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Climatic Fluctuations in the Great Basin, 1931-56

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Drought is a persistent problem for effective range management in the drier portions of the western United States. Whereas considerable study has been directed toward correlation of varying precipitation amounts and range yields, little research has been directed toward an understanding of the magnitude of fluctuation in the areal dimension. While this is a problem which assumes importance for the geographer, since his primary concern is one of spatial relationships, it is not without significance to those concerned with effective utilization of our western drylands.

Introduction

The expansion or contraction, and the deepening or lessening in severity, of the dryland climates of the Great Basin of the United States have resulted in serious dislocation to the Great Basin grazing economy. Areal expansions of aridity bring drought to agricultural regions that are inexperienced in coping with decreased moisture; increases in the severity of drought upset delicately balanced agricultural adjustments. Much has been written on the variability of one or more of the climatic elements. Such studies have emphasized the fact that the magnitude of year to year fluctuations is sufficient to obviate the use of long term averages. The present paper intends to explore the year-to-year variability of climate, both as to the areal magnitude and degree of fluctuation of aridity, in the Great Basin of the United States.

The Great Basin of the United States

"Great Basin" is the topographic term commonly applied to a major physiographic province of the western United States. The province, as generally accepted, includes the basin and range country of Nevada, western Utah and sections of eastern California, southeastern Oregon and southern Idaho which lies between the principal crest lines of the Wasatch Mountains and the Sierra Nevada-Cascades. Within these east-west bounds drainage is centripetal. The northern and southern limits of the Great Basin are not so clearly defined; nor is there unanimity among physiographers concerning them. Since the present paper is concerned less with physiographic and more with climatic homogeneity a northern limit has been selected so as to include the five southeastern counties of Oregon and all of Idaho south of the Idaho Rockies. A somewhat arbitrary southern limit was selected which marks the topographic and climatic transitions into the Sonoran desert area. This southern boundary roughly parallels U.S. Highway 91, extending in a straight line from El Cajon Pass, east of the Los Angeles lowlands, to a point in southwestern Utah indicating the separation between the Basin and the Colorado Plateau.

The Great Basin thus delimited is admittedly a region more of convenience; however, a considerable degree of geographical homogeneity is achieved within the area. Aridity, in varying degrees, is generally prevalent throughout the region, except in peripheral areas and at higher elevations, and rather clearly separates the Basin from adjoining areas to the north, east and west. Edaphic and biotic environments also are remarkably similar within the Basin and dissimilar from adjacent regions.

The Great Basin thus delimited represents an area of approximately 238,000 square miles.

Climatic Elements

The climatic elements of temperature, precipitation and relative humidity, however, exhibit remarkably little north-south gradation in the Great Basin. Hot droughty summers, large diurnal ranges of temperature, low relative and absolute humidities, general aridity and *wide yearly and seasonal fluctuations from mean values* characterize the climate of the entire Basin.

Average (Mean) Temperatures

Great Basin temperatures are extreme for their latitudes. In general, average annual temperatures show a decrease with increasing latitude with Death Valley (70°s) and areas in southern Nevada (60°s) the warmer. However, secondary warm regions also occur along the north in the lowlands of the Snake River and around the Great Salt Lake and Salt Lake Desert areas. Latitudinal effects on mean annual temperatures are modified significantly by elevation, exposure, and the proximity of large water bodies.

Average summer temperatures show slight gradation from south to north. The less direct solar radiation in the higher latitudes is partially compensated by the increased duration of sunlight at the more northerly stations. Only increased elevation brings lower summer temperatures.

Average winter temperatures show greater latitudinal variation than do the summer temperatures—southern areas maintain approximately 45° January temperatures while more northerly stations fall to below 20°.

The control upon temperatures exerted through latitude, coupled to the known high degree of atmospheric transparency, the duration of sunlight, and the meagerness of a protective vegetation cover bespeak of the entire Basin as an area of temperature extremes.

Temperature Variability

Although temperature differences from place to place in the Great Basin appear to be minimized when mean monthly or annual values are employed, the year-to-year fluctuations from these average values are most pronounced. Departure from, rather than adherence to, mean temperature values is the rule.

No part of the Great Basin has been completely free from freezing temperatures—indeed, only a few locales have escaped subzero minima. Conversely, with the exception of a few highland locations, daytime summer maximum temperatures everywhere in the Basin have exceeded 100°. Many stations have recorded absolute maxima in excess of 110°; principally in the valley of the Snake River, the Salt Lake Desert and in southern Nevada and California, and a few locales have exceeded 120° (Death Valley, southern Utah and California).

Winter temperatures in particular seem most susceptible to wide departure from mean values. January, 1937 and 1949 were abnormally cold with average monthly temperatures well below mean values (Figure 1). During these years all of the Great Basin, excepting a 12,000 square mile area in extreme southern Nevada and California, experienced average monthly temperatures of less than 30°, and extensive areas throughout the Basin recorded values of less than 10°. In contrast, January, 1953 was abnormally warm. During this latter year January temperatures everywhere were above 30°, large areas experienced 40° temperatures and southern regions remained in the 50°s.

Year-to-year fluctuations in monthly, seasonal and annual temperatures are of sufficient magnitude to seriously affect the agricultural economy of the

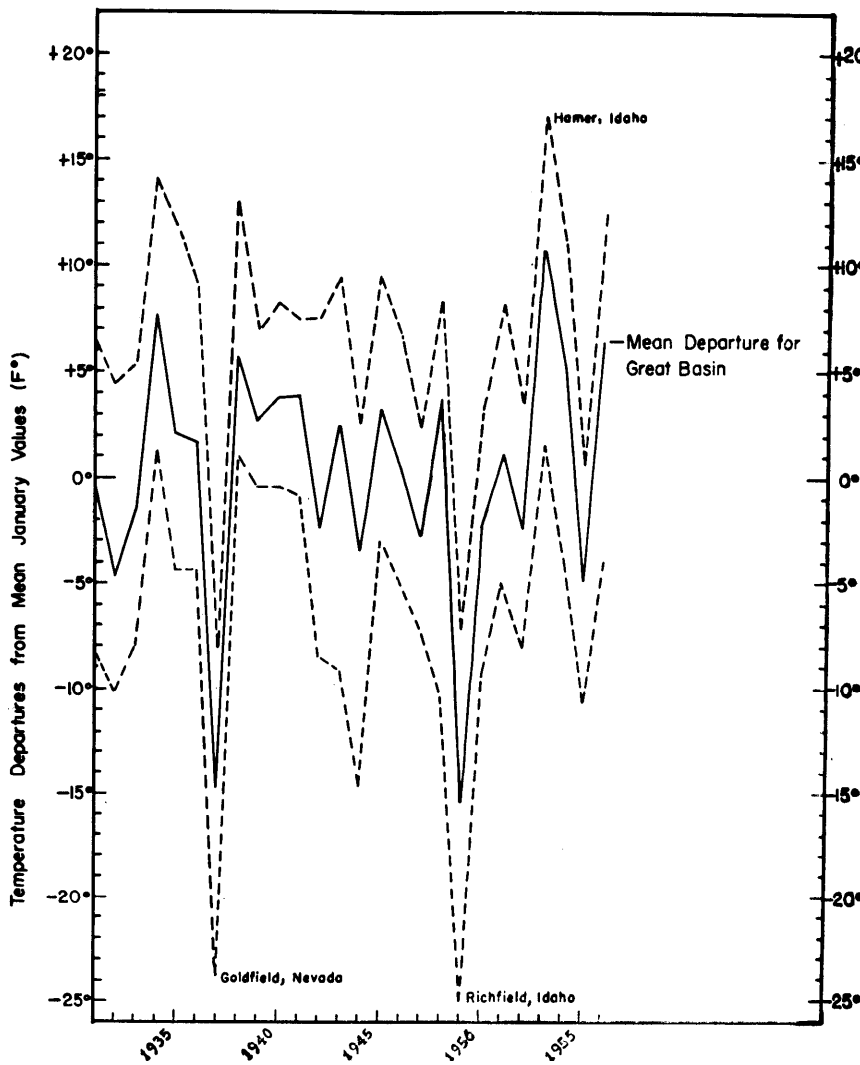

FIGURE 1. Departures of Annual January Temperatures from Mean Values, 1931-1956, the Great Basin. Solid lines indicate temperature departures for the entire Great Basin (224 stations), broken lines indicate departures for extreme stations.

Great Basin. Particularly the livestock industry, through loss by exposure, and winter wheat, through failure of germination, will suffer. Again stations farther north, particularly in Idaho and northern Nevada, appear more susceptible to greater temperature fluctuations in January than are the more southern locales.

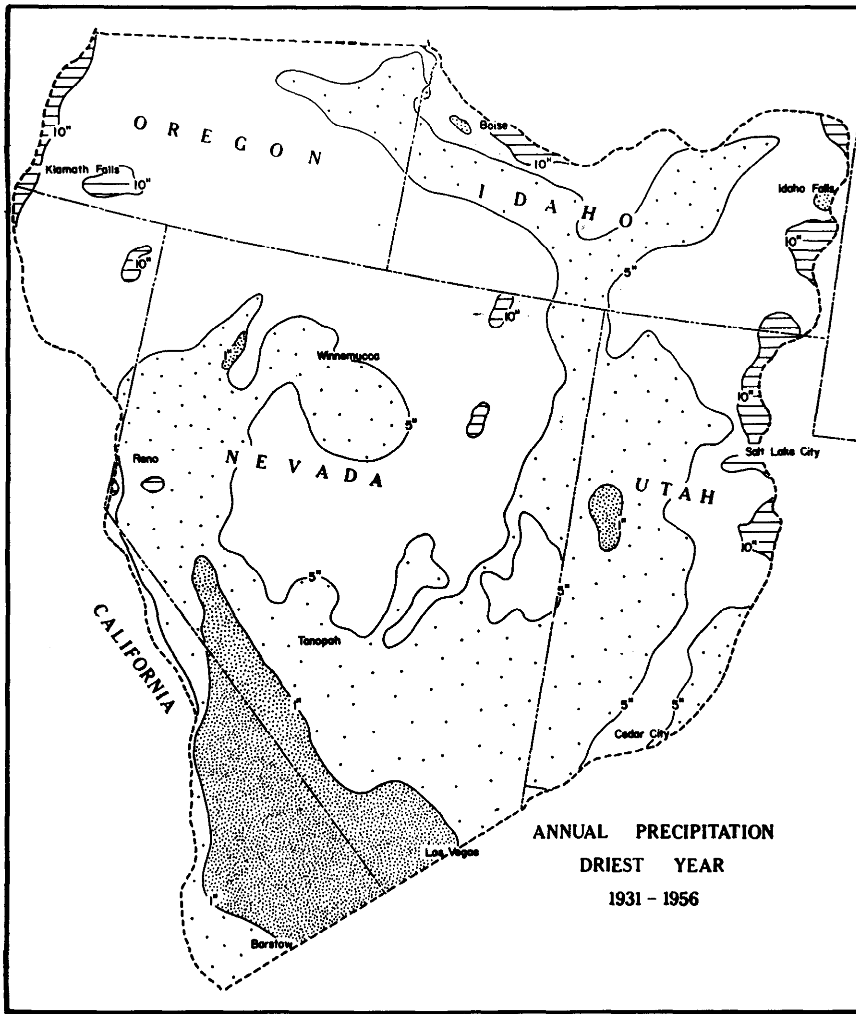

FIGURE 2. Annual Precipitation of the Driest Year for the Great Basin, 1931-1956.

The magnitude of fluctuation in summer temperatures is neither as great nor as significant agriculturally as the winter temperature fluctuations.

Average Precipitation

In general the Great Basin can be considered as a region of light (subhumid) precipitation. Approximately one-seventh of the Great Basin receives an average annual precipitation of less than five inches; over one-half receives less than ten inches, and 98-99 per cent receives less than twenty inches annually (Table 1). Extensive areas of the Great Basin are too dry for non-irrigated agriculture in normal precipitation years, in spite of a tendency throughout the Basin toward a winter maximum regime of precipitation and consequent lower evaporation. Those areas located at higher elevations with western exposures generally receive greater amounts of precipitation; eastern slopes and interior basins, particularly in more southerly latitudes, receive least amounts. An extensive area in southeastern California and western Nevada lying immediately east of the Sierra Nevadas and extending northward to the latitude of Reno receives the least precipitation (under 5 inches).

Table 1. Percentage of the Total Area of the Great Basin Included Within Selected Annual Precipitation Categories, 1931-1956*

Annual Precipitation	Normal Year	Driest Year	Wettest Year
Less than 5"	15.3	47.6	0.5
5"-10"	36.5	49.9	11.7
10"-20"	47.1	2.5	73.0
More than 20"	1.1	0.0	14.8

*Driest and wettest years are not necessarily simultaneous for each station.

Table 2. Percentage of the Total Area of the Great Basin Included Within Each Climatic Type, 1931-1956*

Type of Climate	Average Year	Driest Year	Wettest Year
Arid (BW)	31.3	74.0	4.7
Semi-Arid (BS)	50.9	23.0	16.4
Humid (C and D)	17.8	3.0	78.9

*Driest and wettest years are not necessarily the same for each station.

Precipitation Variability

The order of magnitude of precipitation variability in the Great Basin is extreme, probably as great or greater than for any other area in the United States (Visher, 1954). Considering the Basin in its entirety, during the period 1931-1956, annual precipitation averaged 11.41 inches. Within this 26-year time span Great Basin annual precipitations have varied from a low of less than 9 inches in 1933 and 1939 to a high of more than

16 inches in 1941 (Figures 2 and 3). Variations in seasonal precipitations from year to year are equally extreme and of critical import to agriculture. The Great Basin receives an average "Spring Precipitation" (April through June) of 2.90 inches, yet values have fluctuated from less than 2 inches in 1931, 1934, 1939 and 1940, and on occasions entire months were rainless, to more than 4 inches in 1941 and 1944.

Consideration of the Great Basin in its entirety, however large the year-to-year departures from mean precipitation values are, overshadows the magnitude of the individual station fluctuations. Not only are variation curves smoothed by averaging, but meteorological phenomena are neither similar nor simultaneous throughout the Basin. Frequently drought in northern sections of the Basin is attended by average or above average precipitation in southern areas, or vice versa. Each station, individually, will experience a much greater magnitude of variability than over-all Basin conditions indicate.

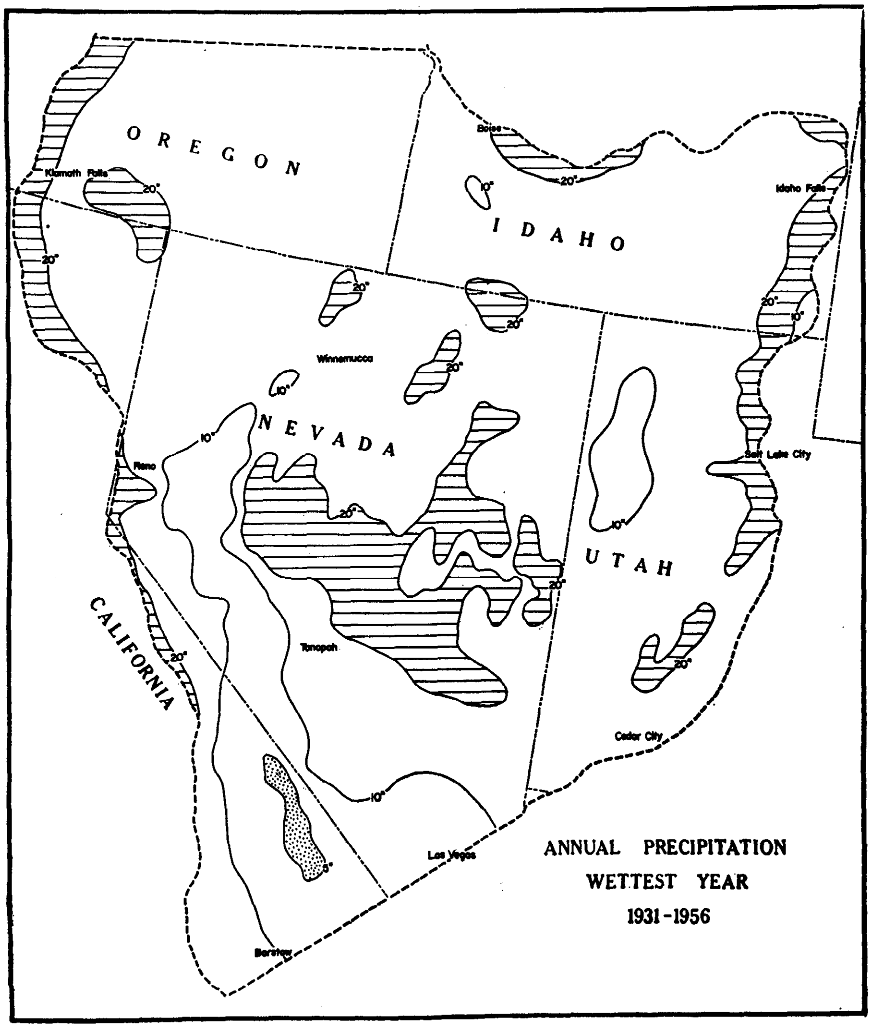

FIGURE 3. Annual Precipitation of the Wettest Year for the Great Basin, 1931-1956.

Plants, whether as an indigenous or cultural cover, are susceptible to precipitation variability. Too little precipitation is especially destructive, resulting in failure to germinate, death, decreased yields, inferior products and a host of attendant symptoms.

Climate

Geographers, climatologists and agriculturists have long sought ways to synthesize the more important elements of a climatic environment in order to analyze the relationships existent between climate and plants. This sought-for objective has not met with complete success. Since the objective of this study concerns climatic variability and this objective can be attained regardless of whether Koppen's system of climatic classification (1936), DeMartonne's index of aridity (1927) or Thornthwaite's precipitation effectivity (1948) is used, the more familiar Koppen classification is employed.[1]

Most of the Great Basin normally experiences subhumid climates (Koppen's BS and BW). Humid climates (Koppen's C and D) are generally encountered only at higher elevations where heavier precipitation, due to orographic lifting, and lower temperatures result in greater availability of moisture for plant nourishment.

Under normal precipitation and temperature conditions approximately 18 per cent of the Basin experiences humid climates, principally in the foothills of the Sierra Nevadas, Cas-

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[1] *The system of climate classification first proposed by Dr. W. Koppen in 1923 and subsequently published in modified form in 1931 and 1936 was based primarily upon botanic associations. Five basic climatic types were recognized and defined:*

A climates—Tropical rainy climates

B climates—Dry climates where evaporation exceeded precipitation. Two subtypes: BS (semi-arid) and BW (arid)

C climates—Warm temperate rainy climates

D climates—Boreal climates

E climates—Polar climates

cades, Wasatch and Bitteroot Mountains, in the higher mountains of central Nevada and in certain central Utah piedmont areas. The remainder to the Basin normally experiences arid or semi-arid climates.

The core of Great Basin aridity lies in western Nevada and eastern California immediately to the east of the Sierra Nevadas. Here a pronounced rain-shadow effect, coupled with the presence of semi-permanent anticyclonic circulation and higher temperatures, have combined to produce a 74,000 square mile area of arid climates. Lesser areas of arid climate are found in the Salt Lake Desert, and in isolated basins in western Nevada. Except under irrigation these arid regions, representing 31 per cent of the Basin area, do not support permanent agriculture.

Much of the remainder of the Great Basin (51 per cent) experiences semi-arid climates—transitional arid-humid climates which neither exclude nor guarantee success in non-irrigated agricultural pursuits.

Climatic Variability

The magnitude of climatic variability is as great as the variability in the individual climatic elements. Only a very small portion of the Basin has remained within the same climatic type during each of the years between 1931-1956. A small 10,000 square mile area in southeastern California and southern Nevada maintains its aridity, while at higher elevations an 8,000 square mile area persists with perennially humid climates. The greater portion of the Great Basin, approximately 92 per cent, alternates from one climatic type to another, frequently with disastrous, although occasionally salubrious, agricultural repercussions.

During the period 1931-1956 fully 74 per cent of the Great Basin experienced at least one arid year, more often undergoing a prolonged series of arid years. Similarly 79 per cent of the Basin experienced at least one humid year with, unfortunately, too seldom frequency (Figures 4 and 5).

Two areas within the Great Basin seem particularly susceptible to frequent and extreme climatic fluctuation: west central Utah and the Snake River valley. In these two regions moist subhumid or dry humid climates prevail sufficiently often to encourage permanent agricultural occupance. Both areas, however, can experience severe aridity, often for prolonged periods.

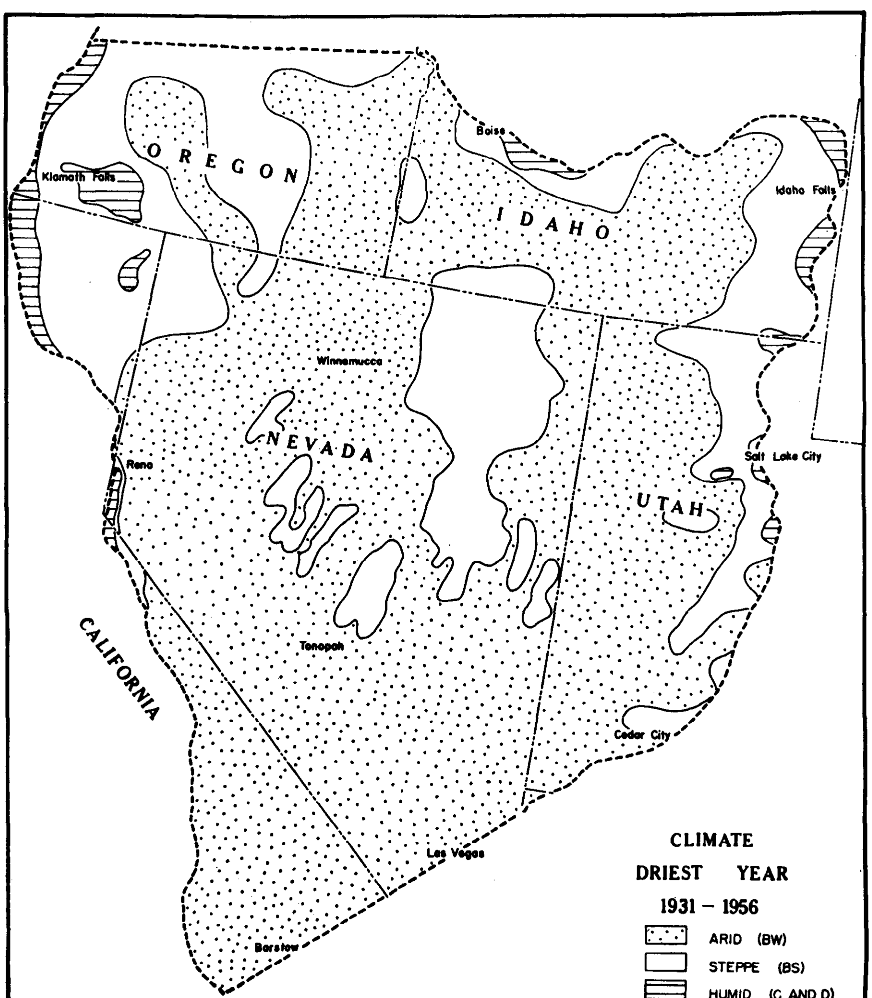

FIGURE 4. Climate of the Driest Year for the Great Basin, 1931-1956, according to the Koppen system of climatic classification.

Summary and Conclusions

The raising of sheep and cattle is a major economic pursuit in the Great Basin. The industry generally is based upon open range grazing for at least a portion of each year. With a major dependence upon the availability and sufficiency of range forage it is obvious that climatic fluctuations will play a dominant role in the success of the grazing economy. Unfortunately statistical data are not perfected to the point that correlation between fluctuating livestock numbers and climatic conditions can be shown. Livestock counts are estimated on January 1st, at

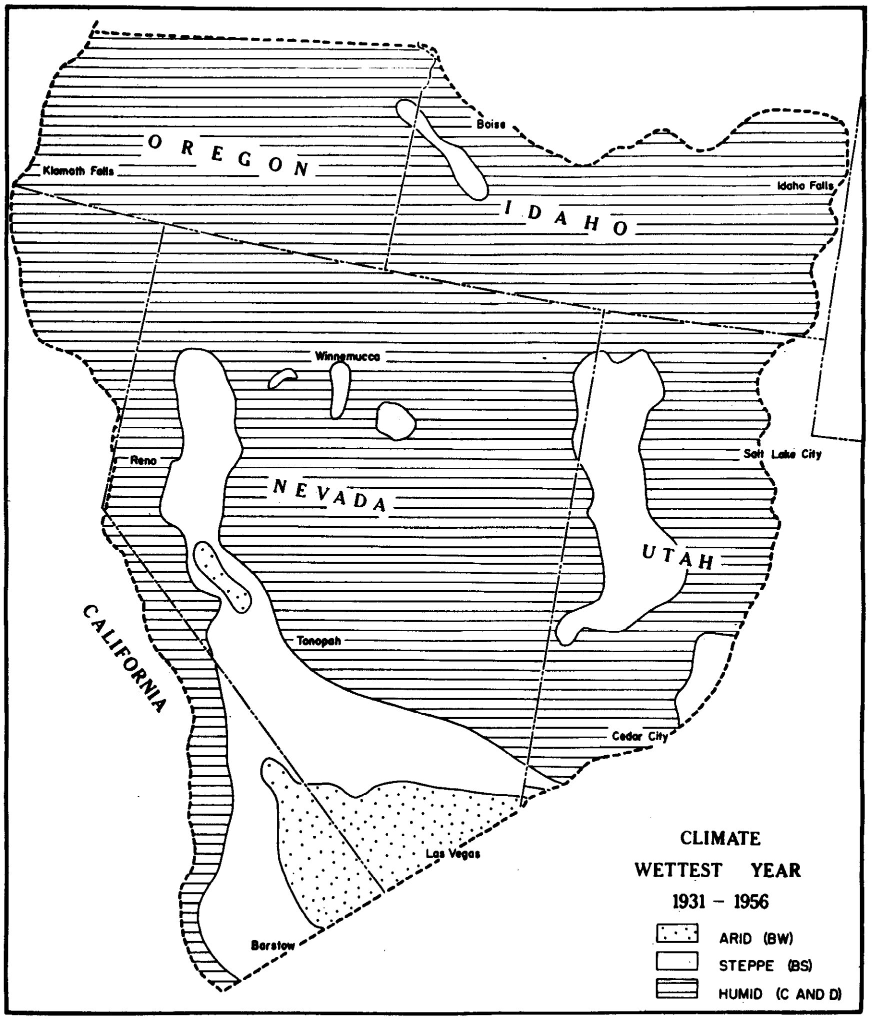

FIGURE 5. Climate of the Wettest Year for the Great Basin, 1931-1956, according to the Koppen system of climatic classification.

a time when losses suffered through preceding severe winter weather conditions and spring or summer drought have been replaced.

In spite of the lack of adequate statistical data, the strong dependence of a livestock industry upon prevailing climatic conditions in the Great Basin can be amply demonstrated. Two climatic conditions appear to materially reduce livestock numbers, i.e., severe winter temperatures and light precipitation. Sections of the Great Basin are particularly susceptible to frequent abnormally cold winters; winters cold enough to materially reduce livestock numbers through exposure, pneumonia, and the inability of livestock to secure forage because of ground conditions. The combination of low precipitation, high day temperatures, low relative humidity, high evaporation, high winds, high proportion of sunshine cause plants to use available water more quickly.

Year-to-year fluctuations in climate, particularly in precipitation and winter temperatures, have profound short term effects upon the livestock industry in the Great Basin. These effects are manifested through reductions of livestock herds brought about by exposure and variations in range herbage supplies.

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Argentine Opportunities

Argentina is interested in a positive program of range improvement. To further its grassland development and cattle improvement programs, Argentina is seeking two North American Range Management Specialists. Recruitment to fill these positions is now in process.

This is a follow-up and result of an earlier visit, in the fall of 1959, of a U. S. agricultural team that went to Argentina to make recommendations on how to improve livestock production on its rangelands.