PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

FOURTH SERIES

VOL. IX, No. 2, pp. 37–67 JUNE 16, 1919

II

LIFE-ZONE INDICATORS IN CALIFORNIA

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INTRODUCTION

An increasing number of naturalists, both botanists and zoologists, are finding in the life-zone system a useful means of handling the facts of distribution. The satisfactory diagnosis of life-zones in the field has been dependent hitherto upon an extensive familiarity with the occurrence of plants and animals over large areas, and this has been possible only to a few persons with abundant opportunity for field work. It is the experience of the present writers that certain critical species can be selected as "life-zone indicators", through the recognition of which the zonal position of any one locality

may be determined with approximate accuracy without an exhaustive study of the entire flora and fauna. The object of the present paper is to make available a partial list of the plants and vertebrate animals which may be depended upon to establish the zonal identity of any locality within the State of California, and so to make it possible for the inexperienced person to "find himself" zonally.

THE LIFE-ZONE CONCEPT

Field biologists of the Pacific Coast are in general agreement as to the value of the life-zone concept. It not only fits in with well established facts but has direct practical application in studies dealing with the ecology and geographic distribution of plants and animals. That there are difficulties in its application, and that there are numerous apparent inconsistencies among life-zone workers, is readily admitted. However, these will doubtless be cleared up as we come to a more intensive study of environments and to a more careful application of the fundamental laws of geographic distribution. In this connection it should perhaps be pointed out that the life-zones as here accepted are not to be compared with the mountain regions of Schimper (1898) and others, nor even with the so-called life "zones" or belts of some workers in our own country. We here refer to those classifications which are based largely upon altitude and latitude and sometimes upon topography. Such zones or belts may be somewhat useful in popular treatises, but are of slight scientific value since their use entirely ignores the local conditions which often greatly modify zonal position.

The idea that life-zones are altitudinal or latitudinal is correct only in a very general way or incidentally. They are, instead, primarily biologic, that is, they are composed of and determined by a certain assemblage of plant and animal species, and are affected by altitude or latitude only as these modify the climate, more especially the temperature during the critical periods of an organism's existence. This effect of a change in latitude or altitude is sometimes overshadowed by the influence of local conditions, resulting in the so-called misplacement and spotting of zones. So frequent is this the

case that the distribution of a taxonomic group can be accurately stated in terms of latitude and altitude only by making the range so inclusive as to render the statement of but general interest.

It is just this failure to recognize the importance of local disturbing conditions that has led some investigators to undervalue both the scientific basis and the utility of the life-zone concept. The more important local influences which interfere with the normal, orderly succession of life-zones may be specified and briefly discussed as follows:

1. *Slope exposure.* Next to altitude and latitude this is apparently the most important determinant of temperature and consequently of zone positions in our western states. As may be determined mathematically, the amount of heat received by a slope with the most favorable gradient is 1.4 times as great as that received by an equal area of level land, other conditions being constant (Hall, 1902, p. 34). It is evident, from such considerations, that any life-zone will occur at higher altitudes on southerly facing slopes (in the Northern Hemisphere) than it will on level areas, and that it will be correspondingly depressed on northerly facing slopes.

2. *Air currents.* It is well known that cold air flows down the cañons in mountainous districts, especially at night. This results in a depression of life-zones, particularly in narrow valleys and cañons. On the other hand, proximity of a desert area or other source of warm air often greatly elevates the position of life-zones on mountain slopes, because of the warm ascending currents. (See Merriam, 1899, p. 51; Shreve, 1914, pp. 197-202.)

3. *Streams carrying cold water.* The effect upon the growth conditions of plants whose roots are in moist soil near these streams is considerable, as indicated by the persistent manner in which species of the higher zones fringe the water courses at lower levels. As an alpine stream descends to the plains, its rise in temperature is much less than is generally supposed. This is indicated by thermometric observations (not yet published) made in the mountains of Colorado by Dr. Gideon S. Dodds.

4. *Evaporation from moist soil.* This likewise depresses the temperature and works in harmony with No. 3. The effect is also noticeable around lakes and moist depressions. The influence is sometimes very local. It is even possible that in tall forests the tree species may belong to one life-zone whereas the communities beneath these trees may contain herbaceous plants and terrestrial animals from the zone next above. In such cases we must consider, in addition to evaporation, such influences as shading, the movement of cold air, the effect of cold water, etc.

5. *Proximity to large bodies of water.* Water is usually an equalizer of temperature, but the presence of unusually cold or warm bodies and ocean currents must be taken into account.

6. *Influence of lingering snow banks and of glaciers.* Because of peculiar topography snow accumulates much more abundantly in some places than in others. These deep snow fields require a longer time for their complete melting, or may persist throughout the summer, thus acting as refrigerators for the immediate neighborhood. The effect is often very local and gives rise to a "spotting" of life-zones which cannot be accounted for on other grounds. Glaciers may produce similar effects.

7. *Changes in the vegetable covering.* Forest fires, avalanches, and other denuding agents may result in a change from a previously existing life-zone to the one next below (Merriam, 1899, p. 51). As the laws of plant succession become operative the species will again change to those of the climax formation, and there will be going on in the meantime a nice adjustment between temperature conditions and plant covering, each acting upon the other. In such cases relicts are sometimes present. These may persist for many years side by side with species brought in by the changed conditions. Such phenomena are exceedingly perplexing to the student of life-zones.

8. *Extent of a mountain area.* The larger a mountain mass the less will be the effect of surrounding influences. For example, in a desert region the zones will occur at

lower altitudes on a broad, massive mountain than they will on a sharp, isolated peak. (See Grinnell and Swarth, 1913, p. 216.)

9. *Rock surfaces.* Rocky slopes, outcroppings, and talus are usually warmer than surrounding areas, and the life-zones are raised in consequence.

10. *Miscellaneous local influences.* The explanation of the apparently abnormal occurrence of a species at stations far removed from the zone in which it is usually found should be sought in a minute examination of local conditions. The influence of man is especially important, and one must be certain that the species is actually established.

THE SELECTION OF LIFE-ZONE INDICATORS

When all of the numerous disturbing "factors" are taken into account we may be able to explain many of the apparent incongruities in the position of life-zones as we find them in nature. In the meantime, it is our clear duty to map these zones in as definite a manner as possible, using for this purpose the occurrence of stenothermic species of animals and plants rather than any preconceived idea as to the temperature or other environmental factor. In selecting these indicative species, or "life-zone indicators", as they are called, one must have regard for a number of considerations. A few of the criteria which the authors have used in making selections for the indicators enumerated beyond may be set forth as follows:

1. Only breeding records have been taken into account. This applies to plants as well as to animals, for seeds are sometimes carried above the normal position for the species. The resulting seedlings may live through several or many seasons and yet not be able to reproduce because of insufficient summer heat. Conversely, plants and animals may be carried to stations below their proper zone, there persist and even reproduce during a few favorable seasons, but without becoming thoroughly established. It is thus evident that the sporadic occurrence of a few individuals does not necessarily

indicate the presence of a zone of which the species is characteristic.

2. In the case of plants, perennials are usually preferred to annuals (Coville, 1893, p. 17).

3. The more abundant a species the greater is its value as a life-zone indicator. Rare or local species may be restricted by other factors than those which influence zone position. A dearth of facilities for dispersal may account for the restricted occurrence of a species which would otherwise inhabit two or more zones. Conversely, organisms with effective provision for wide dispersal may be considered as having been already distributed and tried out over a number of zones, so that their absence from any one of them may be taken as evidence that they are there unable to persist.

4. Certain indicators may be absolutely constant as to their zonal position in one portion of their range but quite unreliable when the entire range of the species is taken into account. This may be due to a variety of causes, chief of which is perhaps the possible development of hardy strains in one portion of the range and not in another. Allowance should also be made for the presence of biotypes which may be so similar in external characters as to escape detection by the taxonomist but which react differently to their environment. Whatever the cause, it should be borne in mind that in a few cases a particular indicator may be of no value when widely separated faunas or floras are to be compared.

5. Since the delimitation of life-zones as outlined by Merriam is accepted in the main by the present authors, these zonal limits are determined as far as possible by means of indicators listed by Dr. Merriam himself, especially in his later publications (Merriam, 1899, etc.). Since the nomenclature first proposed by Merriam has now become well established we consider it highly undesirable that any other should be promulgated. Uniformity in the use of terms applied to the various zones is essential to ready intelligibility and to scientific accuracy. However, the present authors do not commit themselves as to the exact temperature factors limiting the various life-zones and the distribution of species as laid down in some detail by Merriam (Merriam, 1898).

RECOMMENDED PRECAUTIONS

It is perhaps needful here to warn those who make use of our lists of indicators that life-zones are not often abruptly defined one against the other, but that belts of some width may mark their boundaries, where overlapping or mixing of ingredients occurs. If the locality to be tested happens to be situated in such an indifferent position, trouble will naturally be encountered and the true state of affairs will not be discovered without a floral and faunal reconnoissance radially in different directions; if on a steep slope, a few rods may suffice; if on more level ground, some miles may need to be traversed.

Another thing to keep in mind is that only a few of the species here listed for a given zone will be likely to occur in any one locality. Various faunal and associational divisions of life-zones exist (Grinnell, 1914, p. 64), so that the critical species are usually limited in their distribution to but a portion of their life-zone. But every such subdivision is represented in our lists by two or more species.

Then it is possible that some of our "indicators" have been selected as such through an incomplete knowledge of their distribution; in other words, in some cases where a species is at first supposed to be an "indicator" (that is, a species not occurring in two or more zones, but in only one), as its distribution becomes better known the less closely may it be found restricted within the limits of one zone, and therefore the poorer "indicator" it becomes. However, a majority of the species of both plants and animals we have selected are conspicuous and well-known species, easily detected. In some of the cases there *is* more or less "spilling over" locally from the critical zone, in one direction or the other or in both directions, though not involving an entire adjacent zone; and with such species letters are affixed by which the zone or zones in which it also occurs are designated. With each of these species, its metropolis is so emphatically within the zone for which it is listed, that its value as an indicator is paramount, especially when the observer takes pains to verify the presence of two or more indicators—the more the better. With migratory birds the zonal position indicated is, of course, that of the *breeding* area.

Axiomatic is the tenet that accurate systematic determination of species must be the foundation for any distributional study.

For life-zone maps relating to California, either for the entire state or for particular areas within the state, the following papers should be consulted: C. Hart Merriam, 1898; C. Hart Merriam, 1899; H. M. Hall, 1902; J. Grinnell, 1908; A. O. U. Committee, 1910; J. Grinnell, 1913; J. Grinnell and H. S. Swarth, 1913; J. Grinnell, 1915. Useful discussions of the life-zone system of distributional treatment of plants and animals will be found in the following papers: C. Hart Merriam, 1899; H. M. Hall, 1902; J. Grinnell, 1915. (For full titles of all these papers, see list of "Literature Cited" on a subsequent page of the present contribution.)

LISTS OF LIFE-ZONE INDICATORS

LOWER SONORAN ZONE

Species closely restricted to this zone, and particularly characteristic of it, are marked with a star (*). Species marked U occur also in the Upper Sonoran Zone.

Plants

Ephedra californica Wats.
Pleuraphis rigida Thurb.*
Tridens pulchellus (H. B. K.) Hitchc.
Washingtonia filifera Wendl.*
Hesperocallis undulatus Wats.*
Yucca brevifolia Engelm. U
Yucca mohavensis Sarg.
Agave deserti Engelm.
Anemopsis californica Hook. U
Phoradendron californicum Nutt.
Rumex hymenosepalus Torr.
Atriplex hymenelytra (Torr.) Wats.
Atriplex lentiformis (Torr.) Wats.*
Spirostachys occidentalis Wats.
Mirabilis froebellii Greene
Lepidium fremontii Wats.
Isomeris arborea Nutt. U
Crossosoma bigelovii Wats.

LOWER SONORAN ZONE—Continued

Acacia greggii Gray*
Astragalus aridus Gray
Astragalus limatus Sheldon
Astragalus pomonensis M. E. Jones
Cassia armata Wats.*
Cercidium torreyanum (Wats.) Sarg.*
Lupinus odoratus Heller
Olneya tesota Gray*
Parkinsonia microphylla Torr.*
Parosela californica (Wats.) Vail
Parosela emoryi (Gray) Heller
Parosela schottii (Torr.) Heller
Parosela spinosa (Gray) Heller
Prosopis glandulosa Torr.*
Prosopis pubescens Benth.*
Sesbania macrocarpa Mühl.
Fagonia californica Benth.*
Larrea divaricata Cav.*
Thamnosma montana Torr. & Frem.
Krameria canescens Gray
Krameria parvifolia Benth.*
Condalia parryi (Torr.) Weberbauer
Malvastrum exile Gray
Sphæralcea emoryi Gray
Sphæralcea orcuttii Vas. & Rose
Fouquieria splendens Engelm.*
Eucnide urens (Gray) Parry
Petalonyx nitidus Wats.
Petalonyx thurberi Gray
Echinocactus lecontei Engelm.
Echinocactus polycephalus Engelm.
Opuntia acanthocarpa Engelm. & Big.
Opuntia bernardina Engelm.*
Opuntia echinocarpa Engelm. & Big.*
Opuntia engelmannii Salm-Dyck
Oenothera brevipes Gray
Asclepias subulata Dec.*
Philibertia linearis heterophylla Gray
Coldenia palmeri Gray

LOWER SONORAN ZONE—Continued

Lippia nodiflora Michx.
Hyptis emoryi Torr.
Salazaria mexicana Torr.*
Datura meteloides DC. U
Datura thomasii Torr.
Lycium andersonii Gray
Nicotiana glauca R. Grah.
Nicotiana trigonophylla Dunal
Mohavea breviflora Coville
Mohavea viscida Gray
Chilopsis linearis (Cav.) Sweet*
Beloperone californica Benth.
Cucurbita palmata Wats.
Acamptopappus sphærocephalus Gray
Amphiachyris fremontii (T. & G.) Gray*
Aster carnosus Gray
Aster spinosus Benth.
Aster tortifolius (T. & G.) Gray*
Atrichoseris platyphylla Gray
Baccharis emoryi Gray
Baccharis sergiloides Gray
Baileya multiradiata pleniradiata (Harv. & Gray) Coville
Baileya pauciradiata Harv. & Gray
Bebbia juncea (Benth.) Greene*
Brickellia arguta Rob.
Brickellia desertorum Coville
Brickellia frutescens Gray
Brickellia incana Gray
Brickellia multiflora Kell.
Chænactis macrantha Eat.
Chænactis stevioides H. & A.
Chrysothamnus paniculatus (Gray) Hall
Chrysothamnus teretifolius (Dur. & Hilg.) Hall U
Conyza coulteri Gray
Dicoria canescens T. & G.
Dysodia cooperi Gray
Dysodia porophylloides Gray
Encelia farinosa Gray*
Encelia frutescens Gray U

LOWER SONORAN ZONE—Continued

Eriophyllum pringlei Gray
Eriophyllum wallacei Gray
Franseria dumosa Gray*
Geræa canescens T. & G.
Gutierrezia lucida Greene*
Heterotheca grandiflora Nutt.*
Hoffmanseggia densiflora Benth.
Hofmeisteria pluriseta Gray
Isocoma veneta acradenia (Greene) Hall
Lepidospartum squamatum Gray*
Lygodesmia exigua Gray
Malacothrix californica DC.
Malacothrix coulteri Gray
Malacothrix glabrata (Eat.) Gray
Monoptilon bellioides (Gray) Hall
Nicolletia occidentalis Gray
Palafoxia linearis Lag.
Pectis papposa Harv. & Gray
Perityle emoryi Torr.
Peucephyllum schottii Gray
Pluchea sericea (Nutt.) Coville
Porophyllum gracile Benth.
Psathyrotes annua (Nutt.) Gray
Psathyrotes ramosissima (Torr.) Gray
Psilostrophe cooperi (Gray) Greene
Tetradymia comosa Gray
Trichoptilium incisum Gray
Viguiera deltoidea parishii (Greene) Rose
Viguiera laciniata Gray

Amphibians

Batrachoseps major Camp
Bufo cognatus cognatus Say
Bufo cognatus californicus Camp
Bufo punctatus Baird & Girard
Bufo alvarius Girard

LOWER SONORAN ZONE—Continued

Reptiles

Coleonyx variegatus (Baird)
Dipso-saurus dorsalis (Baird & Girard)
Uma notata Baird
Callisaurus ventralis ventralis (Hallowell)
Crotaphytus silus Stejneger
Sauromalus ater Duméril
Uta stansburiana elegans Yarrow U
Uta stansburiana hesperis Richardson U
Uta graciosa (Hallowell)
Uta ornata Baird & Girard
Sceloporus magister Hallowell
Phrynosoma platyrhinos Girard
Phrynosoma m'callii (Hallowell)
Xantusia vigilis Baird
Cnemidophorus tigris tigris Baird & Girard
Cnemidophorus tigris mundus Camp U
Cnemidophorus hyperythrus beldingi (Stejneger)
Leptotyphlops humilis (Baird & Girard)
Thamnophis marcianus (Baird & Girard)
Chilomeniscus cinctus Cope
Sonora occipitalis (Hallowell)
Sonora episcopa (Kennicott)
Lampropeltis conjuncta Cope
Rhinocheilus lecontei Baird & Girard
Coluber flagellum frenatus (Stejneger)
Arizona elegans Kennicott
Tantilla eiseni Stejneger
Crotalus atrox Baird & Girard
Crotalus mitchellii (Cope)
Crotalus cerastes Hallowell
Testudo agassizii (Cooper)

Birds

Lophortyx gambeli gambeli Gambel
Melopelia asiatica trudeaui (Audubon)
Falco mexicanus Schlegel U
Micropallas whitneyi whitneyi (Cooper)

LOWER SONORAN ZONE—Continued

Otus asio gilmani Swarth
Dryobates scalaris cactophilus Oberholser
Centurus uropygialis uropygialis Baird
Colaptes chrysoides mearnsi Ridgway
Phalænoptilus nuttalli nitidus Brewster
Chordeiles acutipennis texensis Lawrence
Calypte costæ (Bourcier)
Tyrannus vociferans Swainson
Pyrocephalus rubinus mexicanus Sclater
Pica nuttalli (Audubon) U
Molothrus ater obscurus (Gmelin)
Icterus cucullatus nelsoni Ridgway
Pipilo aberti Baird
Guiraca cærulea salicarius Grinnell
Piranga rubra cooperi Ridgway
Vireo belli pusillus Coues
Vireo belli arizonæ Ridgway
Vermivora luciæ (Cooper)
Dendroica æstiva sonorana Brewster
Mimus polyglottos leucopterus (Vigors)
Toxostoma lecontei lecontei Lawrence
Toxostoma crissale Henry
Heleodytes brunneicapillus couesi (Sharpe)
Auriparus flaviceps flaviceps (Sundevall)
Polioptila plumbea (Baird)
Polioptila californica Brewster

Mammals

Scapanus latimanus grinnelli Jackson
Scapanus latimanus campi Grinnell & Storer
Notiosorex crawfordi crawfordi Baird
Macrotus californicus Baird
Myotis velifer (J. A. Allen)
Myotis occultus Hollister
Myotis yumanensis yumanensis (H. Allen)
Myotis californicus pallidus Stephens
Pipistrellus hesperus hesperus (H. Allen)
Pipistrellus hesperus merriami (Dobson) U

LOWER SONORAN ZONE—Continued

Euderma maculatum (J. A. Allen)
Corynorhinus rafinesquii pallescens Miller
Antrozous pallidus (LeConte)
Antrozous pacificus Merriam U
Eumops californicus (Merriam)
Canis ochropus estor Merriam
Vulpes macrotis macrotis Merriam
Vulpes macrotis muticus Merriam
Vulpes macrotis arsipus Elliot
Urocyon cinereoargenteus scotti Mearns
Procyon lotor pallidus Merriam
Mephitis estor Merriam
Onychomys torridus pulcher Elliot
Onychomys torridus tularensis Merriam
Onychomys torridus ramona Rhoads
Peromyscus crinitus stephensi Merriam
Peromyscus eremicus eremicus (Baird)
Peromyscus eremicus fraterculus (Miller)
Sigmodon hispidus eremicus Mearns
Neotoma albigula venusta True
Neotoma intermedia intermedia Rhoads U
Neotoma intermedia desertorum Merriam U
Thomomys bottæ angularis Merriam
Thomomys bottæ pascalis Merriam
Thomomys bottæ pallescens Rhoads
Thomomys perpallidus perpallidus Merriam
Thomomys perpallidus albatus Grinnell
Thomomys perpallidus aureus J. A. Allen
Thomomys perpallidus perpes Merriam
Thomomys perpallidus mohavensis Grinnell
Thomomys operarius Merriam
Perognathus longimembris brevinasus Osgood
Perognathus bombycinus Osgood
Perognathus inornatus inornatus Merriam U
Perognathus inornatus neglectus Taylor
Perognathus formosus Merriam U
Perognathus penicillatus penicillatus Woodhouse
Perognathus penicillatus stephensi Merriam
Perognathus fallax fallax Merriam

LOWER SONORAN ZONE—Continued

Perognathus fallax pallidus Mearns
Perognathus californicus ochrus Osgood
Perognathus spinatus spinatus Merriam
Perodipus tularensis Merriam
Perodipus swarthi Grinnell
Perodipus dixoni Grinnell
Perodipus mohavensis Grinnell
Perodipus ingens Merriam
Perodipus microps Merriam U
Perodipus levipes Merriam
Dipodomys deserti Stephens
Dipodomys merriami simiolus Rhoads
Dipodomys merriami parvus Rhoads
Dipodomys merriami nitratoides Merriam
Dipodomys merriami exilis Merriam
Citellus tereticaudus tereticaudus (Baird)
Citellus tereticaudus chlorus Elliot
Citellus tereticaudus eremonomus Elliot
Citellus mohavensis (Merriam)
Ammospermophilus leucurus leucurus (Merriam) U
Ammospermophilus nelsoni nelsoni (Merriam)
Ammospermophilus nelsoni amplus Taylor
Lepus californicus richardsoni Bachman
Lepus californicus deserticola Mearns U
Sylvilagus auduboni vallicola Nelson
Sylvilagus auduboni arizonæ (J. A. Allen)
Cervus nannodes Merriam
Odocoileus hemionus eremicus (Mearns)
Ovis canadensis nelsoni Merriam U

UPPER SONORAN ZONE

Species closely restricted to this zone, and particularly characteristic of it, are marked with a star (*). Species marked L occur also in the Lower Sonoran Zone; those marked T occur also in the Transition; those marked C occur also in the Canadian.

Plants

Ephedra viridis Coville
Cupressus macnabiana Murray
Cupressus sargentii Jepson
Juniperus californica Carr. L

UPPER SONORAN ZONE—Continued

Pinus monophylla Torr. & Frem.*
Pinus sabiniana Dougl.
Pinus tuberculata Gordon
Stipa pulchra Hitchc. L
Lilium rubescens Wats.
Nolina parryi Wats.
Yucca whipplei Torr.*
Juglans californica Wats.
Castanopsis chrysophylla minor DC.
Quercus agrifolia Nee.
Quercus douglasii H. & A.
Quercus dumosa Nutt.*
Quercus wislizenii DC.
Eriogonum fasciculatum Benth. L
Aristolochia californica Torr.
Atriplex confertifolia (Torr. & Frem.) Wats. L
Eurotia lanata (Pursh) Moq. L
Grayia spinosa (Hook.) Moq. L?
Sarcobatus vermiculatus (Hook.) Torr. L
Dendromecon rigidum Benth.*
Dicentra chrysantha H. & A.
Ribes gracillimum Cov. & Britt.
Ribes malvaceum Smith
Ribes speciosum Pursh
Adenostoma fasciculatum H. & A.*
Adenostoma sparsifolium Torr.
Cercocarpus betulæfolius Nutt.*
Cercocarpus parvifolius Nutt.
Photinia arbutifolia (Ait.) Lindl. T
Prunus ilicifolia (Nutt.) Walp.
Purshia tridentata (Pursh) DC. T
Cercis occidentalis Torr.*
Hosackia glabra (Vogel) Torr.
Pickeringia montana Nutt.*
Ptelea baldwinii T. & G.
Rhus diversiloba T. & G. T
Rhus ovata Wats.
Rhus trilobata Nutt.
Aesculus californica (Spach) Nutt.

UPPER SONORAN ZONE—Continued

Ceanothus crassifolius Torr.*
Ceanothus cuneatus (Hook.) Nutt.*
Ceanothus divaricatus Nutt.*
Ceanothus oliganthus Nutt.
Ceanothus perplexans Trel.
Ceanothus vestitus Greene
Malvastrum fasciculatum (Nutt.) Greene L
Hypericum concinnum Benth. T
Mentzelia aurea (Lindl.) Baill.
Mentzelia lævicaulis (Dougl.) T. & G. L
Datisca glomerata (Presl) B. & W. T
Garrya pallida Eastw.
Garrya rigida Eastw.
Garrya veatchii palmeri (Wats.) Eastw.
Arctostaphylos canescens Eastw.
Arctostaphylos glandulosa Eastw.
Arctostaphylos glauca Lindl.
Arctostaphylos manzanita Parry
Arctostaphylos pungens H. B. K.
Arctostaphylos viscida Parry
Styrax californica Torr.
Fraxinus dipetala H. & A.
Gilia californica (H. & A.) Benth.
Salvia apiana Jepson L
Salvia clevelandii (Gray) Greene
Salvia leucophylla Greene
Salvia mellifera Greene
Salvia spathacea Greene
Sphacele calycina Benth.
Trichostema lanatum Benth.
Castilleia foliolosa H. & A.
Pentstemon cordifolius Benth.
Pentstemon heterophyllus Lindl.
Pentstemon ternatus Torr.
Artemisia californica Less. L
Artemisia tridentata Nutt. T C
Brickellia microphylla (Nutt.) Gray
Ericameria arborescens (Gray) Greene
Senecio eurycephalus T. & G.

UPPER SONORAN ZONE—Continued

Amphibians

Aneides lugubris lugubris (Hallowell) T
Batrachoseps attenuatus (Eschscholtz) T
Ambystoma tigrinum (Green)
Hyla arenicolor Cope L
Rana aurora draytonii Baird & Girard T

Reptiles

Sceloporus occidentalis occidentalis Baird & Girard T
Sceloporus occidentalis bi-seriatus Hallowell L
Sceloporus orcutti Stejneger
Gerrhonotus scincicauda scincicauda (Skilton) T
Gerrhonotus scincicauda webbii Baird L
Xantusia henshawi Stejneger
Plestiodon skiltonianum Baird & Girard T
Thamnophis ordinoides hammondii (Kennicott) L T
Diadophis amabilis Baird & Girard T
Lampropeltis californiæ (Blainville)
Coluber lateralis (Hallowell)
Coluber tæniatus (Hallowell)
Crotalus exsul Garman
Crotalus tigris Kennicott

Birds

Lophortyx californica vallicola (Ridgway) L T
Gymnogyps californianus (Shaw)
Strix occidentalis occidentalis (Xantus) T
Dryobates nuttalli (Gambel)
Melanerpes formicivorous bairdi Ridgway T
Phalænoptilus nuttalli nuttalli (Audubon)
Phalænoptilus nuttalli californicus Ridgway
Calypte anna (Lesson)
Aphelocoma woodhousei (Baird)
Aphelocoma californica californica (Vigors)
Aphelocoma californica oocleptica Swarth T
Aphelocoma californica immanis Grinnell
Icterus parisorum Bonaparte
Astragalinus lawrencei (Cassin)

UPPER SONORAN ZONE—Continued

Ammodramus savannarum bimaculatus Swainson
Chondestes grammacus strigatus Swainson L
Spizella atrogularis (Cabanis)
Amphispiza belli (Cassin)
Amphispiza nevadensis canescens Grinnell
Aimophila ruficeps ruficeps (Cassin)
Pipilo crissalis crissalis (Vigors)
Pipilo crissalis carolæ McGregor
Pipilo crissalis senicula Anthony L
Vireo huttoni huttoni Cassin
Vireo vicinior Coues
Dendroica nigrescens (Townsend) T
Toxostoma redivivum redivivum (Gambel) L
Toxostoma redivivum sonomæ Grinnell
Catherpes mexicanus punctulatus Ridgway T
Thryomanes bewicki eremophilus Oberholser
Thryomanes bewicki charienturus Oberholser
Thryomanes bewicki drymœcus Oberholser
Thryomanes bewicki spilurus (Vigors) T
Bæolophus inornatus inornatus (Gambel)
Bæolophus inornatus murinus Ridgway
Bæolophus inornatus griseus (Ridgway)
Psaltriparus minimus minimus (Townsend) T
Psaltriparus minimus californicus Ridgway
Psaltriparus plumbeus (Baird)
Chamæa fasciata henshawi Ridgway
Chamæa fasciata fasciata (Gambel)
Polioptila cærulea obscura Ridgway

Mammals

Sorex californicus californicus Merriam
Sorex sinuosus Grinnell
Myotis orinomus Elliot
Corynorhinus rafinesquii intermedius H. W. Grinnell
Ursus californicus Merriam T
Ursus magister Merriam T
Urocyon cinereoargenteus californicus Mearns T
Bassariscus astutus raptor (Baird) T
Onychomys leucogaster brevicaudus Merriam

UPPER SONORAN ZONE—Continued

Onychomys leucogaster fuscogriseus Anthony
Reithrodontomys megalotis longicaudus (Baird) T L
Peromyscus truei truei (Shufeldt)
Peromyscus truei gilberti (J. A. Allen) T
Peromyscus truei martirensis (J. A. Allen)
Peromyscus crinitus crinitus (Merriam)
Peromyscus californicus californicus (Gambel) T
Peromyscus californicus insignis Rhoads
Thomomys bottæ mewa Merriam
Thomomys bottæ diaboli Grinnell
Thomomys bottæ nigricans Rhoads T
Thomomys scapterus Elliot T
Perognathus longimembris panamintinus Merriam L
Perognathus californicus californicus Merriam
Perognathus californicus femoralis J. A. Allen
Perodipus perplexus Merriam
Perodipus venustus Merriam T
Perodipus elephantinus Grinnell
Perodipus streatori Merriam
Perodipus panamintinus Merriam
Perodipus leucogenys Grinnell T
Perodipus monoensis Grinnell
Dipodomys californicus californicus Merriam
Dipodomys californicus trinitatis Kellogg
Microdipodops californicus Merriam
Microdipodops polionotus Grinnell
Citellus mollis stephensi (Merriam)
Eutamias pictus (J. A. Allen) T
Eutamias panamintinus (Merriam)
Eutamias sonomæ Grinnell T
Eutamias merriami merriami (J. A. Allen) T
Eutamias merriami kernensis Grinnell & Storer T
Eutamias merriami mariposæ Grinnell & Storer T
Lepus californicus californicus Gray
Lepus californicus wallawalla Merriam T
Sylvilagus auduboni auduboni (Baird)
Sylvilagus bachmani bachmani (Waterhouse)
Sylvilagus bachmani cinerascens (J. A. Allen)
Sylvilagus bachmani mariposæ Grinnell & Storer

TRANSITION ZONE

Species closely restricted to this zone, and particularly characteristic of it, are marked with a star (*). Species marked U occur also in the Upper Sonoran Zone; those marked C occur also in the Canadian.

Plants

Abies concolor L. & G. C?
Abies venusta (Dougl.) Koch
Cupressus macrocarpa Hartw.
Libocedrus decurrens Torr.*
Pinus lambertiana Dougl.*
Pinus muricata Don
Pinus ponderosa Dougl. (typical form)*
Pinus radiata Don
Pseudotsuga taxifolia (Poir.) Britt.
Sequoia gigantea (Lindl.) Dec.
Sequoia sempervirens (Lamb.) Endl.*
Taxus brevifolia Nutt. C
Torreya californica Torr.
Camassia quamash (Pursh) Greene C
Clintonia andrewsiana Torr.
Lilium pardalinum Kell. U
Lilium parryi Wats.
Scoliopus bigelovii Torr.
Smilax californica (DC.) Gray
Trillium ovatum Pursh
Trillium sessile chloropetalum Torr.
Trillium sessile giganteum H. & A.
Iris hartwegii Baker
Iris hartwegii australis Parish
Iris missouriensis Nutt.
Castanopsis chrysophylla (Dougl.) DC.
Corylus rostrata californica DC.
Pasania densiflora (H. & A.) Oersted
Quercus chrysolepis Liebm. U
Quercus kelloggii Newb.*
Asarum caudatum Lindl.
Asarum hartwegii Wats.
Actæa spicata arguta (Nutt.) Torr. C
Vancouveria parviflora Greene
Boykinia major Gray

TRANSITION ZONE—Continued

Heuchera micrantha Dougl.
Mitella diversifolia Greene
Mitella ovalis Greene
Saxifraga peltata Torr.
Tellima grandiflora (Pursh) Dougl.
Whipplea modesta Torr.
Chamæbatia foliolosa Benth.*
Cratægus rivularis Nutt.
Fragaria californica C. & S.
Fragaria californica crinita (Rydb.) Hall
Fragaria chiloensis Duch.
Fragaria virginiana platypetala (Rydb.) Hall C
Geum macrophyllum Willd.
Horkelia tenella (Wats.) Rydb.
Horkelia tridentata Torr.
Physocarpus capitatus (Pursh) Ktze. U
Prunus demissa (Nutt.) Walp. U
Rubus leucodermis Dougl.
Rubus parviflorus Nutt. U C
Rubus spectabilis Pursh
Hosackia crassifolia Benth. U
Hosackia macrantha Greene
Lathyrus sulphureus Brewer
Geranium incisum Nutt.
Acer circinatum Pursh
Acer macrophyllum Pursh*
Ceanothus cordulatus Kell. C
Ceanothus integerrimus H. & A. U
Ceanothus palmeri Trel.
Ceanothus prostratus Benth.*
Ceanothus thyrsiflorus Esch.
Ceanothus velutinus Dougl. C
Viola lobata Benth.
Viola sarmentosa Dougl.
Angelica tomentosa Wats.
Cicuta douglasii (DC.) C. & R.
Cœlopleurum maritimum C. & R.
Aralia californica Wats.
Cornus nuttallii Aud.*

TRANSITION ZONE—Continued

Pyrola aphylla Sm.
Pyrola picta Sm. C
Sarcodes sanguinea Torr. C
Arbutus menziesii Pursh U
Arctostaphylos patula Greene C
Gaultheria shallon Pursh
Rhododendron californicum Hook.
Rhododendron occidentale (T. & G.) Gray
Vaccinium ovatum Pursh
Frasera neglecta Hall
Frasera nitida Benth. U
Frasera tubulosa Cov.
Draperia systyla (Gray) Torr.*
Cynoglossum occidentale Gray
Agastache urticifolia (Benth.) Ktze. C
Scutellaria angustifolia Pursh
Scutellaria californica Gray
Pentstemon labrosus Hook.
Kelloggia galioides Torr. C
Adenocaulon bicolor Hook.
Anaphalis margaritacea occidentalis Greene
Antennaria argentea Benth.
Antennaria rosea Greene C
Petasites speciosa (Nutt.) Piper
Rudbeckia californica Gray

Amphibians

Plethodon croceater Cope
Aneides ferreus (Cope)
Aneides iëcanus (Cope)
Ambystoma ensatum (Eschscholtz)

Reptiles

Sceloporus graciosus graciosus Baird & Girard U
Sceloporus graciosus vandenburgianus Cope
Gerrhonotus cœruleus Wiegmann U
Charina bottæ (Blainville)

TRANSITION ZONE—Continued

Thamnophis ordinoides atratus (Kennicott) U
Thamnophis ordinoides elegans (Baird & Girard) C
Contia mitis Baird & Girard U
Lampropeltis pyromelana multicincta (Yarrow)

Birds

Oreortyx picta plumifera (Gould) C
Bonasa umbellus sabini (Douglas) C
Columba fasciata fasciata Say
Accipiter velox (Wilson) C
Strix occidentalis caurina (Merriam)
Glaucidium gnoma californicum Sclater
Glaucidium gnoma grinnelli Ridgway U
Xenopicus albolarvatus albolarvatus (Cassin) C
Xenopicus albolarvatus gravirostris Grinnell C
Sphyrapicus varius daggetti Grinnell
Chætura vauxi (Townsend)
Selasphorus alleni Henshaw U
Nuttallornis borealis (Swainson) C
Cyanocitta stelleri frontalis (Ridgway) C
Cyanocitta stelleri carbonacea Grinnell
Carpodacus purpureus californicus Baird
Zonotrichia nuttalli Ridgway
Junco oreganus pinosus Loomis
Piranga ludoviciana (Wilson) C
Tachycineta thalassina lepida Mearns
Lanivireo solitarius cassini (Xantus)
Vermivora ruficapilla gutturalis (Ridgway)
Dendroica occidentalis (Townsend)
Oporornis tolmiei (Townsend)
Nannus hiemalis pacificus (Baird)
Certhia familiaris occidentalis Ridgway
Sitta pygmæa pygmæa Vigors
Sitta pygmæa leuconucha Anthony
Penthestes rufescens rufescens (Townsend)
Penthestes rufescens neglectus (Ridgway)
Penthestes rufescens barlowi (Grinnell)
Hylocichla guttata slevini Grinnell

TRANSITION ZONE—Continued

Mammals

Scapanus townsendii (Bachman) C
Scapanus latimanus sericatus Jackson
Neurotrichus gibbsii gibbsii (Baird)
Neurotrichus gibbsii hyacinthinus Bangs
Sorex montereyensis montereyensis Merriam
Sorex montereyensis mariposæ Grinnell
Sorex pacificus Baird C
Myotis longicrus longicrus (True) U
Myotis longicrus interior Miller U
Lasionycteris noctivagans (LeConte)
Urocyon cinereoargenteus sequoiensis Dixon U
Peromyscus boylei boylei (Baird) U
Peromyscus boylei rowleyi (J. A. Allen) U
Phenacomys longicaudus True
Thomomys alpinus awahnee Merriam
Zapus orarius Preble C
Eutamias quadrimaculatus (Gray)
Eutamias townsendi ochrogenys Merriam C
Eutamias hindsi (Gray)
Eutamias merriami pricei (J. A. Allen) U
Sciurus griseus griseus Ord
Sciurus griseus nigripes Bryant
Sciurus griseus anthonyi Mearns
Sylvilagus nuttalli nuttalli (Bachman) U
Sylvilagus nuttalli grangeri (J. A. Allen) U
Sylvilagus bachmani ubericolor (Miller)
Cervus roosevelti Merriam

CANADIAN ZONE

Those species marked T occur also in the Transition Zone; those marked H occur also in the Hudsonian.

Plants

Abies grandis Lindl. T?
Abies magnifica Murr.
Abies magnifica shastensis Lemmon
Picea sitchensis (Bong.) T. & M. T?
Pinus contorta Dougl. T

CANADIAN ZONE—Continued

Pinus monticola Don H
Pinus murrayana Balf. H
Pinus ponderosa jeffreyi (Balf.) Vas. T
Allium validum Wats. H
Populus tremuloides Michx. T
Salix glauca villosa (Don) Anders. H
Castanopsis sempervirens (Kell.) Dudley T H
Quercus vaccinifolia Kell.
Lewisia triphylla (Wats.) Rob. H
Aconitum columbianum Nutt.
Caltha biflora DC. H
Delphinium glaucum Wats. H
Mitella breweri Gray H?
Mitella pentandra Hook. H
Saxifraga arguta Don
Saxifraga bryophora Gray H
Pirus occidentalis Wats. H
Potentilla breweri Wats. H
Potentilla flabellifolia Hook. H
Acer glabrum Torr. T
Pyrola minor Linn.
Arctostaphylos nevadensis Gray H
Vaccinium occidentale Gray H
Polemonium pulcherrimum Hook. H
Mimulus lewisii Pursh H
Pentstemon gracilentus Gray
Pedicularis grœnlandica Retz. H
Arnica longifolia Eat. H
Erigeron salsuginosus Gray H
Hieraceum gracile detonsum Gray H

Reptiles

Sceloporus occidentalis taylori Camp
Gerrhonotus palmeri Stejneger

Birds

Dendragapus obscurus sierræ Chapman T
Astur atricapillus striatulus Ridgway

CANADIAN ZONE—Continued

Otus flammeolus (Kaup)
Sphyrapicus thyroideus thyroideus (Cassin)
Chordeiles minor hesperis Grinnell T
Stellula calliope (Gould) T
Empidonax hammondi (Xantus)
Empidonax wrighti Baird T
Perisoreus obscurus obscurus Ridgway
Perisoreus obscurus griseus Ridgway H
Hesperiphona vespertina californica Grinnell T
Carpodacus cassini Baird H
Melospiza lincolni lincolni Audubon
Passerella iliaca canescens Swarth
Passerella iliaca fulva Swarth
Passerella iliaca monoensis Grinnell & Storer
Passerella iliaca mariposae Swarth
Passerella iliaca stephensi Anthony T
Passerella iliaca brevicauda Mailliard T
Oreospiza chlorura (Audubon) T
Sitta canadensis Linnæus T
Regulus satrapa olivaceus Baird T
Myadestes townsendi (Audubon) T
Hylocichla guttata sequoiensis (Belding) H
Ixoreus nævius nævius (Gmelin)

Mammals

Neosorex bendirei bendirei (Merriam)
Myotis lucifugus altipetens H. W. Grinnell H
Ursus americanus Pallas T
Vulpes cascadensis Merriam H
Vulpes necator Merriam H
Martes caurina sierræ Grinnell & Storer H
Martes pennanti pacifica (Rhoads) H
Mustela muricus (Bangs) H
Evotomys obscurus Merriam
Evotomys californicus Merriam
Microtus montanus dutcheri Bailey H
Thomomys jacinteus Grinnell & Swarth
Thomomys alpinus alpinus Merriam H

CANADIAN ZONE—Continued

Thomomys monticola monticola (J. A. Allen) H
Thomomys monticola premaxillaris Grinnell
Thomomys monticola mazama Merriam H
Zapus major Preble H
Zapus trinotatus alleni Elliot H
Erethizon epixanthum epixanthum Brandt T
Aplodontia rufa californica (Peters) T H
Eutamias amœnus amœnus (Allen) T
Eutamias amœnus monoensis Grinnell & Storer
Eutamias speciosus speciosus (J. A. Allen) H
Eutamias speciosus frater (J. A. Allen) H
Eutamias speciosus inyoensis Merriam H
Eutamias senex (J. A. Allen) T
Glaucomys sabrinus flaviventris Howell
Glaucomys sabrinus lascivus (Bangs) T
Glaucomys sabrinus californicus (Rhoads) T
Lepus washingtoni klamathensis Merriam

HUDSONIAN ZONE

Species marked C occur also in the Canadian Zone; those marked A occur also in the Arctic-Alpine.

Plants

Pinus albicaulis Engelm.
Pinus balfouriana Murr. C?
Tsuga mertensiana (Bong.) Sarg.
Polygonum shastense Brewer A
Draba corrugata Wats. A
Ribes montigenum McCl.
Potentilla fruticosa Linn. C
Fragaria sibbaldifolia Rydb. C
Epilobium obcordatum Gray A
Cassiope mertensiana Don
Kalmia polifolia microphylla (Hook.) Rehder A
Artemisia norvegica Fries
Erigeron compositus Pursh A
Erigeron ursinus Eat. A
Macronema discoidea Nutt. C

HUDSONIAN ZONE—Continued

Macronema suffruticosa Nutt. A
Stenotus acaulis Nutt. C

Amphibians

Spelerpes platycephalus Camp

Birds

Picoides arcticus (Swainson)
Nucifraga columbiana (Wilson) C
Pinicola enucleator californica Price
Zonotrichia leucophrys (Forster)
Hylocichla guttata polionota Grinnell C

Mammals

Gulo luscus luteus Elliot
Citellus beldingi (Merriam)
Eutamias alpinus (Merriam)
Ochotona schisticeps schisticeps (Merriam)
Ochotona schisticeps muiri Grinnell & Storer C A
Ochotona schisticeps albatus Grinnell A
Ovis canadensis sierræ Grinnell C

ARCTIC-ALPINE ZONE

Species marked H occur also in the Hudsonian Zone.

Plants

Trisetum congdonii Scribn. & Merr.
Carex breweri Boott
Salix arctica petræa Anders.
Oxyria digyna Camptd. H
Lewisia pygmæa (Gray) Rob. H
Ranunculus eschscholtzii Schlect.
Draba breweri Wats.
Saxifraga tolmiei T. & G. H
Horkelia pygmæa (Gray) Rydb.
Sibbaldia procumbens Linn. H

ARCTIC-ALPINE ZONE—Continued

Podistera nevadensis Wats.
Primula suffrutescens Gray H
Polemonium eximium Greene
Pentstemon davidsonii Greene
Antennaria media Greene H
Hulsea algida Gray
Hulsea nana Gray
Raillardella argentea Gray H
Senecio petrocallis Greene

Birds

Leucosticte tephrocotis dawsoni Grinnell

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