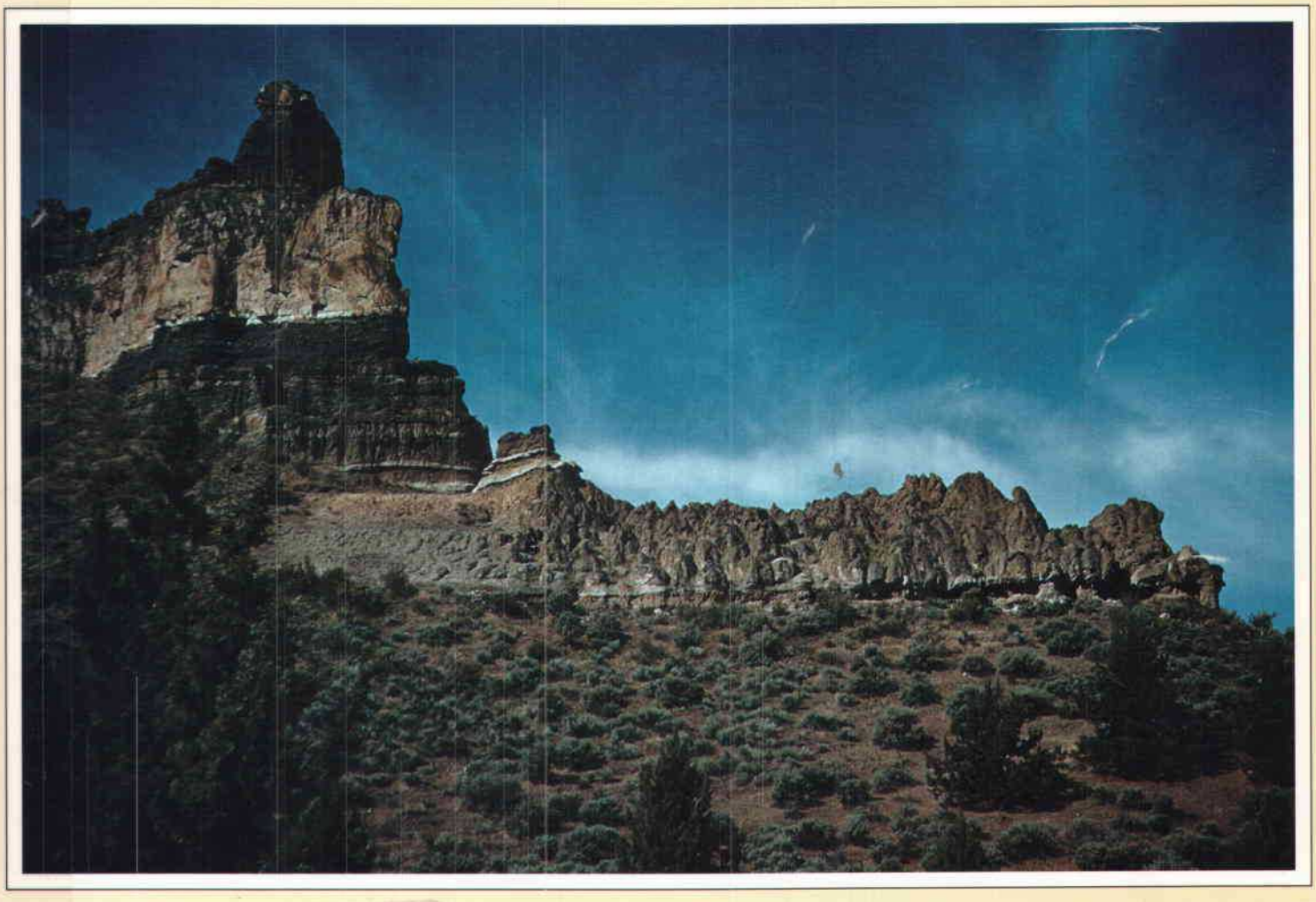
ogical Provinces of Oregon

A treatise on the basic ecological geography of the state



E. William Anderson,
Michael M. Borman, and William C. Krueger
Oregon Agricultural Experiment Station

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Front cover: Stratified ancient geological formation typical of John Day Ecological Province, Oregon.

Back cover: Overview of Snake River Ecological Province, looking northwest across the Malheur Reservoir area into the extensive, light-colored ancient lake lacustrine landforms that typify Snake River Ecological Province, Oregon.

Opposite: View of Mt. Thielsen over snow-covered pumice desert as seen from Crater Lake in Mazama Ecological Province, Oregon.

All photos by E. William Anderson.

The Ecological Provinces of Oregon

A treatise on the basic ecological geography of the state

By
E. William Anderson,
Michael M. Borman,
and William C. Krueger

Oregon Agricultural Experiment Station
May 1998

This publication synthesizes over 40 years of study by E. William (Bill) Anderson and his co-workers. Oregon is extremely fortunate that Bill Anderson was the Chief of Party for the initial range surveys in the late 1930s and that he remained in Oregon for the rest of his career. Since his retirement, Bill has continued to study Oregon's resources and to develop the concept and descriptions of ecological provinces for Oregon. This is a prime example of having the right person in the right positions at the right times and for the duration of time necessary to develop a sufficient understanding of these resources to produce this document. All of us working with natural resources in Oregon owe Bill a tremendous debt of gratitude.

WILLIAM C. KRUEGER
MICHAEL M. BORMAN

Authors

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Over the years, the following people in the USDA Soil Conservation Service made major contributions to formulating the ecological province concept by helping to characterize and delineate lines of demarcation between ecological provinces out on the land and by allowing this activity in Oregon.

Range conservationists: Fred Greenfield, Duane Town, Eugene Hickman, and David Franzen.

Soil scientists: George Green, Elmer Hill, Burrell Lovell, Joe Cahoon, Grant Lindsay, Eugene Dyksterhuis, and William Powers.

State administrators: Harold Tower, Tom Helseth, and A. J. Webber.

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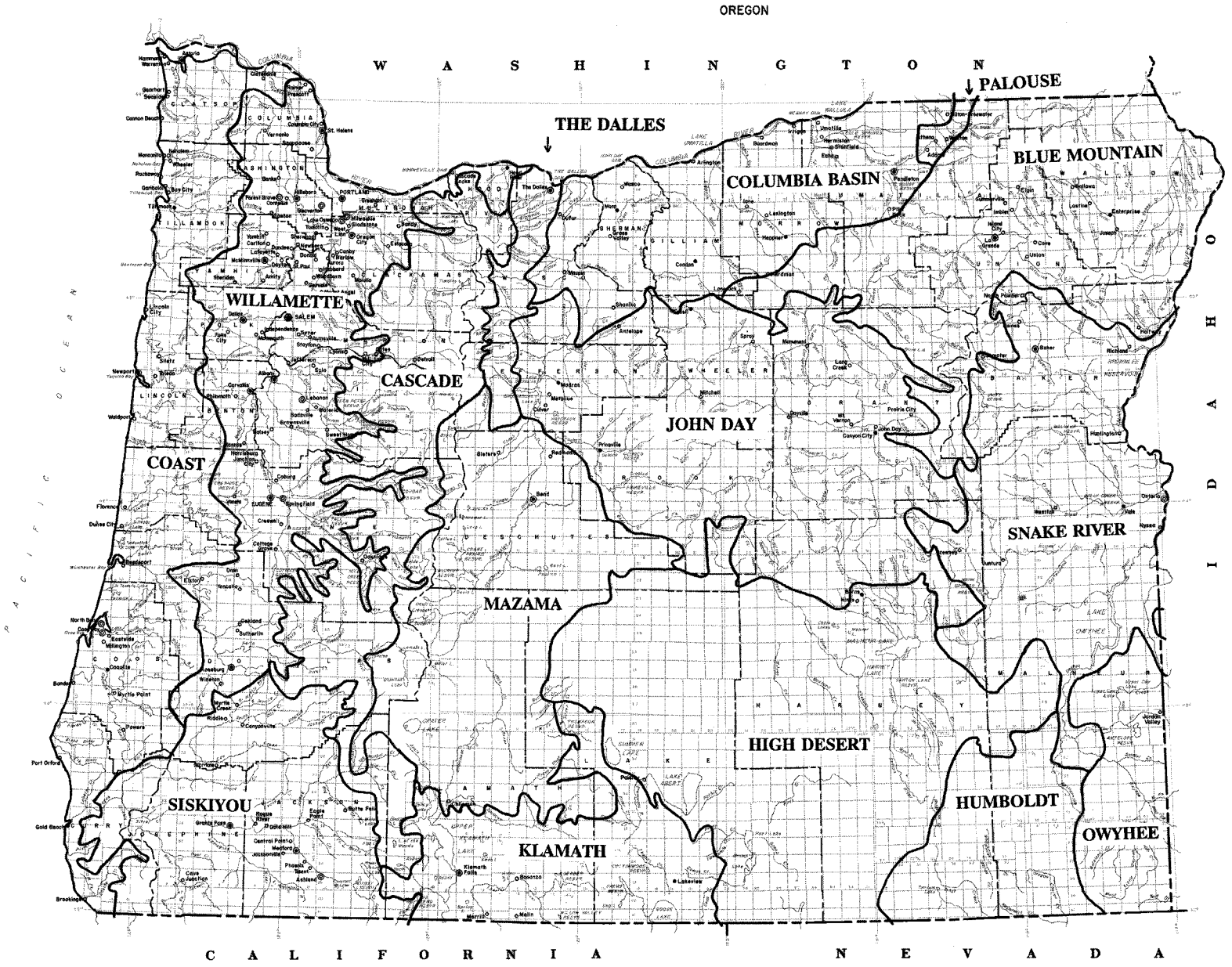


ECOLOGICAL PROVINCES OREGON

E. William Anderson - Michael M. Borman - William C. Krueger

Introduction

An ecosystem's processes function on a variety of temporal and spatial scales. Planning and management likewise must be on a related scale. For management purposes, it is important to understand the concepts of ecological sites and ecological provinces—areas within which there is relative similarity in resource type, quality, quantity, and associations. This publication describes Oregon's ecological provinces and lists references for further information.

An ecological site is a local combination of certain soils, climate, topography, and vegetation; the combination has management implications.

An ecological province, which is a subdivision of a region, has a distinctive combination of geological features and ecological sites. In an ecological province, general regional differences in vegetation complexes among ecological sites are related to basic differences in underlying geology, geomorphology, and climate on a relatively broad scale that encompasses a number of ecological sites.

For public and private land managers and technicians, the concept of ecological provinces is a valuable framework within which to consider potential large-scale system responses to management activities. The ecological-provinces framework describes spatial homogeneity in ecosystems which generally influences types, quality, and quantity of environmental resources.

In managing water quality, for example, it is important to separate attainable water quality from that which is diminished by land use. Quality attainable in one region may not be attainable in another due to natural factors. Agency guidelines for vegetation composition, distribution, and cover should also be based on what is attainable. These attributes will be similar within ecological provinces and dissimilar among them.

Monitoring efficiency, data interpretation, and detection of trends in important ecological attributes can all be improved if monitoring is organized based on ecological provinces.

Within Oregon, the ecological provinces described in this publication stratify the natural variation that exists across watershed basins and political boundaries such as counties, national forests, and Bureau of Land Management districts. Although monitoring is essential to detect trends toward or away from management goals, it is often neglected due to budget constraints.

It is important to keep in mind that an ecological province is not homogeneous. For example, High Desert Province is characterized by large and small closed basins surrounded by extensive terraces with interspersed ridges, hilly uplands, isolated buttes, and block-faulted formations. The terrace and basin portion of the province is flat to gently sloping; intermediate hills, buttes, and mountains are steep to very steep. Ecological sites range from arid low-lying terraces to subalpine mountain tops and from lake beds that are nearly always dry to permanent wetlands and marshes. However, a unifying characteristic is the dry, cold climate that significantly influences growing conditions through its impact on effective environment.

The effective environment of a given site is produced by the interaction of all environmental factors there—including soil, aspect, slope, elevation, moisture, and temperature—and supports a specific combination of plant species. Each province has some individual characteristics or combinations that sufficiently influence effective environment so that each produces or supports vegetational composition and structure that is similar within a province and different among provinces. Vegetation on north-facing slopes within a province will be reasonably similar, but frequently there are important differences between provinces in the characteristics of soils and vegetation on north-facing slopes.

Demarcation between provinces in Oregon is quite distinct in some locations, as between the John Day and Columbia Basin provinces along the breaks of a large rocky plateau near Clarno (Fig. 1) and also between the John Day and High Desert provinces north of Hampton (Fig. 2). At other locations, the line of demarcation is broad and transitional, as in an area near Kinzua where a mixture of forested soils representing both the John Day and Blue Mountain provinces forms a transition band 2 to 3 miles wide. Another example is between the Mazama and High Desert provinces where the pumice mantle, which distinguishes Mazama from adjacent provinces, gradually thins into the High Desert Province. The vegetational differences, and thus the provincial boundary, are not clear-cut but rather occur within a belt of demarcation.

The descriptions of the 15 ecological provinces in Oregon provide valuable information including: location; a general description of the province; general soils description and soil series identifications; climate information with a focus on temperatures, growing seasons, and precipitation amounts and distribution; descriptions of vegetation complexes and their relationships to soils and climatic variables; and a discussion of management implications.

Each province also has a description of the line or band of demarcation between it and adjacent provinces so that field workers can determine on the ground when they are at a transition from one province to another. This is an extremely valuable resource to help field personnel look for and evaluate changes based on what should be expected and to refine salient differences and similarities between provinces.

Prologue

In June 1949, the USDA Soil Conservation Service (SCS), now called the Natural Resources Conservation Service, began the task of identifying and describing the range sites in Oregon.

The concept of "range site" was relatively new at that time although Oregon SCS had been making range surveys since about 1939 in which units of the landscape that were ecologically different were mapped. The first of these surveys was of the Keating Soil & Water Conservation District in Baker County, E. W. Anderson, Chief of Party. World War II interrupted development of this kind of resource inventory on rangelands in the Pacific Northwest mainly because most SCS range conservationists enlisted for military service.

Assessing and mapping rangelands' ecological status, which was originally called "range condition," also originated in the Pacific Northwest, circa 1937. These were significant changes from the general kind of range survey being conducted throughout the West in that early era. These involved mapping 18 vegetation types; e.g., grassland type, sagebrush type, annual type, juniper type, and meadow type. The vegetation types represented then-current stands of vegetation rather than ecological sites.

At an early stage, it became apparent that the basic purpose of this Oregon site-identification project necessitated studying woodlands and forests as well as rangelands, because of the interrelationship of forage, wood products, and soil conservation aspects involved in comprehensive management of renewable resources, which was a basic program of SCS in Oregon at that time. A major factor in precipitating this approach was the view held by most ranchers that their "range" was the entire area on which their livestock grazed, be it sagebrush hills or forests. Consequently, by the mid-1950s, the narrow concept of range site was broadened in Oregon to include these other kinds of land, and the term "ecological site" was coined to better represent the actual situation. Official SCS approval for this change was never requested. Instead, the concept of ecological site was allowed to quietly materialize as a locally accepted version of the principles incorporated in the term "range site" as it applied to rangelands east of the Rocky Mountains.

After years of studying and describing ecological sites in eastern Oregon, this definition was formulated in the 1960s: An ecological site is an area of land having a distinctive combination of soils and climatic, topographic, and natural biotic (chiefly vegetation) factors that has management implications.[4]

It also became apparent early in the project that data on ecological sites in one segment of eastern Oregon differed significantly in several ways from data on comparable sites in other segments of eastern Oregon.

For example, the makeup of reasonably relict native plant communities on undulating topography in Gilliam County differed markedly from a comparable situation in Baker County, and they both differed markedly from a comparable situation in Harney County. Soil characteristics might be somewhat similar from place to place yet differed significantly in certain important aspects, especially at the soil-series level of soil classification.

In some cases, herbage production on comparable sites also differed significantly from one segment of eastern Oregon to another, suggesting that this was likely due to broad climatic differences. Forested sites in the Blue Mountains produced essentially the same tree species as those in the Ochoco Mountains or those on east slopes of the Cascade Mountains near The Dalles, yet the understory plant communities differed markedly from one place to the other, as did the soils. Searching for reasons for these differences helped formulate the concept that broadly homogeneous natural subdivisions of Oregon existed and that they, like ecological sites, could be and should be identified, described, and mapped. If the broad soil–plant relationships were as outstandingly consistent within each of these subdivisions and as different from one subdivision to another as they appeared to be at that time, then it seemed reasonable that any sound agricultural or resource-oriented program must recognize these natural subdivisions of the state.

Furthermore, these natural subdivisions and the specific soil–plant relationships within them do not coincide with political boundaries such as counties, national forests, BLM districts, or private ownerships. Thus, it seemed imperative that educators and technicians in forestry, range, wildlife, hydrology, agronomy, economics, and soils and even some property owners and managers needed to recognize and understand these basic facts about the ecological patterns of the countryside.[1] Consequently, as early as 1950 it became an unofficial component of the site-identification project to identify, characterize, and delineate these broad natural subdivisions of Oregon.

One of the confounding questions early in the process of characterizing and delineating these natural subdivisions of eastern Oregon was what to call them.

At first, in 1949-50, they were called "problem areas," and they certainly presented some problems. However, the term "problem areas" in Soil Conservation had been used previously in the 1930s by Dr. H. H. Bennett, founder of the soil conservation movement, so we decided "problem areas" was not appropriate for use in our Oregon situation. Instead we used "natural range areas." However, this term eventually did not fit the nature of the study because it involved kinds of land in addition to rangelands. Therefore, the

term was changed to "land resource areas" during the 1950s and was used until about 1965 when SCS Soil Science Division published USDA Agricultural Handbook 296, "Land Resource Regions and Major Land Resource Areas of the United States." [8] The publication was revised in 1981.[29] The meaning of "land resource area" in this SCS publication was basically different from that of the original term in Oregon. The published term was predicated primarily on soils, whereas the original term was predicated on ecological units in which soil was only one of several differentiating factors.

After publication of Agricultural Handbook 296, the natural subdivisions of Oregon were renamed "resource provinces" to avoid conflict and confusion.

About 1980, the term was made more precise by the change to "ecological province" with the following definition: a subdivision of a region having a distinctive combination of geological features and ecological sites.

The concept of ecological sites and natural subdivisions of Oregon has been presented in a simple informational talk at many local meetings of conservation districts and agricultural and livestock organizations in Oregon. It was first published in 1956 in a discussion of soil–plant relationships.[1] It was later published, in 1962, in a discussion of the behavior of forage yields[3] and in 1986 in relation to plant indicators of effective environment within the various ecological provinces of Oregon.[5]

Definitions and Abstracts

Definitions

Ecological province A subdivision of a region having a distinctive combination of geological features and ecological sites.

Ecological site An area of land having a distinctive combination of soil, climatic, topographic, and natural biotic (chiefly vegetation) factors; the combination has management implications.

Abstracts

Blue Mountain Province The mountainous segment of northeast Oregon. It is characterized by extensive, very thick basalt bedrock, groups of rugged mountains, steep canyons, and extensive ridges and plateaus. Rugged mountains consist of uplifted granites, basalt, and various metamorphosed shales, sandstones, limestones, greenstones, and tuffs. Elevations in Oregon range from about 1,000 feet in the northeast corner to 9,839 feet on Sacajawea Peak in the Eagle Mountains. Elevations are mainly between 3,000 and 5,000 feet.

Cascade Province The higher elevations and crest of the Cascade Mountains. It is characterized by andesitic or basaltic mountainous terrain with steep dendritic drainage patterns, especially where associated with upper reaches of the Willamette River system. Elevations range from about 1,200 feet at the northwest boundary to above 5,500 feet at the southern boundary.

Coast Province The mountainous uplands of the Coast Mountains and the hills, valleys, tidelands, headlands, and beaches between the mountains and the ocean. It is characterized by very steep dendritic drainages related to 20 rivers draining into the ocean. Elevations in Oregon range from sea level to about 4,000 feet on prominent mountains.

Columbia Basin Province The basin draining north into the Columbia River in north-central Oregon. It is characterized by basaltic hilly uplands and a sizable sandy basin west of the Hermiston area that are dissected by six major drainages flowing into the Columbia River. Elevations in Oregon range from about 100 feet along the Columbia River to about 3,500 feet.

High Desert Province The most northern extent of the Great Basin of North America. It is in south-central Oregon. It is characterized by numerous large and small closed basins surrounded by extensive terraces formed in ancient lakes. Interspersed are low basaltic ridges, hilly uplands, isolated buttes, mountains, and block-faulted igneous formations. Elevations in Oregon range from 4,030 feet at Harney Lake to 9,670 on Steens Mountain. Elevations of basins and terraces in Oregon are between 4,030 and about 4,500 feet.

Humboldt Province A segment of the northern portion of the Great Basin of North America. It is in southeastern Oregon. It is characterized by long, generally north-to-south mountain ranges and valleys with ancient lake terraces and fans lying along the footslopes. Elevations in Oregon range from 4,025 at Alvord Desert to 8,545 feet on the Pueblo Mountains.

John Day Province The rugged north-central area of Oregon. It is characterized by extensive, geologically eroded, steeply dissected hills of thick, ancient sedimentary materials interspersed with buttes and plateaus capped with basalt or tuffaceous rock. Elevations range from about 1,000 feet in the northwest corner to 7,360 feet at Fields Peak in the Ochoco Mountains.

Klamath Province The basaltic mountainous part of south-central Oregon, characterized by large basins consisting of lakebeds surrounded by extensive ancient lake terraces interspersed with extensive basaltic terrain. Drainage is south, mainly through the Klamath River system. Elevations in Oregon range from 4,050 feet at Malin to 8,405 feet at Drake Peak northeast of Lakeview.

Mazama Province The area covered by a continuous mantle of aeolian deposits of pumice and other volcanic materials spewed over the countryside when Mt. Mazama erupted explosively about 6,500 years ago. Other volcanic activity and eruptions, as well as glacial actions, have created areas consisting of basaltic, andesitic, rhyolitic, and tuffaceous deposits and cinders and glacial till. Elevations range from 2,700 feet at the northwest boundary to 8,390 feet on Gearhart Mountain. Most of the province lies between 4,000 and 5,000 feet elevation.

Owyhee Province The western foothills and associated plains of the Owyhee Mountains, which are in southwestern Idaho. It is characterized by extensive, very rocky uplands sloping down to the west and by numerous basalt-rim canyons, lava fields, rhyolites, a few ancient lake basins, and some mountainous areas. Elevations in Oregon range from about 4,000 feet to 6,168 feet on the Mahogany Mountains. Most of the province lies between 4,000 and 5,000 feet elevation.

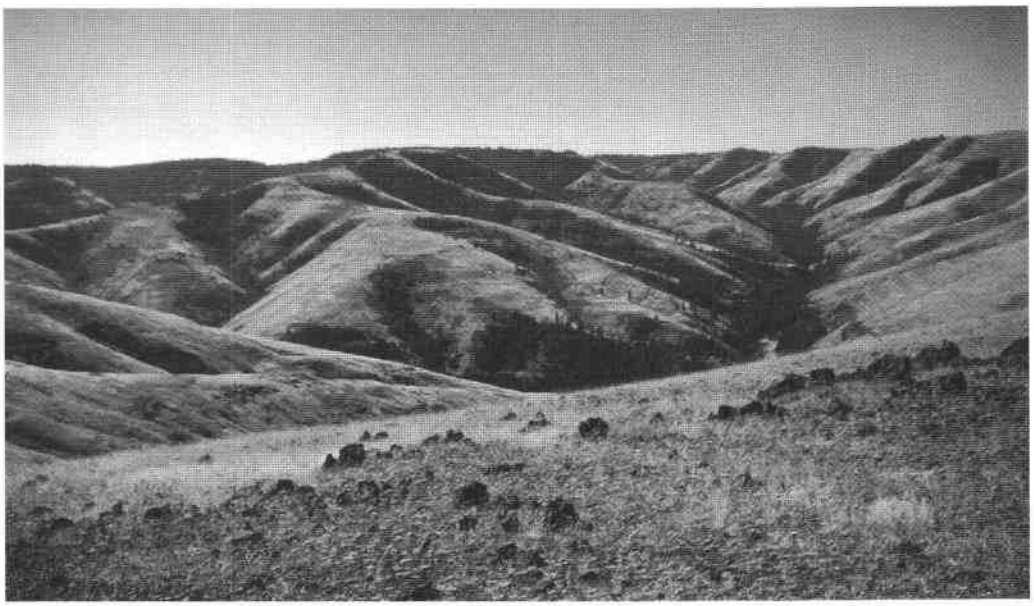
Palouse Province The gently sloping to rolling cultivated area lying northeast of the Pendleton Branch Agricultural Experiment Station in Umatilla County. It is the only area in eastern Oregon suitable for long-term dryland farming under an annual cropping rotation with no need to summer fallow for additional soil moisture. Elevations in Oregon are mainly between 1,350 and 2,000 feet.

Siskiyou Province The area in southwestern Oregon that is strongly influenced by the mild climate of northern California. It is characterized by extensive mountainous areas of the Klamath and Siskiyou mountains and western footslopes of the southern portion of the Cascade Mountains. Elevations in Oregon range from 925 feet at Grants Pass to 7,533 feet at Mt. Ashland.

Snake River Province The Oregon portion of the huge Snake River basin that extends across southern Idaho. It is characterized by extensive ancient terraces which are geologically eroded and dissected to currently appear as plateaus, basins, and low rolling and prominent hills interspersed with basaltic mountainous terrain. Elevations in Oregon range from 1,800 feet at Copperfield on the Snake River to 7,127 feet on Lookout Mountain in eastern Baker County.

The Dalles Province The lower eastern slopes and foothills along the north portion of the Cascade Mountains. It is the transition zone between the hot, dry climate of eastern Oregon and the cool, moist climate of the Cascade Mountains. Elevations in Oregon range from about 100 feet at the Columbia River to 5,110 feet on Green Ridge near the Metolius River. Most of the province in Oregon lies between 2,000 and 4,500 feet elevation.

Willamette Province The huge valley lying between the Cascade and Coast mountain ranges in Oregon. It is characterized by flood plains, old valley fill, and ancient high terraces and relatively low residual hill lands which include the foothills of both mountain ranges. Elevations in Oregon range from about 50 feet at the Columbia River to about 2,000 feet on mountains. Most of the province in Oregon lies below 1,700 feet.



Blue Mountain Ecological Province

Location

In Oregon, this province constitutes the mountainous northeastern segment of the state. It covers slightly less than 6 million acres including all of Wallowa County, major segments of Union, Umatilla, Baker, Grant, and Morrow counties, and small segments of Wheeler and Gilliam counties. The old mill town of Kinzua in northwestern Wheeler County is in the westernmost tip of Blue Mountain Province. The province extends north into Washington and east into Idaho.

Description

Blue Mountain Province in Oregon is typified by groups of rugged mountains, steep canyons, and extensive plateaus divided by dendritic-pattern drainages (Fig. 3). Basalt is the major bedrock underlying mountains and plateaus, which accounts for the typical rimrock canyons. The most rugged mountains in the province are the Eagle Mountains in the area where Wallowa, Union, and Baker counties join; the Elkhorn Mountains in western Baker and northeastern Grant counties; and the Strawberry Mountain area in central Grant County. These mountains consist of uplifted granitic, basaltic, and various metamorphosed shales, sandstones, limestones, greenstones, and tuffs.[9]

The Wallowa Valley from Wallowa to Joseph and the Grand Ronde Valley from Union to LaGrande and Elgin are used for irrigated agriculture and for some dryland farming. South of Pilot Rock and east of Pendleton, some footslopes of Blue Mountains are dryland farmed to produce mainly wheat and barley. Most of the province is timbered and natural grasslands (Fig. 4).

Elevation within Blue Mountain Province in Oregon is mainly between 3,000 and 5,000 feet. The lowest point is below 1,000 feet where Oregon, Washington, and Idaho join on the Snake River; i.e., at the extreme northeast corner of Oregon and the extreme southeast corner of Washington.

The highest peaks in the Eagle Mountains are Sacajawea Peak at 9,839 feet, Matterhorn at 9,832 feet, and Aneroid Peak, Petes Peak, Twin Peaks, and Point Joseph which are all above 9,600 feet. In the Elkhorn Mountains, Rock Creek Mountain is 9,106 feet, Elkhorn is 8,931 feet, Twin Peaks is 8,897 feet and Mt. Ireland is 8,321 feet. In the Strawberry group, Strawberry Mountain is 9,038 feet, Slide Mountain is 8,521 feet, Canyon Mountain is 8,007 feet, Indian Creek Butte is 7,889 feet, and Pine Creek Mountain is 7,390 feet. (Elevations are from U.S. Forest Service maps.)

Soils

Soils of the Blue Mountain Province can be conveniently grouped according to the natural vegetation produced: upland grasslands, upland shrub–grasslands, meadows, forested areas, subalpine, and alpine.

Upland soils that produce natural grasslands (i.e., less than 10% natural shrub cover) are quite uniform in characteristics throughout the province. They have been formed primarily in silty aeolian deposits that reportedly originated and were blown south during the era of receding glaciers farther north in Washington. Subsequent aeolian deposits of volcanic ash during eruptions, such as Mazama's, influenced the parent materials in which these soils were formed.

Where these soils lie on plateaus and north-facing slopes under climatic conditions associated with mountainous topography—usually about 3,500 to 4,000 feet elevation and receiving about 15 inches or more annual precipitation—they generally are moderately deep to shallow, have very dark brown to black fairly thick silt-loam-texture surface layers, and dark brown moderately fine to clayey subsoils over basalt bedrock. Grassland soils on north-facing slopes are normally deeper than those on plateaus. This is probably due

to the snow-drift effect of prevailing southerly winds that have redistributed aeolian deposits. Soils on south- and west-facing slopes in canyons and mountainous terrain at these elevations have dark brown medium-texture surface layers and moderately fine-texture subsoils. They are usually extremely stony and fairly shallow over basalt bedrock.

Upland soils that produce natural shrub–grassland vegetation (i.e., 10% or more natural shrub cover) are mainly in two situations in Blue Mountain Province. The most common is locally called scabland. These soils, which are on plateaus and ridgetops, are very shallow and very stony. They have thin loamy surface layers and clayey subsoils and are usually less than 10 inches deep to basalt bedrock. Normally, they frost heave severely and are very susceptible to sheet erosion.

The other upland soils that produce natural shrub–grassland vegetation are on very steep north-facing areas within the elevation range of natural grasslands. These areas represent snowdrift pockets that receive moisture beyond that from normal precipitation. The north-facing aspect also increases effectiveness of the moisture received. These soils are moderately deep to very deep and usually not stony. They have thick black silty surface layers and brown silty to clayey subsoils. Outcrops of bedrock may exist.

Throughout the natural grasslands of Blue Mountain Province, grassland soils on some plateaus and ridges commonly occur in a unique land pattern locally called biscuit scabland. This pattern consists of small mounds of grassland soils 5 to 20 feet or more in diameter and usually about 20 to 36 inches deep over basalt bedrock. Each mound, or biscuit, is surrounded by very shallow, very stony shrub–grassland soils over basalt bedrock, which are locally called scabland. Hence the name, biscuit scabland.

The biscuits vary in shape, usually round but sometimes oblong. They occupy from about 5 to 30% of the area in which they occur. Some spectacular biscuits are in the vicinity of Flora in north-central Wallowa County; they are 5 feet high or more. Also in that vicinity are biscuits on which ponderosa pine grows.

For an explanation of the origin of this particular land pattern, see the description of Columbia Basin Ecological Province in which biscuit scabland is a prominent, widespread phenomenon.

Soils on meadows vary from locality to locality because they are formed in alluvium from adjacent watersheds and are directly related to the degree and longevity of wetness, which varies from sometimes dry to always wet.

Soils along major streams usually have medium- or loamy-texture surface layers and gravelly substrata. Gravelly surface layers and gravel bars are common. Woody vegetation can flourish on these kinds of meadows partly because water flowing through the soil profile is aerated. In contrast, meadow soils in swales and along minor meandering waterways usually have medium-texture surface layers and clayey substrata. These soils seldom produce native shrubby species, except for certain species of willow, because water in the soil is ponded and not aerated.

Some soils on mountain meadows in Blue Mountain Province have prominent, sometimes thick layers of volcanic ash in the profile that likely washed off surrounding watersheds. These ashy soils erode like "sugar" when disturbed or exposed and form vertical, sometimes deep channels which are very difficult to rehabilitate because of the erosiveness of the ash layers.

Soils of dry meadows generally have medium-texture surface layers and clayey subsoils. These soils occur as small basins within the forested area, as areas around the perimeters of wet meadows, and as shoestring bottoms along intermittent streams. They are moderately deep and usually not stony.

Soils in prominent valleys generally are a mixture of alluvium and low-terrace materials; the mixture varies from location to location within a valley. In the vicinity of Hot Lake in Grande Ronde Valley, the soils are poorly drained and affected by sodium; they are known as black alkali. This is probably the only occurrence of sodic soils in Blue Mountain Province.

Soils of forested areas in Blue Mountain Province vary according to the type of forest. Stands of ponderosa pine with an understory of bunchgrasses usually grow on plateaus, ridgetops, and south-facing slopes. These soils have loamy surface layers and clayey subsoils over basalt bedrock. They are usually shallow, stony, susceptible to erosion, and, when severely eroded, they frost heave. This forms a stone pavement on the surface which seriously hinders natural revegetation and increases water loss from the watershed through runoff.

Several combinations of soils, moisture, aspect, and slope are related to mixed ponderosa pine–Douglas-fir stands that have an understory of pinegrass, elk sedge, and associated species.

- In areas receiving about 26 to 40 inches precipitation on shallow-soil south exposures. These soils have loamy surface layers and clayey subsoils and usually are stony.
- In areas receiving about 16 to 26 inches precipitation on moderately deep to deep soils that are nearly level or slope slightly north or south. These soils have loamy or ashy surface layers and moderately fine to clayey subsoils. They may be stony.
- On steep, north-facing slopes of drainages below the main forested zone. These soils generally are moderately deep and stony with loamy or ashy surface layers and loamy to moderately fine-texture subsoils.

Soils of the grand fir–Douglas-fir and the grand fir–alpine fir forests generally are moderately deep to very deep with thick ashy upper layers and loamy to clayey subsoils. These soils lie on moderately steep to steep north-facing slopes and, above about 6,000 feet where precipitation exceeds about 40 inches, the soils are on gently sloping to rolling topography. Soils of the subalpine fir–whitebark pine and of

Table 1. Climatic Data for Blue Mountain Ecological Province, Oregon.[17]

Station and length of record (years)	Elevation (feet)	Precipitation			Average maximum and minimum temperatures (°F)	
		Annual (inches)	Nov.-March (%)	April-July (%)	January	April-July
Baker County						
Halfway 10	2,675	20.2	63	26	31.6-8.6	75.2-39.2
Sparta 34	4,150	20.8	63	41	33.3-16.2	69.5-40.5
Grant County						
Granite 7	4,939	27.1	61	26	22.6*	48.0*
Olive Lake 5	5,937	32.8	60	27	31.5-9.2	58.1-31.7
Umatilla County						
Meacham 29	4,050	34.7	62	24	32.0-17.7	63.2-39.9
Ukiah 18	3,340	18.2	52	32	34.0-11.9	69.9-34.6
Union County						
Cove 21	3,000	22.5	47	37	36.1-20.8	70.5-42.2
Elgin 10	2,666	22.3	57	26	35.8-18.9	73.4-40.2
LaGrande 21	2,786	20.1	54	31	38.0-21.8	73.3-45.0
Starkey 7	3,400	18.0	44	37	36.7-14.2	68.8-34.7
Union 22	2,765	12.9	43	40	35.8-22.4	72.0-41.6
Wallowa County						
Enterprise 20	3,700	13.3	38	42	33.0-12.5	70.2-36.5
Joseph 20	4,175	16.2	39	42	32.1-12.9	66.9-39.1
Wallowa 18	2,950	17.4	49	33	33.8-15.0	73.2-38.4
County Averages						
Baker		20.5	63	34	32.5-12.4	72.4-39.9
Grant		30.0	61	27		
Umatilla		26.5	57	28	33.0-14.8	66.6-37.3
Union		19.2	49	34	36.5-19.6	71.6-40.7
Wallowa		15.6	42	39	33.0-13.5	70.1-38.0
Province Average		22.4	54	32	33.8-15.1	70.2-38.0

No official weather stations in Blue Mountain Province in Gilliam, Morrow, or Wheeler counties.

* average

alpine nonforested areas generally are very gravelly, stony, or rocky and very shallow to moderately deep. In the Blue Mountain Province they are mainly at about 7,000 feet elevation. Essentially, these soils are primarily raw materials from the wide variety of parent materials forming the mountains.

Climate

Based on data from 14 official weather stations, representing a cross-section of the province, average annual precipitation for the province is about 22.4 inches. About 32% of annual precipitation falls during April through July, the herbaceous native-plant growing season. November through March precipitation is about 54% of the annual total. Average January maximum and minimum temperatures are 33.8 and 15.1°F, respectively. Average April through July maximum and minimum temperatures are 70.2 and 38°F, respectively. Precipitation and temperature data vary by locality (Table 1).

A recent precipitation map[53] shows about 115 inches annual precipitation in the Eagle Mountains south of Enterprise, over 45 inches in the Elkhorn Mountains west of Baker City, and over 35 inches in the Strawberry Mountain group southeast of John Day.

The most arid part of Blue Mountain Province is the lower reaches of the Imnaha and Snake River canyons; it also is the lowest elevation in the province.

Vegetation

According to the 1936 State of Oregon Forest Type Map,[54] which predates extensive logging, about a third of all Blue Mountain Province at that time was primarily natural grasslands; about two-thirds was forested.

Natural grasslands (i.e., less than 10% natural shrub cover) are sporadic throughout lower elevations of the Blue Mountain Province. They range in size from small openings and long narrow ridgetops in forested areas to extensive open grasslands. They extend along the entire northern province boundary from near Pilot Rock west to near Kinzua; in the vicinity of Ukiah, Starkey, LaGrande, and Elgin; and in central and northern Wallowa County from

Wallowa–Enterprise–Joseph east and north past Findley Buttes and Zumwalt, including the breaks of the Snake, Imnaha, and Grande Ronde canyons.

The grasslands near Findley Buttes are the highest native-forage-producing upland sites in eastern Oregon when in vigorous, high-ecological status. They probably are a model of what has been called the Palouse Prairie (Fig. 5).

Essentially the same combination of plant communities and soil series occurs throughout these widely separated grasslands, due to the provincewide uniformity of soil parent materials and climatic conditions under which these soils and plant communities formed.

On these natural grassland ecological sites, basic perennial grasses are Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass, and prairie junegrass. Big bluegrass, pinegrass, elk sedge, and timothy grow on more moist upland sites. Dry meadows have a wide variety of species including Idaho fescue, sod bluegrasses, slender wheatgrass, thin bentgrass, California oatgrass, Columbia needlegrass, and threadleaf sedge. Wet meadows are typified by tufted hairgrass, redtop, slender wheatgrass, sod bluegrasses, baltic rush, Nebraska sedge, and red fescue.

Uniquely, in the lower reaches of the Snake and Imnaha canyons, the most arid portion of this province, there are small areas containing Fendler threeawn. This is probably the only location in Oregon where it grows. Its major range is in the Great Plains. Oldtimer local ranchers called it "democrat" grass and claimed it did not show up until Franklin D. Roosevelt and the Democrats came into political power in the 1930s. Peck's 1961 manual of higher plants of Oregon[23] cites it as being in these canyons.

It is possible that ranchers, having wintered livestock in the canyons for years, first noticed this grass when the severe drought of the 1930s diminished other forage species; coupled with intense winter grazing, this made the previously unnoticed threeawn appear prominent because it is apparently unpalatable when mature. How the species got there in the first place could be the basis for a campfire storytelling session: Nez Percé Indians returning from buffalo hunts in Montana? Was explorer Frémont's expedition once lost in the Imnaha canyon?

Blue Mountain Province natural grassland sites are characterized by an abundance and wide variety of perennial forb species which make up 10 to 15% of natural plant communities on most sites. Several low shrubs, such as low Oregon-grape, wax currant, rose, common snowberry, green and gray rabbitbrushes, and herbaceous sage commonly grow in trace amounts in these natural grasslands.

One distinctive feature of Blue Mountain Province is the overall scarcity of big sagebrush and other tall shrubs that dominate much rangeland in Oregon. Even on grasslands in deteriorated ecological status, shrubs do not become prominent in Blue Mountain Province. Rather, deteriorated grasslands are characterized by a dominance of perennial forbs, such as yarrow, lupine, gumweed, and biscuitroot and annual forbs and grasses. However, at least four species of the genus *Artemisia* grow in the province: big and stiff sagebrushes, tarragon, and lobed wormwood.

Along the line of demarcation between Blue Mountain and John Day provinces, both big sagebrush and western juniper, strongly characteristic of John Day Province, grow within the band or area where the two provinces join. This band of integrated vegetation is likely natural. However, it is also likely that characteristic John Day Province vegetation such as sagebrush and juniper has expanded into Blue Mountain Province due to severe grazing and timber harvesting which degraded the vigor of original Blue Mountain plant communities, thereby allowing encroachment of John Day woody species.

Expansion of Blue Mountain vegetation south into John Day Province is unlikely because the climate becomes abruptly more arid on the John Day side of the line. Ecological invasion more often is from arid to more moist situations.

Three major kinds of natural shrub–grassland (i.e., 10% or more natural shrub cover) are in Blue Mountain Province. The most common is the site locally called scabland. Vegetation on this very shallow, very stony site is dominated by Sandberg bluegrass. Bluebunch wheatgrass, Idaho fescue, and a few other perennial grass species occur sparsely between the surface stones. Perennial forbs, such as Hooker balsamroot, biscuitroot, bighead clover, bitterroot, onion, and snow buckwheat are prominent. Stiff sagebrush is the dominant shrub; however, an occasional rose or common snowberry may grow.

An entirely different kind of natural shrub–grassland occurs on very steep north-facing areas within the elevation range of natural grasslands. These areas represent snowdrift pockets which receive moisture beyond normal precipitation. Vegetation is dominated by shrubs such as common snowberry, rose, chokecherry, hawthorn, mockorange, and ninebark. An occasional ponderosa pine or Douglas-fir may be seen. The understory is dominated by Idaho fescue along with such grasses as timothy, oniongrass, Kentucky bluegrass, Columbia needlegrass, pinegrass, mountain brome, bluebunch wheatgrass, and many perennial forb species.

Bottomlands along major streams, where soils are usually gravelly, produce woody vegetation along with meadow vegetation. Water flowing through the gravelly soils is aerated, and woody species such as cottonwoods, some willow species, alder, birch, and ponderosa pine are capable of flourishing in spite of seasonal or periodic high-water tables or overflow.

The understory vegetation varies widely according to the frequency and duration of soil water; the plant communities range from dry meadow to wet meadow species, usually occurring in patches.

Coniferous forest occupies most of Blue Mountain Province. These forests represent five generalized plant communities (with transition from warm to cool to cold forest), each with management implications.

Table 2. Average Dates Vegetation Growth Begins and Ends in Blue Mountain Ecological Province, Oregon.

Station and length of record (years)	Elevation (feet)	Average date growth begins*	Average date growth ends*
Baker County			
Halfway 10	2,675	March 24	August 21
Sparta 34	4,150	April 1	September 12
Grant County			
Granite 7	4,939	April 26	Does not occur
Olive Lake 5	5,937	May 7	Does not occur
Umatilla County			
Meacham 29	4,050	April 7	Does not occur
Ukiah 18	3,340	April 1	August 17
Union County			
Cove 21	3,000	March 27	September 21
Elgin 10	2,666	March 15	August 18
LaGrande 21	2,786	March 15	August 13
Starkey 7	3,400	April 1	August 15
Union 22	2,765	March 15	July 2
Wallowa County			
Enterprise 20	3,700	April 1	July 10
Joseph 20	4,175	April 4	July 31
Wallowa 18	2,950	March 24	August 4

No official weather stations in Gilliam, Morrow, or Wheeler counties in Blue Mountain Province, Oregon.

* The average date vegetation growth begins on native perennial bunchgrasses is approximately the date the average daily temperatures reach 39 to 40°F. Average date vegetation growth ends is considered to be when available soil moisture is depleted. Interpretations are based on data in Johnsgard.[17]

1. Ponderosa pine with understory dominated by Idaho fescue, bluebunch wheatgrass, many forb species, and shrub species with pine reproduction. A warm forest.
2. Ponderosa pine with understory dominated by pinegrass, elk sedge, Idaho fescue, bluebunch wheatgrass, many forb species, and many shrub species with pine reproduction.
3. Mixed ponderosa pine, Douglas-fir, some grand fir, and some larch with an understory consisting of pinegrass, elk sedge, Idaho fescue, other shade-tolerant grass and forb species, and many shrub species with pine and Douglas-fir reproduction. A cool forest (Fig. 6).
4. Mixed grand fir, Douglas-fir, larch, lodgepole pine, and Engelmann spruce with sparse understory of shade-tolerant grass and forb species mainly in openings, shade-tolerant shrubs, and much grand fir and Douglas-fir reproduction.
5. Subalpine fir, larch, lodgepole pine, and Engelmann spruce with a sparse understory of shade-tolerant forbs and shrubs. A cold forest.

Subalpine areas contain a variety of plant communities that include species such as whitebark pine; subalpine fir; elk, Ross, and Hood sedges; green and Idaho fescues; yarrow; fleeceflower; and mountain big sagebrush. These are not coniferous forests. Rather, they are patchy patterns of various plant communities (Fig. 7).

The different kinds of soil that help differentiate Blue Mountain Province from John Day Province are supported by significant differences in the site-specific plant communities. For example, the ponderosa pine–bunchgrass ecological site is in both provinces and, based on casual observation, the sites resemble each other: pine trees, shrubs, grasses, and forbs. However, numerous samples of this ecological site in both provinces reveal significant differences in the species that constitute the plant community of the site.

In Blue Mountain Province, the following species regularly grow but are rarely, if ever, found on this site in John Day Province: Kentucky bluegrass, onespike oatgrass, threadleaf sedge, huckleberry, mockorange, and herbaceous sage. On the other hand, the following species regularly grow on this site in John Day Province but are rarely, if ever, found on this site in Blue Mountain Province: Wheeler bluegrass, Ross sedge, Thurber needlegrass, mountain snowberry, green rabbitbrush, curlleaf mountain-mahogany, big sagebrush, and western juniper. Obviously, these differences are not readily apparent within the belt of demarcation between provinces but are apparent in provincewide data.

Even greater differences occur on the ponderosa pine–sedge ecological site in each of the provinces. The following species regularly grow in Blue Mountain Province but rarely, if ever, are found on this site in John Day Province: slender wheatgrass, timber oatgrass, western fescue, Columbia needlegrass, threadleaf sedge, blue wildrye, slender hairgrass, deerbrush, elderberry, spirea, ninebark, huckleberry, serviceberry, syringa, dogbane, chokecherry, bitter cherry, oceanspray, bearberry, and herbaceous sage.

The following species regularly grow on this site in John Day Province but rarely, if ever, on this site in Blue Mountain Province: basin wildrye, Wheeler bluegrass, mountain snowberry, curlleaf mountain-mahogany, green rabbitbrush, big sagebrush, and western juniper.

Generally, forested-site plant communities in Blue Mountain Province include more species than those in John Day Province. This is especially noticeable in the shrub component. The reason might be related to the soils and climate of Blue Mountain Province compared to those of John Day Province.

A study of the geographic distribution of major plant species within Oregon, based on their occurrence within specific ecological provinces and on specific ecological sites, would be a worthwhile contribution to coming generations of resource scientists and managers who are increasingly required to set goals and objectives for various ecological situations.

Management Implications

Blue Mountain Province includes irrigated agriculture mainly in the vicinity of LaGrande, Elgin, and Enterprise which produces specialized crops, such as seed potatoes, turfgrass seed, grains, and animal forages. There is a little dryland farming for grain, and some irrigated areas, between Pilot Rock and Cayuse on the Umatilla River. Some previously dryfarmed areas were put into perennial cover under the Conservation Reserve Program of the 1980s.

Most grasslands in Blue Mountain Province are privately owned, but grazing on much of these lands is closely interrelated with grazing on public lands. Public forested lands provide a high proportion of summer grazing for livestock, elk, and deer, and provide summer habitat for much of the province's wild mammals. In contrast, winter ranges for livestock and most wildlife are lower elevation private lands or BLM public lands.

The ashy Tolo soil series is probably the most productive forest soil in eastern Oregon, and the Waha and Wahala series are probably the most productive upland range soils in eastern Oregon.

A very large part of the province is rangeland and forested. A high proportion of forested land is publicly owned and managed under the Wallowa-Whitman, Umatilla, and Malheur national forests. A small proportion of BLM-administered public land lies along the eastern fringe of the province.

The North Fork John Day Wilderness, Hells Canyon National Recreation Area, Hells Canyon Wilderness, Eagle Cap Wilderness, Strawberry Mountain Wilderness, most of Monument Rock Wilderness, and most of the Umatilla Indian Reservation are in Blue Mountain Province. Collectively, this is a huge set-aside area requiring stringent integrated resource management.

Blue Mountain Province essentially is the entire source of water upon which all life in northeast Oregon—and farther—depends. It holds a myriad of subwatersheds that capture, store, and release water into numerous drainages. This fact must be given prime consideration in all management strategies, small or large.

Resource issues, problems, opportunities, and options usually involve multiple ownerships, resources, and resource uses within Blue Mountain Province as well as in adjacent provinces. The result of what happens in Blue Mountain watersheds is far-reaching.

Province Demarcation

Blue Mountain–Snake River Demarcation

The line of demarcation between Blue Mountain and Snake River provinces begins in the Snake River canyon at Copperfield on the Oxbow where Snake River exits the Snake River Province and enters the Blue Mountain Province in the upper Hells Canyon. From that point, the line runs southwest up the ridge between Pine Creek and Snake River. All drainage into Pine Valley and Pine Creek is considered to be in Blue Mountain Province; however, the nearby deep Snake River canyon makes this line a matter of judgment based mainly on native plant communities and soils. From the divide on Highway 86 between Eagle Valley and Pine Valley, the line runs westerly at about 4,000 feet elevation along the upper edge of the ancient terraces south of Sparta, in Blue Mountain Province.

The line crosses into Union County east of Pondosa at about 4,000 feet elevation and continues northwesterly through Telocaset and around the north and west edges of North Powder Valley, then south at about 4,000 feet elevation to just west of Baker City. The ancient lake terraces, which typify the Snake River Province, are fairly apparent around the north and west sides of North Powder Valley where they butt into the basaltic mountainous uplands to the west, which typify Blue Mountain Province. West of Baker City is an apparent geological uplift that abruptly elevates the line between terraces and mountainous uplands to about 5,000 feet elevation.

The demarcation line continues south from that point west of Baker City at about 5,000 feet elevation and then west along the north side of Sumpter Valley to Sumpter and south along the west side of Sumpter Valley. Sumpter is at the edge of Snake River Province.

From Sumpter Valley, the line continues southwest at about 5,000 feet elevation around the north side of Whitney Valley in upper North Fork Burnt River. About 5 miles northwest of Whitney on Camp Creek, the line of demarcation abruptly drops back to about 4,000 feet elevation where it continues around the west side of Whitney Valley and south along the North Fork, up the Middle Fork, then south and up the South Fork Burnt River southwest of Unity.

Some segments of the line described above have stands of coniferous trees, mainly ponderosa pine, on both sides, i.e., in both provinces. However, the conifer stands in Snake River Province are growing on deep soils related to ancient Snake River terraces; tree stands in Blue Mountain Province are growing on primarily aeolian soils overlying basalt formations which typifies the Blue Mountain Province. Based solely on the presence of pines, this line of demarcation may seem insignificant. However, differences in growth indices of pine might prove significant and should be compared. Based on the total plant community—understory vegetation and associated trees—this major soils line is definitely significant from an ecological standpoint.

In the head of South Fork Burnt River about 8 miles southwest of Unity at about 4,500 feet elevation, the line of demarcation between Blue Mountain and Snake River provinces continues

(continued on page 12)

Table 3. Major Ecological Sites in Blue Mountain Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Natural grassland (less than 10% canopy cover of shrubs)	Droughty rolling hills Bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass Rolling hills[a] Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass Moist rolling hills Idaho fescue/low shrubs Droughty south exposure Bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue Steep south exposure Bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue Droughty north exposure Bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass North exposure Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass Steep north exposure Idaho fescue, bluebunch wheatgrass/low shrubs Alpine grassland[b] Green fescue, Idaho fescue, needlegrass, elk sedge	Moist bottom Basin wildrye Dry meadow Idaho fescue, sod bluegrasses Wet meadow Tufted hairgrass, redtop, sod bluegrasses
Shrub–grassland (10% or more canopy cover of shrubs)	Scabland[a] Sandberg bluegrass, bluebunch wheatgrass/stiff sagebrush Clayey terrace Idaho fescue/stiff sagebrush Shrubby north exposure Tall shrubs/Idaho fescue/forbs Alpine sagebrush[b] Mountain big sagebrush/elk sedge	
Mixed coniferous–deciduous tree (5% or more canopy cover of trees)		Well-drained bottom Dry-wet meadows/shrubs/aspen, cottonwood, ponderosa pine
Coniferous tree (5% or more canopy cover of trees)	Pine–bunchgrass Ponderosa pine/Idaho fescue, bluebunch wheatgrass Pine–pinegrass Ponderosa pine/pinegrass, Idaho fescue Lodgepole pine–pinegrass Lodgepole pine/pinegrass, elk sedge Pine–Douglas-fir–pinegrass Ponderosa pine, Douglas-fir/pinegrass, elk sedge Douglas-fir–ponderosa pine forest Douglas-fir, ponderosa pine/shade plants Grand fir–Douglas-fir forest Grand fir, Douglas-fir/twinflower, shade plants Subalpine fir forest Subalpine fir, larch, spruce/shade plants Alpine open woodland[b] Subalpine fir, whitebark pine/shrubs/sedge	

[a] Biscuit scabland is a mapping unit that is a complex of two ecological sites, rolling hills (the biscuits) and scabland, in which the biscuits occupy about 5% or more of the area in the unit. If biscuits occupy less than 5%, the unit should be mapped as scabland.

[b] Alpine was not studied sufficiently to identify specific ecological sites.

south and rises up to the vicinity of Table Rock at 7,873 feet elevation. This appears to be caused by a huge geologic uplift, the eastern edge of which appears to be the Table Rock–Bullrun Rock–Lone Rock escarpment of the uplifted plateau. The very rough country to the east of this uplift lies in Snake River Province. Southwest of Lone Rock, the line of demarcation returns to about 5,000 feet elevation where it stays as it continues south and around the upper North Fork Malheur River.

Near where Crane Creek joins North Fork Malheur River, the Blue Mountain Province line goes west and around the south side of Crane Prairie at about 5,000 feet elevation. It is near the junction of Crane Creek and North Fork Malheur River that the Blue Mountain, Snake River, and John Day provinces join.

Blue Mountain–John Day Demarcation

From this junction, the line of demarcation between Blue Mountain and John Day provinces continues northwesterly from south of Crane Prairie in southeastern Grant County at about 5,500 feet elevation, which places it between Summit Prairie, in Blue Mountain Province, and Logan Valley which is in John Day Province.

The line follows the rims southwest of High Lake around the south slopes of Strawberry Mountain, Indian Creek Butte, and Pine Creek Mountain at about 5,500 feet elevation, and then west and north along the western slopes of Canyon Mountain. Along the north-facing slopes of Canyon Mountain, Baldy Mountain, and Strawberry Mountain (all in Blue Mountain Province), the line falls at about 4,500 to 5,000 feet or lower, based on the elevation at which volcanic ash is prominent in soils on these north-facing slopes. The volcanic ash soils typify Blue Mountain Province.

The line crosses the Middle Fork John Day River about 6 miles upstream from Bates, at about 4,500 feet elevation. Bates is in John Day Province as is the entire downstream reach of the Middle Fork. It is at this point above Bates that the Blue Mountain Province is only about 5 miles wide, from John Day Province on the west to Snake River Province on the east. This narrow area of Blue Mountain Province straddles the divide between Middle Fork John Day River and the West Fork and Middle Fork Burnt River.

The demarcation line runs northwesterly from Bates at about 4,500 feet elevation in the upper slopes of Middle Fork John Day River drainage. The old mining town of Susanville is in John Day Province.

From Susanville, the line continues north at about 4,500 feet elevation, about the level at which truncated or exposed tuffaceous deposits form steep slopes or escarpments. These tuffaceous deposits and underlying clayey materials typify the John Day Province.

From just west of Putney Mountain, in Blue Mountain Province, the line continues west and crosses Highway 395 near Meadow Brook Summit south of Dale at about 4,000 feet elevation. From there the line meanders generally northwest at about 4,000 feet elevation then pitches abruptly down a ridgetop to cross the North Fork John Day River at the first oxbow that changes the river's flow from west to south, about 18 miles downriver from Dale Bridge.

From west of Putney Mountain to the point where the line of demarcation crosses the North Fork John Day River, all watersheds draining north into the North Fork are in Blue Mountain Province. These include Desolation Creek, Meadow Brook Creek, and the steep north-facing timbered slopes along the North Fork.

Soils in these watersheds are medium-texture. Usually they have ashy surface layers formed by aeolian deposits of volcanic ash that accumulated on the north-facing slopes like snowdrifts. Underlying materials are generally basaltic. Ashy surface soils and basaltic underlying materials typify much of the Blue Mountain Province, especially in timbered areas, and the timber exists because of these soils, not vice versa.

From the oxbow of the North Fork John Day River where the line of demarcation crosses, the line follows the river east upstream to about a half mile west of the confluence of Deerhorn Creek with North Fork.

At this point, the line rises north out of the John Day canyon along the ridge west of Deerhorn Creek to about 4,000 to 4,500 feet elevation. From there it meanders westerly in and out of tributary canyons as it follows the major upper-level rimrocks at the south edge of the plateau. Plateau areas north of this line are in Blue Mountain Province; the canyon slopes of North Fork and tributaries below about 4,000 feet elevation are in John Day Province.

Placing the line of demarcation up the ridge west of Deerhorn Creek was a judgment call. It was deemed that the Deerhorn and Camas creeks' drainages resemble the upstream Blue Mountain Province soils and vegetation more than they do the downstream John Day Province soils and vegetation.

Buckaroo Flat, Thompson Flat, Potato Hill, Grassy Butte, and other such plateau points above about 4,000 feet elevation that jut out into the John Day River drainage are in Blue Mountain Province.

There is evidence that this junction actually may be a belt, rather than a line, which is common where ecological provinces or ecological sites join. For example, at Thompson Flat at the south end of Potamus Ridge is an area of biscuit scabland (patterned ground) in which the soil of a biscuit was 0 to 6 inches silt loam, 6 to 10 inches silty clay loam (these are typical surface soil textures in Blue Mountain Province), 10 to 20 inches silty clay, and 20 to 30 inches or more clay (these are typical subsoil characteristics in John Day Province). In this biscuit scabland site, the interspersed scabland soil is very shallow and very stony with abundant surface basaltic stones, which is typical for scabland in both Blue Mountain and John Day provinces.

Geologists have reported that the Blue Mountains of Oregon were at one time

the north shore of an ancient sea. If so, clay deposits such as at Thompson Flat, at about 4,000 feet elevation, are likely associated with ancient lake terraces.

It is interesting to note, as supporting evidence, that the ancient lakeshore terraces signifying where Snake River Province joins Blue Mountain Province in Baker County are very visible at 4,000 feet elevation near Keating and Richland. The continuity of the 4,000 feet elevation level, coupled with evidence of ancient lakebed terraces, obviously has great significance from an ecological province perspective.

Kinzua is in westernmost Blue Mountain Province. South and west of Kinzua the line of demarcation between Blue Mountain and John Day provinces is about 4,000 feet elevation.

This area has a mixture of forested soils that typify the Blue Mountain Province and other forested soils that typify John Day Province. This pattern of soils creates a belt of demarcation 2 to 3 miles wide. Consequently, a mapped line, such as the 4,000 feet elevation, is judgmental yet consistent with the line of demarcation southeast of Kinzua. The major difference in these soils is that those typifying Blue Mountain Province have medium- or moderately fine-texture profiles and are usually atop basalt bedrock; soils typifying John Day Province have clayey or clay subsoils and are atop ancient fine-texture sediments or tuffaceous deposits.

Blue Mountain – Columbia Basin Demarcation

About 4 miles northwest of Kinzua, the Blue Mountain, John Day and Columbia Basin provinces join near the old Hoover School at about 4,000 feet elevation. From that point north and east, the line of demarcation is between Blue Mountain and Columbia Basin provinces at about 3,500 feet elevation, within natural grasslands. About 22,000 acres in the Lonerock vicinity of southeastern Gilliam County lie in Blue Mountain Province. Within this segment of Blue Mountain Province is an island of John Day Province which surrounds Lonerock and covers about 7,500 acres in Gilliam County.

The line of demarcation between Blue Mountain and Columbia Basin provinces in southeastern Gilliam and southwestern Morrow counties is about 3,500 feet elevation. This elevation approximates major soil lines that are the basis for differentiating between Blue Mountain and Columbia Basin provinces.[78, 85]

On the Columbia Basin (north) side of this line, the major soil series are predominantly Condon, Morrow, and Lickskillet which have thin gray-brown to brown silt loam surface layers and brown silt loam or silty clay loam subsoils over basalt bedrock.

On the Blue Mountain (south) side of this line, the major soil series include Waha, Wahala, and Gwin, which have thick, very dark brown to black silt loam or silty clay loam surface layers and dark brown silty clay loam or clay subsoils over basalt bedrock. Obviously, these soil differences are not abrupt in the landscape but occur in a relatively narrow belt.

The significance of these major soil differences, from an ecological province perspective, is that the Blue Mountain Province soils with their darker color, thicker surface layers, and finer texture reflect, among other things, more precipitation and a colder climate than in the Columbia Basin. As a result, grasslands in Columbia Basin Province (with its more arid climate) are dominated by bluebunch wheatgrass with some Idaho fescue in the stand; on the Blue Mountain side of the line, Idaho fescue strongly dominates the composition with some bluebunch wheatgrass in the stand. There are several other significant differences between these two generalized plant communities.

Note that the line of demarcation between Blue Mountain and Columbia Basin provinces lies along the north- and northwest-facing foothill slopes of the Blue Mountains. This northerly aspect likely is another ecological factor that helps explain soil and plant differences on the line of demarcation because of associated storm patterns, cooler temperatures, and snowpack.

The demarcation line crosses from southeastern Gilliam County to southern Morrow County about 3 miles north of Lonerock at about 3,500 feet elevation. It crosses Highway 207 about 1 mile south of Hardman and meanders northeast to just south of Lena on the South Fork Butter Creek, where the Hughes cattle ranch is headquartered.

From the top of Franklin Hill, it runs east across North Fork Butter Creek and crosses Highway 395 about 8 miles south of Nye Junction. From this point, the line continues northeast along Owens Creek and lower Birch Creek and declines to about 2,000 feet elevation south of Pilot Rock. From there, the line goes northeast at about 2,000 feet elevation along the footslopes of upland foothills to Cayuse on the Umatilla River, at about 1,500 feet elevation.[75, 85]

Blue Mountain – Palouse Demarcation

Just on top of the hill north of Cayuse, the Blue Mountain, Columbia Basin, and Palouse provinces join. From that point, the line of demarcation between Blue Mountain and Palouse provinces runs northwest to Weston at about 2,000 feet elevation. It continues around the east side of the valley at Milton-Freewater and north into Washington at about 2,000 feet elevation. The latter part of this line is based on the soil line separating Athena silt loam and the high-rainfall phase of Walla Walla silt loam soil series, which typify the Palouse Province in Oregon, from the stony foothill soils of Blue Mountain Province.[75]

Cascade Ecological Province

Location

Cascade Ecological Province of Oregon encompasses high elevations of the Cascade Mountains from Columbia River Gorge south to within about 10 miles of the California state line in southwestern Klamath County. It includes the cooler, more moist mountains west of the hot, dry eastern Oregon area, north of the hot, dry Klamath Falls–Ashland–Medford area, and east of the warm Willamette Valley. Cascade Province is typified by Douglas-fir–true fir–hemlock forests (Fig. 8). Western hemlock is the key ecological indicator species distinguishing Cascade Province.

The province covers about 3.7 million acres in Hood River, Multnomah, Clackamas, Wasco, Jefferson, Marion, Lane, Linn, Douglas, Jackson and Klamath counties. It is physically separated from the Cascade Mountains in Washington by the Columbia River Gorge, which is in Willamette Province. The entire Cascade Province is in Oregon.

Description

Cascade Province is characterized by mountainous terrain related to the Cascade Mountain range in Oregon and by steep dendritic drainage patterns which are primarily associated with the Willamette River system. Lower elevations in the province are along the western boundary at about 1,200 feet elevation on north-facing slopes of streams draining west from the Cascade Range in Multnomah, Clackamas, Marion, Linn, and Lane counties. Along the eastern border of the province, lower elevations vary from about 2,000 feet west of Hood River Valley in Hood River County to about 4,000 feet in western Wasco County. Southward, near the California border, the lower elevations of Cascade Province are about 5,500 feet.

The highest elevation within Cascade Province is Mt. Hood at 11,245 feet. Other high points within the province are Mt. Jefferson, 10,405 feet; Mt. McLoughlin, 9,497 feet; Pelican Butte, 8,025 feet; Brown Mountain, 7,990 feet; and Klamath Point, 7,510 feet. The high country within the province is generally between 5,000 and 6,000 feet elevation (Fig. 9). Other spectacular peaks in the Cascade Mountains lie in Mazama Province. (Elevations are from USGS 1:250,000 topographic maps.)

Numerous field observations are that the advent of western hemlock in the forest composition is a reliable and widespread ecological indicator of the point at which a very significant ecological change occurs in soils, vegetation, and management implications when transecting from arid, warm forest to moist, cold forest. Changes in other species—woody and herbaceous —are concurrent with the advent of western hemlock. Western hemlock in a forest apparently is an indicator of an effective environment with 60 inches or more of precipitation annually as well as significantly cooler local climatic conditions.[45, 46]

When transecting from the arid, warm forest of The Dalles Province west into the moist, cool forest of Cascade Province, the advent of western hemlock in the plant community apparently signals the zone of more moisture and cooler temperatures, which also is indicated by the Divers, Hutson, and Thader soil series in Hood River County.

Consequently, western hemlock was chosen as the key indicator species differentiating Cascade Province from continguous provinces in Oregon because, first, it is widespread at higher elevations on both east and west slopes of the Cascade Mountains; and, second, a tree is a reliable indicator of average climatic conditions over long cycles.

Soils

The geomorphology of soils typifying Cascade Province shows a variety of parent materials associated

with the geology of the Cascade Mountains. Primary parent materials include residuum and colluvium from basalt, andesite, tuffs, breccias, and ash related to the volcanic activity and weathering during formation of the current mountain range.

Cascade Province extends about 250 miles, north to south, in Oregon. Consequently, the province includes a very wide cross-section of climatic and geologic situations which results in numerous soil series (Table 4).

Climate

Based on two official weather stations at upper elevations in Cascade Province, average annual precipitation is about 84.5 inches, of which about 21% occurs during the herbaceous-plant growing season, April through July. October through March ("winter") precipitation is about 70% of the annual total. Average January maximum and minimum temperatures are 38.1 and 21.6°F, respectively. Average April through July growing season maximum and minimum temperatures are 58 and 37.3°F, respectively.

Based on four official weather stations representing the lower western boundary of the province, average annual precipitation is about 72.5 inches, of which about 19% occurs during the herbaceous-plant growing season, April through July. October through March precipitation is about 77% of the total. Average January maximum and minimum temperatures are 40.9 and 28.1°F, respectively. Average April through July growing season maximum and minimum temperatures are 67.8 and 42.9°F, respectively.

A recent precipitation map[53] shows about 60 inches or more average annual precipitation along the east boundary of Cascade Province. Along the west boundary, average annual precipitation is about 70 inches or more.

However, where the province extends west on north-facing exposures along major drainages, the average annual precipitation in the general area is less than 70 inches. Nevertheless, the effect of north-facing cool exposures increases the effectiveness of the actual precipitation to the equivalent of 70 inches or more. This map also shows nearly 200 inches average annual precipitation on Mt. Hood and nearly 150 inches on Mt. Jefferson.

Table 4. Distribution of Prominent Soil Series in Cascade Ecological Province, Oregon.

	Oregon counties										
Representative soil series	Clackamas	Douglas	Hood	Jackson	Jefferson	Klamath	Lane	Linn	Marion	Multnomah	Wasco
Aschoff	x									x	
Bohannon		x					x				
Bull Run	x									x	
Coyata				x		x					
Divers			x								
Dumont				x		x					
Henline								x	x		
Holderman		x					x				
Howard					x						x
Hutson			x								
Jojo					x						x
Keel		x					x				
Kinney		x					x				
Klickitat								x	x		
Mackatie					x						x
McCully								x	x		
Pinhead					x						x
Reinecke				x		x					
Thader			x								

Vegetation

According to the 1936 State of Oregon Forest Type Map,[54] the only sizable nonforested areas in Cascade Province were areas above timberline on Mt. Hood and Mt. Jefferson and a few scattered burns which were less than 10% restocked. Otherwise, the province was forested except for some small mountain meadows, bogs, and bands of natural shrublands in timbered areas and sporadically where deep, longlasting snowpacks form.

Soil and plant studies of specific ecological sites within Cascade Province are not available if, indeed, such studies have been made. However, general observations indicate that above 3,500 to 4,000 feet elevation, noble and shasta fir and mountain hemlock are prominent trees; lodgepole pine is common on flats and in concave areas. Beargrass, rhododendron, red huckleberry, trailing blackberry, salal, sword fern, Cascade Oregon-grape, and bush chinkapin are common in the forest understory and diminish in abundance above about 5,000 feet elevation.

Below about 3,500 to 4,000 feet, Douglas-fir, white and grand fir, and western hemlock are prominent trees, occasionally with white pine in the northern portion or sugar pine in the southern portion and, at lower elevations, bigleaf maple. The understory is fairly abundant at these elevations and includes vine maple, bush chinkapin, snowbrush, grayleaf manzanita, Cascade Oregon-grape, bracken fern, and blue huckleberry.

Mountain meadows and bogs are typified by species such as Crater Lake sedge, black alpine sedge, Drummond rush, alpine aster, and tall trisetum. Subalpine zones include such species as subalpine fir, Engelmann spruce, and

Table 5. Climatic Data for Cascade Ecological Province, Oregon.[17]

Station and length of record (years)	Elevation (feet)	Precipitation			Average maximum and minimum temperatures (°F)	
		Annual (inches)	Oct.-March (%)	April-July (%)	January	April-July
High Country						
Clackamas County						
Government Camp 29	3,580	85.1	72	19	37.4-22.9	56.8-36.5
Douglas County						
Musick 6	5,530	84.8	69	23	38.8-23.3	59.3-38.0
High Country Average		84.5	70	21	38.1-21.6	58.0-37.3
Low Western Boundary						
Clackamas County						
Sundown Ranch 21	2,400	74.6	76	19	41.7-30.0	62.1-42.5
Three Lynx 22	1,135	67.7	77	18	41.6-29.7	69.8-45.1
Zig Zag 11	1,435	73.3	74	20	39.6-27.5	68.0-43.2
Marion County						
Detroit 15	1,400	74.2	79	17	40.7-25.3	71.2-40.8
Low Western Boundary Average		72.5	77	19	40.9-28.1	67.8-42.9

No official weather stations in Cascade Province in Hood River, Jackson, Jefferson, Klamath, Lane, Linn, Multnomah, or Wasco counties.

whitebark pine. Bands of shrubs around timbered slopes include huckleberry, heather, and a wide variety of forbs.

Management Implications

Much of Cascade Province consists of steep mountainous watersheds related to the dendritic pattern of upper drainages, primarily into the Willamette River system. Because of the steep slopes and fragile soils, roads must be restricted as well as carefully planned and maintained in order to maintain or restore acceptable watershed quality.

Watershed implications in this province are probably the greatest of any province in Oregon because of urbanization in the Willamette Valley. Water from these watersheds is increasingly important; thus, in the Cascade Province watershed values should be a primary consideration in management decisions.

Some areas in the province may be suitable for intensive forestry—tree farming. Other areas undoubtedly need to be managed primarily for watershed quality, which would likely involve such practices as selective harvesting to achieve prescribed watershed qualities with minimum soil deterioration.

The character of Cascade Province and its watershed implications suggest the need to consider a land classification system that distinguishes between areas suited to tree farms and areas in which forestry should be oriented primarily around watershed management.

A precedent for this approach has been used in general agriculture. There, a system classifies land according to various degrees of suitability for agricultural use. During early stages of the national soil conservation movement, this land-use approach was effective in informing the public and landowners about basic conservation principles. It also helped landowners make relatively broad determinations, based primarily on soils and slopes, of types of land-use activities and management options. A similar classification of forested lands would likely help publicize and put into use basic forest management principles related to watershed quality as well as commercial use.

Province Demarcation

Cascade – Willamette Demarcation

The juncture between Cascade, The Dalles, and Willamette provinces is about 6 miles south of Parkdale in Upper Hood River Valley and east of Highway 35, at an elevation of about 3,000 feet. Starting from this location, the line meanders northwest to the Columbia River Gorge where it continues along steep breaks of the gorge. Hood River Valley and Columbia Gorge are in Willamette Province.[44] The line of demarcation between Cascade and Willamette provinces is signified by the appearance of western hemlock in the Cascade forests.

North of Larch Mountain in eastern Multnomah County, the line gradually drops to about 1,400 feet in the vicinity of Bridal Veil, and from this area the line veers south at about that elevation. As the line goes south, it follows eastward up the south-facing slopes of each major drainage that heads in the Cascade Mountains and returns westward along the base of north-facing slopes of that same drainage.

This path reflects a significant pattern in the elevations at which western hemlock signifies the Cascade Province. Obviously, the pattern is an effect of the warm arid climate of Willamette Valley which extends up these valleys. Along the base of north exposures,

western hemlock is at about 1,200 feet, and that elevation on north exposures in drainages does not vary significantly from the Sandy River southeast of Portland south to the North Umpqua River northeast of Roseburg. Western hemlock grows at about 1,200 feet elevation on north-facing slopes of each major drainage in this part of Oregon.

However, in this same area on south-facing slopes (which represent increasingly drier and warmer situations) western hemlock rises in elevation from north to south. For example, along the Sandy River southeast of Portland, western hemlock occurs at about 1,400 feet elevation on south-facing slopes. But, when the line of demarcation continues southward from the vicinity of Firwood on Highway 26 in Clackamas County, the appearance of western hemlock on south exposures rises to about 1,600 feet. Farther south along South Santiam River, western hemlock grows at about 1,800 feet elevation on south-facing slopes.[45]

Western hemlock on south-facing slopes and on climate-climax positions probably grows at about 1,800 feet elevation along the Santiam, Calapooya, and McKenzie river drainages. However, farther south along the Middle Fork Willamette River, the occurrence of western hemlock rises to about 2,000 feet elevation on both south- and north-facing slopes.

In this north-to-south transition, the line of demarcation between Cascade and Willamette provinces extends east, up the Sandy River to about Brightwood; up the Clackamas River to about Fish Creek; up the Little North Santiam to about Elkhorn; up the North Santiam River to about 6 miles east of Mill City; up the Middle Santiam River to just below Green Peter Dam; up South Santiam River to about House Rock Forest Camp; up the Calapooya River to about King Camp; and up McKenzie River to about Belknap Springs.

Near Belknap Springs, the eastern boundary of Willamette Province is close to the western boundary of Mazama Province. A narrow strip connects the part of Cascade Province north of the McKenzie River and the portion south of it. The line between Cascade and Willamette provinces east of Cottage Grove, which is in Willamette Province, lies at about 2,000 feet elevation on west-facing slopes. It meanders up and back down various minor drainages between there and the North Fork Umpqua River.

The line crosses North Fork Umpqua River about 5 miles northeast of Glide, in Willamette Province, near Idleyld Park in the topographic gap where Rock Creek fish hatchery is. From this gap, the line runs south up the ridge to about 2,800 feet elevation on south-facing slopes near Shivigny Mountain, which is in Cascade Province.

From this area around the upper reaches of Little River, hemlock grows at about 1,500 feet elevation on north-facing slopes and at about 2,800 feet on west- and south-facing slopes. Unpublished studies[36] indicate that areas above about 3,600 feet in Cascade Province are forested mainly by true fir and mountain hemlock. These high-elevation areas have been referred to locally as the High Cascades, and they are components of Cascade Province.

Cascade–Siskiyou Demarcation

In the vicinity of Lane Mountain about 10 miles east of Roseburg, which is in Willamette Province, lies the junction of Cascade, Willamette, and Siskiyou provinces.[36,50] In this vicinity, the drainages into South Umpqua River are southwesterly which exposes the generally south-facing headwaters of the drainages to the arid, hot climate that typifies Siskiyou Province. Consequently, the line between Cascade and Siskiyou provinces generally follows around the headwaters of the drainages at about 3,000 feet on south- and west-facing slopes.

In the headwaters of South Umpqua River and its tributaries, the line of demarcation wanders south at about 4,000 feet elevation. It continues along the west slopes of Quartz Mountain and then southerly along the west slopes of Bald Mountain to cross the Rogue River about 6 miles below the community of Prospect, which is in Mazama Province. In this area the narrow ash flow out of Mt. Mazama (Crater Lake), which extends southwest between the communities of Union Creek and Prospect, creates a narrow strip connecting the portions of Cascade Province that lie to the north and the south of Crater Lake.

From about 6 miles below the community of Prospect, the line meanders

Table 6. Average Dates Vegetation Growth Begins and Ends in Cascade Ecological Province, Oregon.

Station and length of record (years)	Elevation (feet)	Average date growth begins*	Average date growth ends*
High Country			
Clackamas County			
Government Camp 29	3,580	April 27	Does not occur
Douglas County			
Musick 6	5,530	April 1	Does not occur
Low Western Boundary			
Clackamas County			
Sundown Ranch 21	2,400	March 7	Does not occur
Three Lynx 22	1,135	February 22	Does not occur
Zig Zag 11	1,435	March 1	Does not occur
Marion County			
Detroit 15	1,400	March 1	Does not occur

* The average date vegetation growth begins on native perennial bunchgrasses is approximately the date average daily temperatures reach 39 to 40°F. Average date growth ends is considered to be when available soil moisture is depleted. Interpretations are based on data in Johnsgard.[17]

southeast at about 4,000 feet elevation. It gradually rises in elevation through the headwaters of drainages into Rogue River, Big Butte Creek, and Little Butte Creek. Mt. McLoughlin is in Cascade Province. Fish Lake at the head of Little Butte Creek is in Siskiyou Province. The juncture of Cascade, Siskiyou, and Klamath provinces is near Brush Mountain in southeastern Jackson County at about 5,500 feet elevation.

Cascade–Klamath Demarcation

The line between Cascade and Klamath provinces runs southeast at about 5,500 feet elevation around the headwaters of Jenny Creek in southwestern Klamath County and on to the south slopes of Buck Mountain. From Buck Mountain, the line turns north on the east side of Buck Peak, Mt. Harriman, Pelican Butte, Lather Mountain, and Klamath Point. Each of these mountains is in Cascade Province. The juncture of Cascade, Klamath, and Mazama provinces is near Klamath Point.

Cascade–Mazama Demarcation

From that juncture, the line between Cascade and Mazama provinces goes northwest about 1 to 3 miles south of and somewhat paralleling Highway 62, to the vicinity of Union Creek community. In this area, the Mazama Province extends southerly in a valley 2 to 3 miles wide lying on each side of Highway 62 from Union Creek south to Prospect.

This narrow extension of Mazama Province appears to be a large ash flow along the upper Rogue River extending southwest from the main pumice mantle near Crater Lake. The soil typifying this ash-flow extension of Mazama Province is Alcot series. Soils in adjacent Cascade Province are Freezner and Geppart.[68]

From the vicinity of Union Creek community, the line runs north across the divide between the Rogue River and North Umpqua River watersheds just east of Buckneck Mountain. From there, it follows northerly down Clear Creek, across the plateau at Toketee airstrip, and across North Umpqua

Table 7. Comparison of the More Abundant and Characteristic Grass, Shrub, and Tree Species in the Cascade, Coast, and Willamette Provinces in Oregon.[7, 23]

Vegetation		Cascade	Coast	Willamette
Grasses				
Bluegrass, annual	*Poa annua*			x
Bluegrass, hotsprings	*Poa laxiflora*		x	
Bluegrass, Kentucky	*Poa pratensis*			x
Bluegrass, Wheeler	*Poa nervosa*	x		
Brome, California	*Bromus carinatus*			x
Brome, Columbia	*Bromus vulgaris*			x
Brome, soft	*Bromus mollis*			x
Fescue, foxtail	*Festuca megalura*			x
Hairgrass, diffuse	*Aira elegans*			x
Hairgrass, silver	*Aira caryophyllea*			x
Oatgrass, tall	*Arrhenatherum elatius*			x
Oniongrass, Alaska	*Melica subulata*			x
Orchardgrass	*Dactylis glomerata*			x
Reedgrass, bluejoint	*Calamagrostis canadensis*	x		
Ryegrass, Italian	*Lolium multiflorum*			x
Ryegrass, perennial	*Lolium perenne*			x
Sweetgrass, California	*Hierochloa occidentalis*	x		
Timothy, alpine	*Phleum alpinum*	x		
Velvetgrass, common	*Holcus lanatus*			x
Woodreed, drooping	*Cinna latifolia*	x	x	
Shrubs				
Alder, mountain	*Alnus tenuifolia*	x		
Alder, red	*Alnus rubra*		x	x
Alder, Sitka	*Alnus sinuata*	x		
Azalea, Cascade	*Rhododendron albiflorum*	x		
Birch, bog	*Betula pumila*	x		
Blackberry, dwarf	*Rubus lasiococcus*	x		
Blackberry, evergreen	*Rubus laciniatus*			x
Blackberry, strawberryleaf	*Rubus pedatus*	x		
Ceanothus, redstem	*Ceanothus sanguineus*			x
Ceanothus, snowbrush	*Ceanothus velutinus*	x		
Cherry, bitter	*Prunus emarginata*			x
Currant, Crater Lake	*Ribes erythrocarpum*	x		
Currant, mapleleaf	*Ribes acerifolium*	x		
Currant, redflower	*Ribes sanguineum*			x
Currant, sticky	*Ribes viscosissimum*	x		
Currant, trailing black	*Ribes laxiflorum*		x	
Dewberry, snow	*Rubus nivalis*	x		
Dewberry, western	*Rubus vitifolius*			x
Dogwood, western red	*Cornus californica*			x
Elderberry, red	*Sambucus callicarpa*		x	
Gooseberry, Watson	*Ribes watsonianum*	x		
Hawthorn, black	*Crataegus douglassii*			x
Hazel, western	*Corylus cornuta*			x
Huckleberry, grouse	*Vaccinium scoparium*	x		
Huckleberry, ovalleaf	*Vaccinium ovalifolium*	x		
Huckleberry, red	*Vaccinium parviflorum*		x	

(continued)

Table 7 (cont'd). Comparison of the More Abundant and Characteristic Grass, Shrub, and Tree Species in the Cascade, Coast, and Willamette Provinces in Oregon.

Vegetation		Cascade	Coast	Willamette
Shrubs *(continued)*				
Huckleberry, thinleaf	*Vaccinium membranaceum*	x		
Kalmia, bog	*Kalmia microphylla*	x		
Manzanita, greenleaf	*Arctostaphylos patula*	x		
Maple, vine	*Acer circinatum*		x	
Menziesia, rustyleaf	*Menziesia ferruginea*	x		
Mountain-ash, dwarf	*Sorbus occidentalis*	x		
Mountain-ash, Pacific	*Sorbus sitchensis*	x		
Oregon-grape, tall	*Berberis aquifolium*			x
Pachystima	*Pachystima myrsinites*	x		
Poison-oak, Pacific	*Rhus diversiloba*			x
Prince's-pine, common	*Chimaphila umbellata*	x		
Rose, Nootka	*Rosa nutkana*			x
Rose, pearfruit	*Rosa pisocarpa*			x
Rose, sweetbrier	*Rosa eglanteria*			x
Scotchbroom	*Cytisus scoparius*			x
Serviceberry, western	*Amelanchier florida*			x
Spirea, Douglas	*Spirea douglasii*			x
Spirea, subalpine	*Spirea densiflora*	x		
Willow, feathervein	*Salix pennata*	x		
Willow, Sierra	*Salix orestera*	x		
Wintergreen, Oregon	*Gaultheria ovatifolia*	x		
Wormwood, Douglas	*Artemisia douglasiana*			x
Trees				
Ash, Oregon	*Fraxinus latifolia*			x
Cottonwood, black	*Populus trichocarpa*			x
Dogwood, Pacific flowering	*Cornus nuttallii*			x
Douglas-fir	*Pseudotsuga menziesii*	x	x	x
Fir, grand	*Abies grandis*	x		x
Fir, Pacific silver	*Abies amabilis*	x		
Fir, subalpine	*Abies lasiocarpa*	x		
Hemlock, mountain	*Tsuga mertensiana*	x		
Hemlock, western	*Tsuga heterophylla*	x	x	
Maple, bigleaf	*Acer macrocephyllum*			x
Oak, Oregon white	*Quercus garryana*			x
Pine, lodgepole	*Pinus contorta murrayana*	x		
Pine, shore	*Pinus contorta contorta*		x	
Pine, western white	*Pinus monticola*	x		
Pine, whitebark	*Pinus albicaulus*	x		
Redcedar, western	*Thuja plicata*	x	x	
Spruce, Sitka	*Picea sitchensis*		x	
Willow, Pacific	*Salix lasiandra*			x
Willow, Piper	*Salix piperi*			x
Willow, Scouler	*Salix scouleriana*			x

River below Toketee Reservoir. It then heads northeast to cross the divide between North Umpqua River and the headwaters of the Middle Fork Willamette River about 5 miles west of the Cascade Range crest.[91]

From the headwaters of the Middle Fork Willamette River, the line between Cascade and Mazama provinces runs north around the west side of Bear Mountain to Salt Creek canyon. There, the Southern Pacific railroad climbs a switchback out of Salt Creek to pass over the summit of the Cascade Mountains just west of Odell Lake, which is in Mazama Province. The line of demarcation goes north, to the west of Waldo Lake, and then east of Moolack Mountain and around the headwaters of the South Fork McKenzie River.[93]

The 1970 General Soil Map of Linn County[80] does not provide soil information in the mountainous eastern portion of the county. Therefore, the line of demarcation between Cascade and Mazama provinces in that area is drawn on the basis of topographic features of the line on maps to the south of this area.

In Lane and Douglas counties, the mapped pumice-mantle boundary is primarily along a major topographic change in the landscape: a relatively undulating or sloping area to the east of the line, which typifies Mazama Province in that area and, to the west, relatively steep mountainous terrain which represents the sharp dendritic drainage pattern of Cascade Province.

Some pumice from the eruption of Mt. Mazama likely fell in the Cascade Mountains west of the current pumice mantle. However, because of the steep dendritic drainage pattern representing headwaters of numerous drainages into the Willamette River, these pumice deposits probably have been washed downstream or may still be in isolated deposits mainly on steep north-facing slopes within Willamette Province.

Using the previously described topographic feature as a guide, the line of demarcation between Cascade and Mazama provinces is predicted to run north from the headwaters of the South

Fork McKenzie River on around the headwaters of the McKenzie and South Santiam rivers near Fish and Lava lakes, about where Highway 20 crosses the pass. From there, the predicted line veers northeast to cross Highway 22 about 4 to 5 miles northwest of Santiam Junction. The line probably continues northeast into Jefferson County north of Three Fingered Jack peak and to where Jefferson Creek joins Metolius River. In that area, Cascade, Mazama, and The Dalles provinces meet.

The demarcation line between Cascade and Mazama provinces in Douglas, Lane, and Linn counties is based on soil lines between Holderman and Keel soil series, which typify Cascade Province, and Winopee and Shukash soil series, which typify Mazama Province.[79] Farther north, in western Jefferson County, the soil series in Cascade Province may be Howash and Mackatie, which typify Cascade Province on the Warm Springs Indian Reservation.[96] Soil series in adjacent Mazama Province include Lapine, Shanahan, Deschutes, and Steiger.[70]

Cascade–The Dalles Demarcation

From the juncture of Cascade, Mazama, and The Dalles provinces in western Jefferson County, the line between Cascade and The Dalles provinces runs north along the eastern slopes of the Cascades at about 4,500 feet elevation—approximately the elevation at which western hemlock becomes a significant component of forested plant communities in this area.

In southwestern Wasco County, the demarcation line drops to about 4,000 feet elevation as it goes north. Western hemlock's growth at lower elevations in northern Oregon than in southern Oregon is seen on both east and west slopes of the Cascades as well as along the east slopes of the Coast Range. Apparently, this is due to an overall warmer climate to the south which causes western hemlock to grow at high elevations. The line meanders north at about 3,000 feet elevation to an area near the southeastern corner of Upper Hood River Valley where Cascade, The Dalles, and Willamette provinces join.

Coast Ecological Province

Location

The Coast Ecological Province in Oregon includes the mountainous uplands of the Coast Range and the hills, valleys, tidelands, and beaches within the fog zone of the Pacific Ocean. It extends about 300 air miles north to south across the entire state from the Columbia River down to the Oregon–California border. It is widest east to west along the Columbia River where it extends from near Fort Stevens west of Astoria upriver about 50 air miles to near Rainier. It is about 45 air miles wide near Cape Blanco in Curry County. Farther south, near Gold Beach, the province is only about 1 to 2 miles wide in a few locations due to upland promontories in Siskiyou Province, such as Grizzly Peak and Sundown Mountain, which are higher than the normal fog zone along the coast.

Coast Province in Oregon covers about 4.5 million acres in Clatsop, Columbia, Washington, Tillamook, Yamhill, Polk, Lincoln, Benton, Lane, Douglas, Coos, and Curry counties. It extends north across the Columbia River into Washington and south into California.

Description

Physiographically, the Coast Province in Oregon includes nearly the entire drainage systems of 20 rivers—from north to south, the Clatskanie, Youngs, Lewis and Clark, Necanicum, Nehalem, Salmonberry, Miami, Wilson, Trask, Nestucca, Siletz, Yaquina, Alsea, Yachats, Coos, Coquille, Sixes, Elk, Pistol, and Chetco.

It also includes lower reaches of three major rivers—Siuslaw, Smith, and Umpqua—which have major watersheds in Willamette Province to the east. About 15 miles of the lower Rogue River, which transects Siskiyou Province to the east, is within the coastal fog zone that characterizes the southern portion of Coast Province in Oregon.

Coast Province has three general geomorphic features: the mountainous Coast Range, coastal terraces, and a narrow coastal plain interrupted by headlands of resistant rocks that extend to the shoreline (Fig. 10).

All principal valley mouths have been drowned by the sea. Extensive sand dunes near the mouths of most rivers are intermittent from Coos Bay north. Drowning of present streams has formed bays and long alluvial flats. The tide commonly reaches 20 miles up a major river.[9]

The entire west boundary of Coast Province is at sea level. The highest point in the province is Marys Peak in Benton County at 4,097 feet elevation (Fig. 11). A few other prominent mountains, including Hanging Rock at 3,954 feet in Coos County and Dutchman Butte at 3,907 feet in Douglas County, are in Coast Province. However, most prominent peaks are less than 3,400 feet elevation. (Elevations are from USGS 1:250,000 topographic maps.)

Numerous field observations are that the advent of western hemlock in the forest composition is a reliable and widespread ecological indicator of the point in the landscape at which a very significant ecological change occurs in soils, vegetation, and management implications when transecting from arid forest to moist forest. Other species, woody and herbaceous, also change with the advent of western hemlock.

In Oregon, western hemlock in a forest apparently indicates an effective environment equivalent to 60 or more inches average annual precipitation and significantly cooler local climatic conditions.[34, 35, 36, 37, 44, 45, 46]

Western hemlock is a reliable indicator of average climatic conditions over long climate cycles. Thus, western hemlock was chosen as the key species differentiating Coast Province, in which

it generally is common in forested uplands, from Willamette and Siskiyou provinces in which it is not generally common in forested uplands.

Soils

The geomorphology of soils typifying Coast Province of Oregon involves a very wide variety of parent materials including geologically recent alluvial terraces and bottomlands along streams, tidal flats at mouths of valleys that have been drowned by the sea, old marine terraces, and the Coast Mountains which consist of sandstone, basalt, breccias, and tuffs.[9] Further complication results from the extent of the Coast Province which, in Oregon, is from the mouth of the Columbia River south to the California border and from the shores of the Pacific to the crest (and beyond in some instances) of the Coast Range in Oregon. The province includes all or part of 12 counties and all or major portions of 20 rivers. Consequently, soil series of Coast Province in Oregon are too numerous to categorize. However, Table 8 illustrates how some series are widespread in the province and others are more or less local.

Table 8. Distribution of Prominent Soil Series in Coast Ecological Province, Oregon.

	Oregon counties											
Representative soil series	Benton	Clatsop	Columbia	Coos	Curry	Douglas	Lane	Lincoln	Polk	Tillamook	Washington	Yamhill
Astoria		x						x	x	x		
Bandon				x								
Bohannon	x			x		x	x	x	x			
Braillier		x					x					
Brenner						x	x			x		
Capeblanco					x							
Cascade			x									
Coquille		x								x		
Depoe								x				
Digger				x	x							
Dullards				x	x	x	x					
Fendall								x				
Floras					x							
Gearhart		x										
Heceta				x								
Hembre		x	x				x	x	x	x	x	x
Honeygrove	x								x			
Klickitat	x	x	x				x	x	x		x	x
Knappe		x						x				
Langlois					x							
Millicoma					x							
Nehalem						x	x	x		x		
Nelscott								x				
Neskowin										x		
Nestucca						x	x					
Netarts										x		
Olyic			x									
Peavine	x								x			
Preacher				x		x						
Quillayute								x				
Reedsport					x							
Sauvie			x									
Slickrock	x							x	x			
Umpcoos				x	x							
Waldport				x								
Warrenton		x										
Westport		x				x	x					
Winema		x								x		
Yaquina							x					

Climate

Based on 24 official weather stations, primarily covering the coastal portion of Coast Province, average annual precipitation is about 76.2 inches. Of that, about 40% falls during the major part of the herbaceous-plant growing season, February through June. October through January (winter) precipitation is about 55% of the precipitation. Average January maximum and minimum temperatures are 49.5 and 35.4°F, respectively. Average February through June maximum and minimum temperatures are 59.4 and 41.6°F, respectively.

The highest precipitation recorded at these stations is 130.6 inches at Glenora, at about 575 feet elevation about 10 miles south of Tillamook community. Lowest precipitation, less than 60 inches, is recorded at Clatskanie on the Columbia River and at Bandon in Coos County.

A recent precipitation map[53] shows about 200 inches average annual precipitation in northeastern Tillamook County where the elevation is over 3,000 feet in the headwaters of the North Fork Wilson River. This is the highest precipitation in Oregon.

This map also shows about 175 inches average annual precipitation in western Polk County, north of the former Valsetz community, at over 3,000 feet elevation near Sugarloaf Mountain; and about 150 inches in northeastern Lincoln County at over 3,000 feet elevation near Stott Mountain. Other

prominent uplands in Coast Province have 100 or more inches average annual precipitation. Tillamook County has the largest area of over-100-inches average annual precipitation in the province. Based on official weather stations, the southern counties of Douglas, Coos, and Curry are more arid annually and warmer in January than other counties to the north. They also have somewhat higher minimum temperatures in the February through June growing season.

Vegetation

From a vegetation standpoint, Coast Province in Oregon is generally the area west of the elevation at which western hemlock grows in forest plant communities of the Coast Range from

Table 9. Climatic Data for Coast Ecological Province, Oregon.[17]

Station and length of record (years)	Elevation (feet)	Precipitation			Average maximum and minimum temperatures (°F)	
		Annual (inches)	Oct.-Jan. (%)	Feb.-June (%)	January	Feb.-June
Clatsop County						
Astor Expt. Sta. 15	50	75.7	54	39	47.4-32.8	58.9-40.3
Astoria 21	10	80.8	55	37	46.7-34.9	58.3-42.1
Jewell 11	200	71.2	55	38	42.5-30.5	58.9-38.9
Seaside 21	10	79.7	54	39	50.6-35.9	58.4-42.1
Columbia County						
Clatskanie 17	50	55.6	55	40	41.9-31.3	58.9-41.3
Coos County						
Bandon 10	8	55.5	57	39	52.6-36.7	58.4-42.1
Coquille 9	61	59.8	56	40	51.3-32.9	62.0-41.2
McKinley 12	140	66.9	54	41	51.4-35.6	61.2-40.0
Marshfield 29	38	64.5	54	41	51.6-36.6	59.3-41.4
North Bend 21	11	62.3	57	39	52.2-38.0	58.5-43.8
Powers 20	275	61.6	57	40	52.9-33.9	63.7-40.8
Curry County						
Brookings 21	80	81.9	56	40	54.0-39.9	60.0-44.1
Gold Beach 16	50	81.6	57	39	54.0-39.9	58.2-44.1
Port Orford 18	24	71.5	54	42	53.6-39.6	58.6-44.1
Douglas County						
Gardiner 22	15	78.1	54	41	50.3-38.6	58.7-43.4
Reedsport 13	12	74.2	55	40	50.7-36.6	59.2-42.6
Lane County						
Canary 20	100	78.6	55	39	49.9-35.0	59.5-40.8
Deadwood 12	350	91.9	57	38	47.2-35.4	61.0-40.9
Lincoln County						
Tidewater Hatchery 11	40	93.0	56	38	46.5-33.8	61.5-41.7
Newport 19	128	65.7	54	40	49.4-38.1	57.1-43.5
Toledo 34	50	75.6	53	42	51.5-34.7	60.5-39.9
Tillamook County						
Cloverdale 11	20	82.7	53	40	48.5-34.4	58.5-41.4
Glenora 25	575	130.6	58	39	42.8-30.5	58.5-36.5
Tillamook 19	15	89.4	54	39	49.0-34.0	58.1-40.4
Province Average		76.2	55	40	49.5-35.4	59.4-41.6
County Averages						
Clatsop		76.9	55	38	46.8-33.5	58.6-40.9
Columbia		55.6	55	40	41.9-31.3	58.9-41.3
Coos		61.8	56	40	52.0-35.6	60.5-41.6
Curry		78.3	56	40	53.9-39.8	58.9-44.1
Douglas		76.2	55	41	50.5-73.6	59.0-43.0
Lane		85.3	56	39	48.6-35.2	60.3-40.9
Lincoln		78.1	54	40	49.1-35.5	59.7-41.7
Tillamook		100.9	55	38	46.8-33.0	58.4-39.4

the Columbia River south to southwestern Douglas County. Along this line of demarcation between Coast and Willamette provinces, Coast Province is typified by forest communities in which such species as western hemlock, Douglas-fir, red elderberry, and red alder are common (Fig. 12). The contiguous Willamette Province to the east is typified by forest plant communities in which western hemlock is scarce or absent but Douglas-fir, bigleaf maple, and Oregon white oak are common.

In southwestern Douglas County, the Coast Province becomes contiguous with Siskiyou Province to the south; the line of demarcation continues southwesterly through Curry County to the normal coastal fog zone about 12 miles upriver from Gold Beach on the Rogue River. Along the line, Coast Province is typified by western hemlock, Douglas-fir, and some scattered tanoak in forest plant communities. Contiguous Siskiyou Province is typified by a dominance of tanoak and abundant Pacific madrone, wedgeleaf ceanothus, and Douglas-fir.

From central Curry County south to the California border, the Coast Province consists of the normal coastal fog zone and continues contiguous to Siskiyou Province. In this area, Coast Province is typified by Sitka spruce, Douglas-fir, western hemlock, red alder, California-laurel, and, in the vicinity of Mt. Emily and Elk Mountain, scattered small stands of coast redwood. Siskiyou Province to the east is typified by tanoak, Pacific madrone, and Douglas-fir with scattered, minor occurrence of western hemlock on north exposures.[51]

Table 10. Average Dates Vegetation Growth Begins and Ends in Coast Ecological Province, Oregon.

Station and length of record (years)	Elevation (feet)	Average date growth begins*	Average date growth ends*
Clatsop County			
Astor Expt. Sta. 15	50	winter growing	Does not occur
Astoria 21	10	winter growing	Does not occur
Jewell 11	200	February 7	Does not occur
Seaside 21	10	winter growing	Does not occur
Columbia County			
Clatskanie 17	50	February 7	Does not occur
Coos County			
Bandon 10	8	winter growing	Does not occur
Coquille 9	61	winter growing	Does not occur
McKinley 12	140	winter growing	Does not occur
Marshfield 29	38	winter growing	Does not occur
North Bend 21	11	winter growing	Does not occur
Powers 20	275	winter growing	Does not occur
Curry County			
Brookings 21	80	winter growing	Does not occur
Gold Beach 16	50	winter growing	Does not occur
Port Orford 18	24	winter growing	Does not occur
Douglas County			
Gardiner 22	15	winter growing	Does not occur
Reedsport 13	12	winter growing	Does not occur
Lane County			
Canary 20	100	winter growing	Does not occur
Deadwood 12	350	winter growing	Does not occur
Lincoln County			
Tidewater Hatchery 11	40	winter growing	Does not occur
Newport 19	128	winter growing	Does not occur
Toledo 34	50	winter growing	Does not occur
Tillamook County			
Cloverdale 11	20	winter growing	Does not occur
Glenora 25	575	March 4	Does not occur
Tillamook 19	15	winter growing	Does not occur

* The average date vegetation growth begins on herbaceous plants is approximately the date average daily temperatures reach 39 to 40°F. Average date growth ends is considered to be when available soil moisture is depleted. Interpretations are based on data in Johnsgard.[17]

For a comparison of the more abundant and characteristic grass, shrub, and tree species in the Cascade, Coast, and Willamette ecological provinces in Oregon, see Table 7, pages 18-19.

According to the 1936 State of Oregon Forest Type Map,[54] about 5% of Coast Province was classified as nonforested lands—native or improved pasture along major river and creek bottoms and wetlands around bays. About 1% of the province was classified as sand dunes and nonforested coastal vegetation. Less than 1% was occupied by shore pine. All the rest was classified as Douglas-fir forest of various age classes of which about 10% was classified as deforested burns, including the huge Tillamook burn.

Clatskanie, Jewell, and Glenora weather stations, inland in northern Coast Province, have average monthly temperatures below 39°F at some time in winter which terminates winter growth on herbaceous plants. Farther south, however, the Deadwood station in Lane County, about 18 air miles inland from the coast in the Siuslaw River drainage, has growing conditions all winter. This likely reflects the generally warmer coastal climate that penetrates up the Siuslaw drainage. The Powers station, which is about 25 air miles inland from Cape Blanco, also has continuous winter growing conditions, likely due to the penetration of coastal climate up the South Fork Coquille River.

Although not supported by official weather station data, higher elevations in the Coast Range have average monthly temperatures in winter that terminate growth of herbaceous plants. Snowfall for brief periods is common in winter on the Coast Range.

Management Implications

Much of Coast Province consists of relatively steep mountains and dendritic drainages of 24 river systems that cross the province to flow into the Columbia River or Pacific Ocean. Forestry is by far the prevalent commercial activity in the province. However tourism, fisheries, wildlife, and agriculture are significant commercial activities that are closely interrelated and, to some degree, interdependent with commercial forestry.

The potential for judicious management of renewable natural resources is significantly complicated by the pattern of ownership in Coast Province.

A map in the 1978 BLM Recreation Guide for Oregon shows private and public land ownership; at that time, about 50% or more of the province was owned privately, including some huge blocks of land. Furthermore, most of the public lands administered by BLM lie in an alternate-section, checkerboard pattern with private lands. This further complicates interrelationships and interdependencies.

The predominant forest aspect and varying soil and physiographic components of Coast Province strongly suggest the need for a land classification procedure that helps identify important bases for management strategies.

The procedure would distinguish, for example, between areas capable of sustaining intensive forestry—tree farming—and other areas where forestry should be designed explicitly to complement other significant values such as watershed, fish, wildlife, and aesthetics. With such land classification, resource management strategies and combinations of practices would be initially predicated on inherent soil and physiographic factors.

It is important that management strategies and practices be devised jointly by appropriate scientists, practitioners, and representatives of the involved public so as to optimize the learning-by-listening process that is basic for resolving complicated resource issues.

A precedent for this approach has been used previously in general agriculture. It is a system for classifying land according to various degrees of capability for agricultural use. During early stages of the soil conservation movement, this land-use capability approach effectively informed the public and landowners about basic conservation principles. It also helped landowners make relatively broad determinations, based primarily on soils and slopes, of various types of land-use activities and management options.

A similar classification of forested lands would likely help publicize and put into practice basic forest management principles related to watershed quality and other commercial values, as it did in agriculture.

Province Demarcations

Coast–Willamette Demarcation

The line of demarcation between Coast and Willamette provinces begins just west of Rainier on the bank of the Columbia River in Columbia County. From there it meanders west along the tops of steep slopes overlooking the Columbia at about 500 feet elevation. About 6 miles east of Clatskanie, the line veers sharply to the south on topography about 750 to 1,000 feet elevation that is west of Clatskanie River.

At the ridge that separates the Clatskanie and Nehalem river drainages, the line of demarcation turns northwest along the north side of Nehalem River drainage at about 1,000 feet elevation. In the upper reaches of Fishhawk Creek, the line goes south to cross Nehalem Valley less than a mile west of Nehalem community, at about 600 feet elevation. From there, it ascends the ridge leading south to Green Mountain where, at an elevation of about 1,750 feet, it circles east and south of the mountain to cross Sunset Highway (U.S. 26) in the headwaters of Rock Creek at about 1,600 feet elevation.

From the summit pass on Highway 26, the line goes southeast at about 1,750 feet elevation to the Tillamook–Washington county line. It cuts south at that elevation around the east and south sides of Round Top and the headwaters of Gales Creek. It crosses the pass between Gales Creek and Wilson River at about 1,600 feet elevation and returns to 1,750 feet elevation to meander south around the headwaters of drainages flowing east into the Tualatin and North Yamhill rivers.

Northwest of McMinnville, the demarcation line makes a huge swing west at about 1,700 feet elevation around the headwaters of drainages flowing south into South Yamhill River. The line crosses Highway 22 northwest of Grande Ronde at about 670 feet elevation and crosses Highway 18 in Van Duzer State Park at about 770 feet elevation. This is the pass between the Yamhill and Salmon river drainages.

From Van Duzer State Park, the demarcation line ascends the ridge to the south. Within about 3 miles it is again at about 1,750 feet elevation on Saddleback Mountain. From there, it goes east and south at about 1,750 feet elevation around headwaters of drainages flowing into Yamhill and Little Luckiamute rivers. From the south side of Monmouth Peak in southwestern Polk County, the line descends the ridge southeasterly to cross the Luckiamute River at about 650 feet elevation. It ascends Cougar Ridge and then meanders south along the crest of the Coast Range. The Coast Range descends on the narrow divide between Marys River and Yaquina River to about 730 feet elevation at the community of Summit, which is about 5 miles northwest of Blodgett on Highway 20.

From the community of Summit, the demarcation line continues west and south along the crest of the Coast Range to cross the Corvallis–Newport highway (U.S. 20) at about 800 feet elevation about 2 miles northwest of Burnt Woods community. This is the

pass between Tumtum River flowing east and Little Elk Creek flowing west. From there, the line of demarcation runs south along the crest of the Coast Range to Marys Peak where it turns north and east around Marys Peak at about 1,700 feet elevation.

The line crosses the pass on Alsea Highway (Oregon 34) at about 1,125 feet elevation and continues southeast up the ridge and around the east slopes of Flat Mountain at about 1,750 feet elevation. From there the line continues south at about the same elevation. This is the crest of the Coast Range between drainages flowing into Alsea River to the west and Long Tom River to the east.

The demarcation line continues south along the crest of the Coast Range to the pass between Wildcat Creek to the west and Noti Creek to the east, which is about 6 miles southwest of Fern Ridge reservoir. The line continues southeasterly along the crest of the Coast Range and then descends into the Siuslaw River drainage to cross the river about 12 miles downriver from Lorane community, which is northwest of Cottage Grove.

From the crossing on the river, the line follows up the northside bottomlands along the river to about 2 miles east of King Ranch. The bottomlands along Siuslaw River below 600 feet elevation are in the fog-belt zone of the Coast Province, which is typified by the presence of occasional Sitka spruce trees. From the vicinity of King Ranch on the Siuslaw, the line travels south along the divide between Siuslaw and Smith rivers and then west around the headwaters of Smith River.[93]

From the headwaters of South Fork Smith River about 5 miles northwest of Drain community, the line veers west along the divide between Smith River to the north and drainages flowing into Umpqua River to the south. This portion of the Umpqua system is in Willamette Province.

About 4 miles north of Scottsburg, the line goes south to cross Umpqua River at Scottsburg community.[36, 71] It ascends the ridge across the river from Scottsburg and goes southeast along the ridgetops to the big bends in Umpqua River west of Kellogg community. From there, it goes south along the ridgetop that divides drainages flowing east into Umpqua River and drainages flowing to the west into the Coos and Coquille rivers.

The line crosses the Coos Bay Wagon Road west of Reston community, which is in Willamette Province, at 1,850 feet elevation and continues southwesterly at about 2,000 feet elevation.[36, 91]

About 7 miles southwest of Camas Valley community, which is in Willamette Province, the line crosses Highway 42 along Middle Fork Coquille River at about 800 feet elevation. From there, the line climbs the ridge southeasterly to Chipmunk Ridge.[51] The junction of the Coast, Willamette, and Siskiyou provinces is near the southeast end of Chipmunk Ridge.

The line of demarcation between Coast and Willamette provinces is based primarily on the elevation at which western hemlock is common. This line also is supported by the general occurrence of such forested soils as the Bellpine, Jory, Retner, and Bateman series, which typify Willamette Province, and by the Bohannon, Blachly, Preacher, and Digger series which typify Coast Province.

It is interesting to note that at locations along the crest of the Coast Range where elevation is significantly below 1,700 feet, the hemlock line is at the pass on the summit. For example, where Sunset Highway (U.S. 26) crosses the summit into the Nehalem River drainage, the province line is about 1,600 feet elevation. At the community of Summit on the pass between Marys River and Yaquina River, the summit is about 730 feet elevation. On Highway 20 between Corvallis and Newport, the summit is about 800 feet elevation. On the Alsea Highway (Oregon 34), the summit is about 1,125 feet elevation.

Farther south, the Coast–Willamette line of demarcation, based on the advent of western hemlock in forested uplands, is about 600 feet elevation where it crosses Siuslaw River, about 470 feet as it crosses Umpqua River, and about 800 feet as it crosses Middle Fork Coquille River. These rivers have major headwaters in Willamette Province. Furthermore, Umpqua River drains sizable watersheds in both Cascade and Siskiyou provinces.

Each of these river crossings and passes in the crest of the Coast Range, where the advent of western hemlock signifies the line of demarcation, apparently marks where the effects of the warm, arid Willamette Valley climate are overcome by the more moist, cool coastal climate.

Coast–Siskiyou Demarcation

From the juncture of Coast, Willamette, and Siskiyou provinces near Chipmunk Ridge in southwestern Douglas County, the line of demarcation between Coast and Siskiyou provinces goes south at about 3,000 feet elevation to Dutchman Butte. It follows Hayes Ridge southwesterly and southward to Ninemile Mountain and continues southwesterly at about 3,200 feet elevation to north of Kelsey Peak in northeastern Curry County.

From there, the line runs west to the vicinity of Big Meadows and then north, west, and southwest at about 3,000 feet elevation around the upper Mule Creek watershed. It follows Panther Ridge southwesterly at about 2,800 feet elevation close to the Coos–Curry county line.

From there, the line extends south along the east slopes of Ophir Mountain and Brushy Mountain at about 2,800 feet elevation. In the vicinity of Lake of the Woods Mountain the line runs southwest to Soldier Camp Mountain, Second Prairie Mountain, and First Prairie Mountain. Elevation decreases from about 2,800 feet at Soldier Camp Mountain to about 1,200 feet in the vicinity of Lobster Hill just north of Rogue River.[51]

The demarcation line in northeastern and north-central Curry County is

based primarily on the elevation at which western hemlock is common in forested uplands in Coast Province, as compared to the common appearance of tanoak, madrone, and other plant species that signify the warmer and drier conditions that typify the western portion of Siskiyou Province.

This line of demarcation also is supported by the general presence of such forested soils as Preacher, Bohannon, Digger, and Umpcoos, which typify Coast Province,[60] and the soil series Atring, Kanid, Acker, Beekman, Pollard, and Vermisa, which typify Siskiyou Province in this vicinity.[56]

In the vicinity of Lobster Hill the line between Coast and Siskiyou provinces intersects the upper boundary of the normal coastal fog zone at about 1,200 feet elevation. This upper boundary coincides with the line of demarcation from this area south to the Oregon–California border. Several sharp bends in the Rogue River near Lobster Hill apparently hinder the fog from going farther upriver. The line of demarcation, therefore, crosses the Rogue River between Lobster Hill and Skookumhouse Butte.

The line, which is the upper boundary of the coastal fog zone, continues at about 1,200 feet elevation around the headwaters of Quosatana Creek and west around Kimball Hill. The line runs southwesterly somewhat parallel to the Rogue River and then south at about 1,200 feet elevation.

It travels up and around the headwaters of Hunter Creek, then west of Sundown Mountain, up and around headwaters of Pistol River and its tributaries, of Chetco River and its tributaries, and of Winchuck River and its tributaries at about 1,200 feet elevation.[51] It crosses from Oregon into California about 8 air miles east of the Pacific Ocean.

From the vicinity east of Lobster Creek, a tributary of the Rogue River, and south to the Oregon–California border, the line of demarcation between Coast and Siskiyou provinces is based on the presence of Sitka spruce, red alder, Douglas-fir, western hemlock, and other species that typify the cool, moist fog zone coastal climate.

By comparison, the common appearance of tanoak, Pacific madrone, and related species signify the warmer, drier conditions that typify Siskiyou Province. This line also is supported by the general presence of such soils as Bosland, Floras, Millicoma, and Reedsport, which typify Coast Province in this area, and Fritsland, Bravo, Mislatnah, and Pollard which typify Siskiyou Province in this area.[56]

From the California border north, the upper boundary of the normal coastal fog zone is at about 1,200 to 1,400 feet elevation in the drainages of Winchuck, Chetco, Pistol, and Rogue rivers where it constitutes the line of demarcation between Coast and Siskiyou provinces.

From the vicinity of the Rogue River north to Humbug Mountain, the upper boundary of the coastal fog zone remains at about 1,200 feet elevation. However, it does not constitute the Coast Province boundary in this area because east of the fog zone in this area are forested uplands in which western hemlock is common.

Western hemlock is a key indicator species that typifies uplands of Coast Province from this vicinity north to the Columbia River.

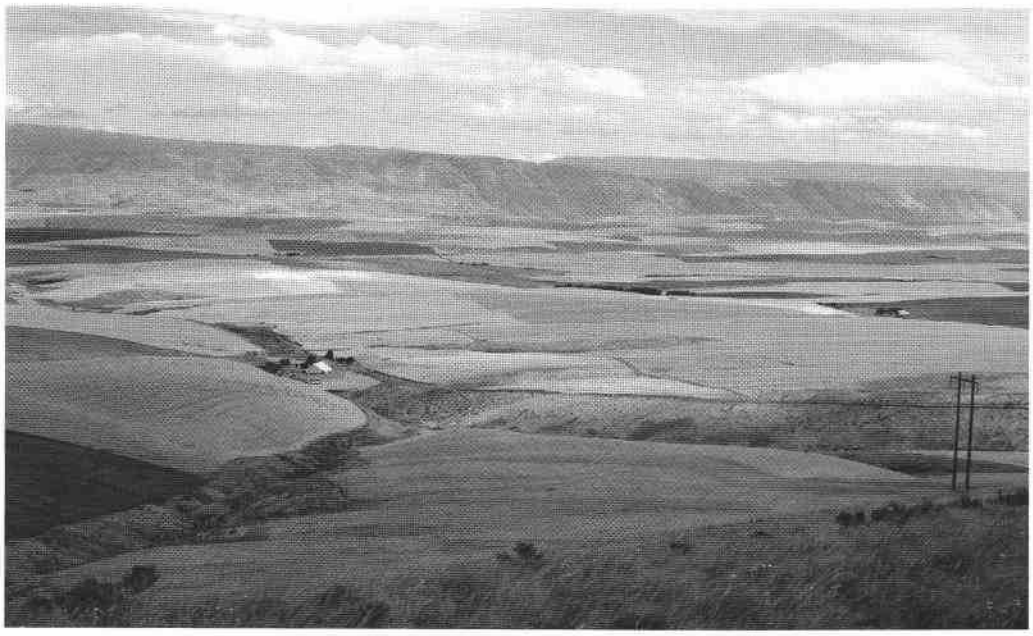
North from Humbug Mountain, the upper level of the fog zone lowers to about 800 feet elevation.[51] Still farther north, the fog zone is up to about 500 to 600 feet elevation in the valleys of major drainages such as the Alsea, Yaquina, and Salmon rivers. There, the fog zone boundary is represented by the appearance of Sitka spruce, a key indicator species of the cool, moist fog zone.[25, 34, 35, 36, 44, 45, 46]

Changes from south to north in the elevation of the upper boundary of the coastal fog zone is likely caused by changes in coastal climatic conditions. Although not substantiated by available weather data, observations of onshore storm patterns have been that stormy weather south from Cape Blanco often is less severe than it is to the north, which may help account for a cooler, more moist annual climate north along the coast. The pattern of plant community composition from south to north supports this view.

The coastal fog zone's upper boundary is the distance that fog normally penetrates major coastal river systems having headwaters at higher elevations in the Coast Range. However, on major coastal rivers with headwaters at low elevations in the Willamette Valley, such as the Umpqua, the normal fog zone penetrates only to the point that the warmer, drier climate of the Willamette Valley resists fog penetration up the drainage. On the upper Umpqua River, for example, the line between Coast and Willamette provinces crosses the river from north to south at Scottsburg, which has an elevation of 47 feet. The Willamette Valley's type of vegetation — representing a warm, dry climate —is very apparent to the east of the line of demarcation at Scottsburg.

The differences between the coastal fog zone north from Humbug Mountain and that from Humbug Mountain south to the California border suggests that further study to the south, into California, might substantiate the existence of a Northern Coast Ecological Province in California.

The coastal fog zone south from Humbug Mountain may be a transition between a vegetation dominated to the north by Sitka spruce/western hemlock/shore pine/Douglas-fir and, to the south, by a vegetation dominated by tanoak/Douglas-fir/coast redwood. However, based on current concepts, the coastal fog zone south from Humbug Mountain, although somewhat different from that north of the mountain in terms of vegetation and soils, has been included in Coast Ecological Province.



Columbia Basin Ecological Province

Location

The Columbia Basin Province in north-central Oregon includes the lower portion, generally below about 3,500 feet elevation, of several major watersheds that drain north into the Columbia River. It covers about 3.25 million acres and includes northwestern Umatilla County, the northern two-thirds of Morrow County, all Gilliam County except for a very small area in the southeast corner, all of Sherman County, much of northeast and southeast Wasco County, a small area in northwest Wheeler County, and about 2,500 acres west of Willowdale in northern Jefferson County.

Milton-Freewater is in the northeast corner of the province; The Dalles is just west (outside) the northwest corner of the province in Oregon. The province is bisected by lower reaches of six major drainages: Deschutes River, John Day River, Rock Creek, Willow Creek, Butter Creek, and Umatilla River, all of which flow generally north. The province extends into Washington.

Description

Elevations within Columbia Basin Province in Oregon range from about 100 feet near The Dalles to about 3,500 feet along the line of demarcation between Columbia Basin and Blue Mountain provinces. The physiography is mainly a hilly upland sloping up from north to south and dissected by numerous dendritic-pattern drainages. A sizable sandy basin lies west of the Hermiston area. There are no prominent mountains in the province in Oregon.

Columbia Basin Province in Oregon has two physiographic subdivisions which have significant ecological and management implications. These are the ancient lake basin, which is largely irrigated agriculture except on the Boardman Bombing Range Reserve, and the silty uplands, which are dryland agriculture and native rangelands.

The smaller of the two subdivisions is the ancient lake basin. Locally, this area is commonly called the Umatilla Basin, probably because early irrigation in the vicinity of Echo, Stanfield, Hermiston, Umatilla, Irrigon, and Boardman depended on water from Umatilla River stored in Cold Springs Reservoir west of Hermiston. More recently, pumping from wells and from the Columbia River has greatly expanded irrigation agriculture in the lake basin and likely would have expanded it a great deal more if it hadn't been for the huge Boardman Bombing Range Reserve.

The lake basin subdivision of Columbia Basin Province covers about 450,000 acres in Oregon.

The lake basin, with its underlying strata of gravel beds, hardpans, and other materials, is geologically related to the era of glacial melt farther north following the ice age. Geologists have reported that the glacial melt resulted in the Missoula flood(s); the ice jam near The Dalles that backed up water (Lake Condon); and the ice floes containing sand, silt, gravel, and other glacial debris and erratics. When the floes melted, these erratics and debris were deposited over the landscape in the lake basin. Skeletal remains of mammoths and other ice-age artifacts have been uncovered in the lake basin.

The silty uplands portion of Columbia Basin Province is almost entirely dryland agriculture and rangeland. Nearly all arable acreage is being farmed or has been at one time, primarily for wheat production in a wheat summer-fallow alternate-year rotation (Fig. 13). All the silty upland rangeland is considered a natural grassland (less than 10% canopy cover of woody species in original ecological status).

Throughout the natural grasslands that have not been cultivated in Columbia

Basin Province in Oregon, silty grassland soils on most plateaus and ridges between about 1,700 and 3,500 feet elevation occur in a unique land pattern locally called biscuit scabland.

The pattern consists of small mounds of grassland soils 5 to 20 feet or more in diameter and usually about 20 to 36 inches deep over basalt bedrock. Each mound, or biscuit, is surrounded by very shallow, very stony soils over basalt bedrock, which locally is called scabland. Hence the name biscuit scabland (Fig. 14). The biscuits vary somewhat in shape and size, usually round but sometimes oblong.

They make up about 5 to 30% or more of the area in which they are found. Where biscuits are in more than about 40 to 50% of the area, some have been farmed. Cultivation has redistributed the soil mantle so that it is essentially continuous but of varying depth—deeper on former biscuits and shallower over what used to be scabland, with an undulate surface.

Biscuit scabland in Columbia Basin Province is common from just west of Pilot Rock in Umatilla County to Dufur in Wasco County; however, the soil of the biscuit component of this pattern changes from location to location.

Soil series on biscuits include Condon, Morrow, Valby, Wapinitia, and Maupin silt loams; Condon series is the most extensive. The soil on the scabland component is Bakeoven. Biscuits do not occur generally below 1,700 feet elevation in aeolian soils such as Ritzville and Walla Walla silt loams.

During the past 150 years, more than 30 hypotheses have been advanced to explain the origin of biscuit scabland, according to John Eliot Allen, emeritus professor of geology at Portland State University. The possible reasons include moles, gophers, Indian burials, hut sites, buffalo wallows, ant hills, and mounds formed around water, gas, oil, or mud springs.

Allen believed four of these were reasonable: erosion, during which the mounds were protected by vegetation; wind deposition, which posits that the mounds are coppice dunes formed around trees or shrubs; freezing and thawing, which, in the far north, produces polygonal ground on tundra; and gophers' tunneling backward from their nest sites which, over the years, gradually built up the area around the nest (this last theory was based on a situation in California).

Undoubtedly, all such mounds are not alike, even though they look alike on the surface. Also, all four of Allen's choices may apply somewhere but, conceptually, do not apply to the biscuit scablands of Columbia Basin Province in Oregon.

Here are some facts about Oregon's biscuit scabland. First, numerous roadcuts throughout the biscuit scabland in Columbia Basin Province prove that the material underlying the biscuits is solid, very thick basalt (Fig. 15). That fact alone discredits some hypotheses cited above, i.e., gophers, ants, trees, and freezing–thawing polygons.

Second, the soil profile of each Columbia Basin biscuit in any general area has essentially, if not exactly, the same sequence of horizons, colors, textures, and depth ranges as nearby continuous mantles of that soil. They are the same soil series whether in biscuits or in continuous mantle. This suggests the geomorphology—the source of parent material and the conditions under which the soil was formed—is the same for the biscuits as for the soil mantle.

One previously unpublished concept of the origination of biscuit scabland is based on much personal experience with the biscuit scabland complex in the Columbia Basin and Blue Mountain provinces in Oregon and on various published articles, one of which lists 23 topical references.[18]

The concept originated with a point made in one of these articles about the era of glaciation in North America. The article noted that there were "sympathetic" ice sheets on areas at higher elevation south of the continental glaciers. This is credible and forms the basis for the following concept of how biscuit scabland originated.

Glaciers lay north of Oregon. Biscuit scabland is on ridges and plateaus between 1,700 and 3,500 feet in Columbia Basin Province and at about 3,500 to 4,500 feet elevation in Blue Mountain Province.

Sympathetic ice sheets likely covered some of these higher areas at the time glaciers were receding. Elevations above 4,500 feet and other, lower areas could have been covered with thick ice or even local glaciers. When a layer of ice melts, it melts uniformly over the surface but also melts faster in some spots than in others to form circular or elongated depressions which eventually become holes in the ice.

As glaciers were receding north, the prevailing winds were from the cold, glacial area to the warm, equatorial area, i.e., from north to south generally. As glaciers receded, glacial debris was exposed. Prevailing winds blew dust south where it was deposited to become the vast aeolian silty soils that typify the upland soils of Columbia Basin and Blue Mountain provinces.

Aeolian soil material was deposited as sympathetic ice sheets melted. Conceivably, the aeolian deposits on the ice washed into and collected in holes where the ice was melting. These collections of silt became mounds as the ice sheet melted. The final ice melt on the sympathetic ice sheet was where scabland now exists between the mounds.

Obviously, erosion from runoff would remove silts from the area that is now scabland. Erosion also would tend to round the top of each biscuit and to slope the sides. Elongated biscuits are oriented generally with the slope of the land, and lines of biscuits oriented with the slope of the land are common. This might indicate that the final melt worked its way downslope in a concentrated stream, thereby flushing off the silt to form a linear pattern of scabland. This water action might also help explain why scabland without biscuits is primarily along outer edges of ridges and on sloping areas in minor drainages where water had concentrated to wash the silt off basalt bedrock.

Some biscuits are deeper than others, which might be related to the thickness of the ice sheet. Holes would have more time to fill with silt where the ice sheet was fairly thick and the process of melting was prolonged. Some areas do not have biscuit scabland but do have a solid mantle of silty soils. This may indicate the absence of an ice sheet at the time of aeolian deposition; many of these extensive soil areas are at relatively low elevations where ice sheets probably did not exist.

After the glaciers receded, prevailing winds returned to the global pattern, generally from southwest to northeast. The winds redistributed the aeolian silts over the landscape to leave shallow soil layers on south- and west-facing slopes and deep deposits like snowdrifts on north-facing slopes. This pattern is typical currently. After the glacial era, prevailing southerly winds deposited and redistributed volcanic ash over the area from sources such as Mt. Mazama. Consequently, volcanic ash is a prominent component of aeolian silty soils in both Columbia Basin and Blue Mountain provinces in Oregon.

Soils

Discharges of materials from prehistoric Umatilla River and wind redistribution of sandy and silty surface materials originating during glacial melt have likely influenced the mix of parent materials of the lake basin soils.

Sandy soils of this basin include such series as Quincy, Royal, Taunton, and Koehler, which represent deep sands as well as sandy soils overlying hardpans or gravel beds and miscellaneous deposits related to the ice age. Stabilized sand dunes, usually oriented southwest to northeast, account for some of the low ridges and valleys that typify parts of the basin. The dunes are represented generally by the Winchester soil series.

Bottomlands along lower Butter Creek and lower Umatilla River, which are used mainly for irrigated agriculture, are not sandy soils. They include such soil series as Onyx and Hermiston, which consist of alluvial silty materials originating in upper reaches of major drainages. Onyx silt loam is one of the best bottomland soils in eastern Oregon for irrigated agriculture. Large areas of strongly sodic bottomland and low terrace soils, such as Stanfield and Umapine series, are around Hermiston.

Along the perimeter of this ancient lake there is evidence of a lakeshore terrace at about 900 feet elevation where it butts against adjacent uplands. Generally, this terrace consists of laminated calcareous silty lacustrine deposits which are likely related to aeolian materials reportedly blown south during the era of receding glaciers farther north.

Conceivably, aeolian materials that were deposited in the ancient lake became mud flats around the perimeter, and these now appear as a lakeshore terrace. Thin, laminated horizontal layers in this silty lakeshore terrace material support the concept that they were lacustrine deposits, i.e., deposited in still water over a long time.

Along the lake basin's northeast perimeter, the lakeshore terrace is overlaid by sandy materials of varying thickness. They likely are related to the prevailing northwesterly winds which redistributed sandy surface materials from the interior to the northeastern edge of the lake basin after the lake receded. Sagehill series soils illustrate the sand overlay of the silty lake terrace.

Along the southeastern and southern part of the lake basin, the lakeshore terrace is overlaid by aeolian silty material of varying thickness. These aeolian deposits likely were made after water receded and the lakeshore terrace was exposed. Usually the line of demarcation is fairly distinct between the aeolian deposit and the underlying lacustrine deposit. Moreover, the aeolian deposit overlying the lakeshore terrace resembles nearby upland aeolian soils in parent material, structure, and texture. Silty soils overlying the lakeshore terrace around the perimeter of this lake basin include series such as Sagemoor, Warden, and Ellisforde.

Basalt underlies Columbia Basin uplands. Soils overlying this basalt bedrock have been formed primarily in silty aeolian deposits that reportedly originated and were blown south during the era glaciers receded in Washington. These silty soils are quite uniform throughout the province but vary somewhat from location to location due to climatic factors that influence soil profile development, such as color and subsoil texture.

For example, Ritzville series is a deep silt loam associated with precipitation of 9 to 11 inches. Walla Walla series is a deep silt loam associated with about 13 to 14 inches precipitation. Soils such as Condon and Valby are moderately deep silt loam over basalt, and Pilot Rock series is moderately deep silt loam over cemented hardpan; all are associated with 12 to 14 inches precipitation. Morrow silt loam is moderately deep over basalt and has a silty clay loam subsoil which reflects the 14-to-15-inch precipitation zone in which it is found.

All these soils in Columbia Basin Province are lighter in color than soils formed in comparable aeolian deposits in Blue Mountain Province.

Grassland soils on north-facing slopes are normally deeper than those on plateaus due to the snowdrift effect that prevailing southerly winds have had in redistributing aeolian deposits. Wrenthem soil series reflects this situation. Soils on south- and west-facing slopes, such as Lickskillet series, are very stony and fairly shallow to bedrock.

The upland soil that suports natural shrub–grassland vegetation in Columbia Basin Province lies on plateaus and ridgetops and is very shallow and very stony. It has a thin loamy surface layer and clayey subsoils and is usually less than 10 inches deep to basalt bedrock. The soil series is Bakeoven, and this land is locally called scabland.

Climate

Based on six official weather stations representing a cross-section of the ancient lake basin area in which farming usually requires irrigation, the average annual precipitation for the

Table 11. Climatic Data for Columbia Basin Ecological Province, Oregon.[17]

Station and length of record (years)	Elevation (feet)	Precipitation			Average maximum and minimum temperatures (°F)	
		Annual (inches)	Oct.-Feb. (%)	March-June (%)	January	March-June
Area in which farming usually requires irrigation						
Gilliam County						
Arlington Airport 20	890	8.8	66	27	38.7-25.1	70.2-44.5
Blaylock 17	237	9.8	68	24	39.9-27.2	71.8-47.3
Morrow County						
Ella 9	830	8.8	61	28	39.7-22.7	70.0-41.6
Umatilla County						
Echo 19	601	10.2	57	33	38.9-24.0	71.8-43.3
Hermiston 22	451	8.5	60	32	39.5-22.4	72.4-42.4
Umatilla 21	285	7.8	59	32	39.7-23.8	71.9-43.1
Irrigated-area Average		9.0	62	29	39.4-24.2	71.3-43.7
Area of dryland summer-fallow farming						
Gilliam County						
Condon 21	2,880	12.4	52	37	36.6-20.7	62.5-35.4
Mikkalo 7	1,500	9.1	61	25	35.6-20.9	65.7-40.1
Morrow County						
Heppner 22	1,950	13.1	50	40	39.9-23.7	64.4-37.4
Sherman County						
Grass Valley 15	2,381	11.2	58	33	38.0-21.8	63.6-34.5
Kent 21	2,707	10.7	53	36	36.6-21.7	62.3-38.2
Moro 22	1,858	11.8	63	30	36.3-22.7	64.6-37.2
Wasco 22	1,270	11.7	65	27	37.0-23.6	66.2-40.6
Umatilla County						
Milton-Freewater 20	1,056	13.8	54	38	39.8-25.3	69.8-44.9
Pendleton						
Roundup Park 40	1,070	14.2	54	33	40.5-24.9	73.7-43.2
Pilot Rock 18	1,817	13.7	48	41	40.5-23.3	67.8-41.2
Wasco County						
Dufur 20	1,250	12.0	67	28	37.9-22.3	66.8-36.0
Dryland-area Average		12.2	57	33	38.0-22.8	66.2-39.0

No official weather station in Columbia Basin Province in Wheeler County.

area is 9 inches. Of this, 29% comes during the growing season of native herbaceous plants, March through June. About 62% of total precipitation falls from October through February. Average January maximum and minimum temperatures are 39.4 and 24.2°F, respectively. Average March through June maximum and minimum temperatures are 71.3 and 43.7°F, respectively.

Based on 11 official weather stations representing a cross-section of the silty upland area in which dryland summer-fallow wheat farming is practiced, the average annual precipitation there is 12.2 inches. Of this, 33% falls during the growing season of dryland agricultural crops and herbaceous native plants, March through June. October through February precipitation is about 57% of total annual precipitation. Average January maximum and minimum temperatures are 38 and 22.8°F, respectively. Average March through June maximum and minimum temperatures are 66.2 and 39°F, respectively. Precipitation and temperature data vary from locality to locality (Table 11).

It should also be noted that this province, especially the ancient lake basin portion, is noted for dense fog in winter. This is a source of precipitation that is not represented in weather-station data, yet likely it has a significant effect on the moisture available for plant growth.

Vegetation

Vegetation in the ancient lake basin portion of Columbia Basin Province in Oregon is a natural shrub–grassland (10% or more canopy cover of shrubs) based on soil and ecological site studies made in the 1950s and 1960s.[38]

Shrubs, such as big sagebrush, rubber rabbitbrush, green rabbitbrush, and broom snakeweed are prominent throughout the lake basin area on deep sandy soils, on sandy soils overlying buried sedimentary deposits, and on shallow silty soils overlying the

sedimentary lakeshore terrace. Broom snakeweed was called matchweed by local old-timers because sheepherders wintering flocks on this "desert range" would crumple a handful of the resinous shrub as tinder to start a fire.

The 1937 Western Range Survey of USDI Grazing Service District 7, which extended more or less from Arlington east to the Stanfield area and from the Columbia River south to about the present southern boundary of the Bombing Range, mapped extensive areas of bitterbrush.

This federal grazing district was, at that time, used primarily to winter sheep and cattle. Subsequent soil and site studies reveal that bitterbrush grows in this area on relatively deep sands and on stabilized sand dunes. In this location and climate, bitterbrush does not grow on sites where the sandy surface soil overlying sedimentary deposits is relatively thin nor on sites where the surface soil is loamy or silty. This suggests a soil–moisture relationship.

The presence of vigorous bitterbrush on sandy soils in this location under a climate of less than 9 inches annual precipitation, over 60% of which falls in winter, is indeed an ecological oddity given the normal habitat of bitterbrush in Oregon. Ecological site studies in Oregon over many years indicate that bitterbrush requires effective moisture of 12 inches annual precipitation or more.[5] In the case of this lake basin, some combination of ecological factors obviously is producing the required effective environment. Possible factors might include the region's fog patterns and soil characteristics.

This basin is noted for dense fog in winter which might augment precipitation records significantly because plant foliage intercepts fog moisture and directs it into the soil profile. Actual annual precipitation may exceed 9 inches in some years. Sandy soils characteristically absorb water readily; a high percentage of water absorbed is readily available to plants; and absorbed water penetrates deeper in sandy soil during a given period than in soils of finer texture.

Table 12. Generalized Moisture Equivalent (Field Capacity) of Various Soil Textures.

Texture	Moisture equivalent (% of dry soil)	Incremental increase
Coarse sand	4.6	
Fine sand	7.6	65% greater than coarse sand
Loamy sand	no data	Possibly 50 to 60% greater than fine sand
Sandy loam	15.5	104% greater than fine sand, but possibly only about 40% greater than loamy sand
Loam	18.9	22% greater than sandy loam
Silt loam	24.4	29% greater than loam
Clay loam	32.4	33% greater than silt loam
Clay	38.2	18% greater than clay loam

Sandy soils actually retain water at depths for longer than one might expect because sand itself acts as a mulch that protects deep soil moisture from excessive evaporation and desiccation. Capillary movement of water upward is less among coarse soil particles than among fine soil particles.

Early soil and site studies in this basin revealed moist to wet sand below about 6 feet deep in July and August. However, the possibility that the moisture was wicked up from an underground aquifer is not improbable in those days before irrigation from wells lowered the water table. Bitterbrush is a very deep-rooted plant once established, and it can utilize such deep soil moisture.

The water-holding capacity of various soil textures (Table 12) indicates there is a greater increment in moisture equivalent (field capacity) between several sandy-soil textures than between loamy soils or soils of finer texture.[19, 20]

An interesting factor in soil–plant relationships is seen in the incremental increases in field capacity—such as the ability of the soil profile to retain water, from coarse sand to fine sand and likely on to loamy sand—and the decreasing increment between loamy sand and sandy loam textures. The relationship between the incremental increase of field capacity in various sandy textures and the occurrence of bitterbrush in this sandy basin is not clear.

However, a cursory study of relationships between bitterbrush stands and soil textures in this sandy lake basin was made during the 1950s or 1960s.[38] Auger holes at most section corners and quarter-corners provided a uniform grid sampling in an area about 4 miles from east to west and 2 miles from north to south. The area had sporadic stands of vigorous bitterbrush, some 30 to 40 sample plots. Essentially all plots with soil described as loamy sand or fine sand produced bitterbrush. In virtually all locations where soil was described as sandy loam there was no bitterbrush.

The phenomenon of loamy sand plots with no bitterbrush suggests a wildfire pattern. The major habitat for bitterbrush in this lake basin portion of Columbia Basin Province are the Quincy loamy fine sand and Koehler loamy sand soil series.

The growing season of bitterbrush in the lake basin is very much earlier than any other bitterbrush site in eastern Oregon. Here, bitterbrush flowers at least 30 days earlier than in other locations where it is common. That indicates that the annual growth cycle of bitterbrush in the basin has adapted to begin and end while adequate soil moisture is available.

The herbaceous vegetation on these sandy sites is dominated by needle-and-thread, Indian ricegrass, Sandberg bluegrass, and varying amounts of Columbia milkvetch, wormwood, pteryxia, Gorman lomatium, and Carey balsamroot. Cheatgrass is a strong winter annual which forms rosettes 3 to 6 inches in diameter over the the winter

and provides excellent spring forage for various classes of grazing animals. These sandy sites also are well known as nesting habitat for curlews.

Herbaceous vegetation on stabilized sand dunes is dominated by Indian ricegrass, yellow wildrye, Sandberg bluegrass, squirreltail, and a variety of perennial forbs such as buckwheat, Gorman lomatium, wormwood, pteryxia, scurfpea, yellow spiderflower, veiny dock, and pricklypear.

Around the southern perimeter of the lake basin, the natural plant community on the silty lake terrace site is one of the simplest natural plant communities in Oregon. It is a shrub–grassland in which big sagebrush, gray rabbitbrush, and broom snakeweed constitute slightly more than 10% canopy cover. Bluebunch wheatgrass and Sandberg bluegrass strongly dominate the total cover; perennial forbs, such as yarrow, snow buckwheat, woollypod loco, and spreading phlox are sparse in the canopy cover. A good example of this site in reasonably natural ecological status is The Nature Conservancy's Boardman Research Natural Area in the southeast corner of the Boardman Bombing Range.

Based on 171 recordings representing examples of eight major ecological sites in this province in southern Umatilla, Morrow, Gilliam, and Sherman counties on which native vegetation was in high ecological status, the natural vegetation of silty uplands in Columbia Basin Province in Oregon is a natural grassland, i.e., less than 10% canopy cover of shrubs (Fig. 16).

Data from these 171 recordings show that low gray rabbitbrush was on 87% of the plots but in very minor amounts. In contrast, big sagebrush was recorded on only 29% of the plots and only in minor amounts. It is typical of rangelands throughout the silty uplands of this province in Oregon to have low gray rabbitbrush and broom snakeweed, rather than big sagebrush, as the shrub component of native plant communities in deteriorated ecological status. Natural revegetation of abandoned croplands in this province results in gray rabbitbrush as the primary shrub component. Other shrubs that are sparse in examples of high-ecological-status plant communities include rose, gray horsebrush, and green rabbitbrush.

Obviously, the question of fire arises in discussions of whether these plant communities are natural grasslands. Fire can temporarily eliminate big sagebrush and may even aggravate growth of gray rabbitbrush. However, the area covered by the recordings is extensive, so it is not reasonable to assume that all examples of high ecological status had uniform and comparable fire histories and that an original sagebrush cover had been uniformly and permanently altered by fire over the entire area.

Based on ecological site studies, the natural shrub pattern on silty upland ranges in Columbia Basin Province of Oregon changes from east to west. East of the southwest corner of Morrow County, big sagebrush is minimal, if present at all, in native plant communities in high ecological status. Big sagebrush is not a prominent shrub even under deteriorated ecological status. However, in the vicinity of southeastern Gilliam County and west into southern Sherman and Wasco counties, the likelihood of big sagebrush increases somewhat, especially under deteriorated ecological status. Still,

Table 13. Average Dates Vegetation Growth Begins and Ends in Columbia Basin Ecological Province, Oregon.

Station and length of record (years)	Elevation (feet)	Average date growth begins*	Average date growth ends*
Area in which farming usually requires irrigation			
Gilliam County			
Arlington Airport 20	890	February 20	May 20
Blaylock 17	237	February 18	May 27
Morrow County			
Ella 9	830	February 25	May 13
Umatilla County			
Echo 19	601	February 20	May 25
Hermiston 22	451	February 25	May 16
Umatilla 21	285	February 22	May 11
Area of dryland summer-fallow farming			
Gilliam County			
Condon 21	2,880	March 15	July 5
Mikkalo 7	1,500	March 1	May 31
Morrow County			
Heppner 22	1,950	March 1	June 22
Sherman County			
Grass Valley 15	2,381	March 7	June 26
Kent 21	2,707	March 15	June 22
Moro 22	1,858	March 7	June 22
Wasco 22	1,270	March 1	June 17
Umatilla County			
Milton-Freewater 20	1,056	February 22	June 22
Pendleton			
Roundup Park 40	1,070	February 22	June 21
Pilot Rock 18	1,817	March 26	June 13
Wasco County			
Dufur 20	1,250	March 1	June 21

* The average date vegetation growth begins on native perennial bunchgrasses is approximately the date average daily temperatures reach 39 to 40°F. Average date growth ends is considered to be when available soil moisture is depleted. Interpretations are based on data in Johnsgard.[17]

shrubs collectively usually do not make up 10% canopy cover on silty upland ranges in that portion of Columbia Basin Province.

Several broad ecological factors are related to this phenomenon.

First, the reason big sagebrush is minimal, if present at all, east of Gilliam County may be that Blue Mountain Province native plant communities form a buffer zone between that portion of the Columbia Basin and the John Day Province to the south.

Big sagebrush is a prominent component of the natural shrub–grasslands that typify the John Day Province. Blue Mountain native plant communities have evolved under very favorable soil and climate conditions, and a wide variety of other shrubs typify this province. For this reason, big sagebrush has not been able to encroach north through the vigorous Blue Mountain plant communities. This explanation is supported by the fact that, throughout Blue Mountain Province, big sagebrush is not a prominent shrub no matter what the plant community's ecological status.

Second, west of Kinzua, the westernmost extent of Blue Mountain Province, a huge topographic saddle extends from Kinzua west about 50 miles to the Mutton Mountains in the northeast corner of Warm Springs Indian Reservation. The Deschutes and John Day rivers flow north through this saddle; however, the rivers' tributaries generally are entirely within John Day or Columbia Basin province. The demarcation line between the two provinces essentially is the division between watersheds draining north into Columbia Basin from those draining south into John Day Province.

Along this huge saddle, the Columbia Basin and John Day provinces are contiguous at a relatively low elevation of 3,000 to 3,500 feet. Presumably, this offers less resistance to encroachment of vigorous shrubs, such as big sagebrush, from John Day Province into Columbia Basin Province, unlike the situation in the Blue Mountain buffer zone. Nevertheless, native plant communities in high ecological status on silty aeolian Columbia Basin sites, such as near Shaniko, generally do not support a 10% canopy cover of shrubs. This is in spite of the likelihood that native vegetation around Shaniko was decimated in early 1900s when Shaniko was the largest inland shipping center for wool in the United States.

Two reasonable conclusions are that the natural native vegetation on upland silty aeolian soils of Columbia Basin Province in Oregon was not a shrub–grassland, and that big sagebrush is not a vigorous component of deteriorated plant communities, such as those in John Day Province.

Specimens of big sagebrush that look very old are in western Columbia Basin Province. They are almost exclusively along drainageway bottoms in the Deschutes and John Day river canyons and their tributaries.

In this part of the province, these drainageway bottoms consist of deep, very gravelly and stony colluvial materials originating from nearby basalt rimrocks and canyon walls. These kinds of soils provide ideal sites for big sagebrush.

In the same area, where silty alluvium from upland silty soils has accumulated as meadows in drainages, natural vegetation consists of basin wildrye and associated meadow species, depending on degree and duration of soil moisture.

It seems reasonable to assume that the incidence of big sagebrush in the western part of the province likely is related to the avenues for encroachment provided over time by the Deschutes and John Day river canyons and their dendritic tributaries, which have suitably deep, coarse, colluvial soils.

In the Columbia Basin Province of Oregon, the silty upland ranges include a ecological site locally called scabland. It occurs along the outer edges of ridgetops and on sloping areas in minor drainages between about 1,000 and 3,500 feet elevation. Slopes vary from 2 to 20%. The soil of this site is very stony loam and is very shallow (7 to 10 inches) over basalt bedrock. Natural vegetation is dominated by Sandberg bluegrass and stiff sagebrush, i.e., a shrub–grassland. Some areas, however, have no stiff sagebrush although the soil and other components of the plant community remain the same.

Overall, the natural plant communities of silty upland sites throughout the Columbia Basin Province of Oregon consist primarily of bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue, and a wide variety of perennial forbs. Idaho fescue is absent on the most droughty sites, such as south exposures, but it strongly dominates the plant community on more moist sites such as steep north exposures.

The cultivar 'Sherman' big bluegrass was originally selected from a grassland site near Moro in Sherman County. Beardless bluebunch wheatgrass, from which the cultivar 'Whitmar' was developed, has been recorded in the silty-soil site west of Boardman and north of the sandy-soil area. However, the type location from which Whitmar was selected is in Whitman County, Washington.

Management Implications

Columbia Basin Province in Oregon includes irrigated agriculture on bottomlands along major drainages such as Rock Creek in Gilliam County; Willow and Butter creeks in Morrow County; and Birch and McKay creeks and Umatilla River in Umatilla County. These sources of irrigation water are fairly reliable because they are renewed by runoff from prominent watersheds. However, water use likely will be more strictly controlled under fish-habitat and similar regional programs. These lands are used primarily to produce livestock forages.

Some farmers use sprinkler irrigation from wells in the vicinity of Athena to produce wheat, peas, alfalfa, and other crops. Irrigation near Milton-Freewater is primarily a gravity-flow system for orchards and a variety of food crops. Boardman-area irrigation involves both gravity-flow systems from water stored in Cold Springs Reservoir and pumping from wells and the Columbia River;

Table 14. Major Ecological Sites in Columbia Basin Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Natural grassland (less than 10% canopy cover of shrubs)	Arid rolling hills Bluebunch wheatgrass, Sandberg bluegrass Rolling hills [a] Bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass Droughty south exposure Bluebunch wheatgrass, Sandberg bluegrass South exposure Bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue Sandy north exposure Needlegrass, big bluegrass, Sandberg bluegrass Droughty north exposure Bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass North exposure Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass Scabland [a] Sandberg bluegrass/snow buckwheat, phlox	Semimoist bottom Basin wildrye, bluebunch wheatgrass, Idaho fescue Moist bottom Basin wildrye, sod bluegrasses Semiwet bottom Redtop, tufted hairgrass, Kentucky bluegrass Alkaline bottom Basin wildrye, saltgrass
Shrub–grassland (10% or more canopy cover of shrubs)	Scabland [a] Sandberg bluegrass/stiff sagebrush Sand dune Indian ricegrass/desert parsley/bitterbrush, big sagebrush Sand terrace Needle-and-thread, Indian ricegrass/bitterbrush, big sagebrush Silty terrace Bluebunch wheatgrass, Sandberg bluegrass/big sagebrush	Moist sodic bottom Basin wildrye, cordgrass, saltgrass/ greasewood
Deciduous tree (5% or more canopy cover of mature trees)		River bottom Forbs/tall shrubs/cottonwoods

[a] Biscuit scabland is a mapping unit that represents a complex of rolling hills ecological site (the biscuits) and scabland ecological site, in which the biscuits occupy 5% or more of the area in the mapping unit. If biscuits cover less than 5%, the site should be considered scabland.

production is of livestock forages, grains, and food crops. State regulations limit use of underground water in order to maintain aquifers. Other water sources are likely to come under stricter control because of regional fish habitat programs.

Wind erosion is a potential problem in the area of irrigated sandy soils if the water supply diminishes significantly. Cultivation has destroyed all native vegetation, so these soils are extremely erodible when exposed and dry. If it becomes necessary to take some lands out of irrigation due to limited water, it will be very difficult to revegetate with species that will establish and persist in the arid climate and shifting sandy soils. Massive sand dunes easily could inundate existing urban and rural homes and businesses and cover otherwise stable agricultural lands.

From Pilot Rock west, arable soils are under a summer-fallow wheat cropping rotation with special effort to minimize erosion, especially in fallow years. Practices such as stubble mulch, cross-slope farming, diversions, terraces, contour strip cropping, and others have been tried with mixed success primarily because these practices often require special equipment and more time and labor, which cuts net income.

The silty upland ranges of Columbia Basin Province in Oregon are not well suited for year-long livestock grazing

because, generally speaking, their summer forage is not good quality.

A well-balanced ranch in this area includes irrigated land for producing winter feeds, some higher-elevation summer rangelands which are usually in Blue Mountain Province, and lower-elevation rangelands in Columbia Basin Province for spring, late autumn, and, to some extent, winter grazing.

The ancient lakeshore terraces west of Butter Creek Junction on Highway 207 are covered by a mantle of silty aeolian soil. Where the overlay is relatively thin, the underlying laminated calcareous lakeshore terrace is close enough to the surface to resist water and root penetration, making these soils generally unsuited for dryland agriculture.

Examples of abandoned cropland are on the lakeshore terrace along the lake's southern perimeter. Some of these abandoned croplands were later seeded to crested wheatgrass in an attempt to replace the destroyed native forage. However, the seedings were largely disappointing or totally unsuccessful, at least partly because the ancient lakeshore terrace is not suited to cultivation or reseeding, even though it is a silty soil and easily worked. Management—or rather, mismanagement—of the grass seedings likely is also a factor in the adverse results.

Ancient Lake Basin Demarcation

The eastern line of demarcation between the ancient lake basin and aeolian silty uplands in Columbia Basin Province begins at the Columbia River near the Oregon–Washington border. It meanders south and up Juniper Canyon to near where the north and south forks of Juniper Canyon merge. From there the line goes southwesterly to about 5 miles east of Cold Springs Reservoir and then generally south to cross Umatilla River about 3 miles southeast of Echo.

In this area, the ancient lakeshore terrace comprises the substrata beneath overlying soils which are the Sagehill fine sandy loam and Ellisforde silt loam soils. The soil representing the aeolian silty uplands to the east of the lake basin is Ritzville silt loam.[75]

From about 1 mile south of Echo, the line follows southwest about 2 miles south of and nearly parallel to the highway between Echo and Highway 207 near Butter Creek. The line veers north to cross Butter Creek at about the junction of Echo Road and Highway 207 and then runs west.

The line between the ancient lake basin and the deep aeolian silty soil uplands to the south continues west to enter Morrow County in the middle of Township 3N R27E. Then it goes southwest to near Sand Hollow where it turns southeast to cross Highway 207 about 2 miles west of Butter Creek Junction. From this point west, the ancient lakeshore terrace that forms the perimeter of the lake basin is covered by a mantle of silty aeolian soil that includes Warden, Ellisforde, and Sagemoor soils.[85]

From the vicinity of Butter Creek Junction, the line goes west across Sand Hollow to upper Juniper Canyon where it follows the canyon northwest to near the south boundary of the bombing range. From there it runs west at about 900 feet elevation along the upper level of the lakeshore terrace to Cecil, where it crosses Willow Creek and enters Gilliam County.

The Oregon Trail traversed from east to west along the southern edge of this ancient lakeshore terrace on the way to Cecil on Willow Creek. Well Spring and the nearby historic site of a skirmish with Indians are on the lakeshore terrace.

From the vicinity of Cecil, where the demarcation line of the ancient lake basin crosses into Gilliam County, the line runs west to Fourmile Canyon. It follows the east canyon rim north and then along the Eightmile Canyon to cross Willow Creek at Rhea.[78] This area of Warden soil in Gilliam County is the farthest west in the Columbia Basin Province in Oregon that a sizable area of the calcareous laminated silty lakeshore terrace exists under a thin mantle of silty aeolian materials.

However, small remnants of this lakeshore terrace can be found about 4 miles up the Deschutes River from Highway 84, which indicates that this terrace may have been between Willow Creek and the Deschutes River while the ancient lake was intact. Conceivably, when the ice jam at The Dalles broke, water in the lake rushing down the Columbia Gorge could have scoured out all but remnants of the silty lakeshore terrace lying west of this remaining segment in northeastern Gilliam County.

Province Demarcation

Columbia – Palouse Demarcation

The line of demarcation between Columbia Basin and Palouse provinces begins at the Oregon–Washington border about 5 miles northwest of Milton-Freewater in Umatilla County. From that point the line runs southwest, passing just east of Milton-Freewater.

About 2 miles south of Milton-Freewater the line turns west to about 3 miles north of Helix where it abruptly veers south across Wildhorse Creek to the Umatilla River about 1.5 miles northeast of Mission. It follows on the north side of the river east upstream to about Cayuse where the Columbia Basin, Palouse, and Blue Mountain provinces join.

The demarcation line from Milton-Freewater to near Mission is the soil line between Walla Walla silt loam series, in Columbia Basin Province, and Walla Walla silt loam, high-precipitation phase, which is in Palouse Province.[75]

Columbia – Blue Mountain Demarcation

The line of demarcation between Columbia Basin and Blue Mountain provinces meanders southwest from near Cayuse along the mountain footslopes at about 2,000 feet elevation to south of Pilot Rock. It continues southwesterly up Owens Creek to cross Highway 395 about 8 miles south of Nye Junction, at an elevation of about 3,500 feet, and continues west across

North Fork Butter Creek to the top of Franklin Hill. It lies just south of Lena on South Fork Butter Creek and travels southwesterly at about 3,500 feet elevation, passing about 6 miles southeast of Heppner and on toward Hardman.[66]

From Hardman vicinity, the line runs west to cross into Gilliam County and then southwest to just north of Lonerock, which is in an isolated segment of John Day Province in southeast Gilliam County.[78]

About 1 mile west of Lonerock, the line is between Columbia Basin and Blue Mountain provinces for about 3 miles; then, near the old Lost Valley School road junction, the line is between Columbia Basin to the north and John Day Province to the south. In this vicinity, the line is a belt several miles wide in which differentiating features of Blue Mountain, Columbia Basin, and John Day provinces intermingle. The mapped line is a judgment call.[78, 90]

Columbia–John Day Demarcation

About 3 miles northwest of Kinzua, which is in Blue Mountain Province, the line of demarcation between Columbia River and John Day provinces goes westerly at about 4,000 feet elevation in the vicinity of Cummings Pass and across Butte Creek about 3 miles northwest of Fossil, which is in John Day Province. From that point, it runs southerly, westerly, and then north at about 4,000 feet elevation to encompass a large rocky plateau that juts south into Wheeler County. The plateau is in Columbia Basin Province.

The plateau's southwest corner, where it overlooks John Day Province in the vicinity of Clarno, is a good place to see a very abrupt province boundary. The view from below, near Clarno, shows the plateau above the basalt rim, which is Columbia Basin Province, and the exposed, light-color tuffaceous and sedimentary deposits below the rim which are typical of John Day Province.

The line between Columbia Basin and John Day provinces crosses the John Day River from Gilliam County into Wasco County at the Wasco–Sherman county line on the river. The John Day River canyon north of this point is in Columbia Basin Province; south, it is in John Day Province.

From this point the line of demarcation meanders southwest along the west-side breaks of John Day River canyon to about 2 miles north of Antelope and continues southwest along the north-side breaks of Antelope Creek. About 2 miles north of Antelope, a roadcut on Highway 218 displays the Columbia Basin basalt cap and silty aeolian soil overlying the light-color sedimentary materials of the John Day Province. This is another example of an abrupt line of demarcation that can be examined closely and easily.

From the vicinity of Kinzua westward, the demarcation line is represented by the soils line between Condon and Bakeoven soils in Columbia Basin Province and Simas and Tub soils in John Day Province.[78, 86, 90]

The line of demarcation crosses Highway 97 in Cow Canyon about 1 mile north of the confluence of Antelope and Trout creeks. From there it goes southwest into Jefferson County to encompass the small plateau area about 2 miles west of Willowdale.[83]

The line then follows north along the east-side rimrocks of Deschutes River canyon to the railroad siding Nena, where it crosses to the west side of Deschutes River. The Deschutes River canyon north from Nena is in Columbia Basin Province; south, it is in John Day Province. Nena railroad siding is about 7 miles upriver from Maupin.

From Nena, the line of demarcation runs southwest up the ridge on the west side of Deschutes River to the top of the divide, which used to be the north boundary of Warm Springs Indian Reservation. Mutton Mountains are in John Day Province. The line follows the ridgetop northwest to the road between Wapinitia and Simnasho. It is near this ridgetop pass on the road that Columbia Basin, John Day, and The Dalles provinces adjoin.

From this point, the line of demarcation between Columbia Basin and The Dalles provinces veers north to pass just east of Pine Grove, which is in The Dalles Province, and north in the vicinity of Smock Prairie School and Wamic, both of which also are in The Dalles Province. From east of Wamic, the line goes north. In this vicinity, the lower reaches of White River canyon, which heads near Mt. Hood, create a narrow strip of The Dalles Province extending into Columbia Basin Province southwest of Tygh Valley.

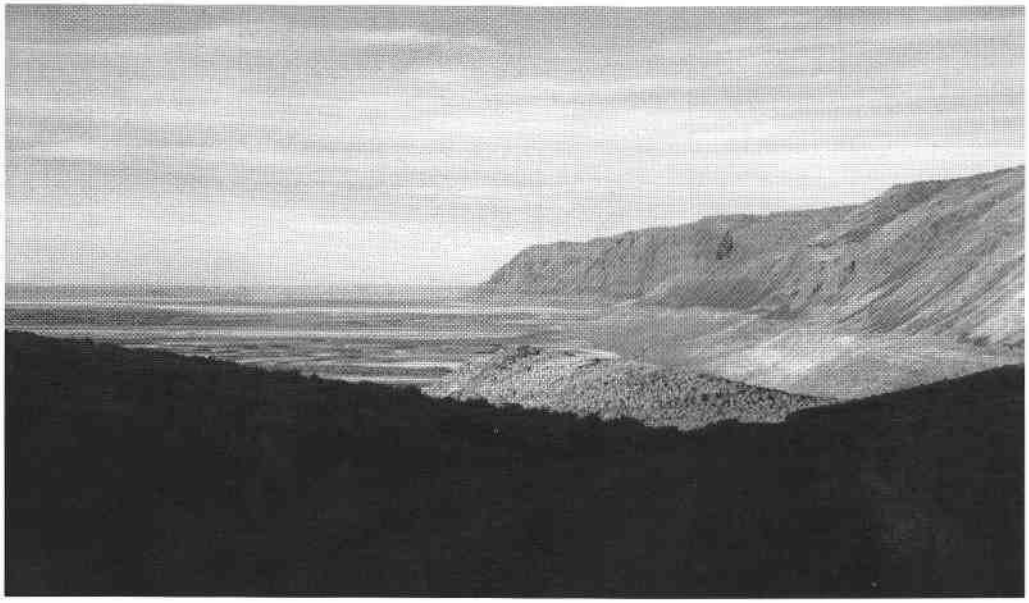
Tygh Valley itself is a small island of John Day Province which extends about 10 miles east to west and about 1 mile north to south. The light-color clayey ancient sediments (Simas and Tub soils) that typify John Day Province are obvious in this location. North of Tygh Valley, Tygh Ridge and Postage Stamp Lookout are in Columbia Basin Province.

Columbia–The Dalles Demarcation

Where the road to Little Badger Forest Camp crosses Tygh Creek about 3 miles northwest of its junction with Highway 197, the line of demarcation between Columbia Basin and The Dalles provinces winds north to Dufur, which is barely inside Columbia Basin Province.

From Dufur, the line travels toward The Dalles. However, the line passes about 2 miles east of The Dalles and ends at the Columbia River near the mouth of Fifteenmile Creek and The Dalles dam. The city of The Dalles is in The Dalles Province.

The line of demarcation between Columbia Basin and The Dalles provinces is based on soil lines between Condon, Walla Walla, Wapinitia, and Maupin soil series, which represent Columbia Basin Province in this vicinity, and Frailey, Wamic, and Skyline soil series, which are on the eastern footslopes of the Cascade Mountains and represent The Dalles Province.[86]



High Desert Ecological Province

Location

High Desert Ecological Province in south-central Oregon is the northernmost segment of the huge western Great Basin that extends south into Mexico and east into west Texas.[24] In Oregon, the province covers about 7.8 million acres, mainly in Lake and Harney counties but with small portions in Malheur, Deschutes, and Crook counties. It extends south into northwestern Washoe County, California and northwestern Humboldt County, Nevada.

Description

High Desert Province is characterized by innumerable large and small closed basins surrounded by extensive terraces formed in ancient lakes. Interspersed in this pattern of closed basins and terraces are low basaltic ridges, hilly uplands, isolated buttes such as Glass, Paiute, and Beattys; mountains such as St. Patrick, Wagontire, and Warner; and block-faulted igneous formations such as Steens Mountain, Abert Rim, and Poker Jim Ridge. Elevations range from 4,030 feet at Harney Lake to 9,670 feet on Steens Mountain. (Elevations are from USGS 1:250,000 topographic maps.)

The terrace and basin portion of the province is flat to gently sloping; intermediate hills, buttes, and mountains are steep to very steep. Ecological sites range from arid low-lying terraces to subalpine mountain tops and from lakebeds that are nearly always dry to permanent wetlands and marshes (Fig. 17).

This is the part of Oregon that apparently was largely inundated by ancient lakes. Evidence of extensive inundation exists in exposed shoreline terraces, such as on the highway roadcut northwest of the Horse Ranch near Fort Rock, and in wave-action beachlines on uplands, such as southeast of Summer Lake and the east side of Warner Valley. These shoreline terraces are at about 4,500 feet elevation (Fig. 18).

Beachlines and shoreline terraces are not in a continuous band around the perimeter of this province because they have been superseded by other geologic formations in various locations. For example, in the area from Fort Rock north to Brothers, the ancient shoreline terrace is obscured by a mantle of pumice and/or lava flows from Mazama, Paulina, and probably other volcanoes. In this area, the boundary between High Desert and Mazama provinces is a belt rather than a distinct line.

Field observations indicate that, where the pumice mantle is more than 8 to 10 inches thick over buried soils, herbaceous vegetation resembles the arid portion of Mazama Province, which is typified by bluebunch wheatgrass and Idaho fescue. Where less than 8 to 10 inches of pumice mantle are over buried soil, herbaceous vegetation resembles the High Desert Province's, which is typified by bluebunch wheatgrass and Thurber needlegrass.[32]

Soils

Soils in the terraces and basins of High Desert Province were formed from parent materials mainly through water action. They range from deep loam to deep clayey soils in basins, and from deep sandy to shallow clayey soils on terraces and fans where weak to strong hardpans are common. On some terraces and fans, the soil surface may be extremely stony, which might be related to thin surface flows of basalt that have fractured or to colluvial action. These soils may be strongly alkaline, calcareous, or neutral. An upland terrace formation occurs in the vicinity of some igneous mountains such as Hart Mountain. The sloping upland terrace landform represents an outflow of igneous tuffaceous material which characteristically weathers into dense clay.

Usually, these upland clayey terraces have a surface cover of basalt stones

but soil beneath surface stones is not stony. This suggests that a thin layer of basalt was deposited on the surface after tuffaceous underlying material had formed the upland terrace landform. The upland clayey terraces usually support a stand of low sagebrush.

Soils developed on basaltic uplands generally are moderately deep to very shallow and stony or gravelly, and they may be extremely rocky. They are generally slightly acidic in surface layers to slightly alkaline in the subsoil.

Soils in the vicinity of Christmas Valley and Fort Rock Valley have sandy surface layers which likely are related to the nearby, upwind, tuffaceous ancient lakeshore terraces. Areas of deep sands, which are probably dunes formed over time, are common. The northwest part of High Desert Province was settled and dry farmed in about 1910. However, settlement quickly dwindled before 1914 when drought began. Extensive stands of gray rabbitbrush in this area indicate previously farmed lands.

Along the north and east boundary of High Desert Province in Oregon, which is mainly in Harney and Malheur counties, available soil data do not suffice to produce groups of soil series to illustrate the soils contrasts that are known to exist between High Desert Province and contiguous provinces—John Day, Snake River, and Humboldt. This is because available soil maps of Harney and Malheur counties show reconnaissance mapping units on nonfarmed lands that merely represent different kinds of soil, e.g., basins/plains, shallow/not shallow, well-drained/less well drained, loamy/clayey. The drainage basin surveys were made primarily to identify areas that might be suitable for irrigation, if feasible.[72, 73, 92, 94]

This deviation from general soil maps for other Oregon counties and river basins, where associations of soil series were mapped, hinders using soil data to help clarify ecological differences between provinces.

Climate

High Desert Province in Oregon is uniformly dry as illustrated by data from 16 official weather stations.[17] All stations, except for Hart Mountain Antelope Refuge, are in or near the bottom of closed basins between 4,100 and 4,500 feet elevation.

Average annual precipitation for the province is about 10 inches. The deviation ranges from 8 inches at Plush to about 12 inches at Diamond and Frenchglen, which are in the vicinity of Steens Mountain. A precipitation map[53] shows several sizable basins in the province that receive less than 10 inches annu-

Table 15. Climatic Data for High Desert Ecological Province, Oregon.[17]

Station and length of record (years)	Elevation (feet)	Precipitation			Average maximum and minimum temperatures (°F)	
		Annual (inches)	Oct.-March (%)	April-June (%)	January	April-June
Harney County						
Blitzen 17	4,300	8.6	57	27	38.8-10.8	69.6-31.6
Burns 29	4,140	10.1	68	23	35.5-12.2	68.7-38.8
Diamond 11	4,130	12.2	51	36	40.3-17.9	66.2-34.2
Frenchglen 5	4,100	12.2	52	37	40.6-18.5	71.2-37.8
Harney Expt. Sta. 22	4,139	9.6	68	24	32.8-9.6	68.3-34.8
Northern Great Basin Expt. Sta. 19	4,675	11.8	58	30	35.4-14.9	65.1-35.0
Sod House 15	4,103	9.2	60	28	36.2-14.5	68.0-37.2
Lake County						
Cliff[a] 10	4,300	9.1	49	34	37.9-14.3	65.8-28.6
Fremont[b] 19	4,300	10.2	65	26	38.3-13.6	66.2-29.2
Hart Mountain 13	5,900	10.2	50	38	36.7-16.1	61.4-33.6
Lake[a] 15	4,316	8.3	48	37	40.0-14.1	67.7-32.1
Paisley 19	4,300	9.9	61	29	39.4-19.8	68.0-38.7
Plush 13	4,385	8.0	50	38	40.0-19.2	67.8-38.9
Silver Lake 26	4,476	9.9	59	27	39.3-16.9	66.5-31.6
The Poplars 6	4,316	9.7	59	33	35.7-8.6	67.5-31.9
Valley Falls 20	4,250	11.9	61	30	40.1-18.8	71.3-35.1
County Averages						
Harney		10.5	59	29	37.1-14.1	68.2-35.6
Lake		9.7	56	32	38.6-15.7	66.9-33.3
Province Average		10.1	58	31	37.9-14.9	67.6-34.5

No weather stations in High Desert Province in Deschutes, Crook, or Malheur counties.

[a] In Christmas Lake Valley

[b] Near Horse Ranch

ally, a few prominent uplands that receive about 15 inches annually, about 25 inches annually on top of Hart Mountain, and over 50 inches annually on top of Steens Mountain. In some instances, these differences exist within a few air miles of each other.

High Desert Province in Oregon also is uniformly cold. Average maximum and minimum temperatures during the normal growing season, April through June, are about 68 and 35°F respectively. Frosts can come any week of the year. The relatively low temperatures during the growing season effectively change the net effective environment on a site[5] which, in turn, significantly influences the kinds of species that naturally are in the plant community as well as the amount of herbaceous growth produced.

Cold springs mean minimum temperatures can offset or minimize benefits derived from favorable moisture conditions. When monitoring responses to climate and/or resource management strategies, mean minimum temperatures in spring are especially significant for evaluating results.

Vegetation on top of large mountains in High Desert Province in Oregon reflects the frigid temperatures and fierce winds there. For example, sagebrush plants on top of Hart Mountain have hedged canopy tops that slant up from west to east, like a roof, away from prevailing westerly winds. Furthermore, rough fescue, which is native to more northern latitudes (primarily north of 47°N latitude in eastern Washington, in western Montana, and in British Columbia and Alberta) grows on both Hart and Steens mountains at about 7,000 feet elevation. This suggests the climatic conditions there may be comparable to the more northern latitudes where rough fescue is a common component of native plant communities.[6]

Throughout High Desert Province, climate varies widely from locality to locality at any given time, both seasonally and from year to year, even though in general it is a uniformly dry climate with extremes of cold and hot.

Vegetation

According to the 1936 Forest Type Map of Oregon,[54] stands of western juniper were at that time on upland areas scattered across High Desert Province in Oregon.

In the area north and northwest of Silver Lake community, juniper stands collectively covered an estimated 18,000 acres in 1936. From the vicinity of Cougar Mountain, about 20 air miles north of Silver Lake, scattered juniper stands existed eastward nearly to Wagontire Mountain and collectively covered an estimated 185,000 acres in 1936. On the western and northern slopes of Steens Mountain, an estimated 80,000 acres of scattered juniper stands existed in 1936.

Natural stands of western juniper in High Desert Province in Oregon usually are associated with rocky or very stony uplands, lava flows, and ridges where understory vegetation, when burning, is insufficient to help create crown fires. In the vicinity of Christmas Lake Valley, some natural juniper stands are on areas of moderately deep sands. Natural stands of juniper are characterized by the presence of very old trees and of uneven-age classes.

An ecological oddity, the Lost Forest, is northeast of Christmas Lake Valley. In 1936 it covered an estimated 2,500 acres and consisted of huge old-growth ponderosa pine with some juniper growing on sandy soils at about 4,500 feet elevation. The pine has been partially harvested by a BLM timber sale. The isolated stand lies about 25 air miles east of the nearest pine forest, which is in Mazama Province.

Another isolated 60-acre grove of ponderosa pine is on the Hart Mountain National Antelope Refuge. It is at about 6,000 feet elevation in a location known as Blue Sky on the east slopes of Warner Peak near Post Meadows, south of the refuge headquarters.

Specimens of white fir, which grow in protected spots at high elevations, are rare in High Desert Province in Oregon.

The 1936 Forest Type Map of Oregon also shows scattered stands of hardwoods, probably aspen, in drainages and on north and northwest slopes of Steens Mountain; collectively the stands covered an estimated 5,000 acres in 1936. Similar stands of aspen on Hart Mountain are too small and scattered to be shown on the 1936 map.

The huge number of closed basins that typify High Desert Province in Oregon include perpetually dry lakebeds, lakebeds that are inundated infrequently and for short periods, perpetual lakes that fluctuate in size over time, and wetlands and marshes that are reasonably perpetual. Vegetation on the bottomlands varies according to the frequency, depth, and duration of inundation.

For example, perpetually dry lakebeds usually are vegetated with drought-tolerant upland species such as big sagebrushes, rabbitbrushes, needlegrasses, ricegrasses, and squirreltail. Lakebeds that are inundated infrequently and for short periods vary from being essentially barren—playas—to those that grow such plant species as silver sagebrush, mat muhly, streambank wheatgrass, basin wildrye, and a variety of forbs.

Larger perpetual lakes that fluctuate in size over time include Silver, Summer, and Abert in Lake County and Silver, Harney, and Malheur in Harney County. They also may vary over time from being essentially barren to being perpetually vegetated by such plants as sedges, rushes, squirreltail, rabbitbrushes, greasewood, and a wide variety of forbs, all of which are affected by soil chemistry.

A good example of how vegetation varies according to duration of standing water can be seen on a shallow lakebed in southeastern Hart Mountain Refuge.

On this lakebed were at least four distinct bands of vegetation between the deepest area and the shoreline. The area of longest inundation was vegtated primarily by spikesedge. The next band, where inundation was of shorter duration, was vegetated by wedgeleaf

Table 16. Average Dates Vegetation Growth Begins and Ends in High Desert Ecological Province, Oregon.

Station and length of record (years)	Elevation (feet)	Average date growth begins*	Average date growth ends*
Lake County			
Cliff 10	4,300	April 1	June 16
Fremont 19	4,300	April 5	June 30
Paisley 19	4,300	March 15	June 15
Lake 15	4,385	April 1	June 5
The Poplars 6	4,316	April 4	June 17
Plush 13	4,385	March 19	May 12
Silver Lake 26	4,476	April 4	June 22
Hart Mountain 13	5,900	April 7	July 2
Valley Falls 20	4,250	April 7	July 7
Harney County			
Sod House 15	4,103	March 22	June 12
Diamond 11	4,130	April 1	July 6
Harney Expt. Sta. 22	4,139	March 27	June 19
Burns 29	4,140	March 18	June 24
Frenchglen 5	4,200	March 11	July 2
Blitzen 17	4,300	April 1	June 11
Northern Great Basin Expt. Sta. 19	4,675	April 1	July 10

* The average date vegetation growth begins on native perennial bunchgrasses is approximately the date average daily temperatures reach 39 to 40°F. Average date growth ends is considered to be when available soil moisture is depleted. Interpretations are based on data in Johnsgard.[17]

dock. The next-driest band was vegetated by mat muhly, and the outside, driest band on the lakebed was streambank wheatgrass. The beachridge, formed by soil blowing off the dry lakebed in summer and which was never inundated, was vegetated by needlegrass and green rabbitbrush. All the variations on this single lakebed are related to the frequency, depth, and duration of inundation (Fig. 19).

In the Harney County lake basin near Burns, the 1974 General Soil Map of Harney County[92] shows several kinds of bottomland associated with the three main sources of water flowing into Silver, Harney, and Malheur lakes: Silver Creek, Silvies River, and Donner and Blitzen River.

In this system of streams and lakebeds, deep well-drained loamy and sandy soils on nearly flat alluvial fans and flood plains were mapped on an estimated 29,000 acres. The native vegetation on the bottomlands probably was a good stand of basin wildrye and other species.

Deep, poorly drained silty and clayey soils on flood plains were mapped on an estimated 188,000 acres. The native vegetation probably consisted of a good stand of mixed meadow grasses, forbs, and shrubs including such species as basin wildrye, streambank wheatgrass, Cusick bluegrass, sedges, rushes, big sagebrush, and green rabbitbrush. Much of this area is currently being used for hay production and pasture and is more or less irrigated. Deep, poorly drained, strongly alkaline soils on flood plains were mapped on an estimated 184,000 acres. The native vegetation probably included such species as saltgrass, sedges, rushes, greasewood, and rabbitbrushes.

The three lakebeds—Silver, Harney, and Malheur—occupied about 2,000 acres, 27,000 acres, and 28,000 acres, respectively, for a total of about 57,000 acres in 1974. These lakes are more or less perpetual but fluctuate in size over time.

The 1971 General Soil Map of Lake County[84] shows that Paulina Marsh, north of Silver Lake community, occupied an estimated 21,000 acres at that time. Soils of the marsh are poorly drained and clayey. The native vegetation probably included tufted hairgrass, bluegrasses, sedges, and rushes and was a natural grassland. The marsh is more or less irrigated and is used for hay production and pasture.

Silver Lake, about 5 miles east of Silver Lake community, occupied an estimated 9,600 acres in 1971. The entire lake was mapped as a playa, indicating that at that time the lake must have been dry. However, circa 1960s, Silver Lake was inundated to the tops of fenceposts between the highway and the north boundary of the lakebed, which illustrates the wide fluctuation in the degree of inundation over time. When the lakebed is partly inundated, it is vegetated with plant species such as squirreltail in drier areas and sedges and rushes in moist or wet areas. The lakebed is used primarily for pasture; however, portions of it have been cultivated and farmed in past years.

Summer Lake in 1971 occupied an estimated 19,000 acres, and the contiguous playa occupied an estimated 22,000 acres, none of which even now is vegetated to any extent. At the north end of Summer Lake is a marsh that occupied an estimated 4,500 acres in 1971. This marsh is maintained by water from the Ana River, which originates at a large spring gushing from the base of Winter Rim near Summer Lake community. The marsh is managed as part of the Summer Lake State Wildlife Management Area. The native vegetation varies from bluegrasses, sedges, and rushes on drier areas to cattails and bulrushes around the edges of ponds, some of which were built and maintained as part of the wildlife management program.

According to the 1971 General Soil Map of Lake County, the Chewaucan Marsh, which is fed by Chewaucan River, occupied an estimated 42,000 acres between Paisley and Valley Falls community. The core of the marsh, an estimated 25,000 acres, consists of two areas of poorly drained silty soils that in native condition probably produced

meadow plants such as tufted hairgrass, redtop, sedges, and rushes.

The area currently is being managed for hay and pasture under extensive water-control systems. These two core areas are separated at The Narrows and nearly surrounded by a contiguous belt of loamy, poorly drained, strongly alkaline soils that occupy an estimated 17,000 acres. In native condition, this area probably produced greasewood, rabbitbrushes, saltgrass, squirreltail, basin wildrye, and similar alkali-tolerant plants. Some of this sodic area is being farmed under irrigation.

Lake Abert north of Valley Falls community occupied an estimated 34,000 acres in 1971. Water is from outlets of Chewaucan Marsh and Crooked Creek. Contiguous to the north end of the lake is a 12,000-acre playa. The shoreline of Lake Abert is not conducive to wetland vegetation. North of Lake Abert are a number of perpetual playas such as Alkali Lake and North Alkali Lake which do not produce wetlands.

The group of lakes collectively known as Warner Lakes in southeast Lake County comprises nine major lakes that vary in size and duration of inundation over time. The lakebeds and their estimated acreages are, from south to north: Crump, 7,400 acres; Hart, 5,400 acres; Anderson, 500 acres; Swamp, 770 acres; Flagstaff, 3,200 acres; Lower

(continued on page 44)

Table 17. Major Ecological Sites in High Desert Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Natural grassland (less than 10% canopy cover of shrubs)		Well-drained bottom Basin wildrye, streambank wheatgrass, saltgrass Poorly drained bottom Tufted hairgrass, northern mannagrass, sedges Semimarsh 25-75% hydrophytic, 75-25% wetland species Dry mountain meadow Nevada and Leiberg bluegrasses, slender wheatgrass Lakebed Spikesedge/wedgeleaf dock/mat muhly Wet sodic bottom Saltgrass, 10-25% wetland species
Shrub–grassland (10% or more canopy cover of shrubs)	Arid rolling hills Bluebunch wheatgrass, Thurber needlegrass/ big sagebrush Shrubby rolling hills Idaho fescue/bitterbrush, big and low sagebrush High rolling hills Rough and Idaho fescue/mountain and low sagebrush Stony terrace Sandberg bluegrass, squirreltail/low sagebrush Gravelly ridgetop Idaho fescue, Sandberg bluegrass/low sagebrush Mahogany rockland Western needlegrass, western melic/curlleaf mountain-mahogany Steep south exposure Squirreltail, bluebunch wheatgrass/big sagebrush South exposure Bluebunch wheatgrass, Idaho fescue/big and low sagebrush Arid north exposure Bluebunch wheatgrass, Idaho fescue/bitterbrush, big sagebrush	Droughty bottom Needlegrasses, Indian ricegrass, basin wildrye/big sagebrush Dry lakebed Idaho fescue, Thurber needlegrass, Indian ricegrass/big sagebrush Intermittent lake Streambank wheatgrass, mat muhly/ silver sagebrush Moist bottomland fan Cusick bluegrass, basin wildrye, streambank wheatgrass/big sagebrush Moist sodic bottom Basin wildrye, streambank wheatgrass/ greasewood, green rabbitbrush Beachridge Western needlegrass, basin wildrye/ green rabbitbrush, greasewood

(continued)

Table 17 (cont'd). Major Ecological Sites in High Desert Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Shrub–grassland *(continued)*	North exposure Idaho fescue, western needlegrass/big and low sagebrushes	
	Snowpockets A Western needlegrass, sedge/chokecherry, big sagebrush	
	Snowpockets B Slender wheatgrass, Columbia needlegrass/ bitterbrush/ aspen	
	Snowpockets C Columbia needlegrass, western needlegrass/ snowbrush	
	Semidesert sand hills Indian ricegrass, needlegrasses/big sagebrush, shadscale	
	Shallow sand hills Thurber needlegrass, thickspike wheatgrass/ green rabbitbrush	
	Deep sand hills Idaho fescue, Thurber needlegrass/bitterbrush, big sagebrush	
	Semidesert terrace Bluebunch wheatgrass, Webber ricegrass/hopsage, shadscale	
	Arid loamy terrace Bluebunch wheatgrass, Indian ricegrass, squirreltail/big sagebrush	
	Claypan terrace Bluebunch wheatgrass, Sandberg bluegrass/ low sagebrush	
	Platy terrace Bluebunch wheatgrass, Thurber needlegrass/ big sagebrush, bitterbrush	
	Mountain swale Basin wildrye, bluegrasses/big sagebrush, green rabbitbrush	
Deciduous tree (5% or more canopy cover of trees)	Aspen grove Bluegrasses, bearded wheatgrass/aspen	
Coniferous tree (5% or more canopy cover of trees)	Juniper rolling hills Bluebunch wheatgrass, Idaho fescue/ big sagebrush/juniper	
	Juniper south exposure Bluebunch wheatgrass, Thurber needlegrass/ big sagebrush/juniper	
	Juniper sand hills Idaho fescue, Thurber needlegrass/big sagebrush/ juniper	
	Pine–juniper–fescue Idaho fescue/bitterbrush/ponderosa pine, juniper (Lost Forest)	

Campbell, 830 acres; Campbell, 2,400 acres; Stone Corral, 1,300 acres; and Bluejoint, 8,300 acres.

Many smaller lakes, ponds, and sloughs are in the Warner Valley wetlands. The valley has poorly drained silty soils that in native condition probably produced meadow plants such as sedges, rushes, tufted hairgrass, and redtop. The wetlands occupy an estimated 34,000 acres in the Warner Lakes basin.

Some of the area is managed for hay and pasture under extensive water-control systems. Contiguous to the wetlands in this huge valley, mainly in the southwest and northeast parts, are areas of loamy, poorly drained, strongly alkaline soils on an estimated 90,000 acres. In native condition, these areas probably grew greasewood, rabbitbrushes, saltgrass, basin wildrye, squirreltail, and similar alkali-tolerant plants. Much of the lake and wetland area is in the BLM Warner Lakes Management Plan.

Probably the most significant and valuable wetlands in High Desert Province, from a total ecosystem viewpoint, are those associated with isolated springs and streams scattered over the arid landscape. No matter how small, each provides the nucleus habitat for a wide variety of birds, mammals, reptiles, and other life which could not exist except for the water and special plant communities there. The wetlands consist of grassland meadows, patches of shrubs, aspen groves, and combinations of these. The variety of shrubs, grasses, and forbs present depends on the degree and duration of wetness and shade at each location.

High Desert Province in Oregon is almost entirely a natural shrub–grassland on uplands. Sagebrushes strongly dominate among a wide variety of shrub species commonly growing in this province.

Sagebrush species are reasonably site-specific in where they grow. For example, Wyoming big sagebrush is the most prominent shrub in the province: it is almost ubiquitous throughout the uplands of the province. Basin big sagebrush grows mainly on sites having moderately deep loamy soils such as are on droughty bottomlands and fans. Mountain big sagebrush is dominant above about 5,500 feet elevation on gravelly or stony upland soils. Low sagebrush is strongly dominant on shallow to very shallow stony upland soils, but also grows mixed among other sagebrush species on moderately deep, very gravelly mountain slopes. Silver sagebrush is on some but not all intermittent lakes. Bud sagebrush grows only on the most arid uplands in the province, which are very shallow, very stony soils. Other shrubs in High Desert Province in Oregon include bitterbrush, mountain snowberry, and lanceleaf green rabbitbrush which grow on certain mountains on moderately deep, gravelly upland soils generally above 5,500 feet elevation.

Such shrubs as hopsage, littleleaf and spiny horsebrushes, bud sagebrush, shadscale, threadleaf green rabbitbrush and winterfat typify the most arid sites in the province, which are usually shallow and stony. These most arid sites are minor in extent in High Desert Province but are widespread in the contiguous Humboldt Province.

Chokecherry and bittercherry, snowbrush, Utah serviceberry, green rabbitbrush, and aspen grow on areas immediately below where snowdrifts normally form in winter. Curlleaf mountain-mahogany grows mainly on rocky ridges and bedrock outcrops above 6,000 feet on some mountains. It usually is in small groves or in elongated strips interspersed with other kinds of vegetation.

About 30 shrub species have been recorded consistently on upland sites and 15 shrub species on bottomland sites in High Desert Province in Oregon. This is obviously an incomplete record.

Predominant grass species in the arid shrub–grasslands include bluebunch wheatgrass, Idaho fescue, Thurber needlegrass, squirreltail, and Sandberg and Canby bluegrasses. The most arid sites may include Indian and Webber ricegrasses and, on sandy soils, needle-and-thread and thickspike wheatgrass.

Rough fescue grows on Hart and Steens mountains above about 6,000 feet on north exposures and above about 7,000 feet on the undulating mountain tops. The presence of rough fescue in High Desert Province in Oregon is an ecological oddity. The natural range of rough fescue is in northeastern Washington, western Montana, southeastern British Columbia, and southwestern Alberta. The rough fescue on Hart and Steens mountains (Fig. 20) is likely the most southern occurrence of this species in the United States. No other sightings have been reported in Oregon.[6]

The most moist uplands in High Desert Province in Oregon apparently are where snowdrifts normally form in winter on north-facing slopes. The areas are typified by stands of tall shrubs and aspen and by certain grass species including big and Wheeler bluegrasses, mountain brome, Columbia and western needlegrasses, oniongrass, bearded and slender wheatgrasses, and basin wildrye. About 35 major grass and grasslike species have been recorded consistently on uplands and about 40 species on bottomlands in High Desert Province in Oregon—obviously an incomplete record.

High Desert Province in Oregon is relatively rich in perennial forb species because habitats range from marsh to arid uplands and climate varies from arid cold desert at about 4,000 feet elevation to over 50 inches annual precipitation with fierce winds and temperatures at nearly 10,000 feet elevation.

Some forb species are widespread in this province; however, a few are specifically oriented to local situations. Identification of forb species can be troublesome in this portion of Oregon because the most commonly used plant manuals in the Pacific Northwest do not adequately apply to this area. However, Peck's manual of higher plants of Oregon[23] has been a reliable reference. Peck's descriptions of uncommon local species and their habitats are surprisingly accurate which indicates that he actually was there and personally observed the species. That certainly cannot be said of some authors' manuals, apparently compiled using work by other taxonomists. Another

useful plant identification manual for this portion of Oregon is "A Manual of the Flowering Plants of California." [15]

Management Implications

Livestock ranching is the dominant economic enterprise in High Desert Province. Agricultural crop alternatives are severely restricted due to adverse climate and scarcity or cost of water for farming. Almost all cropland production is oriented toward livestock ranching. Tourism and outdoor recreation are growing enterprises, but their potential is somewhat curtailed by immense distances, topographic features, few all-weather roads, weather restrictions, limited kinds of recreational activities, distance from populated areas, and the seasonal nature of recreational activities such as hunting.

The physical and ecological nature of High Desert Province historically has led to huge ranches and large herds of livestock. The ranches are so big and complicated as to defy quick acquaintance with the resources, problems, needs, options, and opportunities. Not just any rancher or manager can operate them successfully at first tenure.

Long-time resource management programs in High Desert Province are hindered by the ever-changing field personnel of public agencies who are routinely transferred and replaced by newcomers. Yet, the huge amount of public land in the province essentially gives government officials and programs a strong impact on management of all the land, private and public.

Potential production of forage per acre on High Desert rangelands is inherently low except on meadows and in higher-precipitation zones. A viable ranching unit requires many acres. Overall, these rangelands have been improving in ecological status, slowly but surely, for several decades. Currently, there is much evidence that proper application of modern rangeland science and technology in High Desert grazing strategies will produce an upward trend in ecological status while at the same time benefitting watershed health, wildlife habitat, aesthetics, and quality and quantity of forage for herbivores, both wild and domestic.

An upward trend in ecological status is the most significant criterion on which to judge progress. Upward trend in ecological and soil status occurs very slowly, especially in early stages, on arid rangelands such as in High Desert Province. Therefore, to attain a verified upward trend is a commendable achievement and should be the goal of contemporary resource management programs (Fig. 21).

Province Demarcation

High Desert– Klamath Demarcation

Beginning at the southwest corner of the High Desert Province in Oregon, which is at the Oregon–California border about 15 air miles southwest of Adel in Lake County, the line of demarcation between High Desert and Klamath provinces lies at about 6,000 feet elevation south of the dry Big Lake.

The line goes north at about that elevation to cross Parsnip Creek west of Adel, up Drake Creek to cross the Plush cutoff road going east of Drake Peak and on north across Twelvemile and McDowell creeks. At Honey Creek, the line turns west to the south end of Abert Rim, then south to Sherman Valley from where it follows north along the west side of Abert Rim escarpment nearly to Lake Abert. From there, it veers southwest to the vicinity of Valley Falls, which is in High Desert Province.

From the vicinity of Valley Falls, the line meanders northwest at about 4,500 feet elevation along the western boundary of Chewaucan Valley, around Tucker Hill, southward up Moss Creek about 6 miles, then northwest along the valley at the base of Winter Ridge. The communities of Paisley and Summer Lake are in High Desert Province.

About 3 miles north of Summer Lake community, the line between High Desert and Klamath provinces turns west along the headwaters of various drainages that drain north into Silver Lake basin. It continues west about 5 miles south of Silver Lake community into the headwaters of Bridge Creek. Here is the juncture of High Desert, Klamath, and Mazama provinces.

The line between High Desert and Klamath provinces is based on soil lines between Booth–Bluejoint and Woodcock–Mound soils associations, which typify the Klamath Province, and Floke–Olson, Harriman–Hager, Crump–Ozamis, and Hart–Plush soil associations typifying High Desert Province.[84]

High Desert– Mazama Demarcation

From the juncture of High Desert, Klamath, and Mazama provinces, the line of demarcation between High Desert and Mazama provinces goes north across Buck Creek at about 4,900 feet elevation and on to the vicinity of Halfway Lake. To the north, it almost parallels Highway 31 for about 10 miles, about 1 to 2 miles west of the highway. The line crosses Highway 31 northwest of the Horse Ranch about 7 miles west of Fort Rock community. Where the line crosses Highway 31 below the rimrocks, the highway roadcut reveals an ancient lakeshore terrace of stratified lacustrine materials, which signifies the boundary of High Desert Province in this area.

From the highway crossing near Horse Ranch, the belt of demarcation between High Desert and Mazama provinces meanders northeast by Hole-in-the-Ground, which is in Mazama Province, on by Cabin Lake Ranger Station, which is very near the line of demarcation, and on to the north portion of Devils Garden, in High Desert Province. From north of Devils Garden, the belt of demarcation between High Desert and Mazama provinces runs northeast to cross Highway 20 about 8 miles northwest of Hampton community at about 4,500 feet elevation. It continues on to the southwest slopes of Hampton Butte and the juncture between High Desert, Mazama, and John Day provinces.

The belt of demarcation between High Desert and Mazama provinces is supported by soils such as Gardone, Floke, and Olson soil series, which

typify High Desert Province in this area, and Shanahan and Lapine soil series which typify Mazama Province.[84]

High Desert–John Day Demarcation

From the juncture of High Desert, Mazama, and John Day provinces at about 4,500 feet elevation on the southwest slopes of Hampton Butte in eastern Deschutes County, the line of demarcation between High Desert and John Day provinces goes southeast along the base of uplands near Hampton community. Then it meanders north for about 20 miles along the headwaters of drainages eastward into the South Fork Crooked River, which is the basin where GI Ranch headquarters are.

The line crosses the South Fork easterly at about 4,500 feet elevation and then south along the east side of North Fork basin to near where Crook, Deschutes, and Harney counties join and on south to near where Deschutes, Lake, and Harney counties join. From this area, the line between High Desert and John Day provinces travels east at about 4,500 feet elevation to the vicinity of Hines, Burns, and Harney, all in High Desert Province. This demarcation is where ancient lake terraces of High Desert Province adjoin uplands to the north, which are in John Day Province.

From the vicinity of Harney community, the line of demarcation lies at about 4,500 feet elevation around the eastern border of Harney Basin to the community of Crane. The juncture of High Desert, John Day, and Snake River provinces is near Crane. From near Hampton east to Harney Basin and Crane, the line between High Desert and John Day provinces is the ancient-lake shoreline at about 4,500 feet elevation, reflected on general soil maps.[70, 72]

High Desert–Snake River Demarcation

Just east of Crane, the line between High Desert and Snake River provinces begins at about 4,250 feet elevation in the gap at Crane. Here, one might speculate that the ancient lake in which terraces of Snake River Province were formed at one time might have been connected to the ancient lake in which terraces of High Desert Province were formed. If this were so, the lakes would have had to exist simultaneously. But it is a matter of conjectural paleontology and has no current significance in differentiating between the two provinces.

Obviously, terraces and basins in High Desert Province suggest quiet-water abatement, which seems logical for such closed basins that would have no strong currents escaping to the ocean. In contrast, the terraces of Snake River Province are typified by strong geologic erosion and sharp dendritic drainage patterns suggesting that the water receded in strong currents, possibly out through the Snake River to the ocean. Consequently, the kinds of ecological sites, soils, plant communities, and especially the management implications are markedly different between Snake River and High Desert provinces.

Demarcation between the provinces south and east from Crane to the vicinity of Folly Farm and northeast toward Crowley is likely a belt. There is no readily apparent line of demarcation anywhere within this belt; therefore, the line becomes a matter of field experience and judgment.[42]

Based on the fact that ancient terrace lines are extensive and consistently visible at about 4,500 feet elevation around the perimeter of the geologic basin that forms High Desert Province, and that Snake River Province line west of Warm Springs Reservoir is at about 4,500 feet elevation, the belt of demarcation between High Desert and Snake River provinces has been placed at about 4,500 feet elevation from the vicinity of Crane southeast to just north of Folly Farm, then northeast to just north of Crowley.

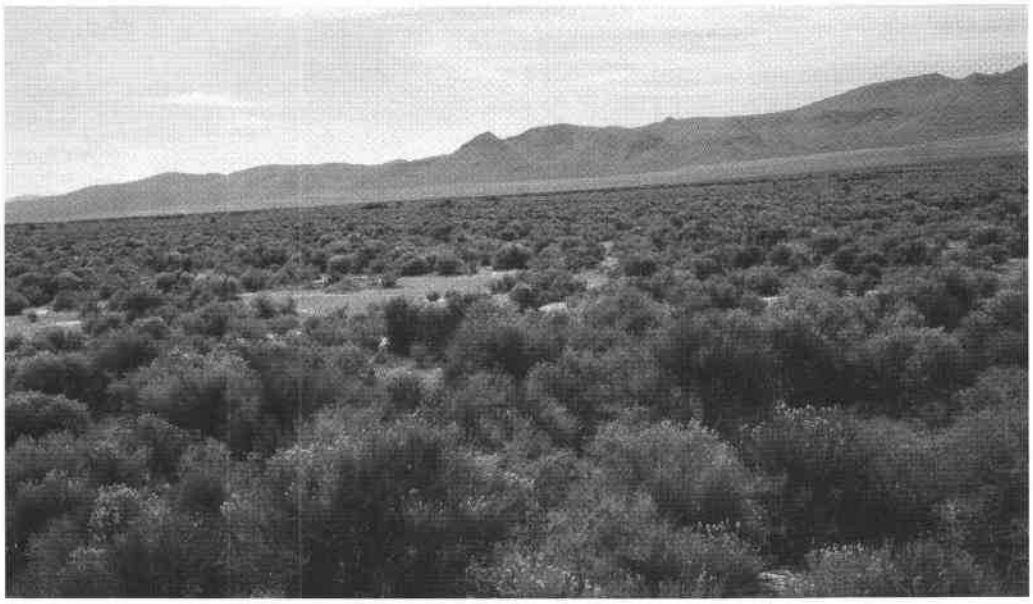
From there it runs east around the south side of Cedar Mountains to the rim of the Owyhee River canyon, which is at 4,000 feet elevation. This demarcation belt places the dry lakebeds and closed basins south of Crowley in High Desert Province, which is typified by similar closed-basin topography; whereas Snake River Province to the north is typified by landscape dissected by dendritic drainages into the Snake River system.

High Desert–Humboldt Demarcation

About 20 miles down the Owyhee River from Rome on Highway 95, on the west rim of the canyon is the juncture between High Desert, Snake River, and Humboldt provinces. From there, the line between High Desert and Humboldt provinces travels southwest to the eastern footslopes of Sheepshead Mountains, then south and west around Sheepshead at about 4,500 feet elevation. The line wanders north of the basin in which Alvord Desert lies to the eastern footslopes of Steens Mountain and then south along the base of Steens Mountain at about 4,500 feet elevation. Sheepshead Mountains and Steens Mountain are in High Desert Province. Pueblo Mountains and Trout Creek Mountains are in Humboldt Province. Alvord Desert and Alvord Lake are in Humboldt Province.

From the vicinity southwest of Alvord Lake, the line between High Desert and Humboldt provinces runs west through the gap between Steens Mountain and Pueblo Mountains on to the southeast rim of Catlow Valley. Then it goes south at about 6,000 feet elevation along the ridge that separates drainages to the west from drainages eastward into Rincon Creek watershed. The line crosses into Nevada about 15 air miles west of the community of Denio.

The line is fairly sharp in the northeast corner of Sheldon National Wildlife Refuge in Nevada. It lies at the summit on Highway 140 which is north of Thousand Creek Ranch. Railroad Point and Jackass Flats are in Humboldt Province; Duferrena is in High Desert Province.



Humboldt Ecological Province

Location

Humboldt Province is in southeastern Oregon. This province and High Desert Province are the part of Oregon lying within the huge western Great Basin that extends south into Mexico and east into west Texas.[24] In Oregon, Humboldt Province covers about 1.8 million acres in southeastern Harney County and southwestern Malheur County. It extends south into Humboldt County, Nevada.

Description

Humboldt Province is characterized by long, generally north–south mountain ranges such as Pueblo and Trout Creek mountains in Oregon and the Pine Forest range and Bilk Creek Mountains in northern Nevada. Long, north–south closed valleys, technically called grabens, lie between these mountain ranges; they include Pueblo Valley in Oregon and Kings Valley and Desert Valley in Nevada.

Between the valley floor and the mountain range are immense, continuous ancient-lake terraces and fans that constitute a more or less foothill formation below about 4,500 feet elevation. The upper elevation of the terraces denotes the extent of inundation by ancient lakes (Fig. 22). Elevations in Oregon's portion of Humboldt Province range from 4,025 feet at Alvord Desert to 8,545 feet on Pueblo Mountains. (Elevations are from USGS 1:250,000 topographic maps, Adel, Oregon.)

Humboldt Province is significantly more arid at lower elevations than is High Desert Province. In Oregon's portion of the Humboldt, this difference is reflected by the increasing incidence from north to south of sites that support stands of vegetation including bud sagebrush, shadscale, winterfat, and similar arid-site species (Fig. 23).

Another feature that helps to characterize Humboldt Province is the common "desert varnish," which is a shiny black coating of manganese dioxide on exposed surfaces of stones and gravel on very arid sites. The coating occurs only under very arid conditions in which indicator species, such as those previously mentioned, also grow.

Soils

Soils of Humboldt Province in Oregon are related to basaltic uplands and ancient lakebeds. Basaltic upland soils are generally shallow to very shallow with loamy surface layers and clayey subsoils. They are very stony or rocky. Very steep slopes are essentially rockland. The soils, formed in ancient lakebeds, constitute bottomlands at the lowest elevations, below 4,200 feet, and as lakeshore terraces and fans below about 4,500 feet elevation.

Two major areas of bottomland soils are in Humboldt Province in Oregon: the Alvord basin, which is about 65 miles long north to south; and, about 12 miles to the east, the Coyote Lake basin, which extends about 28 miles north to south. Alvord basin contains Alvord Lake, which fluctuates in size over the years and receives its water through Wildhorse Creek to the north. Coyote Lake basin drains into the playa Coyote Lake.

Bottomland soils in Alvord basin occupy about 143,000 acres extending from the north boundary of Alvord Desert south nearly to the Nevada border, a distance of about 50 miles. This area of bottomland soils varies in width, east to west, from about 1 mile to 10 miles; the widest area is just south of Alvord Desert. The long, relatively narrow bottomlands in Alvord basin are typical of Humboldt Province physiography.

Bottomland soils of Alvord basin occupy about 4,000 acres in Alvord lakebed, about 29,000 acres in Alvord Desert, and about 8,000 acres in other playas within the basin. These lakebed soils are poorly drained and clayey. About 31,000 acres of bottomlands are loamy, well-drained soils, and about

Table 18. Climatic Data for Humboldt County, Nevada.

Station	Elevation (feet)	Precipitation			Average temperatures (°F)				Killing frosts		Growing season (days)
		Annual (inches)	Oct.-March (%)	April-June (%)	Jan.	July	Max.	Min.	Last	First	
Orovada	4,400	10.1	56	35	27.1	71.2	108	-35	June 3	Sept 16	105
Paradise Valley	4,600	8.4	65	26	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Quinn River Ranch	4,100	5.9	65	23	25.6	69.7	105	-34	June 20	Sept 5	77
County Average		8.1	62	28	26.4	70.4	107	-35	June 12	Sept 11	91

9,000 acres are silty and very poorly drained, but these areas are not wetlands because of insufficient moisture. About 58,000 acres of bottomlands are poorly drained silty to clayey soils that are strongly alkaline but are not wetlands. About 4,000 acres within the bottomlands are shallow silty soils overlying lacustrine sediments.[92]

Bottomland soils in Coyote Lake basin occupy about 63,000 acres of which about 3,000 acres are Coyote Lake playa and about 4,500 acres are other playas in the basin. The soils are poorly drained and clayey. About 12,000 acres of the bottomlands are loamy well-drained soils, and about 1,500 acres are clayey poorly drained soils.

About 26,000 acres of bottomlands are strongly alkaline soils, and about 16,000 acres are shallow silty soils over lacustrine sediments. None of these bottomlands are wetlands.[92, 94]

Climate

There are no official weather stations in Oregon's portion of Humboldt Province.[17, 28] However, the 1941 Yearbook of Agriculture provides climatic data for three stations less than 30 miles south of the Oregon border which are very likely in Humboldt Province in Nevada.[28] All three stations are near major highways in huge north–south valleys.

A precipitation map[53] shows that a sizable portion of Humboldt Province in Oregon, such as around Alvord Lake, receives less than 10 inches annual precipitation. This map also shows about 15 inches annual precipitation on Pueblo Mountains and about 25 inches annual precipitation on Trout Creek Mountains, both in Humboldt Province in Oregon.

These data substantiate that, based on plant communities and soils, Humboldt Province in Oregon is significantly more arid than High Desert Province in Oregon, although both are components of the western Great Basin.

Vegetation

In Oregon, vegetation on uplands in the Humboldt Province is typified by both desert shrub and shrub–grassland climax types according to unpublished field studies.[47, 49]

A natural grassland climax type also occurs but only on bottomland sites that receive run-on water; however, some shrubs naturally grow in the plant communities of these bottomland sites. A deciduous tree climax type, which consists of aspen groves, occurs in scattered areas at higher elevations on some mountains.

Prominent shrubs that grow on sites in the desert shrub climax type include black greasewood, spiny hopsage, shadscale, bud and Wyoming sagebrushes, winterfat, and spiny horsebrush. Prominent grasses on sites in the desert shrub climax type include Indian ricegrass, squirreltail, basin wildrye, inland saltgrass, sand dropseed, and desert needlegrass.

Prominent shrubs that grow on sites in the shrub–grassland climax type include Wyoming, mountain, threetip, and low sagebrushes; green rabbitbrush; spiny hopsage; shrubby buckwheat; and mountain snowberry. Prominent grasses that grow on sites in the shrub–grassland climax type, which includes the mountainous uplands, include bluebunch wheatgrass, Sandberg and Cusick bluegrasses, Idaho fescue, squirreltail, Thurber and western needlegrasses, basin wildrye, and Indian ricegrass.

Prominent shrubs that grow on lower bottomland sites, which are alkaline, include black greasewood, basin big sagebrush, gray and green rabbitbrushes, golden currant, silver buffaloberry, and willow. Prominent grasses that grow on lower bottomland sites include basin wildrye, inland saltgrass, Lemmon alkaligrass, alkali bluegrass, and alkali sacaton.

Dry meadows and wet mountain meadows are in Humboldt Province in Oregon but have not been sampled sufficiently to characterize them. They probably resemble equivalent sites in High Desert Province because of the cold, wet nature of these sites.

Plant species recorded in Humboldt Province, Oregon but not in High Desert Province in Oregon include alkali sacaton, desert needlegrass, sand dropseed, silver buffaloberry, green ephedra, and pickleweed (iodine bush).

Management Implications

Livestock ranching is the dominant economic enterprise in Humboldt Province in Oregon. The physical and ecological nature of Humboldt Province historically has been a basis for huge ranches and large herds of livestock. The ranches are so complicated and extensive as to defy quick acquaintance with their resources, problems, needs, options, and opportunities. Not just any rancher or manager

(continued on page 50)

Table 19. Major Ecological Sites in Humboldt Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Natural grassland (less than 10% canopy cover of shrubs)		Saline meadow Saltgrass, Lemmon alkaligrass, alkali sacaton Moist sodic bottom Alkali sacaton, basin wildrye/currant Well-drained bottom Basin wildrye (undescribed) Dry mountain meadow Bluegrass, sedge (undescribed) Wet mountain meadow Wetland species (undescribed)
Desert shrub (10% or more canopy cover of shrubs)	Mixed desert shrub Wyoming sagebrush, greasewood/Indian ricegrass, squirreltail Semidesert shrub Wyoming sagebrush, hopsage/Indian ricegrass, squirreltail Desert terrace Shadscale, budsage, winterfat/sand dropseed Desert south Green ephedra, bitterbrush, hopsage/desert needlegrass Desert steep south Purple sage, littleleaf horsebrush, Nevada ephedra/ desert needlegrass Blacksage hills Blacksage, budsage, shadscale/Sandberg bluegrass, squirreltail	Dry sodic bottom Greasewood/basin wildrye, saltgrass Desert beachridge Budsage, horsebrush, winterfat/ needle-and-thread Saline beachridge Greasewood/saltgrass, basin wildrye Dry floodplain Basin big sagebrush, gray rabbitbrush/ basin wildrye Silty plain Winterfat, Nuttall saltbush/Indian ricegrass Moist sodic terrace Greasewood, saltbush/saltgrass, alkali sacaton Desert sodic terrace Greasewood, hopsage, budsage, shadscale/basin wildrye Desert playa Shadscale, budsage, hopsage/ squirreltail, basin wildrye
Shrub–grassland (10% or more canopy cover of shrubs)	Arid sand hills Indian ricegrass, needle-and-thread/Wyoming big sagebrush Arid north Bluebunch wheatgrass, Indian ricegrass/Wyoming big sagebrush, ephedra South exposure Bluebunch wheatgrass, Sandberg bluegrass/ Wyoming big sagebrush Droughty rolling hills Bluebunch wheatgrass, Thurber needlegrass/ Wyoming sagebrush Shrubby south Bluebunch wheatgrass, Idaho fescue/bitterbrush, big sagebrush Steep north Idaho fescue, bluebunch wheatgrass/mountain big sagebrush	

(continued)

Table 19 (cont'd). Major Ecological Sites in Humboldt Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Shrub–grassland *(continued)*	High rolling hills Idaho fescue, western needlegrass/ mountain big sagebrush	
	Shrubby mountain north Idaho fescue, Canby and Cusick bluegrasses/mountain big sagebrush, mountain snowberry	
	Shrubby mountain south Basin wildrye/mountain big sagebrush, mountain snowberry	
	Shallow south Bluebunch wheatgrass/low sagebrush	
	Clayey upland Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass/low sagebrush	
	Shallow north Idaho fescue, bluebunch wheatgrass/ low sagebrush, buckwheats	
	Gravelly ridgetop Idaho fescue, Sandberg bluegrass/ low sagebrush	
	Moist north Idaho fescue, bluebunch wheatgrass, Sandberg and Cusick bluegrasses/ threetip sagebrush	
	Mahogany rockland Curlleaf mahogany (undescribed)	
Deciduous tree (5% or more canopy cover of trees)	Aspen grove Quaking aspen (undescribed)	

can operate these ranches successfully at first tenure.

Potential production of forage per acre on Humboldt rangelands is inherently low except on meadows and in the higher-precipitation zones. A viable ranching unit requires many acres.

Overall, these rangelands have been improving in ecological status, slowly but surely, for several decades. Currently there is much evidence that proper application of modern science and technology in Humboldt grazing strategies will produce an upward trend in ecological status while at the same time benefitting watershed health, wildlife habitat, aesthetics, and quality and quantity of forage for herbivores, both wild and domestic. An upward trend in ecological status is the most significant criterion on which to judge progress.

Upward trend in ecological and soil status occurs very slowly, especially in early stages, on arid rangelands such as in Humboldt Province. Therefore, to attain a verified upward trend is, by itself, a commendable achievement and should be the goal of contemporary resource management programs.

Province Demarcation

Humboldt– High Desert Demarcation

Beginning at the southwest corner of Humboldt Province in Oregon, which is at the Oregon–Nevada border about 15 air miles west of Denio community, the line of demarcation between Humboldt and High Desert provinces heads northwest and northerly along the west side of Rincon Creek watershed to the southeast end of Catlow Valley and then north along the rimrocks east of the valley.

The line veers east through the pass between Pueblo Mountains, in Humboldt Province, and Steens Mountain in High Desert Province. The line goes north along the footslopes of Steens Mountain at about 4,500 feet elevation, passing west of Alvord Lake, Alvord Desert, Mann Lake, and Tudor Lake, all in Humboldt Province (Fig. 24).

From the vicinity of Tudor Lake, the line goes south, east, and north at about

4,500 feet elevation around the footslopes of Sheepshead Mountains, which are in High Desert Province.

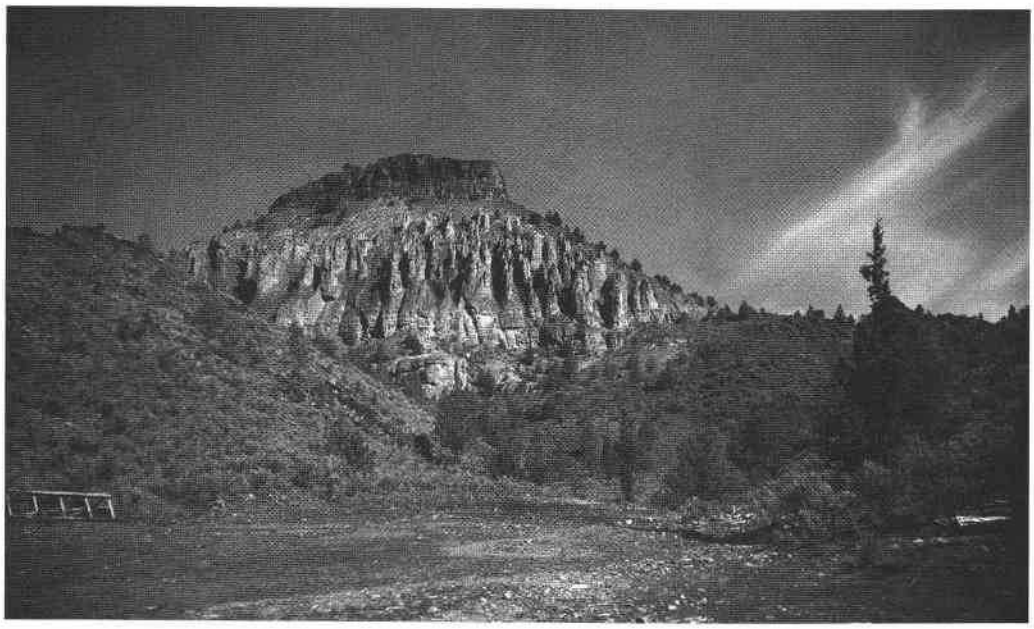
From this location, the line veers east to cross Highway 78 about 7 miles southeast of Folly Farm. It continues northeast along the northern border of extensive lava fields west of Owyhee River in this vicinity.[39, 42, 52] Here, about 20 miles down the Owyhee River from Rome on Highway 95 and on the canyon's west rim, is the juncture of Humboldt, High Desert, and Snake River provinces.

Humboldt–Snake River Demarcation

From that juncture, the line between Humboldt and Snake River provinces travels southerly along the west rim of Owyhee River canyon and the breaks of drainages into the river. It crosses Highway 95 about 3 miles east of Burns Junction, where highways 78 and 95 merge. From there the line runs east along the south breaks of Owyhee River canyon to about 7 miles north of Jackie's Butte and the juncture of Humboldt, Snake River, and Owyhee provinces at about 4,000 feet elevation.

Humboldt–Owyhee Demarcation

From the juncture of Humboldt, Snake River, and Owyhee provinces, the line of demarcation between Humboldt and Owyhee provinces wanders around the western slopes of Jackie's Butte, which is in Owyhee Province, at about 4,000 feet elevation and then south along the west edge of the plateau where it butts into hilly uplands such as Battle Mountain. The line continues south to the Nevada border along the western boundary of the sloping basaltic plateau where it butts up against the hilly uplands.



John Day Ecological Province

Location

John Day Province encompasses the rugged north-central segment of Oregon. It covers about 7 million acres mainly in Grant, Wheeler, Jefferson, Wasco, Crook, and Harney counties. Small segments are in Umatilla, Morrow, and Deschutes counties. Mutton Mountains in the northeast corner of Warm Springs Indian Reservation and Willowdale are in the northwest part of the province.

Madras, Culver, and Prineville are in the western part, and Austin and Prairie City are in the eastern extent of the province. Antelope, Fossil, Spray, and Monument are in the northern extent. John Day Province adjoins High Desert Province to the south in the vicinity of Burns and Hines. The entire John Day Province is in Oregon.

Description

John Day Province includes virtually the entire watersheds of Crooked River and of the mainstem and south and middle forks of John Day River. Upper North Fork John Day River is in Blue Mountain Province. The middle reach of Deschutes River from above Billy Chinook Lake north to about the railroad siding at Nena, which is 6 to 7 miles upriver from Maupin, is in John Day Province. The upper watersheds of Silver Creek, Silvies River, and Malheur River are in John Day Province.

Physiographically, John Day Province consists of extensive areas of steeply and intricately dissected hills interspersed with buttes and plateaus. The hills are mainly geologically eroded ancient lacustrine materials; plateaus and buttes are capped with igneous or tuffaceous rock (Fig. 25).

The Ochoco Mountains are the higher elevation areas within John Day Province. Although they are contiguous to the Blue Mountains and similar in vegetation, they are significantly different from an ecological standpoint, including soil–plant relationships and management implications.

John Day Province is rugged topography. Elevations range from about 1,000 feet near the railroad siding of Nena on Deschutes River to about 7,360 feet at Fields Peak in the Ochoco Mountains southwest of Mt. Vernon in Grant County. (The Strawberry Mountain group above about 5,000 feet elevation is in Blue Mountain Province.) The Middle Fork and mainstem John Day River thread through long, deep valleys and canyons surrounded by mountains, buttes, and plateaus. The spectacular topography of John Day Province presumably resulted from terrific folding, faulting, and volcanic action, plus geologic erosion of thick sedimentary deposits and tuffaceous materials related to geologic formations—such as John Day, Clarno, Mascall, and Rattlesnake—some of which are noted for containing plant and animal fossils.[9] Multiple basalt flows are exposed in some canyons, such as near Picture Rock Gorge near Dayville, and rhyolite buttes and hills are in various locations, such as south of Ashwood in Jefferson County.

John Day Province is typified by extensively exposed ancient sediments and tuffaceous materials representing various geologic formations. A cursory observation of the sideslopes of buttes, hills, and mountains reveals the surface is covered by basalt stones and rocks. This has been construed to mean that the soil mantle overlies basalt bedrock. Sometimes this is true. However, a more thorough investigation by digging a soil pit almost always reveals that the underlying material consists of ancient, nonstony sedimentary materials. Many roadcuts substantiate this fact. On top of buttes and some plateaus, the underlying material is basalt bedrock.

The widespread feature of a very stony soil mantle overlying thick beds of

nonstony fine-texture sedimentary or tuffaceous materials supports the view that, originally, much of John Day Province was capped by a continuous flow of basalt overlying thick beds of sedimentary materials. Subsequently, geologic folding, faulting, and volcanic action fragmented the basalt cap, thus exposing the underlying sedimentary materials to geologic erosion. As fine-texture underlying materials eroded, the basalt cap was undercut and fractured into stones and rocks which formed the surface colluvium now lying on sideslopes. Some basalt caps remain, some are gone, but the surface layers of hilly sideslopes are usually very stony.

Some horizontally layered rock formations in John Day Province look like basalt escarpments from a distance but are actually flows of tuffaceous materials that resemble basalt only in their outward physical features.

Basalt escarpments, being hard rock, show angular protruding edges; tuffaceous escarpments, being relatively soft materials, appear smooth and have rounded edges due to weathering. A good example is just north of Burns where Highway 395 traverses Devine Canyon. The canyon escarpment nearest Burns is tuffaceous material; farther north, at a higher elevation, the escarpment is basalt.

Hills formed through geologic erosion of ancient sedimentary or tuffaceous materials in John Day Province can be identified by their rounded tops. In contrast, hills on which part of the original basalt cap still exists are flat-topped buttes or plateaus. Round-top hills are a distinguishing feature of John Day Province (Fig. 26).

Soils

Physiographically, John Day Province consists of extensive areas of steeply and intricately dissected hills interspersed with isolated buttes, extensive plateaus, and large and small valleys.

The hills, which usually are round-topped because of geologic erosion, generally are at lower elevations than surrounding butte tops and plateaus. These hills consist mainly of ancient sedimentary and tuffaceous materials. Buttes and plateaus normally are capped by remnants of the igneous or tuffaceous materials that probably capped much of the thick underlying sediments in this province. Soils in the province are directly related to these different geologic formations; they are the parent materials in which the soils have formed.

For example, gray-brown Simas soils are representative of south-facing slopes, and black Tub soils are representative of north-facing slopes in hilly areas where clayey ancient materials constitute the landscape. Some areas of Tub soils have been dryfarmed. The Day soils represent areas of red clay that have been exposed sporadically within the ancient materials.

According to Baldwin,[9] these red clay sediments are the base component of the John Day geological formation. The formation's other components are a middle greenish layer and a top layer that is buff or white (Fig. 25). Soils on steep north-facing slopes in the hilly area, such as the Curant series, appear to be primarily aeolian materials which probably accumulated in this topographic position as prevailing winds redistributed volcanic ash and other geologically recent silty materials, forming deposits like snowdrifts on lee slopes. Basaltic and tuffaceous formations are widespread throughout the province. Soils related to these areas are generally very stony and shallow to moderately deep over basalt bedrock or tuffaceous hardpans.

Anatone, Madras, Lamonta, Era, and Agency soil series represent this group. The soil Rockly, which represents the scabland ecological site in John Day Province, has a clayey, very shallow, very stony profile. Its counterpart in Columbia Basin Province, Bakeoven, has a loamy, very shallow, very stony profile. In areas where soils formed in shaley parent materials, Venator and Utley soils are representative.[62]

From the mainstem John Day River southeast of Prairie City, the sloping terrace that extends from the river south to the footslopes of Strawberry Mountain group and west to John Day and Canyon City is the Oxbow soil, named after Oxbow Ranch. It is a black clayey soil derived from ancient sediments that overlie a cemented hardpan.

This area is a good example of a remnant of an ancient lakeshore terrace. It is probably the only area of Oxbow soil in Oregon. Native vegetation was an Idaho fescue/low sagebrush plant community which, coupled with its blackish soil that often connotes strong organic content, suggests that this area has a moist, cool environment due to its being close to and north from the Strawberry Mountain group.

In higher-elevation Ochoco Mountains, soils in natural shrub–grassland openings are related to ancient sediments. However, some surface soils in these openings contain aeolian silty materials which overlie the clayey subsoils derived from sedimentary materials. The Marsden soil in Bear Valley represents this situation. Pine- and fir-forested soils geomorphically related to ancient sediments are represented by the Hankins soil series. Other pine- and fir-forested soils that show evidence of aeolian materials in surface layers overlying clay sediments include Kahler and Boardtree. Pine- and fir-forested soils lying above basalt bedrock are represented by the Yawkey soil, and those lying over shale bedrock are represented by Laycock soil.

Soils of the pine- and fir-forested area of John Day Province differ from those in Blue Mountain Province. John Day pine- and fir-forested soils contain more clay, especially in subsoils, and normally are underlaid by fine-texture sediments or tuffaceous materials. In contrast, Blue Mountain pine- and fir-forested soils are silt loam in texture and normally lie over buried aeolian soils or basalt bedrock.

Casual observation commonly equates these two forested areas because they produce the same tree species. However, from an ecological and total ecosystem management standpoint, they are significantly dissimilar in ways described later, in the section on vegetation.

Early soil surveys recorded areas of Hall Ranch, Klicker, and Tolo soils in the pine- or fir-forested areas in John Day Province.[71, 82] The type locations of these soils is in Blue Mountain Province, and areas mapped at that time as these soils in John Day Province were thought to resemble the Blue Mountain soils. However, it should be noted that, in the era of general soil surveys, the soil scientists of Soil Conservation Service were not authorized to map soils in national forests; areas were examined incidental to cross-country travel. Consequently, soil mapping in pine- or fir-forested areas was based on sketchy data. Furthermore, in later years, formal soil correlation studies revealed significant differences between the pine- or fir-forested soils of John Day Province and those in Blue Mountain Province. For example, the Tolo soil, which typifies Blue Mountain Province, is typically about 30 inches of silt loam volcanic ash over a buried nonashy aeolian silt loam soil that also is about 30 inches or more thick. Tolo soils lie primarily on high-elevation plateaus and north-facing slopes in Blue Mountain Province.

A former soil scientist at Oregon State University, Ellis Knox, was a key observer of differences between John Day Tolo soils and Blue Mountain Tolo soils. He once suggested that the name of the John Day Tolo be changed to Tolocho, i.e., Tolo in the Ochocos (personal communication to author). Unfortunately, the soil correlation team did not adopt this excellent suggestion.

However, to correct the situation, two soil series representing ashy soils in the pine- or fir-forested area of John Day Province were established subsequently. Boardtree soils consist of about 30 inches of ashy gravelly loam over buried clay that is related to ancient sediments; Yawkey soils consist of ashy gravelly loam and clay loam layers over very gravelly clay underlaid by basalt bedrock at 40 to 60 inches.

In view of the source of aeolian ash in which Tolo soils were formed, i.e., the Mazama eruption, and the very widespread geographic distribution of this deposit, it is reasonable to expect to find some genuine Tolo soils on higher-elevation forested areas, especially on north exposures, in John Day Province. For example, north-facing slopes on Rudio Mountain west of Fox Valley closely resemble similar sites in Blue Mountain Province in terms of soil and vegetation. However, no test was made regarding the clay content of subsoils, which is a differentiating characteristic of John Day Province.

The fine-texture upland soils of John Day Province are highly susceptible to water erosion. Consequently, colluvial and alluvial soils are along drainages as bottomlands and as upland fans and terraces. Kimberly, Courtrock, and Dayville are loamy soils underlaid by sand and gravel; they are along streams such as John Day River. Loamy soils, such as Hack series, are on alluvial fans and terraces. Damon is a black clayey soil typical of meadows in cold valleys such as Bear Valley and Silvies Valley south of Canyon City.

Climate

Based on 15 official weather stations, which represent a cross-section of John Day Province, the average annual precipitation for the province is about 13.3 inches. Of that, about 28% falls during the herbaceous native-plant growing season, April through June. November through March precipitation is about 53% of the annual total. Average January maximum and minimum temperatures are 38.9 and 18.4°F, respectively. Average April through June maximum and minimum temperatures are 68.1 and 36.2°F, respectively.

A precipitation map[53] shows 25 to 30 inches annual precipitation in the Ochoco Mountains south of Mitchell and about the same in the mountains east of Seneca and around the footslopes below about 5,000 feet elevation on the Strawberry range. The area above 5,000 feet elevation in Strawberry range, which receives over 35 inches annual precipitation, is in Blue Mountain Province. Other mountainous areas in John Day Province average about 15 to 20 inches; lower elevation areas average between 10 and 15 inches annual precipitation.

Vegetation

According to the 1936 State of Oregon Forest Type Map[54] which predates extensive logging, nearly half the entire John Day Province was covered by pine, fir, and mixed pine–fir forests. About 40% was nonforested with primarily sagebrush–grassland in lower elevations. A surprisingly small part of the province, probably less than 10%, was occupied by stands of western juniper during that era. The lack of western juniper is particularly noticeable in the John Day River drainage where only scattered stands existed in the late 1930s. The upper Crooked River drainage east of Paulina also had only scattered stands of juniper.

In the southwest part of John Day Province in the vicinity of Prineville, juniper stands occupied a high proportion of the landscape. They extended east up the Crooked River to about Paulina. Preponderance of juniper around Prineville and lower Crooked River in John Day Province likely is due to the huge seed source provided by junipers that blanketed the nearby pumice-soil area (Mazama Province) from Redmond to Bend and east to about Hampton.

Unpublished field studies of juniper stand structure and age classes on these pumice soils helped form the belief that western juniper is a climax species on pumice soils in this particular area. Growth-ring counts of huge junipers, some about 3 feet in diameter and most of which were hollow, indicated such trees were hundreds of years old. All age classes were represented in the stand, which indicates the likelihood of stand perpetuation over time, i.e., climax species.[40]

In the 1960s, Larry Haverfield, an SCS range conservationist, and Bill Anderson observed that the stand of juniper north of the mainstem John Day River was increasing rapidly over the landscape at that time. Likely it had originated from the stand of old juniper growing on rocky ridges several miles to the north. In this study, growth rings on all trees along a transect from the river north to the forest boundary,

Table 20. Climatic Data for John Day Ecological Province, Oregon.[17]

Station and length of record (years)	Elevation (feet)	Precipitation			Average maximum and minimum temperatures (°F)	
		Annual (inches)	Nov.-March (%)	April-June (%)	January	April-June
Crook County						
Ochoco Ranger Sta. 15	3,979	19.3	56	25	33.4-13.5	64.1-32.6
Prineville 22	2,868	9.4	47	32	40.9-18.3	68.4-34.8
Grant County						
Austin 18	4,200	18.6	62	22	33.8-7.3	65.9-30.2
Beach Creek 8	4,710	18.7	50	31	36.6-18.4	61.3-35.1
Canyon City 13	3,194	15.3	52	31	39.5-21.8	69.2-40.7
Dayville 17	2,400	11.4	46	34	43.0-22.8	71.9-40.2
Prairie City 10	3,425	14.1	51	29	40.2-21.6	71.7-39.8
Seneca 13	4,666	11.2	60	23	34.9-4.9	63.6-30.7
Jefferson County						
Grizzly 7	3,672	13.8	50	29	36.1-17.2	65.2-35.1
Hay Creek 13	2,938	10.1	48	32	41.3-22.7	68.9-36.9
Madras 21	2,265	9.1	53	27	40.0-19.3	70.5-34.7
Warm Springs Agency 25	1,500	10.0	61	19	42.7-24.2	71.9-39.5
Wasco County						
Antelope 20	2,690	12.5	54	26	39.7-19.6	69.2-37.2
Wheeler County						
Fossil 6	2,660	14.4	55	28	38.4-18.4	67.7-35.7
Mitchell 16	2,766	11.2	42	40	42.9-24.3	69.9-40.1
Province Average		13.3	53	28	38.9-18.4	68.1-36.2

No weather stations in John Day Province in Deschutes, Harney, Morrow, or Umatilla counties

which was essentially the top of the main ridge, showed increasing age classes from the river to the ridgetop. The study also showed that the expansion of junipers had begun about the early 1900s. The very old juniper, the seedstock, grew on rocky ridgetops where they likely were protected somewhat from wildfire because of lack of surface fuel.

The spread of juniper in the mainstem John Day River valley near Dayville also was documented by a sequence of photos spanning several decades.

This set of photos has been used to illustrate the juniper problem in John Day Province. Bill Farrell, then Grant County Extension agent, obtained the first old photo, taken in 1920, from a local person (Fig. 27-a). He and E. W. Anderson, then range conservationist for Soil Conservation Service, located the approximate point from which the original photo was taken, and they took photos in 1945, 1956, and 1965 (Figs. 27-b through 27-d).

The major increase of western juniper in John Day Province has been on lower-elevation soils, such as Tub and Simas, that are geomorphically related to the clayey ancient sediments of the Clarno Formation.

One explanation for this phenomenon is that western juniper has an affinity for calcium; the clayey ancient sediments usually are calcareous. The affinity of western juniper for calcium can be demonstrated by measuring the pH of litter and surface soils under the canopy of a large juniper and then comparing it with the pH of surface soil material away from the juniper canopy. The pH is higher under the canopy, apparently because juniper roots extract calcium from the soil in a very wide radius from each tree and subsequent leaf-fall deposits calcium on the surface under the tree.

The calcareousness of soils formed in ancient sediments of John Day Province can be demonstrated by dropping some diluted hydrochloric acid on a bare, dry surface of Tub or Simas soil in summer after surface soil moisture has evaporated. The soil surface will effervesce.

These are basic ecological relationships that augment the more common, but only partial, explanation for the spread of juniper, which is that too much fire control has been practiced over the years. Prolonged grazing which severely uses herbaceous ground cover, reducing wildfire's ability to travel, likely is a significant factor in this complex biological equation. As juniper increase in density, thereby totally dominating the biological situation, solving these problems becomes more difficult and expensive.

Both basaltic and rhyolitic igneous formations are in John Day Province; basalt is by far the more prominent. Rhyolite is light in color, even pinkish; basalt is dark in color. Chemically, rhyolite is acidic; basalt is basic. It is not known whether the chemistry of soils formed in each of these materials

is ecologically significant. However, casual observation not supported by data indicates there might be an ecological significance.

For example, observations of soils formed in rhyolite are that they tend to be more clayey than soils formed in basaltic materials. Also, Idaho fescue seems to be better adapted to clayey rhyolitic soils than is bluebunch wheatgrass, provided of course that the effective environment of the site is suitable for growth of Idaho fescue.

In northeastern Jefferson County south of Ashwood is a large area of rhyolitic parent material known as Blizzard Ridge. The Prag soil series formed in these rhyolitic parent materials.[62] In July 1959 the extensive rhyolitic area on Blizzard Ridge contained no juniper; however, on the adjacent hilly ancient sediments—calcareous Tub and Simas soils—juniper were profuse. Prag, Tub, and Simas series all are clayey soils.

Since the affinity of western juniper for calcium in the soil has been verified, the question now is whether the absence of western juniper on soils derived from rhyolitic parent materials is due to the acidic nature of rhyolite.

Another example of how different plant communities might be related to rhyolitic and basalt parent materials is near Mitchell in Wheeler County. White Butte, likely a rhyolitic volcanic cone, and Black Butte, likely a basaltic volcanic cone, produce different plant communities. Western juniper is prominent on Black Butte but not on White Butte.

Table 21. Average Dates Vegetation Growth Begins and Ends in John Day Ecological Province, Oregon.

Station and length of record (years)	Elevation (feet)	Average date growth begins *	Average date growth ends *
Crook County			
Prineville 15	2,868	March 15	June 2
Ochoco Ranger Sta. 22	3,979	April 5	July 30
Grant County			
Dayville 17	2,400	February 24	June 2
Canyon City 13	3,194	March 7	July 13
Prairie City 10	3,425	March 7	July 5
Austin 18	4,200	April 9	September 5
Seneca 13	4,666	March 11	July 13
Beach Creek 8	4,710	April 1	August 7
Jefferson County			
Warm Springs Agency 25	1,500	February 25	June 5
Madras 21	2,265	March 15	June 3
Hay Creek 13	2,938	March 5	June 4
Grizzly 7	3,672	March 27	July 12
Wasco County			
Antelope 20	2,690	March 15	July 1
Wheeler County			
Fossil 6	2,660	March 17	July 16
Mitchell 16	2,766	March 5	June 7

No official weather stations in John Day Province in Deschutes, Harney, Morrow, or Umatilla counties.

* The average date vegetation growth begins on native perennial bunchgrasses is approximately the date average daily temperatures reach 39 to 40°F. Average date growth ends is considered to be when available soil moisture is depleted. Interpretations are based on data in Johnsgard.[17]

Soil–plant relationship studies of ecological sites in John Day Province indicate that nearly all nonforested sites were natural shrub–grasslands originally, i.e., having 10% or more canopy cover of shrubs.

However, steep north-facing slopes in John Day Province nonforested areas likely are natural grasslands on which Idaho fescue very strongly dominated the plant community. A variety of shrub species grow sparsely (less than 10% canopy cover collectively) on these steep north-facing sites in spite of the strong competition from dense Idaho fescue. These shrubs include bitterbrush, wax currant, rose, low Oregon-grape, buckwheats, green rabbitbrush, and common snowberry.

On lower-elevation, more arid natural shrub–grassland sites in John Day Province, the canopy cover of shrubs includes big sagebrush, bitterbrush, gray horsebrush, gray and green rabbitbrushes, buckwheats, wax currant, low sagebrush, and broom snakeweed. On more moist natural shrub–grassland sites at higher elevations, the shrub component also includes such species as low Oregon-grape, common snowberry, serviceberry, rose, and green rabbitbrush.

The natural shrub–grassland site locally called scabland, which is mainly on very shallow, very stony ridgetops, is found in John Day Province as well as in Columbia Basin and Blue Mountain provinces.

The major shrub on scabland in John Day Province is low sagebrush but is rigid sagebrush on scabland in Columbia Basin and Blue Mountain provinces. On some plateaus and ridges in John Day Province is a unique land pattern called biscuit scabland. For an explanation of the origin of this land pattern, see the section on Columbia Basin Province; there, biscuit scabland is prominent and widespread.

The widespread presence of basin wildrye on small colluvial fans, terraces, and pockets of colluvial soil scattered over the landscape in hilly ancient sediments is typical for John

Day Province. Erosion and local deposition of fine materials creates these pockets or stringers of deeper colluvial soils where basin wildrye becomes established (Fig. 28). Basin wildrye also dominates on floodplains and fans along intermittent and small perennial streams.

Prominent perennial streams, such as Bear Creek near Seneca, typically produce wet-meadow vegetation, sometimes interspersed with patches of dry-meadow vegetation on high spots, and usually with a dry-meadow fringe on the perimeter where meadow adjoins uplands.

Natural stands of coniferous trees occupied about half the area in John Day Province in 1936. The stands comprised five generalized plant communities which have management implications.

1. Western juniper with an understory of bunchgrasses such as bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass, Thurber needlegrass, basin wildrye; a wide variety of perennial forbs; shrubs such as bitterbrush, big sagebrush, gray horsebrush, and green rabbitbrush; and juniper reproduction.

2. Ponderosa pine with an understory of bunchgrasses such as Idaho fescue, bluebunch wheatgrass, Wheeler bluegrass, Thurber needlegrass, prairie junegrass, and sedge; many perennial forbs; a wide variety of shrubs such as bitterbrush, mountain and common snowberry, wax currant, low Oregon-grape, curlleaf mountain-mahogany, and wax currant; an occasional western juniper; and pine reproduction.

3. Ponderosa pine with an understory dominated by sedge and a wide variety of grasses such as big, Kentucky, Wheeler, and Sandberg bluegrasses, Idaho fescue, mountain brome, prairie junegrass, and pinegrass; many perennial forbs; shrubs such as bitterbrush, mountain and common snowberry, snowbrush, willow, and wax currant; and pine reproduction.

4. Ponderosa pine/Douglas-fir/grand fir with a midstory of saplings and pole-size trees; a dense cover of sedge with some big, Kentucky, Sandberg, and Wheeler bluegrasses, pinegrass, prairie junegrass, and other bunchgrasses; shade-tolerant forbs such as arnica, woollyweed, green lupine, pearly everlasting, strawberry; shrubs such as bitterbrush, common snowberry, spirea, willow, and low Oregon-grape; and reproduction of all tree species.

5. Douglas-fir/grand fir/ponderosa pine, usually on north-facing slopes above 3,500 feet elevation, with abundant saplings and pole-size trees; a sparse understory of shade-tolerant grasses, forbs, and shrubs; and reproduction of all tree species although ponderosa pine is sparse.

The kinds of soil that help differentiate John Day Province forested areas from Blue Mountain Province forested areas are reflected in significant differences in site-specific plant communities.

For example, John Day Province has natural juniper stands but Blue Mountain Province does not. Ponderosa pine/bunchgrass ecological sites are in both provinces, and based on superficial observation they resemble each other—pine trees, grasses, forbs, and shrubs.

However, field studies of this ecological site in both provinces reveal significant differences in the species that constitute the plant community of the site. In John Day Province, the following species regularly grow on the pine–bunchgrass site but are rarely, if ever, found on this site in Blue Mountain Province: Wheeler bluegrass, Thurber needlegrass, mountain snowberry, curlleaf mahogany, green rabbitbrush, big sagebrush, and western juniper. On the other hand, the following species regularly grow on the pine–bunchgrass site in Blue Mountain Province but are rarely, if ever, found on this site in John Day Province: onespike oatgrass, threadleaf sedge, huckleberry, mock-orange, and herbaceous sage.

Even greater differences exist on the ponderosa pine–sedge ecological site in each of these provinces. For example, the following species regularly grow on this site in John Day Province but rarely, if ever, on this site in Blue Mountain Province: basin wildrye, Wheeler bluegrass, mountain snowberry, curlleaf mahogany, green rabbitbrush, big sagebrush, and western juniper.

The following species regularly grow in Blue Mountain Province on this site but rarely, if ever, on this site in John Day Province: slender wheatgrass, timber oatgrass, western fescue, Columbia needlegrass, threadleaf sedge, blue wildrye, slender hairgrass, deerbrush, elderberry, spirea, huckleberry, ninebark, serviceberry, dogbane, syringa, chokecherry, bittercherry, oceanspray, bearberry, and herbaceous sage.

Generally, John Day Province pine/fir plant communities consist of fewer species than those in Blue Mountain Province. This might be related to the soils and climate of the two provinces. Average precipitation for John Day Province is significantly lower than for Blue Mountain Province, and the percentage of annual precipitation that falls during the growing season of perennial herbaceous species also is lower (see the section on climate in each province description).

It also should be noted that the herbaceous understory of pine/sedge and pine/Douglas-fir/sedge ecological sites in John Day Province is strongly dominated by sedge, whereas the herbaceous understory of equivalent ecological sites in Blue Mountain Province is strongly dominated by pinegrass. This situation also might be related to soils and climates of the two provinces.

Management Implications

The geomorphology of many soils in John Day Province is related to ancient sedimentary and tuffaceous formations. These soils are finely textured (clayey), very sticky when wet, and highly susceptible to erosion by precipitation. They frost heave in winter and spring and crack open in summer when denuded of vegetation, which presents serious problems of resource stability and potential for natural rehabilitation.

Except for the irrigated areas, such as around Prineville and Madras, cropland

Table 22. Major Ecological Sites in John Day Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Natural grassland (less than 10% canopy cover of shrubs)	Steep north Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass	Bottomland fan Basin wildrye, Idaho fescue, Sandberg bluegrass
	Deep scabland Sandberg bluegrass, bluebunch wheatgrass, Idaho fescue	Moist bottom Basin wildrye, big bluegrass, Idaho fescue, Kentucky bluegrass
		Dry mountain meadow Idaho fescue, Nevada bluegrass, various grasses and forbs
		Wet mountain meadow Tufted hairgrass, Nevada bluegrass, redtop, sedges
		Alkaline bottom Basin wildrye, quackgrass, Idaho fescue
Shrub–grassland (10% or more canopy cover of shrubs)	Arid rolling hills Bluebunch wheatgrass, Sandberg bluegrass, Thurber needlegrass/big sagebrush	Sodic bottom Basin wildrye, saltgrass/greasewood
	Rolling hills Bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass/big sagebrush	
	Moist rolling hills Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass/mixed shrubs	
	Scabland Sandberg bluegrass/low sagebrush	
	Droughty south exposure Bluebunch wheatgrass, Sandberg bluegrass, Thurber needlegrass/sagebrush	
	South exposure Bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue/sagebrush	
	Droughty north exposure Bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass/sagebrush	
	Mahogany rockland Idaho fescue, bluebunch wheatgrass/curlleaf mountain-mahogany	
	Sand hills Bluebunch wheatgrass, Indian ricegrass/ mixed shrubs	
	Sandy north exposure Idaho fescue, needlegrass/mixed shrubs	
	Clayey terrace Idaho fescue, bluebunch wheatgrass/ low sagebrush	
Mixed coniferous–deciduous tree (5% or more canopy cover of trees)		Semiwet bottom Redtop, Idaho fescue, Kentucky bluegrass/ cottonwood, ponderosa pine

(continued)

Table 22 (cont'd). Major Ecological Sites in John Day Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Coniferous tree (5% or more canopy cover of mature trees)	Juniper rolling hills Bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass/bitterbrush/juniper Juniper south exposure Bluebunch wheatgrass/bitterbrush/juniper Pine–bunchgrass Idaho fescue, bluebunch wheatgrass/ bitterbrush/ponderosa pine Pine–sedge Sedge, Idaho fescue/bitterbrush/ ponderosa pine Pine–mixed fir–sedge Sedge, pinegrass/bitterbrush/ponderosa pine, firs Mixed fir–pine forest Shade-tolerant understory/firs, ponderosa pine Mixed fir forest Sparse understory/Douglas-fir, true firs	

agriculture is limited to narrow irrigated valleys, most of which are devoted to producing livestock forages. The general lack of local winter feed restricts management options of lower-elevation rangelands that have been used historically for spring turnout and/or winter grazing.

Based on a few near-relict areas located during soil and site studies, the clayey soils of John Day Province generally are quite productive when a good stand of healthy perennial grasses is present. The wide variety of perennial grasses, forbs, and shrubs documented as growing on these calcareous fine-texture soils in John Day Province suggests that the original shrub–grasslands of this province probably were some of the best, if not the best, rangelands in Oregon for species diversity.

The original potential of these sites certainly has been lost or seriously diminished by irremediable changes in soil and/or site. However, potential for recovering some vegetation cover exists and is worth considering if practical ways can be devised to control soil erosion and noxious plants, especially juniper.

Expansion of western juniper, which now encompasses virtually all calcareous landscapes in John Day Province, is a major problem of resource management. Once established, juniper becomes a vigorous competitor for moisture and nutrients. That the very extensive root system of western juniper is a strong deterrent to rangeland recovery on clayey calcareous soils under known management options has been a central point of concern since the mid-1950s.

During early years of concern over juniper proliferation, it was obvious that juniper had to be eradicated before herbaceous growth could increase.

Various eradication methods were tested. Some areas were chained, bulldozed, chainsawed, burned, and treated with chemicals. The main lesson learned: eradicating juniper isn't easy. Neither is it always cost-effective.

The history of many of these trials was that any increases in herbaceous growth following juniper eradication seemed merely to attract more domestic and wild herbivores to graze which, in turn, aggravated juniper reproduction. Initiating and perpetuating a complete management program was so difficult and expensive that it was accomplished rarely, and then only by certain ranch operators.

Reseeding suitable areas of soils formed in ancient sediments and tuffaceous materials also has been tested with varying degrees of success in John Day Province.

The abandoned croplands of Central Oregon Land Utilization Project near Madras, now the Crooked River National Grasslands, are soils having loamy surface layers over clay or tuffaceous hardpans. Soil Conservation Service successfully seeded these, primarily to crested wheatgrass, prior to the early 1950s.

Productivity has been more or less maintained over the years by grazing management strategies. The extensive seedings are on plateaus and slopes thought to be arable before the big drought of 1930s. In other locations, Conservation Reserve Program seedings are on soils recently farmed, which contributes to the belief that John Day Province clayey soils can be reseeded on slopes where equipment can operate. However, special attention to grazing management is required to maintain production.

The most extensive need for revegetation in the province is in the huge area of hilly clayey soils, yet the terrain is unsuitable for seeding equipment.

However, one project did achieve some success in that kind of terrain. The 1956 Northside Game Range planning project extended from Prairie City west to Picture Rock Gorge below Dayville on the north side of mainstem John Day River. The project demonstrated the feasibility and effectiveness of seeding all or the most suitable small areas in a grazing unit and then managing the unit on the basis of those seedings. Collectively, a number of small seedings on flatter land enhanced early forage on a number of ranches in the project. Obviously, perpetuating the effectiveness of this investment requires very specific management of the small seedings.

Historically, John Day Province has been highly touted for its deer and elk antler trophies and superb hunting. It is very likely that there is a relationship between this longstanding reputation and the wide variety of plant species, especially shrubs, which provide high-quality big game habitat, and the calcareous soils as a source of calcium for excellent bone growth.

In recent years, research by Lee Eddleman and Rick Miller of Oregon State University has revealed the meteorological, physiological, and ecological implications of the dominance of western juniper and big sagebrush on arid native rangelands, such as in John Day Province.[11, 12, 21] The seriousness of this situation has been well publicized. This is an invaluable contribution to the process of determining management options and forming plans for resource rehabilitation in John Day Province.

Province Demarcation

John Day–Columbia Basin Demarcation

Starting in northwest John Day Province near the railroad siding of Nena in the Deschutes River canyon, about 7 miles upriver from Maupin, the line of demarcation between John Day and Columbia Basin provinces runs southeast and south along the east rim of the Deschutes canyon in Wasco County and south into Jefferson County to encompass the small plateau about 2 miles west of Willowdale.[83, 86]

From this plateau, it meanders northeast to cross Highway 97 in Cow Canyon about 1 mile north of the confluence of Antelope and Trout creeks and then follows the north-side breaks of Antelope Creek to its headwaters. About 2 miles north of Antelope, the abrupt demarcation is exposed in a roadcut on Highway 218. The roadcut displays Columbia Basin Province's basalt cap and silty aeolian soil, which extends to the north, overlying the light-color sedimentary materials that typify John Day Province, which is to the south of this point. The line runs northeast along west-side breaks of John Day River canyon to the point where the northeast corner of Wasco County and the southeast corner of Sherman County join on the John Day River. The John Day River canyon north of this point is in Columbia Basin Province; south, it is in John Day Province.

From where the line crosses John Day River, it travels south, east, and north along the breaks of a large rocky plateau that juts south into Wheeler County. The plateau is in Columbia Basin Province; the area west, south, and east of the plateau is in John Day Province. The plateau's southwest corner, overlooking the area around Clarno, is a good example of an abrupt province boundary. It can be viewed from below, near Clarno.

The line between John Day and Columbia Basin provinces goes east about 3 miles north of Fossil at about 4,000 feet elevation in the vicinity of Cummings Pass. About 3 miles east of the pass, the line between John Day and Columbia Basin provinces becomes the demarcation between John Day and Blue Mountain provinces.

The demarcation line between John Day and Columbia Basin provinces is the general line between soil series such as Simas and Tub, which are very clayey (John Day), and the Condon series, which is an aeolian silt loam (Columbia Basin).

John Day–Blue Mountain Demarcation

From about 3 miles northwest of Kinzua, the line of demarcation between John Day and Blue Mountain provinces continues southeast at about 4,000 feet elevation. In this vicinity is a mixture of those forested soils that typify Blue Mountain Province and those that typify John Day Province. The soil pattern creates a belt of demarcation 2 to 3 miles wide in this particular area.[90]

Farther east, however, the belt narrows considerably at about 4,000 feet elevation as the line of demarcation follows east along the north breaks of John Day River drainages. Grassy Butte, Potato Hill, Thompson Flat, Buckaroo Flat, and other plateau points above about 4,000 feet elevation that jut out into the John Day River drainage are in Blue Mountain Province; slopes into river drainage to the south are in John Day Province.

The adjoinment of the two provinces along this segment of the line is illustrated by an area of biscuit scabland (patterned ground) at Thompson Flat at the south end of Potamus Ridge. Here, the soil profile of a biscuit was 0 to 6 inches silt loam; 6 to 10 inches silty clay loam (these are typical upper-profile textures in Blue Mountain Province); 10 to 20 inches silty clay; and 20 to 30 or more inches clay (these are typical subsoil characteristics of John Day Province). In this biscuit scabland site, the interspersed scabland soil is very shallow and very stony with abundant surface basaltic stones, which is typical for scablands in both Blue Mountain and John Day provinces.

Geologists have reported that the Blue Mountains of Oregon were, at one time, the north shore of an ancient lake. These thick clay deposits, such as the one at Thompson Flat at about 4,000 feet elevation along the line of demarcation, are likely associated with remnants of ancient lake terraces.

It is interesting to note that, as supporting evidence, the ancient lakeshore terraces that signify where Snake River Province adjoins Blue Mountain Province in Baker County are very visible at about 4,000 feet elevation near Keating and Richland. The continuity of elevation at the 4,000-foot

level, coupled with evidence of ancient lakebed terraces, obviously has great significance from an ecological province perspective.

An excellent illustration of the demarcation between John Day and Blue Mountain provinces is on Highway 207 between Hardman in Morrow County and Spray on the John Day River in Wheeler County. About 15 miles north of the river and east of Mahogany Butte, the highway ascends the hairpin turns on the face of the escarpment that is the upper reaches of geologically eroded ancient sediments and tuffaceous materials that typify John Day Province. North of the escarpment, the plateau is Blue Mountain Province. Below the escarpment are many good opportunities to view scenic landscapes of John Day Province.

The line between John Day and Blue Mountain provinces heads east along the north breaks of John Day River drainage until it reaches the ridge west of Deerhorn Creek.

There, it veers south to the North Fork John Day River about one-half mile west of the confluence of Deerhorn Creek and the river. Then it continues west downstream to the first oxbow that changes the direction of river flow from west to south. At this oxbow, the line turns southeast up the ridgetop and continues at about 4,000 feet elevation to cross Highway 395 near Meadow Brook summit south of Dale.

The line continues east to just west of Putney Mountain at about 4,000 feet elevation where it travels southeast at about 4,500 feet elevation in the upper slopes of the Middle Fork John Day River. That is approximately the level at which truncated or exposed tuffaceous deposits and underlying clayey materials typify the John Day Province. The old mining town of Susanville is in John Day Province.

From about 1 mile north of Susanville, the line continues southeast to cross the Middle Fork John Day River about 6 miles upstream from Bates at about 4,500 feet elevation. Bates is in John Day Province.

From that point, the line heads west and around the north side of Dixie Butte at about 5,600 feet elevation. Dixie Butte and the area above about 5,600 feet elevation that surrounds it are in Blue Mountain Province. Where the line crosses Highway 28 southwest of Dixie Summit, spectacular roadcuts display beds of tuffaceous sediments, which typify the upper-elevation boundary of John Day Province, overlaid by a medium-texture, aeolian soil mantle that typifies Blue Mountain Province.

From the vicinity of Dixie Summit, the line of demarcation meanders south at about 4,500 feet elevation to cross the upper John Day River near Blue Mountain Hot Springs. It continues west along the north-facing slopes of Strawberry Mountain, Baldy Mountain, and Canyon Mountain at about 4,500 feet elevation or possibly lower, depending on the elevation at which volcanic ash is prominent in soils on these north-facing slopes. Volcanic ash soils typify Blue Mountain Province. The line runs around the west slopes of Canyon Mountain and then southeast at about 5,500 feet to 6,000 feet elevation along the rims southwest of High Lake and between Summit Prairie, which is in Blue Mountain Province, and Logan Valley, which is in John Day Province. It continues around the south of Crane Prairie, in Blue Mountain Province.

The line goes through pine- and fir-forested areas from near Kinzua in northeastern Wheeler County to the vicinity of Crane Prairie in southeastern Grant County. Major pine- and fir-forested soils that typify John Day Province are Hankins, Koehler, and Boardtree, all of which have clayey substrata. Hall Ranch and Tolo soils typify Blue Mountain Province; substrata of these soils are loamy and underlaid by basalt bedrock.

John Day–Snake River Demarcation

John Day, Blue Mountain, and Snake River provinces adjoin near the confluence of Crane Creek, which flows east out of Crane Prairie, and the North Fork Malheur River in southeastern Grant County.

From this point, the line between John Day and Snake River provinces meanders south at about 4,000 feet elevation along the east side of Stinking Water Mountain, then between Warm Springs Reservoir, which is in Snake River Province, and Coleman Mountain in John Day Province. The line is at about 4,000 feet elevation along the west breaks of the South Fork Malheur River and westward along the north breaks of Crane Creek, which flows east in northeastern Harney County.

It is near Crane that the John Day, Snake River, and High Desert provinces adjoin. Stinking Water Mountains and Stinking Water Pass on Highway 20 between Burns and Juntura are in John Day Province.

John Day–High Desert Demarcation

From the gap at Crane, in High Desert Province, the line of demarcation between John Day and High Desert provinces runs north and west at about 4,500 feet elevation along the edge of Malheur Lake basin. Harney, Burns, and Hines are just inside High Desert Province. This portion of the line of demarcation is obvious where ancient lake terraces of High Desert Province adjoin the uplands to the north, which are in John Day Province. From Hines, the line goes west at about 4,500 feet elevation to near where Harney, Deschutes, and Crook counties adjoin. From there the line veers north and follows around the basin in which GI Ranch is headquartered. The line runs southwest to the base of uplands just north of Hampton. Southwest of Hampton Butte, the John Day, High Desert, and Mazama provinces adjoin.

John Day–Mazama Demarcation

West of Hampton Butte, the line of demarcation between John Day and Mazama provinces more or less follows the boundary between the basin and the uplands to the north and then west and north of Grassy Butte at about 5,000 feet elevation.

However, elevation is not as much a criterion in demarcation between John

Day and Mazama provinces as it is between John Day and High Desert and other provinces. This is because Mazama Province is the area covered by an aeolian pumice mantle and lava flows reportedly associated with the eruption of Mt. Mazama (Crater Lake), and the deposit of aeolian material was not necessarily affected by elevation.

It should be noted, however, that the pumice deposit at the perimeter of the Mazama pumice mantle was and is thinner than toward the interior of the fallout area. Unpublished field studies indicate that where about 8 to 10 inches or more of pumice lies over buried soils, herbaceous vegetation resembles the arid nonforested portion of Mazama Province, i.e., bluebunch wheatgrass/ Idaho fescue. Less than 8 to 10 inches of pumice mantle over buried soils apparently produces High-Desert-type herbaceous vegetation, i.e., bluebunch wheatgrass/Thurber needlegrass.[32]

It also should be noted that Mazama aeolian pumice falling on hilly uplands in a relatively thin mantle along the perimeter of the fallout pattern likely was washed into adjacent valleys and drainages by subsequent precipitation. Therefore, hilly uplands in the vicinity of the line of demarcation between John Day and Mazama provinces likely contribute to the location of this line; generally, the flatter land is in Mazama, and the hilly uplands are in John Day Province.

About 5 miles north of Brothers, the demarcation line veers northwest and north to the vicinity of the confluence of Bear Creek with Crooked River. From there it essentially follows the west canyon rim of Crooked River. At the mouth of Crooked River canyon about 6 miles south of Prineville, the line turns northwest to cross Highway 126 on the plateau about 4 miles east of Powell Butte and continues northwest to Crooked River east of Smith Rock.

Powell Butte, Redmond, and Terrebonne are in Mazama Province; Prineville, Smith Rock, Gray Butte, and nearly all the Crooked River National Grasslands are in John Day Province. From Smith Rock, the line follows the west canyon wall of Crooked River to the confluence of Squaw Creek with Deschutes River, which places the Peninsula and the Island Natural Area in John Day Province.[70]

In this vicinity, soils typifying John Day Province include the Madras, Ochoco, and Agency series which overlie tuffaceous or sedimentary hardpans. Soils typifying Mazama Province have a pumice-dominated layer over buried soils or basalt bedrock and include such series as Deschutes and Shanahan.

John Day–The Dalles Demarcation

John Day, Mazama, and The Dalles provinces adjoin about 3 to 4 miles west of the confluence of Squaw Creek with Deschutes River at about 2,500 feet elevation on the west side of what has been called the Lower Desert.

From this point, the line of demarcation between John Day and The Dalles provinces wanders north at about 2,500 feet elevation where rocky tablelands of John Day Province join the footslopes of the Cascade Mountains, which are in The Dalles Province. Metolius Bench, Sawmill Butte, and Hehe Butte on the Warm Springs Indian Reservation are in The Dalles Province.

In the northeast portion of Warm Springs Indian Reservation, which is west of the Deschutes River, there is a real mishmash of vegetation–soil relationship patterns.[70] Small to large islands of vegetation and soils that are more or less typical of John Day or The Dalles or Columbia Basin provinces are interspersed over the landscape from the vicinity of Warm Springs north to Pine Grove and Wapinitia.

This is probably the clearest example in Oregon of why the line of demarcation between provinces must sometimes be a matter of judgment. It also is an excellent example of how a highly complex pattern of very different ecological units over a huge area can present a bewildering basis for site-specific resource management decisions. Based on field observations, it was decided that ecological features typifying John Day Province dominate the mishmash area. Therefore, the area north from Warm Springs and east of The Dalles Province is placed in John Day Province. From the vicinity of Hehe Butte, the demarcation line turns east, then north and west to encompass the area around Simnasho, which is in The Dalles Province. About 1 mile north of Simnasho, the line goes north at about 3,000 feet elevation to where the previous northern boundary of Warm Springs Indian Reservation, which is on a ridge, intersects the road between Wapinitia and Simnasho.

John Day– Columbia Basin Demarcation

It is near this ridgetop pass on the road between Wapinitia and Simnasho that John Day, The Dalles, and Columbia Basin provinces adjoin. From this point, the line of demarcation between John Day and Columbia Basin provinces was placed east along the ridge that marks the previous northern boundary of the reservation and then north around the east side of Nena Creek basin to cross Deschutes River near the railroad siding of Nena, which is 7 to 8 miles upstream from Maupin. Mutton Mountains are in John Day Province; most of Nena Creek watershed and Juniper Flat are in Columbia Basin Province.

Tygh Valley, about 15 miles north of this line, is a small island of John Day Province that is typified by exposed Clarno geologic formation in which Tub and Simas soils have been formed. A similar island of John Day Province lies around Lonerock in southeastern Gilliam County within Columbia Basin Province. Other instances exist where outcrops of Clarno formation, rated as one of the oldest geologic formations in Oregon, are exposed under more recent formations, such as along the upper North Fork John Day River and north of Kinzua.

Klamath Ecological Province

Location

Klamath Ecological Province in south-central Oregon lies mostly in western Lake County and southern Klamath County with a very small part in southeastern Jackson County. In Oregon, the province covers about 2.7 million acres. It extends south into Siskiyou and Modoc counties in California.

Description

Physiographically, Klamath Province in Oregon is typified by large basins consisting of lakebeds surrounded by extensive ancient lake terraces interspersed with basaltic mountainous terrain. Existing lakes in Oregon include Upper Klamath Lake, Agency Lake, and the northern third of Goose Lake, plus two large reservoirs, Drews and Gerber. In California, the province includes Lower Klamath Lake, Tulelake, Clear Lake, and the southern two-thirds of Goose Lake. Upper Klamath Lake drains to the south through Klamath River. Goose Lake seldom overflows, but when it does it drains south into Pit River.

The highest elevations in Klamath Province in Oregon are in the north–south chain of basaltic mountains, Warner Mountains, east of Lakeview in Lake County. These include Drake Peak, 8,405 feet; Light Peak, 8,220 feet; Twelvemile Peak, 8,080 feet; and Crane Mountain, 8,446 feet. In the western portion of Lake County, high elevations in the province include Dead Indian Mountain, 7,060 feet; Winter Rim, 7,280 feet; Slide Mountain, 7,840 feet; Coleman Rim, 7,470 feet; Cougar Peak, 7,925 feet; and Grizzly Peak, 7,775 feet. None of these peaks reach timberline.

The portion of Klamath Province in Klamath County is less mountainous than in Lake County. High elevations include Fishhole Mountain, 7,020 feet; Horsefly Mountain, 6,480 feet; Yainax Butte, 7,240 feet; Saddle Mountain, 6,835 feet; Swan Lake Point, 7,320 feet; Haymaker Mountain, 6,585 feet; and Stukel Mountain, 6,525 feet.

Lowest elevations in the province in Oregon are in Klamath County—Malin, 4,050 feet; Merrill, 4,070 feet; Klamath Falls, 4,100 feet; and Klamath Lake, 4,136 feet. In Lake County, the lowest elevation in the province is along the line of demarcation between Klamath and High Desert provinces from the vicinity of Valley Falls to near Paisley. This line lies at about 4,500 feet elevation. Goose Lake is 4,680 feet and Lakeview is 4,746 feet elevation. (Elevations are from USGS 1:250,000 topographic maps.)

Lake basins and terraces occupy about 50% of the land area of the province that lies in Klamath County and about 20% of the province that is in Lake County. Lake basins and terraces in both Lake and Klamath counties are used primarily for irrigated agriculture. The rest of the province in Oregon is rangeland and forest.

Soils

Noncultivated upland soils typifying the Lake County part of Klamath Province are derived primarily from tuffaceous and basaltic materials. Sagebrush–bunchgrass rangeland soils are primarily the Booth–Bluejoint soil association, which are clayey soils, and the Hapgood–Hartig soil association, which are loamy soils. Pine- and fir-forested soils are primarily the Woodcock–Mound soil association, which are well-drained loamy soils.

Soils being cultivated, mainly under irrigation, on terraces and fans in the Lakeview vicinity are typically the Drews soil series. Soils on well-drained bottomlands are in the Lakeview soil series. Poorly drained flood plains include the Goose Lake, Scherrard, and Stearns soil series, the latter two being alkaline.[84]

In the Klamath County part of Klamath Province, the major rangeland soil is

Lorella series, which is formed in tuffaceous and basaltic materials and grows juniper, sagebrush, and bunchgrasses. The Merlin soil series represents the major low sagebrush scabland site. Forested areas are associated primarily with Woodcock, Pokegema, and Turnquist soil series, which are formed in andesitic parent materials.

Various soil series are associated with the extensive valleys and low terraces that are cultivated, mainly under irrigation, in the Klamath County part of the province.

The soils are formed in lacustrine sediments consisting of tuffaceous and basaltic materials and are represented by such soil series as Malin, Scherrard, Bedner, Calder, and Laki. Fordney series is in sandy basins and fans. Soils that are poorly drained include Ontko, Klamath, Pit, and Henley; some are alkaline. Marsh soils are represented by Tulano, Algoma, Yamsay, and Moyina series, which are formed primarily in lacustrine diatomaceous materials. The Tulano series, where drained, probably is the most extensive cultivated soil in Klamath Province.[79]

Climate

Based on eight official weather stations representing Klamath Ecological Province in Oregon, average annual precipitation for the Lake County portion of the province is 14.2 inches, of which 35% falls during the herbaceous native-plant growing season, April through July. The average annual precipitation for the Klamath County part of the province is 14 inches, of which 27% falls during the growing season. October through March (winter) precipitation for the province is about 61% of total precipitation in Lake County and 66% in Klamath County.

Average temperatures do not vary significantly between Lake and Klamath county weather stations. Average January maximum and minimum temperatures for the province are 37.8 and 16.4°F, respectively. Average April through July maximum and minimum temperatures for the province are 70.9 and 38.9°F, respectively.

A precipitation map[53] shows a high for the province of about 65 inches annually in the Crane Mountain area southeast of Lakeview, which is also the highest elevation in the province. A few mountainous areas scattered throughout the province show average annual precipitation above 25 inches; the south portion of Winter Rim shows about 35 inches. The most arid part of the province is near the California state line at Malin and Merrill, southeast of Klamath Falls, where annual precipitation is about 10 to 12 inches.

Vegetation

According to the 1936 State of Oregon Forest Type Map,[54] which predates extensive logging activities, about 70% of the Lake County portion of Klamath Province was covered by trees, primarily ponderosa pine. A small area above about 7,000 feet elevation southeast of Lakeview was forested with such species as true fir. About 30% of this part of the province was unforested. Of that, about 5% was cultivated, 5% was lakebed in the vicinity of Lakeview, and the other 20% was likely shrub–grassland.

Only about 1% of the Lake County part of the province was covered in juniper stands. The stands were mainly in two locations, about 12 miles west of Lakeview and south of Highway 66, and on the rocky plateaus sloping east between Warner Mountains and Warner Valley.

In the part of Klamath Province in Klamath and Jackson counties, about 50% was covered by trees consisting primarily of ponderosa pine. In addition, about 10% of the area was covered by stands of juniper distributed throughout the area. Unforested areas, which were probably cropland and shrub–grass rangelands, covered about 40% of the area; lakes, marshes, and wet meadows occupied about 10% of the area.

Radical changes since 1936 in Klamath Province of Oregon include expanded juniper coverage and increased cropland acreage resulting from sprinkler irrigation and the drainage of marshes and shallow lakes.

Natural grasslands in Klamath Province of Oregon grow only on bottomlands,

Table 23. Climatic Data for Klamath Ecological Province, Oregon.[17]

Station and length of record (years)	Elevation (feet)	Precipitation			Average maximum and minimum temperatures (°F)	
		Annual (inches)	Oct.-March (%)	April-July (%)	January	April-July
Klamath County						
Dairy 17	4,150	14.2	70	26	37.9-15.9	71.7-35.8
Gerber Dam 7	4,850	18.6	69	26	37.2-11.1	71.6-37.5
Klamath Falls 22	4,100	13.9	64	23	37.1-20.8	71.7-43.7
Malin 15	4,050	12.1	67	36	38.6-18.9	72.3-38.8
Merrill 16	4,070	10.6	68	25	37.4-16.8	72.4-37.0
Round Grove 19	4,888	16.1	63	30	37.8-15.2	68.2-34.1
Yonna 22	4,147	12.7	61	24	38.0-15.7	71.2-35.6
Klamath County Average		14.0	66	27	38.7-16.3	71.3-37.5
Lake County						
Lakeview 21	4,746	14.2	61	35	36.9-16.4	70.5-40.3
Province Average		14.1	64	31	37.8-16.4	70.9-38.9

Table 24. Average Dates Vegetation Growth Begins and Ends in Klamath Ecological Province, Oregon.

Station and length of record (years)	Elevation (feet)	Average date growth begins*	Average date growth ends*
Klamath County			
Dairy 17	4,150	March 22	July 25
Gerber Dam 7	4,850	April 1	August 24
Klamath Falls 22	4,100	March 15	July 26
Malin 15	4,050	March 15	July 6
Merrill 16	4,070	April 1	June 27
Round Grove 19	4,888	April 7	August 13
Yonna 22	4,147	March 24	July 15
Lake County			
Lakeview 21	4,746	March 27	July 24

No official weather stations in Klamath Province in Jackson County.

* The average date vegetation growth begins on native perennial bunchgrasses is approximately the date average daily temperatures reach 39 to 40°F. Average date growth ends is considered to be when available soil moisture is depleted. Interpretations are based on data in Johnsgard.[17]

and the vegetation varies according to degree and duration of wetness. The driest natural grasslands in Klamath Province are well-drained bottoms on which basin wildrye dominates a wide variety of grass species.

Associated soils include the Modoc series. The wettest natural grasslands in the province are wet mountain meadows on which tufted hairgrass dominates in a wide variety of grasses, sedges, and rushes. Associated soils include Gooselake, Klamath, and Lakeview series. Meadows of intermediate wetness are dominated by a variety of bluegrasses, including Leiberg, Nevada, Kentucky, Canby, and Sandberg, and a wide variety of other grasses, sedges, and rushes. Associated soils include Whitworth and Yocum series.

Marshlands, the transitions from lake to meadow, are typified by bullrushes and cattails. Associated soils include Tulano, Algoma, Yamsay, and Moyina series.

Natural shrub–grasslands grow within the lake basins of Klamath Province in Oregon mainly on lakebed terraces and stony sloping tuffaceous plateaus and on some south-facing slopes at lower elevations in mountainous areas (Fig. 29). Shrub–grasslands on very shallow or claypan soils are strongly dominated by low sagebrush with minor amounts of shrubby buckwheat and bitterbrush. Associated soils include Lorella and Booth series.

Klamath Province shrub–grasslands on moderately deep soils are notable for their wide array of shrub species. Big sagebrush and bitterbrush are widely prominent. Other shrubs include Klamath plum, serviceberry, desert gooseberry, shrubby buckwheat, gray horsebrush, gray and green rabbitbrushes, curlleaf mountain-mahogany, chokecherry, wax currant, granitegilia, rose, mountain snowberry, blue elderberry, oceanspray, and, on steep north exposures, birchleaf mountain-mahogany.

Klamath Province shrub–grasslands also are notable for the wide variety of perennial grass and forb species in plant communities. It is not uncommon for a sizable plant community in relatively good ecological status to contain about 10 perennial grass species and about 20 perennial forb species.

Soils associated with shrub–grasslands in the province in Oregon include Calimus, Bluejoint, Drews, Hartig, Lorella, Crume, Modoc, and Nuss series.

Most shrub, grass, and forb species in this province in Oregon are the same species found to the east and north in other Oregon ecological provinces. However, at least three species common in Klamath Province in Oregon do not grow in other eastern Oregon provinces: woolly wyethia, Klamath plum, and birchleaf mountain-mahogany. In its wide variety of shrub, grass, and forb species, Klamath Province represents a transition between other eastern Oregon provinces and Siskiyou Province in southwest Oregon, which also is typified by a wide variety of native species many of which apparently do not grow in eastern Oregon.

Natural juniper sites are considered to be sites on which mature juniper trees constitute 5% or more of canopy cover and in which all age classes of juniper live, indicating the stand's perpetuation.

East of Warner Mountains in Lake County, natural juniper stands grow on extensive areas of basalt rubbleland—land where rock outcrops and stone-size rubble cover about 90% of the land surface. Plant growth is confined to areas between the rubble; low sagebrush is the dominant shrub (Fig. 30). These are likely the same areas that were mapped as juniper trees in 1936.

Similar examples of natural juniper stands also are to the west in the province. Associated soils include the Hart–Rockland and the Lorella–Booth–Rockland complexes.

Other natural juniper stands are on undulating south-facing slopes having shallow, stony soils. Bitterbrush, big sagebrush, and a variety of bunchgrasses grow in the understory. Associated soils include Lorella and Fuego series.

In addition to juniper, stands of other coniferous trees in 1936 covered about 70% of Klamath Province. In this area, ponderosa pine is the most widespread tree species and grows in a variety of environments because of its wide ecological amplitude. In Klamath Province, it appears that ponderosa pine can encroach into disturbed forests, including into stands of white fir.[39]

White fir is the next most widespread tree species in the province. (Both white fir and grand fir are collectively called white fir in this instance.) Commonly, a single tree will have

needle characteristics of both species, indicating that cross-breeding has produced a hybrid. This also occurs in Blue Mountain Province of Oregon where the two species intermingle.

Fred Hall, an ecologist in Region 6 of the U.S. Forest Service (Portland), once aptly suggested the hybrid should be classified as *Abies grandcolor* to dispense with debate (personal communication to author). The ecological amplitude of white fir in Klamath Province in Oregon extends from the dry ponderosa pine zone, where it is normally on north exposures, to high cold ridges of about 6,700 feet elevation.

Douglas-fir is common only in the western portion of Klamath Province. Sugar pine extends throughout the province but is not dominant in any stand. It usually is on north-facing slopes in the province east of Klamath Falls and on south-facing slopes west of Klamath Falls. It appears to be somewhat tolerant of shade and always grows in mixed stands. Incense cedar generally is associated with sugar pine in Klamath Province in Oregon.

Lodgepole pine is uncommon in Klamath Province but grows in cold

Table 25. Major Ecological Sites in Klamath Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Natural grassland (less than 10% canopy cover of shrubs)		Well-drained bottom Basin wildrye, Kentucky bluegrass, Canby bluegrass, beardless wildrye Dry meadow Leiberg bluegrass, Nevada bluegrass, Kentucky bluegrass, slender wheatgrass Wet meadow Tufted hairgrass, redtop, Nebraska sedge, rushes
Shrub–grassland (10% or more canopy cover of shrubs)	Droughty rolling hills Bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue/mixed shrubs Rolling hills Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass/ mixed shrubs Scabland Sandberg bluegrass/low sagebrush Very cobbly land Idaho fescue, Sandberg bluegrass/ low sagebrush South exposure Bluebunch wheatgrass, Sandberg bluegrass/ mixed shrubs North exposure Idaho fescue, bluebunch wheatgrass, big bluegrass/mixed shrubs Steep north Idaho fescue, blue wildrye/mixed shrubs, birchleaf mountain-mahogany Deep sand hills Needlegrasses, ricegrass/bitterbrush Mahogany rockland Idaho fescue, bluebunch wheatgrass/mixed shrubs, curlleaf mountain-mahogany Clayey terrace Idaho fescue, Sandberg bluegrass/ low sagebrush Loamy terrace Bluebunch wheatgrass, Idaho fescue, needlegrass/bitterbrush	Claypan bottom Idaho fescue, Nevada bluegrass/low sagebrush

(continued)

Table 25 (cont'd). Major Ecological Sites in Klamath Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Coniferous tree (5% or more canopy cover of mature trees)	Juniper rolling hills Bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass/mixed shrubs/juniper Juniper rubbleland Bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass/low sagebrush/juniper Juniper–pine–bunchgrass Bluebunch wheatgrass, Idaho fescue, Thurber needlegrass/mixed shrubs/pine, juniper Pine–bunchgrass Idaho fescue, bluebunch wheatgrass/ mixed shrubs/ponderosa pine Pine–sedge Sedge, Idaho fescue/mixed shrubs/ponderosa pine Mixed pine–fir–sedge Sedge/mixed shrubs/mixed pine, fir Fir–pine forest Shade-tolerant grasses/shrubs/mixed fir, mixed pine Fir forest Shade-tolerant understory/true firs Lodgepole forest Shade tolerant understory/lodgepole pine	
Deciduous tree (5% or more canopy cover of trees)	Aspen grove Mixed grasses/mixed forbs/mixed shrubs/ aspen	Aspen meadow Wet meadow grasses/forbs/aspen, willow

areas above about 6,700 feet elevation, such as on Swan Lake Point and Yainax Butte. It also occurs in concave cold and wet locations.

Soils associated with pine, fir, and mixed pine–fir forests include Mound, Woodcock, Tournquist, Lobert, and Bly series. Aspen is the most abundant and widespread native deciduous tree in the province and is restricted to cold, wet areas. Soils associated with aspen stands include Mitten Springs series. The greatest abundance of tree species, and for that matter of all plant species, is in the far west, most moist part of Klamath Province in Oregon. This area is near Siskiyou and Cascade provinces.

Management Implications

The geomorphology of many soils in Klamath Province in Oregon is related to ancient sedimentary and tuffaceous lakeshore terraces and basins. These soils generally have loamy surface layers and loamy to clayey subsoils. The surface is often stony or gravelly, and hardpans may be present. These features are important to irrigated cropland agriculture on sloping lands.

Much of Klamath Province rangelands in Oregon are typified by basalt stones and outcrops on the surface, especially on upland slopes and plateaus. Associated soils commonly are shallow over clayey subsoils. These soils readily erode if herbaceous cover is depleted.

Stones, exposed by erosion, can form a stone pavement that seriously impedes reestablishment of forage plants. Resource-management plans to improve range ecological status and forage production must fully recognize that stone pavement on an area essentially determines how much the vegetation can be improved. Costs to implement management plans should be weighed realistically against benefits that might be achieved.

Successful livestock ranching in Klamath Province in Oregon depends largely on irrigated pasture during part or all of the summer grazing period because of the lack of native summer range in the area. A few ranches have summer and early fall grazing in the forested area west of Klamath Falls and on several mountains.

This general lack of native summer range at least partly explains why rangeland ecological status generally is quite low in the province. Historic pressure to turn out on the range as soon as possible in spring and to stay off irrigated fields until crops are harvested in autumn likely contributed to current ecological status.

Expansion of western juniper, which now covers virtually all noncultivated and nonforested areas in the province, is a major problem. Various methods of eradication have been tested; the main lesson learned is that eradicating juniper is not easy nor always cost-effective. However, some juniper control projects, coupled with grazing management systems, have improved ecological status and produced more and better livestock and wildlife forage, and better soil protection by the improved vegetation.

One of the most important aspects of Klamath Province in Oregon is its excellent wildlife habitat. The wide variety of herbaceous and shrub species forms ideal habitat, especially for deer. Nearly all sites except in forested areas produce significant amounts of bitterbrush, a prime winter-range browse for deer. Normal use for big game should be considered when managing livestock and other uses of the area.

Province Demarcation

Klamath–High Desert Demarcation

The line of demarcation between Klamath and High Desert provinces begins at the Oregon–California border at about 6,000 feet elevation south of the dry Big Lake, which is southwest of Adel in Lake County. The line meanders north at about that elevation to cross Parsnip Creek west of Adel, up Drake Creek to cross the Plush cutoff road east of Drake Peak, and on northward across Twelvemile and McDowell creeks.

At Honey Creek, the line veers west, to the south end of Abert Rim, then south to Sherman Valley. From there it follows north along the west side of Abert Rim escarpment nearly to Lake Abert. Then it turns southwest to the vicinity of Valley Falls, in High Desert Province.

From the vicinity of Valley Falls, the line travels northwesterly at about 4,500 feet elevation along the western boundary of Chewaucan Valley, around Tucker Hill, south up Moss Creek about 6 miles, then northwest along the valley at the base of Winter Ridge. The communities of Paisley and Summer Lake are in High Desert Province.

About 3 miles north of the community of Summer Lake, the line goes west along the headwaters of various drainages that drain north into Silver Lake basin. It continues west about 5 miles south of Silver Lake community into the headwaters of Bridge Creek. At this location, Klamath, High Desert, and Mazama provinces join.

The line between Klamath and High Desert provinces is based on soil lines between Booth–Bluejoint and Woodcock–Mound soil associations, which typify Klamath Province, and the Floke–Olson, Harriman–Hager, Crump–Ozamis, and Hart–Plush soil associations which typify High Desert Province.[84]

Klamath–Mazama Demarcation

The line of demarcation between Klamath and Mazama provinces runs south to the west of Thompson Reservoir, which is in Klamath Province, then around Sycan Butte, which is in Mazama Province, and along the east side of Sycan Marsh, also in Mazama Province.[76]

From about 5 miles southwest of Sycan Marsh on the Sycan River, the line heads east and runs northeast across the headwaters of Sycan River and then southeast in the vicinity of Winter Rim. From the south portion of Winter Rim, the line travels south across upper Elder Creek to west of Campbell Lake and south of Deadhorse Rim where it veers west along the south-facing slopes of Gearhart Mountain, which is in Mazama Province.[84]

From the area south of Gearhart Mountain, the line goes west to North Fork Sprague River. Then it snakes its way west more or less near the north boundary of Sprague River valley. Ferguson Mountain is in Mazama Province.

From the vicinity of Knott Tableland, which is in Klamath Province, the line meanders northwest, passing about 5 miles north of Sprague River community which is in Klamath Province. From there, it runs south and west to the vicinity of Chiloquin and south to Lobert Junction.

From the vicinity of Lobert Junction on Highway 97, the line winds north along the east side of Agency Lake to the vicinity of Klamath Agency, which is in Mazama Province, then northwesterly to about 4 miles west of Fort Klamath along the east side of Klamath Point. Klamath, Mazama, and Cascade provinces join in the vicinity of Klamath Point.

The demarcation between Klamath and Mazama provinces is based on soil lines between Woodcock–Mound, Hart, and Lorella soil series, which typify Klamath Province, and Lapine, Shanahan, and Kirk–Chock soil series, which typify Mazama Province.[84]

Klamath–Cascade Demarcation

From the vicinity of Klamath Point, in Cascade Province, the line of demarcation between Klamath and Cascade provinces heads south at about 5,500 feet elevation along the east side of Klamath Point, Lather Mountain, Pelican Butte, Mt. Harriman, Buck Peak, and Buck Mountain.

From Buck Mountain the line turns northwest at about 5,500 feet elevation around the headwaters of Jenny Creek to the area southwest of Brush Mountain, which is in Cascade Province. It is in this vicinity that Klamath, Cascade, and Siskiyou provinces join.

The line of demarcation between Klamath and Cascade provinces is not based on soil maps. Rather, the line represents the approximate boundary between the mixed-pine–mixed-fir forests of Klamath Province and the colder, more moist mixed-fir–hemlock forest, which typifies Cascade Province.[50] However, in this area, the Dumont–Coyata and Donegan–Killet soil associations are associated with mixed fir–hemlock forest of Cascade Province; Pokegema–Woodcock soil association is associated with the mixed-pine–mixed-fir forests of Klamath Province.[61]

(continued on page 85)

The Ecological Provinces of Oregon

Some representative views

Figure 1. Looking northeast at an example of an abrupt line of demarcation between ecological provinces: Columbia Basin Province on the basaltic plateau (background), and the geologically eroded ancient sediments of John Day Province (foreground) near Clarno, Oregon.

Figure 2. Looking north at an example of an abrupt line of demarcation between ecological provinces: High Desert Province (foreground), and John Day Province (background), north of Hampton, Oregon.

Figure 3. Rugged basaltic foothills of Blue Mountain Province, Oregon.

Figure 4. Typical view of Blue Mountain Province, showing interspersed natural grasslands and forested areas.

Figure 5. Managed natural grasslands in Blue Mountain Province, Oregon.

Figure 6. Typical pine–fir–pinegrass forest in Blue Mountain Province, Oregon.

Figure 7. Looking south from Hawkins Pass, which is the source of South Fork Imnaha River in Blue Mountain Province, Oregon.

Figure 8. Douglas-fir, noble fir, and hemlock forest at about 4,000 feet elevation along the highway near Marion Forks in Cascade Province, Oregon

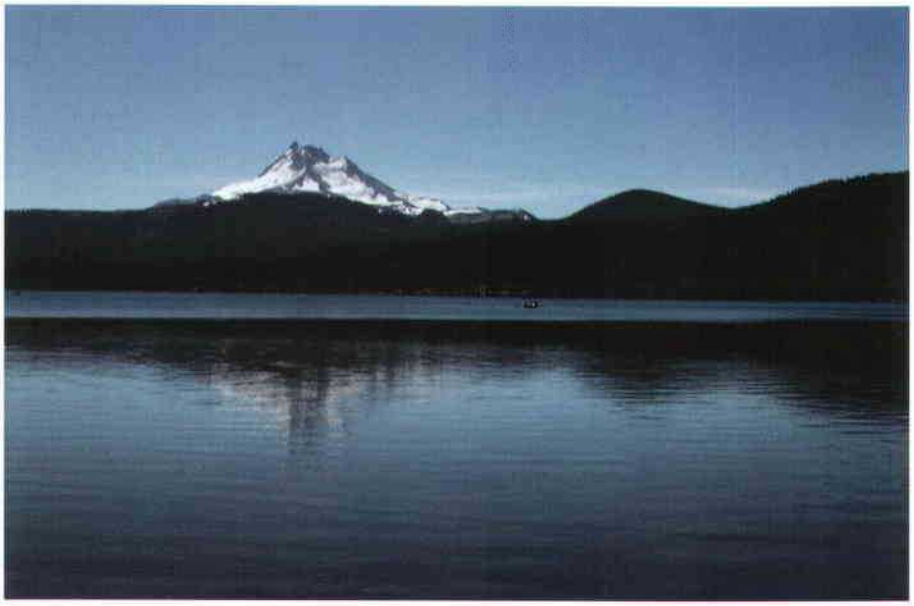


Figure 9. Olallie Butte, elevation 7,210 feet, on the crest of the Cascade Range as seen from Olallie Lake in Cascade Province, Oregon.

Figure 10. Sandy beaches and coastal headlands south of Cape Lookout in the northern portion of Coast Province, Oregon.

Figure 11. Looking southwest from Marys Peak into Coast Province, Oregon. Fog in valleys that extend to the ocean is typical for this province.

Figure 12. Douglas-fir–western hemlock forest in upper Siletz River drainage of Coast Province, Oregon, showing abundance of deciduous trees that commonly proliferate after logging or burning.

Figure 13. Overview of extensive dryland farming area within Columbia Basin Province, Oregon. Washington state, north of the Columbia River, is in the background.

Figure 14. Biscuit scabland is extensive in Columbia Basin Province, Oregon.

Figure 15. A cross-section of a typical biscuit scabland in Columbia Basin Province, Oregon. It shows the massive basalt underlying both the biscuits of soil and the adjacent scablands.

Figure 16. Managed natural upland grasslands in Columbia Basin Province, Oregon.

Figure 17. Overview of extensive closed basins typifying High Desert Province, Oregon. Wagontire Mountain is on the horizon at right.

Figure 18. Ancient shoreline of Warner Valley along the west side of Poker Jim Ridge on Hart Mountain National Antelope Refuge in High Desert Province, Oregon.

Figure 19. Concentric bands of vegetation on a shallow lakebed in Hart Mountain National Antelope Refuge, in High Desert Province, Oregon. The vegetation bands are related to the frequency, depth, and duration of inundation.

Figure 20. Stand of rough fescue in a managed natural shrub grassland at about 7,000 feet elevation on Hart Mountain in High Desert Province, Oregon.

Figure 21. Managed natural shrub–grassland dominated by bluebunch wheatgrass and Thurber needlegrass in the vicinity of Glass Buttes, High Desert Province, Oregon.

Figure 22. Immense sodic bottomlands and mountain ranges in Humboldt Province near the Oregon–Nevada border. Continuous ancient-lake terraces and fans appear as a lighter-color formation between the bottomlands and the mountains.

Figure 23. Managed natural desert shrub range on very stony ancient lakeshore terraces and fans that typify Humboldt Province, Oregon.

Figure 24. Ancient-lake terraces along the eastern footslopes of Steens Mountain, in High Desert Province, and Alvord Lake basin, which is in Humboldt Province, Oregon.

Figure 25. Geologically eroded ancient lacustrine materials capped with basaltic or tuffaceous rock typify John Day Province, Oregon.

Figure 26. General view of John Day Province showing round-top hills, remnants of basalt flows, and exposed ancient sediments.

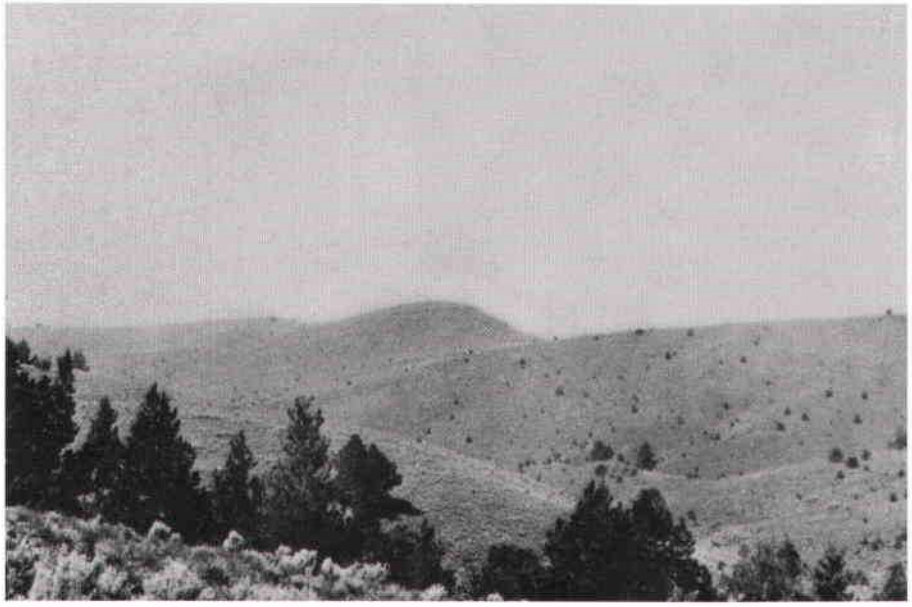


Figure 27-a. This photo and the three following, taken over a 45-year period, document the spread of western juniper in the mainstem John Day River valley near Dayville. This photo was taken in 1920 by a local person.

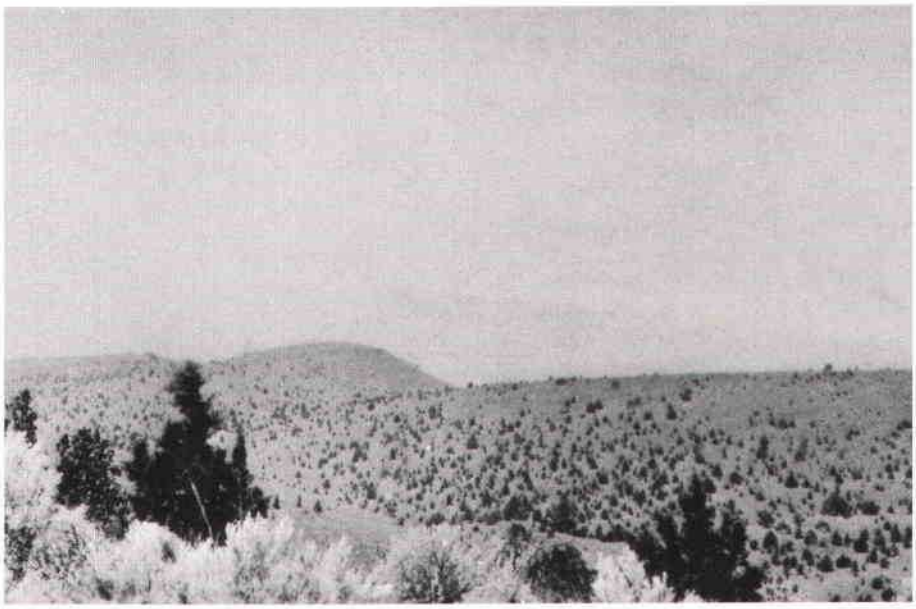


Figure 27-b. Taken in 1945 by E. W. Anderson and W. Farrell; the latter was Grant County Extension agent at that time.

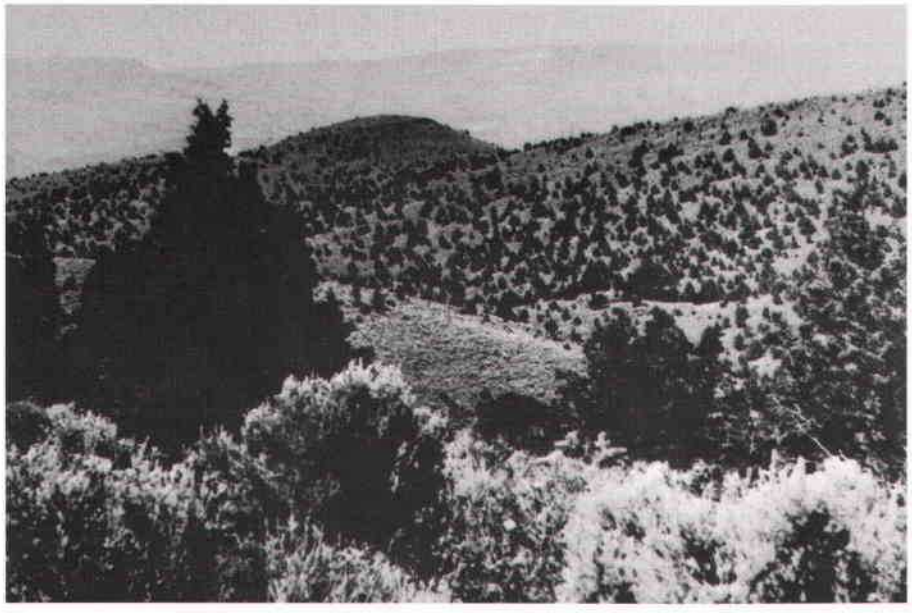


Figure 27-c. Taken in 1956 by E. W. Anderson and W. Farrell.

Figure 27-d. Taken in 1965 by E. W. Anderson and W. Farrell.

Figure 28. A managed natural shrub–grassland on which basin wildrye (the light-color vegetation) is growing in colluvial soils on uplands near Waterman Flat, Wheeler County, in John Day Province, Oregon.

Figure 29. Rangeland on ancient-lake terraces in the eastern portion of Klamath Province, Oregon.

Figure 30. Managed natural shrub–grassland on very stony land producing Idaho fescue, low sagebrush, and scattered western juniper in the eastern portion of Klamath Province, Oregon.

Figure 31. View of Mt. Thielson over snow-covered pumice desert as seen from Crater Lake.

Figure 32. Mt. Thielsen as viewed from Diamond Lake, one of the many natural lakes that receive heavy recreational use in Mazama Province, Oregon.

Figure 33. A mantle of aeolian pumice overlying ancient landforms and buried soils typifies Mazama Province in Oregon.

Figure 34. The ponderosa pine–mixed shrub–bunchgrass zone on pumice–loam soils in Mazama Province, Oregon.

Figure 35. A dense, vigorous stand of basin wildrye and Nevada bluegrass on a bottomland in the vicinity of Jordan Valley in Owyhee Province, Oregon. The man standing in the grass is Bud Town, SCS Range Conservationist.

Figure 36. Groves of curlleaf mountain-mahogany on Mahogany Mountains in the northern portion of Owyhee Province, Oregon.

Figure 37. A mosaic of wedgeleaf ceanothus, Oregon white oak, and grassy openings typifies the nonforested portions of Siskiyou Province, Oregon.

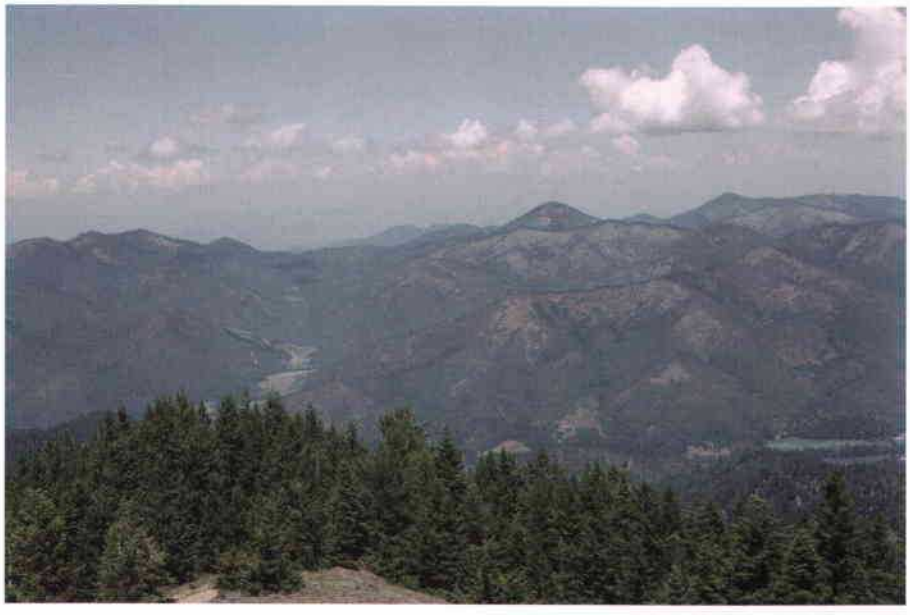


Figure 38. Overview of the steep topography, interspersed valleys, contrasting vegetation cover, and the wide variety of elevations that, together, typify much of Siskiyou Province, Oregon.

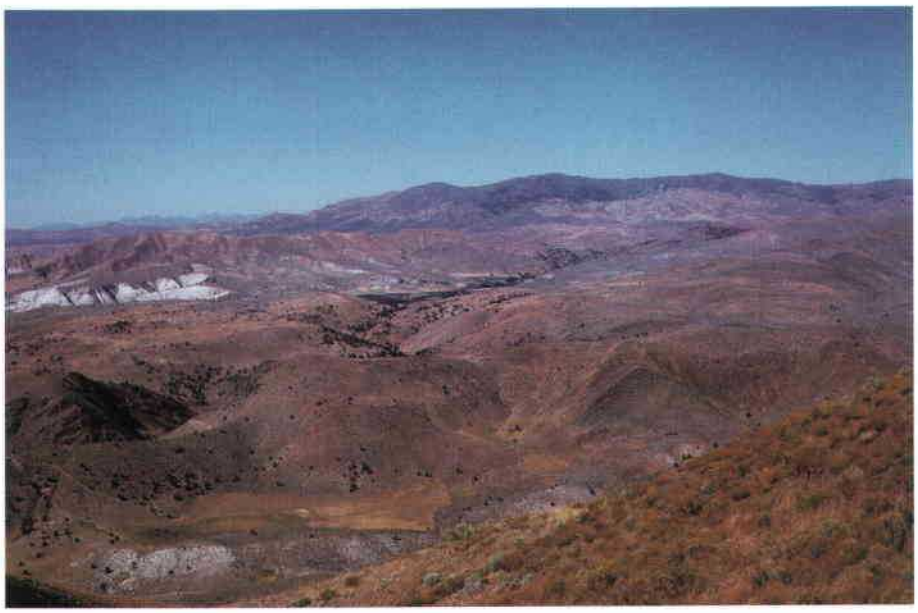


Figure 39. Dissected ancient-lake terraces, hills and interspersed valleys characterize Snake River Province, Oregon.

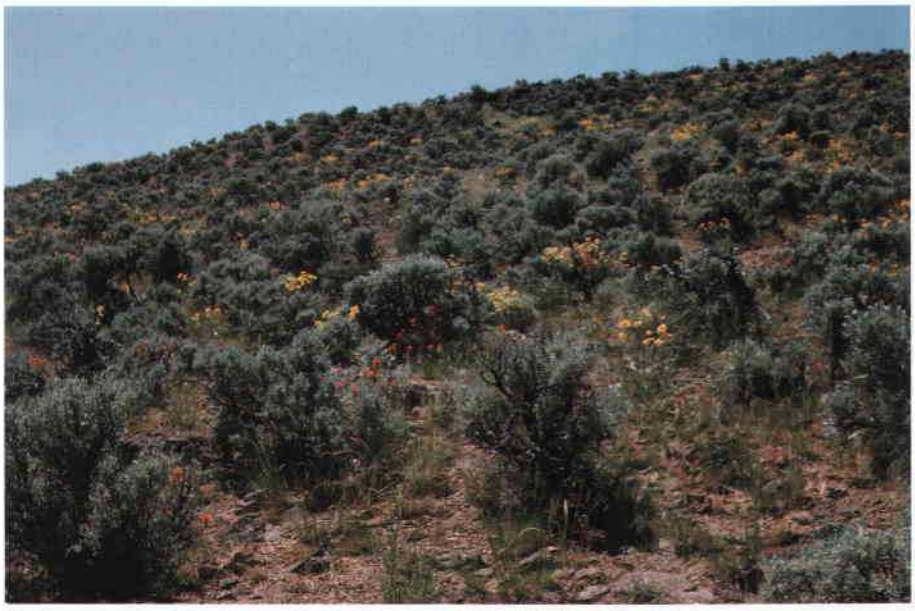


Figure 40. A managed shrub–grassland range in Snake River Province, Oregon.

Figure 41. Prominent ancient-lake dissected terraces north of the Powder River in eastern Baker County represent the northern boundary of Snake River Province in Oregon where it butts into the mountainous Blue Mountain Province (background) at about 4,000 feet elevation.

Figure 42. A mosaic of natural grasslands and stands of deciduous and coniferous trees typifies The Dalles Province, Oregon.

Figure 43. A relict stand of oak forest on the Finley Wildlife Refuge near Corvallis, in Willamette Province, Oregon.

Figure 44. Agriculture in close proximity to woodland is common in Willamette Province, Oregon.

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It is possible that more intensive soil investigations might reveal distinguishable differences at the soil series level between the mixed-fir–hemlock forest of Cascade Province and the mixed-pine–mixed-fir forest of Klamath Province in the vicinity of this portion of the demarcation line.

Klamath–Siskiyou Demarcation

From the juncture of Klamath, Cascade, and Siskiyou provinces southwest of Brush Mountain in eastern Jackson County, the line of demarcation between Klamath and Siskiyou provinces follows southward near Grizzly Creek and then down Jenny Creek to cross Highway 66 near Pinehurst. From the vicinity of Pinehurst, the line runs east to south of Parker Mountain and to the Klamath River where the line veers south to the California state line.

The line is not based on soil maps. Rather, it is the approximate boundary between the area vegetated with juniper, oak, and wedgeleaf ceanothus plant communities, which typify Siskiyou Province in this area, and the mixed-pine–mixed-fir plant communities, which typify Klamath Province.[50] However, the Pokegema–Woodcock soil association is associated with the mixed-pine–mixed-fir forests of Klamath Province in this area and the Skookum–McMullin and McNull–McMullin soil associations are associated with plant communities including juniper, oak, pine, and wedgeleaf ceanothus in this area, which typify Siskiyou Province. Wedgeleaf ceanothus is a key ecological indicator species on arid sites in Siskiyou Province.

Mazama Ecological Province

Location

Mazama Ecological Province, in central Oregon, is entirely within the state. It is the area covered by an aeolian deposit of pumice and other volcanic materials spewed over the countryside when Mt. Mazama erupted explosively about 6,500 years ago.

Due to prevailing southwesterly winds, the pumice mantle lies primarily north and east of Crater Lake, which is in the caldera of Mt. Mazama. The mantle extends about 120 miles north from Crater Lake to the area north of Sisters and Redmond in northern Deschutes County, about 110 miles northeast to the vicinity of Brothers in northeast Deschutes County, and about 60 miles southeast to Gearhart Mountain in western Lake County. The pumice mantle extends only about 6 miles southwest of Crater Lake. Also, the western edge of the mantle is about 10 miles west of Crater, Diamond, Crescent, and Odell lakes and continues northerly about 5 miles west of the Cascade crest.

Other volcanic activities and eruptions, such as those related to Newberry Crater, as well as glacial actions have created areas within this province consisting of basaltic, andesitic, rhyolitic, and tuffaceous deposits, cinders, and glacial till.

The province covers about 5.1 million acres mainly in Deschutes, Klamath, and Lake counties east of the crest of the Cascade Range. Minor portions of the province are near the Cascade crest in northeast Jackson County, eastern Douglas and Lane counties, and southeast Linn County and in the southwest corner of Jefferson County.

Communities in the province include Sisters, Redmond, Powell Butte, Brothers, and Bend in the northern part; Lapine, Gilchrist, Crescent, and Chemult along Highway 97 in the central part; and Chiloquin and Fort Klamath in the south.

Description

Mazama Province is characterized by sloping and undulating plateaus in the northern and northeastern portions and by hilly to mountainous topography interspersed with basins throughout most of its interior and western portion. Innumerable large and small buttes, cones, ridges, and mountains formed by volcanism are interspersed across the landscape. Fields of raw lava and pumice are common.

The lowest elevation in the province is about 2,700 feet which is near the northern province border, south of The Peninsula where the Deschutes and Crooked rivers join. Most of the province lies between 4,000 and 5,000 feet elevation. South Paulina Peak in the northeast part of the province is 8,010 feet elevation; Gearhart Mountain in the southeast part is 8,390 feet elevation. Yamsey Butte east of Klamath Marsh in the south of the province is 8,085 feet elevation.

Many peaks in the western part of the province, which includes the Cascade Range, exceed 8,000 feet elevation. (Elevations are from USGS 1:250,000 topographic maps.) They include Mt. Scott just east of Crater lake, 8,339 feet; Mt. Bailey just west of Diamond Lake, 8,363 feet; Bachelor Butte southwest of Bend, 9,040 feet; and Broken Top west of Bend, 9,165 feet.

The crest of the Cascade Range within Mazama Province has spectacular peaks including Mt. Thielsen, 9,182 feet; Diamond Peak, 8,744 feet; South Sister, 10,430 feet; Middle Sister, 10,053 feet; and North Sister, 10,009 feet (Fig. 31).

The western part of the province is noted for its numerous mountain lakes and recreation areas (Fig. 32). Diamond, Lemolo, and Waldo lakes lie west of the Cascade crest; Crescent, Summit, Odell, Wickiup, Davis, Crane Prairie, Cultus, Sparks, and others lie

east of the crest. All are in Mazama Province.

Klamath Marsh and Sycan Marsh are two significant wetlands in the province. The major drainage from the province is via the Deschutes River which flows north to exit the province near The Peninsula northwest of Redmond (Fig. 31).

Soils

The primary upland soils typifying Mazama Province have been developed in various combinations of aeolian pumice and volcanic ash overlying basaltic bedrock or ancient soils at varying depths from about 8 to 10 inches up to about 15 feet.

Major soil series typifying uplands include Deschutes and Steiger, which generally are relatively thick deposits of aeolian pumice. Lapine and Shanahan soil series generally are aeolian pumice overlying buried loamy soil at varying depths to about 40 inches.

Certain major soil series typify bottomland or topographic basins. Wickiup series is a deep, imperfectly drained, very gravelly, coarse pumicy soil that occurs in basins and draws in forested uplands. Skellock series is a deep, gravelly, sandy loam that lies on the fringe of marshy areas.

Lodgepole pine is very likely the climax tree species on Wickiup and Skellock soils because of its tolerance for imperfectly drained, cold sites. The Dilman series is a black, clayey, imperfectly drained soil typically associated with flood plains, such as along the Deschutes River, and with mountain meadows such as Long Prairie south from Lapine. Pumicey soils on marshes, such as Sycan and Klamath marshes, include soil series such as Chinchallo, Yamsay, and Moyina, which are black, poorly drained soils that may have layers of organic matter in the profile.

A very small part of Mazama Province is used for irrigated pasture and cropland; such agricultural use is restricted primarily to the area bounded by the communities of Sisters, Redmond, and Pilot Butte on the north and by Alfalfa and Bend on the south. Irrigated fields within this area are somewhat scattered, isolated by low ridges and mounds of basalt bedrock and rubble. The primary soil series being irrigated is Deschutes sandy loam.

Climate

Twelve official weather stations represent a cross-section of Mazama Province. Average elevation of the five stations in Deschutes County, which constitute the northern part of the province, is about 3,900 feet; average elevation of seven stations in Klamath County to the south is about 4,200 feet.

In contrast to this relatively insignificant difference in elevation from north to south within the province, the average annual precipitation in Deschutes County is 14.7 inches but 38.6 inches in Klamath County. Sixty-seven percent of annual precipitation in the north portion falls during winter (November through March), 26% during the growing season (April through July). In the south, 77% of annual precipitation is in winter and 19% in the growing season. The north part of the province apparently is slightly warmer than the south.

Maximum and minimum temperatures in January are 39.2 and 15.4°F, respec-

Table 26. Climatic Data for Mazama Ecological Province, Oregon.[17]

Station and length of record (years)	Elevation (feet)	Precipitation			Average maximum and minimum temperatures (°F)	
		Annual (inches)	Nov.-March (%)	April-July (&)	January	April-July
Deschutes County						
Bend 22	3,599	12.0	64	24	39.9-20.3	65.4-38.6
Fall River Hatchery [a] 9	4,250	19.1	71	23	38.9-15.4	70.2-31.4
Lapine 10	4,382	14.2	65	29	39.6-12.5	71.6-29.2
Redmond 21	2,982	8.6	58	33	42.1-20.9	73.3-39.5
Wickiup Dam 11	4,330	19.8	76	19	35.6-7.9	66.7-32.9
Klamath County						
Cascade Summit 15	4,841	49.4	80	17	33.8-20.0	61.4-35.2
Chemult 14	4,750	26.7	78	18	38.6-9.6	69.0-30.1
Chiloquin 17	4,200	17.5	72	23	38.6-14.8	71.1-34.5
Crater Lake 18	6,475	68.4	80	17	33.3-17.0	57.2-33.1
Crescent 8	4,452	19.1	66	23	41.0-11.8	67.9-28.3
Odell Lake 6	4,788	60.4	80	15	30.9-15.5	61.0-34.4
Sand Creek Station 16	4,682	28.4	80	19	36.4-12.6	67.9-31.9
County Averages						
Deschutes County		14.7	67	26	39.2-15.4	69.4-34.3
Klamath County		38.6	77	19	36.1-14.5	65.1-32.5
Province Average		26.7	72	23	37.7-15.0	67.3-33.4

[a] On Fall Creek, along Century Drive, about 25 miles southwest of Bend.

tively, in the north compared to 36.1 and 14.5°F, respectively, in the south. Growing season maximum and minimum temperatures follow this pattern: 69.4 and 34.3°F in the north compared with 65.1 and 32.5°F in the south.

A precipitation map[53] clearly shows the broad precipitation patterns in most of Mazama Province and the Cascade Range's contribution to overall precipitation. The map shows 145 inches annual precipitation in the Three Sisters area west of Bend, which is the highest precipitation in the province. The map also shows about 10 inches annual precipitation at Brothers in the northeast part of the province. Johnsgard's data show 8.6 inches annual precipitation for Redmond weather station, which likely is the lowest annual precipitation in the province.[17]

Table 27. Average Dates Vegetation Growth Begins and Ends in Mazama Ecological Province, Oregon.

Station and length of record (years)	Elevation (feet)	Average date growth begins*	Average date growth ends*
Deschutes County			
Bend 22	3,599	March 20	June 30
Fall River			
Hatchery 9	4,250	April 1	September 23
Lapine 10	4,382	April 11	August 3
Redmond 21	2,982	March 7	May 20
Wickiup Dam 11	4,330	March 27	September 30
Klamath County			
Cascade Summit 15	4,841	April 19	Does not occur
Chemult 14	4,750	April 15	Does not occur
Chiloquin 17	4,200	April 1	August 9
Crater Lake 18	6,475	May 7	Does not occur
Crescent 8	4,452	April 3	Does not occur
Odell Lake 6	4,788	April 26	Does not occur
Sand Creek Station 16	4,682	April 15	Does not occur

* The average date vegetation growth begins on native perennial bunchgrasses is approximately the date average daily temperatures reach 39 to 40°F. Average date growth ends is considered to be when available soil moisture is depleted. Interpretations are based on data in Johnsgard.[17]

Vegetation

According to the 1936 State of Oregon Forest Type Map[54] which predates extensive logging activity, about 1% of Mazama Province was then natural grassland, mainly in Klamath and Sycan marshes. About 4% was open and unforested, likely covered by sagebrush and bunchgrasses. About 10% was in stands of western juniper. About 20% was in stands of lodgepole pine, some of which likely represented fire scars.

However, some lodgepole stands undoubtedly represented the current ecological stage of succession in forest development. These included stands on imperfectly drained depressions and swales where lodgepole pine is probably the climax tree species because of its tolerance of imperfectly drained situations and cold temperatures.

Most of the province, about 55% of it, was covered by stands of ponderosa pine with some small areas including Douglas-fir and other minor species. About 10% of the province was covered by stands of true fir and hemlock or subalpine vegetation; this was mainly along the top of the Cascade Range. Three isolated areas of a true fir–hemlock forest type were mapped on Paulina Peak, Yamsay Mountain, and Gearhart Mountain, each of which is about 8,000 feet or more in elevation.

It is interesting to note pollen analyses that show vegetation on the soils now buried in pumice included many of the tree species still common in the region.[14]

Mazama Province has the widest range in upland vegetation zones of any of Oregon's ecological provinces. These zones range from the most arid (10 inches or less precipitation) sagebrush/bunchgrass zone in the northeast of the province to the true fir/hemlock and subalpine zones along the top of the Cascade Range where over 75 inches of precipitation falls annually.

Vegetation zones in Mazama Province are not as closely related to specific soil series or to groups of series as in most other ecological provinces in Oregon. This is largely because soil series in Mazama Province are based primarily on relatively uniform physical characteristics of the overall aeolian pumice mantle. The primary parent material of these soil series is unusually uniform over large areas because of its origin as an aeolian deposit. The result is fewer soil series per given area than when the geomorphology of residual soils is closely related to various landforms and topographic features.

Consequently, a single upland soil series in Mazama Province usually lies in more than one vegetation zone. Conversely, a single vegetation zone may be on more than one soil series. In this situation, the vegetation is much less responsive to the relatively uniform edaphic factors than it is to the prevailing climatic factors or effective environment.

Management Implications

Much of Mazama Province is characterized by a pumice mantle overlying buried landforms, including ancient soils, at depths varying from about 8 to 10 inches up to 40 inches or more. These buried soils, which are usually reddish brown stony to nonstony loams, are important for ecological and management reasons because they lie in the vegetation rooting zone and thereby influence overall soil moisture, nutrient relationships, native species composition, and tree growth rates (Fig. 33).

The overlying pumice mantle also is important for ecological and manage-

ment reasons. Individual particles of pumice soil consist of volcanic glass shards which are porous. Consequently, there are more interstices and angles that carry water films— capillary water —than are normal in mineral soils of the same texture in which soil particles are solid and rounded. Essentially, porous particles of pumice soil store water within as well as on the surface of each soil particle; solid soil particles in mineral soils store water primarily on the surface of each particle. This beneficially influences the water-holding capacity and cation exchange capacity of the pumice-soil profile.

Furthermore, the mantle of pumice overlying a buried soil apparently acts as a mulch which produces an effective environment more beneficial to vegetation. In the most arid, eastern, portion of Mazama Province this is evidenced by the widespread dominance of Idaho fescue, for example, on pumice-mantle soils. On nearby areas of loamy soils without a pumice mantle, in High Desert Province, Thurber needlegrass and bluebunch wheatgrass are dominant under equivalent climatic conditions. In this particular area, a pumice mantle about 8 to 10 inches thick over buried loamy soil was needed to benefit plants' effective environment, according to an unpublished field study.[32]

Another unpublished field study[39] made on a tract of Brooks-Scanlon timber land near Bend showed natural regeneration of ponderosa pine on deep pumice sands was very unsatisfactory from a forester's viewpoint, and junipers encroached following logging.

In contrast, at nearby locations where the pumice mantle was about 20 to 30 inches thick over a buried loamy soil, ponderosa pine regeneration was excellent. Furthermore, maturing ponderosa pine trees growing on pumice-loam soils showed a significantly better rate of wood production than those growing on nearby deep pumice sands.

Obviously, two different ecological situations were involved in this case. The less desirable, from a forestry standpoint, was the ponderosa pine–juniper–bunchgrass vegetation zone, and the more desirable was the ponderosa pine–mixed shrub–bunchgrass zone (Fig. 34). The Brooks-Scanlon forester was much impressed with these soil–plant relationships and with the fact that they could be predicted reliably merely by interpreting the ecological indicator species growing on the site.

At one time, Weyerhaeuser Company at Klamath Falls was having problems with survival of planted ponderosa pine nursery stock on pumice soils. Apparently, this was caused primarily by desiccation due to porous surface layers. Later, an employee solved the problem to a degree by planting nursery stock with 18-inch roots instead of the standard 12 inches.

Examples such as these strongly indicate that the porous nature of pumice particles and, in general, the Mazama pumice mantle, makes it impossible to successfully employ practices and concepts used to manage land and vegetation on conventional mineral soils.

Pumice soils require special knowledge and attention. An unpublished report[30] pointed out that Mazama pumice soils were laid down quite recently, geologically speaking. Weathering and soil formation have not progressed very far. So, now most areas have a surface layer about 12 inches thick, which has undergone weathering and contains incorporated organic matter, underlaid by relatively unweathered pumice.

Although the weathered surface layers' fertility is usually quite satisfactory, the fresh pumice below is markedly deficient in several nutrient elements, including nitrogen and phosphorus and the minor element boron. The unfavorable nutrient balance may help explain the scarcity of roots in the unweathered pumice.

Pumice soils have unusual moisture relations. Due to its porous nature, pumice soils can retain unusually large quantities of water. However, upward capillary movement of water is slow in these zones. Plant roots must grow down into the moisture.

In some areas, on sites that are apparently quite dry, it appears that not all moisture that should be available to plants is utilized. Most of this "surplus" water is contained in the unweathered pumice layers, and it goes unused probably because roots are almost nonexistent in these zones.

Pumice soils are quite easily modified. The changes are noted in characteristics such as bulk density, moisture-holding capacity, capillary movement of soil water, and soil fertility. Compaction resulting from equipment or concentrations of grazing animals considerably modifies pumice soil. This is evidenced by the extremely fine dust common on roads during dry seasons in Mazama Province. Fresh pumice fragments brought to the surface will weather rapidly, much more readily than any other type of volcanic rock.

Dyrness[30] emphasized the need to identify and delineate understory plant communities when mapping pumice soils because the presence of a specific group of plants sometimes is indicative of soil characteristics that cannot be easily discerned simply by looking at the soil profile.

For example, pumice soil in Mazama Province that is growing snowbrush contains appreciably more nitrogen and calcium than does the soil in bitterbrush areas. Also, grass and forb species in an area may indicate imperfect soil drainage even though soil-profile characteristics may be completely devoid of evidence of a seasonally high water table. This is common on depressions and basins where lodgepole is likely the climax tree species.

Soil survey information alone in areas of immature pumice soils gives an inadequate basis for stratifying land for timber management. This is because young soils tend to exhibit little change in morphological characteristics over large areas even though there may be marked differences in temperature, precipitation, and other important environmental factors. For this reason, surveys in Mazama Province should map both soils and vegetation.

(continued on page 91)

Table 28. Major Ecological Sites and Vegetation Zones in Mazama Ecological Province, Oregon.[51]

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Natural grassland (less than 10% canopy cover of shrubs)		Pumice meadow Nevada, Kentucky, and Cusick bluegrasses, threadleaf sedge Mountain meadow Tufted hairgrass, bluegrasses, sedges Wet meadow Sedges, rushes, tufted hairgrass Meadow swale Rushes, sedges Marsh Bullrush, cattail, aquatic plants
Shrub–grassland (10% or more canopy cover of shrubs)	Deep pumice Idaho fescue, Thurber needlegrass/ bitterbrush, mountain sagebrush Pumice-loam hills Idaho fescue, bluebunch wheatgrass, needlegrass/bitterbrush, mountain sagebrush Pumice-loam flat Western needlegrass, Ross sedge/ mountain sagebrush Shallow pumice-loam Idaho fescue, needlegrasses/low sagebrush Gravelly terrace Needlegrasses, Idaho fescue/ Wyoming sagebrush North exposure Idaho fescue, bluebunch wheatgrass, needlegrass/bitterbrush, Wyoming sagebrush	
Juniper (5% or more canopy cover of mature juniper)	Juniper pumice hills Idaho fescue, needlegrasses/bitterbrush/ juniper Juniper pumice-loam hills Bluebunch wheatgrass, Idaho fescue/ bitterbrush, juniper Juniper pumice terrace Idaho fescue, needlegrasses/bitterbrush/ juniper Juniper shallow pumice terrace Bluebunch wheatgrass, needlegrasses/ bitterbrush/juniper Juniper south exposure Bluebunch wheatgrass, Thurber needlegrass/ Wyoming sagebrush/juniper Juniper lavaland Bluebunch wheatgrass, Sandberg bluegrass/ big sagebrush/juniper Juniper cinder hills Bluebunch wheatgrass/Wyoming sagebrush/ juniper	

(continued)

Table 28 (cont'd). Major Ecological Sites and Vegetation Zones in Mazama Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Lodgepole pine (5% or more canopy cover of mature lodgepole pine)	Lodgepole low gravelly Squirreltail, western needlegrass/ big sagebrush, bitterbrush/lodgepole Lodgepole arid pumice-loam Idaho fescue/big sagebrush, bitterbrush/ lodgepole Lodgepole high gravelly Western needlegrass, Ross sedge/lodgepole	Lodgepole wetland Nebraska sedge, meadow barley/lodgepole Lodgepole moist bottom California oatgrass, blue wildrye/ mixed shrubs/aspen, lodgepole Lodgepole dry bottom Onespike oatgrass, bentgrass/bearberry/ lodgepole Lodgepole basin Western needlegrass, Ross sedge/bitterbrush/ lodgepole
Coniferous tree vegetation zones	Ponderosa pine–juniper–bunchgrass Ponderosa pine–bitterbrush–bunchgrass Ponderosa pine–mixed shrubs–bunchgrass Ponderosa pine–mixed fir–mixed shrub Mixed pine–mixed fir True fir–hemlock	

Province Demarcation

Mazama–John Day Demarcation

The first point is at the north boundary near where Deschutes River exits Mazama Province at what is locally known as Lower Desert, which is where The Dalles, John Day, and Mazama provinces join.

From there, the line of demarcation between the Mazama and John Day provinces goes southeast along the Crooked River past Smith Rock and continues across the plateau crossing Highway 126 about 4 miles east of the community of Powell Butte. Powell Butte, Redmond, and Terrebonne are in Mazama Province; Smith Rock, Gray Butte, Prineville, and nearly all of the National Grasslands are in John Day Province.

At the mouth of Crooked River canyon about 6 miles south of Prineville, the line between Mazama and John Day provinces essentially follows the west canyon rim of Crooked River to the vicinity of its confluence with Bear Creek. From there it continues south along the east side of Bear Creek and then southeast along the breaks of Bear Creek. About 5 miles north of Brothers the line turns east at about 5,000 feet elevation to the area north of Grassy Butte.

Elevation is not as significant in demarcation between Mazama and John Day provinces as it is between some other provinces. This is because Mazama Province is an ancient landscape covered by an aeolian pumice mantle that is not necessarily affected by elevation or landform. It should be noted, however, that the pumice deposit at the perimeter of the pumice mantle likely was thinner than toward the interior of the fallout area.

Unpublished field studies indicate that where about 8 to 10 inches or more of pumice lies over buried soils, herbaceous vegetation resembles that of the arid nonforested portion of Mazama Province, i.e., bluebunch wheatgrass/ Idaho fescue. Less than 8 to 10 inches pumice mantle over buried soils produces herbaceous vegetation typical of High Desert Province, i.e., bluebunch wheatgrass/Thurber needlegrass. Obviously, these are not clear-cut differences out on the land because they occur within a belt of demarcation.[32]

It also should be noted that Mazama aeolian pumice falling on existing hilly uplands in a relatively thin mantle along the perimeter of the fallout pattern likely was washed into adjacent valleys and drainages by subsequent precipitation. Therefore, hilly uplands in the vicinity of the line of demarcation between Mazama and John Day provinces help establish the location of this line; generally, the flatter land is in Mazama and hilly uplands are in John Day Province.

North of Hampton Butte the line turns south more or less along the boundary between the basin and uplands. Southwest of Hampton Butte, Mazama, John Day, and High Desert provinces join about 5 miles northwest of Hampton.

The line between the provinces is based on soil lines between Deschutes, Shanahan, and Lapine soil series, which typify Mazama Province, and Agency, Madras, and Simas soil series which typify John Day Province.[70]

Mazama–High Desert Demarcation

The line between Mazama and High Desert provinces crosses Highway 20 about 8 miles northwest of Hampton. From there it wanders southwest along the north portion of Devils Garden and continues southwest by Cabin Lake Ranger Station, which is

very near the line, and on to Hole-in-the-Ground, which is in Mazama Province. This section of the line is more a belt in which the pumice mantle to the west is generally 8 to 10 inches or more thick over buried soil and represents Mazama Province. The area to the east of this belt generally has less than 8 to 10 inches of pumice mantle, if any, and is in High Desert Province.

From Hole-in-the-Ground, the line heads south at about 4,500 feet elevation. Where it crosses Highway 31 below the rimrocks northwest from Horse Ranch, the highway roadcut reveals an ancient lakeshore terrace of layered lacustrine materials, which signifies the boundary of High Desert Province.

After the line crosses Highway 31 northwest of Horse Ranch, it runs south almost parallel and about 1 to 2 miles west of the highway for about 10 miles until it veers south to the vicinity of Halfway Lake and the eastern portion of Antelope Flat. From this point, the line goes east across Buck Creek and Bridge Creek; at this point, at about 4,900 feet elevation, Mazama, High Desert, and Klamath provinces join.

The line between Mazama and High Desert provinces is based on soil lines between Shanahan and Lapine soil series, which typify Mazama Province, and Gardone, Floke, and Olson soil series which typify High Desert Province.[84]

Mazama–Klamath Demarcation

The line of demarcation between Mazama and Klamath provinces runs south to the area west of Thompson Reservoir, which is in Klamath Province, then around Sycan Butte, which is in Mazama Province, and along the east side of Sycan Marsh, also in Mazama Province.[84]

From about 5 miles southwest of Sycan Marsh on the Sycan River, the line turns east and travels northeast across the headwaters of Sycan River and then southeast in the vicinity of Winter Ridge. From the south portion of Winter Ridge, the line goes south across upper Elder Creek to west of Campbell Lake and south of Deadhorse Rim where it turns west along the south-facing slopes of Gearhart Mountain, in Mazama Province.[84]

From the area south of Gearhart Mountain, the line runs west to North Fork Sprague River. From there it snakes its way west more or less near the north boundary of Sprague River valley. Ferguson Mountain is in Mazama Province. From the vicinity of Knott Tableland, which is in Klamath Province, the line heads northwest, passing about 5 miles north of Sprague River community, which is in Klamath Province. From there, it goes south and west to the vicinity of Chiloquin and south to Lobert Junction.

From the vicinity of Lobert Junction on Highway 97, the line runs north along the east side of Agency Lake to the vicinity of Klamath Agency, which is in Mazama Province, then northwesterly to about 4 miles west of Fort Klamath along the east side of Klamath Point. It is in this vicinity that the juncture between Mazama, Klamath, and Cascade provinces lies.

The line of demarcation between Mazama and Klamath provinces is based on soil lines between Lapine, Shanahan, and Kirk–Chock soil series, which typify Mazama Province, and Woodcock, Hart, and Lorella soil series, which typify Klamath Province.[77]

Mazama–Cascade Demarcation

From the junction of Mazama, Klamath and Cascade provinces northwest of Fort Klamath, the line of demarcation between Mazama and Cascade provinces goes northwest, then about 1 to 3 miles south and somewhat paralleling Highway 62 to the vicinity of Union Creek community. From this point, the Mazama Province extends southerly in a valley 2 to 3 miles wide lying on each side of Highway 62 from Union Creek south to Prospect. This narrow extension of Mazama Province appears to be a large ash flow along the upper Rogue River extending southwest from the main pumice mantle near Crater Lake.

The soil series typifying this ash flow extension of Mazama is Alcot. Soils in the adjacent Cascade Province are Freeznor and Geppert.[68]

From the vicinity of Union Creek community, the line goes north, crossing the divide between Rogue River and the North Umpqua River watersheds just east of Buckneck Mountain. From there, it follows northerly down Clear Creek, across the plateau at Toketee airstrip, and across North Umpqua River below Toketee Reservoir. It then travels northeasterly to cross the divide between North Umpqua River and the headwaters of Middle Fork Willamette River about 5 miles west of the Cascade Range crest.[91]

From the headwaters of Middle Fork Willamette River, the line goes north around the west side of Bear Mountain and to the Salt Creek canyon where the Southern Pacific Railroad makes a switchback out of Salt Creek to pass over the summit of the Cascade Mountains just west of Odell Lake, which is in Mazama Province. The line wanders northward west of Waldo Lake and then east of Moolack Mountain and around the headwaters of the South Fork McKenzie River.[93]

The Linn County soil map[80] does not provide soil information in the mountainous east portion of the county. Therefore, the line of demarcation between Mazama and Cascade provinces in that area is drawn on the basis of topographic features apparent on maps showing the line of demarcation to the south of this area.

In Lane and Douglas counties, the mapped pumice-soil boundary is primarily along a major topographic feature: a relatively undulating or sloping area to the east, which typifies the pumice-soil (Mazama) area, and relatively steep mountainous terrain to the west (Cascade) which represents the sharp dendritic drainage pattern of tributaries into the Willamette River.

It seems reasonable to assume that some pumice from the eruption of Mt. Mazama fell in the Cascade Mountains to the west of the current pumice

mantle. However, because of the steep dendritic drainage pattern of headwaters of numerous drainages into the Willamette River, these pumice deposits probably have been washed downstream or may still lie in isolated deposits mainly on steep north-facing exposures within Cascade Province.

Using the previously described topographic feature as a guide, the demarcation line is predicted to run north from the headwaters of the South Fork McKenzie River on around the headwaters of McKenzie and South Santiam rivers, near Fish and Lava lakes about where Highway 20 crosses the pass.

From there, the predicted line veers northeast to cross Highway 22 about 4 to 5 miles northwest of Santiam Junction. The line probably continues northeast into Jefferson County north of Three Fingered Jack peak and on to about where Jefferson Creek joins Metolius River. At that point, Mazama, Cascade, and The Dalles provinces join.

The line between Mazama and Cascade provinces in Douglas, Lane, and, likely, Linn counties is based on soil lines between Winopee and Shukash soil series, which typify Mazama Province, and Holderman and Keel series, which typify Cascade Province.[91, 93]

At the northern boundary of Mazama Province, the soil series in Mazama Province may be much like Lapine, Deschutes, Shanahan, and Steiger pumicey soils.[62] Soil series in Cascade Province in this area may be Howash and Mackatie, which typify Cascade Province on the Warm Springs Indian Reservation.[96]

Mazama–The Dalles Demarcation

Where Jefferson Creek joins the Metolius River in southwestern Jefferson County, Mazama, Cascade, and The Dalles provinces join. From that point, the line of demarcation between Mazama and The Dalles provinces follows south along Green Ridge to the east side of Black Butte, which is in Mazama Province. From there it meanders east and northeast to Lower Desert, which is the junction of Mazama, The Dalles, and John Day provinces.[70]

Owhyee Ecological Province

Location

Owyhee Province in the southeastern corner of Oregon comprises the western foothills and associated plains of the Owyhee Mountains, which are in southwestern Idaho. In Oregon, this province covers about 1.4 million acres, all in Malheur County. Owyhee Province extends south into Humboldt County, Nevada and east into Owyhee County, Idaho.

Description

The southern portion of Owyhee Province in Oregon is characterized by very extensive, very rocky uplands generally sloping down to the west from the Oregon–Idaho border. This part of the province, which lies south of Highway 95 going west from Jordan Valley community, encompasses the entire upper watershed of Owyhee River that lies in Oregon from about 6 miles upriver from the community of Rome.

This portion of the Owyhee River watershed is a continuous dendritic pattern of basalt-cliff canyons that dissect the huge basaltic plain. The north portion of the province in Oregon consists of lava fields, a few lake basins, and some mountainous areas lying south and east of the major Owyhee River canyon breaks.

Elevations in Owyhee Province in Oregon generally are between 4,000 and 5,500 feet. Highest elevations include Mahogany Mountains at 6,168 feet elevation, which is in the northern part of the province, and Oregon Hill at 6,445 feet elevation, which is near the Nevada border. (Elevations are from USGS 1:250,000 topographic quads, 1958.)

Some valleys and areas with suitable soil are farmed and irrigated, primarily for livestock feed. Rangeland strongly dominates the province in Oregon, which also has small, isolated dry lake basins.

Soils

Soils of Owyhee Province are related to very extensive basaltic uplands associated with the Owyhee Mountains in southwestern Idaho that typify the province in Oregon. Soils on plains are moderately sloping, clayey, very stony or rocky, and shallow to very shallow over basalt bedrock or hardpans. On buttes and mountain slopes, soils are relatively steep, loamy, stony, and moderately deep. North of Highway 95 and west from Jordan Valley community, basalt flows cover most of the surface on about 107,000 acres. Some flows are relatively small, but there are four sizable ones of about 10,000, 16,000, 23,000, and 53,000 acres.

Two major bottomlands are in Oregon's portion of the province. These are in the Cow Creek basin and the Jordan Creek basin. The Cow Creek basin contains about 6,000 acres of very deep silty to clayey soils that are moderately well drained. The Jordan Creek basin contains about 12,000 acres of very deep silty to clayey soils that are moderately well drained and about 1,300 acres of very deep clayey soils that are poorly drained.[94]

Climate

The 1941 Yearbook of Agriculture showed no official weather stations in Owyhee Province in Oregon.[28] Johnsgard[17] shows one: at Danner, about 15 miles west of Jordan Valley community and north of Highway 95. The station is now abandoned. The 22-year record at Danner shows an average annual precipitation of 10.6 inches of which 53% falls in winter (November through March) and 31% in the herbaceous native-plant growing season (April through June).

A precipitation map[53] shows much of this province in Oregon receives between 10 and 15 inches annual precipitation. Areas in the western part of the province, contiguous to Humboldt Province, receive about 10 inches precipitation; areas on the east side,

where the effects of Idaho's Owyhee Mountains are apparent, receive about 15 inches annual precipitation.

Average January maximum and minimum temperatures at Danner station are 37.1 and 12.3°F, respectively, and the maximum and minimum temperatures for April through June are 70.8 and 35.8°F, respectively.

Vegetation

In Oregon, vegetation associated with the extensive basaltic uplands of Owyhee Province is a shrub–grassland climax type, i.e., with 10% or more natural canopy cover of shrubs. On the extensive sloping stony plains where soils are very shallow, low sagebrush is the dominant shrub. On buttes and mountain slopes where soils are shallow to moderately deep, Wyoming big sagebrush is the dominant shrub. Bluebunch wheatgrass, Sandberg bluegrass, and squirreltail are prominent grasses.

Native vegetation associated with the well-drained bottoms in Cow and Jordan creek basins is a natural grassland climax type, i.e., with less than 10% canopy cover of shrubs.

Originally, these bottomlands likely produced a dense, vigorous stand of basin wildrye (Fig. 35).[43] Poorly drained bottomlands likely produced basin wildrye, sedges, rushes, sod bluegrasses, and other such species that tolerate alternating wet and dry periods, which would occur in this arid climate.

Riparian areas in Owyhee Province in Oregon are primarily along the perennial streams in the upper Owyhee River system. These streams run in very extensive basalt-walled canyons and are relatively inaccessible from contiguous uplands. Based on the USGS 1:250,000 topographic quad map, these canyon-walled perennial streams extend about 120 miles collectively in Oregon's portion of Owyhee Province.

The significance of these riparian areas to wildlife is obvious even though there is a myriad of manmade water holes throughout Owyhee Province in Oregon. Vegetation in these perennial-stream riparian areas includes a variety of species which signify different degrees of wetness.

Scattered, small, clayey semiwet meadows in areas such as Mahogany Mountains are typified by species such as Nevada and Kentucky bluegrasses, meadow sedges, timothy, redtop, meadow barley, iris, cinquefoil, and yampa. These are natural grasslands.

The 1936 Forest Type Map of Oregon[54] shows no stands of western juniper or other trees in Owyhee Province in Oregon. This indicates that, if junipers were on mountain slopes or buttes in the province at that time, they likely were scattered. However, a map that covers the north portion of Owyhee Province in Oregon shows about 2,500 acres of shrubs and trees on Mahogany Mountains southeast of Malheur Reservoir.[55]

The shrubs and trees indicated on this map represent groves of curlleaf mountain-mahogany growing at about 5,700 feet elevation (Fig. 36). This is an interesting ecological phenomenon. Plant species growing here and the deep, black silty soils on north exposures in this isolated mountainous terrain are comparable to other isolated high-elevation mountains such as Hart and Steens mountains in High Desert Province of Oregon.

In Mahogany Mountains, some of the oldest mahogany plants are huge. They grow in crevices of basalt bedrock outcrops on ridgetops. One mahogany tree measured 18 inches in diameter at 10 inches above ground level and was 20 feet high with a crown 25 feet in diameter. One old stump, probably cut for firewood by old-time sheepherders, was about 22 inches in diameter at the top of the stump, 18 inches above ground level. Most of the mahogany trees were cut a long time ago, and the remaining stumps show that the original stand of mature trees, 12 to 24 inches in diameter, were spaced about 10 feet apart.[32] No western juniper trees were recorded in these studies.

By 1962, it was apparent that this high-elevation, well-watered area had been severely grazed by sheep and cattle over many years.[41] It is an ideal summer range in an otherwise arid area and likely attracted the greatest concentration of grazing animals, including deer.

The dense stands of younger mahogany and reproduction on north-facing slopes in the area suggested that continued close use over the years resulted in the mahogany's encroaching, or increasing, on these shrub-covered north exposures, which are snowdrift locations that typically have deep, black silty soils.

In 1962, the snowdrift areas had produced an overstory of mahogany and an interesting array of plant species in the understory.[41] These included shrubs such as bitter cherry and chokecherry, mountain snowberry, snowbrush, mountain spirea, low Oregon-grape, big sagebrush (the variety was not noted at that early date but likely was mountain big sagebrush), and mahogany reproduction.

Distinctive grass species on these sheltered sites included pinegrass; blue and basin wildrye; big, Canby, and Wheeler bluegrasses; a dryland sedge; Columbia needlegrass; and Idaho fescue. This is an interesting shrub–grassland climax type in an isolated high-altitude location. It also proved to be a haven for rattlesnakes.

The 1962 studies of Mahogany Mountains area[41] indicated that the upland slopes are a shrub–grassland climax type with big sagebrush and green and gray rabbitbrushes as the major shrubs. Predominant grasses include bluebunch and beardless wheatgrasses, Idaho fescue, Columbia and Thurber needlegrasses, Sandberg and Canby bluegrasses, oniongrass, and squirreltail. Arrowleaf balsamroot was the most prominent forb.

Management Implications

The southern portion of Owyhee Province in Oregon has natural restrictions on management options: extensive, very stony, shallow-soil series and the many continuous basalt-cliff

Table 29. Ecological Sites and Natural Landforms in Owyhee Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Natural grassland (less than 10% canopy cover of shrubs)		Moist bottom Basin wildrye, Nevada bluegrass Wet meadow Nevada bluegrass, redtop, sedges, rushes
Shrub–grassland (10% or more canopy cover of shrubs)	Scabland Sandberg bluegrass, squirreltail, bluebunch wheatgrass/low sagebrush Arid rolling hills Bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass/big sagebrush Moist rolling hills Idaho fescue, bluebunch wheatgrass/ big sagebrush South exposure Bluebunch wheatgrass, Sandberg bluegrass, Thurber needlegrass/big sagebrush North exposure Idaho fescue, bluebunch wheatgrass, western needlegrass/big sagebrush Steep north Idaho fescue, bluebunch wheatgrass/mountain snowberry, cherry, big sagebrush Shrubby north Pinegrass, basin and blue wildrye, big and Wheeler bluegrasses, Columbia needlegrass/ mixed shrubs Mahogany rockland Bluebunch wheatgrass, Columbia needlegrass, Idaho fescue, Canby bluegrass/ mixed shrubs, curlleaf mountain-mahogany	

Natural landforms: Lavaland, basalt flows, rockland, and canyon escarpments and outcrops

canyons along major drainages and tributaries of Owyhee River.

Large grazing units are essentially mandated here, as in High Desert and Humboldt provinces in Oregon, but without the flexibility of vehicular traffic on roads crisscrossing the country. Recreational activities are similarly restricted.

The BLM Vale Project covered much, if not all, of Oregon's portion of Owyhee Province. Consequently, many rangeland manipulations and improvements were made. This benefitted many resource values such as wildlife, watershed, recreation, water quality, and range condition while at the same time providing great benefits to livestock ranching. As a result, resource management problems in this portion of Oregon's Owyhee Province appear to be minimized compared with some other provinces.

The ranching element around Jordan Valley seems to be effectively sponsoring perpetually beneficial programs on both private and public lands.

Province Demarcation

Owyhee–Humboldt Demarcation

Beginning at the southwest corner of Owyhee Province in Oregon, which is at the Oregon–Nevada border about 13 miles east of where Highway 95 crosses the border and about 4 miles southwest of Oregon Hill, the line of demarcation between Owyhee and Humboldt provinces lies at about 5,000 feet elevation along the western boundary of the sloping basaltic plateau, which is in Owyhee Province, and the hilly uplands to the west, which are in Humboldt Province. The line continues north along the western edge of the plateau to the vicinity of Battle Creek Ranch and on north at about 4,000 feet elevation to about 4 miles west of Jackie's Butte, in Owyhee Province. From northwest of Jackie's Butte the line of demaracation between Owyhee and Humboldt Provinces veers east and north at about 4,000 feet elevation to about 7 miles north of Jackie's Butte where Owyhee, Humboldt, and Snake River provinces adjoin at about 4,000 feet elevation.

Owyhee–Snake River Demarcation

From the juncture of Owyhee, Humboldt, and Snake River provinces, the line of demarcation between Owyhee and Snake River provinces meanders north at about 4,000 feet elevation to cross Owyhee River about 6 miles upriver from Rome community, which is in Snake River Province. From this point, the line runs north at 4,000 feet elevation to the vicinity of Arock community, which is in Snake River Province. From the vicinity of Arock, the line follows north and northeasterly along the rim of Owyhee River canyon at about 4,000 feet elevation. It follows along this elevation, which is the approximate break between the vast basalt plateau and scattered hills of Owyhee Province and the exposed sedimentary and tuffaceous materials lying below the rimrocks to the north, which typify Snake River Province. The line of demarcation continues northeast along the rimrocks to the north of Mahogany Mountains and east to the vicinity of the abandoned community of Rockville, in Snake River Province. The line continues around the Sucker Creek watershed at 4,000 feet elevation north and then east to cross the Oregon–Idaho border about 15 air miles south of the Snake River.

Palouse Ecological Province

Location

In Oregon, the Palouse Province includes the gently sloping to rolling cultivated area northeast of Pendleton that surrounds the Pendleton Branch Agricultural Experiment Station and the towns of Adams and Athena. The province extends northeast to just north of Weston and just east of Milton-Freewater. It also extends into the state of Washington. In Oregon, it covers about 112,000 acres, all in Umatilla County.

Description

Practically all of this province in Oregon is farmed. It is the only sizable area in eastern Oregon in which annual cropping under dryland conditions is successful, due to the favorable climate and good soils. Wheat and green peas for canning, grown in alternate years, is the common crop rotation. However, the climate is suitable for growing other crops that require 15 inches or more annual precipitation. Some areas are irrigated by sprinkler.

Elevations in the Oregon portion of Palouse Province are mainly between about 1,350 and 2,000 feet, and the topography is sloping to rolling or slightly hilly. Oregon's portion of the province contrasts topographically with the area known as the "Palouse" which is farther north, in Washington and northern Idaho. The Palouse is steeply rolling and hilly. Annual cropping is practiced in both locations.

Soils

Major soils of the Palouse Province in Oregon are Walla Walla silt loam, high-precipitation phase, and Athena silt loam. These soils were formed in aeolian deposits that reportedly were blown south during the era of receding glaciers farther north, in Washington.

Surface layers of Walla Walla high-precipitation phase are dark grayish brown silt loam about 12 inches thick. Subsoil is dark brown silt loam about 48 inches thick. Depth to basalt bedrock or laminated sediments is from 40 inches to more than 5 feet. Surface layers of Athena series are very dark brown silt loam about 26 inches thick. Subsoil is dark brown silt loam about 20 inches thick. The substratum is dark yellowish brown silt loam to more than 5 feet in depth and is commonly calcareous.

These dark-color soils reflect the favorable climate in which they were formed in thick aeolian deposits. They are very productive under dryland farming. It is very likely that, before cultivation, these soils produced a Palouse Prairie natural grassland dominated by Idaho fescue and resembling the existing natural grasslands near Findley Buttes in Wallowa County.

Climate

Based on data from two official weather stations in the Oregon segment of Palouse Province, the average annual precipitation for the area is 18.2 inches of which about 54% falls during winter and 40% during the growing season of adapted farm crops, March through July. Average January maximum and minimum temperatures are 38.3 and 24.1°F, respectively. Average March through July maximum and minimum temperatures are 71 and 43.5°F, respectively.

Comparing precipitation and temperatures for the two Palouse Province stations in Oregon and two official weather stations in adjacent Columbia Basin Province, very near the line of demarcation, substantiates significant reasons why darker soils have evolved under Palouse Province climate than under the Columbia Basin Province climate (Table 30). The comparison also helps explain why annual dryland farming is possible in Palouse Province but the climate of Columbia Basin

Table 30. Climatic Data for Palouse Ecological Province, Oregon.[17]

Station and length of record (years)	Elevation (feet)	Precipitation			Average maximum and minimum temperatures (°F)	
		Annual (inches)	Oct.-Feb. (%)	March-July (%)	January	March-July
Umatilla County						
Milton Power House 7	1,350	21.8	53	41	36.1-23.0	70.3-43.8
Weston 21	1,800	19.0	55	40	38.2-24.0	70.0-45.1
Pendleton Expt. Sta. 7	1,440	15.9	54	40	40.6-25.2	72.5-41.5
County Average		18.2	54	40	38.3-24.1	71.0-43.5
Stations nearby, in Columbia Basin Province						
Milton-Freewater 20	1,056	13.8	54	41	39.8-25.3	73.9-47.8
Pendleton 40	1,070	14.2	54	36	40.5-24.9	73.7-43.2
Nearby Stations' Average		14.0	54	39	40.2-25.1	73.8-45.5

Province requires summer-fallow dryland farming. Furthermore, such crops as green peas can be grown in rotation with small grains in Palouse Province, whereas only small grains, mainly wheat and barley, are produced under wheat/summer-fallow farming in Columbia Basin Province.

Under the relatively mild winter temperatures of these two provinces, the key climatic factor is 15 inches or more of precipitation annually with a significant portion of that during the farm crop growing season, i.e., a pattern typical of Palouse Province.

Management Implications

Essentially, all land in Palouse Province in Oregon is privately owned; some is owned by Native American families and leased out to established farming operations.

Soil erosion in winter, when some lands are essentially bare and surface layers often are frozen, is a concern because this area lies within a storm pattern that sometimes produces sudden precipitation. Sloping lands along the eastern portion of the province near the Blue Mountains are especially susceptible to erosion and sometimes to hail damage during thunderstorms about harvest time in late summer.

Annual wheat yields in Palouse Province in Oregon are significantly greater than in Columbia Basin Province. In addition, lands in Columbia Basin Province normally produce an agricultural crop every other year, but lands in Palouse Province normally produce an agricultural crop every year.

Province Demarcation

Palouse–Blue Mountain Demarcation

The line of demarcation between Palouse and Blue Mountain provinces in Oregon is on the line separating the Athena soil series in Palouse Province from the Waha and Couse soil series in Blue Mountain Province.[75] This line is at about 2,000 feet elevation about 4 miles east of Milton-Freewater. The line continues southwest to just north of Weston and then south and west to just north of Cayuse on the Umatilla River. It is in this vicinity that the Palouse, Blue Mountain, and Columbia Basin provinces join.

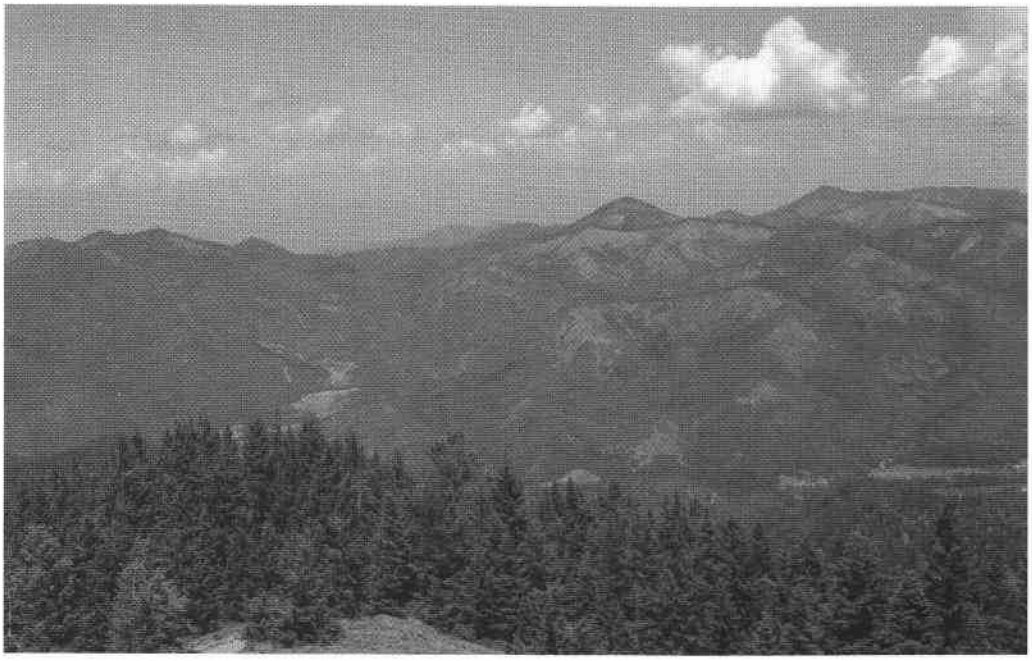
Palouse–Columbia Basin Demarcation

From Cayuse, the line between Palouse and Columbia Basin provinces runs west on the bench north of Umatilla River for about 3 miles and then veers north across Wildhorse Creek to the vicinity of Helix. Here, the line of demarcation is on the line separating the Walla Walla silt loam high-precipitation phase, which typifies Palouse Province, from Walla Walla silt loam association, which typifies Columbia Basin Province.[75] About 3 miles north of Helix, the line of demarcation heads east at about 2,000 feet elevation to a point about 2 miles south of Milton-Freewater. From there it turns to the northeast, passing just east of Milton-Freewater, to enter the state of Washington. Milton-Freewater is in Columbia Basin Province.

Table 31. Average Dates Vegetation Growth Begins and Ends in Palouse Ecological Province, Oregon.

Station and length of record (years)	Elevation (feet)	Average date growth begins*	Average date growth ends*
Umatilla County			
Milton Power House 7	1,350	February 22	August 14
Pendleton Expt. Sta. 7	1,440	March 1	July 15
Weston 21	1,800	March 1	August 1

* The average date vegetation growth begins on native perennial bunchgrasses is approximately the date average daily temperatures reach 39 to 40°F. Average date growth ends is considered to be when available soil moisture is depleted. Interpretations are based on data in Johnsgard.[17]



Siskiyou Ecological Province

Location

The Siskiyou Ecological Province in Oregon encompasses a very small area in the southwest corner of Klamath County, most of Jackson County, the southern portion of Douglas County, all of Josephine County, and the mountainous eastern portion of Curry County. It extends about 100 air miles east to west and about 75 air miles north to south in Oregon. Siskiyou Province covers about 3.7 million acres in Oregon and extends into California.

Description

Siskiyou Province in Oregon is influenced by the mild climate of northern California. Physiographically, the portion of the province in Oregon encompasses nearly the entire Rogue River drainage system, including its tributaries, the Illinois and Applegate rivers.

The lower Rogue River—about 15 riverbank miles upriver from Gold Beach—is in the normal coastal fog zone and, therefore, in Coast Province. Headwaters of the Rogue River above about 4,000 feet elevation in northeastern Jackson County are in Cascade and Mazama provinces. However, tributaries to the Rogue below about 4,000 feet elevation in eastern Jackson County are in Siskiyou Province.

The South Umpqua River drainage in southern Douglas County is in Siskiyou Province upriver from the Highway I-5 bridge over the river, which is about 4 miles northwest of Myrtle Creek community.

A small portion of Siskiyou Province in southwestern Klamath and southeastern Jackson counties is drained south by Klamath River which flows into California. A small area of Siskiyou Province in southeastern Curry County is drained to the south by Smith River.

Siskiyou Province in Oregon includes extensive mountainous areas of the Klamath and Siskiyou mountains and the western slopes of the Cascade Mountains in which dendritic drainage patterns are seen in steep terrain (Fig. 37).

Geomorphic features include granitic, serpentine, schist, volcanic, sedimentary, and intrusive igneous rocks.

Valleys of the Rogue, Illinois, and Applegate rivers and their major tributaries consist of flood plains, terraces, alluvial fans, and low hills which formed through geologic erosion and extensive deposition of alluvial outwash and colluvium from surrounding mountains.[59, 61] Rocks of Klamath Mountains are considered to be much older than those in any other part of western Oregon, and the area probably contains the oldest geologic formations in the state.[9]

The highest elevation in Siskiyou Province in Oregon is Mt. Ashland at 7,533 feet, which is about 7 air miles south of the city of Ashland in Jackson County. Other high promontories in the province in Oregon include Whiskey Peak, 6,497 feet, in the headwaters of Applegate River, and Chinquapin Mountain, 6,155 feet, Soda Mountain, 6,135 feet, and Table Mountain, 6,125 feet, all east of Ashland.

Most of the mountain promontories in the province in Oregon are about 5,000 feet elevation or less.

The lowest elevation in Siskiyou Province in Oregon is on the Rogue River about 15 riverbank miles upriver from Gold Beach. In this vicinity there is a series of sharp bends in the river and upland topography that, based on hillside vegetation, apparently diminish the effects of the normal coast fog zone penetration farther upstream. This elevation is less than 100 feet.

Soils

The geomorphology of soils typifying Siskiyou Province in Oregon involves a wide variety of parent materials ranging from geologically recent alluviums in valleys to what is thought to be the oldest geologic formations in the state. This is further complicated by the presence within the province of the lower western slopes of Cascade Mountains in southeastern Douglas and eastern Jackson counties, of the Siskiyou Mountains in southern Josephine County, and of the Klamath Mountains in Josephine and Curry counties, each of which is significantly different from the others.

Soil parent materials in Siskiyou Province can be grouped into six general categories: soils formed in materials weathered from igneous rocks; sedimentary, sandstone, and siltstone rocks; altered sedimentary and igneous rocks; granitic rocks; serpentine rocks; and schist rocks.[56, 61, 91, 95]

Each of these six categories includes a distinct group of soil series which may vary according to location within the province (Table 32).

The data in Table 32 reflect the fact that soils derived from igneous materials in Siskiyou Province in Oregon have been mapped only in Jackson County.

Based on field studies, the soils were mapped primarily in eastern Jackson County where the line of demarcation lies between Siskiyou and Cascade and Klamath provinces, both with extensive igneous formations. Soils derived from sedimentary, sandstone, and siltstone

Table 32. Parent Materials and Distribution of Some Representative Soil Series in Siskiyou Ecological Province, Oregon.[56, 59, 61, 95]

Parent material and soil series	Oregon counties			
	Curry	Douglas	Jackson	Josephine
Igneous				
Bybee			x	
Carney			x	
Farva			x	
Medco			x	
McMullin			x	
McNull			x	
Pinehurst			x	
Rustlerpeak			x	
Skookum			x	
Tatouche			x	
Sedimentary, sandstone, and siltstone				
Atring	x			
Brader			x	
Debinger			x	
Kanid	x			
Langellain			x	
Altered sedimentary and igneous				
Acker			x	
Althouse	x			x
Beal		x		
Beekman	x		x	x
Bravo	x			
Caris			x	
Cassidy	x			
Colestine				x
Frisland	x			
Jayar	x			x
Josephine		x	x	x
Lettie		x		
Manita				x
Norling			x	
Offenbacher			x	
Pollard	x			x
(continued)				

Parent material and soil series	Oregon counties			
	Curry	Douglas	Jackson	Josephine
Altered sedimentary and igneous *(continued)*				
Rilea	x			
Skymore	x			
Speaker		x	x	
Stackyards	x			
Vannoy			x	x
Vermise	x			x
Vourhies				x
Yorel	x			
Granite				
Crannier				x
Goodwin				x
Rogue				x
Shefflein			x	
Siskiyou			x	x
Tallowbox			x	
Tethrick			x	x
Wolfpeak			x	
Serpentine				
Cedarcamp	x			
Cornutt				x
Dubakella				x
Eightlar				x
Gravecreek	x			
Greggo	x			
Mislatnah	x			
Perdin	x			
Schist				
Barkshanty	x			
Deadline	x			
Nailkeg	x			
Saddlepeak	x			
Scalerock	x			
Threetrees	x			

rocks have been mapped in Jackson and Curry counties. Soils derived from altered sedimentary and igneous materials have been mapped in Douglas, Jackson, Josephine, and Curry counties; these parent materials exist over a major portion of Siskiyou Province in Oregon. Soils derived from granitic rock have been mapped in Jackson and Josephine counties. Granitic parent materials appear as low as about 800 feet (Siskiyou soil series) to about 7,000 feet elevation (Crannier soil series), both in Josephine County. Soils derived from serpentine materials have been mapped in Josephine and Curry counties. These soils are very high in magnesium and very low in calcium, which limits plant growth and results in the growth of specific plant species that apparently can tolerate this radical imbalance of soil nutrients.

In general, the soils of Siskiyou Province in Oregon are clayey, especially in the subsoils. Soil formed in materials weathered from granitic rock, however, are loamy and sandy. These factors have significant impact on erodibility, potential natural vegetation cover, and responses to management strategies.

Climate

The climate of Siskiyou Province in Oregon is the most diverse of all the ecological provinces in Oregon. Dramatic climatic gradients are common. One such gradient extends from the normal coastal fog zone, where average minimum January temperatures are about 40°F and average annual precipitation is about 80 inches, eastward over the crest of Klamath Mountains where precipitation exceeds 125 inches annually, to interior valleys such as at Medford where average minimum January temperatures are about 27°F and average annual precipitation is about 20 inches. A less dramatic gradient occurs north to south, from the mild, moist southern Willamette Valley to the warm dry climate of northern California.

Such regional climatic gradients are further complicated by mountainous topography of the Cascade, Siskiyou, and Klamath mountains within the province which produce a wide variety of local climatic gradients such as between Ashland at 1,750 feet elevation and Mt. Ashland at 7,503 feet elevation just 7 air miles south of Ashland.

A precipitation map[53] shows the highest average annual precipitation in Siskiyou Province in Oregon is about 160 inches. This is on the crest of Klamath Mountains about 10 air miles west of Cave Junction and about 30 air miles inland from the Pacific Ocean. This high country, about 4,000 to 4,500 feet elevation, is a portion of a precipitation zone receiving over 125 inches annu-

Table 33. Climatic Data for Siskiyou Ecological Province, Oregon.[17]

Station and length of record (years)	Elevation (feet)	Precipitation			Average maximum and minimum temperatures (°F)	
		Annual (inches)	Oct.-Jan. (%)	Feb.-June (%)	January	Feb.-June
Curry County						
Illahe 13	176	85.8	60	37	45.8-34.6	64.4-41.8
Douglas County						
Glendale 13	1,441	37.7	57	40	47.1-31.8	65.1-38.2
Riddle 17	700	30.5	58	38	48.3-38.2	66.3-40.0
Jackson County						
Ashland 22	1,750	20.1	53	41	45.3-29.3	64.1-39.2
Hillcrest orchard 17	1,595	17.4	53	39	45.4-29.7	66.2-38.6
Jacksonville 17	1,640	24.1	54	41	42.8-30.7	63.8-40.2
Lake Creek 16	2,000	29.6	49	46	46.1-28.4	64.8-36.7
Medford 15	1,457	20.6	56	38	44.7-27.1	65.3-34.4
Modoc orchard 22	1,270	22.6	59	37	45.9-28.1	67.8-37.8
Siskiyou 6	4,125	34.0	53	40	37.0-26.3	55.5-35.5
Talent 22	1,550	19.1	53	40	44.9-29.2	65.5-39.1
Josephine County						
Grants Pass 21	925	30.1	60	36	45.7-31.3	68.5-39.3
Sexton Summit 29	3,836	30.9	55	39	41.6-30.0	54.7-35.8
Waldo 15	1,650	52.1	53	42	44.1-28.3	62.9-36.1
Williams 34	1,368	31.7	58	38	50.3-29.7	65.4-36.0
Wolf Creek 8	1,274	40.9	58	40	45.8-31.4	65.9-37.8
County Averages						
Curry County		85.8	60	37	45.8-34.6	64.4-41.8
Douglas County		34.1	58	39	47.7-32.5	65.7-39.1
Jackson County		23.4	54	40	44.0-28.6	64.1-37.7
Josephine County		37.1	57	39	45.5-30.1	63.4-37.0
Province Average		45.1	57	39	45.8-31.7	64.4-38.9

ally. The zone extends about 45 air miles, from near the California border north to about 10 miles east of Illahe, which is on Rogue River.

According to this precipitation map, Mt. Ashland, the highest promontory in Siskiyou Province in Oregon, receives about 65 inches average annual precipitation. The major portion of Siskiyou Province in Oregon receives between 20 and 50 inches average annual precipitation.

Vegetation

The Siskiyou Province in Oregon is defined in terms of vegetation as generally that area in southwestern Oregon that is affected by the warm climate of northern California to the extent that certain plant species common in California grow there but only rarely, if at all, in other Oregon ecological provinces. These species include wedgeleaf ceanothus, whiteleaf and hoary manzanita, boxleaf silktassel, California buckthorn, California-laurel, California black oak, Sadler oak, canyon live oak, huckleberry oak, tanoak, Jeffrey and knobcone pine, Port-Orford-cedar, and Brewer spruce.

Table 34. Average Dates Vegetation Growth Begins and Ends in Siskiyou Ecological Province, Oregon.

Station and length of record (years)	Elevation (feet)	Average date growth begins*	Average date growth ends*
Curry County			
Illahe 13	176	winter growing	Does not occur
Douglas County[1]			
Glendale 13	1,441	winter growing	Does not occur
Riddle 17	700	winter growing	Does not occur
Jackson County			
Ashland 22	1,750	February 1	August 2
Hillcrest orchard 17	1,595	February 1	July 14
Jacksonville 17	1,640	February 7	August 25
Lake Creek 16	2,000	February 1	Does not occur
Medford 15	1,457	February 7	August 8
Modoc orchard 22	1,270	February 1	August 5
Siskiyou 6	4,125	March 5	Does not occur
Talent 22	1,550	February 1	July 24
Josephine County			
Grants Pass 21	925	January 19	Does not occur
Sexton Summit 29	3,836	March 15	Does not occur
Waldo 15	1,650	February 7	Does not occur
Williams 34	1,368	January 23	Does not occur
Wolf Creek 8	1,274	January 22	Does not occur

[1]The Douglas County stations represent the transition zone between Willamette and Siskiyou provinces.

* The average date vegetation growth begins on native perennial bunchgrasses is approximately the date average daily temperatures reach 39 to 40°F. Average date growth ends is considered to be when available soil moisture is depleted. Interpretations are based on data in Johnsgard.[17]

Pacific madrone, which also occurs to a minor degree in Willamette Province to the north, is abundant and ubiquitous, except in high-elevation, cold-climate conditions, in conifer forest plant communities throughout most of Siskiyou Province in Oregon. Madrone is especially abundant as a shrub on disturbed forested areas.

Golden chinkapin, Pacific madrone, tanoak, California-laurel, and canyon live oak are species that are shrubs in arid effective environments or in snow zones but are trees in warm, moist effective environments such as north-facing exposures.

Madrone, tanoak, and canyon live oak are examples of Siskiyou shrubs that readily sprout after being injured by cutting or burning, thereby becoming significantly competitive with other plant species and causing severe restrictions in resource management strategies. In lower elevations of central and eastern portions of Siskiyou Province in Oregon, poison-oak, wedgeleaf ceanothus, whiteleaf manzanita, and a wide variety of other shrub species dominate disturbed plant communities. There is a very wide variety of shrub species within Siskiyou Province, especially on forested sites.

Changes in vegetation that are related to higher elevations begin at about 3,000 feet; the snow zone begins at about 4,000 feet. Plant species generally associated with snow zones include Douglas-fir, white fir, sugar pine, and Brewer spruce, with understory species such as prince's-pine, Sadler oak, common snowberry, and Cascade Oregon-grape. Above about 5,000 feet elevation the colder climate is signalled by a dominance of white fir, Shasta red fir, and mountain hemlock.

Observations of Douglas-fir, the most dominant and widespread coniferous tree in both Siskiyou and Coast provinces in Oregon, indicate a subtle but visible difference in the species according to which province it is in. In the more moist Coast Province, Douglas-fir usually have moss growing on them; in the drier Siskiyou Province, moss is scarce or absent.

Plant communities in southeast Siskiyou Province in Oregon include some species that typify the adjoining Klamath Province and much of eastern Oregon in general. This can be attributed to the southern termination of Cascade Province in this area about 10 air miles north of the California border at about 5,500 feet elevation. This leaves a lower-elevation gap through which plant species such as bitterbrush, birchleaf mountain-mahogany, and western juniper apparently have extended their range from east to west. There is only a mild climatic barrier between Siskiyou and Klamath prov-

inces in the topography traversed by Highway 66 from Klamath Falls to Ashland. Consequently, the transition from one province to the other is a belt: the line of demarcation is a judgment call based primarily on the presence of such Siskiyou Province species as Oregon white oak and wedgeleaf ceanothus. Vegetation characteristics of Siskiyou Province cited here are based on unpublished field studies.[36, 37, 39, 51]

Temperature and the amount and timing of precipitation are primary factors in variability of local effective environments. Undoubtedly they also are major influences in the geographical distribution and abundance of certain plant species within Siskiyou Province in Oregon. However, geographic distribution of certain plant species also is somewhat related to the nature of soils formed in materials weathered from various kinds of geological formations.

Table 35 shows the distribution of prominent woody-plant species by geographic areas—counties—and various soil parent materials.

Only woody species are cited because shrubs and trees are reliable indicators of average climatic conditions that have prevailed over long climatic cycles. Obviously, species listed grow on soil parent materials other than as noted in Table 35. However, the species listed were selected by members of the soil survey party as being prominent components of plant communities growing on soil series formed in the various parent materials.[56, 59, 61]

Management Implications

Siskiyou Province is the most complex ecological province in Oregon, especially from a resource management standpoint.

Diverse geological formations result in an unusually wide variety of soil parent materials, each having inherent features that affect local resource management strategies. The variable climate of the province, which ranges from near-coastal to arid interior valleys to near-alpine, also has great influence on resource management strategies.

The situation is further complicated by the diverse assemblage of plants which includes species that are representative of contiguous provinces including the Klamath area of eastern Oregon, the

Table 35. Distribution of Prominent Woody-plant Species by County and Soil Parent Materials in Siskiyou Ecological Province, Oregon.[7, 51, 54, 56]

	Upland soil parent materials and the counties in which they are found*											
	Igneous	Sedimentary, sandstone, & siltstone		Altered sedimentary & igneous			Granite		Serpentine		Schist	
Prominent plant species	Jac.	Jac.	Cur.	Jac.	Jos.	Cur.	Jac.	Jos.	Jos.	Cur.	Cur.
Alder, red						x						x
Azalea, western										x		
Bitterbrush, antelope	x											
Blackberry, trailing						x						
California-laurel						x				x		
Ceanothus, deerbrush		x			x	x	x	x				
Ceanothus, snowbrush						x		x				
Ceanothus, squawcarpet										x		
Ceanothus, wedgeleaf	x				x	x						
Cedar, western red						x						x
Chinkapin				x		x		x				x
Dogwood, Pacific flowering			x	x	x	x	x					
Douglas-fir	x	x	x	x	x	x	x	x	x	x		x
Fir, grand			x			x						
Fir, Shasta red					x	x		x				
Fir, white	x			x	x	x		x				
Hazel, western			x		x	x			x			
Hemlock, western						x						x
Huckleberry, evergreen			x			x						
Huckleberry, red						x						
Incense-cedar									x	x		
Juniper, western	x											
Madrone, Pacific			x	x	x	x	x	x	x			x
Manzanita, greenleaf						x				x		
Manzanita, pinemat						x				x		
Manzanita, whiteleaf						x	x		x	x		

(continued)

lower western slopes of the Cascade Mountains, the southern portion of the Willamette Valley, the lower southeast slopes of the Coast Range, the coastal fog zone, and, most significant, the warm climate of northern California.

Resource management strategies are also complicated by the topographic pattern of interspersed valleys, low hills, dendritic drainage patterns with steep slopes and very contrasting north and south exposures, and a wide range of elevation patterns (Fig. 38).

A preponderance of shrubby species in nearly all natural plant communities, typical of Siskiyou Province in Oregon, has strong influence on resource management strategies. Some of the species, such as tanoak and Pacific madrone, are trees under certain, favorable conditions but are aggressive shrubs under other conditions. Furthermore, some Siskiyou shrub species are strongly prolific when damaged by burning, logging, overgrazing, or other activity that damages the shrubs or the site. This results in areas of dense shrubs that hinder most remedial resource management activities designed to obtain natural rehabilitation and growth of desirable plant species.

Not all shrubs in Siskiyou Province have undesirable characteristics. Many forested plant communities include a wide variety of nonaggressive shrubs that help provide the necessary layering in the canopy cover, benefitting watershed quality and tree regeneration. These shrubs also provide nutritious forage important for food and cover for wildlife and domestic livestock. It is noteworthy that cattle accustomed to grazing Siskiyou-type plant communities use an unusual amount of browse in their diets by choice, even when adequate herbaceous forage is readily available.

The extent and pattern of public and private land ownership is another important feature of Siskiyou Province

Table 35 (cont'd). Distribution of Prominent Woody-plant Species by County and Soil Parent Materials in Siskiyou Ecological Province, Oregon.

	Upland soil parent materials and the counties in which they are found*																			
	Igneous			Sedimentary, sandstone, & siltstone			Altered sedimentary & igneous				Granite				Serpentine				Schist	
Prominent plant species	Jac.			Jac.		Cur.	Jac.		Jos.	Cur.	Jac.		Jos.			Jos.		Cur.		Cur.
Maple, Rocky Mountain	x																			
Mountain-mahogany, birchleaf				x																
Oak, California black	x			x			x		x	x	x		x							
Oak, canyon live						x			x	x			x			x				x
Oak, huckleberry									x	x								x		
Oak, Oregon white	x			x		x				x										
Oak, Sadler										x								x		
Oceanspray	x			x		x	x		x	x	x		x					x		
Oregon-grape, Cascade	x					x	x		x	x	x		x					x		x
Oregon-grape, tall	x			x			x				x									
Pine, Jeffrey																x		x		
Pine, knobcone																		x		
Pine, lodgepole																		x		
Pine, ponderosa	x			x					x	x			x			x				
Pine, sugar						x			x	x	x		x					x		
Pine, western white																		x		
Poison-oak, Pacific				x		x	x		x	x	x		x			x				
Port-Orford-cedar										x								x		x
Prince's-pine, western									x	x			x							
Rhododendron, Pacific							x		x	x			x							
Rose, baldhip	x					x				x	x									x
Salal						x	x			x										x
Serviceberry, Pacific	x			x			x			x										
Silktassel, boxleaf																		x		
Snowberry, common	x			x			x		x	x	x		x							
Tanoak						x			x	x						x		x		x
Whipplevine							x			x	x									
Yew, Pacific	x																			

* Jac. = Jackson Jos. = Josephine Cur. = Curry

Table 36. Some Major Ecological Sites in Siskiyou Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Natural grassland (less than 10% canopy cover of shrubs)	Foothill south exposure Bluebunch wheatgrass, Lemmon needlegrass Mountain south exposure Idaho fescue, bluebunch wheatgrass, pine bluegrass High mountain grassland zone Several sites not yet described	Dry meadow California oatgrass, pine bluegrass, yampa Semiwet meadow California oatgrass, sedge, buttercup Wet meadow Tufted hairgrass, sedges, false-hellebore
Shrub–grassland (10% or more canopy cover of shrubs)	Shrubby scabland Bluebunch wheatgrass, Lemmon needlegrass/ wedgeleaf ceanothus High mountain shrub zone Several sites not yet described are typified by sagebrushes, curlleaf mountain-mahogany, greenleaf manzanita	
Deciduous tree (5% or more canopy cover of trees)	Oak–mahogany–fescue Idaho fescue/birchleaf mountain-mahogany/ white oak Oak–fescue Idaho fescue, bluebunch wheatgrass, pine bluegrass/white oak	Hardwood bottomland Blue wildrye, Kentucky bluegrass/many shrubs/cottonwood, Oregon ash, black and white oaks
Mixed deciduous–coniferous tree (5% or more canopy cover of trees)	Oak–pine–oatgrass California oatgrass/minor shrubs/white and black oaks, ponderosa pine Pine–oak–fescue Idaho fescue/mixed shrubs/ponderosa pine, white and black oaks	Pine–oak bottomland Idaho fescue/mixed shrubs/ponderosa pine/ black and white oaks

(continued)

in Oregon that has major implications on resource management strategies.

About 75% of Siskiyou Province in Oregon is publicly owned and is administered by the U.S. Forest Service and the Bureau of Land Management. Also, except for the major valley area around Ashland and Medford, nearly all private lands are in an alternate-section checkerboard pattern with BLM lands. That land pattern further complicates relationships and interdependencies that are basic considerations in resource management strategies.

Broad vegetation characteristics differentiate between Willamette and Siskiyou provinces. For example, uplands below about 1,300 feet in southern Willamette Province are typified by bigleaf maple, Oregon white oak, scotchbroom, and some Pacific madrone. Equivalent uplands in Siskiyou Province are typified by California black oak, wedgeleaf ceanothus, and abundant madrone, which strongly dominates logged or otherwise disturbed forested areas.

Province Demarcation

Siskiyou–Klamath Demarcation

The line of demarcation between Siskiyou and Klamath provinces begins at the Oregon–California border in southwestern Klamath County on the east side of Klamath River. At this point, the line coincides reasonably well with the soils line between Pinehurst, Greystoke, and Bly soil mapping units, which represent Klamath Province, and Skookum–McMullin soil map unit, which represents Siskiyou Province.[61] The line travels up Klamath River about 5 miles and then meanders west to the Jackson–Klamath county line at about 4,000 feet elevation where it goes northwest to pass close by Pinehurst on Highway 66.

From the vicinity of Pinehurst, the line runs north up Jenny Creek and intersects the juncture of Siskiyou, Klamath, and Cascade provinces at about 5,000 feet elevation west of Brush Mountain, which is in Cascade Province.

The demarcation line between Siskiyou and Klamath provinces in this area is not based on soil maps. Rather, the line is the approximate boundary between the area vegetated with plant communities that include oak and wedgeleaf ceanothus, which typify Siskiyou Province in this area, and the mixed-pine–mixed-fir plant communities which typify Klamath Province.[50]

However, the Skookum–McMullin and McNull–McMullin soil map units are generally associated with plant communities that include white oak, ponderosa pine, and wedgeleaf ceanothus, which typify Siskiyou Province in this area, and the Pokegma–Woodcock soil map

Table 36 (cont'd). Some Major Ecological Sites in Siskiyou Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Coniferous tree (5% or more canopy cover of mature trees)	*Open stands* Pine–Douglas-fir–fescue California and Idaho fescue/many shrubs, ponderosa pine, Douglas-fir, madrone Mixed pine–Douglas-fir–fescue Idaho fescue/mixed shrubs/ponderosa and sugar pines, Douglas-fir, madrone Douglas-fir–mixed pine–fescue California and western fescue/many shrubs/ Douglas-fir, ponderosa and sugar pines, madrone Mixed fir–mixed pine–sedge Ross sedge/many shrubs/Douglas-fir, white fir, ponderosa and sugar pines, madrone *Dense stands* Douglas-fir forest Many shade forbs/many shrubs/Douglas-fir, madrone, black oak Douglas-fir–madrone forest Many shade forbs/many shrubs/Douglas-fir, madrone, white fir Mixed fir forest Many shade forbs/many shrubs/Douglas-fir, white fir, black oak, ponderosa and sugar pines Mixed fir–dogwood forest Many shade forbs/dense shrubs/white fir, Douglas-fir, Pacific dogwood High white fir forest Many shade forbs/mixed shrubs/white fir High mixed fir–hemlock forest White fir, Shasta red fir, mountain hemlock	

units which are associated with the mixed-pine and mixed-fir forest of Klamath Province in this area.[61] Wedgeleaf ceanothus is a key indicator species of Siskiyou Province arid sites.

Siskiyou–Cascade Demarcation

The line of demarcation between Siskiyou and Cascade provinces wanders north from the vicinity of Brush Mountain at about 5,500 feet elevation to Fish Lake and along the western slopes of Mt. McLoughlin, which is in Cascade Province. The line continues north in the headwaters of Big Butte Creek and its tributaries, on to Rustler Peak, and then northwest to cross Rogue River and Highway 62 about 6 miles below the community of Prospect. The line in this area is based on forested plant communities dominated by Douglas-fir, grand fir, sugar pine, and ponderosa pine, which represent Siskiyou Province, and forested plant communities dominated by mountain hemlock and true firs, which represent Cascade Province.[50]

From where the line crosses Highway 62 near Prospect, it runs northward around the headwaters of Elk Creek and South Umpqua River at about 4,000 feet elevation.

The line turns west around headwaters of tributaries of South Umpqua River, which are in Siskiyou Province, at about 3,500 feet elevation. Consequently, the south- and west-facing slopes along South Umpqua River are in Siskiyou Province. In the vicinity of Tater Hill, the line veers northwest to White Rock at about 3,000 feet elevation and on to Lane Mountain where Siskiyou, Cascade, and Willamette provinces join.

The line between Siskiyou and Cascade provinces in the vicinity of South Umpqua River is based on the presence of western hemlock in Cascade Province forested plant communities and on a lack of western hemlock in the more arid forested plant communities of Siskiyou Province.

The line is supported in this area by such soil series as Holderman and Keel, which represent Cascade Province,[91] and Lettia, Beal, Acker, Kanid, and Atring series, which represent Siskiyou Province.[95]

Siskiyou–Willamette Demarcation

From the junction of Siskiyou, Cascade, and Willamette provinces on Lane Mountain about 10 air miles east of Roseburg in Douglas County, the line between Siskiyou and Willamette provinces goes southwest down the ridge to Brushy Butte and Dodson Mountain to cross South Umpqua River at the Interstate I-5 bridge over the river about 4 air miles northwest of Myrtle Creek community.[36, 95]

From the I-5 bridge, the line follows the southern border of bottomlands along South Fork Umpqua River and Olalla Creek at about 600 feet elevation. From there it veers south up the ridge separating drainages flowing west into lower Olalla Creek, in Willamette Province, from drainages flowing north, which are in Siskiyou Province, to Big Baldy Mountain about 4 air miles northwest of Riddle community.

From Big Baldy Mountain the line goes southwest along the ridgetop at about 2,500 feet elevation past Buck Mountain to Table Mountain where it curves north to circle the headwaters of Olalla Creek, in Siskiyou Province. The line follows the ridge from Live Oak Mountain southwest to Chipmunk Ridge, where the junction of Siskiyou, Willamette, and Coast provinces lies.

The line between Siskiyou and Willamette provinces, which is about 70 miles long, is not always clear-cut in terms of soil or vegetational differences. Both provinces have arid, warm climatic conditions though Siskiyou is relatively more arid and warm than Willamette Province.

The line was selected by using data shown on the 1993 Preliminary General Soil Map, Douglas County, Oregon[95] which covers the area where these two provinces join. The line was drawn between upland soils that have been mapped definitely within Willamette Province to the north and upland soils that have been mapped in other areas definitely within Siskiyou Province. Upland soils definitely associated with Willamette Province include Oakland, Sutherlin, Nonpariel, Philomath, and Dixonville series. Upland soils definitely associated with Siskiyou Province include Speaker, Josephine, Lettia, and Beal series.

Broad vegetation characteristics differentiate between Willamette and Siskiyou provinces. For example, uplands below about 1,300 feet elevation in southern Willamette Province are typified by the common presence of bigleaf maple, Oregon white oak, scotchbroom, and some Pacific madrone. Equivalent uplands in Siskiyou Province are typified by California black oak, wedgeleaf ceanothus, and abundant madrone, which strongly dominates logged or otherwise disturbed forested areas.

Siskiyou – Coast Demarcation

From the junction of Willamette, Siskiyou, and Coast provinces in the vicinity of Chipmunk Ridge in southwest Douglas County, the line between Siskiyou and Coast provinces goes south at about 3,000 feet elevation to Dutchman Butte. It follows Hayes Ridge southwesterly and south to Ninemile Mountain and continues southwesterly at about 3,000 feet elevation to north of Kelsey Peak in northeastern Curry County. From there, the line wanders west to Big Meadows vicinity and then north, west, and southwest at about 3,000 feet elevation around the upper Mule Creek watershed. It follows Panther Ridge southwesterly at about 2,000 feet elevation close to the Coos–Curry county line.

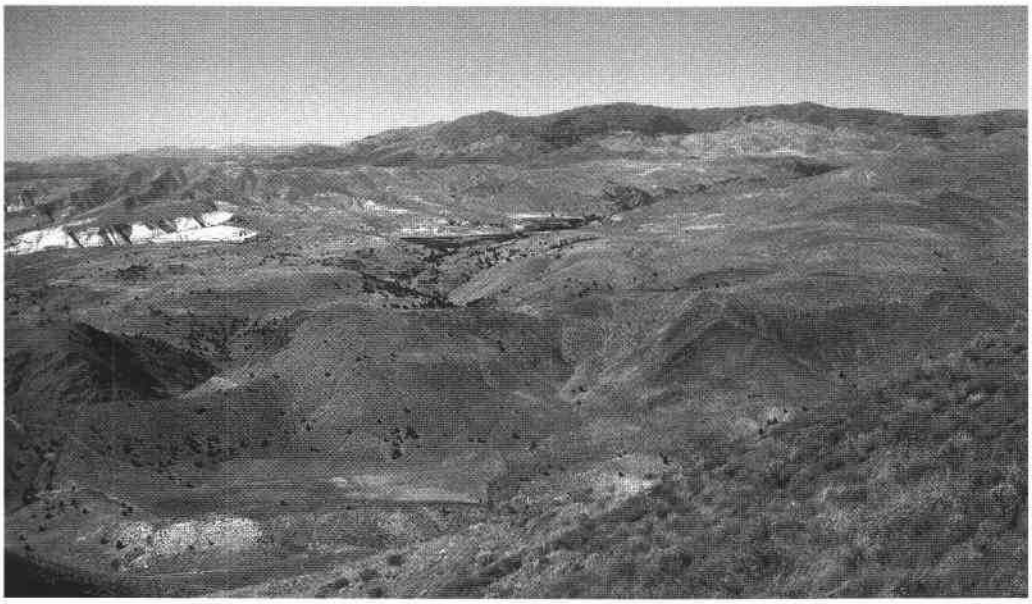
From this point, the line extends south along the east slopes of Ophir Mountain and Brushy Mountain at about 2,000 feet elevation. Near Lake of the Woods Mountain the line goes southwest to Soldier Camp Mountain, Second Prairie Mountain, and First Prairie Mountain while decreasing in elevation from about 2,000 feet at Soldier Camp Mountain to about 1,200 feet near Lobster Hill just north of Rogue River.[51]

The line in northeastern and north-central Curry County is based primarily on the elevation at which western hemlock is a common component of forested uplands in Coast Province, compared to the common appearance of tanoak, madrone, and other plant species that signify warmer and drier conditions typifying the western part of Siskiyou Province. The line also is indicated by the general presence of such forested soils as Preacher, Bohannon, Digger, and Umpcoos, which typify Coast Province,[60] and the soil series Atring, Kanid, Acker, Beekman, Pollard, and Vermisa, which typify Siskiyou Province in this vicinity.[56]

Around Lobster Hill, the line intersects the upper boundary of the normal coastal fog zone at about 1,200 feet. This boundary coincides with the line between provinces from this area south to the California border. Several sharp bends in Rogue River near Lobster Hill apparently hinder the normal fog zone boundary from extending farther upriver. The line of demarcation, therefore, crosses Rogue River between Lobster Hill and Skookumhouse Butte.

The line—the upper boundary of the coastal fog zone—continues at about 1,200 feet around the headwaters of Quosatana Creek and west around Kimball Hill. It goes southwest, somewhat parallel to Rogue River, and then south at about 1,200 feet. It winds up and around the headwaters of Hunter Creek, west of Sundown Mountain, up and around headwaters of Pistol River and its tributaries, of Chetco River and its tributaries, and of Winchuck River and its tributaries at about 1,200 feet.[51] It crosses from Oregon into California about 8 air miles east of the ocean.

From the area east of Lobster Creek, which is a tributary of Rogue River, and south to the California border, the line is based on the presence of Sitka spruce, red alder, Douglas-fir, western hemlock, and other species that typify the cool, moist fog zone coastal climate compared to the common tanoak, Pacific madrone, and related species that signify the warmer, drier conditions of Siskiyou Province. The line also is indicated by the general presence of such soils as Bosland, Floras, Millicoma, and Reedsport, which typify Coast Province in this area, and Fritsland, Bravo, Mislatnah, and Pollard soil series which typify Siskiyou Province in this area.[56]



Snake River Ecological Province

Location

This province in Oregon includes the western portion of the huge Snake River basin that extends east across southern Idaho. In Oregon, the province covers about 4.9 million acres, mainly in Malheur and Baker counties but with small segments in Harney, Grant, and Union counties. It extends eastward into Idaho.

Description

Snake River Province of Oregon is typified by extensive dissected terraces formed in ancient lakes. These terraces are geologically eroded to the point that they appear as plateaus, basins, low rolling hills, and prominent hills separated by sharp dendritic drainage patterns. Mountainous terrain is interspersed throughout most of the province (Fig. 39). For example, Lookout Mountain is basaltic/granitic; the mountains south of Burnt River are largely limestone from which cement is ground from open-pit mines at Lime; and other mountains, such as Ironside Mountain, Cedar Mountains, and Owyhee Ridge just east of Owyhee Reservoir, are rugged basaltic formations.

Alluvial valleys, which are used for irrigated agriculture, run along major watercourses. These include Eagle Valley, Keating Valley, Baker Valley, North Powder Valley, Burnt River Valley, and the extensive valley around Vale, Ontario, and Nyssa. Some low-lying terraces are irrigated in the Vale–Ontario vicinity, near North Powder, around the north and west perimeter of Baker Valley, and in Eagle Valley.

Elevations within Snake River Province are mostly between 3,000 and 5,000 feet. The lowest point, about 1,800 feet, is at Copperfield on the Oxbow of Snake River where it exits this province and enters Blue Mountain Province to the north in upper Hells Canyon. High promontories within Snake River Province include Mahogany Mountain at 6,524 feet, about 14 miles northeast of Sheaville in Malheur County; Bald Mountain at 6,683 feet, about 15 miles south of Baker City in Baker County; Castle Rock at 6,847 feet, about 8 miles north of Beulah in Malheur County; Lookout Mountain at 7,127 feet, about 12 miles south of Richland in Baker County and only about 35 air miles from the lowest point on Oxbow; and Ironside Mountain at 7,815 feet, about 12 miles southwest from Ironside in Malheur County.

Soils

The soils formed on ancient terraces in Snake River Province vary considerably by location according to the terrace materials in which they were formed. Some are very gravelly, some are stony, some are nonstony. Most of these terrace soils have medium- to fine-texture surface layers and clayey subsoils. Depths vary from shallow to deep, and soils may be underlaid by hardpans.

A good example of ancient-terrace soils underlaid by hardpans can be studied on Highway 86 roadcuts in the vicinity of Virtue Flat about 12 miles east of Baker City.

Soils formed on mountain slopes may be shallow to deep, nonstony to very stony. They usually have medium-texture surface layers and clayey subsoils.

Soils in valleys are usually deep, of medium texture, moderately well drained, and fertile. Some bottomlands, however, are imperfectly to poorly drained, usually moderately deep over hardpans, and are alkaline or sodic.

Climate

For nine of the 14 official weather stations, which represent a cross-section of the province, the average annual precipitation is about 9.9 inches, of which only 28% occurs during the native-plant growing season, April

through June. November through March precipitation is about 55% of the annual total. Average January maximum and minimum temperatures are 35.5 and 16°F, respectively. Average April through June maximum and minimum temperatures are 71.3 and 39.6°F, respectively. Precipitation and temperatures vary by locality, as shown in Table 37.[17]

Field observations in Snake River Province are that storm patterns appear to be related to the mountainous topographic features that help typify this province. Consequently, the paths these storms follow receive considerably more precipitation than other areas just a short distance away, but this is not documented by existing official weather stations.

However, both soils and plant communities reflect these favorable moisture conditions which are highly significant from a resource management aspect, especially when they occur during the native-plant growing season.

A precipitation map[53] shows greater than 15 inches precipitation for mountainous areas in the province and about 30 inches precipitation for the Lookout Mountain–Sheep Mountain–Little Lookout Mountain group southeast of Baker City, which is the highest precipitation shown for the province.

Vegetation

According to the 1936 State of Oregon Forest Type Map,[54] which predates extensive logging, only about 0.4% of Snake River Province was covered by coniferous trees at that time.

About 0.1%, or 66,000 acres, was covered by stands of western juniper which grew primarily in five general locations. About 23,000 acres were in the extreme southwest part of the province on mountainous terrain. About the same acreage was in the area between Juntura and north to the vicinity of Beulah Reservoir.

North of the Burnt River in the vicinity of Hereford about 7,000 acres of juniper grew on upper portions of south-facing slopes. Also along Burnt River about halfway between Bridgeport and Durkee, about 6,000 acres were near ridgetops on south-facing slopes. On the south-facing slopes of Lookout Mountain were stands of juniper totalling about 7,000 acres.

Ponderosa pine, primarily stands of large old-growth, was on about 134,000 acres or 0.3% of the province. Some of these stands were along the line of demarcation between Snake River and Blue Mountain provinces; the largest area, of about 46,000 acres, was from Whitney southward. Other stands of ponderosa pine grew in the interior of the province. The east–west ridge between Burnt River and Powder River had about 80,000 acres of pine. This stand included the Dooley Mountain area. In the high country southwest of Bridgeport between Burnt River and the headwaters of Willow Creek were stands covering about 6,000 acres. In Timber Canyon on the north-facing portion of Little Sheep Mountain were about 1,000 acres of pine and Douglas-fir. And, a small stand of pine and Douglas-fir appeared on the north-facing slopes of Lookout Mountain.

In terms of acreage, the vegetation of Snake River Province is primarily a shrub–grassland climax type. Sagebrushes dominate; however, the province is characterized by a variety of shrub species that flourish on the hills and terraces above the most arid low-lying portions of the province (Fig. 40).

Wyoming and basin big sagebrushes are the most prominent shrubs on uplands. Basin big sagebrush also grows on well-drained bottomlands. Greasewood and green rabbitbrush are typical of sodic bottomland sites. Mountain big sagebrush appears in higher elevations where precipitation is about 12 inches or more. Rigid and threetip sagebrushes grow mainly on shallow clayey scabland sites. Louisiana wormwood grows on some moist

Table 37. Climatic Data for Snake River Ecological Province, Oregon.[17]

Station and length of record (years)	Elevation (feet)	Precipitation			Average maximum and minimum temperatures (°F)	
		Annual (inches)	Nov.-March (%)	April-June (%)	January	April-June
Baker County						
Baker City 40	3,471	11.8	48	31	32.5-17.4	63.4-39.4
Huntington 20	2,150	10.9	65	21	37.4-19.7	75.8-47.2
Richland 26	1,900	9.7	55	27	37.6-18.3	72.5-39.5
Unity 12	4,031	10.8	49	29	31.6-9.8	65.4-33.1
Malheur County						
Adrian 20	2,240	8.8	57	27	37.0-19.6	75.3-43.9
Beulah 8	3,269	11.0	61	25	35.2-11.4	70.5-34.3
Harper 12	2,156	8.2	54	26	35.6-15.3	73.5-40.8
Riverside 10	3,000	9.2	50	29	36.7-16.4	73.9-37.7
Warm Springs Res. 21	3,332	7.9	51	32	35.8-15.3	72.6-39.8
County Averages						
Baker County		10.8	54	27	34.8-16.3	69.3-39.8
Malheur County		9.0	55	28	36.1-15.6	73.2-39.3
Province Average		9.9	55	28	35.5-16.0	71.3-39.6

Table 38. Average Dates Vegetation Growth Begins and Ends in Snake River Ecological Province, Oregon.

Station and length of record (years)	Elevation (feet)	Average date growth begins*	Average date growth ends*
Baker County			
Baker City 40	3,471	March 27	July 4
Huntington 20	2,150	March 4	June 17
Richland 26	1,900	March 7	June 6
Unity 12	4,031	April 4	July 1
Malheur County			
Adrian 20	2,240	March 4	June 2
Beulah 8	3,269	March 27	July 4
Harper 12	2,156	March 9	May 20
Riverside 10	3,000	March 15	June 7
Warm Springs Res. 21	3,332	March 13	May 21

* The average date vegetation growth begins on native perennial bunchgrasses is approximately the date average daily temperatures reach 39 to 40°F. Average date growth ends is considered to be when available soil moisture is depleted. Interpretations are based on data in Johnsgard.[17]

bottomland sites. Bitterbrush, squaw-apple, currants, chokecherry, buck-wheats, gray and green rabbitbrushes, gray horsebrush, and spiny hopsage are on various rangeland sites. Curlleaf mountain-mahogany grows on rocky outcrops and ridges.

The basic perennial grasses on range-land sites in the province are bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass and squirreltail. Indian rice-grass, Thurber needlegrass, and needle-and-thread also grow on the more arid sites. Onespike oatgrass, Kentucky bluegrass, Columbia and western needlegrasses, and oniongrass also grow in more moist upland sites.

Basin wildrye is common throughout the province on concave areas or those with deeper soil in the uplands as well as on nearly all bottomland sites and riparian areas that have not been farmed. Cheatgrass is very prolific throughout the province. Medusahead wildrye signifies clay spots. Beardless bluebunch wheatgrass grows in the Baker County portion of the province.

More than 100 species of perennial forbs are recorded as regularly growing on upland sites in this province. This obviously is an incomplete record. Even the most arid sites in this province are characterized by a good variety of 25 or more perennial forb species.

Forested areas in the province are on higher elevations and north-facing slopes in mountainous areas. They consist mainly of combinations of ponderosa pine, Douglas-fir, and grand fir with some western juniper on shallow rocky areas and in the fringe between timbered and sagebrush areas.

Shrubs commonly associated with forested areas include wax currant, low Oregon-grape, rose, serviceberry, and spirea. Grasses include Idaho fescue, bluebunch wheatgrass, elk and threadleaf sedges, Kentucky, Canby, and Sandberg bluegrasses, prairie junegrass, Columbia needlegrass, pinegrass, and basin wildrye. A wide variety of shade-tolerant forbs grow in this coniferous tree climax type.

Originally, basin wildrye probably dominated most, if not all, bottomlands and riparian areas in the province, whether moist, semimoist, alkaline, or otherwise. Associated grass, forb, and shrub species varied according to degree of wetness and alkalinity.

Management Implications

The province includes irrigated intensive agriculture in the Vale–Ontario–Nyssa area which is devoted primarily to growing food for human use. All other valleys in the province are essentially fully used for irrigated agriculture with emphasis on production of livestock forage and feeds.

A large part of the province is public land, especially in Malheur County which is about 80% public land. The Baker County part of the province has a much lower proportion: about 40% publicly owned lands. Management of the public lands indirectly exerts a significant influence on the use and management of private lands in the province. Resource issues, problems, opportunities, and options nearly always involve both kinds of ownerships in the province, especially in the northern portion. This makes the coordinated resource management planning (CRMP) process a very appropriate way to resolve issues and improve overall resource management.

Some rangelands in low-precipitation areas near Snake River have been irretrievably damaged by nearly a century of excessive livestock grazing, wildfires, soil erosion, and possibly dryland farming. The result has been significant changes in soils and their capability to recover naturally.

Seeding to selected forage species, together with prescribed grazing systems, have proved successful in returning these lands to forage production as well as in much improving watershed quality and wildlife habitat.

In areas of about 12 inches precipitation or more, the soils inherently are more able to recover from past uses. This has been demonstrated on many ranches in the province where modern range management technology has installed practical grazing programs with good success. Although the nature of the terrace soils is such that erosion and compaction are serious considerations, these soils also respond well to seeding for rehabilitation.

The BLM Vale Project covered a large portion of the province in Malheur County, and other programs promoted by the Vale BLM District treated much BLM land in Baker County. Consequently, many effective rangeland manipulations and improvements have

been made. This benefitted many resource values including wildlife habitat, recreation, watershed quality, and range condition in addition to providing great benefits to livestock ranching. There are many examples of treatments that are effective, and some that are not, for the soil, topographic, and climatic conditions on both public and private lands in the province.

From the viewpoint of watershed quality and soil erosion, which are most important considerations, it is highly desirable to culturally revegetate all suitable soil areas in the province that are seriously depleted and not likely to recover naturally because of permanent changes in the original soil situation and plant cover.

Delays in revegetation run the risk of soil erosion, leading to a new, lower potential state. In the long run, for the health and stability of the basic resource —soil—it is far more judicious to revegetate these areas by seeding as soon as possible.

Province Demarcation

Snake River–Blue Mountain Demarcation

The line of demarcation between Snake River and Blue Mountain provinces in the northeast begins in the Snake River canyon at Copperfield on the Oxbow where the river exits Snake River Province and enters Blue Mountain Province in upper Hells Canyon. From that point, the line runs southwest up the ridge between Pine Creek and Snake River.

All drainage into Pine Valley and Pine Creek is considered to be in Blue Mountain Province, although the deep Snake River canyon makes this line a matter of judgment based mainly on native plant communities and soils. All of Eagle Valley is in Snake River Province. From the divide on Highway 86 between Eagle Valley and Pine Valley, the line runs westerly at about 4,000 feet elevation along the upper edge of the ancient terraces south of Sparta. In this area between Eagle Valley and Keating Valley and north of Powder River, there are excellent examples of dissected ancient terraces which typify Snake River Province (Fig. 41).

The line of demaracation crosses into Union County east of Pondosa at about 4,000 feet elevation and continues northwesterly through Telocaset and around the north and west edges of North Powder Valley, then south at about 4,000 feet elevation to just west of Baker City. There, an apparent geological uplift has abruptly placed the upper line of the terrace at about 4,500 feet elevation. The line continues south at about 4,500 feet elevation until just west of Unity where another apparent uplift places the upper terrace level at about 5,000 feet elevation.

The demarcation line ends southwest of Ironside Mountain where Blue Mountain Province reaches its most southern point and joins John Day Province to the south. Ironside Mountain is in Snake River; Strawberry Mountain and Prairie Hill are in Blue Mountain; Antelope Mountain east of Seneca is in John Day Province.

Snake River–John Day Demarcation

The line of demarcation between Snake River Province and John Day Province to the west, which is about 5,000 feet elevation on the uplifted area east and south of Antelope Mountain, drops down to about 4,500 feet west of Drewsey and Warm Springs Reservoir and proceeds south along the east slopes of Stinking Water Mountains.

Snake River–High Desert Demarcation

Just east of Crane, the line of demarcation between Snake River and High Desert provinces begins at about 4,250 feet elevation. It is at this point, the gap at Crane, that one might speculate about how the ancient lake, in which the terraces of Snake River Province were formed, at one time might have been connected to the ancient lake in which the terraces of the High Desert Province were formed. For this to have happened, the lakes would have had to exist simultaneously. But this is a matter of conjectural paleontology and has no current significance in differentiating between the two provinces.

Obviously, the terraces and basins in High Desert Province suggest quiet-water abatement which seems logical for such interior basins that had no strong currents escaping to the ocean. In contrast, the terraces of Snake River Province are typified by strong geologic erosion and sharp dendritic drainage patterns that suggest water receded in strong currents out through Snake River to the ocean. Consequently, the kinds of ecological sites (soils, plant communities, topography) and especially the management implications are markedly different between Snake River and High Desert provinces.

Demarcation between the provinces is likely a belt south and east of Crane to the vicinity of Folly Farm and northeast toward Crowley. There is no readily apparent line of demarcation anywhere within this belt; therefore, the line becomes a matter of field experience and judgment.

Based on the fact that ancient-terrace lines are extensive and consistently visible at about 4,500 feet elevation around the perimeter of the geologic basin that forms High Desert Province, and that the Snake River Province line west of Warm Springs Reservoir is at about 4,500 feet elevation, the line of demarcation between Snake River and High Desert provinces has been placed at about 4,500 feet elevation from the vicinity of Crane southeast to just north of Folly Farm, then northeast to just north of Crowley.

From there it runs east around the south side of Cedar Mountains to the rim of the Owyhee River canyon, which is at 4,000 feet elevation. This line places the dry lakebeds and closed basins south of Crowley in High Desert Province, which is typified by similar closed-basin topography, whereas Snake River Province to the north is typified by landscape dissected by dendritic drainages into the Snake River system.

(continued on page 114)

Table 39. Major Ecological Sites in Snake River Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Natural grassland (less than 10% canopy cover of shrubs)	Rolling hills Idaho fescue, bluebunch wheatgrass, big bluegrass, sedge/big sagebrush High clayey terrace Idaho fescue, bluebunch wheatgrass, bluegrass, sedge/rigid sagebrush	Semimoist bottom Basin wildrye, bluebunch wheatgrass, big bluegrass/basin big sagebrush Moist bottom Basin wildrye, Kentucky bluegrass, sedge, quackgrass/golden currant, Louisiana wormwood
Shrub–grassland (10% or more canopy cover of shrubs)	Droughty rolling hills Bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass/big sagebrush, bitterbrush Droughty south exposure Bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass/big sagebrush, bitterbrush South exposure Bluebunch wheatgrass, Idaho fescue/big sagebrush, bitterbrush, squawapple Droughty north exposure Bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass/big sagebrush, bitterbrush, squawapple North exposure Idaho fescue, big bluegrass, sedge/mixed shrubs Droughty terrace Bluebunch wheatgrass, Idaho fescue, Thurber needlegrass/squawapple, big sagebrush, rabbitbrush Clayey terrace Idaho fescue, bluebunch wheatgrass, bluegrasses, sedge/rigid sagebrush Mahogany rockland Idaho fescue, bluebunch wheatgrass, bluegrasses, Thurber needlegrass/curlleaf mountain-mahogany, big sagebrush, wax currant Moist scabland Idaho fescue, Sandberg bluegrass, bluebunch wheatgrass, onespike oatgrass/low sagebrush, bitterbrush, squawapple Scabland Sandberg bluegrass, Idaho fescue, bluebunch wheatgrass/low sagebrush, buckwheat, bitterbrush	Sodic bottom Basin wildrye, saltgrass, foxtail barley/ greasewood, green rabbitbrush
Coniferous tree (5% or more canopy cover of mature trees)	Juniper–pine–bunchgrass Bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass/mixed shrubs/juniper, ponderosa pine Pine–bunchgrass Idaho fescue, bluebunch wheatgrass, mixed grasses/ mixed shrubs/ponderosa pine Pine–Douglas-fir–fescue Idaho fescue, elk sedge, needlegrass, pinegrass/ mixed shrubs/ponderosa pine, Douglas-fir Pine–sedge Elk sedge, Idaho fescue, Columbia needlegrass/arnica, strawberry, lupine/mixed shrubs/ponderosa pine Pine–Douglas-fir–sedge Elk sedge, Idaho fescue, pinegrass/mixed shrubs/ ponderosa pine, Douglas-fir Fir–pine forest Shade-tolerant grasses/forbs/mixed shrubs/Douglas-fir, grand fir, larch, ponderosa pine, lodgepole pine	

Snake River–Humboldt–Owyhee Demarcation

Snake River Province includes the Owyhee River canyon up to about 6 miles upstream from Rome. In this canyon are exposed thick layers of sedimentary or tuffaceous materials that typify Snake River Province. The basalt plateau and terraces to the west of the canyon are in Humboldt Province; those to the east of the canyon are in Owyhee Province.

From the vicinity of Rome and Arock, the line between Snake River and Owyhee provinces goes north along the rim of Owyhee River canyon at about 4,000 feet elevation. It follows this elevation, which is the approximate break between the higher basalt plateaus and hills of Owyhee Province and the exposed sedimentary materials lying to the north at lower elevations, which typify Snake River Province. The line of demarcation follows along the north side of Mahogany Mountains east to Rockville and then north and east into Idaho at about the 4,000 foot elevation.

The Dalles Ecological Province

Location

The Dalles Ecological Province in north-central Oregon lies along the lower eastern slopes of the Cascade Mountains generally between about 2,000 and 4,000 feet elevation in the northern part and between about 2,500 and 4,500 feet elevation farther south, on the Warm Springs Indian Reservation. The province is relatively narrow, varying from about 6 to 15 miles wide east to west, and extends about 100 miles north to south.

This strip of country lying parallel to the Cascade Mountains is an area in which the hot, dry eastern Oregon summer climate significantly affects the ecology along the east slopes of the Cascades. It constitutes the transition between normal grasslands of Columbia Basin Province and Douglas-fir–hemlock forests of Cascade Province (Fig. 42).

In Oregon, the province covers about 530,000 acres mainly in Wasco and Jefferson counties with a small proportion in Hood River County and a very small proportion in Deschutes County near Black Butte. The province extends north across the Columbia River into Washington.

In Oregon, The Dalles city is in the extreme northeast corner of the province. Mosier is in the northwest corner. Friend, Wamic, Pine Grove, and Simnasho are just inside the eastern boundary; there are no towns in the southern part of the province.

Description

Physiographically, The Dalles Province in Oregon consists mainly of east-sloping foothills and mountain slopes bisected west to east by numerous drainages, many having abrupt basalt cliff canyons originating in the Cascades and draining into Deschutes and Columbia rivers. Elevations range from about 100 feet along the Columbia River between Mosier and The Dalles to 5,110 feet on the north end of Green Ridge near Metolius River in the southern part of the province.

Soils

Soils typifying The Dalles Province in Oregon have developed in a variety of parent materials related to the geology of the eastern slopes of Mt. Hood and the Cascade Mountains. Included are aeolian silts and volcanic ash, andesitic, basaltic, and sedimentary colluviums, and glacial outwash. Some small areas of alluvial soils lie along stream channels.

The major cultivated area in the province in Oregon lies south and west of The Dalles city. The soils are Chenoweth and Cherryhill loams and silt loams formed in old alluvium and consolidated colluvium on undulating 1 to 50% slopes. At one time much of this area was in orchards.

From The Dalles city south to about Wamic along the eastern part of the province is a sloping plateau dissected from west to east by numerous drainages, many basalt rimmed. Some small areas in the plateau have been dry-farmed for cereal grains. Soil series typifying this plateau are Ortley and Wamic which are formed in aeolian silts and volcanic ash overlying basalt bedrock.

Noncultivated soils can be grouped by the natural vegetation produced: upland natural grasslands; bottomland natural grasslands; Oregon white oak; mixed ponderosa pine/oak; pine/bunchgrass; mixed ponderosa pine/Douglas-fir; and Douglas-fir/grand fir forest.

Soils associated with upland natural grasslands are on steep south-facing slopes along major drainages in the low-elevation northeastern part of the province. These soils are shallow cobbly loam with 45 to 75% slopes. A major soil series is Bodell, which is formed in basaltic colluvium over basalt bedrock.

Soils associated with bottomland natural grasslands are limited to certain reaches in major drainages. These alluvial soils are nearly level, deep sandy loams derived from an aggregation of upstream parent materials. A major bottomland soil series is Tygh.

Soils associated with nearly pure stands of white oak are mainly in the northern part of the province on steep south-facing slopes in higher, more moist elevations than where upland natural grasslands are on similar topography. These soils are shallow to moderately deep cobbly loam with 35 to 65% slopes. Soil series include steep phases of Wamic, Skyline, and Hesslan, which are formed in a mix of aeolian and colluvium materials over basalt or sedimentary bedrock.

Soils associated with stands of mixed oak and ponderosa pine are mainly in the northern and eastern parts of the province at mid-elevations on plateaus and steep south-facing slopes.

On some plateaus, the soils are in a complex soil pattern of nonstony mounds interspersed with very shallow stony soils, a pattern called biscuit scabland. Oak and pine grow on the biscuits which are typified by Ortley, Wamic, and Skyline soil series; they are derived from aeolian materials overlying basalt or sedimentary bedrock.

The interspersed scabland is Bakeoven series which, in this province in Oregon, atypically does not produce a low-growing species of sagebrush. For one explanation of the origin of this patterned land, see the earlier section on Columbia Basin Ecological Province in which biscuit scabland is a prominent, widespread phenomenon.

On other plateaus, mixed oak and pine grow on relatively level soils having deep, medium-texture surface layers and loamy subsoils. A representative soil series is Wamic, which is formed in aeolian materials over basalt bedrock.

In more moist, higher elevations, mixed oak and pine are on steep (45 to 75%) south-facing slopes of soils that are moderately deep cobbly or stony loams. A representative series is Bald, which is formed in aeolian materials and basalt colluvium overlying basalt bedrock.

Soils associated with ponderosa pine and bunchgrass plant communities lie mainly in the south half of the province, on the Warm Springs Indian Reservation. The soils include Booten and Shiva, which are sandy loams formed in basalt colluvium; Tenwater, Milldam, and Tolius, which are very cobbly silt loams formed in glacial outwash; and Hehe and Teewee, which are very stony loams formed in basalt colluvium.

Soils associated with ponderosa pine and Douglas-fir forests are in higher footslopes throughout the length of the province in Oregon. In the north, these soils include Bald, Wamic, Ketchly, and Frailey, which are formed in aeolian materials and colluviums over bedrock. Farther south on the reservation, these soils include series such as Smiling, Simnasho, and Pipp, which are strong sandy loams formed in colluvium of igneous rock and ash.

Soils associated with Douglas-fir and grand fir forests, which are mainly on north exposures at higher elevations in the northern part of the province in Oregon, are typified by such soils series as Bins and Fouts. These soils are formed in aeolian materials and basaltic and andesitic colluviums over bedrock.

Climate

Based on six official weather stations in the eastern low-elevation part of The Dalles Province in Oregon, average annual precipitation in this area is about 14.5 inches of which about 25% is during the herbaceous native-plant growing season, March through June. October through February (winter) precipitation is about 66% of total annual precipitation.

Average January maximum and minimum temperatures for this portion of the province are 38.7 and 22.6°F, respectively. Average March through June maximum and minimum temperatures are 65.5 and 36.5°F, respectively.

A precipitation map[53] shows about 50 inches or more annual precipitation along the western boundary of The Dalles Province in Oregon. Temperatures at about 4,000 feet elevation, which is the western boundary of the province in Oregon, are not represented in data from official weather stations.

Along the province's eastern boundary in Oregon, precipitation increases from east to west as elevation increases. The southernmost weather station, Montgomery Ranch south of Metolius River in Jefferson County, is both drier and warmer than stations farther north. This correlates with the previously described phenomenon of the advent of western hemlock at increasing elevations from north to south along the Cascade Mountains in Oregon.

Vegetation

According to the 1936 State of Oregon Forest Type Map[54] which predates extensive logging, about 85% of The Dalles Province in Oregon was covered by coniferous and mixed coniferous and oak forest at that time. About 5% was covered by Oregon white oak savannah, and about 10% was nonforested and conceivably in natural grasslands (less than 10% canopy cover of shrubs).

According to this map, ponderosa pine was by far the dominant tree species in the province. Based on field ecological studies, other coniferous tree species include Douglas-fir, grand fir, western white pine, lodgepole pine, western larch, and western red cedar, depending on the effective environment of the particular site.

Natural grasslands in The Dalles Province in Oregon are primarily on arid south-facing slopes in lower elevations along the northeastern portion of the province. Dominant species include bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue, prairie junegrass, Lemmon needlegrass, and a wide variety of perennial forbs such as arrowleaf balsamroot, barestem and heartleaf buckwheats, barestem lomatium, yarrow, and lupine. Sagebrush is not a component of upland plant communi-

Table 40. Climatic Data for The Dalles Ecological Province, Oregon.[17]

Station and length of record (years)	Elevation (feet)	Precipitation			Average maximum and minimum temperatures (°F)	
		Annual (inches)	Oct.-Feb. (%)	March-June (%)	January	March-June
Jefferson County						
Montgomery Ranch[a] 17	1,900	14.2	67	26	40.9-22.5	66.8-33.1
Wasco County						
Ortley Station[b] 12	1,600	21.9	74	18	35.5-23.7	60.2-37.3
The Dalles 21	96	13.8	72	22	39.6-27.3	69.5-45.4
Dufur[c] 20	1,250	12.0	65	28	37.9-22.3	66.8-36.0
Ramsey Station[d] 16	1,350	15.3	52	25	not available	not available
Friend 9	2,500	16.8	68	26	34.6-17.2	60.2-32.7
Wamic 15	1,800	15.0	69	22	40.3-23.9	64.4-35.2
Average along eastern (low-elevation) province border		14.5	66	25	38.7-22.6	65.5-36.5

No official weather stations in The Dalles Province in Deschutes or Hood River counties.

[a] South of Metolius River in Jefferson County.

[b] About 2 miles southwest of Rowena.

[c] Within Columbia Basin Province but very close to The Dalles Province line.

[d] About 5 miles southwest of Dufur.

ties in The Dalles Province even under deteriorated conditions. This includes very shallow, very stony scablands which normally grow low or rigid sagebrush in other provinces. However, sagebrush has encroached on some deteriorated bottomland sites. Gray rabbitbrush, gray horsebrush, and poison-oak grow in minor amounts on upland grassland sites.

Oak savannahs are primarily on south-facing slopes ranging from about 1,200 to 3,500 feet elevation and on steep north-facing slopes from about 1,000 to 3,000 feet elevation in the northeastern part of the province in Oregon. On south-facing slopes, the stand of oak is sparse; however, it dominates the aspect of the site.

The understory is strongly dominated by bluebunch wheatgrass, Sandberg bluegrass, and Idaho fescue. A variety of perennial forbs and a few shrubs and oak reproduction are common. On steep north-facing slopes, oak grows with good stand density. Occasionally there are ponderosa pine and Douglas-fir. Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass, and big and Kentucky bluegrasses are prominent. A wide variety of perennial forbs and such shrubs as bitterbrush, deerbrush ceanothus, serviceberry, snowberry, rose, gray rabbitbrush, and both oak and sparse pine reproduction are common.

The most arid portion of coniferous forest in The Dalles Province in Oregon is in stands of mixed ponderosa pine and Oregon white oak which are on ridgetops and sloping areas ranging from about 1,000 to 2,500 feet elevation. The overstory consists of ponderosa pine and oak; all age classes of both species are represented. A wide variety of perennial bunchgrasses and forbs constitute the understory along with abundant bitterbrush, deerbrush ceanothus, rose, serviceberry, snowberry, poison-oak, greenleaf manzanita, and both oak and pine reproduction.

As the effective environment improves due to increased elevation and/or increased moisture, conifer forest areas of The Dalles Province in Oregon are characterized by different plant communities; for example, ponderosa pine/bitterbrush/bunchgrass sites; ponderosa pine/Douglas-fir/mixed shrubs/elk sedge sites; mixed fir/ponderosa pine forest sites; and mixed fir forest sites.

Ponderosa pine/bitterbrush/bunchgrass sites occur from about 1,700 to 2,700 feet elevation. The shrub understory is dominated by bitterbrush. Dominant grasses include Idaho fescue and bluebunch wheatgrass.

Pine/Douglas-fir/mixed shrubs/elk sedge sites lie from about 1,200 to 3,000 feet elevation. The herbaceous understory typically consists of a wide variety of perennial species such as elk sedge, Idaho and western fescues, spike trisetum, Alaska oniongrass, Kentucky and pine bluegrasses, blue wildrye, pinegrass, and mountain brome.

The forb component consists of such species as peavine, American vetch, woollyweed, cinquefoil, shining frasera, Douglas deervetch, white hawkweed, licoriceroot, lupine, penstemon, strawberry, yarrow, big deervetch, mountain sweetroot, and arrowleaf balsamroot.

The shrub component is also typified by numerous species in abundance. It commonly includes species such as bitterbrush; redstem, deerbrush and squawcarpet ceanothus; mockorange; blue elderberry; serviceberry; pipsissewa; oceanspray; greenleaf and pinemat manzanita; shinyleaf spirea; low Oregon-grape; rose; snowberry; and hazel. Ponderosa pine, Douglas-fir, incense-cedar, and white oak of all age classes may be in the stand.

The mixed fir–pine forest grows from about 2,500 to about 2,800 feet elevation on north-facing slopes and sloping areas. It has a relatively dense tree canopy cover which may include minor amounts of grand fir. The midstory consists of about 25% canopy cover of tall shrubs such as willow,

thimbleberry, rose, blue elderberry, serviceberry, redstem and deerbrush ceanothus, mockorange, Cascade Oregon-grape, hazel, ninebark, trailing blackberry, oceanspray, snowberry, pinemat manzanita, pipsissewa, and birchleaf spirea. Both grasses and forbs constitute a sparse stand of shade-tolerant species such as pinegrass, elk sedge, blue wildrye, Kentucky bluegrass, false solomonseal, woollyweed, and strawberry.

The mixed-fir forest is on mountain slopes ranging from about 2,500 to 4,000 feet elevation. It is primarily a Douglas-fir–grand fir forest which may have an occasional ponderosa pine, western larch, or western white pine in the stand. The understory is very sparse and consists of shade-tolerant species.

The herbaceous understory is typified by Alaska oniongrass, elk sedge, blue wildrye, western fescue, mountain brome, tall trisetum, white hawkweed, peavine, strawberry, sword fern, arnica, mountain sweetroot, trillium, bunchberry dogwood, meadowrue, solomonplume, phantom-orchid, cleavers bedstraw, sandwort, pathfinder, and starflower.

The shrub understory is typified by willow, vine maple, serviceberry, redstem ceanothus, snowberry, rose, hazel, honeysuckle, oceanspray, thimbleberry, bittercherry, trailing blackberry, golden (bush form) chinkapin, pipsissewa, greenleaf manzanita, Cascade Oregon-grape, twinflower, and reproduction of both Douglas-fir and grand fir.

The Dalles Province in Oregon is noteworthy for its wide variety of shrub, grass, and forb species and their abundance under tree canopies.

Table 41. Average Dates Vegetation Growth Begins and Ends in The Dalles Ecological Province, Oregon.

Station and length of record (years)	Elevation (feet)	Average date growth begins*	Average date growth ends*
Jefferson County			
Montgomery Ranch 17	1,900	March 1	June 5
Wasco County			
Dufur 20	1,250	March 1	June 21
Friend 9	2,500	March 27	August 12
Ortley Station 12	1,600	March 11	September 3
Ramsey Station 16	1,350	March 11	July 20
The Dalles 21	96	February 18	June 25
Wamic 15	1,800	March 14	July 17

No official weather stations in The Dalles Province in Deschutes or Hood River counties.

*The average date vegetation growth begins on native perennial bunchgrasses is approximately the date average daily temperatures reach 39 to 40°F. Average date growth ends is considered to be when available soil moisture is depleted. Interpretations are based on data in Johnsgard.[17]

Management Implications

A very large portion of The Dalles Province in Oregon is forest and rangeland. An area of Chenoweth and Cherryhill soils south and west of The Dalles city was at one time used for orchards. Some areas of Wamic and Ortley soils are used primarily for dryland farming for cereal grain. All these soils are subject to soil erosion during storm seasons and spring runoff.

The southern half of the province in Oregon lies in the Warm Springs Indian Reservation and in Deschutes National Forest. Much of the north half in Oregon lies in Mt. Hood National Forest. Only about 25% of the province in Oregon is privately owned.

Province Demarcation

The Dalles–Columbia Basin Demarcation

The line of demarcation between The Dalles Province and Columbia Basin Province in Oregon starts in the northeast corner of The Dalles Province on the Columbia River east of The Dalles city near the mouth of Fifteenmile Creek and The Dalles dam. From there, the line goes south about 2 miles east of The Dalles city and continues south to west of Dufur, which is in Columbia Basin Province. The line continues south to a point just east of Friend, which is in The Dalles Province, and to a point east of Wamic which also is, barely, in The Dalles Province. From Wamic, the line wanders southwest to near Smock Prairie and then south to Pine Grove on Highway 216. From Pine Grove the line goes southeast to the pass on the ridge where the Wapinitia–Warm Springs road crosses the major ridge going south, the top of the Mutton Mountains. At this ridgetop crossing, Columbia Basin, The Dalles, and John Day provinces join.

The demarcation line between The Dalles and Columbia Basin provinces in Oregon is based on soil lines between Frailey, Wamic, and Skyline soils, which typify the eastern footslopes of the Cascade Mountains—The Dalles Province—and the Condon, Walla Walla, Wapinitia, and Maupin soil series, which typify Columbia Basin Province.[86]

The Dalles–John Day Demarcation

At the ridgetop where the Wapinitia–Warm Springs road crosses the major ridge going south, the line of demarcation between The Dalles and John Day provinces winds south to the vicinity of Simnasho, which is in The Dalles Province. The line circles around Simnasho to the east and south and then heads west toward Hehe Butte, also in The Dalles Province. From Hehe Butte the line travels south at about 2,500 feet elevation passing near Sawmill Butte, across the headwaters of Tenino Creek, and then southwest to Metolius River. The line follows Metolius River downstream to Fly

Table 42. Major Ecological Sites in The Dalles Ecological Province, Oregon.

Climax type	Upland site types & characteristic vegetation	Bottomland site types & characteristic vegetation
Natural grassland (less than 10% canopy cover of shrubs)	Arid south exposure Bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue, Lemmon needlegrass/ bitterbrush	Moist bottom Basin wildrye, bluebunch wheatgrass.
Deciduous tree (5% or more canopy cover of trees)	Oak south exposure Bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass/bitterbrush/oak Oak north exposure Idaho fescue, bluebunch wheatgrass, Kentucky bluegrass/shrubs/oak	
Mixed coniferous–deciduous tree (5% or more canopy cover of trees	Ponderosa pine–oak–fescue Idaho fescue, elk sedge/shrubs/pine, oak	
Coniferous tree (5% or more canopy cover of mature trees)	Pine–bunchgrass Idaho fescue, bluebunch wheatgrass/ bitterbrush/ponderosa pine Pine–Douglas-fir–sedge Elk sedge, western fescue, blue wildrye/oak, incense-cedar, ponderosa pine, Douglas-fir Mixed fir–pine forest Shade plants/many shrubs/Douglas-fir, grand fir, ponderosa pine Mixed fir forest Shade plants/many shrubs/Douglas-fir, grand fir	

Creek and then up Fly Creek and around the east side of Squaw Back Ridge at about 2,500 feet elevation to what is locally called Lower Desert. It is at this location that The Dalles, John Day, and Mazama provinces join.

The line of demarcation between The Dalles and John Day Provinces is based on soil lines between soil series such as Smiling, Hehe, Simnasho, and Pipp, which typify The Dalles Province, and soil series such as Simas, Watama, Prill, Mutton, and Madras, which typify John Day Province on the Warm Springs Indian Reservation.[96]

The Dalles–Mazama Demarcation

From the location near Lower Desert, the line of demarcation between The Dalles and Mazama provinces goes south and west to encompass a small area in Deschutes County that is southeast of Black Butte, which is in Mazama Province.

From the east side of Black Butte, the line goes northerly along Green Ridge at about 4,500 feet elevation to about where Abbot Creek joins Metolius River. There, The Dalles, Mazama, and Cascade provinces join.

The line of demarcation between The Dalles and Mazama provinces is a relatively short distance of about 35 miles. The line is based on soil lines between soil series such as Hehe, Teewee, Smiling, and Pipp, which typify The Dalles Province on the Warm Springs Indian Reservation, and soil series such as Deschutes and Shanahan, which represent the pumice mantle that typifies Mazama Province lying to the south of the reservation.[70, 96]

The Dalles–Cascade Demarcation

From the point that The Dalles, Mazama, and Cascade provinces join, the line of demarcation between The Dalles and Cascade provinces in Oregon meanders northward along the mountains at about 4,500 feet elevation. This line is the approximate elevation at which western hemlock becomes a component of forested plant communities in this area.

The advent of western hemlock signifies the location on the upper Cascade footslopes and mountain sides where the hot, dry summer climate of eastern Oregon is no longer an ecological factor influencing forest composition. Below this line, the forest is typified by ponderosa pine, Douglas-fir, and Oregon oak; above the line, the forest is typified by Douglas-fir, true firs, and hemlocks.

Numerous field observations over several decades are that the advent of western hemlock in the forest composition is a reliable widespread ecological indicator of the location on the landscape at which a very significant ecological change occurs when transecting from arid and warm forest to moist and cold forest.

Other species—trees, shrubs, and herbaceous—also change from zone to zone in transecting dry–warm to moist–cold conditions. However, western hemlock was chosen as the key indicator species to differentiate between some ecological provinces in western Oregon because, first, it is widespread at higher elevations on both east and west slopes of the Cascades and from the Coast Range west to the Pacific Ocean; and, second, a tree reliably indicates average climatic conditions that have prevailed over long cycles.

Elevations cited as western hemlock's entry level in the forested plant community are based on observations of sites representing the climatic climax, i.e., on relatively level topography not significantly influenced by topographic exposure and where the plant community and soils likely are in equilibrium with long-term climatic conditions.

Obviously, western hemlock cited as occurring at about 4,000 feet elevation in a climatic climax location will be at somewhat higher elevations on more arid south-facing slopes and at somewhat lower elevations on more moist north-facing slopes because of the influence of topographic exposure.

In the southern part of Wasco County, the line of demarcation between The Dalles and Cascade provinces, which is based on the appearance of western hemlock, drops to about 4,000 feet as it goes north. Western hemlock's growth at lower elevations in northern parts of Oregon than in southern parts is true for both eastern and western slopes of the Cascade Mountains as well as along the eastern slopes of the Coast Range. Apparently, this is due to the overall warmer climatic conditions to the south, which causes western hemlock to first appear at a higher elevation on mountain ranges.

The line of demarcation between The Dalles and Cascade provinces runs north to a point near the southeast corner of the upper Hood River Valley. At this point, The Dalles, Cascade, and Willamette provinces join.

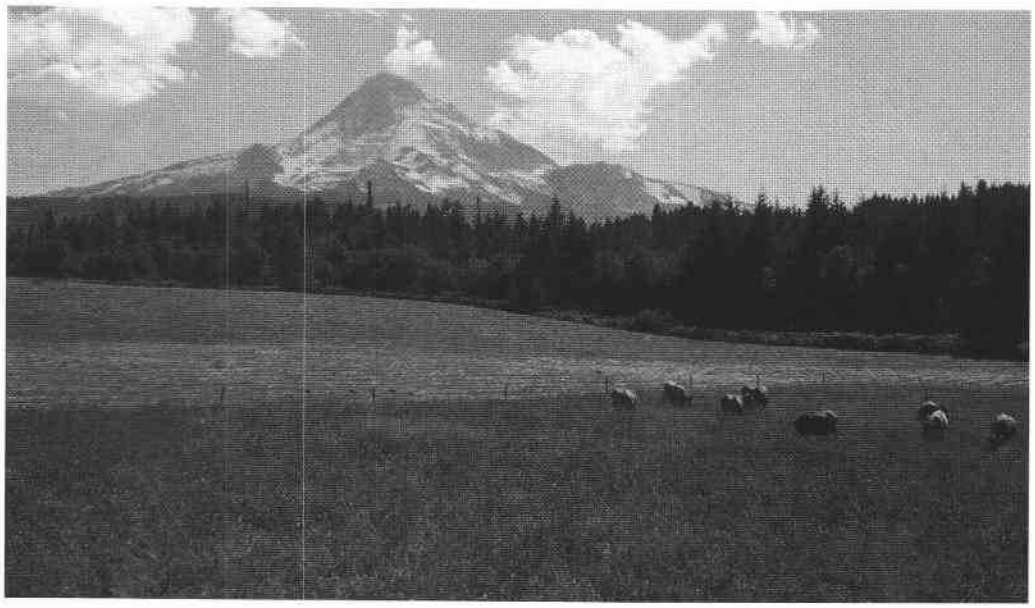
Although the line between The Dalles and Cascade provinces is based on the elevation at which western hemlock appears, the line also is indicated by the general presence of such forested soils as Smiling, Simnasho, and Pipp, which typify The Dalles Province, and Howash and Mackatie forested soils, which typify Cascade Province on the Warm Springs Indian Reservation.[96] Farther north, the line of demarcation is indicated by the general presence of such forested soils as Bald, Ketchly, and Frailey, which typify The Dalles Province in Oregon, and Divers, Hutson, and Thader forested soils, which typify Cascade Province in Oregon.[89]

The Dalles–Willamette Demarcation

The line of demarcation between The Dalles and Willamette provinces in Oregon goes north from near the southeast part of upper Hood River Valley at about 4,000 feet elevation. It runs along the ridge east of the valley and winds around the head of Neal Creek and north down the ridge nearly to Highway I-84 along the Columbia River.

Here it veers sharply upriver nearly to Mosier, which is in The Dalles Province. The town of Hood River and the entire Hood River Valley are in Willamette Province.

The line of demarcation between The Dalles and Willamette provinces in Oregon is based on soil lines between Bald, Bodell, Frailey, and Ketchly soil series which typify The Dalles Province in Oregon, and Hood, Van Horn, Oak Grove, and Bins soil series, which typify Willamette Province in Oregon.[89]



Willamette Ecological Province

Location

Willamette Ecological Province in Oregon lies between the Cascade and Coast mountain ranges in western Oregon. It extends west to east along the south side of the Columbia River from about Rainier in Columbia County upriver to about Mosier in northwest Wasco County, a distance of roughly 100 riverbank miles.

From north to south, it extends from the Columbia River near Rainier to about 25 miles southwest of Roseburg in Douglas County. It is about 50 miles wide, east to west, at Corvallis; the narrowest area, about 15 miles wide, is near Cottage Grove. The province is about 220 air miles long from north to south.

Willamette Province in Oregon covers about 6.2 million acres in Clatsop, Columbia, Tillamook, Washington, Multnomah, Hood River, Yamhill, Clackamas, Polk, Marion, Lincoln, Benton, Linn, Lane, Coos, and Douglas counties. It extends north across the Columbia River into Washington.

Description

Physiographically, Willamette Province in Oregon includes nearly the entire drainage system of the Willamette River, which flows into the Columbia River at Portland. It also includes major portions of the Hood River system, which flows into the Columbia River at Hood River, and the Umpqua River system, which flows into the Pacific Ocean at Winchester Bay. To a lesser extent, upper reaches of Nehalem, Siuslaw, and Coquille rivers, which flow into the Pacific Ocean, are within Willamette Province.

Willamette Province has three general geomorphic features:

- Geologically recent alluvial low terraces and floodplains—the valley floor;
- Old valley fill and ancient high terraces; and
- Relatively low-elevation residual hill lands, mainly less than 1,700 feet elevation, which include the foothills of both the Cascade and Coast mountain ranges.

The lowest elevation in the province is about 50 feet at Rainier on the Columbia River. A number of isolated buttes and mountains 2,000 feet or more in elevation are throughout the province. Most of the province is below about 1,700 feet elevation, which is the approximate elevation in the foothills at which western hemlock begins to grow along the Cascade and Coast mountain ranges.

Numerous field observations are that the advent of western hemlock in the forest composition is a reliable, widespread ecological indicator of the location on the landscape at which a very significant ecological change occurs in soils, vegetation, and management implications when transecting from arid, warm forest to moist, cold forest. Other species—woody and herbaceous—also change concurrently with the advent of western hemlock.

In Oregon, western hemlock in a forest apparently indicates an effective environment equivalent to 60 or more inches annual precipitation and significantly cooler local climatic conditions.[34, 35, 36, 37, 44, 45, 46]

Western hemlock, being a tree, reliably indicates average conditions that have prevailed over long climatic cycles. Consequently, western hemlock was chosen as the key indicator species to differentiate Willamette Province, in which western hemlock is not generally common in forested uplands, from the contiguous Cascade and Coast provinces in which western hemlock generally is common in forested uplands.

Soils

The geomorphology of soils typifying Willamette Province in

Oregon involves a variety of parent materials including geologically recent alluvial low terraces and floodplains in the Willamette Valley, old valley fill, ancient high terraces, and low residual foothills of both the Cascade and Coast mountain ranges. Further complication results from the geographic extent of Willamette Province. The province includes all or part of 16 counties as well as nearly the entire Willamette River drainage system and parts of Hood, Umpqua, Nehalem, Siuslaw, and Coquille rivers' drainage systems.

Consequently, soil series of Willamette Province are too numerous to categorize. However, a geographic listing of prominent soil series illustrates how some series are widespread in the province whereas others are more or less localized (Table 43).

Climate

Based on 36 official weather stations representing Willamette Province in Oregon, average annual precipitation is about 50.4 inches, of which about 38% falls during the herbaceous-plant growing season, February through June. October through January (winter) precipitation is about 56% of the total. Average January maximum and minimum temperatures are 43.9 and 30.3°F, respectively. Average February through June growing season maximum and minimum temperatures are about 61.4 and 40.2°F, respectively.

The lowest average annual precipitation is recorded at Hood River Experiment Station at 29.5 inches. However, 35% of this falls during the herbaceous-plant growing season, which is typical of the precipitation pattern throughout the province. The highest recorded average annual precipitation is 74.7 inches at the Portland Water Bureau Station on Bull Run River in eastern Clackamas County. Of this, 40% falls during the herbaceous-plant growing season.

Douglas County weather stations are the warmest in the province, undoubtedly because they are near Siskiyou Province to the south, which overall has a warmer, California-type climate. A precipitation map[53] reflects the relatively uniform precipitation pattern throughout Willamette Province in Oregon. Precipitation and temperature data vary by location, as shown in Table 44 (page 108).

Vegetation

In terms of vegetation, Willamette Province in Oregon is that area below the elevation at which western hemlock grows, starting from the vicinity of Hood River Valley downriver to about Bridal Veil and then south along the foothills of the Cascade Range at about 1,400 to 1,800 feet elevation. The west boundary of Willamette Province is that area below the elevation at which western hemlock grows, from the vicinity of Rainier on the Columbia River south along the foothills and crest of the Coast mountain range generally at or below about 1,750 feet elevation. Along both these demarcation lines, Willamette Province is typified by Douglas-fir, white fir, bigleaf maple, and Oregon white oak. By contrast, the Cascade and Coast provinces are typified by the advent of western hemlock in forested plant communities.

Refer to Table 7 (pages 18-19) in the section on Cascade Ecological Province for a comparison of the more abundant and characteristic grass, shrub, and tree species in the Cascade, Coast, and Willamette provinces in Oregon.

The southern boundary of Willamette Province is contiguous with Siskiyou Province. Several key indicator vegetation species typify each province. For example, uplands below about 1,300 feet elevation in southern Willamette Province are characterized by the common presence of bigleaf maple, Oregon white oak, scotchbroom, and small amounts of Pacific madrone. Equivalent uplands in Siskiyou Province are typified by California black oak, wedgeleaf ceanothus, and abundant madrone, which strongly dominates logged and otherwise disturbed forested areas.

Towle[31] summed up a number of documented observations made in mid-1840s by saying, "The Willamette Valley presented to the first settlers a remarkably open landscape set between the dense forest of the Cascades and the Coast Range. Perhaps Wilke's [an expedition in 1841] observation that the prairie occupied one-third more of the valley than did woodland is a fair general estimate of its extent."

Habek[13] studied land survey records made when Willamette Valley was being subdivided during the 1850s. From survey notes, he constructed a vegetation map that includes seven townships transecting east and west in Marion and Polk counties, a total of 252 square miles. He believed this transect to be representative of a large portion of Willamette Valley at that time. He showed five major vegetational types on the map: oak opening, oak forest, Douglas-fir forest, bottomland forest, and prairie.

Oak openings had trees 50 feet or more apart; if less than 50 feet, they were reported as oak forest. Average distance between trees in oak openings was 143.6 feet compared with 36.5 feet in oak forest. Oak openings were widely distributed in the transect; one township had about 90% oak openings.

Only a small portion of the area included in the transect was covered by oak forest. After valley fires were controlled and oak reproduction was successful in oak openings, the total amount of oak forest gradually increased. Habek[13] states that in 1961 oak forests were not uncommon in much of Willamette Valley (Fig. 43).

Isolated groves surrounded by prairie were limited in species composition to white oak and Douglas-fir with the exception of scattered concentrations of ponderosa pine on more droughty sites, especially in southern parts of the valley.

Habek's map[13] shows that Douglas-fir forest dominated both the west and east sides of the valley transect. He noted that this forest type is located at distinctly higher elevations and should perhaps be more properly considered as a part of the mountain ranges on either

(continued on page 125)

Table 43. Distribution of Some Representative Soil Series in Willamette Ecological Province, Oregon.

Representative soil series	Oregon counties											
	Benton	Clackamas	Columbia	Douglas	Hood River	Lane	Linn	Marion	Multnomah	Polk	Washington	Yamhill
Aloha		x									x	x
Amity								x				x
Awbrey							x					
Bashaw						x	x					
Bellpine				x		x					x	
Bins					x							
Camas				x								
Cascade		x	x						x		x	
Cazadero		x										
Chehalis	x							x		x		
Cloquata						x	x	x		x		
Coburg				x								
Concord								x				
Conser							x					
Culberson					x							
Dayton	x						x	x				x
Dixonville				x			x					
Evans				x								
Goble			x						x			
Hembre						x				x		
Hillsboro		x										
Honeygrove	x					x	x			x		
Hood					x							
Jory	x	x					x	x		x		x
Klickitat	x			x		x	x			x		
Latourell									x			
Laurelwood											x	
Melby											x	
Multnomah									x			
Nehalem			x									
Nekia							x	x		x		x
Newberg				x		x	x	x		x		
Oak Grove					x							
Oakland				x								
Olyic			x								x	
Parkdale					x							
Peavine	x			x		x	x			x		x
Philomath	x			x		x						
Powell									x			
Price	x											
Ritner	x											
Sauvie			x						x			
Steiwer										x		
Sutherlin				x								
Waldo						x						
Wapato												x
Willakenzie				x								x
Willamette	x						x			x		x
Woodburn	x	x					x	x		x	x	x
Wyeast					x							
Yamhill												x

Table 44. Climatic Data for Willamette Ecological Province, Oregon.[17]

Station and length of record (years)	Elevation (feet)	Precipitation			Average maximum and minimum temperatures (°F)	
		Annual (inches)	Oct.-Jan. (%)	Feb.-June (%)	January	Feb.-June
Benton County						
Alpine 16	400	49.2	58	36	46.1-33.5	60.6-38.3
Corvallis 21	205	37.2	59	36	46.2-33.5	63.1-42.1
Clackamas County						
Estacada 21	414	57.4	52	41	45.5-31.7	62.0-45.7
Miramonte 31	162	43.5	53	39	44.4-32.8	60.6-40.8
Portland						
Water Bureau Sta. 22	747	86.2	53	40	42.2-30.9	60.1-39.6
Stafford 22	413	49.4	54	38	44.8-33.3	60.0-40.8
Columbia County						
Birkensfield 8	540	70.7	55	40	44.8-28.1	60.1-36.1
Clatskanie 17	50	55.6	55	40	41.9-31.3	58.9-40.5
Doraville 29	600	47.9	54	38	41.1-30.8	57.6-38.5
Vernonia 14	628	45.3	55	39	43.7-27.3	59.9-36.3
Douglas County						
Drain 15	302	47.4	59	36	47.3-33.9	64.7-41.2
Elkton 15	125	50.2	57	39	46.9-33.4	64.4-40.6
Roseburg 57	464	32.5	55	39	47.2-34.9	63.1-41.9
Hood River County						
Cascade Locks 21	100	76.6	57	37	40.6-30.7	61.4-42.3
Hood River Exp. Sta. 22	500	29.5	61	35	38.4-26.8	61.0-39.2
Parkdale 22	1,740	46.0	61	35	37.3-22.3	59.1-34.3
Lane County						
Cottage Grove 22	650	46.3	56	39	46.1-32.1	62.1-39.7
Eugene 57	361	40.6	59	36	44.5-31.4	61.2-40.2
Fern Ridge Dam 9	380	37.9	58	37	43.3-29.9	60.4-44.9
Leaburg 19	675	59.7	53	41	45.6-32.8	63.1-41.3
McKenzie Bridge 18	1,200	69.0	55	40	41.6-27.3	62.9-37.0
Oakridge 17	1,275	43.7	54	40	46.2-30.0	65.1-39.0
Linn County						
Albany 22	212	40.7	57	37	45.4-32.5	63.3-41.8
Cascadia 19	796	60.2	51	43	44.4-29.7	62.4-38.8
Marion County						
Mount Angel 37	485	47.2	53	37	45.4-34.2	60.8-43.0
Salem 52	182	41.3	56	38	45.0-31.8	62.1-40.5
Silver Creek Falls 12	1,340	74.2	51	42	44.3-28.2	59.1-35.7
Multnomah County						
Bonneville Dam 15	55	72.5	55	38	40.0-30.3	60.0-42.8
Portland 52	33	42.1	55	38	44.3-34.4	60.8-44.4
Polk County						
Dallas 16	325	48.8	57	39	43.9-29.4	62.2-38.1
Falls City 20	355	72.7	60	36	44.7-30.4	61.1-41.2
Wallace orchard 21	173	38.4	55	38	44.6-31.4	61.1-40.2
Washington County						
Forest Grove 22	180	46.2	59	35	43.2-30.7	62.8-40.2
Hillsboro 22	203	38.3	58	35	44.0-30.7	63.0-39.8
Yamhill County						
Cherry Grove 15	900	52.5	57	38	42.2-29.4	58.0-39.3
McMinnville 17	145	42.6	58	37	43.7-30.9	62.8-40.3
Newberg 11	400	48.7	55	38	45.4-33.8	60.3-40.6
Province Average		50.4	56	38	43.9-30.3	61.4-40.2

side of the valley, which is what the concept of Willamette Province does. The high density of trees in the fir forest was one feature particularly noted by early surveyors. Douglas-fir also was locally abundant in ravines and on floodplains.

Bottomland forests occupied the floodplains along creeks and rivers. Four tree species were about equally common: Oregon ash, black cottonwood, Douglas-fir, and bigleaf maple. Other species included white oak, laurel, alder, cherry, and willow. The understory included a large number of shrub species. Towle[31] calls these bottomland forests "gallery forests."

Prairie type was grassland vegetation which occupied a rather large portion of mid-Willamette Valley according to Habek's map.[13] A small portion was low, wet prairie, and the remainder was upland prairie. Unfortunately, very little information is provided about the kinds of plants that composed the grasslands since surveyors' references to herbaceous plants were to "grasses," "ferns," and "weeds."

The study made in the Salem area by Nelson[22] provides a list of native and introduced grass species. Of the 106 species listed, 55 were introduced species and 51 were thought to be native. That was in 1919. It is interesting that the grasses on well-drained sites include six species of fescue: sixweeks, California, red, western, bearded, and Idaho.

Accurate information about forbs associated with native prairie grasses has not been found. According to Habek, a search for prairie relicts in Willamette Valley was unsuccessful.

According to the 1936 State of Oregon Forest Type map[54] representing the part of Willamette Province north of Eugene, about 45% of the province was classified as agricultural land. About 35% was classified as forest, including huge areas of heavily cut-over and second-growth trees in Columbia County. About 20% was classified as nonforest. The map, because of scale, does not show the bottomland forests along streams and drainages which, collectively, must have been a significant feature of areas classified as agricultural and nonforest.

In the part of the province south of Eugene, the vegetation pattern was very different due, at least partially, to the narrowing of the valley floor. In this part of the province, about 45% was classified as forest with recent cut-over land around Cottage Grove. About 25% was classified as nonforest, and about 20% was covered by oak.

Authors who have written about Willamette Valley vegetation express little doubt that the potential natural vegetation of the valley and adjacent uplands was a forest system of some type. They also point out that annual fires set by the Calapooya people, and to a lesser extent by early settlers, were probably the single most important barrier to forest expansion.

The scale and frequency of fires declined abruptly with agricultural settlement; this must have allowed woodland to transgress on uncultivated prairie in early days. Areas not cleared for farming likely were transformed into oak forests.

As of 1964, an estimated 400,000 hectares (1 million acres) of oak woodland were in the Willamette Valley.[29] Open woodland, an extensive type in 1854, had virtually disappeared by 1970.[31] Level and gently sloping lands, formerly woodlands, were changed to agriculture. On steeper slopes, open woodland changed to forests. The result: a considerable drop in number of trees in the valley floor and a considerable increase in the number of trees in the hills.

Several other authors have published assessments of Willamette Province vegetation from a historical viewpoint.[10, 16, 25, 27]

The data for Lane County represent a reasonable cross-section of Willamette Province climatic conditions. The county lies in the center of the province, and data include three stations on the main valley floor and three stations in extensions of the valley eastward up major drainages.

It should be noted that the three weather stations in Douglas County, which reflect average January temperatures that permit growth of herbaceous plants all winter, are in the Umpqua Valley. This is at the south end of Willamette Province, contiguous to Siskiyou Province, where a California-type climate prevails.

Management Implications

In managing Willamette Province's natural resources, it is essential to recognize that the basic ecology has not changed over time. Unless humans intervene, the trend still is and will continue to be some sort of plant succession toward a forest climax type because of climatic factors in Willamette Province that favor tree growth.

Calapooya people managed the resources for their use with annual fires. Early settlers also used fire but to a lesser extent. As human activities increased and expanded in the province, more and more restrictions on using fire have been enforced. Consequently, prescribed fire is virtually always against some law, except for limited and specifically approved field and slash burning. Essentially, this means that the natural ecological succession in Willamette Province is largely unimpeded except where farming practices and approved chemicals, or housing developments, are applicable (Fig. 44).

In the absence of fire, weeds and brush are early successional stages in a forest climax type. On permanent pasture, grazing alone is not likely to control brush encroachment permanently. Severe utilization of the pasture may actually accelerate brush encroachment and, eventually, tree encroachment. However, using selected classes of animals, such as sheep and goats, and beneficial grazing management may be reasonably successful in postponing natural ecological succession toward a forest climax type.

Encroachment and increased density of woody species in Willamette Province, which naturally occurs in successional stages toward forest climax, should be

expected unless deliberately controlled. Increasing forested areas, coupled with growing demand for housing sites in a perceived rural lifestyle, increases the risk of wildfire damage; increases public costs for transportation, sewage, domestic potable water, pollution control, household services, roads, and police protection; and sets up conflicts between residents and those who work in agriculture and forestry, even when these enterprises are in equilibrium with sustainable uses of a healthy forest climax.

As population increases in Willamette Province, social aspects of managing natural renewable resources in the province certainly are going to increase in prominence.

Province Demarcation

Willamette–Coast Demarcation

Starting just west of Rainier on the bank of the Columbia River in Columbia County, the line of demarcation between Willamette and Coast provinces in Oregon goes west atop steep slopes overlooking Columbia River at about 500 feet elevation. About 6 miles east of Clatskanie, the line cuts sharply to the south on topography about 750 to 1,000 feet elevation that is west of Clatskanie River.

At the ridge that separates the Clatskanie and Nehalem river drainages, the line turns northwest along the north side of Nehalem River drainage at about 1,000 feet elevation. In the upper reaches of Fishhawk Creek, the line travels south to cross Nehalem valley less than a mile west of Nehalem community at about 600 feet elevation. From there, it ascends the ridge leading south to Green Mountain where, at an elevation of about 1,750 feet, it circles east and south of the mountain and crosses Sunset Highway (U.S. 26) in the headwaters of Rock Creek at about 1,600 feet elevation.

From the summit pass on Highway 26, the line winds southeast at about 1,750 feet elevation to the Tillamook–Washington county line. It turns south at that elevation around the east and

Table 45. Average Dates Vegetation Growth Begins and Ends in Willamette Ecological Province, Oregon.

Station and length of record (years)	Elevation (feet)	Average date growth begins*	Average date growth ends*
Benton County			
Alpine 16	400	January 15	Does not occur
Corvallis 21	205	January 25	Does not occur
Clackamas County			
Estacada 21	414	January 22	Does not occur
Miramonte Station 31	162	February 1	Does not occur
Portland			
Water Bureau Sta. 22	747	February 15	Does not occur
Stafford 22	413	January 22	Does not occur
Columbia County			
Birkensfield 8	540	February 7	Does not occur
Clatskanie 17	50	February 7	Does not occur
Doraville 29	600	February 15	Does not occur
Vernonia 14	628	February 15	Does not occur
Douglas County			
Drain 15	302	Winter growing	Does not occur
Elkton 15	125	Winter growing	Does not occur
Roseburg 57	464	Winter growing	Does not occur
Hood River County			
Cascade Locks 21	100	February 15	Does not occur
Hood River Expt. Sta. 22	500	February 25	Does not occur
Parkdale 22	1,740	March 11	Does not occur
Lane County			
Cottage Grove 22	650	January 15	Does not occur
Eugene 57	361	January 22	Does not occur
Fern Ridge Dam 9	380	February 4	Does not occur
Leaburg 19	675	January 15	Does not occur
McKenzie Bridge 18	1,200	February 22	Does not occur
Oakridge 17	1,275	February 1	Does not occur
Linn County			
Albany 22	212	January 15	Does not occur
Cascadia 19	796	February 7	Does not occur
Marion County			
Mount Angel 37	485	January 15	Does not occur
Salem 52	182	January 24	Does not occur
Silver Creek Falls 12	1,340	February 15	Does not occur
Multnomah County			
Bonneville Dam 15	55	February 11	Does not occur
Portland 52	33	January 15	Does not occur
Polk County			
Dallas 16	325	February 4	Does not occur
Falls City 20	355	February 1	Does not occur
Wallace orchard 21	173	February 1	Does not occur
Washington County			
Forest Grove 22	180	February 1	Does not occur
Hillsboro 22	203	February 1	Does not occur
Yamhill County			
Cherry Grove 15	900	February 11	Does not occur
McMinnville 17	145	February 1	Does not occur
Newberg 11	400	January 15	Does not occur

* The average date vegetation growth begins on native perennial bunchgrasses is approximately the date average daily temperatures reach 39 to 40°F. Average date growth ends is considered to be when available soil moisture is depleted. Interpretations are based on data in Johnsgard.[17]

south sides of Round Top and the headwaters of Gales Creek. It crosses the pass between Gales Creek and Wilson River at about 1,600 feet elevation and returns to 1,750 feet elevation to run south around the headwaters of drainages flowing eastward into Tualatin and North Yamhill rivers.

Northwest of McMinnville, the line makes a huge swing westward at about 1,750 feet elevation around the headwaters of drainages flowing south into South Yamhill River. The line crosses Highway 22 northwest of Grande Ronde at about 670 feet elevation and crosses Highway 18 in Van Duzer State Park at about 770 feet elevation. This is the pass between the Yamhill and Salmon river drainages.

From Van Duzer State Park, the line ascends the ridge to the south. Within about 3 miles it is again at about 1,750 feet elevation on Saddleback Mountain. From there, it goes east and south at about 1,750 feet elevation around headwaters of drainages flowing into Yamhill and Little Luckiamute rivers.

From the south side of Monmouth Peak in southwest Polk County, the line descends the ridge southeasterly to cross Luckiamute River at about 650 feet elevation. It climbs Cougar Ridge and then winds south along the crest of the Coast Range. The Coast Range drops in elevation on the narrow divide between Marys River and Yaquina River to about 730 feet elevation at the community of Summit, about 5 miles northwest of Blodgett on Highway 20.

From the community of Summit, the line continues west and south along the crest of the Coast Range to cross the Corvallis–Newport Highway (U.S. 20) at about 800 feet elevation about 2 miles northwest of Burnt Woods community. This is the pass between Tumtum River flowing east and Little Elk Creek flowing west. From there, the line goes south along the crest of the Coast Range to Marys Peak, winding north and east around Marys Peak at about 1,700 feet elevation. The line crosses the pass on Alsea Highway (Oregon 34) at about 1,125 feet elevation, runs southeast up the ridge and around the east slopes of Flat Mountain at about 1,750 feet elevation, and continues south at about that elevation. This is the crest of the Coast Range between drainages flowing into Alsea River to the west and Long Tom River to the east.

The line of demarcation between Willamette and Coast provinces continues south along the crest of the Coast Range to the pass between Wildcat Creek to the west and Noti Creek to the east, which is about 6 miles southwest of Fern Ridge Reservoir. The line continues to wind southeasterly along the crest of the Coast Range, then descends into the Siuslaw River drainage to cross the river about 12 miles downriver from Lorane community, which is northwest of Cottage Grove.

From the river crossing, the line follows up the northside bottomlands along the river to about 2 miles east of King Ranch. The bottomlands along Siuslaw River below 600 feet elevation are in the fog-belt zone of Coast Province, which is typified by the occasional Sitka spruce tree. From the vicinity of King Ranch on the Siuslaw, the line travels southerly along the divide between Siuslaw and Smith rivers and then westerly around the headwaters of Smith River.[93]

From the headwaters of South Fork Smith River about 5 miles northwest of Drain community, the line veers west along the divide between Smith River to the north and drainages flowing into Umpqua River to the south. This portion of the Umpqua system is in Willamette Province.

About 4 miles north of Scottsburg, the line turns south to cross Umpqua River at Scottsburg community.[36, 91] It ascends the ridge across the river from Scottsburg and goes southeast along the ridgetops to the big bends in Umpqua River west of Kellogg community. From there, it goes south along the ridgetop that divides drainages flowing to the east into Umpqua River from drainages flowing to the west into Coos and Coquille rivers. The demarcation line crosses the Coos Bay Wagon Road west of Reston community, which is in Willamette Province, at 1,850 feet elevation and continues southwest at about 2,000 feet elevation.[36, 91]

About 7 miles southwest of Camas Valley community, in Willamette Province, the line of demarcation crosses Highway 42 along Middle Fork Coquille River at about 800 feet elevation. From there, the line ascends the ridge southeasterly to Chipmunk Ridge.[51] It is near the southeast end of Chipmunk Ridge that Willamette, Coast, and Siskiyou provinces join.

The line of demarcation between Willamette and Coast provinces is based primarily on the elevation at which western hemlock grows. However, the line also is indicated by the general presence of such forested soils as Bellpine, Jory, Retner, and Bateman series, which typify Willamette Province, and Bohannon, Blachly, Preacher, and Digger series, which typify Coast Province.

Although the line of demarcation is based on the elevation at which western hemlock generally is common in forested uplands, it is interesting to note that at locations along the Coast Range crest where elevation is significantly below 1,700 feet, the hemlock line is at the pass on the summit.

For example, where Sunset Highway (U.S. 26) crosses the summit into Nehalem River drainage, the province line is about 1,600 feet elevation. The Gales Creek Highway (Oregon 6) summit into Wilson River drainage also is about 1,600 feet elevation. At the community of Summit on the pass between Marys River and Yaquina River, the summit is about 730 feet elevation. On Highway 20 between Corvallis and Newport, the summit is about 800 feet elevation. On the Alsea Highway (Oregon 34), the summit is about 1,125 feet elevation. Farther south, the Willamette–Coast line of demarcation, based on the advent of western hemlock in forested uplands, is about 600 feet elevation where it crosses Siuslaw River, about 470 feet where it crosses Umpqua River, and about 800 feet where it crosses Middle Fork Coquille River. These rivers have

major headwaters in Willamette Province. Furthermore, Umpqua River drains sizable watersheds in both Cascade and Siskiyou provinces.

Each of these river crossings and passes in the crest of the Coast Range, where the advent of western hemlock signifies the line of demarcation between Willamette and Coast provinces, apparently represents the points at which the effects of the warmer, drier Willamette Valley climate are overcome by the more moist, cool coastal climate.

Willamette–Siskiyou Demarcation

From the junction of Willamette, Coast, and Siskiyou provinces near Chipmunk Ridge in southwest Douglas County, the line between Willamette and Siskiyou provinces goes along the ridgetop north to the vicinity of Live Oak Mountain and continues northerly to circle the headwaters of Olalla Creek, which are in Siskiyou Province, and then south to Table Mountain.

From there, the line meanders northeasterly along the ridgetop past Buck Mountain at about 2,500 feet elevation. About 4 miles northwest of Riddle, in Siskiyou Province, the line veers north and northwest by Big Baldy Mountain along the ridge separating drainages flowing west into lower Olalla Creek, in Willamette Province, from drainages in Siskiyou Province that flow north.

The line descends northwesterly to the edge of bottomlands along Olalla Creek at about 600 feet elevation and follows the southern border of these bottomlands north and east and along South Umpqua River, which is in Willamette Province at this location, to the bridge where Highway I-5 crosses South Umpqua River.[36, 95]

From the I-5 bridge across South Umpqua River, the line climbs the ridge northeast to Dodson Butte, Brushy Butte, and Lane Mountain. It is near Lane Mountain that the Willamette, Siskiyou, and Cascade provinces join.[36, 51]

The line of demarcation between Willamette and Siskiyou provinces, which is about 70 miles long, is not clear-cut in terms of soil or vegetation differences throughout its extent. Both provinces have arid, warm climates with Siskiyou being relatively more arid and warm than Willamette Province.

The line was judged using data in the 1993 Preliminary General Soil Map, Douglas County, Oregon,[95] which covers the area where the two provinces join. The line was drawn between upland soils that have been mapped definitely within Willamette Province to the north and upland soils that have been mapped in other areas definitely within Siskiyou Province. Upland soils definitely associated with Willamette Province include Oakland, Sutherlin, Nonpariel, Philomath, and Dixonville series. Upland soils definitely associated with Siskiyou Province include Speaker, Josephine, Lettia, and Beal series.

Broad vegetation characteristics differentiate between Willamette and Siskiyou provinces. For example, uplands below about 1,300 feet elevation in southern Willamette Province are typified by the common presence of bigleaf maple, Oregon white oak, scotchbroom, and some Pacific madrone.

Equivalent uplands in Siskiyou Province are typified by California black oak, wedgeleaf ceanothus, and abundant madrone, which strongly dominates logged or otherwise disturbed forested areas. Certain segments of the demarcation line between Willamette and Siskiyou provinces demonstrate these vegetation comparisons.

Willamette–Cascade Demarcation

From the junction of Willamette, Siskiyou, and Cascade provinces near Lane Mountain about 10 miles east of Roseburg, the line of demarcation between Willamette and Cascade provinces goes north at about 1,500 feet elevation on north-facing slopes and at about 2,800 feet elevation on west- and south-facing slopes. The line is based on the advent of western hemlock in the forest which signifies the colder, more moist effective environment of Cascade Province as compared with Willamette Province.

The line travels east around the upper reaches of drainages into Little River and then northwest at about 2,000 feet elevation in the vicinity of Shivigny Mountain, which is in Cascade Province. It continues on northwesterly to cross North Umpqua River about 5 miles northeast of Glide, which is in Willamette Province, near Idleyld Park in the topographic gap where Rock Creek Fish Hatchery is.

From this gap, the line heads north at about 2,000 feet elevation around the west slopes of Scott Mountain, Brown Mountain, and across Calapooya Divide. From near Calapooya Divide, the line goes north at about 1,800 feet elevation to the vicinity of Cottage Grove, extending up each major drainage that flows into Coast Fork Willamette River.

Northeast of Cottage Grove, which is in Willamette Province, the line goes generally north at about 1,800 feet elevation but extending up each major drainage that flows into Willamette River from the east. The line extends up Middle Fork Willamette River to about 17 miles south of Oakridge, which is in Willamette Province.

The line stretches up McKenzie River nearly to Belknap Springs; up Calapooia River to about King Camp; up South Umpqua River to about House Rock Forest Camp; up Middle Santiam River to just below Green Peter Dam; up North Santiam River to about 6 miles east of Mill City; up Little North Santiam River to about Elkhorn; up Clackamas River to about Fish Creek; and up Sandy River to about Brightwood.

The pattern of western hemlock growth, extending east up each major drainage that heads in the Cascade Mountains, signifies the effects of the warmer, drier Willamette climate extending up these valleys.

The line between Willamette and Cascade provinces near Firwood on Highway 26 in Clackamas County is at about 1,600 feet elevation. Farther

north along Sandy River southeast of Portland, western hemlock grows at about 1,400 feet elevation, including near Bridal Veil on the Columbia River.

From the vicinity of Bridal Veil, the line of demarcation winds easterly along steep breaks of Columbia Gorge to pass west and south of Hood River Valley, which is in Willamette Province, at about 3,000 feet elevation. It continues to a point about 6 miles south of Parkdale in upper Hood River Valley. Near here, Willamette, Cascade, and The Dalles provinces join.

Although the line of demarcation between Willamette and Cascade provinces in Oregon is based primarily on the elevation at which western hemlock grows, the line also is indicated by the general presence of such forested soils as Honeygrove, Peavine, Bellpine, Philomath, Jory, Cazadero, Parkdale, Hoodview, and Bins, which typify Willamette Province, and by Klickitat, Kinney, Bohannon, Holderman, Henline, Aschoff, Bull Run, Divers, and Thader, which typify Cascade Province.

Willamette – The Dalles Demarcation

From the junction of Willamette, Cascade, and The Dalles provinces in Oregon, the line of demaracation between Willamette and The Dalles provinces runs along the ridge east of Hood River Valley and northeast down the ridge nearly to Highway I-84 along the Columbia River. Here it veers sharply upriver nearly to Mosier, which is in The Dalles Province.

The towns of Hood River and Parkdale and the entire Hood River Valley are in Willamette Province; this is substantiated by the common presence of bigleaf maple, which does not grow in The Dalles Province.

The line between The Dalles and Willamette provinces in Oregon, which is about 30 miles long, is based on soil lines between Hood, Van Horn, Oak Grove, and Bins series, which typify Willamette Province in the vicinity of Hood River Valley, and Bald, Bodell, Frailey, and Ketchly series, which typify The Dalles Province in Oregon.[89]

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Common-name Checklist of Plants[7]

Grasses*

Common name	Scientific name
Alkaligrass, Lemmon	*Puccinella lemmoni*
Barley, meadow	*Hordeum brachyantherum (Criteseon brachyantherum)*
Bentgrass, thin	*Agrostis diegoensis*
Bluegrass	*Poa*
big	*ampla*
alkali	*juncifolia*
Canby	*canbyi*
Cusick	*cusickii*
hotsprings	*laxiflora*
Kentucky	*pratensis*
Leiberg	*leibergii*
Nevada	*nevadensis*
pine	*scabrella*
Sandberg	*sandbergii*
Wheeler	*nervosa*
Brome	*Bromus*
California	*carinatus*
Columbia	*vulgaris*
mountain	*marginatus*
soft	*mollis*
Cheatgrass	*Bromus tectorum*
Cordgrass	*Spartina gracilis*
Danthonia (see Oatgrass)	
Dropseed, sand	*Sporobolus cryptandrus*
Fescue	*Festuca*
bearded	*subulata*
California	*californica*
foxtail	*megalura*
green	*viridula*
Idaho	*idahoensis*
red	*rubra*
rough	*scabrella*
sixweeks	*octoflora*
western	*occidentalis*
Hairgrass	*Aira*
diffuse	*elegans*
silver	*caryophyllea*
Hairgrass	*Deschampsia*
slender	*elongata*
tufted	*caespitosa*
Junegrass, prairie	*Koeleria cristata*
Mannagrass, northern	*Glyceria borealis*
Medusahead	*Taeniatherum caput-medusae*
Melic, western	*Melica*
Muhly, mat	*Muhlenbergia richardsonis*
Needle-and-thread	*Stipa comata*
Needlegrass	*Stipa*
Columbia	*occidentalis nelsoni*
desert	*speciosa*
Lemmon	*lemmoni*
Thurber	*thurberiana*
western	*occidentalis*
Oatgrass (Danthonia)	*Danthonia*
California	*californica*
onespike	*unispicata*
timber	*intermedia*
Oatgrass, tall	*Arrhenatherum elatius*
Oniongrass	*Melica bulbosa*
Alaska	*subulata*
Orchardgrass	*Dactylis glomerata*
Pinegrass	*Calamagrostis rubescens*
Quackgrass	*Agropyron repens (Elytrigia repens)*
Reedgrass, bluejoint	*Calamagrostis canadensis*
Redtop	*Agrostis alba*
Ricegrass	*Oryzopsis*
Indian	*hymenoides*
Webber	*webberi*
Ryegrass	*Lolium*
Italian	*multiflorum*
perennial	*perenne*
Sacaton, alkali	*Sporobolus airoides*
Saltgrass	*Distichlis*
alkali	*stricta*
inland (see Saltgrass, alkali)	
Squirreltail, bottlebrush	*Sitanion hystrix (Elymus elymoides)*
Sweetgrass, California	*Hierochloa occidentalis*
Threeawn, Fendler	*Aristida fendleriana*
Timothy	*Phleum*
alpine	*alpinum*
common	*pratense*
Trisetum	*Trisetum*
spike	*spicatum*
tall	*canescens*
Velvetgrass, common	*Holcus lanatus*

(continued)

* Barkworth, M. E. and D. R. Dewey. 1985. Genomically based genera in the perennial Tritieae of North America: Identification and membership. American Journal of Botany 72(5):767-776. Barkworth and Dewey's proposed revisions noted in parentheses.

Grasses *(continued)*

Common name	Scientific name
Wheatgrass	*Agropyron*
bearded	*caninum*
beardless bluebunch	*inerme (Pseudoroegneria spicata* subsp. *inermis)*
bluebunch	*spicatum (Pseudoroegneria spicata* subsp. *spicata)*
slender	*trachycaulum (Elymus trachycaulus)*
standard crested	*desertorum*
streambank	*riparium (Elymus lanceolatus* subsp. *lanceolotus)*
thickspike	*dasystachyum (Elymus lanceolatus* subsp. *lanceolotus)*
Wildrye	*Elymus*
basin	*cinereus (Leymus cinereus)*
blue	*glaucus*
medusahead (see Medusahead)	
yellow	*flavescens (Leymus flavescens)*
Woodreed, drooping	*Cinna latifolia*

Grasslike

Common name	Scientific name
Bulrush	*Scirpus* spp.
Rush	*Juncus*
baltic	*balticus*
Drummond	*drummondii*
Sedge	*Carex*
black alpine	*nigricans*
Crater Lake	*scopulorum*
elk	*geyeri*
Hood	*hoodii*
Nebraska	*nebraskensis*
Ross	*rossii*
threadleaf	*filifolia*
Spikesedge (Spikerush)	*Eleocharis* spp.
Spikerush (Spikesedge)	*Eleocharis* spp.

Forbs

Common name	Scientific name
Arnica	*Arnica* spp.
Aster, alpine	*Aster alpigenus*
Balsamroot	*Balsamorhiza*
arrowleaf	*sagittata*
Carey	*careyana*
Hooker	*hookeri*
Beargrass	*Xerophyllum tenax*
Bedstraw, cleavers	*Galium aparine*
Biscuitroot	*Lomatium* spp.
Bitterroot	*Lewisia rediviva*
Buttercup	*Ranunculus* spp.
Cattail, broadleaf	*Typha latifolia*
Cinquefoil	*Potentilla* spp.
Clover, big-headed	*Trifolium macrocephalum*
Deervetch	*Lotus*
big	*crassifolius*
Douglas	*douglasii*
Desert-parsley	*Lomatium* spp.
Dock	*Rumex*
veiny	*venosus*
wedgeleaf	*cuneifolius*
Dogbane	*Apocynum* spp.
Dogwood, bunchberry	*Cornus canadensis*
False-hellebore	*Veratrum* spp.
False Solomon's seal (see Solomon's seal, false)	
Fern, western bracken	*Pteridium aquilinum*
Fern, western sword	*Polystichum munitum*
Fleeceflower	*Polygonum* spp.
Frasera	*Frasera (Swertia)*
shining	*finitida*
Gumweed, curlycup	*Grindellia squarrosa*
Hawkweed, white	*Hieracium albiflorum*
Iodine bush (see Pickleweed)	
Iris	*Iris* spp.
Lewisia, bitterroot	*Lewisia rediviva*

(continued)

Forbs *(continued)*

Common name	Scientific name
Licoriceroot	*Ligusticum* spp.
Loco, woollypod	*Astragalus purshii*
Lomatium	*Lomatium*
barestem	*nudicaule*
Gorman	*Gormanii*
Lupine	*Lupinus* spp.
Meadowrue	*Thalictrum* spp.
Milkvetch, Columbia	*Astragalus succumbens*
Onion	*Allium* spp.
Parsley, desert (see Desert-parsley)	
Pathfinder	*Adenocaulon bicolor*
Pearly everlasting	*Anaphalis margaritacea*
Peavine	*Lathyrus* spp.
Penstemon	*Penstemon* spp.
Phantom-orchid	*Eburophyton austinae*
Phlox, spreading	*Phlox diffusa*
Pickleweed (Iodine bush)	*Allenrolfea occidentalis*
Pricklypear, plains	*Opuntia polycantha*
Pteryxia, wormwood	*Peteryxia terebinthina*
Sandwort	*Arenaria* spp.
Scurfpea	*Psoralea* spp.
Solomon's seal, false	*Smilacina racemosa*
Spiderflower, yellow	*Cleome lutea*
Starflower	*Trientalis* spp.
Strawberry	*Fragaria* spp.
Sweetroot, mountain	*Osmorhiza chilensis*
Tarragon	*Artemisia dracunculus*
Trillium	*Trillium* spp.
Twinflower	*Linnaea borealis*
Vetch, American	*Vicia americana*
Woollyweed	*Hieracium scouleri*
Wormwood	*Artemisia*
Douglas	*douglasiana*
lobed	*vulgaris*
Louisiana	*ludoviciana*
Wormwood pterixia (see Pteryxia, wormwood)	
Wyethia, woolly	*Wyethia mollis*
Yampa	*Perideridia gairdneri*
Yarrow	*Achillea millefolium*

Shrubs and Trees

Common name	Scientific name
Alder	*Alnus*
mountain	*tenuifolia*
red	*rubra*
Sitka	*sinuata*
Ash, Oregon	*Fraxinus latifolia*
Aspen, quaking	*Populus tremuloides*
Azalea	*Rhododendron*
Cascade	*albiflorum*
western	*occidentale*
Bearberry (see Manzanita, bearberry)	
Birch	*Betula*
bog	*pumila*
Bitterbrush, antelope	*Purshia tridentata*
Blackberry	*Rubus*
dwarf	*lasiococcus*
evergreen	*laciniatus*
strawberryleaf	*pedatus*
trailing	*nivalis*
Buckthorn, California	*Rhamnus californica*
Buckwheat	*Eriogonum*
barestem	*nudum*
heartleaf	*compositum*
snow	*niveum*
Buffaloberry, silver	*Shepherdia argentea*
California-laurel	*Umbellularia californica*
Ceanothus	*Ceanothus*
deerbrush	*integerrimus*
redstem	*sanguineus*
snowbrush	*velutinus*
squawcarpet	*prostratus*
wedgeleaf	*cuneatus*
Cherry	*Prunus*
bitter	*emarginata*
choke	*virginiana*
Chinkapin	*Castanopsis*
bush	*sempervirens*
golden	*chrysophylla*
Cinquefoil	*Potentilla* spp.
Cottonwood, black	*Populus trichocarpa*
Currant	*Ribes*
black trailing	*laxiflorum*
Crater Lake	*erythrocarpum*
golden	*aureum*
mapleleaf	*acerifolium*
redflower	*sanguineum*
sticky	*viscosissimum*
wax	*cereum*
Deerbrush	*Ceanothus integerrimus*

(continued)

Shrubs and Trees *(continued)*

Common name	Scientific name
Dewberry	*Rubus*
snow	*nivalis*
western	*vitifolius*
Dogwood	*Cornus*
flowering (see Dogwood, Pacific flowering)	
Pacific flowering	*nuttalli*
western red	*californica*
Douglas-fir	*Pseudotsuga*
coastal	*menziesii menziesii*
interior	*menziesii glauca*
Elderberry	*Sambucus*
blue	*cerulea*
red	*racemosa arborescens*
Ephedra	*Ephedra*
green	*viridis*
Nevada	*nevadensis*
Fir	*Abies*
grand	*grandis*
noble	*procera*
Pacific silver	*amabilis*
Shasta red	*magnifica shastensis*
subalpine	*lasiocarpa*
white	*concolor*
Gooseberry	*Ribes*
desert	*velutinum*
Watson	*watsonianum*
Granitegilia	*Leptodactylon pungens*
Greasewood, black	*Sarcobatus vermiculatus*
Hawthorn, black	*Crataegus douglasii*
Hazel, western	*Corylus cornuta*
Hemlock	*Tsuga*
mountain	*mertensiana*
western	*heterophylla*
Hopsage, spiny	*Grayia spinosa*
Honeysuckle	*Lonicera* spp.
Horsebrush	*Tetradymia*
gray	*canescens*
littleleaf	*glabrata*
spiny	*spinosa*
Huckleberry	*Vaccinium*
blue	*globulare*
evergreen	*ovatum*
grouse	*scoparium*
ovalleaf	*ovalfolium*
red	*parvifolium*
thinleaf	*membranaceum*
Incense-cedar	*Libocedrus decurrens*
Juniper, western	*Juniperus occidentalis*
Kalmia, bog	*Kalmia microphylla*
Larch, western	*Larix occidentalis*
Madrone, Pacific	*Arbutus menziesii*
Manzanita	*Arctostaphylos*
bearberry	*uva-ursi*
common	*manzanita*
gray	*cinerea*
greenleaf	*patula*
hoary	*canescens*
pinemat	*nevadensis*
whiteleaf	*viscida*
Maple	*Acer*
bigleaf	*macrophyllum*
Rocky Mountain	*glabrum*
vine	*circinatum*
Menziesia, rustyleaf	*Menziesia ferruginea*
Mockorange (Syringa)	*Philadelphus lewisii*
Mountain-ash	*Sorbus*
dwarf	*occidentalis*
Pacific	*sitchensis*
Mountain-mahogany	*Cercocarpus*
birchleaf	*montanus*
curlleaf	*ledifolius*
Ninebark, common	*Physocarpus opulifolius*
Oak	*Quercus*
California black	*kelloggii*
canyon live	*chrysolepis*
huckleberry	*vaccinifolia*
Oregon white	*garryana*
Sadler	*sadleriana*
Oceanspray	*Holodiscus discolor*
Oregon-grape	*Berberis*
Cascade	*nervosa*
low	*repens*
tall	*aquifolium*
Pachystima	*Pachystima myrsinites*
Pine	*Pinus*
Jeffrey	*jeffreyi*
knobcone	*attenuata*
lodgepole	*contorta latifolia*
ponderosa	*ponderosa*
shore	*contorta contorta*
sugar	*lambertiana*
western white	*monticola*
whitebark	*albicaulis*
Pipsissewa (Prince's-pine, common)	*Chimaphila umbellata*
Plum, Klamath	*Prunus subcordata*
Port-Orford-cedar	*Chamaecyparis lawsoniana*
Poison-oak, Pacific	*Rhus diversiloba*
Prince's-pine, common (Pipsissewa)	*Chimaphila umbellata*

(continued)

Shrubs and Trees *(continued)*

Common name	Scientific name
Purple sage (see Sage, desert)	
Rabbitbrush	*Chrysothamnus*
gray (rubber)	*nauseosus nauseosus*
lanceleaf green	*viscidiflorus lanceolatus*
rubber (gray)	*nauseosus nauseosus*
threadleaf green	*viscidiflorus stenophyllus*
green	*viscidiflorus viscidiflorus*
Redcedar, western	*Thuja plicata*
Redwood	*Sequoia sempervirens*
Rhododendron, Pacific	*Rhododendron macrophyllum*
Rockspirea, bush	*Holodiscus dumosus*
Rose	*Rosa*
baldhip	*gymnocarpa*
Nootka	*nutkana*
pearfruit	*pisocarpa*
sweetbrier	*eglanteria*
Sage, desert (Purple sage)	*Salvia dorrii*
Sagebrush	*Artemisia*
basin big	*tridentata tridentata*
black	*arbuscula nova*
bud	*spinescens*
low	*arbuscula arbuscula*
mountain big	*tridentata vaseyana*
silver	*cana cana*
stiff (rigid)	*rigida*
threetip	*tripartita*
Wyoming big	*tridentata wyomingensis*
Salal	*Gaultheria shallon*
Saltbush, Nuttall	*Atriplex nuttallii*
Scotchbroom	*Cytisus scoparius*
Serviceberry	*Amelanchier*
Utah	*utahensis*
western	*florida*
Shadscale	*Atriplex confertifolia*
Silktassel, boxleaf	*Garrya buxifolia*
Snakeweed, broom	*Gutierrezia sarothrae*
Snowberry	*Symphoricarpos*
common	*albus*
mountain	*oreophilus*
Snowbrush	*Ceanothus velutinus*
Spirea	*Spiraea*
birchleaf	*betulifolia*
Douglas	*douglasii*
mountain (subalpine)	*densiflora*
shinyleaf	*betulifolia lucida*
subalpine (mountain)	*densiflora*
Spruce	*Picea*
Brewer	*breweriana*
Engelmann	*engelmannii*
Sitka	*sitchensis*
Squawapple	*Peraphyllum ramosissimum*
Syringa (see Mockorange)	
Tanoak	*Lithocarpus densiflora*
Thimbleberry	*Rubus parviflorus*
Whipplevine	*Whipplea modesta*
Willow	*Salix*
feathervein	*pennata*
Pacific	*lasiandra*
Piper	*piperi*
Scouler	*acouleriana*
Sierra	*orestera*
Winterfat	*Eurotia lanata*
Wintergreen, Oregon	*Gaultheria ovatifolia*
Yew, Pacific	*Taxus brevifolia*

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