to manage all water uses in Lower Colorado River Basin.
1931	California Seven Party Agreement	• Prioritized California's allotment among local water management entities–Palo Verde Irrigation District, Yuma Project, Imperial Irrigation District, Coachella Valley Irrigation District, Metropolitan Water District, and the City and County of San Diego.
1944	Mexican Water Treaty	• Committed 1.5 million ac-ft/yr (1.9 billion m3/yr) of Colorado River water to Mexico.
1948	Upper Colorado River Basin Compact	• The Upper Colorado River Commission was created and apportioned the Upper Colorado River Basin's 7.5 million ac-ft/yr (9.3 billion m3/yr) to Colorado (51.75%), New Mexico (11.25%), Utah (23%), and Wyoming (14%). The northern portion of Arizona located within the Upper Colorado River Basin was granted 50,000 ac-ft/yr (62 million m3/yr).

Table F.20.2-4. Summary of Components to the Law of the River (Cont.)

Year	Agreement	Components
1956	Colorado River Storage Project Act	• Provided comprehensive water resources development plan for the Upper Colorado River Basin and authorized the construction of the Glen Canyon, Flaming Gorge, Navajo, and Curecanti Dams, as well as several irrigation projects.
1961	Columbia River Treaty	• Provided for cooperative development of the water resources of the Columbia River Basin for flood control and power generation. Three Canadian dams and one United States dam were constructed and are operated under the provisions of the Treaty.
1964	Arizona v. California U.S. Supreme Court Decision	• Settled dispute between Arizona and California regarding each state's allotment of Colorado River water. Directed the Secretary of the Interior to account for consumptive use of Colorado River water.
	Supplemental Decree (1979)	• Addressed the current status of perfected water rights outlined in the Colorado River Compact and the Boulder Canyon Project Act.
	Consolidated Decree (2006)	• Provided a single reference to the 1964 U.S. Supreme Court Decision and provisions. Also incorporated provisions for Tribal water rights for the Fort Yuma Indian Reservation.
1974	Colorado River Basin Salinity Control Act	• Authorized desalinization projects, including the Yuma desalting plant, to improve water quality. A 1984 amendment directs the Secretary of the Interior to develop a comprehensive program for minimizing salt contributions to the Colorado River from BLM-administered lands.

Source: BOR (2023).

F.20.3 Supplemental Material for Impacts Assessment

A utility-scale PV solar energy project can affect surface water and groundwater in several ways, including the use of water resources, modification of the natural surface water and groundwater flow systems, alteration of the interactions between groundwater and surface waters, contamination of aquifers, wastewater treatment either on- or offsite, and water quality degradation by runoff or withdrawals, as well as from leaks and spills of fuels and chemicals used during construction and operation of the project. PV solar energy facilities generally have lower water and chemical use than concentrating solar power facilities. This section discusses the potential effects on both water quantity and water quality associated with utility-scale PV project activities.

Water Management. The 11-state planning area has considerable climatic and landscape variability. While the Southwest is largely composed of arid landscapes, parts of the western and northwestern United States have milder climates with wet winters and warm, dry summers. Thus, the spatial and temporal distribution of water quantity and water quality, the water requirements of solar energy development, and impacts on water resources will vary at different locations. The analysis of water resource impacts also requires analysis of water and land management practices and consideration of the BLM's sustained-yield mission. Acquiring reliable, long-term water supplies to support utility-scale solar energy facilities may entail either the acquisition of unallocated water supplies (depending on availability) or the transfer of permits from current uses. Water could be obtained from either surface water, groundwater, or recycled water, depending on the location of the water supply source. The quality of water required for solar energy development depends on the purpose of that water in the project. For example, potable water would be needed to support the workforce during construction and operation. However, reclaimed or recycled water may suffice for PV panel cleaning. In many regions of the 11-state planning area, the legal availability of water, including existing consumptive, instream, and in-situ uses of surface water and groundwater, and future water needs may also need to be addressed. The need to secure water for solar energy development could compete with other human and ecosystem needs for water in the region, which could reduce the amount of water available for agricultural, municipal, environmental, industrial, and ecological uses. Use of either surface water or groundwater could also affect vegetation and aquatic habitat for species of concern. Depending on the local physical and legal availability of water resources and water management laws and procedures, solar energy development can lead to the conversion of land use practices in the region.

The myriad of applicable laws and agencies regulating water resources is complex and often needs to be assessed on a case-by-case basis. States have primary authority and responsibility for the allocation and management of water resources within their borders except as otherwise specified by Congress. Federal laws and policies are directed toward controlling floodplain development, water quality, and waste disposal. The primary federal law pertaining to the protection of water quality is the Clean Water Act (CWA). The CWA establishes the framework for federal and state collaboration in regulating direct and indirect discharges (including stormwater discharges) from construction and industrial activity and prohibits alteration to waters of the United States (including wetlands) unless a permit is obtained. Section 401 of the CWA requires a licensing or permitting process to take place for the construction or operation of facilities that may discharge to receiving waters to ensure that water quality standards of the CWA are met. Section 402 of the CWA establishes the U.S. Environmental Protection Agency's (EPA's) National Pollution Discharge Elimination System (NPDES) to regulate discharges from both construction sites and industrial facilities (including stormwater and wastewater). Section 404 of the CWA pertains to the regulation of activities that involve the dredging or filling of jurisdictional water of the United States (can include ephemeral washes) and is administered jointly by the EPA and the U.S. Army Corps of Engineers (USACE). Executive Order (E.O.) 11988, "Floodplain Management" (Federal Register, Volume 42, page 26951, May 24, 1977), and E.O. 11990, "Protection of Wetlands" (Federal Register, Volume 42, page 26961, May 24, 1977), direct federal agencies to "avoid to the extent possible the long- and short-term impacts" of modifications to or the destruction of floodplains and wetlands, respectively. The BLM ensures that use authorizations provide for compliance with the CWA as well as state water-quality standards and implementing regulations and may not authorize activities that will contribute to the degradation and/or listing of water bodies as impaired under the Section 303(d) of the CWA, or that will lead to further degradation of water bodies listed as impaired.

A recent U.S. Supreme Court ruling (Sackett v. Environmental Protection Agency, 598 U.S. ___, 2023) resulted in CWA rule changes with respect to jurisdictional wetlands and waters of the United States. The EPA and the USACE revised the definition of the Waters of the United States (Federal Register, Volume 88, page 61964, September 8, 2023); the revised definition was effective September 8, 2023. Additional regulation of water resources can be imposed by federal, state, Tribal, and local agencies through various laws, water rights administration processes, court decisions and decrees, contracts, international treaties, and interstate compacts pertaining to water resources. The BLM ensures that use authorizations granted to third parties contain appropriate terms and conditions to protect water quality and BLM-administered water rights and uses. Third-party uses of appropriated water on BLM-administered lands that operate under BLM permitting authority shall comply with applicable state laws, federal laws, and executive orders.

F.20.3.1 Direct and Indirect Impacts

This section describes impacts on water resources from water use by PV solar energy facilities and impacts on water quality. Impacts during site characterization, construction, operation, and decommissioning/reclamation are included. In addition, impacts related to transmission lines are also described.

F.20.3.1.1 Site Characterization

Activities during site characterization related to water resources may include limited modification or construction of access roads to transport drilling and meteorological equipment, groundwater exploration drilling and testing to evaluate water availability, and deep soil coring to gather information necessary for the design of substantial structure foundations. These activities would vary by site. Water also would be used for dust suppression and the workforce’s potable supply, which would need to be transported from an offsite or local source.

The impacts on water resources resulting from site characterization activities are considered minor because they are limited in extent and duration if appropriately mitigated. Access road modification and construction could require the modification of natural drainage systems, which could (1) increase sediment and dissolved solid loads in the water downstream from disturbed areas and (2) lead to flooding. Any alteration of waters of the United States would require a Section 404 permit (see Section 5.20). During investigation of groundwater systems and deep soil sampling for geotechnical purposes, water would likely be transported from offsite. Mud pits would be dug to contain drilling mud for reuse. Cuttings from drilling would be managed according to federal and state regulations on containment and disposal of waste. The extent of ground disturbance would likely be limited but could cause some soil erosion and surface water quality degradation in downstream waters.

F.20.3.1.2 Construction

Use of Water Resources. Water usage for solar energy development occurs as withdrawals (the amount of water removed from the ground or diverted from a source for use), and consumption (the amount of water that is evaporated, transpired, or otherwise removed from the immediate environment). Withdrawn water that is not consumed may not be returned to its original source or may be returned with degraded water quality. Water would be needed for various activities in the construction phase, including concrete preparation for foundations of the support structures for PV panels (if needed) and buildings, drinking water for site workers, vehicle washing, road construction, and dust control on roads and construction sites. For PV solar energy facilities, the major water use during construction relates to fugitive dust control and workforce potable supply (see Section 3.2). The methodology for estimating the amounts of water needed by PV solar energy technology and by project size is described in Section 3.1. Water sources are likely to be local groundwater, surface water bodies, or recycled water depending on their availability. Water could be transported from offsite sources as well. Water used for making concrete would likely be derived from an offsite source. Water rights and/or permits would need to be obtained from applicable local, state, and/or regional water authorities before water use on BLM-administered lands could occur.

In most areas, groundwater would likely be withdrawn from regional or local aquifers to meet the project's water needs. Depending on project site locations, groundwater may be present in alluvial, sedimentary rock, or bedrock aquifers under confined or unconfined conditions (see Figure 4.20-2). Groundwater withdrawals reduce the amount of water stored in an aquifer and/or deplete groundwater discharge from an aquifer by the amounts and rates withdrawn. These changes in the water budget could lower water levels in lakes, wetlands, and wells; reduce the flow of hydrologically connected springs, seeps, and streams; cause land subsidence; and cause saltwater intrusion or other types of water-quality degradation.

These impacts could include loss of obligate and facultative wetland vegetation species; habitat and forage for fish and wildlife, wild horses, and livestock, and special status species; and could reduce the drought resilience of groundwater-dependent ecosystems and sources of water supply. Factors affecting the timing and magnitude of these impacts include the geology, dimensions, and hydraulic properties of the aquifer system; the distances between pumping wells and areas of aquifer recharge and discharge; and the rate of withdrawal.

If surface water were used, the withdrawal of surface water from a stream would reduce streamflow. Reduced streamflow could affect water quality (including temperature), floodplain connectivity, shallow aquifer recharge, and the fluvial processes necessary for healthy riverscapes (sediment erosion, transport and deposition). Since streamflows in arid and semiarid environments fluctuate dramatically with seasons, the reduction of streamflows could have significant impacts, especially during low-flow periods and drought conditions. These impacts could include loss of habitat for aquatic species and organisms, including special status species, and reduced ecosystem resilience to drought.

In general, the timing, magnitude, and acceptability of these water resource impacts determine whether a specific rate of water use is sustainable. The BLM manages public land based on multiple use and sustained yield, where sustained yield is defined as the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of BLM-managed lands without permanent impairment of the productivity of the land. Preventing permanent impairment means that renewable resources such as water are not depleted, and that desired future conditions are met for future generations.

Streams: Perennial, Intermittent, and Ephemeral. Construction activities could affect natural surface water and groundwater flow systems by diverting and/or channelizing onsite and nearby streams to accommodate access road and facility construction. The level of impacts resulting from alterations of natural drainage patterns for elevated roadbeds would depend on road orientation, drainage structure, and the type of landscape that the roads cross. Hard structures, such as foundations, could increase erosion around such structures. In some cases, upstream drainage would be altered such that flow would be routed around the site and through stormwater infrastructure. Excavation (trenching) or horizontal boring activities to bury pipes or cables might alter surface overland flow and allow subsurface flow to follow the filled trenches or borings. Construction activities could also damage or destroy desert pavement and biological crusts (if present), thus increasing the rate of soil erosion.

The modification of streams, washes, and drainages would alter surface runoff timing and drainage patterns and could increase peak flows and water flow velocities of downgradient streams. All these processes could lead to increased erosion, sediment transport, and sediment deposition. The discharge of wastewater and stormwater could also increase the flow rates of the receiving surface waters. Land disturbance impacts are expected to be greater in areas occupied by an alluvial fan or other landscape features with variable topography more so than in flat regions.

The modification of the natural drainage patterns of a potential development site affects more than just the surface runoff and erosion processes. Ephemeral streams, washes, and drainages often provide critical habitat for many plant and animal populations as well as connect surface water and groundwater resources in desert environments. The modification of ephemeral water bodies in areas of concentrating drainage patterns could also result in the landscape receiving less water. The loss or modification of ephemeral water bodies either by erosion or drainage alterations could result in the loss of vegetation and landscape features that generate critical habitat and connectivity corridors for local wildlife.

Floodplains, Wetlands, Playas, and Riparian Areas. Adverse effects on existing floodplains, wetlands, playas, and riparian areas could result from land disturbance activities. The land disturbance activities can alter the natural drainage patterns (described previously) that feed into these receiving areas. Land disturbance activities can affect floodplains, wetlands, and riparian areas onsite as well as downstream of and adjacent to the development site. Modification to these areas could cause flooding and erosion issues and could affect critical habitats for plants and animals. Reductions to the connectivity of these areas with existing surface waters and groundwater could (1) affect wildlife corridors and (2) limit water availability and thus alter the ability of the area to support vegetation, resulting in impacts on habitat quality. Additionally, increases in water and sediment transported to floodplains, wetlands, and riparian areas could result in localized erosion and sedimentation that can have detrimental effects on the ecological and hydrological functioning of these habitats. Potential effects on habitat include inhibiting growth of vegetation, water quality alterations, clogging groundwater recharge areas, and changing the overall stability of the natural landscape.

Degradation of Water Quality. Both groundwater and surface water quality could be affected by construction activities. These activities include land disturbance-related soil erosion and sedimentation; fuel and chemical spills; storage and potential treatment of wastewater; and the potential application of pesticides, herbicides, and dust suppressant chemicals. Surface water quality could be adversely affected in areas hydraulically downstream and downwind from disturbed areas, including staging areas, construction sites, access roads, soil piles, foundation excavation, trenching, and borrow pits. Sediments from these disturbed areas can be transported by wind or water to adjacent water bodies (including stream, lakes, playas, wetlands, and washes) and degrade water quality through the addition of sediments, dissolved solids, metals, and organics.

Improperly designed groundwater wells could create conduits for poor-quality groundwater, as well as contaminants, to move between aquifers. Chemical and fuel spills could infiltrate groundwater and could spread by surface runoff to surface water features. Wastewater will most likely be contained in portable toilets, onsite sewage lagoons, or septic tanks with leach fields. Leaky wastewater storage containers could degrade groundwater and surface water quality and introduce pathogens. Developers would have to follow applicable federal, state, and local regulations and potentially coordinate with local treatment facilities for wastewater storage, transport, and treatment either onsite (e.g., septic tank with leach field) or offsite. If pesticides or herbicides are used, the leaching or transport of undegraded pesticides and herbicides could negatively affect downstream waters or groundwater. Dust suppression by water or water mixed with dust suppression chemicals could degrade water quality by increasing total dissolved solids concentrations in nearby water bodies and groundwater through evaporation or using poor-quality groundwater or recycled water.

F.20.3.1.3 Operations

Potential impacts on water resources during the operations phase of a PV solar energy project include land disturbance-related issues, water use, wastewater generation, and potential chemical releases affecting water quality. Land disturbance activities include truck traffic, soil disturbance while servicing and cleaning PV panels, and surface runoff and erosion resulting from the altered hydrology imposed by the solar energy facility structures. Impacts associated with land disturbance from truck traffic and maintenance are considered minor given the limited temporal and spatial extent over which these activities would occur during the operations phase. Impacts relating to the altered hydrology can be reduced through the implementation of mitigation measures and best management practices (BMPs) relating to site design, stormwater conveyance, and avoidance of critical landscapes (e.g., ephemeral washes and wetlands).

Groundwater or surface water withdrawals would likely continue in the operations phase to meet project water needs once the solar energy facility was constructed unless recycled water was available to meet the needs of the facility. Groundwater withdrawals cause a cone of depression to form around a pumping well, which will expand until the rate of water extraction is balanced by the capture of groundwater that would otherwise discharge from the aquifer to springs or streams or be consumed by plants. Groundwater level elevations in the region surrounding a pumping well or wells decline during this pre-equilibrium phase because groundwater is mined from aquifer storage while the cone of depression is expanding, which can have adverse impacts on phreatophytic vegetation, wetlands, springs, and other groundwater users, contribute to land subsidence, and result in a loss of groundwater storage capacity throughout the basin. Reaching an equilibrium between extraction and capture can take a long time to achieve depending upon distances to potential groundwater capture sources, other groundwater pumping operations in the basin, and the transmissive and storage properties of the aquifer system (Bredehoeft and Durbin 2009; Barlow and Leake 2012).

When a new equilibrium is reached, groundwater levels will stabilize but discharge to springs, streams, and adjacent aquifers will be reduced by rates equal to the rate of groundwater extraction.

If stream water were used, water withdrawal would reduce streamflow downstream from water intake areas. Loss of streamflow could reduce groundwater recharge and floodplain interaction affecting riparian vegetation and could affect instream habitat (i.e., certain flow and sediment conditions) that fish and other aquatic organisms rely on to survive.

Sanitary wastewater is generated by the solar energy facility workforce. It is likely that these wastewaters would be contained or treated to comply with federal, state, and local regulations regarding wastewater. Onsite treatment of wastewater may be accomplished by using evaporation ponds (industrial wastewater only) or septic tank-leach fields. Additionally, any wastewater or treated effluent from onsite wastewater treatment discharged to a surface water body would need NPDES permitting. Offsite treatment of wastewater would require the PV solar energy facility to coordinate with local wastewater treatment facilities and comply with federal, state, and local regulations regarding the storage and transport of wastewater. Impacts from the storage and potential treatment of wastewater onsite are primarily associated with the leakage of wastewater from storage containers. Wastewaters could introduce organics, salts, metals, and pathogens to nearby surface waters and groundwater, resulting in degraded water quality and potential public health concerns.

Water quality could also be degraded during the operations phase because of the application of herbicides and pesticides used for controlling onsite vegetation. Additionally, accidental spills of chemicals from a PV solar energy facility such as dielectric fluids could contaminate nearby surface waters and groundwater.

F.20.3.1.4 Decommissioning/Reclamation

Decommissioning activities would involve removal of all buildings, structures, access roads, and onsite roads. Disturbed land areas would likely be restored to their original grade and revegetated. During the removal of surface structures, the onsite water needs would be on the same order of magnitude as those for construction. Water most likely would be used to restore the vegetation onsite as well. Any groundwater wells no longer in use would be sealed and abandoned in place following practices established by the local and state regulations.

If groundwater withdrawals from an aquifer were discontinued, groundwater levels would start to recover as water stored in the aquifer fills the cone of depression created by the previous pumping. During this time, groundwater that would otherwise have discharged to springs or streams or adjacent aquifers instead goes into aquifer storage, so the capture of groundwater discharge may continue even though pumping has ceased. Aquifer recovery could take much longer than the period of pumping and decommissioning of pumping activities, and the maximum depletion of springs and streams could occur after pumping stops. The factors that control rate of groundwater level recovery are the same as those that affect the rate of groundwater-level decline during pumping: the geology and dimensions of the aquifer, hydraulic properties of the aquifer materials, distances between wells and areas of aquifer recharge and discharge, in addition to changing climatic conditions. The time lag for aquifer recovery could be substantial where aquifer diffusivity is low and the distances between pumping wells and springs and streams is large.

If withdrawals from a stream were discontinued, the streamflow would return to preconstruction levels. However, the potential impacts due to soil disturbance would largely be the same as those described for the construction phase.

F.20.3.1.5 Transmission Lines

Surface activities associated with the site characterization, construction, operation, and decommissioning/reclamation for transmission lines, and those associated with line upgrades, could adversely affect the quality of surface water in a way similar to that described for solar energy facilities in Sections F.20.3.1.1 through F.20.3.1.4. The water needs for activities related to transmission lines include potable needs and water for vehicle washing and dust suppression. The surface activities common to transmission lines include construction of transmission line supports and new access roads, modification of existing access roads, and heavy equipment traffic. Increases of surface runoff as a result of new and modified access roads and drainage systems could affect sediment and dissolved solid loads in the receiving water. Contaminants from surface spills and improperly stored materials, as well as the application of herbicides to control vegetation growth, could potentially enter nearby surface waters and groundwater and adversely affect water quality.

F.21 Wildland Fire

F.21.1 Methods Used for Evaluation

This Programmatic EIS for wildland fires expounds on the 2012 Western Solar Plan by integrating observation data and climate projections for the 11-state planning area to understand typical locations, size, and causes (if available) of wildland fires, and assess the potential non-stationarity of wildland fires due to climate change. Non-stationarity is defined as a time series of data whose statistical properties are changing over time, compared to a stationary series whose statistical properties remain constant over time. Climate projections by the mid-century expect there to be numerous changes in the intensity and amount of wild fires, which are best modelled by non-stationary statistics. The Canadian Forest Fire Weather Index System (also known as the Fire Weather Index) and probability of the land burning (estimated under 2014 landscape conditions) is used in the climate analysis.

Historical Wildfire

For historical wildfire data, the Fire Program Analysis Fire-Occurrence Database (FPA FOD; Short 2014) from the USDA provides a comprehensive record of federal, state, and local wildland fire records from 1992–2020 with data for location, cause, discovery date, and final fire size. To analyze trends in fire characteristics, the 28-year period is disaggregated into 14-year chunks. Summary statistics for fire characteristics over time are presented in tables. Pie charts for common causes of wildfires are included alongside a comparison of types of human-caused fires.

Climate Projection

Comparisons of current and future wildfire risk leverage high-resolution (12 km), dynamically downscaled projections of future climate scenarios produced at Argonne (Wang and Kotamarthi et al. 2015). The Canadian Forest Fire Weather Index System (CFWI; also known as FWI) is calculated from fuel aridity and weather conditions (noontime relative humidity, wind speed, air temperature, and daily precipitation) to assess risk. These factors are shown to effectively account for the initial spread and buildup of wildland fires. CFWI is one of the most commonly used fire danger indices in North America, including by the U.S. Geological Survey. Summary maps for change in CFWI communicate the spatial distribution of non-stationary wildland fire risk. Accompanying analysis compares areas with high and low change in CFWI to burn probability to assess the impact non-stationarity of CFWI can have on areas with large amounts of fuel.

CFWI projections are also converted into relative fire risk classes (Very Low, Low, Moderate, High, Very High, and Extreme) developed by the European Forest Fire Information System (EFFIS). A table summarizing changes in the total number of acres in each state that fall into each category from historic to mid-century projections provides a non-parametric method for analyzing change in different levels of wildland fire risk.

Based on collaboration with BLM experts, the impact section looks at the intersection of lands available for application under the BLM alternatives with the number of acres burned based on total number of fires in the past 20 years to identify potential risk areas for land managers and planners. Proper mitigation measures are identified to prevent increased burn frequency and avoid the identified impacts at both the solar facility, due to equipment and personnel, and surrounding lands. This includes indirect induction of fires due to construction and operation of solar energy facilities or introduction of invasive species of vegetation into the region which could provide fuel for future fire events. Combining this knowledge of historic fire occurrence with changes in CFWI and burn probability identifies potential risk areas. Areas with an increased CFWI by the mid-century and high burn probability are the most susceptible lands for future fire occurrence. Cross-referencing these lands with the historic 20-year burn data identifies areas that may not be suitable for solar facility construction or identify applicable mitigation measures to decrease this risk. Fire mitigation strategies are also developed based on known causes of fires in specific BLM identified areas, as the causes of fires vary based on geographic location. Indirect impacts from fires, such as effects on local communities, are analyzed and design features were developed to minimize potential impacts (Appendix B, Section B. 21).

F.21.2 Supplemental Material for Affected Environment

Table F.21.2-1a presents forest fire classification categories based on dynamically downscaled climate model simulations for the historical (1995–2004) and mid-century

(2045–2054) periods. The EFFIS identifies relative risk for wildland fires based on both the fire risk (from the CFWI) and the likely damage that would occur.

Table F.21.2-1. European Forest Fire Information System (EFFIS) Classification

State	1995–2004 Average (Millions of Acres)						2045–2054 Average (Millions of Acres)					
	Very Low	Low	Moderate	High	Very High	Extreme	Very Low	Low	Moderate	High	Very High	Extreme
Arizona	16.5	8.0	11.0	14.8	8.7	11.6	13.1	8.2	11.9	15.4	8.8	13.2
California	30.6	10.1	13.1	20.0	11.1	11.4	28.1	10.1	13.7	20.7	11.3	12.4
Colorado	29.5	8.0	9.6	10.3	3.4	2.0	28.5	8.7	10.3	10.0	3.2	2.1
Idaho	29.9	4.3	5.2	6.5	2.5	1.4	29.3	4.5	5.3	6.5	2.6	1.5
Montana	45.3	10.9	12.0	11.4	4.1	3.2	45.0	11.5	12.9	11.6	3.5	2.4
Nevada	25.2	7.1	8.7	13.4	7.0	5.5	23.4	7.4	9.2	13.2	7.3	6.4
New Mexico	24.2	10.9	14.4	15.9	5.9	4.5	21.0	11.8	15.4	15.9	6.0	5.6
Oregon	34.8	6.0	6.6	7.3	2.3	.9	34.2	6.3	6.7	7.5	2.3	1.0
Utah	21.6	5.4	6.6	8.9	4.8	3.9	20.7	5.8	6.8	8.4	4.8	4.8
Washington	25.7	4.0	3.9	4.3	1.5	.7	25.5	4.1	3.9	4.4	1.6	.7
Wyoming	29.0	6.9	8.0	9.1	3.4	2.5	28.4	7.4	8.6	8.9	3.1	2.2

Source: San Miguel Ayanz et al. 2003

Table F.21.2-2. Federal, State, and Local Wildland Fires, 1992–2005 and 2006–2020*

State	Average Number of Fires		Average Fire Size (Acres)	
	1992–2005	2006–2020	1992–2005	2006–2020
California	8,230	8,990	52	108
Nevada	757	653	432	597
Utah	1,311	1,241	119	139
Oregon	2,623	2,308	91	224
Washington	1,326	1,434	94	233
Idaho	1,667	1,242	228	522
Montana	1,753	1,834	93	176
Colorado	1,428	3,245	52	58
Wyoming	554	816	127	163
Arizona	3,422	3,768	64	88
New Mexico	1,748	1,277	109	213

*Note: The dataset is split in half to analyze trends between the two time periods.

Source: USDA FPA FOD Dataset (Short 2022)

Figure F.21.2-1. Twenty-Year Wildfire Burn Frequency on BLM-administered Lands

Table F.21.2-3.Acres of Lands Burned

State	Times Burned in 20 Years (2003–2022)							
Arizona	280,250	102,655	22,075	19,537	455	0		
California	742,891	362,029	39,744	4,955	186	21	3	1
Colorado	209,645	150,392	19,603	154	93	3		
Idaho	1,972,969	812,829	255,607	40,501	40,460	13,697	7,882	0.01
Montana	228,923	127,190	34,493	3,093	237	418		
Nevada	3,430,086	922,357	181,995	34,973	1,203	102		
New Mexico	237,138	27,228	4,488	71	1			
Oregon	2,178,111	448,394	76,274	6,418	495	18	0	
Utah	628,106	468,978	58,252	18,568	429	733	55	
Washington	82,777	69,825	24,441	6,688	1,311	82		
Wyoming	205,163	63,232	6,095	777	3			
Total	**10,196,059**	**3,555,108**	**723,067**	**135,734**	**44,871**	**15,073**	**7,939**	**1**

F.21.3 Supplemental Material for Impacts Assessment

Table F.21.3-1. Alternative 1: Acres of Available Lands Burned

State	Times Burned in 20 Years (2003–2022)							
								Total
Arizona	49,009	16,277	461	13				**65,760**
California	242,655	56,523	5,384	2,025	81			**306,668**
Colorado	66,973	18,703	15,086	63	17			**100,841**
Idaho	617,218	235,632	102,388	31,988	34,526	7,024	1,632	**1,030,407**
Montana	38,801	18,371	6,946	931	110	409		**65,569**
Nevada	660,101	83,261	34,588	5,482	0			**783,432**
New Mexico	94,059	12,314	402	65				**106,840**
Oregon	302,497	79,815	23,458	699	256	2	0.0002	**406,727**
Utah	326,844	367,487	34,554	4,404	308	491	17	**734,106**
Washington	72,995	53,859	21,500	6,256	1,311	82		**156,003**
Wyoming	58,331	6,646	117	146				**65,239**
Total	**2,529,484**	**948,888**	**244,884**	**52,071**	**36,607**	**8,008**	**1,649**	**3,821,591**

Source: Data provided by the Wildland Fire Interagency Geospatial Services (WFIGS) Group under the interagency Wildland Fire Data Program.

Table F.21.3-2. Alternative 2: Acres of Available Lands Burned

State	Times Burned in 20 Years (2003–2022)							
State								**Total**
Arizona	10,253	4,538	33	6				**14,830**
California	9,492	3,514	48	10	1			**13,063**
Colorado	16,587	1,419	1,754					**19,759**
Idaho	490,267	197,559	86,385	26,099	29,899	3,049	427.1	**833,684**
Montana	7,773	1,170	634	33	12	7		**9,629**
Nevada	304,465	41,759	12,183	964				**359,371**
New Mexico	51,400	3,490	272	58				**55,220**
Oregon	89,354	29,322	5,048	78	7	0.1	0.0002	**123,810**
Utah	125,734	222,365	11,970	561	5			**360,635**
Washington	20,633	17,307	6,588	2,799	1,025	51		**48,403**
Wyoming	27,712	4,882	34	146				**32,773**
Total	**1,153,670**	**527,325**	**124,949**	**30,753**	**30,948**	**3,107**	**427.1**	**1,871,178**

Source: Data provided by the Wildland Fire Interagency Geospatial Services (WFIGS) Group under the interagency Wildland Fire Data Program.

Table F.21.3-3. Alternative 3: Acres of Available Lands Burned

State	Times Burned in 20Years (2003–2022)							
State								**Total**
Arizona	4,584	3,984	7	6				**8,580**
California	4,503	3,221	48	7	1			**7,779**
Colorado	11,479	1,080	272					**12,831**
Idaho	375,708	166,641	49,306	18,644	29,694	3,049	427.1	**643,469**
Montana	1,337	556	51	14				**1,958**
Nevada	224,568	21,075	11,877	964				**258,483**
New Mexico	7,049	232						**7,281**
Oregon	35,235	4,074	1,859	78	7	0.1	0.0002	**41,253**
Utah	66,314	156,021	9,586	434	5			**232,360**
Washington	18,181	12,140	5,147	641	18			**36,127**
Wyoming	12,685	3,949	34	146				**16,813**
Total	**761,642**	**372,975**	**78,186**	**20,933**	**29,724**	**3,049**	**427.1**	**1,266,936**

Data provided by the Wildland Fire Interagency Geospatial Services (WFIGS) Group under the interagency Wildland Fire Data Program

Table F.21.3-4. Alternative 4: Acres of Available Lands Burned

State	Times Burned in 20 Years (2003–2022)							
State								**Total**
Arizona	1,385	2,718	31	6				**4,138**
California	4,746	510	47	10	1			**5,313**
Colorado	4,910	472	225					**5,607**
Idaho	213,855	68,061	13,427	4,038	1,393	177	0.1	**300,952**
Montana	2,595	310	68	0.04				**2,973**
Nevada	53,432	4,131	75					**57,639**
New Mexico	8,734	226	14					**8,974**
Oregon	20,993	2,364	760	78	7	0.1	0.0002	**24,202**
Utah	37,898	103,501	7,237	514	5			**149,155**
Washington	13,545	9,695	3,896	2,794	1,025	51		**31,007**
Wyoming	14,677	2,189	34	146				**17,045**
Total	**376,769**	**194,178**	**25,815**	**7,585**	**2,430**	**228**	**0.1**	**607,005**

Source: Data provided by the Wildland Fire Interagency Geospatial Services (WFIGS) Group under the interagency Wildland Fire Data Program.

Table F.21.3-5. Alternative 5: Acres of Available Lands Burned

State	Times Burned in 20 Years (2003–2022)							
State	1	2	3	4	5	6	7	**Total**
Arizona	1,137	2,627	4	6				**3,774**
California	2,888	476	47	7	1			**3,419**
Colorado	3,926	397	202					**4,524**
Idaho	193,073	65,571	11,666	3,865	1,392	177	0.1	**275,744**
Montana	396	197	16	0.04				**609**
Nevada	45,596	3,223	68					**48,886**
New Mexico	2,156	123						**2,279**
Oregon	17,775	979	760	78	7	0.1	0.0002	**19,600**
Utah	25,352	69,589	5,594	387	5			**100,927**
Washington	13,020	6,317	3,059	636	18			**23,051**
Wyoming	9,457	1,881	34	146				**11,517**
Total	**314,776**	**151,378**	**21,450**	**5,125**	**1,423**	**177**	**0.1**	**494,330**

Source: Data provided by the Wildland Fire Interagency Geospatial Services (WFIGS) Group under the interagency Wildland Fire Data Program.

Figure F.21.3-1. Twenty-Year Wildfire Burn Frequency on Lands Available for Application under the No Action Alternative

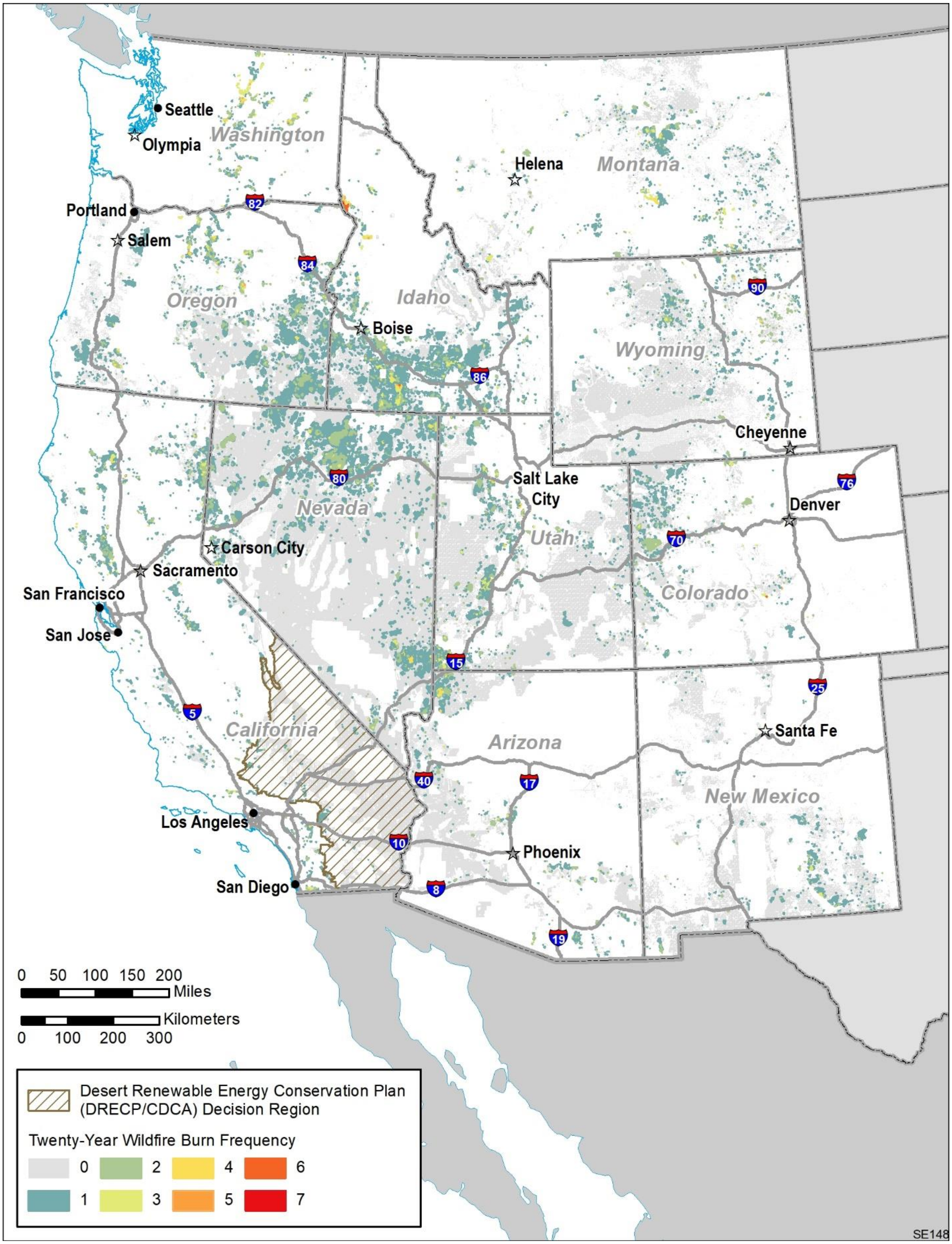


Figure F.21.3-2. Twenty-Year Wildfire Burn Frequency on Alternative 1 Lands Available for Application

Figure F.21.3-3. Twenty-Year Wildfire Burn Frequency on Alternative 2 Lands Available for Application

Figure F.21.3-3. Twenty-Year Wildfire Burn Frequency on Alternative 3 Lands Available for Application

Figure F.21.3-4. Twenty-Year Wildfire Burn Frequency on Alternative 3 Lands Available for Application

Figure F.21.3-5. Twenty-Year Wildfire Burn Frequency on Alternative 4 Lands Available for Application

Figure F.21.3-6. Twenty-Year Wildfire Burn Frequency on Alternative 5 Lands Available for Application

F.22 References

F.22.1 Acoustic Environment

Alberts, D. J., 2006, *Primer for Addressing Wind Turbine Noise*, Revised Oct. Available at https://www.milwaukee.gov/ImageLibrary/Groups/cityGreenTeam/documents/AddressingWindTurbineNoise.pdf. Accessed April 2023.

Anderson, G. S., and U. J. Kurze, 1992, "Outdoor Sound Propagation," in *Noise and Vibration Control Engineering: Principles and Applications*, L.L. Beranek and I.L. Vér (editors), John Wiley & Sons, Inc., New York, NY.

Beranek, L. L., 1988, *Noise and Vibration Control*, rev. ed., Institute of Noise Control Engineering, Washington, D.C.

Cavanaugh, W. J., and G. C. Tocci, 1998, "Environmental Noise: The Invisible Pollutant," *Environmental Excellence in South Carolina (E2SC), USC Institute of Public Affairs* 1(1):1–11, Fall. Available at https://www.nonoise.org/library/envarticle/. Accessed April 2023.

Miller, N. P., 2002, "Transportation Noise and Recreational Lands," *Proceedings of Inter-Noise 2002*, Dearborn, Mich., Aug. 19-21, 2002. Available at https://rosap.ntl.bts.gov/view/dot/18011. Accessed April 2023.

Noise Pollution Clearinghouse (NPC), 2023, *NPC Law Library*. Available at https://www.nonoise.org/lawlib. Accessed August 2023.

Quagliata, A., M. Ahearn, E. Boeker, C. Roof, L. Meister, and H. Singleton, 2018, *Transit Noise and Vibration Impact Assessment Manual*, FTA Report No. 0123, prepared by Federal Transit Administration, John A. Volpe National Transportation Systems Center, and Cross Spectrum Acoustics, Sept. Available at https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/118131/transit-noise-and-vibration-impact-assessment-manual-fta-report-no-0123_0.pdf.

Saurenman, H., J. Chambers, L. C. Sutherland, R. L. Bronsdon, and H. Forschner, 2005, Atmospheric Effects Associated with Highway Noise Propagation, prepared for Arizona Department of Transportation, Phoenix, Ariz., Aug. Available at https://apps.azdot.gov/files/ADOTLibrary/publications/project_reports/pdf/az555.pdf. Accessed April 2023.

State of California, 2017, General Plan Guidelines, Governor's Office of Planning and Research. Available at https://opr.ca.gov/docs/OPR_COMPLETE_7.31.17.pdf. Accessed April 2023.

U.S. Census Bureau (USCB), 2021, Average Household Size and Population Density – County. Available at https://covid19.census.gov/datasets/21843f238cbb46b08615fc53e19e0daf_1/explore?location=18.269497%2C0.315550%2C1.64. Accessed April 2023.

F.22.2 Air Quality and Climate

Arizona Department of Environmental Quality (ADEQ), 2019, *Air Quality Monitoring and Assessments*. Available at https://azdeq.gov/node/225, revised April 23, 2019. Accessed March 2023.

California Air Resources Board (CARB), 2016, *California Ambient Air Quality Standards*. Available at https://ww2.arb.ca.gov/resources/california-ambient-air-quality-standards (5/4/16). Accessed March 2023.

Colorado Department of Public Health and Environment (CDPHE), 2023, *Air Quality Control Commission, Air Quality Standards, Designations and Emission Budgets,* 5 CCR 1001-14. Available at https://www.sos.state.co.us/CCR/GenerateRulePdf.do?ruleVersionId=10678&fileName=5%20CCR%201001-14. Accessed April 2023.

Energy Information Administration (EIA), 2023a, *Form EIA-860 detailed data with previous form data (EIA-860A/860B)*, Release date: June 1, 2023. Available at https://www.eia.gov/electricity/data/eia860/. Accessed August 2023.

Energy Information Administration (EIA), 2023b, *Form EIA-923 detailed data with previous form data (EIA-906/920)*, Release date: July 26, 2023. Available at https://www.eia.gov/electricity/data/eia923/. Accessed August 2023.

Environmental Protection Agency (EPA), 2016a, *What Climate Change Means for Arizona*, EPA 430-F-16-005, Aug. Available at https://www.epa.gov/sites/default/files/2016-09/documents/climate-change-az.pdf. Accessed April 2023.

Environmental Protection Agency (EPA), 2016b, *What Climate Change Means for California*, EPA 430-F-16-007, Aug. Available at https://www.epa.gov/sites/default/files/2016-09/documents/climate-change-ca.pdf. Accessed April 2023.

Environmental Protection Agency (EPA), 2016c, *What Climate Change Means for Colorado*, EPA 430-F-16-008, Aug. Available at https://www.epa.gov/sites/default/files/2016-09/documents/climate-change-co.pdf. Accessed April 2023.

Environmental Protection Agency (EPA), 2016d, *What Climate Change Means for Idaho*, EPA 430-F-16-014, Aug. Available at https://www.epa.gov/sites/default/files/2016-09/documents/climate-change-id.pdf. Accessed April 2023.

Environmental Protection Agency (EPA), 2016e, *What Climate Change Means for Montana*, EPA 430-F-16-028, Aug. Available at https://www.epa.gov/sites/default/files/2016-09/documents/climate-change-mt.pdf. Accessed April 2023.

Environmental Protection Agency (EPA), 2016f, *What Climate Change Means for Nevada*, EPA 430-F-16-030, Aug. Available at https://www.epa.gov/sites/default/files/2016-09/documents/climate-change-nv.pdf. Accessed April 2023.

Environmental Protection Agency (EPA), 2016g, *What Climate Change Means for New Mexico*, EPA 430-F-16-033, Aug. Available at https://www.epa.gov/sites/default/files/2016-09/documents/climate-change-nm.pdf. Accessed April 2023.

Environmental Protection Agency (EPA), 2016h, *What Climate Change Means for Oregon*, EPA 430-F-16-039, Aug. Available at https://www.epa.gov/sites/default/files/2016-09/documents/climate-change-or.pdf. Accessed April 2023.

Environmental Protection Agency (EPA), 2016i, *What Climate Change Means for Utah*, EPA 430-F-16-046, Aug. Available at https://www.epa.gov/sites/default/files/2016-09/documents/climate-change-ut.pdf. Accessed April 2023.

Environmental Protection Agency (EPA), 2016j, *What Climate Change Means for Washington*, EPA 430-F-16-049, Aug. Available at https://www.epa.gov/sites/default/files/2016-09/documents/climate-change-wa.pdf. Accessed April 2023.

Environmental Protection Agency (EPA), 2016k, *What Climate Change Means for Wyoming*, EPA 430-F-16-052, Aug. Available at https://www.epa.gov/sites/default/files/2016-09/documents/climate-change-wy.pdf. Accessed April 2023.

Environmental Protection Agency (EPA), 2023a, *NAAQS Table*. Available at https://www.epa.gov/criteria-air-pollutants/naaqs-table, last updated March 15, 2023. Accessed April 2023.

Environmental Protection Agency (EPA), 2023b, *Download Data: eGRID with 2021 Data.* Available at https://www.epa.gov/egrid/download-data, last updated January 31, 2023. Accessed May 2023.

Idaho Department of Environmental Quality (IDEQ), 2023, *Air Quality Division, 58.01.01 – Rules for the Control of Air Pollution in Idaho*. Available at https://adminrules.idaho.gov/rules/current/58/580101.pdf. Accessed March 2023.

Interagency Working Group on Social Cost of Greenhouse Gases) (IWG), 2021, *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990*, Feb. Available at https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf. Accessed March 2023.

Jacobson, M. Z., 1999, *Fundamentals of Atmospheric Modeling*, Cambridge University Press, Cambridge, U.K.

Montana Department of Environmental Quality (MDEQ), 2021, *State of Montana, Air Quality Monitoring Network Plan*. Available at https://deq.mt.gov/files/Air/AirMonitoring/Documents/2021_ANMP.pdf. Accessed March 2023.

National Centers for Environmental Information (NCEI), 2022, *State Climate Summaries 2022*, NOAA. Available at https://statesummaries.ncics.org/downloads/. Accessed April 2023.

National Centers for Environmental Information (NCEI), 2023a, *2022 Local Climatological Data Annual Summary with Comparative Data*, National Oceanic and Atmospheric Administration (NOAA). Availablehttps://www.ncdc.noaa.gov/IPS/lcd/lcd.html. Accessed April 2023, 2

National Centers for Environmental Information (NCEI), 2023b, *Integrated Surface Data (ISD), DS3505 Format*, database, Asheville, N.C. Available at https://www.ncei.noaa.gov/data/global-hourly/archive/isd/. Accessed April 2023.

Nemet, G. F., 2009, "Net Radiative Forcing from Widespread Deployment of Photovoltaics," *Environmental Science & Technology* 43(6): 2173–2178. Available at https://doi.org/10.1021/es801747c.

Nevada Division of Environmental Protection (NDEP), 2023, *State Standards of Quality for Ambient Air*, Nevada administrative Code 445B.22097. Available at https://www.leg.state.nv.us/nac/nac-445b.html#NAC445BSec22097. Accessed April 2023.

New Mexico Environment Department (NMED), 2023, *Ambient Air Quality Standards,* 20.2.3 New Mexico Administrative Code. Available at ttps://www.srca.nm.gov/parts/title20/20.002.0003.html. Accessed March 2023.

Oregon Department of Environmental Quality (ODEQ), 2022, *Ambient Air Quality Standards and Prevention of Significant Deterioration Increments*, Oregon Secretary of State. Available at https://secure.sos.state.or.us/oard/displayDivisionRules.action?selectedDivision=1530. Accessed April 2023.

Utah Department of Environmental Quality (UDEQ), 2021, *Utah Division of Air Quality, 2020 Annual Report*, Feb. Available at https://documents.deq.utah.gov/air-quality/planning/air-quality-policy/DAQ-2021-000768.pdf. Accessed March 2023.

Washington Department of Ecology (WDOE), 2023, *Ambient Air Quality Standards*, Chapter 173-476, Washington Administrative Code. Available at https://apps.leg.wa.gov/wac/default.aspx?cite=173-476&full=true&pdf=true. Accessed April 2023.

Western Regional Climate Center (WRCC), 2023, *Climate Narratives by State*. Available at https://wrcc.dri.edu/Climate/narratives.php. Accessed March 2023.

Wohlfahrt, G., et al., 2008, "Large Annual Net Ecosystem CO_2 Uptake of a Mojave Desert Ecosystem," *Global Change Biology* 14(7):1475–1487. Available at https://doi.org/10.1111/j.1365-2486.2008.01593.x.

Wyoming Department of Environmental Quality (WDEQ), 2023, *Ambient Standards: Wyoming Ambient Air Quality Standards (WAAQS)*. Available at https://www.wyvisnet.com/AmbientStandards.html. Accessed March 2023.

F.22.3 Cultural Resources

F.22.4.1 Vegetation

Kleinhesselink, A.R., et al., 2022, "Long-Term Trends in Vegetation on Bureau of Land Management Rangelands in the Western United States," *Rangeland Ecology and Management*, 87(1) : 1-12.

F.22.4.2 Aquatic Biota

Archer, S. R., and K. I. Predick, 2008, "Climate Change and Ecosystems of the Southwestern United States" *Rangelands* 30:23–28.

Bilotta, G. S., and R. E. Brazier, 2008, "Understanding the Influence of Suspended Solids on Water Quality and Aquatic Biota," *Water Research* 42:2849–2861.

Bureau of Land Management (BLM), 2018, Environmental Assessment for Sweetwater Solar Energy Facility, WY-D040-2017-0008-EA, Rock Springs Field Office, Wyoming, April. Available at https://eplanning.blm.gov/public_projects/nepa/69990/140357/172580/sweetwater_solar_EA_chap1_thru_chap7_20180406.pdf.

Bureau of Land Management (BLM), 2019, Gemini Solar Project Final Resource Management Plan Amendment and Environmental Impact Statement, DOI-BLM-NV-S010-2018-0051-EIS. Available at https://eplanning.blm.gov/eplanning-ui/project/100498/570.

Bureau of Land Management (BLM), 2021, Environmental Assessment for Oberon Renewable Energy Project, DOI-BLM-CA-D060-2020-0040-EA, U.S. Department of the Interior, Washington, D.C., August. Available at https://eplanning.blm.gov/public_projects/2001226/200478716/20043975/250050165/Environmental%20Assessment%201-Main%20Text.pdf

Datry, T., 2011, “Benthic and Hyporheic Invertebrate Assemblages along a Flow Intermittence Gradient: Effects of Duration of Dry Events,” *Freshwater Biology* 57(3):563–574.

Field, J. P. et al., 2010, “The Ecology of Dust,” *Frontiers in Ecology and the Environment* 8(8):423–430.

Grippo, M., J. W. Hayse, and B. L. O’Connor, 2015a, Solar Energy Development and Aquatic Ecosystems in the Southwestern United States: Potential Impacts, Mitigation, and Research Needs. *Environmental Assessment* 55:244–256.

Hazel, J. R., 1993, “Thermal Biology,” Chapter 14, pages 427–467 in *The Physiology of Fishes*, D. H. Evans (editor), CRC Press, Inc., Boca Raton, Fla.

Horváth, G., et al., 2010, “Reducing the Maladaptive Attractiveness of Solar Panels to Polarotactic Insects,” *Conservation Biology* 24:1644–1653.

Ice, G. G., et al., 2010, “Discussion: Stream Temperature Relationships to Forest Harvest in Western Washington,” *Journal of the American Water Resources Association* 46 (4):838–842.

Lake, P. S, 2003, “Ecological Effects of Perturbation by Drought in Flowing Waters,” *Freshwater Biology* 48:1161–1172.

Larned, S., et al. 2010, “Emerging Concepts in Temporary-River Ecology,” *Freshwater Biology* 55:717–738.

McCluney, K. E., and J. L. Sabo, 2011, “River Drying Lowers the Diversity and Alters the Composition Assemblage of Desert Riparian Arthropods,” *Freshwater Biology* 57(1):91–103.

Miller, S. W., D. Wooster, and J. Li, 2007, “Resistance and resilience of macroinvertebrates to irrigation water withdrawals,” *Freshwater Biology* 52: 2494–2510.

Miller, S. W., D. Wooster, and J. Li, 2012, “Developmental, growth, and population biomass responses of a river-dwelling caddisfly (*Brachycentrus occidentalis*) to irrigation water withdrawals,” *Hydrobiologia* 679: 187–203.

O’Connor, B. L., Y. Hamada, E. E. Bowen, M. A. Grippo, H. M. Hartmann, T. L. Patton, R. A. Van Lonkhuyzen, and A. E. Carr, 2015, Quantifying the sensitivity of ephemeral streams to land disturbance activities in arid ecosystems at the watershed scale. *Environmental Monitoring and Assessment* 186:7075–7095.

Riggs, A. C., and J. E. Deacon, 2002, “Connectivity in Desert Aquatic Ecosystems: The Devils Hole Story,” *Conference Proceedings, Spring-Fed Wetlands: Important Scientific and Cultural Resources of the Intermountain Region*, May 7–9, Las Vegas, Nev.

Sponseller, R. A., et al., 2010, “Responses of Macroinvertebrate Communities to Long-term Flow Variability in a Sonoran Desert Stream,” *Global Change Biology* 16:2891–2900.

Stanley, E. H., et al., 1994, “Invertebrate Resistance and Resilience to Intermittency in a Desert Stream, *American Midland Naturalist* 131:288–300.

Steward, Alisha L., T. Datry, and S. D. Langhans, 2022, The terrestrial and semi-aquatic invertebrates of intermittent rivers and ephemeral streams. Biological Reviews 97:1408–1425.

Száz, D., D. Mihályi, A. Farkas, et al., 2016, Polarized light pollution of matte solar panels: anti-reflective photovoltaics reduce polarized light pollution but benefit only some aquatic insects. *J Insect Conserv* 20: 663–675. https://doi.org/10.1007/s10841-016-9897-3.

Vander Vorste, R., R. Sarremejane, and T. Datry, 2020, Intermittent Rivers and Ephemeral Streams: A Unique Biome with Important Contributions to Biodiversity and Ecosystem Services. *Encyclopedia of the World’s Biomes*, Volume 4, 419–429.

Waters, T. F., 1995, *Sediment in Streams: Sources, Biological Effects, and Control*, American Fisheries Society Monograph 7, American Fisheries Society, Bethesda, Md.

F.22.4.3 Wildlife

AMEC Americas Limited, 2005, *Mackenzie Gas Project Effects of Noise on Wildlife*, prepared for Imperial Oil Resources Ventures Limited, July. Available at http://www.ngps.nt.ca/Upload/Proponent/Imperial%20Oil%20Resources%20Ventures%20Limited/birdfield_wildlife/Documents/Noise_Wildlife_Report_Filed.pdf. Accessed February2010.

Barber, J. R., et al., 2010, “The Costs of Chronic Noise Exposure for Terrestrial Organisms,” *Trends in Ecology and Evolution* 25(3):180–189.

Bartzke, G. S., et al., 2014, “The Effects of Power Lines on Ungulates and Implications for Power Line Routing and Rights-of-Way Management,” *International Journal of Biodiversity and Conservation* 6(9): 647–662.

Bayne, E. M., et al., 2008, “Impacts of Chronic Anthropogenic Noise from Energy-Sector Activity on Abundance of Songbirds in the Boreal Forest,” *Conservation Biology* 22(5):1186–1193.

Berger, J., 2004, “The Last Mile: How to Sustain Long-Distance Migration in Mammals,” *Conservation Biology* 18(2):320–331.

Biasotto, L. D., and A. Kindel, 2018, “Power Lines and Impacts on Biodiversity: A Systematic Review,” *Environmental Impact Assessment Review* 71: 110–119.

BirdLife International, 2003, *Protecting Birds from Powerlines: A Practical Guide on the Risks to Birds from Electricity Transmission Facilities and How to Minimise Any Such Adverse Effects*, T-PVS/Inf (2003) 15, Convention on the Conservation of European Wildlife and Natural Habitats, Standing Committee, 23rd Meeting, Strasbourg, December 1-4. Available at http://www.coe.int/T/E/Cultural_Co-operation/Environment/Nature_and_biological_diversity/Nature_protection. Accessed October 2006.

Bowen, A. E., et al., 2020, “Anthropogenic Noise Reduces Male Reproductive Investment in an Acoustically Signaling Insect,” *Behavioral Ecology and Sociobiology* 74: 103.

Brattstrom, B. H., and M. C. Bondello, 1983, “Effects of Off-Road Vehicle Noise on Desert Vertebrates,” pp. 167-206 in *Environmental Effects of Off-Road Vehicles, Impacts and Management in Arid Region,* R.H. Webb and H.G. Wilshire (editors), Springer-Verlag, New York, N.Y. (as cited in Larkin 1996).

Bureau of Land Management (BLM), 2015, Soda Mountain Solar Project Proposed Plan Amendment/Final Environmental Impact Statement/Environmental Impact Report. *BLM/CA/PL-2015/010+1793.*

Bureau of Land Management (BLM), 2018, Palen Solar Project Final Supplemental Environmental Impact Statement, DOI-BLM-CA-060-2017-001-EIS.

Bureau of Land Management (BLM), 2019, Gemini Solar Project Final Resource Management Plan Amendment and Environmental Impact Statement, DOI-BLM-NV-S010-2018-0051-EIS. Available at https://eplanning.blm.gov/eplanning-ui/project/100498/570.

Bureau of Land Management (BLM), 2020a, Yellow Pine Solar Project Record of Decision. DOI-BLM-NV-S010-2017-0110-EIS.

Bureau of Land Management (BLM), 2020b, Yellow Pine Solar Project Final Environmental Impact Statement. Volume I: Chapters 1-4. DOI-BLM-NV-S010-2017-0110-EIS.

Bureau of Land Management (BLM), 2021, Environmental Assessment for Oberon Renewable Energy Project, DOI-BLM-CA-D060-2020-0040-EA, U.S. Department of the Interior, Washington, D.C., August. Available at https://eplanning.blm.gov/public_projects/2001226/200478716/20043975/250050165/Environmental%20Assessment%201-Main%20Text.pdf

Bureau of Land Management (BLM), 2023, Colorado Wildlife. Available: https://www.blm.gov/programs/fish-and-wildlife/wildlife/about/colorado#:~:text=Colorado’s%20broad%20diversity%20of%20wildlife, invertebrates%2C%20including%20mollusks%20and%20crustaceans. Accessed March 2023.

California Department of Fish and Wildlife (CDFW, 2023, Biogeographic Information and Observation System (BIOS). Available at https://wildlife.ca.gov/Data/BIOS. Accessed April 2023.

Chock, R. Y., et al., 2021, “Evaluating Potential Effects of Solar Power Facilities on Wildlife from an Animal Behavior Perspective,” *Conservation Science and Practice* 3(2): e319.

Coates, P. S., et al., 2014, “Common Raven Occurrence in Relation to Energy Transmission Line Corridors Transiting Human-altered Sagebrush Steppe,” *Journal of Arid Environments* 111: 68-78.

Colorado Parks and Wildlife (CPW), 2022, Colorado Parks and Wildlife Species Data. Available at https://hub.arcgis.com/maps/9a845acae8f34d718caf9fd9a0e5e177/about. Accessed April 2023.

Davis, D. M., et al., 2015, "Genetic Structure of Greater Sage-Grouse (Centrocercus urophasianus) in a Declining, Peripheral Population," The *Condor: Ornithological Applications* 117: 530–544.

Delaney, D. K., et al., 1999, "Effects of Helicopter Noise on Mexican Spotted Owls," *Journal of Wildlife Management* 63(1):60–76.

Demerdzhiev, D. A., 2014, "Factors Influencing Bird Mortality Caused by Power Lines within Species Protected Areas and Undertaken Conservation Efforts," *Acta Zoologica Bulgarica* 66(2): 411–423.

Dixon, J .D., et al., 2007, "Genetic Consequences of Habitat Fragmentation and Loss: The Case of the Florida Black Bear (*Ursus americanus floridanus*)," *Conservation Genetics* 8(2):455–464.

Dudley, I. F. et al., 2021, "Large-Scale Wildfire Reduces Population Growth in a Peripheral Population of Sage-Grouse," *Fire Ecology* 17 (15).

Dutta, H., 2018, "Insights into the Impacts of Three Current Environmental Problems on Amphibians," *European Journal of Ecology* 4(2): 15–27.

Dyal, J. R., et al., 2021, "White-tailed Deer Movement in Response to Helicopter Surveys," *Wildlife Society Bulletin* 46: e1383.

Eccleston, D. T., and R. E. Harness, 2018, "Raptor Electrocutions and Power Line Collisions" Chapter 12, pp. 273-302 in *Birds of Prey: Biology and Conservation in the XXI Century*, J.H. Sarasola et al. (editors), Springer, Switzerland.

Edison Electric Institute, 1980, *Compatibility of Fish, Wildlife, and Floral Resources with Electric Power Facilities*, Washington, D.C.

Epps, C. W., et al., 2005, "Highways Block Gene Flow and Cause a Rapid Decline in Genetic Diversity of Bighorn Sheep," *Ecology Letters* 8:1029–1038.

Falcón, J., et al., 2020, "Exposure to Artificial Light at Night and the Consequences for Flora, Fauna, and Ecosystems," *Frontiers in Neuroscience* 14:1–39.

Fernie, K. J., and S. J. Reynolds, 2005, "The Effects of Electromagnetic Fields from Power Lines on Avian Reproductive Biology and Physiology: A Review," *Journal of Toxicology and Environmental Health, Part B* 8:127–140.

Ford, W. M., et al., 1999, "Effects of a Community Restoration Fire on Small Mammals and Herpetofauna in the Southern Appalachians," *Forest Ecology and Management* 114:233–243.

Gaines, W. L., et al., 2003, *Assessing the Cumulative Effects of Linear Recreation Routes on Wildlife Habitats on the Okanogan and Wenatchee National Forests*, General Technical Report PNW-GTR-586, U.S. Department of Agriculture, U.S. Forest Service, Pacific Northwest Research Station, Portland, Ore.

Geffroy, B., et al., 2015, “How Nature-Based Tourism Might Increase Prey Vulnerability to Predators,” *Trends in Ecology & Evolution* 30(12):755–765.

Grippo, M., J. W. Hayse, and B. L. O’Connor, 2015a, Solar Energy Development and Aquatic Ecosystems in the Southwestern United States: Potential Impacts, Mitigation, and Research Needs. *Environmental Assessment* 55:244–256.

Groves, C. R., and K. Steenhof, 1988, “Responses of Small Mammals and Vegetation to Wildfires in Shadscale Communities of Southwestern Idaho,” *Northwest Science* 62:205–210.

Guiller, C., et al., 2017, “Impacts of Solar Energy on Butterfly Communities in Mediterranean Agro-Ecosystems,” Environmental Progress and Sustainable Energy 36(6): 1817–1823.

Hagan, J. M., et al., 1996, “The Early Development of Forest Fragmentation—Effects on Birds,” *Conservation Biology* 10(1):188–202.

Hallisey, N., et al., 2022, “Estimating Road Mortality Hotspots While Accounting for Imperfect Detection: A Case Study with Amphibians and Reptiles,” *Land* 11: 739.

Harju, S. M., et al., 2018, “Common Raven Movement and Space Use: Influence of Anthropogenic Subsidies Within Greater Sage-grouse Nesting Habitat,” *Ecosphere* 9(7): e02348

Harper, K. A., et al., 2005, “Edge Influence on Forest Structure and Composition in Fragmented Landscapes,” *Conservation Biology* 19(3):768–782.

Hedlund, J. D., and W. H. Rickard, 1981, “Wildfire and the Short-Term Response of Small Mammals Inhabiting a Sagebrush-Bunchgrass Community,” *Murrelet* 62:10–14.

Hobbs, N. T., 1989, “Linking Energy Balance to Survival in Mule Deer: Development and Test of a Simulation Model,” *Wildlife Monographs* 101:1–39.

Hockin, D., et al., 1992, “Examination of the Effects of Disturbance on Birds with Reference to Its Importance in Ecological Assessments,” *Journal of Environmental Management* 36:253–286.

Holmes, T. L., et al., 1993, “Responses of Wintering Grassland Raptors to Human Disturbance,” *Wildlife Society Bulletin* 21:461–468.

Idaho Fish and Game (IDFG), 2019, Idaho Mountain Goat Management Plan 2019-2024. Idaho Department of Fish and Game, Boise, USA.

Idaho Fish and Game (IDFG), 2020, Idaho Moose Management Plan, 2020–2025. Idaho Department of Fish and Game, Boise, USA.

Idaho Fish and Game (IDFG), 2023a, Idaho Fish and Wildlife Information System. Available: https://idfg.idaho.gov/species/taxa/list. Accessed March 2023.

Idaho Fish and Game (IDFG), 2023b, Statewide IDFG Movements and Migrations GIS data (Current as of 12/18/23). Received 12/18/23.

Ingelfinger, F., and S. Anderson, 2004, "Passerine Response to Roads Associated with Natural Gas Extraction in a Sagebrush Steppe Habitat," *Western North American Naturalist* 64: 385 395.

Irons, D. B., et al., 2000, "Nine Years after the Exxon Valdez Oil Spill: Effects on Marine Bird Populations in Prince Sound, Alaska," *The Condor* 102:723–737.

Jalkotzy, M. G., et al., 1997, *The Effects of Linear Developments on Wildlife: A Review of Selected Scientific Literature*, prepared by Arc Wildlife Services Ltd., Calgary, Alberta, Canada, for Canadian Association of Petroleum Producers.

Johnston, D., et al., 2014, "The Response of an Insectivorous Bat Community to Solar Development," 99th ESA Annual Convention. Conference Paper.

Jones, J. K., Jr., D. M. Armstrong, R. S. Hoffmann, and C. Jones, 1983, Mammals of the Northern Great Plains. University of Nebraska Press, Lincoln, Nebraska.

Keeley, W.H. and M. J. Bechard, 2011, "Flushing Distance of Ferrugionous Hawks Nesting in Rural and Exurban New Mexico," *The Journal of Wildlife Management* 75(5): 1034–1039.

Ketcham, S. L., and Koprowski, J. L., 2013, Impacts of wildfire on wildlife in Arizona: a synthesis. In (Gottfried, G. J., Gebow, B. S., and Eskew, L. G., eds.) Biodiversity and Management of the Madrean Archipelago III, pp. 345–350. U.S. Forest Service, General Technical Report RMRS-P 67, Fort Collins.

Kosciuch, K., et al., 2020, "A Summary of Bird Mortality at Photovoltaic Utility Scale Solar Facilities in the Southwestern U.S.," *PLoS ONE* 15: e0232034.

Krausman, P. R., et al., 2004, "Effects of Military Operations on Behavior and Hearing of Endangered Sonoran Pronghorn," *Wildlife Monographs* 157:1–41.

Lackey, M .A., et al., 2012, "Experimental Determination of the Response of Golden-Cheeked Warblers (*Setophaga Chrysoparia*) to Road Construction Noise," *Ornithological Monographs* 74: 91–100.

Lonsdorf, E., et al., 2018, "Modeling Golden Eagle-Vehicle Collisions to Design Mitigation Strategies," *The Journal of Wildlife Management* 82(8): 1633–1744.

Loss, S. R., et al., 2014, "Refining Estimates of Bird Collision and Electrocution Mortality at Power Lines in the United States," *PLoS ONE* 9(7): e101565.

Lovich, J. E., and D. Bainbridge, 1999, "Anthropogenic Degradation of the Southern California Desert Ecosystem and Prospects for Natural Recovery and Restoration," *Environmental Management* 24(3):309–326.

Lovich, J. E., and J. R. Ennen, 2011, "Wildlife Conservation and Solar Energy Development in the Desert Southwest, United States," *BioScience* 61(12): 982–992.

Lyon, L. J., et al., 2000a, "Direct Effects of Fire and Animal Responses," in *Wildland Fire in Ecosystems: Effects of Fire on Fauna*, J.K. Smith (editor), General Technical Report RMRS-GTR-42-Vol. 1, U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Ogden, Utah.

Lyon, L.J., et al., 2000b, "Fire Effects on Animal Populations," in *Wildland Fire in Ecosystems: Effects of Fire on Fauna*, J.K. Smith (editor), General Technical Report RMRS-GTR-42-Vol. 1, U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Ogden, Utah.

May, R., et al., 2017, "Future Research Directions to Reconcile Wind Turbine-Wildlife Interactions," Köppel, J. (eds) Wind Energy and Wildlife Interactions. Springer, Cham. https://doi.org/10.1007/978-3-319-51272-3_15

McCullough, D. R., 1985, Variables influencing food habits of white-tailed deer on the George Preserve. J. Mamm. 66: 682–692.

Mech, L. D., et al., 1987, Relationship of deer and moose populations to previous winters' snow. J. Anim. Ecol. 56:615–627.

Mills, L. S., et al., 2000, *Highways as Potential Barriers to Movement and Genetic Exchange in Small Vertebrates*, Montana Department of Transportation, Helena, Mont. Available at http://www.mdt.mt.gov/research/docs/research_proj/vert_barriers/proposal.pdf. Accessed July 2008.

Montana Fish, Wildlife, and Parks (MFWP), 2023, Moose — Alces alces. Montana Field Guide. Available at https://fieldguide.mt.gov/speciesDetail.aspx?elcode=AMALC03020. Accessed March 2023.

Montana Fish, Wildlife, and Parks (MFWP), 2023a, Maps & GIS Resources: Wildlife. Available: https://gis-mtfwp.hub.arcgis.com/search?tags=wildlife. Accessed April 2023.

Montana Natural Heritage Program (MNHP), 2023, Species Snapshot. Available at https://mtnhp.org/SpeciesSnapshot/?Vector=&Species=&Rank=. Accessed March 2023.

Mountain Lion Foundation (MLF), 2023, About Mountain Lions. Available at https://mountainlion.org/about-mountain-lions/#!threats. Accessed April 2023.

Murphy-Mariscal, M., et al., 2018, "Solar Energy Development and the Biosphere," *A Comprehensive Guide to Solar Energy Systems*, Letcher, T.M. et al. (editors), Academic Press.

NatureServe, 2023, NatureServe Network Biodiversity Location Data accessed through NatureServe Explorer [web application]. NatureServe, Arlington, Virginia. Available https://explorer.natureserve.org/. (Accessed: March 27, 2023).

Nevada Department of Wildlife Data Portal (NDOW), 2023, Available at https://gis-ndow.opendata.arcgis.com/. Accessed 4/21/23.

Oregon Department of Fish and Wildlife (ODFW), 2021, Compass. Available: https://compass.dfw.state.or.us. Accessed April 2023.

Oregon Department of Fish and Wildlife (ODFW), 2023, Hoofed Mammals. Available at https://myodfw.com/wildlife-viewing/species/hoofed-mammals. Accessed March 2023.

Oregon State University (OSU), 2023, Oregon Explorer. Available athttps://oregonexplorer.info/topics/birds?ptopic=179. Accessed March 2023.

Pérez-García, J. M., et al., 2017, "Using Risk Prediction Models and Species Sensitivity Maps for Large-Scale Identification of Infrastructure-Related Wildlife Protection Areas: The Case of Bird Electrocution," *Biological Conservation* 210: 334–342.

Pitman, J. C., et al., 2005, "Location and Success of Lesser Prairie-Chicken Nests in Relation to Vegetation and Human Disturbance," *Journal of Wildlife Management* 69(3):1259–1269.

Reed, R. A., et al., 1996, "Contribution of Roads to Forest Fragmentation in the Rocky Mountains," *Conservation Biology* 10(4):1098–1106.

Rioux, S., et al., 2013, "Avian Mortalities Due to Transmission Line Collisions: A Review of Current Estimates and Field Methods with an Emphasis on Applications to the Canadian Electric Network," *Avian Conservation and Ecology* 8(2): 7.

Rytwinski, T., and L. Fahrig, 2015, "The Impacts of Roads and Traffic on Terrestrial Animal Populations," *Handbook of Road Ecology*, R. van der Ree et al. (editors), John Wiley & Sons, Ltd.

Sanderfoot, O. V., et al., 2021, "A Review of the Effects of Wildlife Smoke on the Health and Behavior of Wildlife," *Environmental Research Letters* 16: 123003.

Sanders, L. E. and A. D. Chalfoun, 2019, "Mechanisms Underlying Increased Nest Predation in Natural Gas Fields: A Test of the Mesopredator Release Hypothesis," *Ecosphere* 10(5): e02738.

Sawyer, H., et al., 2006, "Winter Habitat Selection of Mule Deer before and during Development of a Natural Gas Field," *Journal of Wildlife Management* 70(2):396–403

Sawyer, H., et al., 2019, "All Routes Are Not Created Equal: An Ungulate's Choice of Migration Route Can Influence Its Survival," *Journal of Applied Ecology* 56: 1860–1869.

Sawyer, H., and F. Lindzey, 2001, *Sublette Mule Deer Study*, Final Report, Wyoming Cooperative Fish & Wildlife Research Unit, Laramie, Wyo., March. Available at http://www.uppergreen.org/library/docs/Muledeerstudy1.pdf. Accessed June 2006.

Sharpe, P. B., and B. Van Horne, 1998, "Influence of Habitat on Behavior of Townsend's Ground Squirrel (*Spermophilus townsendii*)," *Journal of Mammalogy* 79:906–918.

Smallwood, K. S., 2022, "Utility-Scale Solar Impacts to Volant Wildlife" *The Journal of Wildlife Management* 86(4): e22216.

Spaul, R. J., and J. A. Heath, 2017, "Flushing Responses of Golden Eagles (Aquila chrysaetos) In Response to Recreation," *The Wilson Journal of Ornithology* 129(4): 834–845.

Steenhof, K., et al., 1993, "Nesting by Raptors and Common Ravens on Electrical Transmission Line Towers," *Journal of Wildlife Management* 57(2):271–281.

Tatum, V. L., 2004, "Toxicity, Transport, and Fate of Forest Herbicides," *Wildlife Society Bulletin* 32(4):1042–1048.

Thomson, J. L., et al., 2005, *Wildlife at a Crossroads: Energy Development in Western Wyoming—Effects of Roads on Habitat in the Upper Green River Valley*, The Wilderness Society, Washington, D.C. Available at http://www.uppergreen.org/library/docs/ WildlifeAtCrossroads_report.pdf. Accessed June 2006.

Tinsley, E., et al., 2023, "Renewable Energies and Biodiversity: Impact of Ground-Mounted Solar Photovoltaic Sites on Bat Activity" *Journal of Applied Ecology* 00:1–11.

Trombulak, S. C., and C. A. Frissell, 2000, "Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities," *Conservation Biology* 14(1):18–30.

United States Geological Survey (USGS), 2022, Ungulate migrations of the western United States, Volume 3: U.S. Geological Survey Scientific Investigations Report 2022–5088, 114 p., https://doi.org/ 10.3133/ sir20225088.

United States Geological Survey (USGS), 2023, Western Migrations. Available: https://westernmigrations.net/. Accessed April 2023.

Utah Division of Wildlife Resources (UDWR), 2008, *Utah Conservation Data Center*, State of Utah Natural Resources, Salt Lake City, Utah. Available at http://dwrcdc.nr.utah.gov/ucdc/default.asp. Accessed October 2008.

Utah Division of Wildlife Resources (UDWR), 2019, Utah Division of Wildlife Resources. Statewide Management Plan for Mule Deer.

Utah Division of Wildlife Resources (UDWR), 2022, Utah Statewide Elk Management Plan. Available at https://wildlife.utah.gov/pdf/bg/elk_plan.pdf. Accessed April 2023.

Utah Division of Wildlife Resources (UDWR), 2023a, Wildlife GIS Data. Available at https://dwr-data-utahdnr.hub.arcgis.com/. Accessed April 2023.

Utah Division of Wildlife Resources (UDWR), 2023b. Utah Species. Available at https://fieldguide.wildlife.utah.gov/. Accessed March 2023.

Utah Division of Wildlife Resources (UDWR), 2023, Statewide Management Plan for Mule Deer. Available at https://wildlife.utah.gov/pdf/bg/mule_deer_plan.pdf. Accessed April 2023.

Walston, L. J., et al., 2018, "Examining the Potential for Agricultural Benefits from Pollinator Habitat at Solar Facilities in the United States," *Environmental Science & Technology* 52:7566–7576.

Wang, M., and A. Schreiber, 2001, "The Impact of Habitat Fragmentation and Social Structure on the Population Genetics of Roe Deer (*Capreolus capreolus L.*) in Central Europe," *Heredity* 86:701–715.

Washington Department of Fish and Wildlife (WDFW), 2023, Moose (Alces alces). Available at https://wdfw.wa.gov/species-habitats/species/alces-alces. Accessed March 2023.

Washington State Department of Natural Resources (WDNR), 2019, Washington Natural Heritage Program List of Animal Species with Ranks October 2017 (edited 2019). Available at https://www.dnr.wa.gov/publications/amp_nh_animals_ranks_2019%20monarch%20edit.pdf. Accessed March 2023.

Wiens, J. D., et al., 2017, "Spatial Demographic Models to Inform Conservation Planning of Golden Eagles in Renewable Energy Landscapes," *Journal of Raptor Research* 51(3): 234–257.

Williams, C. E., 1995, "Effects of Powerline Corridors on Forest Ecosystem Integrity," Chapter 6, pp. 76–86 in *Environmental Contaminants, Ecosystems and Human Health*, S.K. Majumdar et al. (editors), The Pennsylvania Academy of Science, Easton, Pa.

Williams, R. D., 1990, "Bobcat Electrocutions on Powerlines," *California Fish and Game* 76(3):187–189.

Willyard, C. J., et al., 2004, *Ecological Effects of Fragmentation Related to Transmission Line Rights-of-Way: A Review of the State of the Science*, prepared by Resources Strategies, Inc., Madison, Wisc., for Wisconsin Focus on Energy, Environmental Research Program, Madison, Wisc. Available at http://www.rs-inc.com/downloads/Ecological_Effects_of_Fragmentation_on_ Rights-of-Way.pdf. Accessed July 2008.

World Health Organization (WHO), 2007, *Extremely Low Frequency Fields*, Environmental Health Criteria 238, WHO Press, Geneva, Switzerland.

Wright, A. J., et al., 2007, "Anthropogenic Noise as a Stressor in Animals: A Multidisciplinary Perspective," *International Journal of Comparative Psychology* 20:250–273.

Wyoming Fish and Game Department (WGFD), 2004, *Recommendations for Development of Oil and Gas Resources within Crucial and Important Wildlife Habitats*, Cheyenne, Wyo., Dec. Available at http://gf.state.wy.us/downloads/ pdf/og.pdf. Accessed July 2006.

Wyoming Game and Fish Department (WGFD), 2023, Big Game. Available at https://wgfd.wyo.gov/Wildlife-in-Wyoming/Geospatial-Data/Big-Game-GIS-Data. Accessed April 2023.

Wyoming Natural Diversity Database (WYNDD), 2023, Available at https://wyndd.org/species_list/?wy_occur=Regular%2CIrregular&wy_origin=Native%2CNonnative&res_status=Current&columns=sciname%2Ccomname%2Csynonyms%2Ctaxgroup%2Ctaxgroup2%2Cblm_wy%2Cg_rank%2Cs_rank%2Cusfws_esa%2Cusfs_sens%2Cusfs_solc%2Cwgfd_sgcn%2Cwy_contrib%2Cwyndd_soc%2Cwy_occur%2Cwy_origin&servicePrefix=prod_. Accessed March 2023.

F.22.4.4 Special Status Species

F.22.5 Environmental Justice

Bureau of Land Management (BLM), 2022, Notice of Intent (NOI) to prepare a Programmatic EIS to Evaluate Utility-Scale Solar Energy Planning and Amend Resource Management Plans for Renewable Energy Development (Programmatic EIS). Federal Register (87 FR 75284). December 8.

Bureau of Land Management (BLM), 2022, (IM2022-059). Addressing Environmental Justice in NEPA Documents: Frequently Asked Questions. U.S. Department of the Interior, Bureau of Land Management, Socioeconomics Program, Washington, DC.

Council on Environmental Quality (CEQ), 1997, Environmental Justice: Guidance Under the National Environmental Policy Act. Council on Environmental Quality, Executive Office of the President. 40 pp. Accessed May 2022. (https://ceq.doe.gov/docs/ceq-regulations-and-guidance/regs/ej/justice.pdf).

Exec. Order No. 12898, 59 Fed. Reg. 7629. 1994. Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. February 11.

Exec. Order No. 14008, 86 Fed. Reg. 7619. 2021. Tackling the Climate Crisis at Home and Abroad. January 27.

Exec. Order No. 14096, 88 Fed. Reg. 25251. 2023. Revitalizing Our Nation's Commitment to Environmental Justice for All. April 21.

U.S. Census Bureau (USCB), 2020, Understanding and Using American Community Survey Data: What All Data Users Need to Know, https://www.census.gov/content/dam/Census/library/publications/2020/acs/acs_general_handbook_2020.pdf. Accessed March 2023.

U.S. Census Bureau (USCB), 2022a, U.S. Census Bureau Releases 2017–2021 ACS 5-Year Estimates, https://www.census.gov/programs-surveys/acs/news/updates.2022.html. Accessed March 2023.

U.S. Census Bureau (USCB), 2022b, 2017–2021 American Community Survey 5-Year Estimates, Data Profile 02, https://data.census.gov/table?tid=ACSDP5Y2021.DP02. Accessed March 2023.

U.S. Census Bureau (USCB), 2022b, 2017–2021 American Community Survey 5-Year Estimates, Data Profile 03, https://data.census.gov/table?tid=ACSDP5Y2021.DP03. Accessed March 2023.

U.S. Census Bureau (USCB), 2022c, 2017–2021 American Community Survey 5-Year Estimates, Data Profile 05, https://data.census.gov/table?tid=ACSDP5Y2021.DP05. Accessed March 2023.

U.S. Census Bureau (USCB), 2022d, 2017–2021 American Community Survey 5-Year Estimates, Table S1702, https://data.census.gov/table?tid=ACSST5Y2021.S1702. Accessed March 2023.

U.S. Census Bureau (USCB), 2022e, 2021 ACS cartographic boundary files, 1 : 500,000 national shapefile, https://www.census.gov/geographies/mapping-files/time-series/geo/cartographic-boundary.html. Accessed March 2023.

EJ IMPACT REFERENCES

Bureau of Land Management (BLM), 2022, Environmental Justice Implementation. IM2022-059. Accessed July 27, 2023 (https://www.blm.gov/policy/im2022-059).

Centers for Disease Control (CDC), 2022, Loud noises can cause hearing loss: What noises cause hearing loss? Accessed April 2023 (https://www.cdc.gov/nceh/hearing_loss/what_noises_cause_hearing_loss.html#print). Nov. 8.

Centers for Disease Control (CDC), 2023, Air quality: Particle pollution. Accessed April 19, 2023 (https://www.cdc.gov/air/particulate_matter.html). Feb. 16.

Environmental Protection Agency (EPA), 2022a, Abandoned mine drainage. Polluted runoff: non-point source (NPS) pollution. Accessed May 2023 (https://www.epa.gov/nps/abandoned-mine-drainage). December

Environmental Protection Agency (EPA), 2022b, Clean Air Act Title IV – Noise Pollution. Clean Air Act Overview. Accessed May 2023 (https://www.epa.gov/clean-air-act-overview/clean-air-act-title-iv-noise-pollution).

Intergovernmental Panel on Climate Change (IPCC), 2023, Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35–115, doi: 10.59327/IPCC/AR6-9789291691647

International Energy Agency (IEA), 2021, *The role of critical minerals in clean energy transitions*. OECD Publishing.

Organisation for Economic Co-operation and Development (OECD), 2016, 2023, OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas. OECD.org. Accessed June 2023 (https://www.oecd.org/corporate/mne/mining.htm).

The White House, 2022, Fact Sheet: Securing a Made in America Supply Chain for Critical Minerals. Accessed May 2023 (https://www.whitehouse.gov/briefing-room/statements-releases/2022/02/22/fact-sheet-securing-a-made-in-america-supply-chain-for-critical-minerals/). Feb. 22.

F.22.6 Geology and Soil Resources

Burchfiel, B. C., et al., 1992, “Introduction,” in The Cordilleran Orogen: Conterminous 20 United States: The Geology of North America, B.C. Burchfiel et al. (editors), Vol. G-3, 21 Geological Society of America, Boulder, Colo.

Dohrenwend, J. C., 1987, “Basin and Range,” pp. 303–341 in Geomorphic Systems of North America, W.L. Graf (editor), Centennial Special Vol. 2, Geological Society of America, Boulder, CO.

Galloway, D., et al., 1999, *Land Subsidence in the United States*, U.S. Geological Survey 27 Circular 1182.

Madole, R. F., et al., 1987, “Rocky Mountains,” pp. 211–257 in *Geomorphic Systems of North America*, W.L. Graf (editor), Centennial Special Vol. 2, Geological Society of America, Boulder, Colo.

National Map, 2023, The National Map – Data Delivery. Available at https://www.usgs.gov/the-national-map-data-delivery. Accessed April 2023.

National Resources Conservation Service (NRCS), 2015, Illustrated guide to soil taxonomy. U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center, Lincoln, Nebraska. Accessed April 2023, at https://www.nrcs.usda.gov/sites/default/files/2022-06/Illustrated_Guide_to_Soil_Taxonomy.pdf.

National Resources Conservation Service (NRCS), 2023, *The Twelve Orders of Soil Taxonomy*. Accessed April 2023, at https://www.nrcs.usda.gov/resources/education-and-teaching-materials/the-twelve-orders-of-soil-taxonomy.

Oregon Department of Geology and Mineral Industries (DOGAMI), 2023, Geologic Provinces, Available at https://www.oregongeology.org/learnmore/GeologicSightseeing.HTM. Accessed April 2023.

Rau, W. W., 1973, “Geology of the Washington Coast”, Washington Department of Natural Resources, Bulletin No. 66. Available at https://www.dnr.wa.gov/publications/ger_b66_geol_wa_coast.pdf. Accessed April 2023.

U.S. Department of Agriculture (USDA), 2021, "Gridded National Soil Survey Geographic (gNATSGO) Database for the Conterminous United States." Washington, D.C. Accessed May 2023, at https://nrcs.app.box.com/v/soils.

U.S. Geological Survey (USGS), 1997, Digital Compilation of Landslide Overview Map of the Conterminous United States, U.S. Geological Survey Open-File Report 97-289, available at https://geochange.er.usgs.gov/sw/impacts/geology/landslides/. Accessed April 2023.

U.S. Geological Survey (USGS), 2004, Physiographic Divisions of the Conterminous U.S., Washington, D.C. Available at https://water.usgs.gov/GIS/metadata/usgswrd/XML/physio.xml#stdorder. Accessed April 2023.

U.S. Geological Survey (USGS), 2018, 2018 United States National Seismic Hazard Maps, Available at https://www.usgs.gov/programs/earthquake-hazards/science/2018-united-states-lower-48-seismic-hazard-long-term-model. Accessed on April 2023.

U.S. Geological Survey (USGS), 2020, Quaternary Fault and Fold Database for the United States. Available at https://www.sciencebase.gov/catalog/item/589097b1e4b072a7ac0cae23. Accessed April 2023.

U.S. Geological Survey (USGS), 2023, Volcano Hazards Map. Available at https://www.usgs.gov/programs/VHP. Accessed April 2023.

Wald, D., et al., 2000, *"Shake Maps" – Instant Maps of Earthquake Shaking*, U.S. Geological Survey Fact Sheet 103-00.

Wayne, W. J., et al., 1991, "Quaternary Geology of the Northern Great Plains," pp. 441-476 in Vol. K-2 of Quaternary Nonglacial Geology; Conterminous United States: The Geology of North America, R. B. Morrison (editor), Geological Society of America, Boulder, CO.

F.22.7 Hazardous Materials and Waste

Semeraro, T., A. Pomes, C. Del Guidice, D. Negro, and R. Aretano, 2018, Planning ground based utility scale solar energy as green infrastructure to enhance ecosystem services. Energy Policy 117:218-227.

F.22.8 Health and Safety

F.22.9 Lands and Realty

F.22.10 Military and Civilian Aviation

F.22.11 Mineral Resources

Bureau of Land Management (BLM), 2023, *Public Land Statistics 2022*, Volume 207, BLM/OC/ST-23/003+1165, U.S. Department of the Interior, Bureau of Land Management, Washington, D.C., June.

Energy Information Administration (EIA), 2021, Annual Coal Report, U.S. Energy Information Administration, Washington, D.C. Available at table1.pdf (eia.gov). Accessed August 2023.

Energy Information Administration (EIA), 2023a, *Crude Oil Production*, U.S. Department of Energy Washington, D.C., May. Available at https://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm. Accessed June 2023.

Energy Information Administration (EIA), 2023b, Natural Gas Annual Supply & Disposition by State. Available at https://www.eia.gov/dnav/ng/ng_sum_snd_dcu_SWY_a.htm. Accessed June 2023.

F.22.12 Paleontological Resources

Bureau of Land Management (BLM), 2023, *Herd Area and Herd Management Statistics as of March 1, 2023*, U.S. Department of the Interior, Bureau of Land Management, Available at 2023 Wild Horse and Burro Population Estimates (blm.gov). Accessed May 2023.

F.22 Rangeland Resources

F.22.13.1 Livestock Grazing

Bureau of Land Management (BLM), 2023a, Public Land Statistics 2022. p. 79. Available at https://www.blm.gov/about/data/public-land-statistics.

F.22.13.2 Wild Horse and Burro

Bureau of Land Management (BLM), 2023, *Herd Area and Herd Management Statistics as of March 1, 2023*, U.S. Department of the Interior, Bureau of Land Management, Available at 2023 Wild Horse and Burro Population Estimates (blm.gov). Accessed May 2023.

F.22.14 Recreation

Bureau of Land Management (BLM), 2023, Public Land Statistics FY 2022. Available at https://www.blm.gov/about/data/public-land-statistics.

F.22.15 Socioeconomics

Arizona Commerce Authority, 2023, Population Projections. Available at https://www.azcommerce.com/oeo/population/population-projections/. Accessed March 2023.

California Department of Finance, 2023, Projections. Available at https://dof.ca.gov/Forecasting/Demographics/projections/. Accessed March 2023.

Colorado Department of Local Affairs, 2023, Population Forecasts. Available at https://demography.dola.colorado.gov/assets/html/county.html. Accessed March 2023.

Idaho Department of Labor, 2023, Population Forecasts. Available at https://lmi.idaho.gov/data-tools/population-projections/. Accessed March 2023.

Montana Department of Commerce, 2023, Population Projection. Available at https://dataportal.mt.gov/t/DOC/views/CEIC_REMI_POPULATION_PROJECTION_COUNTY_AGE_RACE_SFE/Table?%3Aorigin=card_share_link&%3Aembed=y. Accessed March 2023.

Nevada Department of Taxation, 2023, Nevada County Population Projections: 2021 to 2040. Available at https://tax.nv.gov/uploadedFiles/taxnvgov/Content/TaxLibrary/Nevada%20County%20Population%20Projections%202021%20to%202040.pdf. Accessed March 2023.

Portland State University, 2023, Population Forecasts. Available at https://www.pdx.edu/population-research/population-forecasts. Accessed March 2023.

University of New Mexico, 2023, Population Projections. Available at https://gps.unm.edu/pru/projections. Accessed March 2023.

University of Utah, 2023, Utah Long-Term Planning Projections. Available at https://gardner.utah.edu/wp-content/uploads/LongTermProj-Jan2022.pdf?x71849&x71849. Accessed March 2023.

U.S. Census Bureau, 2023a, P1 RACE. 2010: DEC Redistricting Data (PL 94-171). Available at https://data.census.gov/cedsci/table?t=Race%20and%20Ethnicity&g=0400000US06_0500000US06037,06059,06073,06083,06111&tid=DECENNIALPL2010.P1. Accessed March 2023.

U.S. Census Bureau, 2023b, P1 RACE. 2020: DEC Redistricting Data (PL 94-171). Available at https://data.census.gov/cedsci/table?t=Race%20and%20Ethnicity&g=0400000US06_0500000US06037,06059,06073,06083,06111&tid=DECENNIALPL2020.P1. Accessed March 2023.

U.S. Census Bureau, 2023c, P2 URBAN AND RURAL 2010: DEC 115th Congressional District Summary File. Available at https://data.census.gov/table?q=urban+population&g=040XX00US04,06,08,16,30,32,35,41,49,53,56&tid=DECENNIALCD1152010.P2. Accessed March 2023.

U.S. Census Bureau, 2023d, DP03 SELECTED ECONOMIC CHARACTERISTICS. 2021: ACS 5-Year Estimates Data Profiles. Available at https://data.census.gov/table?t=Employment+and+Labor+Force+Status&g=040XX00US04,06,08,16,30,32,35,41,49,53,56&tid=ACSDP5Y2021.DP03. Accessed March 2023.

U.S. Census Bureau, 2023e, S2403 INDUSTRY BY SEX FOR THE CIVILIAN EMPLOYED POPULATION 16 YEARS AND OVER. 2021: ACS 5-Year Estimates Subject Tables. Available at https://data.census.gov/table?q=S2403:+INDUSTRY+BY+SEX+FOR+THE+CIVILIAN+EMPLOYED+POPULATION+16+YEARS+AND+OVER&g=040XX00US04,06,08,16,30,32,35,41,49,53,56&tid=ACSST5Y2021.S2403. Accessed March 2023.

U.S. Census Bureau, 2023f, DP04 SELECTED HOUSING CHARACTERISTICS. 2021: ACS 5-Year Estimates Data Profiles. Available at https://data.census.gov/table?g=040XX00US04,06,08,16,30,32,35,41,49,53,56&tid=ACSDP5Y2021.DP04. Accessed March 2023.

U.S. Census Bureau, 2023g, GS00LF01State and Local Government Finances by Level of Government: US and States: 2017 – 2021: 2021: PUB Public Sector Annual Surveys. Available at https://data.census.gov/table?t=Government:Government+Employment+and+Payroll:State+Government+Finances&g=040XX00US04,06,08,16,30,32,35,41,49,53,56. Accessed March 2023.

U.S. Department of Commerce, 2023, County BEARFACTS. Bureau of Economic Analysis Available at https://apps.bea.gov/regional/bearfacts/countybf.cfm. Accessed March 2023.

Washington Office of Financial Management, 2023, Projections. Available at https://ofm.wa.gov/tags/projections. Accessed March 2023.

Wyoming Department of Administration and Information, 2023, Population Projections. Available at http://eadiv.state.wy.us/pop/wyc&sc40.htm. Accessed March 2023.

F.22.16 Specially Designated Areas and Lands with Wilderness Characteristics

Bureau of Land Management (BLM), 2020a, *National Landscape Conservation System: National Scenic and Historic Trails*, U.S. Department of the Interior, Bureau of Land Management, Washington, D.C., Sept. Available at Rivers_Q2_2020.pdf (blm.gov). Accessed April 2023.

Bureau of Land Management (BLM), 2022a, *National Landscape Conservation System: National Monuments*, U.S. Department of the Interior, Bureau of Land Management, Washington, D.C., March. Available at National Monuments Web Detail Table.pdf (blm.gov). Accessed April 2023.

Bureau of Land Management (BLM), 2022b, *National Landscape Conservation System: Wilderness Areas*, U.S. Department of the Interior, Bureau of Land Management, Washington, D.C., Feb. Available at Wilderness_Web_Table_2022.pdf (blm.gov). Accessed April 2023.

Bureau of Land Management (BLM), 2023a, *National Landscape Conservation System: National Conservation Areas and Similar Designations*, U.S. Department of the Interior, Bureau of Land Management, Washington, D.C., March. Available at NCAs_and_Sim_Q1_2023.pdf (blm.gov). Accessed June 2023.

Bureau of Land Management (BLM), 2023b, *Current List of ACECs*, U.S. Department of the Interior, Bureau of Land Management, Available as Excel file at ACEC | Bureau of Land Management (blm.gov). Accessed March 2023.

Bureau of Land Management (BLM), 2023c, Section 368 Energy Corridor Mapping Tool, Available at https://bogi.evs.anl.gov/section368/portal/. Accessed April 2023.

Bureau of Land Management (BLM), 2023d, Solar Energy Environmental Mapper, Available at https://bogi.evs.anl.gov/solmap/portal/. Accessed April 2023.

Bureau of Land Management (BLM), 2023e, *National Landscape Conservation System: Wilderness Study Areas*, U.S. Department of the Interior, Bureau of Land Management, Washington, D.C., Jan. WSAs_Q1_2023 (1).pdf (blm.gov). Accessed June 2003.

Bureau of Land Management (BLM), 2023f, *Public Land Statistics 2022*, Volume 207, BLM/OC/ST-23/003+1165, U.S. Department of the Interior, Bureau of Land Management, Washington, D.C., June.

Perfors, T., 2023, Email from T. Perfors, Planning and Environmental Coordinator, Bureau of Land Management, BLM CO, NM, UT, and WY Renewable Energy Coordination Office, Dolores, Colorado, to J. Kuiper, Principal Geospatial Engineer, Argonne National Laboratory, Environmental Science Division, Argonne, Illinois. Subject: New LWC Shapefiles. May 17, 2023.

F.22.17 Transportation

F.22.18 Tribal Interests

F.22.19 Visual Resources

Bureau of Land Management (BLM), 1984, *Visual Resource Management*, BLM Manual Handbook 8400, Release 8-24, U.S. Department of the Interior, Washington, D.C.

Bureau of Land Management (BLM), 1986a, *Visual Resource Inventory*, BLM Manual Handbook 8410-1, Release 8-28, U.S. Department of the Interior, Washington, D.C., Jan.

Bureau of Land Management (BLM), 1986b, *Visual Resource Contrast Rating*, BLM Manual Handbook 8431-1, Release 8-30, U.S. Department of the Interior, Washington, D.C., Jan.

Cinzano, P., F. Falchi, and C. D. Elvidge, 2001, “The First World Atlas of the Artificial Night Sky Brightness.” Monthly Notices of the Royal Astronomical Society, 328, 689–707.

Hankinson, M., 1999, “Landscape and Visual Impact Assessment,” in *Handbook of Environmental Assessment, Volume 1: Environmental Impact Assessment Process, Methods, and Potential*, J. Petts (editor), Blackwell Scientific Ltd., Oxford, United Kingdom.

Perfors, T., 2023, Email from T. Perfors, Planning and Environmental Coordinator, Bureau of Land Management, BLM CO, NM, UT, and WY Renewable Energy Coordination Office, Dolores, Colorado, to J. Kuiper, Principal Geospatial Engineer, Argonne National Laboratory, Environmental Science Division, Argonne, Illinois. Subject: New LWC Shapefiles. May 17, 2023.

U.S. Forest Service (USFS), 1995, Landscape Aesthetics, A Handbook for Scenery Management, Agriculture Handbook 701, U.S. Department of Agriculture, Washington, D.C.

F.22.20 Water Resources

Azcentral, 2010, *Palo Verde Water Deal a Boost for Scottsdale's Coffers*. Available at http://www.azcentral.com/news/articles/2010/04/15/20100415palo-verde-water-deal-scottsdale.html. Accessed July 22, 2010.

Barlow, P. M., and Leake, S. A., 2012, Streamflow depletion by wells—Understanding and managing the effects of groundwater pumping on streamflow: U.S. Geological Survey Circular 1376, 84 p. (Also available at http://pubs.usgs.gov/circ/1376/.)

Bredehoeft, J., and T. Durbin, 2009, "Ground Water Development—The Time to Full Capture Problem," Ground Water 47(4): 506–514.

Bureau of Land Management (BLM), 2007a, *Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States, Final Programmatic Environmental Impact Statement*, FES 07-21, U.S. Department of the Interior, Reno, Nev., June. Available at http://www.blm.gov/wo/st/en/prog/more/veg_eis.html/. Accessed October2008.

Bureau of Land Management (BLM), 2017, Quality of Water – Colorado River Basin, Progress Report No. 25. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region. Available at https://www.usbr.gov/uc/progact/salinity/pdfs/ProgressReports/PR25final.pdf. Accessed June 2023.

California Department of Water Resources (CADWR), 2010a, *Groundwater Management, Court Adjudications*. Available at http://www.water.ca.gov/groundwater/gwmanagement/court_adjudications.cfm. Accessed September 2010.

California Department of Water Resources (CADWR), 2010b, *Groundwater Information Center.* Available at http://www.water.ca.gov/groundwater/index.cfm#. Accessed September 2010.

Colorado Division of Water Resources (CDWR), 2008, *Guide to Colorado Well Permits, Water Rights, and Water Administration*, January 2008.

Colorado Legislative Council Staff (CLCS), 2009, *Regulation of Transbasin Diversions and Large Water Transfers,* Memorandum, December 24, 2009.

Colorado River Basin Salinity Control Forum (CRBSCF), 2020, *2020 Review, Water Quality Standards for Salinity, Colorado River System*, October 2020. Available at https://coloradoriversalinity.org/docs/2020%20REVIEW%20-%20Final%20w%20appendices.pdf. Accessed May 2023.

Congressional Research Service (CRS), 2005, *Report to Congress, the United States–Mexico Dispute over the Waters of the Lower Rio Grande River*, Order Code RS22085, March 21.

Environmental Protection Agency (EPA), 2023a, *Clean Water Act Section 303(d): Impaired Waters and Total Maximum Daily Loads (TMDLs)*. Available at https://www.epa.gov/tmdl. Accessed May 2023.

Environmental Protection Agency (EPA), 2023b, *Sole Source Aquifers for Drinking Water*. Available at https://www.epa.gov/dwssa. Accessed May2023.

Environmental Protection Agency (EPA), 2023c, *Map of Sole Source Aquifer Locations.* Available at https://www.epa.gov/dwssa/map-sole-source-aquifer-locations. Accessed May 2023.

Federal Emergency Management Agency (FEMA), 2023, Flood Map Products. Available at https://www.fema.gov/flood-maps/products-tools/products. Accessed May 2023.

Gerlak, A. K., and J. E. Thorson, 2006, "General Stream Adjudications Today: An Introduction," Journal of Contemporary Water Research and Education, Issue 133, pp. 1–4.

Healy, R. W., Alley, W. M., Engle, M. A., McMahon, P. B., and Bales, J. D., 2015, The water-energy nexus—An earth science perspective: U.S. Geological Survey Circular 1407, 107 p., http://dx.doi.org/10.3133/cir1407.

Hobbs, G. J., 2006, "Overview of Western Water Adjudications: A Judge's Perspective," *Journal of Contemporary Water Research and Education*, Issue 133, pp. 5–9.

Hockaday, S., and K. J. Ormerod, 2020, *Western Water Law: Understanding the Doctrine of Prior Appropriation*, Extension | University of Nevada, Reno, IP-20-01.

Hutson, S. S., et al., 2004, *Estimated Use of Water in the United States in 2000: U.S. Department of the Interior*, U.S. Geological Survey Circular 1268.

International Boundary and Water Commission (IBWC), 2023a, *The International Boundary & Water Commission, United States and Mexico – United States Section*. Available at https://www.ibwc.gov/home.html. Accessed May 2023.

International Joint Commission (IJC), 2023, *Role of the IJC*. Available at https://www.ijc.org/en/who/role. Accessed May 2023.

Littlefield, D. R., 1999, *The History of the Rio Grande Compact of 1938,* Water Resources Research Institute Conference Proceedings, 1999.

National Integrated Drought Information System (NIDIS), 2023, *Special Edition Drought Status Update for the Western United States, May 11, 2023*. Available at https://www.drought.gov/drought-status-updates/special-edition-drought-status-update-western-united-states-2023-05-11. Accessed June 2023.

National Park Service (NPS), 1998, *An Introduction to Wild and Scenic Rivers*, Technical Report of the Interagency Wild and Scenic Rivers Coordinating Council, Nov.

Nevada Department of Conservation & Natural Resources (NDCNR), 2022, State Engineer Designated Groundwater Basins of Nevada. Available at http://water.nv.gov/mapping/maps/designated_basinmap.pdf. Accessed August 2023.

Nevada Division of Water Resources (NDWR), 2018, Summary of Statutory Procedures for Filing Claims of Vested Rights, Making Application for a Water Right and a Summary of Fees of the State Engineer.

New Mexico Environment Department, 2022, *EPA-Approved 2022-2024 Integrated Report (April 26, 2022)*. Available at https://www.env.nm.gov/surface-water-quality/303d-305b/. Accessed May 2023. State of Nevada Department of Conservation and Natural Resources, Division of Water Resources. Available at http://water.nv.gov/Documents/SE_Procedures_Fees_Brochure.pdf. Accessed August 2023.

New Mexico Office of the State Engineer (NMOSE), 2004, *Part 13: Active Water Resource Management,* Title 19: Natural Resources and Wildlife, Chapter 25: Administration and Use of Water-General Provisions. Dec. 30.

New Mexico Office of the State Engineer (NMOSE), 2010c, *Acequias.* Available at http://www.ose.state.nm.us/isc_acequias.html. Accessed September 2010.

New Mexico Office of the State Engineer (NMOSE), 2010e, *Declared Groundwater Basins.* Available at http://www.ose.state.nm.us/water_info_groundwater_special_orders.html. Accessed September 2010.

New Mexico Office of the State Engineer (NMOSE), 2023, Active Cases. Available at https://www.ose.state.nm.us/Legal/activeCases.php. Accessed May 2023.

Planert, M., and J. S. Williams, 1995, *Ground Water Atlas of the United States: California, Nevada,* HA 730-B, U.S. Geological Survey.

Robson, S. G., and E. R. Banta, 1995, *Ground Water Atlas of the United States: Arizona, Colorado, New Mexico, Utah*, HA 730-C, U.S. Geological Survey.

Rumsey, C. A., O. Miller, R. M. Hirsch, T. M. Marston, and D. D. Susong, 2021, *Substantial declines in salinity observed across the Upper Colorado River Basin during the 20th century, 1929–2019*. Water Resources Research, 57, e2020WR028581. https://doi.org/10.1029/2020WR028581

Sackett v. Environmental Protection Agency, 598 U.S. ___ (2023), available at https://www.supremecourt.gov/opinions/22pdf/21-454_4g15.pdf

United States Geological Survey (USGS), 2008a, *Water Resources of the United States¾ Hydrologic Unit Maps*. Available at http://water.usgs.gov/GIS/huc.html. Accessed November 2008.

United States Geological Survey (USGS), 2023a, *Transboundary Aquifer Assessment Program (TAAP)*. Available at https://webapps.usgs.gov/taap/. Accessed May 2023.

U.S. Bureau of Reclamation (BOR), 2023, *Law of the River*. Available at https://www.usbr.gov/lc/region/g1000/lawofrvr.html. Accessed May 2023.

U.S. Department of the Interior (DOI), 2017, Quality of Water Colorado River Basin Progress Report No. 25, Bureau of Reclamation, Upper Colorado Region. Available at https://www.coloradoriversalinity.org/docs/Progress%20Report%2025%20-%20Reclamation.pdf. Accessed May 2023.

Whitehead, R. L., 1994, *Ground Water Atlas of the United States: Idaho, Oregon, Washington,* HA 730-H, U.S. Geological Survey.

Whitehead, R. L., 1996, Ground Water Atlas of the United States: Montana, North Dakota, South Dakota, Wyoming, HA 730-I, U.S. Geological Survey.

Williams, A. P., B. I. Cook, and J. E. Smerdon, 2022, Rapid intensification of the emerging southwestern North American megadrought in 2020–2021. *Nat. Clim. Chang.* 12,
232–234. https://doi.org/10.1038/s41558-022-01290-z

Williams, S .M., 1997, "Overview of Indian Water Rights," *Water Resources Update,* Universities Council on Water Resources, 107:6–8.

F.22.21 Wildland Fire

San Miguel Ayanz, J., P. Barbosa, G. Schmuck, G. Liberta, E. Schulte, and I. Z. Gitas, 2003, Towards a coherent forest fire information system in Europe: the European Forest Fire Information System (EFFIS). Environmental Monitoring in the South-Eastern Mediterranean Region Using RS/GIS Techniques; Gitas, IZ, San Miguel Ayanz, J., Eds, 5–16.

Short, K. C., 2014, A spatial database of wildfires in the United States, 1992–2011. Earth System Science Data, 6(1), 1–27.

Short, Karen C. 2022. Spatial wildfire occurrence data for the United States, 1992-2020 [FPA_FOD_20221014]. 6th Edition. Fort Collins, CO: Forest Service Research Data

Short, Karen C., Mark A. Finney, Kevin C. Vogler, Joe H. Scott, Julie W. Gilbertson-Day, and Isaac C. Grenfell, 2020, Spatial datasets of probabilistic wildfire risk components for the United States (270m). 2nd Edition. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2016-0034-2.

Wagner C. E. V., 1974, Structure of the Canadian Forest Fire Weather Index (Ottawa: Department of the Environment, Canadian Forestry Service).

Wagner, C. E. V., 1987, Development and structure of the Canadian Forest Fire Weather Index System (Ottawa: Canada Communication Group Publ).

Wang, J., and V. R. Kotamarthi, 2015, High-resolution dynamically downscaled projections of precipitation in the mid and late 21st century over North America. Earth's Future, 3, 268–288.

Zobel, Z., J. Wang, D. J. Wuebbles, and V. R. Kotamarthi, 2017, Evaluations of high-resolution dynamically downscaled ensembles over the contiguous United States. Climate Dynamics. doi:10.1007/s00382-017-3645-6

Zobel, Z., J. Wang, D. J. Wuebbles, and V. R. Kotamarthi, 2018, Analyses for High-Resolution Projections through the End of the 21st Century for Precipitation Extremes over the United States. Earth's Future. https://doi.org/10.1029/2018EF000956