THE DISTRIBUTION OF BIOTA IN OREGON

by

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Typed by Dorothy A. Bratz

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The entire project would have been impossible without the constant encouragement, companionship, and actual work provided by my wife.

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THE DISTRIBUTION OF BIOTA IN OREGON

Introduction

Oregon, in 1952, embraces as great a diversity as can be found in any comparable area (96,699 square miles). The diversity is evidenced climatically, botanically, zoologically, agriculturally, geologically, physiographically--in almost every possible regard. Many of these features exhibit similar patterns of distribution over the state, due to the controlling influence of climate. Of biological interest is the association in distribution of the flora, fauna, and soils in relation to the climatic and other regulatory factors. These provide the material for this thesis.

Climates are generally classified separately, with a notation of the type of vegetation representative of the climatic area. Modern pedologists classify and map the distribution of soils and indicate the principal climatic features and vegetation types associated with each soil group. Plant distribution is commonly studied with the consideration of climate as the major control, and with edaphic and biotic factors. Zoologists, on the other hand, must include plants, climates, and sometimes soils to achieve an adequate coverage of the distribution of animals. Each can survey the distribution maps of the others and find a strikingly close agreement in the location of limits and bounds. One could say, then, that for each climatic area there is not just a representative type of vegetation, but a particular association of plant and animal species and a predominant type of soil development. Actually, there will be found also characteristic crops, methods of farming, distribution of settlements, and the like, but these go beyond the limits of this study.

No existing distributional scheme includes all of these phenomena in the manner suggested. Most of them probably could be modified to do so, but in some cases the modifications might not be particularly satisfactory. This thesis does not attempt an extension of any of the schemes, nor does it present a new scheme to further complicate the situation. Rather, it is intended to study the distribution of climate, soils, plants, and animals as they occur in Oregon, and to emphasize the interrelationships involved, from the viewpoint of a biologist.

Methods and Approach

For an adequate and intimate acquaintance with the state of Oregon, the writer travelled over 16,000 miles expressly for thesis purposes within a two-year period. Additional travels and study within the four years previous to the completion of this paper would make the total considerably more than 20,000 miles (Figure 1). The travel has been at all seasons of the year, and under all weather conditions. An effort was made to get into as many areas as possible in the early summer when plants and animals are most evident and abundant. Few truly remote areas are to be found in Oregon, and it is principally these areas which were least adequately covered in the mileage given--the main body of the Wallowa Mountains, southeastern Malheur County, interior Curry County, and the high mountain peaks. Even so, these areas were not completely by-passed.

At the beginning of thesis travel, a mimeographed form was prepared as a convenient means of recording field observations. Figure 2 is a reproduction of a blank form. Township, range, and section were included, principally for location of areas when an accurate description of the location could not be made. Temperature and general weather conditions were listed for their possible effect upon the extent of the observations; actually, under field conditions little attention was given to these items after the first few forms had been used. If the weather was particularly adverse, a general notation was made; otherwise, the space was left blank.

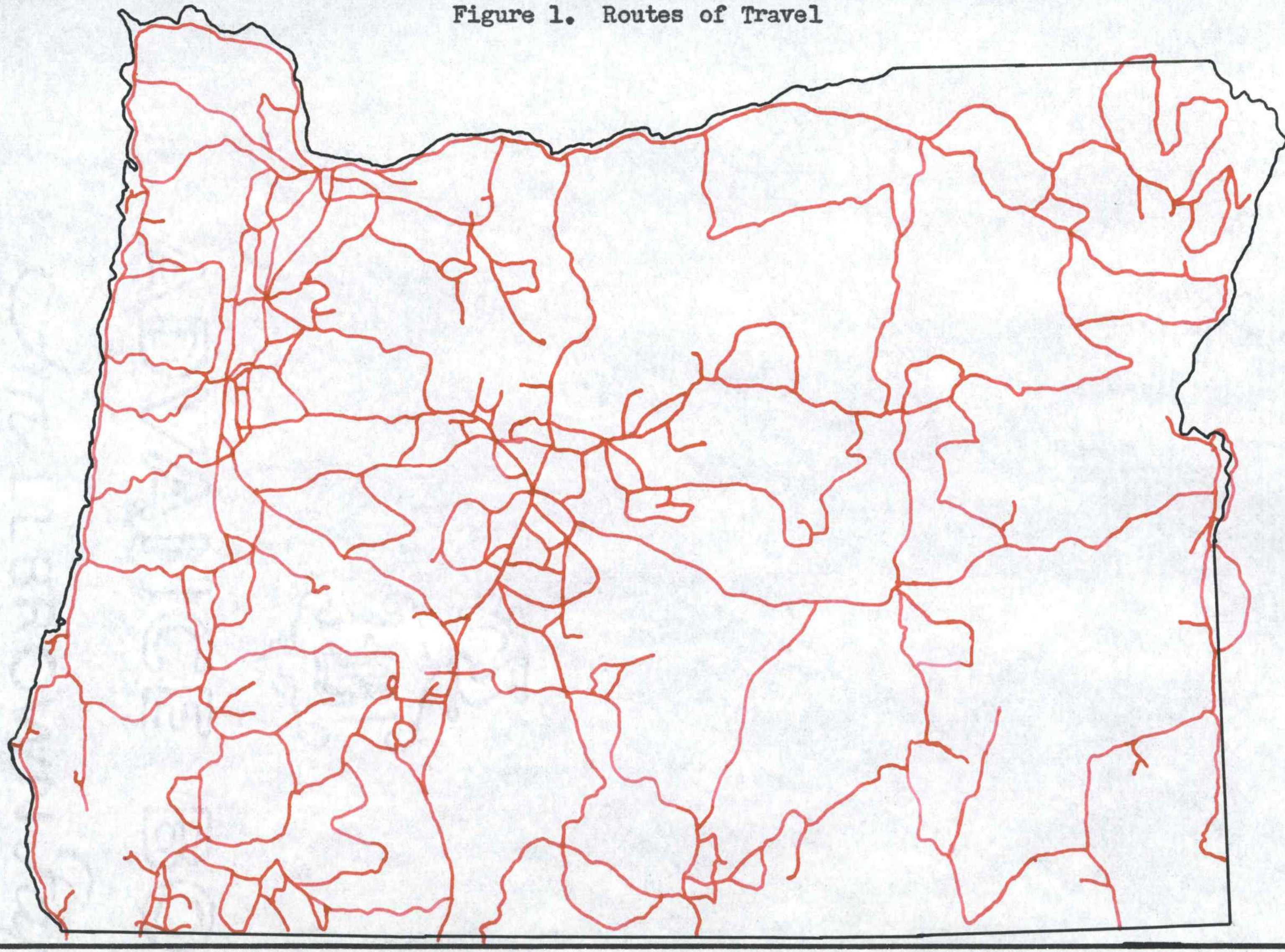


Figure 1. Routes of Travel

Figure 2. Form for Field Observations

Robert D. Bratz Sample #
Date / /

T. R. Sec. W. M. Location:

Temp. ° F. Weather:

Time, start : m.; finish : m. Total Hours:

Climatic data: Photos: ______________
Station:

Elev. __________ ft. Topography:

Soil color, texture, etc.:

Biome: Association: Climax
Disclimax
Seral:

Stratification:

Trees

Mammals

Birds
Perm. Res.

Shrubs

Summer Res.

Reptiles & Amphibians

Herbs

Winter Res.

Entering a starting and finishing time has provided a fairly accurate record of the total time covered by the listed observations, 673 hours (this time is further supplemented by many hours of observations while driving, particularly along main highways, for which notes were not made). With almost 300 forms completed, an average of more than two hours is represented in each set of observations.

It has been decided to treat the climatic considerations separately from the data on the forms, since so many of the areas visited are not represented by weather stations. Elevations were noted in the field, when possible, from bench marks or other known points; otherwise, the elevation was determined as accurately as possible at a later time from topographic or other maps. Generally the space for notes on soils was left blank, except in instances of a striking characteristic, as in the Miller Lake area (Plate 66) where virtually raw pumice was found. Biomes, associations, etc. were an early idea which proved impractical to determine in too many field situations. Stratification was annotated in the more unusual circumstances.

The listing of plant and animal species in their respective places was made on the basis of conspicuous and common forms in the area concerned. These lists were then compiled for the various biotic areas to be discussed, and the compilations were used as the basis for descriptions and discussions of each area. Several of the forms represent localities that do not conform to the surrounding type, and these aberrant localities will also be considered.

Photographs in both color and black and white were taken in an effort to give adequate pictorial reproduction of as many typical areas as possible. Color pictures for the thesis were ruled out because of finances, but about 500 transparencies have been taken which give a fairly good color representation of Oregon. From more than 600 black and white pictures, 73 have been selected in an attempt to show pictorially the major biotic areas of Oregon and some of the variations which are to be encountered. All photographs were taken by the author; most of the pictures were taken with a $2\frac{1}{4} \times 3\frac{1}{4}$ Certix camera with Zeiss Tessar f4.5 lens, using a yellow filter and Ansco Plenachrome film. A few pictures were taken with a 116-size box camera, and one (Plate 22) was taken with a 35 mm. Clarus camera, which was used for all of the color pictures. The enlargements for the thesis were also produced by the author on lightweight Kodabromide A paper.

General descriptions of the state of Oregon are fairly abundant; those given in the books most used by the author (2, 17, 32, 33) seem adequate enough, as are most others which are generally available. It is deemed unnecessary to repeat this type of information here. Instead, a brief survey of climatic elements and their distribution is presented, together with a review of the major climatic features of Oregon, as a more basic concern to the development of this study. In view of the regulatory influence of climate, the biotic areas of Oregon are described, followed by a discussion of distribution schemes.

No collecting of specimens, plant or animal, has been attempted; to do so would have involved either a considerably longer period of time or a greatly reduced itinerary. For the geographical approach it was decided that more extensive travel would provide a better acquaintance with the state.

Special efforts have been made to designate the biotic areas herein described with names which, insofar as possible, would avoid connotations suggestive of any of the distribution schemes to be discussed later. In some instances this has been almost impossible. The use of "biotic areas" has been made for the same purpose; the areas so described are not intended as units or categories within any of the schemes. It is hoped thereby to approach the problem from a more or less impartial point of view.

The use of certain terms has been undertaken with some apprehension because of possible connotations or misunderstandings; in any questionable case, it is hoped that general, broad definitions will be assumed by the reader unless the particular situation implies a more specific usage of the term. For instance, the Moist Coniferous Forest, described as a biotic area, is not necessarily equivalent to the moist coniferous forest biome; and the Palouse Prairie biotic area is used in reference to the portion of Columbia basin grasslands which occur in Oregon. Both of these are used and described in this paper as neutral units, regardless of their occurrence in various distributional schemes.

The Climates of Oregon

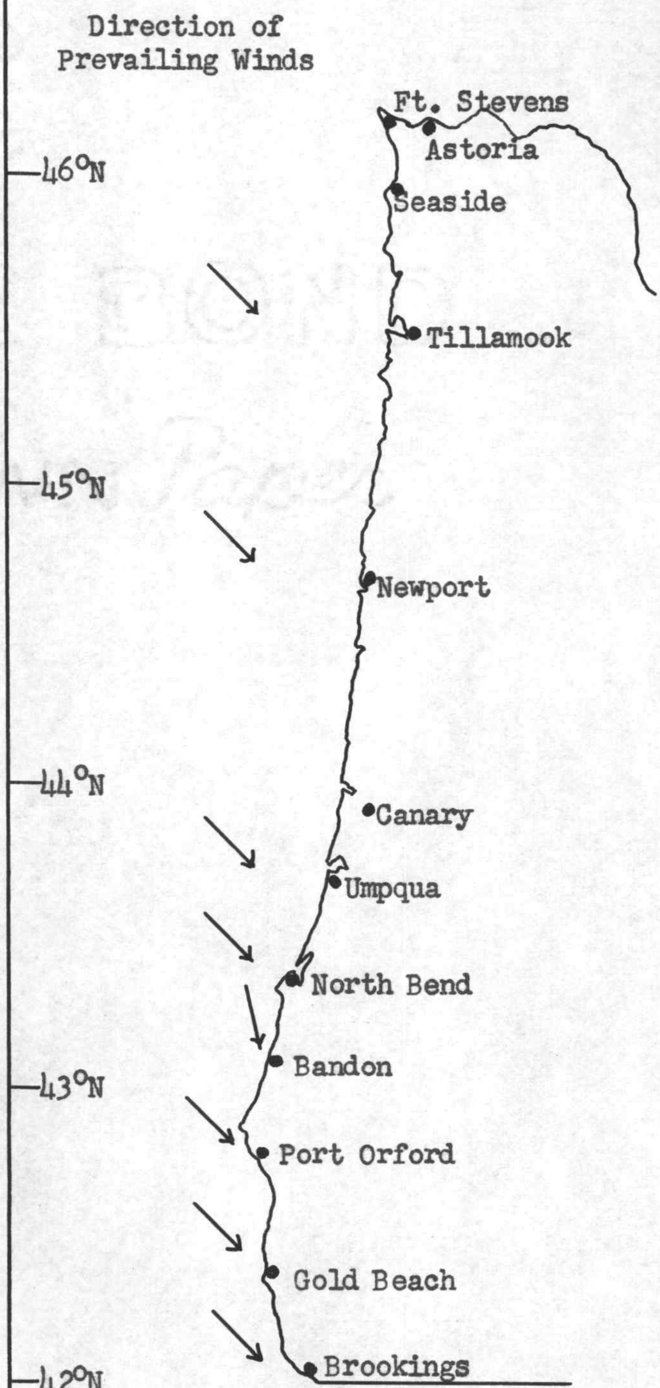
Temperature, precipitation and humidity, winds and air pressure are the primary elements of weather and climate. The distribution of these over the surface of the earth is influenced by a number of direct and interacting climatic controls, principal among which are latitudinal position, relationship to land and water, winds and air masses, altitude, mountain barriers, ocean currents, and storms (15, pp.23-24).

Latitudinal position is basically concerned with the amount of solar insolation, but its complex influences are closely interrelated with all of the other controls. Fundamentally, the effect of latitudinal position is illustrated by the progressive decrease of temperature from tropical regions to the poles. This gradation is often altered or concealed by other climatic regulators, but in a relatively uniform area the gradual progression can be noted. The Oregon coast line is one such area for which adequate data are available, and Figure 3 exemplifies this point. The seasonal variations of temperature are an additional product of latitude.

Coincident with temperature is illumination, but its latitudinal progression is less modified by other controls--altitude and cloudiness (storms) providing the main variations.

The distribution of precipitation and humidity in relation to latitude is not particularly pronounced, except in connection with latitudinal belts of prevailing winds and their causative air pressures.

Figure 3. Latitudinal Gradation of Temperatures Along the Oregon Coast.



	Average Temperatures		
	Annual	January	July
Ft. Stevens	50.3° F.		
Astoria	51.2	40.4° F.	61.0° F.
Seaside	51.9	44.2	59.6
Tillamook	50.6	42.5	58.8
Newport	50.9	43.8	57.0
Canary	52.0	43.4	60.0
Umpqua	51.8		
North Bend	51.9	44.2	59.4
Bandon	51.8	45.5	58.3
Port Orford	52.8	46.5	59.3
Gold Beach	52.3	46.4	57.9
Brookings	53.0	46.6	58.5

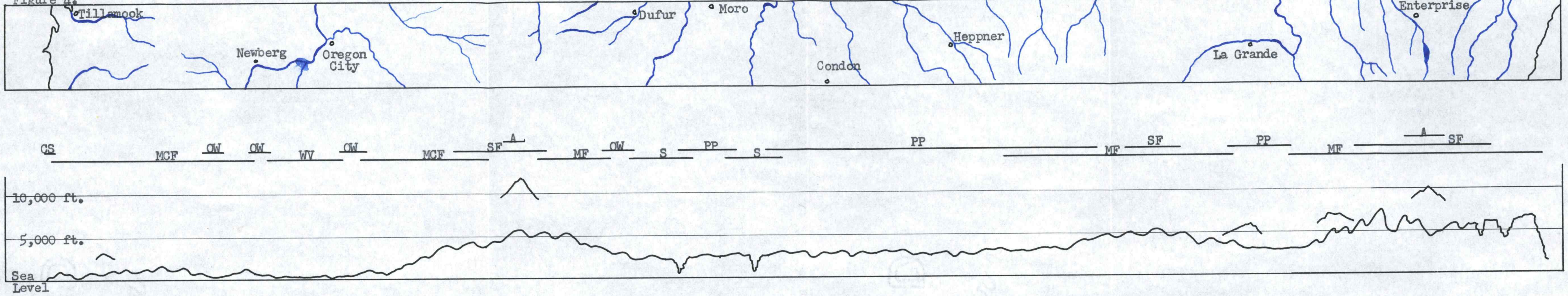
Data from U.S. Weather Bureau, Climatological Data (52) and Climatic Summary (51)

The pattern of westerlies, trades, and easterlies, and the belts of high and low pressures are produced by latitudinal differences in insolation, fluctuate northward and southward with the seasons, but are altered extensively by the other regulators.

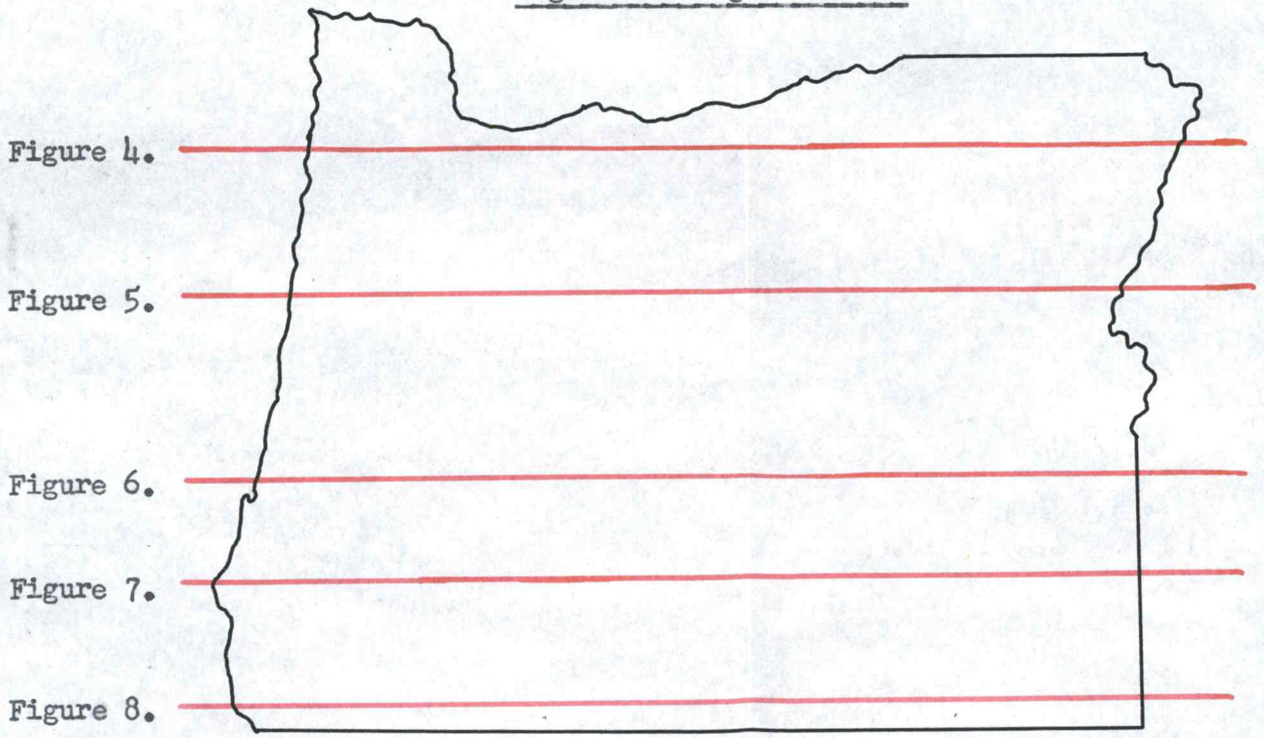
Whereas there is a tendency for development of climatic belts in accordance with the latitudes, certain of the remaining controls cause a considerable disruption and fragmentation of the latitudinal pattern. Predominant among these is the relationship of land and water masses--the distribution of continents and oceans, which follows no apparent pattern. Because of differences in specific heat and other qualities of land and water, the temperature of air over large bodies of water possesses relatively low diurnal and annual ranges, while over land the ranges may be great. To the leeward of large bodies of water this moderated condition is carried by prevailing winds; the moderating effect diminishes gradually in moving over the continent, until the extreme ranges of temperature are encountered near the continental interior and/or its leeward side. A mountain barrier oriented transverse to the flow of air may reduce the moderating effects of temperature (as does the Oregon Coast Range), or it may nearly completely eliminate them (as does the Cascade Range). Figures 4-12 illustrate the extent of these conditions in Oregon.

Precipitation and humidity are also reduced toward the interior of continental land masses, and are similarly influenced by mountain barriers and other factors. Winds and air pressures undergo

Figure 4.



Legend for Figures 4 - 8



Symbols:

A - Alpine Summits
CS - Coast Strip
JW - Juniper Woodland
MCF - Moist Coniferous Forest
MF - Montane Forest
OW - Oak Woodland
PP - Palouse Prairie
S - Sagelands
SF - Subalpine Forest
WV - Willamette Valley mixture

Horizontal scale, approximately 1 inch to 20 miles.
Vertical scale, 1 inch to 10,000 feet.

Profiles represent approximate center of map strip.

Figure 5.

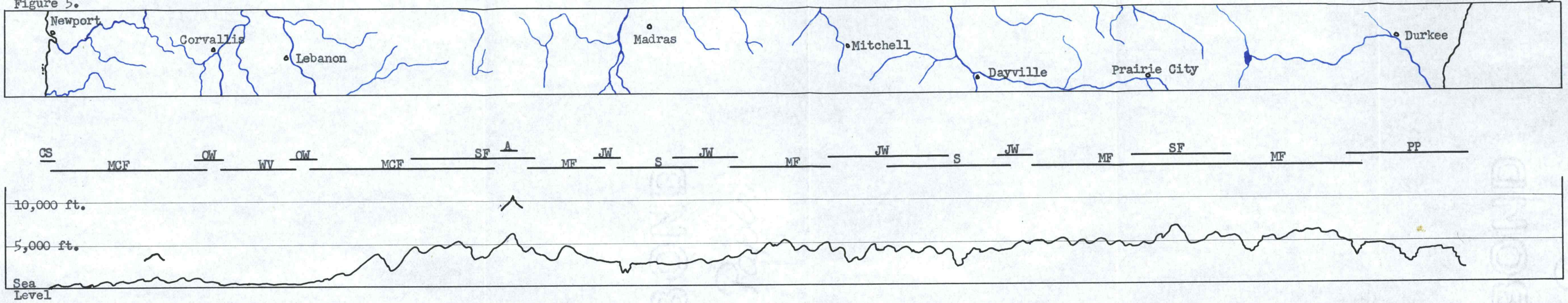


Figure 6.

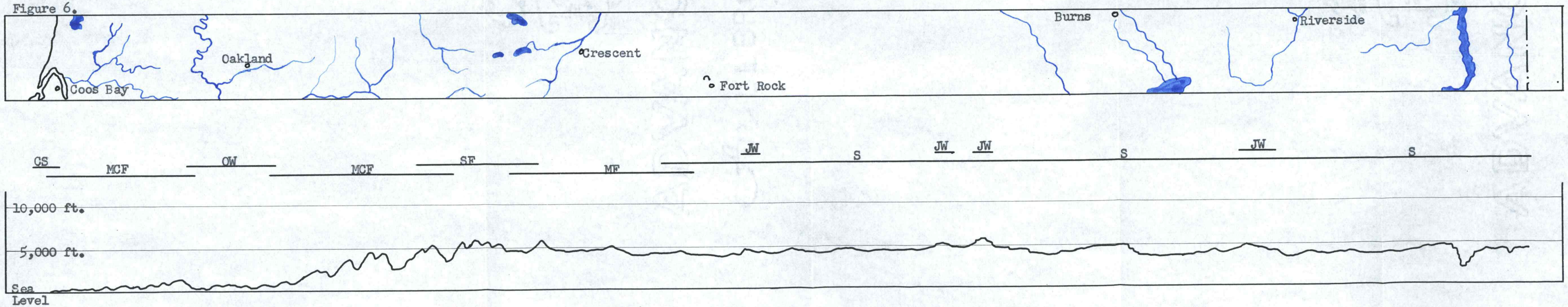


Figure 7.

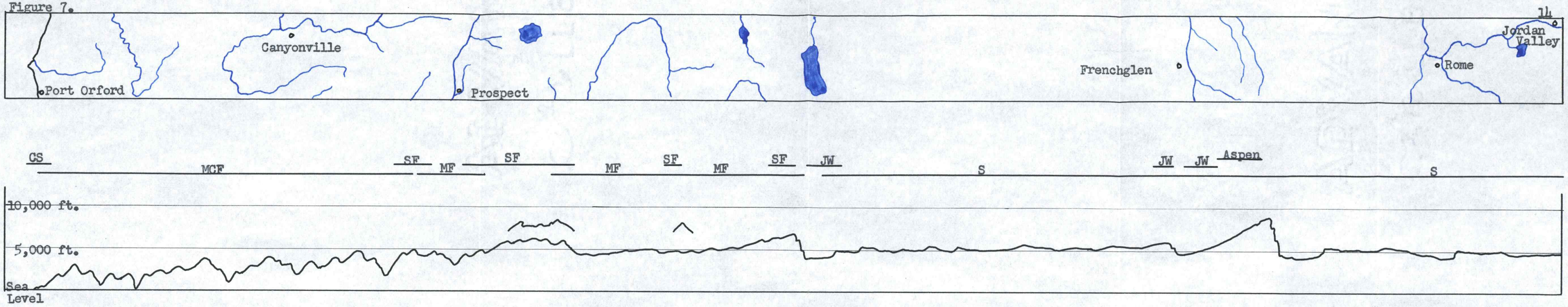
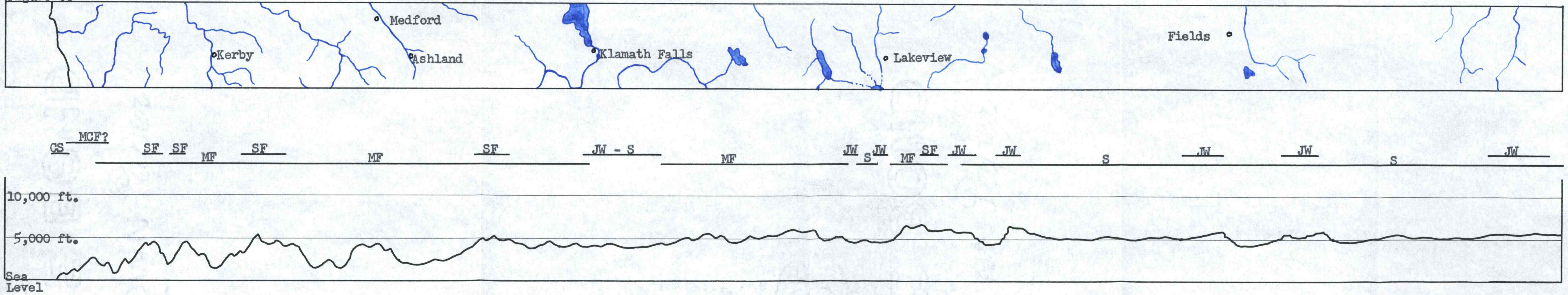


Figure 8.



complex changes as they progress toward the interior, but the results of these changes are of less significance to our present considerations.

Gradual changes in altitude produce almost imperceptible effects, but as the change in altitude becomes more rapid, the results become more apparent. Mountainous areas are the regions of greatest altitudinal variation; here also is the greatest variation in climates, vegetation, animal life, soils, etc. Altitudinal increases tend to simulate latitudinal increases, but there are basic differences. At high elevations there is no diminution of amounts of illumination and insolation, but actually an increase because of the clearer atmosphere. The patterns of weather and climate are essentially the same as for surrounding lowlands; temperatures average lower and humidities higher, irrespective of the orographic increase in precipitation. Nevertheless, the number of daylight hours is fairly constant along any degree of latitude, and the seasonal distribution of weather phenomena remains unaltered. Thus, there are distinct latitudinal and altitudinal features of mountain climates.

The origin of Merriam's Life Zones is attributable to the characteristic altitudinal zonation of vegetation on mountain slopes, and indeed it is in certain mountain situations that the Life Zones have been most satisfactorily applied. Several soil studies have noted a similar zonation of soils (27, 31, 38). The latitudinal variation of mountain vegetation--the subalpine forest, for example--may be partially assigned to isolation, time, and other factors affecting the distribution of species, but undoubtedly part of the variation must be attributed to the latitudinal-altitudinal complex mentioned above: greater illumination toward the equator, and seasonal differences due to the latitude. At certain elevations, podzolic soils are to be expected, but the podzolic soils at the equator in the high Andes will differ from the podzolic soils in the mountains of western North America, and these from the true podzols across Canada. These differences in soils are also influenced by the differences in vegetation due to the various factors mentioned and others. The interrelationships of factors become exceedingly complex in mountain areas.

Comparable altitudinal belts are highest at the equator and extend to lower elevations toward the poles. Also, they are highest on mountains near the continental interior and lowest along the western coasts. Both of these gradations are in evidence in Oregon: Timberline on Mount McLoughlin is in the vicinity of 7,500 feet; in the Three Sisters area, it is in the range of 6,800 to 7,500 feet; while on Mount Hood, it is from 6,000 to 6,500 feet. For the latter case, the Coast Range is not high enough to have a timberline, but in contrast to the elevations given for timberline in the Cascades, the limit of tree growth in the Blue and Wallowa mountains is about 8,000 feet. (Figures 4, 5)

In addition to the altitudinal controls of climate, mountains exert another control as barriers, and this is particularly well demonstrated in Oregon (Figures 4-8, 12). Winter storms advancing onto the North American Continent are cooled adiabatically, with the Coast Range and the Cascades acting as orographic instruments; heavy precipitation results. The low Coast Range, of course, has less marked effects, but the height of the Cascades is adequate to remove a high percentage of moisture from the air masses. In descending the short east slope of the Cascades (and to a lesser extent of the Coast Range), the air is warmed katabatically, and its moisture-holding ability is increased; the result is the "dry shadow" extending over considerable expanses to the east. In a comparable situation at the southern tip of South America, the higher Andes induce much higher precipitation on the Chilean slopes, and a much drier "shadow" across southern Argentine. In Northern Europe where mountains are lacking, the marine west coast influence penetrates into western Russia.

In eastern Oregon the Blue Mountains bring about another lifting of the air masses that gives northeastern Oregon its rainfall. The Steens Mountains (Figures 7, 12; Plates 61, 64) are another barrier, and although precipitation data are lacking, the orographically increased snowfall of winter is adequate to endure the long, dry summers.

The role of ocean currents in regulating climate sometimes seems to be less significant than the other controls discussed, but it is evident that the warm currents of the north Pacific Ocean are important in helping to moderate the temperatures over Oregon. The moderating influence is reaching its inland limits near the eastern border of the state. In addition, there is an upwelling of cold water from the ocean depths along the entire Oregon coast. The influence of this upwelling is greatest in the summer when warm moist winds are moving inland; in passing over the cold water, fog is formed. If the winds are light, the fog may hang just offshore, not penetrating inland, but frequently the winds carry the fog up the coastal valleys. It is not unusual for the fog to persist for several days, but it rapidly disappears when it laps over the Coast Range into the interior valleys. The fog has a stabilizing influence upon both temperatures and humidity, and may be considered a supplement to precipitation on the coastal slopes of the Coast Range.

Cyclonic storms are directly responsible for a very large part of Oregon's weather. For the state as a unit, about 90 per cent of the precipitation is brought by the cyclonic westerlies, and again, the higher percentages of non-cyclonic precipitation are toward the interior. The cyclonic storms which affect the weather of Oregon have two general centers of development: One of these is off to the southwest in the middle to western regions of the Pacific; as they advance toward the continent, warm moist air is drawn into the storm and long, gentle, but copious rains result. This is more typical of the storms of late fall and early winter. In mid-winter, storms develop with great rapidity in the vicinity of the semi-permanent "Aleutian low", and move over Oregon from the northwest with heavy showers, frequently marked by brief patches of clear sky between showers. The air masses associated with these storms are cold and unstable, and it is not infrequent that snow is deposited over most of Oregon by such storms.

It is in relation to the movement of the cyclonic storms that winds and air masses have their most noticeable effect upon the climate of Oregon. Storms directed toward the Oregon coast may occasionally be diverted to the north or to the south by the development of a high pressure area over Oregon or the northern Great Basin. A flow of cold dry air from a massive high pressure area over interior Canada may sometimes invade eastern Oregon and the northern Great Basin, generally spilling cold air through the Columbia Gorge and over the low passes of the Cascades. When the invasion is well developed, storms may be stalled in the Pacific for several days. It is at such times that the coldest temperatures for Oregon have been recorded, the cold mass with the accompanying clear atmosphere inducing excessive radiant cooling in eastern Oregon with temperatures reaching as low as 50° F. below zero.

A similar continental air mass in summer frequently invades Oregon with hot, dry air which lowers humidities markedly, right down to the coast. It is in such conditions that the extensive burns in the coast forest have been created. These conditions also produce the highest temperatures recorded throughout the state.

Distribution of Elements

There are, then, four dimensions in the variations of climatic elements in Oregon: a north-south, or latitudinal, range;

an east-west range, or from the coast toward the interior; an altitudinal range; and the variations in time, the changes from season to season and year to year.

Temperatures and humidities are more nearly uniform along the Oregon coast, and have greatest ranges in the interior of Oregon. The lowest annual temperatures are undoubtedly in the alpine areas of the high peaks, although records are not available for these regions; the highest annual temperatures are in the lower Snake and Columbia river valleys of eastern Oregon.

Precipitation is greatest where the orographic effect of the Coast Range and of the Cascades is greatest. The lowest precipitation records are for southeastern Oregon. Precipitation is most reliable in northwestern Oregon--where the amounts are largest, and least reliable where the average annual precipitation is lowest. Figures 9-12 show the general distribution of temperatures and precipitation over Oregon.

Because of the dimensional variations of the elements, any one climatic region or belt will contain variations in the four directions; some of the variations will not be as apparent as others, while in certain local situations the variation may be quite extreme. The response of plants, animals, and soils to the climatic gradations is not always constant, so that additional variations are involved.

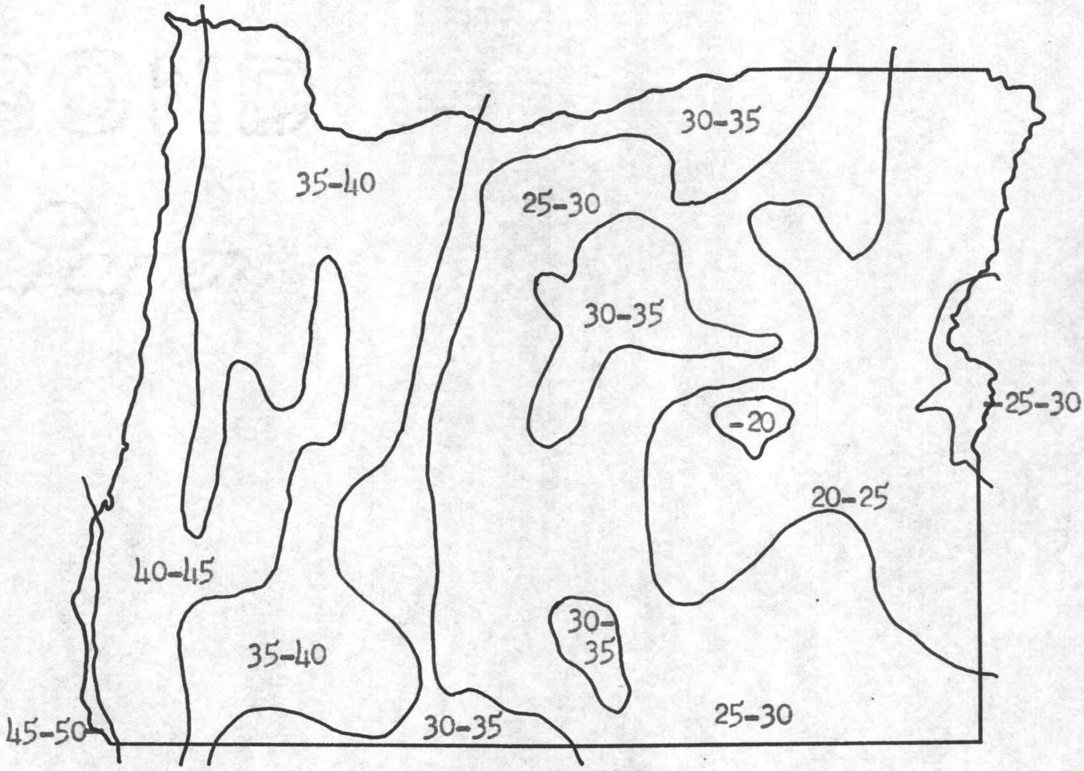


Figure 9. January Average Temperature (°F)

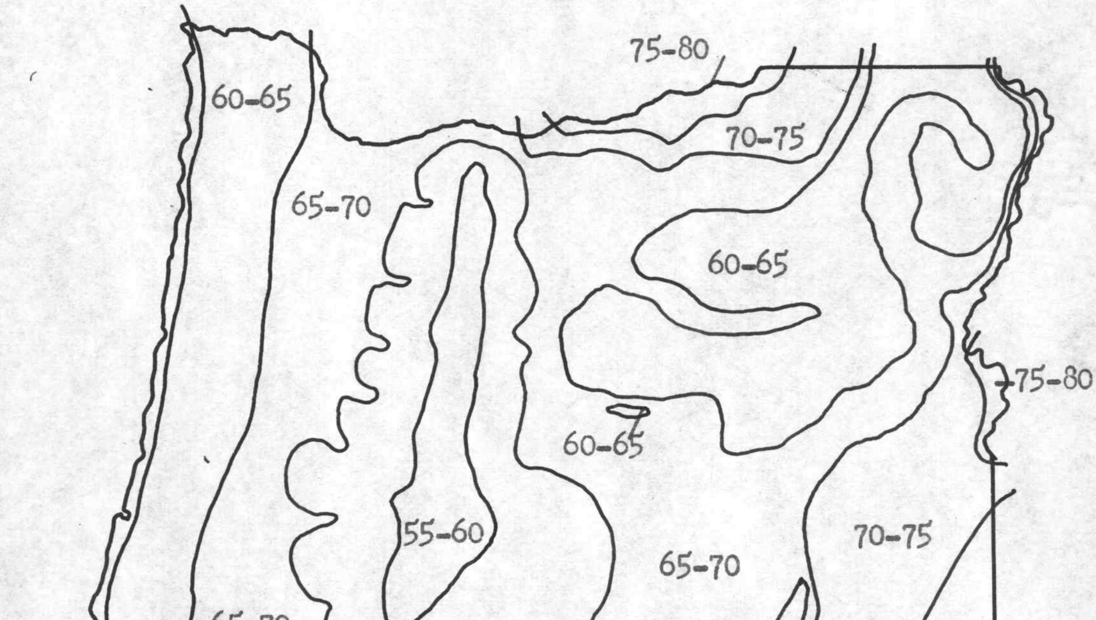


Figure 10. July Average Temperature (°F)

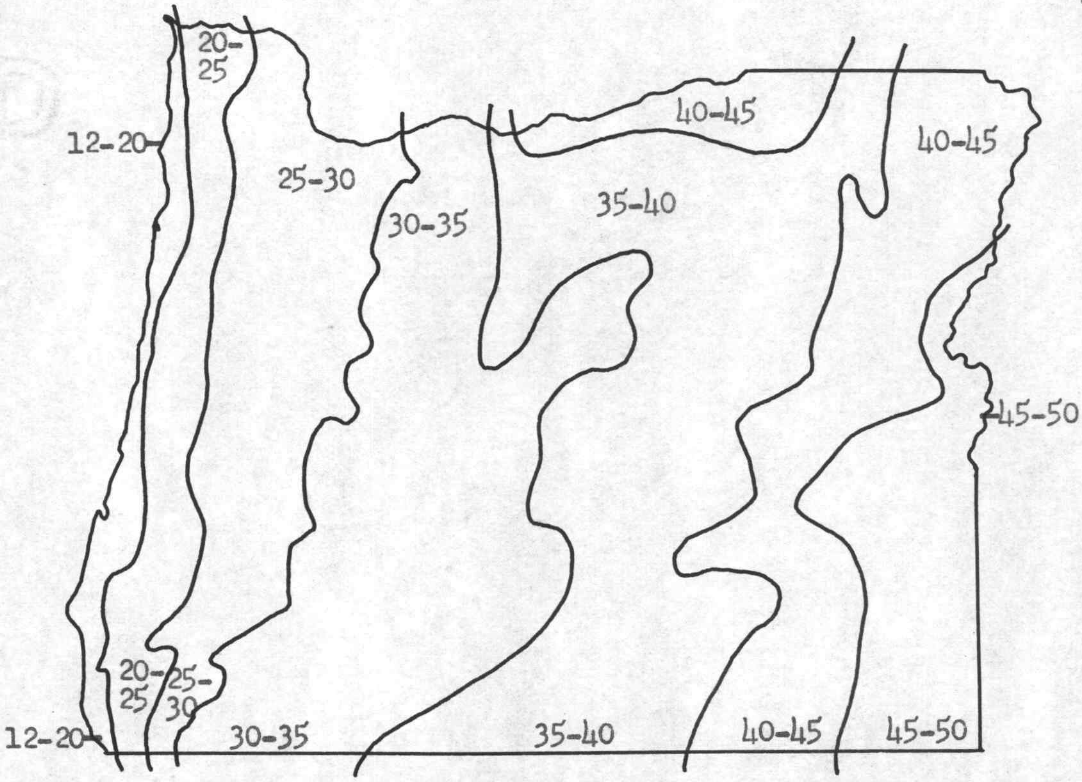


Figure 11. Average Range of Temperature (July Ave.-Jan. Ave.; °F)

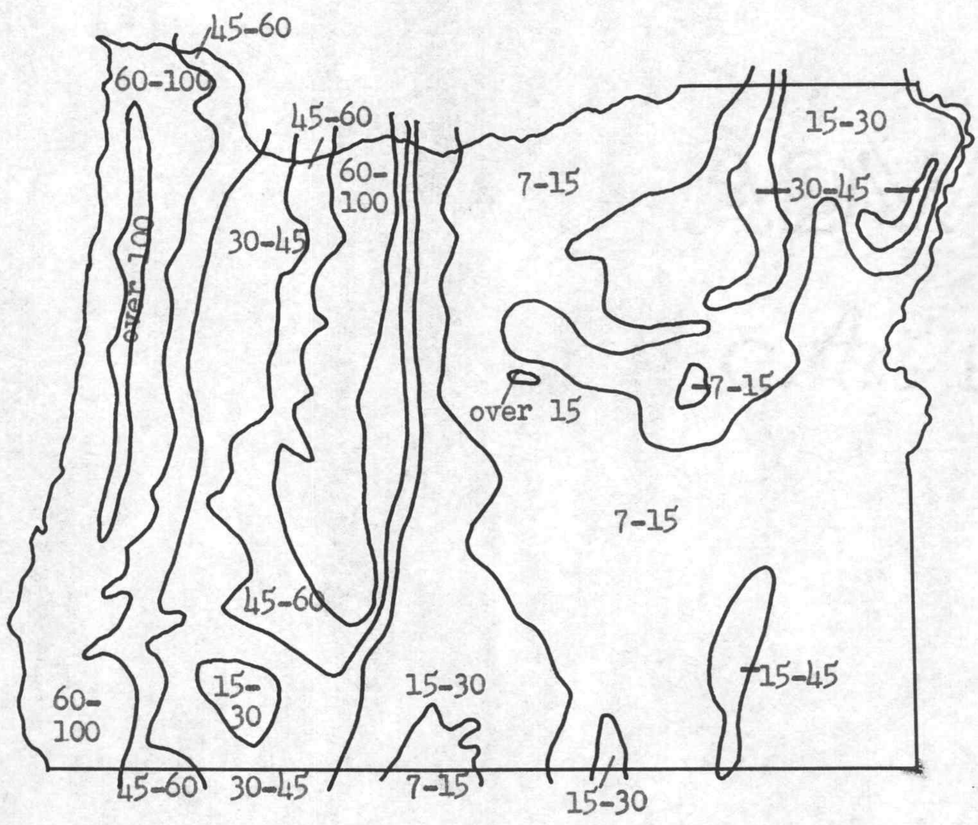


Figure 12. Average Annual Precipitation (inches)

Physiography and Microclimates

First order relief, the positions of continents and ocean basins, has already entered our discussion, and some attention has been given to major mountain ranges as features of second order relief. The Columbia Plateau is an additional form of second order relief which has an influence upon climates and biota of Oregon. The elevated position of most of eastern Oregon is frequently not fully appreciated; actually, the average crest level of the Cascades is about 5,000 feet, probably less, while extensive areas of the sage and juniper country range near that elevation. The Steens Mountains begin from a base level not far below 5,000 feet, and the same is true of many of the small groups making up the Fremont Ranges. It is principally to emphasize the elevations eastward from the Cascades that the 5,000- and 10,000-foot lines were drawn across the profiles in Figures 4-8.

Relief features of the third order, the valleys, hills, scattered mountains, and the slopes and exposures associated with them, have only minor effects upon the distribution of broad climatic regions. However, in ecological studies their local effect becomes very significant. Plate 19, a photograph of a portion of Joseph Creek Canyon in Wallowa County, shows how delicate the balance may be between forest and grassland with only slight differences of slope and exposure. Such localized expressions of climate are commonly considered as the microclimate, and as such are influenced about equally by local physiography and the vegetation. There is a definite response of soils, plants, and animals to variations of the microclimate. In this general survey, it need only be mentioned that the microclimate is an important source of variation in the distribution (particularly in a small area) of the various elements of climate, soils, and biota. A thorough approach to the study of microclimates has been presented by Geiger (18).

Distribution of Soils in Oregon

Since climate and vegetation are of primary importance in soil genesis, each climatic-vegetation zone is characterized by a specific process of soil development. Thus, within a typical climatic region the soil supporting climax vegetation may be expected to belong to the great soil group associated with that climate. If the vegetation is subclimax or has been disturbed, one may expect a subclimax or disturbed condition of the soil profile. Where climate and/or vegetation are less typical--i.e., within ecotones or near them--soils should show similar variations. The soils associated with the major climatic regions of the world are termed the zonal, or climatogenic, soils.

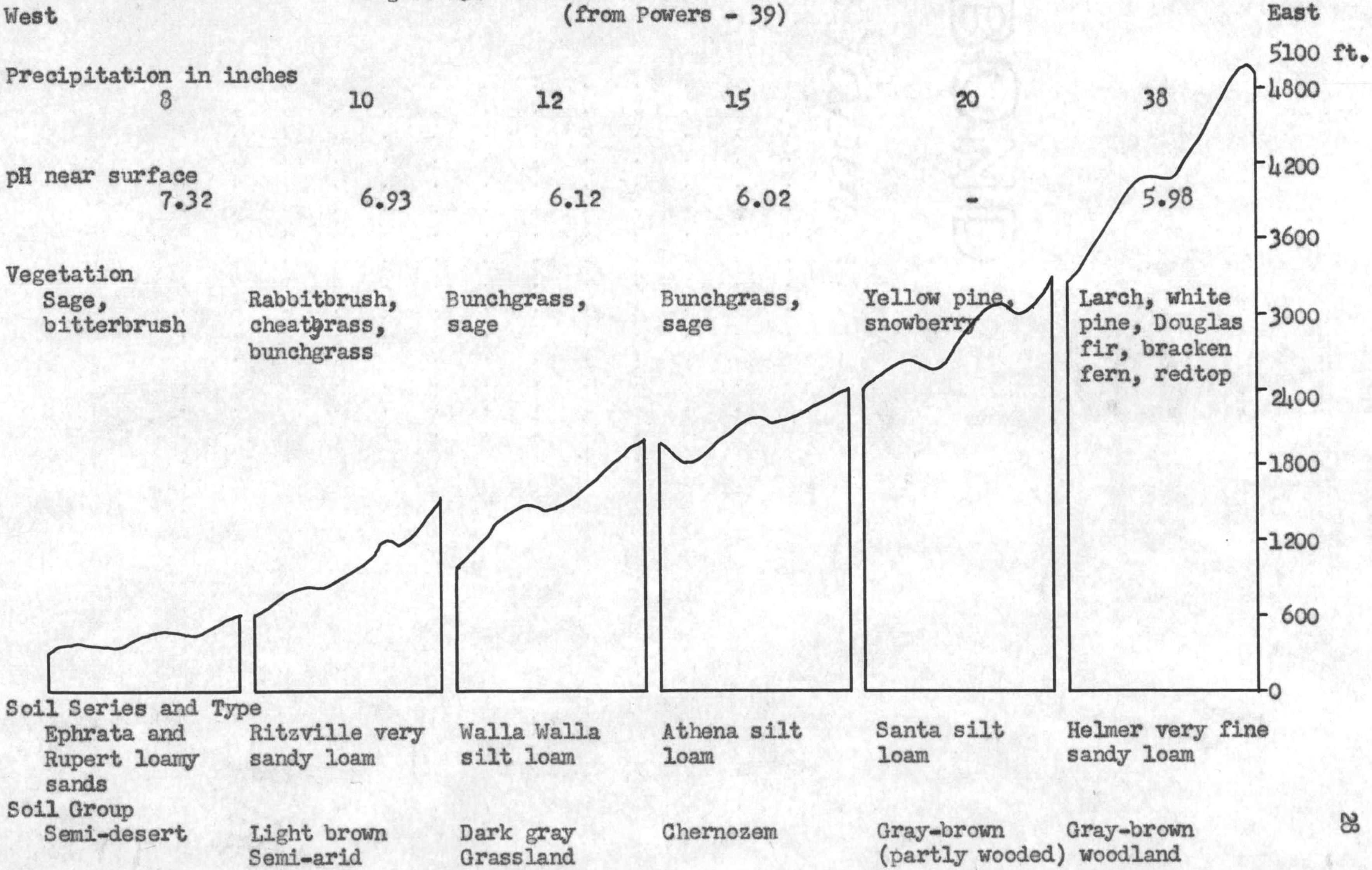
Climatogenically subdued soils occur when the parent material or some other element of the environment (e.g., drainage) prevents the normal expression of climate and vegetation upon soil development. Certain soils in this group show no profile development due to the nature of the parent material or to some other environmental impediment; sand dunes, recent alluvials, and the like are considered azonal, and are distributed without regard to the climatic pattern. When the impediment premits some development of profile, the soils are classed as intrazonal and may occur within any two or more soil zones. Rendzina, solonchak, solonetz, and solodi are examples of the intrazonal soils.

With the great diversity of climates and vegetation in Oregon, it is to be expected that the soils of the state will represent most of the groups mentioned above; such is exactly the case. Dr. Powers, who has studied the soils of Oregon for nearly half a century, describes the climatic soil groups present in Oregon as follows (38):

> Podzolic soils recognized include (a) coastal ground water (within Blacklock soil series), (b) valley or meadow podzol (as in the Dayton series), (c) forest pigmy podzols (within Springdale, Waha, and Santa), and (d) some podzolic mountain meadow soils. A classical podzol may be seen on the coast highway north of Mercer Lake.
>
> Lateritic red loams occur on (a) basaltic parent material, and to a lesser extent on (b) sedimentary beds. In the Rogue, Umpqua, and upper Willamette valleys these seem to meet the requirements of red loams. In northwestern Oregon they are more deeply weathered and show characteristics of relict laterites. Fossil palms indicate that the climate was formerly semitropical, and some bleaching appears to have set in during very recent geological times.
>
> Brown and gray-brown earth is developed under oak and related broadleaf vegetation in the well-drained, slightly undulating lands of the western Oregon valleys, of which the Willamette and Carlton series are typical.
>
> Some dark brown "prairie" soils occur in the Willamette Valley. They are grasslands and have droughty subsoils.
>
> There is little, if any, good rendzina in Oregon. A little coastal rendzina appears near shell beds, and the Coker series in southern Oregon may be rendzinalike if not too old.
>
> Black-earthlike soils are recognized in the more elevated and moist grassland areas of eastern Oregon. Such soil occurs on Steen Mountain and Weston Mountain, about the head of the John Day and the northern Grande Ronde valleys, and is best expressed in the upper Wallowa Valley, under 20- to 24-inch rainfall.
>
> The light brown semidesert soils are extensive, and true desert soils are little in evidence. Desert soil appears to occur east of Steen Mountain, but has not been carefully studied. Some of the very productive recent alluvial soils, like the Chehalis series, show slight eluviation.
>
> There is a vertical zoning of vegetation and soil in the Umatilla soil-survey area, with increase in elevation and rainfall. With elevation, analyses show increase in organic matter and less base saturation, or greater depth to calcareous horizon. More typical chestnut soil will be studied in the Baker area survey now under way.

The vertical zonation of soils in the Umatilla area is of particular interest to illustrate further the close association of climate, vegetation, and soils. From Powers' more detailed report of this study (39), some of the data have been compiled into Figure 13. Other studies (28, 32) are concerned with vertical zonation of soils in mountainous areas in other states, and are additional substantiation for the extensiveness of this correlation of climate, soils, plants and animals.

Figure 13. Zonation of Soils in the Umatilla Area
(from Powers - 39)



Biotic Variations

Sources of Variation

It has been emphasized that plants and animals follow closely the pattern of climatic distribution. In addition to the climatic variations which are responsible for a certain amount of variation in biotic distribution, other sources of variability are to be considered.

The genetic structure of plant and animal species is subject to constant change--that is, evolution is taking place at all times and under all conditions. Although genetic changes are generally slow in being expressed, they must, nevertheless, be taken into account, for they may result in ecological alterations, large or small, for the species. Indirect effects may influence the status of other species associated with the changing forms. The amount of subspeciation now recognized in many species of plants and animals is evidence of the extensiveness of phylogenetic changes which may affect biotic distribution.

The developmental progression of plant and animal groups from past forms under remote climatic conditions into the associations we now know has a very strong bearing upon the present-day distributions. Knowledge of paleoecological relationships between extinct plant and animal species, or even larger groups, is very meager, and holds little promise of ever becoming adequate. Most of the broad associations of plants and animals have long had a close association in development: grasslands, ungulates, and burrowing rodents, for example. The geographic distribution need not be static.

The age and the history of development of individual species (or the lineage resulting in our present species) is another element for consideration. Some cases of discontinuous distribution are apparently solved by paleontological evidence of this nature. This is of particular value in regard to species with small ranges, although it is not always determinable whether or not the species in question is very young or very old. There are several noteworthy examples in Oregon of species, either young or old, which have limited natural distribution: Port Orford cedar, weeping spruce, *Kalmiopsis leachiana*, mountain beaver, and pygmy rabbit.

The motility of organisms--the wide dispersal of seeds and other propagules by wind and other agencies, and the migrations and wanderings of animals--makes it possible for individuals of many species to appear (at least temporarily) in areas far removed from the range of normal occurrence. Usually such erratics need not be considered, but this is one of the methods by which isolated habitats may receive inhabitants. The differential ability of plant and animal species to cross gaps may determine which species will be found in isolated areas.

The regular migrations of many species of birds and of some mammals plus the wanderings of others cause them to be considered as seasonal residents, migrants, or sporadic or regular visitors to several climatic or vegetational zones.

Distribution of Species

In the discussion of soils (page 25) the zonal, intrazonal, and azonal nature of soil distribution was considered. The three terms were originated in the study of soils, and have not been specifically applied elsewhere. However, the basic idea behind the terms might well be utilized in our consideration of biotic distribution.

Species with zonal type of distribution are exemplified by Steller's jay, pileated woodpecker, western tanager, hermit warbler, red crossbill, Oregon and Canada jays, red-breasted nuthatch, creeper, varied thrush, the kinglets; pine squirrels, varying hares, marten--all of which range extensively through the western coniferous forests. There is a narrower zonal distribution in plants of the coniferous forests, and this results in the types of forest for different climatic conditions: western hemlock and western red cedar in Moist Coniferous Forest; several species of Abies, mountain hemlock, Engelmann spruce, in the Subalpine Forests; and western yellow pine in the Montane Forests.

Turkey vultures, ravens, robins, flickers, juncoes, many hawks, coyotes, cougars, bears, and deer range widely through forests, woodland, sage and grasslands; as species they are distributed without particular regard for the zonal distribution of vegetation or climates. Thus, they demonstrate the azonal type of distribution. Among the higher plants no species have been found which illustrate effectively this point, but the closely-related species of a few groups do suggest azonal dispersal: wild strawberry, lupines, violets, etc.

In regard to intrazonal distribution, organisms seem to exhibit special versatility. At any rate, examples are abundant. Aquatic habitats of various stages of development occur in practically all climatic and vegetational belts. Cattails, rushes, and sedges; redwings, marsh wrens, many species of waterfowl; muskrats and often other aquatic mammals--some or all are to be expected wherever marshes or shallow ponds occur within any climatic region. House sparrows and starlings stay close to human habitations--house sparrows even live around remote ranch houses when settlements become scarce (Plate 44). Crows and various blackbirds feed in fields and pastures all over the country. The deciduous growth along streams and elsewhere does not always consist of the same species of plants, but many plants are regularly found in this environment and in this regard are intrazonal. The downy woodpecker is consistently found in association with such deciduous growths, and various other species often are found in similar situations.

Not all species of plants and animals will fit into these categories without raising dissension somewhere along the list, but it is suggested that a majority of organisms might well be separated on this basis. The importance of this method of grouping species is that species of the azonal and intrazonal types are generally of little value as indicator species for the major climatic regions.

One additional consideration can be added to this discussion: certain organisms have been mentioned with small or restricted areas of natural distribution; these obviously are of a sub-zonal category, and due to their limited occurrence must be used as indicators only with reservation. The presence of such a species in a natural environment may be used as an indication of the major region, but the absence of the species is negative evidence only.

Biotic Areas

We now confront the problem of segregating areas of more or less uniform constituency from other areas. The task is immediately seen to resemble the taxonomic question, "What is a species?" The resemblance is considerable, except that in this situation there has not yet evolved a system of classification (or scheme of distribution) as universally acceptable as the Linnean system is to taxonomists.

As in taxonomy, lumpers formulate large basic units, comprising more diversity than splitters will agree to, so the splitter erects units too small for practicality. A suitable intermediate unit is yet to be determined.

In this survey of the distribution of flora and fauna in Oregon, an area which appears to possess a reasonably well-integrated aggregation of plant and animal species associated with fairly distinctive soil and climatic features is termed a biotic area. The term is used in a general, neutral sense, and is not intended to refer to any specific category or division of any of the distribution schemes. The descriptions of biotic areas are to a certain extent tentative; they are presented principally as a more accurate account of biological phenomena as they occur in Oregon than the author has encountered in most of the publications he has seen. The biotic areas form part of the basis for the discussion of distribution schemes which follows.

On the basis of the field work for this thesis, the following biotic areas and subdivisions of them are recognized:

1. The Coast Strip
   a. Northern subdivision
   b. Southern subdivision

2. The Moist Coniferous Forest

3. The Montane Forest
   a. Cascade subdivision
   b. Blue Mountain subdivision
   c. Fremont subdivision
   d. Siskiyou subdivision

4. The Subalpine Forest
   a. Cascade subdivision
   b. Blue Mountain subdivision
   c. Fremont subdivision
   d. Siskiyou subdivision

5. The Alpine Summits
   a. Cascades
   b. Wallowas

6. The Juniper Woodlands
   a. Typical woodlands
   b. Mountain mahogany thickets

7. The Oak Woodlands
   a. Hood River subdivision
   b. Willamette Valley subdivision
   c. Umpqua Valley subdivision
   d. Rogue River Valley subdivision

8. The Sagelands

9. The Palouse Prairie

The first four areas could be grouped under a larger unit, the Coniferous Forest, on the basis of a number of animals, common to all four areas, and perhaps a few plants (Douglas fir, for instance).

In addition to this list, there are several localities which do not satisfactorily conform to the surrounding areas or to any of the other areas; several of these will be examined as possible sources of additional information. The Steens Mountains, the Miller Lake area, the summit of Black Butte, Cache Mountain, and the Willamette Valley are the principal anomalous areas.

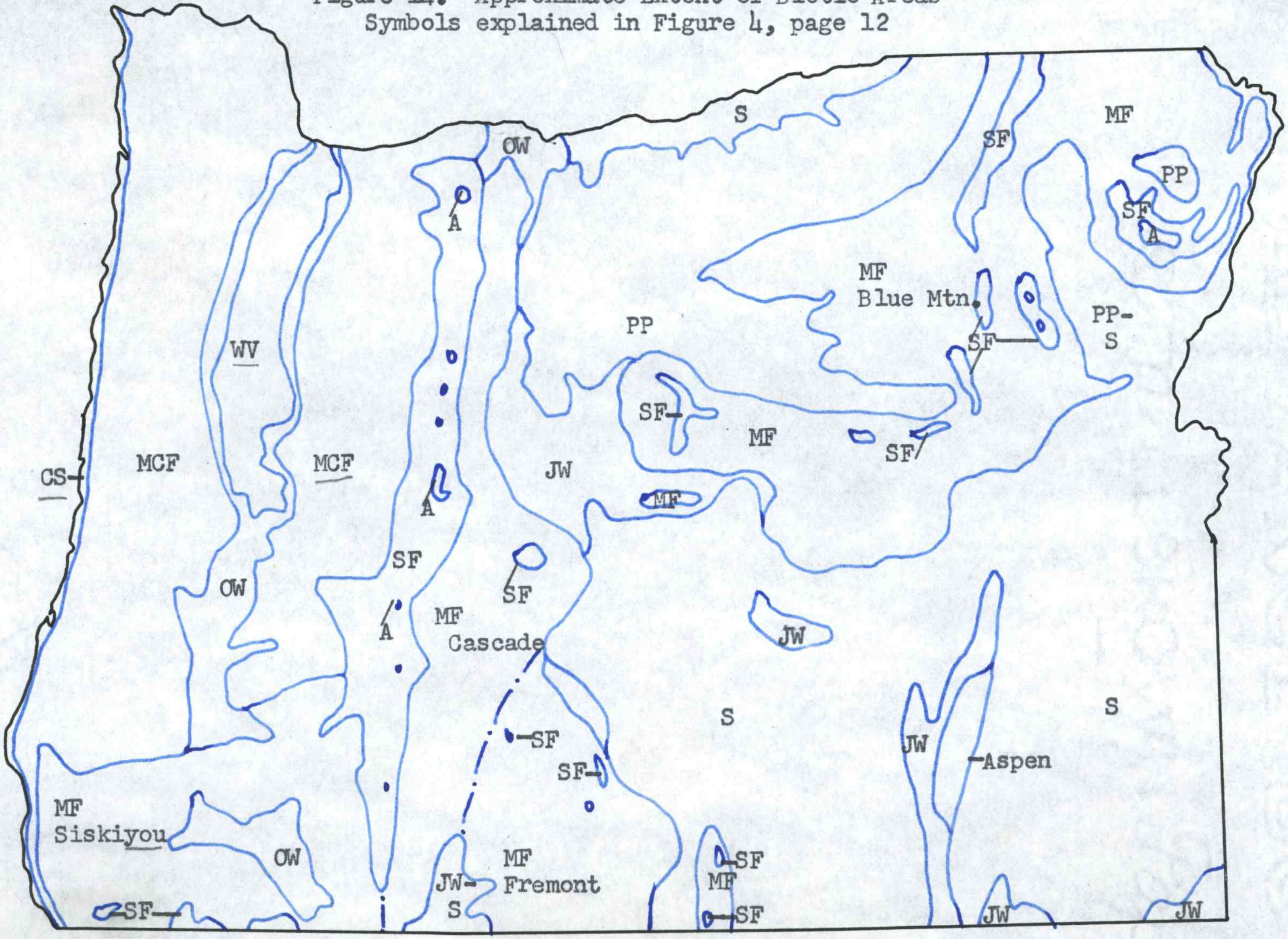
Biotic Areas of Oregon

1. The Coast Strip. Figure 14; Plates 1, 2.

This narrow fringe along the coast line may sometimes extend only a few hundred feet inland, and never exceeds a few miles. Its separation from the adjoining forest is seldom distinct, and much of the flora and fauna is common to both areas. The trees of the Coast Strip seldom attain commercial proportions, but destruction of the original conditions on a very extensive scale has resulted from recreational and tourist interests. Ocean-front homes and tourist accommodations are already congested along many miles of the Oregon coast, particularly north of Yaquina Bay, and clearing and construction are progressing at a very rapid rate. The Curry County coast has been cleared locally to support a thriving sheep industry.

Storms, particularly in winter, hit the Coast Strip in full fury. The effect of the storms and of the prevailing onshore winds upon the condition of tree forms is frequently a close indication of the extent of the Coast Strip (Plate 1). The areas of stunted, wind-swept trees may consist of Sitka spruce or shore pine in pure stands or mixed. The cover between patches of trees is generally a virtually impenetrable tangle of salal and other shrubs. More recently stabilized sand dunes may bear a few scattered trees with a fairly solid grass turf, with other herbaceous plants reproducing by runners, as wild strawberry and the sand verbena (Abronia sp.).

Figure 14. Approximate Extent of Biotic Areas
Symbols explained in Figure 4, page 12



In protected situations the wind-swept character is absent and the merger with the moist coniferous forest becomes even less distinct.

The strip undergoes an interesting and important transition between Cape Blanco and Coos Bay, or in the vicinity of the mouth of the Coquille River. The northern portion can be considered more typical, for here the best development of shore pine and Sitka spruce occurs; south of the Coquille River these trees and some of the shrubs and herbs to the north become less common and their places are taken by tanbark oak, California laurel, and various shrubs and herbs of more southern affinities.

CLIMATE. The entire coast strip is climatically distinct from the remainder of Oregon for the uniformity of temperatures (Figure 3). Weather data for stations along the Curry County coast show a difference of only 12° F. between January and July average temperatures, while for the northern coast the difference ranges from 13° F. to nearly 18° F. (the latter, higher difference is from a station not directly on the coast). The climatic differences along the coast are slight, but they are consistent, as is further indicated by the maps in Figures 9-12.

The coast has more days with fog than elsewhere in Oregon (page 18), and relative humidities are consistently higher--only rarely in summer going below the 30 per cent level when dry continental winds predominate (page 19).

SOILS. Podzolic soils of a coastal variety occur commonly (mostly within the Blacklock series) from the vicinity of Florence northward. A weak podzolic development has been detected in the Bandon area (mouth of the Coquille River). The soils of the Curry County coast have not been described. In the northern portions, the podzolization is largely restricted to the coast strip and to sandstone parent material which facilitates the podzolic processes.

Bogs are responsible for the occurrence of intrazonal peat soils, especially in the north coast strip. Stabilized sand dunes often retain their azonal character for several years, if shifting of the sands does not recommence.

FLORA. The plants of the Coast Strip contribute greatly to its distinctiveness, and at the same time indicate some unique affinities with plants of higher altitudes and/or more northern latitudes. The most common plants north of the Coquille River are listed below (those which are also common in the adjacent coast forest are designated by an asterisk).

*Sitka spruce (*Picea sitchensis*)
Shore pine (*Pinus contorta*)
*Douglas fir (*Pseudotsuga taxifolia*)
*Western hemlock (*Tsuga heterophylla*)
*Western red cedar (*Thuja plicata*)
*Big-leaf maple (*Acer macrophyllum*)
*Alder (*Alnus* spp.)
*Willow (*Salix* spp.)
Rhododendron (*Rhododendron californicum*)
Hairy manzanita (*Arctostaphylos columbiana*)
Kinnikinnick (*A. uva-ursi*)
*Salal (*Gaultheria shallon*)
Sweet gale (*Myrica gale*)
Wax myrtle (*M. californica*)

*Huckleberries (Vaccinium spp.)
*Salmonberry (Rubus spectabilis)
*Thimbleberry (R. parviflora)
*Oregon grape (Berberis nervosa)
Garrya elliptica
Coyote brush (Baccharis pilularis)

South of the Coquille River, the following species cause conspicuous changes in the flora, while many of the species above become less common. (These species are common in the forest to the east.)

California laurel (Umbellularia californica)
Tan oak (Lithocarpus densiflora)
Western azalea (Rhododendron occidentale)
Blue ceanothus (Ceanothus thyrsiflorus)
Dwarf juniper (Juniperus communis var. sibirica)

Rhododendron, hairy manzanita, and kinnikinnick are most common in Oregon in the coast strip and at higher elevations (above 3,000 feet) in the Cascades, while Garrya and coyote brush have their greatest abundance in the south coast strip and southward into California. Empetrum nigrum, a species not listed above because it is of only local occurrence along the coast, has a circumpolar distribution at higher latitudes.

The herbaceous species were incompletely covered in my field survey, but Peck (34, pp.16-18) lists a number of such plants which further substantiate the north-south division of the coast strip.

FAUNA. The mammals of the coast strip are by and large species from the adjacent forest: Townsend's chipmunk, deer, moles, and so on. There is one notable exception, for the grey digger (Citellus beecheyi douglasii) occurs in several places along the coast, but occurs in the coast ranges only in some of the larger valleys.

The wren-tit (Chamaea fasciata) in Oregon is almost restricted to the shrubby growth of the coast strip, although there is some evidence that it may be moving inland into the extensive brushlands which develop in the Coast Range following logging and/or burning. The house finch (Carpodacus mexicanus) is found locally along the coast, particularly in settled areas, but does not invade the Moist Coniferous Forest. Bald eagles, and a few ospreys, duck hawks, and pigeon hawks frequent the headlands and coastal cliffs. There is, of course, a great variety of water and shore birds, but their occurrence is more directly associated with the ocean and bays. Otherwise, the birds of the Moist Coniferous Forest are more or less common in the Coast Strip.

A subspecies of the California jay (Aphelocoma coerulescens caurina) inhabits the Coast Strip in Curry County, and thus is about the only avifaunal distinction between the north and south sections.

Herpetologically, the Coast Strip has most of the species of amphibians and reptiles of the adjacent forests, but in addition, the western toad (Bufo boreas) is found here and from the high Cascades eastward--but not in the intervening forests and valleys! Among the salamanders there is a further justification for the separation of the northern and southern portions of the coast strip; the red-backed salamander (Plethodon vehiculum) occurs in the northern section (it is characteristic of the Moist Coniferous Forest), while along the Curry County coast Plethodon elongatus, Batrachoseps attenuatus, and Ensatina eschscholtzii picta are to be encountered.

2. <u>The Moist Coniferous Forests</u>. Figure 14; Plates 3-10, 12, 71.

Although separated by the Willamette and other interior valleys, the climate, soils, and biota of the Coast Range and of the lower west slopes of the Cascades are hardly divisible. The conspicuous difference between the two areas is in physiography: The Coast Range consists of low mountains with few basaltic or other rock outcroppings (Plate 3); local relief rarely exceeds 2,000 feet. The west slope of the Cascades has several prominent basaltic features (Plates 5, 12), and a much more rugged character with local relief generally exceeding 3,000 feet. Because of their easier access, the forests of the Coast Range have been so extensively logged and burned that few areas remain which approximate to any extent the original conditions. There will apparently be no natural area reserved anywhere within the Oregon Coast Range, except a small area of Port Orford cedar in southern Coos County (this area is not typical of the Coast Range to the north). Some extensive areas of old-growth forest remain on the west slope of the Cascades, but their slaughter continues unabated with demands that the government provide more access roads.

Northward the Moist Coniferous Forest continues into western Washington, but its southern limits are reached in Oregon in the vicinity of the Coquille and upper Umpqua rivers. The most distinct break in Coast Range vegetation is right at the Coos-Curry county line on the divide between the Coquille and Rogue rivers. As one crosses this summit on the Powers-Agness road, the transition between the humid forest on the north and the subhumid scrubby growth on the south slope is striking. The Iron Mountain road traverses the ridge westward from the summit and climbs to about 3,500 feet. In Curry County on the south exposure, the vegetation includes a large portion of sugar pine and scattered patches of knobcone pine (Plate 23), but when the road crosses back to the north slope the forest consists of western hemlock, Port Orford cedar, and Douglas fir. It is on this slope of the upper drainage basin of the South Coquille River that the Port Orford cedar attains its best and most extensive growths; 9,000 acres are set aside for an experimental forest, and over 1,000 acres are preserved in the Port Orford Cedar Natural Area. Thus, the Moist Coniferous Forest of the Coast Range definitely terminates at the northern limits of the Rogue River drainage, and is undergoing transition through most of the extent of the Coquille River basin.

Along the west slope of the Cascades the change of forest types is less pronounced. The Crater Lake Highway along the upper Rogue River passes through a well-developed, mixed montane forest of sugar pine, western yellow pine, incense cedar, white fir, and Douglas fir. To the north, the next major route, the Willamette Highway, is within fairly typical Moist Coniferous Forest. In the area between these highways--thus, the area of the upper Umpqua River drainage--the blending of the two forests takes place. The road along the North Umpqua River gives a good view of the ecotone: Yellow pine is mainly at the lower elevations; incense cedar is sparingly scattered here and there; sugar pine is common along ridges and mixes with western hemlock and Douglas fir in many sites, while the hemlock and Douglas fir predominate in the most humid localities. Sugar pines persist as far north as Marion County (near Detroit), and at least a few trees are visible along the Willamette, McKenzie, and South Santiam highways--but nowhere north of the Umpqua drainage is the sugar pine a characteristic species in the flora! There is a complete lack of climatic data for the upper Umpqua drainage basin--the most extensive portion of western Oregon with no weather stations, existing or in the past!

CLIMATE. As evidenced by its name, the climate of the Moist Coniferous Forest is humid, or superhumid, and fairly equable. Minimum precipitation for typical development of this forest seems to be about 40 inches, but this is not to be taken rigidly, for temperatures and relative humidity are important influences. Precipitation ranges from the minimum of 40 inches to recorded maxima of at least 168 inches (52, Valsetz, 1950); it is possible that higher averages might be obtainable if there were more stations within this forest. The bulk of the precipitation is in the form of rain, and most of it falls in the period from late fall to early spring. Snow at low elevations is only occasional and of short duration, but at the upper altitudinal limits--particularly in the Cascades--several feet of snow is customary, and may persist throughout the winter and most of the spring. At such elevations, there will be some mingling with the subalpine forests, however.

The precipitation is very reliable; even at the minimal margin the drier years have more than 30 inches of rain, while stations with averages above 100 inches a year seldom receive less than 100 inches. Valsetz, in a rainy pocket, has records as high as 168 inches within one year. The highest precipitation records are for stations in the Coast Range, but amounts exceeding 85 inches (average) occur in the Cascades.

Despite the generous rains, summers can become quite dry for brief periods; the summer of 1951 broke many records for extended periods of low humidities. Relative humidities of 30 to 35 per cent are considered the critical point for halting logging operations, but forest fires, once started, burn nicely with humidities much higher than this. Normally, sea breezes sweep inland each afternoon to lower temperatures and raise humidities; the sea breeze, obviously, is less effective on the west slope of the Cascades. Except in periods when the continental east winds are predominant (page 19), summer temperatures and humidities are mild because of the maritime influence. The same applies in winter, but at that season the east winds are cold.

SOILS. With heavy precipitation and mild temperatures, the soils of the Moist Coniferous Forest tend to show weak to moderate amounts of laterization at low elevations; but with increasingly cooler temperatures as elevation increases the degree of laterization will obviously decrease. In fact, for most of this region with excessive precipitation and moderate temperatures, the soil development does not meet the specifications for any of the existing great soils groups (32). The Melbourne and Olympic soils are the most frequently encountered series described so far for the low elevations of the Moist Coniferous Forest. Both of these are classed as lateritic red loams; their principal distinction is based on type of parent material: Olympic series on basaltic rock, and Melbourne on sedimentary sandstones and shales.

FLORA. Douglas fir (Pseudotsuga taxifolia) is the most common tree throughout the Moist Coniferous Forest, but its distribution extends far beyond the limits of this forest type; within these limits it is considered to be only subclimax. The climax trees (53) are western hemlock (Tsuga heterophyla) and western red cedar (Thuja plicata), but these are slow in returning to disturbed areas. The western red cedar reaches its greatest abundance along stream courses and on the cooler, more moist slopes; it is generally the last of the climax trees to reappear following a disturbance. Western hemlock seems to prefer the portion of this area which is cooler and with heavier precipitation; that is, toward the coastal margin and at higher elevations (over 1,000 feet) in both the Coast and Cascade ranges. In such conditions it occasionally becomes re-established in logged or burned areas before Douglas fir does. In general, however, logging and burning tend to promote and maintain a Doublas fir subclimax. Lowland white fir (Abies grandis) and Pacific yew (Taxus brevifolia) occur commonly throughout the Moist Coniferous Forest but seldom if ever in pure stands. Conifers from neighboring types enter in the ecotones described above.

Big-leaf maple (Acer macrophyllum) and red alder (Alnus rubra) are the most abundant deciduous trees, particularly along streams, while vine maple (Acer circinatum) and various species of willow (Salix spp.) often attain small tree proportions.

The variety of shrubs and herbs is fairly extensive; the following lists are not intended to be comprehensive, but rather to suggest the more conspicuous and characteristic species. Locally, species not included here may be quite common.

Salal (Gaultheria shallon)
Salmonberry (Rubus spectabilis)
Thimbleberry (Rubus parviflora)
Oregon grape (Berberis nervosa)
Ocean spray (Holodiscus discolor)
Huckleberries (Vaccinium spp.)
Wild hazel (Corylus californica)
Red-flowering currant (Ribes sanguinea)
Devil's club (Oplopanax horridum)
Cascara (Rhamnus purshiana)
Iris tenax
Violets (Viola spp.)
Oxalis (Oxalis spp.)
Wild ginger (Asarum caudatum)
Vancouveria hexandra
Bracken fern (Pteridium aquilinum)
Sword fern (Polystichum munitum)
Foxglove (Digitalis purpurea)

FAUNA. Townsend's chipmunk (Eutamias townsendii), Douglas pine squirrel (Tamiasciurus douglasii douglasii), brush rabbit (Sylvilagus bachmani), Columbia black-tailed deer (Odocoileus columbianus columbianus) are probably the most conspicuous mammals whose ranges are fairly closely restricted to moist coniferous forest conditions. Equally characteristic are Townsend's mole (Scapanus townsendii), shrew-mole (Neurotrichus gibbsii), several species and subspecies of shrews, mice, and pocket gophers.

My master's thesis was a study of bird habitats in the central Coast Range; more recent field trips into other sections of the Coast Range and along the west slope of the Cascades indicate that this work on birds was reasonably applicable to general conditions throughout the Moist Coniferous Forest in Oregon. From that study, and other field work, the most common birds for this region include the following:

Steller's jay (Cyanocitta stelleri)
Chestnut-backed chickadee (Penthestes rufescens)
Pileated woodpecker (Dryocopus pileatus)
Red-breasted nuthatch (Sitta canadensis)
Golden-crowned kinglet (Regulus satrapa)
Red-breasted sapsucker (Sphyrapicus varius)
Brown creeper (Certhia familiaris)
Olive-sided flycatcher (Nuttallornis borealis)
Oregon junco (Junco oreganus)
Western evening grosbeak (Hesperiphona vespertina)
Oregon jay (Perisoreus obscurus)
Sooty grouse (Dendragapus fuliginosus)
Pine siskin (Spinus pinus)
Band-tailed pigeon (Columba fasciata)
Red crossbill (Loxia curvirostra)
Hermit warbler (Dendroica occidentalis)
Raven (Corvus corax)
Western tanager (Piranga ludoviciana)

Many of these species are not restricted to the Moist Coniferous Forest, but their ranges indicate, instead, a unity of all coniferous forests.

The reptiles of the Moist Coniferous Forest are not particularly distinctive, as is to be expected; a swift (Sceloporus occidentalis), an alligator lizard (Elgaria coeruleus), and a few varieties of garter snakes (Thamnophis spp.) are about all that one may encounter, and these are generally in open or logged areas.

On the other hand, the Moist Coniferous Forest is quite unique from other areas for the amphibians within its limits. The frogs most closely associated with this region are _Ascaphus truei_ and _Rana aurora_. The more striking feature is that here are found the greatest number of species of salamanders in any comparable area in the western United States:

Plethodon vehiculum
Plethodon dunni
Batrachoseps wrighti
Aneides ferreus
Ensatina eschscholtzii
Dicamptodon ensatus
Rhyacotriton olympicus
Triturus granulosus
Ambystoma gracile

3. _The Montane Forests_. Figure 14; Plates 11, 13-27, 38.

The forests of Oregon in which western yellow pine (_Pinus ponderosa_) is a common and characteristic floral element are here considered as the Montane Forests. They are extensively distributed over parts of southwestern, central and eastern Oregon, thus embodying considerable variation. Although western yellow pine is the principal species serving to unite these forests into one group, the range of the pygmy nuthatch (_Sitta pygmaea_) in Oregon closely approximates the extent of yellow pine forests. The golden-mantled ground squirrel (_Citellus lateralis_) reaches its greatest abundance in the montane forests, but does often occupy open subalpine forests and extend out into the junipers below the yellow pine areas. Other species to lesser degrees help to integrate these forests.

The Montane Forests are extensively logged, but fortunately the United States Forest Service has been fairly successful in helping to establish selective logging practices which cause relatively minor disturbances to the biotic habitats. In some of the selectively logged sections, the only evidences of logging are the scattered stumps. Soil disturbance is at a minimum, reforestation is rapid, and the appearance of the forest is not critically altered. There actually are a number of logged areas in central and eastern Oregon, and a few in southwestern Oregon where successful selective logging has been accomplished, particularly on national forests. Regretfully, privately owned forest lands are seldom handled with the same care, even by logging outfits that comply with Forest Service specifications when on government land.

Based principally on coniferous species, which to varying extents help to make up the Montane Forests, four main subdivisions may be recognized: 1. The Cascade Montane Forest along the east slope of the Cascades; 2. the Blue Mountain Montane Forest covering the Blue Mountain ranges from the Ochoco and Maury mountains on the southwest to the Wallowa Mountains on the northeast; 3. the Fremont Montane Forest on the ranges included by and adjoining the Fremont National Forest (herein referred to as the Fremont Ranges); and 4. the Siskiyou Montane Forest of the Siskiyou and neighboring mountains of southwestern Oregon.

The Cascade Montane Forest extends along the east base of the Cascades for the entire north-south distance of Oregon; the east-west extent varies from only a few miles in the Warm Springs Indian Reservation to about fifty miles in the Paulina Mountain sector. Latitudinally, the variations serve to correlate this central subdivision with the others. North of the Warm Springs Reservation, there is a strong mixture of Douglas fir, western larch (Larix occidentalis), and white firs (Abies grandis and/or concolor), which gives a close approximation to the constituency of much of the Blue Mountain Montane Forest, despite a very distinct geographical separation of the two areas. Southward, the other two subdivisions are more or less continuous with the Cascade region, so that the lines of separation become somewhat arbitrarily placed.

The westward margin of the Cascade Montane Forest is marked by a gradation into Subalpine Forest, which in places may extend over several miles, due largely to the long gentle slopes. In fact, the Cascade subdivision is distinct for its nearly flat terrain, interrupted occasionally by cinder cones of varying ages (Plates 11, 13). Likewise, the eastern edge of this Montane Forest has a broad ecotone, usually with juniper woodland as along the Bend-Sisters Highway, or with sagebrush as shown in Plate 22.

In typical climax conditions, this forest consists of a relatively dense stand of yellow pine with other conifers occurring very rarely; the broken undercover of brush consists almost entirely of green manzanita (Arctostaphylos patula), bitterbrush (Purshia tridentata), and Ceanothus velutinus. Reproduction is generally complete, as evidenced by trees of all age-groups. Natural clearings and meadows are scarce, but some do occur at higher elevations.

The soil is generally a light, sandy soil, rather shallow and developed on a substrate of pumice or tuff. Recent pumice deposits are quite extensive in the area north and east of Crater Lake and in the Paulina Mountains. On these pumice flats, lodgepole pine is commonly the dominant (and sometimes only) biotic form present (Plates 15, 16, 66). On practically raw pumice lodgepole pine seems to be the only species, plant or animal, really adapted for successful existence. A few shrubs and herbaceous plants are occasionally found, but often the stand of lodgepoles is so dense as to crowd out all other plants and prevent human passage without an axe or heavier equipment. Ground squirrels and a few other animals may be encountered in more open lodgepole pine flats; several species of birds forage through the lodgepoles, but few appear to nest in them. Pumice flats, then, may well be considered biological deserts, but in no other way do they resemble true desert conditions.

Lava flows apparently underlie all of the east slope of the Cascades, but recent flows appear on the surface throughout much of the area. Less recent flows may be largely disintegrated and occur as more or less obscure ridges (Plate 14) with little effect upon the normal forest appearance. Recent flows, dating back 1,000 to perhaps 10,000 years ago, present an entirely different environment (Plate 73). The lava in many of these seems hardly touched by the agents of weathering, and one might be inclined to think of them as completely barren. Nevertheless, a little scrutiny shows old tree trunks rotting on the surface, while gnarled and twisted trees have gained a foothold and are able to exist on nearly bare rock. The roots of such trees may traverse thirty or more feet of rock surfaces before gaining entry into a suitable crevice. Several species of shrubs and herbs occur where deposits of dust and organic debris collect. Due to the porosity of the lavas in this region, their insulation effectiveness is great; on a hot summer day, the upper surfaces of a small chunk of lava may be very warm to the touch, but the under surfaces will be decidedly cooler. On this account, the small cavities which are common in the flows are occasionally utilized by chipmunks, ground squirrels, and perhaps other small mammals.

The Blue Mountain Montane Forest in its best development contains a generous mixture of species--western yellow pine, Douglas fir, white fir, and western larch, with occasional additions of Engelmann spruce (Picea engelmanni), western white pine (Pinus monticola), and lodgepole pine from the higher Subalpine Forests (Plate 32). There is a common difference of distribution on north and south slopes; yellow pine often forms pure stands on south exposures and may be absent from the mixture of trees on north slopes. In the Ochoco and Maury mountains, the southwestern limits of this subdivision, yellow pine occurs in extensive parklike stands on the south slopes (Plate 17); in such areas shrubs may be entirely absent, but there is a profusion of wild flowers in spring and early summer. To the northeast the pure stands of yellow pine are less common, although still present.

To the west and south at lower elevations the Montane Forest gives way to Juniper Woodland ordinarily, or occasionally to sagebrush; the elevation of the ecotone is quite variable depending upon local conditions. In northern sectors there is an ecotone with Palouse Prairie or with small valleys similar to the Palouse (Plate 60). For Oregon the eastward distribution of Montane Forests is limited by the Snake River Canyon and its tributaries. In Wallowa County, the distribution of forest and grassland in the upper parts of the canyons may be under delicate control of conditions resulting from very slight differences in slope and exposure (Plate 19). Somewhat similar situations prevail in connection with other canyons (Plates 20, 21) in this corner of the state.

High ridges in the southern portion of this subdivision are often very dry, due partly to the snowfall being blown from the ridgetops and partly to drainage and soil conditions; the result is a recurrence of junipers along ridge summits above the yellow pine forests as well as on the lower slopes below them (Plate 18).

There has been little if any volcanic activity in the Blue Mountain region; thus the parent materials of the soils are predominately sedimentary. The soils in general are heavier (more clays, etc.) and resemble soils of the Gray-Brown Podzolic group (38, 39).

The <u>Fremont Montane Forest</u> is characterized by a scarcity of Douglas fir, but has an increased amount of white fir (<u>Abies concolor</u>).

This is the driest portion of the Montane Forests; thus to the eastward the lower limits of forest growth occur progressively higher. In the Warner Mountains, the easternmost range, the Montane Forest is almost entirely above 5,000 feet, whereas along the western margin the forest often extends down to about 4,000 feet. This subdivision, as in the case of the Blue Mountain region, is considerably fragmented by the isolated ranges and groups of hills comprising the Fremont Ranges. Some of the lower valleys are irrigated; most of them were originally covered with sagebrush and some of them have been only moderately altered by grazing.

White fir often exists in almost equal numbers with the yellow pine, particularly in the Warner Mountains. In the eastern sector there is often little differentiation between conditions of growth on north and south slopes. In the western sector pumice flats, outliers of the Cascade subdivision, support their dense stands of lodgepole pines and from these the lodgepole has spread into other parts of the forest. Some incense cedar (Libocedrus decurrens) is scattered through most of this forest. Near the upper elevational limits of the Montane Forest in the Warner Mountains and perhaps elsewhere some western white pine is encountered. Prior to early logging, sugar pine (Pinus lambertiana) apparently grew in the western sector, and may still persist in a few of the more remote, high areas (as Yamsay Mountains).

In the Cascade Montane Forest the brush undercover is generally extensive; in the Blue Mountain Forests brush is very scarce.

Brushy undergrowth in the Fremont Ranges is more or less intermediate between the two; locally it may be absent and elsewhere quite dense. The species of shrubs are about the same as found in the Cascade region.

The Fremont Ranges are composed principally of old volcanic materials, including some fault blocks of sizable proportions (Winter Ridge, Warner Mountains). Being on the minimal margin of precipitation, the soils associated with the lower forests are often immature stony soils, and some toward the western margin are recent pumice soils. Nevertheless, at higher elevations where heavier precipitation is received, soils of the Gray-Brown Podzolic group may be expected.

Vertical zonation of vegetation is probably demonstrated as clearly on the Fremont Ranges as anywhere else in Oregon. At least the Warner Mountains serve as an excellent example, for the portion of this range which extends into Oregon is encompassed by sagebrush and similar shrubs. The lower slopes of the range bear a narrow belt of junipers which soon give way to yellow pine with white fir appearing only slightly higher. The Montane Forest is quite extensive, from about 5,000 or 5,500 feet to about 7,500 feet. At this point a narrow belt of lodgepole pine in typical subalpine conditions is encountered. Then, at the highest elevations, generally above 8,000 feet, whitebark pine (Pinus albicaulis) indicates that the upper limit of tree growth is near, although none of the peaks reaches into alpine conditions. This zonation is partially illustrated in Plates 34-38.

The _Siskiyou Montane Forest_ contains the greatest mixture of species to be found in the Montane Forests of Oregon. Western yellow pine is rather persistent throughout this subdivision, but may be absent locally. Sugar pine has its greatest abundance in Oregon in this region, as does also the incense cedar. White fir and Douglas fir are also common. Knobcone pine (_Pinus attenuata_) appears locally, while at the higher limits there is extensive mixing with the subalpine species.

Hardwood trees also become more conspicuous; black oak (_Quercus kelloggii_), madrone (_Arbutus menziesii_), one or two live oaks and occasionally other trees mix with the conifers at lower elevations and in successional stages. The brush cover under a typical forest (as along the Crater Lake Highway) is often scattered, but may be fairly dense. In disturbed areas a wide variety of shrubby forms take over; several species of manzanita and ceanothus are generally the most common.

The exact limits of this subdivision are difficult to determine. The low elevation of the southern Cascade crest permits a direct contact of this forest with the Cascade Montane, and thus the line of demarcation here is completely obscured. Along the west slope of the southern Cascades this section of the Montane Forest can be found in reasonably typical development at least to the divide between the Rogue and Umpqua rivers. It has already been mentioned that sugar pine and other species of this forest are well-mixed with the Moist Coniferous Forest through most of the drainage basins of the upper Umpqua rivers.

A satisfactory separation from the Moist Coniferous Forest in the Coast Range has also been indicated in the vicinity of the northern boundary of Curry and Josephine counties. As difficult a problem as any is the western limit, for Curry County encloses some of the most inaccessible areas in Oregon. From the western slopes of Iron Mountain on the Coos-Curry county line, I was able to detect with the aid of 8x binoculars sugar pines growing in fair abundance along ridge tops which must be within ten miles of the coast. So far as I know, sugar pines cannot be seen anywhere along the Curry County coast, but in going inland on the few roads available, as along the Chetco River, conditions similar to the Moist Coniferous Forest exist (but considerably modified). Thus, there seems to be a narrow belt of atypical Moist Coniferous Forest separating the Siskiyou Montane Forest from the Coast Strip.

The lower elevations of the Siskiyou Montane Forest have been extensively logged and burned; extensive brush areas, chaparral-like in development, have taken over. It is possible that some of the shrub cover at lowest elevations could be the climax vegetation for small areas (Plate 67); at higher elevations it is probably seral. Nevertheless, the lower elevational limits have been obscured.

In the Siskiyou Mountains and the southern Coast Range area, the soils have developed on sedimentary rocks. At low to moderate elevations laterization occurs, but at the higher limits of this forest the Gray-Brown Podzolic soils may be expected. Along the west slope of the Cascades similar soils will be found, except that in places they have developed on volcanic materials; in the Crater Lake area a few pumice flats occur, generally toward the upper limits of the Montane Forest.

CLIMATE. The approximate minimal precipitation for maintenance of montane forest conditions appears to be 12 to 15 inches, while the transition into Subalpine Forest is generally at elevations where about 40 inches of precipitation may be expected. In the Siskiyou subdivision the amounts may be higher for both limits, while vast expanses of the Blue Mountain and Fremont forests crowd the minimal margin. The Siskiyou section probably has the least snow cover normally, as well as the longest growing season. The other three regions receive a greater proportion of their precipitation in the form of snow, and frost-free periods are generally rather short in duration. The Blue Mountain forest probably receives greatest convectional precipitation in summer; the Fremont Ranges should receive only slightly less, but the Cascade and Siskiyou sections will average considerably less.

Temperatures range from relatively uniform along the western fringe of the Siskiyou region to the greatest extremes in the north-east portion of the Blue Mountains. East of the Cascade crest the maritime influence is reduced; summers are definitely warm and spells in winter see temperatures go far below zero. Relative humidities are consistently low in summer in all but the western Siskiyou region. Extended periods with humidities below 20 per cent are common, and readings as low as 10 per cent are occasional. Nevertheless, forest fires are generally less common and less severe than in the Moist Coniferous Forest, probably because of less rugged terrain and the more open condition of forest and brush growth.

FLORA. The principal trees and shrubs have already been mentioned for each subdivision, with one exception. Quaking aspen (Populus tremuloides) is almost equally characteristic with yellow pine in the Montane Forests in Oregon. Aspen groves are generally limited to streamsides and other moist situations; such sites may be even swampy at times. In the Cascade and Siskiyou regions the aspen is somewhat limited in occurrence, but in the Blue Mountains and the Fremont Ranges it is very common around streams and meadows (Plate 25). Since this species seldom ranges below the Montane Forests and only occasionally into true subalpine conditions, its occurrence on the Steens Mountains serves as an indicator of adequate montane conditions in this isolated range (Plate 63).

Ferns are scarce in Montane Forests, but flowering herbs are very abundant. In each region there are a number of characteristic species, but there are few which range throughout the Montane Forests without going beyond the limits of the forests. In the Cascade and Siskiyou subdivisions meadows are at a minimum, but in the Fremont Ranges and the Blue Mountains open areas are of frequent occurrence. These relatively flat areas are variously termed meadows, flats, or prairies. They are generally well-watered through spring and into early summer, but become dry about midsummer (Plate 26). In spite of heavy grazing after early summer, there is a profusion of wild flowers from soon after the recession of the snow cover.

FAUNA. Herpetologically, the Montane Forest contains few, if any, distinctive species; the wide-ranging (azonal and intrazonal) species of frogs, salamanders, lizards, and snakes are to be found in favorable areas. The rubber boa (Charina bottae) appears to be closely associated with the Montane Forests, and its occurrence in the Willamette Valley is largely in open areas and habitats not too different from montane forest conditions.

Most of the birds listed for the Moist Coniferous Forest (page 48) are also common in the Montane Forests. In addition there are the pygmy nuthatch (Sitta pygmaea), Townsend's solitaire (Myadestes townsendi), Clark's nutcracker (Nucifraga columbiana), and mountain chickadee (Penthestes gambeli) which are common in the Montane Forests but are of rare occurrence in the Moist Coniferous Forest.

The mammals of the Montane Forests differ considerably from those of the Moist Coniferous Forest. In place of Townsend's chipmunk (which does get into the Siskiyou and the western part of the Cascade sections), there are several other species and subspecies of chipmunks. The Douglas pine squirrel is replaced by other subspecies, and even by another species (Tamiasciurus hudsonicus richardsoni) in the Blue Mountain subdivision. The range of the Columbia black-tailed deer meets that of the mule deer (Odocoileus hemionus macrotis) at the crest of the Cascades. Shrews and moles are less common in the Montane Forests, although some are still present, while the brush rabbit is replaced by a greater variety and abundance of cottontails and jackrabbits. In the subspeciation of the mammalian fauna the four subdivisions of the Montane Forest seem particularly suitable.

4. The Subalpine Forests. Figure 14; Plates 28-37, 39-43.

The Subalpine Forests are considered here as the forests growing at elevations higher than those for the forests previously discussed, and including the trees on up to timberline. The lower elevation is roughly about 4,000 feet (on the west slope of the Cascades) and about 4,500 feet (often more) on the east slope of the Cascades. Eastward the lower limits rise to about 6,000 feet on the Paulina Mountains, and to more than 7,000 feet on some of the other ranges in the state. Timberline, the upper limits of subalpine vegetation, follows a similar pattern, although few peaks outside the Cascades and Wallowas are high enough to show characteristic timberline conditions.

Because of increasing altitudinal effects, there tends to develop some distinction between the forests at lower elevations (approximately the lower half of the subalpine altitudinal range for any given area) and the forests at higher elevations. This suggests the Canadian and Hudsonian Life Zones, according to the life zone concept. Actually, the lower Subalpine Forests differ from the upper sections in containing many trees from the Moist Coniferous and/or Montane Forests. For example, Douglas fir is present in greater or lesser abundance well into the Subalpine Forests of all but the Fremont

Ranges in Oregon; in the Blue Mountains and the northern Cascades, western larch persists to rather high elevations. Thus, the lower subalpine is often a transition, more or less, from the lower coniferous forests to the forests just below timberline.

As with the Montane Forests, the Subalpine Forests of Oregon are divisible into the same four geographic regions, with the separation being based on differing combinations of conifers in each area.

The Cascade Subalpine Forest is undoubtedly the most extensive of these subdivisions (Plate 28), for it extends almost continuously from the Mount Hood area on the north end of the Oregon Cascades to the Mount McLoughlin area south of Crater Lake. The lower portion of this subalpine region has a strong infiltration of species from the surrounding forests; in small areas (as along the upper South Fork of the Rogue River) as many as twelve species of conifers may help comprise the forest. In some respects this portion of the forest resembles the Moist Coniferous Forest, but the growth is less luxuriant (undergrowth is commonly scarce) and the species of trees are different. The similarities are undoubtedly due to the humid climatic conditions which prevail here. The snowfall is consistently heavy (Plates 30, 31) and lasts well into the summer except at the very lowest fringes. The cooler temperatures, due to altitude, aid the snowfall in maintaining high relative humidities for all but a brief period in late August and early September. Snow depths of more than ten feet are not uncommon; the survival of any plant in this area depends upon its ability to withstand such a heavy weight, especially when the plant is young. A drastic effect upon the existence of animals is also attributable to the snow cover; the animals either migrate, hibernate, or are small enough to live in burrows under the snow or to run about on the surface with facility. Needless to say, birds are rarely encountered in the Subalpine Forests in winter, except during brief periods of fair weather.

In the upper Subalpine Forest of the Cascades, mountain hemlock (Tsuga mertensiana), subalpine fir (Abies lasiocarpa), and whitebark pine (Pinus albicaulis) are by far the predominant species, but they tend to occur in unmixed stands at timberline.

An outlying segment of the Cascade Subalpine Forest occurs on Newberry Crater and the higher cinder cones in the Paulina Mountains; because of the intermediate location the subalpine vegetation bears some resemblance to the Fremont subalpine although it is most similar to the main mass of the Cascade subdivision.

The Blue Mountain Subalpine Forest is more fragmented and less extensive than the Cascade subdivision. Nevertheless it is rather expansive in the Wallowa Mountains and along the main chain of the Blue Mountains. The smaller, isolated patches on the higher parts of the Ochocos and other mountains are probably less typical. In its best development, this subdivision exhibits a rather thorough mixture of species (western larch, Douglas fir, western white pine, subalpine fir, white fir, lodgepole pine, mountain hemlock, and whitebark pine), although at lower levels, mountain hemlock, subalpine fir, and whitebark pine are of limited occurrence. Again, the last three species are the trees to be expected at timberline. Here, the snow depth is considerably less than in the Cascades, but still adequate to have a restrictive influence upon both plants and animals.

The Fremont Subalpine Forest is of very limited and widely scattered distribution in Oregon. It consists principally of two species, lodgepole pine and whitebark pine, which apparently occur in two belts on the few isolated higher peaks (about 8,000 feet). At least in the Warner Mountains this condition is well-expressed in a belt of lodgepole pine below the fringe of whitebark pines on the leeward side of the summits (Plates 34-37). With such restricted extent and isolated occurrence, it is doubtful that in any of the typical species of the Subalpine Forests would occupy these areas. In this subdivision the snowfall is still less than that in the Blue Mountain region, so that its influence is somewhat lessened. Nevertheless, the larger drifts in the subalpine reaches endure summer temperatures into August.

The Siskiyou Subalpine Forest in Oregon is somewhat fragmented, but is fairly extensive in the central portion of the Siskiyou Range near the California border. Here, the number of species comprising the forest is again increased. Red fir (Abies magnifica) enters the eastern sector, while noble fir (Abies procera) is common in the western sector (Plates 41, 42). Alaska cedar (Chamaecyparis nootkatensis) reaches its southernmost distribution in this forest. A few isolated patches of weeping spruce (Picea breweriana) mark the extent of this species in Oregon. Whitebark pine, if present at all, is not common, and apparently subalpine fir is lacking entirely. Thus, mountain hemlock is the principal timberline species (Plates 39, 40). Western white pine, lodgepole pine, and Douglas fir are the other common species. Snowfall in this region is approximately the same as for the Blue Mountain Subalpine--appreciably less than in the Cascades--but probably does not persist as late into summer because of the more direct maritime influence.

SOILS. Subalpine soils vary from Gray-Brown Podzols in the lower elevations to various mountain modifications of podzolic soils. In Oregon the generally heavy snowfall and the warm, dry periods in late summer are special conditions which would alter the normal processes of podzolization. The soils of the frequent subalpine meadows have been termed "mountain-meadow" podzols (38).

FLORA. In addition to the trees which have already been discussed, the subalpine vegetation includes a number of shrubs which are typically low or prostrate forms. These reach greatest abundance in the high subalpine areas of the Cascade and Blue Mountain subdivisions where various species of huckleberries (*Vaccinium* spp.), heathers (*Cassiope* spp., *Phyllodoce* spp.), and other shrubs are to be found. At lower elevations on all but the Fremont Ranges, kinnikinnick (*Arctostaphylos uva-ursi*) and dwarf juniper (*Juniperus communis* var. *sibirica*) are occasionally encountered. Mahala mat (*Ceanothus prostratus*) and pine-mat manzanita (*Arctostaphylos nevadensis*) are additional prostrate forms in the Siskiyou and Cascade sections. Toward the lower limits, taller shrubs find suitable habitats; these include rhododendron (Rhododendron californicum and R. albiflorum), hairy manzanita (Arctostaphylos columbiana), dwarf maple (Acer glabrum), and Oregon boxwood (Pachystima myrsinites) among others. I doubt that any of these shrubs occur on the Fremont Ranges because of the poorer development of subalpine conditions in this region.

It is doubtful if any other vegetation type can surpass the Subalpine Forests in profusion and variety of wild flowers. There is a continuous succession of flowers for practically all of the period between snow covers, from early summer until October. Beneath the heavier forests bear grass (Xerophyllum tenax), Clintonia uniflora, twinflower (Linnea borealis), lupines, and others are common. But the meadows (Plate 43), lake and stream borders, and similar sites support the greatest share of the variety. Violets (Viola spp.), shooting stars (Dodecatheon spp.), cat's ears (Calochortus lobbii), Caltha spp., Pedicularis spp., Mimulus spp. and a host of others are common on the meadows, along with the grasses, sedges and rushes.

FAUNA. Scarcely any species of animals are actually restricted to the Subalpine Forests. This may be partly due to the severity of winter conditions, but is also partly due to the similarity of all coniferous forests (in Oregon) so far as life form and the general environment is concerned. Many species show a distinct preference for the subalpine conditions, but range fairly extensively through coniferous forests as a unit. Others merely migrate to lower forests as a means of avoiding the inconveniences imposed by the heavy snows.

Animals common in the Subalpine Forests are chipmunks, pine squirrels, golden-mantled and other ground squirrels, porcupines, marmots, martens, deer, red-backed mice (*Clethrionomys* spp.), tree mice (*Phenacomys* spp.), meadow mice (*Microtus richardsoni*), and water shrews (*Neosorex palustris*). Among the common birds are varied thrush (*Ixoreus naevius*), Oregon jay (*Perisoreus obscurus*), Canada jay (*P. canadensis*, in the Blue Mountains), Clark's nutcracker (*Nucifraga columbiana*), Cassin's purple finch (*Carpodacus cassini*), hermit warbler (*Dendroica occidentalis*), western tanager (*Piranga ludoviciana*), mountain chickadee (*Penthestes gambeli*), and red-breasted nuthatch (*Sitta canadensis*).

On the meadows the western toad (*Bufo boreas*), *Hyla regilla*, and *Thamnophis sirtalis tetrataenia* seem to be always abundant. The Cascade frog (*Rana cascadae*) is fairly closely restricted to streams and lakes in the Cascade subalpine area(13). The pygmy horned lizard (*Phrynosoma douglasii douglasii*) has been reported several times from pumice flats and "sand blows" in the high Cascades.

5. Alpine Summits. Figure 14; Plates 28, 45, 46.

Alpine vegetation in Oregon covers the well-isolated summits of the highest peaks of the state, generally at elevations above 7,000 feet. One of the most extensive areas of Alpine development is in the vicinity of the Three Sisters and Broken Top (Plate 28), where these four peaks and a few neighboring points of lesser elevation are only partially or incompletely separated by Subalpine Forest. Perhaps the greatest concentration of Alpine Summits is in the Wallowa Mountains where a number of high peaks bear perpetual snow fields. Related to the Wallowa section are a few scattered peaks in the Elkhorn, Greenhorn, Strawberry, and perhaps other ranges of the Blue Mountain system. There may be some minor indications of alpine infiltration on the highest peaks of the Siskiyou and Fremont Ranges, but in Oregon these mountains generally reach elevations of less than 8,000 feet; the few points in the Fremont Ranges that are over 8,000 feet are farther inland where alpine limits have been raised to higher elevations. Alpine characteristics are present along the summit of the Steens Mountains, but this will be discussed with the anomalous areas.

On rare occasions only are the Alpine Summits of Oregon lacking patches of snow; in fact, at elevations of about 10,000 feet glaciers are to be encountered on the high peaks of the Cascades and of the Wallowas, the two principal areas of alpine development. The stony texture of the soil, such as it is, is a further characteristic of the alpine environment. This suggests a difference from conditions of the arctic tundras, of which the Alpine Summits are altitudinal equivalents, for in tundra regions drainage is generally impeded either by frozen subsoil, levelness of terrain, or other factors. Alpine Summits have only local interference with drainage because of the prevailingly precipitous slopes; the result is more sparce vegetative cover and more immature soil conditions.

Despite the isolated occurrence of high peaks in Oregon, there is a remarkably uniform distribution of alpine plants. Peck (34, p.29) and others attribute this to migration of plants in connection with the recent ice age, when alpine conditions were more continuous and extended to lower elevations, and probably had a fairly close connection with the Arctic flora. Such a situation obviously would leave the Cascade and Wallowa areas well separated; that this was the case is evidenced by the differences in species of plants in the two areas. The alpine flora of the Wallowas shows an affinity with the flora of the Rocky Mountains, which is in keeping with its geological history and other features of that region.

The alpine flora consists principally of dwarf plants which are capable of blossoming and maturing seed within the limits of the very brief growing season. Among the typical alpine plants in Oregon are the characteristic sedges, dwarf willows, saxifrages, and various species of *Pentstemon*, *Silene*, *Draba*, *Anemone*, *Potentilla*, and the like.

The alpine fauna is almost non-existent in Oregon. Rosy finches (*Leucosticte tephroctis*) are fairly abundant in the Wallowas and occasional in the Cascades. Also, the American pipits (*Anthus spinoletta*) have approximately the same distribution. Other birds are principally summer visitors or stragglers from the Subalpine Forests. Pikas, or conies, (*Ochotona* spp.) and a few other animals of the rocky habitats of lower elevations often range into the alpine areas.

6. <u>Juniper Woodlands</u>. Figure 14; Plates 47-48.

The Juniper Woodlands of Oregon are of discontinuous and scattered distribution; typically, the woodlands exist as a narrow zone of separation between the Montane Forest and the Sagelands, but the juniper may be absent in local areas. The most extensive juniper country in Oregon is in the central Oregon area between Sisters, Prineville, Bend, and Horse Ridge; woodlands, more or less continuous with this area, extend eastward around the Maury Mountains, and southward along the east edge of the Paulina Mountains. The transition from Montane Forest to Juniper Woodland may be fairly distinct, but often covers several miles. Sagebrush (<u>Artemisia tridentata</u>) and rabbitbrush (<u>Chrysothamnus</u> spp.) are the principal shrubs within the woodlands, and since scattered junipers recur throughout the sage country, it is obvious that the distinction between Juniper Woodland and the Sagelands is often very arbitrary.

Typical woodlands develop under the influence of 10 to 15 inches of precipitation, so that wherever elevated ridges or buttes induce a little increase in rainfall junipers are to be expected. The density of juniper cover seems to respond to amounts of precipitation, or at least to effective precipitation. Toward the upper limits the trees attain large size and almost reach forest conditions; in the transition into sage country the junipers are small and become increasingly farther apart.

Since Juniper Woodlands receive less precipitation than the Montane Forest, it is normal that relative humidities will be consistently lower. Warmer summers and winters at least as cold as the Montane Forest are further aids to the low humidities. Snow cover is never as deep as in the yellow pine forests, and of course does not remain for very long periods.

In many areas the Juniper Woodlands have developed with thin, stony soils on fairly recent lava flows, but commonly the soil is loose, sandy, and deep enough to suit the needs of kangaroo rats (Dipodomys spp.) and other burrowing animals. I have found no specific reference of the great soil group to which soils of the Juniper Woodland belong, but it is very likely that they are related to the Semi-Desert, or Gray Desert soils. At any rate, junipers in Oregon do not tolerate surface alkalis.

In addition to the sagebrush and rabbitbrush already mentioned, bitterbrush is a frequent shrub, and other species of shrubs are less common. The variety of wild flowers is not great, including principally the species from the nearby forests or sagelands.

Of animals, the flocks of pinon jays in Oregon forage almost entirely in Juniper Woodlands, but few other animals are so closely restricted. Several species are especially abundant, although some of them have much more extensive ranges: kangaroo rats (Dipodomys spp.), wood rat (Neotoma cinerea), black-throated gray warbler (Dendroica nigrescens), Townsend's solitaire (Myadestes townsendi), magpie (Pica pica hudsonica), and others. The common presence of junipers in the vicinity of rim rocks brings other species into a more or less accidental association with the woodland; that is, golden eagles, various hawks, and other animals utilize the rim rocks for nesting, shelter, etc., but are not dependent upon the presence of juniper in their environment. Snakes and lizards are common, but amphibians are rare; none of these are known to be restricted to the Juniper Woodlands.

Mountain mahogany (Cercocarpus betuloides) (Plates 49, 50) does not actually become an integrated part of Juniper Woodland, but because of a generally similar type of development and distribution in the semi-arid parts of the state, it seems best to consider the thickets of mountain mahogany as a semi-arid woodland type. The climatic requirements of mahogany thickets are poorly known, but the trees seem to avoid low and hot localities; this would indicate a preference for a narrow range of conditions. The presence of this same species at 7,000 feet on Dutchman's Peak in the Siskiyou Mountains (Plate 40) seems to further complicate the matter. The total extent of mountain mahogany is rather small and widely scattered so that it is unlikely for any close correlation of distribution with any animal species to develop. Nevertheless, it is possible that some of the mahogany thickets (as on the Mahogany Mountains) encourage the presence of some woodland species of birds in areas otherwise entirely covered by sagebrush.

7. Oak Woodland. Figure 14; Plates 51-54.

Oak Woodland occurs in the Hood River Valley and surrounding areas (Plate 52), the Willamette Valley (Plate 51), the Umpqua Valley, and the Rogue River Valley. In the Hood River area, the oaks are entirely Oregon white oaks (Quercus garryana), with a considerable mixture of yellow pine and Douglas fir from the Montane Forest; bigleaf maple (Acer macrophyllum) and alders are the other deciduous trees. In the Willamette Valley, white oak is the characteristic woodland tree, but a few black oaks (Quercus kelloggii) get into the southern part of the valley. There are local mixtures of coniferous trees (this time from the Moist Coniferous Forest), and a liberal addition of other deciduous trees and shrubs. White oaks and black oaks occur separately and mixed in the woodlands of the Umpqua and Rogue River valleys, but in the latter there is generally more of the black oaks. Less infiltration of coniferous trees is characteristic in these latter areas. In any of the four areas the Oak Woodland may occur in such dense stands that conditions of deciduous forests often exist (Plate 52).

The Oak Woodlands seem to be the principal remnants in Oregon of the once extensive Tertiary deciduous forests. Evidence of this exists in the variety of shrubs and trees which appear to be closely related to similar plants in the eastern deciduous forests: hawthorn (Crataegus douglasii), serviceberry (Amelanchier spp.), poison oak (Rhus diversiloba), Oregon ash (Fraxinus oreganus), maples (Acer spp.), hazelnut (Corylus rostrata), snowberry (Symphoricarpos alba), elderberry (Sambucus spp.), and others. (Some of these species are not directly associated with the oakwoods.) Oregon fossils of other genera best represented today in the eastern deciduous forest add support to this idea. Many of the plants listed above are found in the bottomland woods along the larger streams in several parts of Oregon (Plates 53, 54)--the bottomlands need not be continuous with the Oak Woodlands.

Since Oak Woodlands have little commercial value (principally for fuel), they are not disturbed by logging--but neither are they actively protected. Much of the original oak cover has been cleared for farming; most of what remains is incorporated into pastures and subjected to varying intensities of grazing. Grazing has its greatest effect upon the herbaceous plants, and in the Oak Woodland local areas have had a large part of the original abundance of wild flowers replaced by weeds and similar plants introduced through feed for the domestic animals and through plantings for improved pasturage. Grazing and clearing have commonly resulted in increased abundance of poison oak and roses in many localities.

The fauna of the Oak Woodlands is best developed and most characteristic in the Rogue and Umpqua valleys, with some decrease in species in the Willamette Valley, and even more in the Hood River Valley. Because of the greater prevalence of Oak Woodlands in California, that region has served as the center of development and distribution of the animals most typical of oak woods habitats. Thus, the divides between the various valleys have had somewhat of a "filter effect" in holding back the spread of some of the species into other woodland areas.

Some of the amphibians and reptiles of the Moist Coniferous Forest get into parts of the Oak Woodland or into bottomland areas, but more distinctively associated with the oaks in all four areas is the alligator lizard (Elgaria multicarinata). Two king snakes occur in Oregon; the coral king snake (Lampropeltis multicincta) is confined to the Rogue River Valley, while Boyle's king snake (L. getulus boylii) is found in both the Rogue and Umpqua valleys.

Common birds of the Oak Woodlands include Lewis woodpecker (Asyndesmus lewis), black-capped chickadee (Penthestes atricapilla), white-breasted nuthatch (Sitta carolinensis), solitary vireo (Vireo solitarius), warbling vireo (Vireo gilvus), and California jay (Aphelocoma coeruleus). The California woodpecker (Balanosphyra formicivora) extends through the Oak Woodlands of the Rogue and Umpqua areas into the southern end of Willamette Valley.

Pocket gophers (Thomomys spp.), wood rats (Neotoma spp.), gray squirrels (Sciurus griseus), and various shrews and moles are common mammals of the oak woods.

Climatic conditions in the Oak Woodlands of Oregon are very irregular in many respects--precipitation in excess of 40 inches a year occurs in parts of the Willamette Valley, and less than 20 inches in the Ashland area. In other features the areas are more nearly similar; in addition to the customary dry conditions of summer the woodlands are located at relatively low elevations where high summer temperatures are prevalent.

Brown prairie-like soils and rich gray-brown soils, both highly valued for agriculture, were to a large extent responsible for the clearing of much of the Oak Woodlands. Although some of the remaining woodlands are probably on rich soils, some of them are probably on less valuable soils, such as the Melbourne and related series, where some laterization takes place. This is particularly true for the Rogue and Umpqua valleys where the warmer temperatures are more conducive to laterization.

8. <u>The Sagelands</u>. Figure 14; Plates 55-58.

One of the most extensive, continuous vegetation types in Oregon today is sagebrush; whether it was so extensive in original conditions is still a debatable question. The precipitation map (Figure 12) indicates that, on the basis of available weather records, most of the Sagelands receive rainfall in the vicinity of the minimal limits for grassland in this latitudinal range (8-12 inches). If the region (or most of it) were once grassland, it would have been of the bunch grass type which is readily removed by overgrazing. Once overgrazed, the land would be very slowly re-occupied by the bunch grasses; the minimal precipitation and continued grazing would be further deterrents, so that sagebrush might well persist (a grazing disclimax, according to Weaver and Clements, 53). Assuming more or less similar climatic conditions for the immediate past, it would have been entirely possible for bunch grasses to have been the dominant plants over most of the present Sagelands, particularly where better soils and slightly higher precipitation combined to form a more favorable environment. Even under such conditions, sagebrush would still have occupied much of the domain on the poorer soil sites and in the drier sections, which are principally leeward to the higher fault blocks and ridges, and in the lower valleys.

Under existing conditions, any bunchgrass in the Sagelands is of rather limited distribution (Plate 55), and is not likely to make a strong return, even when the sagebrush is cleared away and the land planted to grasses. The amount of grazing which bunch grass will tolerate in areas of minimal rainfall appears to be quite small.

The Sagelands are seldom as monotonous as they are commonly described; several species of shrubs are common and widespread besides the true sagebrush (Artemisia tridentata) for Oregon (Plate 56). Wild flowers are quite common from late March through June, the season of growth for the plants. The topography--rimrocks, canyons, and fault blocks--adds to the diversity of plant habitats as well as to the scenic features.

A large part of the Sagelands is contained in the northernmost extension of the Basin and Range physiographic province. This is characterized by the numerous lakes in southeastern and south central Oregon which have no external drainage. The larger of these lakes are permanently supplied with water (Abert, Summer, Malheur, Harney, and Warner lakes), although in long periods of subnormal precipitation even these may become dry or nearly so. Smaller lakes may contain a shallow body of water each spring, or may have water only in the "wet years". In any event, the lack of external drainage and the excessive evaporation are responsible for high alkaline contents in all of these lakes, both of the water and of the soil deposits of the dry lake beds, or playas. Summer winds proceed to accumulate the fine silt deposits of the playas into sand dunes (Plate 58), which may be extensive to the leeward of large playas. Due to alkalinity and periodic inundations, the level surface of a playa is completely devoid of vegetation and animal life. The shifting sand dunes with their alkali sands generally support scattered clumps of greasewood (Sarcobatus vermiculatus) and little else. A few reptiles and small mammals may range into dune areas.

Alkali is not limited to playas and lakes, but is a problem to farmers in several of the valleys and other agricultural lands wherever evaporation from the soil surface can cause a concentration of salts. This may result from poor drainage, or from an underground water supply. Plate 57 shows typical greasewood growth on an alkali flat adjacent to the Owyhee River. Depending upon the degree of alkalinity, such alkali areas may have a greater or lesser variety of plant and animal species.

Most of the soils of the Sagelands are light brown semi-desert soils, and commonly are very stony or immature. Another characteristic of these soils is a pronounced layer of lime deposition only a few inches below the surface; the actual depth varies with the average precipitation. The white lime deposits on the rocks are exposed in roadside ditches, and other digging in such areas.

Pronghorn antelopes (Antilocapra americana), marmots (Marmota flaviventris), badgers (Taxidea taxus), coyotes (Canis latrans), bobcats (Lynx rufus), jack rabbits (Lepus spp.), cottontails (Sylvilagus spp.), ground squirrels (Citellus spp.), kangaroo rats

(Dipodomys spp.), wood rats (Neotoma spp.), and several genera of mice (Onychomys, Peromyscus, Reithrodontomys, Microtus, Perognathus, and others) are among the common mammals of the Sagelands. The pygmy rabbit (Brachylagus idahoensis) occurs in the southeastern corner of Oregon.

The greatest variety of birds is found in the valleys and canyons of the Sagelands where water is available and a greater diversity of habitats is found. In open sage country there are a number of characteristic species: sage grouse (Centrocercus urophasianus), Brewer's sparrow (Spizella breweri), sage thrasher (Oreoscoptes montanus), mountain bluebird (Sialia currucoides), loggerhead shrike (Lanius ludovicianus), and others. In the vicinity of canyons and rimrocks one finds a number of hawks, ravens, golden eagles, and other birds, utilizing holes in the canyon walls for nesting and shelter (Plates 69, 72). Isolated ranch houses (Plate 44) and occasional ponds or waterholes serve to increase the variety of species in local areas.

Of the reptiles, gopher snakes (Pituophis catenifer), rattlesnakes (Crotalus viridis), racers (Coluber taeniatus), horned lizards (Phrynosoma spp.), swifts (Sceloporus spp.), and Uta stansburiana are fairly common, and several other species are occasionally encountered.

9. The Palouse Prairie. Figure 14; Plates 59-60.

The original Palouse Prairie in Oregon is now almost completely given over to agriculture--either large-scale wheat farming or ranching. The disturbance is so extensive that it is difficult to describe the area in terms of natural conditions. Precipitation tends to be inadequate (8-12 inches); wheat farmers commonly practice summer fallowing (planting wheat in alternate years in any one field). There is a general tendency toward over-grazing on most of the pastures and rangelands. Only at the upper elevational limits (near the forest ecotone) is the precipitation sufficient (12-15 inches) to maintain a luxuriant growth of grass. In some of the small valleys of the Blue Mountain region, Palouse-like extensions of grassland occur; these generally receive 12-15 inches of precipitation, and are largely taken over by ranches. The adjoining forests provide summer range (Plate 60), so that the valley pastures are generally kept in fair condition. Larger extensions occur in the Wallowa, Grande Ronde, Baker, and John Day valleys.

Many of the soils have developed on wind-deposited sediments (loess, or loess-like) and are deep, rich, agricultural soils, when properly cared for. In best development they form reasonably good black-earth, or chernozem, soils; this is particularly true of the soils in the Wallowa Valley, which receive 15-20 inches of precipitation.

Introduced species are more conspicuous, and often more abundant, than native plants; in fact, extensive cultivation and grazing have more or less restricted the existing native flora to genera and species which have generally wide ranges of distribution.

The fauna is essentially similar to that of the Sagelands, except that the larger mammals are less common, and certain characteristic birds of the sage country are absent. The common birds, meadowlarks, horned larks, magpies, blackbirds, robins, flickers, various sparrows, goldfinches, and the like, are principally the birds to be found in most of the agricultural areas of Oregon.

Anomalous Areas

In working with any of the distributional schemes, one is apt to come across a locality now and then that does not fit into any of the units or categories of that classification. Small areas may be relatively unimportant, especially in the consideration of broad groupings; nevertheless, it is often that studies of abnormalities provide a better understanding of normal conditions.

My travels over Oregon have turned up a number of more or less anomalous localities, and there undoubtedly are others. For the most part, they appear to be produced by three or more factors, which may operate independently or in conjunction with others: (1) isolation, (2) area too small for normal development, and (3) transitional or ecotonal complexes. These may be further modified or influenced by local conditions of soil, physiography, climate, biota, geology, and the like.

An anomalous area produced almost entirely through the effects of isolation is found in the Steens Mountains (Plates 61-64). A classic example of a fault block, the Steens Mountains extend about 80 miles in a south-southwest to north-northeast direction, and are about 25 miles wide in the central portion. They are effectively isolated from all forested areas, and apparently have not had even close proximity to forests in recent geological times. Rising from a base elevation of about 4,500 feet, the Steens are completely encompassed by Sagelands. With only slight increase in elevation on the long west slope, one soon enters a belt of Juniper Woodland, as is to be expected at comparable elevations on other mountains in eastern Oregon. The junipers disappear at about the probable elevation for Montane Forest (6,000 to 6,500 feet)--but no forest is there! Instead, through the altitudinal range where yellow pines would be expected, the only tree is quaking aspen (Populus tremuloides) which occurs in scattered groves (Plate 63) separated by expanses of sagebrush. At about the proper elevation for good development of Subalpine Forest (8,500 feet), the aspens disappear--there are no other trees, and the shrub cover (mostly sagebrush) becomes progressively more stunted and widely scattered. Peck (34, p.28) lists several alpine and subalpine species of plants which occur along the highest part of the Steens. Perpetual snowbanks (Plate 64) suggest that alpine conditions are present at least in local areas.

There exists on the Steens Mountains then a reasonable expression of altitudinal zonation, but with a meager representation of species. What is the cause? It has been considered by some that the Steens are too arid for forest development (2, pp.23-24), but snow survey measurements of recent years (44, p.45) reveal that the average snow depth (for seven years, 1939-1945, inclusive) at an elevation of 7,900 feet in late March was 66.7 inches! The average water content was 23.6 inches, but snow measurements seldom account for more than 75 per cent of the precipitation. Thus, an annual average in the vicinity of 30 inches seems to be a justifiable estimate for precipitation at 8,000 feet on the west slope of the Steens Mountains. This is certainly adequate for growth of Montane Forests. It may be reiterated that quaking aspen in Oregon is closely associated with the Montane Forests, and occur principally in moist sites. On the Steens the aspen groves often cover hundreds of acres on the long slopes; they do avoid the drier and more exposed sites, which is to be expected. It must be concluded that isolation is by far the more probable factor responsible for the absence of montane and subalpine trees and shrubs from the Steens Mountains.

Just how large an area has to be in order for normal development of the flora and fauna would be difficult to determine. That an area can be too small seems rather evident in respect to some summit areas to be discussed here. For instance, on the summit of Mary's Peak (4,097 feet) in the Coast Range, there occurs a small stand of noble fir (Abies procera). In the Cascades and Siskiyous, noble fir is principally a tree of the low Subalpine Forests. An elevation of 4,000 feet in the Coast Range at this latitude is not unreasonable as the suitable altitude for development of subalpine conditions. But the extent of the area even above 3,500 feet is exceedingly small, and is found only on Mary's Peak. It seems then that the normal development of subalpine conditions is limited by lack of sufficient area. The absence of other subalpine species may be due to the effects of isolation. A number of mountains in the Cascades and elsewhere in Oregon terminate at about the proper elevation for the expression of the next higher biotic type. With a restricted area and with greater or lesser extent of isolation, abnormal development is to be expected.

Black Butte (6,415 feet), an outstanding landmark northwest of Sisters, is entirely within the Cascade Montane Forest. Situated ten miles east of the crest of the Cascades, it is not particularly surprising that the Montane Forest in a typical condition of growth extends to about 5,700 or 5,800 feet on the south slope. It is unusual, however, that the yellow pines are replaced in a very sharp ecotone by whitebark pines interspersed through a dense brush cover (Plate 65). The absence of a more typical Subalpine Forest is somewhat unique, but the tangle of shrubs is quite abnormal. Their presence must be due to some feature or combination of features resulting from the temperature, precipitation, and soil conditions on the south and west slopes. Below the sharp ecotone the undergrowth of the yellow pine forest is approximately normal. The trail to the summit avoids the north exposure, but indications from the Black Butte Lookout are that at least a comparable portion of the upper slopes is covered by a dense Subalpine Forest dominated by various species of Abies with some mountain hemlock. It is only at the summit that the whitebark pine and Abies lasiocarpa occur together. (It is interesting to note further that pygmy horned lizards (Phrynosoma douglasii douglasii) have been collected from the summits of Black Butte, Cache Mountain (5,570 feet; seven miles west), and Sand Mountain (5,460 feet; another seven miles west, and thus west of the Cascade crest), but have not yet been reported from the intervening forested areas.)

Other small summit areas are equally interesting, and may be more or less anomalous (Plates 18, 34, 40). If the areas are too small for characteristic development of vegetation, it is logical that the fauna associated with it will be poorly represented also.

An ecotone is a strip of varying width between adjacent areas with differing constituencies--the zone of transition (Plate 22). The mixing of species in the ecotone can be considered as normal in most instances; however, other factors may become involved, in which case the transition may become complex. Such anomalous cases may be further affected by isolation, or even by a restriction in the extent of the area involved.

The Willamette Valley is often mapped as part of the forests of northwestern Oregon, or perhaps as Oak Woodland, or even grassland. Actually, there is a mixture of all three types of vegetation, and this apparently was the condition of the original cover (43). Whether the reportedly extensive burnings attributed to the Indians had influenced the vegetation remains debatable. Even the climate is difficult to classify; all of western Oregon is subjected to the marine west coast climate in winter, but the summers bear some resemblance to Mediterranean climatic conditions. This is most markedly expressed in the Willamette, Umpqua, and Rogue valleys. Precipitation in the Willamette Valley ranges around 40 inches, the minimal margin for Moist Coniferous Forest; in the Umpqua Valley, the rainfall is about 30 inches, while in the Rogue Valley it ranges from 30 inches to less than 20 inches. Going south from the Willamette Valley, climatic conditions and vegetation resemble more and more the climate and plant cover of the Central Valley of California. The Central Valley was originally grassland, but Oak Woodlands occur around the edges of the valley where rainfall is higher. Thus, the Willamette Valley may be characterized as a complex ecotone between the Moist Coniferous Forest and a mixture of woodlands and grasslands--but the more typical and extensive woodlands and grasslands are removed far to the south instead of being adjacent to the ecotone! The Umpqua and Rogue Valleys probably should be considered as segments of this complex ecotone. The distinct differences in the plants and animals on the north and south slopes of the hills and buttes in the Willamette Valley--even the diversity of the biota and of the soils on the level valley floor--show characteristic features of this unique transition. Often on north slopes, conditions of the Moist Coniferous Forest prevail, while the south slope may be Oak Woodland, grassland, or a mixture of the two.

In the Miller Lake area of northern Klamath County, northeast of Mount Thielsen, the yellow pine forest with occasional pumice flats extends westward and upward to an elevation above 5,000 feet, retaining typical montane forest conditions. Ascending a low bench or terrace, one encounters a rapid infiltration of sugar pines (*Pinus lambertiana*) until it occurs in almost pure stands (Plate 66). If one examines the soil, it is found to be substantially raw pumice, with chunks of pumice not uncommon. A few straggly lodgepole pines and scattered clumps of manzanita comprise the understory. Progressing westward and climbing gradually, one next notices red fir (*Abies* *magnifica*) entering the forest, and a little later western white pine (*Pinus monticola*) makes its appearance. About this time the sugar pine begins to decrease, and for a short distance the forest is dominated by the red firs and western white pines; this is at an elevation about 5,600 feet. The soil is still essentially raw pumice. Near Miller Lake (5,616 feet) the red fir gives way to other species of *Abies* (*A. lasiocarpa*, *A. amabilis* ?, and *A. concolor* ?). The forest bordering the lake is fairly typical Subalpine Forest, and the soil, although sandy, is more nearly mature and developed from older pumice deposits. Thus, in a distance of less than three miles one passes through a unique ecotone. The north-south extent of the ecotone is not known; this is approaching the northern limits of both red fir and sugar pine along the east side of the Cascade crest. Just what factors of the environment subdue the lodgepole pines in favor of the other trees would require a more detailed study.

The localities described above are by no means all of the anomalous areas that occur in Oregon--they are merely suggestive of the nature of the anomalies. Since this thesis is basically geographical and because of time limitations, these abnormal areas could not be adequately covered for a thorough examination of all the factors involved.

Discussion

Maps and classifications of natural phenomena vary greatly in their degrees of accuracy and dependability (6, pp.187-188). Physical geographers, dealing with geology, topography, and soils, produce generally reliable maps which are very useful, even indispensable, to many fields of study. Similarly, the relatively high accuracy of agricultural maps reflects the availability of extensive factual data. However, in mapping and classifying climatic and biological data, the diversity of results is astounding. There is, nevertheless, adequate explanation for the variability, for first of all, data are often lacking over extensive areas (even the collection of reliable data often requires many years for one locality, e.g., climatic averages). Then, due to the nature of much of the data, they are subject to various methods of integration and interpretation (my own selection of data shown in Figures 9-12 is an example). Particularly in the interpretation of these data, an even greater variance is involved; this includes individual philosophies and preferences--the personal viewpoint. Furthermore, in the absence of data, it is a common practice either to interpolate for the vacant area, or to utilize earlier maps or other works, the reliability of which may be very questionable; in this manner there is a "perpetuation of mistakes and some very rough approximations of the truth" (6, p.188). Similarly, the degree of accuracy in mapping or classifying biological and climatic data is variously dependent upon the concepts involved (compare Koppen's (1) and

Thornthwaite's (48, 49) climatic maps, and the maps of life zones (2) and biotic provinces (12)).

The existing maps of life zones, biotic provinces, and biomes for Oregon (essentially the climax formations of Clements in reference 53) show many inconsistencies apparently due to factors mentioned in the discussion above. It was in part due to looking at the divergencies of these maps that this thesis had its start. It was hoped that a close acquaintance with the biotic elements and their distribution would lead to a more accurate delineation of biotic distribution in Oregon. This was the ideal; although I am not prepared to present a large-scale map of these data with this thesis, I do hope that some of the descriptions will help to clarify some of the inaccuracies.

The life zones of Oregon (2, map) seem particularly inadequate for describing the state as I have seen it. The humid, subhumid, and semi-arid divisions of the Transition Zone do not remove the undesirable features of this unit--it just contains too much diversity. To incorporate Moist Coniferous Forest, Oak Woodland, Montane Forests, Juniper Woodland, and parts of the Sagelands and grasslands under the Transition Life Zone implies relationships between the areas that do not exist. To divide the sage country and grasslands between the Transition, Upper Sonoran, and (worse yet) Canadian Life Zones is awkward because of relationships that do exist. The mapping of Canadian, Hudsonian, and Arctic-Alpine zones on the Steens Mountains seems logical enough, but I am uncertain as to the actual feasibility in view of the poor representation of typical species due to the isolation.

Some of the concepts formulated by Dice for biotic provinces (12, 27) are not too objectionable, but the mapping of the provinces for Oregon seems at best very impractical. The division between the Artemisian and Palouse Provinces is especially vulnerable, for none of its entire length in Oregon is marked by any natural distinctions--it bisects Montane Forest, Sagelands, Subalpine Forest, some Juniper Woodlands, and even extensions of the Palouse Prairie! The fragmenting of affiliated or united areas does not stop here, for Montane Forests occur in three of the four provinces in Oregon, and Subalpine Forests in all four--the natural affinities of these and other areas are almost completely discarded.

The biotic provinces have been modified by Munz and Keck (31) recently in reference to California, but even the altered form does not fully eliminate the criticisms above. In addition, their work is based entirely upon plants, so that it is not a complete utilization of the scheme.

Bio-ecology, the biological approach to ecology, appeals to me. As is evident from the descriptions I have presented, I am of the opinion that studies of plants and animals are incomplete unless both sections of the biota are given full consideration. The expressions of Taylor (47) and others, who emphasize the need for a bio-ecological approach to many of the problems in agriculture, range management, forestry, natural resources, and so on, receive my full support.

However, the biome, the major unit in the classification generally advocated by bio-ecologists, places me in a position of uncertainty. Several studies have utilized the biome and its smaller categories to full advantage (8, 14, 37, 40), and I do not question the value of these works. Since there has been no detailed study of the biomes in Oregon, or to my knowledge any local studies within a biome in Oregon, it is difficult to suggest direct criticisms as to the schemes above. Nevertheless, having been directly adapted to the classificatory structure of Clements' formations, it is subjected to the same general criticisms and questions (6)--the reality of the monoclimax and the like. In view of the descriptive areas which I have suggested and on the basis of my acquaintance with biotic distribution in Oregon (which is not necessarily adequate for a final decision), I do not feel that the biomes offer a really satisfactory system for mapping and classifying the biotic units of this state. There are, for example, many sections of Oregon not represented sufficiently by climax vegetation, according to Clementsian standards; because of human influences, the subclimaxes will be maintained indefinitely. I also feel that the scheme is somewhat encumbered by a number of unnecessary super-technical terms, which are a serious handicap to a relative simplicity of terms which I consider desirable.

In this paper I have given emphasis to the correlations in distribution of climates, soils, and biota; none of the schemes above give full cognizance to this idea. The nearest approach to this position is described by Tansley (45, 46) as the ecosystem, comparable to the "physical systems of which the universe is composed--systems which mark positions of relative, if only temporary, stability in the general flux." (45, p.228). There has been no further development of the idea, or suggestions as to use in field studies or the like. Indeed, there is no assurance that the ecosystem can be feasibly utilized in field work.

Summary

The state of Oregon has been used as the area for a geographical-ecological survey of the distribution of biota (at least, the portion of the biota including higher plants and land vertebrates). Information and material for the descriptions presented and the views expressed were gathered from extensive travels (over 20,000 miles) and studies in Oregon in a four-year period.

The climatic elements (temperature, precipitation, humidity, winds, and air pressure) show variations in response to increasing latitude, to progression from coast to interior, to altitudinal increases, and to the passing of time. The distribution of the climatic elements is affected by several direct and interacting controls: latitudinal position, relationship to land and water, winds and air masses, altitude, mountain barriers, ocean currents, and storms. All of the controls have an influence on Oregon climate, and are at least partly responsible for the extensive variations over the state. The effect of physiography, particularly on microclimates, is evidenced by many instances in Oregon.

In general, the distribution of soils in Oregon follows the diversities of climate and of vegetation, and most of the great soil groups are represented. An example of vertical zonation of soils, in conjunction with precipitation and vegetation in the Umatilla area, is described and illustrated.

Genetic variations as indicated by subspeciation, the history of individual species, the development of plant and animal associations, and the motility of organisms are considered as sources of variations in the distribution of biota. It is noted that species have distributions similar in general respects to the zonal, intrazonal, and azonal distribution of soils, and that species of the azonal and intrazonal types, in general, are of little value as indicators in biotic units.

The description of biotic units in Oregon is undertaken, utilizing the term biotic area in a neutral or impartial sense--that is, not in conjunction with any of the distribution schemes that have been propounded by various workers. The areas and subdivisions recognized are as follows:

1. The Coast Strip
   a. Northern subdivision
   b. Southern subdivision

2. The Moist Coniferous Forest

3. The Montane Forest
   a. Cascade subdivision
   b. Blue Mountain subdivision
   c. Fremont subdivision
   d. Siskiyou subdivision

4. The Subalpine Forest
   a. Cascade subdivision
   b. Blue Mountain subdivision
   c. Fremont subdivision
   d. Siskiyou subdivision

5. The Alpine Summits
   a. Cascades
   b. Wallowas

6. The Juniper Woodlands
   a. Typical woodlands
   b. Mountain mahogany thickets

7. The Oak Woodlands
   a. Hood River subdivision
   b. Willamette Valley subdivision
   c. Umpqua Valley subdivision
   d. Rogue River Valley subdivision

8. The Sagelands

9. The Palouse Prairie

A unity of the coniferous forest areas is also indicated.

The Steens Mountains are mentioned as an example of an anomaly in biotic distribution produced by isolation; here, quaking aspen forms extensive groves in the elevational range normally occupied by Montane Forest. Snow surveys further indicate the occurrence of precipitation adequate for the growth of yellow pine forests.

That an area can be too small in extent for normal development of the biota is postulated, using a small stand of noble fir on Mary's Peak as an example. Anomalies produced by complex ecotones or transitions are illustrated by the Willamette Valley, and by an unusual mixture of trees in the Miller Lake area of northern Klamath County.

Problems involved in the mapping and classification of climatic and biological data are discussed, and the existing biotic schemes are criticized in terms of this survey of biotic distribution in Oregon. The life zones and biotic provinces principally fail to recognize the relationships and affinities between areas, while the biome system is held in question in regard to general criticisms associated with the monoclimax concept.

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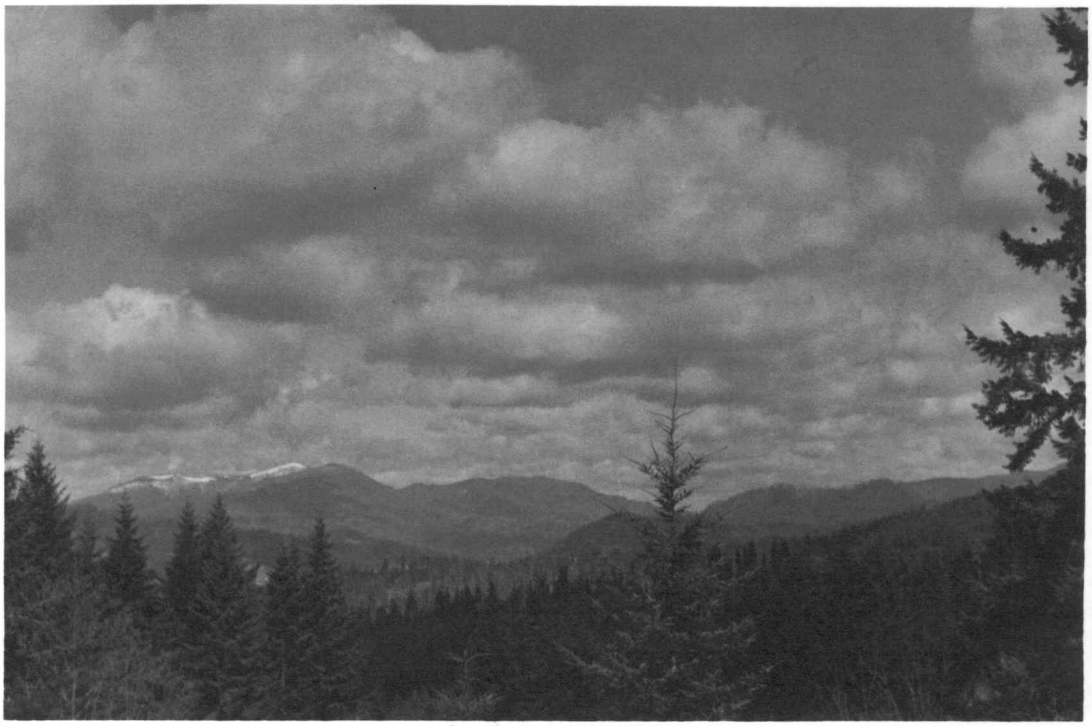
Appendix

Plate 1. The north Coast Strip, looking south from Cape Perpetua viewpoint, Siuslaw National Forest. Slopes above Highway 101 show wind-swept form of Sitka spruce and shore pine, mixing with Moist Coniferous Forest near left margin. Lower left, large trees of Sitka spruce in sheltered Cape Creek Canyon; many of these trees were blown down in a severe storm in early December, 1951--the wind-swept forms nearby were undamaged! Most of lighter gray slopes are dense cover of brush or grass.
July, 1949.

Plate 2. Humbug Mountain from Highway 101 along Curry County coast. Grassy slope in foreground is maintained as sheep pasture. Trees shown are Sitka spruce and Douglas fir; alders along lower margin.
November, 1950.

Plate 3. Coast Range horizon: low, rounded mountains. Early spring view of snow-capped Mary's Peak (4,097 feet), left of center, and upper Alsea drainage basin from trail on north slopes of Prairie Mountain, south of Alsea P. O. Conifers in foreground show characteristics of Douglas fir at different ages. Siuslaw National Forest.
April, 1949.

Plate 4. Corvallis watershed, a protected area of Moist Coniferous Forest, mostly old second-growth Douglas fir. Willamette Valley in the distance; noble firs in foreground identify view from near summit of Mary's Peak, almost 4,000 feet.
October, 1949.



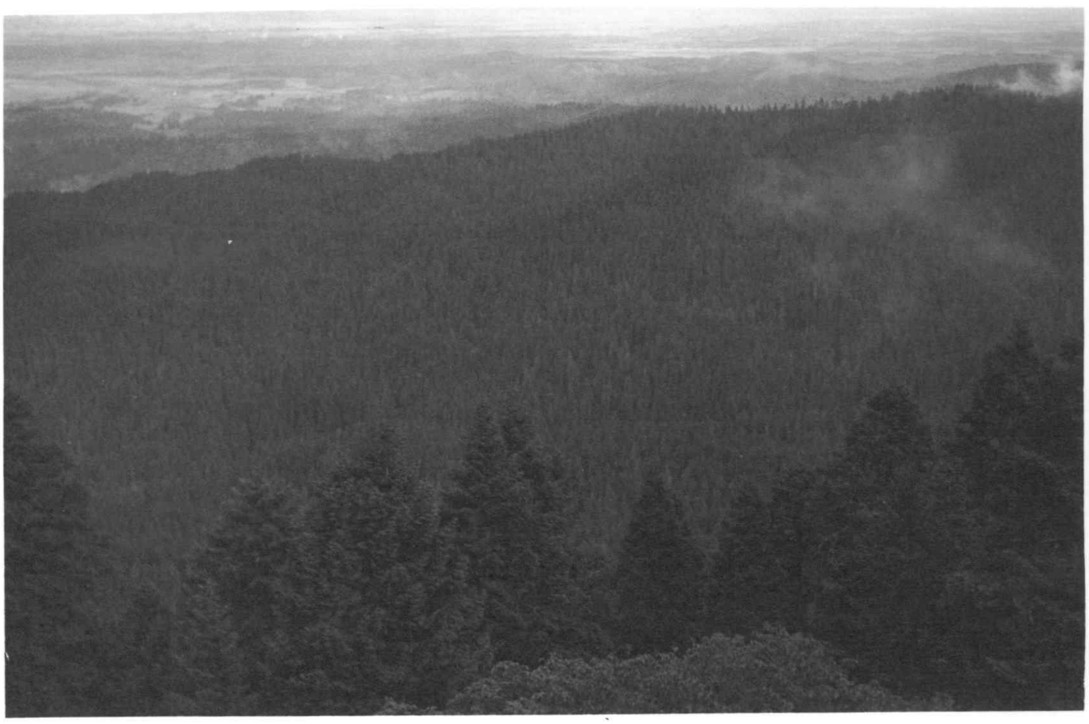


Plate 5. Jumpoff Joe, prominent basaltic landmark of western slope of Cascades, as seen from South Santiam Highway in the Willamette Mational Forest. Young trees and snags on the steep slopes mark the occurrence of large fires during the 1920's or earlier. "Clouds" above horizon probably consist of smoke from fall slash-burnings.
October, 1948.

Plate 6. Even-aged stand of second-growth forest, predominantly Douglas fir, along Salt Creek Canyon (Willamette Highway). Dense forests of this sort have few large animals; small animals and birds are largely seed-eaters, feeding on cone crop produced by the trees. Willamette National Forest.
October, 1951.

Plate 7. Clear-cut logging on a steep slope south of Roseburg, as viewed from Highway 99. Clear-cut method leaves much to be desired esthetically; loggers contend it is the only feasible method in Moist Coniferous Forest conditions. Theoretically, the logged area is supposed to be reseeded naturally by the surrounding forest. June, 1951.

Plate 8. Logged area with slashings burned, south slope of Mary's Peak. Clear-cut logging proponents fail to consider soil changes imposed by such a complete removal of vegetation; heavy precipitation quickly leaches out most of the organic fertility maintained by forest cover. Burning, following logging, leaves soil in virtually raw, mineral condition; leaching slows rebuilding of the organic content. Most common plants in area shown are pioneer plants (senecios, thistles, etc.) whose wind-borne seeds are carried great distances. This area is included in the area shown in Plate 9.
August, 1949.

Plate 9. Fire, in this case slash burning, includes area shown in Plate 8 on the south slope of Mary's Peak. Fall slash burnings are not always given adequate attention and frequently burn more than the slashings. Forest fires and slash burnings have a critical effect on soil fertility and impede reforestation. Damage to animal habitats and food is equally severe.
October, 1948.

Plate 10. Extensive old burn area around Valsetz Lake, similar in appearance to the notorious Tillamook Burn farther north. Precipitation has been recorded at Valsetz Lake in amounts approaching 200 inches a year. Excessive rainfall was producing a luxuriant growth of forest giants before fire; now, because of leaching out of organic accumulations, the rains must be a critical deterrent to reforestation. Soil erosion in the first few years following logging or burning is magnified by persistent downpours of winter.
November, 1949.

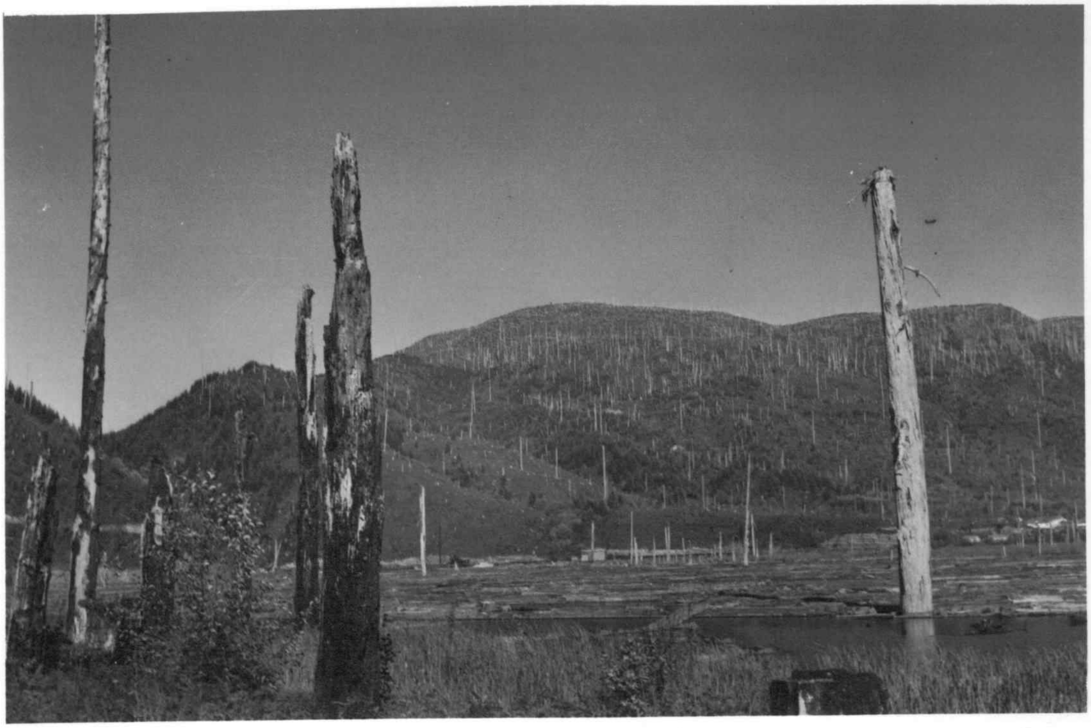


Plate 11. The east slope of the Cascades, looking southeast from Cache Mountain Lookout (5,570 feet) near Santiam Pass. The elevation of the ridges at the right margin is about 7,000 feet; the flat regions at the left margin are about 3,000 feet above sea level. The distance covered is over 20 miles. Yellow pine forest covers all of the area shown except along the right margin where subalpine conditions are found and in the hazy distance near the left margin which extends into Juniper Woodland. Deschutes National Forest.
August, 1951.

Plate 12. The west slope of the Cascades as viewed from Cache Mountain Lookout; compare with Plate 11. The rugged nature of the terrain is obvious although only the higher elevations are shown. The peaks and ridges forming the horizon range about 5,000 feet in elevation. The crest of the Cascades (about 4,800 feet) passes through the relatively flat Subalpine Forest shown in the foreground; Big Lake, the only visible one of the many lakes dotting this area, is just west of the crest. The foreground forest is low subalpine and contains a mixture of species from the Moist Coniferous Forest with yellow pine from the Montane Forest persisting on drier exposures. All of the trees except lodgepole pine reach a size only slightly smaller than the trees of the climax Moist Coniferous Forest farther west. August, 1951.

Plate 13. Northwest portion of the Paulina Mountains, looking south from Lava Butte Lookout, south of Bend, in the Deschutes National Forest. The few trees in the immediate foreground are growing on the rim or in the crater of Lava Butte (5,000 feet); the forest beyond these trees is at 4,500 feet elevation with the terrain rising to over 7,000 feet for the rim of Newberry Crater forming the left horizon. Above 5,500 to 6,000 feet is Subalpine Forest. The cinder cones shown are only a few of the 150 or more parasitic cones on the Newberry Crater shield; their north slopes are fairly well forested, but the south slopes may be bare cinders or at best only sparsely covered. Numerous lava flows occurred in the area pictured, including the flow shown in Plate 73.
August, 1950.

Plate 14. Cascade Montane Forest in the southern portion of the Paulina Mountains, Deschutes National Forest. An old lava flow is visible behind the closer trees. Forest is typical in showing large amount of reproduction; not so typical is the absence of brush cover. This area may have been selectively logged, as evidenced by open stand and immature condition of growth of most of the trees.
April, 1951.

Plate 15. Lodgepole pine forest on pumice flat west of Crescent, northern Klamath County. The dense stand and almost complete absence of competing species and of shrubs is very characteristic. Also typical is the large amount of downed trees, the result of natural thinning as the stand matures. Deschutes National Forest.
April, 1951.

Plate 16. Interior of lodgepole pine forest; this picture was taken inside the forest across the road from the area shown in Plate 15. The conditions of growth were about the same. Here are shown one or two shrubs of the sparse undercover. Growth of younger trees can be so dense as to be nearly impenetrable..
April, 1951.

Plate 17. Parklike yellow pine forest at Wiley Flat, southeast portion of the Maury Mountains in the Ochoco National Forest. Forests of this type are often extensive in the Maury and Ochco mountains and occasionally eastward. White fir and Douglas fir are found near water courses and on north slopes.
June, 1951.

Plate 18. High ridge (about 5,500 feet) extending south from Fields Peak, southwest of Canyon City, Malheur National Forest. Strong west winds apparently keep snow cover to a minimum along ridge top; drainage and soil conditions are further encouragement to growth of junipers above the Montane Forest. Much of the main ridge of the Maury Mountains also supports juniper. Most of forest trees in picture are yellow pine, but Douglas fir and western larch were seen deeper in Tex Creek Canyon.
June, 1951.

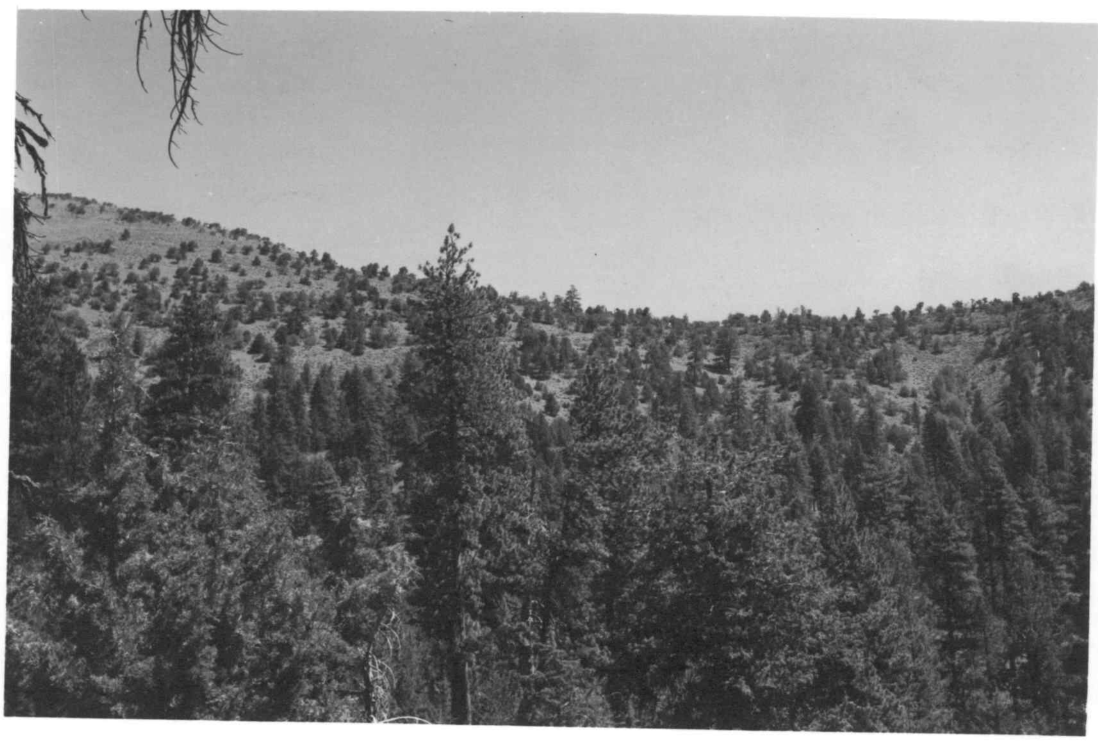


Plate 19. Joseph Creek Canyon in Wallowa County looking east from Viewpoint on Enterprise-Lewiston Highway. This shows how delicate the distribution of forest and grassland can be; very slight differences in environment due to direction of exposure or degree of slope determines presence or absence of trees. Grassland, even on steep canyon walls, is subjected to grazing by sheep. Note also the numerous horizontal layers of lava flows characteristic of canyons in Wallowa County. Wallowa National Forest.
June, 1951.

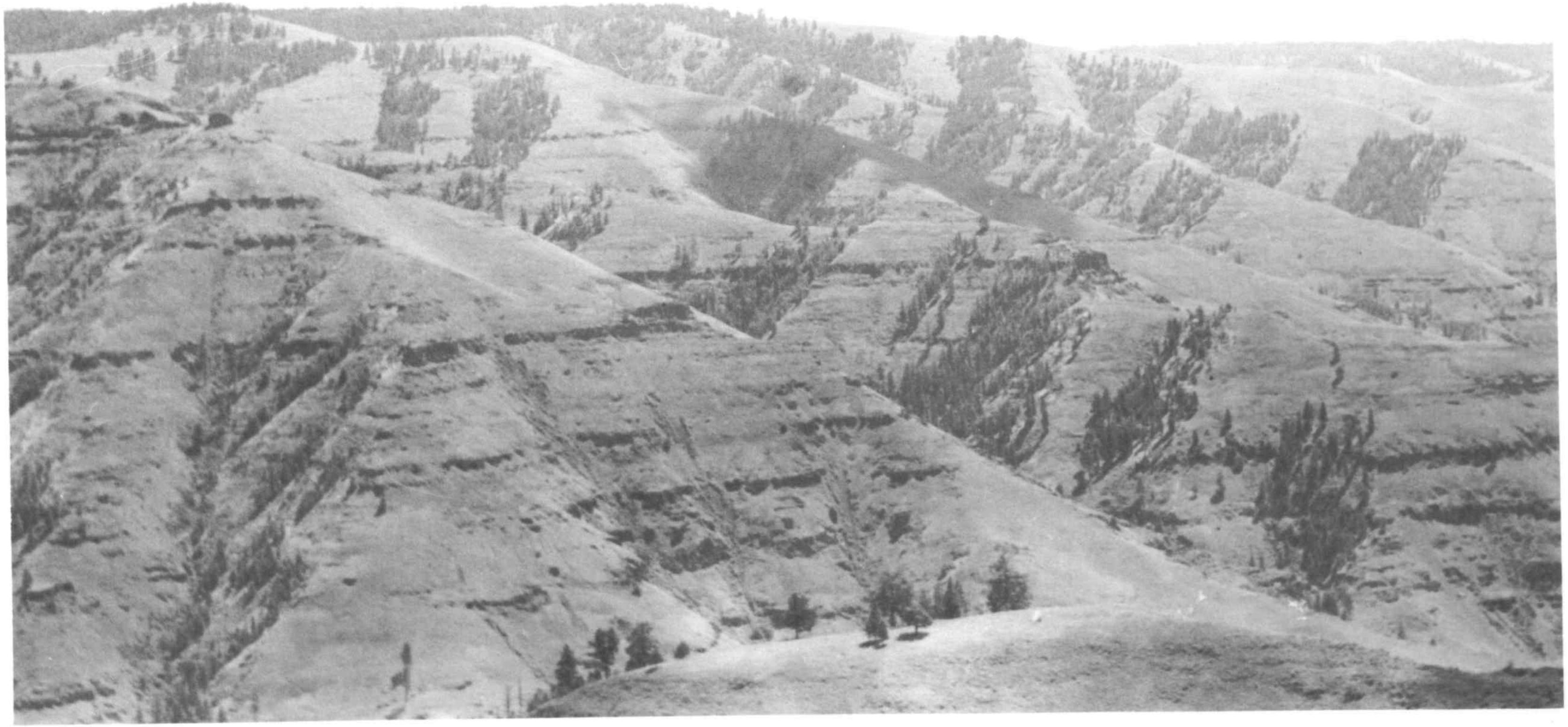


Plate 20. Burnt River Valley west of Bridgeport, southern Baker County. Montane Forest occurs in sheltered pockets near summit of ridge on southside of valley, while a few trees follow ravines down nearly to valley floor. Willows occur along riverbank; poplars and other trees have been planted around houses. Wet meadow (flood irrigated) grows poor hay, but a narrow belt of bunch grass borders irrigated area where drainage is better; sagebrush takes over where irrigation effects leave off.
June, 1951.

Plate 21. Looking east, down Burnt River Canyon northeast of Bridgeport. When canyon walls close in on river, the Montane Forest straggles down wherever possible right to river bank. Where shaded north slopes are found, large patches of forest occur, such as this stand of Douglas fir. Elsewhere, yellow pine uses similar sites, or mixes with the fir. Mountain mahogany forms scattered thickets in a few places, but little juniper is to be seen. Riverbank often supports rank growth of shrubs: willows, syringa, hackberry, sumac, clematis, birch, etc.
June, 1951.

Plate 22. Sagebrush and yellow pine forest ecotone southwest of Cabin Lake Ranger Station, Deschutes National Forest. View southeast from Hole-in-the-Ground. Where does Montane Forest terminate and Sagelands commence? In this area where junipers are absent, the sagebrush forms continuous ground cover beneath open forest over east-west distance of several miles. Many animals of sage country follow sagebrush under yellow pine forest, while animals of the forest, especially the birds of the tree tops, forage out as far as pines persist. This is an excellent example of how gradual the separation between two very different vegetation types can be.

July, 1950.

Plate 23. Sugar pine forest along Coquille-Rogue divide, northern Curry County. This is south slope of ridge, in Rogue River drainage; on north slope--Coquille River drainage is less than $\frac{1}{4}$ mile away--is a forest of western hemlock, Port Orford cedar, Douglas fir--very definitely of Moist Coniferous Forest type. This is one of the sharpest ecotones between forest types in Oregon, but even here the separation is not always so distinct. Knobcone pine, left corner and low foreground, has greatest Oregon distribution in Siskiyou Montane Forest to which this area is allied despite absence of western yellow pine.
November, 1951.

Plate 24. Siskiyou Montane Forest in Illinois River Canyon, western Josephine County. This is almost typical Siskiyou forest; trees in this vicinity (not all shown in this picture) are incense cedar, yellow pine, Douglas fir, sugar pine, white fir, knobcone pine, Port Orford cedar, and perhaps others. Shrubs include 3 or 4 species of manzanita, at least two species of ceanothus, western azalea, and California laurel.
June, 1951.

Plate 25. Aspen grove in the Maury Mountains. Similar groves, larger or smaller in size, are common through most of the Montane Forests. In the grove above, false hellebore (Veratrum sp.) forms a dense and rank growth beneath the aspens; iris and other wild flowers are abundant in clearings.
June, 1951.

Plate 26. Big Summit Prairie in the Ochoco Mountains; Lookout Mountain in the distance. Prairies and flats support a great variety of flowering herbs through spring and early summer, before soil becomes too dry. Surface water may persist for a long time; rushes form dark patch in the meadow marking presence of surface water.
April, 1951.

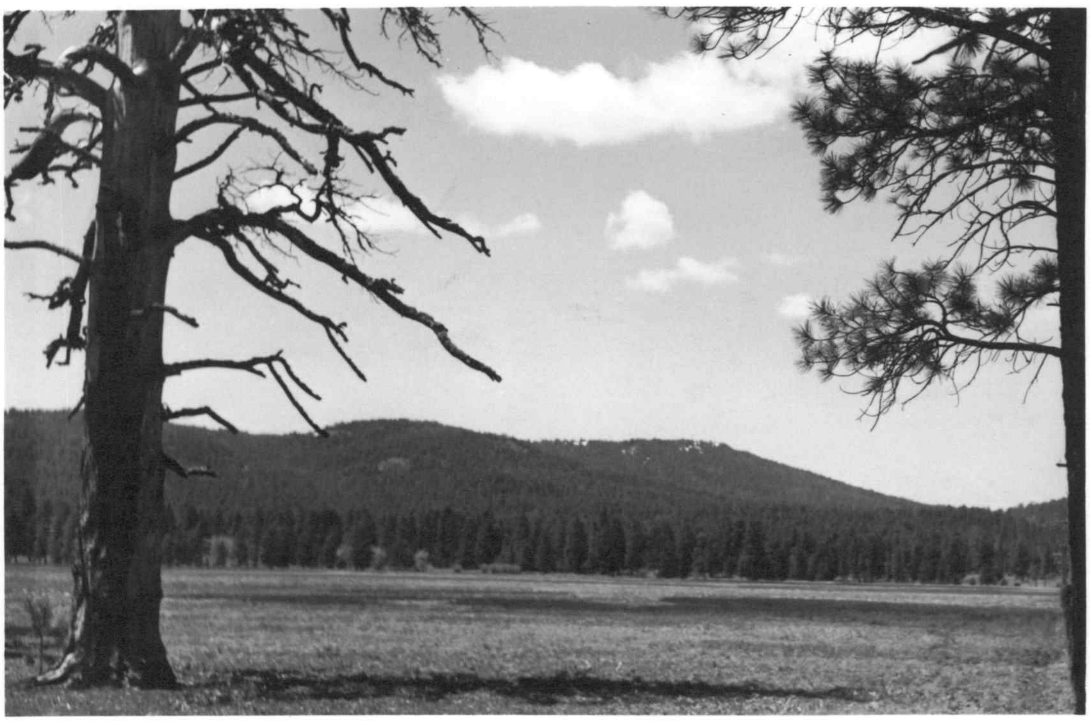


Plate 27. Distribution of vegetation in accordance with drainage patterns. Head of Gold Creek, over 6,500 feet elevation, southwest of Paisley in Fremont National Forest. Yellow pine and aspen share favored sites; sagebrush and other shrubs, and perhaps some juniper, take over dry slopes. Willows, and wet-meadow plants occur where drainage is slightly retarded. Some white fir is in heavier stands of forest in distance; one small white fir is in the heavy foreground shadow.

June, 1951.

Plate 28. Cascade Subalpine Forest around bases of Broken Top (right, 9,165 feet) and Three Sisters (all three over 10,000 feet) in central Oregon, as viewed from summit of Tumalo Mountain (7,770 feet). Denser forests in lower portion of picture are low subalpine vegetation (Plate 12); more open forest and scattered trees mark upper subalpine type (Plate 29). Summits of Three Sisters and Broken Top form most extensive, almost-continuous Alpine region in Oregon. Deschutes National Forest.
September, 1950.

Plate 29. Upper Subalpine Forest in Broken Top Meadows (over 7,000 feet), near timberline in area shown in front of Broken Top, upper right of Plate 28. Note distribution of trees in sheltered areas and along drainage; also snowbank, right of center, still present in late August. Foreground vegetation includes heathers, Indian paint brush, pussy paws, and lupines. Trees are predominantly mountain hemlock.
August, 1950.

Plate 30. Lower subalpine forest under late winter snow cover in area of recent lava flows along South Santiam Highway (about 3,800 feet). Snow depth is not indicated because of continuous cover, but along roadside it was over 10 feet deep (Plate 31). In this area on March 8, 1952, a Townsend's chipmunk was seen in lower part of a tree, and a flock of small birds were heard in distance. Movement of animals is seriously impeded by deep snows. Willamette National Forest.
March, 1952.

Plate 31. Highway cleared through subalpine snow, road to rim of Crater Lake, snow depth about 15 feet (note car near curve in road). This illustrates how a narrow highway can be a serious barrier to movement of animals; nevertheless, martens, porcupines, and a few other animals remain active on top of the snow. In March, 1952, snow depth at Crater Lake reached record level of almost 20 feet at Park headquarters below rim.
March, 1951.

Plate 32. This picture is at an elevation too low (3,300 feet) for normal subalpine forest in the Blue Mountains, but on the north exposure here are principal trees of lower Blue Mountain Subalpine Forest: Engelmann spruce, western larch, Douglas fir, lodgepole pine, western white pine, white fir. Western yellow pines in foreground and along top of ridge at right are more typical at lower elevations. Pioneer Forest Camp along Highway 30 in Whitman National Forest.
June, 1951.

Plate 33. Blue Mountain Subalpine Forest in glaciated Lostine Canyon, Wallowa Mountains. A variety of subalpine trees occur on lower part of canyon wall, as well as willows and alders. Higher trees probably include mountain hemlock and subalpine fir. Bare rock exposures are characteristic of most high subalpine reaches. View from French Forest Camp (5,500 feet), Wallowa National Forest.
June, 1951.

Plate 34. Whitebark pines on summit of Drake Peak (8,215 feet) in Warner Mountains, Fremont National Forest. Semi-desert shrubs in foreground, but few typical subalpine plants other than whitebark pine which occurs in narrow strip along leeward portion of summit. Heaviest snow accumulation is in large drift immediately below these trees in large cirque-like amphitheater which suggests possibility of small glacier here during ice age. Sage grouse and pronghorn antelope occasionally wander into this high subalpine area during summer.

September, 1951.

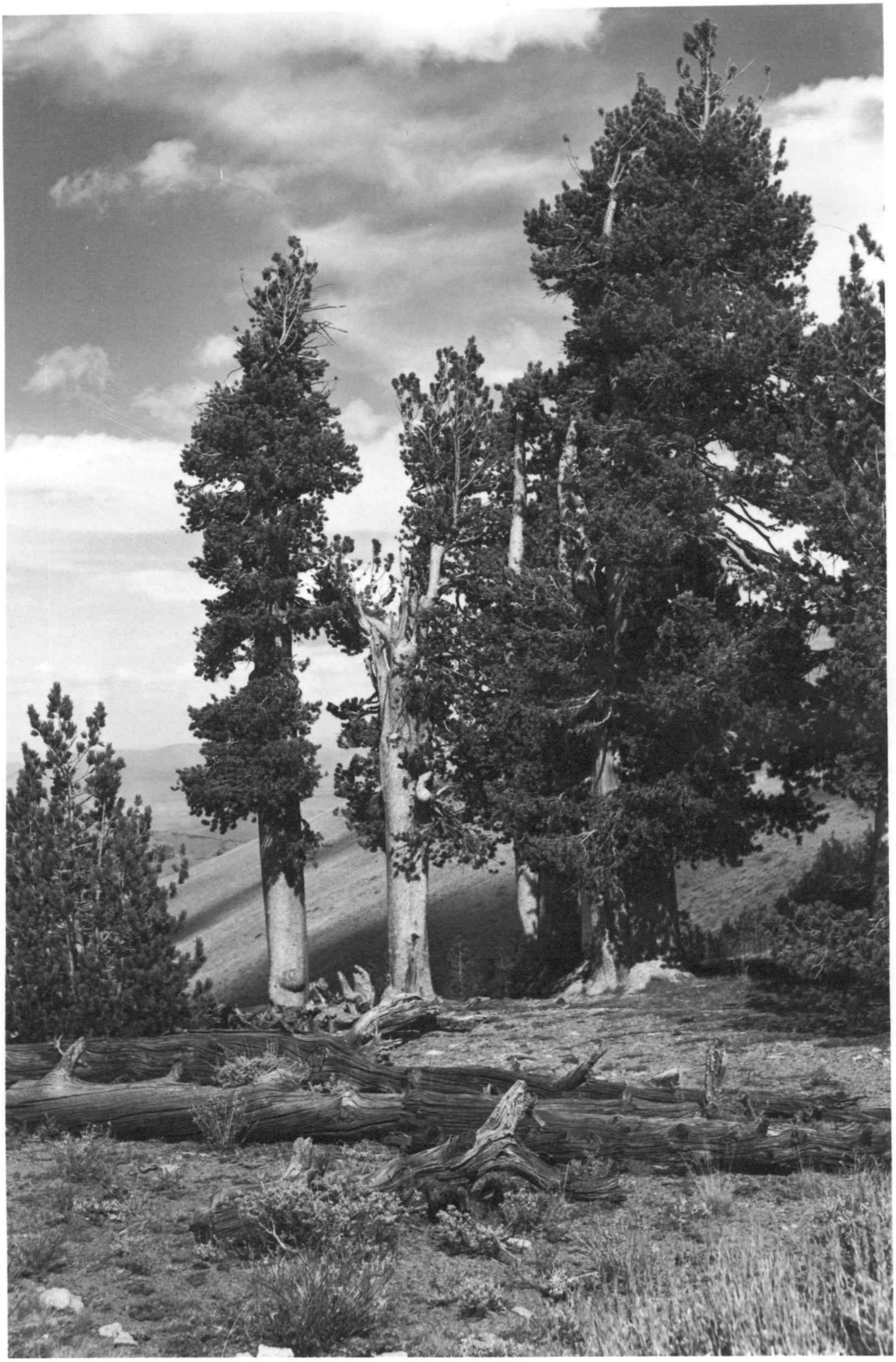
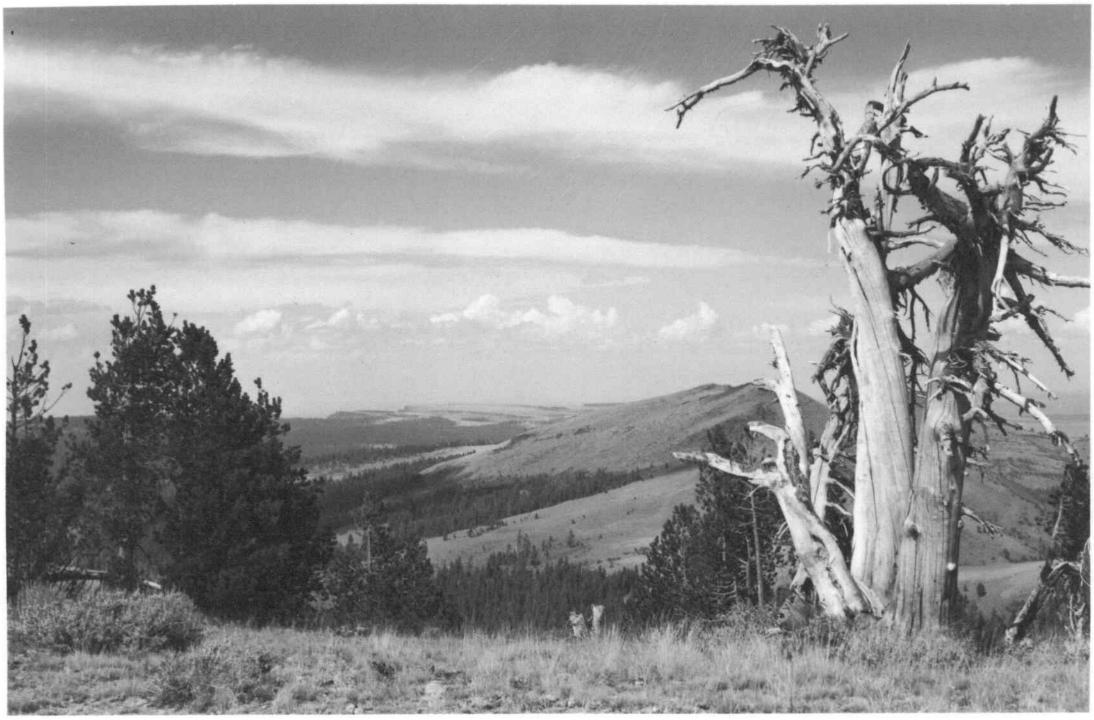


Plate 35. Whitebark pines on summit of Drake Peak as in Plate 34, but showing characteristic dead tree and view to north. Center horizon is Abert Rim, north of Lakeview; view of Abert Rim along Highway 395 is conspicuously arid, rather barren, but here patches of Montane Forest are seen scattered along higher part of east slope. Long gentle east slope of fault block is suggested by picture despite obstruction to view by Crook and Twelvemile peaks (see pictures of Steens Mountains, Plates 61, 62).
September, 1951.

Plate 36. Windward slope on summit of Drake Peak, looking upward toward crest of ridge (tops visible of whitebark pines similar to those shown in Plates 34, 35). Bitterbrush, sparse grasses, and a composite are kept in prostrate condition by winds; little grazing is done at this high elevation. Typical subalpine shrubs and herbs are very scarce.
September, 1951.



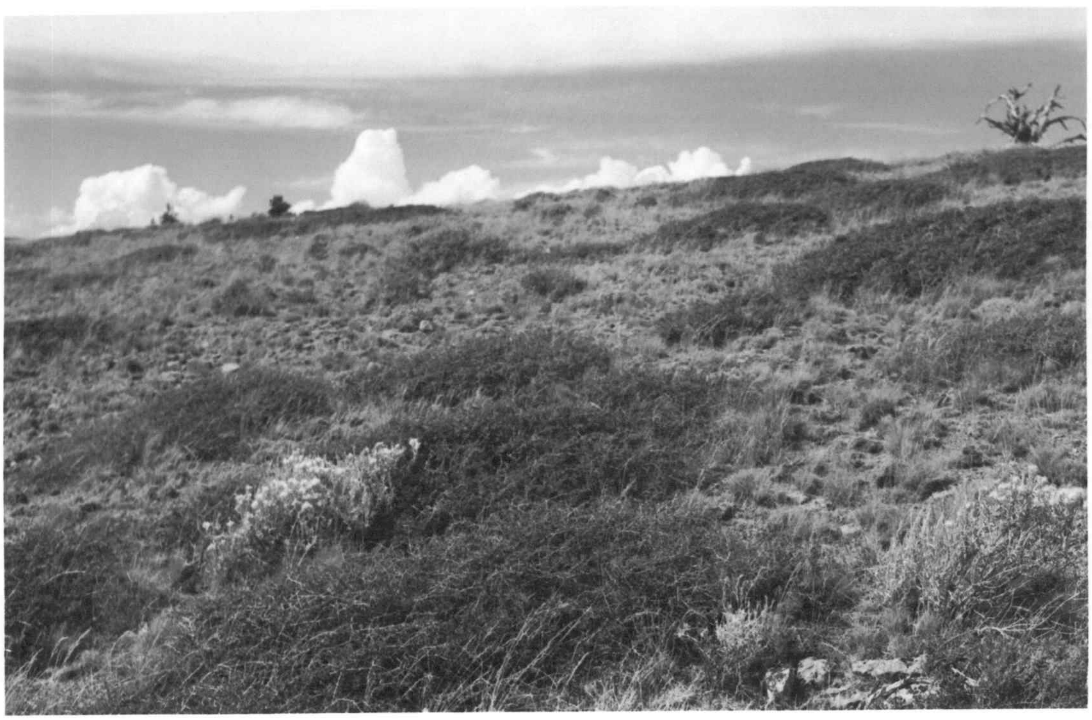


Plate 37. Lodgepole pines form lower subalpine belt beneath whitebark pines (see preceding plates) on Drake Peak. Lodgepole pines are in narrow belt above 7,500 feet and are replaced by whitebark pines about 8,000 feet on Drake Peak (summit with whitebark pines in distance).
September, 1951.

Plate 38. Fremont Montane Forest below lodgepole pine belt (Plate 37) is mixture of western yellow pine and white fir, with some western white pine entering in higher areas. Undergrowth is generally sparse as shown here in vicinity of Drake Spring, about 7,000 feet on southwest slope of Drake Peak, Fremont National Forest.
September, 1951.

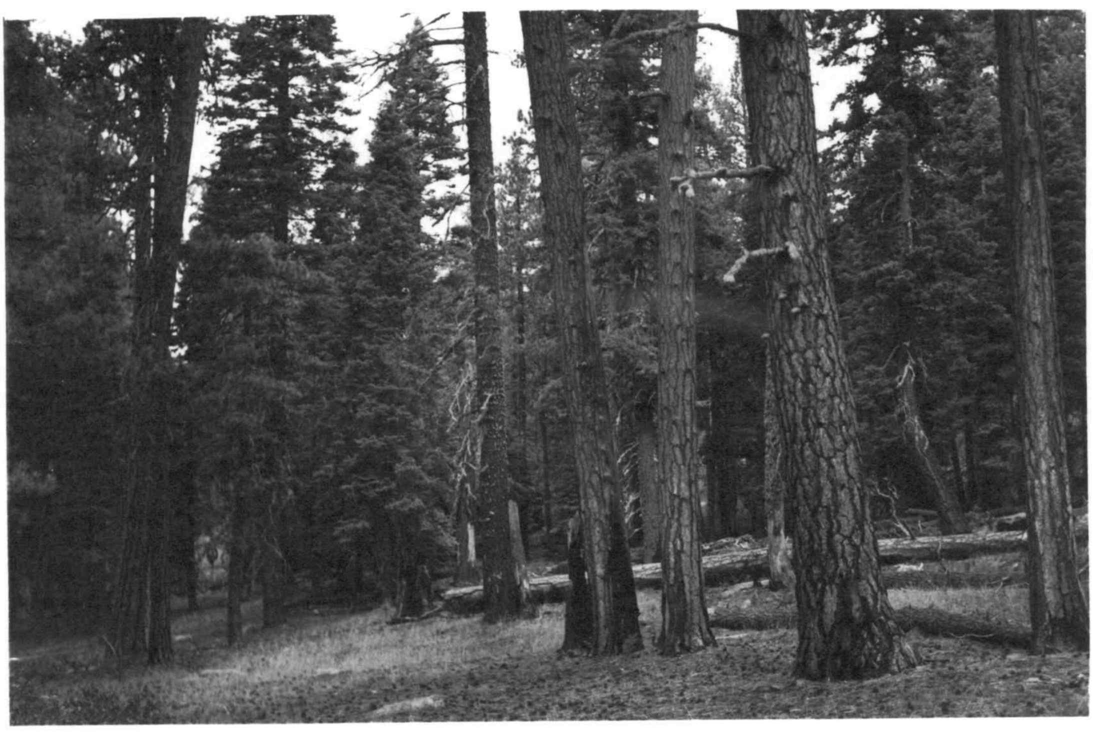


Plate 39. Siskiyou Subalpine Forest, about 7,000 feet elevation near Dutchman's Peak, southwest of Ashland. Upper subalpine forest here consists of mountain hemlock, red fir, possibly some subalpine fir; weeping spruce may occur in small patches in similar areas. Fog in upper half of picture hindered photographic efforts all morning. This view, looking south, and that in Plate 40, looking north, were taken only a few feet apart.
Rogue River National Forest.
June, 1951.

Plate 40. Dutchman's Peak (over 7,000 feet), showing unusual occurrence of mountain mahogany and mountain hemlock in close proximity. Low wind-swept trees to the left are mountain mahogany, characteristically found in semi-arid conditions through most of central and eastern Oregon; their presence here is somewhat unusual. Matted shrubs on windward slope include manzanita, ceanothus, and some semi-desert shrubs (Artemisia sp. ?). On leeward slope and in snow drifts all the trees seen are mountain hemlock, characteristic of high subalpine areas. Most of the other shrubs and wild flowers are common in Siskiyou Subalpine Forest.
June, 1951.

Plate 41. Siskiyou Subalpine Forest of noble fir, Alaska cedar around meadow below Bolan Lake (about 5,000 feet), south of Oregon Caves. Willows and alders are shrubs in meadow; wild flowers include false hellebore, Caltha, forget-me-not, shooting star, paintbrush, false Solomon's seal. Several species of gooseberries and currants (Ribes spp.) were found in surrounding area. Siskiyou National Forest.
June, 1951.

Plate 42. Siskiyou Subalpine Forest of noble fir and white fir along Bolan Lake road, west of locality shown in Plate 41. Heavy forest excludes most undergrowth, but following fire, shrubs form very dense cover.
June, 1951.

Plate 43. Subalpine meadow south of Diamond Lake; Mt. Thielsen (9,178 feet) in the distance. Forest is principally of lodgepole pine and red fir. Meadow has abundance of wild flowers, provides food for deer, ground squirrels, and other animals. Umpqua National Forest.
June, 1951.

Plate 44. C Ranch on Oregon-Idaho border in high sage country between Middle and South Forks of Owyhee River about 60 miles south of Jordan Valley (the nearest town). Permanent spring yields water for ranch and some hay fields, made possible the introduction of Lombardy poplars and other trees around ranch house. Nesting in the vicinity of the ranch house in June, 1949, were at least 17 species of birds; many of them were either scarce or absent in the surrounding Sagelands.
June, 1949.

Plate 45. Alpine vegetation on Mount Hood (11,245 feet) includes remnants of Subalpine Forest and distinctive flora of alpine areas. Much of the area remains under snow most summers; rocks make up most of soil for plants. Highest trees here are mountain hemlock and subalpine fir. Mount Hood National Forest. July, 1949.

Plate 46. Bachelor Butte (9,060 feet) in central Oregon Cascades, showing alpine and subalpine areas as seen from Tumalo Mountain (7,770 feet). Compare with Plate 28. Foreground shows pure stand of whitebark pine at about upper limits of tree growth. Deschutes National Forest.
September, 1950.

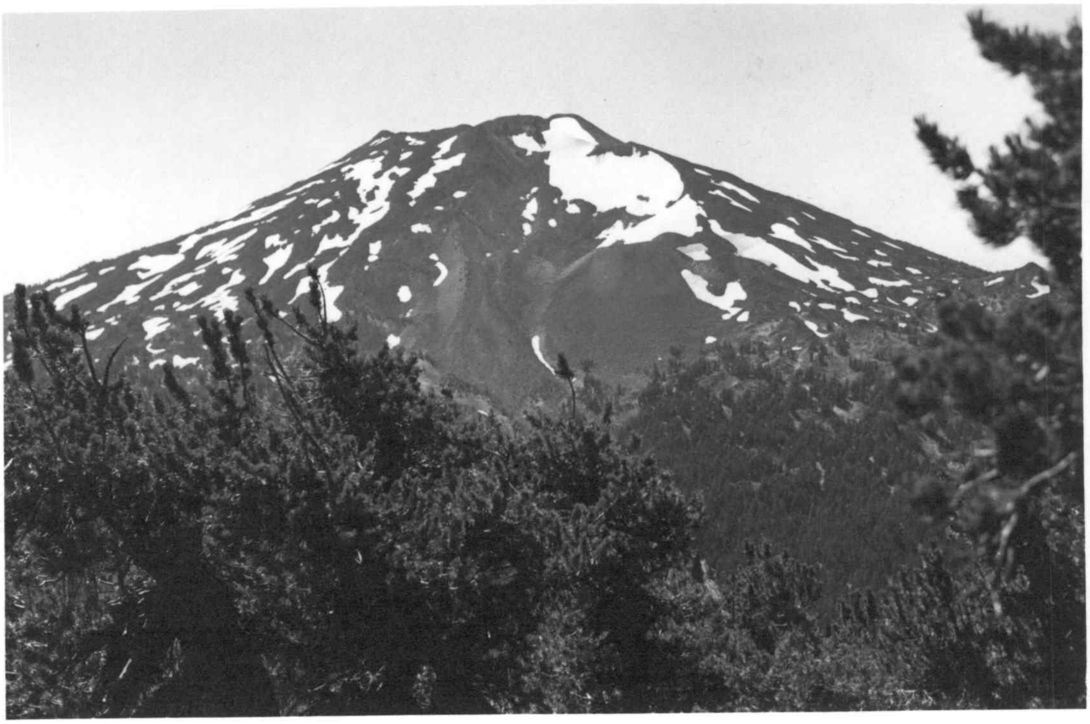


Plate 47. Juniper Woodland in typical open growth along lower Mill Creek, east of Prineville. Occurrence of rock outcroppings and rimrock is common in juniper areas. Ranches are equally characteristic, with hay fields in valleys where water is available. October, 1951.

Plate 48. Juniper Woodland along Highway 28 west of Prineville. Areas with deep loose soil are favored by kangaroo rats and other burrowing forms. Fires in Juniper Woodland are infrequent and often not suppressed; in the sparse growth fires often burn themselves out within small areas. In other areas fires can be extensive and quite complete in their destruction.
April, 1951.

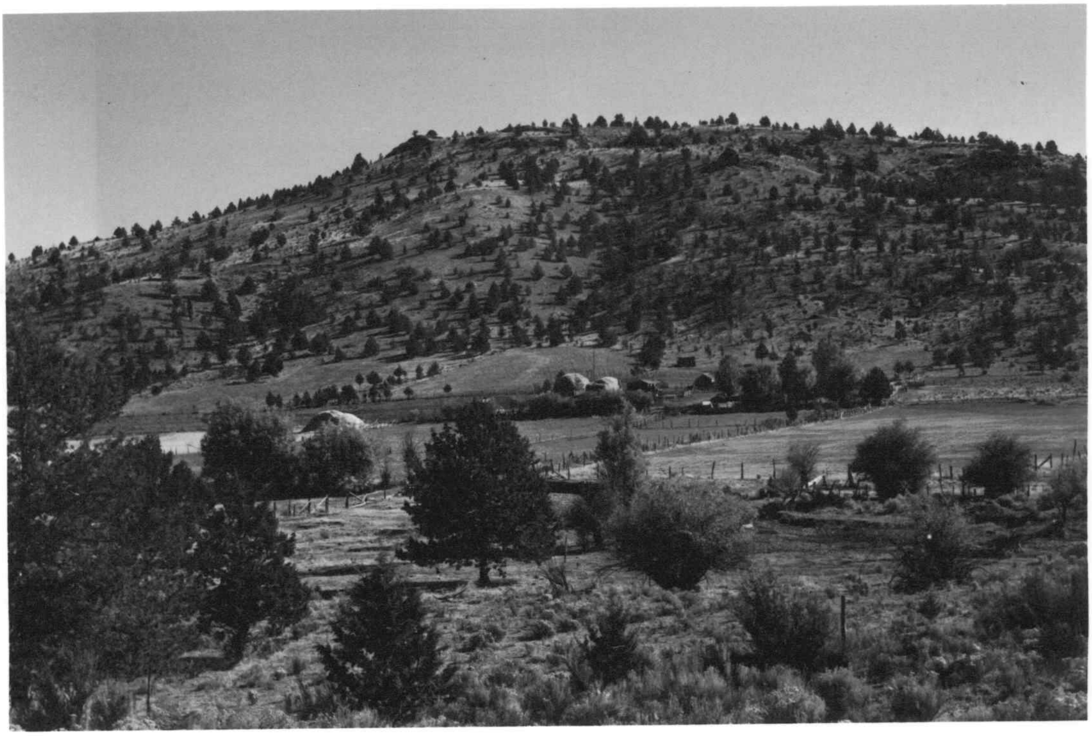


Plate 49. Mountain mahogany on Mahogany Mountains in eastern Malheur County. This is one of the most extensive areas covered by mountain mahogany in Oregon. The view is southward from Leslie Gulch on the east side of the Owyhee Reservoir; rocks in foreground are very colorful and only a small sample of their extensiveness in that region.
June, 1949.

Plate 50. Interior of thicket of mountain mahogany, west of Cabin Lake Ranger Station in southern Deschutes National Forest. Mountain mahogany provides both browse and shelter for deer, perhaps other animals.
April, 1951.

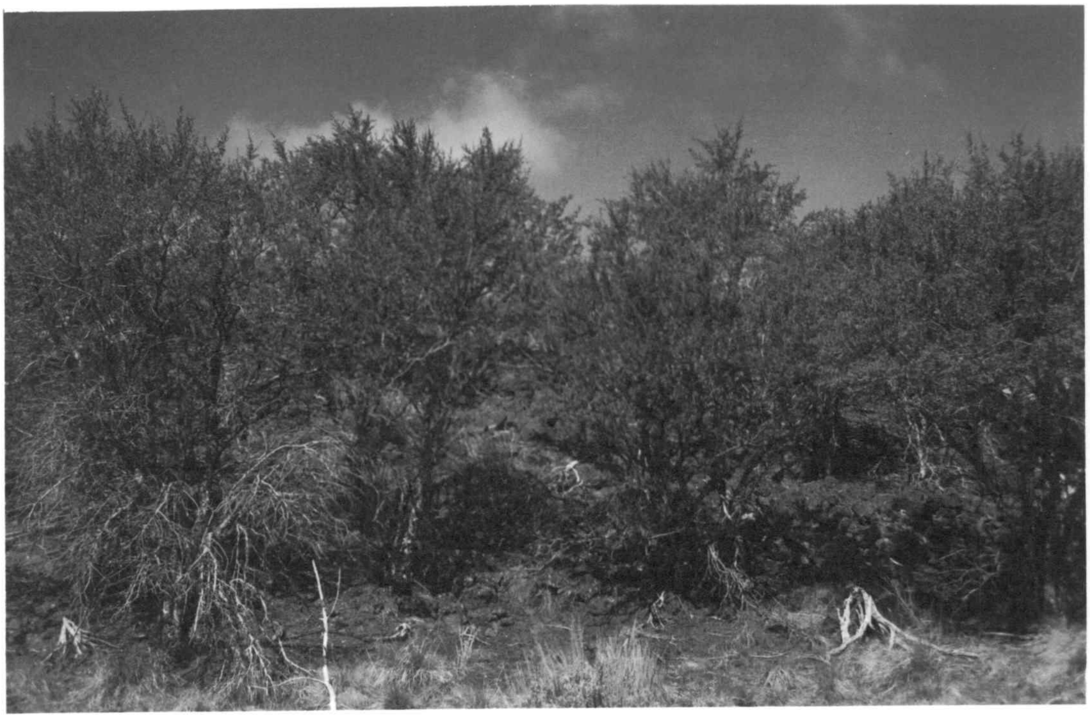


Plate 51. Oak Woodland on hills northwest of Corvallis, typical of open growth in pastures in Willamette, Umpqua, and Rogue river valleys. Shrubs often are not especially abundant, but the overall variety expresses a relationship with the eastern deciduous forests. Pastures have replaced much of original flora with introduced grasses and weeds.
May, 1950.

Plate 52. Oak Woodland in Hood River Valley. Extensive dense growth is suggestive of deciduous forest. There is strong mixture with trees of Montane Forest in this section.
November, 1951.

Plate 53. Bottomland woods along Luckiamute River in Willamette Valley. The bottomlands of Willamette Valley streams support luxuriant woods with a variety of trees and shrubs. In this picture there are bigleaf maple, Oregon ash, cottonwood, alder, some white oak, and perhaps other trees, with an occasional Douglas fir.
October, 1951.

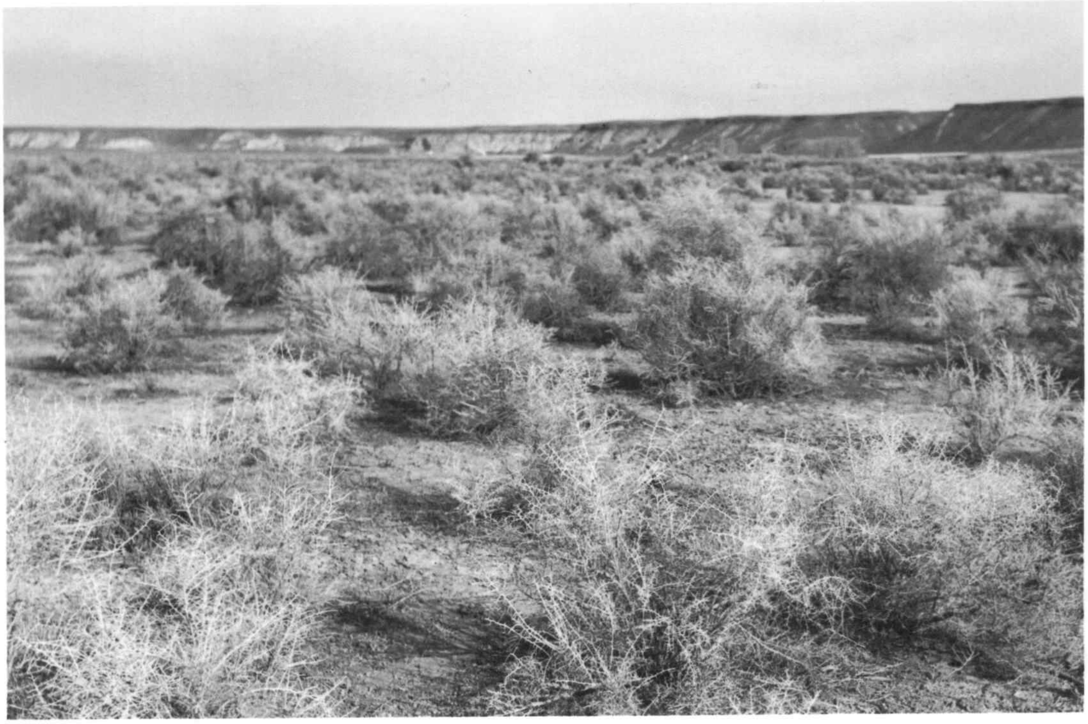
Plate 54. Bottomland woods along Shitike Creek near Warm Springs Agency. Deciduous trees of bottomlands (cottonwoods and willows) stand in sharp contrast to surrounding junipers and sage. Some junipers and yellow pines enter bottomland habitat. Fauna of bottomlands in Plate 53 is about the same as for surrounding area, but in localities as shown here the fauna is quite distinct from that of surrounding terrain.
November, 1951.

Plate 55. Typical view across Sagelands with a few clumps of bunch grass in the foreground. A few scattered junipers are generally visible almost anywhere in sage country. Bunch grass is less common, being quickly eliminated by heavy grazing. Most of Sagelands are too heavily grazed to permit existence of bunch grasses, which were much more common before the introduction of cattle and sheep. Scene here is east of Silver Lake in Lake County, about 4,500 feet in elevation.
June, 1951.

Plate 56. Wide variety of shrubs often are mixed with sagebrush; shown here in small canyon off Frenchglen road in Harney County are shadscale, in immediate foreground, and greasewood, darker shrub in foreground. While camped at this site, we heard the only good chorus of coyotes in four years of travel throughout Oregon with many nights spent in even more remote sage country.
September, 1951.

Plate 57. Greasewood flats along Owyhee River near Rome, Malheur County. Soil has moderate alkali content in upper horizons; greasewood is almost only species growing in this situation. To irrigate such an area as shown above would require a very extensive drainage system which is not always feasible when land is only a few feet above the river level. Jackrabbits and some ground squirrels inhabit some greasewood flats and are responsible for badgers and other predators coming into such areas.
March, 1951.

Plate 58. Small playa in Christmas Lake Valley, Lake County. Cracked, crusted surface indicates recent presence of water from spring runoff. Evaporation over the years has built up a very high alkaline content of playa surfaces. Occasional shallow water drowns out any organisms which might withstand alkali. Playas are most barren areas to be found in Oregon. Shrubs around playa and on shifting sands which often border playas are almost entirely greasewood. Beyond ring of alkali concentration, sagebrush and other plants take over.
June, 1951.



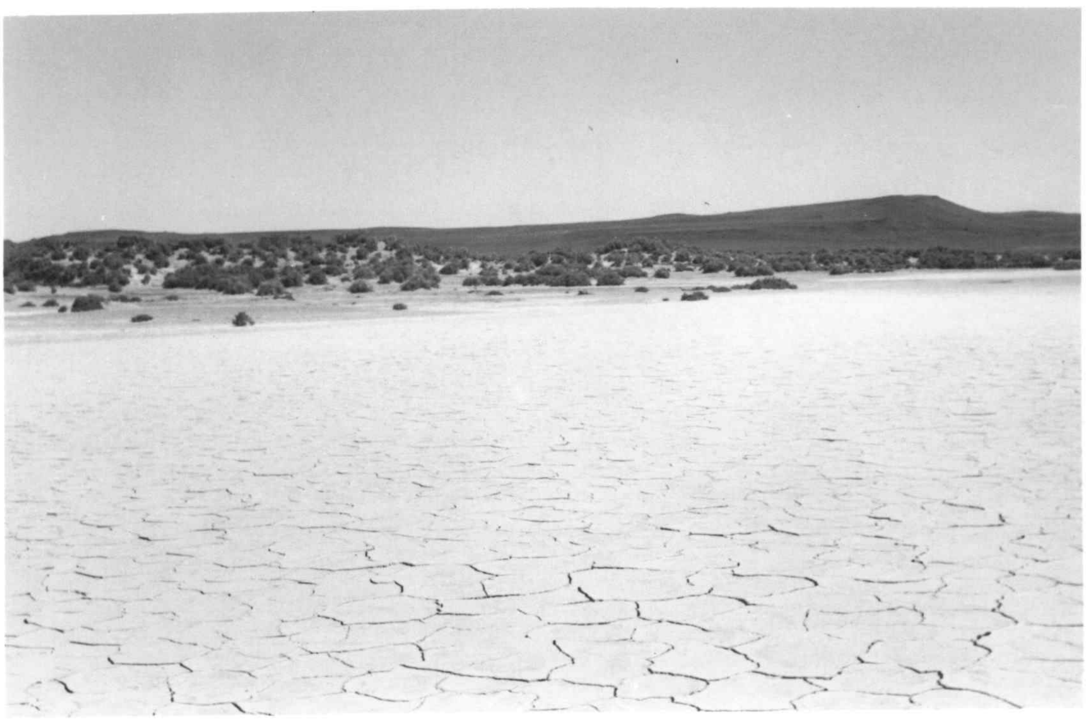


Plate 59. Palouse Prairie and Umatilla River Valley east of Pendleton. Now covered by extensive wheat farms and ranches, little remains of original plant cover. River is marked by band of trees extending across picture; farmsteads are indicated by small clumps of trees dotting landscape. Most areas not under cultivation are over-grazed (foreground); photographed in June when other parts of state generally supported fairly good growth of grass (Plate 60).
June, 1951.

Plate 60. Palouse-like grasslands occur in several valleys of northeastern Oregon, with Montane Forests on the bordering ridges. This view is near Beech Creek P. O., Grant County. Little farming is done in these small valleys; grasslands support cattle which are grazed in forests during the summer. Note also the scattering of trees in more moist sites below general level of forest, about 4,700 feet elevation.
June, 1951.

Plate 61. West slope of the Steens fault block as seen from ridge above Frenchglen. From Donner und Blitzen Valley in the middle distance to horizon marking crest of Steens Mountains is over 20 miles, with elevational difference of about 4,000 feet. The notch at highest part of horizon, right of center, is glaciated Kiger Gorge. Almost straight line slanted from below notch is Fish Lake road, an extension of which is shown in Plate 64 near the summit of the Steens.
September, 1951.

Plate 62. East face of Steens fault block. In contrast to west slope (Plate 61) the view here shows elevational range of over 4,000 feet in about three miles horizontal distance. Foreground shows part of Pike Creek alluvial fan; note large boulders on upper part of fan.
March, 1951.

Plate 63. Aspen woodland forms extensive growth on west slope of Steens Mountains at elevations from about 6,500 feet to 8,500 feet. View here is about 8,000 feet. Snow course below Fish Lake has average snow cover of 66 inches for measurements taken each year about April 1; water content of snow cover at this time averages over 23 inches. This would indicate annual precipitation in the vicinity of 30 inches, which would certainly be adequate for yellow pine forest. Absence of forest must be attributed to isolation of Steens from all Montane Forests even during Pleistocene glaciation with the large migrations of plants at that time.

Aspens were nearing peak of fall color in mid-September, indicating early fall frosts common to high elevations. Browse line maintained by sheep is evident on most of the trees. September, 1951.

Plate 64. Alpine summit of Steens Mountains, about 9,000 feet. Three snow banks shown have endured the long hot summer of 1951, which broke many records for extended periods of high temperatures and no precipitation. Comparable snow banks on high peaks of Cascades (see Plate 65) are fed by precipitation exceeding 80 inches, with occasional relief from the hot sun, especially in late summer. No weather records are available for the high part of the Steens.

Canyon is near the headwaters of the Little Blitzen River. Road is highest in Oregon, goes well over 9,000 feet. Sparse vegetation includes some alpine species which indicate an affinity with the Blue Mountain and Rocky Mountain alpine flora.

September, 1951.

Plate 65. Southwest exposure below summit of Black Butte, near Sisters. Trees in foreground are western white pine; forest in lower left corner is upper limit of yellow pine forest, about 5,800 feet. Yellow pine forest has exceedingly sharp ecotone with subalpine whitebark pine. Unusual is dense brush cover among scattered whitebark pines; brush forms broken undergrowth in yellow pine forest. On north slope subalpine fir forms dense forest; whitebark pine and subalpine fir mix at summit (6,415 feet). Peak on horizon at right is Three-Fingered Jack (7,848 feet; note sparse snow banks in August (see Plate 64).
August, 1951.

Plate 66. Sugar pine forest on virtually raw pumice in Miller Lake area, Deschutes National Forest, northern Klamath County. Anomalous situation has developed here with lodgepole pine playing a very minor role on the recent pumice flat; sugar pines and manzanita form most of the cover. At a slightly higher elevation red fir mixes with the sugar pine, and still higher western white pine replaces the sugar pine. Soil still contains large chunks of pumice. This is within elevation range from over 5,000 to 5,600 feet, east of Miller Lake.
June, 1951.

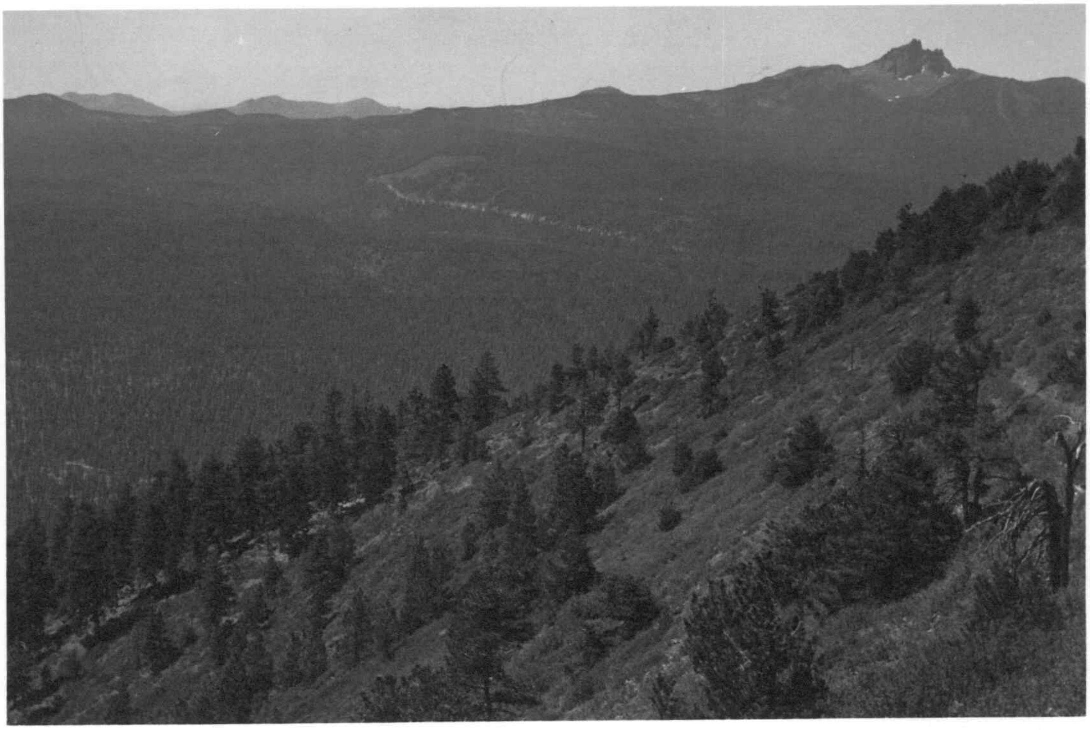


Plate 67. Chaparral-like shrub cover along Dead Indian Road east of Ashland, about 2,000 feet elevation. Patches of trees and occasional snags suggest that in this area shrubs may be successional stage following logging or fire. In other areas, some of the shrub cover of this sort appears to be climax vegetation.

June, 1951.

Plate 68. Snake River Canyon near historic Brownlee Ferry. Hackberry (trees in lower left corner) and western sumac are common in the lower canyons of northeastern Oregon where highest annual temperatures for Oregon have been recorded. Taller shrubs with sumac are serviceberry, with some mountain mahogany on higher parts of canyon walls. Western kingbirds and eastern kingbirds were both seen here and in similar settings along lower Grande Ronde Canyon in Wallowa County. Elevations in both canyons are about 1,500 feet.

June, 1951.

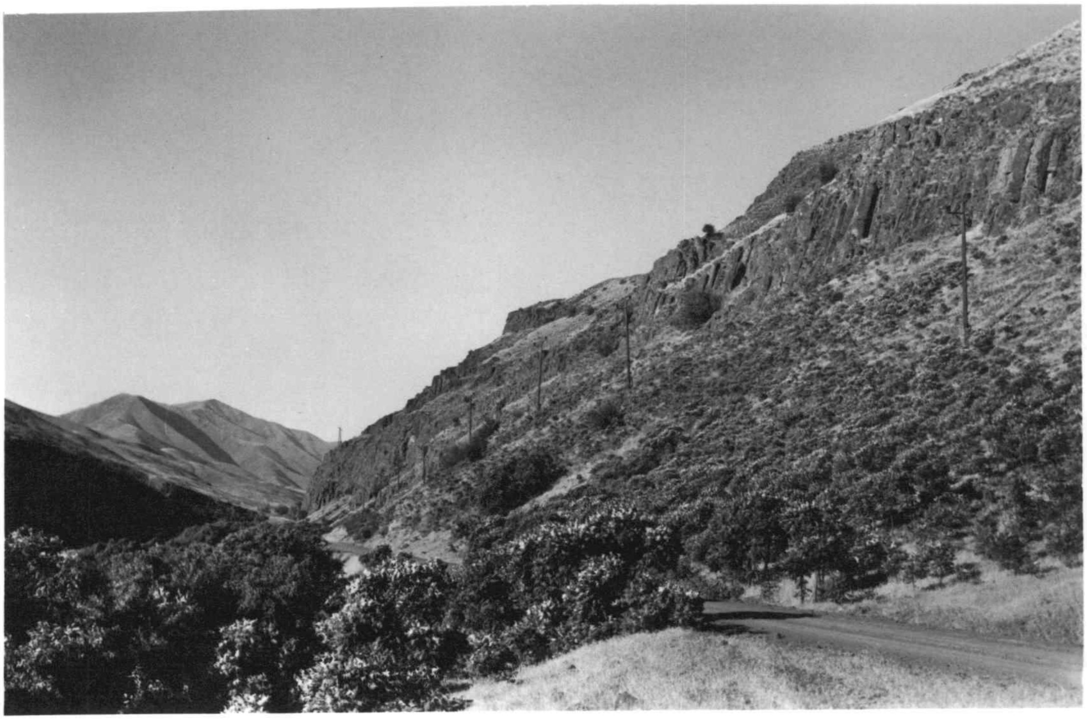


Plate 69. Canyon of the South Fork, Owyhee River, near Three Forks of the Owyhee area, about 40 miles south of Jordan Valley, Malheur County. Despite sparse vegetation, canyons are favored by many animals. Hawks, eagles, ravens, and other birds nest in cavities in canyon walls; river provides water for many birds, deer, and other animals. Lizards and snakes are also common. June, 1949.

Plate 70. Rogue River Canyon below Grave Creek bridge, northwest of Grants Pass. Here shrubs and trees dot steep canyon walls; heavy forest avoids steep and rocky parts of canyon. The canyon attracts few animals not encountered in surrounding forest, and is somewhat intermediate between conditions shown in Plates 69 and 71. Siskiyou National Forest. June, 1951.

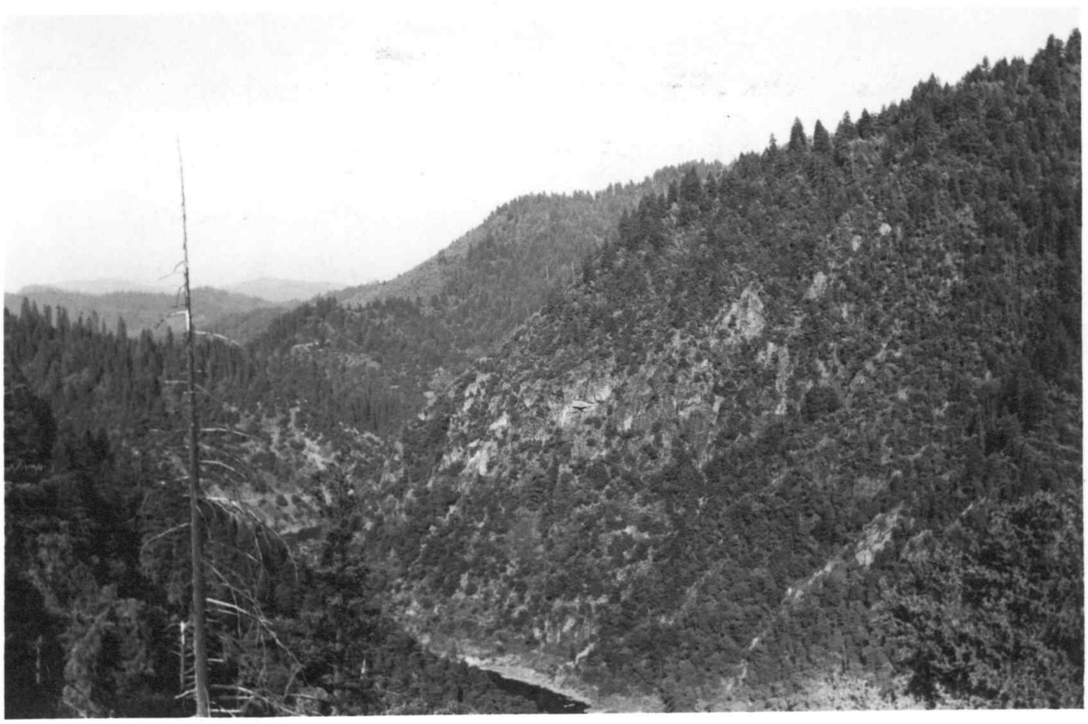


Plate 71. South Umpqua Canyon is typical of canyons along west slope of Cascades where the Moist Coniferous Forest extends down to the river bank. Only birds unique to canyon area are dippers and occasional kingfishers. Compare with other canyons pictures (Plates 19, 21, 33, 49, 54, 68, 69, 70, 72.). Umpqua National Forest.
April, 1951.

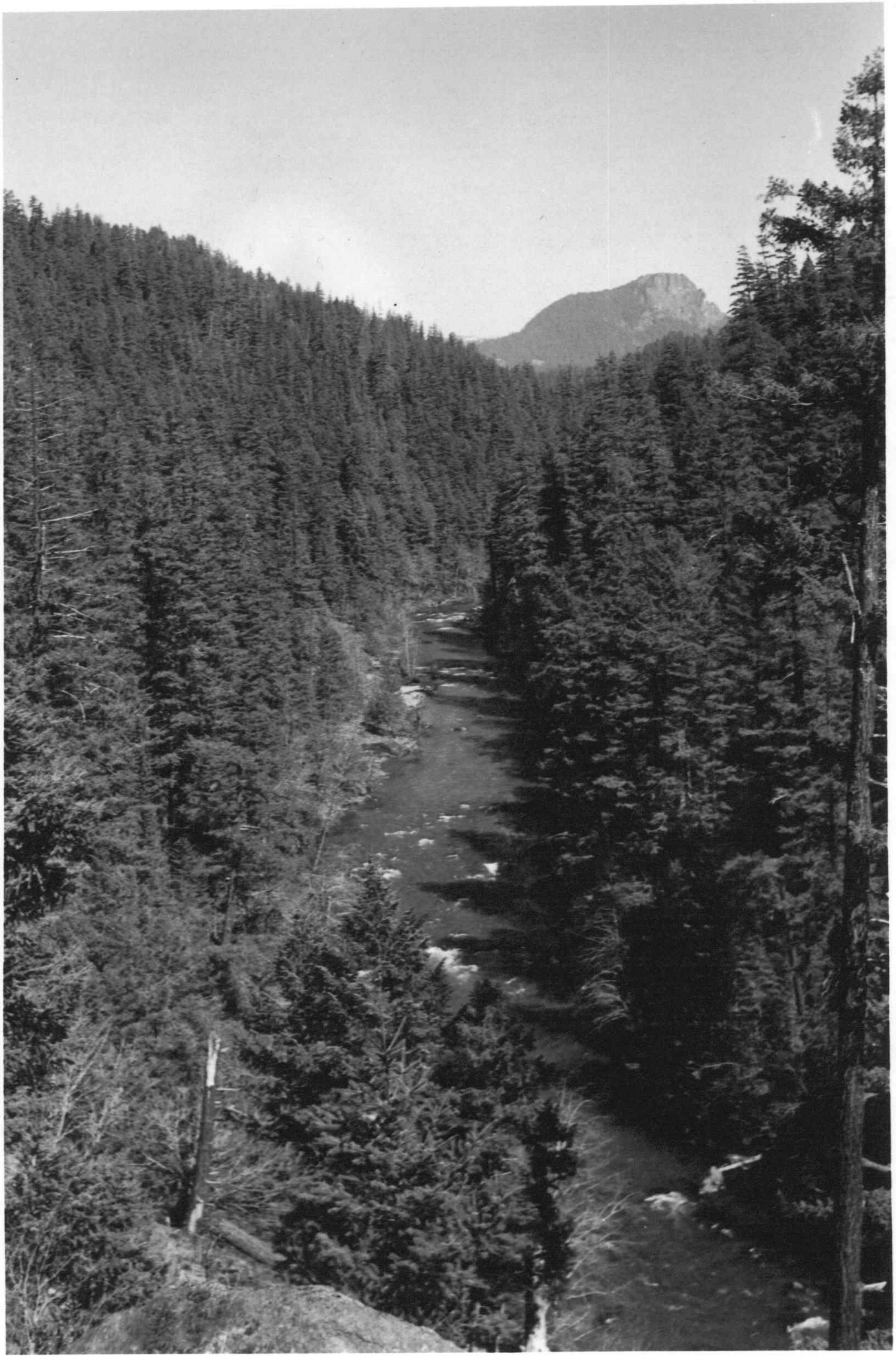


Plate 72. Wall of Owyhee Canyon below Three Forks (Plate 69), southeastern Malheur County. Cavities in rocks provide nesting sites for many hawks, eagles, ravens, and smaller birds, including flickers and robins, also for wood rats and other mammals. A deer was observed to climb this canyon wall (about 1,000 feet high) in less than three minutes. Although plant cover is sparse, animal life abounds.
June, 1949.

Plate 73. Recent lava flow in north Paulina Mountains, in area included in Plate 13. This flow formed Lava Cast Forest, unique for casts of trees and logs formed when lava, apparently near freezing point, flowed through yellow pine forest. Upright casts above level of lava may have been formed by lava "splashing" against tree trunks; flow came from upper right of picture. Trees shown on top of flow are not survivors of the volcanic event of some 2,000 to 5,000 years ago; forest in distance is on older pumice deposits. Animals are never abundant on recent lavas, but some do use cavities for shelters.
July, 1950.