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DISTRIBUTION OF THE LAND VERTEBRATES
OF SOUTHEASTERN WASHINGTON

BY

LEE RAYMOND DICE

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DISTRIBUTION OF THE LAND VERTEBRATES
OF SOUTHEASTERN WASHINGTON

A THESIS SUBMITTED IN PARTIAL SATISFACTION OF
THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
AT THE UNIVERSITY OF CALIFORNIA

BY

LEE RAYMOND DICE

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THE NEW
AMERICAN

DISTRIBUTION OF THE LAND VERTEBRATES OF SOUTHEASTERN WASHINGTON

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INTRODUCTION

In the following paper the local and geographical distribution of the land vertebrates of Walla Walla and Columbia counties, southeastern Washington, is considered. The region selected is of considerable geographical extent. It is especially adapted to the present study because it possesses a wide range of climatic conditions, giving a variety of habitats. In the presentation of the facts the endeavor is made to show how the consideration of local distribution may be combined with the consideration of geographical distribution.

The dependence of animals on their habitats does not seem to have been sufficiently taken into account in the study of distribution. Many species are closely restricted to certain kinds of habitats. If a particular kind of habitat does not occur in a region the species of animals restricted to it must also be absent. This applies to the habitats of great extent as well as to the habitats which always occur in limited areas. We should not expect to find typically desert animals except in a desert habitat. In order to explain distribution we should give much attention to the causes producing the different kinds of habitats.

Usually the fauna of each geographical region has been studied as a whole and whole faunas have been compared together without regard to differences in the habitats of the component species. It seems that such a method cannot lead to the most exact knowledge of the factors limiting the distribution of animals on the continent of North America or of the relation in origin of particular species or faunas.

In order to show the relation of the faunal areas of southeastern Washington to the faunal divisions of North America, the position of the region in the zoogeographical system of considering distribution and in the life-zone system is determined as closely as possible. Finally, a critical comparison is made of the several methods of studying animal distribution which are at present in use.

The latter part of the field-work and the preparation of the results have been supervised by Professor S. J. Holmes, who has given much valuable criticism. I am also indebted to Dr. Joseph Grinnell for advice and criticism. Professor J. C. Merriam furnished most of the notes on the geological history of the region.

TOPOGRAPHY

The topographical features of southeastern Washington have been described in detail by Russell (1897, pp. 14-28). The western part of Walla Walla County has in general a low relief and is largely formed of several "Flats." However, south of the Walla Walla River in this region there is a high range of hills.

East of Lamar the hills become somewhat abruptly higher and the prairie region of eastern Walla Walla County and western Columbia County is characterized by high, rolling hills. The hills are steepest on the northeast slopes and these northern hillsides are damper and colder and support a more luxuriant growth of vegetation than the southern slopes. Along the northern boundary of Walla Walla and Columbia

Fig. A. Map of Walla Walla and Columbia counties, southeastern Washington, showing the principal streams and localities.

counties the Snake River has cut a deep cañon, reaching in places to a depth of 1500 feet or more.

The Blue Mountains in southeastern Columbia County form a region of steep slopes and rather sharp ridges, with an elevation of 4000 to 6000 feet. The cañons are deep and the valleys narrow.

GEOLOGICAL HISTORY

In early Miocene time the greater portion of eastern Washington and also a portion of eastern Oregon and Idaho were flooded by a series of lava flows. These Columbia Lavas have a thickness in places of probably over 4000 feet. All the visible rocks of Walla Walla and Columbia counties are basalts probably formed at the time of these lava flows. The cañon walls of Snake River indicate at least ten successive flows, between some of which sufficient time elapsed for soil to form and forests to grow.

Volcanic outbursts continued during the Middle Miocene and much volcanic ash was thrown out. In eastern Oregon extensive lake deposits, the Mascall beds, were formed at that time.

The climate of the region in the period succeeding the lava flows must have been more moist than at present. Before the middle of the Pliocene, however, the Cascade Mountains had been elevated and these mountains robbed the winds from the ocean of their moisture long before they reached eastern Washington. A dry period necessarily ensued.

The time of the uplifting of the Blue Mountains is not certainly known, but their present elevation had probably been reached before the beginning of the Pliocene.

In Pleistocene time the presence of glaciers in northern Washington seems to have caused a return of moist conditions over the region. At that time also the gorge of the Columbia River through the Cascade Mountains seems to have been blocked, resulting in the formation of a large lake, Lake Lewis, which covered a large part of the Columbia Basin. In Walla Walla County this lake probably extended eastward as far as Eureka, but no evidences of it east of this point have been found.

METHODS OF STUDY EMPLOYED

The principal aim in the present study has been to determine the vertebrate associations of the region. The wide range of climatic and vegetational conditions which occurs gives a very good opportunity to

study the extent to which the different species are restricted to particular habitats. The habitats have been described in some detail in order to facilitate comparison with the habitats of other regions.

The attempt has been made to study and describe the habitats and associations in as nearly their native and normal conditions as possible, but for many habitats it has been difficult to find a sufficient area retaining anything like the original conditions.

While many of the associations here considered could be easily subdivided or several could perhaps be combined, yet it is believed that the present arrangement is the most useful one for the study of vertebrate distribution in the region. A region is divided into associations as a matter of convenience in studying and describing the environments and the habitat preferences of the animals. To increase the number of associations unduly would destroy the convenience of use for which the classification is made, while to lump the associations might obscure important facts. It cannot be hoped that the relative abundance of the species in the different associations as here given is fully accurate, for the observations on which the results are founded are known in many cases to be too few in number.

In order to show the relative abundance of each species in the different habitats it has been desirable to use a system of nomenclature modified from that used by Grinnell (1914, p. 67). As here considered, the relative abundance of each species in the different habitats of the same area is compared. No attempt is made to compare the relative abundance of a species in the different faunal areas. When a species occurs in only one habitat in an area, this is designated the *exclusive* habitat. If the species occurs in more than one habitat in the area, the habitat in which it occurs most abundantly is said to be its *major* habitat and all others are said to be *minor* habitats. If the data are insufficient to determine the major habitat, the term *reported* is used to refer to each habitat in which the species is known to occur. The relative abundance in the different habitats has been determined on the basis of the comparative number of individuals actually observed or trapped in each.

Active observation of the birds in the region near Prescott was begun by the author in December, 1904, and attention was later directed to the other vertebrates. The observations have been much interrupted by the conflicting claims of other duties and by prolonged absences from the region. In the summer of 1914 ten days were spent in the region near Wallula, a shorter excursion was made to Lyon's

Ferry on the Snake River, and three weeks were spent in the Blue Mountains in very intensive study. Notes published by others bearing on the distribution of the vertebrates of the region have been used whenever possible. Mr. S. H. Lyman of Dayton has kindly allowed the use of his unpublished notes on the birds of the region. It is hoped that the full accounts of the distribution of each species of vertebrates in the region, which were prepared in working up the present paper, may soon be published.

Great care has been taken to obtain accuracy in the specific identifications. Specimens have been secured when possible, except of easily recognized forms. In a few cases the subspecific identification is based on the geographical distribution as given by recognized authorities. Dr. Joseph Grinnell has checked a large number of identifications of mammals and birds. The identification of the reptiles and amphibians is due to Mr. Charles L. Camp.

The botanical names used have been taken from Piper (1906) except in a few cases where other names seemed more desirable. Specimens of many of the more important species of plants were collected. Dr. H. M. Hall identified a number of specimens and Dr. H. S. Yates determined several grasses.

FAUNAS AND ASSOCIATIONS OF THE REGION

In southeastern Washington three prevailing types of vegetation may be recognized. Along the Columbia River there is an area where sagebrush is the dominant plant; further east is a region where bunchgrass forms the most prominent part of the natural vegetation; and the Blue Mountains are largely covered by conifer forests. Correlated with these differences in vegetation there are important differences in the species of vertebrates found in each of these districts. The assemblage of species found in each such region delimited by climatic features may be called a *fauna*, and the region itself may be called a *faunal area*, or, more simply, an *area*. The term "area" as here used refers to the whole of any geographical district where a particular type of vegetation is dominant and includes all of the habitats in such a district.

Each faunal area is made up of several different kinds of habitats and each habitat shelters a different association of vertebrates. Some habitats and associations in the different faunal areas are very similar,

but in the present paper an association is not considered to extend beyond the limits of a single faunal area.

The lines separating the different faunal areas are not sharp. Probably the best criterion for characterizing faunal areas is the dominance of particular habitats. It is evident that in passing from one area to another a situation will be met where the dominant habitat of one area will equal in extent the dominant habitat of the other area. It is at this point that the line separating the two must be drawn. Each area will usually show at its edges some development of the dominant habitats of the adjacent areas. In many cases a dominant habitat from one area may recur as a subdominant habitat throughout an

Fig. B. Map of Walla Walla and Columbia counties, southeastern Washington, showing the extent of each of the three faunal areas, Columbia Basin sagebrush area, Columbia Basin prairie area, and Blue Mountain area.

adjacent area. However, it is best to consider each area in sections where it is typically developed and not along its edges.

Lists of the characteristic species of each of the faunas are given. Each list includes those native breeding species which in southeastern Washington are definitely known from only one faunal area. Lists are also given of the species making up the different associations of each fauna. As here given the lists record all the forms noted in each of the corresponding habitats. Trapping records are included in some instances to show the relative abundance of some of the smaller mammals. Unless otherwise noted, only the results of the first night's trapping on any trap line are included. Traps are usually set from five to ten yards apart and in a continuous line.

COLUMBIA BASIN SAGEBRUSH FAUNAL AREA AND FAUNA

Habitats and Associations:

Sagebrush.	Water-margin.
Rocky-slope.	Aquatic.
Willow.	Aerial.

The Columbia Basin sagebrush area is characterized by the dominance of the sagebrush habitat. This is found well developed in the western end of Walla Walla County near the Columbia and Snake rivers. Sagebrush extends up the valley of the Walla Walla River to the neighborhood of the town of Touchet or a little above this. It also extends up Snake River for some distance, but the exact limits are not known. Sagebrush is not dominant south of the Snake River at Lyon's Ferry, so the sagebrush area does not extend eastward that far. Between the Walla Walla and Snake rivers the sagebrush area extends eastward a number of miles, but as the land rises the sagebrush gradually gives place to the prairie. The change is very gradual and no abrupt line of demarcation can be drawn. The typical sagebrush area probably does not extend eastward from the Columbia River more than about ten miles.

There are some rocky slopes in all the higher hills of the sagebrush area and along the streams there are numerous basaltic bluffs. Along the Walla Walla River there is a narrow growth of willows, but along the Columbia and Snake rivers in western Walla Walla County there are almost no trees, and brush is developed in only a few places, so that along these streams the willow habitat appears only in isolated patches.

CHARACTERISTIC SPECIES OF THE COLUMBIA BASIN SAGEBRUSH FAUNA

Scaphiopus hammondii hammondii.	Lanius ludovicianus excubitorides.
Sceloporus graciosus.	Onychomys leucogaster fuscogriseus.
Phrynosoma douglassii douglassii.	Perognathus parvus parvus.
Centrocercus urophasianus.	Perognathus lordi columbianus.
Amphispiza nevadensis nevadensis.	Perodipus ordii columbianus.

The Columbia Basin sagebrush fauna is characterized by the presence of a considerable number of species nearly all of which are specially adapted to semi-desert conditions and are inhabitants of the sagebrush habitat.

SAGEBRUSH HABITAT AND ASSOCIATION (SAGEBRUSH AREA)

Exclusive:

Sceloporus graciosus.	Lanius ludovicianus excubitorides
Phrynosoma douglassii douglassii.	—summer.
Speotyto cunicularia hypogaea—	Canis latrans lestes.
summer.	Taxidea taxus neglecta.
Sturnella neglecta—summer.	Perognathus parvus parvus.
Chondestes grammacus strigatus—	Perodipus ordii columbianus.
summer.	Citellus townsendii.
Amphispiza nevadensis nevadensis	Lepus californicus wallawalla.
—summer.	

Major:

Scaphiopus hammondii hammondii.	Sylvilagus nuttallii nuttallii.
Chordeiles virginianus hesperis—	
summer.	

Minor:

Crotalus oregonus.	Pica pica hudsonia—resident.
Oxyechus vociferus vociferus—	Icterus bullocki—summer.
summer.	Euphagus cyanocephalus—summer.
Zenaidura macroura marginella—	Thomomys columbianus.
summer.	

Reported:

Pedioecetes phasianellus colum-	Asio flammeus—summer.
bianus—resident.	Astragalinus tristis pallidus—
Centrocercus urophasianus—	summer.
resident.	Onychomys leucogaster fuscogriseus.
Falco sparverius sparverius—	
summer.	

The sagebrush habitat, where it was studied three miles east of Wallula, is not entirely homogeneous. The dominant plant is the common sagebrush (*Artemisia tridentata*). Commonly mixed with this are two species of rabbit brush (*Chrysothamnus viscidiflorus* and *Chrysothamnus nauseosus graveolens*). In places one or other of these shrubs may be more abundant than the sagebrush. The hop sage (*Grayia spinosa*) and the antelope brush (*Kunzia tridentata*) occur in lesser abundance. In sandy areas a cactus (*Opuntia polyacantha*) is often found. The wheat bunchgrass (*Agropyron spicatum*) is found very sparingly, but under native conditions was evidently much more abundant than at present. Where there has been extensive pasturage and tramping by stock the yarrow (*Achillea millefolium lanulosa*) is common.

The soil in the sagebrush habitat is light and sandy and being subjected to high winds often drifts, and areas of drifting sand are common. The sand heaps up about the various shrubs, forming small dunes. Being continually shifting it would not seem to be a good place for ground-dwelling animals to make their homes. There are small areas where there are no shrubs or plants but only drifting sand, which in some places near the larger rivers forms good-sized dunes. Over large areas covered by sagebrush the sand is packed and is being eroded by the wind. In these places the sand is removed as soon as it is loosened so that little loose sand is present. By the erosion small sand bluffs are sometimes exposed.

The sagebrush association is represented by a considerable number of species, most of which are characteristic of semi-desert conditions. A few birds, which breed along the streams, forage out a considerable distance into the sagebrush.

Trapping in sagebrush three miles east of Wallula on the nights of June 10, June 12, and June 17, 1914, produced a total of 1 *Onychomys leucogaster fuscogriseus*, 6 *Perognathus parvus parvus*, and 6 *Perodipus ordii columbianus*. On these nights there were 61, 66, and 61 traps used respectively. This gives a total of 188 "trap-nights" (Grinnell, 1914, p. 92). Most of the traps were "out-o-sight" mouse traps, but 5 or 6 were rat traps.

ROCKY-SLOPE HABITAT AND ASSOCIATION (SAGEBRUSH AREA)

Exclusive:

Salpinctes obsoletus obsoletus—summer.

Major:

Crotalus oregonus.

Minor:

Peromyscus maniculatus gambelii.

Sylvilagus nuttallii nuttallii.

Reported:

Buteo borealis calurus—summer

Neotoma cinerea occidentalis.

The rocky-slope habitat is made up of the slopes covered by broken rock and of the exposures of solid basalt and their talus slopes. Some vegetation is usually found in the soil among the rocks and, because the basalt rapidly decomposes, there is a tendency for plants to increase rapidly in numbers. The vegetation usually agrees in character with that of the surrounding country. Sagebrush (*Artemisia tridentata*) and wheat bunchgrass (*Agropyron spicatum*) usually both

occur and one or the other is dominant, depending on whether the region is dominated by sagebrush or bunchgrass. In general the habitat is strikingly arid.

The species of the rocky-slope association are few in number and represent species which in general show a fondness for the neighborhood of rocks.

In ten traps set among rocks on a steep hillside three miles south-east of Wallula one *Peromyscus maniculatus gambelii* was taken on June 16, 1914.

WILLOW HABITAT AND ASSOCIATION (SAGEBRUSH AREA)

Exclusive:

<i>Colinus virginianus virginianus</i> —resident.	<i>Dendroica aestiva aestiva</i> —summer.
<i>Asio wilsonianus</i> —resident.	<i>Icteria virens longicauda</i> —summer.
<i>Otus asio macfarlanei</i> —summer.	<i>Dumetella carolinensis</i> —summer.
<i>Colaptes cafer collaris</i> —summer.	<i>Penthestes atricapillus septentrionalis</i> —resident.
<i>Corvus brachyrhynchos hesperis</i> —summer.	<i>Planesticus migratorius propinquus</i> —summer.
<i>Molothrus ater artemisiae</i> —summer.	<i>Sorex vagrans dobsoni</i> .
<i>Melospiza melodia merrilli</i> —resident.	<i>Reithrodontomys megalotis nigrescens</i> .
<i>Zamelodia melanocephala</i> —summer.	<i>Mus musculus musculus</i> .
<i>Passerina amoena</i> —summer.	

Major:

<i>Zenaidura macroura marginella</i> —summer.	<i>Euphagus cyanocephalus</i> —summer.
<i>Tyrannus tyrannus</i> —summer.	<i>Mephitis occidentalis major</i> .
<i>Tyrannus verticalis</i> —summer.	<i>Peromyscus maniculatus gambelii</i> .
<i>Pica pica hudsonia</i> —resident.	<i>Thomomys columbianus</i> .
<i>Icterus bullocki</i> —summer.	

Minor:

<i>Thamnophis elegans</i> .	<i>Sylvilagus nuttallii nuttallii</i> .
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Reported:

<i>Pituophis catenifer catenifer</i> .	<i>Erethizon epixanthum epixanthum</i> .
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The timber found along the Walla Walla River near Wallula is made up largely of willows (*Salix*) of several species. Cottonwoods (*Populus trichocarpa*) are rare and so are many of the shrubs which grow along the streams nearer the Blue Mountains. The habitat is limited in extent and does not usually extend more than a few rods from the banks of the river, when it ceases abruptly and gives place to the sagebrush. The willows are mostly small in size and grow very

thickly together, forming a dense thicket. On some of the very low land near the river there are small meadows where the willows have not been able to establish themselves or from which they have been cleared by man.

The majority of the species of the willow association are not found in the adjacent sagebrush association and these two associations are very distinct. The species of the willow association in the sagebrush area are all found also in the cottonwood-willow association of the prairie area.

Twenty-nine traps set at the edge of the willows along the Walla Walla River three miles east of Wallula took, on June 13, 1914, 7 *Reithrodontomys megalotis nigrescens*, 8 *Peromyscus maniculatus gambelii*, and 6 *Mus musculus musculus*. On June 15, the third day's trapping in this trap-line, one *Sorex vagrans dobsoni* was taken, and also several mice. It is evident that small mammals are much more numerous in these willows than in other habitats of the area. This is true of birds also, for more were seen here than elsewhere.

WATER-MARGIN HABITAT AND ASSOCIATION (SAGEBRUSH AREA)

Major:

Thamnophis elegans.

Oxyechus vociferus vociferus—
summer.

Minor:

Scaphiopus hammondii hammondii.

Reported:

Rana pipiens brachycephala.

Agelaius phoeniceus neutralis—
summer.

The water-margin habitat comprises the shores of streams, irrigating ditches, and lakes. Only a few seepage lakes occur in western Walla Walla County and streams and irrigating ditches are not numerous. There is a considerable extent of barren sandy and gravelly shore along the Columbia and Snake rivers. Little study was made of the life of those places. Along the Walla Walla River the water-margin habitat is a very narrow strip between the river and the growth of willows. A few bars of mud and gravel occur, but these are not extensive.

In the sagebrush area the water-margin association is not very important and is made up of only a few characteristic species.

AQUATIC HABITAT AND ASSOCIATION (SAGEBRUSH AREA)

*Reported:**Ondatra zibethicus osoyoosensis.*

The aquatic association as here considered includes the animals which inhabit the open water of the streams away from the proximity of the shores. Vertebrate members of the association other than the fishes are few in the region. The Columbia and Snake rivers are both swift and during most of the year carry much mud and sand. The lower part of the Walla Walla River is much more sluggish and there are a number of quiet pools. However, there is little aquatic vegetation and few aquatic insects, and the habitat does not appear very suitable for the higher vertebrates.

AERIAL HABITAT AND ASSOCIATION (SAGEBRUSH AREA)

*Minor:**Chordeiles virginianus hesperis*—
summer.*Tyrannus tyrannus*—summer.
Tyrannus verticalis—summer.*Reported:**Tachycineta thalassina lepida*—summer.

The aerial association is considered to be made up of those animals which feed in the air. Most birds fly about in the air more or less, but the association should be limited to those species which carry on a vital activity in the habitat.

COLUMBIA BASIN PRAIRIE FAUNAL AREA AND FAUNA

Habitats and Associations:

Bunchgrass.

Rocky-slope.

Cottonwood-willow.

Water-margin.

Aquatic.

Aerial.

The bunchgrass habitat is dominant over most of Walla Walla County and the western part of Columbia County. In typical parts of the area it covers the entire region with the exception of small areas of rocky slopes and the small amount of surface occupied by the streams and their adjacent habitats. Sagebrush is well developed in local areas on the flats to the west of Lamar and in a few places in the cañons near Snake River, but in the typical part of the prairie area sagebrush is clearly subordinate to the bunchgrass and does not form

a distinct habitat. Near Nine-mile, on the Walla Walla River, the valley is definitely semi-desert, and sagebrush extends up the side cañons, but the vegetation of the higher land is dominated by bunchgrass. Bunchgrass is also dominant on the upper parts of the range of hills south of the Walla Walla River. Yellow pines invade the prairie from the Blue Mountains, coming down along the north and northeastern hillsides and appearing in the bottoms of the cañons in the foothills.

Along Snake River the region is drier than at Prescott and the rocks lie closer to the surface. Along the cañons in that region there are high basaltic bluffs and many rocky slopes. Toward the Blue Mountains also there are numerous outcroppings of rocks, but over most of the prairie area rocks are rarely found at the surface of the ground.

Streams are not numerous in the prairie area. There is a growth of willows and other deciduous trees and shrubs along the smaller streams, but along Snake River there are few native trees or shrubs, so that no cottonwood-willow habitat is formed along this stream.

CHARACTERISTIC SPECIES OF THE PRAIRIE FAUNA

<i>Aneides iëcanus.</i>	<i>Empidonax trailli trailli.</i>
<i>Hyla regilla.</i>	<i>Ammodramus savannarum bimaculatus.</i>
<i>Chrysemys bellii.</i>	<i>Riparia riparia.</i>
<i>Actitis macularius.</i>	<i>Stelgidopteryx serripennis.</i>
<i>Numenius americanus.</i>	<i>Vireosylva gilva swainsoni.</i>
<i>Accipiter velox.</i>	<i>Geothlypis trichas occidentalis.</i>
<i>Buteo swainsoni.</i>	<i>Setophaga ruticilla.</i>
<i>Bubo virginianus occidentalis.</i>	<i>Troglodytes aëdon parkmani.</i>
<i>Dryobates pubescens homorus.</i>	<i>Scapanus orarius schefferi.</i>
<i>Asyndesmus lewisi.</i>	<i>Mustela arizonensis.</i>
<i>Archilochus alexandri.</i>	<i>Microtus nanus canescens.</i>
<i>Selasphorus rufus.</i>	<i>Perognathus lordi lordi.</i>
<i>Myiochanes richardsoni richardsoni.</i>	

The majority of species known from the Columbia Basin prairie area are known also from the sagebrush area or from the Blue Mountains. Of the species here given as unique most will probably later be found to occur in the adjacent faunas.

BUNCHGRASS HABITAT AID ASSOCIATION (PRAIRIE AREA)

Exclusive:

Numenius americanus—summer.
Archibuteo ferrugineus—summer.
Asio flammeus—summer.
Speotyto cunicularia hypogaea—
 summer.
Otocoris alpestris arcticola—
 winter.
Otocoris alpestris merrilli—
 resident.

Ammodramus savannarum bimaculatus—summer.
Chondestes grammacus strigatus—
 summer.
Spizella breweri—summer.
Anthus rubescens—migrant.
Perognathus lordi lordi.
Lepus campestris townsendii.
Lepus californicus wallawalla.

Major:

Pituophis catenifer catenifer.
Pedioecetes phasianellus columbianus—resident.
Buteo borealis calurus—resident.
Buteo swainsoni—summer.
Falco mexicanus—resident.
Sturnella neglecta—resident.

Passerculus sandwichensis alaudinus—migrant.
Sialia currucoides—summer.
Canis latrans lestes.
Taxidea taxus neglecta.
Citellus townsendii.

Minor:

Crotalus oregonus.
Anas platyrhynchos—winter.
Ardea herodias treganzai—
 resident.
Oxyechus vociferus vociferus—
 resident.
Phasianus torquatus—resident.
Zenaidura macroura marginella—
 resident.
Accipiter velox—resident.
Falco sparverius sparverius—
 resident.
Asyndesmus lewisi—summer.
Colaptes cafer collaris—resident.
Tyrannus tyrannus—summer.
Tyrannus verticalis—summer.
Sayornis sayus—summer.
Pica pica hudsonia—resident.
Molothrus ater artemisiae—
 summer.

Icterus bullocki—summer.
Euphagus cyanocephalus—resident.
Astragalinus tristis pallidus—
 resident.
Spizella passerina arizonae—
 summer.
Salpinctes obsoletus obsoletus—
 summer.
Planesticus migratorius propinquus—resident.
Sialia mexicana occidentalis—
 migrant.
Mustela arizonensis.
Mephitis occidentalis major.
Reithrodontomys megalotis nigrescens.
Peromyscus maniculatus gambelii.
Thomomys columbianus.
Citellus columbianus columbianus.

Reported:

Pisobia bairdi—migrant.

Cathartes aura septentrionalis—
 migrant.

The bunchgrass habitat is characterized by the wheat bunchgrass (*Agropyron spicatum*). With this are associated the balsam root (*Balsamorhiza sagittata*), clarkia (*Clarkia pulchella*), Indian bullet (*Lithospermum ruderales*), phlox (*Phlox* sp.) and several lupines

(*Lupinus*). Common sagebrush (*Artemisia tridentata*) and rabbit brush (*Chrysothamnus viscidiflorus* and *Chrysothamnus nauseosus graveolens*) occur sometimes in the bottoms of the drier ravines and on exposed hillsides. In damp situations, in the bottoms of ravines or on north hillsides, the rye grass (*Elymus condensatus*) forms large clumps. Where the land has been much pastured the yarrow (*Achillea millefolium lanulosa*) grows abundantly. There are also a number of kinds of mustards and many other less important plants. In damp places on the north hillsides a few woody shrubs may be found and these are more numerous the more closely the mountains are approached. The more important of these are the rose (*Rosa*) and service-berry (*Amelanchier florida*).

Near Prescott almost all of the bunchgrass hills have been plowed and are planted to wheat and barley. On alternate years the land is allowed to lie fallow. The bunchgrass which remains unplowed has been heavily pastured, so that the grass has been partially killed out and yarrow, lupine, and other weeds have greatly increased.

The bunchgrass association includes a considerable number of plains-loving species.

Traps set in bunchgrass habitat in the hills two miles southeast of Prescott produced, for a total of 148 "trap-nights," on June 27, July 1, and July 7, 1914, five *Perognathus lordi lordi*. One of these trap lines, of 33 traps, produced on the second day's trapping, July 8, one *Peromyscus maniculatus gambelii*.

ROCKY-SLOPE HABITAT AND ASSOCIATION (PRAIRIE AREA)

Major:

Crotalus oregonus.

Salpinctes obsoletus obsoletus—
summer.

Minor:

Pituophis catenifer catenifer.

Tyrannus verticalis—summer.

Zenaidura macroura marginella—
resident.

Petrochelidon lunifrons lunifrons—
summer.

Buteo borealis calurus—resident.

Peromyscus maniculatus gambelii.

Falco sparverius sparverius—
resident.

Sylvilagus nuttallii nuttallii.

There is usually very little sagebrush growing among the rocks in the rocky-slope habitat of the prairie area. The wheat bunchgrass (*Agropyron spicatum*) grows abundantly among the rocks wherever soil is present. Along Snake River a few shrubs grow among the

rocks on the north slopes. The most important of these are a service-berry (*Amelanchier* sp.) and a rose (*Rosa* sp.).

The characteristic species of the rocky-slope association are few in number. Several species of birds find suitable nesting sites about rock cliffs.

About the rocks and rock cliffs near Lyon's Ferry 7 *Peromyscus maniculatus gambelii* were taken on June 23 and 24, 1914, from 115 trap-nights.

COTTONWOOD-WILLOW HABITAT AND ASSOCIATION (PRAIRIE AREA)

Exclusive:

Anides iëcanus.	Melospiza melodia merrilli—
Bufo columbiensis.	resident.
Hyla regilla.	Passerella iliaca schistacea—
Perdix perdix—resident.	summer.
Colinus virginianus virginianus—	Pipilo maculatus curtatus—winter.
resident.	Zamelodia melanocephala—summer.
Bonasa umbellus togata—resident.	Passerina amoena—summer.
Accipiter cooperi—summer.	Piranga ludoviciana—summer.
Astur atricapillus striatulus—	Bombycilla garrula—winter.
winter.	Vireosylva olivacea—summer.
Asio wilsonianus—resident.	Vireosylva gilva swainsoni—
Otus asio macfarlanei—resident.	summer.
Bufo virginianus lagophonus—	Dendroica aestiva aestiva—summer.
winter.	Dendroica auduboni auduboni—
Bufo virginianus occidentalis—	migrant.
resident.	Dendroica townsendi—migrant.
Dryobates villosus orius—winter.	Oporornis tolmiei—summer.
Dryobates pubescens homorus—	Geothlypis trichas occidentalis—
resident.	summer.
Phloeotomus pileatus picinus—	Icteria virens longicauda—summer.
migrant.	Wilsonia pusilla pileolata—migrant.
Archilochus alexandri—summer.	Dumetella carolinensis—summer.
Selasphorus rufus—summer.	Troglodytes aëdon parkmani—
Cyanocitta stelleri annectens—	summer.
winter.	Nannus hiemalis pacificus—
Corvus brachyrhynchos hesperis—	migrant.
resident.	Certhia familiaris montana—winter.
Hesperiphona vespertina montana	Sitta carolinensis aculeata—summer.
—winter.	Sitta canadensis—winter.
Spinus pinus pinus—winter.	Penthestes atricapillus septentrion-
Passer domesticus—resident.	alis—resident.
Zonotrichia leucophrys gambeli—	Penthestes gambeli gambeli—
winter.	winter.
Spizella monticola ochracea—	Penthestes rufescens rufescens—
winter.	winter.
Junco hyemalis shufeldti—winter.	Regulus satrapa olivaceus—winter.

Regulus calendula calendula—
winter.
Myadestes townsendi—winter.
Hylocichla guttata sequoiensis—
summer.

Ixoreus naevius naevius—migrant.
Sorex vagrans dobsoni.
Microtus nanus canescens.
Mus musculus musculus.
Eutamias amoenus amoenus.

Major:

Phasianus torquatus—resident.
Zenaidura macroura marginella—
resident.
Accipiter velox—resident.
Falco sparverius sparverius—
resident.
Pandion haliaëtus carolinensis—
summer.
Asyndesmus lewisi—summer.
Colaptes cafer collaris—resident.
Tyrannus tyrannus—summer.
Tyrannus verticalis—summer.
Sayornis sayus—summer.
Nuttallornis borealis—migrant.
Myiochanes richardsoni richard-
soni—summer.
Empidonax difficilis difficilis—
summer.
Empidonax trailli trailli—summer.
Empidonax wrighti—summer.
Pica pica hudsonia—resident.

Molothrus ater artemisiae—
summer.
Icterus bullocki—summer.
Euphagus cyanocephalus—resident.
Astragalinus tristis pallidus—
resident.
Spizella passerina arizonae—
summer.
Setophaga ruticilla—summer.
Planesticus migratorius propin-
quus—resident.
Sialia mexicana occidentalis—
migrant.
Mustela arizonensis.
Mephitis occidentalis major.
Reithrodontomys megalotis
nigrescens.
Peromyscus maniculatus gambelii.
Thomomys columbianus.
Citellus columbianus columbianus.
Sylvilagus nuttallii nuttallii.

Minor:

Rana pipiens brachycephala.
Pituophis catenifer catenifer.
Thamnophis elegans.
Ardea herodias treganzai—resident.
Pedioecetes phasianellus colum-
bianus—resident.
Buteo borealis calurus—resident.
Buteo swainsoni—summer.
Falco mexicanus—resident.
Streptoceryle alcyon caurina—
resident.
Agelaius phoeniceus neutralis—
summer.
Sturnella neglecta—resident.

Passerculus sandwichensis alau-
dinus—migrant.
Stelgidopteryx serripennis—summer.
Sialia currucoides—summer.
Myotis yumanensis (?).
Myotis californicus californicus.
Lasiurus cinereus.
Canis latrans lestes.
Procyon psora pacifica.
Mustela vison energumenos.
Taxidea taxus neglecta.
Citellus townsendii.
Castor canadensis canadensis.

Reported:

Bascanion constrictor vetustum.
Cryptoglaux acadica acadica—
winter.
Lanius borealis—winter.

Seiurus noveboracensis notabilis—
migrant.
Lynx sp.

The growth of timber along the smaller streams of the prairie area does not extend far from the banks of the streams. In most places along the Touchet River trees do not naturally grow more than a quarter of a mile from the stream, and often the width of the habitat is much less than this. As the valley of the Touchet near Prescott is nearly a mile broad on the average, it is evident that the growth of trees and brush covers only a portion of the nearly level floor of the valley.

The most conspicuous plants of the habitat are the cottonwood (*Populus trichocarpa*) and willows (*Salix*) of several species. Other trees and shrubs which are common along the banks of the Touchet River near Prescott are the birch (*Betula microphylla*), alder (*Alnus rhombifolia*), chokecherry (*Prunus demissa*), thorn (*Crataegus brevispina*), service-berry (*Amelanchier florida*), red osier (*Cornus stolonifera*), and syringa (*Philadelphus lewisii*). Less important species are the cascara sagrada (*Rhamnus purshiana*), ninebark (*Opulaster pauciflorus*), elder (*Sambucus glauca*), wild cherry (*Prunus emarginata*), snowberry (*Symphoricarpos* sp.), and clematis (*Clematis ligusticifolia*). Roses (*Rosa* sp.) occur commonly, especially along the outer margins of the timber. The cottonwood often makes very large trees with a height of 80 to 100 feet and with trunks three to four feet in diameter, but the other trees are much smaller. Under the trees there is nearly always a heavy growth of shrubby underbrush. A growth of shrubs also covers many small areas over which trees have not become dominant. Where the habitat has not been disturbed by man the thick tangle of smaller shrubs, thorns, and vines makes excellent refuges for birds and mammals.

The cottonwood-willow association is made up of a great number of species. A large number of these are closely restricted to the cottonwood-willow habitat. A few species which reach their greatest abundance in the cottonwood-willow association are found in lesser abundance in the bunchgrass association. Other species of greatest abundance in the bunchgrass association are sparingly represented in the cottonwood-willow association. Several species of birds nest or obtain shelter in the cottonwood-willow habitat but forage out into the adjacent bunchgrass.

Sixty traps set in the timber and brush along the Touchet River two miles east of Prescott caught on July 2, 1914, 2 *Reithrodontomys megalotis nigrescens*, 8 *Peromyscus maniculatus gambelii*, and 5 *Microtus nanus canescens*.

WATER-MARGIN HABITAT AND ASSOCIATION (PRAIRIE AREA)

*Exclusive:**Chrysemys bellii*.*Grus mexicana*—summer.*Actitis macularius*—summer.*Major:**Rana pipiens brachycephala*.*Thamnophis elegans*.*Anas platyrhynchos*—winter.*Nettion carolinense*—winter.*Ardea herodias treganzai*—resident.*Oxyechus vociferus vociferus*—
resident.*Agelaius phoeniceus neutralis*—
summer.*Procyon psora pacifica*.*Mustela vison energumenos*.*Ondatra zibethica osoyoosensis*.*Castor canadensis canadensis*.*Minor:**Spatula clypeata*—migrant.*Streptoceryle alcyon caurina*—
resident.*Riparia riparia*—summer.*Mephitis occidentalis major*.*Peromyscus maniculatus gambelii*.*Reported:**Bascanion constrictor vetustum*.

Along the smaller streams of the prairie are numerous small gravel and dirt bars. These usually become very dry in summer and the grasses and herbs growing on them dry up, except in a few places at the level of the water or along the rare sloughs.

Along Snake River there is a considerable width of water-margin habitat, which is annually covered during the spring high water. There are few willows or shrubs along this stream and the water-margin habitat is broad except where cliffs reach the edge of the water. Near the edge of the water plants are almost absent, only a few herbs being found. On the higher level of the beach there is considerable driftwood and the ground is quite sandy. In among the logs the plants of the bunchgrass habitat appear and so also do a number of weeds.

The water-margin association of the prairie is chiefly made up of species which feed along the shores of the streams. Kingfishers and bank swallows are known to nest in holes in the soft dirt banks. Robins gather mud for plastering their nests from along the shore. A number of species from both cottonwood-willow and bunchgrass associations probably come to the water's edge to drink.

Twenty traps set among rocks and driftwood on the shore of Snake River near Lyon's Ferry caught two *Peromyscus maniculatus gambelii* on June 25, 1914.

AQUATIC HABITAT AND ASSOCIATION (PRAIRIE AREA)

Exclusive:

Charitonetta albeola—migrant.

Major:

Spatula clypeata—migrant.

Streptoceryle alcyon caurina—
resident.*Minor:*

Anas platyrhynchos—winter.

Mustela vison energumenos.

Nettion carolinense—winter.

Ondatra zibethica osoyoosensis.

Pandion haliaëtus carolinensis—
summer.

Castor canadensis canadensis.

Reported:

Mergus americanus—winter.

Fulica americana—migrant.

Mareca americana—migrant.

The Snake River is a large stream with a rapid current, but the other streams of the prairie area are small. These smaller streams have usually a rapid current, and quiet pools are rare. Lakes are entirely absent.

The kingfisher, osprey, and mink feed in the river habitat. Of the other forms observed on the rivers some probably feed in the habitat while others rest or take refuge there.

AERIAL HABITAT AND ASSOCIATION (PRAIRIE AREA)

*Major:*Petrochelidon lunifrons lunifrons—
summer.

Myotis yumanensis (?).

Riparia riparia—summer.

Myotis californicus californicus.

Stelgidopteryx serripennis—
summer.

Lasiurus cinereus.

Minor:

Tyrannus tyrannus—summer.

Empidonax difficilis difficilis—
summer.

Tyrannus verticalis—summer.

Sayornis sayus—summer.

Empidonax trailli trailli—summer.

Nuttallornis borealis—migrant.

Empidonax wrighti—summer.

Myiochanes richardsoni richardsoni—summer.

Stetophaga ruticilla—summer.

*Reported:*Chordeiles virginianus hesperis—
summer.Tachycineta thalassina lepida—
summer.

The aerial association is represented in the prairie area by night-hawks, flycatchers, swallows, and bats. Some of the swallows are present at certain localities in immense numbers.

BLUE MOUNTAIN FAUNAL AREA AND FAUNA

Habitats and Associations:

Rocky-slope.
 Yellow-pine.
 Buckbrush.
 Alpine-fir.

Lowland-fir.
 Water-margin.
 Aquatic.
 Aerial.

The Blue Mountain area is characterized by the dominance of conifer forests of several kinds. In the bottoms of the cañons the forest is often very heavy and is dominated by the lowland fir (*Abies grandis*). On the tops of the higher ridges the alpine fir (*Abies lasiocarpa*) is the dominant type of tree. On the lower ridges and slopes and in the valleys of the more arid parts of the mountains the open yellow-pine type of forest prevails. It has been very difficult to determine the relation of the species of vertebrates to the different kinds of conifer forest. There seems to be a restriction of certain species to the higher ridges and of others to the cañons, but no species seems to be clearly limited to any particular type of forest. It will require a very considerable amount of further study before the distribution of the vertebrates in the area is at all satisfactorily known.

The Blue Mountains are at the present time only partially covered by forests. Many of the steep, rocky slopes are nearly or quite bare of timber. Also, much of the region has been burned over, destroying the forests. Following the fires, or in some cases starting on bare slopes where probably no fire has been, there have sprung up extensive growths of deciduous brush. This brush is best developed near the summits of the ridges, but extends down the slopes for considerable distances, reaching the bottoms of the cañons at the heads of a number of streams.

SPECIES CHARACTERISTIC OF THE BLUE MOUNTAIN FAUNA

Rana pretiosa.
Charina bottae.
Dendrapagus obscurus richardsoni.
Picoides americanus dorsalis.
Sphyrapicus thyroideus.
Phloeotomus pileatus picinus.
Stellula calliope.
Empidonax hammondi.
Perisoreus canadensis capitalis.
Nucifraga columbiana.
Junco hyemalis shufeldti.
Dendroica townsendi.

Cinclus mexicana unicolor.
Nannus hiemalis pacificus.
Sitta pygmaea pygmaea.
Penthestes gambeli gambeli.
Regulus satrapa olivaceus.
Myadestes townsendi.
Neosorex navigator navigator.
Myotis longierus.
Ursus altifrontalis.
Vulpes macrourus.
Martes sp.
Mustela cicognanii leptae.

Evotomys gapperi saturatus.
Microtus mordax mordax.
Thomomys fuscus fuscus.
Zapus princeps oregonus.
Callospermophilus chrysodeirus

chrysodeirus.
Sciurus hudsonicus richardsonii.
Lepus bairdii bairdii.
Odocoileus hemionus hemionus.

The Blue Mountain fauna contains a number of species which in southeastern Washington are not found in the other faunal areas. Many of these species are characteristic of conifer forests elsewhere.

ROCKY-SLOPE HABITAT AND ASSOCIATIONS (BLUE MOUNTAIN AREA)

Exclusive:

Salpinctes obsoletus obsoletus—summer.

Major:

Peromyscus maniculatus gambelii.

Callospermophilus chrysodeirus
chrysodeirus.

Minor:

Falco sparverius sparverius—
 summer.

Citellus columbianus columbianus.
Eutamias amoenus amoenus.

Thomomys fuscus fuscus.

Outcroppings of basaltic rock are common in the Blue Mountains. Besides the numerous small rock bluffs there are many rocky slopes covered by broken pieces of rock of various sizes. These rocky slopes often cover large areas. On exposed slopes grasses and small shrubs such as ninebark (*Opulaster pauciflorus*) grow among the rocks and in many places there are scattered yellow-pine trees (*Pinus ponderosa*). The habitat in such places often gradually gives way to the yellow-pine forest habitat.

Seventy-eight traps set on a rocky slope near Hompeg Falls captured 23 *Peromyscus maniculatus gambelii* and 2 *Eutamias amoenus amoenus* on July 24, 1914.

YELLOW-PINE HABITAT AND ASSOCIATION (BLUE MOUNTAIN AREA)

Minor:

Dendrapagus obscurus richardsoni—
 resident.

Piranga ludoviciana—summer.
Penthestes gambeli gambeli—

Falco sparverius sparverius—
 summer.

summer.
Planesticus migratorius propinquus—summer.

Sphyrapicus thyroideus—summer.

Sialia currucoides—summer.

Empidonax wrighti—summer.

Corvus brachyrhynchos hesperis—
 summer.

Peromyscus maniculatus gambelii.

Spizella passerina arizonae—
 summer.

Thomomys fuscus fuscus.

Eutamias amoenus amoenus.

Junco hyemalis shufeldti—summer.

Callospermophilus chrysodeirus
chrysodeirus.

Reported:

Sialia mexicana occidentalis—summer.

Over the foothills and exposed, lower slopes of the Blue Mountains the yellow pine (*Pinus ponderosa*) forms the dominant forest. This species seems to be able to endure much drier conditions than any of the other conifers. It is limited in vertical range and is not found on the higher parts of the Blue Mountains. As found near Hompeg Falls yellow pine is in many places associated with Douglas spruce (*Pseudotsuga taxifolia*). The trees in this forest usually grow rather far apart. On the exposed slopes there is little underbrush, but the ground is stony or covered by grasses and prairie plants. On somewhat sheltered slopes a considerable amount of underbrush may be developed. In this the ninebark (*Opulaster pauciflorus*) is most abundant and in places on eastern slopes forms a thick covering to the ground. Other shrubs such as service-berry (*Amelanchier*), currants (*Rubus*), spirea (*Spirea*), willows (*Salix*), and alders (*Alnus*) occur also. On the higher slopes the forest is heavier and Douglas spruce tends to become dominant.

No trapping was done in the yellow-pine habitat and only incidental observations were made in this type of forest. The animal inhabitants are surely much more numerous than indicated in the above list.

BUCKBRUSH HABITAT AND ASSOCIATION (BLUE MOUNTAIN AREA)

Exclusive:

Taxidea taxus neglecta.

Major:

Buteo borealis calurus—summer.

Spizella passerina arizonae—
summer.

Junco hyemalis shufeldti—summer.

Thomomys fuscus fuscus.

Zapus princeps oregonus.

Eutamias amoenus amoenus.

Lepus bairdii bairdii.

Odocoileus hemionus hemionus.

Minor:

Colaptes cafer collaris—summer.

Peromyscus maniculatus gambelii.

Evotomys gapperi saturatus.

Microtus mordax mordax.

Citellus columbianus columbianus.

Callospermophilus chrysodeirus
chrysodeirus.

Reported:

Vulpes macrourus.

Lynx sp.

The principal plant of the buckbrush habitat is the buckbrush (*Ceanothus velutinus*). Associated with this are often willows (*Salix*), alders (*Alnus*), and a number of other shrubs. Near the tops of the ridges stunted aspens (*Populus tremuloides*) sometimes appear.

The brush often grows so thickly that it is very difficult to force one's way through it, but it is likely to be in clumps and there are many open places. Rock outcroppings are numerous. The height of the brush is usually from four to eight feet, but around springs or damp places it may grow much higher. There is much down and partly burned timber in some parts of the habitat, and an occasional stump or tree has survived the fires. Young conifers are springing up in places and of these the lodgepole pine (*Pinus murrayana*) is most numerous on the ridges. On the lower slopes the buckbrush habitat overlaps in some places the range of the yellow pine (*Pinus ponderosa*) and isolated old yellow pine trees may often be found growing in among the shrubs.

Trapping on August 3 and August 9, 1914, in buckbrush on the ridge near Twin Buttes R.S. produced 1 *Peromyscus maniculatus gambelii*, 1 *Evotomys gapperi saturatus*, 6 *Zapus princeps oregonus*, and 2 *Eutamias amoenus amoenus* from a total of 50 trap-nights.

ALPINE-FIR HABITAT AND ASSOCIATION (BLUE MOUNTAIN AREA)

Exclusive:

Dryobates villosus orius—summer.	Sitta canadensis—summer.
Nucifraga columbiana—resident.	

Major:

Colaptes cafer collaris—summer.	Sialia currucoides—summer.
Spinus pinus pinus—summer.	Evotomys gapperi saturatus.
Penthestes gambeli gambeli—summer.	

Minor:

Dendrapagus obscurus richardsoni—resident.	Myadestes townsendi—summer.
Buteo borealis calurus—summer.	Planesticus migratorius propinquus—summer.
Falco sparverius sparverius—summer.	Peromyscus maniculatus gambelii.
Sphyrapicus thyroideus—summer.	Microtus mordax mordax.
Cyanocitta stelleri annectens—resident.	Thomomys fuscus fuscus.
Spizella passerina arizonae—summer.	Zapus princeps oregonus.
Junco hyemalis shufeldti—summer.	Eutamias amoenus amoenus.
Nannus hiemalis pacificus—summer.	Callospermophilus chrysodeirus chrysodeirus.
Regulus satrapa olivaceus—summer.	Sciurus hudsonicus richardsonii.
	Lepus bairdii bairdii.
	Odocoileus hemionus hemionus.

Reported:

Picoides arcticus.	Passerella iliaca schistacea—summer.
Picoides americanus dorsalis—summer.	Ursus altifrontalis.
	Lynx sp.

The alpine fir (*Abies lasiocarpa*) forms extensive forests on the higher ridges of the Blue Mountains. It does not grow in the cañons or on the lower slopes, so it may be considered the characteristic tree of the ridge forest. Alpine-fir forest is abundantly developed in many of the sheltered coves near the tops of the ridges. In these coves the ground is fairly moist. The forest developed is not dense, and there is plenty of room to walk between the trees. The size reached by the alpine firs is not very large and few of the trunks would measure over fifteen inches in diameter. Some lodgepole pines (*Pinus murrayana*) are often mixed with the alpine firs and in places where new growth is springing up lodgepole may be the dominant tree. There is usually very little undergrowth under the alpine-fir forest, there being commonly only a few very low shrubs. On the ridges alpine fir is less common and the forest is more open and commonly includes many Douglas spruces (*Pseudotsuga taxifolia*). The ground here is drier than in the coves and there is much exposure to sun and wind. The trees occur singly or in small groups. Douglas spruce is the dominant tree in the most exposed places.

In many of the coves and on protected slopes near the tops of the ridges forests of western larch (*Larix occidentalis*) are developed. This may be developed as a pure forest or may be mixed with alpine firs or Douglas spruces. The pure larch forest is very open and underbrush is scanty and the forest floor may be covered entirely by grasses. The trees reach a good size with trunks several feet in diameter. On the damper slopes Douglas spruce usually dominates over the larch and a rather dense forest is developed. This contains much more underbrush and the ground is commonly quite damp. In such places Engelmann spruces (*Picea Engelmanni*) may occur commonly.

Although the alpine-fir association is made up of a considerable number of forms very few are restricted to the association. Neither do very many reach their greatest abundance in this habitat.

Trapping in forest habitats on the ridges near Twin Buttes R.S. on July 28, July 29, and August 3, 1914, produced 8 *Peromyscus maniculatus gambelii*, 1 *Microtus mordax mordax*, 4 *Eutamias gapperi saturatus*, and 1 *Eutamias amoenus amoenus* from a total of 181 trap-nights.

LOWLAND-FIR HABITAT AND ASSOCIATION (BLUE MOUNTAIN AREA)

Exclusive:

Phloeotomus pileatus picinus—
summer.

Melospiza melodia merrilli—
summer.

Penthestes atricapillus septentrionalis—summer.

Major:

Dendrapagus obscurus richardsoni
—resident.

Falco sparverius sparverius—
summer.

Sphyrapicus thyroideus—summer.

Empidonax difficilis difficilis—
summer.

Empidonax hammondi—summer.

Empidonax wrighti—summer.

Nannus hiemalis pacificus—summer.

Cyanocitta stelleri annectens—
resident.

Corvus brachyrhynchos hesperis
—summer.

Piranga ludoviciana—summer.

Regulus satrapa olivaceus—summer.

Myadestes townsendi—summer

Planesticus migratorius propinquus—summer.

Citellus columbianus columbianus.

Sciurus hudsonicus richardsonii.

Minor:

Thamnophis elegans.

Colaptes cafer collaris—summer.

Spinus pinus pinus—summer.

Spizella passerella arizonae—
summer.

Junco hyemalis shufeldti—summer.

Peromyscus maniculatus gambelii.

Evotomys gapperi saturatus.

Microtus mordax mordax.

Thomomys fuscus fuscus.

Eutamias amoenus amoenus.

Castor canadensis canadensis.

Lepus bairdii bairdii.

Odocoileus hemionus hemionus.

Reported:

Bufo columbiensis.

Charina bottae.

Bonasa umbellus togata—resident.

Otus asio macfarlanei—summer.

Stellula calliope—summer.

Passerella iliaca schistacea—
summer.

Dendroica townsendi—summer.

Oporornis tolmiei—summer.

Certhia familiaris montana—
summer.

Penthestes rufescens rufescens—
summer.

Hylocichla ustulata swainsoni—
summer.

Sorex vagrans dobsoni.

Martes sp.

Mustela cicognanii lepta.

In the deeper cañons of the Blue Mountains the lowland fir (*Abies grandis*) is the dominant tree. These trees reach quite a large size, trunks estimated at over four feet in diameter being seen. Near Hompeg Falls this type of forest is well developed. However, there are many open places washed out by the stream or due to the action of former fires. Associated with the lowland fir are Douglas spruce (*Pseudotsuga taxifolia*), yellow pine (*Pinus ponderosa*), western yew

(*Taxus brevifolia*), western larch (*Larix occidentalis*), cottonwood (*Populus trichocarpa*), and birches (*Betula microphylla*). A few Englemann spruces (*Picea Englemanni*) occur and one silver pine (*Pinus monticola*) was seen. There is a small amount of underbrush, composed chiefly of dwarf maples (*Acer glabrum*) and alders (*Alnus* sp.). The lowland-fir type of forest occurs only in the bottoms of deep cañons and in very damp places, and does not extend up on the mountain slopes.

On sheltered lower slopes the western larch and Douglas spruce make up the larger part of the forest. Sometimes one and sometimes the other is dominant. The larch is best developed in damp situations, while the Douglas spruce covers drier slopes. Near Hompeg Falls the larch-Douglas spruce forest occupies the north slopes of the side ravines which branch from the main cañon. The larch largely occupies the bottoms of the ravines, while the Douglas spruce extends further up the sides, and towards the tops of the ridges spreads out to form a more extended forest. The Douglas spruce forest is usually fairly dense in this situation and many of the slopes which it covers are very steep. Under the heaviest forest of this kind there is no underbrush, but the ground is entirely covered by dead needles. In other places the forest is more open and more or less brush occurs, in which the alder (*Alnus* sp.) is the most abundant type. The larch forest is more open and usually does not have a heavy growth of underbrush.

Along Butte Creek, where the bottom of the narrow cañon has been much washed over by the stream, much of the lowland-fir forest has been washed out and is replaced in patches by a deciduous forest which is notable for the thickness of the underbrush. The dominant trees are cottonwood (*Populus trichocarpa*) and the willows (*Salix*). The brush was composed principally of alder (*Alnus* sp.), thorn (*Crataegus brevispina*), service-berry (*Amelanchier florida*), wild cherry (*Prunus demissa*), red osier (*Cornus stolonifera*), dwarf maple (*Acer glabrum*), and snowberry (*Symphoricarpus*).

Traps set in the lowland-fir habitat near Hompeg Falls on July 23, 25, and 26, 1914, caught 1 *Sorex vagrans dobsoni*, 23 *Peromyscus maniculatus gambelii*, 1 *Evotomys gapperi saturatus*, and 2 *Eutamias amoenus amoenus* from a total of 201 trap-nights.

WATER-MARGIN HABITAT AND ASSOCIATION

(BLUE MOUNTAIN AREA)

*Exclusive:**Rana pretiosa.**Neosorex navigator navigator.**Major:**Thamnophis elegans.**Castor canadensis canadensis.**Microtus mordax mordax.**Minor:**Cinelus mexicana unicolor—
summer.**Evotomys gapperi saturatus.**Reported:**Telmatodytes palustris plesius—summer.*

Along the streams of the Blue Mountain gravel or mud bars are rare and the forest often reaches the edge of the stream and partially overhangs the water. Springs are quite numerous in the bottoms of the cañons and these often produce moist areas which make little swamps. Such swamps are often shaded by the heavy lowland fir trees and have only a low growth of vegetation, but in more open spots grasses and horsetails as well as smaller herbs make a luxuriant growth. Swamps also occur along small sloughs diverted from the main streams or about ponds caused by the damming of some stream by a beaver dam or by the natural accumulation of drift.

AQUATIC HABITAT AND ASSOCIATION (BLUE MOUNTAIN AREA)

*Major:**Streptoceryle alcyon caurina—
summer.**Cinelus mexicanus unicolor—
summer.**Minor:**Castor canadensis canadensis.*

The streams in the Blue Mountains are all small and have swift currents. There are many rapids and low falls and the pools are small. There is very little extent of open water free from the margins of the streams.

AERIAL HABITAT AND ASSOCIATION (BLUE MOUNTAIN AREA)

*Minor:**Empidonax difficilis difficilis*—
summer.*Empidonax hammondi*—summer.
Empidonax wrighti—summer.*Reported:**Chordeiles virginianus hesperis*—
summer.*Myotis longicrus*.

Flycatchers, nighthawks, and bats make up the members of the aerial association in the Blue Mountains. Swallows were seen flying over some of the ridges but the species was not determined.

CLIMATE

Climatological records have been taken for a number of years in southeastern Washington by Weather Bureau Stations. The accumulated data have been kindly furnished by the United States Weather Bureau. A summary of this is presented in Table 1. The data is most complete for the prairie area and least so for the Blue Mountains. The stations are usually located in towns and so the records do not indicate the conditions in any particular habitat, but they do give a basis for comparing the climatic conditions in different faunal areas.

Table 2, which gives the climatological data for each month at Walla Walla, is presented to illustrate the weather conditions in the region at the different seasons. In southeastern Washington the precipitation is unequally distributed throughout the year, being greatest in winter, while in summer very little rain falls. The summers are very hot, and the winters moderately cool with occasional very cold periods of short duration. There is a considerable daily range of temperature and even in the hottest weather the nights are cool. The humidity of the air is very low in summer, but is higher in winter. There is an abundance of sunlight in summer, while in winter the light is much weaker. Winds are quite common and especially in spring may be very strong. Their usual direction is from the southwest. A peculiar wind which deserves notice is the "chinook." This is a dry, warm wind from the southwest which may start at any time of the day or night in winter. It rapidly melts the snow and dries the surface of the ground. In consequence, snow seldom lies for any length of time upon the ground, except in the Blue Mountains.

TABLE I

COMPARISON OF CLIMATOLOGICAL DATA FROM SOUTHEASTERN WASHINGTON

Station	Columbia Basin sagebrush area		Columbia Basin prairie area			Blue Mountain area	
	Kennewick	Touchnet	Walla Walla	Huntsville	Dayton	Dixie (near)	Touchnet Ridge
Elevation	368	556	1000	1400	1700	.....	2500
No. years record	19	7	30	3	28	4	4
Temperature, ° F.							
Mean annual	54.1	51.5	53.4	.....	50.1	.....	.....
Mean maximum	67.0	.....	63.0	.....	61.8	.....	.....
Absolute maximum	115.0	107.0	113.0	.....	100.0	.....	.....
Mean minimum	41.2	.....	44.0	.....	39.5	.....	.....
Absolute minimum	-21.0	-10.0	-17.0	.....	-20.0	.....	.....
Mean annual range.....	46.4	40.3	41.9	.....	36.9	.....	.....
Absolute annual range..	136.0	114.0	130.0	.....	120.0	.....	.....
Mean daily range	25.8	.....	19.6	.....	22.3	.....	.....
Precipitation, inches—							
Mean annual	6.34	9.71	17.34	21.28	22.73	48.88	51.53
Maximum	9.92	12.44	23.07	24.30	33.52	56.95	60.80
Minimum	3.58	7.84	11.66	18.87	16.25	41.98	37.26
Average snowfall	13.5	8.6	24.3	41.6	40.9	.....	178.7
No. rainy days	52	78	112	81	105	.....	132
Sky—							
Clear days	197	166	142	178	125	.....	137
Partly cloudy days.....	91	95	93	71	132	.....	125
Cloudy days	81	106	131	116	108	.....	103
Direction of wind	SW.	SW.	S.	.....	SW.	SW.	SW.

The growing season of southeastern Washington is comparatively long. At Prescott it is often possible to plant the seeds of hardy vegetables in the open ground in the first week of March or earlier. The frostless season is also comparatively long (Table 3), although irregular frosts late in spring often do considerable damage to fruit and garden crops.

TABLE III

FROST DATA

Station—	Columbia Basin sagebrush area		Columbia Basin prairie area	
	Kennewick	Touchet	Walla Walla	Dayton
Length of record	7	5	23	5
Average date first frost in Autumn	Oct. 15	Sept. 13	Nov. 3	Oct. 13
Average date last killing frost in Spring	Apr. 28	Apr. 23	Apr. 1	Apr. 25
Earliest date of killing frost in Autumn	Sept. 25	Aug. 25	Sept. 28	Sept. 23
Latest date of killing frost in Spring	May 25	May 8	May 3	May 8
Average season between frosts—days	170	143	216	171
Frostless season—days	123	109	148	138

No records of humidity are available from the various habitats of Walla Walla and Columbia counties, but in Whitman County, Washington, and in the Thatuna Hills of Idaho, Weaver (1914) has obtained records of the rate of evaporation as determined by a porous-cup atmometer during the summer. These records show that the rate of evaporation is highest in the rocky-slope habitat and that in the other habitats it decreases in the following order: prairie, S.W. exposure; prairie, N.E. exposure; yellow pine; fir-tamarack; cedar. The sagebrush habitat was not included in these observations.

The prominent features of the climate of the sagebrush area is the small annual precipitation and the high temperature of summer. No records of wind velocities are available from these stations, but it is known that the area is subject to strong winds which act powerfully to drift the sandy soil.

The prairie area as a whole shows a lower average temperature and particularly a lower temperature in the summer months than is found in the typical part of the sagebrush area as recorded at Kennewick. Also the prairie area shows a greater rainfall and this rainfall is greater the more closely the Blue Mountains are approached. It may

be said also that the winds of the prairie area are probably less strong than those of the sagebrush area.

Climatological data from the Blue Mountains is very scanty and consists only of records of precipitation at two stations on the lower ridges. It is evident that the precipitation is very much higher on these ridges than in the prairie area. The temperature of the area is considerably lower than in the adjacent areas, but no definite records could be obtained. There is a much greater snowfall in the mountains than in the lower country and the snow lies on the mountains all winter and often until late in the spring.

INFLUENCE OF ARTIFICIAL CONDITIONS

The animal habitats of southeastern Washington have been greatly altered by the work of man. Farming is extensively carried on and in the prairie area a very large percentage of the land is under cultivation. Irrigation is also practiced in the valleys of both the prairie and sagebrush areas. All of the land not under direct cultivation has been heavily grazed by cattle and stock. Part of the timber along the streams has been cut down and much of the brush has been cleared away. Houses have been built and shade trees planted in places where formerly no trees grew. In the Blue Mountains there have been many destructive forest fires and much timber has been cut. In the region it is now difficult to find an area of any size which shows the primitive conditions in completeness.

These changes in the environment have caused great changes in the abundance of the different species of vertebrates. Some species are greatly reduced in numbers or have been exterminated in the region; others have held their own or have increased to some extent. The species of the open fields have probably suffered most by the occupation of the region by man. Extensive hunting has operated to reduce in number or exterminate some of the game animals. On the other hand, a few game species have been intentionally introduced by man, and a few obnoxious species have been unintentionally introduced.

COMPARISON WITH OTHER SCHEMES OF ECOLOGICAL DISTRIBUTION

The vertebrate associations as here recognized cannot be compared directly with other schemes of vertebrate associations, because the local distribution of no other region of similar climatic conditions has been studied by the associational method. However, a comparison can be made with several schemes of ecologic distribution used in other regions.

Weaver (1914) has studied the plant associations found in Whitman County, Washington, and the Thatuna Hills of adjacent Idaho, where the vegetational features are somewhat similar to those of the region we are studying. He recognizes the following plant associations: bunchgrass-rimrock association, prairie association, yellow pine association, fir-tamrack association, and cedar association. The bunchgrass-rimrock association corresponds to the rocky-slope association of the prairie area as used in this paper. The prairie association is the same as our bunchgrass association.

Gates (1911, pp. 9-11) has included flycatchers and swallows in the aquatic association because they capture insects in the air over the water. However, such forms cannot be considered to be aquatic in any sense of the term and we have therefore placed them in the aerial association.

Shelford (1913, p. 262) in the Chicago area has recognized a distinct animal community in the narrow border of shrubs and weeds occurring between the prairie and the forest proper. This forest-margin community is very distinct in many regions, but it has been thought undesirable to recognize it as an association between the willow associations and the bunchgrass or sagebrush associations of southeastern Washington. The willow habitat in the region is usually narrow and is often rather open. It resembles in these respects the forest margin rather than a true forest habitat. In the Blue Mountains the yellow pine forests pass over into the prairie usually without any indication of a marginal habitat. The other conifer forests of the area are sometimes bordered by an extensive growth of brush and this has been called the buckbrush habitat.

Kennedy (1914) in a study of the birds of the Yakima Valley, Washington, gives separate lists of the birds of the sagebrush and of those found along the streams. No attempt is made to distinguish

those of the timber and brush from those of the stream shore. The Yakima Valley belongs in the Columbia Basin sagebrush faunal area and the environmental conditions of the sagebrush in that valley seem to be very similar to those of the sagebrush in western Walla Walla County. Of the species of birds stated to be characteristic of the sagebrush of the Yakima Valley all except five, *Sayornis sayus*, *Otocoris alpestris merrilli*, *Poocetes gramineus confinus*, *Spizella breweri*, and *Oreoscoptes montanus*, have been reported from the sagebrush of western Walla Walla County.

The roadside association recognized by Jackson (1914, pp. 23, 24) in the conifer forests of Wisconsin belongs to a habitat at the edge of a clearing in a heavy forest and seems to have many features in common with the forest-margin communities recognized in other regions. Such an association might be recognizable in the Blue Mountains, but roads are few in that area and it is impossible to define such an association without more data than is at present at hand.

Animal habitats are sometimes divided into strata. Shelford (1913, p. 165) recognizes five strata in some terrestrial habitats, extending from the subterranean stratum to the tree stratum. No attempt has been made to divide the habitats of southeastern Washington into strata, although various strata could undoubtedly be distinguished.

Much has been made of the succession of animal species due to the change in habitats induced or correlated with plant succession (Adams, 1908). In southeastern Washington many of the associations and habitats seem to have reached an equilibrium and succession is not very prominent. In the sagebrush and prairie areas the rocky-slope habitat tends to change to the sagebrush or bunchgrass habitat. Modifications which occur by the shiftings of the stream channels produce changes in the riparian associations. Floods sometimes wash out part of the willow habitat and even at times part of the bunchgrass or sagebrush habitat. Also, the willow habitat tends to invade the river beds. At every shifting of the stream channel there are changes in the extent and position of the water-margin habitat. In the Blue Mountains the conditions are probably less stable and changes in habitats are probably in more active progress. Weaver (1914) has suggested that in Whitman County, Washington, and in the adjacent parts of Idaho the succession is the following direction: (1) bunchgrass; (2) yellow pine; (3) Douglas spruce and western larch; (4) cedar. Cedar does not occur on the Blue Mountains as a distinct habitat, but its place is probably taken by the alpine fir.

Associations may, for ease in comparison, be grouped in either of several different manners. Grinnell and Swarth (1913, pp. 218-220) have considered two kinds of associations, major and minor. Each major association is made up of one or more minor associations. Major associations recognized in the San Jacinto area of California are: chaparral, forest, riparian, rupestrine, meadow and sand-flat. It is considered that a given major association may occur in several faunal areas and life-zones, but its minor divisions are much more restricted. The associations of southeastern Washington recognized in this paper would belong in general to the class of major associations according to this classification, for no attempt has been made in most cases to work out the finer divisions of the associations.

Another method of comparing associations is to group them into formations. A *formation* is stated to be a group of physiologically similar associations (Shelford, 1913, p. 38). Formations may themselves be combined into still larger groups. The classification of the formations of the world is still in its preliminary stages.

Shelford (1911, pp. 604, 605) has proposed a classification of formations with which it will be illuminating to compare the associations of southeastern Washington. The conifer forest associations of the Blue Mountains must be referred to his second division, *formations of forests with narrow, thick leaves*. The bunchgrass associations belong to the third division, *formations of savannas and grasslands*, and to the subdivision *c*, *cool steppe formations*. The associations of the rivers belong to division seven, *formations of fresh water*. The other associations are harder to place in the system.

ZOOGEOGRAPHIC POSITION OF SOUTHEASTERN WASHINGTON

The accompanying table (Table 4) shows the general relations of the vertebrate faunas of southeastern Washington to the faunas of adjacent regions. In this table the occurrences in the adjacent regions are given of those species whose ranges are well known and which have been definitely identified from Walla Walla County or Columbia County. Of the birds only those species occurring in the regions in summer and which are presumably breeding are included.

The Columbia Basin sagebrush fauna shows in this comparison much greater affinity to the fauna of the Great Basin than to the

TABLE IV

Occurring in S.E. Washington in:	No. of forms considered	Occurring in adjacent districts				Unique in	
		Rocky Mts.	Cascade Mts.	Great Basin	Puget Sound	Columbia Basin	Blue Mts.
Sagebrush fauna only....	11	1	0	8	3	3	....
Prairie fauna only.....	29	20	4	23	15	1	....
Blue Mountain fauna only	35	30	18	3	10	....	1
In both sagebrush and prairie faunas	34	25	5	34	14	....	....
In both prairie and Blue Mountain faunas.....	17	14	8	7	7	....	....
In sagebrush, prairie, & Blue Mt. faunas.....	16	12	6	15	7	....	....

faunas of other adjacent regions. It must be placed in the Great Basin district of Allen (1892, p. 237). As the Great Basin seems to have had a rather stable climate and a continuous sequence of forms for a long period of geologic time it is allowable to suppose that many of the forms of the Columbia Basin sagebrush fauna originated in the Great Basin and migrated into southeastern Washington at some period later than the Middle Miocene.

The fauna of the Blue Mountains is most closely related to the fauna of the Rocky Mountains. The Blue Mountain area must be placed in a subdivision of the Canadian subregion of *Holarctica* (Lydekker, 1896, p. 360). It seems logical to suppose that the fauna of this area has been derived largely from the North.

The fauna of the Columbia Basin prairie area is related to the faunas of both the Rocky Mountains and the Great Basin. It has seemingly been produced largely by an admixture of elements from these two places.

The maintainance of the distinctness of the fauna of the Columbia Basin prairie area must be due to the climatic barriers which separate it from the Columbia Basin sagebrush fauna and from the Blue Mountain fauna. Differences in temperature and rainfall and perhaps other factors are effective in separating the fauna of the prairie from that of the Blue Mountains. The difference in temperature between the prairie area and the sagebrush area in southeastern Washington is not marked and the difference in rainfall is probably the chief factor separating the faunas of the two places.

LIFE-ZONES OF SOUTHEASTERN WASHINGTON

The sagebrush region about Wallula belongs certainly to the Upper Austral life-zone. It is placed in this zone on the basis of the flora by Piper (1906, p. 35). Merriam (1898, p. 30) states that a part of the Upper Austral zone in Washington, in the valleys of the Snake and Columbia rivers, has so hot a climate that it might almost be placed in the Lower Austral zone.

The Columbia Basin prairie area must be placed in the Transition life-zone although it contains a strong Upper Sonoran element. In the area there are no species which have not elsewhere been reported to occur in zones above the Upper Sonoran. Four breeding species, *Mustela arizonensis*, *Citellus columbianus columbianus*, *Passerella iliaca schistacea*, and *Oporornis tolmiei*, are characteristic of the Transition or higher life-zones. Further, the area has been placed in the Transition life-zone by Piper (1906, p. 48) on the basis of the flora.

In the Transition life-zone must be included the bunchgrass hills south of Wallula and also those north of the Walla Walla River east of Nine-mile. Sagebrush as a dominant habitat extends up the Walla Walla Valley as far as Touchet, and this would seem to mark the eastern limit of the Upper Austral life-zone in the region. Piper (1906, map) extends a tongue of Upper Austral as far east as Walla Walla, but there seems no justification for this, for the plant and animal associations at Walla Walla, so far as can be judged under the present altered conditions, are essentially the same as in the bunchgrass region to the north and east. Piper also places the cañon of Snake River, for the whole of the distance that this extends through Washington, in the Upper Austral life-zone. However, in the cañon of Snake River at Lyon's Ferry sagebrush was not the dominant vegetation and the characteristic vertebrates of the Upper Austral life-zone found at Wallula were not present.

Temperature records of the kind used by Merriam (1894) in defining the limits of the life-zones are available only for Walla Walla (Bigelow, 1908, p. 90). At Walla Walla daily normal temperatures of 43° F. and above occur throughout the period between March 12 and November 16, giving an average growing season of 249 days. The sum of the daily normal temperatures for this season is 15352° F. The hottest six weeks of summer at Walla Walla are the last three weeks of July and the first three weeks of August. The average tem-

perature of this period is 74.8° F. On the basis of temperature it would be necessary to place Walla Walla and the Columbia Basin prairie area about midway in the Upper Austral life-zone (Merriam, 1894, p. 236), but the fauna indicates closer affinity to the Transition life-zone. In this matter the fauna is probably a better criterion than the temperature, because the life-zones are founded primarily on faunal relationships.

The yellow-pine areas of the lower parts of the Blue Mountains in Columbia County make up the timbered division of the Transition life-zone as recognized by Piper (1906, p. 35).

The part of the Blue Mountain area above the Transition life-zone belongs to the Boreal region of Merriam. Piper (1906, pp. 58, 60, 62) recognizes Canadian, Hudsonian, and Arctic life-zones in the flora of these mountains. In the vertebrate fauna the Arctic life-zone cannot be distinguished and the Canadian and Hudsonian life-zones are very difficult to separate. If the Hudsonian life-zone be recognized as distinct it must be restricted to the summits of the ridges. Here is found the alpine fir (*Abies lasiocarpa*), a characteristic Hudsonian tree (Piper, 1906, p. 60). The vertebrate species found on these higher ridges, and not reported from lower altitudes, are *Zapus princeps oregonus*, *Picoides americanus dorsalis*, and *Nucifraga columbiana*. None of these species can be considered strictly Hudsonian. It seems best to place the part of the Blue Mountain area above the Transition life-zone in a single life-zone, the Boreal.

COMPARISON OF THE DIFFERENT SYSTEMS OF CONSIDERING DISTRIBUTION

The facts of animal and plant distribution are very complex and it is convenient to have some system or systems of arranging these facts so that they can be considered in groups rather than as isolated instances. Several systems are now in use. Each of these emphasizes different features of the facts of distribution.

THE ZOOGEOGRAPHICAL SYSTEM

The system of zoogeography points out the barriers to distribution, and indicates something as to the origin of the faunas of different regions. Because different species of animals are not limited by the same barriers, they do not all fall evenly into zoogeographical divisions.

Routes of migration have been opened and closed at irregular times, and many groups have become differentiated only to become exterminated. Climatic barriers are hard to determine and different species show various degrees of limitation by such barriers. It is a difficult matter to divide any region into satisfactory zoogeographical areas. It has been pointed out that the zoogeographical divisions of the globe are different for each group of animals and that in any one group these divisions indicate roughly the length of time the different sections of the group have been separated (Gadow, 1913, p. 13-15).

The zoogeographical method has many limitations and it is unwise to attempt to apply it too closely. Species are limited in distribution by various factors or complexes of factors. The zoogeographical divisions are founded on comparative statistics and there will always be exceptions. In some cases the exceptions will almost equal the number following the rule. The zoogeographical divisions are more or less arbitrary and there are sure to be many places of uncertain position. Still, the system greatly simplifies the consideration of the facts of distribution.

THE LIFE-ZONE SYSTEM

The significance of the life-zone method lies in its indication of climatic barriers on the continent of North America, and the origin of the faunas of the several life-zones. Although this method of considering distribution has come into rather general use, it has a number of disadvantages and difficulties, and a considerable amount of criticism has been directed at the system. It seems advisable therefore to consider its history and some of the objections which have been raised against it.

On the high mountains of the western United States there are different zones of vegetation at different levels, and with each of these vegetational zones there are associated particular species of animals. Merriam (1890, pp. 7-11) found seven such zones of life on San Francisco Mountain, Arizona. Beginning at the top he gave these the names of Alpine zone, Subalpine or Timberline zone, (Central) Hudsonian or Spruce zone, (Central) Canadian or Balsam Fir zone, Neutral or Pine zone, Piñon zone, and the Desert Area. He showed that some species in the fauna and flora of the uppermost four of these zones were characteristic of much more northern regions. On the mountains of central Idaho, Merriam (1891, pp. 21-25) distin-

guished six life-zones which he called respectively the Arctic-alpine zone, the Subalpine or Timberline zone, the (Central) Hudsonian or Spruce zone, the (Central) Canadian or Douglas Fir zone, the Neutral or Transition zone, and the Upper Sonoran zone.

The faunal divisions of eastern North America generally recognized by students of distribution, particularly by ornithologists, at the time Merriam began his work on correlation, were eight in number. Passing from north to south these divisions were (1) Arctic, (2) Hudsonian, (3) Canadian, (4) Alleghanian, (5) Carolinian, (6) Louisianian, (7) Floridian, and (8) Antillean (Merriam, 1890, p. 18).

Merriam (1890, p. 18) was much impressed with the similarities between the zones of the higher parts of San Francisco Mountain and the faunal areas of northeastern North America and states that

in many instances, the zones of the mountain may be recognized by the identical species which characterize them in New England and Canada. In short it was found that the faunal and floral zones which go to make up the Boreal province in the East may be traced in a northwesterly direction around the northern end of the Plains of the Saskatchewan, and then south along the sides of the Rocky Mountains even to this isolated peak in Arizona.

Merriam (1892, p. 22) later extended the correlation of the zones of the eastern and western United States and stated "with some confidence" that the Transition zone of the mountains of the West is the equivalent of the Alleghanian of the East and also that the Upper Sonoran is the equivalent of the Carolinian, and the Lower Sonoran of the Austroriparian. He thought that these life-zones followed "the lines of equal temperature during the season of reproduction," and based the correlation mainly on that factor.

Since that time members of the United States Bureau of Biological Survey and others have extensively followed the life-zone method in describing distribution in North America. A brief statement of the birds and mammals characteristic of each life-zone was published by Merriam in 1898. As used as present, the Timberline zone originally recognized by Merriam has been merged into the Hudsonian zone, but no other important modification has been made.

Each of the life-zones of the Sonoran region is divisible into two or more faunal areas (Merriam, 1898, pp. 20-49). These faunal divisions are based upon differences in the atmospheric humidity in different parts of the same life-zone (Grinnell and Swarth, 1913, p. 217). In California a considerable number of these *faunas* have been distinguished by Grinnell (1902, p. 7).

The idea that temperature is the fundamental factor in limiting the distribution of species is dominant in the conception of life-zones, and in 1894 Merriam made an attempt to determine the temperature limits of each life-zone. By running various isothermal lines he determined that the northern limits of the life-zones agreed fairly well in having the same total quantity of heat. The total quantity of heat is the sum for the year of the daily mean temperatures above 6° C. This temperature is assumed to be the point at which life begins activity. The southern limits of the life-zones, however, did not agree with the isotherms thus determined, but did approximately agree with isotherms of the hottest period of the year.

One criticism which should be made of this correlation of life-zones and isotherms is that the northern and southern limits of the life-zones are not determined by the same temperature criteria and that therefore in some places the life-zones may not meet each other. If dependence be placed on these temperature criteria alone, some regions must be placed in two life-zones and theoretically some in none at all. Along the Pacific Coast in particular there is much overlapping of the life-zones. Merriam (1894, p. 233-235) considers that in that region the northern forms are able to come far south on account of the low temperature of the summers, while the southern forms are able to extend their ranges far to the north on account of the long growing season. Thus is explained the great overlapping of northern and southern forms in the "Pacific Coast strip." However, it cannot be considered proved that the temperature relations established by Merriam are the particular ones which determine the limits of distribution of any species of animal.

Another criticism of Merriam's determination of life-zone temperatures is that no thorough attempt has been made to determine if these temperatures actually do apply to all parts of the life-zones as they have been plotted in North America. Indeed, the temperatures of some parts of the life-zones in the West were obtained by applying temperature data obtained in the corresponding faunal areas of the eastern United States (Merriam, 1890, pp. 31, 32). There are some facts which seem to indicate that the temperatures determined by Merriam do not apply in parts of some life-zones. For instance, according to temperature Walla Walla and the Columbia Basin prairie area of southeastern Washington would be placed well within the Upper Austral zone, but the faunal relationships are with the Transition zone, or at least are not definitely Upper Austral.

In the life-zone system, humidity is recognized to have considerable influence on distribution, but is held to be always subordinate to the influence of temperature. However, it seems that either of several climatic factors may be of importance in limiting organic distribution. An extreme variation of humidity, or probably of other climatic factors besides temperature, may form a positive barrier to the distribution of species. All the climatic factors are complexly interrelated and a variation of any factor has an influence on the effect of the others. Different organisms are adapted to different climatic complexes and react in different manners to different factors and to varying degrees of the same factor. Temperature perhaps often is the most important factor in limiting distribution, but it would seem to be impossible to base a system of distribution on variations in any one climatic factor without obscuring many facts of prime importance. It has not yet been established that small differences of temperature of the degree supposedly separating some of the life-zones are as important barriers to distribution as are some of the more marked differences due to variations in rainfall and humidity.

The zones of life which occur in any given locality may be dependent in part on temperature, yet there are other factors which evidently have a very strong modifying influence. Differences in rainfall, in the humidity of the air, in slope exposure, or in other factors may greatly modify the position of zones. It may be that differences in some of those factors, other than temperature, might even be the principal cause in the production of certain zones. In each given case it is probably the complex of climatic factors which determines the occurrence of the zone rather than the action of one factor alone.

Three distinct regions of life may be recognized in North America, the Holarctic (Boreal) region, the Sonoran (Austral) region, and the Neotropical region (Tropical zone) (Lydekker, 1896, frontispiece). The limitation of many characteristic species and genera to each of these regions is probably due principally to the action of temperature as a barrier. In the Holarctic region of North America three transcontinental belts of life, Arctic, Hudsonian, and Canadian, have been recognized by nearly all students of geographical distribution. These belts of life are probably also determined largely by the effect of temperature. However, there is much more difficulty in recognizing transeontinental life belts within the Sonoran region, and in the truly tropical regions zones of distribution corresponding to isotherms have not been recognized.

Zones of life are clearly evident upon many mountains and in many regions which are not mountainous. The life of the uppermost of some of these mountain zones is evidently related to the life of more northern regions. However, the life of the mountain zones is never identical with the life of any particular northern transcontinental belt. Neither do the zones found on mountains in different parts of the United States exactly correspond. Grinnell finds the Canadian and Hudsonian life-zones in California to be far less distinct than the other life-zones in the state. Also in California those two life-zones are much less distinct than they are in the northern part of the continent. In the Blue Mountains of Washington it is almost impossible to separate the Hudsonian life-zone from the Canadian. In the Pine Forest Mountains of Nevada, Taylor (1912, p. 339) recognizes an area which is referred to the Transition life-zone, but which has a "Boreal infusion." It seems that the zones of life found on the upper parts of southern mountains show less affinity to particular northern transcontinental life belts than they do to an alpine or Arctic type of life in general.

The life-zones of the various parts of the Sonoran region present still greater difficulties in homologizing. In the first place it may be doubted if transcontinental life-zones really show in the best manner the similarities and differences of the faunas in the various parts of the region. Allen (1892, pp. 217-218) has demonstrated that the genera and subgenera of mammals of the arid division of the Sonoran region are more different from those of the humid division, than are those of a northern transcontinental division of the region from those of a southern division. It seems, then, that the first division of the Sonoran region should be into eastern and western sections.

The zones of the Sonoran region found in the various parts of the western United States are very difficult to correlate. The number of zones to be distinguished is variable and those of different regions do not seem to be exactly homologous. Following Merriam's classification the three life-zones, Transition, Upper Sonoran, and Lower Sonoran have usually been recognized. However, other zones are sometimes apparent. Grinnell and Swarth (1913, p. 217) have split the Transition zone in the San Jacinto area of southern California into an upper and a lower division. In eastern Washington a division of the Transition zone has also been made and these divisions are as distinct as are any other two zones. As an instance of the difficulty of homologizing zones in different regions, we may mention the Columbia Basin prairie

area. This area seems to show homologies to both the upper Sonoran and to the Transition zones as found in other parts of the West.

Certain species seem to have a different "zonal" position in different regions. Those which in one place are restricted to a certain life-zone range elsewhere into areas which must be placed in other life-zones. Many of the species and several of the genera given by Merriam (1892 and 1898) as characteristic of the various life-zones are now known to range beyond the limits stated by him. Grinnell and Swarth (1913, p. 217) mention the case of a "Transition infiltration into a prevailing Upper Sonoran area" in the San Jacinto region of southern California. Cases like this indicate very strongly that there is often a lack of homology between the zones of life found in different regions.

In a restricted region of general climatic similarity the zones of life may usually be easily homologized. In California Grinnell (1902, p. 6) has recognized several zones which are evidently natural divisions of the fauna, and each of which is seemingly homologous throughout its extent in the state. However, the zones of life found in different regions, particularly in regions under different climatic conditions, show much less similarity and in many cases are certainly not directly homologous.

In some cases the life-zone system seems to be largely dependent upon the distribution of particular associations of plants and animals. The life-zones are based on temperature differences, yet "it is obvious that, throughout considerable portions of the continent, the details of temperature distribution are not known with any approach to precision. Thus, the actual criterion which the field zoologist falls back upon in any given case is the character of the fauna and flora which he finds associated together. The presence of certain species shows him that he chances to be in this or that 'life-zone'" (Sumner, 1915, p. 67). On Alder Creek in northern Nevada, Taylor (1912, p. 331) has placed the vegetation along the stream in the Transition zone, while the treeless slopes away from the narrow strip of vegetation are placed in the Upper Austral zone. There may be a temperature difference between the strip along the stream and the immediately adjoining timberless slopes sufficiently great to maintain different life-zones in the two places, but there is no proof that such is the case. On the contrary, it seems that the differences are those that would naturally be produced by habitat differences. There is no justification for assuming that the differences in this and many other similar cases are

due to differences in temperature until the effect of difference in habitat has been eliminated.

We believe that the true significance of the facts considered in the life-zone method of studying distribution in North America would be better presented by an extension of the zoogeographical method of Lydekker and Allen. This method would recognize the zones of life found in the various parts of the continent. It would recognize the relation of the zones on the higher parts of the mountains to the belts of life in the North by placing these higher zones in subdivisions of the Holarctic region. Under this system there would be no compulsion to recognize a certain number of life-zones in each region, but the number of divisions could be varied to fit the circumstances. The effect of temperature as a barrier to distribution in places where that is important would be shown, and the effects of other climatic barriers could also be emphasized.

THE ECOLOGICAL METHOD

The ecological method of studying the distribution of animals and plants brings out chiefly the relations of the organisms to their environments. It makes as simple as possible the comparison of environments and of adaptational structures and habits in different species and in different localities. The different associations and formations of any region can be compared with associations and formations in any other part of the world. At present our knowledge of associations and formations in general is too slight to point out the significance of each ecological division in southeastern Washington, but we feel certain that the study of the distribution of the species of animals in relation to the distribution of different kinds of environments will lead to results of the highest value.

The classification of the habitats of a region and the placing of the species in associations, which to some extent at least are arbitrary divisions, may be objected to on the ground that such a system apparently indicates a discontinuity in nature which does not exist. However, it is thought that the use of terms showing the relative abundance of each species in the different habitats, prevents the associations from assuming more of a definite character than they actually possess.

The different systems used for describing animal distribution are used for convenience in classifying the complexly related facts in-

volved. It seems impossible to organize all the facts into a perfect system, but it is desirable to have as great uniformity as possible and not unduly to increase systems or complexity of nomenclature. As the facts become better known systems will have to be changed to agree with the increased knowledge. At present it seems desirable to use two systems, both starting with the same unit, the species. By the first method, zoogeography, species and taxonomic groups are considered in relation to geographical divisions. The second method, the ecological method, groups species according to similarity of adaptational features and of environmental conditions.

A combination of these two methods of studying distribution should lead to excellent results. Usually the study of zoogeography has been carried on without reference to the particular habitats in which the organisms live. A comparison of the animals in similar habitats in different faunal areas is sure to bring to light many important facts about the evolution of the different groups and of topographical and climatic changes in general. Further, the relation between an organism and its environment cannot be fully understood without reference to the mode of origin both of the organism and of the environment.

SUMMARY

In southeastern Washington we may distinguish three faunal areas, each containing a number of distinct habitats. Each habitat is occupied by a different vertebrate association.

The Columbia Basin sagebrush fauna belongs to the Great Basin division of the Sonoran region. The Blue Mountain fauna belongs to the Canadian subregion of Holarctica. The Columbia Basin prairie fauna shows affinities to the life both of the Rocky Mountains and of the Great Basin.

An Upper Austral life-zone, a timberless and a timbered division of the Transition life-zone, and a Boreal life-zone may be recognized in the region.

Although temperature seems to be the climatic barrier which is most important in separating the faunas of the zoogeographical regions (Holarctic, Sonoran, and Neotropical) represented in America, yet within the limits of the Sonoran region it has not been proved that temperature is as important a barrier to distribution as are the factors connected with differences in rainfall and humidity.

Zones or belts of life may be recognized in many regions. However, it is very difficult to homologize the zones of life which occur in widely separated parts of North America. The division of the continent into a definite number of transcontinental life-zones seems to be contrary to a number of the facts of distribution.

The ecological method of studying distribution furnishes valuable information about the relation between organisms and their environments. The use of this method in conjunction with the zoogeographical method should lead to results of great value.

LITERATURE CITED

ADAMS, C. C.

1908. The ecological succession of birds. *Auk*, 25, 109-153.

ALLEN, J. A.

1892. The geographical distribution of North American mammals. *Bull. Amer. Mus. Nat. Hist.*, 4, 199-244, 4 maps.

BIGELOW, F. H.

1908. The daily normal temperature and the daily normal precipitation of the United States. U. S. Dept. Agr., Weather Bureau, *Bull. R.*, 186 pp.

GADOW, HANS.

1913. The wanderings of animals (University Press, Cambridge), viii + 150 pp., 17 maps.

GATES, FRANK C.

1911. Summer bird life in the vicinity of Havana, Illinois, in its relation to the prominent plant associations. *Wilson Bull.*, 23, 1-27.

GRINNELL, J.

1902. Check-list of California birds. Cooper Ornith. Club, Pacific Coast Avifauna, 3, 98 pp., 2 col. pls.

1914. An account of the mammals and birds of the lower Colorado Valley with especial reference to the distributional problems presented. *Univ. Calif. Publ. Zool.*, 12, 51-294, pls. 3-13, 9 figs.

GRINNELL, J., AND SWARTH, H. S.

1913. An account of the birds and mammals of the San Jacinto area of southern California, with remarks upon the behavior of geographic races on the margins of their habitats. *Univ. Calif. Publ. Zool.*, 10, 197-406, pls. 6-10, 3 figs.

JACKSON, HARTLEY H. T.

1914. The land vertebrates of Ridgway Bog, Wisconsin: their ecological succession and source of ingress. *Bull. Wisc. Nat. Hist. Soc.*, 12, 4-54, 9 figs.

KENNEDY, C. L.

1914. The effects of irrigation on bird life in the Yakima Valley, Washington. *Condor*, 16, 250-255.

LYDEKKER, R.

1896. Geographical history of mammals. (University Press, Cambridge), xii + 400 pp., 82 figs., 1 map.

MERRIAM, C. HART.

1890. Results of a biological survey of the San Francisco Mountain region and desert of the Little Colorado, Arizona. U. S. Dept. Agri., Div. Orni. and Mamm., North Amer. Fauna, 3, 136 pp., 14 pls., 2 figs., 5 maps.
1891. Results of a biological reconnoissance of southcentral Idaho. U. S. Dept. Agri., Div. Orni. and Mamm., North Amer. Fauna, 5, 132 pp., 4 pls., 4 figs.
1892. The geographic distribution of life in North America with special reference to the mammalia. Proc. Biol. Soc. Wash., 7, 1-64, map.
1894. Laws of temperature control of the geographic distribution of terrestrial animals and plants. Natl. Geog. Mag., 6, 229-238, 3 pls. (maps).
1898. Life zones and crop zones in the United States. U. S. Dept. Agri., Div. Biol. Surv., Bull. No. 10, 79 pp., 1 map.

PIPER, C. V.

1906. Flora of the State of Washington. Smithsonian Inst., Contrib. U. S. Natl. Herb., 11, 637 pp., 22 pls., 1 map.

RUSSELL, I. C.

1897. A reconnoissance in southeastern Washington. U. S. Geol. Surv., Water Supply Paper No. 4, 96 pp., 7 pls., 3 figs.

SHELFORD, V. E.

1911. Physiological animal geography. Jour. Morph., 22, 551-618, 19 figs.
1913. Animal communities in temperate America, as illustrated in the Chicago region. A study in animal ecology. Bull. Geog. Soc. Chicago, 5, xiii + 362 pp., 306 figs., 2 maps.

SUMNER, F. B.

1915. Review of Grinnell (1914): An account of the mammals and birds of the lower Colorado Valley, with special reference to the distributional problems presented. Science, n.s., 41, 65-69.

TAYLOR, W. P.

1912. Field notes on amphibians, reptiles, and birds of northern Humboldt County, Nevada, with a discussion of some of the faunal features of the region. Univ. Calif. Publ. Zool., 7, 319-436, pls. 7-12.

WEAVER, JOHN E.

1914. Evaporation and plant succession in southeastern Washington and adjacent Idaho. Plant World, 17, 273-294, 10 figs.

PLATE 24

Fig. 1. Packed sand situation in sagebrush habitat, three miles east of Wallula, June 13, 1914. The plants are common sagebrush (*Artemisia tridentata*) and rabbit brush (*Chrysothamnus viscidiflorus* and *Chrysothamnus nauseosus graveolens*).

Fig. 2. Drifting sand situation in sagebrush habitat, three miles east of Wallula, June 13, 1914. The plants are common sagebrush and rabbit brush and a few individuals of the hop sage (*Grayia spinosa*). In the distance are the bunchgrass-covered hills south of the Walla Walla River.

Figure 1

Figure 2

PLATE 25

Fig. 3. Bunchgrass habitat in the prairie area one mile south of Lyon's Ferry, June 24, 1914. The principal plant is the wheat bunchgrass (*Agropyron spicatum*).

Fig. 4. The Touchet Valley, two miles east of Prescott, July 9, 1915. The cottonwood-willow habitat is shown in typical development along the river. The conspicuous trees are cottonwoods (*Populus trichocarpa*). The hills and the greater part of the valley were natively covered by bunchgrass, but now are nearly entirely in cultivated fields.

Figure 3

Figure 4

PLATE 26

Fig. 5. The eastern side of the cañon at Hompeg Falls, Blue Mountain area. The considerable extent of the rocky-slope habitat at this point is shown. The trees on the slopes are mostly yellow pines (*Pinus ponderosa*). Toward the upper part of the ridge a yellow-pine habitat occurs. In the bottom of the cañon is a lowland-fir habitat.

Fig. 6. Forests in the Blue Mountains near the head of the South Fork of the Touchet River, Aug. 1, 1915. The forest in this section is chiefly made up of young trees. Douglas spruce (*Pseudotsuga taxifolia*) and western larch (*Larix occidentalis*) are the dominant species.

Figure 5

Figure 6

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