World Soils Book Series

Thor Thorson · Chad McGrath · Dean Moberg ·
Matthew Fillmore · Steven Campbell · Duane Lammers ·
James G. Bockheim

The Soils of Oregon

Springer

World Soils Book Series

Series Editor

Alfred E. Hartemink
Department of Soil Science, FD Hole Soils Laboratory
University of Wisconsin–Madison
Madison, WI
USA

The World Soils Book Series publishes peer-reviewed books on the soils of a particular country. They include sections on soil research history, climate, geology, geomorphology, major soil types, soil maps, soil properties, soil classification, soil fertility, land use and vegetation, soil management, soils and humans, soils and industry, future soil issues. The books summarize what is known about the soils in a particular country in a concise and highly reader-friendly way. The series contains both single and multi-authored books as well as edited volumes. There is additional scope for regional studies within the series, particularly when covering large land masses (for example, The Soils of Texas, The Soils of California), however, these will be assessed on an individual basis.

More information about this series at https://link.springer.com/bookseries/8915

Thor Thorson • Chad McGrath •
Dean Moberg • Matthew Fillmore •
Steven Campbell • Duane Lammers •
James G. Bockheim

The Soils of Oregon

Springer

Thor Thorson
USDA Natural Resources Conservation Service
Tualatin, OR, USA

Chad McGrath
USDA Natural Resources Conservation Service
Tigard, OR, USA

Dean Moberg
USDA Natural Resources Conservation Service
Portland, OR, USA

Matthew Fillmore
USDA Natural Resources Conservation Service
Lebanon, OR, USA

Steven Campbell
USDA Natural Resources Conservation Service
Portland, OR, USA

Duane Lammers
USDA Forest Service
Philomath, OR, USA

James G. Bockheim
University of Wisconsin-Madison
Madison, WI, USA

ISSN 2211-1255 ISSN 2211-1263 (electronic)
World Soils Book Series
ISBN 978-3-030-90090-8 ISBN 978-3-030-90091-5 (eBook)
https://doi.org/10.1007/978-3-030-90091-5

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Foreword

We walk above soil, stepping lightly on spring meadow grasses that grow out of it on our way to a favorite lake. We curse and call it mud as we attempt to clean it off our shoes and our pets after a particularly wet hike through forests in the Coast Range. We rinse it from our favorite farmer's market treats, and plant our own flowers and tomatoes in it, anticipating summer's bounty. Soil is a part of everyday life for anyone who loves the outdoors or Oregon's celebrated "foodie" culture.

But soil provides so much more richness to Oregon than most of us recognize. Created from epic floods and volcanoes, decaying plants and hungry microorganisms, healthy soils benefit every part of our lives. You don't need to be a soil scientist (or even aspire to be one), to benefit from knowing more about the value soil adds to our lives. Understanding Oregon soils helps us appreciate Oregon's rich history, natural diversity, and the cultural and economic drivers that support Oregon families today.

Soils support Oregon's Indigenous Culture. Indigenous Peoples have cared for the lands and waters of Oregon and this country since time immemorial, and continue to do so today. Their resilient communities are integrally tied to the health and abundance of the natural resources derived from soil. As Indigenous Peoples have long recognized, healthy soils support the food that people, plants, fish, and wildlife need—not just for Oregonians now, but for future generations as well.

Soils support healthy ecosystems and local economies. Western Oregon's forest soils grow big trees. When managed with care, those trees create a system that can support homes for owls, habitat for salmon, and a sustainable timber harvest. Our Eastern Oregon soils grow sagebrush where birds nurture and protect their young, and ranchers raise cattle that thrive and return nutrients to those same soils. Healthy soils capture water, holding it for use by plants during Oregon's dry, Mediterranean-like summer months. And these same soils are home to countless beneficial microorganisms that are a critical food source in the web of life.

Soils grow great food and fiber. Soils are a major component of the "terroir" that we reference when sampling a great wine in the Willamette Valley, southern Oregon, or the Columbia Gorge—supporting a $3.35 billion wine economy in Oregon[1]. Soil is the essential ingredient in which Oregon farmers are able to grow over 220 agricultural products[2]—not just for our local farmer's markets, but also for national and international consumers.

Soils cool the earth. Healthy soils can mitigate the impacts of climate change by storing carbon that has been taken out of the atmosphere by plants through photosynthesis. Sustainable management of plants and soils opens up new opportunities to sequester carbon, creating a vital tool in our ability to address a changing climate.

"The Soils of Oregon" provides those of us who are not soil scientists with a broad understanding of the soils we walk on, drive by, and consume products from every day. This book is for anyone who doesn't just want to taste great food, wine, and beer. It's for people who want to better understand the soils that make these things taste so incredibly good.

---

[1]Oregon Wine Board 2015. "Oregon's Wine Industry Contributes $3.35 Billion to Oregon's Economy."
[2]Oregon Department of Agriculture. 2021. "Oregon agricultural statistics and directory 2021." Salem, OR.

Whether you've always wanted to know what a "Lickskillet stony loam" was and what types of plants prefer it, have a burning desire to impress your friends with the difference between wines that come from Jory or Willakenzie soils, or just want to know more about how epic prehistoric floods that started in Montana result in great Oregon blueberries, this is the book for you. You can carry it with you just like you would a book on roadside geology or wildflowers, read it cover-to-cover, or keep it handy as a reference. However you choose to use your new-found knowledge, a good understanding of Oregon's soils will help you better recognize why Oregon is such a unique and special place to visit or live.

Meta Loftsgaarden
Former Executive Director
Oregon Watershed Enhancement Board
Salem, Oregon, USA

Preface

This book discusses the nature, properties, genesis, classification, and use of the soils of Oregon and provides maps of dominant soil great groups in Oregon based on Soil Taxonomy. The study of soils in Oregon originated with a reconnaissance soil survey of Baker City in 1903, shortly after the Bureau of Soils, a precursor to the Soil Conservation Service and the more encompassing Natural Resources Conservation Service (NRCS), was established. Portions of all but five of the 36 counties in Oregon have received an order 2 or 3 soil survey (scale 1:24,000). Oregon has a variety of physiographic provinces that have led to the mapping of more than 1,700 soil series in the state. This study was made easier by an abundance of natural resource maps (vegetation, geology, etc.) and other technical information. We were assisted in this endeavor by Cory Owens, Oregon State soil scientist, and Whityn Owen, NRCS Oregon GIS specialist/coordinator.

This book is dedicated to the professional soil scientists from the Natural Resources Conservation Service, US Forest Service (US Department of Agriculture), Bureau of Land Management (US Department of Interior), Bureau of Indian Affairs, National Park Service, US Fish and Wildlife Service , soil and water conservation districts, and the Oregon Agricultural Experiment Station (Oregon State University), who contributed to the mapping of soils in Oregon. We would like to acknowledge the support of these agencies and other land management agencies that contributed to soil surveys. This book could not have been written without the support of NRCS database managers.

This book originated from data collected by the USDA-Natural Resources Conservation Service, including the Soils Data Mart and Web Soil Survey, and by approximately 100 research reports dealing with the soils, geology, and vegetation of Oregon. The interpretations were made solely by the authors. This book should be of interest to individuals in federal, state, county, and non-government organizations who are interested in and responsible for safeguarding Oregon's natural resources. The book will be of interest to students in soil science and allied disciplines.

Tualatin, USA — Thor Thorson
Tigard, USA — Chad McGrath
Portland, USA — Dean Moberg
Lebanon, USA — Matthew Fillmore
Portland, USA — Steven Campbell
Philomath, USA — Duane Lammers
Madison, USA — James G. Bockheim

Contents

About the Authors

Thor Thorson was the USDA Oregon Natural Resources Conservation Service (NRCS) State Soil Scientist from 2012 to 2015. He is a native of Wisconsin and attended the University of Wisconsin-Madison, graduating with a Bachelor's degree in Soil Science in 1974. In 1974 he began his career with USDA as a field Soil Scientist in California. He worked on four California soil surveys prior to transferring to Oregon in 1980 as the Oregon State Soil Correlator. From 1983 to 2012 he held positions as Oregon Assistant State Soil Scientist and as a Regional Soil Data Quality Specialist covering parts of Oregon, Idaho, and Washington. He retired in 2015 from government service and resides in the Portland, Oregon area. He enjoys golfing, hunting, and fishing and continues to provide soil expertise to the Oregon NRCS as a volunteer.

Chad McGrath received his B.S. degree in Forest Resource Management from the University of Idaho in 1966. He then served as an officer in the US Navy. In 1975, he received his M.S. degree in Forest Soils from the University of Idaho. He worked as a Soil Scientist for the Idaho Soil Conservation Commission from 1975 to 1976. In 1976, he was hired as a Soil Scientist by the Soil Conservation Service: 1976–1977 Power County Area, Idaho; 1977–1978 Oneida County Area, Idaho; 1978–1983 Soil Survey Project Leader for four surveys in southeastern Idaho; completed Soil Survey Reports for two of those surveys; 1983–1987 Area Soil Scientist for Southeastern Idaho; 1987–1995 Soil Correlator for Idaho. In 1995 he moved to Portland, Oregon as State Soil Scientist and Leader for MLRA Regional Office One which covered parts of Oregon, Idaho, and most of Washington. As State Soil Scientist he provided leadership for the soil survey program in Oregon. MLRA Regional Office provided technical assistance and guidance for all aspects of the soil surveys within the area of responsibility. In 2012, he retired from the Natural Resources Conservation Service.

Dean Moberg joined the USDA-Natural Resources Conservation Service (NRCS) in 1984 and worked for NRCS in Oregon, Wisconsin, and Michigan. His final position was to serve as the Basin Resource Conservationist in northwest Oregon. Prior to NRCS, Dean taught high school and worked on vegetable farms, dairy farms, and a maple syrup operation. He obtained his B.S. in Plant Science from the University of California, Davis, a M.A. in Teaching from Cornell University, and a Ph.D. in Environmental Science and Engineering from Oregon Health & Sciences University. Dean and his wife Sara have two daughters. His hobbies include fly fishing, scuba diving, skiing, and gardening.

Matthew Fillmore attended Oregon State University (OSU) in Corvallis where he received B.S. degrees in Soil Science and Wildlife Science in 1976. He began his more than 37-year career with USDA Soil Conservation Service in Oregon as a field Soil Scientist in 1977 working in Linn County. In 1983 he was transferred to Baker County in northeastern Oregon. In 1987 he was promoted to Soil Survey Project Leader for the Curry County survey project in southwestern Oregon. In 1994 he moved back to Corvallis and was stationed in the Soil Science Department at OSU to begin the initial MLRA-based update for Oregon in Benton

County under the newly named USDA-Natural Resources Conservation Service. In 2008 he became the initial MLRA Soils Office Leader for all of western Oregon based in Salem. He mapped over 1 million acres throughout Oregon and authored three soil survey manuscripts (Curry, Benton, and Tillamook counties) during his career. He retired in 2013 from government service and lives in Lebanon, Oregon. He enjoys woodworking, baseball and softball, fishing, traveling, and photography in retirement.

Steven Campbell obtained B.S. degree in Forest Management from Washington State University in 1976. He has been a soil scientist with the Natural Resources Conservation Service from 1976 to the present, including being a Project Member and Project Leader for soil survey areas in Washington State, Resource Soil Scientist in the Spokane Washington Area Office, Soil Scientist at the NRCS State Office in Portland, Oregon, Soil Data Quality Specialist in the Pacific Northwest Soil Survey Regional Office in Portland, and is at present Soil Scientist at the West National Technology Support Center in Portland. His current responsibilities include providing training and technical support to the West Region States on a wide variety of soils-related topics.

Duane Lammers received a B.S. degree in Agricultural Science (Soils) from Montana State University in 1967 and a Ph.D. in Soils from Utah State University in 1975. He was then employed by the Soil Conservation Service in Utah 1975–1976—Alton Pipeline Corridor Soil Survey, 1976–1983 Project Leader on three soil survey areas in southeastern Utah, 1983-1985 Monitoring and Evaluation Team Leader, Uinta Basin Colorado River Salinity Project. In 1985 he moved to Corvallis, Oregon, and a U.S. Forest Service position in an acidic deposition study—the Direct-Delayed Response Project. For this project, Duane lead the soil mapping effort of watersheds selected for study in the Southern Blue Ridge, Mid-Appalachian, and NE United States. In 1990 he accepted a job as Soil Correlator for Region Six (WA and OR) of the Forest Service. His work from 1990 to 2008 included field review, correlation, and classification of soils on NF System Lands in Oregon and Washington. Most of his work on forests in Oregon was on the east side of the Cascade Range where soils have been influenced by tephra from Mt. Mazama. He considers this to be one of the "big" stories about soils in Oregon.

James G. Bockheim was a professor of Soil Science at the University of Wisconsin from 1975 until his retirement in 2015. He has conducted soil genesis and geography studies in many parts of the world, including five field seasons along the Oregon coast. Jim lives in Oregon, Wisconsin. He enjoys writing, reading, biking, photography, and traveling.

Acronyms and Abbreviations

ac	Acre
AFO	Animal Feeding Operation
Al	Aluminum
AUM	Animal unit month
B	Boron
B&B	Balled and burlapped nursery stock
BLM	Bureau of Land Management
°C	Degrees Celsius
C	Carbon
Ca	Calcium
$CaCO_3$	Calcium carbonate
CAFO	Concentrated Animal Feeding Operation (federal acronym)
CAFO	Confined Animal Feeding Operation (Oregon acronym)
CBD	Cannabidiol
CEC	Cation exchange capacity
cfs	Cubic feet per second
CH_4	Methane
cm	Centimeter
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CRP	Conservation Reserve Program
CSA	Community supported agriculture
Cu	Copper
CWA	Clean Water Act (United States)
CWPP	Community Wildfire Protection Plan
DLCD	Department of Land Conservation and Development (Oregon)
DOD	Department of Defense (United States)
DOGAMI	Department of Geology and Mineral Industries (Oregon)
DOI	Department of Interior (United States)
dS	Decisiemens
EC	Electrical conductivity
EFU	Exclusive farm use
EPA	Environmental Protection Agency (United States)
ESA	Endangered Species Act
ESD	Ecological site description
Fe	Iron
FEMA	Federal Emergency Management Agency
FIA	Forest Inventory and Analysis
FSA	Farm Service Agency
FSG	Forage suitability group
GHG	Green house gas

GWP	Global warming potential
ha	Hectare
HCl	Hydrochloric acid
HEL	Highly erodible land
IET	Integrated Erosion Tool
in	Inch
IPCC	Intergovernmental Panel on Climate Change
K	Potassium
ka	Thousands of years ago
KCl	Potassium chloride
kg	Kilogram
km	Kilometer
KOH	Potassium hydroxide
LCC	Land capability class
LCDC	Land Conservation and Development Commission
M	Magnitude (when used in connection with earthquakes)
m	Meter
M	Molar (when used in connection with chemical solutions)
MAAT	Mean annual air temperature
MAP	Mean annual precipitation
Mg	Magnesium
MLRA	Major land resource area
mm	Millimeter
MMBF	Million board feet
Mn	Manganese
Mo	Molybdenum
Mt	Million metric tonnes
N	Nitrogen
N_2O	Nitrous oxide
NaF	Sodium fluoride
NaOH	Sodium hydroxide
NASIS	National Soil Information System
NASS	National Agricultural Statistics Service
NCS	Natural climate solutions
NFIP	National Flood Insurance Program
NFSAM	National Food Security Act Manual
NH_4-N	Ammonium nitrogen
NIPF	Non-industrial private forestland
NO_3-N	Nitrate nitrogen
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service (United States)
NRI	National Resource Inventory
NWOS	National Woodland Owner Survey
O&C	Oregon and California (railroad)
OCCRI	Oregon Climate Change Research Institute
OCMP	Oregon Coastal Management Program
ODA	Oregon Department of Agriculture
ODF	Oregon Department of Forestry
OPOA	Oregon Property Owners Associatoin
OSSPAC	Oregon Seismic Safety Policy Advisory Commission
OSU	Oregon State University

OWRD	Oregon Water Resources Department
P	Phosphorus
PRISM	Parameter-elevation Regressions on Independent Slopes Model
PSNT	Pre-sidedress nitrate test
RCP	Representative concentration pathway
REIT	Real estate investment trust
RUSLE2	Revised Universal Soil Loss Equation
S	Sulfur
SI	Site index
SMR	Soil moisture regime
SNC	Swiss needle cast
SOC	Soil organic carbon
SOD	Sudden oak death
SSURGO	Soil Survey Geographic Database
STATSGO2	Digital General Soil Map of the United States
STR	Soil temperature regime
SWCD	Soil and water conservation district
t	Metric tonne
T	Soil loss tolerance
THC	Tetrahydrocannabinol
TIMO	Timber investment management organization
UGB	Urban growth boundary
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
W	Watt
WEPS	Wind Erosion Prediction System
WSS	Web Soil Survey
WUI	Wildland-urban interface
yr	Year
Zn	Zinc

Introduction

1

1.1 Etymology

The origin of the word "Oregon" is disputed. However, three suggestions suggest that it originates from (1) the French Canadian word, *ouragan*, which means "windstorm" after the chinook winds on the lower Columbia River; (2) *orejón*, meaning "big ear," after Indigenous Peoples living in the area; and (3) the spice, orégano, which grew in the territory (http://www.netstate.com).

1.2 Geography

Oregon is bounded by the Pacific Ocean on the west, the Columbia River on the north, the Snake River and the 117°W longitude on the east, and the 42nd parallel on the south. At 254,800 km^2 (98,380 mi^2), Oregon is the ninth largest state in the United States. The state is 475 km (295 mi) north to south and 635 km (395 mi) east to west. Elevation varies from 0 m along the Pacific Coast to 3,429 m (11,249 ft) at the summit of Mt. Hood. Oregon has some of the most diverse terrain in the United States, including an eroded ancient mountain chain (Coast Range), a tectonically active mountain range (Cascade Mountains), an area with substantial serpentinite (Klamath Mountains), a glaciated mountain range in the northeast (Blue Mountains), a valley (Willamette) filled with multiple layers of sediments from catastrophic Pleistocene floods, high plateaus (Deschutes–Umatilla Plateau, Owyhee and High Lava Plains), and alternating mountain ranges and valleys resulting from faulting due to tectonic activity (Basin and Range).

Major water bodies in Oregon are shown in Fig. 1.1. Major rivers that drain from the Coast Range or Klamath Mountains to the Pacific Ocean include, from north to south, the Nehalem, Nestucca, Siletz, Yaquina, Siuslaw, Umpqua, Millicoma, Coos, Coquille, Elk, Rogue, Pistol, Chetco, and Winchuck. The Smith and Klamath Rivers (Williamson, Sprague, and Lost), in southwest Oregon, flow into California, then to the Pacific Ocean. Major rivers draining into the Columbia River include, from west to east, the Willamette (Clackamas), Sandy (Salmon), Hood, Deschutes (Crooked), John Day, and Umatilla (Butte). Rivers draining into the Snake River include, from north to south, Grande Ronde (Wallowa and Lostine), Imnaha, Powder, Burnt, Malheur, and Owyhee. Crater Lake, a drowned crater from the eruption of Mt. Mazama, is the deepest lake in the United States at 594 m (1,949 ft) and second largest (53 km^2) natural water body in Oregon. Smaller lakes in the High Cascades include Diamond, Waldo, and Odell.

Major lakes in Oregon that are remnant from larger pluvial lakes from the late Wisconsinan include Upper Klamath Lake (249 km^2), Malheur Lake (201 km^2), Harney Lake (107 km^2) and lakes in Lake County (Goose Lake, 380 km^2; Lake Abert, 150 km^2; Summer Lake, 109 km^2; and the Warner Lakes) (Fig. 1.1). Major reservoirs include Fern Ridge (410 km^2), Lake Wallula (157 km^2), Hells Canyon Reservoirs (61 km^2), and Wickiup Reservoir (45 km^2).

1.3 Demographics

With a population of 4.2 million, Oregon was the 27th most populous US state in 2019. Major cities and 2019 populations include Portland (653,000), Salem (174,000; also the capital city), Eugene (173,000), Gresham (109,000), Hillsboro (109,000), Beaverton (99,000), Bend (100,000), Medford (83,000), Springfield (63,000), Corvallis (59,000), Aloha (55,000), Tigard (56,000), and Albany (55,000) (United States Census Bureau 2021). Oregon is divided into 36 counties that range in size from Multnomah County, which is the smallest (1,204 km^2) to Harney County, which is the largest (26,490 km^2) (Fig. 1.2) (Oregon Secretary of State 2021).

T. Thorson et al., *The Soils of Oregon*, World Soils Book Series,
https://doi.org/10.1007/978-3-030-90091-5_1

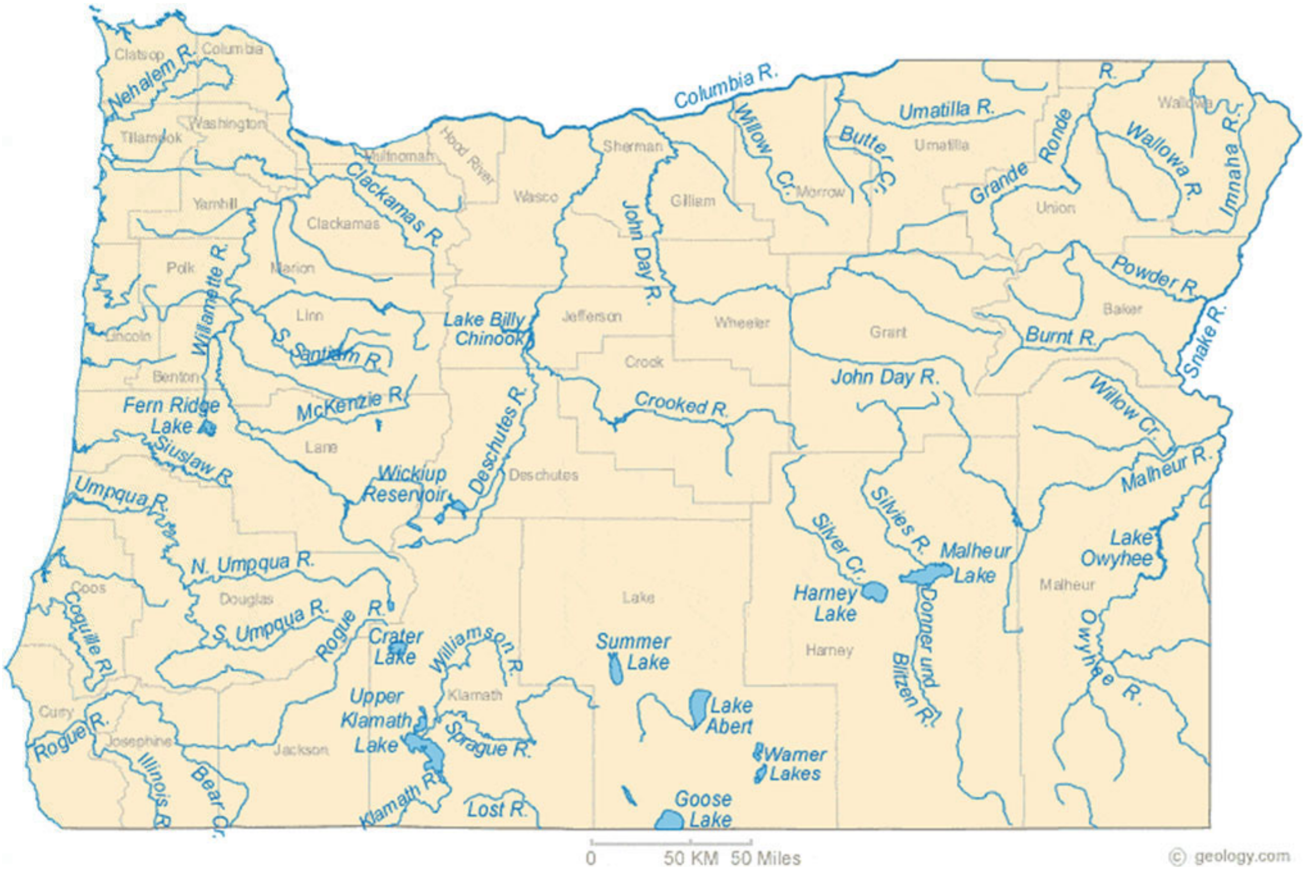

Fig. 1.1 The rivers and lakes of Oregon. *Source* http://geology.com

1.4 History

Artifacts from Indigenous Peoples[1] who lived in Oregon 15,000 years ago have been recovered throughout the state. By the sixteenth century, a number of indigenous tribes lived in Oregon, including the Chinook, Coquille, Bannock, Chasta, Kalapuya (Calapooya), Klamath, Klickitat, Molalla, Nez Perce, Takelma, Killamuk, Neah-kah-nie, Umatilla, and Umpqua.

The first Europeans to visit Oregon were Spanish explorers led by Juan Rodriguez Cabrillo in 1543. Sir Francis Drake, sailing in the Golden Hind, sheltered near Cape Arago in 1579. In 1778, James Cook explored the Oregon coast. French Canadian trappers and missionaries arrived in Oregon in the late 1700s and early 1800s. The Lewis and Clark Expedition Corps of Discovery camped the winter of 1805–1806 at Fort Clatsop, arriving and returning via the Columbia River. Representing the North West Company, David Thompson may have been the first European to navigate the entire Columbia River. John Jacob Aster financed the establishment of Fort Astoria, an outpost of the Pacific Fur Company, in 1811 at the mouth of the Columbia River. This was the first permanent European establishment in Oregon.

In the War of 1812, the British gained control of all Pacific Fur Company posts. The Treaty of 1818 gave joint custody of the region from the Rocky Mountains to the Pacific Ocean to the United States and Great Britain. The first wagon trains on the Oregon Trail arrived in the Willamette Valley in 1842. This trail provided a major conduit for emigration for more than a decade. Oregon was admitted to the US as the 33rd state in 1859.

1.5 Economy

In 2018, the gross domestic product for Oregon was $214 billion, ranking as the sixth wealthiest state in the United States. Manufacturing accounts for 47% of the GDP, including high-technology industries located in the “Silicon Forest,” the industrial corridor between Beaverton and Hillsboro. Agriculture, forestry, and fishing account for

[1] Terminology used here follows, as much as possible, guidance set forth in Gregory Younging’s Elements of Indigenous Style (2018).

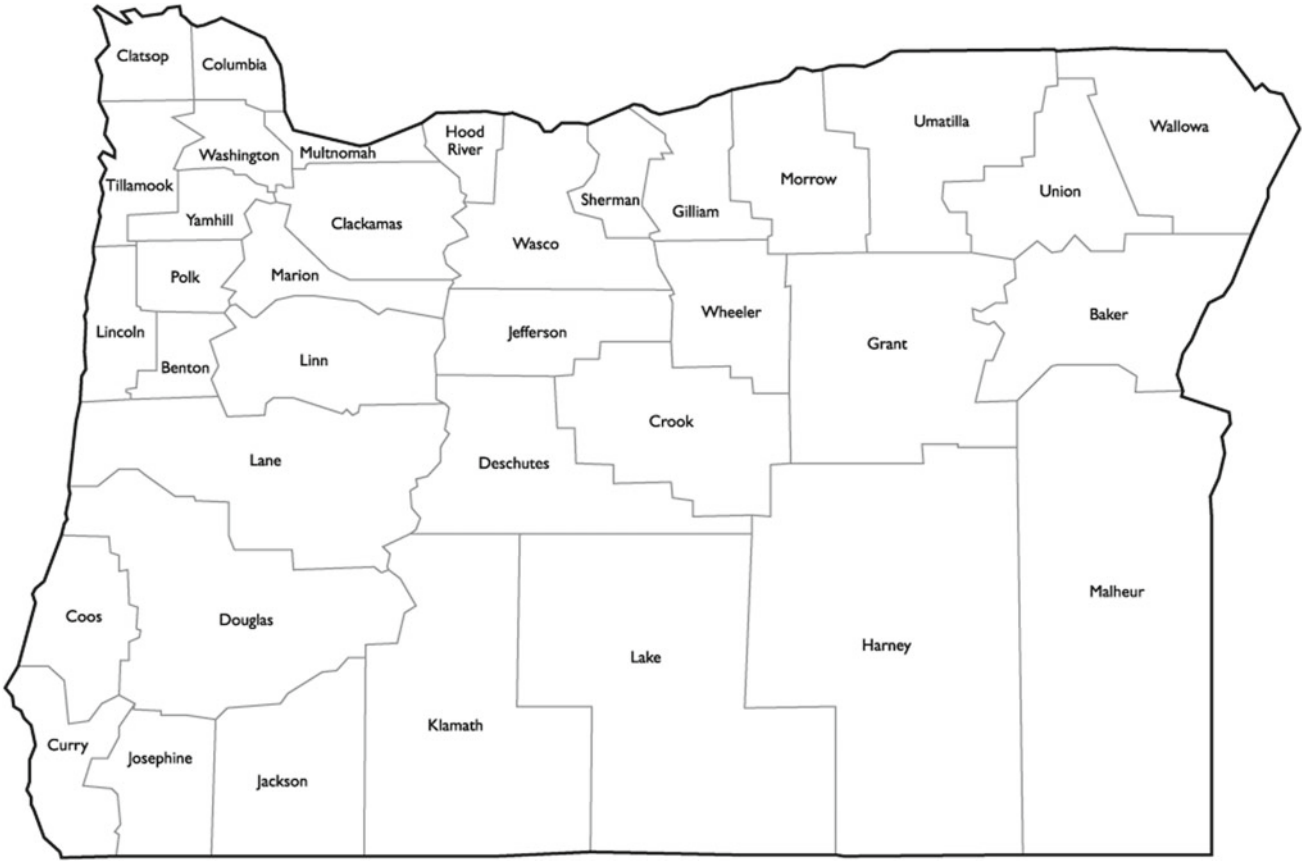

Fig. 1.2 Oregon counties. *Source* GIS Geography

4.2% of the GDP. The top five agricultural industries are greenhouse and nursery products, hay, cattle and calves, milk, and grass seed. Oregon is the top producer of softwood lumber in the contiguous United States and has one of the largest salmon fisheries in the world.

1.6 Summary

The origin of the word "Oregon" may originate from the French Canadian word, ouragan, which means "windstorm," orejón, meaning "big ear," after Indigenous Peoples living in the area; or the spice, orégano, which grew in the territory. Oregon is the ninth largest state in the United States and is one of the most diverse states in the United States, in terms of elevation, rock types, physiographic provinces, climate, and vegetation. Oregon is the 27th most populous state in the United States, with 70% of the population living in the Willamette Valley. The history of Oregon includes Indigenous Peoples, Spanish explorers, French Canadian trappers and missionaries, the Lewis and Clark Voyage of Discovery in 1804–1806, and settlers who arrived along the Oregon Trail in 1842–1843. In 2018, Oregon was ranked sixth in the USA in gross domestic products, primarily from manufacturing. Agriculture, forestry, and fishing are important industries in the state.

References

Oregon Secretary of State (2021) Oregon blue book. Retrieved May 27, 2021, from https://sos.oregon.gov/blue-book/Pages/default.aspx

U.S. Census Bureau (2021) Explore census data. Retrieved May 27, 2021, from https://data.census.gov/cedsci/

Younging G (2018) Elements of Indigenous style: a guide for writing by and about Indigenous Peoples. Brush Education Inc

2 History of Soil Studies in Oregon

2.1 Introduction

Oregon has a rich and long history of soils investigations that began at the turn of the twentieth century with 1:63,360-scale soil surveys of Baker City (Jensen and Mackie 1903) and Salem (Jensen 1903) by the Bureau of Soils under the auspices of Milton Whitney. The first countywide soil survey was of Yamhill County during World War I (Kocher et al. 1917). As of 2020, all or a large portion of 32 of the 36 counties in Oregon have been mapped, generally at a scale of 1:24,000. Soil mapping continues at present, largely by the Natural Resources Conservation Service (NRCS), with the assistance of federal agencies such as the US Forest Service (USFS), the Bureau of Land Management (BLM), the US Fish and Wildlife Service, the National Park Service, and Indigenous tribes. This work has been complemented with soils research by university, the Natural Resources Conservation Service (NRCS), BLM, and USFS personnel over the past 55 years.

2.2 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 (v) 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."

2.3 Soil Surveys

Under the auspices of Milton Whitney, the Bureau of Soils conducted the first soil surveys in Oregon at Baker City (Fig. 2.1) and Salem (Fig. 2.2). The first countywide soil survey in Oregon was of Yamhill County Area in 1917 (Fig. 2.3).

Soil mapping in Oregon increased from 1900 to 1930 and then proceeded slowly from 1930 to 1970 as the United States endured the Great Depression, World War II, and the Vietnam War (Fig. 2.4). The cumulative number of soil surveys increased sharply from 1970 to 2010 and has since tapered off. These trends also are reflected by the cumulative area of the state that has been mapped. Nearly two-thirds (64%) of the soil mapping to date occurred between 1975 and 1990 (Fig. 2.5). These trends reflect the development of a new soil classification system, the *Seventh Approximation*, when soil mapping began in earnest in Oregon. The last archived soil survey in Oregon was of Tillamook County in 2013 (Table 2.1). At the present time, mapping is reported digitally on Web Soil Survey, and about 68% of the state has received detailed soil mapping (Fig. 2.6). Only Alaska and Idaho have greater proportions of areas unmapped in the United States. About 26% of Oregon is undergoing initial surveying, particularly in Malheur, Grant, Wheeler, and Crook Counties and in portions of Linn, Lane, and Klamath Counties. When these areas are complete, only about 6% of the state will remain unmapped.

Table 2.1 provides a listing for all of Oregon's archived published soil surveys and their publication date. All of the survey text material is available online. In about 2005, the USDA phased out printing soil survey reports and made the Web Soil Survey the official source for soil survey information. In most cases, published soil survey reports are available for reference and information at local NRCS offices and public libraries. However, copies for distribution are not available. Official soil survey information for all of the Oregon soil survey areas shown in Fig. 2.6 is available online using Web Soil

T. Thorson et al., *The Soils of Oregon*, World Soils Book Series,
https://doi.org/10.1007/978-3-030-90091-5_2

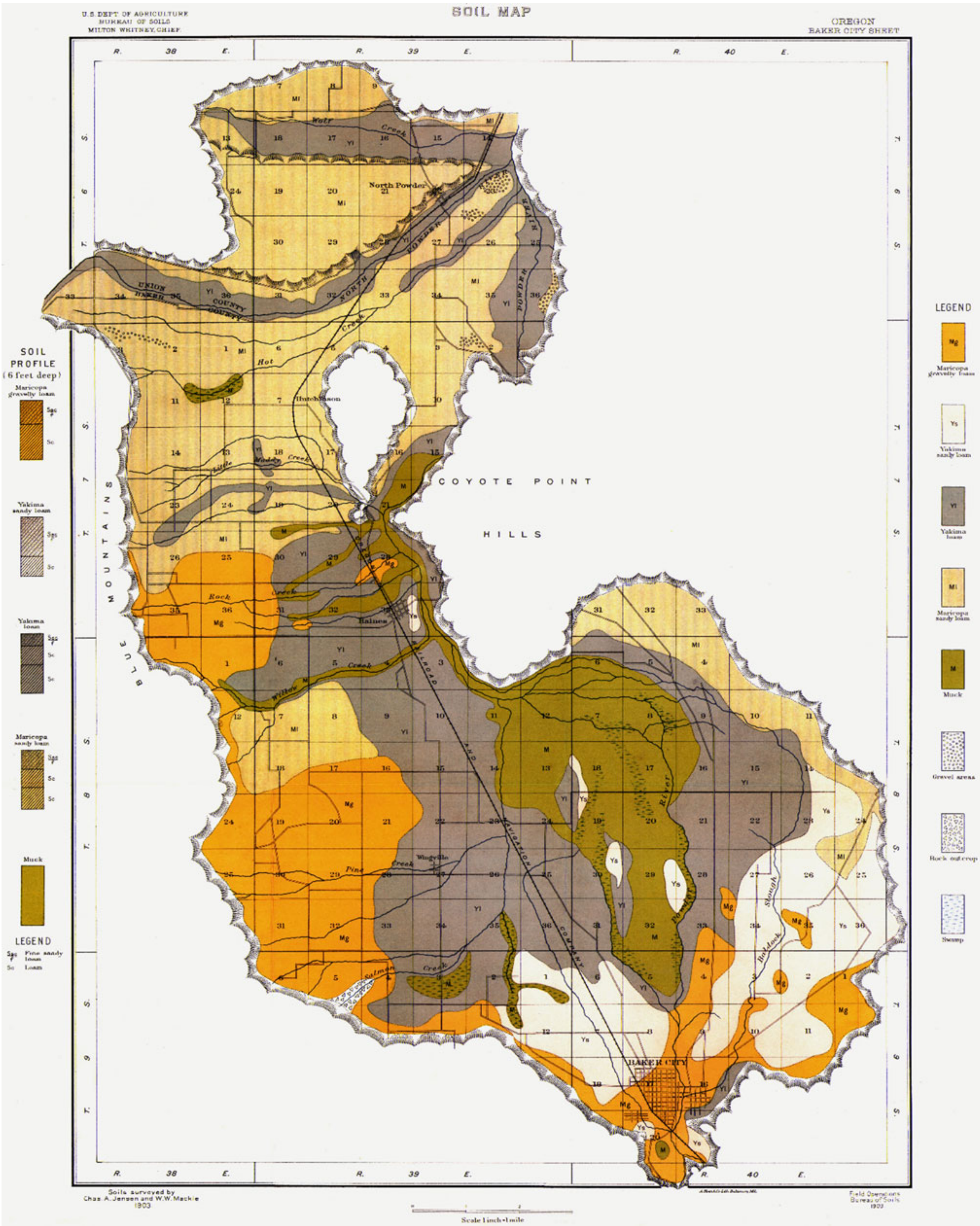

Fig. 2.1 Soil map of Baker City, Oregon, published in 1903 at a scale of 1:63,360. *Source* USDA Bureau of Soils, 1903

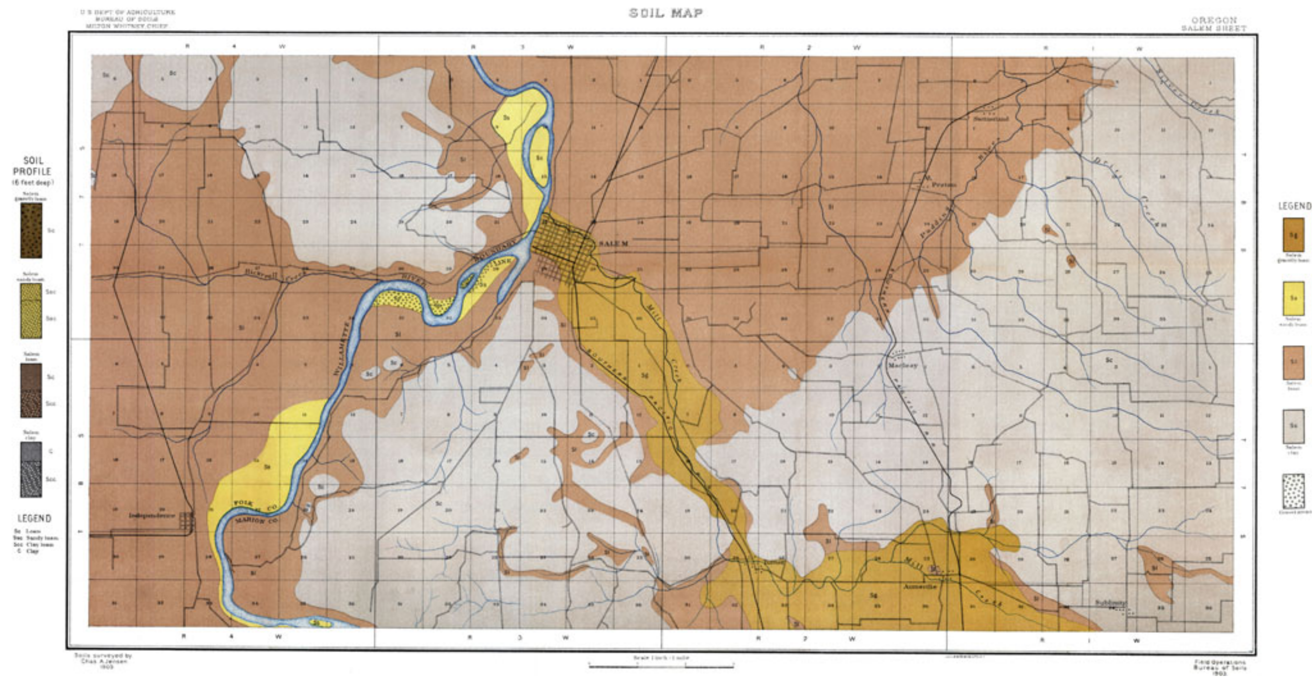

Fig. 2.2 Soil map of Salem, Oregon, published in 1903 at a scale of 1:63,360. *Source* USDA Bureau of Soils, 1903

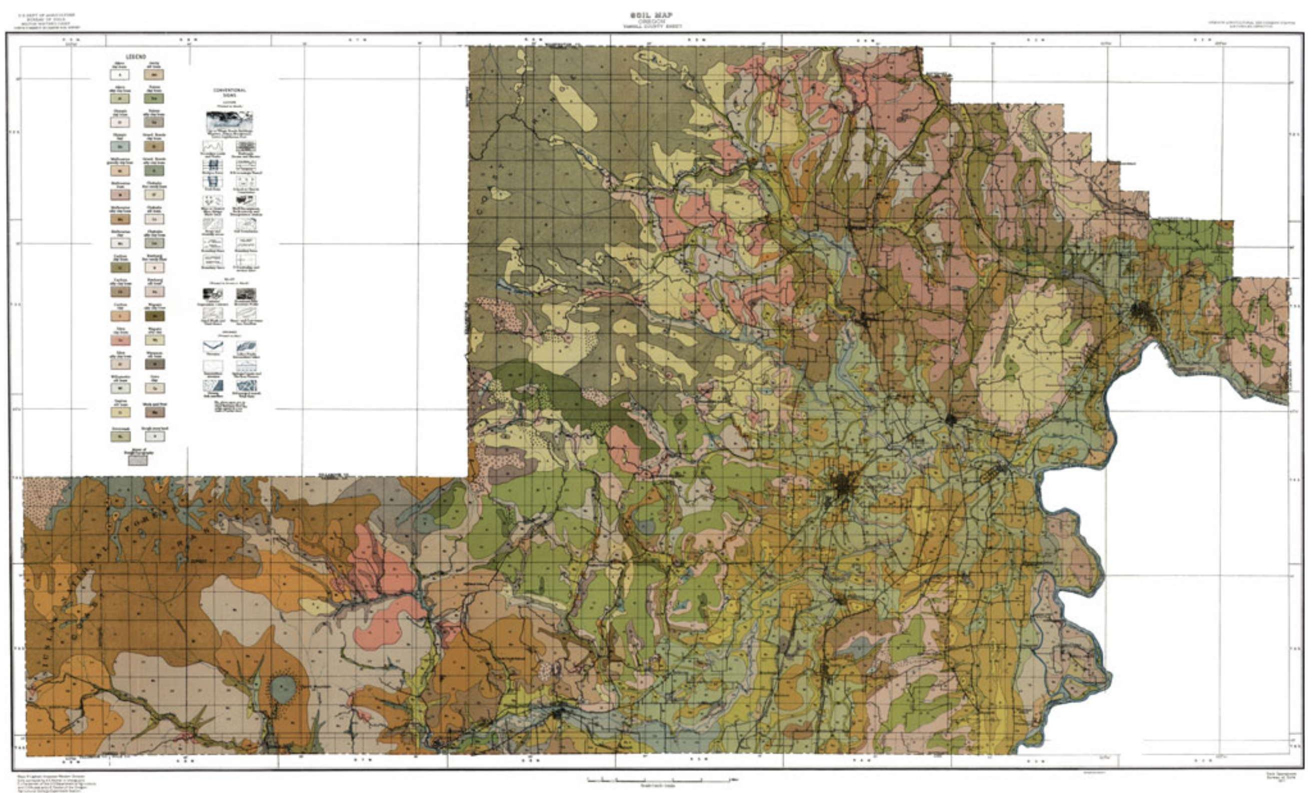

Fig. 2.3 General soil map of Yamhill County, Oregon, published in 1917 at a scale of 1:63,360. *Source* USDA Bureau of Soils, 2017

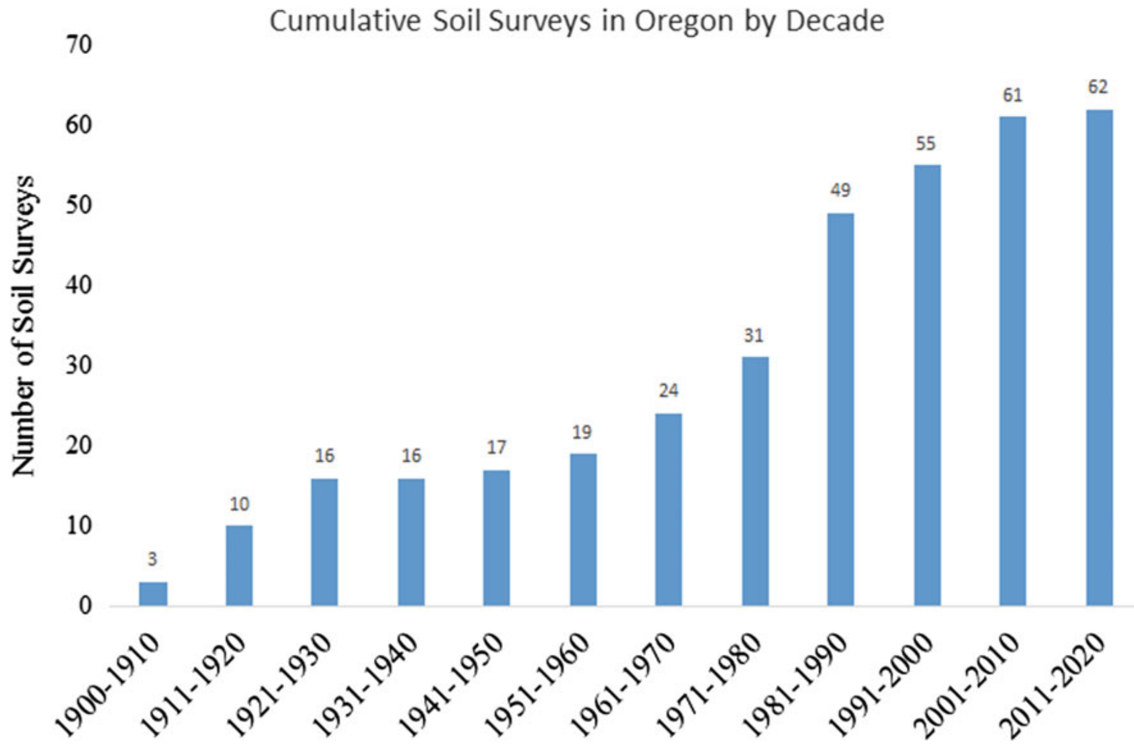

Fig. 2.4 Cumulative soil surveys in Oregon by decade

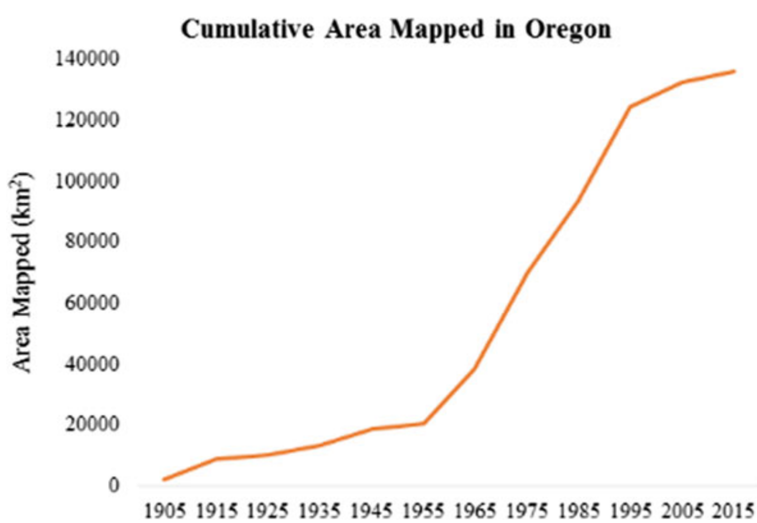

Fig. 2.5 Cumulative area mapped in Oregon by decade

Survey at https://websoilsurvey.sc.egov.usda.gov. To start using Web Soil Survey, click on one of the links under Browse by Subject or on the large green button that says start WSS. The amount of soil information for any given survey will depend on the completeness of the survey. Areas in green in Fig. 2.6 are very complete, areas in yellow are ongoing and data is less complete, and areas in gray have little or no information.

2.4 Soil Series

The early concept of the soil series is that all occurrences of a series would have the same, or very nearly the same, chemical composition because they were derived from the same rocks. Maps completed between 1903 and 1914

Table 2.1 Archived Oregon soil survey publications

Soil survey name	Publ. date
Alsea Area	1973
Astoria Area	1949
Baker Area	1954
Baker City Area	1903
Baker County Area	1997
Benton County Area	1975
Benton County	1920
Benton County	2009
Clackamas County Area	1985
Clackamas County	1926
Clatsop County	1985
Columbia County	1925
Columbia County	1986
Coos County	1989
Crater Lake National Park	2009
Curry Area	1970
Curry County	2005
Deschutes Area	1958
Douglas County Area	2003
Eugene Area	1930
Gilliam County	1984
Grand Ronde Valley Area	1930
Grant County, Central Part	1981
Harney County Area	2006
Hood River County Area	1981
Hood River-White Salmon River Area, OR-WA	1914
Jackson County Area	1993
Josephine County	1923
Josephine County	1983
Klamath County, Southern Part	1985
Klamath Reclamation Project	1908
Lake County, Northern Part	2012
Lake County, Southern Part	1999
Lane County Area	1987
Lincoln County Area	1997
Linn County Area	1987
Linn County	1924
Malheur County, Northeastern Part	1980
Marion County Area	1972
Marion County	1927
Marshfield Area	1911
Medford Area	1913
Morrow County	1983
Multnomah County	1919

(continued)

Table 2.1 (continued)

Soil survey name	Publ. date
Multnomah County	1983
Polk County	1928
Polk County	1982
Prineville Area	1966
Salem Area	1903
Sherman County	1964
Sherman County	1999
South Umpqua Area	1973
Tillamook Area	1964
Tillamook County	2013
Trout Creek- Shaniko Area	1975
Umatilla Area	1948
Umatilla County Area	1988
Union Area	1985
Upper Deschutes River Area	1999
Wallowa Area	2007
Warm Springs Indian Reservation	1998
Wasco County, Northern Area	1982
Washington County	1919
Washington County	1982
Yamhill Area	1974
Yamhill County	1917

showed 7 or fewer soil series and 15 or fewer soil types. Those created from 1917 to 1929 showed between 14 and 20 soil series, 27–41 soil types, and 2–6 land types (Table 2.2). In *Soils of Oregon: Their Classification, Taxonomic Relationships, and Physiography*, Huddleston (1979) reported about 800 soil series, of which over 100 series are no longer recognized in Oregon, and over 900 series have been added. Many of the early maps, particularly those of Benton County in 1920 and Marion County in 1927, were truly works of art.

By 2019 more than 1,700 soil series had been identified in Oregon, 73% of which are identified only in Oregon (Fig. 2.7). The historical trends in the number of soil surveys (Fig. 2.4) and soil series (Fig. 2.8) illustrate the marked growth in both surveys and identified series between 1961 and 2010.

2.5 Soil Classification

Early soil classification schemes developed in the United States were not used in soil survey reports. The 1938 zonal soil classification system developed by Baldwin and others was used in Oregon from 1954 to 1966. After more than a decade of development, in 1960 the *Seventh Approximation*, a new classification scheme and a precursor to *Soil Taxonomy* (Soil Survey Staff 1999) was published. Beginning in the Curry County Area in 1970, *Soil Taxonomy* was used exclusively in the state.

2.6 Soil Taxonomy

All soils in Oregon are now classified using *Soil Taxonomy*, which 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 of diagnostic surface and subsurface horizons. Both *Soil Taxonomy* and *Keys to Soil Taxonomy* are available online and readers are directed to those publications for detailed explanations of concepts.

For classification purposes, the upper limit of the soil is defined as the boundary between the soil (including organic

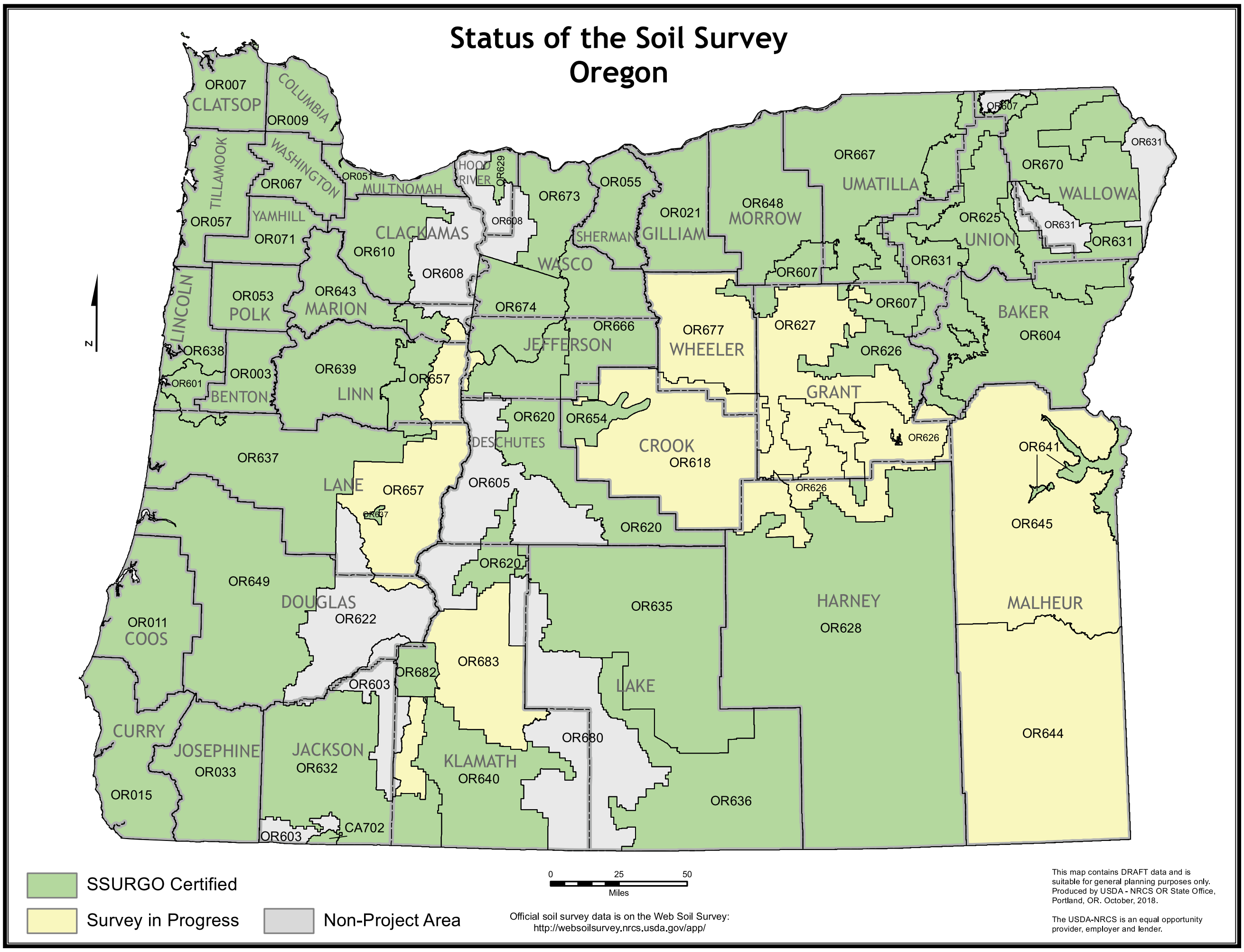

Fig. 2.6 Status of soil surveying in Oregon as of 2018. *Source* NRCS

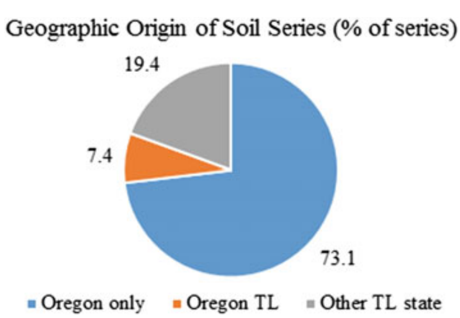

Fig. 2.7 Proportion of soil series that occur only in Oregon, elsewhere but where Oregon is the lead state (TL), and elsewhere where Oregon is not the lead state (Other TL)

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. *Soil Taxonomy* is similar to the taxonomic classification of living organisms, from broadest to narrowest levels, into kingdom, phylum, class, order, family, genus, and species. Casual readers may be unfamiliar with soil taxonomic terms, which often employ abbreviations based on Latin or Greek words. Those readers will benefit from a glossary of terms, such as the online Soil Formation and Classification provided by the NRCS (2022) or Chap. 7, Nomenclature, of Soil Taxonomy (1999). Introductory soil science textbooks, such as Weil and Brady's *The Nature and Properties of Soils* (2016), also explain soil taxonomy, as

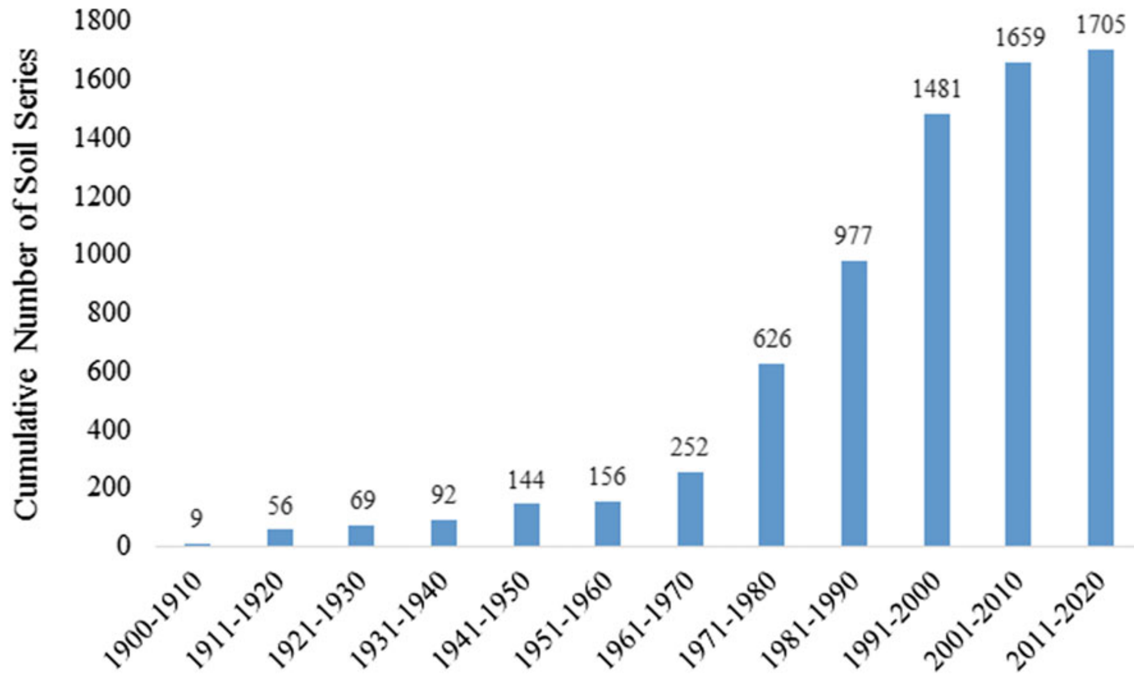

Fig. 2.8 Cumulative number of soil series recognized in Oregon by decade

Table 2.2 Number of soil series, soil type, and land types recognized in 1:62,500-scale soil surveys in Oregon from 1908 to 1929

		No. soil	No. soil	No. land	
Year	Area	Series	Types	Types	Total
1908	Klamath Reclamation Project	2	9	1	10
1911	Marshfield County Area	7	15	5	20
1913	Medford County Area	23	42	4	46
1914	Hood R.-White Salmon R	7	16	2	18
1917	Yamhill Co. Area	15	29	4	33
1919	Multnomah County Area	14	27	6	33
1920	Benton County Area	16	30	2	32
1923	Josephine County Area	14	37	5	42
1926	Clackamas County Area	19	33	4	37
1927	Marion County Area	20	41	4	45
1928	Polk County Area	16	31	2	33
1929	Columbia County Area	16	34	4	38

well as other aspects of soil science. In any case, the soil taxonomic system is logical and consistent, and reveals a wealth of information about soils in a concise manner.

Soil taxonomic names are constructed in an order that progresses from narrow to broad, unlike biological classifications, which progress from broad to narrow. For example, the taxonomic classification of Douglas-fir progresses from kingdom (broad) to species (narrow) as follows: Plantae (kingdom)-Pinopsida-Pinales-Pinaceae-*Pseudotsuga-menziesii* (species). In contrast, a soil taxonomic classification for the Puderbaugh soil series to the subgroup level is "Pachic Argixeroll." In this compact and efficient system, the following terms are used, progressing from narrow to broad:

- "Pachic" describes a soil subgroup (narrow classification) with a thick epipedon,
- "Argi" describes a soil great group with a horizon that has accumulated clays from an overlying horizon,
- "xer" describes a soil suborder with an annual dry season, and
- "oll" describes a soil in the order of Mollisols (broad classification).