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Characterizing Ecoregions and Montane Perennial Watersheds of the Great Basin

David I. Board, Thomas E. Dilts, Peter J. Weisberg, Anna C. Knight, Jeanne C. Chambers, Mark L. Lord, and Jerry R. Miller

Forest Service | Rocky Mountain Research Station | General Technical Report RMRS-GTR-419 | September 2020

Board, David I.; Dilts, Thomas E.; Weisberg, Peter J.; Knight, Anna C.; Chambers, Jeanne C.; Lord, Mark L.; Miller, Jerry R. 2020. Characterizing ecoregions and montane perennial watersheds of the Great Basin. Gen. Tech. Rep. RMRS-419. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 51 p.
Research data doi: https://doi.org/10.2737/RDS-2020-0059.

Abstract

Multiple research and management partners collaboratively developed a multiscale approach for assessing the geomorphic sensitivity of streams and ecological resilience of riparian and meadow ecosystems in upland watersheds of the Great Basin to disturbances and management actions. The approach builds on long-term work by the partners on the responses of these systems to disturbances and management actions. At the core of the assessments is information on past and present watershed and stream channel characteristics, geomorphic and hydrologic processes, and riparian and meadow vegetation. In this report, we describe the approach used to delineate Great Basin mountain ranges and the watersheds within them, and the data that are available for the individual watersheds. We also describe the resulting database and the data sources. Furthermore, we summarize information on the characteristics of the regions and watersheds within the regions and the implications of the assessments for geomorphic sensitivity and ecological resilience. The target audience for this multiscale approach is managers and stakeholders interested in assessing and adaptively managing Great Basin stream systems and riparian and meadow ecosystems. Anyone interested in delineating the mountain ranges and watersheds within the Great Basin or quantifying the characteristics of the watersheds will be interested in this report.

Keywords: Great Basin, mountain range delineation, watershed delineation, watershed characteristics, watershed database, topography, climate, geology, hydrology, vegetation, disturbances, species at risk

Cover: Big Creek watershed in central Nevada. Photo by Jeanne Chambers.

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Acknowledgments

We thank the members of the multipartner working group for their help in developing the project: Cheri Howell, Jim Hurja, John McCann, Dirk Netz (USDA Forest Service, Humboldt-Toiyabe National Forest); Shawn Espinosa, Jasmine Kleiber, and Chris Crookshanks (Nevada Division of Wildlife); Boris Poff and Sarah Peterson (USDOI Bureau of Land Management); John Tull (USDOI U.S. Fish and Wildlife Service); Brook Bushman and Laurel Saito (The Nature Conservancy); Keirith Snyder (USDA Agricultural Research Service); Jason Dunham (USDOI U.S. Geological Survey); Erica Fleishman (Oregon State University); and Rosemary Carroll and Ken McGwire (Desert Research Institute). The comments of the working group members helped improve the manuscript. Natasha Wesely and Evan Thompson (University of Nevada, Reno) assisted with development of the geographic information systems database. The Great Basin Landscape Conservation Cooperative, Nevada Division of Wildlife, and Bureau of Land Management provided funding for this project.

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INTRODUCTION

In 2016, a multipartner working group was established to create a multiscale resilience-based approach for restoring and conserving Great Basin riparian and meadow ecosystems. Riparian and meadow ecosystems are rare and valuable resources in the Great Basin. Many of these ecosystems have been degraded by various anthropogenic activities and are further threatened by climate change.

Restoration and conservation of these ecosystems require a sound understanding of their responses not only to natural and anthropogenic disturbances but also to management actions. Assessments of the geomorphic sensitivity of streams and ecological resilience of riparian ecosystems can provide the basis for understanding their past responses to disturbances and management actions and predicting how they are likely to respond in the future. These assessments gather information on the capacity of streams and riparian ecosystems to regain fundamental structures, processes, and functions, or in other words to recover, when disturbances alter geomorphic and hydrologic regimes and vegetation structure and composition. They assist in determining the relative stability of streams and riparian ecosystems, whether a threshold in a system state has been or is about to be crossed, and whether a new stable state has been reached after a threshold is crossed. Thus, assessments of geomorphic sensitivity and ecological resilience can provide the basis for prioritizing areas for conservation and restoration activities and determining effective management strategies.

The multiscale approach builds on long-term work by the team and its research and management partners on the sensitivity and resilience of upland watersheds of the Great Basin to natural and anthropogenic disturbances (Chambers and Miller 2004, 2011). The target audience is managers and stakeholders interested in assessing and adaptively managing Great Basin stream systems and riparian and meadow ecosystems.

A two-part general technical report, “Geomorphic Sensitivity and Ecological Resilience of Great Basin Streams and Riparian Ecosystems” (Chambers et al. in preparation) accompanies this report. Part I provides background information on sensitivity and resilience concepts and the responses of Great Basin streams and riparian ecosystems to disturbances and management actions. Part I also includes a categorization of sensitivity and resilience that can be used to evaluate past and likely future responses of the watersheds to disturbance and determine appropriate management strategies. Part II provides a rapid assessment protocol for evaluating the sensitivity of the stream systems and resilience of the riparian ecosystems within focal watersheds. In Part II, watershed-scale data are combined with field-collected data to provide a multiscale approach for assessing the sensitivity of streams and resilience of

riparian and meadow ecosystems in upland watersheds of the Great Basin to disturbances and management actions.

At the core of assessments of geomorphic sensitivity and ecological resilience is information on past and present watershed and stream channel characteristics, geomorphic and hydrologic processes, and riparian and meadow vegetation characteristics. A database of the characteristics of the watersheds was developed for the project and is available at: https://doi.org/10.2737/RDS-2020-0059. Data can also be loaded directly in ArcGIS Pro, ArcGIS Desktop, or open-source QGIS software from: https://www.arcgis.com/home/search.html?q=greatbasinwatersheds. Key elements of the database include:

1. A delineation of the mountain ranges that support perennial watersheds in the Great Basin
2. A delineation of the perennial watersheds within Great Basin mountain ranges
3. A database of characteristics of the individual watersheds: topography, climate, geology, hydrology, vegetation
4. The type and amount of select disturbances: wildfire, roads, and dams and diversions
5. Habitat probabilities of animal species at risk within the watersheds

The data provided in the database, the description of the data, and the data sources are in Appendix A.

In this report, we describe the delineation of the mountain ranges and watersheds within them, and the data collected for the individual watersheds. We also describe the variables in the database and the data sources. Furthermore, we summarize information on the characteristics of the regions and watersheds within regions and the implications for assessing geomorphic sensitivity and ecological resilience.

GREAT BASIN GEOGRAPHIC REGIONS

The focal area encompasses most of the Northern and Central Basin and Range ecoregions as defined by the U.S. Environmental Protection Agency's (EPA's) level III ecoregions (USEPA 2013). This area is in northern and central Nevada, western Utah, southern Idaho, and southeastern Oregon. The focal area was divided into seven geographic regions: the Lava Plains, Lahontan, Humboldt and Owyhee Uplands, Southeastern Idaho, Central Nevada, Eastern Nevada, and Western Utah (fig. 1, Appendix B). The regions were delineated on the basis of their distinctive montane EPA level IV ecoregions. These regions vary in size from 2.5 million ha to 8.1 million ha (table 1).

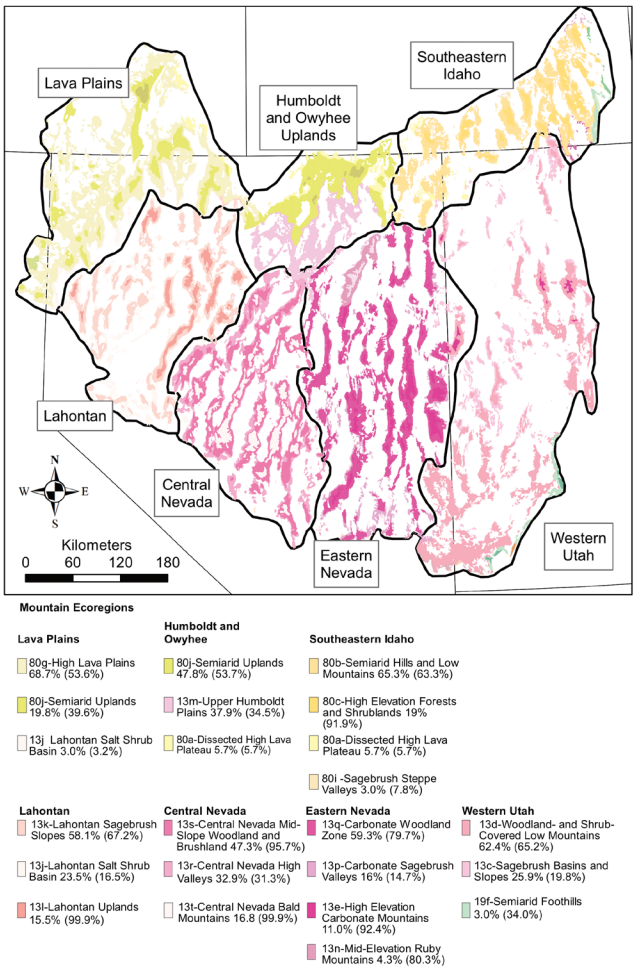

Figure 1—Map of the seven geographic regions. Regions were identified by having distinctive montane level IV ecoregions (USEPA 2013). The code and name of the level IV ecoregions encompassing 90 percent of the montane area in each region are listed, followed by the percentage of the ecoregion occupying the region and, in parentheses, the percentage of the ecoregion occurring within the mountains of each region.

Table 1—General characterization of the size, montane area, average elevation of the montane area (digital elevation model reference), and population (U.S. Census Bureau 2017) of the geographic regions.

Variable	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah
Area of region (ha)	4,795,440	4,183,715	2,456,022	3,425,263	4,215,448	6,625,356	8,064,334
Montane area (ha) (proportion of total area)	2,200,902 (45.9%)	1,426,729 (34.1%)	1,236,030 (50.3%)	1,270,689 (37.1%)	1,875,388 (44.5%)	2,258,610 (34.1%)	1,875,388 (23.3%)
Average elevation of montane area (m)	1,726	1,600	1,965	1,837	2,084	2,132	1,836
Population	31,827	75,622	55,817	166,481	17,452	71,435	788,742

METHODS FOR DELINEATING THE MOUNTAIN RANGES AND WATERSHEDS

We began by defining the boundaries of mountain ranges within each region. We developed models on the basis of three slope thresholds (4, 6, and 8°) combined with three neighborhood sizes (10, 20, and 30 km). We compared model results to existing hand-digitized data on mountain ranges within the Nevada portion of the area (Biological Resources Research Center 1997). We tested accuracy of our models against these hand-digitized data with 1,765 random points for each region (table 2). A 10-km-square neighborhood performed best across all regions and this neighborhood size was used to delineate mountain ranges. In contrast, we allowed slope to vary across regions (table 2).

Table 2—Slope parameters used to delineate mountain ranges for each geographic region and accuracy of mountain selection based on Nevada mountain ranges (Robert Elston, Jr., University of Nevada, Reno, personal communication, August 18, 2004).

Region	Slope (degrees)	Accuracy
Central Nevada	6	90.2%
Eastern Nevada	8	89.7%
Western Utah	8	82.9%
Lahontan	6	91.5%
Humboldt and Owyhee Uplands	4	84.1%
Lava Plains	4	81.5%
Southeastern Idaho	6	89.1%

Within the mountain ranges, we delineated watersheds, defined stream networks, and calculated watershed morphometrics with a 10-m-resolution digital elevation model (DEM; USGS 2017b) in ArcGIS 10.4.1 (ESRI 2015). We removed any streams in the National Hydrography Dataset Plus (NHD; USGS 2013) that originated outside of a given mountain range but that occurred within the range. We identified pour points at the bottom of each watershed within every mountain range. We then evaluated these pour points and manually adjusted the spatial position of the points to meet criteria determined by project geomorphologists. These criteria were based on topography, distribution of piedmont deposits, evidence of linear fault structures, shoreline features associated with pluvial lakes, and degree of channel incision. We drew watershed boundaries around all DEM (USGS 2017b) cells flowing into a given pour point. We removed any watershed smaller than 40 ha or that did not contain a perennial water source, as indicated by NHD (USGS 2013), from further analysis. We defined stream networks on the basis of flow accumulation with a threshold of 4,000 cells.

DATABASE OF THE CHARACTERISTICS OF THE INDIVIDUAL WATERSHEDS

Information in the Database and Intended Use

The database contains information on watershed topography, climate, geology, hydrology, vegetation, and common disturbances (Appendix A). Data are also available on animal species at risk within the Great Basin. The data are intended to aid in the assessment of geomorphic sensitivity and ecological resilience of Great Basin streams and riparian ecosystems (Chambers et al. in preparation) or any other assessment of watersheds and riparian ecosystems within the region. For example, basin morphometric parameters related to runoff can be used to assess the likelihood of a watershed generating high discharges and stream powers (Ritter et al. 2011). Mean annual precipitation and basin area are both in the database and are particularly useful in evaluating runoff and sediment mobility because increases in precipitation and basin area generally lead to an increase in peak flows. In addition, information is available on natural and human-caused disturbances that can provide insights into the ecological integrity of a watershed. Also available is information on the species' distributions or probability of habitat occurrence, which can indicate the potential of a watershed or particular reach type to support species at risk.

Accessing the Data

The database is available as an ArcGIS shapefile and as a streaming web service. The shapefile includes an associated layer file that determines the drawing properties when the file is added into ArcMap or ArcGIS Pro software and an associated metadata file in .xml format. Additionally, metadata are available in .docx format and include descriptions of attribute fields and data sources from which the values were derived. The streaming web service file format can be obtained in ArcMap, ArcGIS Pro, or open-source QGIS software, and symbols for attributes have already been delineated. The streaming web services can also be viewed with ESRI's built-in web viewer on ArcGIS online, which provides access to users outside the geographic information systems (GIS) community.

To access the data within ArcMap in the Catalog window click on "GIS servers," followed by "add GIS Server," and type in https://services3.arcgis.com/QCH1Le0vwRIyplqB/ArcGIS/rest/services.

Scroll down to the feature services named "GreatBasinWatersheds"; feature datasets other than "GreatBasinWatersheds" are not related to this project. Unfortunately, ArcMap does not provide options for filtering feature services within an institutional ArcGIS Online account.

The streaming web services can also be accessed in open-source QGIS. Open QGIS, go to "Layers," click on "Add Layer," and click on "Add ArcGIS Feature

Server Layer." Next, type in a name for your new feature server and copy in https://services3.arcgis.com/QCH1Le0vwRIyplqB/ArcGIS/rest/services.

ArcGIS Online provides a number of visualization options for non-GIS users. To launch the browser, type https://www.arcgis.com/home/search.html?q=greatbasinwatersheds into your web browser. All of the datasets tagged with "GreatBasinWatersheds" will be shown. Regions and mountain ranges have simple attributes. The database has the full suite of attributes and is probably going to be the most interesting to viewers. Watersheds display with a default color ramp based on the attribute "area_km" (area in square kilometers). Users may change colors and symbol size on the basis of attributes within the table. Click the "visualization" tab. Next, click the "change style" button (which has a red square, yellow circle, and blue triangle). Select one or more attributes on which the map will be based. Next, select one of the symbol types. "Counts and amounts color" allows the watershed polygons to be colored on the basis of a single quantitative attribute such as average elevation, watershed relief, or drainage density. "Counts and amounts size" will depict each watershed with a point symbol in which the size represents the quantity. Both symbol types provide interactive tools that allow the user to customize the color ramps and symbol sizes. A third useful symbol encompasses two quantities. Select the two attributes that you wish to display (e.g., relief and average elevation). This will render a bivariate map that allows users to explore relations between two variables (fig. 2). In this example, mountain ranges with both high relief (difference between maximum and minimum elevations) and high elevation are present in both Eastern and Central Nevada. Watersheds with high relief but low elevation are primarily in the northwestern part of the area in the Lava Plains region. Watersheds with low relief but high elevation are scattered throughout but are more common in Southeastern Idaho. Users who have a free ArcGIS Online account can also overlay their own data on the database.

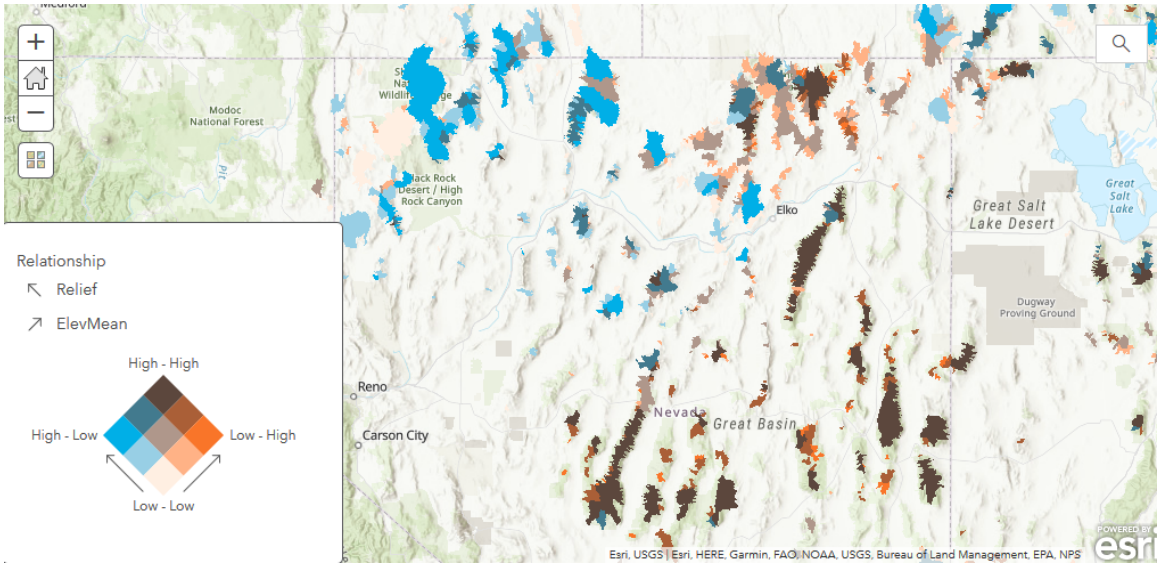

Figure 2—Illustration of the type of visualization available in ArcGIS Online for datasets tagged with "GreatBasinWatersheds." ArcGIS Online can be launched from the viewer's browser by typing in https://www.arcgis.com/home/search.html?q=greatbasinwatersheds. Instructions for using the tool are in text.

REGIONAL OVERVIEW OF WATERSHED CHARACTERISTICS

Description and Data

To understand the biophysical setting and ecosystem threats within the individual regions, we evaluated their geology, vegetation types, extent of cheatgrass (*Bromus tectorum*, a nonnative annual grass), fire history, and human population size. We characterized the geology of the mountain ranges within each region on the basis of the state geologic map compilation (Horton 2017). We evaluated vegetation types within the mountain ranges, including nonnative annual grasslands, with the existing vegetation types in LANDFIRE (USGS 2016). We evaluated the distribution of cheatgrass within the mountain ranges and regions on the basis of Boyte et al. (2016). We derived the land areas that burned from 1984 through 2015 from the Monitoring Trends in Burn Severity (USGS 2017a) dataset. We derived population sizes for each region from the 2010 census (U.S. Census Bureau 2017). We examined climate with data from the PRISM Climate Group (2017) and with climatic water deficit, a measure of aridity (Dobrowski et al. 2013).

To understand the geomorphic, hydrologic, and climatic characteristics of the watersheds, we used the identified watersheds and their associated stream networks. We based geomorphic variables on the derived watershed polygons and 10-m DEMs (USGS 2017b), determined hydrologic variables from NHD (USGS 2012), and derived stream networks from the DEM. We determined geologic variables from the state geologic map compilation (Horton 2017) and derived climatic variables from the PRISM Climate Group (2017) (Appendix A).

General Watershed Characteristics

The regions are fairly mountainous, with as much as 50.3 percent of the region classified as part of a mountain range in the Humboldt and Owyhee Uplands and as little as 23.3 percent in Western Utah (table 1) (USGS 2017b). The mountains in the Central and Eastern Nevada regions are the highest with an average elevation of 2,084 m and 2,132 m, respectively. In contrast, the Lava Plains and Lahontan regions have mountain ranges with lower elevations, averaging 1,726 m and 1,600 m, respectively. Population sizes in the area are fairly low, although the Western Utah region captures part of the Salt Lake City metropolitan area, which has a population of 788,742 according to the 2010 U.S. census (U.S. Census Bureau 2017). This contrasts sharply with Central Nevada, which has 17,452 people.

Geology

The montane geology of the region is a mixture of extrusive igneous rocks (45.6 percent, composed largely of rhyolite [25.5 percent] and basalt [10.2 percent]) and sedimentary rock (37.5 percent, composed largely of limestone [12.1 percent] and sandstone [8.5 percent]) with small percentages of metamorphic

(2.6 percent) and other rock (9.7 percent) types (fig. 3, table 3, Appendix C) (Horton 2017). Extrusive igneous rock dominates the western regions. The Lava Plains and Lahontan regions are a mixture of basalt and rhyolite (37.6 percent basalt and 30.0 percent rhyolite in the Lava Plains and 18.8 percent basalt and 17.8 percent rhyolite in the Lahontan), whereas rhyolite dominates the Humboldt and Owyhee Uplands (44.5 percent) and Central Nevada (50.8 percent). Sedimentary rock types are concentrated in the eastern regions. Limestone is the most common rock type in Southeastern Idaho (30.3 percent) and Eastern Nevada (23.9 percent), whereas Western Utah has similar amounts of limestone (18.9 percent) and sandstone (15.9 percent).

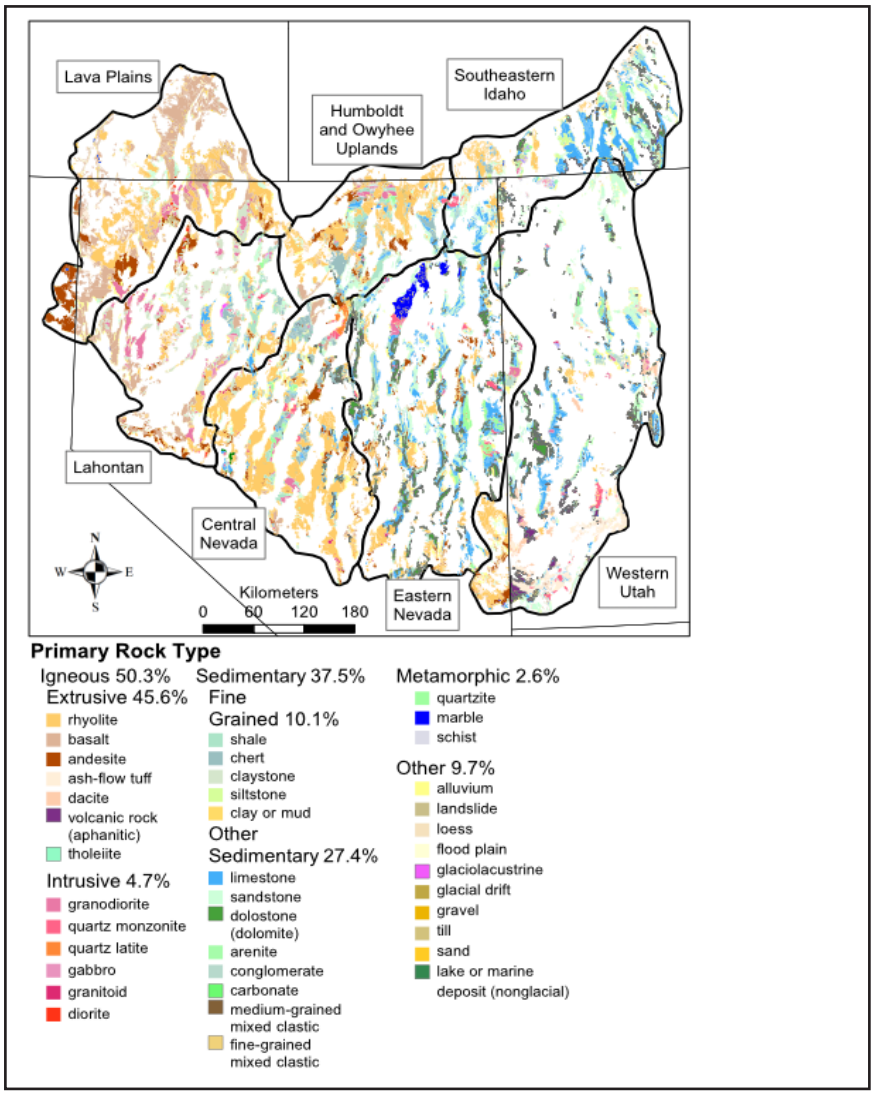

Figure 3—Map of the primary rock types (>5 percent of the montane area) in the mountains of the geographic regions. Rock types are categorized as igneous (extrusive and intrusive), sedimentary (fine grained and other), metamorphic, and other (dominant depositional types) (Horton 2017).

Table 3—The geologic rock types that make up more than 5 percent of the area within the mountains of the geographic regions, the area occupied in hectares, and the percentage of each region occupied in parentheses. Data are from the state geologic map compilation (Horton 2017).

Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Basalt 827,298 (37.6%)	Basalt 267,768 (18.8%)	Rhyolite 550,016 (44.5%)	Limestone 385,624 (30.3%)	Rhyolite 952,198 (50.8%)	Limestone 538,254 (23.9%)	Limestone 354,383 (18.9%)	Rhyolite 3,090,885 (25.5%)
Rhyolite 659,877 (30.0%)	Rhyolite 253,628 (17.8%)	Chert 146,655 (11.9%)	Sandstone 212,945 (16.8%)	Chert 173,757 (9.3%)	Dolostone (dolomite) 337,642 (15.0%)	Sandstone 298,717 (15.9%)	Limestone 1,467,066 (12.1%)
Andesite 229,862 (10.4%)	Claystone 205,413 (14.4%)	Sandstone 123,057 (10.0%)	Rhyolite 182,314 (14.3%)	Alluvium 162,010 (8.6%)	Rhyolite 185,543 (13.7%)	Alluvium 208,055 (11.1%)	Basalt 1,036,232 (10.2%)
	Granodiorite 130,864 (9.2%)	Andesite 93,987 (7.6%)	Alluvium 95,455 (7.5%)	Andesite 112,290 (6.0%)	Alluvium 22,038 (9.9%)	Ash-flow tuff 187,799 (10.0%)	Sandstone 1,036,232 (8.5%)
	Alluvium 124,575 (8.7%)	Shale 82,774 (6.7%)			Sandstone 219,561 (9.8%)	Rhyolite 185,543 (9.9%)	Alluvium 926,683 (7.6%)
	Andesite 99,658 (7.0%)	Limestone 71,955 (5.8%)			Shale 184,333 (8.2%)	Dacite 132,733 (7.1%)	Andesite 665,147 (5.5%)
	Shale 91,850 (6.4%)					Dolostone (dolomite) 120,388 (6.4 %)	

Climate

The montane climate in the geographic regions is heavily influenced by elevation. The higher elevation and more mountainous regions are wetter and cooler (fig. 4a,b; table 4) (PRISM Climate Group 2017). In general, the northeastern part of the area also tends to be cooler and wetter. The wettest region is Southeastern Idaho, where the 30-year normal average annual montane precipitation is 496 mm. The coolest region is the Humboldt and Owyhee Uplands, where the 30-year normal average annual montane temperature is 6.4 °C. This region is also the highest, with a mean montane elevation of 1,965 m (table 1), and the most montane area (50.3 percent). The warmest and driest region is the Lahontan, with an average annual temperature of 9.8 °C and annual precipitation of 283 mm. This region also has the lowest mountains (1,600 m). Precipitation arrives primarily in winter, although the southeastern montane portion of the area can receive as much as 33.1 percent of the annual precipitation in summer (fig. 4d). Overall aridity,

measured as water deficit, is generally higher in the southern portion of the area and lowest in the northeast (fig. 4c) (Dobrowski et al. 2013). The driest region is the Lahontan (average water deficit of 1,005 mm), which reflects its low mountains and higher temperatures.

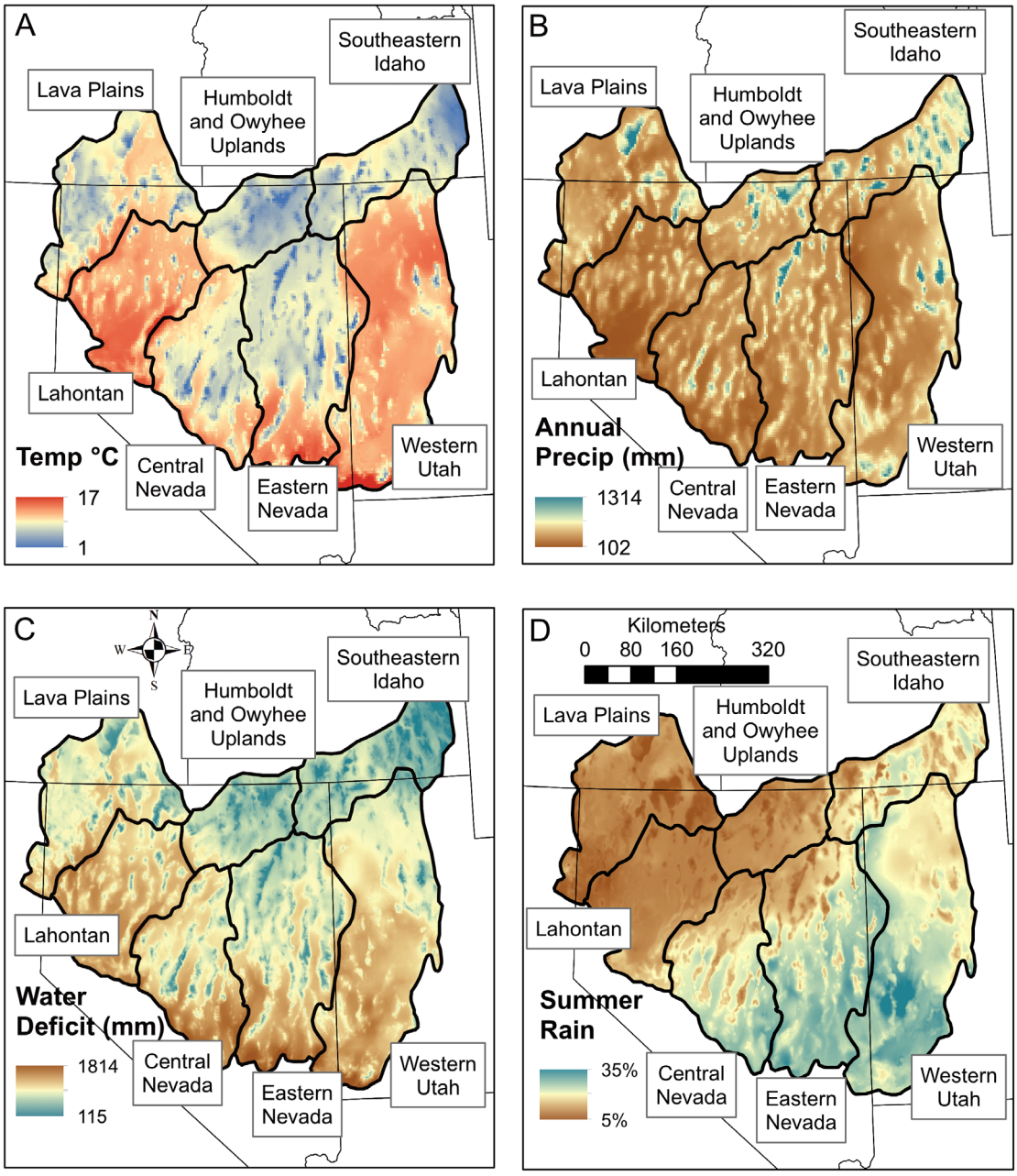

Figure 4—Maps of climatic conditions in the geographic regions. A) 30-year normal average annual temperature (PRISM Climate Group 2017); B) 30-year normal annual precipitation (mm) (PRISM Climate Group 2017); C) water deficit (mm) (Dobrowski et al. 2013); D) percentage of precipitation (mm) that occurs in June, July, and August (monsoonality) (PRISM Climate Group 2017).

Table 4—Temperature, precipitation, average water deficit, and percentage summer precipitation (precipitation arriving in June, July, and August) for the geographic regions derived from 30-year normals based on PRISM Climate Group (2017). Water deficit was derived from Dobrowski et al. (2013).

Variable	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah
Average annual temperature (°C)	8.6	9.8	6.4	6.8	8.0	7.4	9.4
Average annual precipitation (mm)	377	283	428	496	320	383	420
Average water deficit (mm)	809	1,005	610	488	923	796	964
Average summer precipitation as a proportion of yearly total	9.3%	13.4%	10.6%	14.7%	16.7%	18.3%	21.8%

Geomorphic Characteristics

Montane perennial watersheds are more common in the northern regions, with 112 watersheds per million hectares in the Humboldt and Owyhee Uplands region and 12 watersheds per million hectares in the Western Utah region (fig. 5). Watersheds tend to be largest in the northwestern portion of the area; watersheds in the Lava Plains region average 3,882 ha (table 5). The highest watersheds occur in the southern part of the area. Eastern Nevada has the highest watersheds, with an average relief of 1,114 m and mean maximum elevation of 3,088 m. The overall watershed shape tends to be broad and flat in the northwestern portion of the area, with tablelands in the uplands and large valleys in the bottoms. Watersheds in the southern portion of the area tend to be narrow and steep, with narrow valley bottoms and more rugged hillslopes. These watershed geomorphic patterns coincide with watersheds dominated by extrusive igneous rock in the northwestern regions and watersheds dominated by sedimentary rock in the eastern regions (table 6).

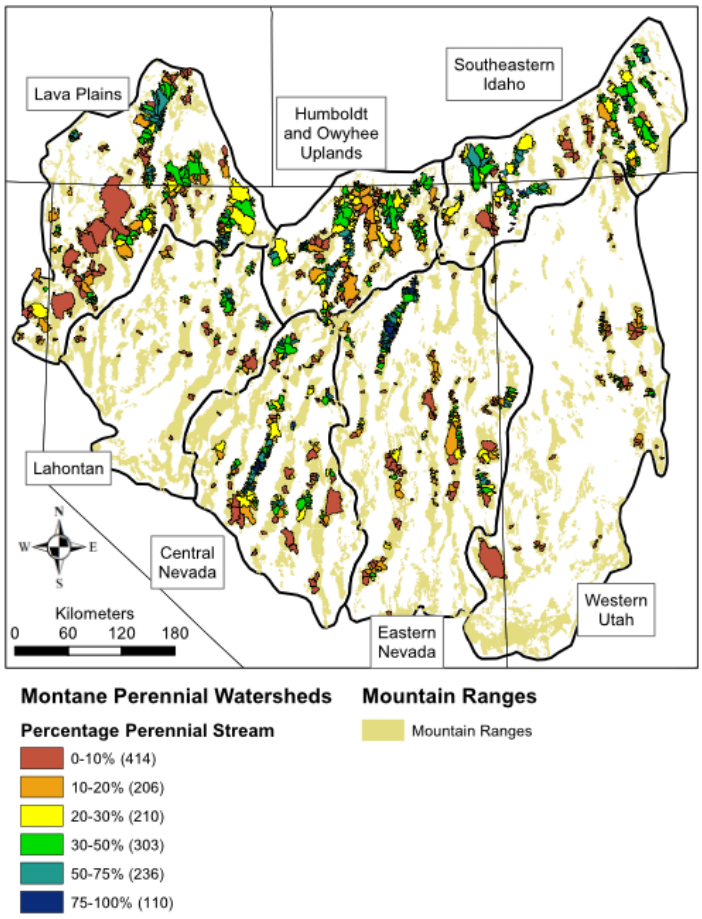

Figure 5—Map of the mountain ranges within the geographic regions, the montane watersheds within the mountain ranges with perennial stream systems, and the percentages of the stream system within the watersheds that are considered perennial with the number of watersheds in each level in parentheses (USGS 2013).

Table 5—A mean count of the perennial montane watersheds by geographic region, and means of the variables used to characterize the watersheds within the regions.

Variable	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah
Mean number of watersheds	309	85	274	263	182	265	101
Watershed size (ha)	3,882	1,686	2,729	2,637	2,839	2,033	2,147
Mean valley bottom width (m)	68.4	68.0	60.0	58.4	62.7	57.2	58.5
Mean proportion of tableland	17%	5%	10%	8%	5%	4%	4%
Mean proportion of stream classified as perennial	25%	24%	31%	35%	35%	34%	23%
Mean annual precipitation (mm)	459	473	454	465	478	463	500
Mean minimum elevation (m)	1,474	1,519	1,795	1,668	1,961	1,974	1,762
Mean relief (m)	847	864	664	738	1,019	1,114	911
Mean maximum elevation (m)	2,321	2,384	2,459	2,406	2,981	3,088	2,673
Mean relief ratio	0.11	0.18	0.087	0.12	0.14	0.19	0.16
Mean total length (m)	50,206	21,158	35,352	32,276	36,503	25,317	28,767

Table 6—Mean proportion of rock types within the watersheds by geographic region derived from the state geologic map compilation (Horton 2017).

Variable	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah
Volcanic rock	74.4%	30.1%	52.7%	12.8%	48.5%	13.0%	14.0%
Sedimentary rock	3.2%	29.3%	31.6%	64.4%	27.0%	57.6%	63.4%
Alluvial rock	4.6%	3.1%	0.8%	5.9%	4.0%	7.2%	13.8%
Fine-grained sedimentary rock	7.6%	23.9%	6.4%	6.4%	11.4%	6.3%	1.6%

Existing Vegetation

Existing vegetation in the montane areas is a mixture of piñon-juniper woodlands, sagebrush shrublands, and nonnative annual grasslands (fig. 6, Appendix D) (USGS 2016). The piñon-juniper woodlands are concentrated in the southern regions and dominated by Great Basin piñon-juniper woodland (24.2 percent of the Great Basin geomorphic region). Sagebrush shrublands are the most common native vegetation types in the four northern regions (Lava Plains, Lahontan, Humboldt and Owyhee Uplands, and Southeastern Idaho). Nonnative upland vegetation-annual grassland is most common in the northwestern regions (Lava Plains, Lahontan, and Humboldt and Owyhee Uplands). In fact, it is the most prevalent vegetation type in the Humboldt and Owyhee Uplands.

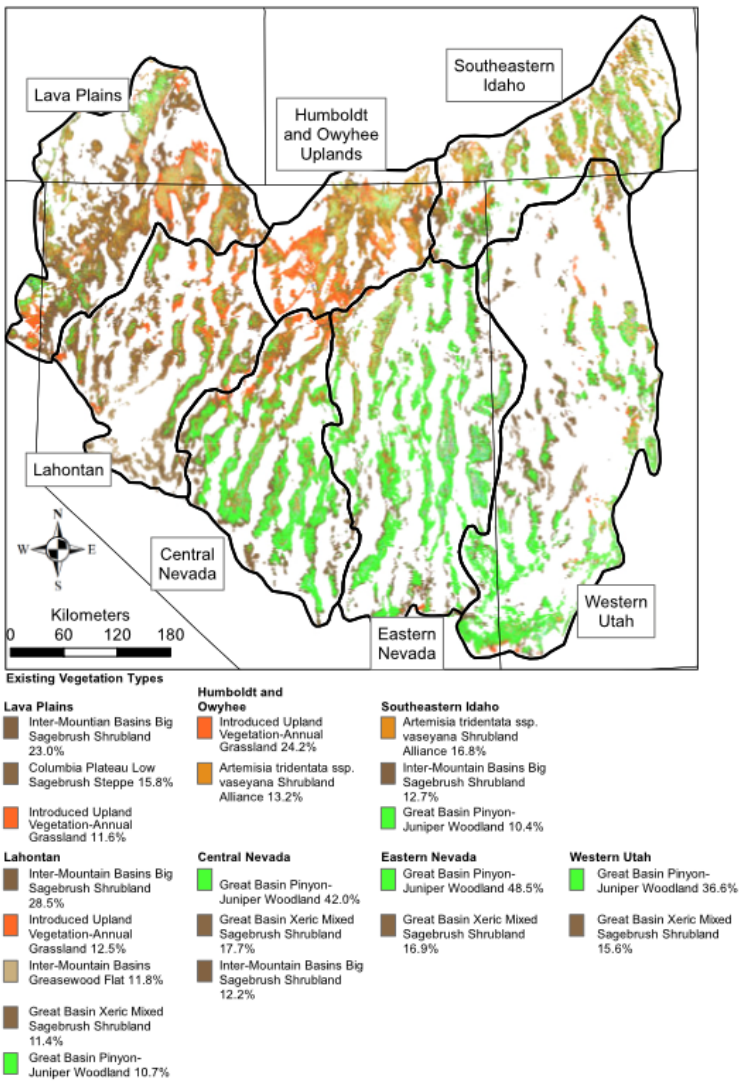

Figure 6—Map of the LANDFIRE Existing Vegetation Types (USGS 2016) within the mountain ranges of the geographic regions that occupy more than 10 percent of the montane area and the percentage of the montane region that they occupy.

Fire

Fires in the area have been concentrated in the north, particularly the Humboldt and Owyhee Uplands, where 39.4 percent of the region burned from 1984 through 2015 (fig. 7, table 7) (USGS 2017a). Seventy-five percent of the fires burned in July and August in the years 1984 through 2015. These northern fires tended to be larger than in other regions; in the Humboldt and Owyhee Uplands they average 8,172 ha compared to 2,849 ha in the Eastern Nevada region. The fires in the north were also more frequent than in other regions. The Humboldt and Owyhee Uplands averaged 2.6 fires per year per million hectares compared to 0.75 fires per year per million hectares in Eastern Nevada. The larger and more-frequent fires were associated with a decrease in summer precipitation despite typically higher annual precipitation. They were also associated with an increase in the area dominated by cheatgrass (table 7, fig. 6) (Boyte et al. 2016; USGS 2016). In general, the proportion of area burned did not differ between the montane areas within each region and the Great Basin region overall, so we present fire statistics for the entire region.

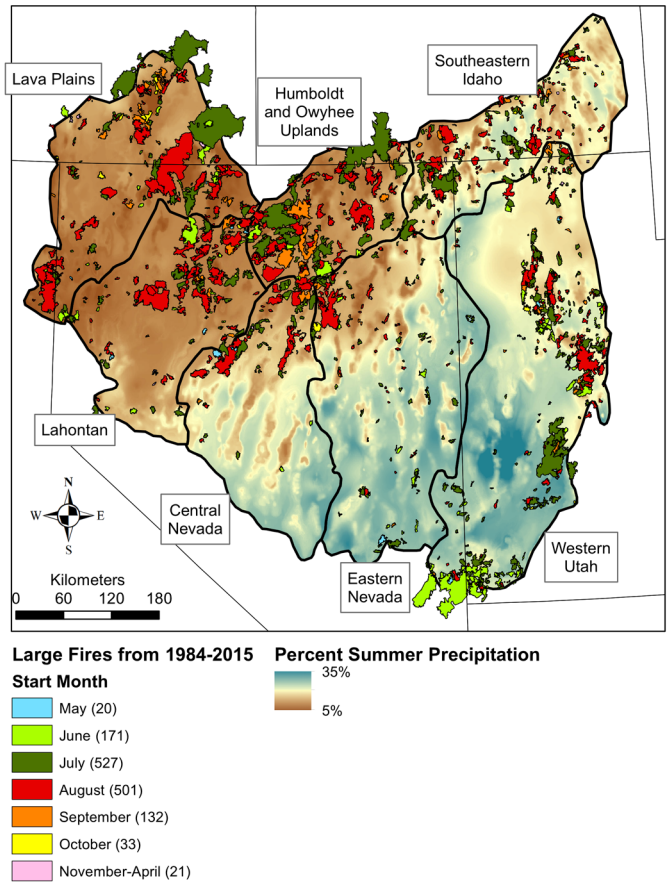

Figure 7—Map of the large fires (>300 ha) from 1984 through 2016 (USGS 2017a) within the geographic regions by month with the number of fires that occurred during a month in parentheses, and the percentage of precipitation (mm) that occurs in June, July, and August.

Table 7—Characterization of fire within the geographic regions based on the perimeters of large fires from 1984 through 2015 derived from Monitoring Trends in Burn Severity data (USGS 2017a).

Variable	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah
Fires per year, scaled	3.8	3.6	6.3	5.3	2.1	1.8	3.9
Fire size (ha)	7,106	5,533	8,172	3,058	5,667	2,849	3,843
Fire season	June 20–Sept. 4	June 28–Aug. 23	July 16–Aug. 23	July 8–Sept. 2	July 4–Aug. 12	July 8–Aug. 14	June 19–Sept. 8
Total area burned per year (ha) (proportion of total)	38,405 (0.8%)	29,616 (0.7%)	42,846 (1.7%)	21,573 (0.6%)	17,701 (0.4%)	11,188 (0.2%)	42,679 (0.5%)
Total number of fires burned	229	167	176	214	79	144	396
Total area burned within region (ha) (proportion of total)	1,011,087 (21.1%)	607,642 (14.5%)	967,723 (39.4%)	533,237 (15.6%)	327,780 (7.8%)	295,558 (4.5%)	999,784 (12.4%)
Total area burned in mountains (ha)(proportion of total)	707,921 (32.2%)	304,621 (21.3%)	570,682 (46.2%)	258,420 (7.5%)	201,451 (4.8%)	165,624 (7.3%)	427,242 (22.8%)
Introduced annual grass existing vegetation type in mountains (ha)(proportion of total)	254,911 (11.6%)	178,123 (12.5%)	293,889 (24.2%)	77,621 (6.1%)	87,434 (4.7%)	44,349 (2.0%)	131,759 (7.1%)

Fires have burned more frequently and covered larger extents in the northwestern watersheds (table 8). In the Humboldt and Owyhee Uplands, 206 watersheds (75.2 percent) have burned. These watersheds have burned an average of 1.5 times, and a greater number of the individual watersheds burned than in any other region except the Lava Plains. In the Lahontan region, an average of 32.5 percent of each watershed has burned. In contrast, in the southeastern regions, fewer watersheds have burned. In Eastern Nevada, 85 watersheds (32.1 percent) burned. The watersheds in Eastern Nevada and Central Nevada have burned less often than in other regions, and except for Southeastern Idaho, less of each watershed has burned.

Table 8—The number of burned watersheds, proportion of watersheds burned, number of times a watershed burned from 1984 through 2015, and average proportion of a watershed that burned from 1984 through 2015, derived from Monitoring Trends in Burn Severity data (USGS 2017a).

Variable	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah
Number of watersheds burned	225	52	206	114	39	85	72
Proportion of watersheds burned	72.9%	61.2%	75.2%	43.3%	21.4%	32.1%	71.3%
Mean times a watershed burned	1.41	1.22	1.48	0.70	0.25	0.38	1.18
Mean proportion of watershed area burned	30.9%	32.5%	30.3%	20.0%	28.1%	21.1%	31.1%

CONCLUSIONS

A working group of research and management partners built on long-term research to develop a resilience-based approach to restoration and conservation of the rare and valuable riparian and meadow ecosystems of the Great Basin. The mountain ranges and watersheds were delineated and data on their characteristics were collected and compiled in a readily accessible database. Managers and other stakeholders can use these data to assess the current biophysical and ecological conditions of the watersheds and to better understand the potential responses of riparian and meadow ecosystems to disturbance and management actions. A sound understanding of the geomorphic sensitivity and ecological resilience of these ecosystems can assist managers in prioritizing areas for conservation and restoration actions and determining the best management approaches.

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Appendix A. Watershed-Scale Data Available for the Great Basin Geographic Regions

This appendix provides the descriptions and data sources of the watershed characteristics in the database for the Great Basin geographic regions (table A.1).

Table A.1—The characteristics, units, descriptions, and data sources for the topographic, climatic, geologic, hydrologic, vegetation, disturbance, and species data in the database for the Great Basin geographic regions (Dilts et al. 2020). The data are available at: https://doi.org/10.2737/RDS-2020-0059. The data can also be downloaded directly in ArcGIS Pro, ArcGIS Desktop, or QGIS at: https://www.arcgis.com/home/search.html?q=greatbasinwatersheds.

Characteristic	Units	Description	Source
Topography			
Watershed area	m^2	Total watershed area	Engelhardt (2009); National Elevation Dataset (USGS 2017)
Mean elevation	m	Mean elevation of the watershed	National Elevation Dataset (USGS 2017)
Ruggedness	-	(Maximum elevation – minimum elevation) × drainage density	Engelhardt (2009); National Elevation Dataset (USGS 2017)
Watershed length	m	Length of the watershed along the main channel	Engelhardt (2009); National Elevation Dataset (USGS 2017)
Relief ratio	-	(Maximum elevation – minimum elevation)/watershed length	Engelhardt (2009); National Elevation Dataset (USGS 2017)
Relative stream power	m^2	Estimate of stream power from watershed area × relief ratio	Engelhardt (2009); National Elevation Dataset (USGS 2017)
Drainage density	km/km^2	Total stream length/watershed area	Engelhardt (2009); National Elevation Dataset (USGS 2017)
Hypsometric integral	%	Percentage area under a dimensionless curve produced as the ratio of h/H and a/A, where h = elevation, H = watershed relief, a = planimetric area above h, and A = planimetric watershed area	Engelhardt (2009); National Elevation Dataset (USGS 2017)
Percent valley bottom	%	Percentage of the watershed mapped as valley bottom based on a 15-m height above nearest drainage	Knight (2019); National Elevation Dataset (USGS 2017); Nobre et al. (2011)
Percent tablelands	%	Percentage of the watershed with slope of less than 5° outside of valley bottoms	National Elevation Dataset (USGS 2017)
Local vector ruggedness	radians/m	Average terrain ruggedness based on the methodology of Sappington et al. (2007) with modifications in which the underlying smooth topography is removed	National Elevation Dataset (USGS 2017); Sappington et al. (2007)

Appendix A (cont.)

Characteristic	Units	Description	Source
Climate			
Annual precipitation	mm	30-year mean annual precipitation	Daly et al. (1994); PRISM Climate Group (2017)
Monsoonality	%	Proportion of precipitation that falls during monsoon season: 30-year mean July to September precipitation/annual precipitation	PRISM Climate Group (2017); Romme et al. (2009)
Snow fraction	%	Proportion of precipitation that is snow: 30-year mean snow precipitation/annual precipitation	Dilts et al. (2015); PRISM Climate Group (2017)
Geology			
Percent carbonate	%	Proportion of watershed area with carbonate bedrock	Horton (2017)
Percent sedimentary	%	Proportion of watershed area with sedimentary bedrock	Horton (2017)
Percent intrusive igneousa	%	Proportion of watershed area with intrusive bedrock	Horton (2017)
Percent volcanica	%	Proportion of watershed area with volcanic bedrock	Horton (2017)
Hydrology			
Percent perenniala	%	Perennial stream length/total stream length	National Hydrography Dataset Plus (USGS 2012)
Perennial stream connectivity	count	Number of unique perennial stream segments within the watershed	National Hydrography Dataset Plus (USGS 2012)
Average perennial length	m	Average length of perennial stream segments within the watershed	National Hydrography Dataset Plus (USGS 2012)
Vegetation			
Annual herbaceous cover	%	Watershed mean of pixel percent cover of provisional herbaceous vegetation	Xian et al. (2015)
Tree cover	%	Watershed mean of pixel percent tree canopy cover	Homer et al. (2015)
Shrub cover	%	Watershed mean of pixel percent shrub cover	Xian et al. (2015)
Disturbance			
Percent burned	%	Cumulative proportional area of watershed burned between 1984 and 2017	Eidenshink et al. (2007); USGS (2000, 2005)
Road density	km/km^2	Density of roads within the watershed	U.S. Census Bureau (2017)
Percent private land	%	Percentage of private land within the watershed	BLM (2015)
Number of dams/ diversions	count	Count of the number of dams and diversions within the watershed	National Hydrography Dataset Plus (USGS 2012)

Characteristic	Units	Description	Source
Species			
Greater sage-grouse	APOC	Average probability of occurrence (APOC) of Greater sage-grouse (*Centrocercus urophasianus*)	Coates et al. (2016); Doherty et al. (2011)
Pygmy rabbit	APOC	Average probability of occurrence of pygmy rabbit (*Brachylagus idahoensis*)	Cushman et al. (2016)
Mule deer	APOC	Average probability of occurrence of mule deer (*Odocoileus hemionus*)	Cushman et al. (2016)
Pronghorn	APOC	Average probability of occurrence of pronghorn (*Antilocapra americana*)	Cushman et al. (2016)
Brewer's sparrow	APOC	Average probability of occurrence of Brewer's sparrow (*Spizella breweri*)	Cushman et al. (2016)
Gray flycatcher	APOC	Average probability of occurrence of gray flycatcher (*Empidonax wrightii*)	Cushman et al. (2016)
Juniper titmouse	APOC	Average probability of occurrence of juniper titmouse (*Baeolophus ridgwayi*)	Cushman et al. (2016)
Sage sparrow	APOC	Average probability of occurrence of sage sparrow (*Artemisiospiza nevadensis*)	Cushman et al. (2016)
Vesper sparrow	APOC	Average probability of occurrence of vesper sparrow (*Poocetes gramineus*)	Cushman et al. (2016)
Pinyon jay	APOC	Average probability of occurrence of pinyon jay (*Gymnorhinus cyanocephalus*)	Cushman et al. (2016)
Native cutthroat trout	m	Length of stream suitable for native cutthroat trouts, including Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) in the watershed	Isaak et al. (2017)
Monarch butterfly	APOC	Average probability of occurrence of breeding monarch butterflies (*Danaus plexippus*) (not including tropical milkweed)	Dilts et al. (2019)

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Appendix B. Ecoregion Data for the Great Basin Geographic Regions

This appendix provides the area and montane extent of level IV ecoregions within the seven geographic regions of the Great Basin (table B.1).

Table B.1—The area that the level IV ecoregions occupy within the geographic regions of the Great Basin, the proportion of the mountains within the geographic region that are identified as that ecoregion, and the proportion of the ecoregion's area that is contained within the mountains of the specified geographic region. Data are from USEPA (2013).

Level IV ecoregion	Area (ha)	Proportion of region's mountains	Proportion of ecoregion within the mountains of the region
Lava Plains			
High Lava Plains	1,512,205	68.7%	53.6%
Semiarid Uplands	436,022	19.8%	39.6%
Lahontan Salt Shrub Basin	65,003	3.0%	3.2%
Dissected High Lava Plateau	55,738	2.5%	4.4%
Salt Shrub Valleys	29,633	1.3%	10.6%
Upper Lahontan Basin	28,169	1.3%	2.4%
Partly Forested Mountains	26,689	1.2%	19.2%
Modoc/Lassen Juniper-Shrub Hills and Mountains	20,272	0.9%	81.3%
Lahontan Sagebrush Slopes	13,092	0.6%	1.1%
Pluvial Lake Basins	10,738	0.5%	3.8%
High Desert Wetlands	1,654	0.1%	2.0%
Lahontan and Tonopah Playas	947	0.0%	0.1%
Sierra Nevada-Influenced Semiarid Hills and Basins	681	0.0%	4.9%
Fremont Pine/Fir Forest	51	0.0%	5.2%
Lahontan			
Lahontan Sagebrush Slopes	828,586	58.1%	67.2%
Lahontan Salt Shrub Basin	335,272	23.5%	16.5%
Lahontan Uplands	221,213	15.5%	99.9%
Upper Lahontan Basin	36,277	2.5%	3.0%
Lahontan and Tonopah Playas	3,635	0.3%	0.6%
High Lava Plains	726	0.1%	0.0%
Humboldt and Owyhee Uplands			
Semiarid Uplands	591,222	47.8%	53.7%
Upper Humboldt Plains	468,276	37.9%	34.5%

Appendix B (cont.)

Level IV ecoregion	Area (ha)	Proportion of region's mountains	Proportion of ecoregion within the mountains of the region
Dissected High Lava Plateau	114,046	9.2%	8.9%
High Lava Plains	28,976	2.3%	1.0%
Partly Forested Mountains	27,191	2.2%	19.5%
Lahontan Sagebrush Slopes	3,694	0.3%	0.3%
Central Nevada High Valleys	2,028	0.2%	0.1%
High Desert Wetlands	1,142	0.1%	1.4%
Upper Lahontan Basin	117	0.0%	0.0%
Southeastern Idaho			
Semiarid Hills and Low Mountains	830,110	65.3%	63.3%
High Elevation Forests and Shrublands	241,742	19.0%	91.9%
Dissected High Lava Plateau	72,332	5.7%	5.7%
Sagebrush Steppe Valleys	37,995	3.0%	7.8%
Semiarid Foothills	33,372	2.6%	20.4%
Malad and Cache Valleys	15,036	1.2%	7.9%
Partly Forested Mountains	12,972	1.0%	9.3%
Wasatch Montane Zone	9,780	0.8%	48.1%
Sagebrush Basins and Slopes	6,146	0.5%	0.2%
Dissected Plateaus and Teton Basin	4,893	0.4%	10.4%
Saltbush-Dominated Valleys	1,771	0.1%	1.4%
Magic Valley	510	0.0%	0.7%
Eastern Snake River Basalt Plains	464	0.0%	0.8%
High Elevation Valleys	435	0.0%	0.8%
Carbonate Sagebrush Valleys	174	0.0%	0.0%
Shadscale-Dominated Saline Basins	139	0.0%	0.0%
Upper Snake River Plain	73	0.0%	0.1%
Central Nevada			
Central Nevada Mid-Slope Woodland and Brushland	887,699	47.3%	95.7%
Central Nevada High Valleys	617,324	32.9%	31.3%
Central Nevada Bald Mountains	315,890	16.8%	99.9%
Lahontan Salt Shrub Basin	22,544	1.2%	1.1%

Level IV ecoregion	Area (ha)	Proportion of region's mountains	Proportion of ecoregion within the mountains of the region
Upper Humboldt Plains	17,504	0.9%	1.3%
Tonopah Basin	10,479	0.6%	1.2%
Lahontan Sagebrush Slopes	2,305	0.1%	0.2%
Carbonate Sagebrush Valleys	1,745	0.1%	0.1%
Upper Lahontan Basin	925	0.0%	0.1%
Tonopah Sagebrush Foothills	81	0.0%	19.3%
Lahontan and Tonopah Playas	17	0.0%	0.0%
Eastern Nevada			
Carbonate Woodland Zone	1,340,001	59.3%	79.7%
Carbonate Sagebrush Valleys	360,493	16.0%	14.7%
High Elevation Carbonate Mountains	248,590	11.0%	92.4%
Mid-Elevation Ruby Mountains	97,116	4.3%	80.3%
Upper Humboldt Plains	62,661	2.8%	4.6%
Woodland- and Shrub-Covered Low Mountains	42,861	1.9%	2.4%
Sagebrush Basins and Slopes	37,773	1.7%	1.5%
High Elevation Ruby Mountains	31,969	1.4%	100.0%
Shadscale-Dominated Saline Basins	15,588	0.7%	0.5%
Tonopah Basin	7,637	0.3%	0.9%
Central Nevada High Valleys	6,047	0.3%	0.3%
Wetlands	309	0.0%	0.2%
Dissected High Lava Plateau	128	0.0%	0.0%
Tonopah Sagebrush Foothills	124	0.0%	29.7%
Salt Deserts	13	0.0%	0.0%
Western Utah			
Woodland- and Shrub-Covered Low Mountains	1,172,271	62.4%	65.2%
Sagebrush Basins and Slopes	487,628	25.9%	19.8%
Semiarid Foothills	55,667	3.0%	34.0%
Semiarid Hills and Low Mountains	38,914	2.1%	3.0%

Appendix B (cont.)

Level IV ecoregion	Area (ha)	Proportion of region's mountains	Proportion of ecoregion within the mountains of the region
Shadscale-Dominated Saline Basins	24,803	1.3%	0.8%
Eastern Mojave Low Ranges and Arid Footslopes	21,117	1.1%	46.5%
High Elevation Carbonate Mountains	20,224	1.1%	7.5%
High Plateaus	14,630	0.8%	40.2%
Carbonate Sagebrush Valleys	14,328	0.8%	0.6%
High Elevation Forests and Shrublands	7,521	0.4%	2.9%
Eastern Mojave Basins	5,406	0.3%	10.6%
Escarpments	4,431	0.2%	29.2%
Salt Deserts	3,501	0.2%	0.2%
Malad and Cache Valleys	1,856	0.1%	1.0%
Eastern Mojave Mountain Woodland and Shrubland	1,700	0.1%	24.9%
Sagebrush Steppe Valleys	1,528	0.1%	0.3%
Moist Wasatch Front Footslopes	560	0.0%	1.2%
Wetlands	22	0.0%	0.0%

REFERENCE

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Appendix C. Geology of the Mountains of the Great Basin Geographic Regions

This appendix presents the area and percentage of the primary rock types in the mountains of each Great Basin geographic region and all regions combined (table C.1).

Table C.1—Montane geology of the seven geographic regions in the Great Basin and all regions combined, with percentages of each region or the entire area in parentheses. Data are from the state geologic map compilation (Horton 2017).

Primary rock type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Igneous	1,880,031 ha (85.4%)	817,641 ha (57.4%)	739,577 ha (59.8%)	220,741 ha (17.4%)	1,242,869 ha (66.3%)	500,641 ha (22.2%)	699,093 ha (37.2%)	6,100,592 ha (50.3%)
Extrusive	1,794,355 ha (81.5%)	638,734 ha (44.8%)	701,719 ha (56.8%)	202,597 ha (15.9%)	1,139,726 ha (60.8%)	416,305 ha (18.5%)	640,078 ha (34.1%)	5,533,514 ha (45.6%)
Rhyolite	659,877 ha (30.0%)	253,628 ha (17.8%)	550,016 ha (44.5%)	182,314 ha (14.3%)	952,198 ha (50.8%)	307,309 ha (13.7%)	185,543 ha (9.9%)	3,090,885 ha (25.5%)
Basalt	827,298 ha (37.6%)	267,768 ha (18.8%)	35,130 ha (2.8%)	3,196 ha (0.3%)	73,390 ha (3.9%)	7,200 ha (0.3%)	27,750 ha (1.5%)	1,241,731 ha (10.2%)
Andesite	229,862 ha (10.4%)	99,658 ha (7.0%)	93,987 ha (7.6%)	63 ha (0.0%)	112,290 ha (6.0%)	94,119 ha (4.2%)	35,168 ha (1.9%)	665,147 ha (5.5%)
Ash-flow tuff	75,775 ha (3.4%)	11,363 ha (0.8%)	22,586 ha (1.8%)	—	—	525 ha (0.0%)	187,799 ha (10.0%)	298,048 ha (2.5%)
Dacite	—	—	—	—	—	3,682 ha (0.2%)	132,733 ha (7.1%)	136,414 ha (1.1%)
Volcanic rock (aphanitic)	—	—	—	—	—	—	71,085 ha (3.8%)	71,085 ha (0.6%)
Tholeiite	—	—	—	16,455 ha (1.3%)	—	—	—	16,455 ha (0.1%)
Metavolcanic rock	—	6,317 ha (0.4%)	—	—	—	—	—	6,317 ha (0.1%)
Volcanic breccia (agglomerate)	—	—	—	—	1,848 ha (0.1%)	3,471 ha (0.2%)	—	5,319 ha (0.0%)
Tuff	1,541 ha (0.1%)	—	—	570 ha (0.0%)	—	—	—	2,110 ha (0.0%)
Volcanic ash	2 ha (0.0%)	—	—	—	—	—	—	2 ha (0.0%)

Appendix C (cont.)

Primary rock type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Intrusive	85,677 ha (3.9%)	178,906 ha (12.6%)	37,858 ha (3.1%)	18,144 ha (1.4%)	103,143 ha (5.5%)	84,336 ha (3.7%)	59,015 ha (3.1%)	567,078 ha (4.7%)
Granodiorite	77,827 ha (3.5%)	130,864 ha (9.2%)	28,621 ha (2.3%)	2,636 ha (0.2%)	34,103 ha (1.8%)	41,485 ha (1.8%)	23,091 ha (1.2%)	338,626 ha (2.8%)
Quartz monzonite	—	12,340 ha (0.9%)	4,404 ha (0.4%)	15,508 ha (1.2%)	32,480 ha (1.7%)	38,101 ha (1.7%)	34,121 ha (1.8%)	136,954 ha (1.1%)
Quartz latite	—	—	3,301 ha (0.3%)	—	24,296 ha (1.3%)	—	—	27,597 ha (0.2%)
Gabbro	—	20,944 ha (1.5%)	—	—	2,095 ha (0.1%)	—	—	23,038 ha (0.2%)
Granitoid	1,246 ha (0.1%)	1,461 ha (0.1%)	52 ha (0.0%)	—	8,490 ha (0.5%)	4,531 ha (0.2%)	1,612 ha (0.1%)	17,392 ha (0.1%)
Diorite	5,456 ha (0.2%)	5,182 ha (0.4%)	1,480 ha (0.1%)	—	1,679 ha (0.1%)	219 ha (0.0%)	190 ha (0.0%)	14,207 ha (0.1%)
Granite	165 ha (0.0%)	8,116 ha (0.6%)	—	—	—	—	—	8,281 ha (0.1%)
Quartz diorite	983 ha (0.0%)	—	—	—	—	—	—	983 ha (0.0%)
Migmatite	—	—	—	—	—	—	—	—
Sedimentary	136,173 ha (6.2%)	473,067 ha (33.2%)	431,554 ha (34.9%)	819,437 ha (64.5%)	427,088 ha (22.8%)	1,310,165 ha (58.2%)	953,837 ha (50.7%)	4,551,322 ha (37.5%)
Fine grained	65,320 ha (3.0%)	342,002 ha (24.0%)	229,429 ha (18.6%)	99,282 ha (7.8%)	268,553 ha (14.3%)	188,216 ha (8.4%)	28,407 ha (1.5%)	1,221,211 ha (10.1%)
Shale	48 ha (0.0%)	91,850 ha (6.4%)	82,774 ha (6.7%)	40,660 ha (3.2%)	78,979 ha (4.2%)	184,333 ha (8.2%)	9,877 ha (0.5%)	488,520 ha (4.0%)
Chert	—	44,740 ha (3.1%)	146,655 ha (11.9%)	18,675 ha (1.5%)	173,757 ha (9.3%)	3,874 ha (0.2%)	—	387,701 ha (3.2%)
Claystone	49,378 ha (2.2%)	205,413 ha (14.4%)	—	—	15,811 ha (0.8%)	—	779 ha (0.0%)	271,381 ha (2.2%)
Siltstone	—	—	—	31,400 ha (2.5%)	6 ha (0.0%)	—	1,002 ha (0.1%)	32,408 ha (0.3%)
Clay or mud	15,895 ha (0.7%)	—	—	2,426 ha (0.2%)	—	9 ha (0.0%)	9,987 ha (0.5%)	28,317 ha (0.2%)

Primary rock type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Other sedimentary	70,853 ha (3.2%)	131,064 ha (9.2%)	202,125 ha (16.4%)	720,155 ha (56.7%)	158,534 ha (8.5%)	1,121,949 ha (49.8%)	925,431 ha (49.2%)	3,330,111 ha (27.4%)
Limestone	—	49,078 ha (3.4%)	71,955 ha (5.8%)	385,624 ha (30.4%)	67,773 ha (3.6%)	538,254 ha (23.9%)	354,383 ha (18.9%)	1,467,066 ha (12.1%)
Sandstone	66,410 ha (3.0%)	70,693 ha (5.0%)	123,057 ha (10.0%)	212,945 ha (16.8%)	44,849 ha (2.4%)	219,561 ha (9.8%)	298,717 ha (15.9%)	1,036,232 ha (8.5%)
Dolostone (dolomite)	—	—	3,867 ha (0.3%)	51,408 ha (4.0%)	31,879 ha (1.7%)	337,642 ha (15.0%)	120,388 ha (6.4%)	545,184 ha (4.5%)
Arenite	—	—	—	58,304 ha (4.6%)	—	5,945 ha (0.3%)	51,939 ha (2.8%)	116,189 ha (1.0%)
Conglomerate	515 ha (0.0%)	11,294 ha (0.8%)	2,913 ha (0.2%)	—	9,989 ha (0.5%)	19,753 ha (0.9%)	32,053 ha (1.7%)	76,517 ha (0.6%)
Carbonate	—	—	—	5,065 ha (0.4%)	—	63 ha (0.0%)	25,980 ha (1.4%)	31,108 ha (0.3%)
Medium-grained mixed clastic	—	—	—	—	—	—	21,334 ha (1.1%)	21,334 ha (0.2%)
Fine-grained mixed clastic	—	—	—	—	—	464 ha (0.0%)	16,083 ha (0.9%)	17,057 ha (0.1%)
Coarse-grained mixed clastic	—	—	—	6,300 ha (0.5%)	—	268 ha (0.0%)	4,513 ha (0.2%)	11,081 ha (0.1%)
Arkose	—	—	332 ha (0.0%)	—	4,044 ha (0.2%)	—	—	4,376 ha (0.0%)
Graywacke	3,893 ha (0.2%)	—	—	—	—	—	—	3,893 ha (0.0%)
Biogenic sediment	—	—	—	—	—	—	40 ha (0.0%)	40 ha (0.0%)
Mixed clastic/ volcanic	35 ha (0.0%)	—	—	—	—	—	—	35 ha (0.0%)

Appendix C (cont.)

Primary rock type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Metamorphic	13 ha (0.0%)	6,632 ha (0.5%)	15,111 ha (1.2%)	49,688 ha (3.9%)	33,518 ha (1.8%)	198,450 ha (8.8%)	10,664 ha (0.6%)	314,077 ha (2.6%)
Quartzite	—	6,472 ha (0.5%)	8,858 ha (0.7%)	26,233 ha (2.1%)	25,940 ha (1.4%)	98,295 ha (4.4%)	5,656 ha (0.3%)	171,454 ha (1.4%)
Marble	—	—	—	—	—	99,613 ha (4.4%)	959 ha (0.1%)	100,573 ha (0.8%)
Schist	—	—	6,253 ha (0.5%)	12,155 ha (1.0%)	—	—	—	18,408 ha (0.2%)
Metamorphic rock	—	—	—	3,062 ha (0.2%)	—	542 ha (0.0%)	4,049 ha (0.2%)	7,653 ha (0.1%)
Greenstone	—	—	—	—	7,438 ha (0.4%)	—	—	7,438 ha (0.1%)
Orthogneiss	—	—	—	5,397 ha (0.4%)	—	—	—	5,397 ha (0.0%)
Metasedimentary rock	—	—	—	2,766 ha (0.2%)	—	—	—	2,766 ha (0.0%)
Serpentinite	13 ha (0.0%)	160 ha(0.0%)	—	—	141 ha (0.0%)	—	—	314 ha (0.0%)
Mica schist	—	—	—	75 ha (0.0%)	—	—	—	75 ha (0.0%)
Other	184,463 ha (8.4%)	127,784 ha (9.0%)	49,820 ha (4.0%)	180,696 ha (14.2%)	171,636 ha (9.2%)	241,975 ha (10.7%)	216,171 ha (11.5%)	1,172,545 ha (9.7%)
Alluvium	84,156 ha (3.8%)	124,575 ha (8.7%)	30,394 ha (2.5%)	95,455 ha (7.5%)	162,010 ha (8.6%)	222,038 ha (9.9%)	208,055 ha (11.1%)	926,683 ha (7.6%)
Flood plain	31,207 ha (1.4%)	—	—	—	—	—	—	31,207 ha (0.3%)
Gravel	21,065 ha (1.0%)	—	—	—	—	—	—	21,065 ha (0.2%)
Sand	11,511 ha (0.5%)	—	—	—	—	—	—	11,511 ha (0.1%)
Alluvial fan	4,091 ha (0.2%)	—	—	—	—	—	—	4,091 ha (0.0%)
Landslide	31,317 ha (1.4%)	3,158 ha (0.2%)	12,349 ha (1.0%)	—	910 ha(0.0%)	469 ha (0.0%)	1,545 ha (0.1%)	49,748 ha (0.4%)

Primary rock type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Loess	—	—	—	46,545 ha (3.7%)	—	—	—	46,545 ha (0.4%)
Eolian	—	—	—	—	—	—	2,431 ha (0.1%)	2,431 ha (0.0%)
Glacial drift	345 ha (0.0%)	—	7,041 ha (0.6%)	36,955 ha (2.9%)	1,076 ha (0.1%)	14,389 ha (0.6%)	2,934 ha (0.2%)	62,739 ha (0.5%)
Glaciolacustrine	—	—	—	21,663 ha (1.7%)	—	—	2,172 ha (0.1%)	23,835 ha (0.2%)
Glacial drift	345 ha (0.0%)	—	7,041 ha (0.6%)	—	1,076 ha (0.1%)	14,389 ha (0.6%)	762 ha (0.0%)	23,612 ha (0.2%)
Till	—	—	—	15,290 ha (1.2%)	—	—	—	15,290 ha (0.1%)
Stratified glacial sediment	—	—	—	1 ha (0.0%)	—	—	—	1 ha (0.0%)
Lake or marine deposit (nonglacial)	—	—	—	881 ha (0.1%)	7,551 ha (0.4%)	5,048 ha (0.2%)	—	13,479 ha (0.1%)
Mud flat	—	—	—	—	—	—	1,125 ha (0.1%)	1,125 ha (0.0%)
Playa	341 ha (0.0%)	41 ha (0.0%)	—	—	89 ha (0.0%)	31 ha (0.0%)	9 ha (0.0%)	511 ha (0.0%)
Water	430 ha (0.0%)	10 ha (0.0%)	36 ha (0.0%)	861 ha (0.1%)	—	—	71 ha (0.0%)	1,409 ha (0.0%)

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Appendix D. Existing Vegetation Types in the Mountains of the Great Basin Geographic Regions

This appendix presents the area and relative amounts of the existing vegetation types in the mountains of each Great Basin geographic region and all geographic regions combined (table D.1).

Table D.1—Area of the existing vegetation types within the seven geographic regions in the Great Basin and all regions combined, with percentages of the individual region or all regions in parentheses. Data are from LANDFIRE (USGS 2016).

Existing vegetation type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Woodland/Forest	305,115 ha (13.9%)	172,603 ha (12.1%)	177,335 ha (14.6%)	477,003 ha (37.6%)	909,604 ha (48.5%)	1,402,311 ha (62.4%)	967,320 ha (52.5%)	4,411,290 ha (36.5%)
Pinon—Juniper Woodlands	123,610 ha (5.6%)	152,599 ha (10.7%)	22,892 ha (1.9%)	135,634 ha (10.7%)	787,660 ha (42.0%)	1,088,679 ha (48.5%)	822,428 ha (44.6%)	3,133,502 ha (26.0%)
Great Basin Pinyon Juniper Woodland	67,737 ha (3.1%)	152,599 ha (10.7%)	22,224 ha (1.8%)	131,564 ha (10.4%)	787,660 ha (42.0%)	1,088,633 ha (48.5%)	674,687 ha (36.6%)	2,925,103 ha (24.2%)
Colorado Plateau Pinyon Juniper Woodland	—	—	—	344 ha (0.0%)	—	—	139,541 ha (7.6%)	139,885 ha (1.2%)
Columbia Plateau Western Juniper Woodland and Savanna	55,850 ha (2.5%)	—	86 ha (0.0%)	1 ha (0.0%)	—	—	—	55,937 ha (0.5%)
Inter Mountain Basins Juniper Savanna	—	—	25 ha (0.0%)	3,569 ha (0.3%)	—	46 ha (0.0%)	8,183 ha (0.4%)	11,823 ha (0.1%)
Juniperus occidentalis Woodland Alliance	23 ha (0.0%)	—	556 ha (0.0%)	54 ha (0.0%)	—	—	—	633 ha (0.0%)
Rocky Mountain Foothill Limber Pine Juniper Woodland	—	—	—	102 ha (0.0%)	—	—	18 ha (0.0%)	120 ha (0.0%)
Other Woodland/Forest	181,505 ha (8.2%)	20,004 ha (1.4%)	154,443 ha (12.7%)	341,369 ha (26.9%)	121,944 ha (6.5%)	313,631 ha (14.0%)	144,891 ha (7.9%)	1,277,789 ha (10.6%)
Rocky Mountain Aspen Forest and Woodland	135,071 ha (6.1%)	11,120 ha (0.8%)	89,793 ha (7.4%)	120,553 ha (9.5%)	26,343 ha (1.4%)	73,687 ha (3.3%)	17,683 ha (1.0%)	474,249 ha (3.9%)
Inter Mountain Basins Curl Leaf Mountain Mahogany Woodland	30,176 ha (1.4%)	7,644 ha (0.5%)	11,319 ha (0.9%)	41,222 ha (3.3%)	66,140 ha (3.5%)	152,483 ha (6.8%)	65,016 ha (3.5%)	374,000 ha (3.1%)
Inter Mountain Basins Aspen Mixed Conifer Forest and Woodland	1,822 ha (0.1%)	—	6,002 ha (0.5%)	51,687 ha (4.1%)	—	4,793 ha (0.2%)	6,259 ha (0.3%)	70,563 ha (0.6%)

Existing vegetation type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and	—	—	494 ha (0.0%)	44,799 ha (3.5%)	—	1,398 ha (0.1%)	9,476 ha (0.5%)	56,166 ha (0.5%)
Inter Mountain Basins Montane Riparian Forest and Woodland	1,336 ha (0.1%)	1,001 ha (0.1%)	3,538 ha (0.3%)	4,309 ha (0.3%)	17,295 ha (0.9%)	12,649 ha (0.6%)	10,484 ha (0.6%)	50,612 ha (0.4%)
Rocky Mountain Bigtooth Maple Ravine Woodland	—	—	58 ha (0.0%)	33,097 ha (2.6%)	—	48 ha (0.0%)	16,220 ha (0.9%)	49,424 ha (0.4%)
Rocky Mountain Montane Riparian Forest and Woodland	6,733 ha (0.3%)	—	14,736 ha (1.2%)	12,982 ha (1.0%)	2 ha (0.0%)	53 ha (0.0%)	3,674 ha (0.2%)	38,180 ha (0.3%)
Rocky Mountain Subalpine Dry Mesic Spruce Fir Forest and Woodland	58 ha (0.0%)	—	15,457 ha (1.3%)	4,394 ha (0.3%)	—	10,605 ha (0.5%)	2,067 ha (0.1%)	32,581 ha (0.3%)
Inter Mountain Basins Subalpine Limber Bristlecone Pine Woodland	417 ha (0.0%)	183 ha (0.0%)	2 ha (0.0%)	27 ha (0.0%)	9,637 ha (0.5%)	20,467 ha (0.9%)	573 ha (0.0%)	31,306 ha (0.3%)
Abies concolor Forest Alliance	—	—	1 ha (0.0%)	315 ha (0.0%)	68 ha (0.0%)	23,179 ha (1.0%)	4,985 ha (0.3%)	28,549 ha (0.2%)
Southern Rocky Mountain Dry Mesic Montane Mixed Conifer Forest A	—	2 ha (0.0%)	89 ha (0.0%)	2,496 ha (0.2%)	145 ha (0.0%)	10,223 ha (0.5%)	3,035 ha (0.2%)	15,991 ha (0.1%)
Rocky Mountain Subalpine Upper Montane Riparian Forest and Woodland	255 ha (0.0%)	—	3,962 ha (0.3%)	6,129 ha (0.5%)	—	56 ha (0.0%)	103 ha (0.0%)	10,506 ha (0.1%)

Existing vegetation type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Rocky Mountain Subalpine Montane Limber Bristlecone Pine Woodland	—	—	5,628 ha (0.5%)	2,691 ha (0.2%)	1,934 ha (0.1%)	82 ha (0.0%)	6 ha (0.0%)	10,341 ha (0.1%)
Xeric Montane Douglas Fir Forest	—	—	—	9,188 ha (0.7%)	—	—	—	9,188 ha (0.1%)
Mediterranean California Subalpine Woodland	—	13 ha (0.0%)	—	—	136 ha (0.0%)	3,558 ha (0.2%)	—	3,707 ha (0.0%)
Northern Rocky Mountain Subalpine Woodland and Parkland	415 ha (0.0%)	—	3,228 ha (0.3%)	10 ha (0.0%)	—	—	—	3,653 ha (0.0%)
Middle Rocky Mountain Montane Douglas Fir Forest and Woodland	24 ha (0.0%)	—	—	3,413 ha (0.3%)	—	—	—	3,436 ha (0.0%)
Rocky Mountain Lodgepole Pine Forest	6 ha (0.0%)	—	—	3,134 ha (0.2%)	—	—	12 ha (0.0%)	3,153 ha (0.0%)
North American Warm Desert Riparian Forest and Woodland	—	—	—	—	—	—	2,898 ha (0.2%)	2,898 ha (0.0%)
Northern Rocky Mountain Dry Mesic Montane Mixed Conifer Forest	2,154 ha (0.1%)	—	—	—	—	—	—	2,154 ha (0.0%)
Southern Rocky Mountain Ponderosa Pine Woodland	—	—	—	—	—	31 ha (0.0%)	2,057 ha (0.1%)	2,088 ha (0.0%)
Dry Mesic Montane Douglas Fir Forest	1,401 ha (0.1%)	—	—	12 ha (0.0%)	—	—	—	1,413 ha (0.0%)
Western Cool Temperate Urban Evergreen Forest	135 ha (0.0%)	25 ha (0.0%)	124 ha (0.0%)	166 ha (0.0%)	233 ha (0.0%)	312 ha (0.0%)	324 ha (0.0%)	1,319 ha (0.0%)
Rocky Mountain Subalpine Mesic Wet Spruce Fir Forest and Woodland	25 ha (0.0%)	—	12 ha (0.0%)	448 ha (0.0%)	—	—	1 ha (0.0%)	486 ha (0.0%)

Appendix D (cont.)

Existing vegetation type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	350 ha (0.0%)	—	—	—	—	—	—	350 ha (0.0%)
Mesic Montane Douglas Fir Forest	203 ha (0.0%)	—	—	111 ha (0.0%)	—	—	—	314 ha (0.0%)
Abies grandis Forest	299 ha (0.0%)	—	—	—	—	—	—	299 ha (0.0%)
Northern Rocky Mountain Foothill Conifer Wooded Steppe	238 ha (0.0%)	—	—	—	—	—	—	238 ha (0.0%)
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	202 ha (0.0%)	—	—	1 ha (0.0%)	—	—	—	203 ha (0.0%)
Subalpine Douglas Fir Forest	3 ha (0.0%)	—	—	180 ha (0.0%)	—	—	—	182 ha (0.0%)
California Montane Woodland and Chaparral	90 ha (0.0%)	—	—	—	—	—	—	90 ha (0.0%)
Mediterranean California Mesic Mixed Conifer Forest and Woodland	68 ha (0.0%)	—	—	—	—	—	—	68 ha (0.0%)
California Montane Jeffrey Pine Ponderosa Pine Woodland	3 ha (0.0%)	9 ha (0.0%)	—	—	11 ha (0.0%)	8 ha (0.0%)	—	31 ha (0.0%)
Southern Rocky Mountain Ponderosa Pine Savanna	—	—	—	—	—	—	14 ha (0.0%)	14 ha (0.0%)
North Pacific Maritime Dry Mesic Douglas Fir Western Hemlock For	9 ha (0.0%)	—	—	—	—	—	—	9 ha (0.0%)

Existing vegetation type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Sierra Nevada Subalpine Lodgepole Pine Forest and Woodland	—	8 ha (0.0%)	—	—	—	—	—	8 ha (0.0%)
Sierran Intermontane Desert Western White Pine White Fir Woodland	8 ha (0.0%)	—	—	—	—	—	—	8 ha (0.0%)
Western Cool Temperate Undeveloped Ruderal Deciduous Forest	—	—	—	6 ha (0.0%)	—	—	—	6 ha (0.0%)
North Pacific Wooded Volcanic Flowage	4 ha (0.0%)	—	—	—	—	—	—	4 ha (0.0%)
Western Warm Temperate Developed Ruderal Evergreen Forest	—	—	—	—	—	—	2 ha (0.0%)	2 ha (0.0%)
Mediterranean California Red Fir Forest	1 ha (0.0%)	—	—	—	—	—	—	1 ha (0.0%)
Shrubland	1,328,015 ha (60.4%)	1,024,154 ha (72.0%)	533,937 ha (44.0%)	616,997 ha (48.7%)	828,269 ha (44.1%)	743,457 ha (33.1%)	673,629 ha (36.5%)	5,748,458 ha (47.6%)
Sagebrush Shrublands	1,282,220 ha (58.3%)	704,381 ha (49.5%)	525,391 ha (43.3%)	574,157 ha (45.3%)	760,442 ha (40.5%)	695,944 ha (31.0%)	503,281 ha (27.3%)	5,045,816 ha (41.8%)
Inter Mountain Basins Big Sagebrush Shrubland	506,863 ha (23.0%)	405,357 ha (28.5%)	96,897 ha (8.0%)	161,442 ha (12.7%)	228,499 ha (12.2%)	143,351 ha (6.4%)	148,597 ha (8.1%)	1,691,006 ha (14.0%)
Great Basin Xeric Mixed Sagebrush Shrubland	88,928 ha (4.0%)	161,812 ha (11.4%)	91,759 ha (7.6%)	75,455 ha (6.0%)	331,343 ha (17.7%)	378,584 ha (16.9%)	288,545 ha (15.6%)	1,416,426 ha (11.7%)
Artemisia tridentata ssp. vaseyana Shrubland Alliance	17,789 ha (0.8%)	33,046 ha (2.3%)	159,984 ha (13.2%)	213,293 ha (16.8%)	91,855 ha (4.9%)	105,668 ha (4.7%)	19,020 ha (1.0%)	640,655 ha (5.3%)
Inter Mountain Basins Big Sagebrush Steppe	142,246 ha (6.5%)	88,068 ha (6.2%)	68,281 ha (5.6%)	48,823 ha (3.9%)	73,183 ha (3.9%)	35,389 ha (1.6%)	18,062 ha (1.0%)	474,052 ha (3.9%)

Appendix D (cont.)

Existing vegetation type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Inter Mountain Basins Montane Sagebrush Steppe	172,488 ha (7.8%)	7,503 ha (0.5%)	67,225 ha (5.5%)	69,720 ha (5.5%)	31,039 ha (1.7%)	28,657 ha (1.3%)	6,005 ha (0.3%)	382,636 ha (3.2%)
Columbia Plateau Low Sagebrush Steppe	348,479 ha (15.8%)	134 ha (0.0%)	26,003 ha (2.1%)	1,766 ha (0.1%)	52 ha (0.0%)	8 ha (0.0%)	149 ha (0.0%)	376,592 ha (3.1%)
Inter Mountain Basins Semi Desert Shrub Steppe	5,427 ha (0.2%)	8,461 ha (0.6%)	15,243 ha (1.3%)	3,603 ha (0.3%)	4,470 ha (0.2%)	4,288 ha (0.2%)	17,001 ha (0.9%)	58,492 ha (0.5%)
Colorado Plateau Mixed Low Sagebrush Shrubland	—	—	—	55 ha (0.0%)	—	—	5,901 ha (0.3%)	5,957 ha (0.0%)
Other Shrubland	45,795 ha (2.1%)	319,773 ha (22.5%)	8,545 ha (0.7%)	42,840 ha (3.4%)	67,827 ha (3.6%)	47,513 ha (2.1%)	170,348 ha (9.2%)	702,642 ha (5.8%)
Inter Mountain Basins Mixed Salt Desert Scrub	23,741 ha (1.1%)	112,184 ha (7.9%)	1,086 ha (0.1%)	4,869 ha (0.4%)	19,827 ha (1.1%)	18,730 ha (0.8%)	109,400 ha (5.9%)	289,837 ha (2.4%)
Inter Mountain Basins Greasewood Flat	13,411 ha (0.6%)	167,518 ha (11.8%)	51 ha (0.0%)	289 ha (0.0%)	21,428 ha (1.1%)	934 ha (0.0%)	2,602 ha (0.1%)	206,232 ha (1.7%)
Mojave Mid Elevation Mixed Desert Scrub	828 ha (0.0%)	35,724 ha (2.5%)	11 ha (0.0%)	6 ha (0.0%)	24,967 ha (1.3%)	17,536 ha (0.8%)	13,752 ha (0.7%)	92,825 ha (0.8%)
Rocky Mountain Lower Montane Foothill Shrubland	74 ha (0.0%)	—	770 ha (0.1%)	12,261 ha (1.0%)	—	3,060 ha (0.1%)	3,657 ha (0.2%)	19,823 ha (0.2%)
Northern Rocky Mountain Montane Foothill Deciduous Shrubland	1,661 ha (0.1%)	—	5,033 ha (0.4%)	11,741 ha (0.9%)	—	—	58 ha (0.0%)	18,493 ha (0.2%)
Quercus gambelii Shrubland Alliance	—	—	—	39 ha (0.0%)	—	6 ha (0.0%)	17,849 ha (1.0%)	17,894 ha (0.1%)
Western Cool Temperate Developed Ruderal Shrubland	811 ha (0.0%)	302 ha (0.0%)	346 ha (0.0%)	6,870 ha (0.5%)	407 ha (0.0%)	744 ha (0.0%)	5,408 ha (0.3%)	14,887 ha (0.1%)
Coleogyne ramosissima Shrubland Alliance	—	1 ha (0.0%)	—	—	7 ha (0.0%)	5,874 ha (0.3%)	6,037 ha (0.3%)	11,918 ha (0.1%)

Existing vegetation type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Rocky Mountain Gambel Oak Mixed Montane Shrubland	—	—	—	4,074 ha (0.3%)	—	3 ha (0.0%)	5,351 ha (0.3%)	9,428 ha (0.1%)
Grayia spinosa Shrubland Alliance	514 ha (0.0%)	3,930 ha (0.3%)	16 ha (0.0%)	—	822 ha (0.0%)	66 ha (0.0%)	—	5,349 ha (0.0%)
Rocky Mountain Subalpine Upper Montane Riparian Shrubland	3,829 ha (0.2%)	—	30 ha (0.0%)	1,082 ha (0.1%)	8 ha (0.0%)	1 ha (0.0%)	—	4,950 ha (0.0%)
Sonora Mojave Semi Desert Chaparral	—	—	—	—	—	6 ha (0.0%)	2,831 ha (0.2%)	2,837 ha (0.0%)
Western Cool Temperate Urban Shrubland	261 ha (0.0%)	113 ha (0.0%)	233 ha (0.0%)	665 ha (0.1%)	329 ha (0.0%)	373 ha (0.0%)	382 ha (0.0%)	2,356 ha (0.0%)
Arctostaphylos patula Shrubland Alliance	—	—	—	—	—	—	1,264 ha (0.1%)	1,264 ha (0.0%)
Great Basin Semi Desert Chaparral	—	—	—	—	—	102 ha (0.0%)	863 ha (0.0%)	964 ha (0.0%)
Rocky Mountain Montane Riparian Shrubland	123 ha (0.0%)	—	291 ha (0.0%)	396 ha (0.0%)	—	—	24 ha (0.0%)	834 ha (0.0%)
Inter Mountain Basins Montane Riparian Shrubland	369 ha (0.0%)	—	144 ha (0.0%)	44 ha (0.0%)	34 ha (0.0%)	75 ha (0.0%)	133 ha (0.0%)	799 ha (0.0%)
Northern Rocky Mountain Subalpine Deciduous Shrubland	148 ha (0.0%)	—	532 ha (0.0%)	114 ha (0.0%)	—	—	—	793 ha (0.0%)
Western Cool Temperate Undeveloped Ruderal Shrubland	7 ha (0.0%)	—	—	384 ha (0.0%)	—	—	95 ha (0.0%)	487 ha (0.0%)
Mogollon Chaparral	—	—	—	—	—	—	348 ha (0.0%)	348 ha (0.0%)
Sonora Mojave Creosotebush White Bursage Desert Scrub	—	—	—	—	—	4 ha (0.0%)	192 ha (0.0%)	195 ha (0.0%)

Existing vegetation type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Quercus turbinella Shrubland Alliance	—	—	—	—	—	—	54 ha (0.0%)	54 ha (0.0%)
Western Warm Temperate Developed Ruderal Shrubland	—	—	—	—	—	—	24 ha (0.0%)	24 ha (0.0%)
Introduced Riparian Shrubland	—	—	—	—	—	—	18 ha (0.0%)	18 ha (0.0%)
North Pacific Broadleaf Landslide Forest and Shrubland	12 ha (0.0%)	—	—	—	—	—	—	12 ha (0.0%)
Rocky Mountain Alpine Dwarf Shrubland	—	—	—	5 ha (0.0%)	—	—	1 ha (0.0%)	5 ha (0.0%)
Southern Colorado Plateau Sand Shrubland	—	—	—	—	—	—	5 ha (0.0%)	5 ha (0.0%)
North Pacific Montane Riparian Woodland and Shrubland	4 ha (0.0%)	—	—	—	—	—	—	4 ha (0.0%)
Columbia Plateau Scabland Shrubland	2 ha (0.0%)	—	—	—	—	—	—	2 ha (0.0%)
Western Warm Temperate Urban Shrubland	—	—	1 ha (0.0%)	—	—	—	1 ha (0.0%)	2 ha (0.0%)
Northern and Central California Dry Mesic Chaparral	1 ha (0.0%)	—	—	—	—	—	—	1 ha (0.0%)
Introduced System	260,568 ha (11.8%)	194,072 ha (13.6%)	301,248 ha (24.8%)	78,137 ha (6.2%)	98,050 ha (5.2%)	48,655 ha (2.2%)	135,759 ha (7.4%)	1,116,488 ha (9.2%)
Introduced Annual System	260,568 ha (11.8%)	194,072 ha (13.6%)	301,248 ha (24.8%)	78,137 ha (6.2%)	98,050 ha (5.2%)	48,655 ha (2.2%)	135,759 ha (7.4%)	1,116,488 ha (9.2%)
Introduced Upland Vegetation Annual Grassland	254,911 ha (11.6%)	178,123 ha (12.5%)	293,889 ha (24.2%)	77,621 ha (6.1%)	87,434 ha (4.7%)	44,349 ha (2.0%)	131,759 ha (7.1%)	1,068,086 ha (8.8%)

Existing vegetation type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Introduced Upland Vegetation Annual and Biennial Forbland	5,657 ha (0.3%)	15,950 ha (1.1%)	7,358 ha (0.6%)	515 ha (0.0%)	10,616 ha (0.6%)	4,305 ha (0.2%)	4,000 ha (0.2%)	48,402 ha (0.4%)
Grassland	165,168 ha (7.5%)	10,919 ha (0.8%)	130,336 ha (10.7%)	48,279 ha (3.8%)	17,139 ha (0.9%)	13,026 ha (0.6%)	22,215 ha (1.2%)	407,082 ha (3.4%)
Columbia Plateau Steppe and Grassland	142,903 ha (6.5%)	—	17,424 ha (1.4%)	4,643 ha (0.4%)	—	—	661 ha (0.0%)	165,632 ha (1.4%)
Northern Rocky Mountain Lower Montane Foothill Valley Grassland	9,391 ha (0.4%)	—	85,607 ha (7.1%)	40,313 ha (3.2%)	—	—	3,085 ha (0.2%)	138,396 ha (1.1%)
Inter Mountain Basins Semi Desert Grassland	6,884 ha (0.3%)	10,911 ha (0.8%)	26,728 ha (2.2%)	830 ha (0.1%)	16,921 ha (0.9%)	12,157 ha (0.5%)	15,021 ha (0.8%)	89,452 ha (0.7%)
Introduced Upland Vegetation Perennial Grassland and Forbland	4,732 ha (0.2%)	8 ha (0.0%)	573 ha (0.0%)	1,867 ha (0.1%)	218 ha (0.0%)	597 ha (0.0%)	576 ha (0.0%)	8,571 ha (0.1%)
Southern Rocky Mountain Montane Subalpine Grassland	—	—	4 ha (0.0%)	360 ha (0.0%)	—	271 ha (0.0%)	2,834 ha (0.2%)	3,470 ha (0.0%)
Northern Rocky Mountain Subalpine Upper Montane Grassland	1,235 ha (0.1%)	—	—	147 ha (0.0%)	—	—	—	1,382 ha (0.0%)
Western Warm Temperate Developed Ruderal Grassland	—	—	—	76 ha (0.0%)	—	—	7 ha (0.0%)	83 ha (0.0%)
Western Cool Temperate Undeveloped Ruderal Grassland	3 ha (0.0%)	—	—	43 ha (0.0%)	—	—	30 ha (0.0%)	77 ha (0.0%)
Columbia Basin Palouse Prairie	16 ha (0.0%)	—	—	—	—	—	—	16 ha (0.0%)
North Pacific Montane Grassland	2 ha (0.0%)	—	—	—	—	—	—	2 ha (0.0%)

Appendix D (cont.)

Existing vegetation type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Rocky Mountain Alpine Turf	—	—	—	—	—	—	1 ha (0.0%)	1 ha (0.0%)
Other	141,368 ha (6.4%)	21,333 ha (1.5%)	70,673 ha (5.8%)	46,874 ha (3.7%)	23,564 ha (1.3%)	38,770 ha (1.7%)	45,329 ha (2.5%)	387,910 ha (3.2%)
Other Undeveloped	92,031 ha (4.2%)	8,045 ha (0.6%)	64,205 ha (5.3%)	15,671 ha (1.2%)	6,930 ha (0.4%)	6,344 ha (0.3%)	12,695 ha (0.7%)	205,921 ha (1.7%)
Rocky Mountain Subalpine Montane Mesic Meadow	91,181 ha (4.1%)	8,045 ha (0.6%)	64,027 ha (5.3%)	14,859 ha (1.2%)	6,929 ha (0.4%)	6,202 ha (0.3%)	12,293 ha (0.7%)	203,537 ha (1.7%)
Rocky Mountain Wetland Herbaceous	841 ha (0.0%)	—	178 ha (0.0%)	346 ha (0.0%)	—	2 ha (0.0%)	1 ha (0.0%)	1,368 ha (0.0%)
Northern Rocky Mountain Conifer Swamp	9 ha (0.0%)	—	—	465 ha (0.0%)	—	—	—	474 ha (0.0%)
North American Warm Desert Riparian Herbaceous	—	—	—	—	—	6 ha (0.0%)	401 ha (0.0%)	408 ha (0.0%)
Mediterranean California Subalpine Meadow	—	—	—	—	1 ha (0.0%)	133 ha (0.0%)	—	134 ha (0.0%)
Other Developed	3,285 ha(0.1%)	3,553 ha (0.2%)	3,468 ha (0.3%)	28,474 ha (2.2%)	2,678 ha (0.1%)	3,416 ha (0.2%)	19,140 ha (1.0%)	64,014 ha (0.5%)
Quarries Strip Mines Gravel Pits	71 ha (0.0%)	2,348 ha (0.2%)	1,606 ha (0.1%)	—	1,364 ha (0.1%)	1,586 ha (0.1%)	4,164 ha (0.2%)	11,139 ha (0.1%)
Developed Roads	1,292 ha (0.1%)	226 ha (0.0%)	978 ha (0.1%)	3,748 ha (0.3%)	733 ha (0.0%)	936 ha (0.0%)	2,465 ha (0.1%)	10,378 ha (0.1%)
Western Cool Temperate Close Grown Crop	576 ha (0.0%)	318 ha (0.0%)	21 ha (0.0%)	6,999 ha (0.6%)	150 ha (0.0%)	23 ha (0.0%)	1,230 ha (0.1%)	9,317 ha (0.1%)
Western Cool Temperate Fallow Idle Cropland	128 ha (0.0%)	242 ha (0.0%)	31 ha (0.0%)	3,643 ha (0.3%)	14 ha (0.0%)	10 ha (0.0%)	4,206 ha (0.2%)	8,275 ha (0.1%)
Western Cool Temperate Wheat	15 ha (0.0%)	5 ha (0.0%)	—	6,470 ha (0.5%)	2 ha (0.0%)	—	1,004 ha (0.1%)	7,497 ha (0.1%)

Existing vegetation type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Western Cool Temperate Pasture and Hayland	231 ha (0.0%)	17 ha (0.0%)	205 ha (0.0%)	5,021 ha (0.4%)	120 ha (0.0%)	271 ha (0.0%)	1,163 ha (0.1%)	7,029 ha (0.1%)
Western Cool Temperate Developed Ruderal Grassland	498 ha (0.0%)	273 ha (0.0%)	257 ha (0.0%)	1,332 ha (0.1%)	118 ha (0.0%)	158 ha (0.0%)	3,769 ha (0.2%)	6,404 ha (0.1%)
Western Cool Temperate Urban Herbaceous	303 ha (0.0%)	32 ha (0.0%)	226 ha (0.0%)	375 ha (0.0%)	125 ha (0.0%)	226 ha (0.0%)	228 ha (0.0%)	1,515 ha (0.0%)
Developed Low Intensity	96 ha (0.0%)	32 ha (0.0%)	44 ha (0.0%)	203 ha (0.0%)	9 ha (0.0%)	101 ha (0.0%)	229 ha (0.0%)	714 ha (0.0%)
Western Cool Temperate Row Crop	35 ha (0.0%)	2 ha (0.0%)	—	174 ha (0.0%)	—	—	185 ha (0.0%)	397 ha (0.0%)
Developed Medium Intensity	14 ha (0.0%)	33 ha (0.0%)	21 ha (0.0%)	45 ha (0.0%)	27 ha (0.0%)	55 ha (0.0%)	191 ha (0.0%)	386 ha (0.0%)
Western Cool Temperate Urban Deciduous Forest	10 ha (0.0%)	—	51 ha (0.0%)	198 ha (0.0%)	—	28 ha (0.0%)	25 ha (0.0%)	312 ha (0.0%)
Western Cool Temperate Developed Ruderal Deciduous Forest	2 ha (0.0%)	2 ha (0.0%)	4 ha (0.0%)	190 ha (0.0%)	6 ha (0.0%)	1 ha (0.0%)	43 ha (0.0%)	247 ha (0.0%)
Western Cool Temperate Developed Ruderal Evergreen Forest	12 ha (0.0%)	19 ha (0.0%)	—	34 ha (0.0%)	7 ha (0.0%)	13 ha (0.0%)	107 ha (0.0%)	193 ha (0.0%)
Developed High Intensity	2 ha (0.0%)	3 ha (0.0%)	1 ha (0.0%)	3 ha (0.0%)	—	3 ha (0.0%)	83 ha (0.0%)	95 ha (0.0%)
Western Cool Temperate Urban Mixed Forest	1 ha (0.0%)	—	23 ha (0.0%)	36 ha (0.0%)	1 ha (0.0%)	4 ha (0.0%)	25 ha (0.0%)	90 ha (0.0%)
Western Warm Temperate Pasture and Hayland	—	—	—	—	—	—	10 ha (0.0%)	10 ha (0.0%)
Western Cool Temperate Orchard	—	—	—	2 ha (0.0%)	—	—	4 ha (0.0%)	6 ha (0.0%)
Western Warm Temperate Close Grown Crop	—	—	—	—	—	—	4 ha (0.0%)	4 ha (0.0%)

Existing vegetation type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Western Warm Temperate Urban Herbaceous	—	—	—	—	—	—	1 ha (0.0%)	1 ha (0.0%)
Western Warm Temperate Urban Evergreen Forest	—	—	—	—	—	—	1 ha (0.0%)	1 ha (0.0%)
Western Warm Temperate Urban Deciduous Forest	—	—	—	—	—	—	1 ha (0.0%)	1 ha (0.0%)
Western Cool Temperate Developed Ruderal Mixed Forest	—	—	—	—	—	—	—	1 ha (0.0%)
Sparse to Barren	46,051 ha (2.1%)	9,735 ha (0.7%)	3,000 ha (0.2%)	2,729 ha (0.2%)	13,956 ha (0.7%)	29,010 ha (1.3%)	13,494 ha (0.7%)	117,975 ha (1.0%)
Inter Mountain Basins Sparsely Vegetated Systems	31,906 ha (1.5%)	4,310 ha (0.3%)	221 ha (0.0%)	238 ha (0.0%)	7,941 ha (0.4%)	6,836 ha (0.3%)	721 ha (0.0%)	52,174 ha (0.4%)
Barren	3,763 ha (0.2%)	3,559 ha (0.3%)	1,858 ha (0.2%)	357 ha (0.0%)	679 ha (0.0%)	10,760 ha (0.5%)	3,719 ha (0.2%)	24,696 ha (0.2%)
Rocky Mountain Alpine Montane Sparsely Vegetated Systems	8,849 ha (0.4%)	232 ha (0.0%)	470 ha (0.0%)	1,005 ha (0.1%)	4,640 ha (0.2%)	3,831 ha (0.2%)	1 ha (0.0%)	19,027 ha (0.2%)
Inter Mountain Basins Sparsely Vegetated Systems II	342 ha (0.0%)	1,196 ha (0.1%)	94 ha (0.0%)	133 ha (0.0%)	449 ha (0.0%)	5,686 ha (0.3%)	6,582 ha (0.4%)	14,481 ha (0.1%)
Open Water	1,185 ha (0.1%)	438 ha (0.0%)	335 ha (0.0%)	770 ha (0.1%)	246 ha (0.0%)	511 ha (0.0%)	177 ha (0.0%)	3,661 ha (0.0%)
Rocky Mountain Alpine Montane Sparsely Vegetated Systems II	—	—	12 ha (0.0%)	179 ha (0.0%)	—	1,015 ha (0.0%)	782 ha (0.0%)	1,990 ha (0.0%)
North American Warm Desert Sparsely Vegetated Systems II	—	—	—	—	—	90 ha (0.0%)	1,495 ha (0.1%)	1,585 ha (0.0%)

Existing vegetation type	Lava Plains	Lahontan	Humboldt and Owyhee Uplands	Southeastern Idaho	Central Nevada	Eastern Nevada	Western Utah	Total area
Snow Ice	—	—	10 ha (0.0%)	48 ha (0.0%)	—	282 ha (0.0%)	—	340 ha (0.0%)
Sonoran Desert Sparsely Vegetated	—	—	—	—	—	—	16 ha (0.0%)	16 ha (0.0%)
Mediterranean California Sparsely Vegetated Systems	5 ha (0.0%)	—	—	—	—	—	—	5 ha (0.0%)
North American Warm Desert Sparsely Vegetated Systems	—	—	—	—	—	—	1 ha (0.0%)	1 ha (0.0%)
North Pacific Sparsely Vegetated Systems	1 ha (0.0%)	—	—	—	—	—	—	1 ha (0.0%)

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