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The Soils of Nevada

Springer

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This book is dedicated to the professional Soil Scientists of the US Department of Agriculture; Natural Resources Conservation Service and US Forest Service and US Department of Interior; Bureau of Land Management that mapped soils in Nevada. We would like to recognize the Range Conservationists from these agencies that worked with the Soil Scientists during the mapping of most of Nevada. We would like to acknowledge the support of management from these agencies and other land management agencies that contributed to soil surveys. We would also like to acknowledge the support from the University of Nevada-Reno and the University of Nevada-Las Vegas personal. This book could not have been written without the support of NRCS database managers and data manipulators.

The NRCS served as the lead agency in mapping the soils in Nevada. This organization began in 1899 as the Division of Soils, became the Bureau of Soils in 1901, the Soil Conservation Service in 1935, and the Natural Resources Conservation Service in 1994.

The report that follows draws primarily on information gathered from the 16 counties of Nevada that were mapped primarily by NRCS personnel, significant area was mapped by BLM Soil Scientists, and smaller areas by the USFS and private contractors.

We thank James Komer, Nevada state Soil Scientist, and his staff for their support of this project. With assistance from Erin Hourihan, Matt Cole produced the general soil map of Nevada.

Preface

In that 84% of the land in Nevada is federally owned, this book is intended for use by employees of the Bureaus of Indian Affairs, Land Management, and Reclamation; the Departments of Defense and Energy; and the US Forest, Natural Resources Conservation, Fish and Wildlife, and National Parks Services. The book will also serve state agencies in Nevada, including the Department of Agriculture; Nevada Wildlife Service; Commissions on Rangeland Resources, Economic Development, and Mineral Resources; Department of Tourism and Cultural Affairs; and Department of Conservation and Natural Resources. The book could be used in natural resource courses at the Desert Research Institute, College of Southern Nevada, the University of Nevada-Las Vegas, the University of Nevada-Reno, the Great Basin College, and Truckee Meadows Community College, as well as universities and colleges in the adjacent states of Oregon, California, Idaho, Utah, and Arizona. The book may also be of interest to persons interested in the geography of soils, particularly in the Western Range and Irrigated land Resource Region.

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Reno, USA	John B. Fisher
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Reno, USA	Joseph V. Chiaretti
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Contents

Authors' Note

With a land area of 286,380 km^2, Nevada is the seventh largest state in the US. Because it has a population of less than 3 million people, Nevada has one of the lowest state population densities in the US. With an average mean annual precipitation of 175 mm (7 in), Nevada is the driest state in the US. More than three-quarters (89%) of the state has been mapped, with the first soil survey being completed in 1909. Dr. C. F. Marbut, a historical figure in the history of soil science in the USA, played a prominent role in delineating Nevada's soils.

Nevada is divided into 10 Major Land Resource Areas and features two major deserts—the Great Basin Desert and the Mojave Desert—and over 100 north-south-trending enclosed basins separated by mountain ranges (Basin and Range Province), several of which have peaks exceeding 3,400 m (11,000 ft).

The soils of Nevada represent 7 of the 12 orders recognized globally, 29 suborders, 69 great groups, and over 1,800 soil series. Some of the classic research on the origin of duripans and petrocalcic horizons has been conducted in Nevada.

This study is the first report of the soils of Nevada and provides the first soil map of Nevada utilizing *Soil Taxonomy*.

About the Authors

Paul W. Blackburn began working as a Soil Scientist for the SCS, later to become the NRCS, in June 1976. Paul retired as an MLRA Project Office Leader in January of 2018 with a total of 41 years of service. Paul is enjoying staying close to home, doing small home remodel projects, and teaching grandsons about soils.

John B. Fisher worked over 41 years as a Soil Scientist in Nevada with NRCS before retiring as a Senior Regional Soil Scientist in 2017. John lives in Reno and enjoys reading, gardening, and playing with his grandsons.

William E. Dollarhide transferred to Nevada NRCS in 1969. He served as a Soil Scientist, Project Leader, Assistant State Soil Scientist, State Soil Scientist, and Major Land Resource leader before retiring in 2010, after 41 years of service. Bill lives in Reno with his family and enjoys gardening and playing senior softball.

Douglas J. Merkler began working as a Soil Scientist for the SCS, later to become the NRCS, in September 1978. Douglas retired as a Resource Soil Scientist for Nevada in July of 2017, just shy of 39 years of service. Douglas remains active in the Soil Science Society of America and the International Biogeographic Society, is currently teaching at Nevada State College, and has started a resource-oriented, drone-based consulting firm with his wife in retirement.

Joseph V. Chiaretti began his career as a Soil Scientist with the BLM in south-central New Mexico in 1978 and then transferred to the SCS (now NRCS) in 1979. He mapped soils on four soil survey areas in New Mexico over 19 years, serving as lead field mapper and Project Leader. Joe, along with co-authors Paul, John, and Douglas, is recognized by the NRCS as a million-acre mapper for the National Cooperative Soil Survey (NCSS) program. In January 1998, Joe transferred to Nevada and conducted quality assurance on soil survey products in the former Great Basin MLRA region until November 2008. He then served on the Soil Survey Standards staff of the National Soil Survey Center in Lincoln, Nebraska as an instructor, the principal editor of NCSS standards documents such as the National Soil Survey Handbook and the Keys to Soil Taxonomy, and the national soil classification expert. Joe retired from federal service in early 2014 and is now enjoying his hobbies of gardening, hiking, and traveling back in his adopted State of Nevada.

James G. Bockheim was Professor of Soil Science at the University of Wisconsin from 1975 until his retirement in 2015. He has conducted soil genesis and geography in many parts of the world. His interest in Nevada stemmed from its high pedodiversity. His previous books include *Pedodiversity* (2013; with J. J. Ibáñez); *Soil Geography of the USA: a Diagnostic-Horizon Approach* (2014); *Cryopedology* (2015); *The Soils of Antarctica* (2015; editor), and *The Soils of Wisconsin* (2017; with A. E. Hartemink), and *Soils of the Laurentide Great Lakes, USA and Canada*.

1 Overview

Abstract

This chapter considers the definitions of soils and briefly reviews the history, major soil regions, and classification of soils in Nevada.

1.1 Definition of Soil

There are many definitions for soil ranging from the utilitarian to a description that focuses on material. Soil has been recognized as (i) a natural body, (ii) a medium for plant growth, (iii) an ecosystem component, (iv) a vegetated water-transmitting mantle, and (iv) an archive of past climate and processes. In this book, we follow the definition given in the *Keys to Soil Taxonomy* (Soil Survey Staff 2014, p. 1) that the soil "is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment".

1.2 Nevada History

The Spanish meaning of Nevada is "snow-clad," in reference to the state's more than 100 mountain ranges, some of which rise above 3,400 m (11,300 feet). The highest elevation in Nevada is 4,007 m (13,147 feet) on the summit of Boundary Peak in the northern end of the White Mountains adjacent to California. With a land area of 286,380 km^2, Nevada is the seventh-largest state in the US. Nevada has only 3 million residents and is ranked 42nd in terms of population density. About one-half (45%) of Nevada's population resides in the Greater Las Vegas area (Table 1.1). The state originally was settled by Native Americans, including the Paiute, Shoshone, and Washoe tribes, and later by the Spanish (Elliott and Rowley 1987). Trappers and experienced scouts such as Joseph R. Walker passed through the region in the 1820s, and John C. Frémont and Kit Carson explored and mapped in what is now western Nevada and eastern California during expeditions in 1843–1844 and 1845. Frémont verified that all the land centered on modern-day Nevada (between Reno and Salt Lake City) was endorheic, without any outlet rivers flowing toward the sea. He is credited with coining the term "Great Basin" to describe the internal drainage of the region he explored in the mid-1840s. In 1848 Nevada, then part of the Utah Territory, was transferred to the U.S. by Mexico following the Treaty of Guadalupe Hidalgo, which ended the Mexican–American War (1846–1848). In 1859, silver was discovered near Mount Davidson in the Virginia Range and was named the Comstock Lode after the discoverer, Henry Comstock. Subsequent minerals mined in Nevada include gold, copper, lead, zinc, mercury, barite, and tungsten. The Nevada Territory gained statehood prior to the presidential election in 1864 as a new State on the side of the Union. The silver mines declined after 1874. Nevada today is officially known as the "Silver State" because of the importance of silver to its history and economy. It is also known as the "Battle Born State", because it achieved statehood during the Civil War.

Nevada has been divided into 16 counties that range in size from 373 km^2 (144 mi^2) (Carson City County) to 47,001 km^2 (18,147 mi^2) (Nye County) (Fig. 1.1). The economy of Nevada is based on cattle ranching, entertainment, government infrastructure, and tourism. From 84 to 87% of the land in Nevada is under federal jurisdiction, including the Bureau of Indian Affairs, the Bureau of Land Management, the Bureau of Reclamation, the Department of Defense, the Department of Energy, the U.S. Fish and Wildlife Service, the US Forest Service, and the National Park Service (Figs. 1.1 and 1.2).

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Table 1.1 Nevada's most populated cities

City	Population	Key industries
Las Vegas*	648,000	tourism
Henderson	308,000	tourism
Reno	245,000	tourism
North Las Vegas	249,000	tourism
Sparks	98,000	warehousing
Carson City	55,000	government

1.3 Major Soil Regions of Nevada

To date, there has not been a book describing Nevada's soils, nor has there been a detailed soil map of the state. However, about 89% of the state has been mapped (Fig. 1.3), and these data are available via the Web Soil Survey. The state is divided into 10 Major Land Resource Areas that reflect differences in physiography, geology, climate, water, soils, biological resources, and land use (Fig. 1.4; Table 1.2). The state also is divided into 5 Level III ecoregions, each containing from 2 to 25 Level IV ecoregions (Fig. 1.5; Table 1.3). The ecoregions approach is comparable to the MLRA approach and is based on differences in geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology.

1.4 Classification of Nevada Soils

The first soil survey in Nevada was conducted in 1909 for the Fallon Area that included parts of Churchill and Lyon Counties. The soil map legend included six soil series, nine soil types, and one land unit (Fig. 1.6). The Las Vegas Area was mapped in 1926 and the Moapa Valley Area in 1928. The former survey showed the distribution of nine soil series; 34 soil types differentiated on the basis of texture, relief, soil thickness, and degree of erosion; and two land types.

From 1905 until 1955 classification of soils in Nevada was limited to soil series and parent material texture, although a national soil classification scheme had been available since 1928 (Marbut 1927; Baldwin et al. 1938). Virtually no soil mapping occurred between 1929 and 1958. The Soil Survey of the Lovelock Area in 1966 was the last to use of the 1938 soil classification system. The Soil Survey of the Las Vegas and Eldorado Valleys Area in 1957 was the first in Nevada to use the *Seventh Approximation* (Soil Survey Staff 1960) for classifying soils of Nevada; this document was the precursor to the first edition of *Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys* (Soil Survey Staff 1975).

All soils in Nevada are now classified using *Soil Taxonomy* (Soil Survey Staff, 1999) and is used throughout this book. The *Keys to Soil Taxonomy* (Soil Survey Staff, 2014) is an abridged companion document that incorporates all the amendments that have been approved to the system since publication of the second edition of soil taxonomy in 1999, in a form that can be used easily in a field setting. *Soil Taxonomy* is a hierarchical classification system that classifies soils based on the properties as contained of diagnostic surface and subsurface horizons. For classification purposes, the upper limit of the soil is defined as the boundary between the soil (including organic horizons) and the air above it. The lower limit is arbitrarily set at 200 cm. The definition of the classes (taxa) is quantitative and uses well-described methods of analysis for the diagnostic properties. The assumed genesis of the soil is not used in the system and the soil is classified "as it is" using morphometric observations in the field coupled with laboratory analysis and other data. The nomenclature in soil taxonomy is mostly derived from Greek and Latin sources, as is done for the classification of plants and animals.

Soil taxonomy classifies soils, from broadest to narrowest levels, into orders, suborders, great groups, subgroups, and families. Families occur in one or more soil series. Soil associations (composed of soil series and miscellaneous areas) and consociations (composed of a single major component) constitute the primary soil map units.

There are eight diagnostic surface horizons (epipedons) defined in soil taxonomy and six of them occur in Nevada: anthropoic, folistic, histic, mollic, umbric, and ochric (Table 1.4). The anthropic epipedon forms in parent materials are strongly influenced by human activity, may contain artifacts, and occur in soils of urban areas and some gardens. The folistic and histic epipedons consist primarily of organic soil materials. The folistic epipedon occurs in well-drained

Fig. 1.1 Location of 16 counties in Nevada

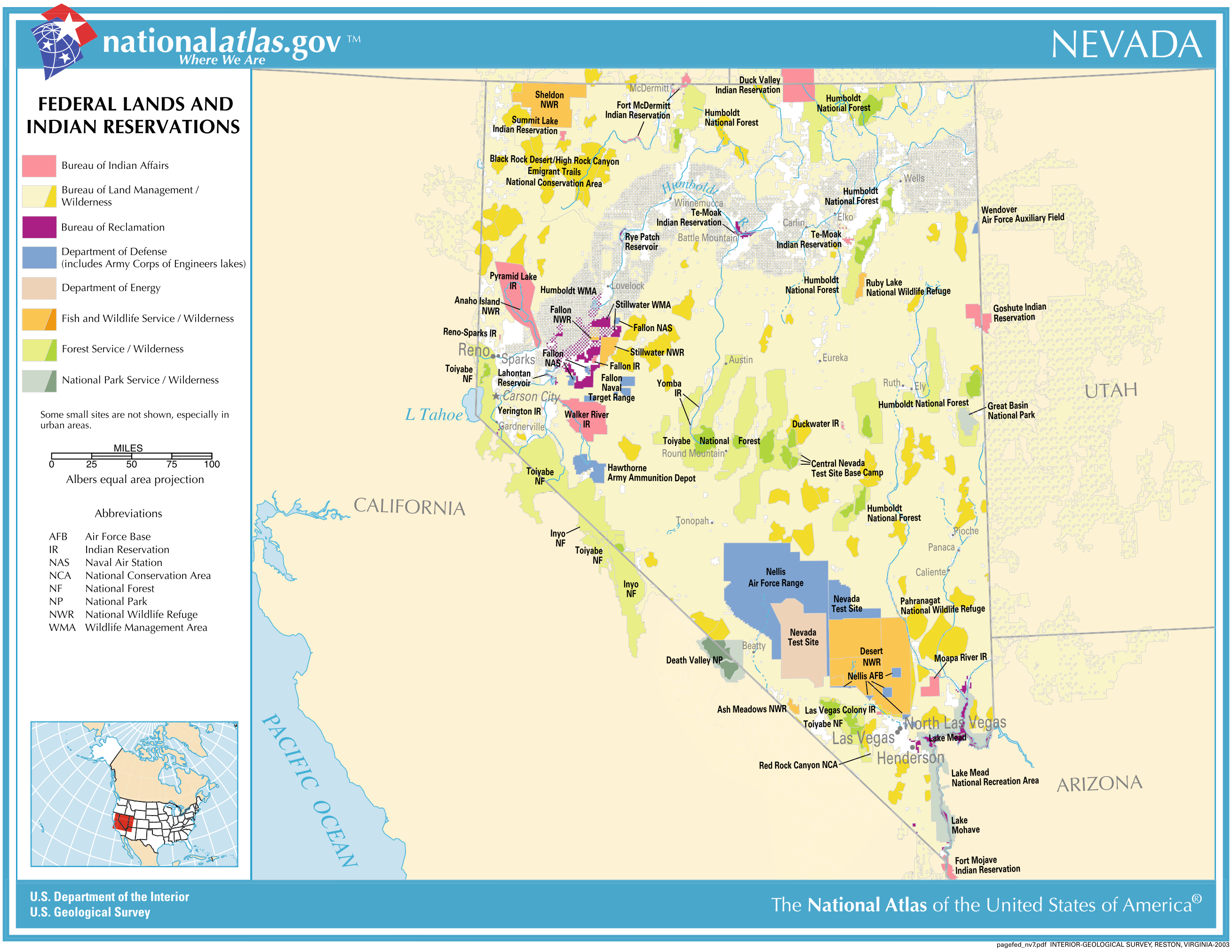

Fig. 1.2 Location of federal lands and Native American lands in Nevada. Legend: red = Bureau of Indian Affairs; yellow = Bureau of Land Management/Wilderness; purple = Bureau of Reclamation; blue = Department of Defense & Army Corps of Engineers; pink = Department of Energy; orange = US Fish & Wildlife Service; green = US Forest Service; light blue = National Park Service/ Wilderness (*Source* nationalatlas.com). (*Source* Nationalatlas.gov)

soils and is not saturated for prolonged periods during the year, while the histic epipedon contains primarily organic materials and is saturated for prolonged periods during the year. The mollic and umbric epipedons occur in mineral soils and are thick, dark-colored, and enriched in organic matter. The mollic epipedon is enriched in base cations, such as calcium, magnesium, and potassium, while the umbric epipedon contains low amounts of these cations. The ochric epipedon is thin, commonly light-colored, and often low in organic matter content.

Ten of the 20 diagnostic subsurface horizons identified in soil taxonomy are present in the soils of Nevada (Table 1.3). The albic horizon is composed of materials from which clay and/or free iron oxides have been removed by eluviation to a degree that primary sand and silt particles impart a light color to the horizon. The argillic horizon is enriched in clay that has moved down the profile from percolating water. The natric horizon is a type of argillic horizon, which shows evidence of clay illuviation that has been accelerated by the dispersive properties of sodium. The cambic horizon shows minimal development other than soil structure and color. The calcic horizon features a significant accumulation of secondary calcium carbonates; this horizon must be 15 cm or more thick, have a 5% or more $CaCO_3$ equivalent, and not be cemented. The petrocalcic horizon is at least 10 cm thick, has sufficient $CaCO_3$ that it is cemented, and roots are unable to penetrate it except along vertical fractures with a horizontal spacing of 10 cm or more. The gypsic horizon

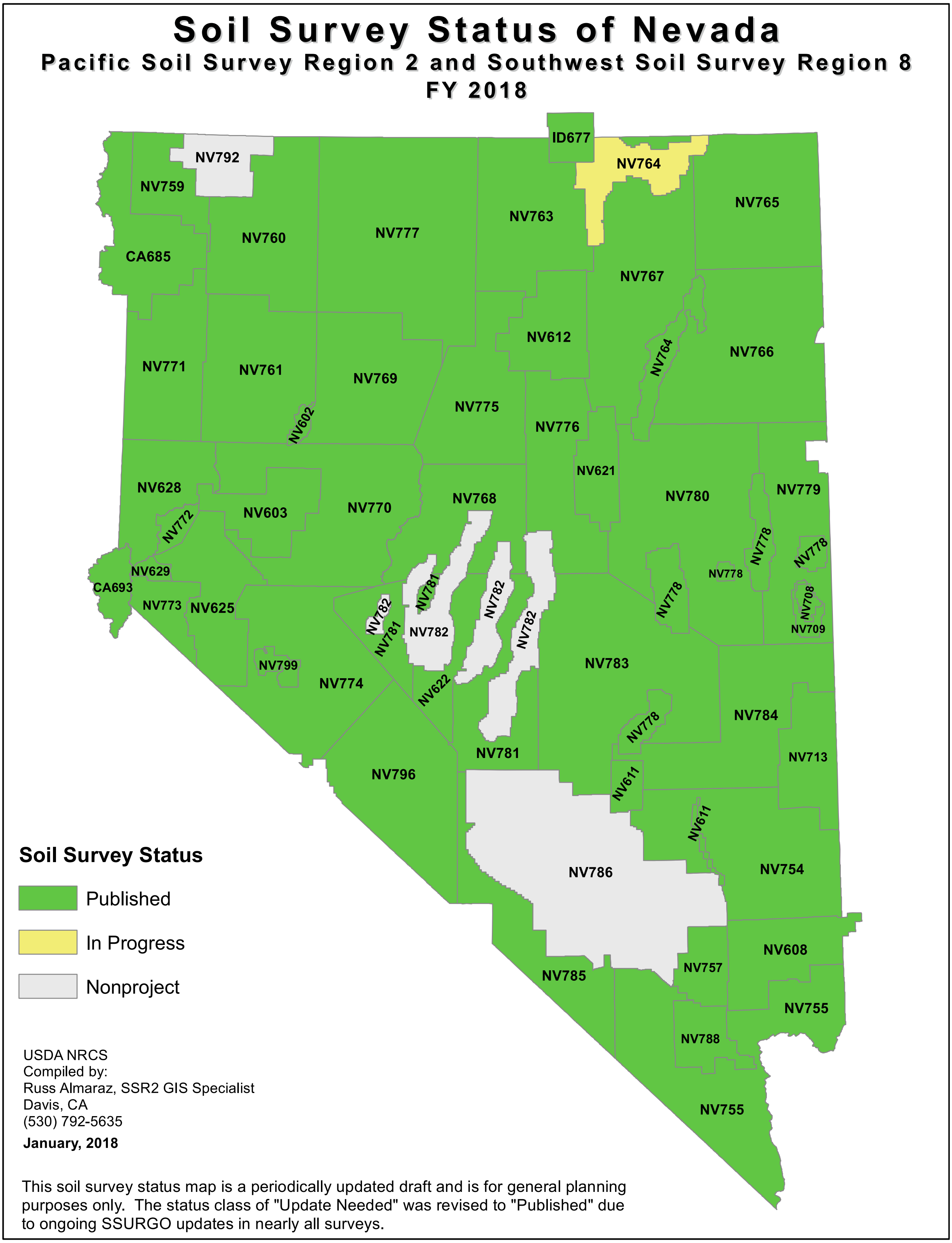

Fig. 1.3 Soil survey status of Nevada, 2018 (*Source* USDA, NRCS)

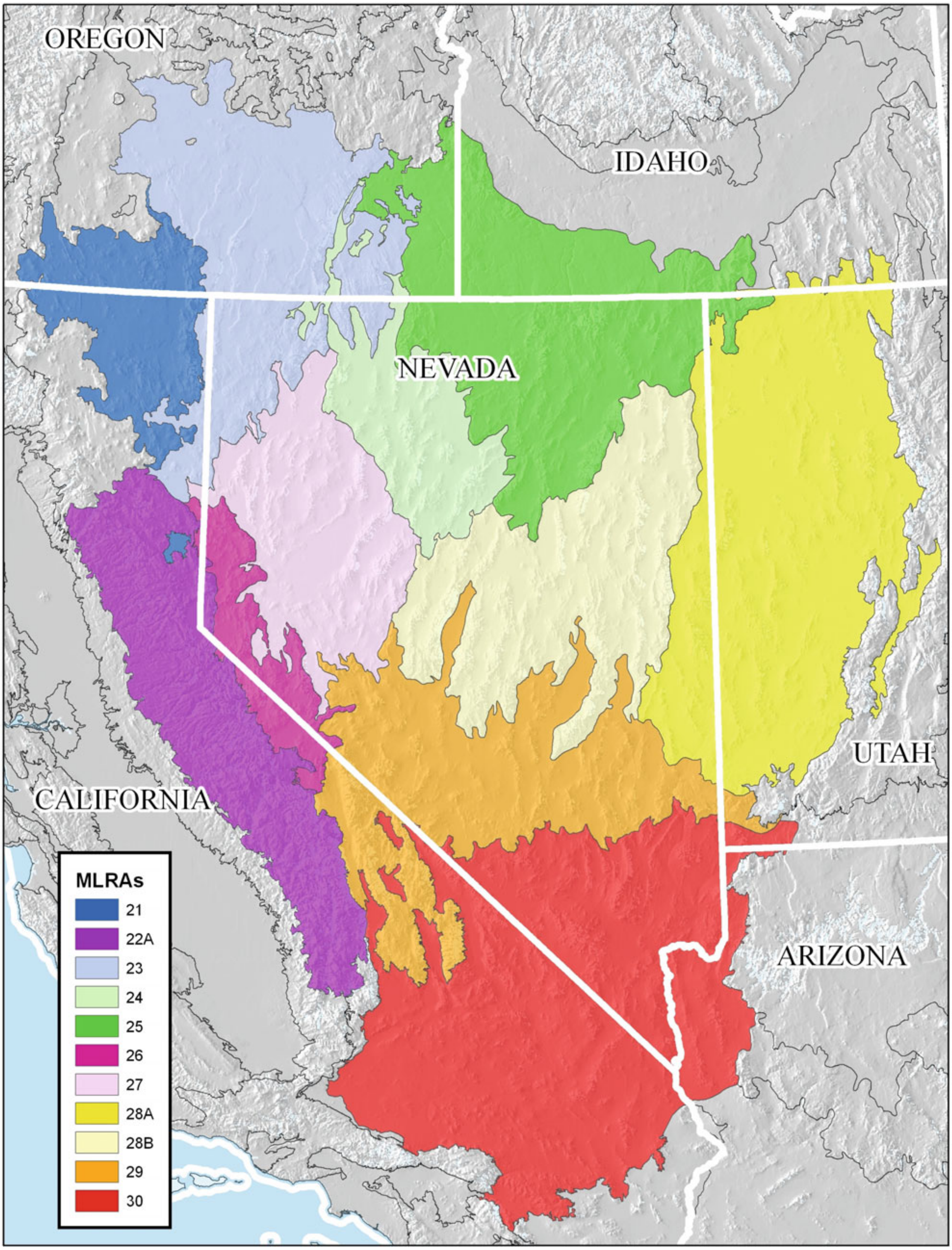

Fig. 1.4 Distribution of Major Land Resource Regions (MLRAs) in Nevada (see Table 1.2 for names and areas) (*Source* USDA, NRCS)

Table 1.2 Major Land Resource Areas represented in Nevada

MLRA	Description	Area (km^2)	%
22A	Sierra Nevada Mountains	975	0.3
23	Malheur High Plateau	14,830	5.1
24	Humboldt Area	30,884	10.7
25	Owyhee High Plateau	38,979	13.5
26	Carson Basin and Mountains	12,668	4.4
27	Fallon-Lovelock Area	32,560	11.3
28A	Great Salt Lake Area	15,248	5.3
28B	Central Nevada Basin and Range	61,035	21.1
29	Southern Nevada Basin and Range	49,742	17.2
30	Mojave Desert	31,744	11.0
		288,665	100.0

features a significant accumulation of gypsum; this horizon must be at least 15 cm thick, have 5% or more gypsum by weight, and not be cemented. The petrogypsic horizon is cemented so that roots are unable to penetrate it except in vertical fractures with a horizontal spacing of 10 cm or more.

A duripan is a silica-cemented subsurface horizon with or without auxiliary cementing agents. The duripan is cemented in more than 50% of the volume of some horizon and shows evidence of the accumulation of opal or other forms of silica, such as laminar caps, coatings, lenses, partly filled interstices, bridges between sand-sized grains, or coatings on rock fragments. Less than 50% of the volume of air-dry fragments slakes in 1 M HCl, but more than 50% slakes in concentrated KOH or NaOH. Roots can only penetrate the pan in vertical fractures with a horizontal spacing of 10 cm or more. Secondary calcium carbonate is often an accessory cementing agent in duripans. Duripans are very common in the soils of central and northern Nevada due in large part to the presence of soluble volcanic glass in soil parent materials. A salic horizon features the accumulation of salts that are more soluble than gypsum in cold water. This horizon must be 15 cm or more thick, have an electrical conductivity for 90 consecutive days or more of 30 dS/m or more in the water extracted from a saturated past; and have the product of the EC and thickness be 900 or more. Photographs of the subsurface horizons are given in chapters describing soils in each of the orders represented in Nevada. The formative elements used in constructing soil names are given in Appendix A.

Soil orders are defined primarily on the basis of diagnostic soil characteristics and diagnostic surface and subsurface horizons. Eight of the 12 orders in soil taxonomy occur in Nevada: Alfisols, Andisols, Aridisols, Entisols, Histosols, Inceptisols, Mollisols, and Vertisols (Table 1.5). Alfisols are base-enriched forest soils with an argillic horizon. Andisols are soils derived from amorphous clays. Aridisols are dry soils that feature the accumulation of clay or some salts. Entisols are very poorly developed recent soils that may have only an anthropic or ochric epipedon. Histosols are organic soils that are rare in Nevada due to the dominantly arid climate. Inceptisols are juvenile soils that contain an epipedon and either a cambic horizon, a salic horizon, or a high exchangeable sodium percentage. Mollisols are dark-colored, base-enriched grassland soils. Vertisols are derived from abundant swelling clays that lead to cracks and slickensides.

Suborders are distinguished by soil climate for five of the seven orders occurring in Nevada: the Alfisols, Andisols, Inceptisols, Mollisols, and Vertisols. Soil parent materials are used to differentiate Vertisols and among Entisols; and the amount of clay or types of salts are used to differentiate among Aridisols. There are 29 suborders of soils in Nevada. Great groups are distinguished from a variety of soil characteristics; there are 69 great groups of soils in Nevada.

On an area basis, 52% of the soil series in Nevada are Aridisols, followed by Mollisols (23%) and Entisols (22%); Inceptisols (1.9%), Alfisols (0.5%), Vertisols (0.4%), and Andisols (< 0.1%) comprise the remaining soil orders (Fig. 1.7). A list of all soil series recognized in Nevada, along with their areas and classification, is given in Appendix A. The thickness of diagnostic horizons of major Nevada soil series is given in Appendix B. Soil-forming factors of major Nevada soil series are listed in Appendix C.

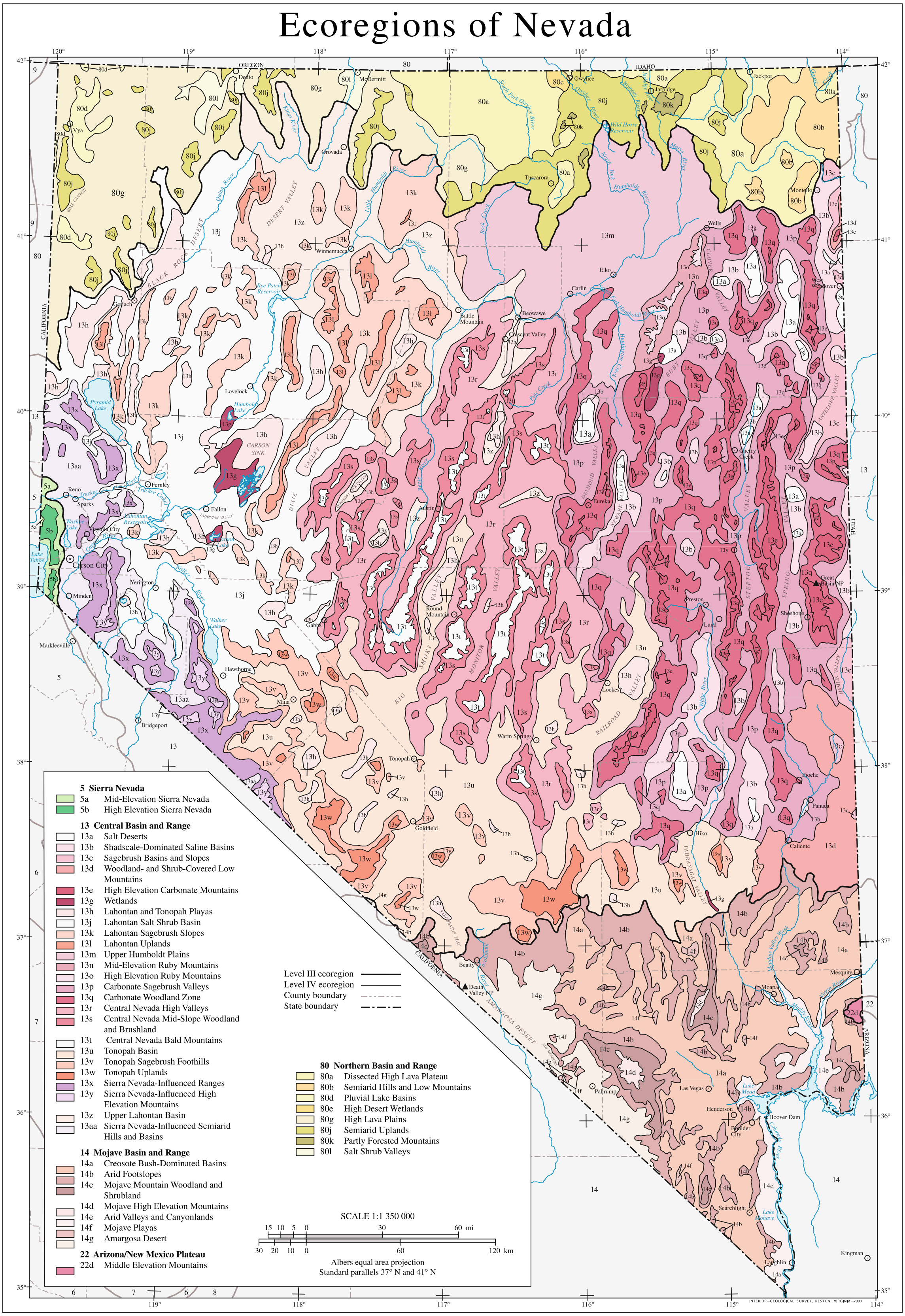

Fig. 1.5 Ecoregions of Nevada (*Source* EPA, NRCS, USGS)

Table 1.3 Legend for Fig. 1.5, Ecoregions of Nevada

5	**Sierra Nevada**
5a	Mid-Elevation Sierra Nevada
5b	High Elevation Sierra Nevada
13	**Central Basin and Range**
13a	Salt Deserts
13b	Shadscale-Dominated Saline Basins
13c	Sagebrush Basins and Slopes
13d	Woodland- and Shrub-Covered Low Mountains
13e	High Elevation Carbonate Mountains
13 g	Wetlands
13 h	Lahontan and Tonopah Playas
13j	Lahontan Salt Shrub Basin
13 k	Lahontan Sagebrush Slopes
13 l	Lahontan Uplands
13 m	Upper Humboldt Plains
13n	Mid-Elevation Ruby Mountains
13o	High Elevation Ruby Mountains
13p	Carbonate Sagebrush Valleys
13q	Carbonate Woodland Zone
13r	Central Nevada High Valleys
13 s	Central Nevada Mid-Slope Woodland and Brushland
13t	Central Nevada Bald Mountains
13u	Tonopah Basin
13v	Tonopah Sagebrush Foothills
13w	Tonopah Uplands
13x	Sierra Nevada-Influenced Ranges
13y	Sierra Nevada-Influenced High Elevation Mountains
13z	Upper Lahontan Basin
13aa	Sierra Nevada-Influenced Semiarid Hills and Basins
14	**Mojave Basin and Range**
14a	Creosote Bush-Dominated Basins 14b Arid Footslopes
14c	Mojave Mountain Woodland and Shrubland
14d	Mojave High Elevation Mountains
14e	Arid Valleys and Canyonlands
14f	Mojave Playas
14 g	Amargosa Desert
22	**Arizona/New Mexico Plateau**
22d	Middle Elevation Mountains
80	**Northern Basin and Range**
80a	Dissected High Lava Plateau
80b	Semiarid Hills and Low Mountains 80d Pluvial Lake Basins
80e	High Desert Wetlands 80 g High Lava Plains
80j	Semiarid Uplands
80 k	Partly Forested Mountains
80 l	Salt Shrub Valleys

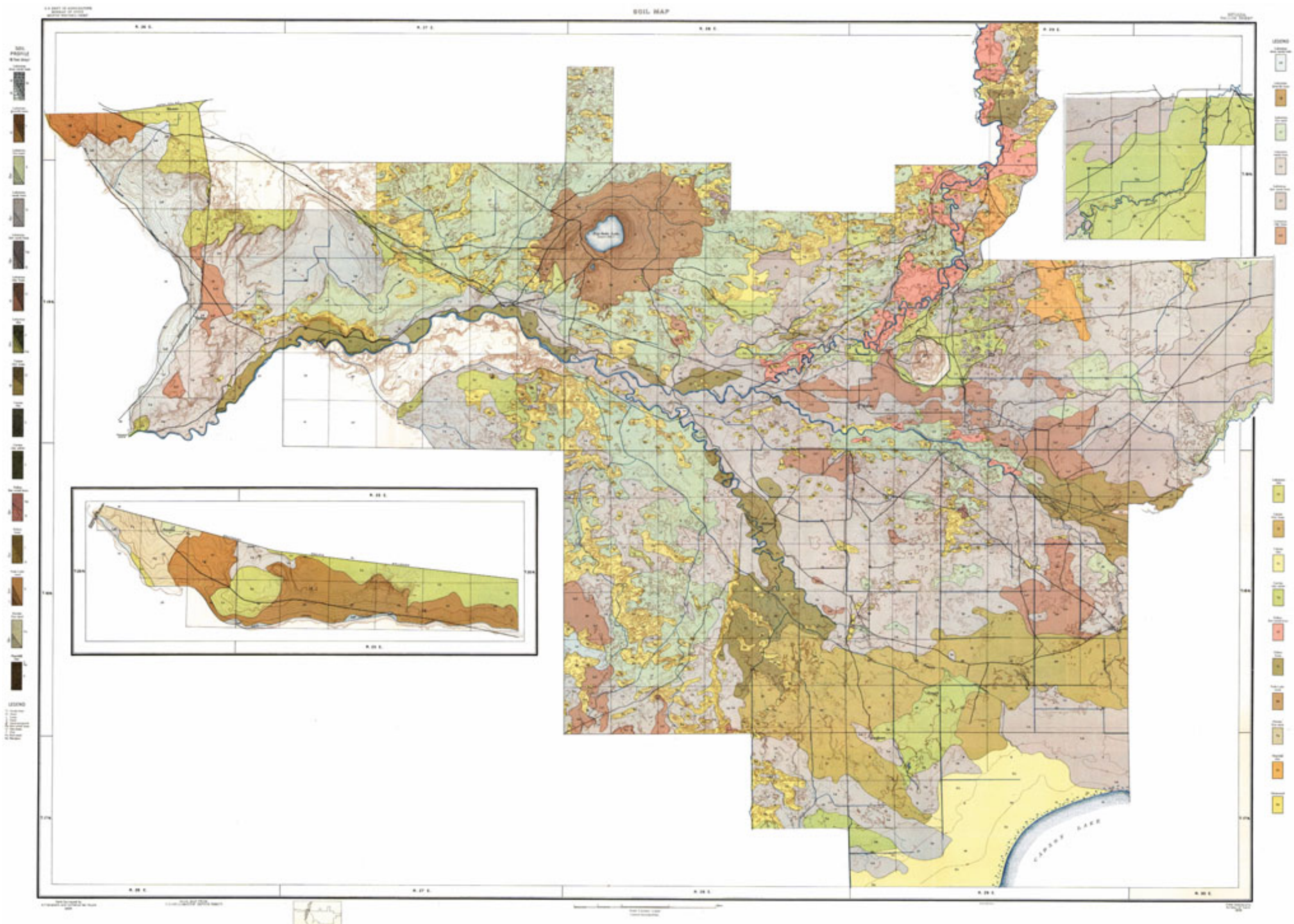

Fig. 1.6 Soil Survey of Fallon Area, Nevada in 1909. The map shows six soil series, nine soil types, and one land unit (*Source* Strahorn and Van Duyne, 1909)

Table 1.4 Definitions of diagnostic horizons present in Nevada soils[a]

Diagnostic surface horizons (epipedons)	
Anthropic	at least 25 cm thick; formed in human-altered or human-transported materials; contains artifacts, midden material, or anthraquic conditions
Folistic	at least 15 cm thick; organic matter content 16% or more; saturated for less than 30 days in normal years
Histic	greater than 20 cm thick; organic matter content 16% or more; saturated for more than 30 days in normal years unless artificially drained
Mollic	at least 18 cm thick; dark-colored; organic C 0.6% or more; base saturation 50% or more
Umbric	at least 18 cm thick; dark-colored; organic C 0.6% or more; base saturation less than 50%
Ochric	an altered horizon that fails to meet the requirements of other epipedons; lacks rock structure or finely stratified fresh sediments; includes underlying eluvial horizons such as albic
Diagnostic subsurface horizons	
Albic	a light-colored eluvial horizon 1 cm or more in thickness; composed of albic materials
Argillic	an illuvial horizon that gives evidence of translocation of clay, based on the ratio of that in the clay-enriched horizon to an overlying eluvial horizon, the presence of clay films (argillans)
Calcic	a non-cemented horizon of secondary carbonate accumulation with at least 15% calcium carbonate equivalent in a horizon, that is at least 15-cm thick, and has at least 5% more carbonate than an underlying layer
Cambic	an altered horizon that shows color and/or structure development, is at least 15-cm thick, and has a texture of very fine sand, loamy very fine sand, or finer

(continued)

Table 1.4 (continued)

Duripan	a horizon that is cemented in more than 50% of the volume by opaline silica; air-dry fragments do not slake in water of HCL but do slake in hot concentrated KOH; restricts rooting of plants except in vertical cracks that have a horizontal spacing of 10 cm or more
Gypsic	a non-cemented horizon of secondary gypsum accumulation that is 15 cm or more in thickness, contains 5% or more gypsum (1% visible), and the product of horizon thickness in cm and gypsum percentage by weight is 150 or more
Natric	meets the requirements of an argillic horizon but also has prismatic, columnar, or blocky structure, an exchangeable sodium percentage of 15 or more, or a sodium adsorption ratio of 13 or more
Petrocalcic	a carbonate-cemented horizon that is 10 cm or more thick and restricts rooting of plants except in vertical cracks that have a horizontal spacing of 10 cm or more
Petrogypsic	a gypsum-cemented horizon that is 5 mm or more thick with at least 40% gypsum by weight and restricts rooting of plants except in vertical cracks that have a horizontal spacing of 10 cm or more
Salic	a horizon of accumulation of salts more soluble than gypsum that is at least 15 cm thick; the electrical conductivity (EC) is at least 30dS/m for 90 consecutive days; the product of horizon thickness in cm and the EC is 900 or more

[a]Revised from Buol et al. (2011)

Table 1.5 Simplified key to soil orders in Nevada[a]

Histosols	Soils that do not have andic soil properties in 60% or more of the upper 60 cm and have organic soil materials in two-thirds or more of the total thickness
Andisols	Other soils with andic soil properties in 60% or more of the upper 60 cm
Vertisols	Other soils with a layer 25 cm or more thick containing either slickensides or wedge-shaped peds, have more than 30% clay in all horizons between depths of 18 and 50 cm or a root-limiting layer if shallower, and have cracks that open and close periodically
Aridisols	Other soils with either an aridic soil moisture regime and some diagnostic surface and subsurface horizons or a salic horizon accompanied by both saturation within 100 cm of the soil surface and dryness in some part of the soil moisture control section during normal years
Mollisols	Other soils with a mollic epipedon and a base saturation (by ammonium acetate at pH 7) of 50% or more in all depths above 180 cm
Alfisols	Other soils with an argillic or natric horizon
Inceptisols	Other soils with an umbric or mollic epipedon, or a cambic horizon, or a salic horizon, or a high exchangeable sodium percentage which decreases with increasing depth accompanied by groundwater within 100 cm of the soil surface
Entisols	Other soils

[a]Revised from Buol et al. (2011)

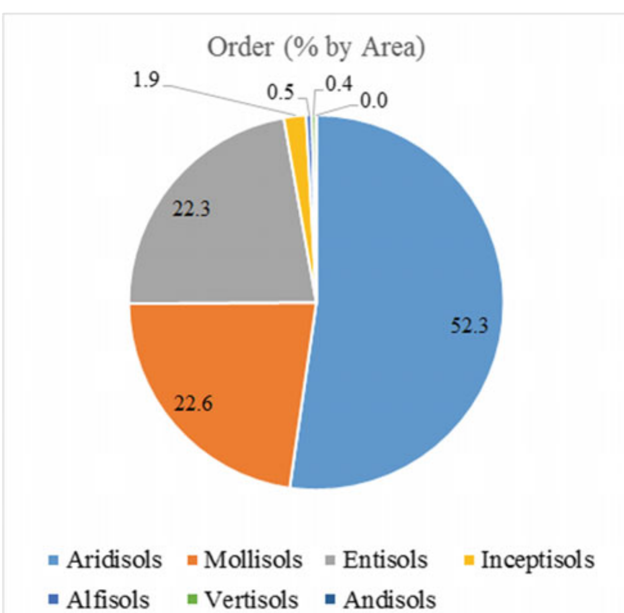

Fig. 1.7 Distribution of soil orders in Nevada (*Source* NRCS database)

1.5 Conclusions

Soil is viewed in this book as a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter *or* the ability to supported rooted plants in a natural environment (Soil Survey Staff 1999).

About 89% of Nevada has been mapped. The state is divided into 10 Major Land Resource Areas and 43 ecoregions that reflect differences in physiography, geology, climate, water, soils, biological resources, and land use. The first soil survey in Nevada was conducted in 1909 in the Fallon Area. This book uses *Soil Taxonomy* (Soil Survey Staff 1999) and the *Keys to Soil Taxonomy* (Soil Survey Staff 2014), which classifies soils into 12 orders based on the presence of diagnostic horizons and characteristics, as well as soil climate (e.g., Aridisols); suborders are delineated primarily on soil climate but also on the types of parent material and salts; other categories in this hierarchical systems are great groups, subgroups, families, and soil series. Nevada has 6 of the 8 diagnostic surface horizons identified in soil taxonomy and 10 of the 20 diagnostic subsurface horizons. Aridisols (52%) are the dominant soil order in Nevada, followed by Mollisols (23%), Entisols (22%), Inceptisols (1.9%), Alfisols (0.5%), Vertisols (0.4%), and Andisols (0.1%).

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Strahorn AT, Van Duyne C (1909) Soil Survey of the Fallon Area, Nevada. In: Field Operations of the Bureau of Soils, Washington, D.C., pp. 1477–1515

2 History of Soil Studies in Nevada

Abstract

Nevada has a rich and long history of soil investigations, which began with the Soil Survey of the Fallon Area in 1909 by the Bureau of Soils and continued with the mapping of all or portions of all 16 counties in Nevada under the leadership of the Soil Conservation Service and later the Natural Resources Conservation Service. This chapter traces the history of soil surveys, briefly describes the nature of soil research, and highlights the Orovada soil series, Nevada's official state soil.

2.1 Introduction

Nevada has a rich and long history of soil investigations that began with the Soil Survey of the Fallon Area in 1909 by the Bureau of Soils (Fig. 1.6) and continued with the mapping of all or portions of all 16 counties in Nevada generally at a scale of 1:24,000 (Table 2.1). This work has been complemented by soil research by university and NRCS, BLM, and USFS personnel over the past 60 years.

2.2 Soil Surveys

Following the initial soil survey of the Fallon Area in 1909, only two other surveys, the Las Vegas Area and the Moapa Valley) were completed in Nevada prior to 1967 (Fig. 2.1). Maps completed between 1909 and 1928 showed a limited number of soil series, the primary soil map unit. In the early 1960s, great soil groups identified by Baldwin et al. (1938) were depicted on soil maps in Nevada. Beginning in the early 1960s, the *Seventh Approximation*, a precursor to *Soil Taxonomy* (Soil Survey Staff 1975, 1999) was employed, and from 1975 to the present, soil taxonomy has been used exclusively throughout the U.S. From the mid-1970s to 2008, the cumulative number of soil surveys in Nevada increased exponentially.

The only areas that have not been mapped in Nevada are the Sheldon Antelope Refuge Area that includes parts of Humboldt and Washoe Counties (NV792); the north part of the Humboldt National Forest that includes part of Elko County (NV764); the central part of the Toiyabe National Forest that includes parts of Eureka, Lander, and Nye Counties (NV782); Death Valley National Park Area that includes parts of Esmeralda and Nye Counties (CA793), and the Energy and Defense Area that includes parts of Clark, Lincoln, and Nye Counties (NV786) (Fig. 1.3).

In 1909, only four soil series had been identified in Nevada, including the Carson, Churchill, Lahontan, and Soda Lake series. From 1909 through 1965, only 126 soil series had been mapped in the state, but accelerated soil survey beginning in the late 1970s under the leadership of Ed Naphan (Blackburn 2000) led to an exponential increase in the number of established soil series (Fig. 2.2). By 2018, over 1,800 soil series had been identified in Nevada, of which 1,309 are found only in Nevada.

2.3 Soil Research

Nevada has benefited from considerable soil research by university and NRCS investigators over the past 60 years. Key soil research efforts have focused on the nature, properties, and genesis of desert soils (Harper 1957; Springer 1958; Morrison 1964; Gile et al. 1966; Gardner 1972; Chadwick 1984; Richmond 1986); the role of eolian deposition on polygenesis of soils (Marion 1989; Chadwick et al. 1995; Reheis and Kiel 1995; Blank et al. 1996; Rehei 2003; Ernst et al. 2003); the timing of fluctuations of pluvial lakes, such as Pleistocene Lake Lahontan, in response to climate change (Chadwick and Davis 1990; Adams and Wesnouskey 1999); the origin of petrocalcic horizons (Amundson et al. 1989a, b; Brock and Buck 2005, 2009; Robins et al. 2012); the origin of duripans and durinodes (Chadwick et al. 1987, 1989); the origin of argillic and natric horizons in

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Table 2.1 Availability of printed soil surveys by county in Nevada

County	Area (km^2)	Scale	Soil survey area
Carson City	373	1:24,000	Carson City Area (1979); Tahoe Basin Area (1974; 2007)
Churchill	12766	1:24,000	Churchill County Area (2001); Fallon-Fernley Area (1975); Lovelock Area (1965)
Clark	20489	1:24,000	Clark County Area (2006); Las Vegas Valley Area (1985); Las Vegas and Eldorado Valley Areas (1967); Virgin River Area (1980)
Douglas	1839	1:24,000	Carson Valley Area (1971); Douglas County Area (1984); Tahoe Basin Area (1974; 2007)
Elko	44501	1:24,000	Diamond Valley Area (1980); Duck Valley Indian Reservation (1986); Elko County, Central Pt. (1997); Elko County, Northeastern Pt. (1998); Elko County, Southeast Pt. (2002); Northwest Elko Area (1997); Tuscarora Mountain Area (1980)
Esmeralda	9295	1:63,360	Esmeralda County Area (1991)
Eureka Humboldt	10816 25014	1:63,360 1:24,000	Diamond Valley Area (1980); Eureka County Area (1989); Northwest Elko Area (1997); Tuscarora Mountain Area (1980); Western White Pine County Area (1998) Humboldt County, East Pt. (2002); Humboldt County, West Pt. (2003)
Lander	14229	1:24,000	Lander County, North Pt. (1992); Lander County, South Pt. (1991); Tuscarora Mountain Area (1980)
Lincoln	27545	1:24,000	Lincoln County, North Pt. (2007); Lincoln County, South Pt. (2000); Meadow Valley Area (1976); Pahranagat-Penoyer Area (1968); Virgin River Area (1980)
Lyon	5164	1:20,000	Churchill County Area (2001); Lyon County Area (1984)
Mineral	9731		Mineral County Area (1991)
Nye	47001	1:24,000	Big Smoky Valley Area (1980); Nye County, Northeast Pt. (2002); Nye County, Northwest Pt. (2002); Nye County, Southwest Pt. (2004)
Pershing	15563	1:24,000	Lovelock Area (1965); Pershing County, East Pt. (1994); Pershing County, West Pt. (1998)
Storey	684	1:24,000	Fallon-Fernley Area (1975); Storey County Area (1990)
Washoe	16426	1:24,000	Fallon-Fernley Area (1975); Surprise Valley-Home Camp Area (1974; 2006); Tahoe Basin Area (1974; 2007); Washoe County, Central Pt. (1997); Washoe County, North Pt. (1999); Washoe County, South Pt. (1983)
White Pine	22991	1:24,000	Diamond Valley Area (1980); Great Basin National Park (2009); Western White Pine County; Area (1998)

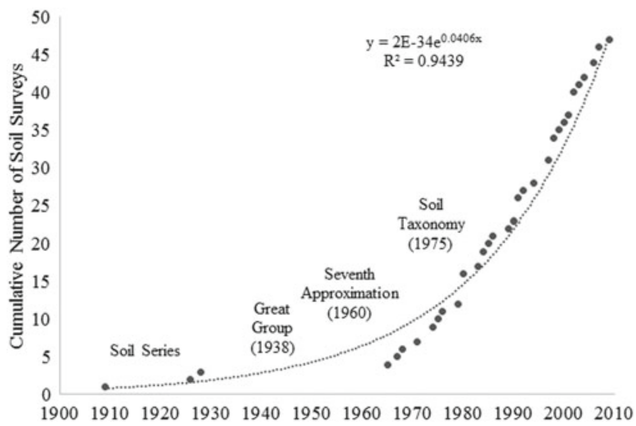

Fig. 2.1 History of soil mapping in Nevada (*Source* NRCS database)

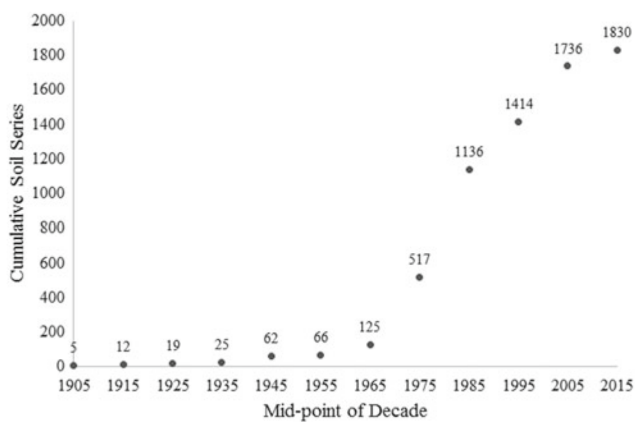

Fig. 2.2 Cumulative number of soil series in Nevada by midpoint of decade (*Source* NRCS database)

desert soils (Nettleton et al. 1975; Alexander and Nettleton 1977; Elliott and Drohan 2009); the importance of soil chronosequences in studying soil evolution (Harden et al. 1991a, b; Reheis et al. 1992); and soil-plant relationships (Nettleton et al. 1986). The Land soil series, a Typic Aquisalids, was the type locality for the salic horizon.

2.4 The State Soil

In 2001, the Orovada soil series was approved as the state soil of Nevada (Fig. 2.3). Orovada became recognized as the state soil thanks to the efforts of the Orovada Elementary School students, with soil scientist Paul Blackburn taking the proposal to the state legislators and the governor. Orovada soils are extensive in northern Nevada, comprising over 1,473 km^2. The soil is common on semiarid rangeland with sagebrush-grass plant communities. The Orovada soil is arable when irrigated and is considered prime farmland. Alfalfa for hay and seed, winter wheat, and barley, and grass for hay and pasture are the principal crops grown on these soils.

2.5 Summary

The first soil survey in Nevada was completed in 1909. Since then the entire state has been mapped except for the Sheldon Antelope Refuge Area, portions of the Humboldt and Toiyabe National Forests, Death Valley National Park Area that includes parts of Esmeralda and Nye Counties (CA793), and

Fig. 2.3 Nevada's state soil, the Orovada soil series. Photo by John Fisher

the Energy and Defense area in southern Nevada. Soil mapping increased exponentially from 1965 to 2008. Soil surveys in Nevada reflect historical changes in soil map units in the U.S., progressing from a limited number of soil series prior to 1938, mapping of zonal great soil groups until 1960, and the use of soil taxonomy thereafter. The number of soil series recognized in Nevada increased markedly from 1965 to 2008. Nearly three-quarters (72%) of the soil series recognized in Nevada occur only in the state.

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3 Soil-Forming Factors

Abstract

The soils of Nevada result from the interplay of five soil-forming factors: climate, organisms, relief, parent material, and time. This chapter considers the effects of present and past climate, vegetation, relief, geologic structure, surficial geology, time, and humans on soil formation in the state.

3.1 Introduction

The expression of a soil results from five factors operating collectively: climate, organisms, relief, parent material, and time. The factors interact and cause a range of soil processes (e.g., illuviation) that result in a diversity of soil properties (e.g., high clay content in the subsoil). Human activities cause soil changes and are often considered a sixth factor. Following the "Russian school of soil science," Kellogg (1930) illustrated the importance of geology, climate, and native vegetation on the distribution of soils in the USA. The following is a review of the role of soil-forming factors in the development of Nevada soils.

3.2 Climate

3.2.1 Current Climate

Nevada lies on the eastern, lee side of the Sierra Nevada Range, a massive mountain barrier that strongly influences the climate of the state. The prevailing winds are from the west; as the warm, moist air from the Pacific Ocean ascends the western slopes of the Sierra, the air cools and condensation takes places, causing most of the moisture to fall as precipitation. As the air descends the eastern slope, it is warmed by compression, and very little precipitation occurs. The seasonal distribution of precipitation in Nevada varies by region. A winter precipitation maximum occurs in the western and south-central portions of the state; a spring maximum occurs in the central and northeastern sections; and a summer maximum occurs primarily in the eastern portion where thunderstorms are most frequent.

With a state average of 175 mm/yr (7 in/yr), Nevada is the driest state in the U.S. The mean annual precipitation ranges from 114 mm/yr (4.5 in/yr) in southern and eastern Nevada to 890 mm/yr (35 in/yr) or more in the higher mountain ranges (Fig. 3.1). The mean annual snowfall in Nevada ranges from 0 cm in Boulder City to 178 cm (70 in) or more in the mountains, especially in the White Mountains, Snake range, Toquima Range, Spring Mountains, Schell Creek Range, Toiyabe Range, and White Pine Range.

The mean annual temperature is dependent on latitude, elevation, and aspect. The mean annual temperature varies from 5.5 °C (42 °F) at Mountain City in northernmost Nevada to 24 °C (73 °F) at Laughlin in southern Nevada. The lowest temperatures occur on the Malheur and Owyhee High Plateaus, the Sierra Nevada Range, and north-south trending mountain ranges throughout the state. The warmest temperatures occur in the Mojave Desert south of latitude 37 °N. There is strong surface heating during the day and rapid nighttime cooling, largely because of the dry air. This results in wide diurnal temperature changes that often range from 16 to 20 °C (30–35 °F). Extreme temperatures in Nevada have ranged from 49 °C (120 °F) to −46 °C (−50 °F).

The soils of Nevada are classified into four soil moisture regimes and five soil temperature regimes that vary according to latitude and elevation and reflect the large climate diversity in Nevada. The soil moisture regimes (SMR) are ranked from greatest to least in terms of area: aridic (torric), xeric, aquic, and ustic (Fig. 3.2). With the *aridic* and *torric* SMRs, the soil is dry in all parts for more than half of the cumulative days per year when the soil temperature at a depth of 50 cm (20 in) is above 5 °C (41 °F) and moist in some or all parts for less than 90 consecutive days when he soil temperature at a depth of 50 cm is above 8 °C (46 °F). With the *xeric* SMR, the winters

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