Variability of Precipitation in the Pacific Northwest: Spatial and Temporal Characteristics

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ABSTRACT

A detailed study of spatial and temporal aspects of precipitation in the Pacific Northwest reveals much about the natural variability of this important climatic element. The data base consists of monthly, seasonal and annual (water year) totals of precipitation for a network of 244 climatological stations in Oregon, Washington and the adjacent area. A complete set of descriptive and inferential statistics was calculated and is presented in tabular form. Maps of key statistics -- means, coefficients of variation and interstation correlation coefficients -- depict spatial patterns. The 40-year normal period is shown to be sufficient for the making of probability estimates of seasonal and annual precipitation.

Temporal variability in seasonal and annual precipitation over the last 100 years is studied with 70 long-term stations in Oregon and Washington. Trends, linear and non-linear, are determined and show that the spatial variation in temporal changes is great. There is little evidence to suggest either a progressive increase or decrease in annual precipitation in Oregon over the last century. In Washington there has been a tendency for decreasing amounts of annual precipitation. Changes over shorter time periods are analyzed with two methods; one being a 9-term weighted moving average used to filter out short-term oscillations, and the other being the calculation of decadal values of means and standard deviations. The one persistent temporal pattern throughout the region is a downward trend extending from the 1890s to about 1930 and a gradual recovery in recent decades. However, there are many local variations of this pattern. The decade of the 1970s is marked by extremely high interannual variability, a finding consistent with studies from all parts of the globe.

FOREWORD

The Water Resources Research Institute, located on the Oregon State University Campus, serves the State of Oregon. The Institute fosters, encourages and facilitates water resources research and education involving all aspects of the quality and quantity of water available for beneficial use. The Institute administers and coordinates statewide and regional programs of multidisciplinary research in water and related land resources. The Institute provides a necessary communications and coordination link between the agencies of local, state, and federal government, as well as the private sector, and the broad research community at universities in the state on matters of water-related research. The Institute also coordinates the inter-disciplinary program of graduate education in water resources at Oregon State University.

It is Institute policy to make available the results of significant water-related research conducted in Oregon's universities and colleges. The Institute neither endorses nor rejects the findings of the authors of such research. It does recommend careful consideration of the accumulated facts by those concerned with the solution of water-related problems.

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I. INTRODUCTION

BACKGROUND

Water has been a key element in the history of the Pacific Northwest and the region owes much of its development to successful exploitation of this resource. Present uses are many and varied. As economic activity and population continue to grow the competition for water becomes more intense. An expanding urban population, the increase in irrigated agriculture on both sides of the Cascades, the greater requirements of the wood and agricultural products processing industries and the growing energy needs of an area largely dependent on hydropower all serve to focus attention upon regional water resources.

The Oregon Water Resources board in 1969 published a report titled Oregon's Long-Range Requirements for Water. The study found that the volume of the waters originating in all of Oregon, that will be exceeded in four out of five years, amounts to 65.9 million acre-feet; and the total demand for the entire state could amount to 80.4 million acre-feet in the year 2070, resulting in a statewide deficit of about 14.5 million acre-feet. Similar projections have been made for the state of Washington (e.g. State of Washington 1971).

Although the Oregon study is generally regarded as a generous estimate of water needs to assure that the state will adequately protect its water for future uses (W.R.R.I. 1977), there is no doubt that any current problems of water supply and demand can only increase in future years. The most basic aspect of water issues is that a large number of uses and demands are competing for a scarce resource. Seasonal, geographic and year-to-year maldistributions between water supply and water use occur throughout the Pacific Northwest. Water shortages occur as do periods of excessive runoff. In the humid, western parts of Oregon and Washington economic activity is not as water-constrained as it is in the central and eastern parts of the two states; but the drought of 1976-1977 made it apparent that even the moisture-rich regions are vulnerable to the problems of water supply.

Intelligent planning for future water use and allocation involves a wide range of information needs, not the least of which is information on the natural variability of streamflow. However, precipitation is the basic source of water supply; streamflow is its visible result. Variability is an inherent characteristic of precipitation as it is of other climatic elements. Therefore, accurate and detailed knowledge of the natural variability of precipitation, variations over area and over time, must be tied in with streamflow records for efficient management of water, a renewable but limited resource.

PURPOSE AND SCOPE OF INVESTIGATION

The purpose of this study is to describe the precipitation climatology of the Pacific Northwest, specifically the natural variability of monthly, seasonal and annual precipitation over space and time. In a spatial dimension the study is limited to the states of Oregon and Washington with the inclusion of some data from adjacent states. In a temporal dimension only the period of instrumental observation (the secular period) is considered -- essentially the last 100 years.

The core of the report is the presentation of a detailed body of descriptive statistics from a dense network of climatological stations. A common base period, 1940-1979, was used for this compilation. Development of the data base is described in Chapter III. Spatial patterns of monthly, seasonal and annual precipitation are presented cartographically in three different formats in Chapter IV and discussed in terms of major climatic controls. A preliminary analysis of changes in annual precipitation over time, both trends and short-period fluctuations, is presented in Chapter V. A network of 70 long-term stations in the two states was developed for this portion of the study.

LITERATURE

The significance of precipitation variability has long been appreciated in the American West and several comprehensive analyses have been completed for various states and regions. One of the earliest was McDonald's (1956) statistical study of aspects of temporal and spatial variability of precipitation in Arizona and their bearing on water resouces of the arid Southwest.

Subsequent work has expanded our understanding of precipitation variability in the West. Pyke's (1966, 1972) work on the geographical and seasonal distribution of precipitation patterns was focused on California but included data from all the far western states. Granger's (1977) detailed analysis dealt with secular fluctuations of seasonal precipitation in lowland California and more recently (Byrne, Granger and Monteverdi 1982) on the correlation between seasonal precipitation in California and western Mexico.

Characteristics of precipitation in the Great Basin were examined by Houghton (1969). His purpose was to explain precipitation characteristics in terms of climatic controls and to develop statistical methods for estimating the long-term precipitation regime at stations with incomplete records.

Certainly the most extensive analysis of regional precipitation in the American West is that of Bradley (1976a, 1976b, 1976c) in which the precipitation history of the Rocky Mountain states is presented. That part of his study which deals with the nineteenth century includes data for stations in Oregon and Washington.

Many of the frequently cited studies of secular climatic fluctuations in the United States are from the eastern half of the country or the arid Southwest (e.g. Sellers 1960, Fritts 1965, LaMarche and Fritts 1971). The series of anomalous winters in the late 1970s led to a number of studies of broad patterns of climatic variability for the nation as a whole (e.g. Chico and Sellers 1979, Diaz and Quayle 1978, 1980). However, in these analyses only a few stations from Pacific Northwest states were included in the data network.

There has been a curiously small amount of research on the variability of precipitation in the Pacific Northwest. Several studies, based generally on only a few scattered stations, are limited in both their spatial and temporal scope (e.g. Carter 1935, Keen 1937, Lynch 1948, Crowe 1963, Church 1974). Roden's (1966) study of west coast climate from 1821 to 1964 was concerned only with temperature data. McDonald and Langbein (1948) analyzed streamflows in the Pacific Northwest but had difficulty in separating the effects of natural climatic variability from land use alterations. Biological evidence (Franklin et al 1971) and glacial activity (most recently, Sigafoos and Hendricks 1973) suggest that there have been important variations in Pacific Northwest precipitation patterns during the last century.

A few excellent studies have focused on specific aspects of precipitation variability in the region. Bates (1978), for example, determined the probability of dry years, a topic of immediate interest following the dought of 1976-1977. Coakley (1979) considered the role of climatic variability on stripe rust disease of winter wheat in parts of eastern Oregon and Washington. Sneva (1977) and others (Sneva and Hyder 1962, Sneva and Calvin 1978) have utilized a knowledge of precipitation variability in eastern Oregon to forecast range herbage production.

Anthropogenic effects on precipitation have been postulated by Fowler and Helvey (1974) for the Columbia

Basin where there is large-scale irrigation and for areas in Washington state downwind from industrial sites (Hobbs and Radke 1970). Results of both of these studies are inconclusive.

REGIONAL CLIMATIC CONTROLS

Numerous references are available to describe the major climatic controls which influence amounts and distribution of precipitation in the Pacific Northwest. These range from far-reaching studies such as Church (1954), Bryson and Hare (1974) and Trewartha (1981) to those of more local concern such as Lynott's (1967) description of precipitation in the Columbia Gorge and Schermerhorn's (1967) and Pittock's (1977) analyses of topographic effects on precipitation.

There are at least three controls which have a definite influence on the climate of the Pacific Northwest. These are: latitude, topography and continental influence.

Latitude

The dominant airstream pattern in the western United States is from the Pacific Ocean and according to Bryson and Hare (1974) is subdivided into the northern portion which is dominant in winter and a southern portion emerging from an oceanic anticyclone over the Pacific and most prominent in summer. The latitude of the Pacific Northwest insures the dominance of the northern Pacific westerlies for much of the year, particularly during the cooler season when it arrives on the west coast quite cool with a near moist-adiabatic lapse rate and with high humidity to a considerable depth. The southern portion of the westerlies subsides from the Pacific anticyclone which migrates northward during the summer and is responsible for a shorter summer season of drier, more stable air and modest precipitation totals, even along the immediate coast.

Topography (see Figure 1)

The Coast and the Olympic mountain ranges are the first to intercept moisture laden marine air masses moving inland from the Pacific Ocean. The cooling of air masses as they ascend the western slopes produces some of the heaviest annual precipitation in the United States and naturally lessens the amount available farther inland. Seventy to 100 miles inland, the Cascade Range, parallel to the Coast Range and to the Puget-Willamette Trough situated between the ranges, plays an important role in modifying temperature and precipitation and essentially divides the region into a wet, mild, green west and a semiarid, cooler, brown east.

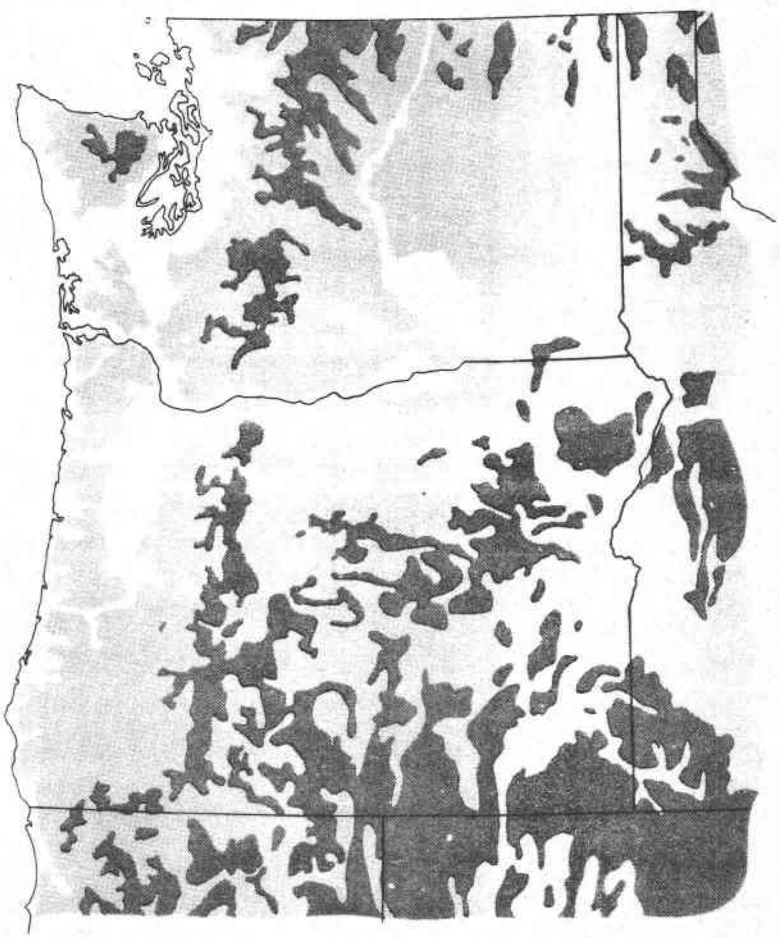


Figure 1. Map of the Pacific Northwest showing Elevation Zones: 0-1000 feet m.s.l. (white shading); 1000-5000 feet (medium shading); and above 5000 feet (dark shading).

However, because the moisture content of the marine air masses is greatly reduced by passage over the Coast Range, the precipitation on the western slopes of the Cascades is lessened and decreases very rapidly once the east side descent begins. Situated along the boundary between Oregon and Washington, the Columbia Gorge has cut its gorge entirely through the Cascades and offers easy passage for marine air from the Pacific which moderates temperatures to the east in both winter and summer and through which continental air occasionally passes in reverse to produce extreme temperatures in the western valleys and the Portland metropolitan area.

Continental Influence

The sharp decline in precipitation and the colder winters and warmer summers experienced east of the Cascades results from the barrier effects of the range, as noted above, and also is due to the increasing distance from the moderating influence of the Pacific Ocean. Interior basins and valleys may experience temperatures well above 100^{o} F when the Pacific anticyclone shifts inland during the summer and temperatures well below 0^{o} F during invasions of Polar Canadian air during the winter.

The combined influence of these three dominant climatic controls in the Pacific Northwest produces the variations in annual precipitation that are greater than anywhere else in the contiguous 48 states. In several areas annual precipitation ranges from less than 20 inches to over 150 inches within a distance of 60 miles. Unrecorded extremes are undoubtedly higher. It is the purpose of this report to describe characteristics of this natural variability.

UNITS

Although metric units have long been the standard language of scientists, the voluminous climatic data for the United States are available primarily in English units. In this report, therefore, the English units are used throughout. In addition, we feel that the majority of users of this report will be persons who are not research scientists and who are likely to be more familiar with the traditional English units.

II. DATA

Given the inherent variability of precipitation over time and space, meaningful comparisons and regional descriptions can best be made with a large data base representing a uniform time period. The primary purpose of this study is to describe the spatial organization of precipitation statistics throughout the Pacific Northwest based on data assembled for a 40-year base period 1940-1979.

SOURCES OF DATA

The main sources of climatic data in the United States are the publications of the National Climatic Center in Asheville, North Carolina. Data are compiled for a dense network of cooperative climatological stations throughout the nation and published on a state by state basis (Figures 2 and 3).

Other useful precipitation summaries have been compiled by various agencies in the Pacific Northwest concerned with the study of regional water resources. The River Forecast Center in Portland is able to supply monthly rainfall totals for several stations in the region for the period 1900 to 1976. In 1968 the Pacific Northwest River Basins Commission compiled a multi-volume study entitled "Climatological Handbook of the Columbia Basin States." Similar compilations on a more modest scale are available from various local, state and federal agencies; for example, data from a network of storage precipitation gages in mountainous areas are maintained by the National Forest Service.

Several of these data sources were consulted, but for the purposes of this study it was decided to rely exclusively on official data obtained from the National Climatic Center. Magnetic computer tapes, one each for the states of Oregon and Washington, were obtained. The tapes include monthly totals of precipitation and temperature at all reporting stations. These data are also available in the monthly publication, Climatological Data, which includes annual summaries. Copies, either bound or microfiche, are maintained in most of the major libraries in the Pacific Northwest. The publications have the advantage of including additional information such as station locations and histories. These station histories are indispensable in determining the length of reliable record at individual stations.

Figure 2. N.O.A.A. Map of Climatological Stations, Oregon,

Figure 3. N.O.A.A. Map of Climatological Stations, Washington.

PERIOD OF RECORD

To make maximum use of the available data and to define spatial patterns, it is necessary that data from as many stations as possible be used for analysis and that the length of the common record period be as long as possible. Obviously, these two needs are in conflict; the longer the period of record the fewer the number of continuous precipitation data series available.

Accepted convention, as adopted by the World Meteorological Organization (W.M.O.) for climatological normals is the 30-year period currently defined as the years 1941-1970, soon to be updated to 1951-1980. Appreciable variations occur from one 30-year period to another and Mitchell (1966) among others suggests that climatic data be summarized for a longer standardized period of years where length of record permits.

After an initial inventory of Oregon and Washington data it was decided to utilize a 40-year standardized period, 1940-1979. More information is included than would be in a 30-year base period; but use of more than 40 years would cause a rapid reduction in the number of continuous records available and thus a less complete geographic representation of the region. The choice of a base period ending in 1979 (as opposed to 1970 or 1980) may seem inconsistent with other established normals; but several climatologists have recommended a change from the W.M.O. practice of defining decades. Instead of counting decades from year one to year ten (e.g. 1961-1970), it would be more convenient if decades were counted fromm zero to nine (e.g. 1960-1969). However, the choice is arbitrary and the decision here was due to the simple fact that at the time this study commenced data for 1980 were not yet processed and published.

Sufficient justification for the use of a 40-year period can be given. Several long-term annual series generated for Chapter V of this report are used to illustrate the relationship between record length and long-term mean, in this case a 90-year period, 1890-1979. Data from three of these stations (Table 1) represent a range of climatic conditions: a semi-arid station in north-central Oregon (Heppner); a humid station in western Washington (Centralia); and a moderately subhumid station in southwestern Oregon (Ashland). These data series do support the choice of a 40-year sample, at least in terms of the ability to represent the 90-year mean. As the record length increases the long-term mean is more closely matched -- a relationship that holds through 40 years at Ashland and Centralia. Beyond 40 years little is gained by using a longer base period except perhaps at Heppner, the drier station. Relative errors are generally greater in areas

Table 1: Mean Annual Precipitation for Different Periods of Record (Expressed as a Percentage of 90-year Mean)

Period of Record	Ashland	Heppner	Centralia
1975-1979 (5 years)	88.7	98.7	95.8
1970-1979 (10 years)	96.4	99.6	101.3
1965-1979 (15 years)	95.8	99.3	101.6
1960-1979 (20 years)	94.0	98.1	103.3
1955-1979 (25 years)	94.8	100.1	103.5
1950-1979 (30 years)	96.1	100.8	103.8
1945-1979 (35 years)	97.9	101.3	102.7
1940-1979 (40 years)	100.3	101.9	100.6
1935-1979 (45 years)	100.4	99.5	100.7
1930-1979 (50 years)	98.8	97.8	100.3
1925-1979 (55 years)	98.7	96.9	99.2
1920-1979 (60 years)	98.2	97.3	99.3
1915-1979 (65 years)	98.1	98.0	99.8
1910-1979 (70 years)	98.7	98.1	100.0
1905-1979 (75 years)	99.2	98.1	100.1
1900-1979 (80 years)	99.9	98.2	100.4
1895-1979 (85 years)	99.3	98.7	100.3
1890-1979 (90 years)	100.0	100.0	100.0

of lower precipitation and smaller in areas of higher precipitation.

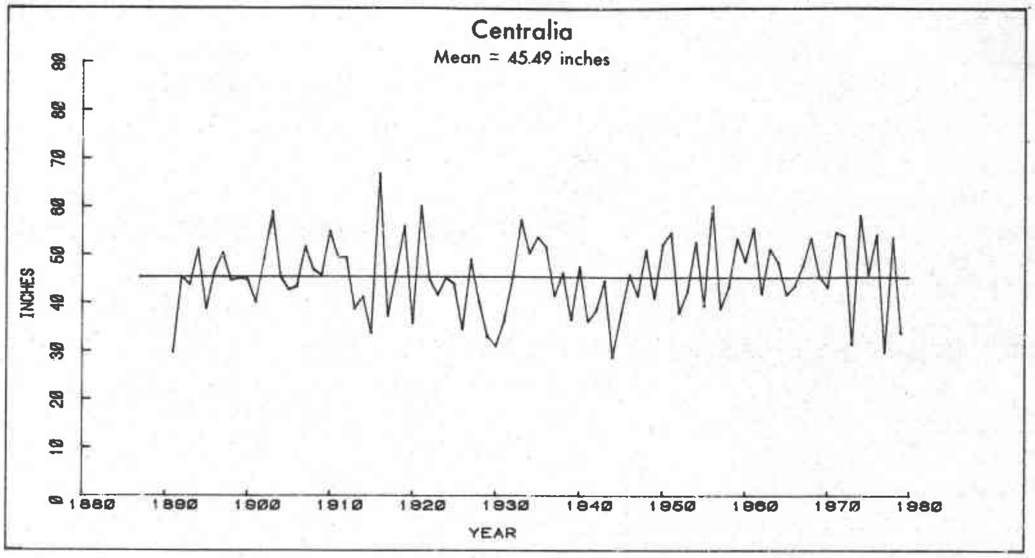
Lee (1980) has presented statistics that illustrate attempts to estimate long-term average precipitation on the basis of shorter-term records in West Virginia, a humid region (Table 2):

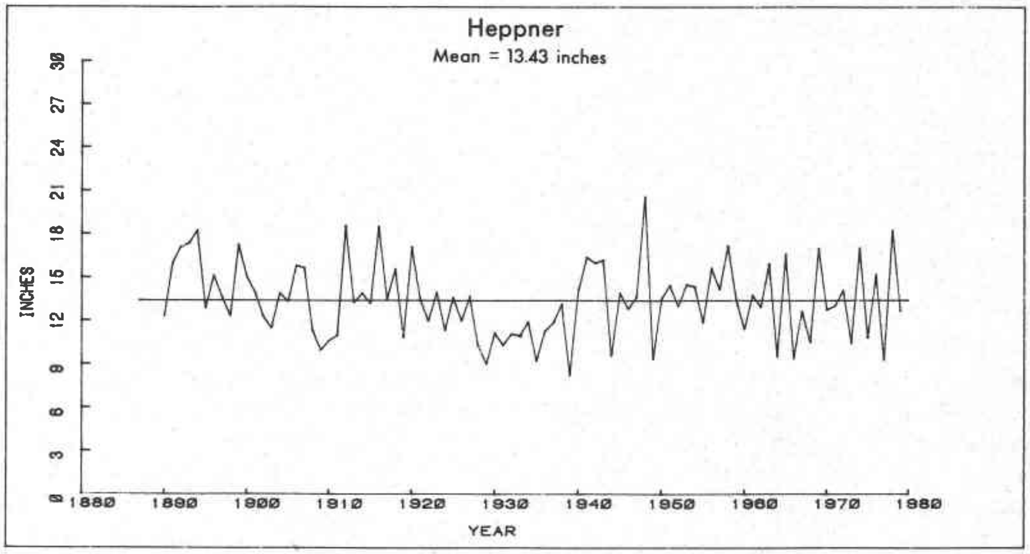
Table 2: Relative Error in Estimating 50-year Mean Precipitation from Shorter Records in West Virginia.

Interval (years)	Mean Error %	Error Range (95% confidence)
5	17.6	14.1 - 21.1
10	11.3	9.6 - 12.9
15	8.1	7.0 - 9.2
20	6.3	5.5 - 7.1
25	4.5	3.8 - 5.2
30	3.7	3.2 - 4.3
40	2.4	2.0 - 2.8

Both of these examples emphasize the advantage of working with a 40-year record as opposed to a standard 30-year record. As this study progressed the period 1940-1979 proved to be a good selection for representing the range of variability in regional precipitation. There is no doubt that a longer series would result in a more stable frequency distribution and sample statistics would be more representative of population statistics. Yet as illustrated by a plot of annual precipitation series of these three stations (Figure 4), the period 1940-1979 includes almost the entire range of extremes experienced within the last ninety years. Subsequent analysis showed this to be true for many climatological stations in the Pacific Northwest.

Thus, based on a compromise between our two criteria, stability of the mean and data availability, the 40-year period 1940-1979 was selected as the "normal" period for this study and will be referenced as such throughout the report.





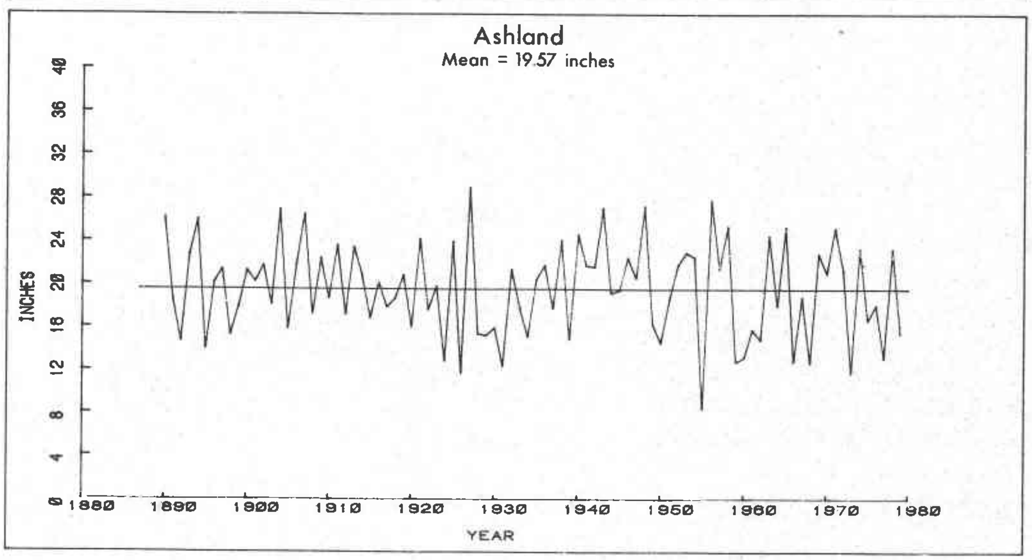


Figure 4. Time Series Graphs of Annual (Water Year) Precipitation at Three Long-Term Stations. Data in Inches.

DATA SURVEY

Over 300 stations in Oregon, Washington and the adjacent areas of California, Nevada and Idaho have records extending through the normal period. All were inventoried to determine the amount of missing data and the reliability, or homogeneity, of the record.

Missing Data

With regard to missing data, the procedure used by Bradley (1976c) was followed: any station with more than five percent of the monthly values absent was eliminated. Interpolated values already in the record as published were assumed to be correct. However, exceptions were made in situations where station records could be combined to produce a continuous record.

For climatological analysis it is desirable to have continuous data series. Missing data for the stations selected were estimated by one of two commonly used techniques, both using data from nearby stations. One is the regression and correlation of measurements from the station of interest with data from a nearby station, a reliable technique if a high correlation exists between the two. A simpler technique is the normal-ratio method of Kohler and Paulhus (1952) in which the missing value is estimated by a weighted average from three surrounding stations. Although both methods were employed, the normal-ratio method was preferred if sufficient data were available. Since stations with more than five percent of monthly values missing were excluded from the network, it is felt that resultant statistics are not noticeably affected, especially for seasonal and annual totals.

Homogeneity

The second problem that had to be addressed in the data survey was that of the reliability, or homogeneity, of the climatic records. Station locations, instrumental exposures and observing standards have generally been determined by immediate operational requirements. Thus, changes in these parameters are common in nearly all station histories, especially in expanding urban areas (Landsberg 1960). Precipitation records are particularly susceptible to changes in local details such as exposure, aspect, surface heating and surface roughness. As a result stations exhibiting truly homogeneous precipitation records are difficult if not impossible to find.

Various statistical methods have been developed to test climatic records for homogeneity. The double-mass plotting technique (Kohler 1949) is one common method for correcting a non-homogeneous record but depends on the reliability of surrounding station records. Barger (1960) felt that adjustment of a record could not be made without loss of some of the statistical properties of the station's rainfall series. It is not unreasonable to expect that many small climatic changes might be introduced in such a procedure. Therefore, no attempt has been made in this study to adjust records for inhomogeneity.

Instead, station histories were studied carefully for changes in location and exposure. Station moves of less than two miles, if infrequent, were considered acceptable if no serious alteration of exposure was implied. Likewise, elevation shifts of less than 100 feet were accepted. Stations exhibiting frequent and/or excessive changes in terms of location and elevation were rejected. This combination of procedures to determine homogeneity is adequate for the determination of basic statistics and for the calculation of interstation correlations. For the more sensitive statistical tests such as the determination of slow climatic trends in Chapter V station records have been scrutinized even more closely.

NETWORK

Completion of the data survey as described above yielded a final network of 244 climatological stations: 108 in Oregon, 115 in Washington and 21 in adjacent areas of California, Idaho and Nevada. These latter were included to better define precipitation characteristics near the state borders. A list of all stations, along with their ID number, latitude, longitude and elevation is given in Appendix A. A map of the network appears as Figure 5.

The network appears to represent the climatic diversity of the region. However, the most unsatisfactory aspect is the relatively small number of high elevation stations available for analysis. This is a persistent problem in climatological analysis throughout the American West. In addition to extreme homogeneity problems involved with location and exposure changes in mountainous terrain, the occurrence of high storm wind velocities and the predominance of snowfall over rainfall during much of the wetter portion of the year compounds the homogeneity problem (Pyke 1966). In addition most of the mountain stations have short records and missing precipitation values.[1]

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[1] The best source of data for precipitation in mountain watersheds is the series of snow survey reports published by the U. S. Soil Conservation Service.

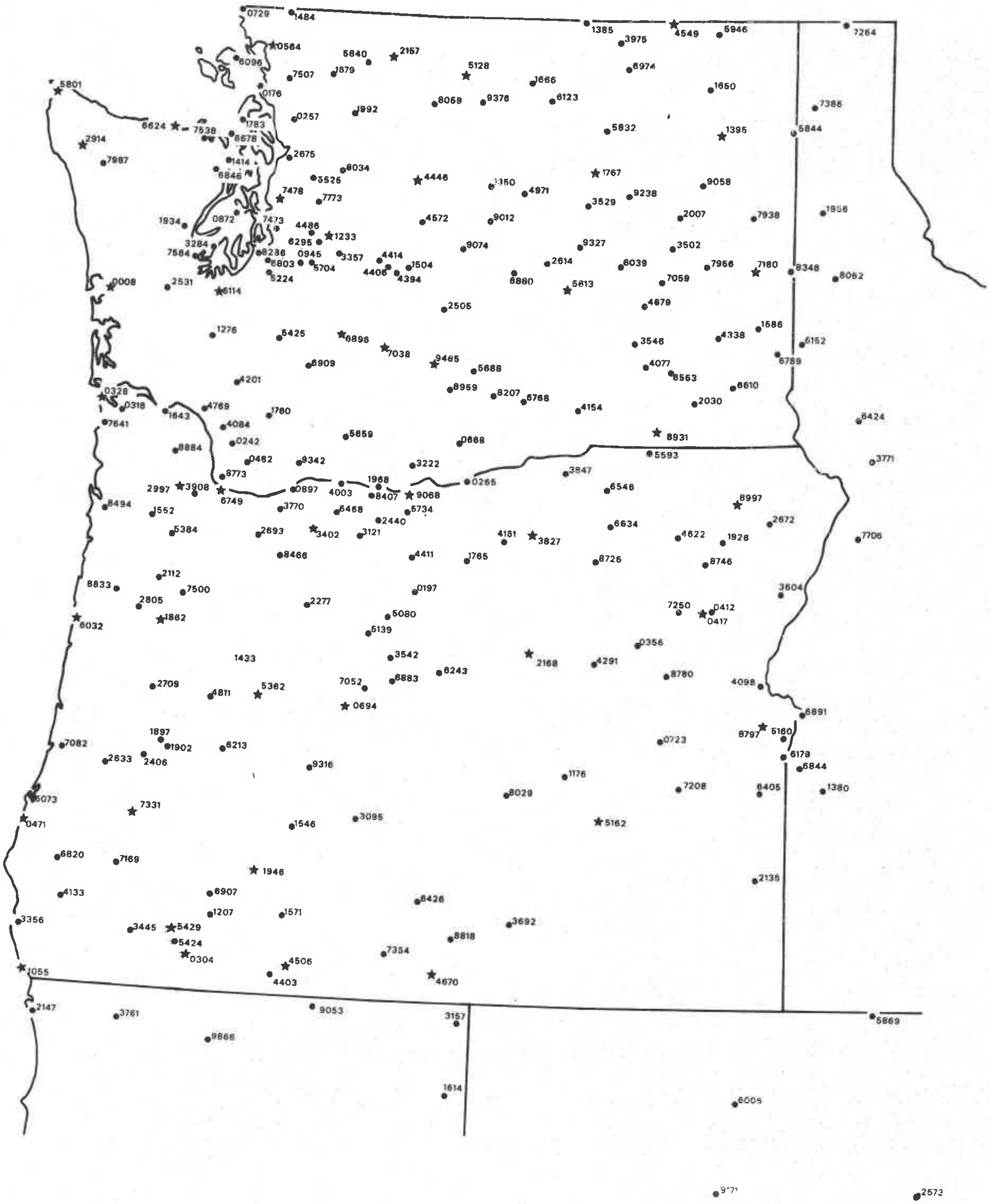


Figure 5. Network of Climatological Stations Used in this Study, 1940-1979 Normal Period. Station Descriptions are in Appendix A. Note: Those indicated with a star are a 43-station subset used for later data summaries in this report.

It is interesting to see the relationship between the elevation range of the region under study and the representativeness of the data network. The average elevation of the stations in the network is 1562 feet m.s.l., ranging from 5616 feet at Hart Mountain Refuge in Oregon to near sea level at several costal stations. This network can be considered to represent a topographic surface across the region (Bradley 1976c) and a map was drawn accordingly. A hypsometric (area-elevation) curve was constructed from the map. A similar curve was drawn from the actual topographic surface of the state (see Figure 1 of regional topography). Figure 6 shows a comparison between the two surfaces as represented by the hypsometric curves. It indicates that elevation zones are increasingly under-represented at higher elevations. Since a general increase in precipitation occurs with elevation, any derived estimates of areal rainfall would necessarily be on the low side. This problem of sampling the actual climatological diversity within the region should be borne in mind by the reader throughout subsequent data analysis presented in this report.

The basic data, then, are the sequences of monthly rainfall totals at 244 climatological stations in the Pacific Northwest for the "normal" period 1940 through 1979. Data are arranged according to the Water Year (WY), 1 October through 30 September, a time frame used routinely in hydrologic and climatological studies; for example, both Bates (1978) and Schermerhorn (1967) followed this convention in their studies of precipitation in Oregon and Washington. From a hydrologic standpoint it coincides with the annual regime of most rivers and, climatologically, it allows the entire winter season to be included in one year rather than being artificially separated by the calendar year. Thus WY 1940 is the period from 1 October 1939 through 30 September 1940 and WY 1979 extends from 1 October 1978 to 30 September 1979.

Monthly totals are also summarized into "winter" and "summer" totals. Throughout this study, winter is the seven month period from October through April, summer the five month period May through September. Specifically, "winter 1940" means the period 1 October 1939 to 30 April 1940. Water Year (WY) totals, then, are a winter-summer sequence.

The choice of a seasonal definition is logical for several reasons. Synoptic weather patterns differ markedly between winter and summer, although there are obviously transition months difficult to classify. Winter precipitation throughout the region is associated with extensive Pacific cyclonic storms, while summer precipitation results predominantly from convective activity over heated land

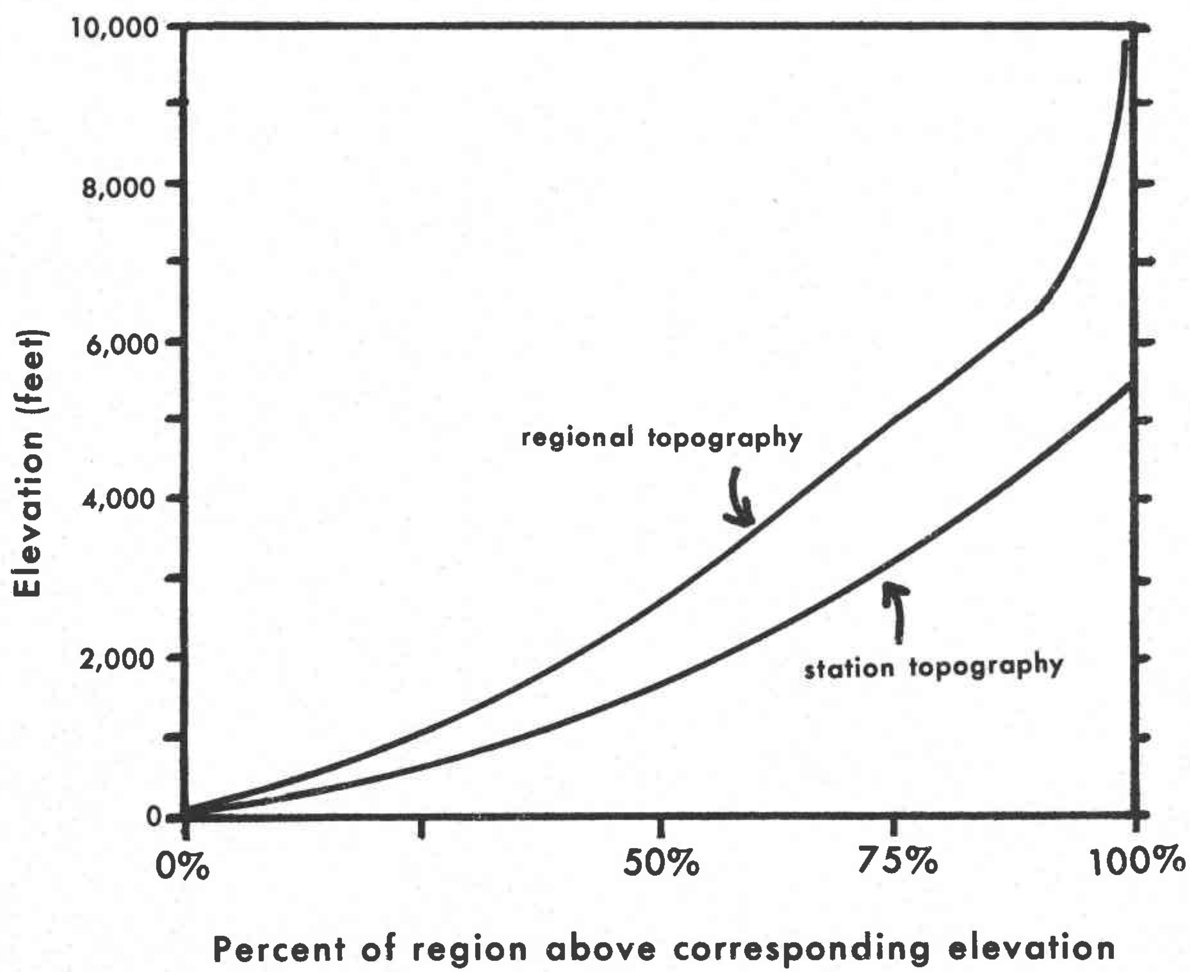


Figure 6. Hypsometric (Area-Elevation) Curves, Illustrating the Comparison Between Regional Topography and Station Network Topography.

surfaces. In the consideration of regional moisture supply and crop water demands the division is also logical. Agriculture in much of the Pacific Northwest is dependent on irrigation water from mountain snowpacks which collect during the winter months. Finally, all official streamflow records maintained by the U. S. Geological Survey are processed and published in the Water Year framework.

III. BASIC STATISTICS

The primary objective of climatological analysis is climatological prediction (Thom 1966). Lacking the ability to forecast future climate on any meaningful scale, the careful evaluation of past data is the preferred method. In the course of this study a detailed set of basic statistics were calculated from monthly, seasonal and annual precipitation data series and are presented in this chapter. This material represents the core of the report.

Basic descriptive statistics for seasonal and annual series are included in Appendix B. Basic descriptive statistics for the monthly data series are not included in their entirety but only for a 43-station subset of the network, selected to represent precipitation characteristics throughout the Pacific Northwest(see Figure 5). These statistics are also in Appendix B. Monthly statistics for any other stations in the network may be obtained from the authors upon request.

The following discussion of statistical procedures used may be elementary to most researchers. However, it is intended that these data be available for a wide variety of applications and to a wide variety of users, many with little knowledge of statistical methods.

DESCRIPTIVE STATISTICS

Basic statistics fall into one of two categories -- descriptive and inferential. The distinction between the two is important for both the researcher and the practical user. The aim of descriptive statistics is to describe a data series numerically so that its magnitude and spread can be expressed concisely and meaningfully. The most important aspects of precipitation data are their mean or average size and the extent and nature of the spread of the data, the variability about the mean.

The mean ($\bar{x}$) is defined as:

$$\bar{x} = \frac{1}{n} \sum x_i \qquad (1)$$

where n is the number of observations.

The statistic used to describe the spread or deviation of values about the mean is the standard deviation (s), defined as:

$$s = \sqrt{\frac{\sum(x_i - \bar{x})}{n-1}} \qquad (2)$$

Other descriptive statistics calculated and presented in Appendix B are the maximum and minimum values (with year of occurrence for seasonal and annual data), coefficient of variation (Cv) and percentile values.

Frequency Distribution

The frequency distribution is the basic tool for describing and analyzing a data series. Histograms of the frequency of precipitation amounts are an informative way of depicting variability. Skewness (Sk) is a useful measure of the symmetry (or asymmetry) of a frequency distribution. It can be expressed in a variety of ways and is herein calculated as follows:

$$Sk = \frac{\sum [(x_i - \bar{x})/s]^3}{n} \qquad (3)$$

In a negatively skewed distribution the tail extends farther toward the small values; in a positively skewed distribution the tail extends toward the larger values (Figure 7). Zero skew is characteristic of a symmetrical curve representing a normally distributed variable.

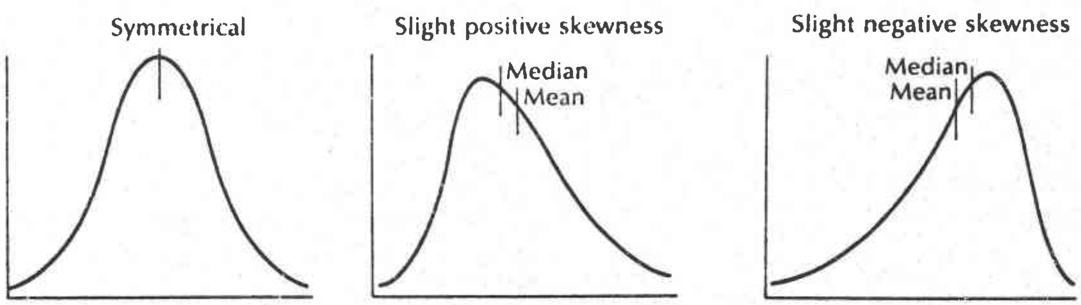


Figure 7. Types of Frequency Curves.

Monthly values of skewness were calculated for all stations and those for the 43-station subset are included in Appendix C. Figure 8 illustrates frequency histograms at four of these stations, selected to represent a range of moisture conditions. Newport is a wet station on the Oregon coast; Forks 1 E is a wetter station on the west side of the Olympic Peninsula; Heppner and Malheur Refuge HQ are two relatively dry stations in central Oregon with differences in elevation and exposure. The ordinate on each graph is the number of cases that fall within the class intervals whose midpoints are designated on the abscissa. Mean ($\bar{x}$) and skewness (Sk) are labeled on each histogram and are collected in Table 3 for comparative purposes.

Table 3: Mean and Skewness for Monthly Precipitation Data (1940-1979). (data in inches)

		October	January	April	July
Forks 1 E	$\bar{x}$	11.47	16.93	8.14	2.41
	Sk	1.06	0.74	0.26	0.99
Newport	$\bar{x}$	6.02	10.89	4.81	0.85
	Sk	0.55	0.44	0.43	1.40
Heppner	$\bar{x}$	1.19	1.43	1.25	0.37
	Sk	1.08	1.15	0.85	1.03
Malheur Refuge HQ	$\bar{x}$	0.78	1.04	0.59	0.29
	Sk	1.69	1.48	1.41	1.62

With regard to these graphs, it can be seen immediately that as the likelihood of reaching an upper or lower limit increases, the frequency distribution tends to become skewed, or asymmetrical (Griffiths 1982). This phenomenon is particularly apparent in monthly histograms. In any single month the likelihood of little or no precipitation exists, certainly a very remote possibility in the winter months in the western part of the region but more likely in the summer months and for all months east of the Cascades. Positively skewed distributions are the result. Exceptions to this are few as seen in Appendix C. Although the calculated values of skewness are probably fairly representative there is no doubt that a sample of many more than 40 observations would allow one to determine the true frequency distribution with more confidence. A further illustration of the difficulty in interpreting monthly distributions from this small sample is given by a comparison of the monthly progression of skewness between

Figure 8.

Frequency Histograms of Monthly Precipitation (1940-1979):

Newport, Oregon

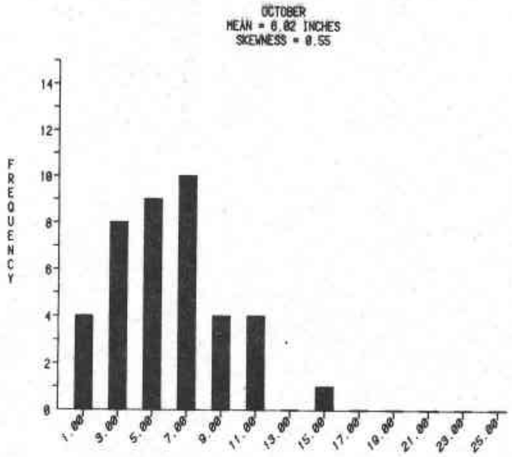
Forks 1E, Washington

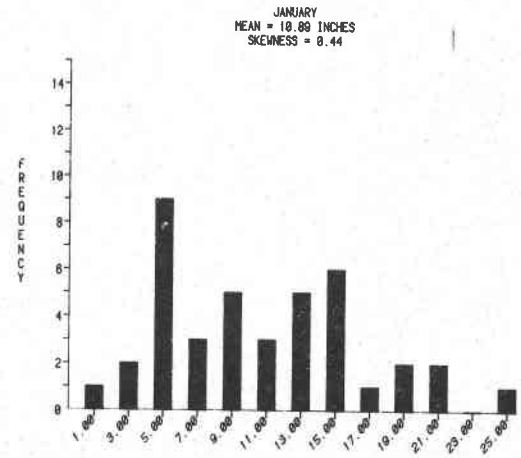
Heppner, Oregon

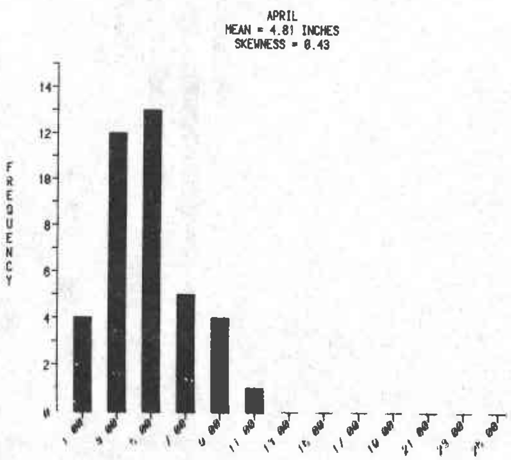
Malheur Refuge HDQ, Oregon

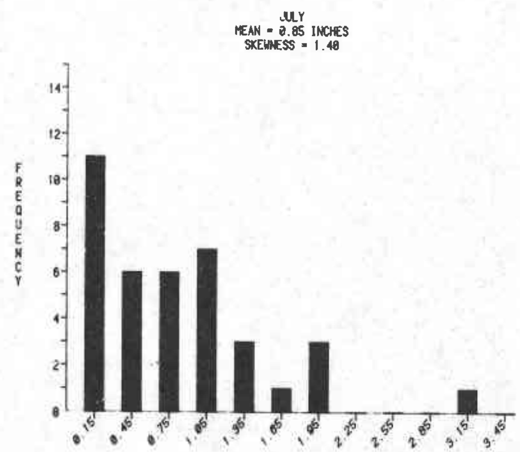
Note: The ordinate is the number of cases that fall within the class intervals whose midpoints are designated on the abscissa. Data are in inches.

Newport

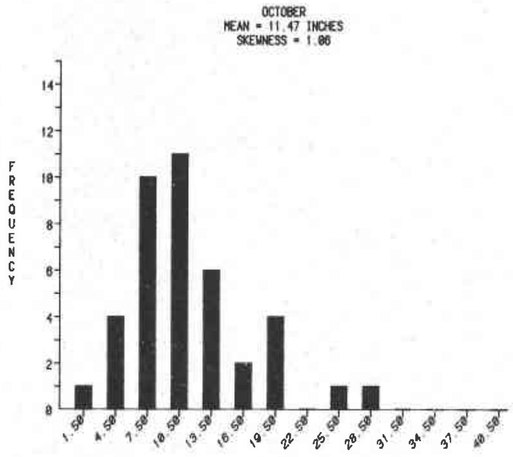

OCTOBER
MEAN = 6.02 INCHES
SKEWNESS = 0.55
FREQUENCY
0 2 4 6 8 10 12 14
1.00 3.00 5.00 7.00 9.00 11.00 13.00 15.00 17.00 19.00 21.00 23.00 25.00

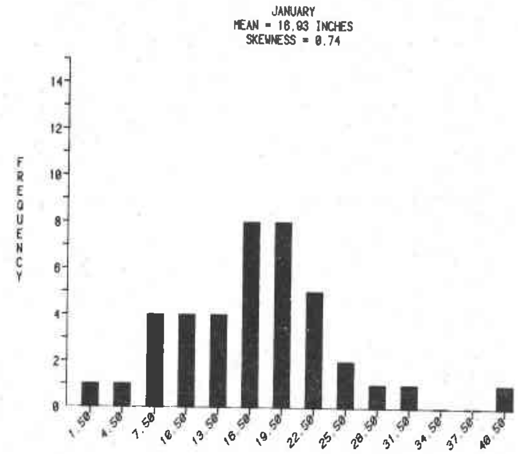

JANUARY
MEAN = 10.09 INCHES
SKEWNESS = 0.44
FREQUENCY
0 2 4 6 8 10 12 14
1.00 3.00 5.00 7.00 9.00 11.00 13.00 15.00 17.00 19.00 21.00 23.00 25.00

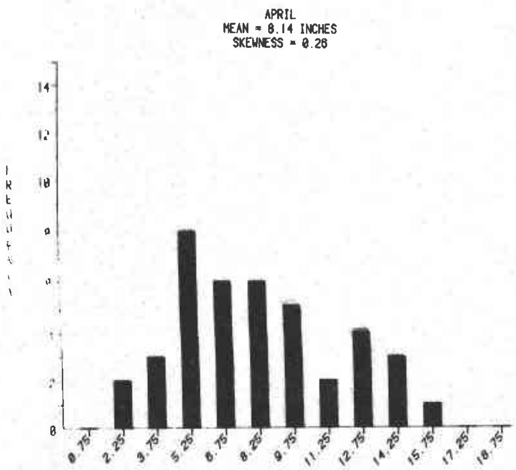

APRIL
MEAN = 4.81 INCHES
SKEWNESS = 0.43
FREQUENCY
2 4 6 8 10 12 14

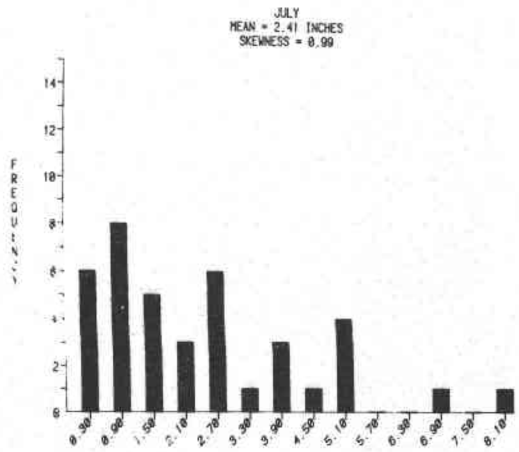

JULY
MEAN = 0.85 INCHES
SKEWNESS = 1.40
FREQUENCY
0 2 4 6 8 10 12 14
0.15 0.45 0.75 1.05 1.35 1.65 1.95 2.25 2.55 2.85 3.15 3.45

Forks 1 E

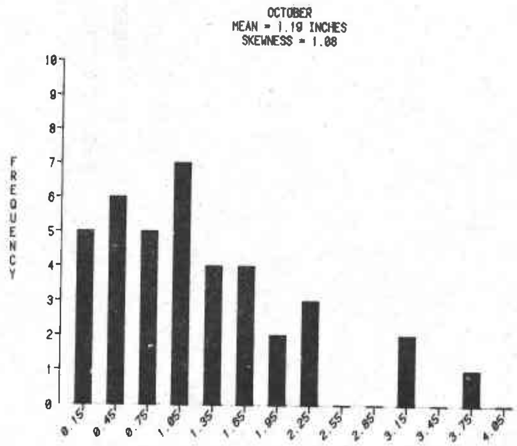

OCTOBER
MEAN = 11.47 INCHES
SKEWNESS = 1.08
FREQUENCY
14
12
10
8
6
4
2
0
1.50
4.50
7.50
10.50
13.50
16.50
19.50
22.50
25.50
28.50
31.50
34.50
37.50
40.50

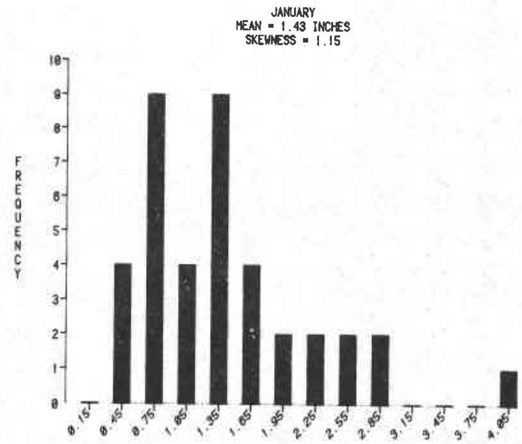

JANUARY
MEAN = 16.93 INCHES
SKEWNESS = 0.74
FREQUENCY
14
12
10
8
6
4
2
0
1.50
4.50
7.50
10.50
13.50
16.50
19.50
22.50
25.50
28.50
31.50
34.50
37.50
40.50

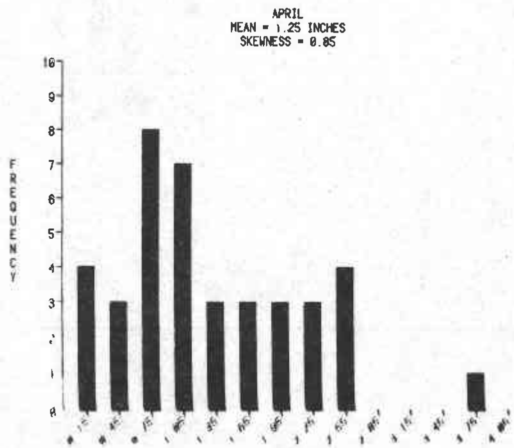

APRIL
MEAN = 8.14 INCHES
SKEWNESS = 0.28
14
10
0
0.75
2.25
3.75
5.25
6.75
8.25
9.75
11.25
12.75
14.25
15.75
17.25
18.75

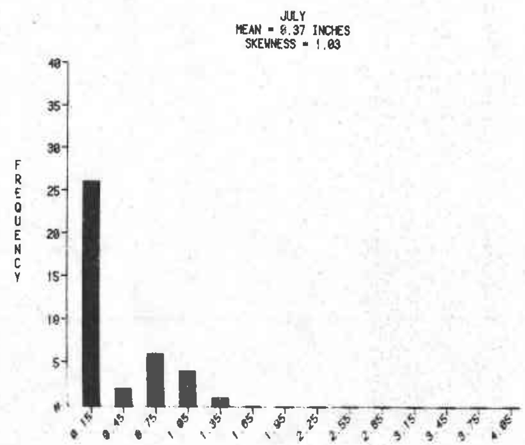

JULY
MEAN = 2.41 INCHES
SKEWNESS = 0.99
14
12
10
8
6
2
0
0.30
0.90
1.50
2.10
2.70
3.30
3.90
4.50
5.10
5.70
6.30
6.90
7.50
8.10

Heppner


OCTOBER
MEAN = 1.19 INCHES
SKEWNESS = 1.08
FREQUENCY
0 1 2 3 4 5 6 7 8 9 10
0.15 0.45 0.75 1.05 1.35 1.65 1.95 2.25 2.55 2.85 3.15 3.45 3.75 4.05

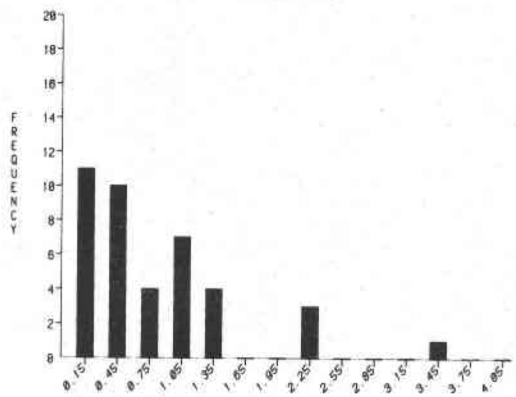

JANUARY
MEAN = 1.43 INCHES
SKEWNESS = 1.15
FREQUENCY
0 1 2 3 4 5 6 7 8 9 10
0.15 0.45 0.75 1.05 1.35 1.65 1.95 2.25 2.55 2.85 3.15 3.45 3.75 4.05


APRIL
MEAN = 1.25 INCHES
SKEWNESS = 0.85
FREQUENCY
3 4 5 6 7 8 9 10

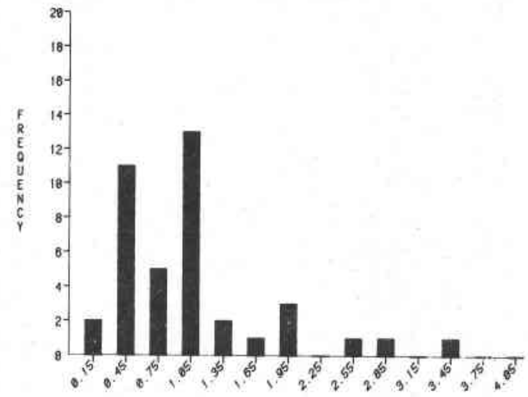

JULY
MEAN = 0.37 INCHES
SKEWNESS = 1.03
FREQUENCY
5 10 15 20 25 30 35 40
0.15 0.45 0.75 1.05 1.35 1.65 1.95 2.25 2.55 2.85 3.15 3.45 3.75 4.05

Malheur Refuge HDQ

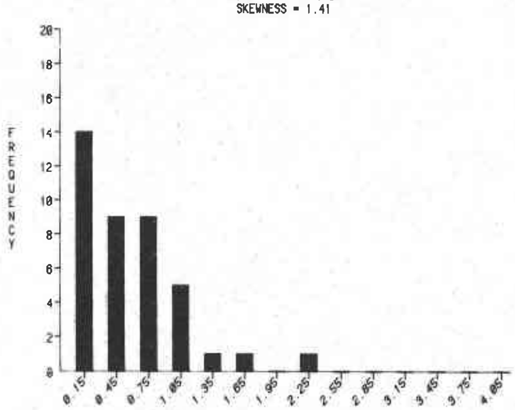
OCTOBER
MEAN = 0.78 INCHES
SKEWNESS = 1.69



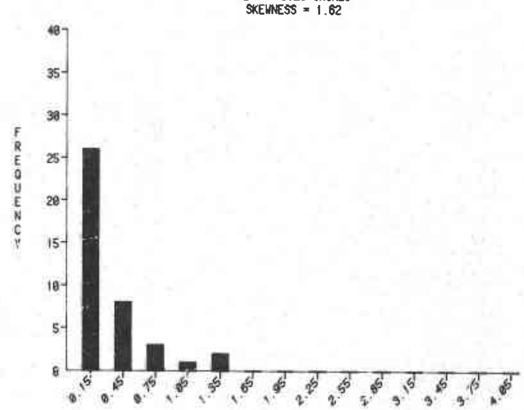
JANUARY
MEAN = 1.04 INCHES
SKEWNESS = 1.48



APRIL
MEAN = 0.59 INCHES
SKEWNESS = 1.41



JULY
MEAN = 0.29 INCHES
SKEWNESS = 1.62



Heppner and Malheur Refuge HDQ, the two dry stations, and between Newport and Forks 1 E, the two wet coastal stations (Figure 9). This progression should be nearly coincident for each pair; that it is not suggests the need of a larger sample.

Of greater interest, because they better represent the true or population distributions, are the frequency histograms of seasonal and annual rainfall series. Skewness for seasonal and annual series at all stations is also listed in Appendix C and frequency histograms of the four previously identified stations are depicted in Figure 10. It is normal expectation that rainfall climatological series for short periods (e.g. months) for which the mean is small generally have positively skewed distributions, as noted above. For seasonal periods in which several months are combined the mean increases and skewness decreases or more nearly approaches zero. Indeed, without exception seasonal values of the statistic are closer to zero than are values of the statistic for the individual months within each season. Thus, these series yield a smoother and more nearly normal distribution.

To illustrate, consider Newport with a 40-year winter mean of 59.96 inches, the driest winter being 26.70 inches in 1977 and the wettest 89.31 inches in 1974. The likelihood of no precipitation at all in a winter season is negligible and the frequency distribution nearly symmetrical (Sk = -0.11). In contrast, mean summer rainfall is considerably less, 10.35 inches, the likelihood of values near zero is greater and there is distinct positive skewness (Sk = 1.05) -- that is, the distribution tails off toward higher values. Annual distributions closely parallel those for winter.

The geographic pattern of seasonal and annual frequency distributions for precipitation in the Pacific Northwest is particularly interesting. The expected inverse relationship between mean and skewness, so evident when considering the length of the averaging period at one station, is not so evident in a spatial dimension. Winter and annual series yield consistently low skewness values, negative as commonly as positive. The pronounced positive skewness of arid and semi-arid rainfall series in other regions such as the American Southwest (see, for example, McDonald 1956) is not evident here. Data series from the drier stations in eastern Oregon and Washington are generally as near-normal as are those from the wet western part of the region. Note, for example, Heppner (annual Sk = -0.08) and Malheur Refuge HDQ (annual Sk = -0.13).

In the summer season, however, distributions exhibit a distinct positive skewness; but again the expected relationship between mean and skewness does not hold. In fact,

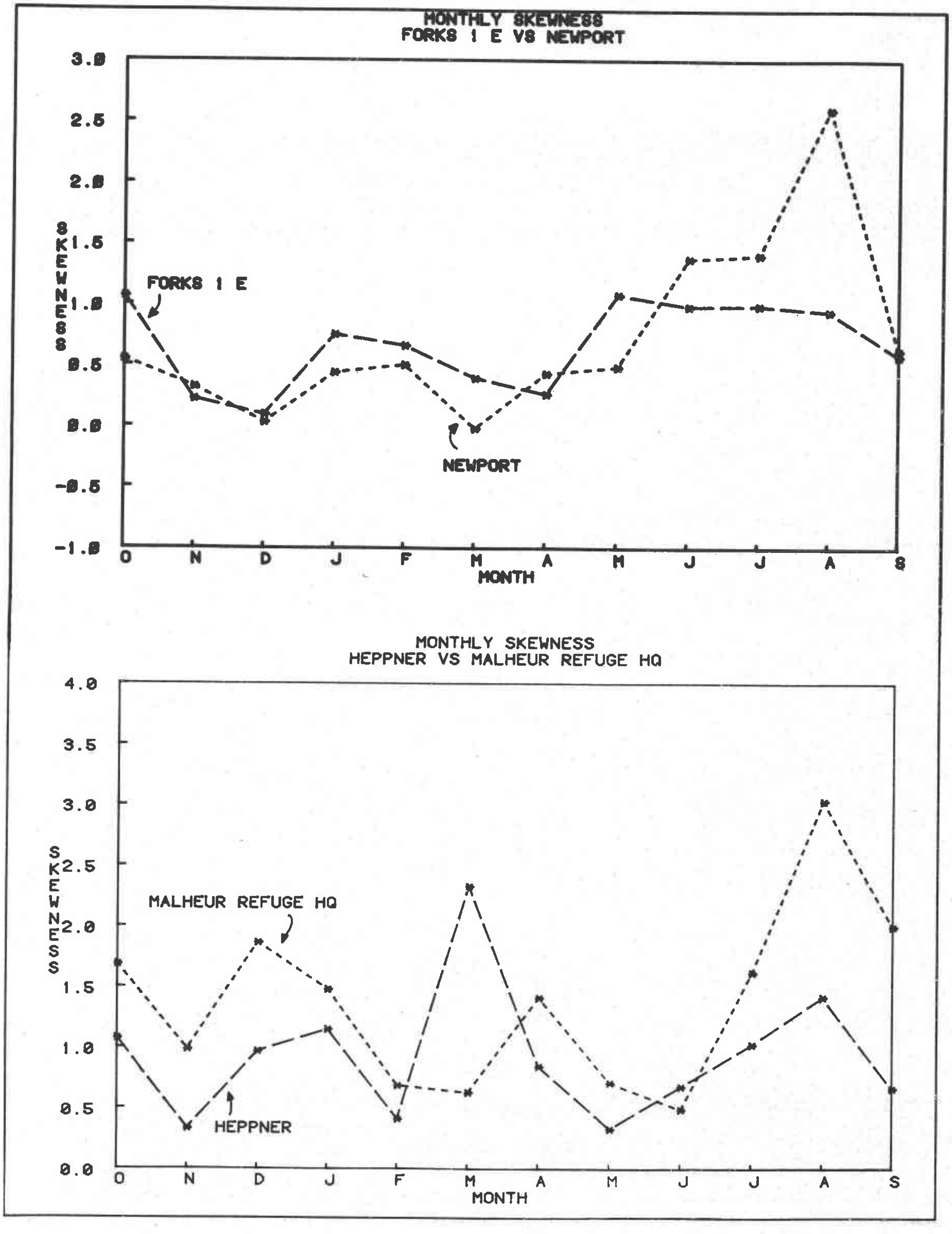


Figure 9. Comparison of Annual Progression of Monthly Skewness, 1940-1979.

Figure 1Ø.

Frequency Histograms of Seasonal and Annual Precipitation (194Ø-1979):

Newport, Oregon

Forks 1E, Washington

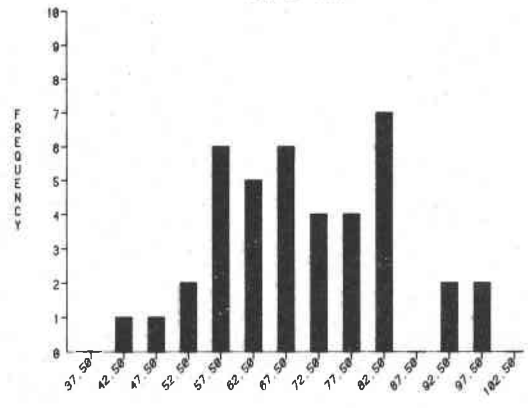
Heppner, Oregon

Malheur Refuge HDQ, Oregon

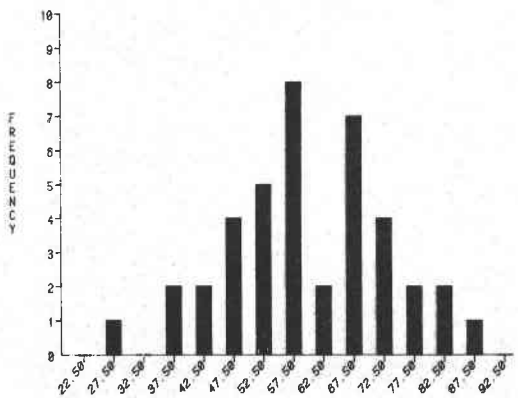
Note: The ordinate is the number of cases that fall within the class intervals whose midpoints are designated on the abscissa. Data are in inches.

Newport

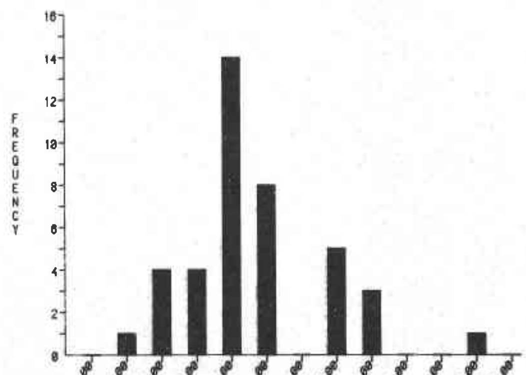
ANNUAL
MEAN = 70.31 INCHES
SKEWNESS = 0.11



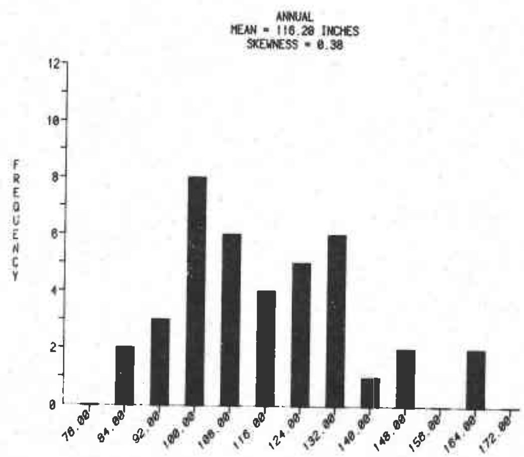
WINTER
MEAN = 59.96 INCHES
SKEWNESS = -0.11

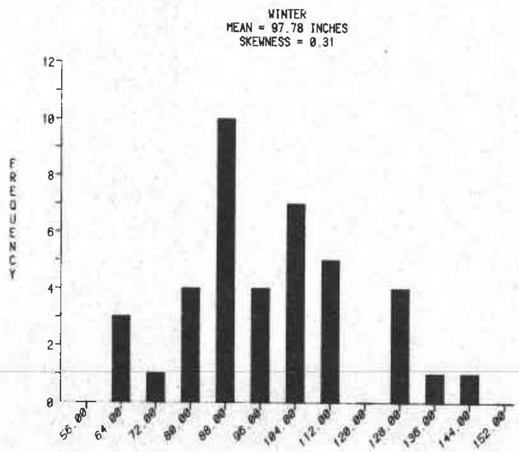


SUMMER
MEAN = 10.35 INCHES
SKEWNESS = 1.05



Forks 1 E


ANNUAL
MEAN = 116.20 INCHES
SKEWNESS = 0.38
FREQUENCY
0
2
4
6
8
10
12
78.00
84.00
92.00
100.00
108.00
116.00
124.00
132.00
140.00
148.00
156.00
164.00
172.00


WINTER
MEAN = 97.78 INCHES
SKEWNESS = 0.31
FREQUENCY
0
2
4
6
8
10
12
56.00
64.00
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88.00
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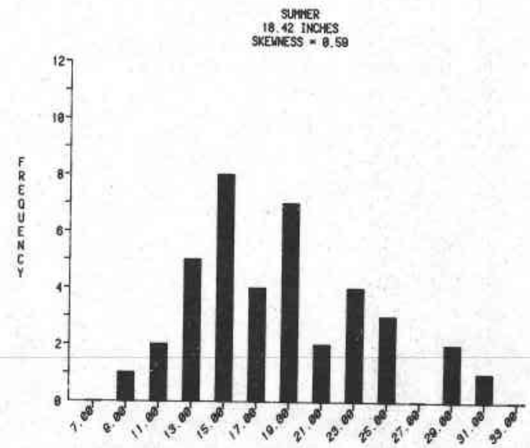
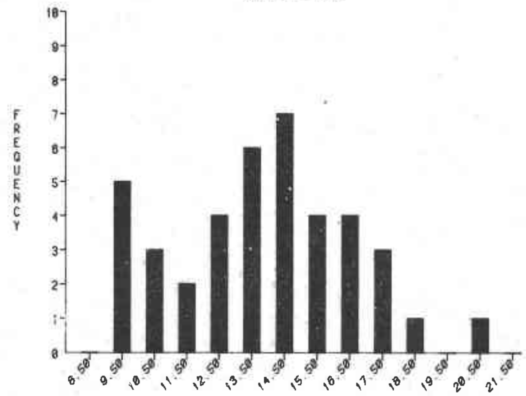
136.00
144.00
152.00

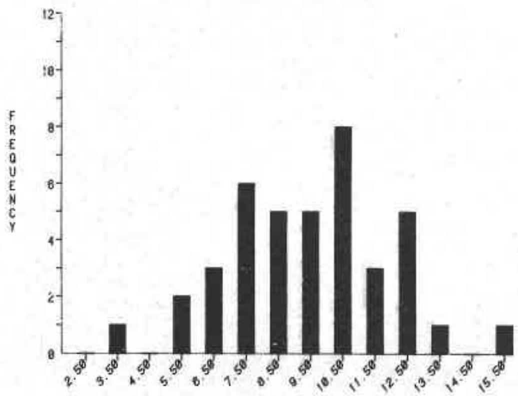

SUMMER
18.42 INCHES
SKEWNESS = 0.59
FREQUENCY
0
2
4
6
8
10
12
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
23.00
25.00
27.00
29.00
31.00
33.00

Heppner

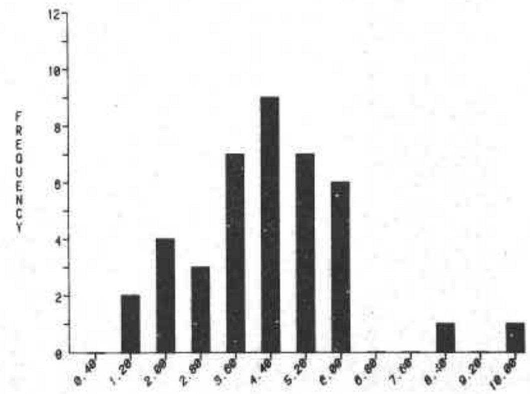
ANNUAL
MEAN = 13.88 INCHES
SKEWNESS = 0.08



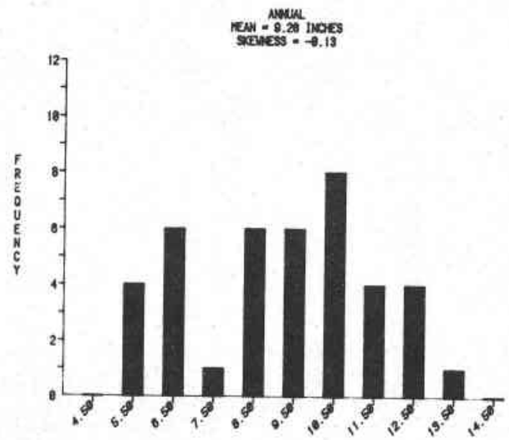
WINTER
MEAN = 9.45 INCHES
SKEWNESS = -0.01

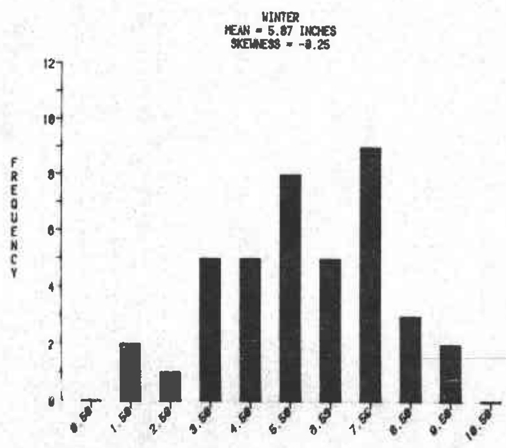


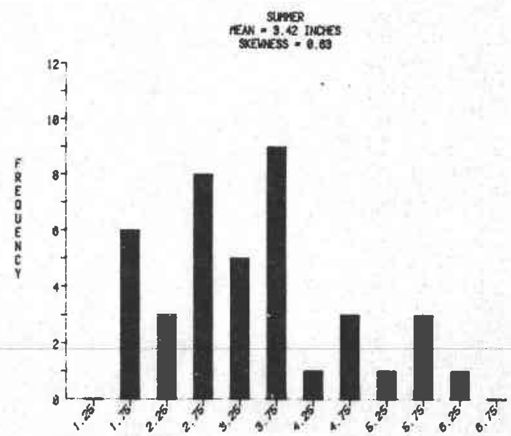
SUMMER
MEAN = 4.35 INCHES
SKEWNESS = 0.04



Malheur Refuge HDQ







larger values of skewness are found for series in the wetter western part of the region. This apparent anomaly is due in part to a weakness in the seasonal definition used for this study. Precipitation in May and September is highly variable from year to year as extratropical storm tracks respectively withdraw from and approach the region. The area west of the Cascades experiences more precipitation at these times than the area east of the Cascades. May and September rainfall tends to dominate in summer totals for the western region because the other summer months are quite dry. Conversely, east of the Cascades May and June are relatively wet months and, as discussed in Chapter IV, are not as variable from year to year as might be expected.

In Table 4 is a comparison of frequency distribution statistics between the 40-year sample and an approximately 90-year sample at Heppner and Newport. It can be seen that sample size has a surprisingly small effect on these statistics. For the summer series there is a slight reduction of skewness with the larger sample at Newport; yet at Heppner skewness is essentially unchanged. Overall, it is apparent that the frequency distributions of winter and annual precipitation data series in the Pacific Northwest for the 40-year sample period do not change significantly with a larger sample and are, in general, normally distributed. Sample statistics derived from the period 1940-1979 are very reliable estimates of population statistics. Summer precipitation series are positively skewed throughout the Pacific Northwest with higher values west of the Cascades.

Mean and Coefficient of Variation

Perceptions of rainfall for most people begin and end with the mean or "normal" amount and it is certainly the most basic descriptive statistic to be calculated from a data series. However, for the study of water resources it is, in itself, an inadequate characterization of data. Equally important is the variability about the mean. The coefficient of variation (Cv) is the best and most stable measure of the variability of precipitation over time and has become the preferred technique for depicting spatial patterns: among others, it has been used by Longley (1952) in the Canadian prairies, Bradley (1976c) in the Rocky Mountains, and Brazel and Ziriax (1979) in central Arizona.

The coefficient of variation is a dimensionless statistic defined as the ratio of the standard deviation to the mean:

$$Cv = \frac{s}{\bar{X}} \qquad (4)$$

Table 4: Comparative Frequency Distribution Statistics for Two Sample Periods (data in inches)

Heppner, Oregon

40 years (1940-1979)

	$\bar{x}$	s	Sk	Max	Min
Winter	9.45	2.40	-0.01	15.13	3.86
Summer	4.35	1.69	0.64	9.65	1.30
Year	13.80	2.69	0.08	20.63	9.26

91 years (1889-1979)

	$\bar{x}$	s	Sk	Max	Min
Winter	9.27	2.03	0.23	15.13	3.86
Summer	4.14	1.59	0.65	9.65	1.30
Year	13.41	2.61	0.32	20.63	8.24

Newport, Oregon

40 years (1940-1979)

	$\bar{x}$	s	Sk	Max	Min
Winter	59.96	13.44	-0.11	89.31	26.70
Summer	10.35	3.95	1.05	23.53	3.50
Year	70.31	13.51	0.11	99.14	42.76

88 years (1892-1979)

	$\bar{x}$	s	Sk	Max	Min
Winter	57.70	12.53	0.05	89.31	26.70
Summer	10.40	3.70	0.69	23.53	3.50
Year	68.11	12.85	0.11	99.14	37.72

It is preferred over the standard deviation which generally increases or decreases with the mean. For example, a three inch standard deviation at Forest Grove (mean annual precipitation = 44.63 inches) in the Willamette Valley would imply only small relative variability, whereas the same three inch standard deviation in a drier location such as Malheur Refuge HDQ (mean annual precipitation = 9.28 inches) would imply a very large value of relative variability. Division by the mean, in effect, normalizes the standard deviation making it comparable between areas of different mean values.

The coefficient of variation thus suggests the dependability of normal rainfall -- whether a station may be expected to receive essentially the same amount each year or if the interannual variation is great. Brazel and Ziriax (1979) have determined that a 40-year sample is sufficient to establish a stable value for the statistic. For other time periods absolute values may vary but the spatial pattern remains essentially the same. Means and coefficients of variation are included in the basic data tables of Appendix B and their spatial distribution is analyzed in Chapter IV.

Percentiles

A common method for assessing the likelihood of certain rainfall amounts, a method independent of the form of the frequency distribution, is the identification of percentiles -- positional measures derived directly from the ordered data. The median is the middle value of the ordered observations (the 50th percentile). In our sample of 40 items the median is defined as the average of the 20th and 21st items. As earlier illustrated, the mean is equal to the median in a normally distributed sample. In a positively skewed distribution the median is less than the mean. There has developed a preference among climatologists for the median as the basic statistic of arid-zone precipitation because the mean value implies an unrealistically high level of expectation.

The data series can be divided into an arbitrary number of equal parts symmetrical about the median. It is usual to divide the sample into ten or four parts, deciles and quartiles. Deciles divide the sample into equal parts of 10 percent each, the quartiles into equal parts of 25 percent each. The first decile is the amount of precipitation not exceeded by the lowest 10 percent of the values, the second decile is the amount not exceeded by the lowest 20 percent of the values and so on. Similarly, the first quartile is the amount not exceeded by 25 percent of the values. The second quartile (equivalent to the fifth decile) is the median. The basic data tables in Appendix B include values of the first and ninth deciles (10 percent and 90 percent) and the first, second and third quartiles (25 percent, median, 75 percent). In Figure 11 is a graphical representation of monthly percentile values at two Washington stations, Aberdeen and Yakima WSO AP.

An interesting application of percentiles in climatological analysis is a study of Australian drought by Gibbs and Maher (1967) in which they demonstrated that the first decile range on annual maps for the period 1885-1965 corresponds well with Australian droughts as recorded by Foley (1957). Further useful information can be obtained from these data with the interquartile range (75th percentile - 25th percentile) and the interdecile range (90th percentile - 10th percentile). The latter is particularly useful for documenting extreme conditions.

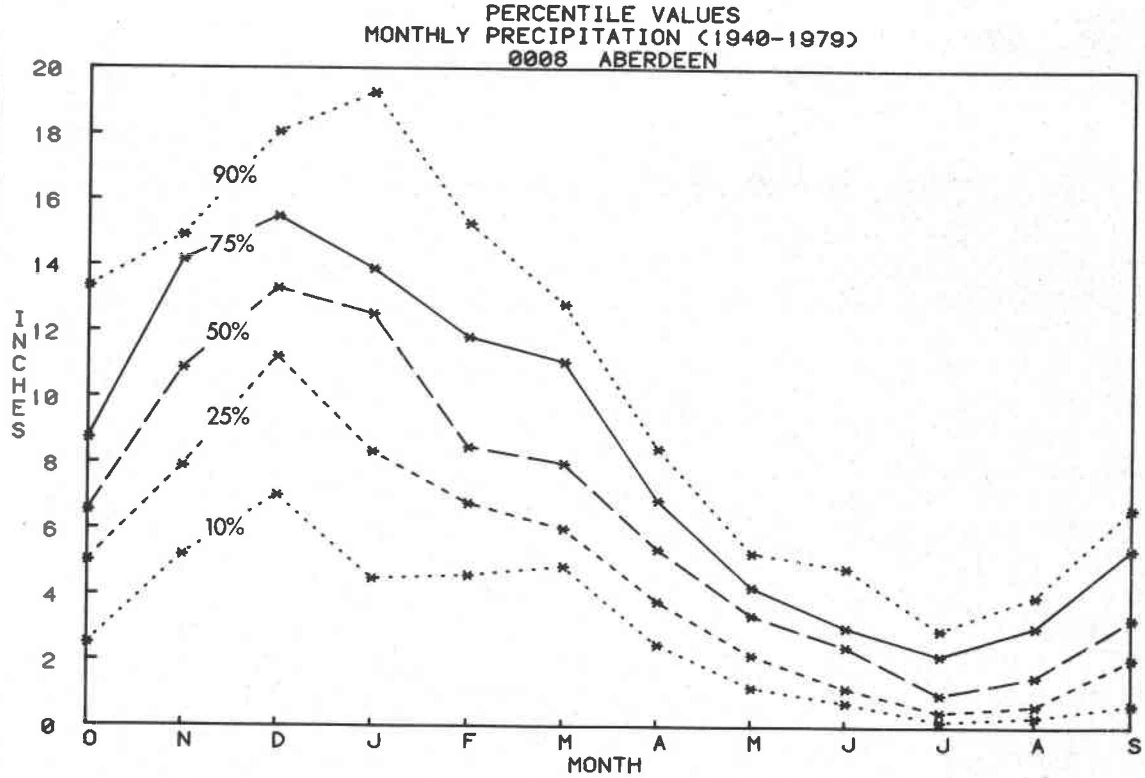
Users of these data should be aware that the percentile values here presented are descriptive statistics rather than inferential; that is, they are not appropriate for prediction in the strict statistical sense. However, if we base our estimate of the climatological future on the record of the past, these data do have predictive value. They do at least help to delimit the range of possibilities.

INFERENTIAL STATISTICS

Inferential statistics, in contrast to descriptive, are involved whenever the question of probability arises. A precipitation data series as developed in this study is necessarily a sample extracted from a much larger population of events. Inferential statistics allow one, within strictly defined limits, to make statements about the population based only on the sample data. Two forms of analysis are discussed below.

Confidence Intervals for Mean Precipitation

The interpretation of a given value for mean precipitation depends on whether one uses the value as a descriptive or as an inferential statistic. Essentially, the mean as a descriptive statistic precisely represents the sample considered; for example, the mean annual precipitation at Ashland for the period 1940 to 1979 was 19.51 inches. However, the use of this sample mean to estimate the population mean is an example of statistical inference. There is a temptation to allow the mean to slip from the category of descriptive statistics to the category of inferential or predictive statistics. Thus it is appropriate to present some quantitative estimates of the



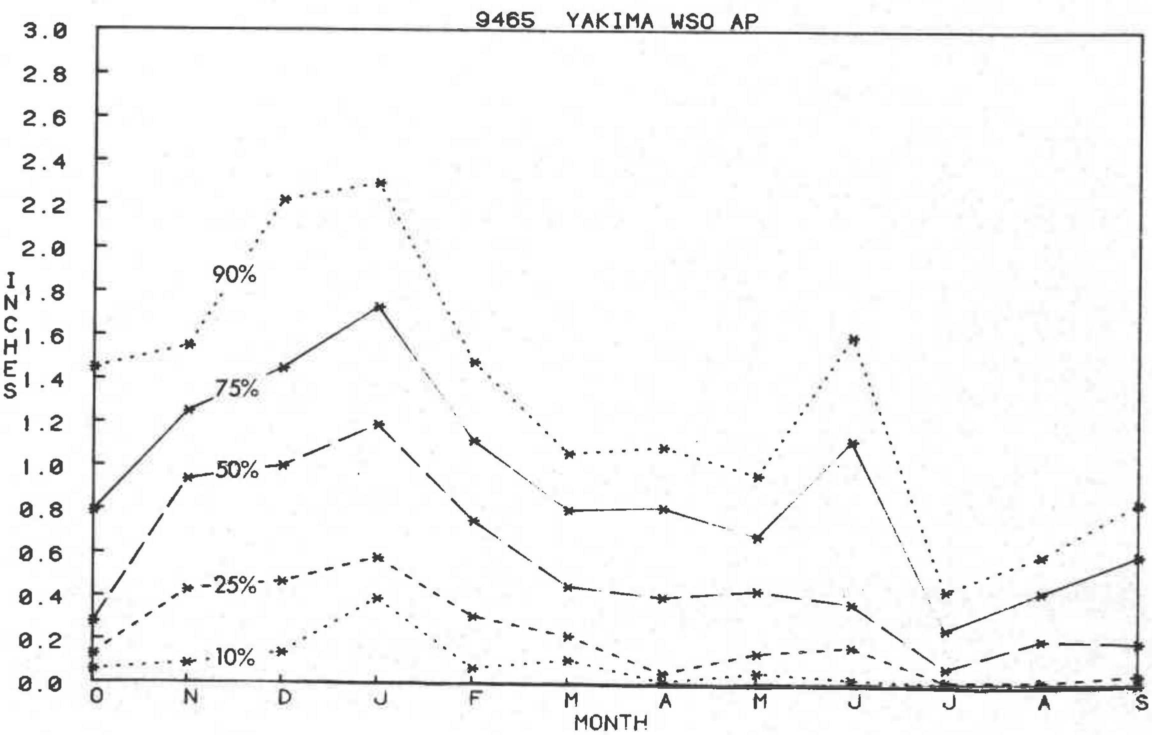


Figure 11. Annual Progression of Monthly Percentile Values, 1940-1979. Data in Inches.

reliability of the mean precipitation amounts listed in the basic data table of Appendix B. For this purpose a two-tailed Student's t-test is used to construct a 95 percent confidence interval statement for the 40-year mean. The format for this statement for a t-distribution with 39 degrees of freedom is:

$$\bar{x} \pm 2.02 \frac{s}{\sqrt{n}} \tag{5}$$

where s is the standard deviation of the sample and n = 40 (sample size)

Substituting the mean annual precipitation at Ashland:

$\bar{x}$ = 19.51 inches ± 1.57 inches,

which says that the population (long-term) mean estimated from our 40-year sample will lie in the range 17.94 inches to 21.08 inches. In other words, if random samples of size 40 are taken from the entire population only five percent of all samples will have such extreme values of and s that they give a mean value outside of 19.51 ± 1.57 inches.

An increase in sample size would lead to a decrease in the width of the confidence interval. The width of the interval as a percentage of the mean will generally be larger in drier areas in which the relative variability is greater. Because the mean is the primary statistic of a precipitation series, confidence intervals have been calculated for seasonal and annual values for all network stations and are included in Appendix D.

It should be noted that one of the assumptions underlying this procedure is that the data be drawn from a normally distributed population. However. other similar studies (e.g. McDonald 1956, Brazel and Ziriax 1979) have shown that the effects of non-normality are not very disturbing. Also, as shown previously, winter and annual rainfall series in the Pacific Northwest are uniformly near normal and even summer series do not deviate as much from normality as they do in other climatic regions. Nevertheless, the tabulated confidence intervals should be viewed as only good approximate measures of the reliability of the mean.

Similarly, a confidence interval can be constructed about the coefficient of variation. It is sufficient to assume that values are accurate within an interval of plus or minus 10 percent of the calculated value.

Probability Estimates

A second example of the use of statistical inference is the determination of the probability of occurrence of various amounts of precipitation during a month, season or water year. Estimates of this type are of particular importance to those involved in the management and utilization of water resources.

For this purpose knowledge of the form of the frequency distribution is critical. Given a normal frequency distribution, the area under the curve can be taken to represent the probabilities of certain values being exceeded or not exceeded. The only statistics necessary to define the curve are the mean ($\bar{x}$) and the standard deviation (s). In a normal distribution about 68 percent of all occurrences fall within one standard deviation above and below the mean, about 95.5 percent within two standard deviations of the mean, and about 99.7 percent within three standard deviations of the mean.

Precipitation data from Newport and Heppner, presented earlier in Table 4, can be used to illustrate. In approximately two-thirds of the years Newport will receive between 46.52 and 73.40 inches of winter precipitation; Heppner will receive between 7.05 and 11.85 inches of winter precipitation; and so on. Calculation of values at any probability level can be done by tabulating the area under a normal curve, a standard table found in most statistical references.

However it is often easier and more useful to work with the cumulative frequency distribution. For this technique we use arithmetic (normal) probability paper which has a vertical scale designed so that the cumulative frequency curve of a normal distribution plots as a straight line. Calculated values of probability are plotted against rainfall values, using the formula (Dunne and Leopold 1978):

$$F_i = \frac{m}{n+1} \times 100\% \qquad (6)$$

where F_i is the cumulative percentage frequency of the variable, or the percentage of years with a rainfall amount equal to or less than the particular rainfall having rank m from the data ordered by magnitude. The percentage of past events is taken as the probability (also in percent) of future events.

Normal probability plots of seasonal data are presented for Newport and Heppner (Figure 12). Winter precipitation values at Newport deviate only slightly from a straight

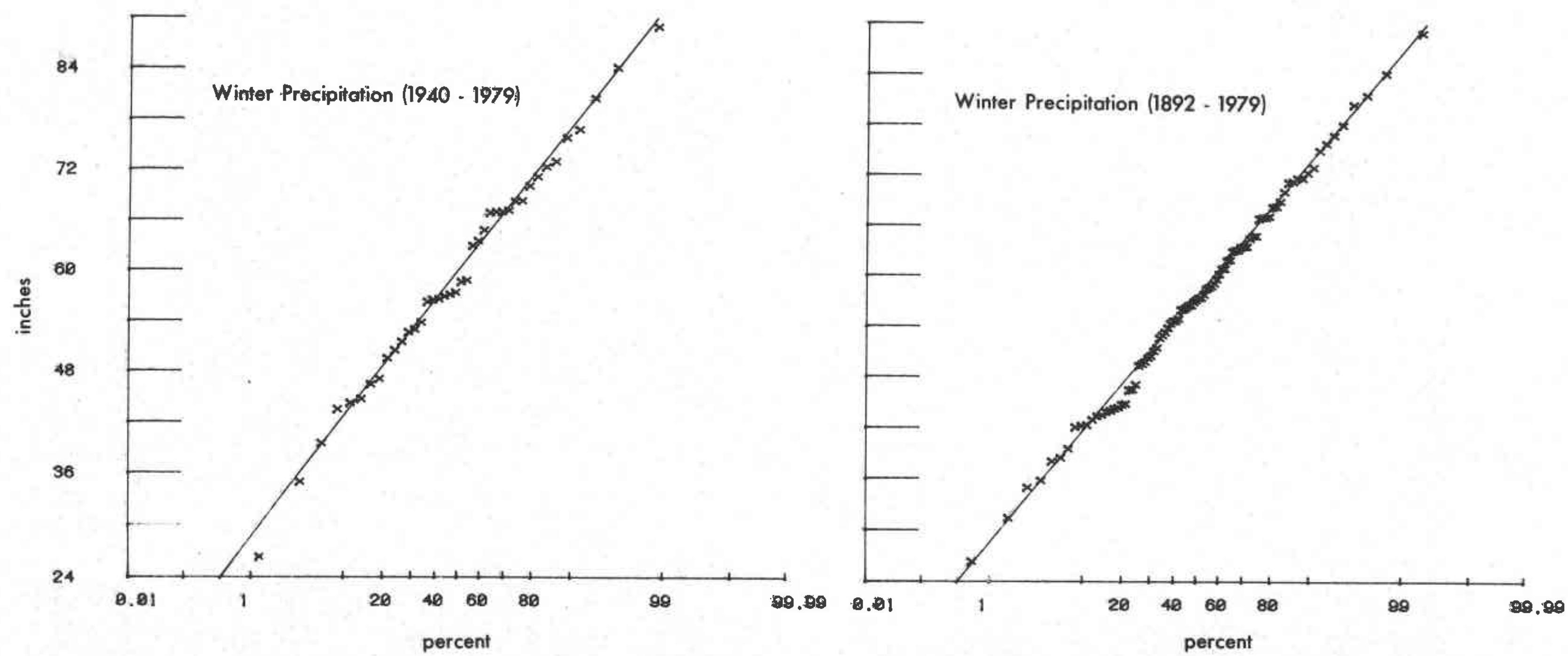
Figure 12.

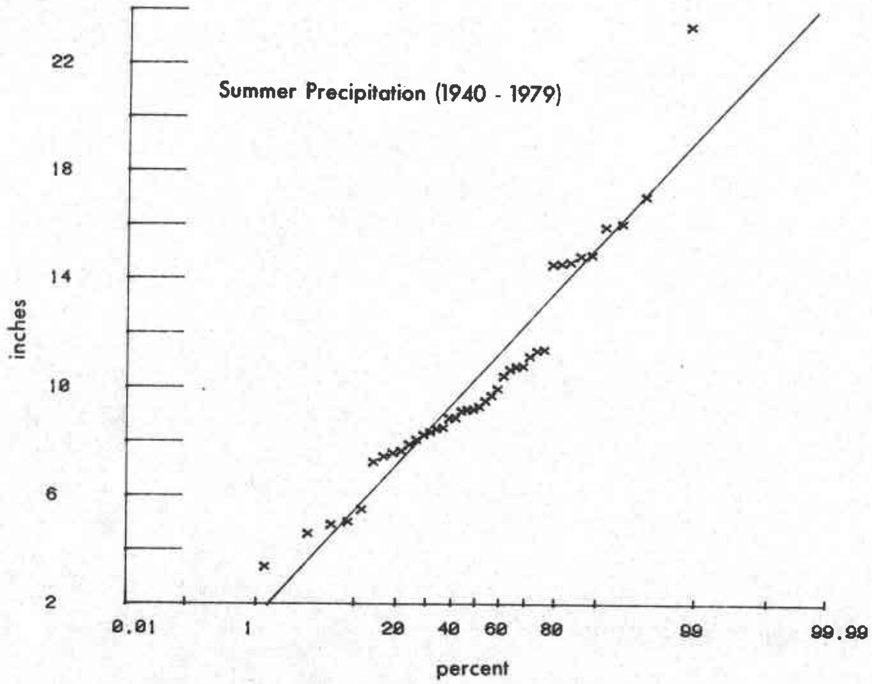
Normal Probability Plots of Seasonal Precipitation:

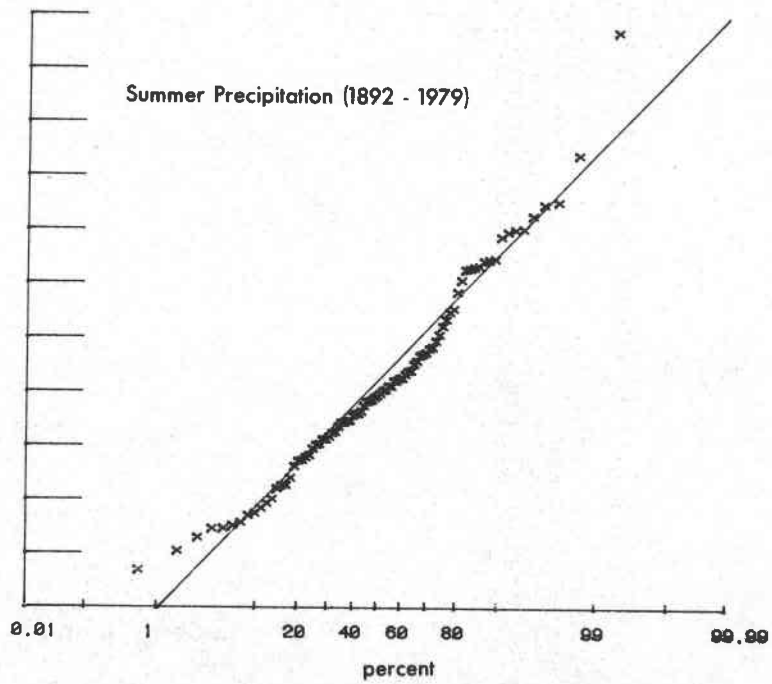
Newport, Oregon (1940-1979)
(1892-1979)

Heppner, Oregon (1940-1979)
(1890-1979)

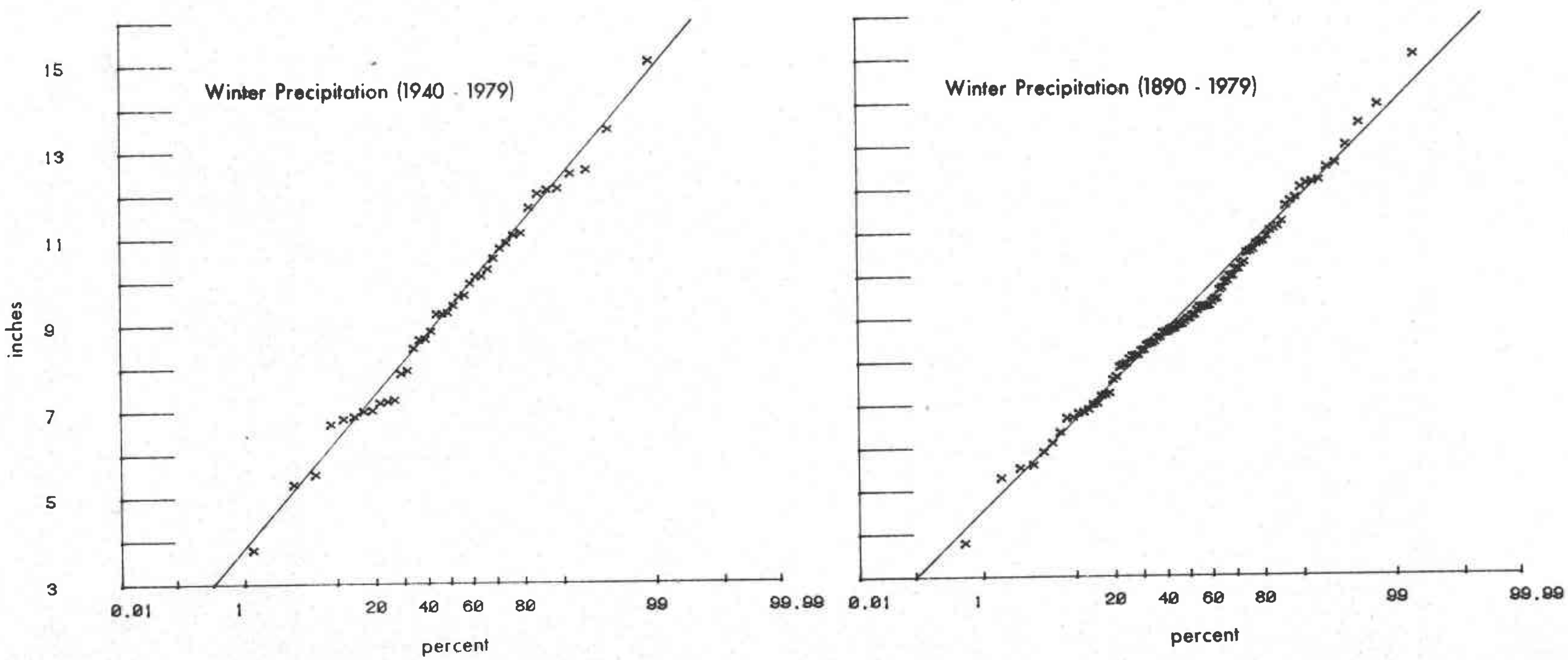
Normal Probability Plot: Newport, Oregon

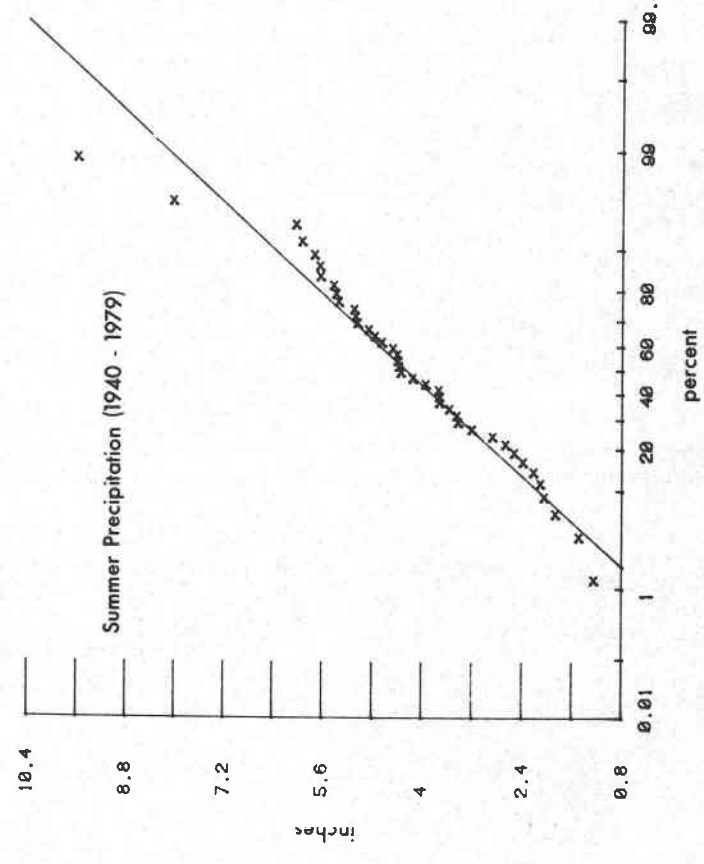



Summer Precipitation (1940 - 1979)
inches
22
18
14
10
6
2
0.01
1
20
40
60
80
99
99.99
percent

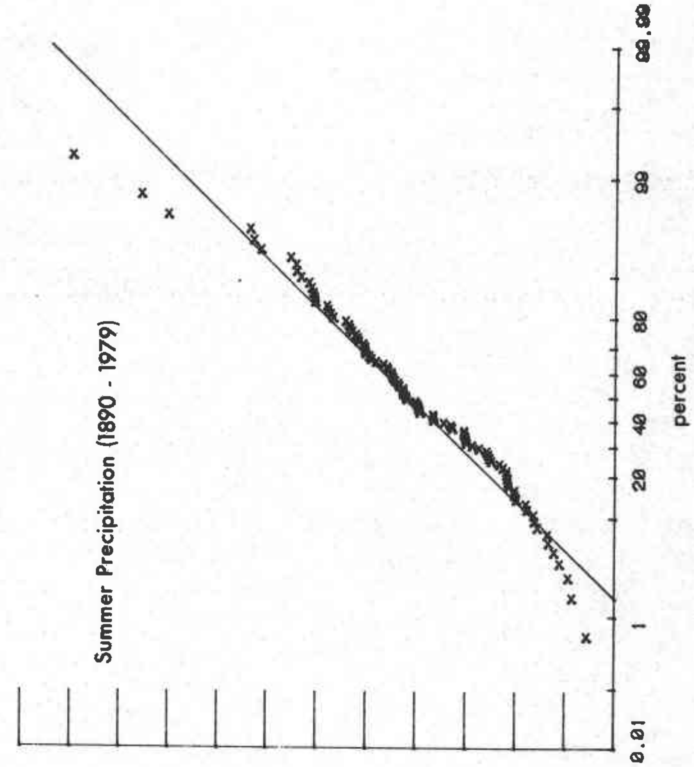

Summer Precipitation (1892 - 1979)
0.01
1
20
40
60
80
99
99.99
percent

Normal Probability Plot: Heppner, Oregon





Summer Precipitation (1940 - 1979)
inches
10.4
8.8
7.2
5.6
4
2.4
0.8
percent
0.01
1
20
40
60
80
99
99.99



Summer Precipitation (1890 - 1979)
percent
0.01
1
20
40
60
80
99
99.99

line, indicating the near-normal frequency distribution. The calculated straight line smooths any irregularities in the data and the mean is equivalent to 50 percent probability. If it has been determined that the data series approximates a normal distribution, it is not necessary to plot all points. Two points are sufficient, for example the mean (50 percent) and the mean ± one standard deviation (16 and 84 percent).

Once constructed, the probability line can be used to determine the probability of precipitation above or below any value. At Newport, for example, there is a 20 percent chance that winter precipitation will be approximately 48 inches or less and a 40 percent probability that winter precipitation will be 56 inches or less. Summer data at Newport do not fit the normal line as closely as do winter data. However, between the 10 percent and 90 percent probability levels the fit is sufficiently accurate. The data series for Heppner also yield a close fit for winter values and within 10 percent and 90 percent for summer values.

Similar probability plots based on a 90-year record are offered for comparison and it can be seen that predicted values assessed from the 40-year record are nearly identical to those from the longer record. In general, the shorter record tends to overestimate the amount at any probability level. For data series whose distributions are moderately skewed in a positive direction it is often possible to modify the shape of the original frequency distribution by transforming the original variables, commonly with the square root or natural log of the data. Fortunately, for the data in this study, even with a positive skew, results of non-transformed data are certainly valid within 10 percent and 90 percent levels.

IV. SPATIAL PATTERNS OF PRECIPITATION

The data compiled, processed and presented in tabular form in Chapter III allow a wide range of possibilities for interpretation and use by researchers and by water managers. In this chapter the data are presented cartographically in three different formats, all of which permit further insight into the complex nature of precipitation variability in the Pacific Northwest. The first presentation is based on a set of isopleth maps depicting means and coefficients of variation for months, seasons and the water year. Next is a series of profiles which illustrate the annual progression of monthly values of the mean and coefficient of variation at individual stations. Third is an analysis of interstation correlations of monthly and seasonal precipitation with the results summarized on a set of isocorr maps.

MEANS AND VARIABILITY

The two statistical characteristics that best illustrate the spatial and temporal variation of precipitation in a region are the mean and the variability about the mean. This section is a discussion of the relationship between mean amounts and interannual variability as expressed by the coefficient of variation (Cv). These statistics for four key months and for winter, summer and annual values were mapped on a base of regional topography and are presented in tandem for ready comparison (Figure 13). A map of the seasonal distribution of annual precipitation, expressed as the percentage occurring in the winter, follows (Figure 14). The maps are intended to represent only the broadscale aspects of precipitation distribution in the Pacific Northwest and not detailed patterns for particular areas. The discussion that follows is based primarily on Trewartha (1981).

Effects of the three dominant climatic controls in the Pacific Northwest -- latitude, topography and continental versus marine influence -- are readily apparent in the map series. The combined influences of latitude and proximity to the Pacific Ocean are best illustrated in the coastal margin. Inland across the Pacific Northwest the marine influence wanes as the continental influence increases. At the same time patterns are modified considerably by topography from west to east. While latitude remains an important control throughout the region its influence is much less apparent to the east, specifically in the large interior region east of the Cascades.

Figure 13.

Map Series of Pacific Northwest Precipitation Statistics (1940-1979) Mean and Coefficient of Variation:

a) Annual (Water Year)

b) Winter (October - April)

c) Summer (May - September)

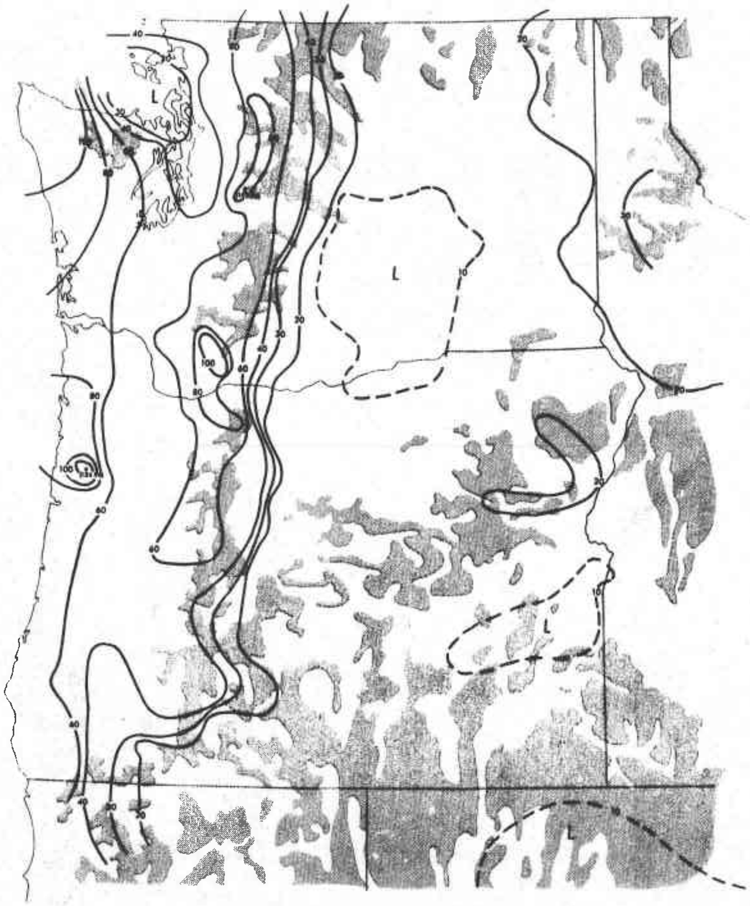
d) October

e) January

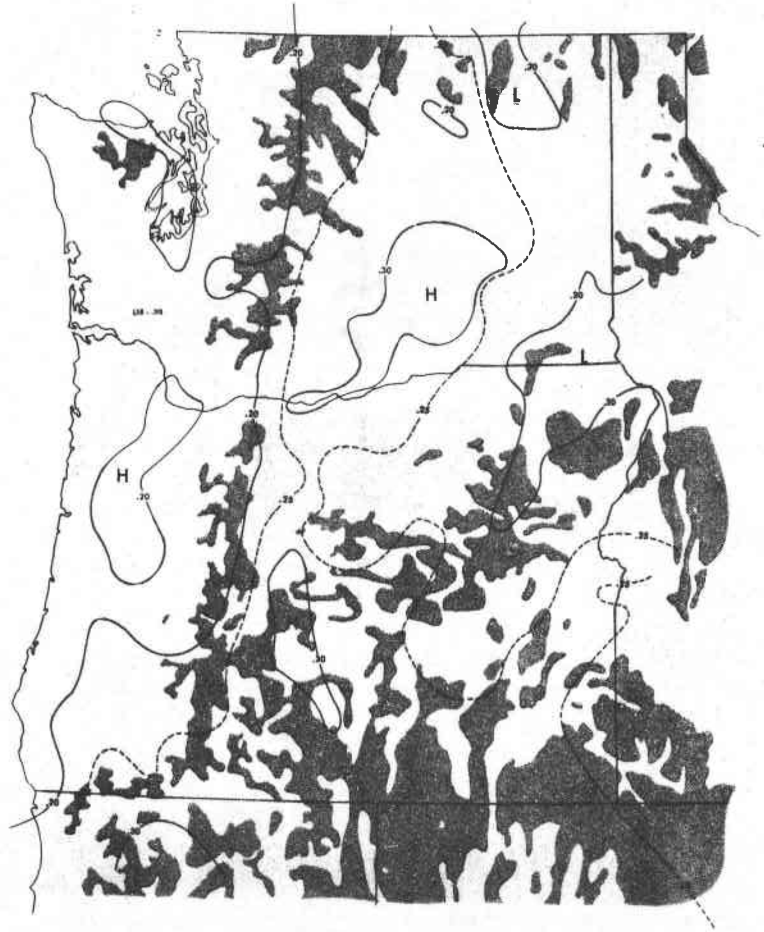
f) April

g) July

a) ANNUAL (WATER YEAR)

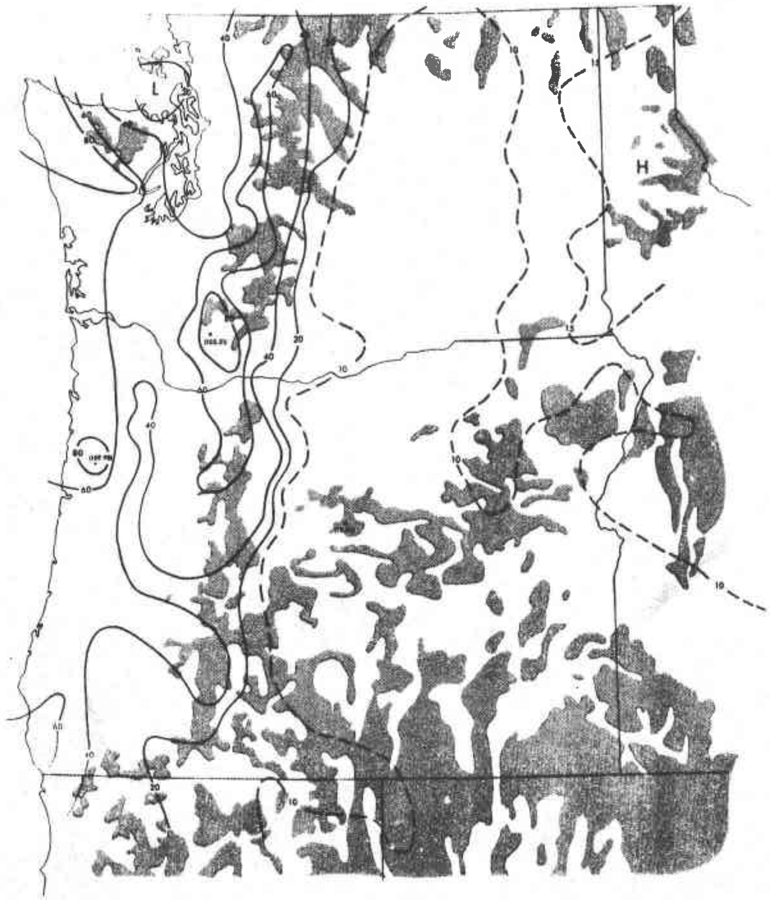


Mean

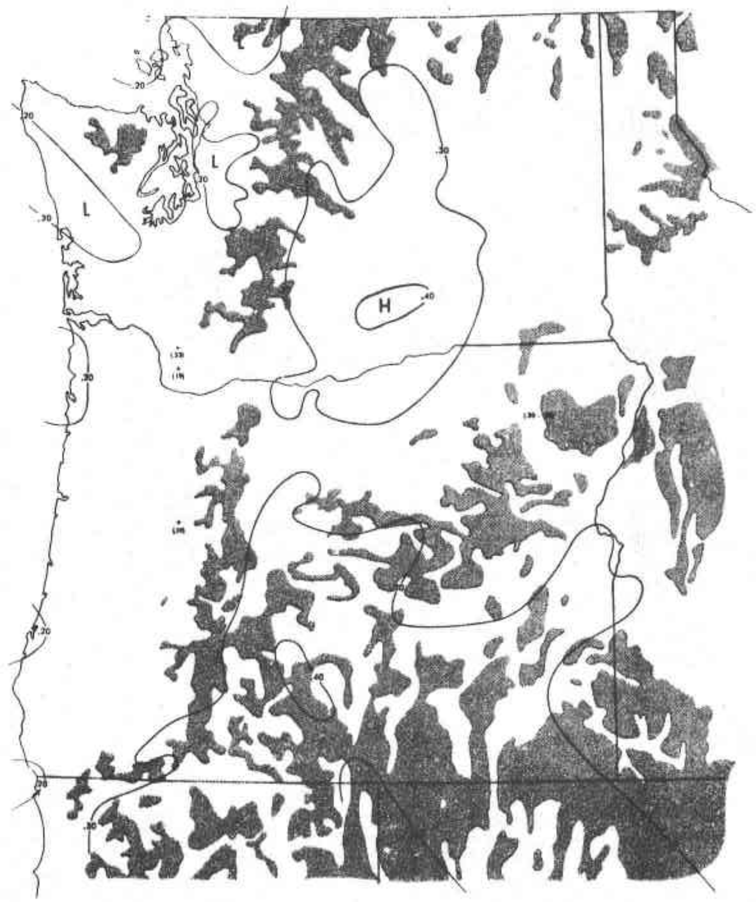


Coefficient of Variation

b) WINTER



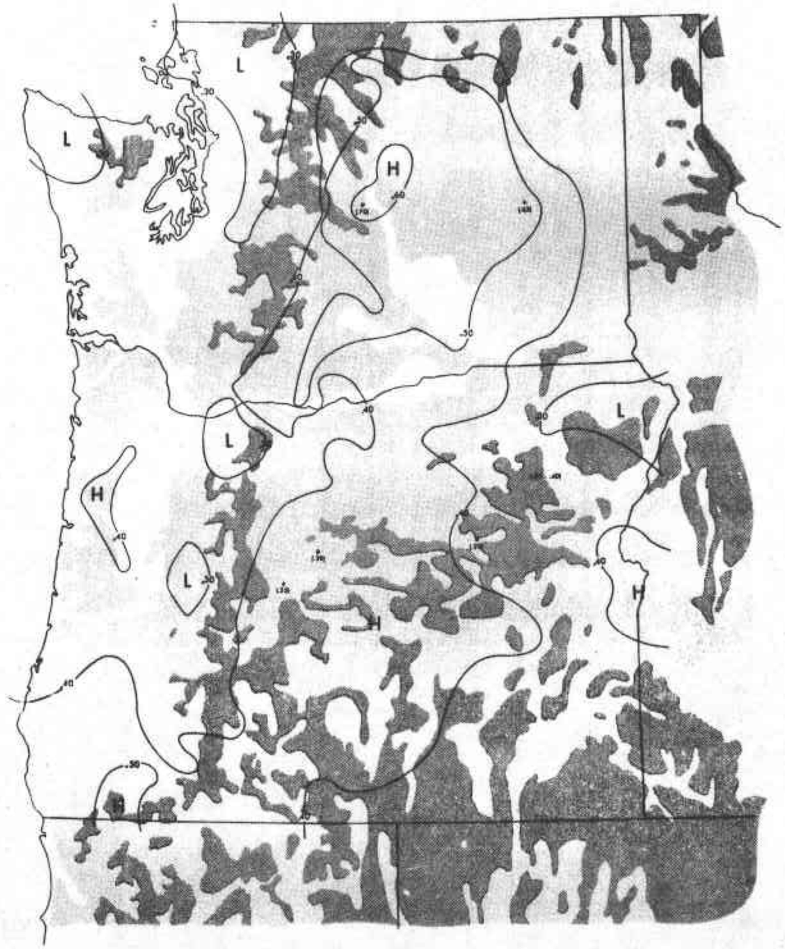
Mean



Coefficient of Variation

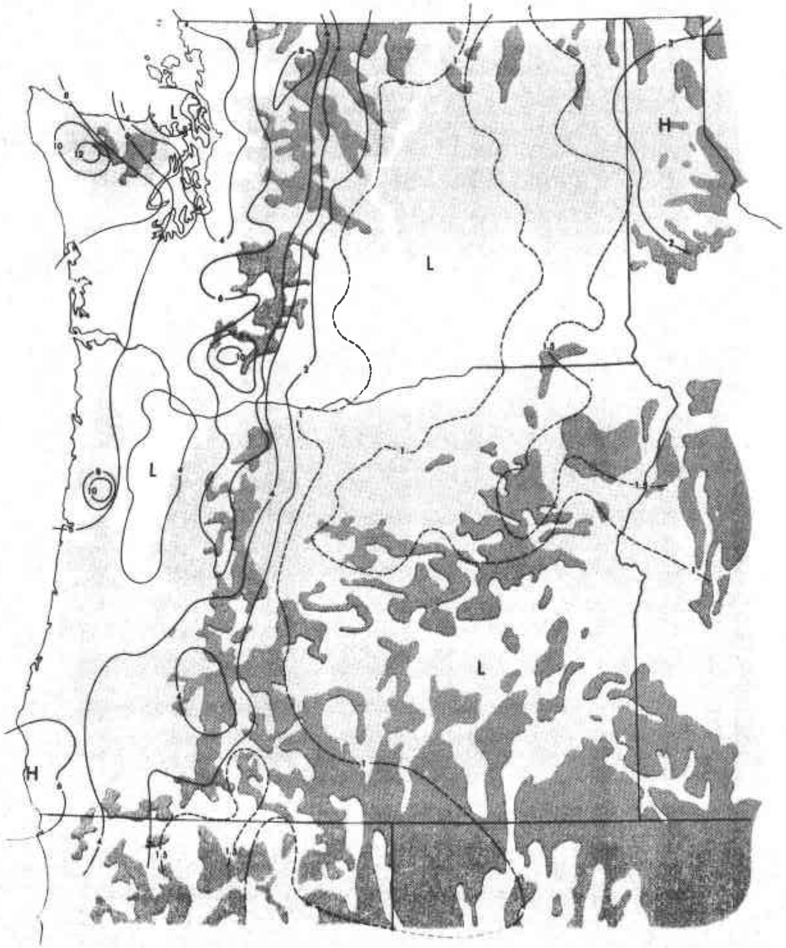
c) SUMMER

Mean

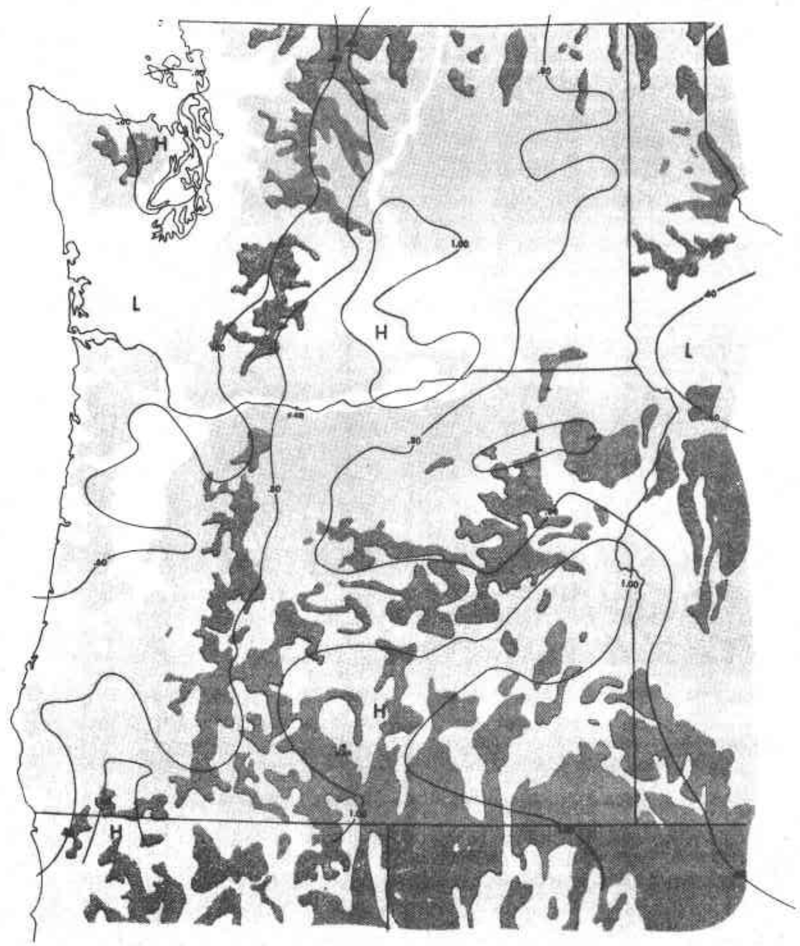


Coefficient of Variation

d) OCTOBER

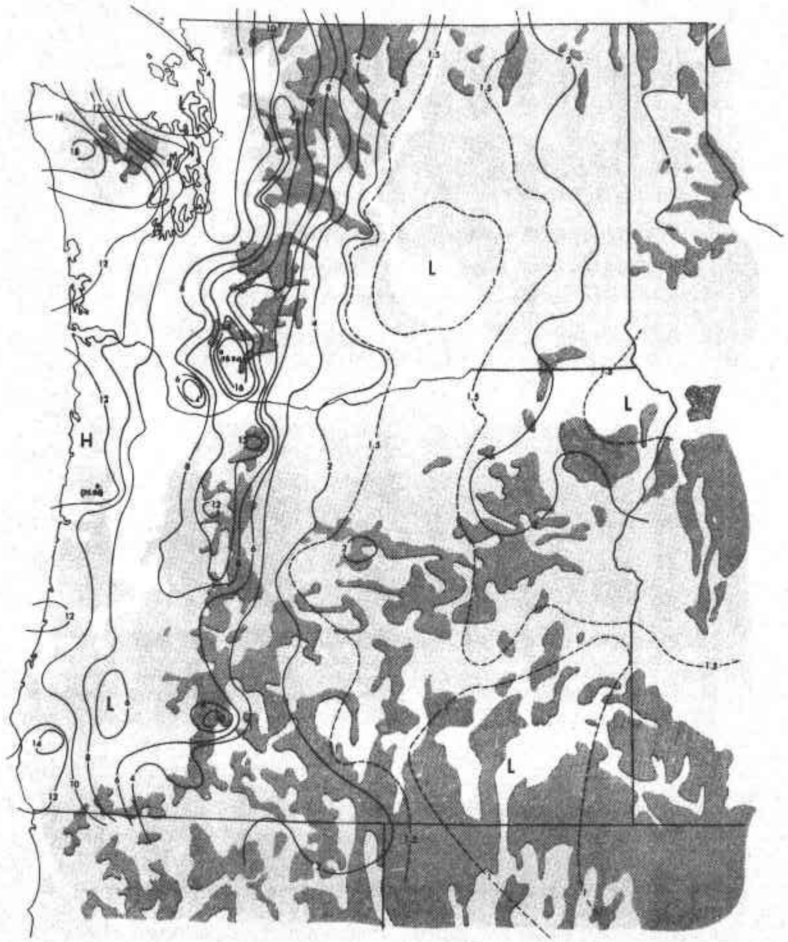


Mean

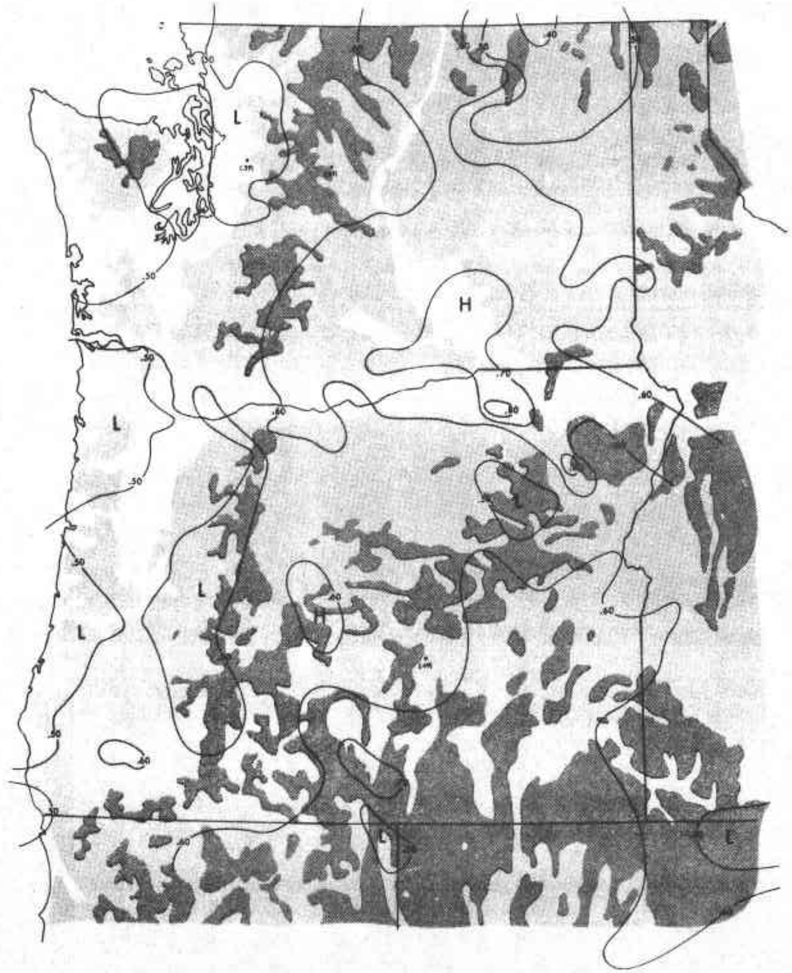


Coefficient of Variation

e) JANUARY

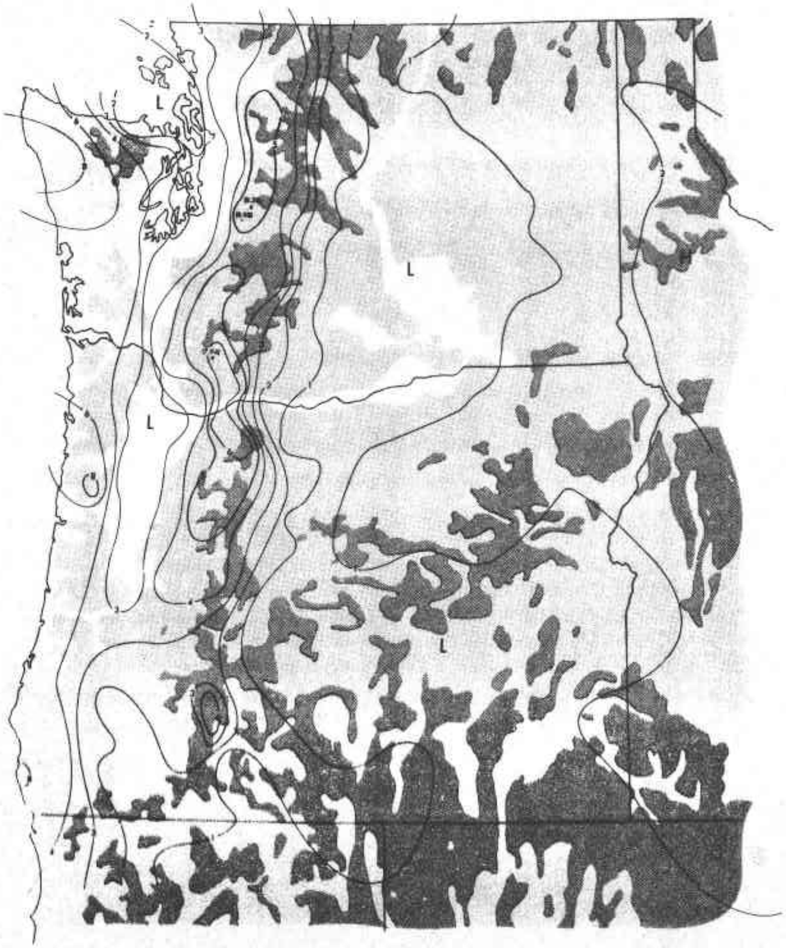


Mean

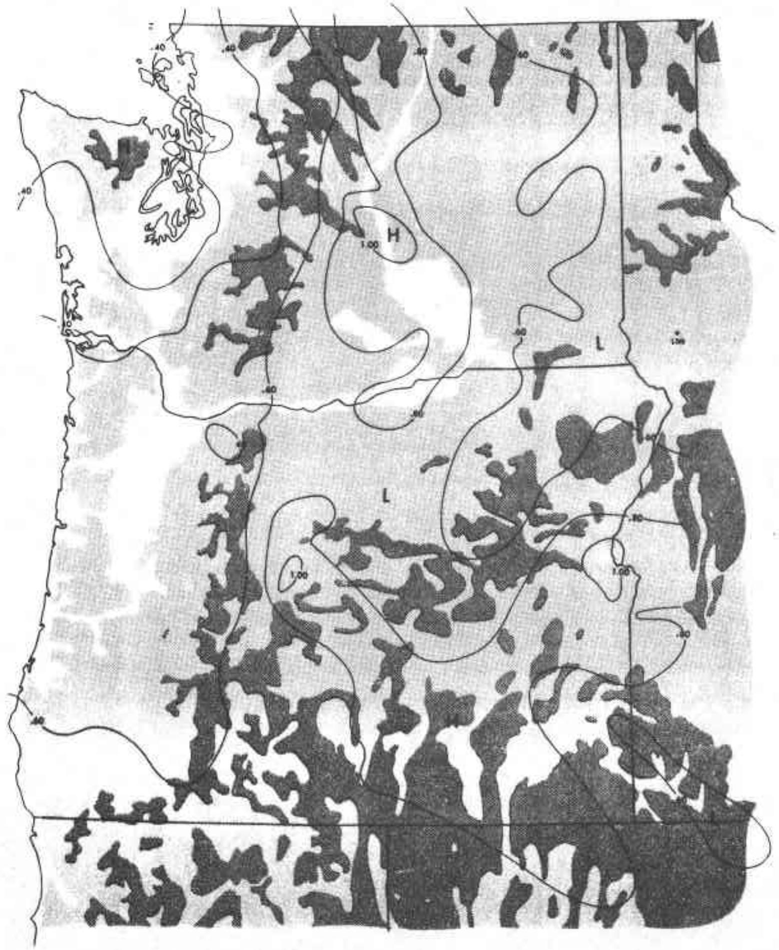


Coefficient of Variation

f) APRIL

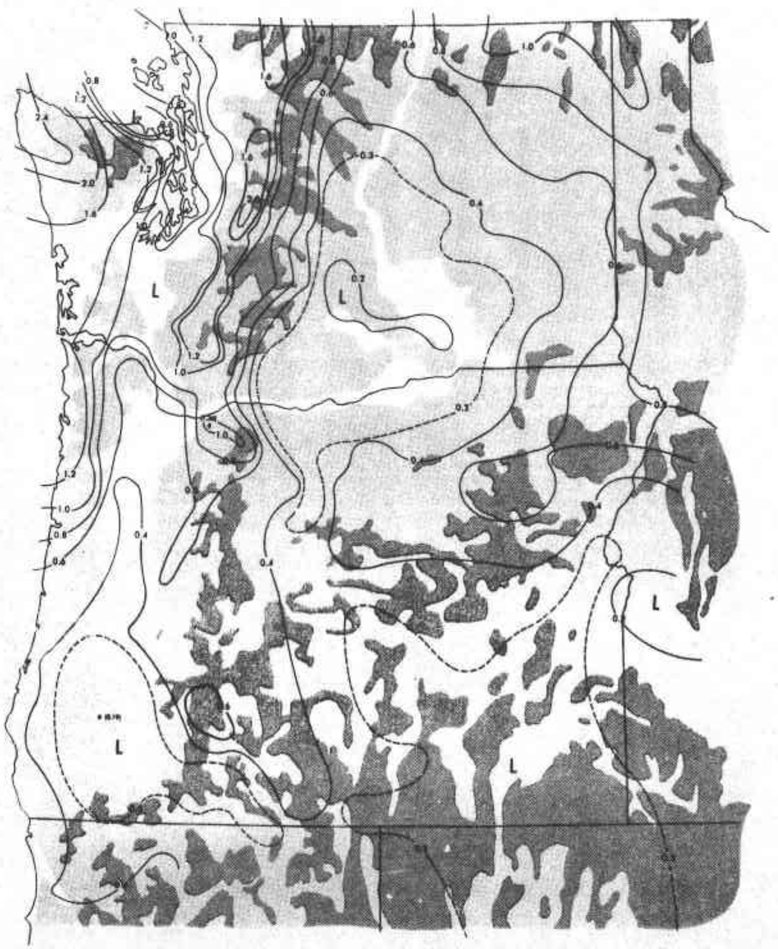


Mean

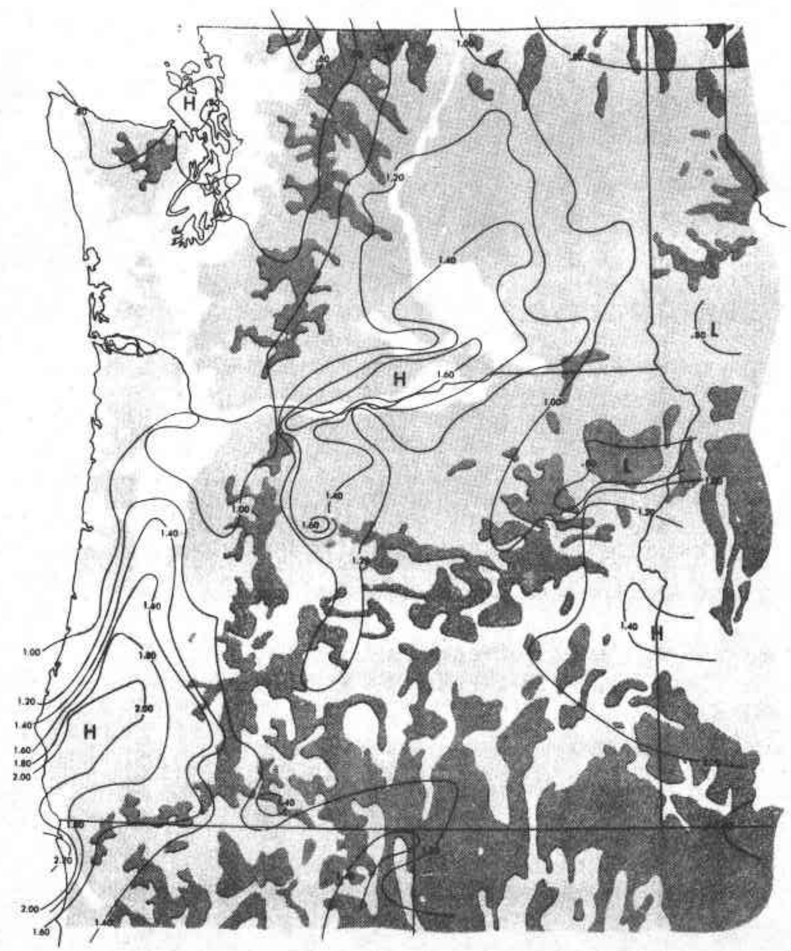


Coefficient of Variation

g) JULY



Mean



Coefficient of Variation

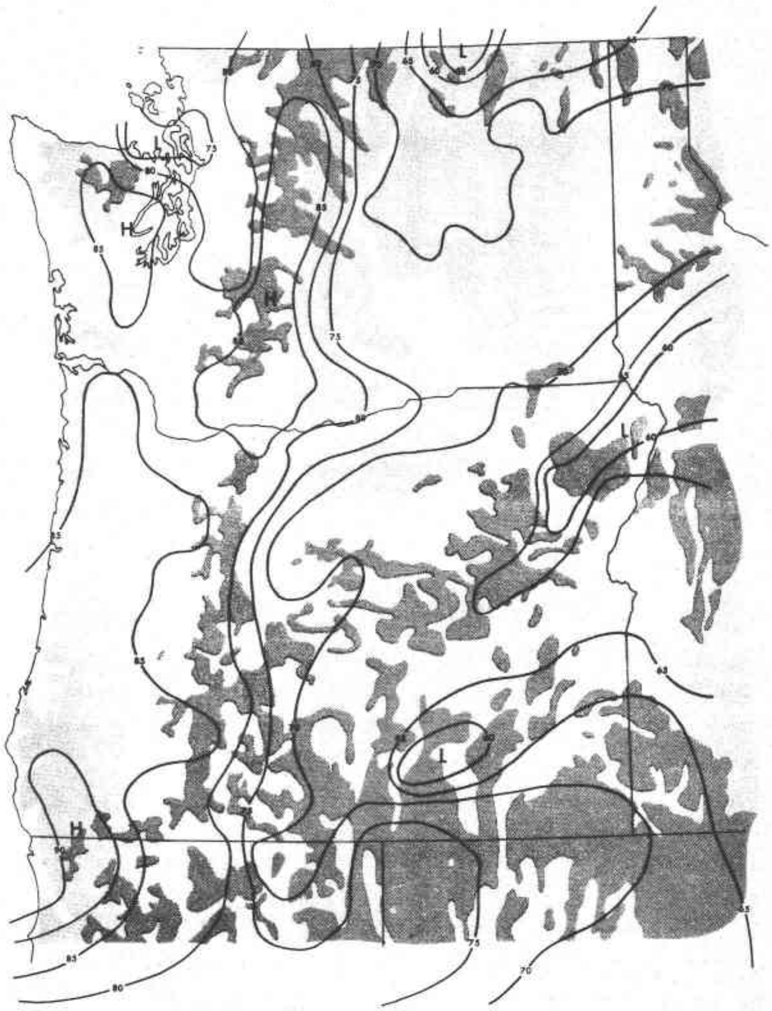


Figure 14. Winter Season Precipitation Expressed as a Percentage of Annual Precipitation, 1940-1979. Data in Inches.

The influence of topography is perhaps best summarized by Trewartha (1981, p. 297):

> The North American West, situated between the Rocky Mountains and the Pacific Ocean, is indeed a region of precipitation complexity both as regards mean annual amounts and seasonal distributions. More than in other parts of the country the West's terrain features, expressed in both altitude and directional alignment, play an important role in influencing the spatial and temporal distribution of rainfall.

The Cascade Range is obviously the dominant terrain feature in the Northwest, indeed one of the most striking climatic divides in the world. It effectively separates the area into two fairly distinct climatic regions, east versus west.

Along the coastal margin precipitation amounts and variability may be explained in terms of the seasonal migration of the North Pacific subtropical high and of the jet stream and associated cyclonic storms on its poleward side. Most of the annual precipitation, from 84 to 90 percent, occurs during the winter season. In fact most of western Oregon and Washington receives more than 80 percent of annual precipitation in winter. This maritime precipitation pattern of the North Pacific Coast is the most important and extensive producer of precipitation in the West. The rainy season extends from September to May, thereby overlapping into our "summer" season.

These rains originate in midlatitude disturbances which in turn are associated with a widely fluctuating jet stream and with large synoptic trough patterns in the atmosphere. Seasonal expansion and contraction of the circumpolar vortex creates a distinct north-to-south gradient of mean amounts and seasonal distribution. With higher latitude the rainy period is of longer duration and seasonal and annual amounts are greater. The highest annual and seasonal amounts occur along the northern Washington coast and lesser amounts occur with decreasing latitude. Departures from this pattern, such as along the southern Oregon coast, probably result from topographic influences. The general north-to-south gradient also exists for monthly means.

The winter concentration of annual precipitation on the southern Oregon coast, almost 90 percent, is as high as anywhere in the country and decreases steadily to the north. The explanation is again in the length of the rainy season. Near the California border it is generally confined to our designated winter months, October through April; to the north it often overlaps into late and early summer.

Interannual variability of annual and winter season precipitation in the coastal margin is essentially uniform from north to south, the entire strip responding to fluctuations in the intensity and frequency of midlatitude storms. However, individual months exhibit a north-to-south gradient in coefficients of variation--increasing values with decreasing latitude. In other words, more variability is found along the outer (lower latitude) margins of the circumpolar vortex. For the same reason coefficients of variation in the summer exhibit a similar gradient, ranging from 26 percent at Neah Bay in the north to 44 percent at Gold Beach in the south. Our definition of "summer" accounts for this as May and September receive most of the "summer" rainfall in western Oregon and Washington.

The lack of significant summer precipitation is due to the unusual poleward displacement along the coast of an arm of the North Pacific high and the cool coastal waters associated with this pattern. As described by Patton (1956), the northward displaced anticyclone is not only effective in stabilizing the air but also acts to block depressions from regular penetration to the continent. Farther north the anticyclone becomes weaker and more variable in position and disturbances bring increased warm season rainfall to the coast.

Inland the marine pattern is still dominant but the effects of topography modify the initial pattern of means and variability. North-to-south gradients are not as clearly defined. Mean precipitation over all time periods increases on windward slopes and extremely high annual precipitation totals occur in the Olympic Mountains of Washington and in the Oregon Coast Range.

On the lee side of the mountains a rainshadow exists, as can be seen most dramatically just east of the Olympic Mountains. To illustrate, Forks 1 E on the west side receives 116.20 inches, mean annual precipitation; Sequim, 60 miles to the east and on the lee side receives 15.97 inches, mean annual precipitation. The rainshadow is pronounced in the Puget Sound area as far south as Tacoma. It is an area of relatively modest precipitation and winter rainfall contributes a smaller percentage to annual totals--the lowest west of the Cascades.

Farther south the less continuous nature of the Coast Range permits easier entrance of Pacific air and allows increased precipitation as far south as Cottage Grove at the southern end of the Willamette Valley. In the interior valleys of southwestern Oregon, in the lee of the higher Klamath Mountains, precipitation again declines (for example, Ashland 19.61 inches).

Although the interior precipitation pattern is altered by topography, the percent of annual rainfall occurring in the winter shows much the same north-to-south gradient as in the coastal zone. This is to be expected because of the influence of the latitudinal control, the percent of winter concentration increasing southward.

The pattern of interannual variability is also altered inland. Coefficients of variation in the lowland between the coast ranges and the Cascades are not uniform from north to south. Stations on the east side of Puget Sound have low values, comparable to their coastal equivalents at the same latitude. Conversely, most of the stations in the Willamette Valley and southwestern Oregon have higher coefficients of variation than their coastal equivalents. On the windward slopes of the Cascades mean precipitation increases and variability remains low throughout the north-south extent of the range.

Eastern Oregon and Washington are a part of the larger Intermontane Region, a climatic type described by Trewartha, which is situated between the Rocky Mountains to the east and the Cascades and Sierras to the west. Precipitation is everywhere less than at equivalent elevations in the Cascades and to the west. However, there is a considerable range in annual amounts. The wettest areas are in northeast Washington and the mountains of northeast Oregon. The driest region in the two states is the Columbia Basin of south-central Washington where mean annual precipitation is below 8.00 inches at several stations. The driest station in this network is Sunnyside (6.94 inches).

Synoptic patterns causing precipitation are two-fold in contrast to the single dominant mechanism to the west. General widespread rains in winter are in response to midlatitude storms which have a lower moisture content after crossing the western mountains. Summer rains are more local and convective in nature but contribute significantly to annual totals. Throughout the Inter-mountain Region winter precipitation is less than 75 percent of the annual total, considerably less than in western Oregon and Washington. As discussed in the next section there is a distinct late spring-early summer rainy period in addition to the winter maximum.

There exists a suggestion of a north-to-south gradient in annual and seasonal totals. As explained, cyclonic control is stronger and winter rains more abundant with increasing latitude along the coast and it is not unexpected that the same is true east of the Cascades, with higher values to the north. However, most of the variation in mean seasonal and annual precipitation appears to be the result of topography rather than latitude.

Spatial distribution of seasonal and monthly precipitation is very similar to the annual pattern, the driest areas being the Columbia Basin and the high desert of southeast Oregon. Northeast Washington and the mountains of northeast Oregon have the highest totals.

Spatial patterns of interannual variability for all time periods reflect closely the patterns of mean precipitation; the areas of lower precipitation exhibit greater coefficients of variation and vice versa. It is interesting to note that, in comparison with equivalent latitudes west of the Cascades, monthly and summer coefficients of variation are definitely higher but winter and annual values are about equal to the western area.

The coefficient of variation is an extremely informative statistic. Although it is a "normalized" measure of variability it is still a function of the mean, making spatial comparisons difficult. Additional information can be obtained by developing a regression relationship between the mean and the coefficient of variation and calculating residuals. For annual data the coefficient of variation decreases with increasing precipitation to a value of about 50 inches, beyond which it changes but little. A curve fitted mathematically to the data yielded an expected high relationship ($r^2 = 0.56$). Residuals from the regression were calculated and plotted for all stations in the network. The same procedure was followed for winter ($r^2 = 0.44$) and summer ($r^2 = 0.51$) data.

The maps of the residuals (Figure 15) highlight some very interesting aspects of interannual variability in the Pacific Northwest. Residuals are interpreted as follows: positive values indicate coefficients of variation higher than expected for the mean precipitation, i.e. high relative variability; negative values indicate low relative variability. Residual values greater than +0.02 or less than -0.02 are considered to be significantly different than zero and only regions of this magnitude are outlined.

Residuals for annual precipitation reveal a rather complex pattern west of the Cascades. High relative variability is apparent in the southern Willamette Valley (e.g. Eugene WSO AP +0.04), through the Umpqua River Valley and into the interior valleys of southwestern Oregon (e.g. Grants Pass +0.05). In contrast, the northern Willamette Valley and much of the Puget Lowland are areas of low relative variability. Low values also prevail in the coastal margin although in most cases absolute values are not as large as in the Puget Sound area. There appears to be no correlation with latitude nor with mean annual precipitation.

Figure 15.

Map Series of Relative Variability of Seasonal and Annual Precipitation, Expressed by Residuals from the Regression of Coefficient of Variation as a Function of Mean:

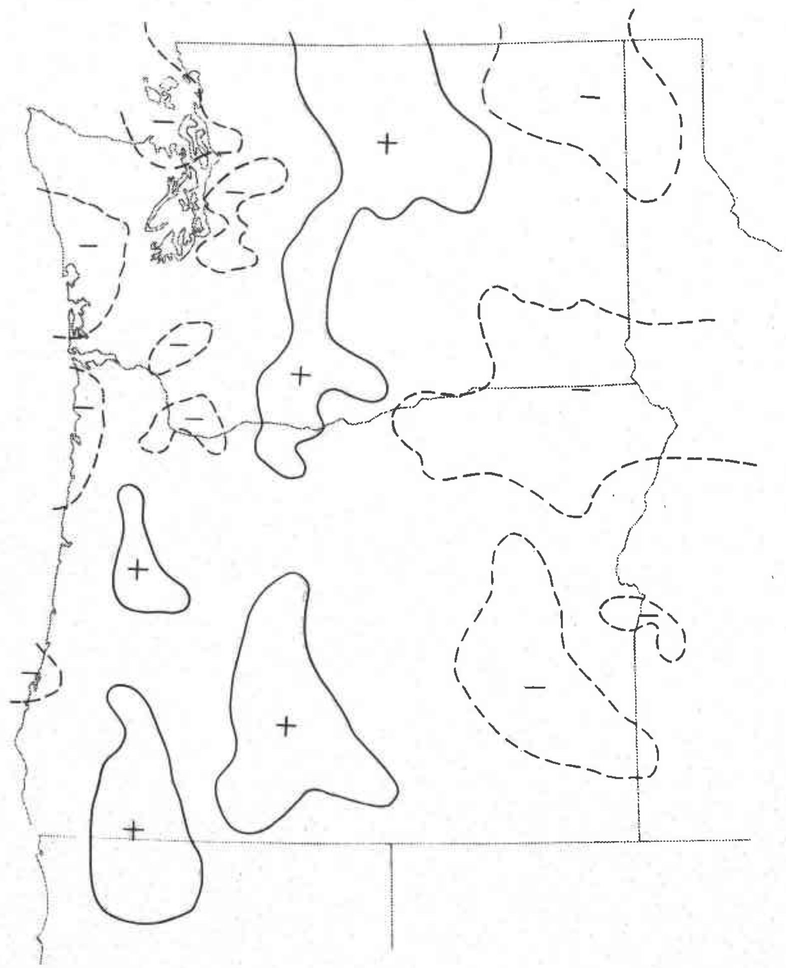
a) Annual (Water Year)

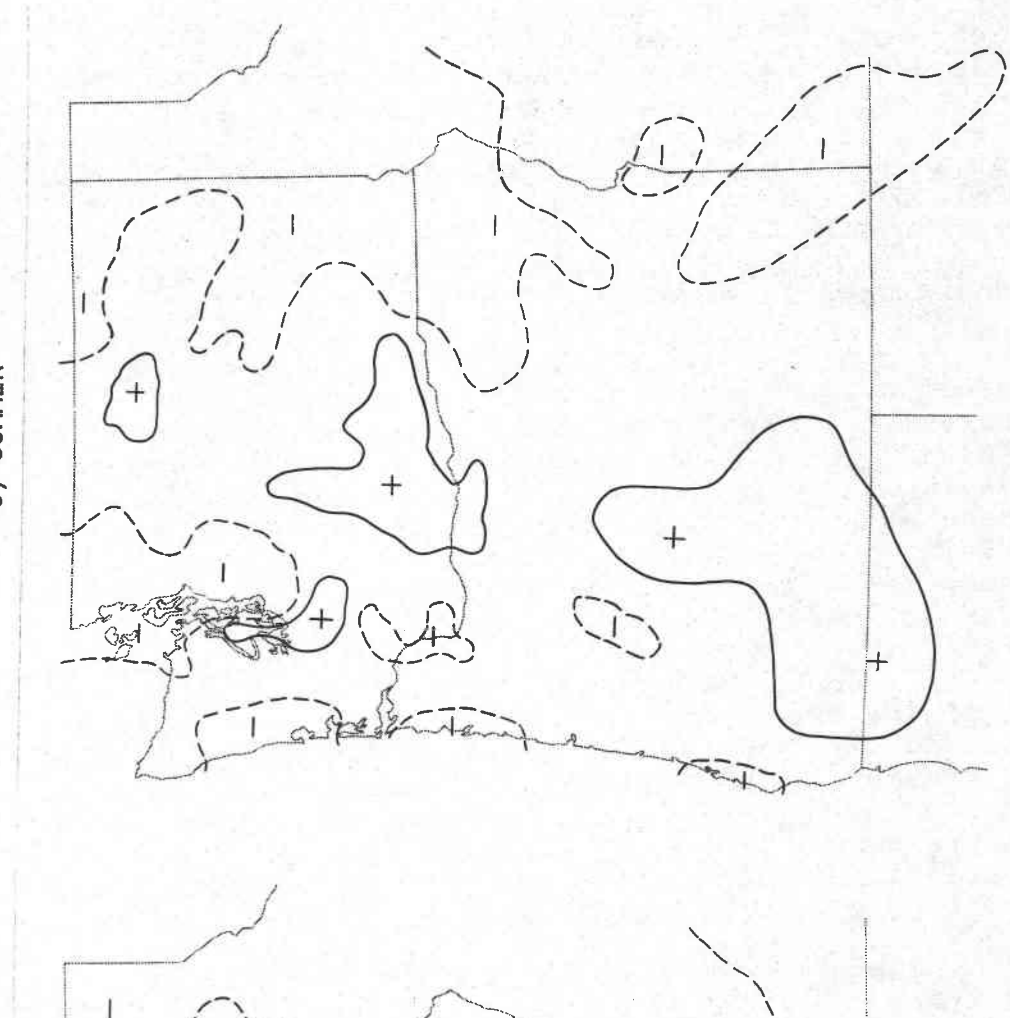
b) Winter

c) Summer

Note: Areas noted as positive are those with high relative variability, residual values greater than +Ø.Ø2. Areas noted as negative are those with low relative variability, residual values less than -Ø.Ø2.

a) ANNUAL (WATER YEAR)





b) WINTER

c) SUMMER

East of the Cascade divide the pattern is more distinct and a dramatic contrast exists. A broad strip including the eastern flank of the range and adjacent areas from Canada to northern California has uniformly high relative variability, residual values ranging from +0.03 to +0.09. Some of the highest values are found at stations just east of the Columbia Gorge. In the north this region of high relative variability extends into the western Okanogan Highlands (e.g. Nespelem 2 S +0.06) and in the south it extends into south central Oregon.

From north to south throughout the eastern third of the Pacific Northwest is a broad region of uniformly low relative variability, residual values ranging from -0.02 to -0.05. Three areas stand out on the annual map: the eastern Okanogan Highlands, the major portion of the Blue Mountains and southeast Oregon including the Snake River Plain. Absolute values of these negative residuals are comparable to those of the interior lowlands west of the Cascades and appreciably higher than those along the coast.

Seasonal concentration of precipitation partially explains the pattern of low relative variability in eastern Oregon and Washington. Late spring and early summer rains contribute a significant percentage to annual totals, thus there are essentially two rainy seasons. However, a correlation between seasonal concentration and relative variability for the rest of the Pacific Northwest is difficult to substantiate.

The distribution of residuals for the winter season differs little from the annual other than having consistently higher absolute values -- as high as +0.14 (Dallesport FAA AP) just east of the Columbia Gorge. The dominant area of high relative variability in winter is in southwest and south-central Oregon, from the Rogue River Valley across the Cascades as far as Lakeview 2 NNW (+0.04).

In summer, as expected, there are greater departures from the annual pattern. Along the Oregon coast are positive residuals, indicating high relative variability. Values range as high as +0.11 (Gold Beach R.S.) on the southern Oregon coast. At the other extreme is Neah Bay 1 E, Washington, with a value of -0.05. Other extensive areas of high relative variability are through the Klamath Mountains of southwest Oregon and in north central Washington east of the Cascades into the Okanogan Highlands. In the western part of the Okanogan Highlands residual values are extreme (e.g. Nespelem 2 S +0.19).

Extensive areas of low relative variability in the summer are found in extreme northwest Washington from the coast to the North Cascades and also in the northern Oregon Cascades. East of the Cascades the area combining the lower Columbia Valley just east of the gorge and the Yakima Valley has the largest negative values (e.g. Dufur -0.15 and Arlington -0.16) in the Pacific Northwest. Eastward the extensive north-to-south belt from the Canadian border through the eastern Okanogan Highlands, along the eastern edge of the Palouse Hills, the eastern Blue Mountains and southward to the Snake River Plain and the Owyhee Uplands has negative values ranging from -0.02 to -0.10.

The discussions that follow in the remainder of this chapter describe in more detail precipitation patterns in the Pacific Northwest but do not explain satisfactorily these observed patterns of relative variability. It is an interesting problem that demands further study.

PRECIPITATION REGIONS

In the preceeding section broad patterns of precipitation and its interannual variability in the Pacific Northwest were described in terms of major climatic controls. Local details are best considered in the context of homogeneous climatic regions; that is, distinct geographic areas within which controls interact so as to produce precipitaion similarities. One of the primary purposes for the identification of homogeneous regions is to permit the characteristics at individual stations to be interpreted as more representative of a larger area, thus being more useful in the study of trends and cycles in the data.

Distinct climatic regions have not been adequately defined for the Pacific Northwest although there has been some interesting work toward this end. Sneva and Calvin (1978) developed an improved thiessen grid system for eastern Oregon precipitation based on interstation correlations. Miller et al (1973) developed relationships between precipitation-frequency values and climatological and topographic factors at observing sites.

A favorite approach among climatologists in recent years has been principal components analysis. The obvious value of the methodology is that it can be used to reduce large arrays of data to delineate homogeneous regions and to more effectively document changes over space and time. Several interesting regional studies have been successfully completed with this technique. For example, precipitation patterns have been described in Nevada (Stidd 1967), Arizona (Johnson 1980), southeast Australia (Wright 1974) and New Zealand (Salinger 1980). Sellers (1968) used the approach to determine precipitation anomaly patterns for the entire western United States for each month and Skaggs (1975) described the spatial pattern of drought in the American Midwest.

In the course of this study attempts have been made to delineate homogeneous regions in the Pacific Northwest. The task is not yet accomplished to our satisfaction and will be described in another report. Fortunately for the discussion that follows there exists a natural and logical division of the Pacific Northwest into regions of precipitation similarity -- the geomorphic regions of Oregon and Washington (Figure 16).

Annual profiles of monthly mean precipitation and monthly coefficients of variation have been prepared for the subset of 43 stations. These profiles are grouped together, by region (in Figure 18, beginning on page 84). Trewartha (1981) used annual profiles of precipitation to typify climates throughout the world. Here we consider the Pacific Northwest in greater detail and include profiles of the coefficient of variation. The study of these profiles as well as those from other stations should answer many questions concerning the spatial distribution of precipitation and its associated variability in the Pacific Northwest but it also raises many questions that require more examination. The discussion that follows is in no way complete but is intended as background for subsequent work.

Olympic Mountains - Coast Range

Located on the peninsula west of Puget Sound the Olympic Mountain Range is a compact elevated structure, heavily glaciated and maturely dissected with sharp ridges and deep valleys. The differences in elevation, from a few hundred to almost 8,000 feet, and the great contrasts in precipitation have produced a diverse pattern of vegetation. Thick stands of conifers dominate the lower and intermediate slopes but give way to areas of subalpine vegetation in the higher elevations. The range of annual precipitation is greater here than for any region in the Pacific Northwest. Western slopes receive very heavy precipitation, as much as 200 inches in some locales, while on the lee side of the mountains are areas with less than 20 inches per year, the driest of any Washington stations west of the Cascades.

South of the Olympics the Coast Range extends to the vicinity of Port Orford on the Oregon coast where it joins the geologically older Klamath Mountains. The range has a relatively simple structure, consisting primarily of moderately upfolded marine sediments. Summit elevations are not impressive although there is a general rise southward from the Chehalis River in Washington to elevations of 3,500 feet adjacent to the Klamath Mountains. Along the western margins in Washington the range is separated from the Pacific Ocean by a lowland that narrows and becomes discontinuous in Oregon where the coastline is one of great

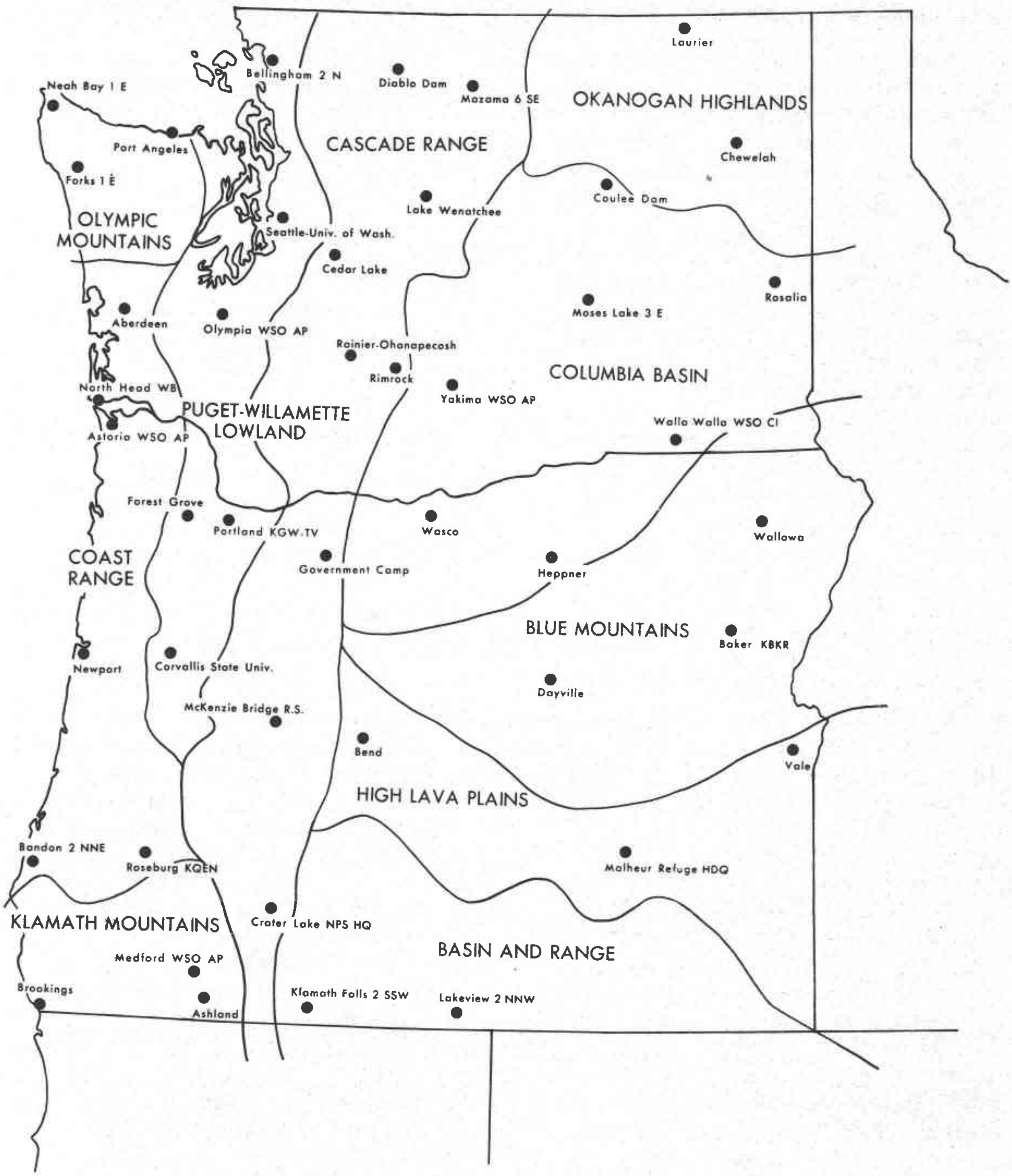


Figure 16. Geomorphic Regions of the Pacific Northwest (after Thornbury 1965 and Highsmith 1973) with 43-Station Subset of Network.

contrast between low sandy beaches and rugged basaltic headlands.

To the east the Coast Range descends to the Puget-Willamette Lowland and stands as a barrier to moisture-bearing air masses from the Pacific. Annual precipitation is abundant along the coast and even greater on the higher western slopes (up to 150 inches) but declines abruptly (35 to 45 inches) in the lowland to the east. The combination of mild temperatures and adequate moisture has permitted the growth of dense coniferous forests with relatively little change in forest composition from north to south or from the coast to the interior lowlands.

The coastal margin of the Pacific Northwest is a typical marine west coast climate, characterized by moderate temperatures with a modest range for its latitude, heavy cyclonic precipitation and a high degree of cloudiness. For the entire coastal margin, and in a modified form throughout all of western Oregon and Washington, at least three features of precipitation are common (Trewartha 1981):

a. there is a conspicuous single maximum in the annual profile of precipitation which occurs in winter;
b. a marked single minimum occurs in the summer; and
c. the month of maximum precipitation is a function of latitude.

These features are all related to the seasonal migration of the North Pacific subtropical high as described in the previous section. Church (1954) believed that North Head WB station, just north of the mouth of the Columbia River, most closely represents a pure form of the coastal precipitation pattern; i.e. one without orographic influence. North Head was not included in this data network because the station closed in 1962. However, the annual profile of precipitation is included in Figure 18 with data for the period 1931-1960.

The most striking characteristic of this profile is the symmetry around December, the wettest month, and July, the driest. At the other coastal stations mean annual precipitation is considerably more than at North Head due to the lifting of maritime air masses by highlands and the character of the annual profile varies with latitude. At stations in Washington and northern Oregon it is very symmetrical around December. At Bandon 2 NNE and Brookings on the southern Oregon coast annual profiles are less symmetrical with essentially no difference between mean amounts for December and January. This change reflects the seasonal progression of the month of precipitation maximum, a distinctive feature of the entire coastal margin of North

America. It occurs later with decreasing latitude, from Anchorage, Alaska (latitude 56°N, maximum rainfall in September), to Northern Baja California (e.g. Ensenada at latitude 32°N, maximum rainfall in February). Oregon and Washington (latitude 42° to 49°N) fall within this progression. The shift is related to the southward shift of the mean jet stream and associated Pacific cyclone track.

Annual profiles of variability also exhibit a north to south pattern in the coastal margin although they are more erractic and difficult to explain. On the Washington and northern Oregon coasts December, the wettest month, is also the month of least interannual variability. Such is not the case on the southern Oregon coast where March is the least variable month even though four other winter months are wetter. The significance of March variability is noted also in northern Washington. At Neah Bay 1 E and Forks 1 E it is the second least variable month after December. Yet at Aberdeen and Astoria WSO AP April stands out over March as a month of surprisingly low variability. This decrease in coefficients of variation in the spring months is difficult to explain and requires further study of cyclonic storm patterns.

The relationship between monthly means and coefficients of variation in the summer is more predictable. July is the driest month throughout the coastal margin in response to the time of maximum strength and northward displacement of the North Pacific subtropical high. Variability is at a maximum in July and August. High values of the coefficient of variation in July are a function of the extremely low rainfall totals but August values are attributable, in part, to the intermittent presence of weak frontal systems which may bring relatively large amounts of rainfall some years whereas August in other years is completely dry.

Puget-Willamette Lowland

The Puget-Willamette Lowland, the only large lowland west of the Cascades, is approximately 350 miles long by 50 miles wide and extends from the Canadian boundary through Washington and into Oregon as far south as Cottage Grove. It is a structural trough downfolded between the major anticlines of the Coast Range and the Cascades, is partially filled by sediments from the ranges and is an area of low elevation and modest relief. The Puget Sound area in the north differs from the Willamette Valley in that it has been glaciated. An expression of this is the irregular form of Puget Sound which inundates a sizeable area and by the covering of glacially deposited sands, gravels and clays that has restricted crop agriculture to the recent alluvial deposits of the river valleys. In contrast, the extensive alluvial deposits of the Willamette Valley have provided a much larger area suitable for intensive farming. Both areas are handicapped by dry summers that require increasing reliance on irrigation water provided by the melting snows of adjoining mountain ranges.

Situated to the east of the Olympics and Coast Ranges, stations of the Puget-Willamette Lowland exhibit annual profiles of precipitation which are basically similar to those at coastal stations. The same strong annual type of variation is immediately apparent with December the wettest month throughout and, as in the coastal margin, profiles are more symmetrical to the north. However, the increasing influence of topography can be seen in the fact that annual profiles are not as symmetrical as at coastal stations of similar latitudes.

Mean annual precipitation is considerably less than in the mountains on either side or in the coastal margin, generally one-half or less at equivalent latitudes. Rainshadow effects are greatest in the northern part of the Puget Sound area. Stations immediately to the lee of the Olympics have very modest amounts of annual precipitation; for example, Port Angeles with 24.65 inches and Sequim (not shown) with 15.97 inches. The entire Puget sound area is one of reduced rainfall but south of Tacoma the lower and less continuous nature of the coastal mountains permits the freer entrance of marine air from the Pacific. Olympia WSO AP is illustrative. Here the mean annual precipitation is 49.14 inches compared to Seattle-Univ. of Washington (35.36 inches) and Bellingham 2N (34.32 inches). South through the Willamette Valley slightly lower amounts of annual precipitation are recorded in comparison to Olympia WSO AP because of the higher coastal mountains.

There exists also a north-to-south gradient in the amplitude of annual profiles. With decreasing latitude the difference between the wet winter months and dry summer months becomes greater. An interesting comparison can be made between Bellingham 2N (latitude 49^{O}N) and Corvallis-State Univ. (latitude 44.5^{O}N). Bellingham 2N receives 13.56 inches in the three wettest months of November-December-January, 4.23 inches in the three driest months of June-July-August. In contrast, Corvallis-State. Univ. has 20.05 inches in the three winter months and only 2.21 inches in the three summer months.

The annual progression of coefficients of variation for stations in the Puget-Willamette Lowland is almost identical to the coastal region and predictably so as interannual variation is due to the same interannual fluctuations in the controlling features of the general circulation. To the north December is decidedly the least variable month while in Oregon there is more consistency among all the wetter winter months. Low values of the coefficient of variation in the spring months of March and April, a feature noted on the coast, is also apparent here. July and August are the months of greatest variability.

Klamath Mountains

Located in the southwest corner of Oregon, the Klamath Mountains adjoin the Coast Range to the north and the Cascades to the east. They can be distinguished from the other two mountain ranges by their older rocks, a more complex geologic history and their greater dissection. The Klamaths are composed of structures of old igneous and metamorphosed materials that have been severely eroded, resulting in high sharp ridge crests and deep narrow valleys. Summit levels have a general similarity of elevation, varying from 3,000 to 5,000 feet, while above them are higher peaks rising to almost 8,000 feet.

Annual precipitation in the mountains varies from 30 to 90 inches and the slopes are largely forest covered. But the Klamath Mountains are higher than the coast ranges (with the exception of the Olympics) and thus the southern Oregon valleys such as that of the Rogue River receive considerably less annual precipitation than the Willamette Valley; for example, Ashland (mean annual precipitation = 19.61 inches) and Medford WSO AP (19.97 inches). In the latitude of southern Oregon the effects of the Pacific high are stronger so lower rainfall amounts are not unexpected.

Although mean annual precipitation is modest the annual profiles are still typical of the marine west coast pattern with December the wettest month and July the driest. However, some aspects of these profiles suggest a stronger continental influence than experienced in the Puget-Willamette Lowland. For example, Ashland receives a larger percentage of annual precipitation in the spring as compared to Brookings, a coastal station at the same latitude. This tendency toward a secondary maximum in the spring is a characteristic of much of eastern Oregon where the continental influence is strong.

Coefficients of variation are, as in the Puget-Willamette Lowland, much the same as at coastal stations at similar latitudes. December, the wettest month, is certainly not the least variable; at Ashland, February is least variable and at Medford WSO AP it is January. This is the same absence of relationship between mean and coefficient of variation noted at stations on the southern Oregon coast.

Cascade Range

The Pacific Northwest portion of the Cascades extends for 500 miles from Canada to California and separates a mild, moist western climate from a cooler, drier east. In Washington the range is a broad uplifted structure that has been deeply eroded by Pleistocene glaciers and rapidly flowing streams. The Oregon Cascades are relatively narrow in east-west extent, have not been as severely glaciated and have much more volcanic rock in the structure with older lava exposed along the flanks and younger flows and fragments strewn along the crest. While there are differences in geologic structure, size and rock type the entire length of the Cascades is surmounted by a string of high, young and potentially active volcanoes, from Mt. Baker in the north to Mt. McLoughlin in southern Oregon.

Being considerably higher than the coast ranges, the Cascades present a major barrier to marine air masses and are a region of heavy precipitation, particularly along the western slopes. A "spillover" effect causes high amounts of precipitation also on the upper eastern flanks. Although precipitation is generally heavy throughout the range amounts vary greatly with differences in elevation and exposure. The heavy precipitation supports the growth of coniferous forests over most of the range. Species vary as temperatures are modified with increased elevation on western slopes and as precipitation lessens with decreased elevations on the lee slopes. Along the crest and on the higher slopes of the major volcanoes are discontinuous areas that extend above timber line and exhibit a tundra vegetation complex up to areas of permanent ice and snow.

High values of monthly, seasonal and annual precipitation on the western side of the Cascades are due not only to the lifting effects of the highlands but to the fact that the mountains delay the progress of cyclonic storms thereby increasing the duration of rainfall. Much of the precipitation at higher elevations occurs as snow and accumulations are among the greatest in the United States. In fact, during WY 1972, 1122.0 inches of snowfall were recorded at Rainier-Paradise Ranger Station (elevation = 5,427 feet), the largest snowfall ever recorded in the United States (Brennan 1981).

Unfortunately, precipitation amounts are difficult to determine for many areas in the Cascades since long term stations are few and totals may vary greatly within short distances as elevations and exposures change. For the most part, stations are located at lower elevations and in relatively well protected valley sites. Of the stations illustrated for this region, Lake Wenatchee, Mazama 6 SE and Rimrock (Tieton Dam) are east of the crest; the others are on the wet western flanks. Even these are not completely representative of the high amounts of precipitation received in some areas. Cedar Lake is the wettest with 102.70 inches annually but there are certainly areas in the northern Cascades where annual totals approach 130 inches. In general, as illustrated by our examples, there is a decrease from north to south.

Other than the obvious differences in magnitude, the annual profiles of precipitation in the Cascades are essentially the same as those for stations at similar latitudes in the Puget-Willamette Lowland. December is the wettest month and July the driest. But there are significant changes in the annual profiles that are a function of latitude. For example, the rainy season begins earlier at higher latitudes and stations in the northern Cascades have relatively higher amounts of precipitation in the fall and early winter. A comparison between Diablo Dam, Washington, and McKenzie Bridge R. S., Oregon, will illustrate. These two stations are similar in mean annual precipitation and in elevation and exposure.

	September-December	March-June
Diablo Dam	39.93 in.	16.05 in.
McKenzie Bridge R.S.	31.02 in	18.69 in.

Early season precipitation is considerably higher at the northern station, but late season precipitation is greater at the southern station. Other stations in the region support this north-to-south difference, a pattern also observed in the annual profiles of coastal stations and throughout western Oregon and Washington. The relationship is difficult to explain. Surely the early season pattern is caused by the expansion of the circumpolar vortex and the associated frequency of cyclonic storm systems but the late season pattern is less clear. Trewartha (1981, p. 301) explains:

> The seasonal shift of the jet poleward in spring and summer does not seem to occur in a steady manner as in the southward movement in the fall and winter, but instead one jet appears to wane in the south in late winter while another develops near the Arctic Circle.

Another explanation, in part, may be the increased convective activity along weak fronts in the spring months when temperatures are higher. On the other hand, summers are drier in the southern portions of the region. McKenzie Bridge R. S. receives 1.74 inches in July and August compared to 3.08 inches at Diablo Dam.

There exists also a clear north-to-south pattern in the annual progression of coefficients of variation. In Washington December is decidedly the least variable month and the amplitude of the annual profile is small. At Diablo

Dam the coefficient of variation in July is 0.60 and in August is 0.65, only slightly more than the 0.53 in January and 0.56 in February. With decreasing latitude the coefficient of variation in December, the wettest month, increases and the amplitude of the profile increases. Note the relatively high values in July and August for the more southern stations.

Annual profiles of precipitation and coefficients of variation for the stations on the east slope are essentially the same as those on the west, other than the obvious decrease in precipitation totals. An exception is the slight tendency for a secondary maximum of precipitation in May and June at Mazama 6 SE. This feature, typical of much of eastern Oregon and Washington, will be discussed later.

The Cascade Range serves as a transition between the climate to the east and that to the west. For the western region as a whole the annual progression of monthly means and coefficients of variation is best expressed in the coastal margin where differences can be clearly explained in terms of latitude. Annual profiles are modified only slightly from the coast to the Cascade Range by the complex influences of topography.

East of the Cascades modifications from the initial pattern become more profound. An excellent introduction to the climate of the Pacific Northwest east of the Cascades is given by Trewartha (1981, p. 305) in his description of the larger Intermontane Region:

> Situated as it is between the Rocky Mountains to the east and the Pacific Coast Mountains to the west, this extensive Intermontane Region is in the rainshadow of highlands. Except at higher elevations it is, therefore, a region of modest precipitation, much of it being classified as steppe or semiarid, although some parts are generally arid and others, chiefly in the north or at higher elevations, subhumid.

A dominant feature of annual precipitation profiles is the biannual variation. One maximum occurs during the winter season, coincident with the rest of the Pacific Northwest, and a second during the warm season although it is quite variable in time of occurrence. The Intermontane Region thus represents a transition between the area of strong winter maximum of the Pacific coastal regions and the marked summer maximum typical of the great continental interior east of the Rocky Mountains. Local variations in total amounts of precipitation and in the annual profiles of precipitation and coefficients of variation are due to the interaction of latitude, relief and distance from the Cascades. Eastern regions of the Pacific Northwest are discussed below from north to south.

Okanogan Highlands

The Okanogan Highlands, extending across the northern section of Washington from the Cascades eastward into Idaho, are a westward extension of the Rocky Mountains containing an old uplifted erosion surface considerably dissected by streams and glaciers. Summit levels are from 4,000 to 5,000 feet, above which rise peaks to elevations over 7,000 feet. Bedrock is a combination of lavas, granitic and metamorphosed materials and mineral deposits are widely distributed. Five major north-south trenches traverse the region and contain the major centers of population and most of the important agricultural production. Moderate amounts of precipitation occur at higher elevations but the valleys receive more modest amounts and irrigation is necessary for such intensive agriculture as the apple production in the Okanogan Valley. Coniferous forests dominate the higher landscapes but give way to a bunch grass-sage complex on lower southern slopes and in the lowlands where elevations may be less than 1,000 feet.

The winter portion of annual profiles of precipitation and coefficients of variation is very much like those of stations west of the Cascades -- that is the profiles are symmetrical about December, the wettest month. December is also generally the least variable month although this feature is not as pervasive as in western Washington. In fact, at Chewelah coefficients of variation are nearly equal in December, January and June. Also obvious is the aforementioned secondary maximum of precipitation in late spring-early summer. At Laurier on the Canadian border, for example, the months of May and June are nearly as wet as the wettest winter months.

The timing of this secondary maximum is coincident with movement of the Pacific anticyclone. A rapid large-scale shift of the general circulation takes place in most years in early July and the center of the Pacific High shifts from about latitude 34° North to approximately 40° North (Figure 17). In May and June the region escapes effects of subsidence and the interior of Washington and Oregon is characterized by low pressure at the surface and an upper level trough which induces a flow of maritime southwesterly air from the Pacific Ocean. The short wet season of late spring-early summer is the result. With the abrupt change in circulation in July anticyclonic control becomes more dominant and precipitation is reduced. Low values of the coefficient of variation in May and June are associated with these wetter months. The amplitude of the annual profile of coefficients of variation is relatively small, similar to those for northern Washington stations west of the Cascades.

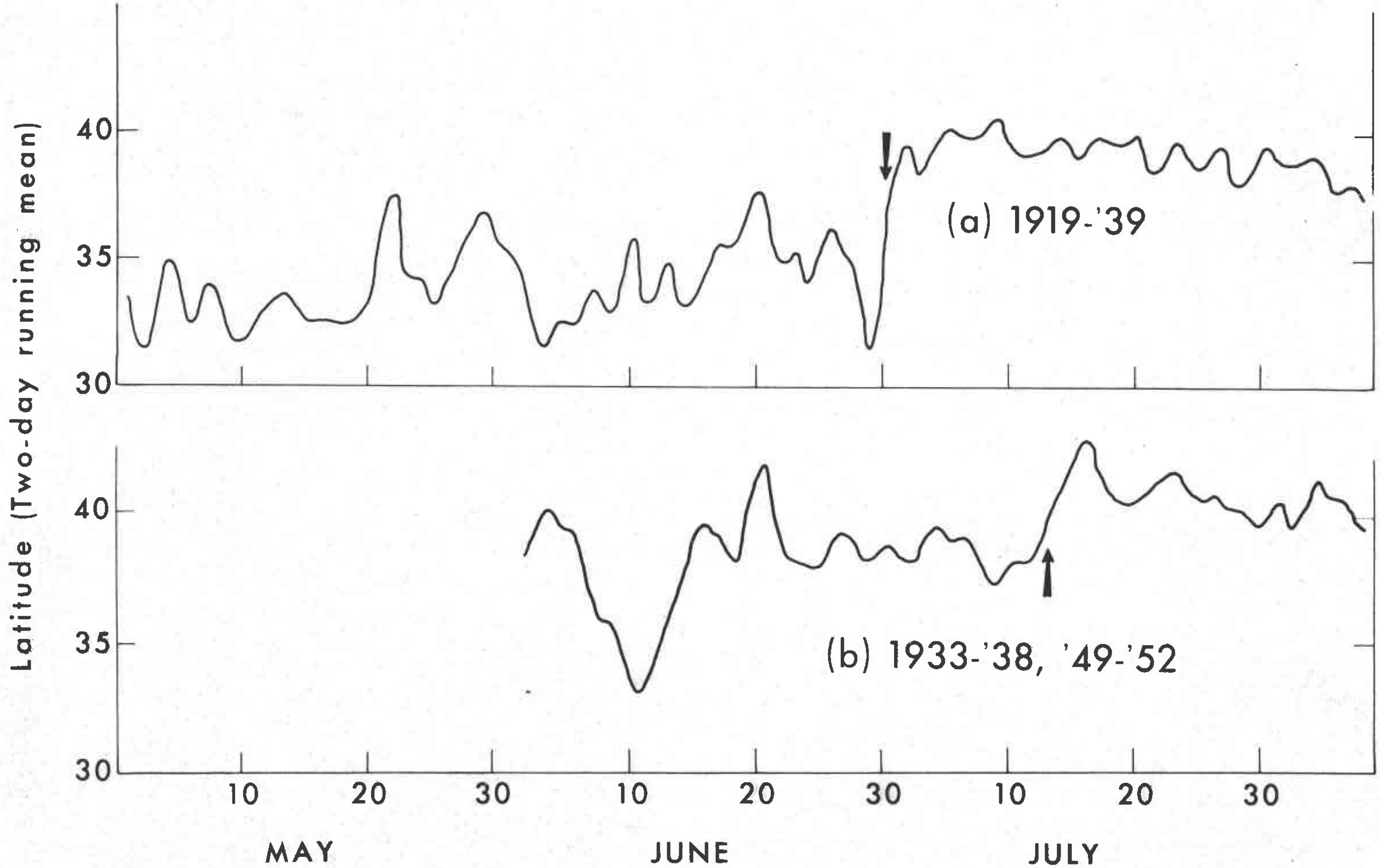


Figure 17. Two-Day Running Latitude of the Eastern Pacific Anticyclone: Two Series (a) 1919-1939, and (b) 1933-1938, 1949-1952; with Two Definitions (Bryson and Lowry 1955).

Columbia Basin

South of the Okanogan Highlands and east of the Cascades is an extensive region, the Columbia Basin, subdivided by geomorphologists into five areas. The Central Plains is a low saucer-shaped depression floored by basaltic lavas and covered by detritus. At somewhat higher elevations and with greater relief are the Waterville Plateau in the north, the Palouse Hills to the southeast, the Yakima Folds to the west and the Deschutes-Umatilla Plateau to the south -- south of the Columbia River in north central Oregon. Lower elevations than in surrounding regions, bedrock formed of basaltic lavas and low amounts of annual precipitation are characteristics shared by all of these subregions.

The entire region is characterized by low precipitation, less than in the Okanogan Highlands to the north, but there is considerable variation in annual amounts and the pattern of distribution is relatively complex, affected by elevation, exposure and the opposing influences of the Cascade barrier and the Columbia River gorge. Lowest precipitation amounts occur where the elevation is low, the area enclosed and the influence of the Cascade barrier is the greatest. Yakima WSO AP (elevation = 1064 feet), for example, has a mean annual precipitation of 7.90 inches. Moses Lake 3 E (elevation = 1208 feet) in the lower portion of the Central Plains, receives 8.23 inches. In the Yakima Valley and the Central Plains irrigation is essential for crop agriculture.

Other parts of the region have sufficient precipitation to support extensive wheat production and livestock grazing in areas of rougher terrain or less arable soils. Rosalia, on the eastern edge of the Palouse Hills, receives 18.02 inches and Walla Walla WSO CI, although at lower elevation, receives 16.63 inches -- being favored by marine influences through the Columbia River gorge and perhaps some orographic effects of the Blue Mountains. On the Deschutes-Umatilla Plateau in north central Oregon annual precipitation is slightly less (Wasco and Heppner).

Annual profiles of precipitation and variability are similar to those for stations of the Okanogan Highlands. The winter maximum is still the primary one and there is a strong secondary maximum in May and June. However, the profiles show more complexity, due in part to the presence of the Columbia River gorge. At Wasco the secondary maximum is almost nonexistent, more typical of regions west of the Cascades. At neither Wasco nor Heppner is December the wettest month. At Heppner, November and December are approximately equal and at Wasco both November and January receive more precipitation than December. At Yakima WSO AP January is decidedly the wettest month. A good comparison can be made with three stations on roughly the same latitude as Yakima west of the Cascades (Rainier-Ohanapecosh, Olympia WSO AP and Aberdeen). December is the wettest and least variable month at these three as opposed to January at Yakima.

Summer patterns are more consistent. July and August are the driest months and generally the most variable although at Moses Lake 3 E and Rosalia coefficients of variation remain quite high through September. Rainfall in these months is convective in nature and highly variable in both space and time.

Blue Mountains

In its broadest sense the term Blue Mountains includes the hilly and mountainous land of northeastern Oregon and southeastern Washington from the Snake River west almost to Prineville only 30 miles from the Cascades. The region includes a variety of uplands and intervening valleys with relief and elevation increasing toward the central core, the Wallowa Mountains, which have elevations of 10,000 feet and the most spectacular alpine scenery in the Pacific Northwest east of the Cascades.

Increasing elevation results in increased precipitation which is in turn reflected in the change from grasses to shrubs to stands of conifers which cover much of the region. Most climatological stations are located in the protected and lower valleys and it is difficult to determine annual precipitation means for the higher exposed areas but it is thought that amounts must approach 50 inches.

Stations in the Blue Mountains exhibit the form of annual profiles of precipitation and variability typical of all the eastern regions. However, there are some significant differences as compared with stations to the north. The late spring-early summer maximum is generally more dominant. In fact, throughout much of the region May is the wettest month of the year rather than December or January. Of the stations represented in this study this is true at Baker KBKR and at Dayville, but not at Wallowa. However, the secondary maximum at Wallowa is nearly equal in magnitude to the winter maximum.

July is the driest and most variable month at most Blue Mountain stations. Otherwise, the expected inverse relationship between monthly means and coefficients of variation is complex and unpredictable. At Wallowa March is the least variable month although far from being the wettest. Winter months are slightly more variable than May and June, a suggestion of the increasing continental influence and associated higher variability of winter precipitation. Yet, at Baker KBKR, while both May and June are decidedly wetter than any of the winter months, coefficients of variation in May and June are higher. The least variable month at Baker KBKR is February which is the driest month between November and June. At Wallowa the least variable month is March, followed closely by February.

Certainly precipitation patterns in this region over space and time are difficult to generalize. The increased continental influence combines with local conditions of elevation and exposure to account for apparent inconsistencies between monthly means and monthly coefficients of variation.

High Lava Plains

This region lies between the Columbia Basin and the Blue Mountains to the north and the Basin and Range province in the south and extends eastward from the Cascades to the Snake River Plain. Topographically it represents a transition from the Deschutes-Umatilla Plateau to the Basin and Range province and exhibits characteristics of both. The region is underlain by horizontal flows of ancient lavas, largely uneroded and covered by younger volcanic materials or stream deposited alluvium. It is one of the driest regions of the Pacific Northwest and has a large section of interior drainage. Only in the west does the Deschutes River and its tributaries flow entirely through the region.

In the western area the nearly level surface is covered with recent lava flows and volcanic ash deposits above which rise numerous cinder cones, volcanic peaks of moderate height and a number of long low ridges in the northern section. In the Harney area to the east the surface is even more level with broad alluvial plains sloping down to the two major lakes, Harney and Malheur. Elevations in the region range from 3,500 feet in the Deschutes Valley to over 6,000 feet in the south.

Annual and seasonal totals of precipitation are similar to the Central Plains of the Columbia Basin -- low values and only modest changes with elevation and exposure. However, there are some interesting contrasts between the regions. It was noted that in the Columbia Basin there is a general increase in annual precipitation from west to east, in other words the rainshadowing effect of the Cascades is greatest immediately to the lee. In the High Lava Plains the reverse seems to be the case. Stations just east of the Cascades (e.g. Bend, mean annual precipitation = 11.94 inches) receive as much or more than those farther east (e.g. Malheur Refuge HQ, 9.29 inches, and Vale, 9.41 inches) a factor not due to differences in elevation.

Similarities in annual profiles are more obvious, in particular the strong secondary maximum in May and June. An exception is at Bend where the winter maximum is very much dominant due to proximity to the Cascades and the profile for the winter season is similar to that of the Cascades and west, although January is the wettest and least variable month rather than December (as is the case at McKenzie Bridge, Corvallis and Newport).

Farther east, at Malheur and Vale, annual profiles are more irregular. The three wettest months at Malheur, November through January, are essentially equal to May and June in mean amounts. May is the least variable month of the year. July is the driest month throughout the region and either it or August the most variable. Of particular interest at these stations is the month of April. With the exception of July, April is the driest month of the year and exhibits extremely high coefficients of variation in comparison to other winter and spring months. It can be considered the transitional dry period between two wetter periods.

Basin and Range

The Basin and Range region lies south of the High Lava Plains and between the Cascades to the west and the Owyhee Uplands to the east. It includes the northern portion of a larger geomorphic province of similar topography, geologic structure and climate that extends southward to Mexico. The Oregon portion is a land of long, narrow mountain ranges whose axes trend north and south. The ranges are the result of block faulting and are asymmetrical, alternating with broad shallow basins.

The mountain ranges, with steep fault scarps facing either east or west, are formed of layers of lava while the basins are covered with debris washed from the adjoining slopes. These basins are characterized by interior drainage and frequently contain large temporary lakes. Klamath Lake is a major exception to the pattern of interior drainage as it receives a greater and more reliable amount of surface runoff from the Cascades and it is drained by the Klamath River flowing southward into California. The average elevation of the basins is above 4,000 feet and the ranges are 1,000 to 5,000 feet higher.

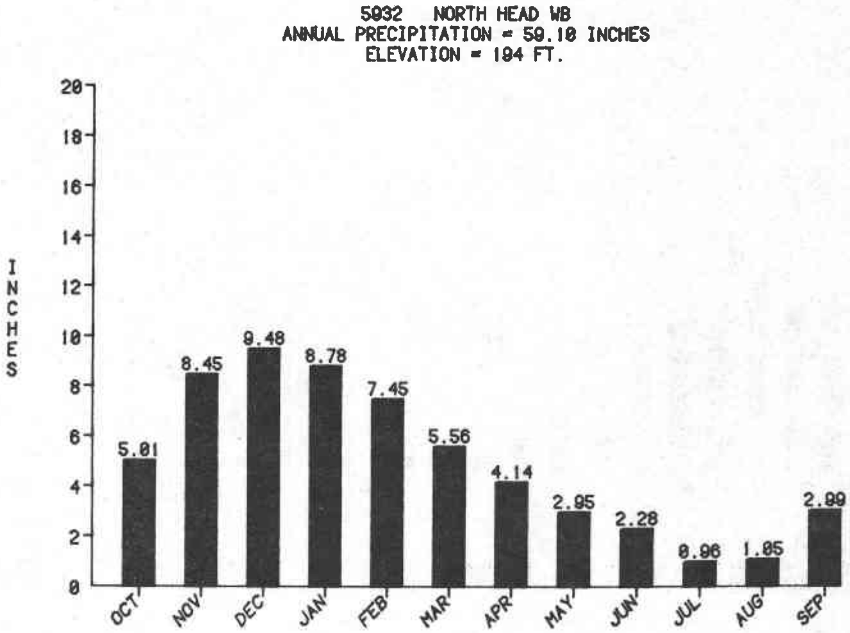
With a short growing season due to high elevations, cold temperatures and low precipitation and few permanently flowing streams to furnish a reliable water supply the possibilites for crop agriculture are limited. Natural vegetation is a grass-desert shrub complex that furnishes the basis for extensive grazing of livestock.

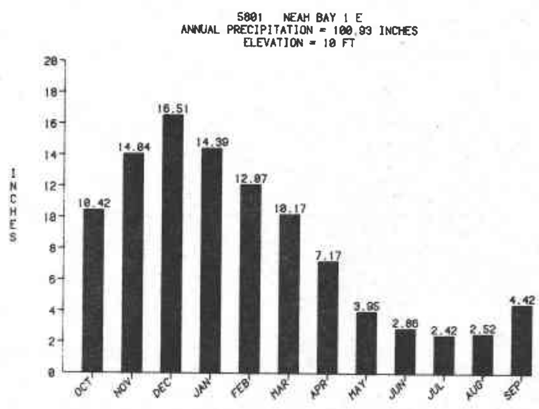
The pattern of precipitation distribution is quite similar to that of the High Lava Plains to the north, although annual totals are generally greater. Precipitation totals seem to decline from west to east although the paucity of long-term station records and differences in elevation and exposure make generalizations difficult. As noted in the annual profiles the winter maximum is dominant -- more so close to the Cascades. To the east, e.g. at Lakeview, the secondary maximum is more pronounced. The month of maximum precipitation varies from station to station, but July is uniformly the driest month. Coefficients of variation in the summer months of July and August are extremely high, but through the rest of the year there is a rather remarkable uniformity of monthly coefficients of variation.

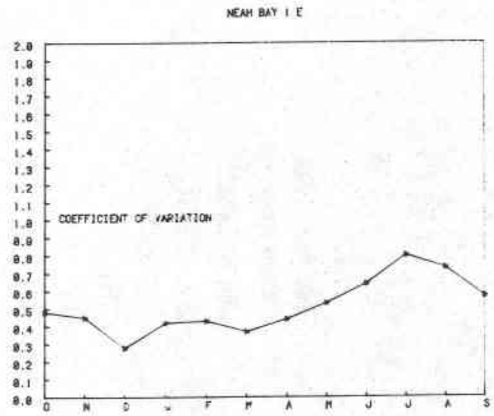
Figure 18.

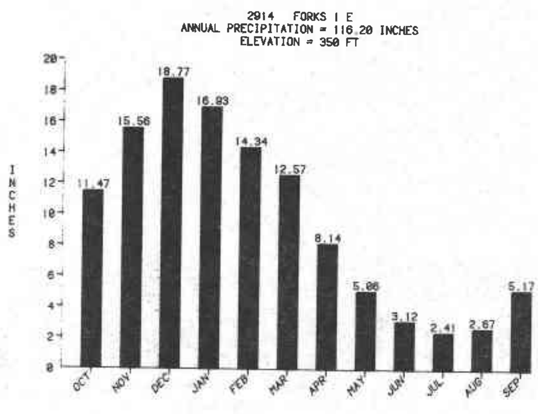
Annual Profiles of Monthly Mean Precipitation and Monthly Coefficients of Variation for 43-Station Subset of Network (1940-1979), Arranged by Geomorphic Region (see Figure 16).

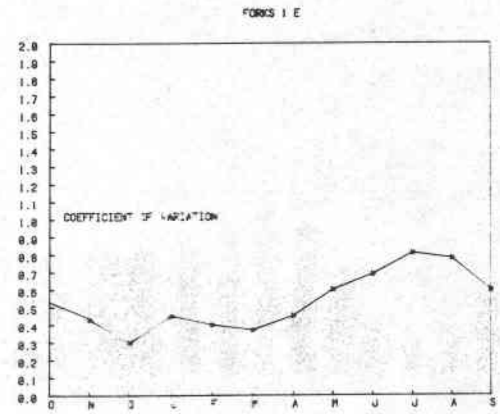
Coast Range—Olympic Mountains

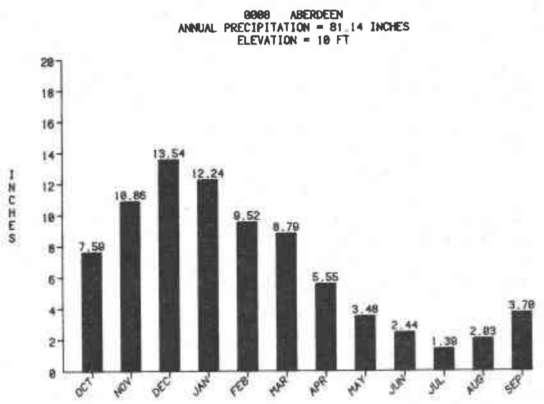


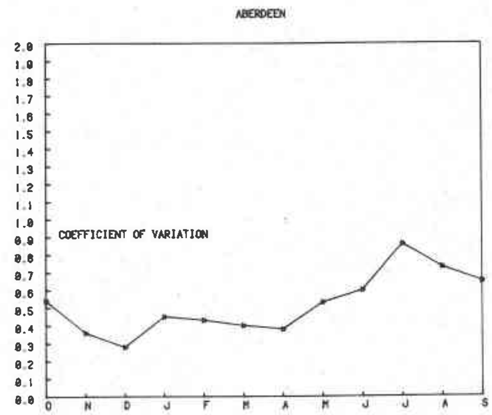


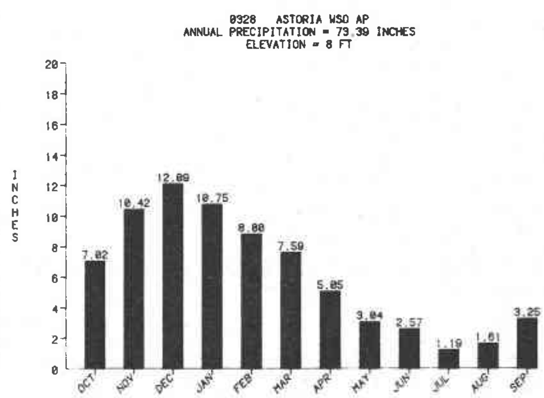


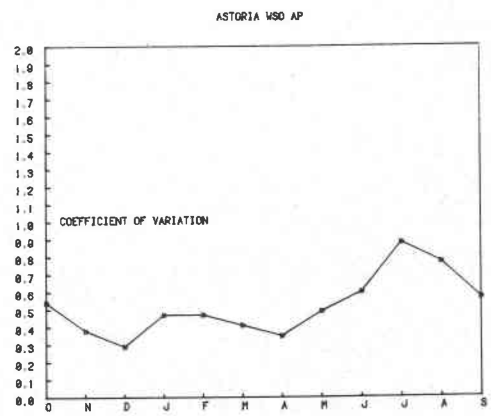


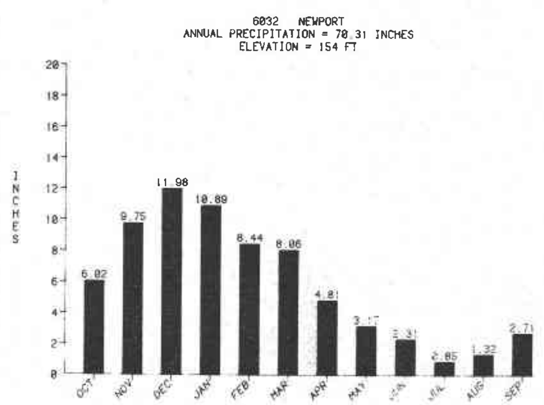


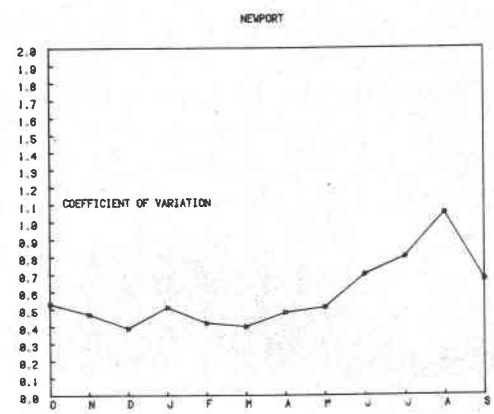

0000 ABERDEEN
ANNUAL PRECIPITATION = 81.14 INCHES
ELEVATION = 10 FT
INCHES
7.59
10.86
13.54
12.24
9.52
8.79
5.55
3.48
2.44
1.39
2.03
3.70
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

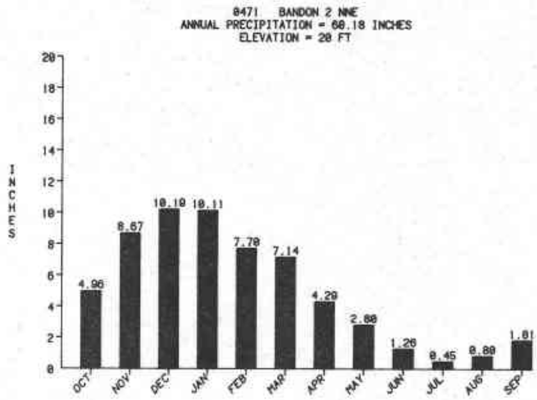

ABERDEEN
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

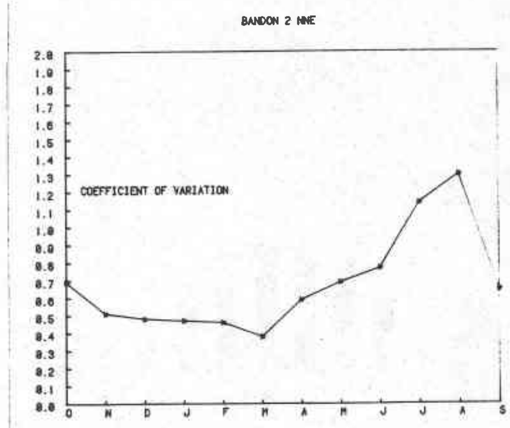

0328 ASTORIA WSO AP
ANNUAL PRECIPITATION = 79.39 INCHES
ELEVATION = 8 FT
INCHES
7.02
10.42
12.09
10.75
8.80
7.59
5.05
3.04
2.57
1.19
1.61
3.25
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

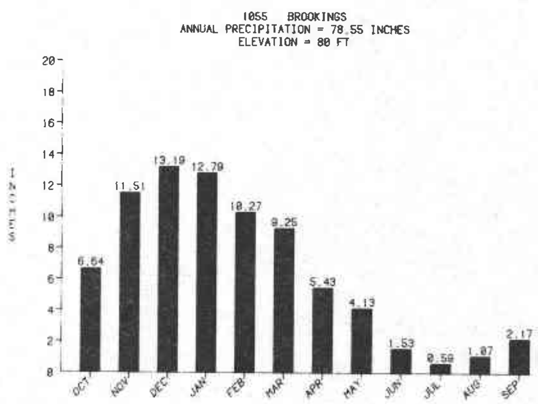

ASTORIA WSO AP
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

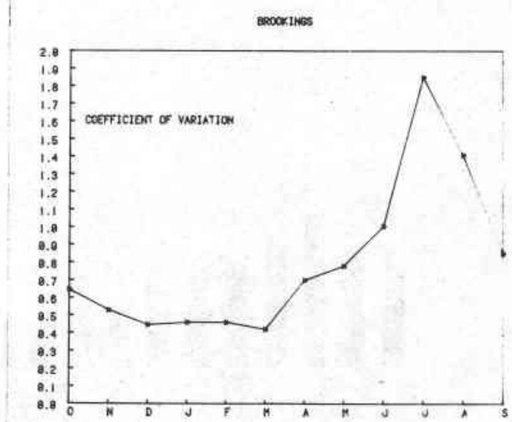

6032 NEWPORT
ANNUAL PRECIPITATION = 70.31 INCHES
ELEVATION = 154 FT
INCHES
6.02
9.75
11.98
10.89
8.44
8.06
1.32
OCT NOV DEC JAN FEB MAR APR MAY AUG SEP

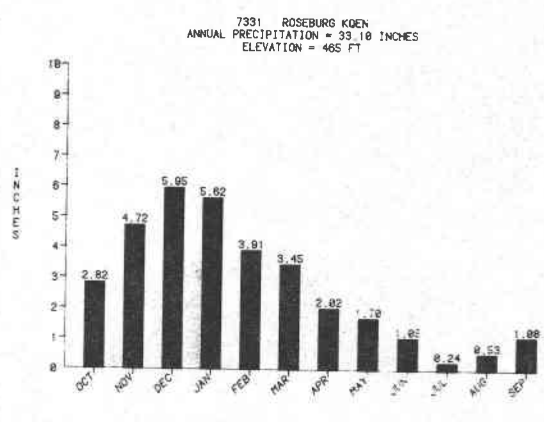

NEWPORT
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

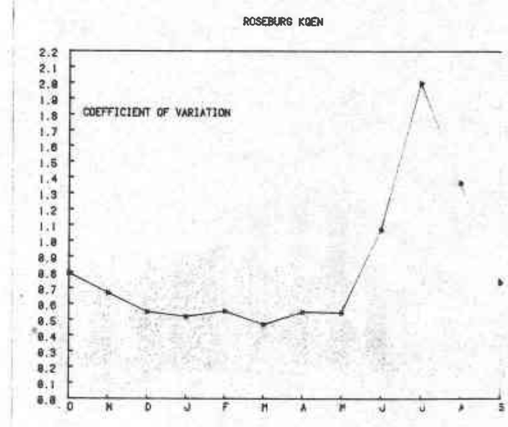

0471 BANDON 2 NNE
ANNUAL PRECIPITATION = 60.18 INCHES
ELEVATION = 20 FT
INCHES
4.96
8.67
10.19
10.11
7.78
7.14
4.29
2.80
1.26
0.45
0.80
1.81
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP


BANDON 2 NNE
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

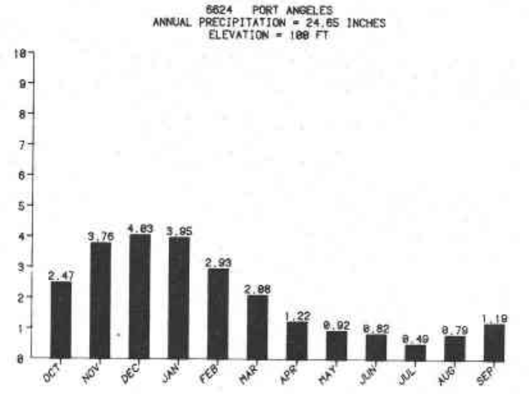

1055 BROOKINGS
ANNUAL PRECIPITATION = 78.55 INCHES
ELEVATION = 80 FT
6.64
11.51
13.19
12.79
10.27
9.25
5.43
4.13
1.53
0.59
1.07
2.17
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

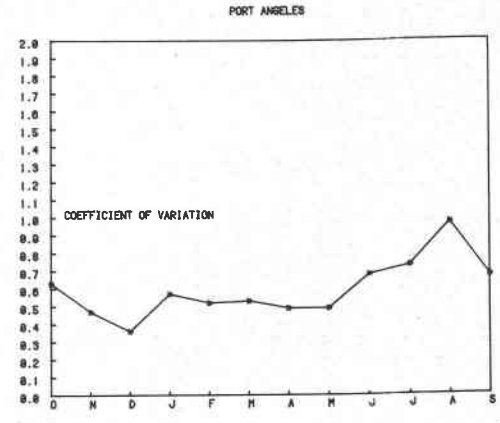

BROOKINGS
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

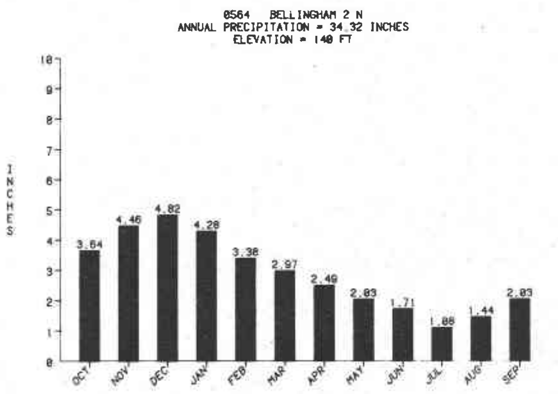

7331 ROSEBURG KQEN
ANNUAL PRECIPITATION = 33.10 INCHES
ELEVATION = 465 FT
INCHES
2.82
4.72
5.95
5.62
3.91
3.45
2.02
1.70
0.24
0.53
1.08
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
AUG
SEP

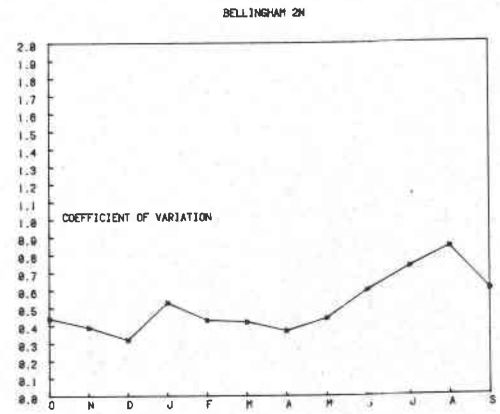

ROSEBURG KQEN
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

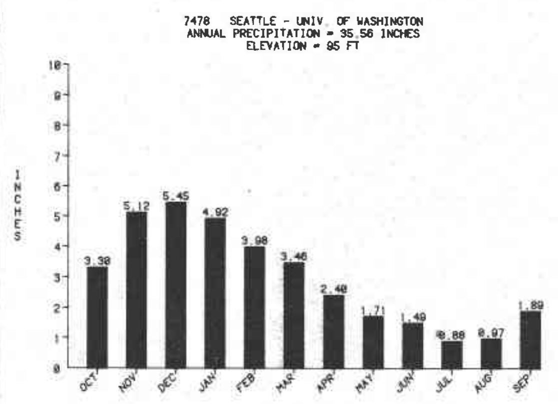
Puget-Willamette Lowland

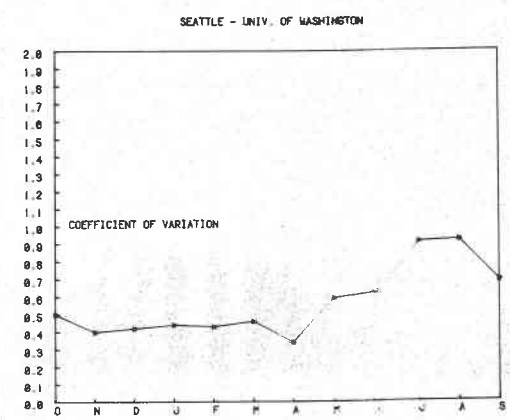


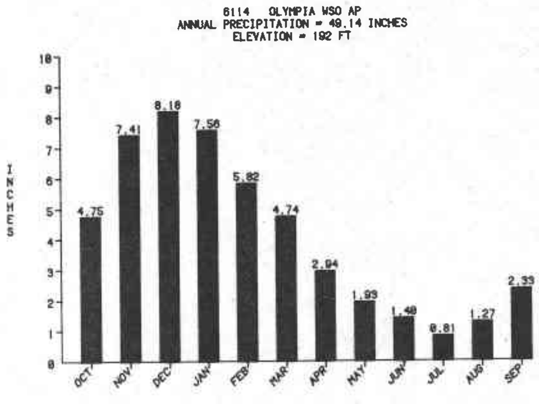


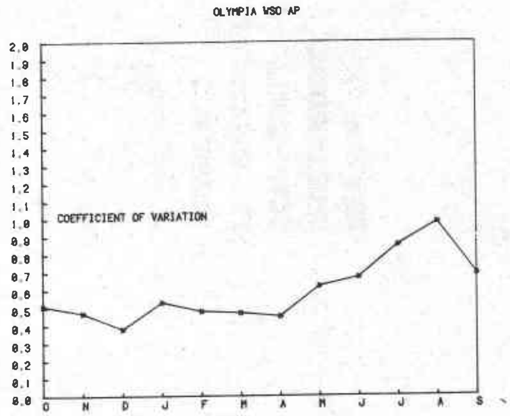


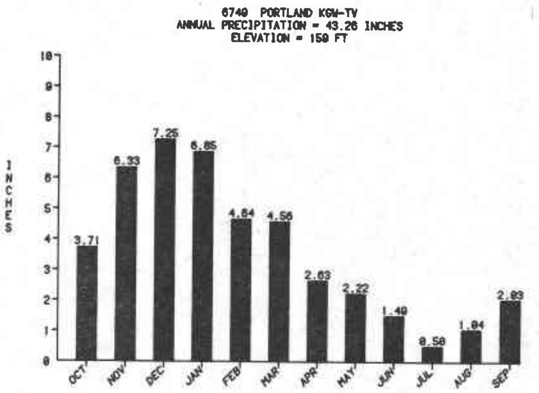


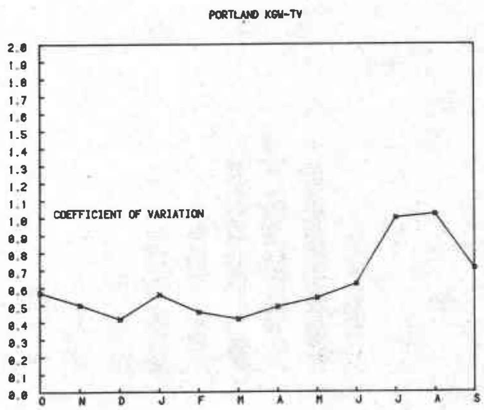


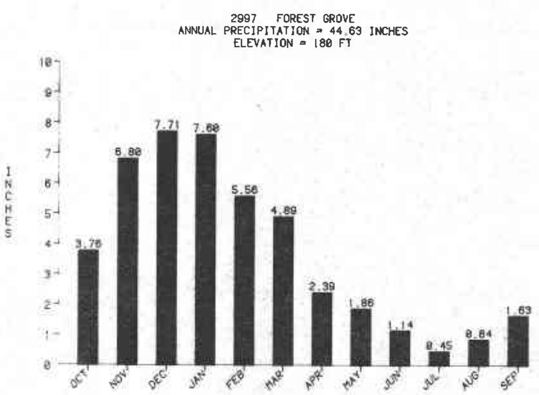


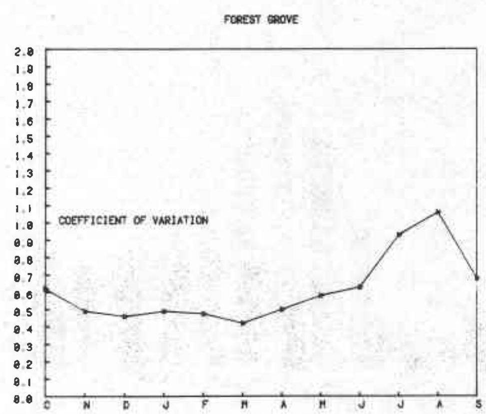

8114 OLYMPIA WSO AP
ANNUAL PRECIPITATION = 49.14 INCHES
ELEVATION = 192 FT
INCHES
4.75
7.41
8.18
7.56
5.82
4.74
2.94
1.99
1.48
0.81
1.27
2.33
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

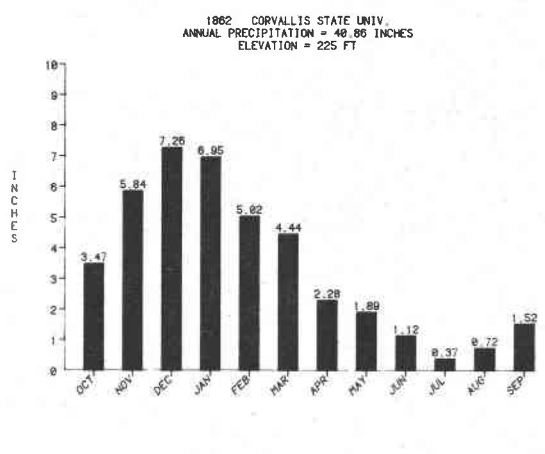

OLYMPIA WSO AP
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

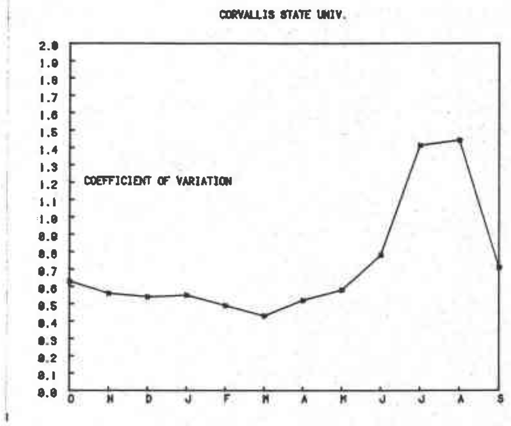

6749 PORTLAND KGW-TV
ANNUAL PRECIPITATION = 43.26 INCHES
ELEVATION = 159 FT
INCHES
3.71
6.33
7.25
6.85
4.64
4.56
2.63
2.22
1.49
0.50
1.04
2.03
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP


PORTLAND KGW-TV
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

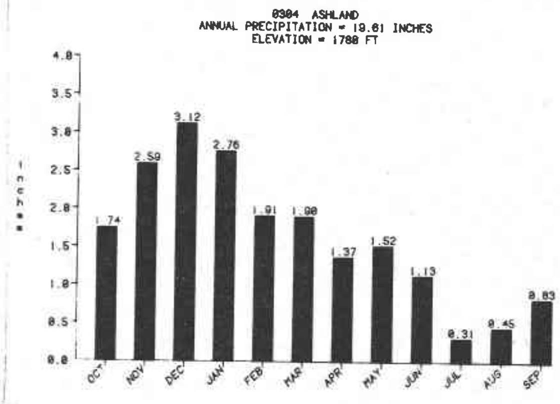

2997 FOREST GROVE
ANNUAL PRECIPITATION = 44.63 INCHES
ELEVATION = 180 FT
INCHES
3.76
6.80
7.71
7.60
5.56
4.89
2.39
1.86
1.14
0.45
0.84
1.63
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

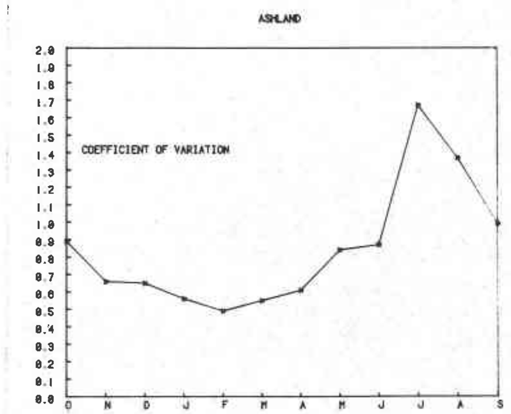

FOREST GROVE
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

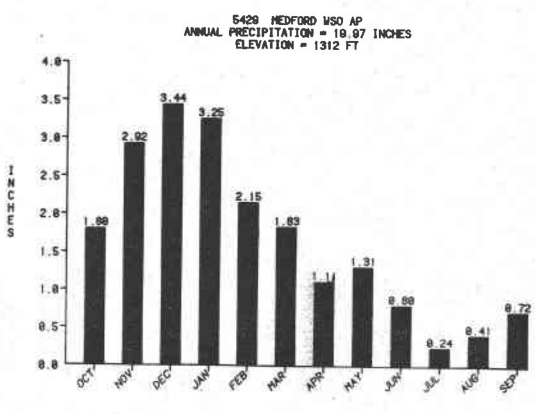


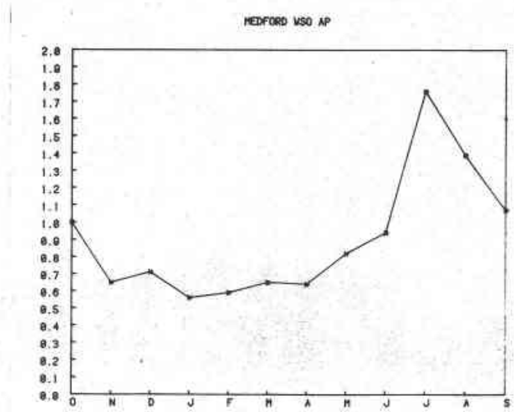


Klamath Mountains

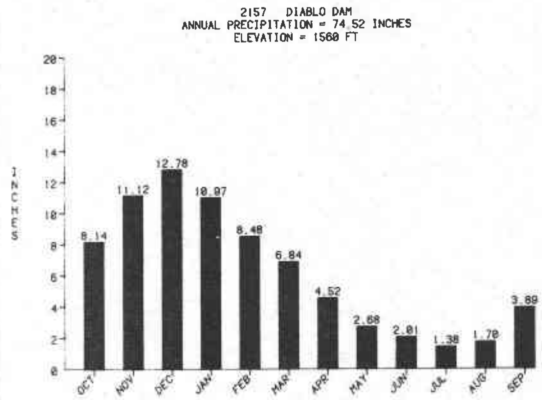


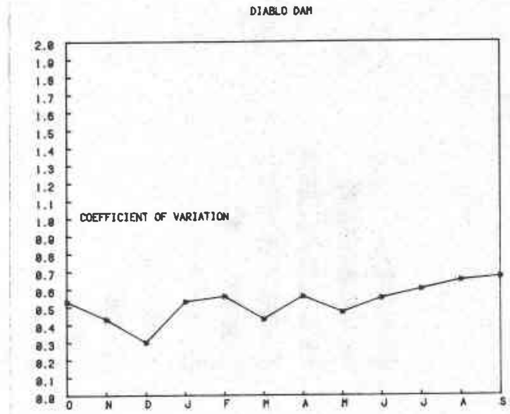


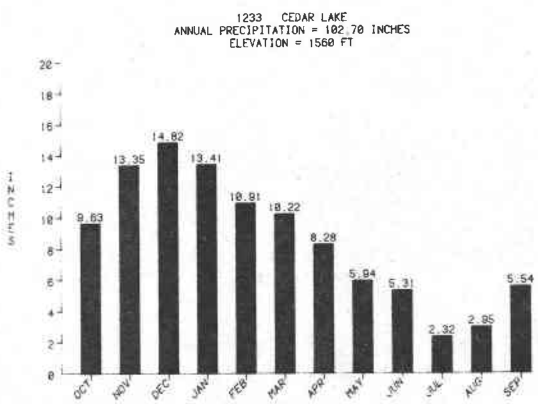


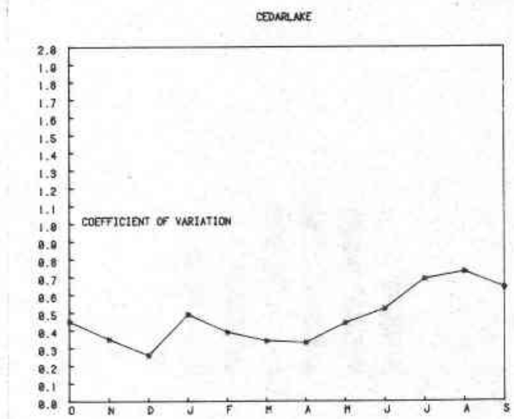


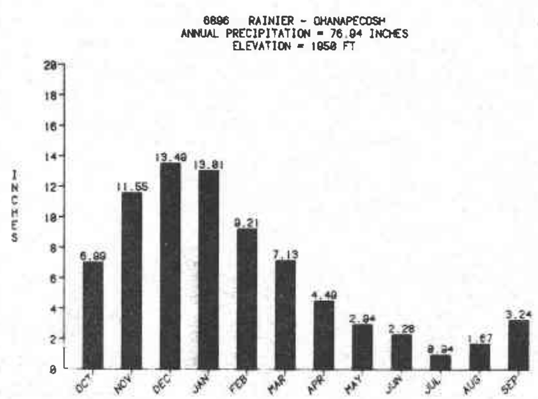
Cascade Range

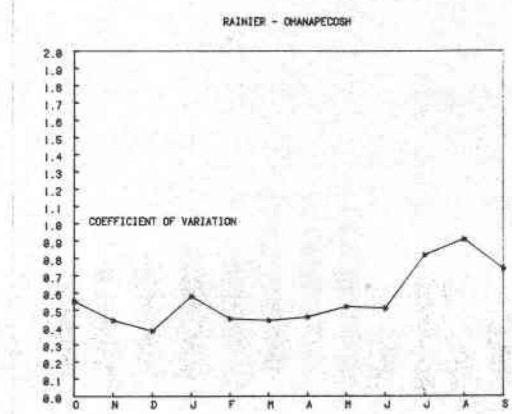


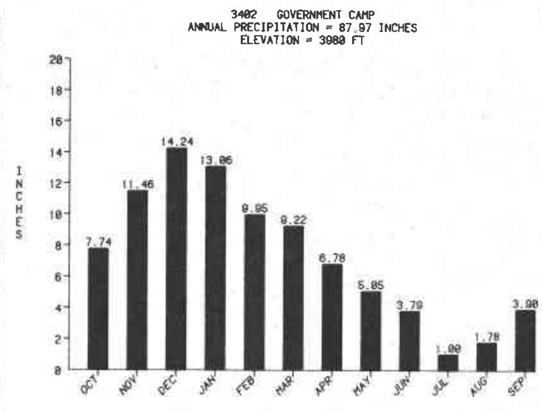


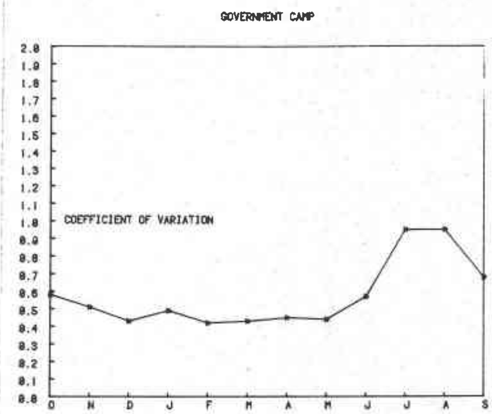


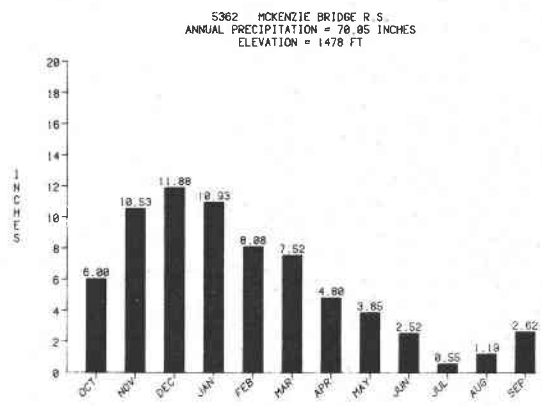


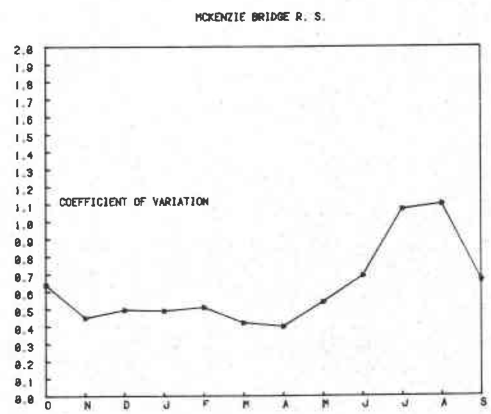


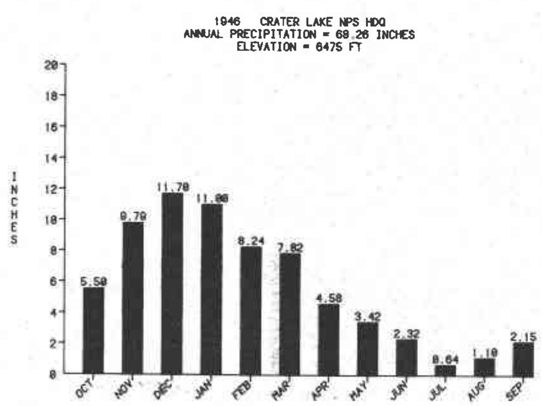


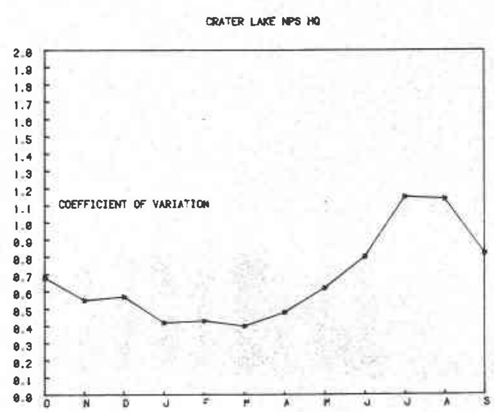

3402 GOVERNMENT CAMP
ANNUAL PRECIPITATION = 87.97 INCHES
ELEVATION = 3980 FT
INCHES
7.74
11.46
14.24
13.06
9.95
9.22
6.78
5.05
3.79
1.00
1.78
3.90
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

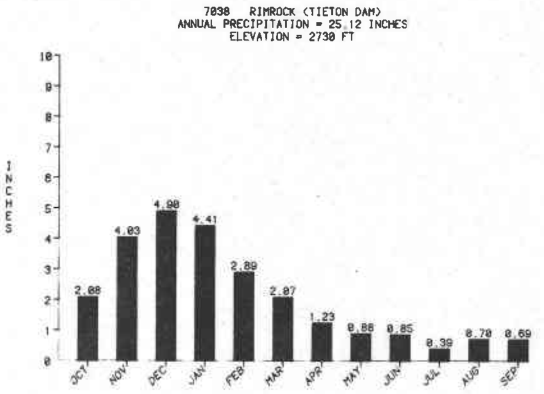

GOVERNMENT CAMP
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

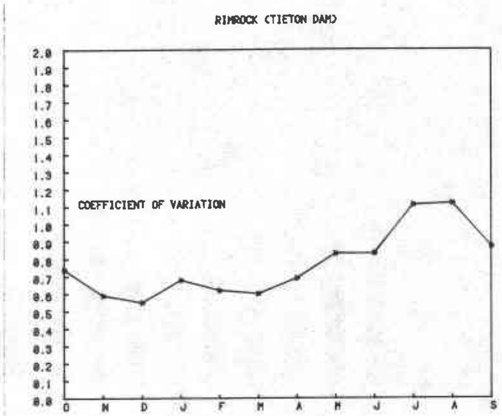

5362 MCKENZIE BRIDGE R.S.
ANNUAL PRECIPITATION = 70.05 INCHES
ELEVATION = 1478 FT
INCHES
6.00
10.53
11.88
10.93
8.08
7.52
4.80
3.85
2.52
0.55
1.18
2.62
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

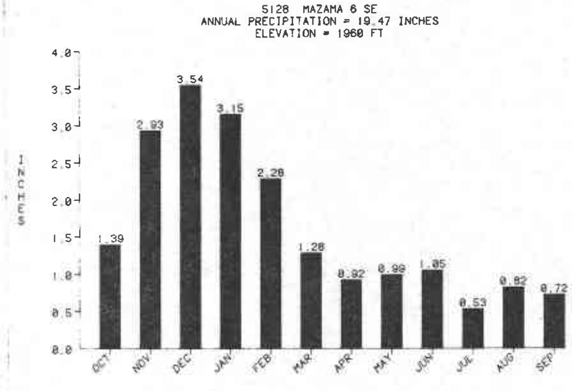

MCKENZIE BRIDGE R. S.
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

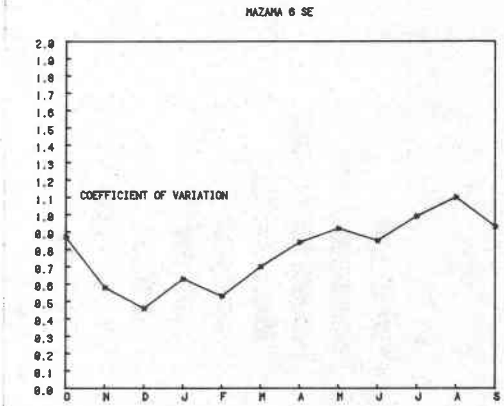

1946 CRATER LAKE NPS HDQ
ANNUAL PRECIPITATION = 68.26 INCHES
ELEVATION = 6475 FT
INCHES
5.50
9.70
11.70
11.00
8.24
7.82
4.50
3.42
2.32
0.64
1.10
2.15
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

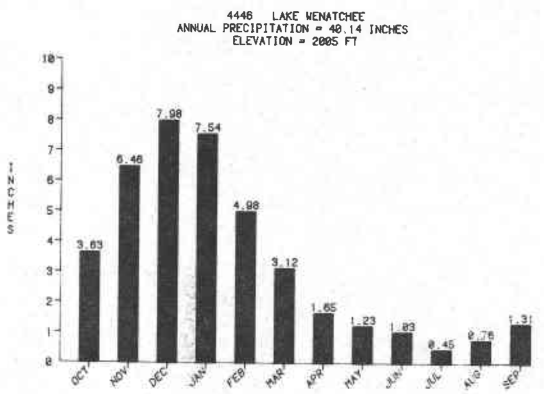

CRATER LAKE NPS HQ
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

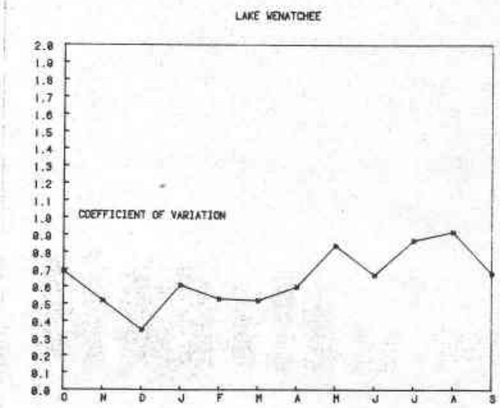

7038 RIMROCK (TIETON DAM)
ANNUAL PRECIPITATION = 25.12 INCHES
ELEVATION = 2730 FT
INCHES
2.08
4.03
4.90
4.41
2.89
2.07
1.23
0.88
0.85
0.39
0.70
0.69
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP


RIMROCK (TIETON DAM)
COEFFICIENT OF VARIATION
O N D J F M A M J J A S


5128 MAZAMA 6 SE
ANNUAL PRECIPITATION = 19.47 INCHES
ELEVATION = 1960 FT
INCHES
1.39
2.93
3.54
3.15
2.28
1.28
0.92
0.99
1.05
0.53
0.82
0.72
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

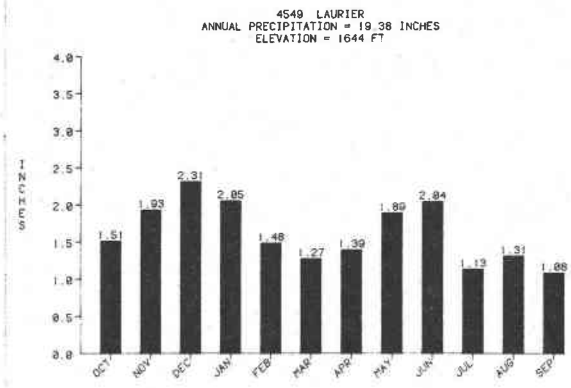

MAZAMA 6 SE
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

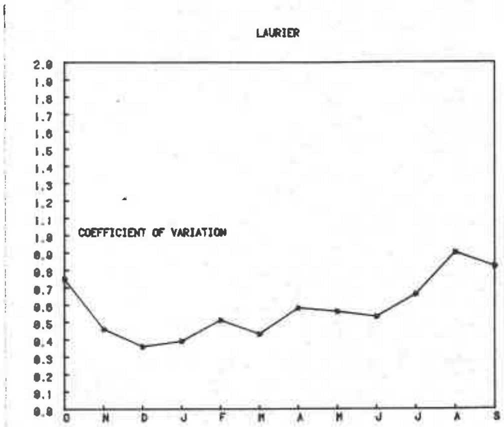

4446 LAKE WENATCHEE
ANNUAL PRECIPITATION = 40.14 INCHES
ELEVATION = 2005 FT
INCHES
3.63
6.46
7.98
7.54
4.98
3.12
1.65
1.23
1.03
0.45
0.76
1.31
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

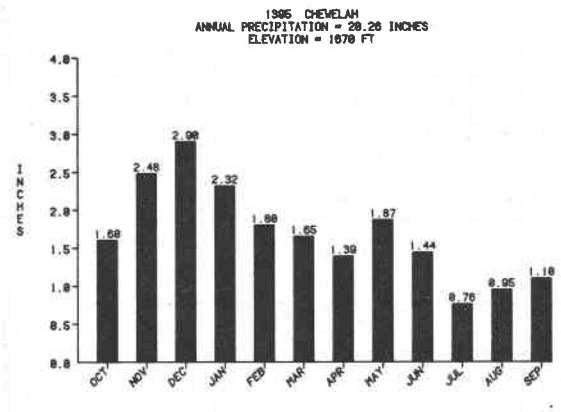

LAKE WENATCHEE
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

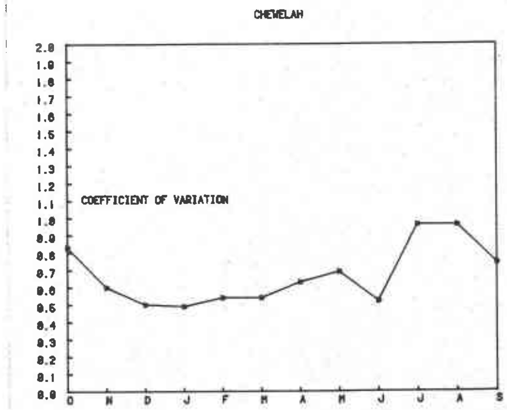
105

Okanogan Highlands

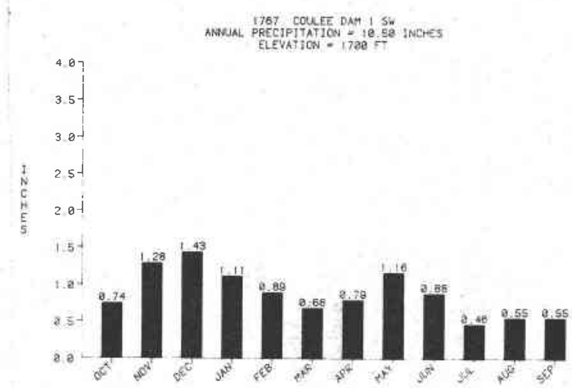


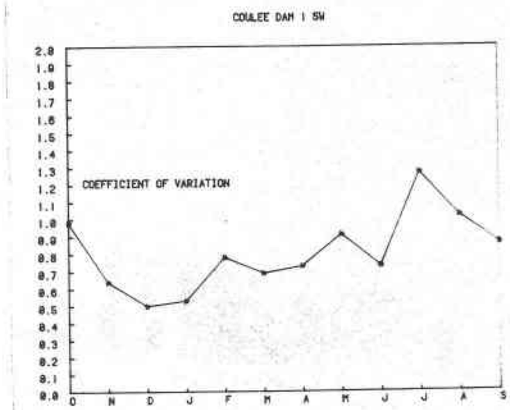


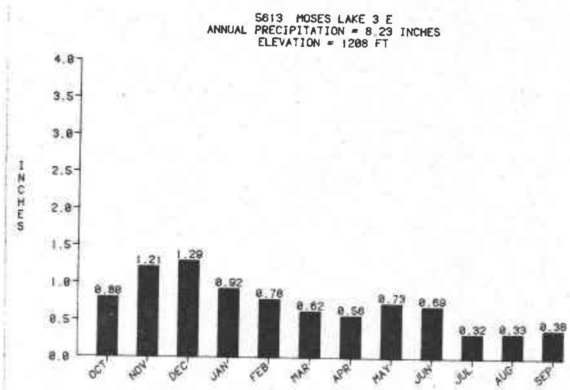


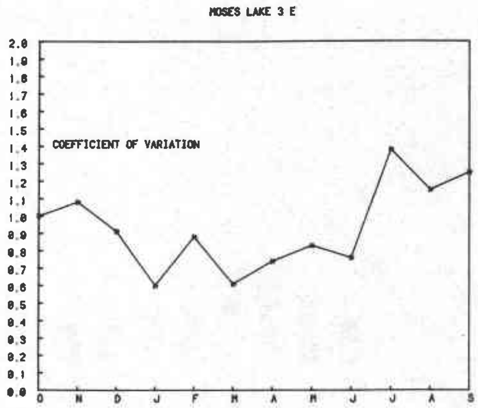


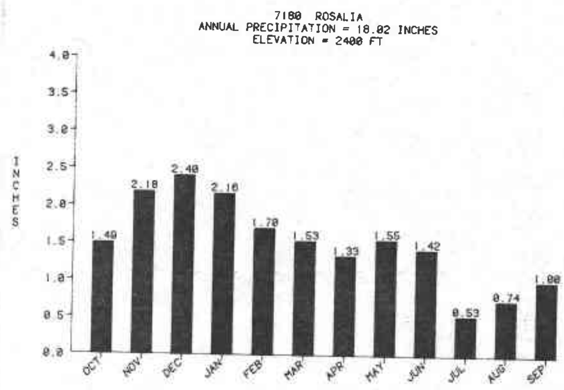
Columbia Basin

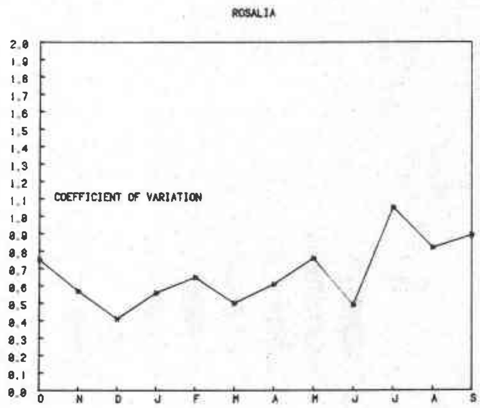


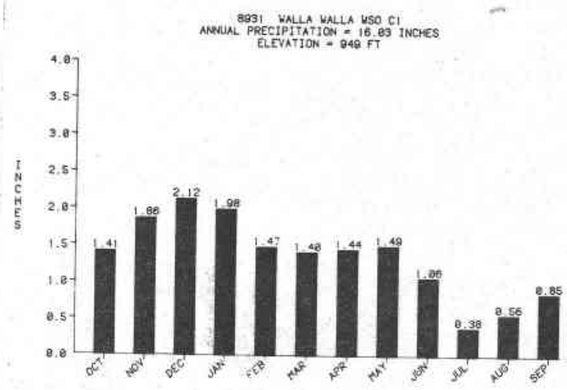


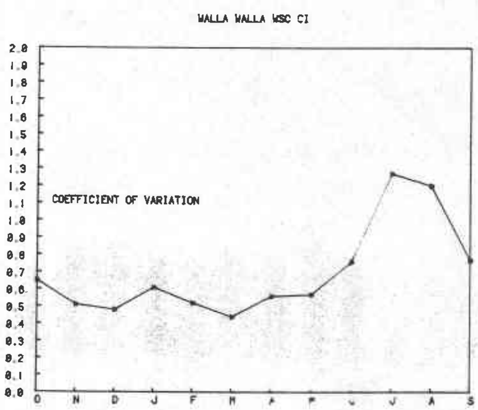

5613 MOSES LAKE 3 E
ANNUAL PRECIPITATION = 8.23 INCHES
ELEVATION = 1208 FT
INCHES
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.80
1.21
1.29
0.92
0.78
0.62
0.50
0.73
0.69
0.32
0.33
0.38
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

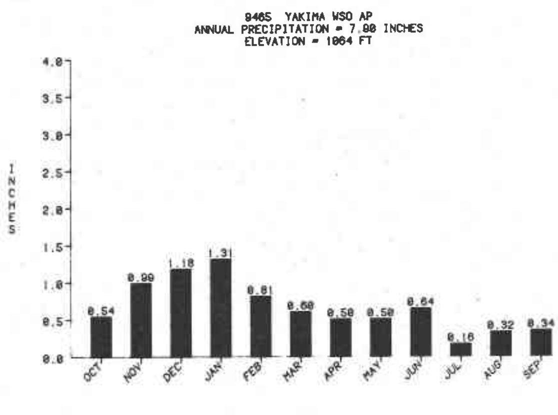

MOSES LAKE 3 E
COEFFICIENT OF VARIATION
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
O N D J F M A M J J A S

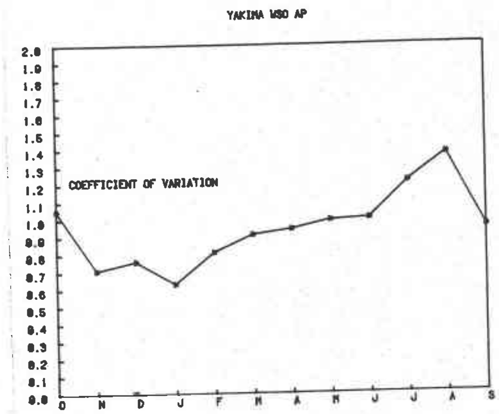

7180 ROSALIA
ANNUAL PRECIPITATION = 18.02 INCHES
ELEVATION = 2400 FT
INCHES
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.49
2.18
2.40
2.16
1.70
1.53
1.33
1.55
1.42
0.53
0.74
1.00
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

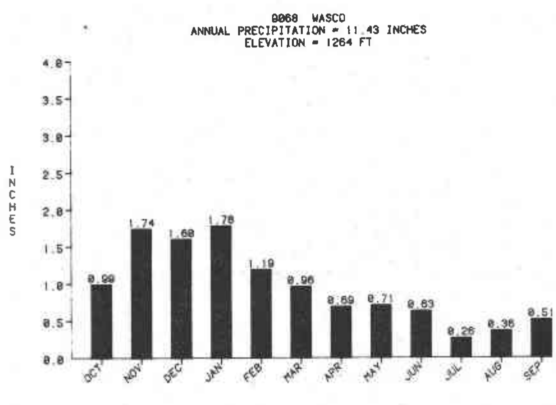

ROSALIA
COEFFICIENT OF VARIATION
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
O N D J F M A M J J A S

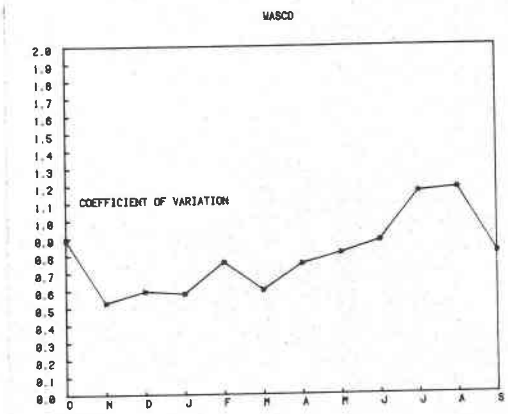

8931 WALLA WALLA WSO CI
ANNUAL PRECIPITATION = 16.03 INCHES
ELEVATION = 949 FT
INCHES
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.41
1.86
2.12
1.98
1.47
1.40
1.44
1.49
1.06
0.38
0.56
0.85
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

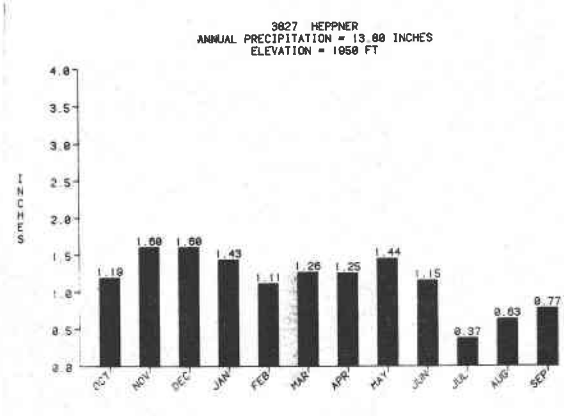

WALLA WALLA WSC CI
COEFFICIENT OF VARIATION
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
O N D J F M

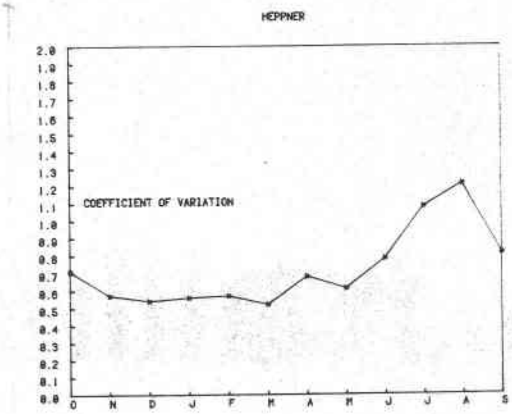

9465 YAKIMA WSO AP
ANNUAL PRECIPITATION = 7.88 INCHES
ELEVATION = 1064 FT
INCHES
0.54 0.99 1.18 1.31 0.81 0.60 0.50 0.50 0.64 0.16 0.32 0.34
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP


YAKIMA WSO AP
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

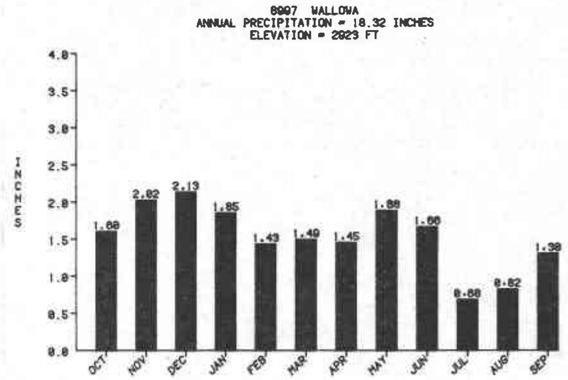

9068 WASCO
ANNUAL PRECIPITATION = 11.43 INCHES
ELEVATION = 1264 FT
INCHES
0.99 1.74 1.60 1.78 1.19 0.96 0.69 0.71 0.63 0.26 0.36 0.51
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

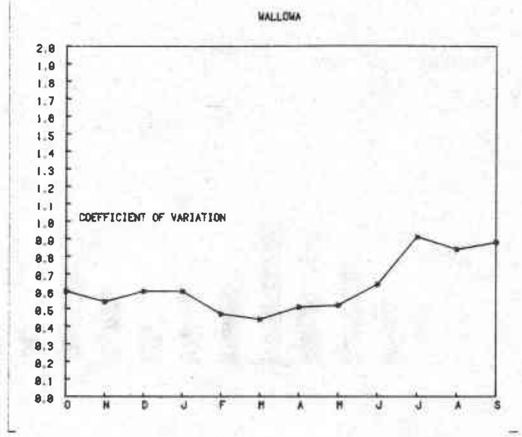

WASCO
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

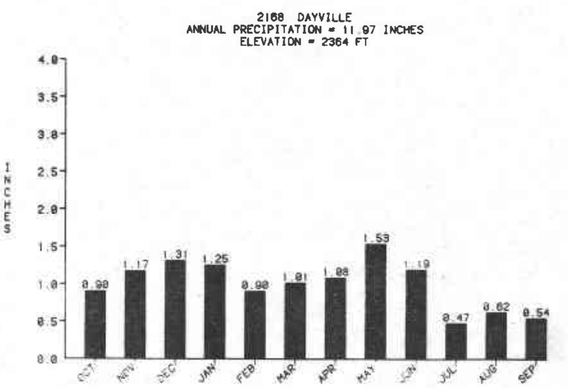

3827 HEPPNER
ANNUAL PRECIPITATION = 13.80 INCHES
ELEVATION = 1950 FT
INCHES
1.18 1.60 1.60 1.43 1.11 1.26 1.25 1.44 1.15 0.37 0.63 0.77
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

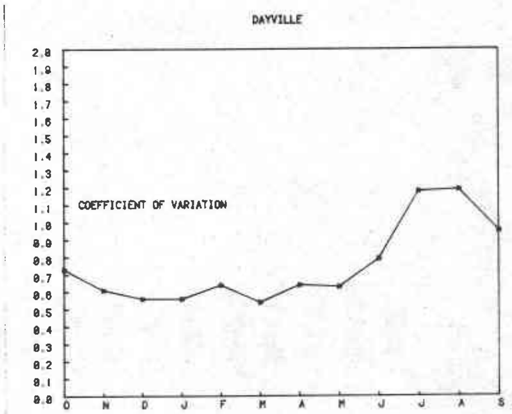

HEPPNER
COEFFICIENT OF VARIATION
O N D J F M A M J J A S

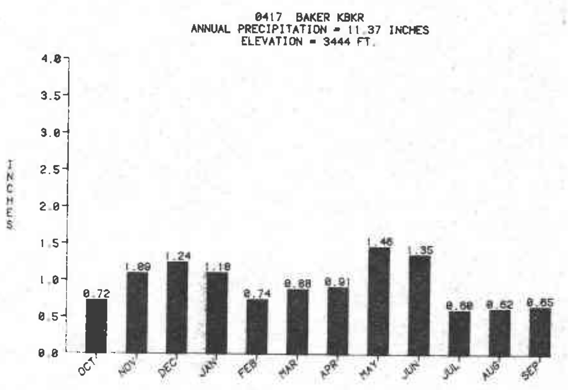
Blue Mountains

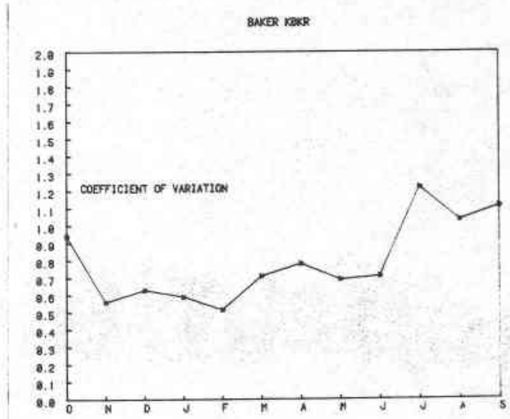




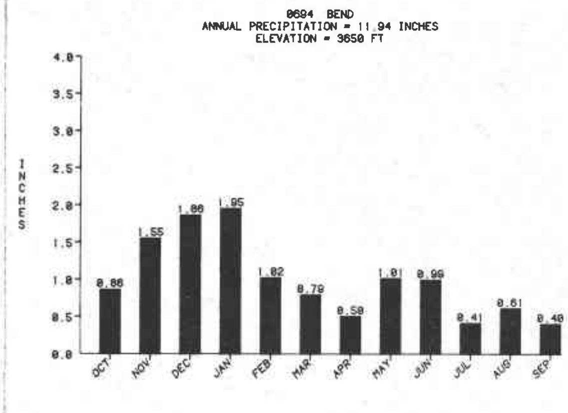


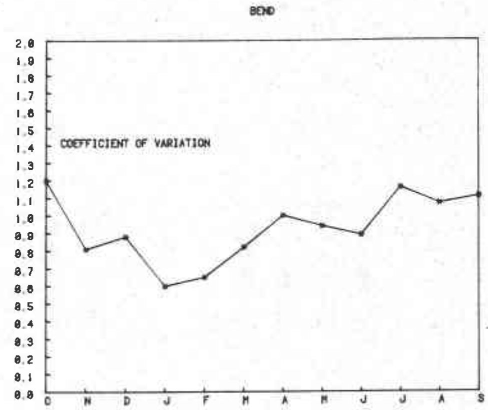


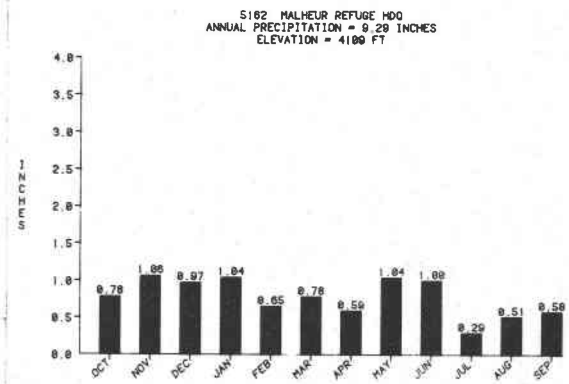


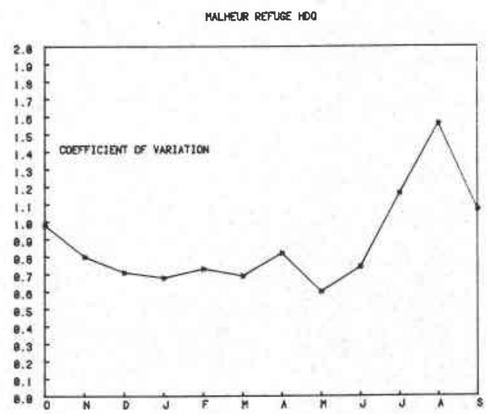


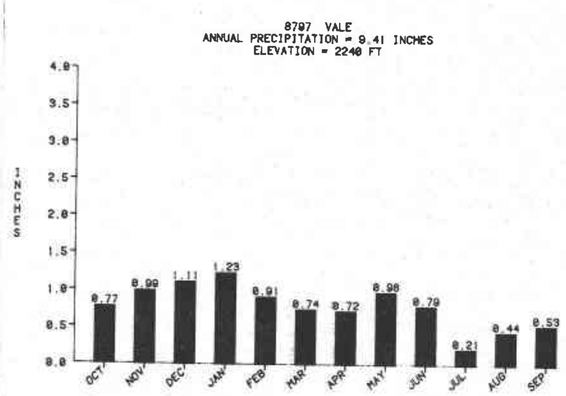
High Lava Plains

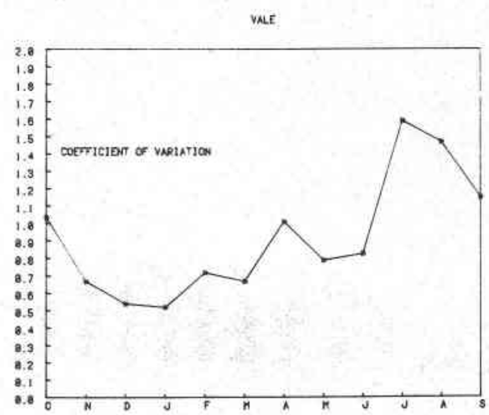




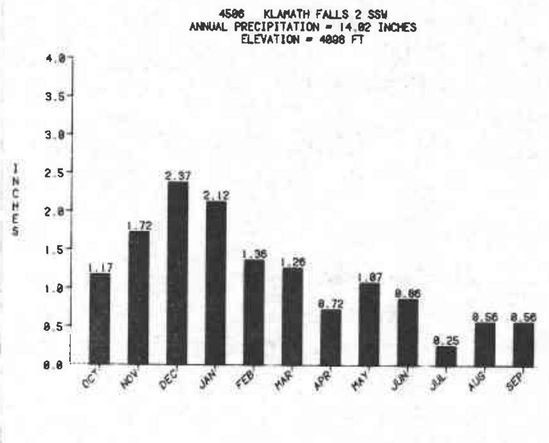


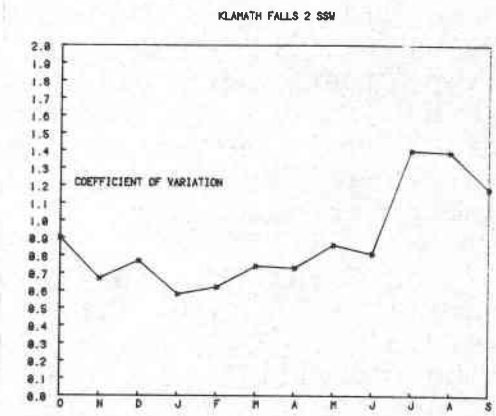


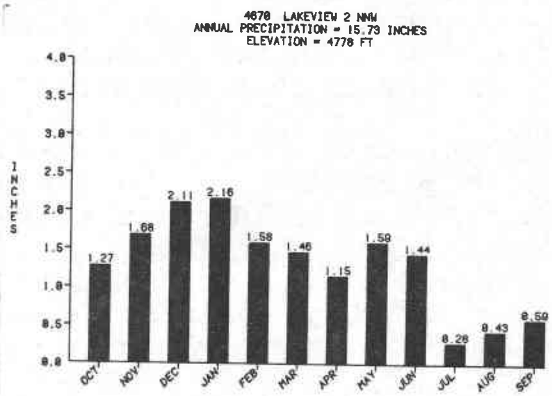


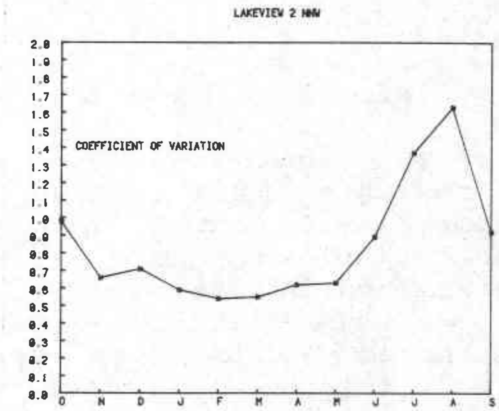


Basin and Range









INTERSTATION CORRELATIONS

Correlation techniques have been used frequently to study the spatial organization of weather and climate elements. Successful analyses of precipitation data include those by Fliri (1967) who investigated space correlation fields of monthly and seasonal precipitation in the Alps, Sharon (1979) in the Jordan Valley and Brazel and Ziriax (1979) in central Arizona. Correlation studies by Huff and Shipp (1969) were made to determine the optimum spacing of weather stations in Illinois and Longley (1974) was able to reveal dominant storm tracks on the Canadian Prairies by analyzing correlation fields of monthly and seasonal precipitation.

As a further aide in visualizing the spatial pattern of precipitation in the Pacific Northwest correlation coefficients (r) were calculated for all network stations using Corvallis-State University as the central station. The choice of Corvallis is based on its location in the western part of the region, the direction from which most storm systems originate, and the reliability of its record. However, the choice is arbitrary and correlation coefficients were also calculated with Baker KBKR as the central station. Isocorrelate maps for each month and the two seasons (with Corvallis-State Univ.) and for January and July (with Baker) are presented in Figure 19 page 1Ø3.

The significance of the coefficients shown here can be approximated with critical values predicted by statistical theory. Based on the assumption of a normal distribution of the variables involved, the significance of r-values can be determined by use of the student's t-test. The assumption of normally distributed variables is very restrictive and, as noted earlier, is seldom met by monthly or summer precipitation data series in the Pacific Northwest. However, no normalization of the data was performed since it has been argued by other investigators that the pattern of isocorrelates is not significantly altered (McDonald 1957). For a sample of 4Ø pairs of observations an r-value of approximately Ø.3Ø can be considered significant at the 95 percent level of confidence; an r-value of Ø.5Ø is significant at the 99 percent level of confidence (Gregory 1973). In a similar analysis Pyke (1966) noted that it was safe to assume that r-values less than about Ø.2Ø are not significant whereas r-values greater than about Ø.4Ø are definitely significant. As an aid in seeing patterns on the two seasonal maps, areas of r-values greater than Ø.6Ø and less than Ø.3Ø are shaded.

The correlation fields as mapped are exceedingly complex as expected for the Pacific Northwest with its great variety of climatic controls. However, some obvious patterns emerge. Yearly r-values (not mapped) are approximately equal to the wetter winter months and seasonal r-values are about equal to those individual months comprising the seasons.

Winter season r-values are generally larger than summer season r-values, an expected relationship due to the more homogeneous nature of winter precipitation. Large-scale cyclonic storms in the winter are more uniform than summer convective rainfall brought by small disturbances in the upper atmosphere.

In both seasons and in all months, there is a general decay of r-values with increasing distance from the central station. Highest values are, of course, at Willamette Valley stations because of their proximity to Corvallis. The decay with distance is more extreme in summer than in winter. There is no single dominant orientation of an axis of maximum correlation. One axis is apparent on a north-south line from Corvallis throughout the region. There is also a zone of very high r-values on the east side of the Washington Cascades. Another axis of high r-values appears to extend discontinuously to the northeast from Corvallis. Also, r-values in eastern Washington and northern Idaho are extremely high. This preference for a north to northeast orientation is a response to the predominant direction of storm movement through the Pacific Northwest. Sneva and Calvin (1978) found that in eastern Oregon r-values between stations lying at a bearing of about 55 degrees (northeast-southwest) from each other were at a maximum. The most rapid decay in r-values from Corvallis is to the east and southeast with the lowest values in far eastern Oregon.

Isocorrelates for Baker in the winter (January) show a distinct axis of maximum correlation on a northeast-southwest line with a particularly rapid decay of r-values perpendicular to this line. Indeed, on the Olympic Peninsula are the lowest values, approaching zero at some stations.

In summer the pattern of isocorrelates with Corvallis is much the same as in winter, the most obvious difference being in the strength of the correlation field, that is, the magnitude of r-values. From Corvallis there exists an axis of maximum correlation north and south through the region. In all other directions the decay of r-values is rapid. In contrast the extremely high correlation with stations in northeastern Washington is particularly striking. Here r-values exceed 0.50 at some stations, considerably higher than in central Washington closer to Corvallis. East of the Cascades in Oregon correlation of summer rainfall with that at Corvallis is essentially non-existent.

Although by definition for this study the summer season consists of the five months from May to September, the summer r-values mask some appreciable and interesting differences as can be seen by studying the monthly maps. For example, r-values are relatively high for eastern Oregon in spring and through the month of May and then decline sharply in June and July. The Columbia Basin has the lowest values in June while the Snake River Plain and southeastern Oregon are the lowest in July. Also, by July the area of low correlation is much larger with r-values in much of southeastern Oregon less than Ø.1Ø and most of the Blue Mountains less than Ø.2Ø. One of the most interesting aspects, however, is the sudden increase in r-values from July to August. In the latter month the values for the region are generally higher than for the winter season. Almost all of eastern Oregon has r-values over Ø.5Ø. Particularly noteable is the Snake River Plain with values of Ø.2Ø to Ø.4Ø in winter but increasing to Ø.6Ø to Ø.8Ø in August.

These correlation fields on a monthly basis are extremely complex. Further interpretation will necessitate mapping correlations with stations other than Corvallis and Baker. However, the potential for identifying homogeneous precipitation regions certainly lies within this statistic.

Figure 19.

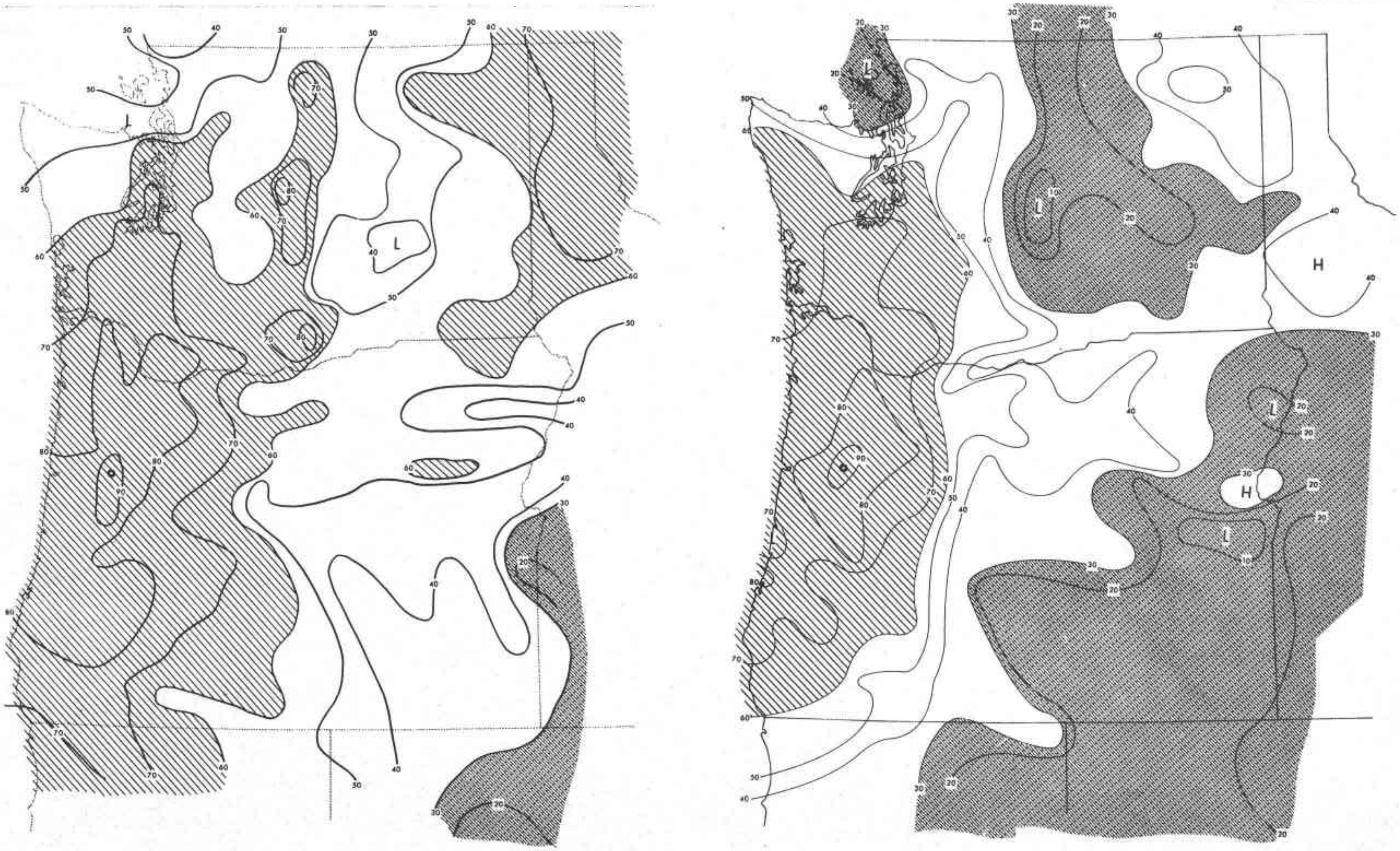
Map Series of Correlation Coefficients, r-values (1940-1979):

a) with Corvallis-State University - seasonal and monthly data

b) with Baker KBKR - January and July data

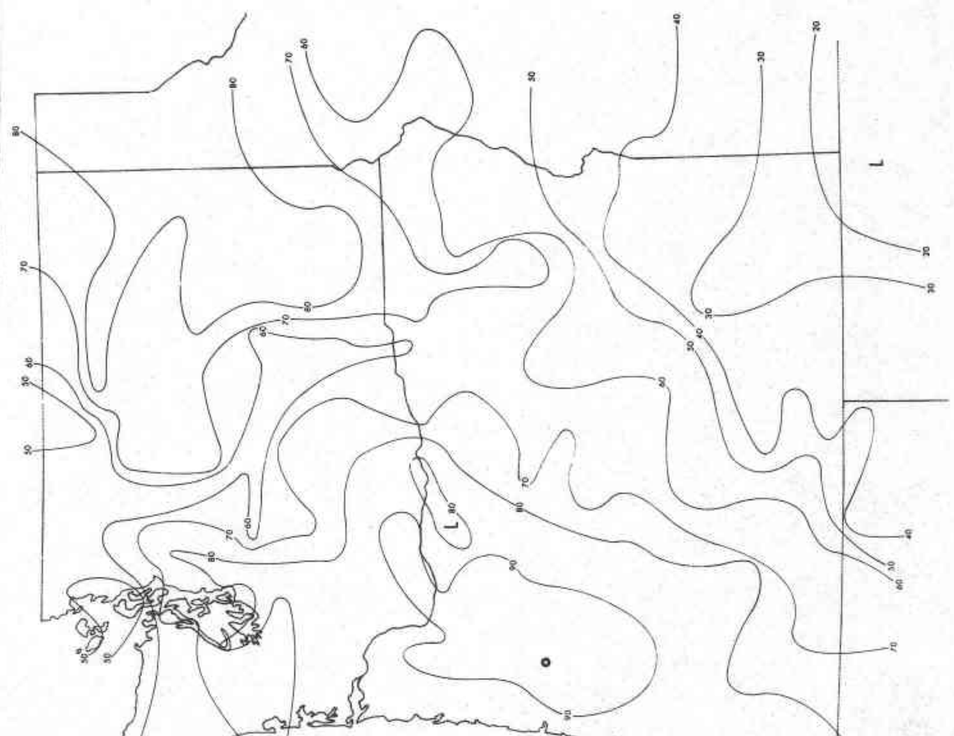
Note: Seasonal maps for Corvallis indicate areas of r greater than .60 (light shading) and less than .30 (dark shading).

a) Corvallis—State Univ.

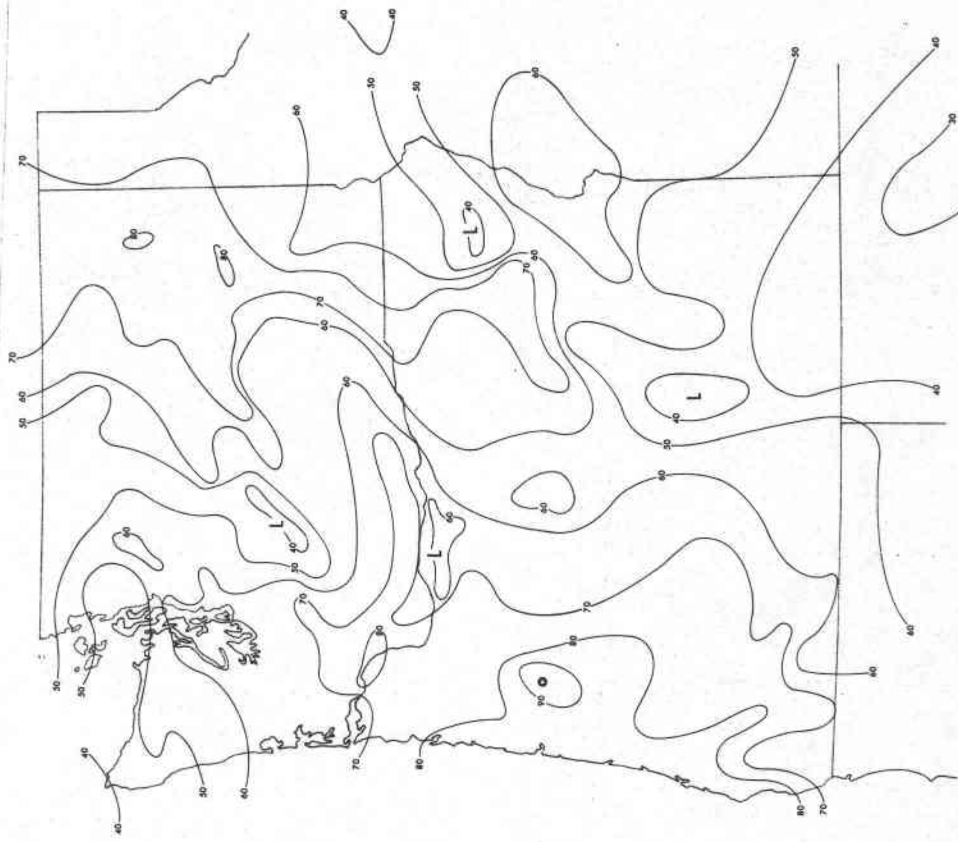


Winter

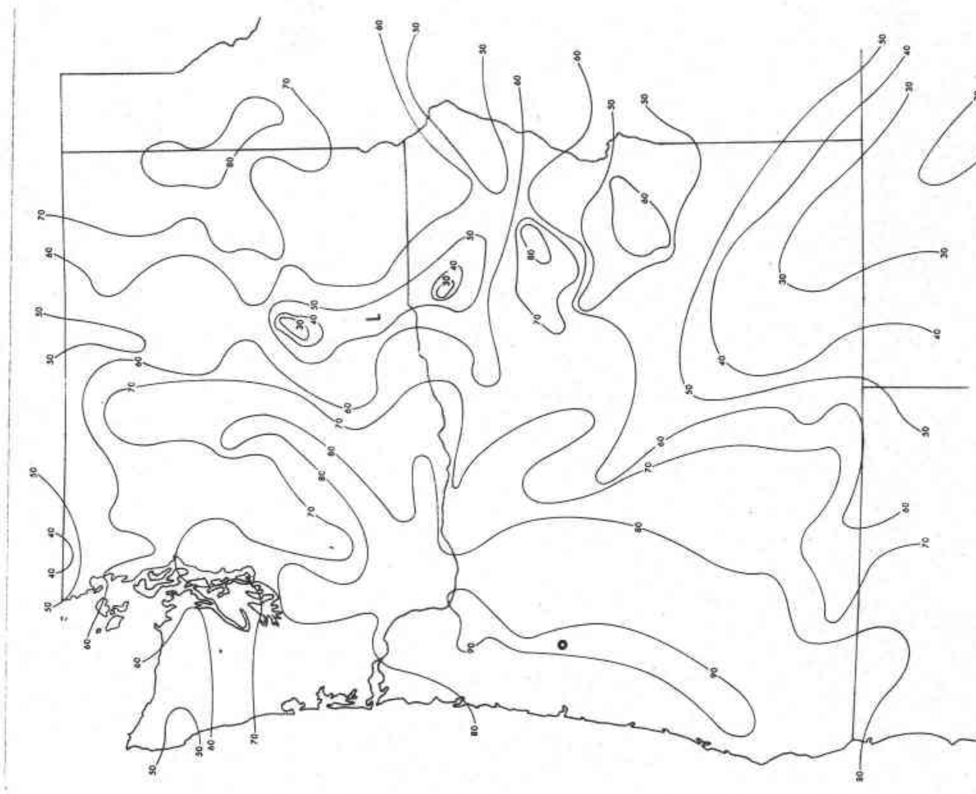
Summer



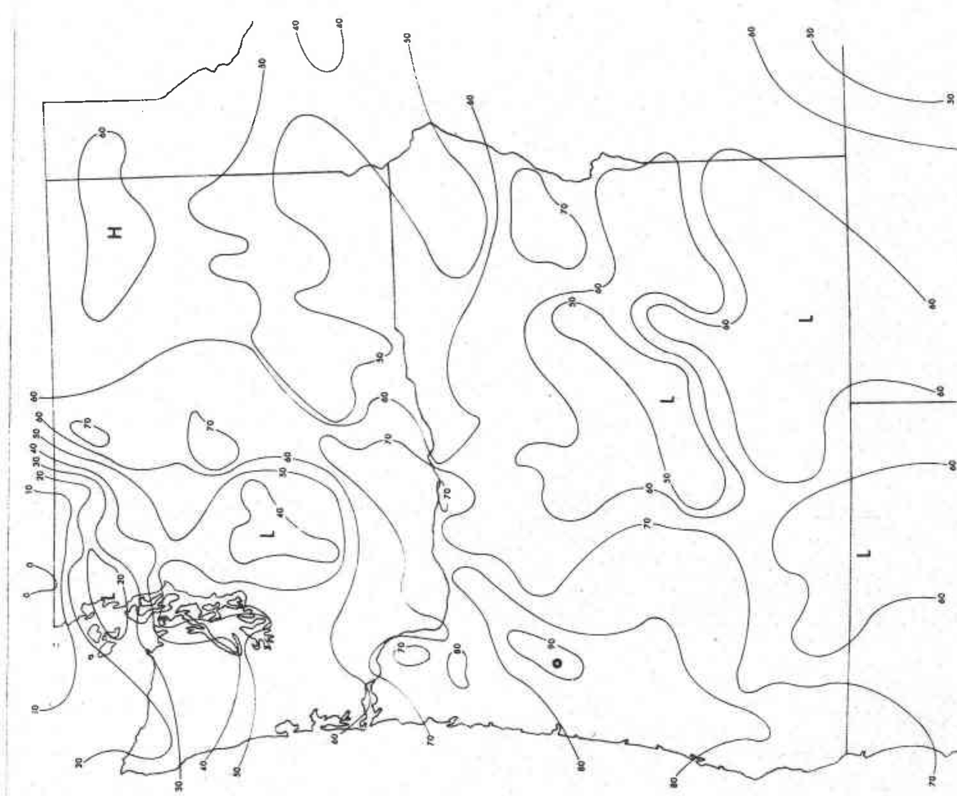
October



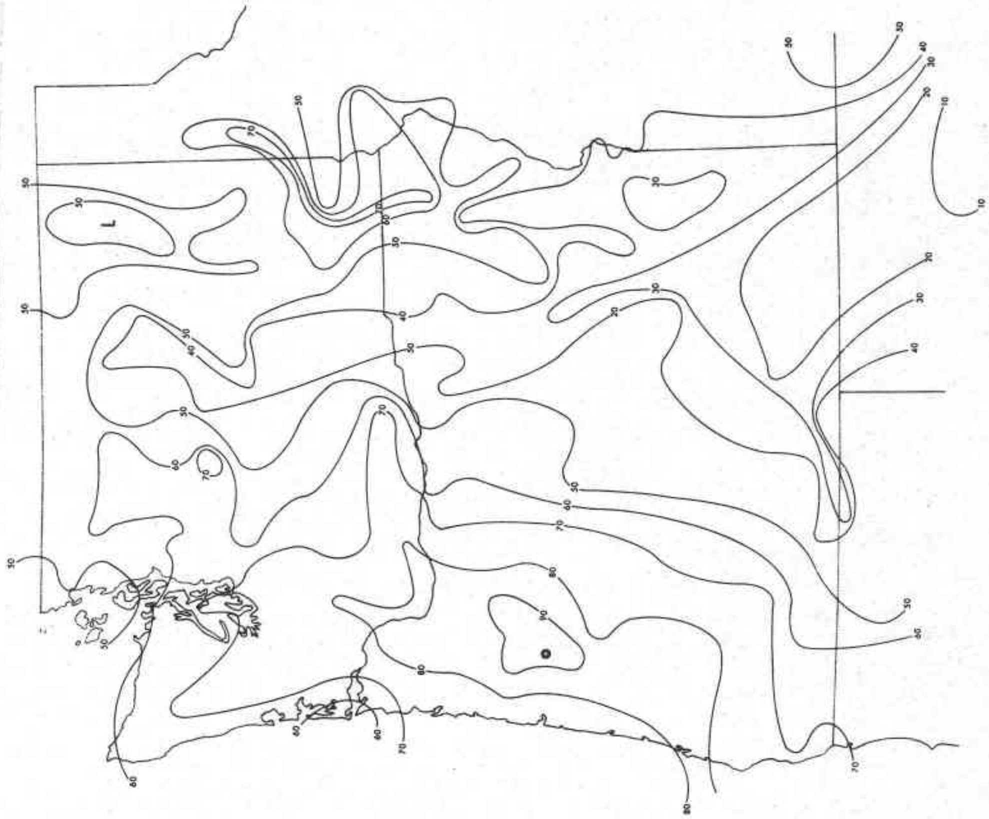
November



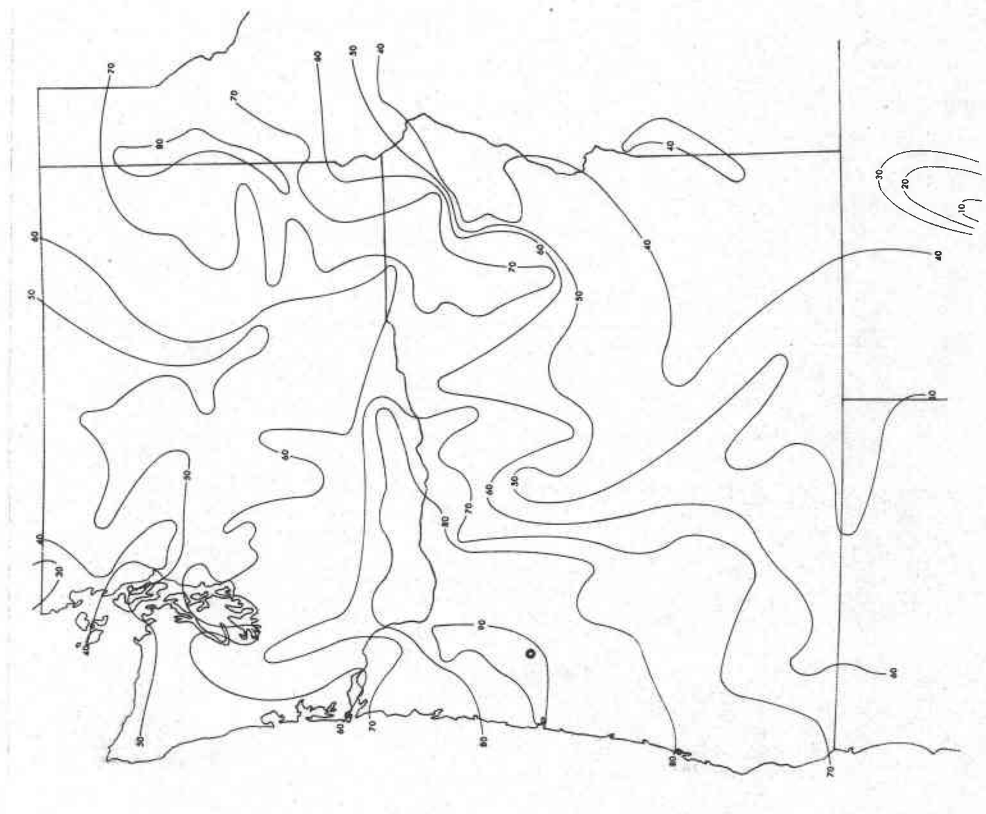
January



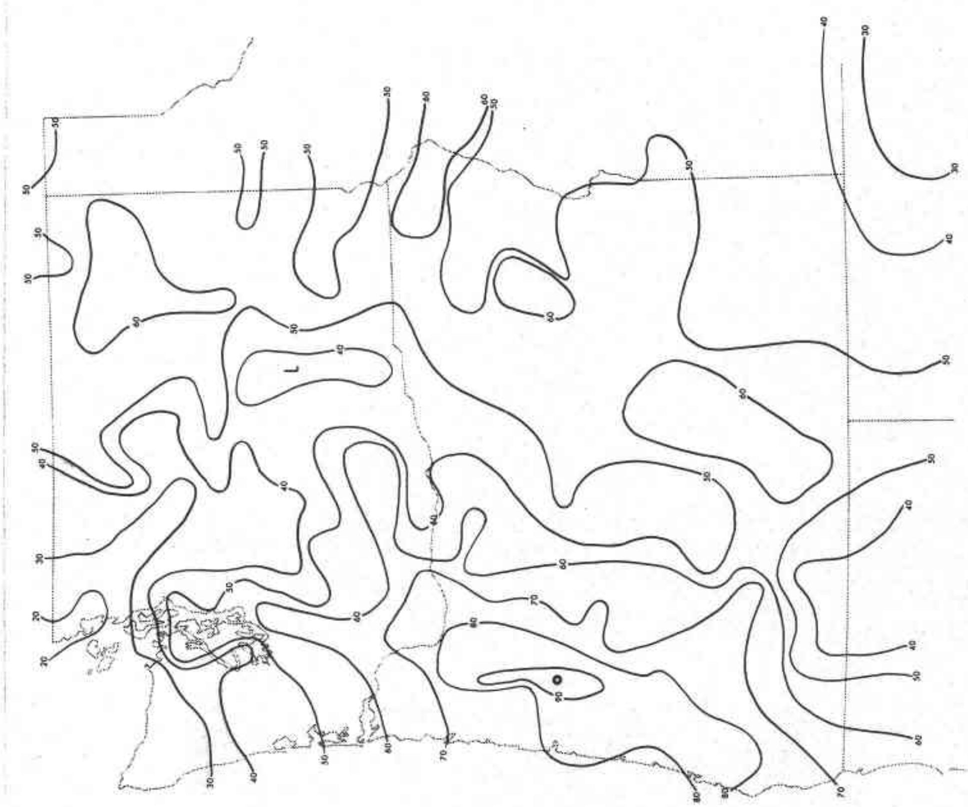
December



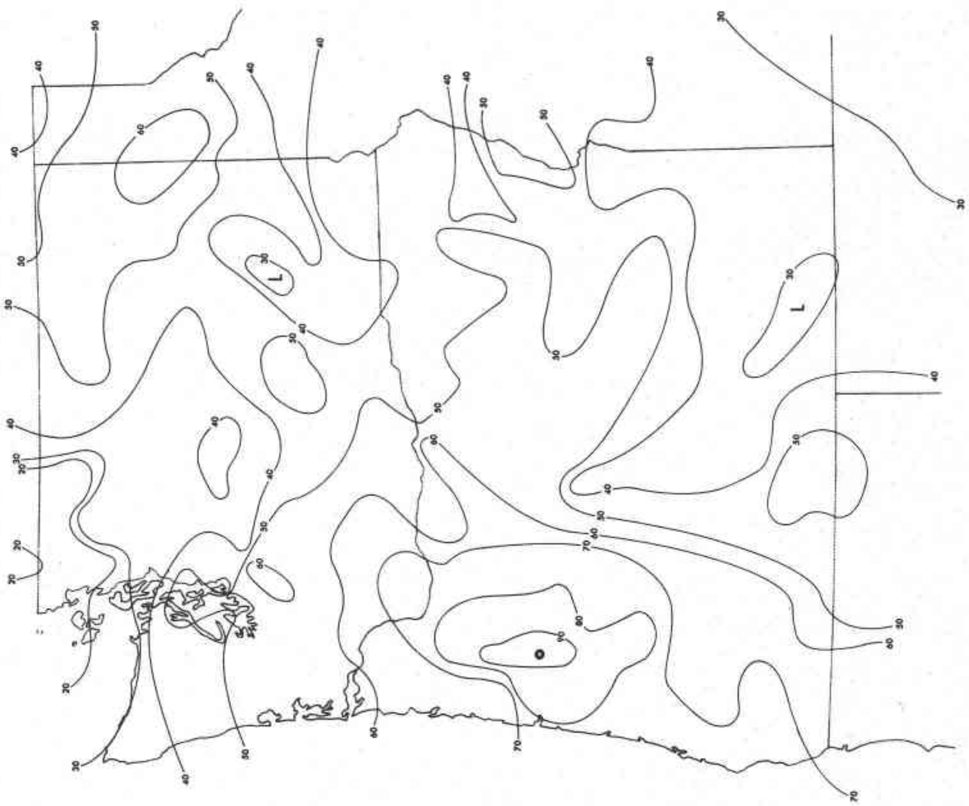
March



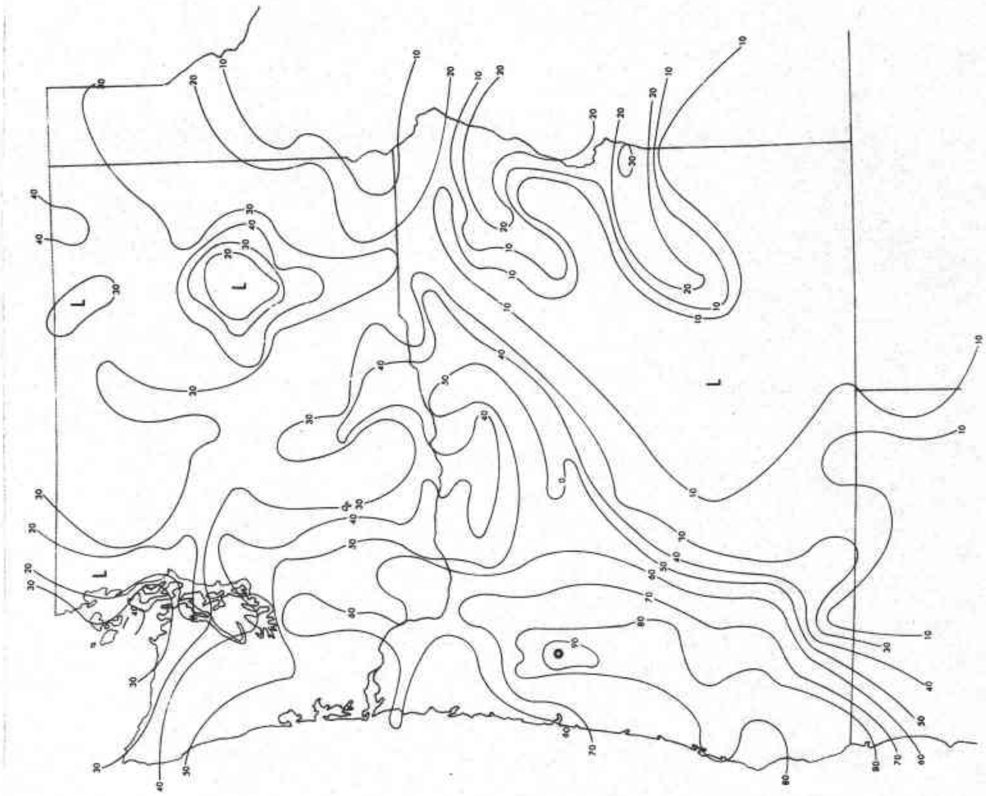
February



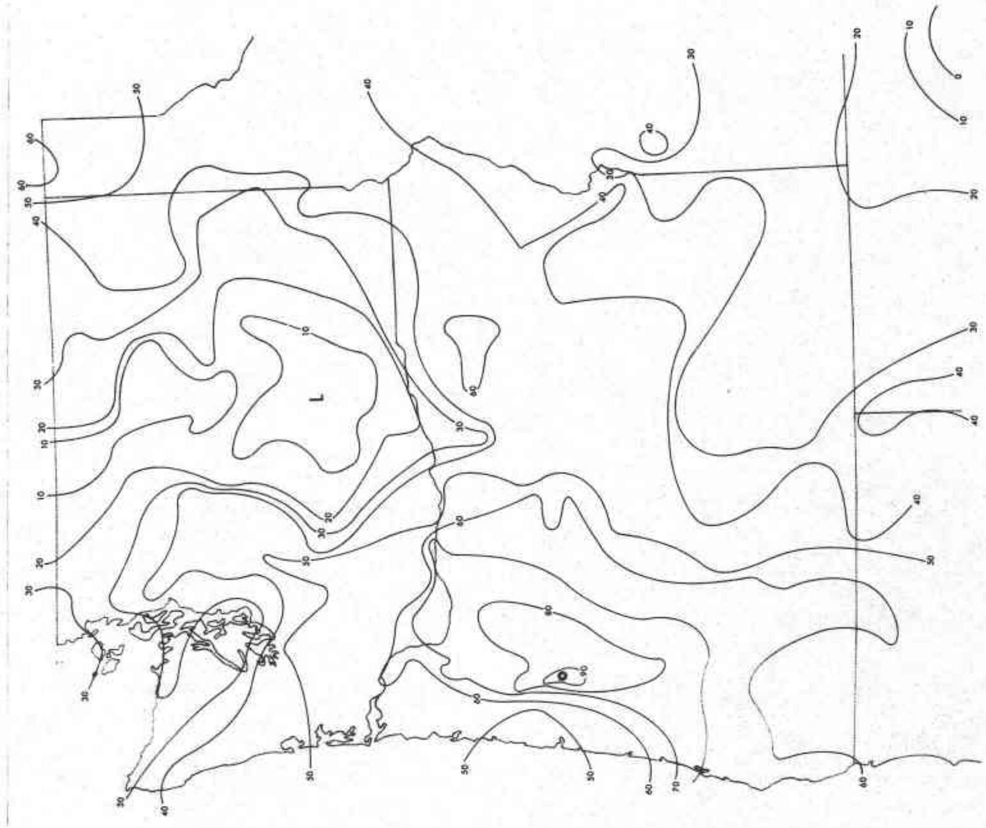
April



May

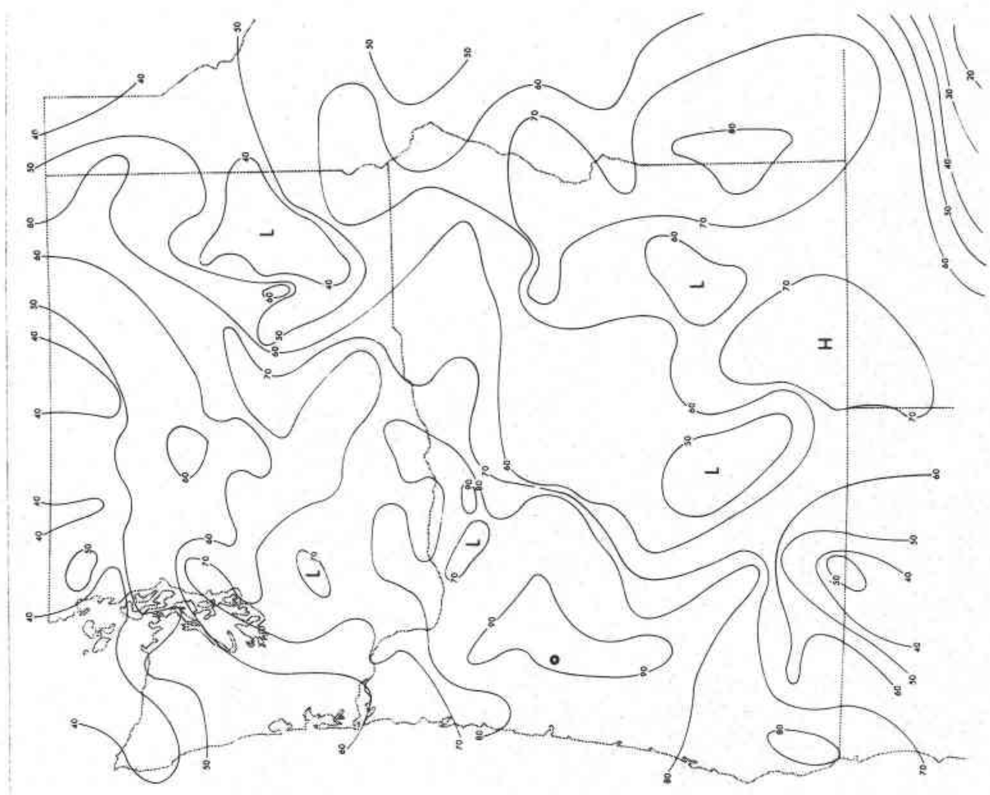


July

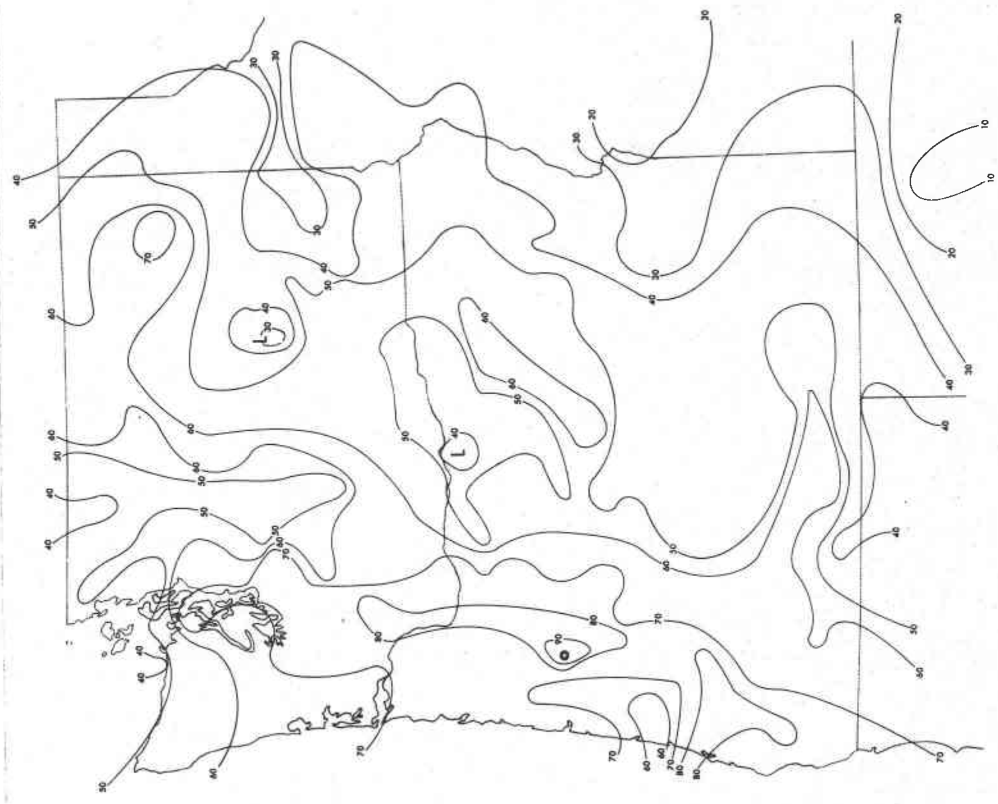


June

121

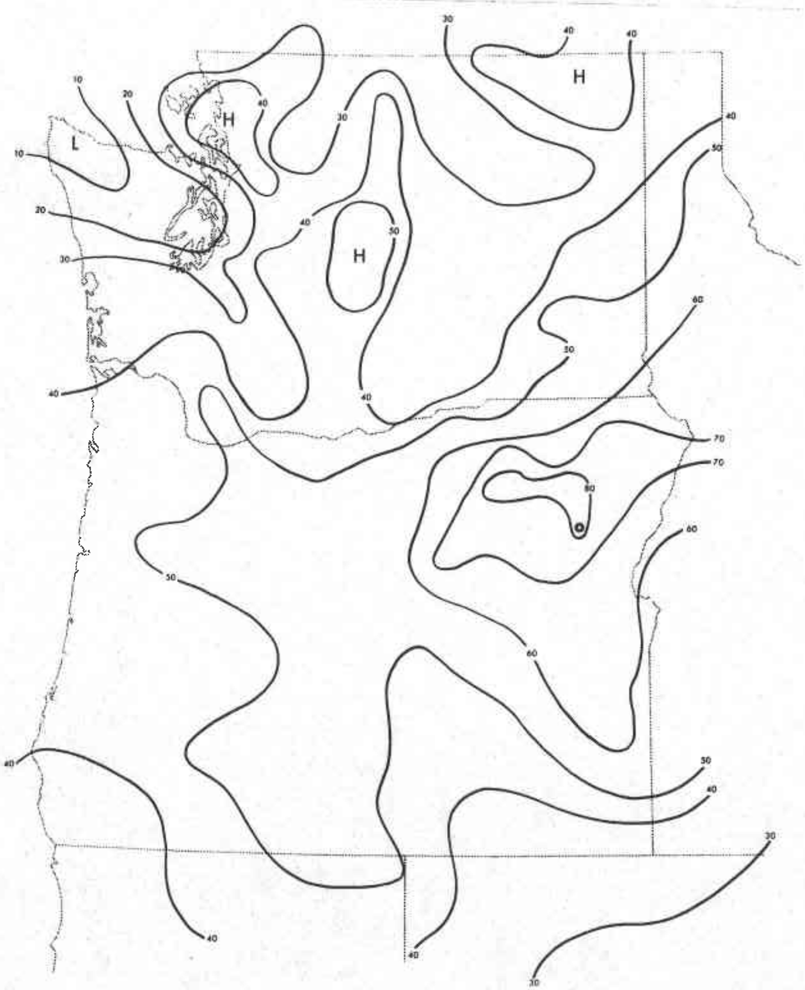


August

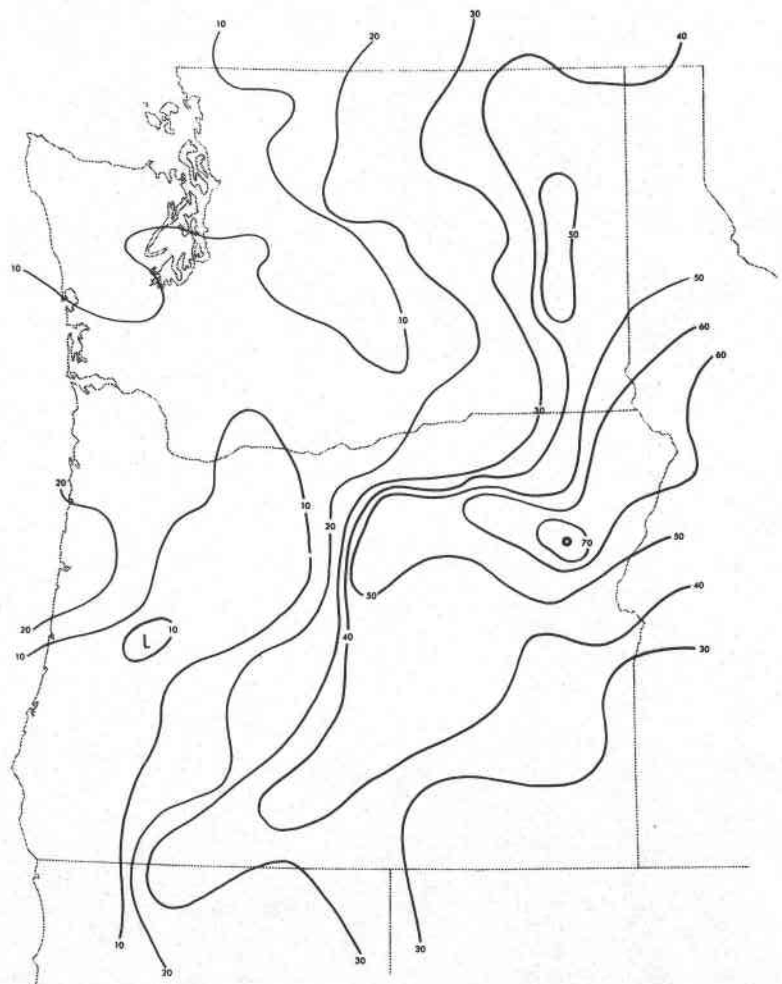


September

b) Baker KBKR



January



July

V. SECULAR CHANGES IN PRECIPITATION

In this study a preliminary examination has been made of changes in annual precipitation throughout the region. The period of record used for this analysis is limited to that for which climatological stations in the Pacific Northwest have been in operation -- the instrumental (or secular) period -- approximately the last 100 years. As an introduction to this material it is useful to "set the scene" with an overview of climatic history in the Pacific Northwest over a much longer time scale.

CLIMATIC HISTORY

Paleoclimate Indicators

The Pacific Northwest has experienced a great range of climatic conditions over the last 20,000 years, variations in climatic elements considerably greater than in the past century and with greater effects on the region. The major climatic division of the last 20,000 years was the termination of the Pleistocene Ice Age which ended suddenly in North American between 10,000 and 12,000 years B. P. (before present) as shown by nearly every fast responding indicator of climate change (Bryson and Hare 1974). Heusser (1977), through the study of pollen profiles and peat stratigraphy, set the boundary between late-glacial and post-glacial climate at about 10,500 B. P. in Washington and southern British Columbia.

Although the change of climate associated with the retreat of the Cordilleran ice sheet from the northern section of the Pacific Northwest was a climactic event in climatic history, the most significant period for the study and interpretation of climatic trends is the last 1,000 years which represents the limit of accuracy for many paleoclimatic indicators and methods of research (Kutzbach 1976) and includes the period of historical records. Three paleoclimatic indicators that have yielded a wealth of information about climates in the American West are tree rings (dendroclimatology is the reconstruction of past climates from tree rings), lake levels and the evidence of movements of mountain glaciers.

Many of the studies relating to climatic history in the West have been based on dendroclimatic reconstructions. The annual nature of tree rings has been known for a long time but the use of tree rings for dating and assessing patterns of temperature and precipitation is a more recent development. Early studies by Douglas (1919-1936, 1937), Antevs (1938), Giddings (1943, 1953) and Schulman (1945, 1947, 1956) established the foundation for tree-ring research in North America. In recent years computer applications and advance statistical techniques have been combined with detailed physiological studies to permit more detailed climatic reconstructions.

A recent book by Fritts (1976) gives a detailed review of the state of the art in tree ring studies. Precipitation, temperature and pressure anomaly patterns for the entire West have been reconstructed and mapped for much of the last millenium (Fritts 1965, LaMarche and Fritts 1971, Fritts and Blasing 1973, Blasing 1975). For the West as a whole Bradley's summary of dendroclimatological studies should be noted (Bradley 1976c, p. 74):

> It is interesting to note that whereas the most recent 30-year normal (1941-1970) is indeed anomalous when compared to records of the last 100-120 years, the entire period considered in this study (approximately 1850-1970) may itself be anomalous when viewed in context of the last millenium. If LaMarche's dendroclimatic inferences are correct (LaMarche 1974), then conditions similar to the most recent "normal" have not prevailed since 1330 A. D. when a 200-year "warm-dry" spell ended, replaced by "cool-moist" conditions. Furthermore, the "warm-moist" conditions of the period c. 1870-1945 may only have occurred once in the last 1100 years -- from c. 1055 to 1130 A. D.

Unfortunately the few tree ring chronologies developed in the Pacific Northwest are in the arid regions of eastern Oregon and Washington (Stokes, Drew and Stockton 1973). No dendrochronologies exist for the humid western areas because abundant precipitation would make climatic interpretations difficult. Keen (1937) studied 1240 ponderosa pines in 40 different localities in eastern Oregon and northeast California and extended a crude index of climatic history back to the year 1268 A. D. He concluded that no clear trends exist for either a drier or wetter climate over this period, that the years 1900 to 1916 experienced close to normal amounts of precipitation when compared to the entire period, and that the drought of 1917-1935 was the most severe in the entire period. Schulman (1947) developed a chronology of tree-ring variations in the Okanogan Valley of southern British Columbia and north-central Washington for the period 1800 to 1941. He noted a relatively high rate of growth for the years 1800 to 1850; a lower rate of growth from 1850 to 1900 although 1861 was a year of exceptionally rapid growth; and an increase from 1900 to 1916 followed by a severe decline to the lowest levels in 1930-1931, followed by an increase from 1931 to 1941.

Lakes in the arid and semiarid interior sections of the American West have long attracted the attention of researchers concerned with climatic change because lake levels undergo considerable and frequent change in response to fluctuations in temperature and precipitation. For example, ancient and modern levels in Lake Bonneville of Utah have been studied extensively. Early studies by Gilbert (1890) and more recently by Ives (1948, 1954) and Antevs (1948, 1955) produced chronologies that place the major part of the history of Lake Bonneville in the late Pleistocene.

Studies of lake levels pertaining to climatic fluctuations in the last two centuries include that of Hardman and Venstrom (1941) who reconstructed changes in the level and volumes of Pyramid and Winnemuca lakes in the Great Basin from the early nineteenth century to 1940. They indicate that the early decades of the nineteenth century were quite dry; the period 1840 to 1860 was relatively dry. The decade of the 1860s experienced greatly increased precipitation, particularly the year 1867 to 1871. The decade of the 1880s was again quite dry, followed by increased precipitation through the 1910s and then a steady decline to the early 1930s. Lynch (1948) studied several interior lakes of the west and noted that they indicate generally heavy precipitation in the latter part of the nineteenth century and early years of the twentieth century, amounts not matched in the past 400 years. Lawrence and Lawrence (1961) studied 20 lakes between central British Columbia and northern California and were able to supplement the findings of others -- high lake levels in the 1870s and 1880s and again in the early 1900s, extreme dessication until the middle and late 1930s, followed by a rather steady rise in the 1940s which accelerated in the 1950s. Fairbanks (1954) noted lake level increases from the late 1930s to almost record levels by 1958 for several eastern Oregon locations and Friedman and Redfield (1971) found a similar rise in Soap Lake in eastern Washington.

High levels of interior lakes in the American West have been found to be generally coincident with periods of advance of mountain glaciers Lawrence (1950, 1958), the most dramatic advance in recent centuries being that of the late seventeenth and early eighteenth centuries, the culmination of the Little Ice Age. Such advances have been documented on Mount Hood, Oregon and on other western mountains. Studies of more recent glacial movements have showed renewed advance since about 1942 after several decades of accelerated recession. Dyson (1948) studied the shrinkage of Sperry and Grinnell glaciers in Glacier National Park, Montana and noted a considerable recession between 1850 and 1900 that become more severe in the early decades of the twentieth century; since 1937-1938 the recession had slowed. The tendency for a readvance was first detected by Johnson (1954) on Nisqually Glacier on Mt. Rainier and supported by Bengston (1956) who noted a spectacular advance of Coleman Glacier on Mt. Baker beginning in 1949. By the middle 1950s Hubley (1956) was able to record enlargements of 50 glaciers in the Olympics and Cascades between 1947 and 1956. Corraborating evidence comes from Franklin et al (1971). In a study of the invasion of trees into the tundra zone of Mt. Rainier, they found that the most extensive period of forest invasion was 1928 to 1937, the same period of time that the Nisqually Glacier was receeding rapidly.

Instrumental Data

There is general agreement that the entire northern hemisphere has experienced a general warming from about 1850 to the 1940s (Mitchell 1961, 1963), attributable in part to increased levels of carbon dioxide in the atmosphere (Willett 1950, Möller 1963, Sellers 1974). Since around 1940, as suggested by the evidence, there has been a reversal of this trend and general cooling, primarily at middle and high latitudes (Lamb 1966, Budyko 1969, Angell and Korshover 1977, 1978). Causes of this cooling episode probably are multiple, including solar variability (Willett 1974 and Agee 1980) and volcanic activity (Oliver 1976). Kalnicky (1974) documented a broadscale shift in the general circulation, a shift to increased meridional flow. However, temperature and precipitation anomalies on a regional basis do not necessarily reflect this hemispheric trend. Some regions of the middle latitudes have actually warmed while others, such as the central and eastern United States, have experienced sharp cooling (Wahl and Lawson 1970).

Perhaps of more significance is the fact that there is a growing body of evidence that the extreme variations in weather patterns of recent years is a return to a period of increasing climatic variability. Wahl and Lawson (1970) echoed the concern of many investigators that the 1930-1960 period was the most abnormal climatic episode in a thousand years. Extreme events of the 1970s such as severe winters in the central and eastern United States (Diaz and Quayle 1978) and drought in the West (Shelton 1977, Bates 1978, Namias 1979) have certainly done nothing to refute this opinion.

Research on climatic change as determined from instrumental data has centered primarily on temperature data. Precipitation data have been less frequently strutinized due to inhomogeneity of records, difficulty in extrapolating point values to areal values and the greater variability in both space and time. However, there have been some excellent studies of precipitation history completed in recent years for various parts of the American West. Sellers (1960) examined temperature and precipitation fluctuations in Arizona and New Mexico since the 1850s and discovered a downward trend in precipitation since 1905, approximately one inch per 30 years, due almost entirely to a decrease in winter precipitation. Von Eschen (1958) found a decrease in precipitation in New Mexico since 1915 accompanied by rising temperatures.

Several studies of California precipitation have also been completed in recent years. Pyke (1966) noted definite fluctuations of precipitation of relatively short duration (10-30 years), particularly in monthly rainfall. In addition a slight downward trend in the annual totals of precipitation, particularly since 1915, is apparent at stations in southern California and along the coast of central California. Some very short (1-10 years) and seemingly random fluctuations were also noticed in annual precipitation in California. Granger (1977) also studied fluctuations in precipitation in lowland California and concluded that while there have been significant fluctuations in precipitation amounts over the past 100 years he could see no regularity in wet and dry cycles that would permit predictions of future precipitation.

Precipitation and temperature fluctuations along the British Columbia coast were examined by Crowe (1963) who noted a rising trend in mean annual temperature from 1900 to 1950 but no significant increase or decrease in mean annual precipitation.

Some of these regional studies of precipitation fluctuations have included data from Oregon and Washington stations. The most useful work for students of precipitation in the Pacific Northwest is that of Bradley (1976a, 1976b, 1976c) who reconstructed the precipitation history of the Rocky Mountain states from instrumental data, i.e. since about 1850. Using early records from all the western states he was able to document variations in precipitation for the latter half of the nineteenth century, comparing precipitation totals to the decade of the 1950s average over much of the western United States from at least 1865 to 1890. Summers 1870-1890 were drier than the 1950s. Falls were very dry at times over large areas in the latter part of the nineteenth century. For the entire instrumental period his analysis is restricted to the states of Idaho, Montana, Wyoming, Utah and Colorado and the data are compared with the 1941-1970 normal. His findings are summarized as follows: (Bradley 1976a, p. 513):

> Generally, precipitation was high in the 1890s, 1910s and/or 1920s, 1940s and 1960s. Other decades were relatively dry, particularly the 1930s. Springs 1941-1970 were wetter than the previous 30 years, but the period 1881-1910 was wetter than the 1941-1970 averages. Considering

summer precipitation, 1941-1970 was probably the most anomalously wet period for at least 110 years and perhaps much longer. Over much of the Rockies the 1960s were extraordinarily wet. Fall precipitation was exceptionally low in the 1950s, but the 1941-1960 average was still relatively high, though generally drier than the 1890s, 1910s and 1920s. Winter precipitation in recent decades has been considerably less than was characteristic of the late 19th and early 20th centuries, except in Idaho. Recurrent anomaly patterns, centered over southern Idaho, are characteristic of the winter record.

When the entire secular period is considered the recent "normal" is anomalous; in particular, summer precipitation has been unusually high and winter precipitation relatively low. One hundred years ago the climate of the Rockies was characterized by wetter winters and springs but much drier summers (and in some areas) drier falls compared to the post-1940 climate of the region.

ANALYSIS

Precipitation Data Series

The majority of studies concerned with precipitation data for the secular period have involved detailed analyses of a few widely scattered stations or have combined a number of stations into a regional average. Given the high degree of spatial variability in Pacific Northwest precipitation it would be impossible to generate a reliable series for the entire region. Instead, in this study a dense network of individual stations has been analyzed.

The reconstruction of long-term precipitation data series in the Pacific Northwest was a more laborious task than was the assembling of a 40-year data base. The history of climatological observations in the region is well described by Roden (1966) and Bradley (1976a, 1976c). They have found no indication of precipitation observations being officially recorded in Oregon or Washington prior to 1849 when records were kept at Fort Steilacoom near present day Puyallup, Washington.

In the 1850s data were recorded at several sites on a continuous basis; for example at Astoria, Fort Dalles, Fort Haskins and Fort Yamhill in Oregon and at Fort Vancouver and Fort Walla Walla in Washington. Early observers were either surgeons at military posts or volunteers reporting to the Smithsonian Institution. In 1870 the coordination of observations and record keeping was transferred to the Chief Signal Officer in the Department of War. The Signal Service maintained the network until 1 July 1891 when the U. S. Weather Bureau was established.

Until the early 1890s the observing network was thus sparse and the majority of stations established remained in operation for only a few years. For the entire nineteenth century records of more than 10 years duration anywhere in the western United States are rare and the vast majority were kept for less than five years. However, as noted earlier, Bradley (1976a, 1976c) was able to use the available data to present a reasonably detailed picture of precipitation fluctuations over the Rocky Mountain states and the Pacific Northwest for the years 1851-1890. This excellent study should be consulted by anyone interested in nineteenth century precipitation in the American west.

The approach in this study was to work exclusively with continuous precipitation data series, where possible those extending from some time in the nineteenth century up to the present. After the establishment of the Weather Bureau in 1891 the observing network became much more dense and by 1900 there were approximately 163 reporting stations in Oregon and Washington, many of which have continued uninterrupted to the present day.

A network of 70 long-term stations was selected for analysis, 33 in Washington and 37 in Oregon. For most of the stations, data for the entire period were obtained from Climatological Data - Annual Summaries and from the N.O.A.A. computer tapes. Where necessary data for the early part of the record were taken from Bulletin W of the U. S. Weather Bureau which includes data from the establishment of stations until 1930, and from Greeley (1889) and Greeley and Glassford (1888). The distribution of these stations reflects the settlement pattern of the region and is weighted toward the more populated areas. Therefore, it was necessary to include several stations with shorter histories in order to fill out the network geographically (Figure 20). This network is listed in Table 5 with the period of continuous record for annual (water year) precipitation, the mean and standard deviation for the period of record and annual totals for the extreme years -- the two wettest and the two driest.

Each of these precipitation data series represents a time series -- a sequence of observations arranged in temporal order. The study of changes and fluctuations in climatic elements is essentially a problem in time series analysis and the amount of information in a series depends directly on its length.

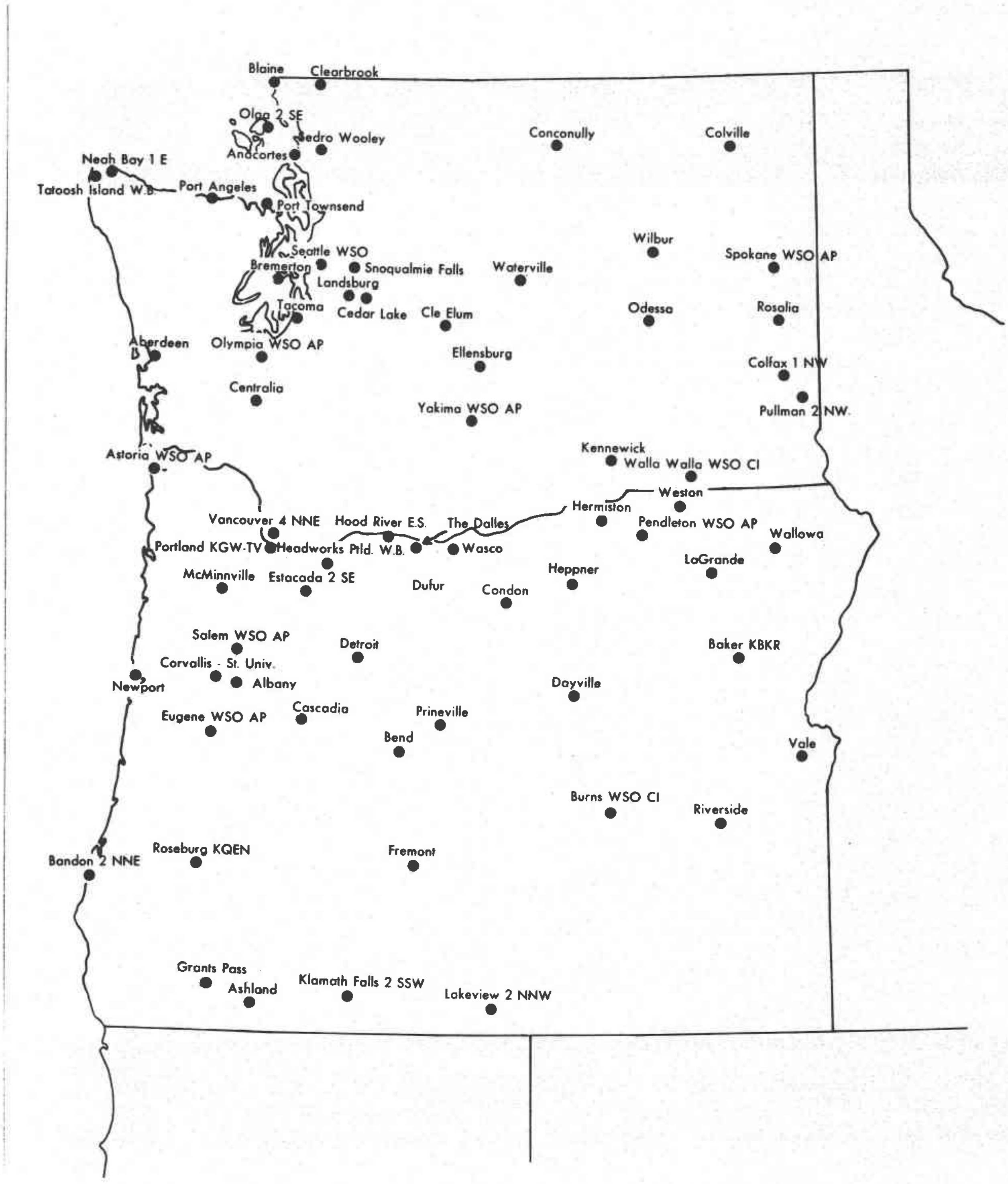


Figure 2Ø. Network of Long-Term Stations Used in this Study. Descriptive Statistics are in Table 5.

Table 5
Long-Term Stations
(all data in inches)

(OREGON)

Station	Years	Mean	StDev	Max(year)	Min(year)
0008 Albany*	1880-1974	41.31	7.21	61.25(1974)	25.14(1924)
				59.55(1894)	28.18(1944)
0304 Ashland	1880-1979	19.62	4.54	28.99(1927)	8.36(1955)
				27.83(1956)	11.26(1883)
0328 Astoria	1854-1979	75.89	13.45	112.82(1976)	43.35(1928)
WSO AP				109.22(1956)	45.51(1977)
(Ft. Stevens 1877-1883)					
0417 Baker KBKR	1890-1979	11.32	2.80	21.32(1894)	5.89(1919)
				19.25(1956)	6.05(1937)
0471 Bandon 2 NNE	1879-1979	57.58	13.86	106.73(1894)	27.07(1924)
				106.54(1895)	30.85(1934)
0694 Bend	1903-1979	12.23	3.73	22.70(1907)	4.35(1955)
				20.87(1948)	6.08(1977)
1176 Burns WSO CI	1893-1979	10.89	3.17	19.98(1906)	5.24(1924)
				17.20(1922)	5.38(1929)
1433 Cascadia	1909-1979	62.12	8.83	81.98(1943)	43.73(1977)
				81.79(1916)	44.50(1973)
1765 Condon	1908-1979	12.74	3.06	21.36(1948)	6.63(1939)
				20.02(1965)	7.80(1949)
1862 Corvallis	1890-1979	40.46	7.79	67.70(1974)	24.60(1977)
State Univ.				58.82(1971)	24.97(1944)
2168 Dayville	1895-1979	11.70	2.80	20.13(1958)	6.97(1949)
				18.87(1948)	7.47(1910)
2277 Detroit	1910-1979	74.95	13.95	110.49(1972)	49.70(1926)
				102.65(1971)	53.48(1977)
2440 Dufur	1910-1979	12.28	3.45	21.43(1916)	5.53(1977)
				19.95(1927)	7.21(1939)
2693 Estacada 2 SE	1910-1979	57.27	9.33	76.98(1956)	40.10(1977)
				76.77(1974)	40.18(1924)
2709 Eugene	1891-1979	40.68	9.12	74.18(1974)	23.68(1924)
WSO AP				63.97(1972)	23.74(1977)
3095 Fremont	1910-1979	10.50	3.46	21.94(1956)	3.53(1955)
				19.95(1965)	4.52(1929)
3445 Grants Pass	1890-1979	30.34	8.01	51.25(1956)	13.06(1924)
				49.95(1890)	16.05(1977)
3770 Headworks,	1899-1979	80.50	13.87	131.10(1933)	53.32(1929)
Portland W. B.				120.02(1943)	57.12(1930)
3827 Heppner	1890-1979	13.43	2.63	20.63(1948)	8.24(1939)
				18.55(1912)	9.02(1929)
3847 Hermiston	1907-1979	8.55	2.14	13.80(1958)	4.43(1908)
				13.73(1974)	5.48(1935)

(OREGON)

Station	Years	Mean	StDev	Max(year)	Min(year)
4003 Hood River	1885-1979	31.03	8.47	62.68(1894)	13.60(1977)
Exp. Sta.				50.55(1899)	14.74(1924)
4506 Klamath Falls	1898-1979	13.36	3.81	23.18(1927)	6.61(1926)
2 SSW				22.79(1956)	7.21(1924)
4622 LaGrande	1899-1979	19.43	3.52	29.04(1912)	10.40(1973)
				26.05(1913)	11.93(1977)
4670 Lakeview	1885-1979	14.58	4.52	26.10(1907)	5.69(1924)
2 NNW				25.24(1894)	6.98(1977)
5384 McMinnville	1888-1979	42.90	8.90	60.75(1897)	23.38(1979)
				60.23(1974)	23.55(1977)
6032 Newport	1892-1979	68.11	12.93	99.14(1974)	42.76(1977)
				95.84(1969)	43.05(1924)
6546 Pendleton	1890-1979	13.13	2.90	20.20(1894)	7.23(1973)
WSO AP				18.66(1912)	7.67(1968)
6749 Portland	1872-1979	42.43	8.88	71.82(1883)	27.18(1924)
KGW-TV				69.51(1876)	27.61(1977)
6883 Prineville	1897-1979	9.47	2.42	16.28(1958)	4.98(1939)
				15.49(1978)	5.08(1955)
7208 Riverside	1898-1979	9.10	2.60	16.24(1917)	4.01(1939)
				15.09(1913)	4.23(1977)
7331 Roseburg	1878-1979	32.50	7.02	49.86(1956)	15.34(1977)
KQEN				47.64(1974)	18.52(1924)
7500 Salem	1893-1979	39.53	7.71	58.48(1974)	20.37(1977)
WSO AP				58.42(1894)	24.48(1924)
8407 The Dalles	1875-1979	13.42	4.00	24.39(1881)	4.43(1977)
				24.31(1884)	5.38(1968)
8797 Vale	1892-1979	9.07	2.30	15.48(1904)	3.61(1949)
				14.09(1978)	4.73(1939)
8997 Wallowa	1904-1979	17.52	3.55	23.71(1956)	7.76(1929)
				23.69(1959)	9.47(1924)
9068 Wasco	1908-1979	11.65	2.69	17.59(1951)	6.52(1977)
				17.35(1916)	6.65(1929)
9213 Weston*	1890-1977	22.54	5.29	35.09(1974)	12.23(1929)
				32.74(1904)	13.03(1944)

(WASHINGTON)

Station	Years	Mean	StDev	Max(year)	Min(year)
0008 Aberdeen	1891-1979	82.50	12.06	105.87(1933)	55.77(1977)
				105.81(1956)	56.28(1979)
0176 Anacortes	1893-1979	26.16	4.73	39.44(1894)	17.07(1958)
				34.94(1918)	17.14(1944)
0729 Blaine	1894-1979	40.70	7.03	59.44(1934)	25.84(1979)
				55.48(1894)	26.31(1929)
0872 Bremerton	1898-1979	41.15	9.49	71.12(1974)	22.65(1939)
				66.99(1956)	23.30(1944)
1233 Cedar Lake	1899-1979	104.19	15.91	134.55(1916)	76.02(1930)
				133.33(1918)	76.20(1915)
1276 Centralia	1891-1979	45.49	7.81	66.83(1916)	28.88(1944)
				60.69(1956)	29.77(1891)
1484 Clearbrook	1903-1979	47.25	7.67	67.55(1972)	31.04(1929)
				63.62(1964)	31.54(1979)
1504 Cle Elum	1899-1979	22.95	5.62	39.57(1959)	12.70(1977)
				38.05(1972)	13.60(1944)
1586 Colfax 1 NW	1893-1979	20.14	4.27	31.06(1894)	10.28(1977)
				31.06(1948)	11.98(1966)
1650 Colville	1898-1979	16.43	3.42	25.39(1969)	10.06(1929)
				24.11(1974)	10.24(1924)
1666 Conconully	1900-1979	14.80	4.13	27.11(1941)	7.22(1931)
				26.76(1937)	7.79(1979)
2505 Ellensburg	1893-1979	8.97	2.42	14.73(1916)	4.20(1973)
				14.17(1907)	4.20(1979)
4154 Kennewick	1895-1979	7.30	2.13	15.50(1948)	3.76(1908)
				12.47(1916)	3.86(1909)
4486 Landsburg	1903-1979	55.21	8.49	74.10(1948)	39.53(1977)
				73.25(1972)	40.40(1930)
5801 Neah Bay 1 E	1884-1979	92.24	21.32	148.04(1976)	57.71(1979)
				140.65(1974)	60.99(1937)
6039 Odessa	1904-1979	9.92	2.54	19.29(1948)	4.67(1929)
				16.45(1941)	5.13(1949)
6096 Olga 2 SE	1890-1979	29.13	4.92	40.02(1894)	13.95(1929)
				38.76(1964)	19.09(1979)
6114 Olympia WSO AP	1878-1979	51.20	10.32	79.51(1878)	27.01(1944)
				70.66(1916)	31.58(1929)
6624 Port Angeles	1879-1979	25.54	5.03	36.71(1916)	14.99(1944)
				35.89(1894)	16.01(1926)

135

(WASHINGTON)

Station	Years	Mean	StDev	Max(year)	Min(year)
6678 Port Townsend	1874-1979	19.24	3.80	35.36(1875) 29.30(1876)	10.27(1930) 12.55(1924)
6789 Pullman 2 NW	1894-1979	20.63	4.20	31.05(1959) 29.68(1927)	13.19(1977) 13.63(1924)
7180 Rosalia	1892-1979	17.98	3.84	31.72(1948) 27.23(1897)	9.51(1922) 9.96(1973)
7488 Seattle WSO*	1879-1979	34.14	6.30	57.37(1879) 46.62(1948)	21.20(1944) 22.58(1929)
7507 Sedro Wooley	1897-1979	46.03	7.77	68.00(1959) 63.07(1933)	31.18(1979) 31.34(1929)
7773 Snoqualmie Falls	1899-1979	58.31	10.19	82.36(1948) 80.21(1972)	39.50(1977) 41.91(1930)
7938 Spokane WSO AP	1882-1979	16.08	3.75	28.78(1948) 23.89(1897)	8.79(1929) 9.83(1924)
8286 Tacoma City Hall	1884-1979	38.10	7.15	53.60(1894) 52.04(1903)	21.66(1952) 23.92(1930)
8332 Tatoosh Island WB*	1879-1966	80.47	13.71	116.05(1879) 112.02(1900)	54.33(1929) 60.99(1937)
8773 Vancouver 4 NNE	1899-1979	38.66	6.64	56.44(1974) 53.20(1956)	25.72(1977) 26.09(1924)
8931 Walla Walla WSO CI	1873-1979	16.13	3.18	25.46(1877) 24.55(1894)	9.87(1929) 10.00(1874)
9012 Waterville	1891-1979	11.07	3.02	23.84(1948) 17.49(1897)	5.27(1977) 5.73(1979)
9238 Wilbur	1900-1979	12.30	3.08	25.26(1948) 18.07(1901)	6.48(1929) 6.51(1930)
9465 Yakima WSO AP	1910-1979	7.36	2.12	14.25(1956) 12.88(1974)	3.92(1979) 4.19(1930)

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* Stations not on 40-year network

0008 Albany 44 39N 123 06W Elev. = 220 feet
(Albany No. 2 since 1963)

9213 Weston 45 50N 118 26W Elev. = 1900 feet

7488 Seattle WSO 47 36N 122 20W Elev. = 14 feet
(Seattle EMSU WSO since 1972)

8332 Tatoosh Island W. B. 48 23N 124 44W Elev. = 101 feet

Three components are generally recognized in any time series:

a. the over-all or long-term trend -- in this case, the secular trend;

b. fluctuations about the trend of a periodic (cyclical) or aperiodic nature;

c. irregular or random variations.

A great variety of statistical tests to detect and define these components has been developed and utilized by numerous investigators in the field of climatic change. There is no question that research findings often vary with the form of analysis that is applied to the data. For this reason three different approaches have been taken in this study: one to detect secular trend in the annual and seasonal precipitation series; a second to detect short-term trends and fluctuations in the series with a filtering technique; and a third to compare annual means and variability for each decade with those for the entire period of record at each station. Methods used here are fairly routine and generally accepted as being appropriate for the analysis of climatic change (Mitchell et al 1966).

Trend

The most likely alternative to a totally random data series is usually some form of trend. A linear least squares regression is often applied to define a trend. However, if a non-linear trend exists this technique will not detect it. In this study the presence or absence of trend was thus tested for in two ways. One is the use of the Kendall rank statistic (Kendall 1970) which has the power of detecting a non-linear as well as linear trend. Additionally, the test is robust -- meaning that departures from a normal distribution do not matter. The Kendall rank statistic (τ) is defined as follows:

$$\tau = \frac{4P}{n(n-1)} - 1 \qquad (7)$$

To determine P, the value of the first term of the series, x_1, is compared with all later terms in the series and the number of values exceeding x_1 are counted. The value of the second term of the series, x_2, is then compared with all subsequent values and so on for every term of the series.

The rank statistic approximates a normal distribution for n greater than 10 and is used to assess the significance of a trend by comparison with the value:

$$(\tau)_t = 0 \pm t_g \sqrt{\frac{4n + 10}{9n\ (n-1)}} \qquad (8)$$

where t_q is the desired probability level of the normal distribution for a two-tailed t-test. The value of τ is positive for an upward trend and negative for a downward trend. The rank statistic for the annual precipitation data series for each station is noted in Table 6. Significance of the statistic at both the 90 percent and the more restrictive 95 percent levels of confidence are noted. The results are also mapped (Figure 21).

It can be seen immediately that not only are precipitation amounts around the Pacific Northwest tremendously variable but so too is the direction of change over time. In Oregon approximately half the station data series (16) yield a positive τ-value and half (21) a negative value. Five of the positive values are statistically significant at the 90 percent level (Headworks, Detroit, Eugene, Condon and Weston) and five of the negative values (Roseburg, Fremont, The Dalles, Pendleton and Baker). There is no geographic preference for positive or negative trends anywhere in the state and no firm relationship with record length, although there is a tendency for negative values at the stations with the longest periods of record. Astoria WSO AP, with the longest data series, has a negative value but it is not statistically significant. All stations with at least 100 years of data show negative trends, significant at Roseburg and at The Dalles. This is certainly due in part to the inclusion of the wet decade of the 1880s.

In the state of Washington a clearer pattern emerges with regard to changes over time. Of the 33 series tested for the rank statistic 24 yielded a negative value. A downward trend in annual precipitation for the last century appears to prevail throughout the state. However, only six of these series are statistically significant and there are several stations which exhibit a positive trend. At Bremerton and Seattle-Univ. of Washington the trend is positive (statistically significant at Bremerton), yet they are surrounded by stations with statistically significant downward trends. It is clear that any regional or state average would certainly be influenced by the group of stations selected and the period of record considered. The comparison of Tatoosh Island WB and Neah Bay 1 E is illustrative. These two stations, in close proximity to each other, both yield a significant (95 percent) rank statistic -- positive at Neah Bay 1 E, negative at Tatoosh Island WB. The period of record at Tatoosh Island is only through 1966. A number of unusually wet years after 1966 are sufficient to change the overall trend to a positive value at Neah Bay 1 E when the entire period to 1979 is considered.

Linear trend was also calculated for all stations (for both annual and seasonal data series) by the standard method of least squares regression. The significance of the

Table 6
Trend Statistics
Values in Inches per Year
Level of Significance
**95%
*90%

Station (period of record)	Rank Statistic (↑)	Regression Coefficient Annual	Winter	Summer
(OREGON)				
0008 Albany (1880-1974)	-.082	-.023	-.011	-.011
0304 Ashland (1880-1979)	-.066	-.016	-.013	-.001
0328 Astoria WSO AP (1854-1979)	-.111	-.062*	-.044	-.018**
0417 Baker KBKR (1890-1979)	-.148**	-.018	-.019**	+.001
0471 Bandon 2NNE (1879-1979)	-.034	-.043	-.025	-.019*
0694 Bend (1903-1979)	-.107	-.033*	-.023	-.010
1176 Burns WSO CI (1893-1979)	+.061	+.011	+.011	+.002
1433 Cascadia (1909-1979)	-.016	-.006	+.020	-.029
1765 Condon (1908-1979)	+.153*	+.035**	+.055	+.019
1862 Corvallis-State University (1890-1979)	-.034	+.010	.000	+.009
2168 Dayville (1895-1979)	-.024	.000	-.006	+.005
2277 Detroit (1910-1979)	+.238**	+.248**	+.219**	+.030
2440 Dufur (1910-1979)	+.130	-.036*	-.022	-.013**
2693 Estacada 2 SE (1910-1979)	-.115	+.086	+.074	+.011
2709 Eugene WSO AP (1891-1979)	+.235**	+.129**	+.143**	-.013
3095 Fremont (1910-1979)	-.204**	+.047**	+.049**	-.002
3445 Grants Pass (1890-1979)	+.013	+.009	+.012	-.004
3770 Headworks, Portland Water Bureau (1899-1979)	+.131*	+.119*	+.108*	+.011
3827 Heppner (1890-1979)	-.057	-.009	-.004	-.005
3847 Hermiston (1907-1979)	+.088	+.013	+.010	+.002
4003 Hood River Exp. Sta. (1885-1979)	-.094	-.068**	-.062**	-.005
4506 Klamath Falls 2 SSW (1898-1979)	+.091	+.018	+.012	+.010
4622 LaGrande (1899-1979)	-.031	-.016	-.004	-.012
4670 Lakeview 2 SSW (1885-1979)	+.016	+.001	-.005	+.007
5384 McMinnville (1888-1979)	+.078	-.032	-.023	-.009
6032 Newport (1892-1979)	+.069	+.062	+.065	-.003
6546 Pendleton WSO AP (1890-1979)	-.210**	-.034*	-.019**	-.015**
6749 Portland KGW-TV (1872-1979)	-.033	-.022	-.030	+.008
6883 Prineville (1897-1979)	+.127*	+.021**	+.015*	+.005
7208 Riverside (1898-1979)	-.067	-.015	-.012	.000
7331 Roseburg KQEN (1878-1979)	-.134**	-.040*	-.033	-.007
7500 Salem WSO AP (1893-1979)	+.060	+.024	+.029	-.005
8407 The Dalles (1875-1979)	-.258**	-.051**	-.048**	-.003
8797 Vale (1892-1979)	-.017	-.001	-.003	+.002
8997 Wallowa (1904-1979)	+.070	+.018	+.011	+.007
9068 Wasco (1908-1979)	-.085	-.014	-.016	-.002
9213 Weston (1890-1979)	+.118*	+.035	+.028	+.009

Station (period of record)	Rank Statistic (τ)	Regression Coefficient Annual	Winter	Summer
	(WASHINGTON)			
0008 Aberdeen (1891-1979)	-.086	-.042	-.034	-.008
0176 Anacortes (1893-1979)	-.126*	-.039**	-.032**	-.006
0729 Blaine (1894-1979)	-.062	-.024	-.013	-.010
0872 Bremerton (1898-1979)	+.248**	+.175**	+.152**	+.024**
1233 Cedar Lake (1899-1979)	+.075	-.085	-.078	-.073
1276 Centralia (1891-1979)	-.122	+.016	+.015	.000
1484 Clearbrook (1903-1979)	-.111	-.044	-.050	+.006
1504 Cle Elum (1899-1979)	-.092	-.027	-.021	-.005
1586 Colfax 1 NW (1893-1979)	-.041	-.022	-.019	-.002
1650 Colville (1898-1979)	+.042	+.013	+.015	-.001
1666 Conconully (1900-1979)	-.086	-.014	-.004	-.010
2505 Ellensburg (1893-1979)	-.057	-.008	-.005	-.003
4154 Kennewick (1895-1979)	+.075	+.009	+.005	+.006
4486 Landsburg (1903-1979)	-.109	+.071*	+.047	+.025
5801 Neah Bay (1884-1979)	+.145**	+.147*	+.126*	-.011
6039 Odessa (1904-1979)	-.018	.000	+.005	-.004
6096 Olga 2SE (1890-1979)	-.057	-.017	-.014	-.003
6114 Olympia WSO AP (1878-1979)	-.135**	-.057*	-.058*	+.001
6624 Port Angeles (1879-1979)	-.240**	-.057**	-.047**	-.010*
6678 Port Townsend (1874-1979)	-.144**	-.028**	-.025**	-.007
6789 Pullman 2 NW (1894-1979)	-.020	-.002	-.005	+.003
7180 Rosalia (1892-1979)	-.079	-.028*	-.021*	-.007
7488 Seattle WSO (1879-1979)	+.010	+.022	+.001	.000
7507 Sedro Wooley (1897-1979)	-.051	-.011	-.010	.000
7773 Snoqualmie Falls (1899-1979)	+.120	+.087*	+.082**	+.004
7938 Spokane WSO AP (1882-1979)	-.067	-.008	-.004	-.003
8286 Tacoma City Hall (1884-1979)	-.177**	-.066**	-.058**	-.008
8332 Tatoosh Island WB (1879-1966)	-.189**	-.170**	-.211**	-.075**
8773 Vancouver 4 NNE (1899-1979)	+.081	+.052*	+.040	+.012
8931 Walla Walla WSO CI (1873-1979)	-.208**	-.019**	-.011	-.007
9012 Waterville (1891-1979)	-.014	-.017	-.014	-.002
9238 Wilbur (1900-1979)	-.044	-.009	-.007	-.002
9465 Yakima WSO AP (1910-1979)	+.108	+.019	+.020*	.000

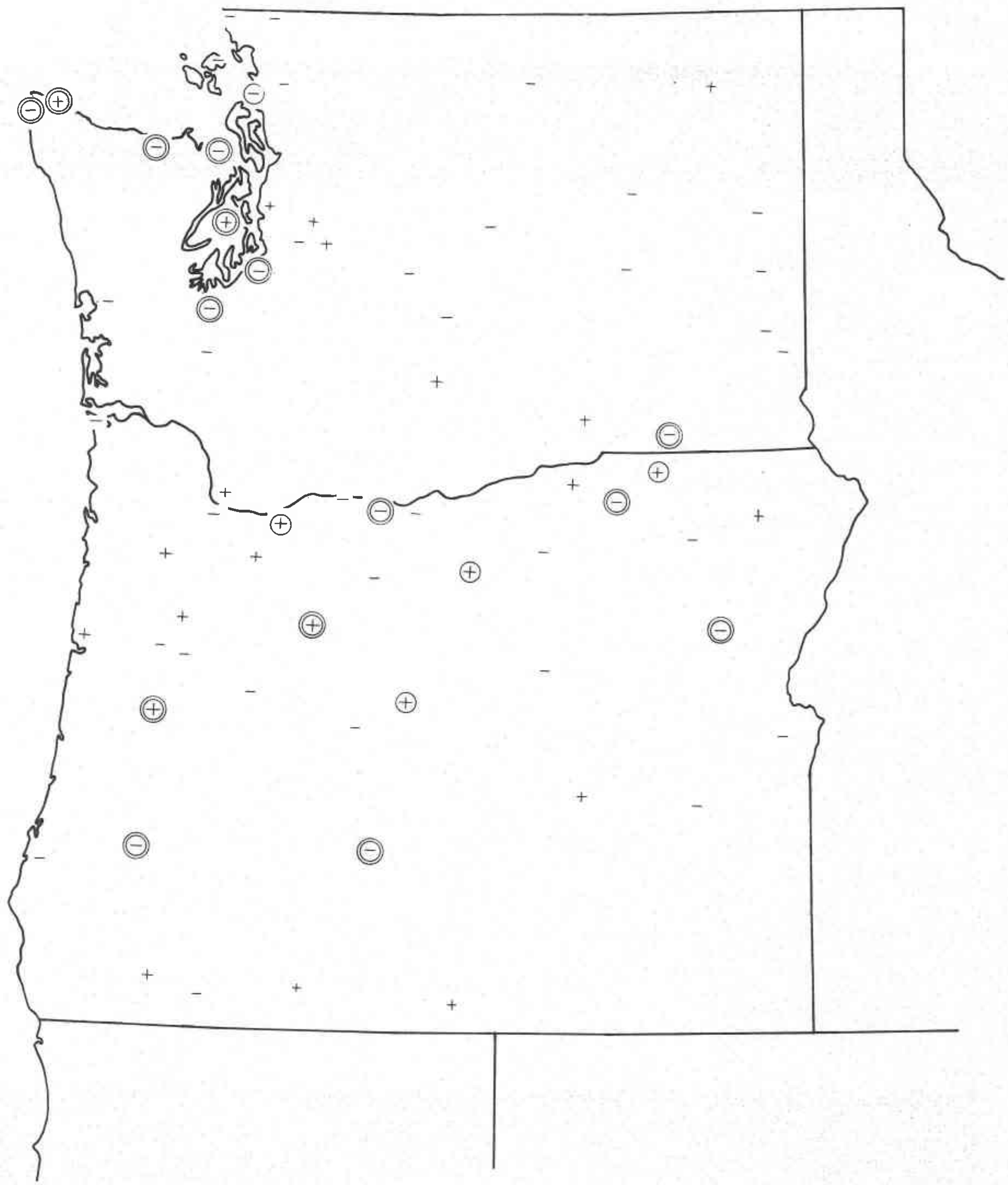


Figure 21. Results of Trend Analysis of Long-Term Data Series. Plus and Minus Values are for the Rank Statistic (see Table 6). Circle Indicates Significance of the Statistic at the 90 Percent Level; Double Circle at the 95 Percent Level.

regression coefficients was evaluated with a two-tailed t-test. Results are included in Table 6. For annual data the results are much the same as those for non-linear trend. In Oregon essentially the same pattern, or lack thereof, exists. Of those regression coefficients that are significant at the 90 percent level seven are negative and six are positive. As with the rank statistic, the stations in the north Oregon Cascades (Headworks and Detroit) show a significant positive trend; otherwise results are mixed. Regression coefficients for winter data, as expected, are uniformly similar to those for the annual series, in most cases at the same level of significance. For the summer season there is a tendency for negative trends to occur and the four significant (90 percent) trends are all negative and widely scattered through the state.

In Washington the analysis of linear trend also yields nearly identical results to the analysis of non-linear trend and winter trends mirror annual trends in most cases. Only three of the summer series were found to have significant regression coefficients, two negative and one positive.

Short-Period Fluctuations

The principal reason that it is so difficult to glean much useful information from trend analysis is that there are fluctuations within the data series, trends that occur over shorter periods of time than the entire period of record. The best way to observe these fluctuations in the data is to simply plot them as a time series. This has been done for the 70 long-term stations. The entire set of graphs is collected in Appendix E. For 12 of these stations, evenly distributed over the two states, seasonal graphs are included (Figure 22).

Due to the rapid fluctuations in the data series, some sort of filtering technique is necessary to allow the investigator to "see" longer-period oscillations. Smoothing, or filtering, of the data with moving averages is a common practice, the purpose being to attenuate the rapid (high-frequency) waves in the data series without significantly affecting the slower (low-frequency components). The assumption here is that the high-frequency oscillations are either random in nature (i.e. noise) or of no particular significance. Thus a "smoothed" value is merely an estimate of what the value would be if noise were not present in the series. If well defined, long-period oscillations do exist in the series the technique can aid in revealing their form.

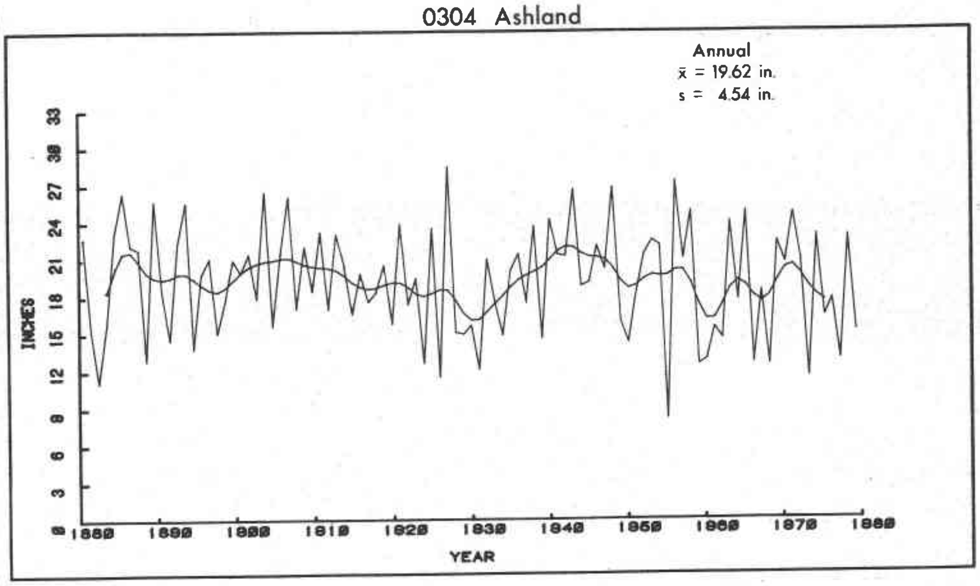
However, long-period variations are generally poorly defined, particularly in precipitation data series where the random component of variation is quite large. In that case an ordinary (equal-weighted) moving average is inappropriate and may even exaggerate long-period oscillations in such a

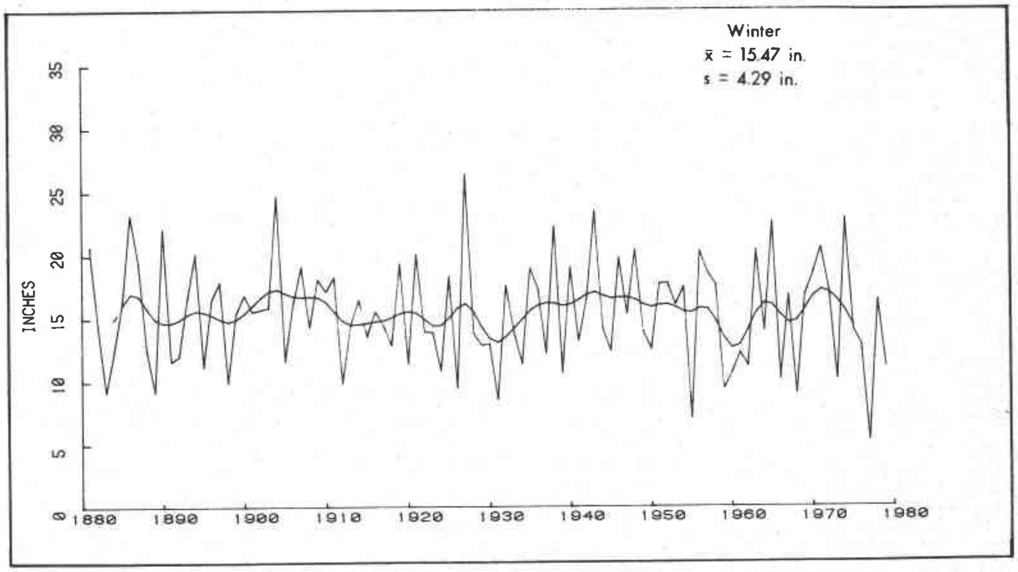
Figure 22.

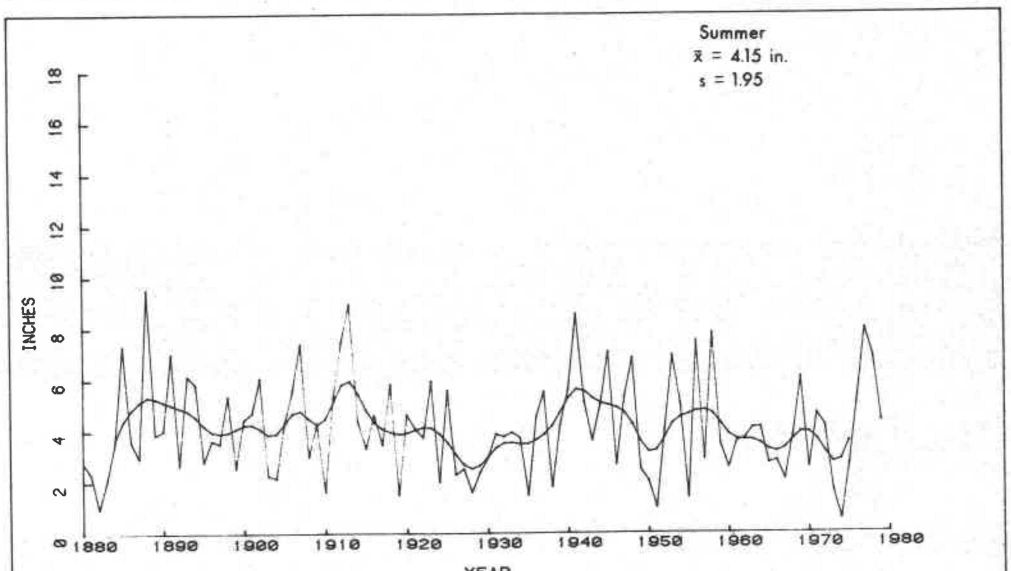
Time Series Graphs of Annual (Water Year) and Seasonal Precipitation at 12 Long-Term Stations in Oregon and Washington:

Oregon:	Ø3Ø4 Ashland
	Ø417 Baker KBKR
	2168 Dayville
	467Ø Lakeview 2 NNW
	6Ø32 Newport
	6749 Portland KGW-TV
Washington:	ØØØ8 Aberdeen
	6114 Olympia WSO AP
	6678 Port Townsend
	7938 Spokane WSO AP
	8931 Walla Walla WSO CI
	9Ø12 Waterville

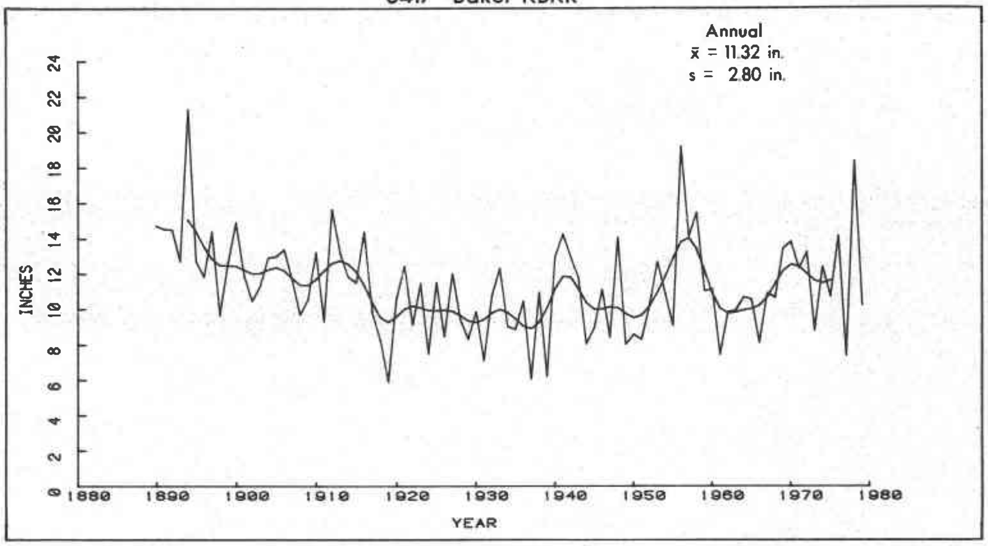
0304 Ashland

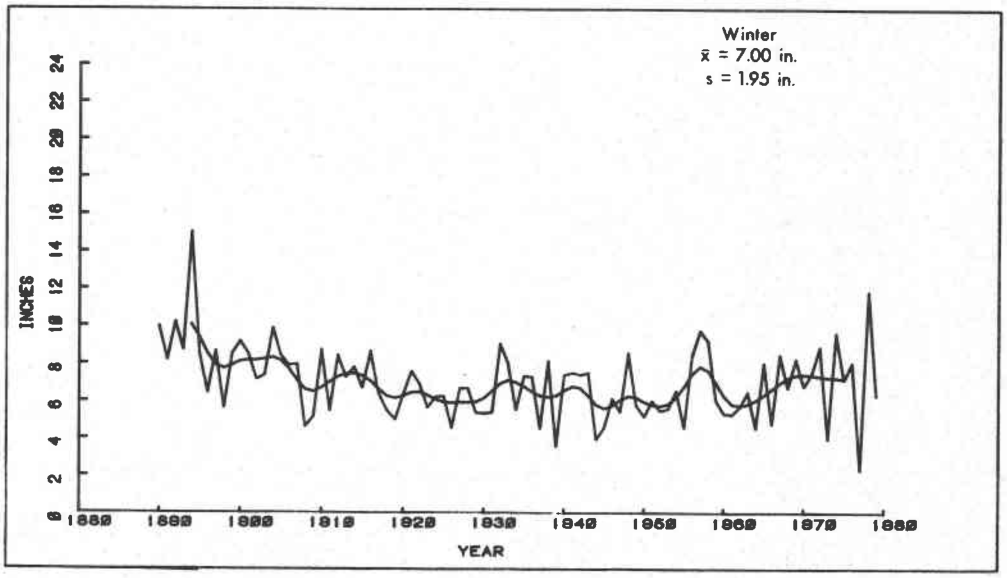


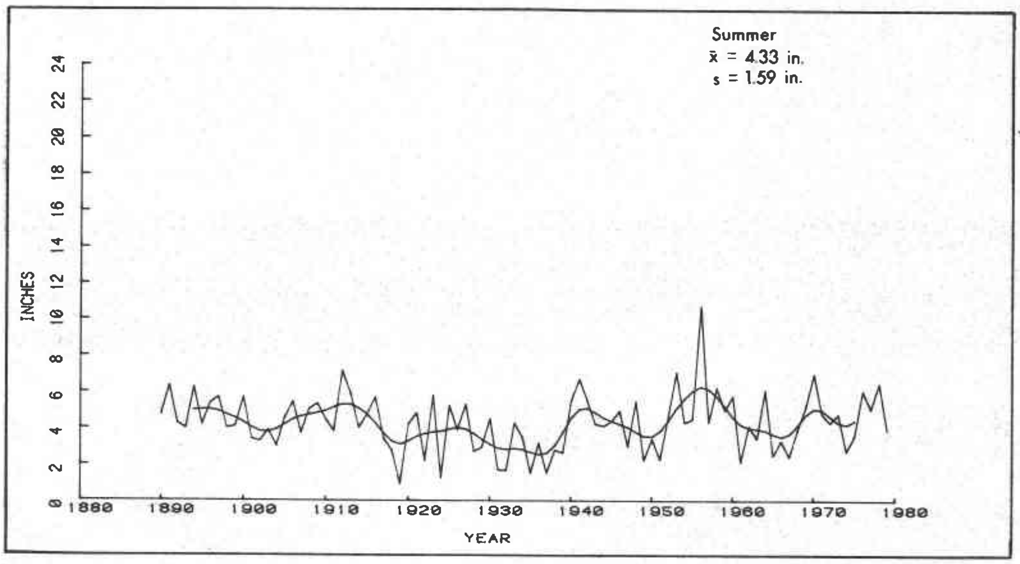




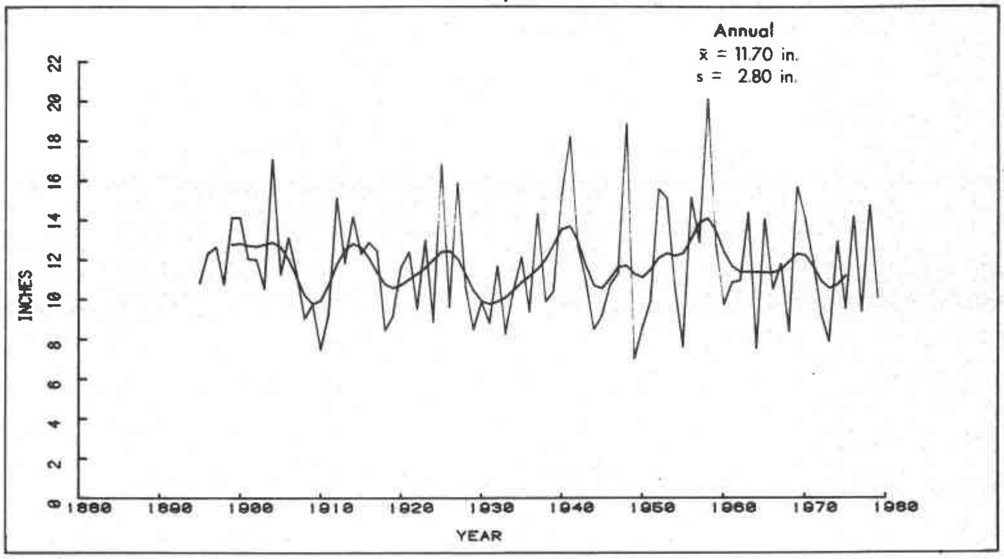
0417 Baker KBKR

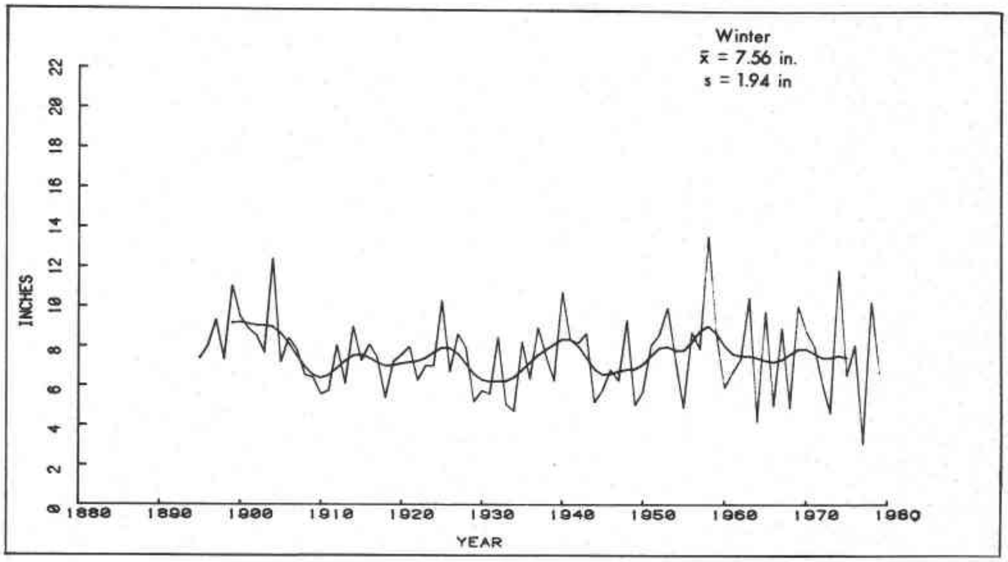


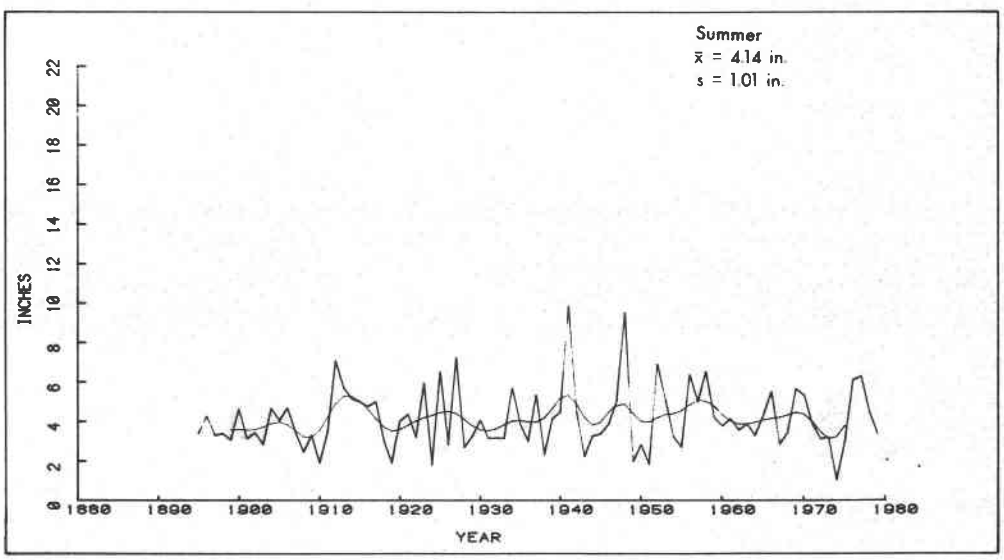




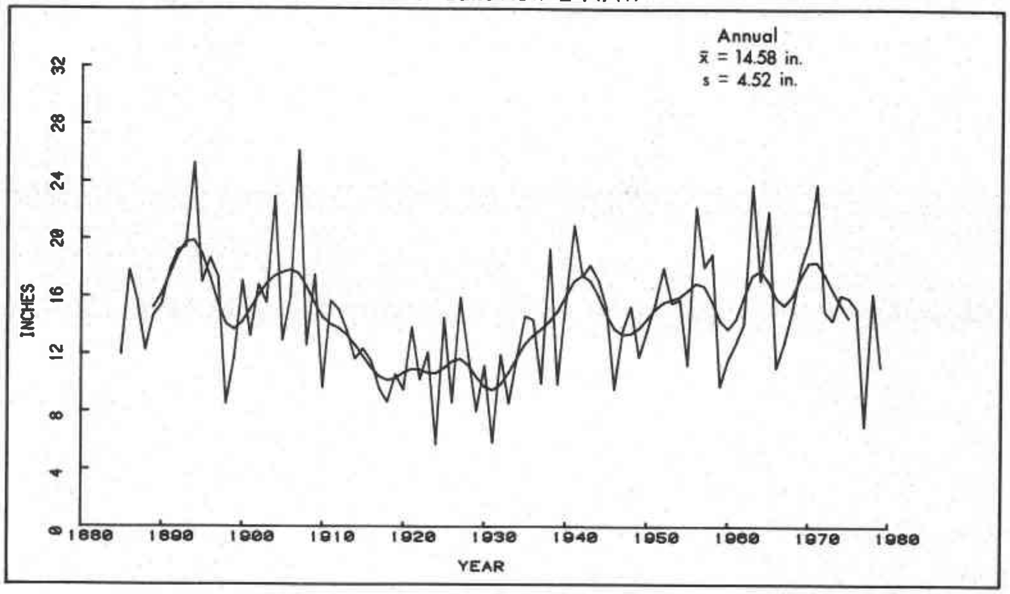
2168 Dayville

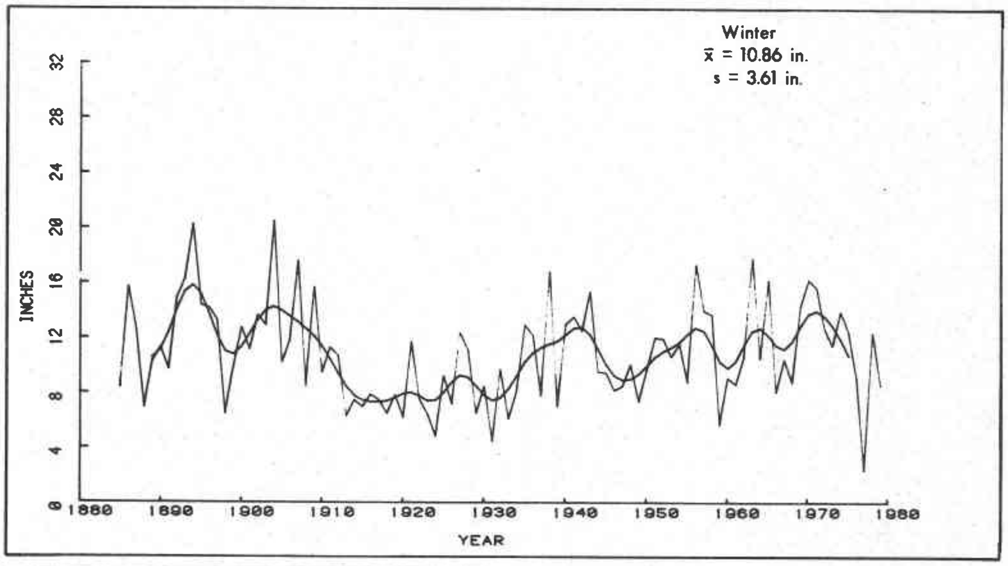


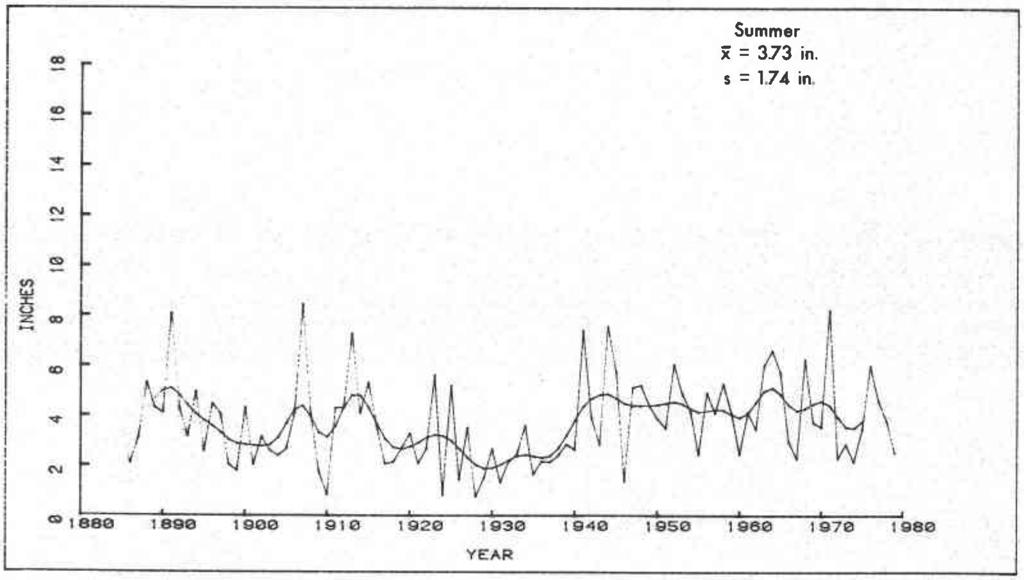




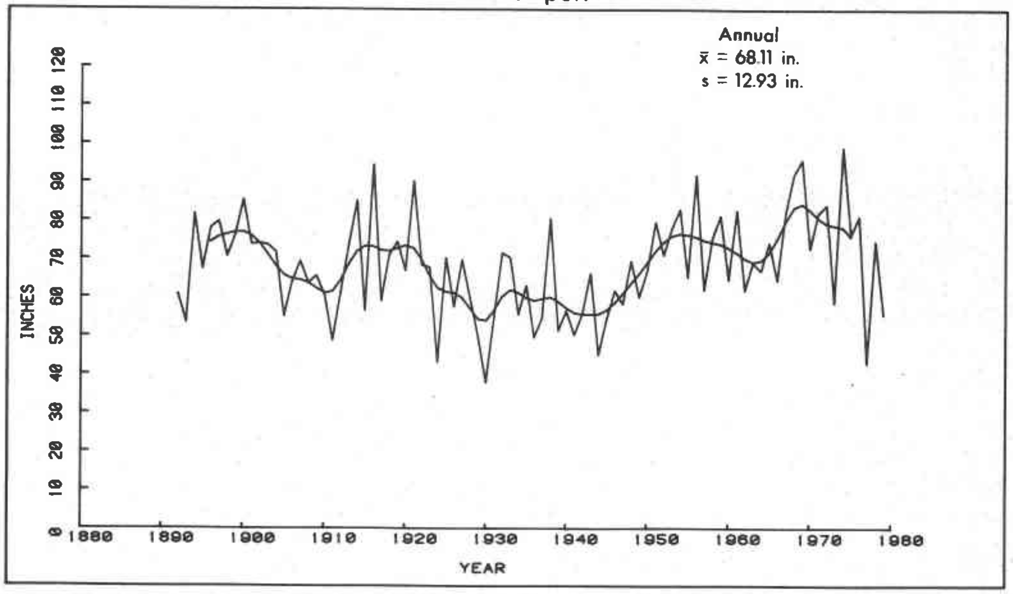
4670 Lakeview 2 NNW

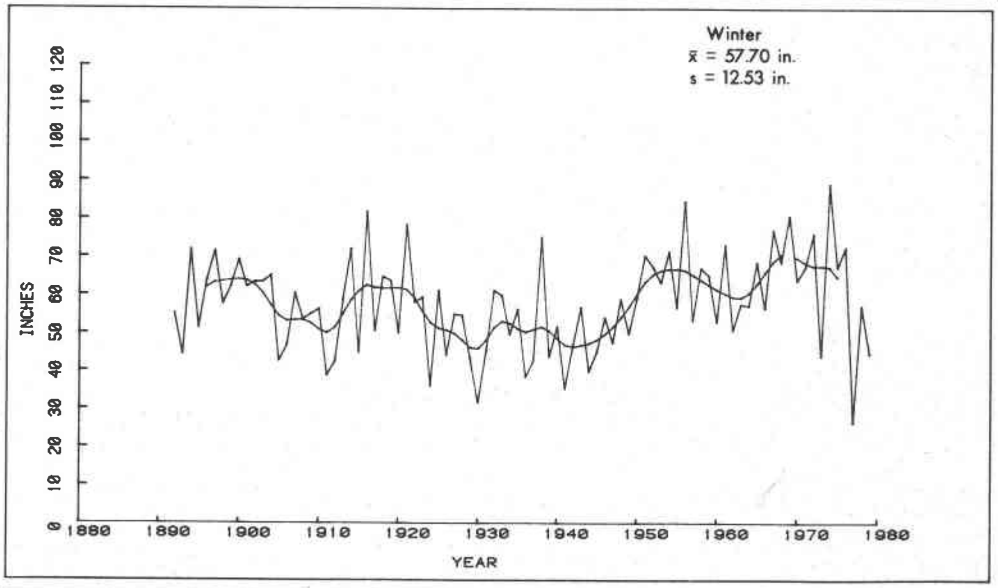


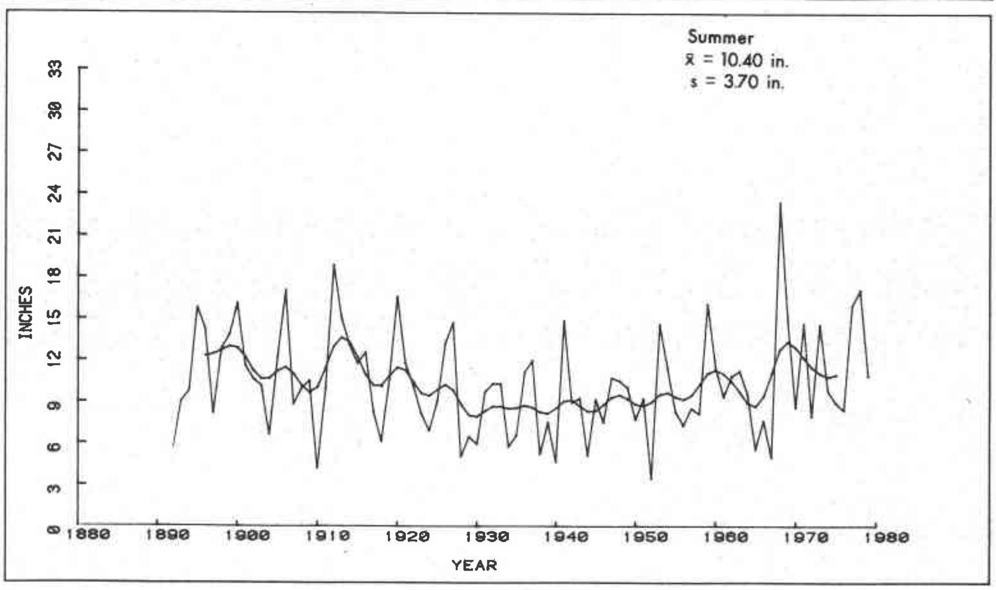


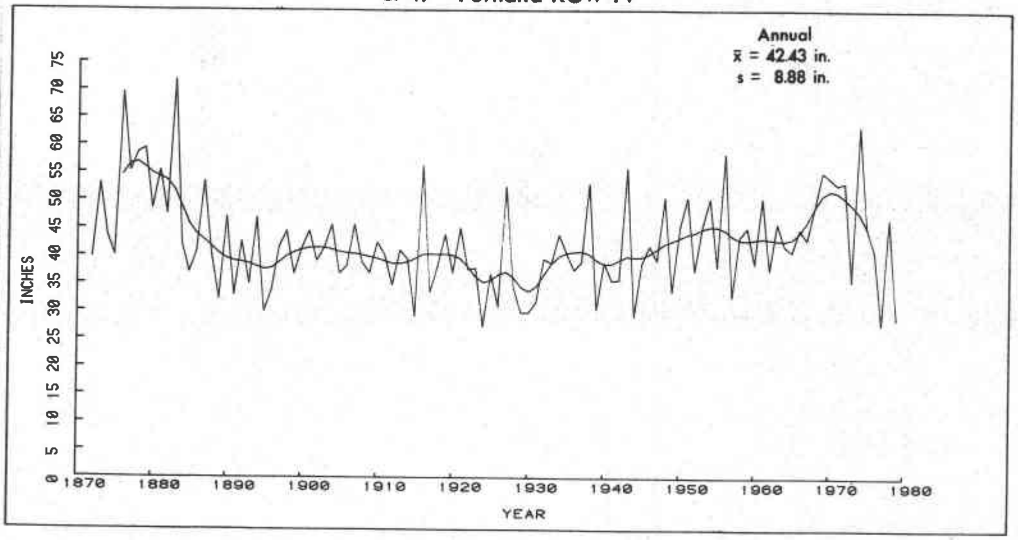


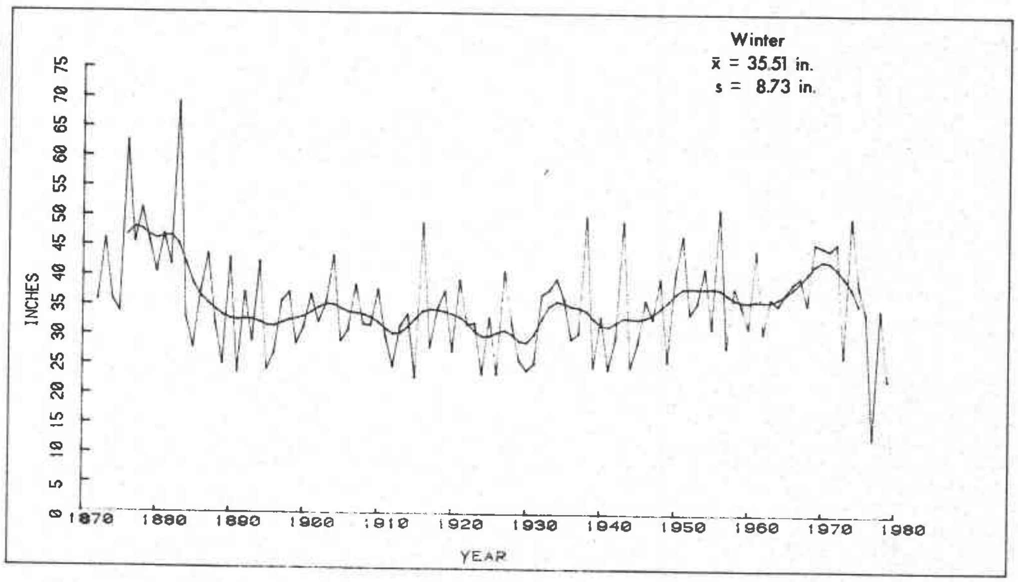
6032 Newport

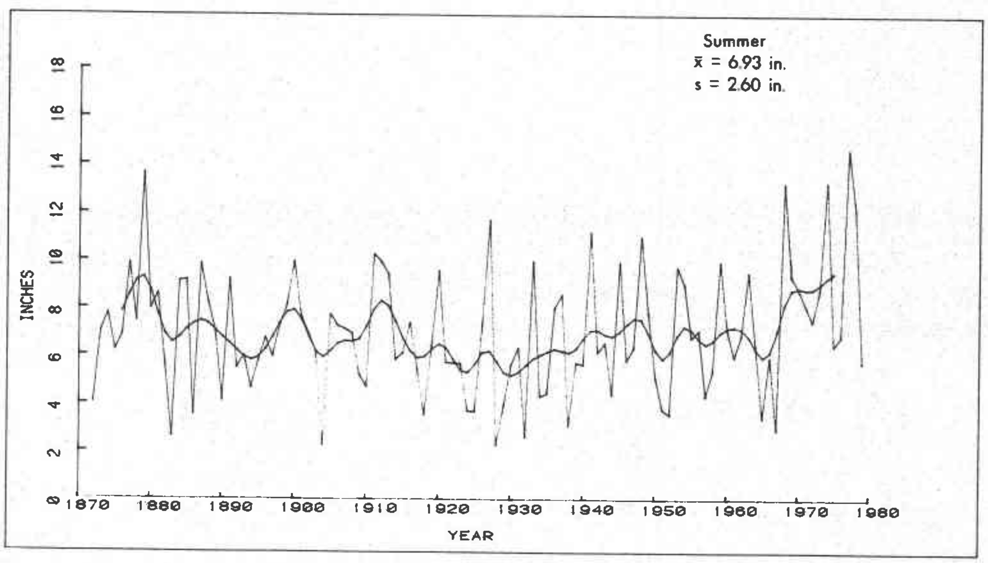




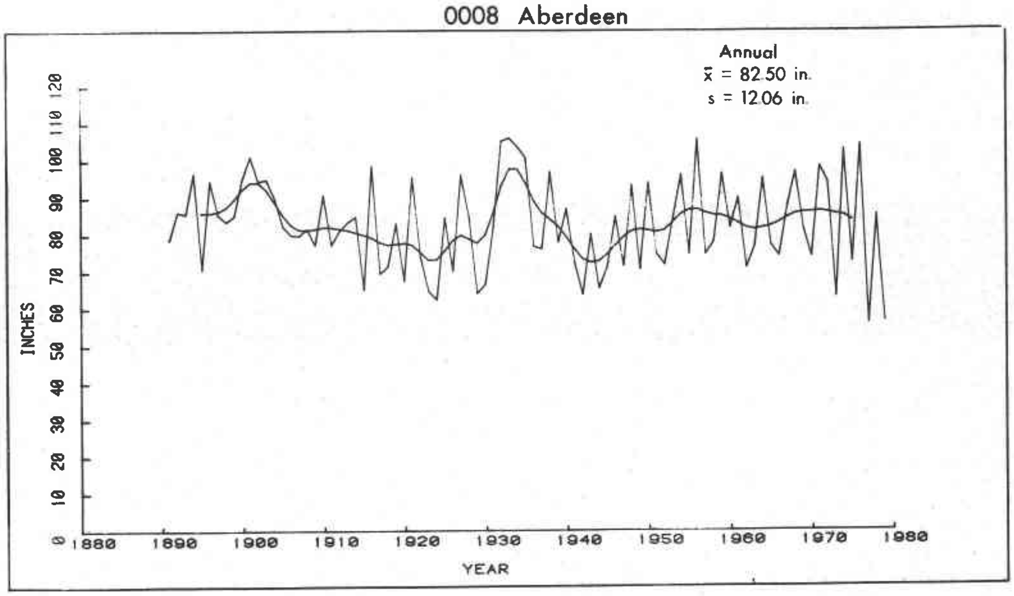


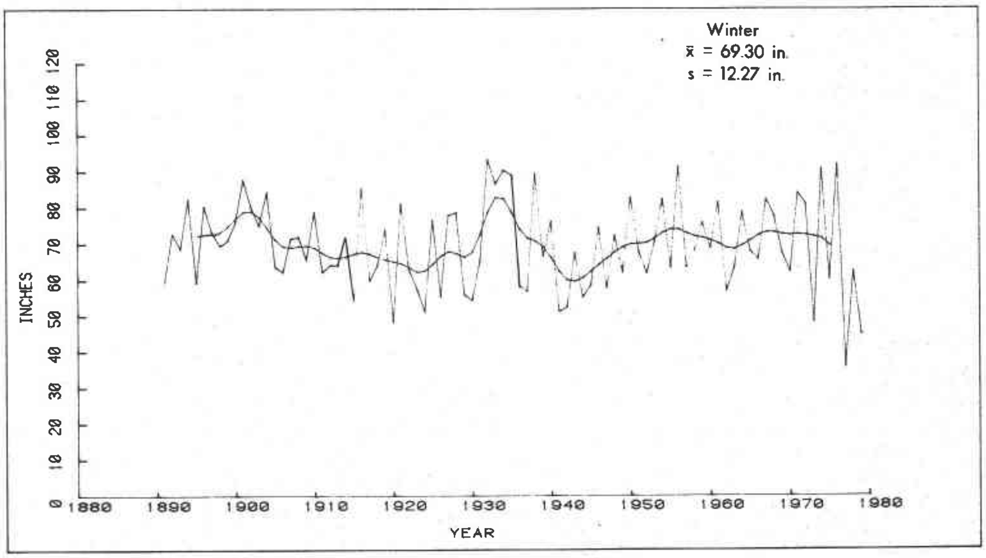

Annual
x̄ = 42.43 in.
s = 8.88 in.
INCHES
YEAR

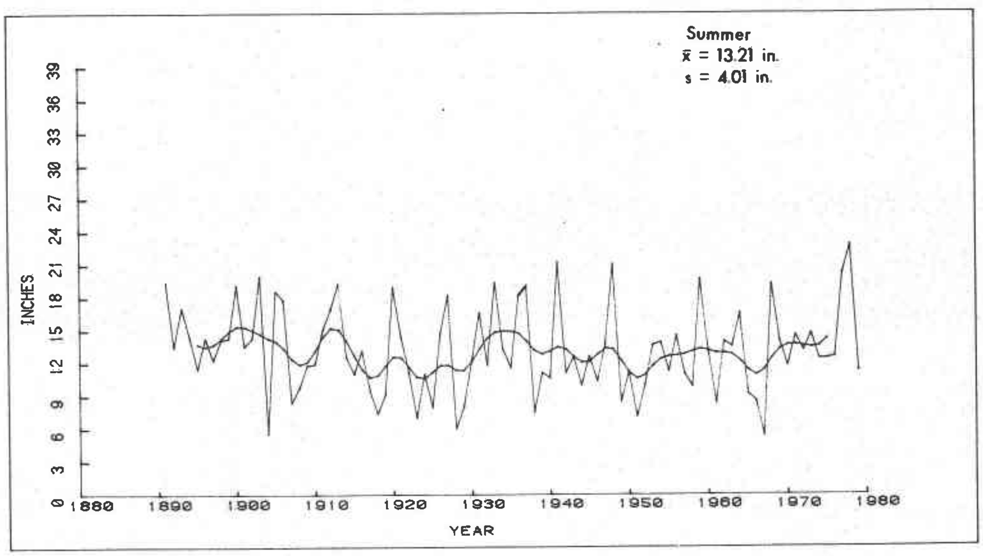

Winter
x̄ = 35.51 in.
s = 8.73 in.
INCHES
YEAR


Summer
x̄ = 6.93 in.
s = 2.60 in.
INCHES
YEAR

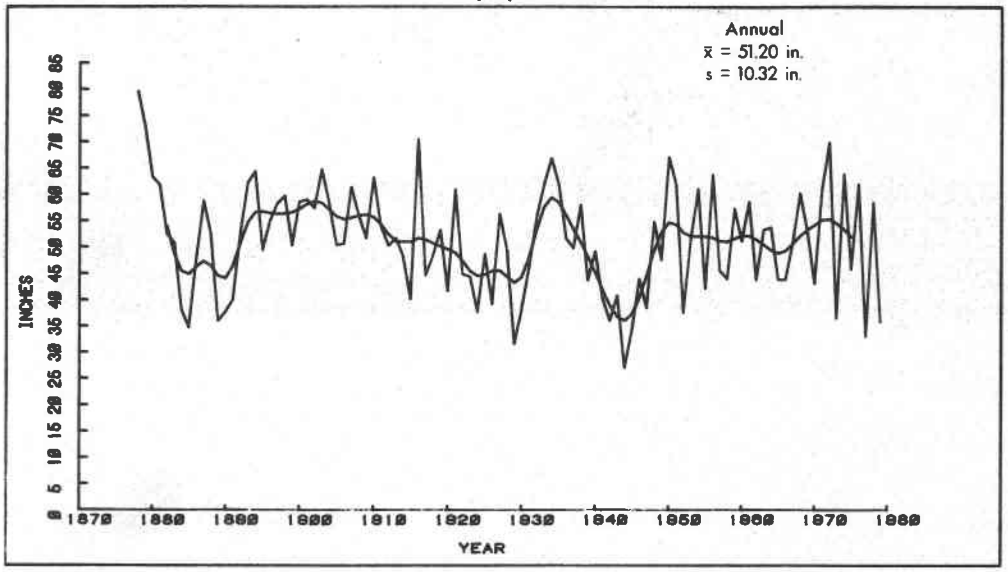
0008 Aberdeen

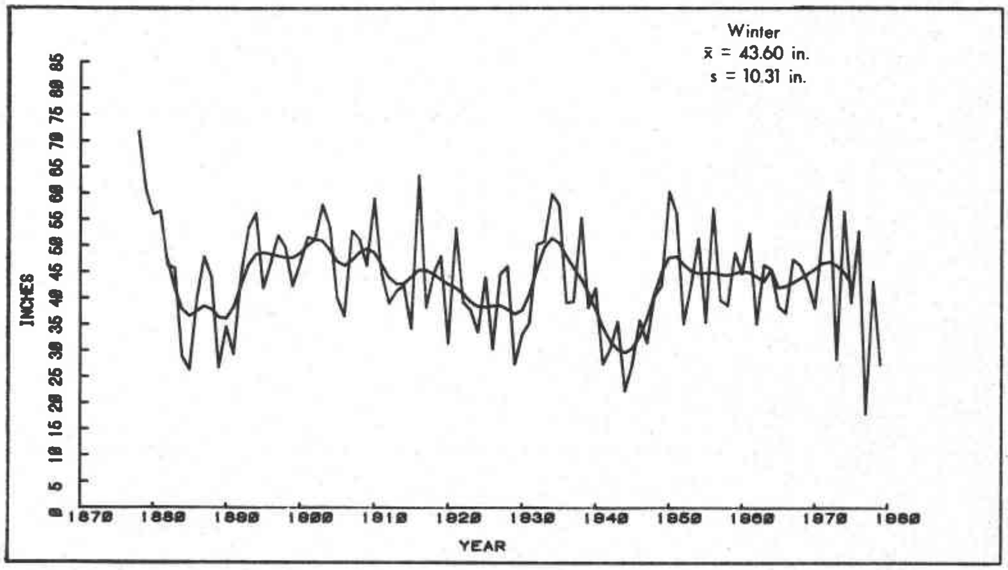


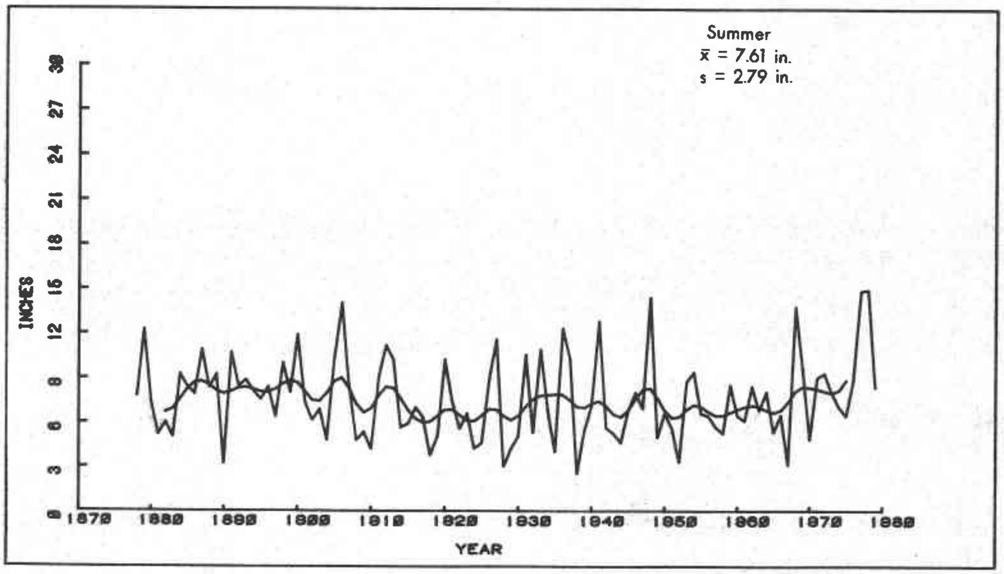




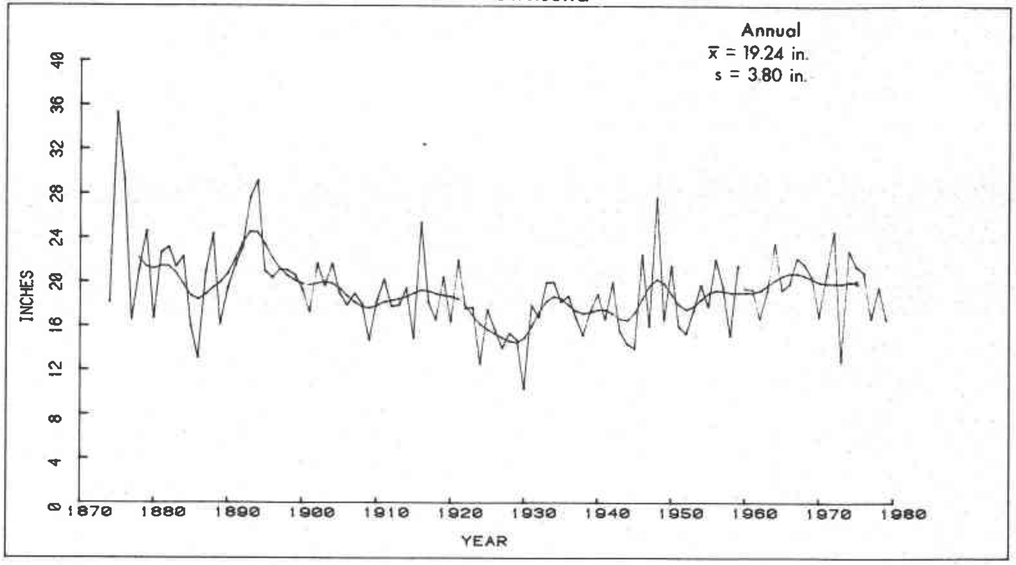
6114 Olympia WSO AP

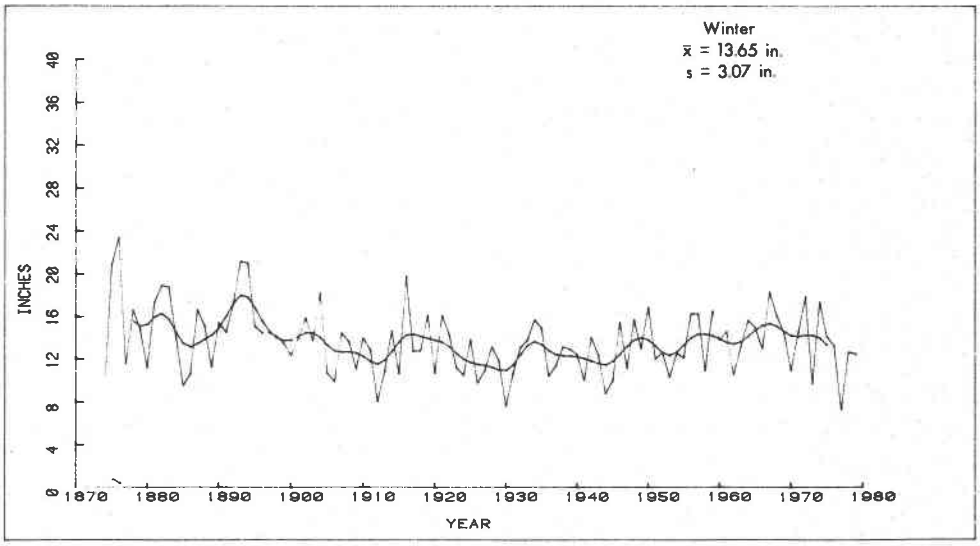


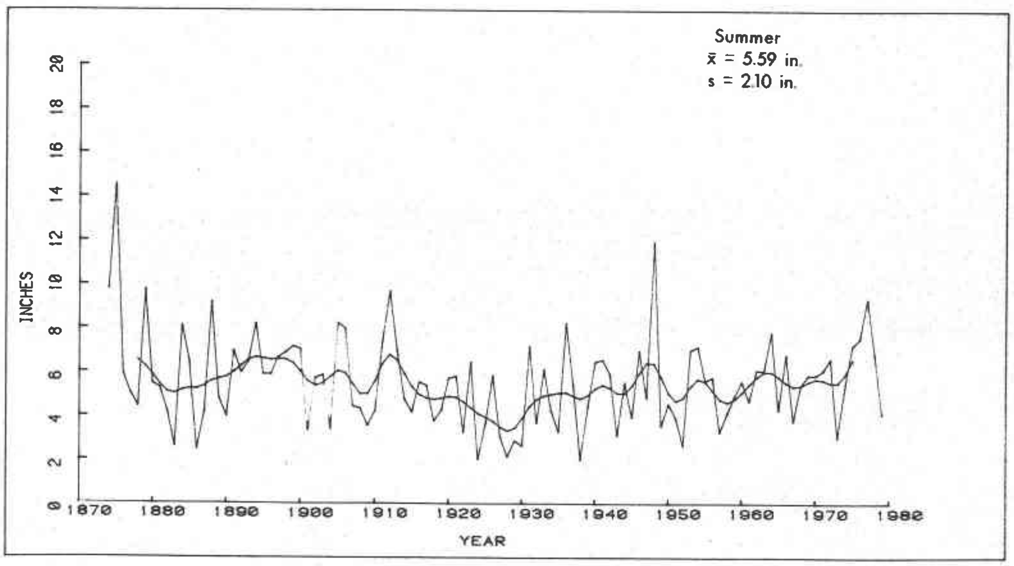




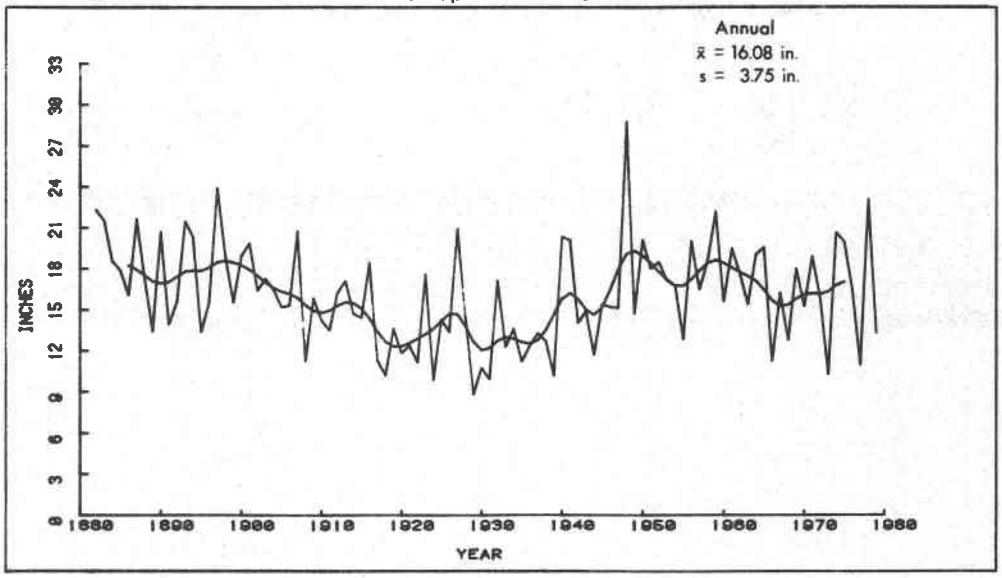
6678 Port Townsend

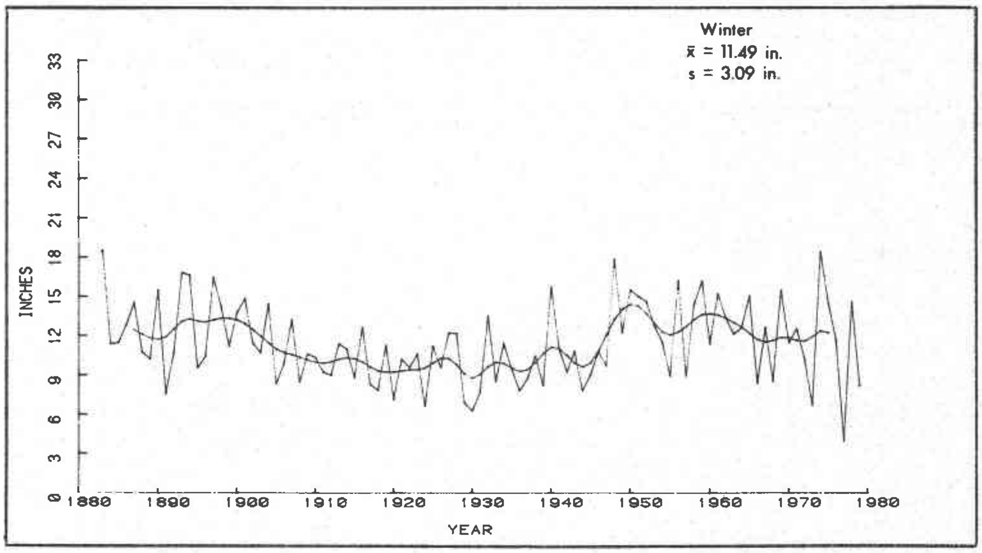


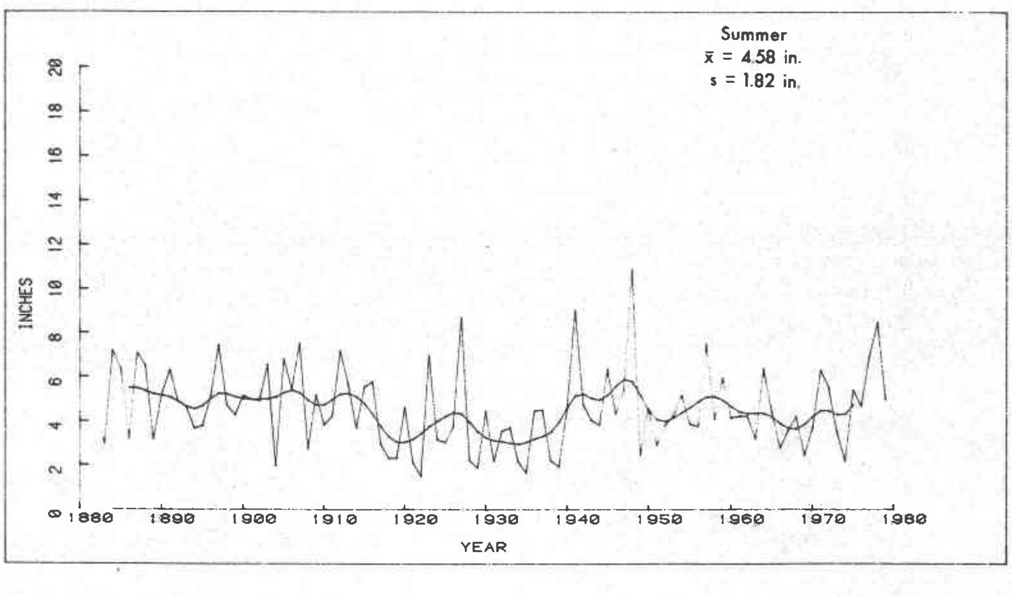




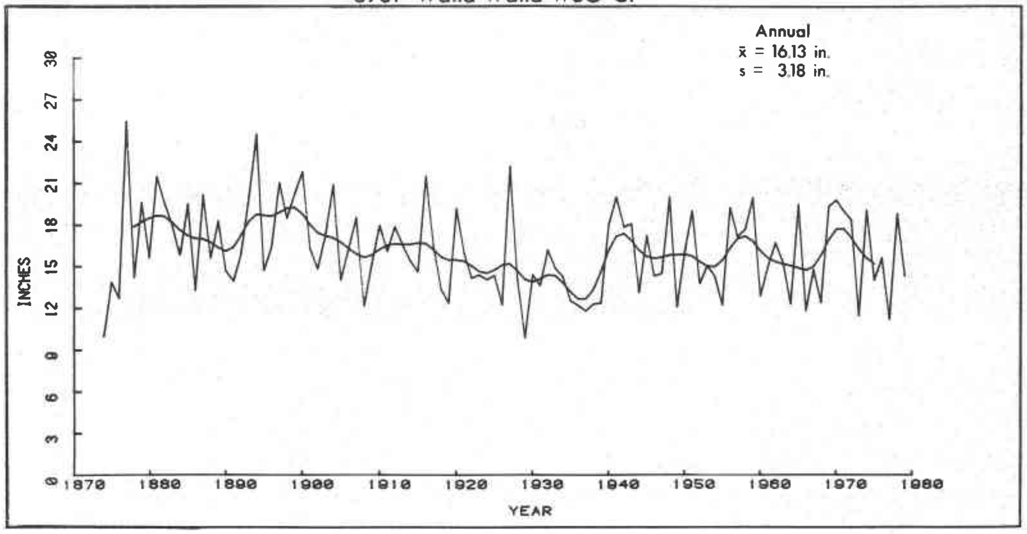
7938 Spokane WSO AP

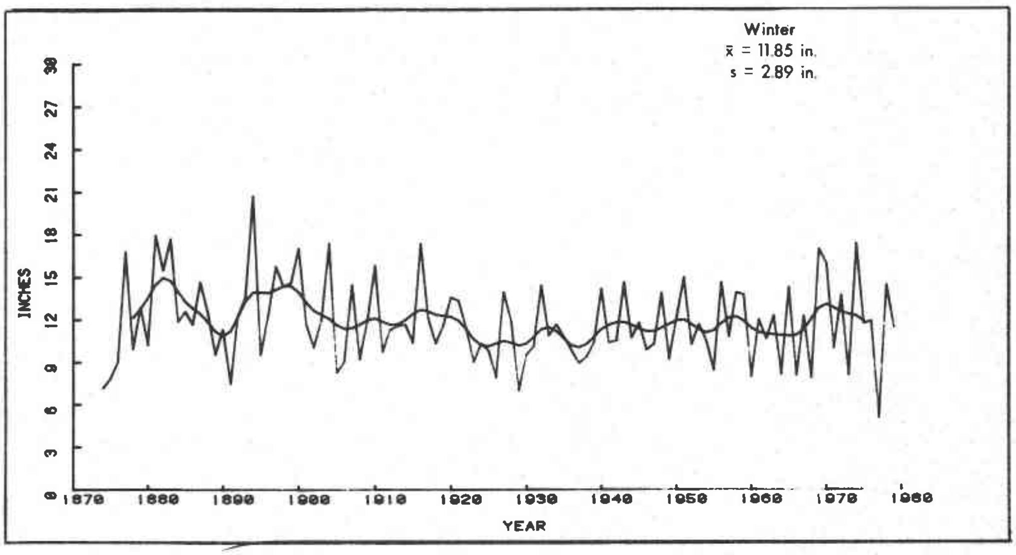


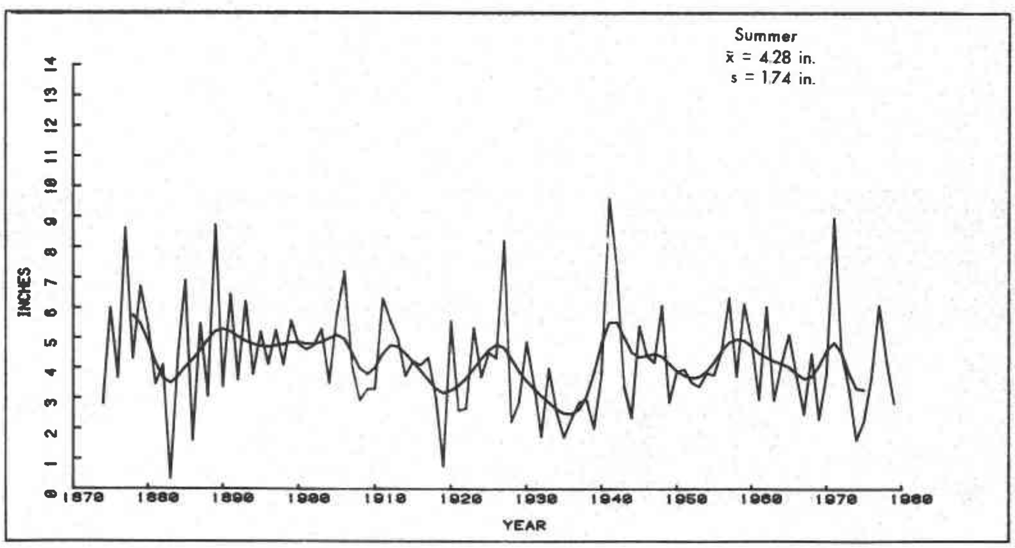




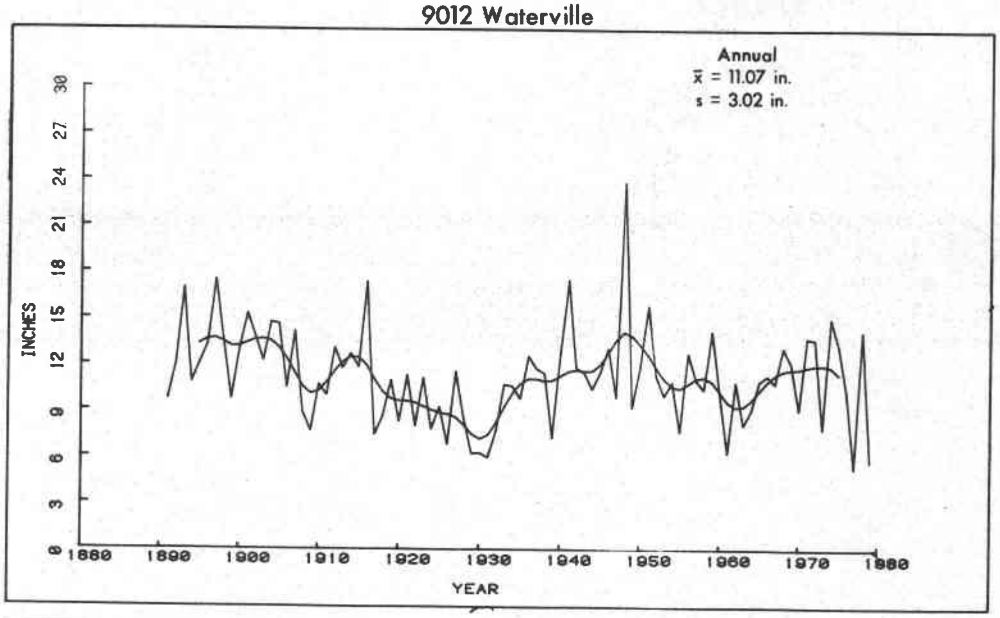
8931 Walla Walla WSO CI

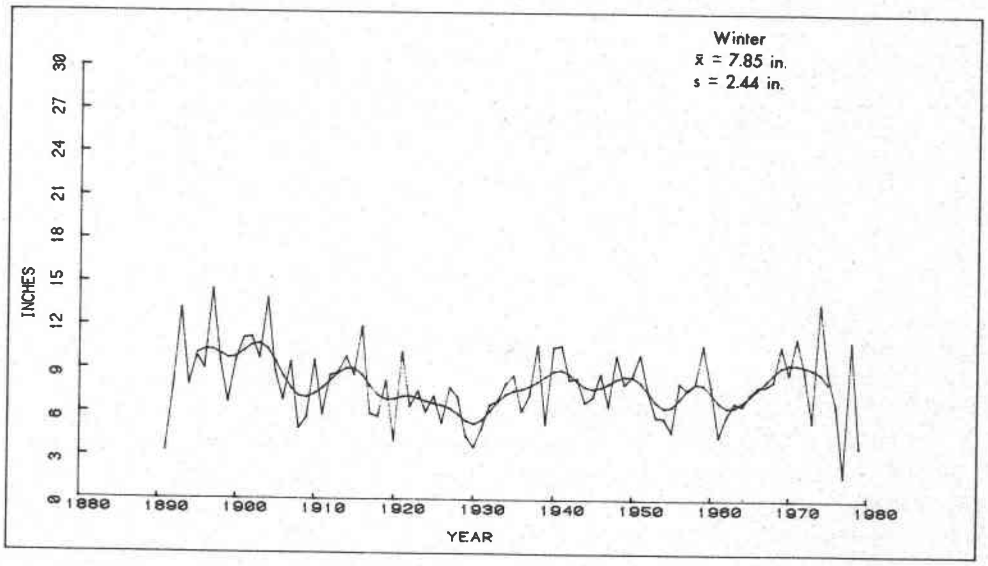


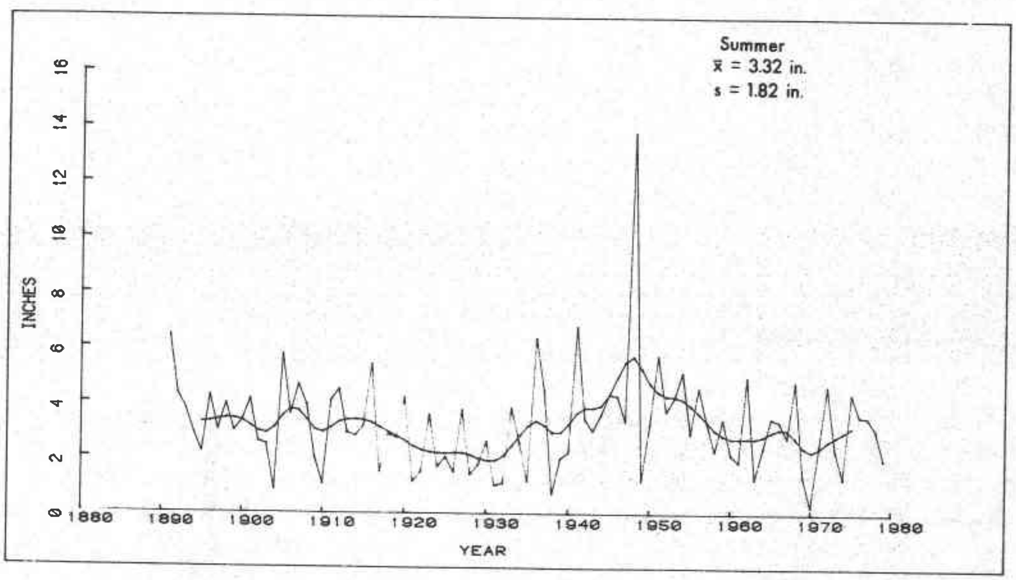




9012 Waterville







way that they appear as prominent cycles or quasi-cycles. Known as the Slutzky-Yule effect, this tendency can introduce apparent cycles which have no physical significance. Another unfortunate result may be the displacement of peaks and troughs in the time series. Early climatological "cycle hunters" were often unaware of these pitfalls, thus perpetuating myths of non-existent periodicites in climatic data (Holloway 1958, Mitchell 1964).

These undesirable effects can be eliminated by modifying the weights in a moving average to create more accurate response characteristics. One standard approach is to set the weights proportional to the ordinates of a Gaussian (normal) probability curve. For a nine-term weighted moving average the weights are as follows:

weight number	weight
x_i-4	.Ø1
x_i-3	.Ø5
x_i-2	.12
x_i-1	.2Ø
x_i	.24
x_i+1	.2Ø
x_i+2	.12
x_i+3	.Ø5
x_i+4	.Ø1

This form of weighted average is used because it is relatively easy to interpret while capable of emphasizing the form of any oscillations. The filter is essentially a "low pass" filter which allows low frequency oscillations to emerge unchanged while attenuating or eliminating those at higher frequencies.

The graphs of Appendix E and of Figure 12 represent a massive amount of data for which it is difficult to generalize and much of the interpretation must necessarily be left to the reader. The simplest approach here is to discuss the data in the context of eastern and western Oregon and eastern and western Washington (divided by the crest of the Cascades) as they are arranged in Appendix E.

Western Oregon

The longest record length is that of Astoria WSO AP (1854-1979), which includes data from Fort Stevens for the years 1877-1883. An important observation that should be made initially is that the series oscillates rapidly. There is little evidence of extended periods of either marked dryness or of marked wetness, in contrast to Granger's (1977) findings for annual precipitation in lowland California. Only a few short periods of years significantly above or below the long-term mean can be identified as follows: 1928-1931 was a dry period; 1932-1935 was a wet period as was 1879-1881. Otherwise the extreme years tend to occur in isolation.

The moving-average line for the Astoria series reveals many short-term trends, up to about 40-years duration. There is an upward trend from the 1850s to the early 1880s, highlighted by the wettest year on record, 1876 (112.82 inches, 148 percent of the long-term mean). The years 1882-1892 were quite dry. Beginning in the wet period of the 1890s there was a downward trend to the early 1930s, highlighted by the driest year on record, 1928 (43.35 inches, 57 percent of the long-term mean). Yet even during this period of decreasing precipitation there were oscillations and some very wet years, specifically 1916 and 1921. Immediately following the dry years around 1930 were the very wet years of the mid-1930s. From the period of relative wetness in the 1950s to the present, then, was a gradual decrease in annual precipitation.

Certainly any statement as to long-term trend in this data series has little meaning. Short-period trends exist but vary in duration and magnitude. There is a temptation in time-series analysis of this type to look for cyclical behavior that might have some predictive value. Spectral analysis is a statistical technique commonly used to detect periodicities and such analysis has been reserved for a subsequent study. However, visual observations of the weighted-average line suggests that for much of the record there is an approximate 20-year period oscillation from one dry period to another or from one wet period to another, perhaps related to the 22-year Hale sunspot cycle thought to exist in climatic series in the western two-thirds of the United States (Mitchell 1979). Without further analysis it would be inappropriate to comment further on the cycle in this report.

At the other stations on the Oregon coast the same general pattern exists as at Astoria although there are some interesting differences. At Newport similar rhythmic oscillation between wetter and drier periods occurs, but it could also be said that the period from the 1930s to the 1970s was one of an upward trend, at least through the early 1970s. At Bandon 2 NNE this same pattern is clear, a downward trend from the 1890s to the 1930s followed by an upward trend from the 1930s to the 1970s. Another cautious reference to cyclical behavior would suggest the so-called Gleissberg cycle of about 88 years (Agee 1980). An anomaly at Bandon is the sequence of three extremely wet years, 1893-1895, the latter two each receiving 185 percent of the long-term normal.

In the Willamette Valley, station series again show the general pattern of decreasing trend from the 1890s to the 1930s and increasing trend from the 1930s to the early of mid 1970s. The early century trend is particularly clear at stations such as Corvallis-State Univ. and Albany and at the stations of southwestern Oregon; for example, Grants Pass and Roseburg KQEN. At several others a downward trend in the early part of the record is less apparent, but the increasing trend in the latter half is consistent. Stations in the Cascades begin only in the 1900s but reflect the short-term trends of valley stations at similar latitudes.

For western Oregon in general it can be said that annual rainfall series exhibit:

a) rapid oscillations from year to year;

b) very few grouping of unusually wet or dry years;

c) a decreasing trend from the 1890s to the 1930s, more so in the southern half of the state;

d) an increasing trend from the early 1930s to the early or mid 1970s.

Eastern Oregon

The observations made for the precipitation series in western Oregon are true in part for eastern Oregon. Heppner in north central Oregon and Lakeview 2 NNW in south central serve as a starting point for discussion. During the dry period of the 1930s there was a sequence of several years well below the long-term mean, at Heppner approximately 1928-1937 and at Lakeview approximately 1928-1934. Indeed at Lakeview the entire period from about 1914-1934 was unusually dry. At Heppner the years 1908-1911 were also consistently dry. Throughout most of eastern Oregon the 1930s dry period was more prolonged than in the western part of the state. Sequences of wet years are also more obvious than in western Oregon.

The prevailing downward trend from the 1890s to about 1930 is seen in most of the series as is the recovy from the 1930s to the early 1970s. However the upward trend since the 1930s occurred primarily in the following decade and the weighted-average line is fairly steady since then, although interannual fluctuations about the mean have been large.

Burns WSO CI provides a good example of this pattern. The 1890s were dry, unlike western Oregon, and the downward trend existed from the 1900s into the 1930s. The year 1906 was the wettest on record (19.98 inches, 183 percent of the long-term mean). Recovery from this dry period was rapid in the 1930s and 1940s and from then until the mid-1970s there is no trend upward or downward. Wasco exhibits a very steady annual series with no distinctly wet or dry periods. In contrast, at Weston in northeastern Oregon an upward trend from the 1930s to the 1970s is clearly noted. Yet at Pendleton WSO AP, also in northeast Oregon, while the decade of the 1930s is also quite dry, there are several years in the subsequent decades just as dry (e.g. 1973: 7.23 inches, 55 percent of the long-term mean) and there is certainly no increasing trend from the 1930s to 1970s. At Baker KBKR, the steady downward trend from 1890 to 1930 is also very clear.

For the eastern half of Oregon, then, generalizations are more difficult. The only consistent feature is the drought of the 1930s which was longer in duration than in western Oregon.

Western Washington

Certain aspects of the general pattern found in the precipitation time series for Oregon are also to be found for those in Washington. The 1890s were relatively wet throughout the state and there was a downward trend from then until about 1930, followed by a quick recovery to normal amounts in the early 1930s. The ensuing decades show very little uniformity over large regions of the state.

Port Angeles and Port Townsend, two stations in close proximity on the north coast of the Olympic Peninsula, serve as a useful starting point for a discussion of time series in western Washington. At Port Townsend 1930 was the driest year on record and a very precise turning point between the downward trend since the 1890s and a subsequent upward trend lasting until about 1970. However, this latter period of increasing annual precipitation did not occur at Port Angeles. Instead there was a small but steady decline beginning in the late 1940s and extending to 1979. The difference in these two locales assumed to be under the same combination of climatic controls is further indication of the danger in generalizing trends and fluctuations in a region of such great spatial variability.

On the far northwest coast at Neah Bay and Tatoosh Island there were several very wet years between 1885 and 1902. This was the wettest period on record at Tatoosh Island (through 1966) and at Neah Bay only three very wet years in the 1970s exceed the values of the wet 1890s. In 1903 annual precipitation decreased drastically and, with the exception of a couple of average years in the 1920s, remained very low through 1930. If there is any trend at all during this period it is slightly upward from 1902 to 1930, again a contrast to this same period at Port Townsend and Port Angeles. At Neah Bay an upward trend continues to the present.

A distinct lack of correlation is also apparent between Neah Bay and Aberdeen, the other Washington coastal station. Unlike Neah Bay, Aberdeen experienced a decrease in annual precipitation from 1900 to 1930. The series of wet years occurred at both stations but at Aberdeen there is no indication of an upward trend over the last 40 years; rather there was an increase through the 1940s and since then a fairly steady mean value.

Periods of wet years and dry years are certainly not uniform throughout western Washington. At Neah Bay, for example, three distinct dry periods can be identified -- approximately 1904-1912, 1922-1930, and 1936-1939. Each one of these varies considerably in magnitude at other stations. The earlier of the three in particular is not to be found at several locations. The latter two were more extensive and in general were separated by a series of very wet years in the early 1930s.

Within the Puget Lowland there is a fairly high degree of uniformity in annual precipitation patterns. At Tacoma, for example, the common downward trend from the 1890s to 1930 occurred. The years 1929-1930 were the only consecutive years decidedly below normal for the entire period of record, 1884-1979. Over the past four decades there has been essentially no clear trend one way or another lasting more than a few years. Slight variations from this overall pattern are seen at Olympia WSO AP and Centralia, particularly the existence of a dry period centered on 1944. To the north at Blaine the dry period around 1930 did not occur. However, the extreme wetness of the middle 1930s is striking, three extremely wet years culminating in 1934 (59.44 inches, 146% of normal).

Time series for those stations to the east side of the Puget Lowland (Clearbrook, Sedro Wooley, Landsburg, and Snoqualmie Falls) are much the same in their temporal pattern. All dramatically show the wet years of the middle 1930s with dry periods immediately before and after. Precipitation values for the middle 1940s to the middle 1970s were quite steady, neither increasing nor decreasing, and show a distinct decline in the late 1970s.

Eastern Washington

Many of the contrasts that were noted between western and eastern Oregon also exist between western and eastern Washington. Waterville, centrally located, serves as a starting point for discussion. Here the fairly widespread trend of decreasing annual precipitation from the 1890s to about 1930 is seen, culminating in a sequence of three very dry years 1929-1931. Through the 1930s and 1940s there was an upward trend which peaked in 1948, the wettest year on record (23.84 inches, 215 percent of the long-term mean). Since about 1950 there have been fluctuations about the mean but little evidence of an upward or downward trend.

The 1890s to 1930 downward trend is a fairly persistent feature throughout eastern Washington as seen from the other precipitation series. Exceptions may be noted for Odessa and Yakima WSO AP. Also with only minor exceptions the years 1929-1931 were the most extensive dry period on record. By 1940 there was a return to average precipitation throughout eastern Washington. An upward trend from 1940 to the 1970s, observed for many locales in Oregon, is found nowhere in eastern Washington. In general there has been a fairly constant mean value over the last 40 years. Some stations experienced a dry period in the early 1950s, coincident with widespread drought in other parts of the country, and in the middle 1960s. The longest record presented for eastern Washington is that of Walla Walls WSO CI. There the 40-year period from 1940 to 1979 is remarkable for its consistency when compared to the entire period of record.

Decadal Analysis of Means and Variability

A third method of evaluating changes over time is to calculate basic statistics for ten-year periods and to compare each period to the entire period of record. Instead of or in addition to an inconstancy of the mean, a climatic fluctuation may also consist of a change in the overall variability. Therefore, decadal means and standard deviations were calculated for all long-term stations and data for about half the stations are presented in Table 7.

The statistical significance of changes in the mean (that is, whether or not the decadal value is different than the long-term value) was determined by using Cramer's test (Mitchell et al 1966); for changes in the standard deviation, the F-ratio test was used (Gregory 1973). These two tests are described briefly as follows:

(a) To apply Cramer's test x and s are defined respectively as the mean and standard deviation of the entire series of n years. Further, x_k is defined as the decadal (10-year) mean to be compared with x. Then:

$$T_k = \frac{(\bar{x}_k - \bar{x})}{s} \qquad (9)$$

The Student's t-statistic with (n-2) degrees of freedom is calculated:

$$t_k = \left[\frac{10\ (n-2)}{n-10\ (1+T_k^2} \right]^{1/2} \cdot T_k \qquad (10)$$

Table 7

Decadal Statistics of Mean and Variability (Standard Deviation), Compared to Long-Term Statistics at 36 stations.

*Value significant at 90 percent level
**Value significant at 95 percent level

WESTERN OREGON

	Ashland		Bandon 2 NNE		Corvallis-St. Univ.	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Long-term	19.62	4.54	57.58	13.86	40.46	7.79
1970s	- 18.95	+ 4.84	+ 59.13	+ 14.58	+ 45.09**	+ 13.95**
1960s	- 17.92	+ 5.11	+ 58.15	- 8.77*	+ 40.90	- 6.60
1950s	+ 19.63	+ 6.35**	+ 65.39*	- 9.72	+ 41.67	- 6.57
1940s	+ 22.04*	- 3.66	- 55.47	- 9.57*	- 35.79**	- 6.46
1930s	- 18.18	- 3.88	- 46.48**	- 12.29	- 36.23*	- 7.38
1920s	- 18.61	+ 5.86*	- 47.73**	- 13.53	- 38.11	+ 8.17
1910s	+ 19.85	- 2.51**	- 52.85	- 9.39*	+ 41.59	- 6.84
1900s	+ 21.23	- 3.79	- 57.41	- 8.70*	+ 43.64	- 4.05**
1890s	+ 19.72	+ 4.63	+ 73.26**	+ 23.56**	+ 41.07	- 7.28
1880s	+ 20.05	+ 5.90*	+ 58.48	- 10.25		

	Eugene WSO AP		Grants Pass		Headworks Ptld. W. B.	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Long-term	40.68	9.12	30.34	8.01	80.50	13.87
1970s	+ 50.07**	+ 15.69**	- 30.26	+ 10.48*	+ 82.97	+ 17.35
1960s	+ 44.26	- 5.95**	+ 32.19	- 4.88**	+ 80.72	- 8.09*
1950s	+ 44.00	- 8.75	+ 34.82*	+ 10.54*	+ 86.55**	- 13.42
1940s	- 38.94	- 8.35	- 30.00	- 7.02	+ 84.62	+ 17.70
1930s	- 36.15	- 7.48	- 27.16	+ 9.02	+ 83.17	+ 21.85**
1920s	- 36.60	- 8.99	- 24.68**	+ 9.06	- 73.15**	- 12.42
1910s	- 38.27	- 8.05	- 28.05	- 4.30**	- 77.16	- 11.41
1900s	- 39.60	- 5.52**	+ 34.52*	- 6.09	- 75.35*	- 9.07*
1890s	- 37.98 (n=9)	- 5.62**	+ 31.40	+ 8.52		

	Newport		Portland KGW-TV		Roseburg KQEN	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Long-term	68.11	12.93	42.43	8.88	32.50	7.02
1970s	+ 72.74	+ 17.23*	+ 44.83	+ 12.35**	- 31.23	+ 10.28*
1960s	+ 75.36*	- 12.85	+ 44.74	- 5.84*	- 31.28	- 5.46
1950s	+ 75.42*	- 9.71	+ 44.44	- 7.95	+ 36.56*	+ 8.12
1940s	- 57.77**	- 7.58**	- 39.97	- 8.40	- 32.01	- 6.09
1930s	- 58.92**	+ 13.21	- 38.48	- 7.38	- 28.73*	- 6.58
1920s	- 64.30	+ 13.59	- 36.91**	- 7.89	- 28.02*	+ 8.22
1910s	+ 68.49	+ 14.73	- 39.84	- 7.76	- 30.43	- 5.68
1900s	+ 69.61	- 8.66*	- 40.83	- 3.62**	+ 33.33	- 4.24
1890s	+ 70.99	- 10.07	- 39.06	- 6.58	+ 37.06**	- 6.14
1880s			+ 46.88*	+ 11.98*	+ 34.13	- 6.05
1870s			+ 52.44** (n=8)	+ 11.25		

EASTERN OREGON

	Baker KBKR		Burns WSO CI		Condon	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Long-term	11.32	2.80	10.89	3.17	12.74	3.06
1970s	+ 12.15	+ 3.28	- 10.82	+ 3.60	+ 14.00	+ 3.22
1960s	- 10.27	- 1.75**	+ 11.95	- 2.87	+ 13.10	+ 4.21
1950s	+ 11.97	+ 3.66*	+ 12.21	- 2.67	+ 13.82	- 2.81
1940s	- 11.07	- 2.64	+ 12.10	- 2.67	+ 12.98	+ 4.09
1930s	- 9.17**	- 2.24	- 7.97**	- 2.80	- 10.90*	- 2.43
1920s	- 10.09	- 1.85*	- 9.86	+ 4.06	+ 13.03	- 2.70
1910s	- 11.31	+ 3.16	- 10.80	- 1.89**	- 11.86	- 2.40
1900s	+ 11.98	- 1.68**	+ 12.51*	+ 3.97		
1890s	+ 13.90**	+ 3.21	- 9.33* (n=7)	- 2.44		

	Dayville		Fremont		Hood River E. S.	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Long-term	11.70	2.80	10.50	3.46	31.03	8.47
1970s	- 11.40	- 2.62	+ 11.58	- 3.19	+ 31.24	+ 10.00
1960s	- 11.39	2.80	+ 10.76	+ 4.12	- 30.63	- 5.15**
1950s	+ 12.82	+ 4.01**	+ 12.36	+ 5.44**	- 30.64	- 5.89*
1940s	+ 12.26	+ 4.23**	+ 11.01	- 1.73**	- 29.48	- 7.99
1930s	- 10.50	- 1.89*	- 9.38	- 2.55	- 26.63*	- 5.26**
1920s	- 11.67	+ 3.05	- 9.25	+ 3.67	- 27.07	- 7.35
1910s	- 11.30	- 2.71	- 8.74	- 2.38*	- 27.32	+ 8.95
1900s	+ 12.02	- 2.45			+ 32.25	- 6.87
1890s	+ 12.14	- 1.57**			+ 42.32**	+ 11.22*
1880s					+ 34.46 (n=5)	+ 9.08

	Lakeview		Prineville		Wallowa	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Long-term	14.58	4.52	9.47	2.42	17.52	3.55
1970s	+ 15.44	+ 4.75	+ 9.92	+ 2.87	+ 17.75	+ 4.35
1960s	+ 15.84	+ 4.60	+ 9.80	+ 2.72	- 17.49	- 2.98
1950s	+ 15.88	- 3.92	+ 10.93*	+ 3.35**	+ 19.51*	- 3.31
1940s	+ 15.48	- 3.45	+ 10.25	+ 2.55	+ 18.54	- 3.04
1930s	- 11.72**	- 3.92	- 8.31	- 1.86	- 15.86	- 2.78
1920s	- 11.01**	- 3.38	- 8.78	+ 2.66	- 16.00	+ 4.72
1910s	- 11.81**	- 2.48**	- 9.08	- 2.40	+ 17.82	+ 4.07
1900s	+ 17.05*	+ 4.62	- 9.05	- 1.18**	- 16.89 (n=6)	+ 3.73
1890s	+ 17.02*	+ 4.77				
1880s	- 14.47 (n=5)	- 2.72**				

WESTERN WASHINGTON

	Aberdeen		Blaine		Centralia	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Long-term	82.50	12.06	40.70	7.03	45.49	7.81
1970s	- 80.65	+ 19.93**	- 39.37	+ 9.65**	+ 46.05	+ 11.38*
1960s	+ 83.13	- 9.39	+ 42.68	- 6.76	+ 47.96	- 4.97*
1950s	+ 84.90	+ 12.64	- 39.29	- 6.32	+ 47.68	+ 8.45
1940s	- 75.87*	- 10.36	- 37.96	- 6.31	- 41.38*	- 6.79
1930s	+ 89.04*	+ 15.57*	+ 44.42*	+ 9.37*	- 45.02	+ 9.00
1920s	- 79.26*	+ 13.64	- 36.56**	+ 7.71	- 42.87	+ 8.41
1910s	- 80.43	- 10.70	+ 41.59	- 5.04	+ 47.42	+ 10.63*
1900s	+ 87.66	- 8.87	+ 41.50 (n=7)	- 3.13**	+ 46.91	- 5.62
1890s	+ 85.21	- 8.11*	+ 44.58* (n=6)	+ 7.19	- 44.07	- 6.43

	Neah Bay 1 E		Olga 2 SE		Olympia WSO AP	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Long-term	92.24	21.32	29.13	4.92	51.20	10.32
1970s	+ 103.12*	+ 33.20**	- 28.04	+ 7.07**	- 50.89	+ 14.32*
1960s	+ 105.72**	- 17.16	+ 30.94	- 4.56	- 51.17	- 6.23*
1950s	+ 102.78*	- 12.82**	+ 30.13	- 4.17	+ 53.15	+ 11.00
1940s	- 86.87	- 12.16**	- 27.28	+ 5.48	- 41.26**	- 8.48
1930s	- 85.23	+ 22.78	- 27.81	- 4.40	+ 53.35	- 9.60
1920s	- 75.64**	- 10.99**	- 26.06*	+ 5.02	- 45.44*	- 9.24
1910s	- 74.60**	- 9.26**	+ 31.24	- 4.41	+ 52.42	- 9.33
1900s	- 84.06	+ 24.53	+ 29.40	- 4.31	+ 56.81*	- 5.02
1890s	+ 108.00**	- 16.56	+ 31.30	+ 5.05	+ 52.98	- 9.39
1880s	+ 99.09 (n=6)	- 19.36			- 49.56	+ 11.07

	Port Angeles		Snoqualmie Falls		Tacoma City Hall	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Long-term	25.54	5.03	58.31	10.19	38.10	7.15
1970s	- 23.53	+ 6.14	+ 61.49	+ 16.61**	- 36.41	+ 8.23
1960s	+ 25.77	- 3.64	+ 61.55	- 8.83	- 36.94	- 4.84*
1950s	+ 27.11	+ 5.04	+ 62.61	- 9.72	- 37.69	+ 8.61
1940s	- 22.19**	+ 5.46	- 57.80	+ 12.00	- 36.53	- 6.86
1930s	- 22.19**	- 3.42*	- 56.79	+ 10.68	- 37.13	+ 8.25
1920s	- 22.01**	- 4.33	- 52.62*	- 6.37*	- 31.68**	- 5.64
1910s	+ 26.10	+ 5.26	- 54.74	- 8.04	+ 38.78	- 6.33
1900s	+ 26.37	- 3.32*	- 57.85	- 9.22	+ 43.02**	- 6.15
1890s	+ 29.73**	- 4.35			+ 44.49**	- 5.88
1880s	+ 29.70**	- 3.65			+ 38.52 (n=6)	- 6.76

EASTERN WASHINGTON

	Cle Elum		Colville		Conconully	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Long-term	22.95	5.62	16.43	3.42	14.80	4.13
1970s	+ 23.08	+ 8.71**	+ 17.34	+ 4.62*	- 14.31	+ 5.47*
1960s	- 22.33	- 3.09**	+ 18.06	+ 3.48	- 13.71	- 2.67*
1950s	+ 23.55	+ 7.82**	+ 16.72	- 1.63**	+ 15.98	- 2.95
1940s	- 20.97	+ 5.66	- 16.27	+ 4.52*	+ 16.36	+ 6.06**
1930s	- 20.27	- 2.34**	- 13.96**	- 2.41	- 13.45	+ 5.94**
1920s	- 22.11	+ 5.69	- 15.13	+ 4.00	- 12.77	- 3.44
1910s	+ 24.12	- 5.15	- 15.91	+ 3.62	+ 15.38	- 3.47
1900s	+ 24.62	- 4.78	+ 18.13	- 2.36*	+ 16.46	- 2.13**

	Kennewick x̄	Kennewick s	Odessa x̄	Odessa s	Pullman 2 NW x̄	Pullman 2 NW s
Long-term	7.30	2.13	9.92	2.54	20.63	4.20
1970s	+ 7.58	+ 2.19	- 9.34	+ 2.65	+ 20.87	+ 4.75
1960s	- 7.05	+ 2.48	- 9.45	- 2.08	+ 21.48	- 3.92
1950s	+ 7.72	- 1.70	+ 10.57	- 2.09	+ 21.55	+ 5.50*
1940s	+ 8.61**	+ 3.28**	+ 12.00**	+ 4.48**	- 19.57	+ 4.51
1930s	+ 6.14*	- 1.27**	- 8.94	- 1.87	- 18.98	- 3.22
1920s	+ 7.60	- 1.87	- 9.13	+ 2.79	- 19.33	+ 5.24
1910s	+ 7.89	+ 2.14	+ 10.24	- 1.59**	- 19.92	- 3.24
1900s	- 6.30	- 2.05	- 9.51 (n=6)	- 1.38**	+ 22.08	+ 4.32
1890s	- 6.30 (n=5)	- 1.66			+ 22.84*	- 3.95

	Spokane WSO AP x̄	Spokane WSO AP s	Walla Walla WSO CI x̄	Walla Walla WSO CI s	Yakima WSO AP x̄	Yakima WSO AP s
Long-term	16.08	3.75	16.13	3.18	7.36	2.12
1970s	+ 16.42	+ 4.45	+ 16.15	+ 3.46	+ 7.48	+ 3.05**
1960s	+ 16.47	- 2.99	- 15.00	- 2.95	+ 7.42	- 1.70
1950s	+ 18.04*	- 2.68	+ 16.45	- 2.72	+ 8.89**	+ 2.52
1940s	+ 17.02	+ 5.15*	+ 16.52	- 2.97	+ 7.81	- 1.92
1930s	- 12.32**	- 2.21**	- 13.47**	- 1.52**	- 6.38	- 1.91
1920s	- 13.44**	+ 3.83	- 15.06	+ 3.65	- 6.55	- 1.59
1910s	- 14.35	- 2.63	+ 16.24	- 2.72	- 6.97	- 2.00
1900s	+ 16.71	- 2.87	+ 16.74	3.18		
1890s	+ 17.92*	+ 3.80	+ 17.99*	+ 3.62		
1880s	+ 18.56**	- 3.22	+ 17.75*	- 2.71		
1870s			- 15.99 (n=6)	+ 6.14**		

The resulting value of t_k is then tested for significance at the 90 percent and 95 percent levels of confidence.

(b) The F-ratio test involves a comparison of the variance (s^2) of two data series of different lengths. The formula used is:

$$F = \frac{\text{greater } s^2}{\text{lesser } s^2} \tag{11}$$

The value of F is then referred to a table of the F-distribution and the significance of the ratio determined at the appropriate level of confidence. These data as presented in Table 7 are summarized below for each decade.

<u>1970s</u>

<u>Western Oregon</u>. Stations throughout the Willamette Valley and the coastal area received above average precipitation, significantly in the mid-Willamette Valley where Corvallis and Eugene experienced their wettest decade on record. In southwestern Oregon (Ashland, Grants Pass and Roseburg) precipitation was slightly below average.

Precipitation in the decade of the 1970s was undeniably the most variable on record. All stations experienced greater than normal variability and at most of these the departures are statistically significant, half of them at the 95 percent level.

<u>Eastern Oregon</u>. Precipitation at most stations was above the long-term average. However, none of these values are significant and at two stations, Burns and Dayville, the decadal average is slightly below that for the long-term.

Although variability was generally greater than normal for most of the region, it was not dramatically so as in western Oregon. In fact, at Dayville in Fremont variability was less than normal.

<u>Western Washington</u>. Precipitation was slightly below average at the majority of stations. However, the only decadal value significantly different from its average was Neah Bay where it was wetter than average.

As in western Oregon precipitation was the most variable of any decade on record. Values were well above averge at all stations, significantly so at all but Tacoma.

Eastern Washington. Precipitation was slightlly above average at the majority of stations and very near average at the others. None of the departures of decadal values are statistically significant.

Variability reached its highest values on record, well above normal at all stations. At about half of these the departures are statistically significant.

1960s

Western Oregon. Precipitation was generally above average everywhere except at Ashland and Roseburg in southwest Oregon. However, unlike the 1970s none of these values are significant at the 95 percent level and only at Newport for the 90 percent level.

Precipitation totals were extremely consistent during the decade. With the exception of Ashland, precipitation variability at all stations was below normal, the values being significant at the majority. The contrast with the 1970s is striking.

Eastern Oregon. Precipitation was near average throughout the region, about half the stations being slightly above average and half slightly below. At no stations were the departures from average statistically significant.

There is no consistent pattern of variability. About half the stations show high variability and about half show low. Low values are statistically significant at Baker and Hood River; the high value at Condon is significant.

Western Washington. Precipitation was above average everywhere except at Tacoma. Again, Neah Bay was the only station with a significant departure, experiencing its wettest decade since the 1890s.

Low variability typifies the region as in western Oregon. At all stations the values are below average, significantly at three of these in the Puget lowland -- Centralia, Olympia and Tacoma.

Eastern Washington. The decade was generally near average with about half the stations recording slightly above averge precipitation and half slightly below. In no case are the departures from the average significant.

Low variability is dominant in the region. However, two stations, Colville and Kennewick had higher than averge variability. The low value at Colville is the only significant value.

1950s

Western Oregon. With the exception of Ashland all stations show above average precipitation, significantly so at several. At Headworks, Newport, Roseburg, and Bandon it was the wettest decade of the twentieth century and was the most uniformly wet decade since the 1880s in western Oregon.

Throughout most of the region low values of variability are found, none of these significant. In contrast, the three stations of southwestern Oregon (Ashland, Grants Pass, and Roseburg) show very high variability, the highest decadal values on record at Ashland and Grants Pass.

Eastern Oregon. This was the most uniformly wet decade of the twentieth century as it was in the western half of the state. With the exception of Hood River E. S. all stations show well-above average precipitation, significant at Prineville and Wallowa.

Half the stations in the region show low variability and the other half high variability. However, the high values are significant and the low values are not. At Baker, Fremont and Prineville variability for the decade was the highest on record; at Fremont it was the second highest decadal value on record.

Western Washington. Precipitation was generally above average, with the exception of Tacoma and Blaine, but only at Neah Bay was the value significantly above average. The pattern then was essentially the same as in the 1960s.

Variability was unremarkable with about half the stations showing below normal. Only the low value at Neah Bay is statistically significant.

Eastern Washington. This was the only decade in which all stations experienced above averge precipitation. At two of these, Spokane and Yakima, the values are significant and Yakima experienced its wettest decade of the century.

Variability was generally below normal, the departure at Colville being the only one of significance. However, of the three stations with higher than normal variability, the values at two are statistically significant (Cle Elum and Pullman).

1940s

Western Oregon. Most stations received below average precipitation, significantly at Corvallis and Newport for both of which it was the driest decade on record. Yet at Headworks and Ashland precipitation was above average, indeed the wettest decade on record at Ashland.

With the exception of Headworks, variability at all stations was less than normal but the only significant values are at the two coastal stations, Bandon and Newport.

Eastern Oregon. In contrast to western Oregon, precipitation was mostly above average throughout the region, much as it was in the 1950s. Only Baker and Hood River E. S. show slightly below average precipitation.

At the majority of stations variability was below normal, significant only at Fremont. At three of the stations values were above normal, significant at Condon and Dayville.

Western Washington. Dry conditions prevailed at all stations, the severity exceeded only in the 1920s. Aberdeen, Centralia and Olympia WSO AP experienced their driest decade on record.

Variability was generally below average, negative departures at six of the stations, positive at the other three. Only the low value at Neah Bay is significant.

Eastern Washington. Wetter than average conditions were dominant with two-thirds of the stations recording above average precipitation. At Kennewick and Odessa the values are statistically significant and it was the wettest decade on record at these two stations.

Variability was well above normal at most stations, seven out of the nine. At three of these, in fact the positive departures were significant at the 95 percent level. Only at Walla Walla and Yakima were the departures slightly negative.

1930s

Western Oregon. Precipitation was below average at all stations except Headworks which approximated the long-term average. Low values at the two coastal stations are significant at the 95 percent level and for Roseburg and Corvallis at the 90 percent level. It should be noted that at Astoria (data not included) on the north coast the decade was wetter than average. Thus dry conditions were not as extensive as would appear from the data presented.

Variability at Headworks was significantly above normal. Otherwise values are predominantly negative, but the magnitude of the departures is not great.

Eastern Oregon. Precipitation was well below average at all stations, showing dry conditions to have been prevalent throughout the region. Low values at five of the nine stations are statistically significant, three at the 95 percent level. At most of the stations this was the driest decade on record.

Variability was consistently below normal throughout the region, all departures being negtive. However, significant values occur only at two of the stations.

Western Washington. Decadal averges show a range from significantly above average to significantly below average. It was relatively dry at a majority of stations, significant at Port Angeles. In contrast precipitation was significantly above average at Aberdeen and Blaine.

Variability departures were also mixed although a majority were positive. High variability was significant at Aberdeen and Blaine.

Eastern Washington. Unlike western Washington, the eastern part of the state was everywhere extremely dry. Precipitation was below average at all stations, the departures being significant at four of the stations. Five of the nine stations experienced their driest decade on record.

Variability was low at all stations except Conconully where the high value is significant at the 95 percent level. Of the eight stations with negative departures, four of them are significant at the 95 percent level.

1920s

Western Oregon. This was the driest decade on record with regard to spatial extent. All stations show below average precipitation, four of these significant at the 95 percent level. At several stations it was the driest decade on record.

Variability departures were mixed with about half above normal and half below. Only the positive value at Ashland approaches statistical significance.

Eastern Oregon. The spatial extent of extremely dry conditions was only slightly less than in the 1930s. Dayville and Condon show average precipitation but all others are well below average, significant only at Lakeview.

Unlike the dry decade of the 1930s, the dry 1920s did not exhibit particularly low variability. Station values are about evenly divided between positive and negative departures.

Western Washington. Precipitation was well below average at all stations, significantly so at all except Centralia. It was the driest decade on record for the region as a whole and for many of the individual stations.

Variability departures were evenly divided between positive and negative values. However, the only two significant values are at Neah Bay and Snoqualmie Falls at which variability was less than normal.

Eastern Washington. Precipition was below average at all stations, but only at Spokane is the departure significant. While dryness was extensive it does not appear to have been as severe as in western Washington.

At none of the nine stations is the departure from normal variability significant. There is a tendency for above normal values at the majority of stations.

1910s

Western Oregon. In general precipitation was near the long-term average throughout the area. The majority of stations were slightly below average, but at no location do the decadal values depart significantly from the long-term average.

Variability was below normal for all stations except Newport. At the two stations in the extreme southwest part of the state, Ashland and Grants Pass, these low values are significant at the 95 percent level.

Eastern Oregon. Although not as severe as in the 1920s and 1930s, dry conditions were prevalent throughout the area, much more so than in western Oregon. Wallowa was slightly above average, Baker and Burns near average, and all others below average.

At the majority of stations, variability was below normal, significant at three of six stations. At the other three stations variability was above normal.

Western Washington. The majority of stations received slightly above average precipitation, none of the values statistically significant. In contrast, at Neah Bay it was the driest decade on record.

Negative departures from normal variability were dominant. Only two stations show high variability. However, at Centralia the high value is significant.

Eastern Washington. With regard to annual precipitation the decade was quite unremarkable. Departures from the long-term mean are divided evenly between those above average and those below. None of the departures are significant.

Variability departures are dominantly negative, only Colville among the nine stations experiencing above normal variability. However, at none of the stations are the values significant.

1900s

Western Oregon. Departures from average precipitation were not consistent throughout the area, being divided between those above and those below their long-term average. Two values are significant at the 90 percent level, Grants Pass above average in the south and Headworks below average in the north.

It was certainly the most stable decade on record with all stations experiencing very low variability. The departures at seven of the nine stations are statistically significant, four of them at the 95 percent level.

Eastern Oregon. Wet conditions were dominant throughout the region. Five of the seven stations show precipitation well above average, significant at Burns and Lakeview. Prineville and Wallowa were slightly below average.

Variability departures were mixed, four of seven being negative. Low values at Baker and Prineville are significant at the 95 percent level.

Western Washington. This decade was similar to the 1910s in that the majority of stations received above average precipitation, the values significant at Olympia WSO AP and Tacoma. Two stations, Neah Bay and Snoqualmie Falls were slightly below average.

With the exception of Neah Bay, all stations experienced below normal variability. At two stations, Blaine and Olympia, these low values are significant at the 95 percent level.

Eastern Washington. The majority of stations received slightly above average precipitation but in no case was it significantly different than the long-term average. Those few stations drier than normal were also only slightly so.

The majority of stations experienced below normal variability, significant at three stations. At two of these, Conconully and Odessa the negative departures are significant at the 95 percent level. Pullman was above normal and at Walla Walla variability was equal to the long-term value.

1890s

Western Oregon. At Eugene and Portland precipitation was slightly below average, in contrast to the other stations which were all above average. In fact, at Roseburg and Bandon it was the wettest decade on record (1880-1979).

Departures from normal variability were mixed. At five of the eight stations, departures were negative, significant at Eugene. Of the three positive values, only that at Bandon is significant.

Eastern Oregon. Of the five stations with data available four show well above average precipitation for the decade. Two of these values, at Baker and Hood River E. S. are significant at the 95 percent level and it was wettest decade on record. Burns was a sharp contrast to these with precipitation significantly below average.

Variability departures were mixed, positive at three stations and negative at two. The only value reaching the 95 percent level of significance is the negative value at Dayville.

Western Washington. The decade was quite wet with decadal averages generally well above average. The values at Blaine, Neah Bay, Port Angeles and Tacoma were significantly wetter than average. Only at Centralia was it slightly drier than average.

Variability was generally low, negative departures at seven of the nine stations. Only at Aberdeen is the value significant even at the 90 percent level. At Blaine and Olga variability was slightly above normal.

Eastern Washington. Precipitation at Kennewick was slightly below average but at the other three stations it was significantly above average. Decadal averages at Pullman and Walla Walla were the greatest on record.

None of the departures from normal variability were of significance; two were positive and two negative.

1880s

Western Oregon. At all four stations with data for this decade precipitation was above average with the value at Portland significant at the 90 percent level.

Bandon and Roseburg both experienced slightly below normal variability while at Ashland and Portland the departures were positive and significant at the 90 percent level.

Eastern Oregon. Only five years of record are available at Lakeview and Hood River E. S. Thus, for the year 1885-1889 Hood River E. S. was slightly wetter than average and Lakeview slightly drier than average.

Variability was slightly higher than normal at Hood River and significantly below normal at Lakeview.

Western Washington. The decade was quite wet at Port Angeles and slightly above average at Neah Bay. Precipitation at Tacoma was near its long-term mean and at Olympia slightly below average.

Variability departures were also mixed and none of the values are significant. At Olympia variability was slightly above normal and at the other three stations values were slightly below normal.

Eastern Washington. At the only two stations for which data is presented, Spokane and Walla Walla, precipitation was significantly above average.

Variability at both stations was lower than normal although neither departure is significant.

1870s

Oregon. Only data from Portland is available and it shows an extremely wet decade, in fact the wettest on record. Reference to the time series plot of Astoria in Appendix E will show that at that long-term station it was also the wettest decade on record (1854-1979). The decadal value of variability at Portland was slightly above normal.

Washington. Data is available only at Walla Walla and it indicates conditions approximately equal to the long-term mean. Variability at Walla Walla was exceptionally high, significant at the 95 percent level. However, the sample here is only six years.

Summary

The one obvious conclusion that can be made about changes in Pacific Northwest precipitation over the past 100 years is that one should not generalize trends and fluctuations in a region where spatial variability is so great.

The analysis of long-term trends at 70 stations in the Pacific Northwest indicates that there has been no uniform increase or decrease in annual precipitation throughout Oregon. In Washington there has been a tendency for declining totals over the last 100 years. However, only a very few of the trend statistics are of a magnitude to be statistically significant.

Study of filtered time series shows that in spite of rapid oscillations from year to year, short term trends in the series do exist. A downward trend from the latter part of the nineteenth century until about 1930 is a feature noted at most stations throughout the Pacific Northwest although there are some exceptions. From the 1930s to the 1970s an upward trend for stations in western Oregon is a dominant feature. Yet in other areas the last 40 years have fluctuated around a fairly constant mean value. Sequences of wet and dry years in the western regions have been few, with extreme years tending to occur in isolation. East of the Cascades wet and dry conditions have been more prolonged and have varied considerably in duration and magnitude from one place to another.

A comparison of decadal means and variability also makes it clear that fluctuations in mean annual precipitation and in the variability about the mean have not been consistent from one part of the Pacific Northwest to another. The data indicate that the only consistent decadal anomalies are the extremely high variability of the 1970s, the wet decades of the 1890s and 1950s and the dry decades of the 1920s and 1930s. There is no apparent tendency for departures from the long-term mean to vary either in unison or in opposition to departures from long-term variability.

In conclusion, it is of interest to consider two selected extreme years, specifically the unusually wet winter of 1956 and the unusually dry winter of 1977 (Figure 23). This comparison would suggest that the extreme conditions of dry years or seasons tend to be more widespread than the extreme conditions of wet years. In winter 1956 much of the region received more than 140 percent of normal precipitation and at several stations it was the wettest winter during the 40 year normal period; yet at many stations it was only slightly wetter than normal. In contrast, winter 1977 was uniformly dry throughout the Northwest. Almost without exception it was the driest winter of the 40 year period. Much of the region received below 40 percent of normal winter precipitation. This relationship generally holds true for other abnormally wet and dry years.

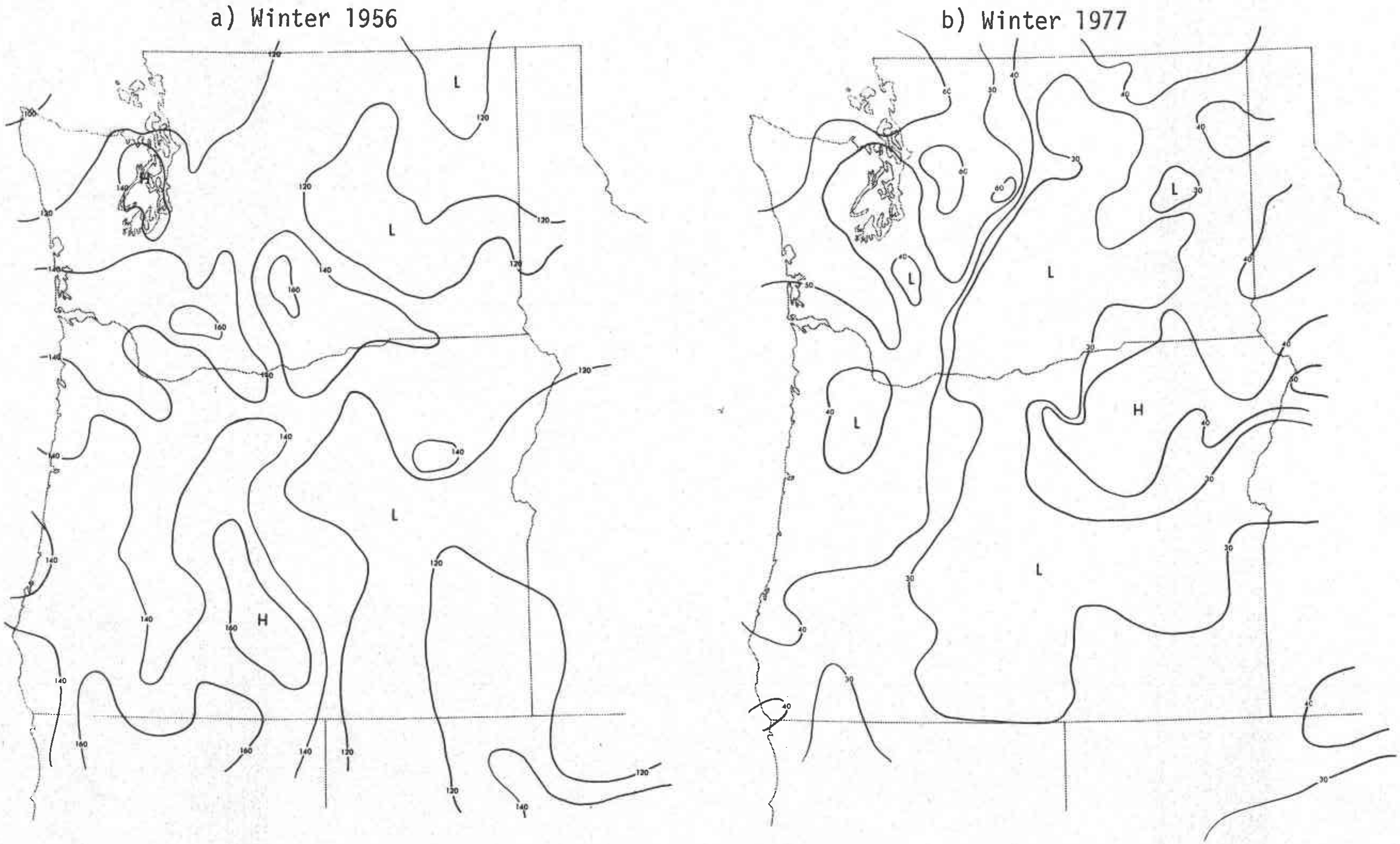


Figure 23. Winter Precipitation 1956 (Wet Season) and 1977 (Dry Season) Expressed as Percentage of Normal Precipitation, 1940-1979.

VI. CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

It is critical to realize that variability is an inherent characteristic of climate, a characteristic the world has become much more familiar with in recent years. In the Pacific Northwest the variability of precipitation is unusually great, both spatially and over a wide range of time scales. These variations must be given careful consideration in all aspects of water resource planning.

In this study monthly, seasonal and annual precipitation characteristics were examined for a dense network of 244 climatological stations in Oregon, Washington and adjacent areas. The primary data base developed for analysis includes monthly precipitation totals for the 40-year base period 1940-1979. The monthly data were further combined into winter (October through April), summer (May through September) and annual (water year) totals.

Various statistics, descriptive and inferential, were calculated to define aspects of variability. The key statistics are the mean and the variability about the mean, expressed by the coefficient of variation. Three different formats were used to summarize this mass of data: a set of isopleth maps depicting means and coefficients of variation for individual months, seasons and the water year; annual profiles of monthly means and coefficients of variation at 43 stations; and a set of isocorr maps showing interstation correlations on a monthly and seasonal basis.

The spatial patterns of precipitation were shown to be a function of the interrelated influences of three dominant climatic controls -- latitude, topography and continental versus marine influence. The general form of these patterns is predictable. However, relative variability is particularly complex. Highest values appear to be immediately to the lee of the Cascades; yet the far eastern portions of Oregon and Washington have relatively low variability. Variations in the seasonal concentration of precipitation do not completely explain this contrast.

The analysis of spatial aspects of precipitation and its associated variability tended to raise more questions than it answered, questions of significance to both climatologists and to water resource managers. Several aspects require additional research, for example:

1) Monthly patterns of variability need to be considered in more detail. In the Willamette Valley, for example, while December is the wettest month, variability is least in March. Many observed relationships of this type are difficult to explain.

2) Apparent anomalies in means and variability need to be examined in terms of features of the general circulation and the seasonal shifts in controlling features.

3) The influence of the Columbia Gorge on mean precipitation and variability needs to be studied in greater detail.

4) The great variety of statistical indices of variability must be compared and evaluated in terms of their usefulness to water managers.

5) A particularly interesting problem is that of defining homogeneous climatic regions. Completion of this task will permit climatic analysis to be carried out using a smaller, but representative, network of stations.

6) Similar statistical analyses need to be done on temperature data and the two climatic elements, temperature and precipitation, should be correlated with snowpack data.

The final section of this report deals with changes in annual precipitation over the last 100 years, the instrumental or secular period. Data for 70 long-term stations were compiled and presented in time-series graphs. Three techniques of analyzing these data series were employed and all yielded important information. Trend analysis showed a tendency for decreasing amounts of annual precipitation in Washington but no tendency for either increasing or decreasing amounts in Oregon. Filtered time series emphasize a number of short-term trends of significance. However, little spatial uniformity was found. Only the gradual decrease in precipitation from the 1890s to about 1930 is a standard feature for the region. Otherwise, there are contrasts in precipitation fluctuations from one area to another. For example, in western Oregon an upward trend from the 1930s to the 1970s is a dominant feature. Yet in the rest of the Pacific Northwest values over the last 40 years have tended to fluctuate about a relatively constant mean.

Decadal values of means and variability were calculated for 36 of the long-term stations in Oregon and Washington. This form of analysis reinforced the finding that changes over time are quite different from one part of the region to another. Certain wet decades, the 1890s and 1950s, stand out as do dry decades, 1920s and the 1930s. But the most consistent feature of the decadal analysis is the interannual variability of annual precipitation in the 1970s. Extremely high variability is obvious at all stations. This finding is consistent with studies from all parts of the globe and may support the contention of some scientists that we have entered a period of global climate distinguished by its extreme variability from place to place and from year to year.

Many suggestions can also be made for subsequent analysis of long-term data series:

1) The severity and spatial extent of drought periods needs to be described on a finer scale.

2) Fluctuations in means and variability need to be specifically compared with other parts of the American West and correlated with changes in indices of the general circulation of the atmosphere.

3) The spatial extent of trends and fluctuations in annual precipitation need to be defined in terms of homogeneous climatic regions.

4) Year-to-year and season-to-season persistence in precipitation needs to be studied to determine if there is any value for forecasting.

The findings of this study and the data presented should be of use to two categories of users: (1) persons and agencies involved in land and water resource management whose effectiveness would be improved by the direct and immediate application of detailed knowledge on the natural variability of precipitation; and (2) persons interested in the broader topic of climatic change. Climatic fluctuations, of any magnitude and duration, have become increasingly relevant as we approach the maximum utilization of limited water resources. Similarly, at a time when man's potential for inadvertent climate modification is a reality, it is necessary to make available a comprehensive analysis of natural climatic variability in order to monitor and document the effects of man's use of the environment.

In conclusion it is appropriate to quote from Pittock et al (1978, p. 179):

> ....the effect of the topography is to amplify quite small exchanges in the general circulation so that much larger magnitude effects are often observed in particular locations. This applies particularly to precipitation in mountainous areas, and thus to watersheds and runoff. The differential nature of the water balance relationships adds to the critical nature of

these effects. It is therefore not surprising that the most dramatic fluctuations in observed climatic variables are those affecting water supply and river flow. The social and economic consequences of these fluctuations loom larger as populations grow and existing water resources are increasingly utilized.

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APPENDICES

VARIABILITY OF PRECIPITATION IN THE PACIFIC NORTHWEST: SPATIAL AND TEMPORAL CHARACTERISTICS

by

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Appendices to
WRRI-77

May 1982

APPENDIX A

NETWORK OF CLIMATOLOGICAL STATIONS

DATA NETWORK: WATER YEARS 1940-1979

(OREGON)

Station I.D.		Name	Latitude	Longitude	Elevation
0197		Antelope	44 55	120 43	2690
0265		Arlington	45 43	120 12	285
0304		Ashland	42 13	122 43	1780
0318	(1)	Astor Experiment Station	46 09	123 49	48
0328	(2)	Astoria WSO AP	46 09	123 49	8
0356		Austin 3 S	44 35	118 30	4213
0412		Baker FAA AP	44 50	117 49	3368
0417		Baker KBKR	44 46	117 50	3444
0471		Bandon 2 NNE	43 09	124 24	20
0694		Bend	44 04	121 19	3650
0723		Beulah	43 55	118 10	3270
0897		Bonneville Dam	45 38	121 57	60
1055		Brookings	42 03	124 17	80
1176		Burns WSO CI	43 35	119 03	4140
1207		Butte Falls 1 SE	42 32	122 33	2500
1433		Cascadia	44 24	122 29	860
1546		Chemult	43 14	121 47	4760
1552		Cherry Grove 2S	45 25	123 15	780
1571		Chiloquin 1 E	42 35	121 51	4220
1643		Clatskanie 3W	46 06	123 17	92
1765		Condon	45 14	120 11	2830
1862		Corvallis-State Univ.	44 39	123 12	225
1897		Cottage Grove 1 S	43 47	123 04	650
1902	(3)	Cottage Grove Dam	43 43	123 03	831
1926		Cove	45 18	117 48	2920
1946		Crater Lake NPS HQ	42 54	122 08	6475
2112		Dallas	44 56	123 19	325
2135		Danner	42 56	117 20	4225
2168	(4)	Dayville	44 28	119 32	2364
2277	(5)	Detroit	44 42	122 07	1452
2406		Drain	43 40	123 19	292
2440		Dufur	45 27	121 08	1330
2633		Elkton 3 SW	43 36	123 35	120
2672		Enterprise	45 26	117 16	3790
2693		Estacada 2 SE	45 16	122 19	410
2709		Eugene WSO AP	44 07	123 13	364
2805	(6)	Falls City 2	44 51	123 26	440
2997		Forest Grove	45 32	123 06	180
3095		Fremont	43 20	121 10	4512
3121	(7)	Friend	45 21	121 16	2440
3356		Gold Beach Ranger Station	42 24	124 25	50
3402		Government Camp	45 18	121 45	3980
3445		Grants Pass	42 26	123 19	925
3542		Grizzly	44 31	120 56	3635

(OREGON)

Station I.D.		Name	Latitude	Longitude	Elevation
3604		Halfway	44 53	117 07	2670
3692		Hart Mountain Refuge	42 33	119 39	5616
3770		Headworks, Portland Water Bureau	45 27	122 09	748
3827		Heppner	45 21	119 33	1950
3847		Hermiston 2 S	45 49	119 17	624
3908		Hillsboro	45 31	122 59	160
4003		Hood River Experiment Station	45 41	121 31	500
4098		Huntington	44 21	117 16	2130
4133		Illahe	42 38	124 03	348
4161		Ione 18 S	45 19	119 51	2130
4291	(8)	John Day	44 26	118 57	3063
4403		Keno	42 07	121 57	4116
4411		Kent	45 12	120 42	2720
4506		Klamath Falls 2 SSW	42 12	121 47	4098
4622	(9)	LaGrande	45 19	118 06	2755
4670		Lakeview 2 NNW	42 13	120 22	4778
4811		Leaburg 1 SW	44 06	122 41	675
5080		Lower Hay Creek	44 44	120 59	1898
5139		Madras	44 38	121 08	2230
5160	(10)	Malheur Branch Experiment Station	43 59	117 01	2240
5162		Malheur Refuge HDQ	43 17	118 50	4109
5362		McKenzie Bridge Ranger Station	44 11	122 07	1478
5384		McMinnville	45 14	123 11	148
5424		Medford Experiment Station	42 18	122 52	1457
5429		Medford WSO AP	42 22	122 52	1312
5593		Milton Freewater	45 57	118 25	970
5734		Moro	45 29	120 43	1870
6032		Newport	44 38	124 03	154
6073		North Bend FAA AP	43 25	124 15	7
6179		Nyssa	43 52	117 00	2175
6213		Oakridge Fish Hatchery	43 45	122 27	1275
6243		Ochoco Ranger Station	44 24	120 26	3975
6405		Owyhee Dam	43 39	117 15	2400
6426		Paisley	42 42	120 32	4360
6468	(11)	Parkdale 2 SSE	45 30	121 35	1940
6546		Pendleton WSO AP	45 41	118 51	1492
6634		Pilot Rock 1 SE	45 29	118 49	1720
6749	(12)	Portland KGW-TV	45 31	122 41	159
6820		Powers	42 53	124 04	230
6883		Prineville	44 21	120 54	2840
6907		Prospect 2 SW	42 44	122 31	2482

(OREGON)

Station I.D.		Name	Latitude	Longitude	Elevation
7052		Redmond 2 W	44 16	121 13	3010
7082		Reedsport	43 42	124 07	60
7169		Riddle	42 57	123 21	680
7208	(13)	Riverside	43 33	118 10	3330
7250		Rock Creek	44 55	118 04	4035
7331	(14)	Roseburg KQEN	43 12	123 21	465
7354		Round Grove	42 20	120 53	4888
7500		Salem WSO AP	44 55	123 01	195
7641		Seaside	45 59	123 55	10
8029		Squaw Butte Experiment Station	43 29	119 41	4665
8407	(15)	The Dalles	45 36	121 12	102
8466		Three Lynx	45 07	122 04	1120
8494		Tillamook 1 W	45 27	123 52	10
8726		Ukiah	45 08	118 56	3355
8746		Union Experiment Station	45 13	117 53	2765
8780		Unity	44 26	118 14	4031
8797		Vale	43 59	117 15	2240
8818	(16)	Valley Falls 3 SSE	42 27	120 15	4580
8833		Valsetz	44 51	123 40	1155
8884	(17)	Vernonia 2	45 52	123 11	625
8997		Wallowa	45 34	117 32	2923
9068		Wasco	45 35	120 42	1264
9316		Wickiup Dam	43 41	121 41	4358

(WASHINGTON)

0008		Aberdeen	46 58	123 49	10
0176		Anacortes	48 31	122 37	30
0242	(18)	Ariel Dam	45 58	122 34	224
0257		Arlington	48 12	122 08	100
0482		Battle Ground	45 47	122 32	295
0564		Bellingham 2 N	48 47	122 29	140
0668		Bickleton	46 00	120 18	3000
0729		Blaine	49 00	122 45	60
0872		Bremerton	47 34	122 40	162
0945		Buckley 1 NE	47 10	122 00	685
1233		Cedar Lake	47 25	121 44	1560
1276		Centralia	46 43	122 57	185
1350	(19)	Chelan	47 50	120 02	1120
1385	(20)	Chesaw 4 NNW	49 00	119 04	3960
1395		Chewelah	48 17	117 43	1670
1414		Chimacum 4 S	47 57	122 47	140
1484		Clearbrook	48 58	122 20	64
1504		Cle Elum	47 11	120 57	1930

(WASHINGTON)

Station I.D.		Name	Latitude	Longitude	Elevation
1586		Colfax 1 NW	46 53	117 23	1955
1650		Colville AP	48 33	117 53	1885
1666		Conconully	48 33	119 45	2320
1679		Concrete	48 33	121 46	195
1760		Cougar 6 E	46 04	122 12	659
1767		Coulee Dam 1 SW	47 57	119 00	1700
1783		Coupeville 1 S	48 12	122 42	50
1934	(21)	Cushman Dam	47 25	123 13	760
1968		Dallesport FAA AP	45 37	121 09	222
1992		Darrington Ranger Station	48 15	121 36	550
2007		Davenport	47 39	118 09	2460
2030		Dayton 1 WSW	46 19	118 00	1557
2157		Diablo Dam	48 43	121 09	891
2505		Ellensburg	46 58	120 33	1480
2531		Elma	47 00	123 24	70
2675		Everett	47 59	122 11	60
2914		Forks 1 E	47 57	124 22	350
3222	(22)	Goldendale	45 49	120 50	1600
3284		Grapeview 3 SW	47 18	122 52	30
3357		Greenwater	47 08	121 38	1730
3502		Harrington 5 S	47 25	118 15	2170
3529		Hartline	47 41	119 06	1910
3546		Hatton 9 ESE	46 45	118 39	1430
3975		Irene Mt. Wauconda	48 49	118 54	2700
4077		Kahlotus 5 SSW	46 35	118 36	1550
4084	(23)	Kalama Falls Hatchery	46 01	122 43	310
4154		Kennewick	46 13	119 06	390
4201		Kid Valley	46 22	122 37	690
4338		La Crosse	46 49	117 53	1480
4394		Lake Cle Elum	47 15	121 04	2255
4406	(24)	Lake Kachess	47 16	121 12	2270
4414	(25)	Lake Keechelus	47 19	121 20	2475
4446		Lake Wenatchee	47 50	120 48	2005
4486		Landsburg	47 23	121 58	535
4549		Laurier	49 00	118 14	1644
4572		Leavenworth 3 S	47 34	120 40	1128
4679		Lind 3 NE	47 00	118 35	1630
4769		Longview	46 09	122 55	12
4971	(26)	Mansfield	47 49	119 38	2265
5128	(27)	Mazama 6 SE	48 32	120 20	1960
5224		McMillin Reservoir	47 08	122 16	579
5425		Mineral	46 43	122 11	1470
5525		Monroe	47 51	121 59	120
5613	(28)	Moses Lake 3 E	47 07	119 12	1208
5659		Mt. Adams Ranger Station	46 00	121 32	1960
5688		Moxee City 10 E	46 31	120 10	1550
5704		Mud Mountain Dam	47 09	121 56	1308

(WASHINGTON)

Station I.D.		Name	Latitude	Longitude	Elevation
5801		Neah Bay 1 E	48 22	124 37	10
5832		Nespelem 2 S	48 08	118 59	1890
5840	(29)	Newhalem	48 41	121 15	525
5844		Newport	48 11	117 03	2135
5946		Northport	48 55	117 47	1350
6039		Odessa	47 20	118 41	1540
6096		Olga 2 SE	48 37	122 48	80
6114		Olympia WSO AP	46 58	122 54	192
6123		Omak 2 NW	48 26	119 32	1228
6295		Palmer 3 ESE	47 18	121 51	920
6553		Pleasant View	46 31	118 20	1665
6610		Pomeroy	46 28	117 37	1810
6624		Port Angeles	48 07	123 26	100
6678		Port Townsend	48 07	122 45	100
6768		Prosser 4 NE	46 15	119 45	903
6789		Pullman 2 NW	46 46	117 12	2545
6803		Puyallup 2 W Experiment Station	47 12	122 20	50
6846		Quilcene 2 SW	47 49	122 55	123
6880		Quincy 1 S	47 13	119 51	1274
6896		Rainier Ohanapecosh	46 44	121 34	1950
6909		Randle 1 E	46 32	121 56	900
6974		Republic	48 39	118 44	2610
7038		Rimrock (Tieton Dam)	46 39	121 08	2730
7059		Ritzville 1 SSE	47 07	118 22	1830
7180		Rosalia	47 14	117 22	2400
7473	(30)	Seattle-Tacoma WSO AP	47 27	122 18	450
7478		Seattle-Univ. of Wash.	47 39	122 17	95
7507		Sedro Wooley	48 30	122 14	60
7538		Sequim	48 05	123 06	180
7584		Shelton	47 12	123 06	22
7773		Snoqualmie Falls	47 33	121 51	440
7938		Spokane WSO AP	47 38	117 32	2349
7956		Sprague	47 18	117 59	1920
7987		Spruce	47 48	124 04	365
8034		Startup 1 E	47 52	121 43	170
8059		Stehekin 4 NW	48 21	120 43	1270
8207		Sunnyside	46 19	120 00	747
8286		Tacoma City Hall	47 15	122 26	267
8348		Tekoa	47 13	117 05	2610
8773		Vancouver 4 NNE	45 41	122 39	210
8931		Walla Walla WSO Cl	46 02	118 20	949
8959		Wapato	46 26	120 25	850
9012		Waterville	47 39	120 04	2620
9058		Wellpinit	47 53	117 59	2450
9074		Wenatchee	47 25	120 19	634
9238		Wilbur	47 45	118 42	2160
9327		Wilson Creek	47 25	119 07	1276
9342	(31)	Wind River	45 48	121 56	1145
9376		Winthrop 1 WSW	48 28	120 11	1755
9465		Yakima WSO AP	46 34	120 32	1064

(IDAHO)

Station I.D.	Name	Latitude	Longitude	Elevation
1380	Caldwell	43 40	116 41	2370
1956	Coeur D'Alene Ranger Station	47 41	116 45	2158
3771	Grangeville	45 55	116 08	3360
6152	Moscow-Univ. of Idaho	46 44	116 58	2660
6424	Nezperce	46 15	116 15	3145
6844	Parma Experiment Station	43 48	116 57	2215
6891	Payette	44 05	116 56	3145
7264	Porthill	49 00	116 30	1775
7386	Priest River Exper. Sta.	48 21	116 50	2380
7706	Riggins	45 25	116 18	1800
8062	Saint Maries	47 19	116 34	2220

(NEVADA)

Station I.D.	Name	Latitude	Longitude	Elevation
2573	Elko FAA AP	40 50	115 47	5075
5869	Owyhee	41 57	116 06	5396
6005	Paradise Valley 1 NW	41 30	117 32	4675
9171	Winnemucca WSO AP	40 54	117 48	4297

(CALIFORNIA)

Station I.D.	Name	Latitude	Longitude	Elevation
1614	Cedarville	41 32	120 10	4670
2147	Crescent City 1N	41 46	124 12	40
3157	Fort Bidwell	41 51	120 08	4500
3761	Happy Camp Ranger Station	41 48	123 22	1210
9053	Tulelake	41 58	121 28	4035
9866	Yreka	41 43	122 38	2625

Footnotes

(1) Station closed July 1973, data to date is 0382: Astoria WSO AP.

(2) Station opened February 1953, prior data is 0324: Astoria (compatible station).

(3) Station opened January 1944, prior data interpolated from 1897: Cottage Grove.

(4) Station closed October 1978, data to date is 2173: Dayville 8 NW (compatible station).

(5) Station closed October 1972, data to date is 2292: Detroit (compatible station).

(6) Station opened June 1961, prior data is 2800: Falls City (compatible station).

(7) Station closed August 1976, data to date interpolated from nearby stations.

(8) Station opened May 1953, prior data is 1352: Canyon City (compatible station).

(9) Station opened September 1965, prior data is 4615: LaGrande (compatible station).

(10) Station opened January 1959, prior data is 8924: Sod House Voltage 2 NW (compatible station).

(11) Station opened May 1969, prior data is 6464: Parkdale (compatible station).

(12) Station opened July 1973, prior data is 6761: Portland WB City.

(13) Station opened November 1966, prior data is 9046: Warm Springs Reservoir (compatible station).

(14) Station opened October 1965, prior data is 7326: Roseburg WB City (compatible station).

(15) Data from July 1967 through January 1975 is 8410: The Dalles 2.

(16) Station opened May 1965, prior data is 8812: Valley Falls (compatible station).

(17) Station opened August 1967, prior data is 8879: Vernonia (compatible station).

(18) Station closed September 1971, data to date is 5305: Merwin Dam (compatible station).

(19) Station known as 4430: Lakeside prior to 1958.

(20) Station opened May 1959, prior data is 1381: Chesaw through October 1958 and 1383 Chesaw 2 NE until May 1959 (compatible stations).

(21) Station closed May 1973, data to date is Cushman Power House.

(22) Station closed March 1972, data to date is 3226: Goldendale 2 E (compatible station).

(23) Station opened in November 1967; prior data is 1485: Kalama 5 ENE.

(24) Station closed August 1977, data to date is interpolated from nearby stations.

(25) Station closed September 1977, data to date is interpolated from nearby stations.

(26) Station closed September 1978, data to date is 4975: Marshfield 7 W (compatible station).

(27) Station closed October 1976; data to date is 5133: Mazama (compatible station).

(28) Station opened September 1947, prior data is 7223: Ruff 3 SW (compatible station).

(29) Prior to 1959, known as 7690: Skagit Power (same station).

(30) Station opened in December 1944; prior data is 7483: Seattle (Boeing Field).

(31) Station closed July 1977, data to date is interpolated from surrounding stations.

APPENDIX B

DESCRIPTIVE STATISTICS (1940-1979)
SEASONAL AND ANNUAL PRECIPITATION - 244 STATIONS
MONTHLY PRECIPITATION - 43 STATIONS
(all data in inches)

DESCRIPTIVE STATISTICS
SEASONAL AND ANNUAL PRECIPITATION
(1940-1979)

(OREGON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
0197 ANTELOPE									
W	8.94	9.03	0.29	5.36	7.37	10.75	12.04	13.67(43)	2.38(77)
S	4.03	3.77	0.40	1.90	2.88	5.30	6.33	7.70(48)	0.56(74)
Y	12.97	13.06	0.24	8.73	10.77	15.00	16.69	19.62(48)	7.59(44)
0265 ARLINGTON									
W	7.31	7.11	0.31	4.66	5.65	8.73	10.09	11.66(51)	1.48(77)
S	1.88	1.73	0.41	1.02	1.39	2.40	2.90	3.82(48)	0.24(49)
Y	9.19	9.23	0.26	6.20	7.11	10.98	12.39	14.05(51)	4.43(77)
0304 ASHLAND									
W	15.38	16.22	0.29	9.71	12.34	18.53	20.49	23.48(43)	5.22(77)
S	4.23	3.90	0.49	1.84	2.65	5.45	7.29	8.56(41)	0.51(74)
Y	19.61	20.83	0.25	12.85	15.36	23.11	25.36	27.83(56)	8.36(55)
0318 ASTOR EXPERIMENT STATION									
W	66.42	65.54	0.24	43.87	59.09	75.49	90.05	99.30(56)	28.42(77)
S	12.39	12.04	0.32	7.72	9.25	14.94	18.22	21.54(68)	6.14(67)
Y	78.81	76.92	0.19	57.43	69.72	89.69	99.83	111.74(56)	45.51(77)
0328 ASTORIA WSO AP									
W	61.73	61.15	0.22	45.25	54.16	69.16	75.75	95.61(56)	28.42(77)
S	11.67	11.60	0.31	7.20	8.94	14.27	17.11	19.77(68)	5.99(67)
Y	73.39	74.04	0.19	57.36	62.75	81.21	92.51	109.22(56)	45.51(77)
0356 AUSTIN 3 S									
W	14.80	13.96	0.25	11.00	12.45	17.51	19.39	23.27(74)	5.86(77)
S	5.50	5.15	0.31	3.45	4.59	6.35	7.53	11.62(41)	2.68(61)
Y	20.30	19.85	0.19	15.44	17.22	22.88	25.76	28.52(65)	13.02(44)
0412 BAKER FAA AP									
W	5.86	5.89	0.28	3.84	4.44	7.33	7.68	10.31(78)	2.46(77)
S	4.58	4.44	0.32	2.68	3.43	5.55	6.80	7.47(64)	1.81(51)
Y	10.44	10.15	0.24	7.63	8.15	12.41	13.55	17.50(78)	6.30(51)

(OREGON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
0417 BAKER KBKR									
W	6.68	6.53	0.29	4.55	5.37	8.06	9.07	11.89(78)	2.30(77)
S	4.68	4.46	0.36	2.50	3.52	5.55	6.64	10.78(56)	2.16(61)
Y	11.37	10.91	0.24	8.09	9.03	13.12	14.23	19.25(56)	7.37(77)
0471 BANDON 2 NNE									
W	53.06	54.77	0.20	40.41	47.81	58.76	64.04	79.37(74)	22.53(77)
S	7.11	6.87	0.37	4.24	4.98	8.62	10.84	13.48(53)	2.80(65)
Y	60.18	62.34	0.17	48.11	53.34	67.50	72.14	85.47(74)	35.59(77)
0694 BEND									
W	8.56	8.68	0.36	5.01	6.47	9.92	13.36	14.93(74)	1.38(77)
S	3.42	3.31	0.55	1.18	1.77	4.69	5.30	10.17(48)	1.02(60)
Y	11.94	11.63	0.31	7.04	9.35	14.34	16.66	20.87(48)	4.35(55)
0723 BEULAH									
W	7.87	7.94	0.29	5.63	6.43	9.35	10.97	12.83(78)	1.65(77)
S	3.30	3.24	0.38	1.68	2.35	4.13	5.12	6.02(64)	1.34(43)
Y	11.17	11.20	0.21	8.14	9.56	12.55	14.04	16.74(65)	6.22(66)
0897 BONNEVILLE DAM									
W	64.20	65.54	0.22	46.09	55.74	73.03	81.58	93.07(74)	30.48(77)
S	11.55	11.48	0.30	7.58	9.22	13.31	17.03	19.67(77)	4.26(67)
Y	75.76	76.34	0.18	56.46	65.85	85.94	93.91	103.17(74)	50.15(77)
1055 BROOKINGS									
W	69.07	71.77	0.19	52.49	60.97	77.30	84.21	92.07(58)	30.63(77)
S	9.49	9.25	0.42	4.45	6.31	12.89	13.98	19.27(53)	3.54(65)
Y	78.55	80.31	0.16	64.82	70.16	87.33	94.61	98.96(78)	44.54(77)
1176 BURNS WSO CI									
W	8.60	8.46	0.28	5.60	6.97	10.67	11.74	12.24(78)	1.98(77)
S	3.08	2.88	0.43	1.38	1.88	4.27	4.79	5.66(48)	0.79(74)
Y	11.69	11.67	0.22	8.40	9.74	13.39	15.65	16.62(63)	5.97(77)
1207 BUTTE FALLS 1 SE									
W	30.50	29.41	0.26	21.89	25.30	34.86	44.14	46.70(43)	10.55(77)
S	6.05	6.06	0.36	3.52	4.72	7.20	9.16	11.28(77)	1.54(74)
Y	36.56	36.04	0.21	26.58	31.53	41.71	47.53	53.93(43)	21.83(77)
1433 CASCADIA									
W	51.02	50.46	0.19	38.42	46.56	56.53	64.58	72.58(74)	25.37(77)
S	11.04	10.11	0.29	7.83	8.28	13.08	15.25	19.53(41)	6.61(65)
Y	62.06	61.56	0.15	52.05	56.14	68.05	73.78	81.90(43)	43.73(77)

(OREGON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
1546 CHEMULT									
W	21.64	20.26	0.33	13.80	17.26	26.40	30.34	40.15(74)	3.87(77)
S	4.34	4.13	0.41	2.02	3.13	5.24	7.05	8.67(44)	1.59(55)
Y	25.98	24.95	0.27	17.80	22.11	31.11	34.66	42.02(74)	9.80(55)
1552 CHERRY GROVE 2 S									
W	48.31	49.15	0.21	35.85	42.95	52.53	59.23	74.90(74)	17.42(77)
S	7.08	6.23	0.36	4.39	5.37	8.67	10.67	12.89(68)	2.46(67)
Y	55.40	55.58	0.17	44.24	48.92	61.39	64.38	79.73(74)	29.54(77)
1571 CHILOQUIN 1 E									
W	14.19	14.35	0.33	8.62	10.50	16.92	21.05	22.87(65)	2.23(77)
S	3.67	3.24	0.44	1.85	2.47	4.45	6.07	7.50(77)	1.29(74)
Y	17.86	18.38	0.26	11.54	13.77	20.53	24.49	28.31(56)	9.68(55)
1643 CLATSKANIE 3 W									
W	49.97	49.47	0.22	34.63	45.08	54.86	64.96	74.43(56)	22.01(77)
S	8.47	7.66	0.35	5.59	6.32	10.15	13.18	16.17(78)	2.67(67)
Y	58.44	57.92	0.18	44.62	52.12	65.48	71.82	83.30(56)	37.38(77)
1765 CONDON									
W	9.33	9.15	0.29	5.91	7.16	10.94	12.97	16.27(74)	3.81(77)
S	4.14	3.96	0.40	2.37	3.00	5.33	5.97	8.42(48)	1.19(49)
Y	13.47	13.09	0.25	9.48	11.07	15.43	18.08	21.36(48)	7.80(49)
1862 CORVALLIS-STATE UNIV.									
W	35.24	33.70	0.25	25.57	29.93	39.89	46.45	63.75(74)	14.18(77)
S	5.61	5.40	0.39	2.93	4.33	6.61	8.47	11.81(68)	2.47(67)
Y	40.86	40.10	0.22	31.97	34.67	45.28	53.24	67.70(74)	24.60(77)
1897 COTTAGE GROVE 1 S									
W	39.83	39.24	0.21	30.10	35.57	44.01	48.53	59.88(74)	15.87(77)
S	6.93	6.72	0.33	3.67	5.67	8.16	10.09	12.45(68)	3.05(74)
Y	46.77	46.54	0.17	37.09	42.60	50.76	56.34	64.11(56)	25.08(77)
1902 COTTAGE GROVE DAM									
W	40.10	40.50	0.22	29.19	34.36	44.30	51.49	61.12(74)	17.46(77)
S	7.35	7.04	0.35	4.12	5.61	8.58	10.91	14.34(68)	2.58(51)
Y	47.45	48.00	0.17	37.07	41.85	51.75	58.86	64.47(74)	28.03(77)
1926 COVE									
W	14.75	14.65	0.21	11.68	13.07	16.79	19.03	21.25(78)	6.46(77)
S	8.14	8.51	0.33	4.99	6.07	9.77	10.75	17.30(51)	2.86(74)
Y	22.89	22.79	0.18	17.42	20.47	25.77	28.70	30.35(41)	13.19(66)

(OREGON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
1946 CRATER LAKE NPS HQ									
W	58.63	56.81	0.23	44.43	50.41	66.67	78.36	85.86(51)	19.74(77)
S	9.63	9.04	0.35	5.75	7.37	11.70	13.12	19.33(77)	4.26(74)
Y	68.26	67.01	0.18	52.72	61.02	78.36	87.39	91.59(51)	39.07(77)
2112 DALLAS									
W	44.41	45.08	0.26	30.99	37.52	51.09	57.01	74.22(74)	17.02(77)
S	5.82	5.57	0.37	3.29	4.23	6.89	9.08	11.15(78)	2.28(70)
Y	50.22	50.99	0.22	35.44	43.42	57.30	63.73	77.81(74)	24.88(55)
2135 DANNER									
W	8.11	8.13	0.25	5.30	6.96	9.55	10.56	12.32(69)	2.52(77)
S	3.90	3.94	0.35	2.00	2.89	5.12	5.59	6.10(52)	1.27(74)
Y	12.02	11.85	0.22	8.97	10.13	14.03	15.40	16.01(71)	5.93(66)
2168 DAYVILLE									
W	7.61	7.93	0.30	4.87	5.83	8.84	10.37	13.57(58)	3.05(77)
S	4.35	3.91	0.42	2.49	3.26	5.24	6.49	9.89(41)	1.06(74)
Y	11.97	11.12	0.27	8.11	9.45	14.30	15.63	20.13(58)	6.97(49)
2277 DETROIT									
W	68.77	69.28	0.22	51.54	59.66	78.50	88.36	102.18(74)	31.47(77)
S	11.60	10.92	0.35	6.82	9.04	13.89	18.33	22.01(77)	4.63(51)
Y	80.37	80.47	0.18	62.14	69.38	90.16	97.13	112.05(74)	53.48(77)
2406 DRAIN									
W	41.28	40.87	0.23	30.26	34.70	47.30	54.77	65.27(74)	16.77(77)
S	6.11	6.12	0.34	3.40	4.47	7.99	9.15	10.96(79)	2.21(73)
Y	47.39	46.82	0.20	37.61	41.42	53.77	59.31	68.45(74)	24.92(77)
2440 DUFUR									
W	9.63	9.39	0.31	6.20	7.38	11.00	14.45	16.10(74)	2.18(77)
S	2.46	2.45	0.26	1.12	2.02	3.23	3.40	4.76(48)	0.86(xx)
Y	12.08	11.64	0.35	8.20	10.24	13.73	17.34	18.20(56)	5.53(77)
2633 ELKTON 3 SW									
W	48.17	48.75	0.22	33.96	41.28	55.09	59.04	75.58(56)	19.96(77)
S	5.39	4.80	0.39	3.04	3.75	6.52	8.74	9.83(71)	2.08(74)
Y	53.55	53.28	0.20	40.68	47.96	60.80	65.07	79.64(56)	23.90(77)
2672 ENTERPRISE									
W	6.84	6.69	0.27	4.55	5.72	7.98	9.59	10.58(42)	2.30(77)
S	6.41	6.54	0.29	4.07	5.30	7.48	8.53	10.77(77)	1.17(74)
Y	13.27	13.05	0.22	9.04	10.92	15.86	17.17	19.42(56)	7.57(66)

(OREGON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
2693 ESTACADA 2 SE									
W	48.02	46.24	0.22	35.75	42.15	54.17	63.78	68.32(56)	22.66(77)
S	11.00	10.50	0.30	6.94	8.66	13.46	16.20	17.44(77)	4.23(67)
Y	59.02	59.21	0.17	47.98	50.79	66.32	73.94	76.98(56)	40.10(77)
2709 EUGENE WSO AP									
W	38.12	36.96	0.26	27.49	32.17	43.68	50.24	70.82(74)	16.73(77)
S	5.87	5.54	0.40	3.37	3.93	7.81	9.24	12.20(68)	2.49(65)
Y	43.99	42.67	0.23	33.52	38.26	48.66	57.92	74.18(74)	23.74(77)
2805 FALLS CITY 2									
W	64.64	65.87	0.26	42.57	52.82	74.75	86.95	99.94(74)	22.14(77)
S	6.90	6.72	0.40	3.15	4.79	9.49	10.54	12.49(41)	2.12(67)
Y	71.54	72.65	0.23	50.70	62.79	81.16	92.55	105.71(74)	32.37(77)
2997 FOREST GROVE									
W	38.71	39.48	0.22	28.72	33.34	43.06	48.97	59.28(74)	14.35(77)
S	5.92	5.55	0.36	3.43	4.68	6.49	9.36	12.24(68)	2.59(70)
Y	44.63	44.96	0.18	34.46	39.26	50.93	54.01	62.77(74)	25.21(77)
3095 FREMONT									
W	8.18	7.89	0.40	4.93	5.60	10.59	12.26	15.17(56)	1.91(77)
S	3.25	3.19	0.42	1.46	2.37	4.00	5.16	6.77(66)	0.84(55)
Y	11.43	10.79	0.31	7.59	8.65	13.79	15.41	21.94(56)	3.53(55)
3121 FRIEND									
W	13.83	13.53	0.28	9.55	11.44	17.14	18.48	23.03(46)	4.12(77)
S	2.82	2.81	0.40	1.40	2.05	3.51	4.29	5.26(48)	0.68(70)
Y	16.65	16.37	0.26	11.14	13.72	19.11	22.67	26.49(43)	8.08(77)
3356 GOLD BEACH RANGER STATION									
W	71.94	70.98	0.21	56.38	62.16	81.99	88.79	106.32(74)	29.76(77)
S	9.58	8.59	0.44	4.55	6.11	13.56	15.45	20.58(53)	3.77(65)
Y	80.78	80.20	0.18	67.29	73.44	92.86	98.24	110.44(74)	46.23(77)
3402 GOVERNMENT CAMP									
W	72.45	72.86	0.23	51.09	61.31	81.84	95.83	109.32(74)	38.56(77)
S	15.52	15.56	0.25	10.86	13.40	16.96	21.39	24.38(31)	5.29(67)
Y	87.97	90.10	0.19	66.92	74.15	97.29	111.55	124.27(74)	60.71(77)
3445 GRANTS PASS									
W	28.08	28.33	0.29	16.61	22.62	32.94	37.25	48.31(74)	8.54(77)
S	3.73	3.72	0.50	1.20	2.39	5.15	5.82	7.78(47)	0.47(74)
Y	31.82	33.12	0.25	20.27	26.58	36.81	40.65	51.25(56)	16.05(77)

(OREGON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
3542 GRIZZLY									
W	8.90	8.89	0.27	5.65	7.68	10.56	12.17	13.16(51)	2.08(77)
S	4.45	4.27	0.44	2.01	3.13	5.54	6.79	9.40(41)	0.70(49)
Y	13.35	13.13	0.24	8.60	11.35	15.77	16.79	21.54(48)	7.36(77)
3604 HALFWAY									
W	16.55	16.23	0.25	11.99	14.71	19.51	21.17	24.30(74)	3.49(77)
S	4.74	4.49	0.32	2.97	3.81	5.65	6.14	9.84(41)	2.22(74)
Y	21.29	21.24	0.21	15.87	19.06	24.23	26.66	29.86(58)	9.46(77)
3692 HART MOUNTAIN REFUGE									
W	6.44	6.31	0.33	3.97	4.83	7.46	9.37	11.83(63)	2.35(77)
S	4.61	4.20	0.40	2.41	3.39	5.65	7.62	8.94(65)	1.50(74)
Y	11.05	10.12	0.27	7.83	8.78	13.59	15.67	18.13(63)	7.47(46)
3770 HEADWORKS, PORTLAND WATER BUREAU									
W	66.45	64.82	0.20	50.74	59.00	73.93	84.37	103.71(43)	32.74(77)
S	16.69	16.13	0.27	10.56	13.84	19.51	22.71	26.99(41)	7.55(67)
Y	83.15	82.26	0.16	66.57	72.98	91.73	102.25	120.02(43)	57.62(77)
3827 HEPPNER									
W	9.45	9.61	0.25	6.83	7.31	11.04	12.38	15.13(74)	3.86(77)
S	4.35	4.44	0.39	2.13	3.38	5.42	5.91	9.65(41)	1.30(40)
Y	13.79	14.05	0.20	9.55	12.23	15.81	17.03	20.63(48)	9.26(77)
3847 HERMISTON 2 S									
W	6.69	6.30	0.31	4.46	5.23	8.05	9.00	12.90(74)	2.46(77)
S	2.31	2.15	0.46	0.91	1.61	2.97	3.65	5.03(48)	0.64(67)
Y	9.00	8.88	0.25	6.15	7.53	10.31	12.11	13.80(58)	5.48(77)
3908 HILLSBORO									
W	31.98	32.45	0.21	24.44	28.04	35.90	41.19	47.92(74)	11.35(77)
S	5.96	5.82	0.36	3.70	4.46	6.74	8.84	11.34(68)	1.97(67)
Y	37.94	37.62	0.17	29.56	33.41	42.51	46.29	51.92(74)	22.58(77)
4003 HOOD RIVER EXPERIMENT STATION									
W	26.59	25.79	0.27	17.64	21.84	31.33	35.25	42.74(74)	7.84(77)
S	3.90	3.55	0.46	1.97	2.86	4.81	5.63	9.59(53)	0.90(67)
Y	30.49	30.80	0.23	21.92	24.79	36.40	38.52	45.69(74)	13.60(77)
4098 HUNTINGTON									
W	8.96	9.04	0.30	5.58	7.44	10.81	12.42	16.19(78)	1.95(77)
S	3.08	3.12	0.43	1.21	1.92	4.04	4.88	5.35(70)	0.85(66)
Y	12.05	12.24	0.26	7.49	9.76	14.34	16.31	18.76(78)	5.93(66)

(OREGON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
4133 ILLAHE									
W	78.83	77.97	0.23	57.59	69.44	92.09	99.54	112.99(74)	28.25(77)
S	7.51	6.81	0.46	4.04	4.53	10.03	12.79	15.39(53)	2.81(74)
Y	86.34	87.62	0.20	64.68	76.12	96.58	109.52	115.80(74)	41.74(77)
4161 IONE 18 S									
W	8.79	8.61	0.30	5.58	7.13	10.79	11.85	15.76(48)	1.74(77)
S	3.88	3.68	0.43	1.72	2.71	5.07	5.52	9.03(48)	0.64(74)
Y	12.67	12.86	0.26	8.65	9.99	14.55	16.31	24.79(48)	6.04(77)
4291 JOHN DAY									
W	9.27	9.85	0.28	5.62	7.55	11.19	12.13	14.97(51)	3.78(77)
S	5.02	4.95	0.29	3.24	4.01	5.80	7.03	8.71(65)	2.38(77)
Y	14.29	14.34	0.23	9.48	11.98	17.20	18.27	20.69(48)	7.15(73)
4403 KENO									
W	15.55	15.07	0.31	9.19	12.41	19.15	21.54	25.40(74)	4.94(77)
S	3.89	3.40	0.42	2.07	2.81	4.79	6.69	7.61(77)	1.37(55)
Y	19.44	19.69	0.24	12.65	16.68	22.92	25.94	27.70(71)	8.64(55)
4411 KENT									
W	8.14	7.87	0.29	5.24	6.45	9.69	11.82	12.33(74)	2.39(77)
S	3.24	3.33	0.43	1.57	2.31	3.89	4.67	7.78(48)	0.89(67)
Y	11.38	11.05	0.25	7.85	8.96	13.22	15.25	17.89(78)	6.32(77)
4506 KLAMATH FALLS 2 SSW									
W	10.72	10.84	0.33	6.44	7.54	13.15	14.96	18.36(56)	2.40(77)
S	3.30	3.11	0.49	1.38	2.02	4.19	5.65	7.54(48)	0.72(70)
Y	14.02	13.97	0.27	8.74	11.37	16.71	19.02	22.79(56)	7.52(55)
4622 LAGRANDE									
W	13.73	13.70	0.22	9.89	12.08	15.71	17.55	18.97(48)	5.69(77)
S	5.87	5.83	0.30	3.73	4.90	6.72	7.53	12.84(41)	2.83(74)
Y	19.59	19.61	0.18	14.72	17.94	22.27	23.46	27.57(48)	10.40(73)
4670 LAKEVIEW 2 NNW									
W	11.41	11.52	0.29	8.12	8.95	13.61	15.93	17.84(71)	2.36(77)
S	4.33	4.11	0.38	2.38	2.94	5.52	6.45	8.25(71)	1.37(46)
Y	15.73	15.58	0.24	11.08	13.60	18.05	21.46	23.86(63)	6.98(77)
4811 LEABURG 1 SW									
W	51.48	50.62	0.20	37.48	44.47	57.64	66.00	74.65(74)	23.80(77)
S	10.15	9.64	0.29	6.24	8.13	12.59	14.92	15.62(41)	4.31(67)
Y	61.28	62.40	0.16	49.13	53.59	67.61	75.97	80.69(74)	38.68(77)

(OREGON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
5080 LOWER HAY CREEK									
W	7.14	6.78	0.32	4.22	5.57	9.10	10.73	11.32(43)	1.66(77)
S	3.18	3.27	0.42	1.48	2.16	4.01	4.90	6.75(48)	0.57(74)
Y	10.33	10.37	0.26	6.59	8.57	12.16	13.95	16.10(48)	5.40(77)
5139 MADRAS									
W	6.84	6.65	0.32	4.46	5.16	8.68	9.77	11.31(78)	1.42(77)
S	3.14	3.15	0.44	1.48	2.33	3.93	4.68	6.83(48)	0.48(49)
Y	9.98	9.98	0.27	6.37	8.25	11.34	14.02	15.52(48)	4.64(77)
5160 MALHEUR BRANCH EXPERIMENT STATION									
W	6.98	7.02	0.27	4.46	6.10	8.15	8.86	11.90(78)	2.17(77)
S	2.89	2.91	0.42	1.44	1.90	3.62	4.45	6.53(41)	0.78(66)
Y	9.87	9.90	0.23	7.07	8.77	11.42	12.24	14.72(41)	4.59(66)
5162 MALHEUR REFUGE HDQ									
W	5.87	5.71	0.34	3.23	4.78	7.45	8.41	9.53(78)	1.51(77)
S	3.42	3.33	0.36	1.93	2.57	3.91	5.61	6.02(76)	1.67(69)
Y	9.29	9.47	0.24	6.02	7.37	10.67	12.43	13.47(78)	5.18(50)
5362 MCKENZIE BRIDGE RANGER STATION									
W	59.32	59.09	0.22	44.74	51.15	67.86	76.79	84.64(43)	25.32(77)
S	10.73	10.57	0.30	6.39	8.45	12.72	15.01	19.20(41)	5.32(52)
Y	70.05	69.26	0.17	55.96	61.41	78.65	85.63	95.82(43)	41.56(77)
5384 MCMINNVILLE									
W	37.24	37.65	0.24	28.12	32.12	41.97	49.08	56.98(74)	13.01(77)
S	5.82	5.29	0.40	3.02	4.28	7.17	8.87	12.28(68)	1.74(65)
Y	43.06	43.01	0.20	32.98	37.30	48.62	56.13	60.23(74)	23.38(79)
5424 MEDFORD EXPERIMENT STATION									
W	17.11	17.03	0.32	11.14	12.81	20.17	22.52	34.74(74)	5.35(77)
S	3.85	3.62	0.49	1.56	2.55	5.24	6.67	8.47(77)	0.58(74)
Y	20.96	20.32	0.26	14.31	16.58	24.91	28.10	35.32(74)	10.68(55)
5429 MEDFORD WSO AP									
W	16.49	16.60	0.30	11.21	13.15	19.77	23.83	27.59(56)	4.74(77)
S	3.48	3.06	0.52	1.35	2.26	4.53	6.31	7.71(77)	0.32(74)
Y	19.97	19.28	0.26	13.31	16.43	23.82	26.13	34.45(56)	8.54(55)
5593 MILTON FREEWATER									
W	9.77	9.82	0.26	6.36	8.66	11.10	13.04	14.86(74)	3.93(77)
S	4.13	4.99	0.37	2.48	3.15	4.99	6.41	8.75(41)	1.49(49)
Y	13.91	13.75	0.20	9.33	12.02	16.10	17.05	19.87(48)	8.79(64)

(OREGON)

	Mean	Median	CV	Percentiles 10	Percentiles 25	Percentiles 75	Percentiles 90	Max(year)	Min(year)
5734 MORO									
W	8.92	8.69	0.31	5.58	7.05	11.00	12.37	14.48(51)	2.12(77)
S	2.63	2.52	0.39	1.27	2.01	3.29	3.79	5.13(77)	0.70(70)
Y	11.55	11.07	0.25	7.75	9.65	13.67	15.80	17.06(48)	6.46(73)
6032 NEWPORT									
W	59.96	58.34	0.22	44.23	51.34	68.61	76.63	89.31(74)	26.70(77)
S	10.35	9.37	0.38	5.39	8.11	11.51	15.54	23.53(68)	3.50(52)
Y	70.31	69.26	0.19	54.92	60.86	81.24	88.01	99.14(74)	42.76(77)
6073 NORTH BEND FAA AP									
W	54.44	55.82	0.19	41.75	47.33	61.65	64.15	79.36(74)	22.00(77)
S	7.26	6.51	0.38	4.17	5.21	9.07	11.62	13.00(71)	3.26(65)
Y	61.70	62.02	0.16	47.71	54.51	68.21	74.06	83.08(74)	32.75(77)
6179 NYSSA									
W	7.17	7.20	0.30	4.32	5.92	8.41	9.68	11.71(58)	0.95(66)
S	2.88	2.55	0.43	1.49	1.93	3.74	4.51	6.43(41)	0.95(66)
Y	10.04	9.90	0.24	6.65	8.54	11.95	13.20	14.92(41)	4.26(49)
6213 OAKRIDGE FISH HATCHERY									
W	38.18	37.11	0.23	27.67	32.56	43.76	49.70	58.81(74)	15.07(77)
S	7.64	7.61	0.30	4.59	5.84	8.96	10.90	12.35(78)	3.71(74)
Y	45.82	47.04	0.19	34.36	39.79	50.91	58.28	62.52(74)	26.93(77)
6243 OCHOCO RANGER STATION									
W	13.26	13.36	0.28	8.68	11.42	15.29	18.24	22.40(43)	3.92(77)
S	5.31	4.97	0.42	3.03	3.87	6.85	8.43	11.25(48)	1.43(49)
Y	18.57	18.37	0.23	13.34	14.95	21.37	25.23	26.49(48)	11.10(73)
6405 OWYHEE DAM									
W	5.60	5.44	0.32	3.10	4.48	6.75	7.82	10.01(78)	1.94(77)
S	3.28	3.29	0.40	1.45	2.49	4.18	4.95	6.12(65)	1.13(66)
Y	8.89	8.88	0.27	6.20	7.03	10.45	11.84	14.50(57)	3.91(66)
6426 PAISLEY									
W	6.80	6.12	0.40	4.03	4.94	8.24	9.91	15.07(56)	1.33(77)
S	3.72	3.38	0.47	1.56	2.54	4.99	5.78	8.32(48)	0.85(70)
Y	10.51	9.85	0.30	7.30	8.03	11.84	14.45	19.48(56)	5.64(72)
6468 PARKDALE 2 SSE									
W	37.31	37.60	0.26	23.33	30.54	45.18	50.37	62.57(43)	8.78(77)
S	4.66	4.85	0.39	2.48	3.18	5.94	7.20	9.21(48)	0.59(67)
Y	42.06	43.48	0.26	27.78	35.24	50.43	54.91	65.59(43)	14.69(77)

(OREGON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
6546 PENDLETON WSO AP									
W	9.07	9.15	0.26	6.02	7.43	10.37	12.06	15.45(74)	3.98(77)
S	3.48	3.49	0.44	1.83	2.15	4.15	5.47	8.72(41)	1.35(74)
Y	12.55	12.25	0.21	9.10	10.87	14.21	16.45	18.45(78)	7.67(68)
6634 PILOT ROCK 1 SE									
W	9.56	9.56	0.26	6.03	7.97	11.49	12.57	14.50(48)	4.18(77)
S	4.55	4.44	0.38	2.51	3.40	5.40	6.74	10.32(41)	1.66(74)
Y	14.11	14.07	0.21	9.63	12.38	15.92	18.29	22.04(48)	8.79(73)
6749 PORTLAND KGW-TV									
W	35.99	35.61	0.23	25.23	31.00	40.79	46.36	51.50(56)	12.92(77)
S	7.28	6.67	0.37	4.00	5.62	9.22	11.13	14.69(77)	2.94(67)
Y	43.26	43.30	0.18	33.10	37.81	49.98	54.27	58.59(56)	27.61(77)
6820 POWERS									
W	54.56	53.02	0.22	39.70	47.40	63.21	65.70	85.50(74)	23.33(77)
S	6.45	5.79	0.46	3.37	4.11	7.36	11.39	14.90(53)	2.45(70)
Y	61.00	59.82	0.19	44.99	53.55	68.35	73.72	88.22(74)	35.13(77)
6883 PRINEVILLE									
W	6.83	7.16	0.32	4.45	5.36	7.67	9.93	11.85(78)	1.45(77)
S	3.61	3.69	0.39	1.81	2.65	4.57	5.65	6.69(41)	0.72(74)
Y	10.44	10.80	0.25	6.96	8.49	11.97	13.95	16.28(58)	5.08(55)
6907 PROSPECT 2 SW									
W	35.58	35.45	0.27	23.85	29.98	42.01	48.63	58.07(74)	12.32(77)
S	6.22	6.08	0.40	3.13	4.59	7.29	9.40	12.31(77)	1.12(74)
Y	41.80	40.35	0.21	28.98	36.98	49.34	53.86	59.19(74)	24.63(77)
7052 REDMOND 2 W									
W	5.51	5.31	0.36	3.13	4.56	6.78	8.15	9.83(78)	1.22(77)
S	2.82	2.77	0.49	1.11	1.91	3.56	4.68	6.72(48)	.52(55)
Y	8.33	8.11	0.31	5.26	6.75	9.56	12.45	13.50(48)	1.75(55)
7082 REEDSPORT									
W	66.26	66.48	0.20	52.31	58.71	72.99	77.86	111.20(74)	26.33(77)
S	9.65	9.56	0.37	5.19	6.80	11.80	14.65	17.80(56)	3.86(66)
Y	75.91	75.37	0.17	60.87	67.78	83.03	89.28	116.43(74)	38.25(77)
7169 RIDDLE									
W	27.66	26.79	0.25	20.65	23.81	31.09	35.48	47.35(74)	9.35(77)
S	3.98	4.07	0.42	1.73	3.01	4.66	6.81	7.51(77)	1.50(74)
Y	31.64	31.35	0.21	23.65	26.96	35.20	38.82	48.85(74)	16.86(77)

(OREGON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
7208 RIVERSIDE									
W	5.98	5.76	0.30	4.09	4.76	6.97	8.34	10.32(70)	1.15(77)
S	3.11	2.87	0.40	1.83	2.14	4.04	5.07	5.79(41)	1.13(74)
Y	9.08	9.17	0.25	6.23	7.34	10.57	11.94	13.88(41)	4.23(77)
7250 ROCK CREEK									
W	14.99	15.22	0.24	10.38	13.05	16.46	19.96	21.86(74)	3.37(77)
S	6.47	6.42	0.29	4.11	4.95	7.46	8.76	13.71(41)	3.40(74)
Y	21.46	21.04	0.20	15.70	18.98	24.03	37.55	30.41(56)	10.75(77)
7331 ROSEBURG KQEN									
W	28.49	28.30	0.25	20.94	23.28	33.20	37.56	45.86(74)	10.43(77)
S	4.60	4.52	0.41	2.27	3.06	5.70	7.35	9.53(47)	1.73(65)
Y	33.10	32.88	0.22	23.96	27.87	37.93	42.45	49.86(56)	18.49(77)
7354 ROUND GROVE									
W	12.88	12.58	0.30	8.37	10.06	16.68	17.89	19.96(56)	3.72(77)
S	5.19	5.22	0.38	2.68	3.67	6.37	7.81	10.93(77)	1.63(72)
Y	18.07	17.41	0.21	13.34	15.69	20.41	23.40	26.88(56)	10.45(55)
7500 SALEM WSO AP									
W	34.50	35.23	0.23	26.33	28.92	38.62	43.93	54.98(74)	11.56(77)
S	6.04	5.74	0.33	3.54	4.92	7.12	8.58	11.79(68)	3.07(52)
Y	40.54	40.68	0.19	31.33	34.56	45.03	52.12	58.48(74)	20.37(77)
7641 SEASIDE									
W	63.86	63.63	0.19	49.30	57.69	71.77	79.38	92.40(56)	26.25(77)
S	11.91	12.09	0.34	7.30	8.44	14.22	18.12	20.58(41)	5.13(67)
Y	75.78	74.75	0.16	62.22	67.24	82.77	90.97	105.03(56)	45.05(77)
8029 SQUAW BUTTE EXPERIMENT STATION									
W	7.43	7.23	0.30	4.87	5.91	9.31	10.14	12.71(58)	2.17(77)
S	3.87	3.63	0.44	1.99	2.58	5.10	6.19	8.47(41)	1.15(62)
Y	11.30	11.43	0.25	7.73	8.82	12.76	15.81	17.52(48)	7.02(59)
8407 THE DALLES									
W	10.34	10.30	0.39	5.69	7.31	12.95	15.03	19.47(56)	1.48(77)
S	1.92	1.91	0.44	.99	1.40	2.25	2.83	4.67(48)	.30(74)
Y	12.26	11.96	0.34	7.20	9.01	15.00	17.96	21.56(56)	4.43(77)
8466 THREE LYNX									
W	59.42	59.65	0.24	40.81	51.12	67.08	75.77	95.98(74)	25.84(77)
S	11.33	10.34	0.28	7.85	9.25	13.07	15.96	18.48(77)	5.42(67)
Y	70.75	71.80	0.18	53.73	61.14	78.32	87.96	105.39(74)	44.32(77)

(OREGON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
8494 TILLAMOOK 1 W									
W	76.69	75.96	0.19	59.09	69.17	86.77	95.02	103.43(56)	36.32(77)
S	14.12	13.34	0.36	7.51	10.88	17.14	21.64	28.60(41)	5.37(67)
Y	90.81	88.78	0.15	74.58	83.09	99.57	108.60	118.65(74)	59.28(77)
8726 UKIAH									
W	12.20	12.47	0.23	8.60	10.16	13.98	15.60	18.97(48)	5.06(77)
S	5.66	5.72	0.37	3.20	4.24	6.59	7.94	13.84(41)	2.77(74)
Y	17.86	18.04	0.21	12.59	15.22	19.67	22.98	27.88(48)	11.49(77)
8746 UNION EXPERIMENT STATION									
W	8.18	8.43	0.23	5.51	7.37	9.41	10.20	11.51(58)	3.24(77)
S	5.90	5.82	0.31	3.73	4.82	7.07	7.82	12.37(41)	2.58(49)
Y	14.08	13.82	0.21	10.21	12.52	15.67	17.73	21.47(41)	8.20(66)
8780 UNITY									
W	6.70	6.88	0.28	4.14	5.39	8.14	9.14	10.12(65)	2.19(77)
S	4.15	4.08	0.33	2.53	3.21	4.97	5.61	7.87(41)	1.86(74)
Y	10.85	10.98	0.24	7.10	8.93	12.53	13.94	17.92(65)	6.08(73)
8797 VALE									
W	6.46	6.47	0.31	3.82	5.50	7.41	8.88	12.64(78)	1.96(77)
S	2.95	2.88	0.41	1.41	2.03	3.90	4.71	5.24(64)	0.78(49)
Y	9.41	9.36	0.25	6.69	7.88	11.16	12.13	14.09(78)	3.61(41)
8818 VALLEY FALLS 3 SSE									
W	9.55	8.84	0.36	5.65	7.45	11.09	15.01	16.88(63)	2.82(77)
S	4.67	4.38	0.41	2.35	3.29	5.69	7.63	9.30(65)	1.86(51)
Y	14.21	13.64	0.28	9.42	11.08	16.75	19.79	22.61(63)	6.50(68)
8833 VALSETZ									
W	110.36	109.72	0.22	78.57	97.77	123.64	140.87	166.02(74)	53.27(77)
S	15.24	15.16	0.41	8.13	9.96	18.03	24.86	30.44(78)	3.69(67)
Y	125.61	124.58	0.19	92.96	111.26	145.14	157.85	181.92(74)	78.14(77)
8884 VERNONIA 2									
W	41.23	41.68	0.23	29.40	35.84	45.96	52.79	62.44(74)	17.97(77)
S	6.95	6.48	0.38	4.24	5.36	7.90	11.17	13.41(68)	2.10(52)
Y	48.18	48.03	0.19	35.66	42.55	54.43	59.64	67.72(56)	29.08(77)
8997 WALLOWA									
W	11.98	11.71	0.24	8.09	10.55	14.33	15.90	16.90(65)	3.54(77)
S	6.35	6.06	0.27	4.41	5.20	7.33	8.30	12.58(41)	2.71(74)
Y	18.32	18.25	0.18	14.13	16.00	20.98	22.91	23.71(56)	11.72(77)

(OREGON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
9068 WASCO									
W	8.95	9.12	0.30	6.03	6.67	10.10	12.32	15.40(51)	2.75(77)
S	2.48	2.57	0.38	1.30	1.86	3.02	3.84	4.73(48)	0.76(74)
Y	11.43	11.60	0.24	7.95	8.79	13.43	15.18	17.59(51)	6.52(77)
9316 WICKIUP DAM									
W	16.11	17.08	0.30	10.13	12.79	18.34	22.39	26.85(74)	3.62(77)
S	4.20	3.89	0.43	1.86	2.75	5.92	6.81	8.36(48)	1.36(67)
Y	20.31	20.94	0.25	14.04	15.89	23.84	26.14	31.20(56)	9.88(77)

(WASHINGTON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
0008 ABERDEEN									
W	68.10	67.59	0.19	51.76	60.86	78.16	83.32	91.83(76)	35.57(77)
S	13.04	12.57	0.31	8.47	10.50	14.28	19.92	22.75(78)	5.34(67)
Y	81.14	79.01	0.16	64.32	72.06	93.60	97.68	105.81(56)	55.77(77)
0176 ANACORTES									
W	19.51	19.79	0.21	13.93	16.64	22.38	24.17	29.33(50)	11.45(44)
S	5.91	5.65	0.31	3.82	4.79	7.18	7.77	11.66(48)	3.30(58)
Y	25.42	25.67	0.18	19.04	21.75	28.59	32.60	34.06(50)	17.07(58)
0242 ARIEL DAM									
W	61.48	60.79	0.22	42.89	55.18	67.75	79.00	94.18(74)	31.74(77)
S	12.69	12.67	0.33	8.08	9.51	15.20	19.13	22.22(67)	5.10(77)
Y	74.17	74.04	0.18	57.62	64.02	81.24	93.42	107.99(74)	50.10(44)
0257 ARLINGTON									
W	34.12	33.88	0.19	25.98	29.82	38.71	42.70	47.12(74)	19.15(77)
S	11.82	10.89	0.31	7.82	9.50	14.29	16.46	21.60(48)	5.51(40)
Y	45.94	45.04	0.16	37.77	40.23	48.71	56.68	68.13(48)	35.50(70)
0482 BATTLEGROUND									
W	41.36	41.37	0.19	31.64	36.86	46.15	51.41	57.65(74)	18.57(77)
S	9.82	9.35	0.31	6.41	7.65	11.47	13.89	18.43(77)	3.86(67)
Y	51.18	51.92	0.14	41.01	46.20	55.97	60.66	67.47(56)	37.00(77)
0564 BELLINGHAM 2 N									
W	26.03	26.19	0.21	19.52	20.83	30.22	33.88	38.08(72)	16.61(44)
S	8.29	7.93	0.29	5.47	6.27	9.82	11.69	13.60(48)	4.36(58)
Y	34.32	34.35	0.19	26.43	29.07	38.69	43.73	47.92(72)	21.87(44)
0668 BICKLETON									
W	11.00	10.27	0.35	6.82	8.76	12.82	16.25	20.83(74)	2.42(77)
S	2.58	2.53	0.46	1.25	1.59	3.29	4.21	5.44(78)	0.56(70)
Y	13.58	12.88	0.30	9.24	10.71	15.03	19.96	25.09(71)	6.82(77)

(WASHINGTON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
0729 BLAINE									
W	31.14	30.93	0.20	22.99	26.16	34.98	40.35	43.89(76)	20.58(76)
S	8.69	8.56	0.29	5.73	6.65	10.04	11.83	16.60(48)	5.06(58)
Y	39.83	39.40	0.17	30.92	33.82	44.34	49.62	53.93(76)	25.84(79)
0872 BREMERTON									
W	38.70	38.11	0.29	24.65	29.79	44.50	54.49	64.50(74)	19.32(77)
S	6.60	6.51	0.42	3.39	3.90	8.58	10.66	12.89(78)	2.94(40)
Y	45.30	43.51	0.27	30.66	35.48	53.28	63.14	71.12(74)	23.30(44)
0945 BUCKLEY 1 NE									
W	36.47	35.95	0.19	28.47	32.28	41.36	46.03	48.94(50)	18.11(77)
S	12.30	11.62	0.28	8.61	10.02	14.92	16.74	20.40(48)	4.98(67)
Y	48.76	48.72	0.15	38.97	43.07	55.00	58.20	63.77(48)	34.78(77)
1233 CEDAR LAKE									
W	80.63	79.74	0.18	63.11	69.53	93.19	98.87	107.30(50)	49.36(41)
S	22.07	21.85	0.28	14.34	17.35	26.54	29.52	33.82(64)	9.11(67)
Y	102.70	101.26	0.16	82.53	87.78	115.83	127.63	131.85(59)	76.58(41)
1276 CENTRALIA									
W	37.59	38.07	0.21	24.50	33.60	43.04	47.90	53.01(56)	16.10(77)
S	8.17	7.78	0.33	4.79	6.52	9.32	13.04	15.50(78)	4.07(52)
Y	45.77	45.87	0.17	35.08	80.71	53.18	54.78	60.69(56)	28.88(44)
1350 CHELAN									
W	8.10	8.01	0.28	5.29	6.62	9.45	10.96	14.50(74)	2.53(77)
S	2.80	1.91	0.61	1.49	1.91	3.13	4.74	10.35(48)	.54(70)
Y	10.91	10.77	0.27	7.75	8.68	12.55	14.91	18.14(48)	4.44(79)
1385 CHESAW 4 NNW									
W	7.90	8.08	0.28	5.27	6.30	9.01	10.60	14.90(56)	3.43(77)
S	6.49	6.61	0.35	3.68	4.91	7.48	9.18	14.12(41)	1.97(49)
Y	14.39	14.39	0.24	9.83	12.35	16.19	18.01	24.13(41)	6.23(49)
1395 CHEWELAH 4 S									
W	14.14	13.79	0.25	10.88	11.75	16.55	18.39	25.59(74)	5.70(77)
S	6.11	5.81	0.35	3.58	4.32	7.47	8.82	11.82(48)	3.26(43)
Y	20.26	19.99	0.20	15.21	17.94	22.20	26.34	30.12(74)	11.81(79)
1414 CHIMACUM									
W	21.96	22.43	0.23	15.37	19.42	25.13	28.52	33.66(56)	9.25(77)
S	6.83	6.97	0.35	4.18	4.56	8.54	9.83	14.05(48)	2.93(67)
Y	28.79	29.11	0.18	21.19	25.72	31.63	36.08	40.56(56)	17.43(44)

(WASHINGTON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
1484 CLEARBROOK									
W	34.78	33.72	0.20	26.45	29.26	39.49	44.23	51.60(72)	22.10(79)
S	11.59	10.93	0.27	8.01	9.00	14.30	15.62	20.32(64)	6.20(58)
Y	46.37	45.74	0.18	36.81	39.74	51.16	57.71	67.55(72)	31.54(79)
1504 CLE ELUM									
W	19.13	18.99	0.31	11.85	14.97	22.17	25.86	35.74(59)	7.18(77)
S	3.35	3.11	0.53	1.64	2.50	3.99	4.90	11.96(48)	0.98(67)
Y	22.48	22.33	0.27	14.55	18.37	25.73	29.80	39.57(59)	12.70(77)
1586 COLFAX 1 NW									
W	15.14	15.50	0.24	11.03	12.80	17.33	19.82	24.27(74)	4.42(77)
S	5.31	4.91	0.36	3.38	4.03	6.07	7.69	11.14(41)	2.61(69)
Y	20.45	20.74	0.20	15.40	17.37	22.70	24.09	31.06(48)	10.28(77)
1650 COLVILLE AP									
W	11.27	11.35	0.26	8.01	9.42	12.82	14.01	20.31(74)	3.96(77)
S	5.83	5.55	0.34	3.57	4.36	7.08	7.84	11.42(48)	3.09(50)
Y	17.10	16.86	0.20	12.78	14.77	19.15	22.29	25.39(69)	10.37(77)
1666 CONCONULLY									
W	9.67	9.45	0.31	6.09	7.43	11.76	13.95	15.32(74)	2.53(77)
S	5.42	5.13	0.49	2.85	3.59	6.24	8.22	15.56(48)	2.22(40)
Y	15.09	14.68	0.28	10.24	11.84	17.78	20.55	27.11(41)	7.79(79)
1679 CONCRETE									
W	55.61	53.58	0.20	41.38	46.79	65.58	68.30	82.12(76)	35.93(77)
S	12.58	12.52	0.27	8.17	10.01	14.32	18.05	20.18(59)	7.12(52)
Y	68.19	64.88	0.18	54.19	58.76	78.67	86.94	96.06(76)	50.23(77)
1760 COUGAR 6 E									
W	103.21	103.25	0.23	70.36	91.26	117.78	127.77	171.30(56)	44.67(77)
S	16.39	16.56	0.33	10.06	12.48	19.24	24.81	28.87(41)	5.22(67)
Y	119.60	116.84	0.19	92.31	104.95	135.12	148.40	186.43(56)	72.89(77)
1767 COULEE DAM 1 SW									
W	6.91	6.71	0.29	4.71	5.53	8.51	9.42	11.28(74)	1.84(77)
S	3.60	3.24	0.58	1.97	2.62	3.82	5.47	13.45(48)	1.02(70)
Y	10.50	9.96	0.29	6.96	8.39	12.28	13.26	21.65(48)	5.22(77)
1783 COUPEVILLE 1 S									
W	13.89	14.00	0.23	9.21	11.75	16.61	17.27	21.21(72)	8.40(44)
S	5.64	5.51	0.31	3.47	4.60	6.76	8.08	11.03(48)	2.95(43)
Y	19.53	19.43	0.19	14.75	16.48	22.11	25.00	28.49(72)	13.46(58)

(WASHINGTON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
1934 CUSHMAN DAM									
W	85.18	83.60	0.22	61.78	74.83	100.11	108.66	112.53(71)	37.91(77)
S	12.08	10.56	0.36	7.32	8.95	15.17	17.95	24.03(48)	4.94(67)
Y	97.27	98.42	0.19	69.12	86.19	110.52	118.18	127.64(71)	54.12(77)
1968 DALLESPORT FAA AP									
W	12.07	11.00	0.41	7.32	9.37	14.03	17.73	30.82(74)	2.53(77)
S	1.75	1.62	0.52	0.87	1.12	2.11	2.77	4.57(47)	0.16(70)
Y	13.83	12.77	0.37	8.83	10.59	15.88	20.01	32.06(74)	5.21(77)
1992 DARRINGTON RANGER STATION									
W	67.55	66.22	0.21	47.99	57.99	80.30	85.28	97.61(74)	38.10(77)
S	13.70	12.62	0.27	9.33	10.21	17.17	19.42	21.66(72)	8.35(57)
Y	81.24	78.03	0.19	63.46	68.45	94.23	101.20	110.10(74)	55.91(77)
2007 DAVENPORT									
W	11.29	11.67	0.25	7.72	9.75	12.93	14.29	17.44(74)	2.61(77)
S	4.64	4.12	0.48	2.61	3.22	5.67	6.65	14.95(48)	2.27(49)
Y	15.93	16.15	0.23	11.90	13.68	17.69	20.16	28.24(48)	8.53(77)
2030 DAYTON 1 WSW									
W	14.32	14.32	0.23	10.49	12.01	16.35	18.74	20.36(74)	5.24(77)
S	4.87	4.30	0.41	2.73	3.27	6.04	7.65	12.00(41)	2.31(63)
Y	19.16	19.60	0.20	14.33	16.05	21.73	23.65	28.20(48)	11.16(77)
2157 DIABLO DAM									
W	62.85	61.35	0.24	43.71	52.09	74.98	80.54	102.63(76)	35.83(73)
S	11.67	10.85	0.30	7.57	9.40	13.71	16.53	20.81(72)	5.86(67)
Y	74.52	72.18	0.21	55.23	63.46	85.77	98.10	115.88(76)	45.46(73)
2505 ELLENSBURG									
W	6.70	6.56	0.32	3.82	5.30	7.95	9.50	11.66(74)	1.58(77)
S	2.22	1.86	0.50	1.23	1.63	2.61	3.49	7.14(48)	0.75(74)
Y	8.92	8.79	0.28	5.44	7.55	10.35	12.68	13.65(48)	4.20(73)
2531 ELMA									
W	55.94	55.60	0.19	40.37	49.41	63.82	70.52	76.79(74)	30.47(77)
S	10.01	9.21	0.32	6.65	7.99	11.19	15.60	17.43(68)	4.08(67)
Y	65.95	64.57	0.17	50.77	58.61	73.68	83.98	86.68(76)	46.44(77)
2675 EVERETT									
W	26.66	27.38	0.21	19.14	22.49	30.33	34.66	37.82(48)	15.33(77)
S	8.91	8.65	0.35	5.59	6.54	10.61	13.01	17.56(48)	4.14(58)
Y	35.57	35.01	0.19	28.23	30.71	37.82	45.31	55.38(48)	22.81(79)

(WASHINGTON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
2914 FORKS 1 E									
W	97.78	94.80	0.20	74.30	85.96	108.60	126.51	143.26(76)	61.87(79)
S	18.42	17.70	0.28	13.05	14.90	21.91	25.18	31.03(48)	9.74(58)
Y	116.20	113.23	0.17	91.97	100.72	130.01	142.92	161.54(76)	80.07(40)
3222 GOLDENDALE									
W	14.59	14.45	0.29	9.52	12.11	17.18	19.72	23.36(51)	2.63(77)
S	2.72	2.58	0.39	1.68	2.03	3.38	3.91	5.89(48)	0.52(70)
Y	17.31	16.90	0.24	11.36	14.63	20.34	22.70	26.19(51)	7.82(77)
3284 GRAPEVIEW 3 SW									
W	44.11	43.95	0.21	30.79	38.85	51.54	56.73	57.84(50)	20.48(77)
S	7.77	6.89	0.36	4.73	6.06	8.97	11.73	15.81(48)	3.72(67)
Y	51.88	51.82	0.18	38.98	45.87	59.32	64.55	66.79(72)	33.56(79)
3357 GREENWATER									
W	45.69	45.22	0.21	33.26	39.10	53.63	57.97	65.02(59)	25.47(77)
S	12.02	10.63	0.31	8.25	9.46	14.03	17.67	20.74(48)	3.57(67)
Y	57.71	56.74	0.19	43.23	50.89	68.92	72.16	85.30(59)	39.01(77)
3502 HARRINGTON 5 S									
W	8.88	8.80	0.27	6.13	7.08	10.67	11.66	16.45(74)	2.58(77)
S	3.79	3.19	0.63	2.03	2.65	4.08	5.94	15.50(48)	1.12(70)
Y	12.68	12.49	0.27	8.82	10.53	14.20	15.81	27.54(48)	7.32(49)
3529 HARTLINE									
W	7.35	7.46	0.31	4.74	6.09	8.88	9.89	14.47(74)	1.68(77)
S	3.47	3.12	0.58	1.81	2.48	3.76	4.74	12.66(48)	0.81(70)
Y	10.82	10.42	0.29	7.40	8.47	12.40	13.29	21.14(48)	5.04(77)
3546 HATTON 9 ESE									
W	7.43	7.63	0.30	5.03	5.54	8.98	10.76	13.03(74)	2.01(77)
S	2.72	2.41	0.44	1.63	1.96	3.77	3.95	7.56(48)	0.76(70)
Y	10.15	9.71	0.24	7.42	8.46	11.53	13.24	18.72(48)	6.34(77)
3975 IRENE MOUNTAIN WAUCONDA									
W	7.47	7.16	0.26	5.18	5.96	8.64	10.53	11.83(58)	2.78(77)
S	7.07	6.81	0.39	3.96	4.74	8.19	10.07	15.21(41)	3.43(70)
Y	14.54	14.56	0.25	9.60	12.16	16.72	18.58	24.56(41)	7.89(77)
4077 KAHLOTUS 5 SSW									
W	7.66	7.19	0.30	5.25	5.85	9.00	11.18	14.18(74)	1.86(77)
S	2.80	2.58	0.42	1.51	1.94	3.82	4.27	6.63(48)	1.03(70)
Y	10.46	10.65	0.24	7.29	8.30	11.70	13.29	17.96(48)	5.17(77)

(WASHINGTON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
4084 KALAMA FALLS HATCHERY									
W	52.17	50.51	0.22	38.45	44.70	58.64	70.02	83.59(74)	24.53(77)
S	11.60	11.13	0.34	7.29	8.46	13.66	18.19	19.85(77)	5.33(67)
Y	63.77	60.53	0.19	51.41	55.27	71.37	81.78	94.58(74)	42.04(44)
4154 KENNEWICK									
W	5.69	5.09	0.37	3.40	4.13	6.94	8.58	11.57(74)	1.89(77)
S	2.05	1.73	0.52	1.05	1.33	2.59	3.58	5.93(48)	0.50(49)
Y	7.74	7.35	0.30	5.40	6.10	8.95	10.65	15.50(48)	3.92(64)
4201 KID VALLEY									
W	47.12	46.77	0.20	34.51	43.09	53.99	59.45	68.31(56)	25.26(77)
S	12.44	11.98	0.32	7.38	9.67	15.01	18.28	20.77(77)	6.40(70)
Y	59.57	58.56	0.16	47.08	52.68	66.74	73.43	80.45(56)	41.58(79)
4338 LA CROSSE									
W	10.10	10.77	0.25	7.26	8.20	11.62	13.31	17.32(74)	3.52(77)
S	3.64	3.17	0.43	2.12	2.58	4.29	5.55	8.88(48)	1.93(70)
Y	13.73	13.68	0.23	9.66	12.24	15.08	17.22	22.52(48)	7.11(77)
4394 LAKE CLE ELUM									
W	32.09	32.36	0.25	21.31	24.42	37.77	41.78	53.27(72)	15.46(77)
S	4.40	4.34	0.38	2.67	3.24	5.31	6.89	10.35(48)	0.73(67)
Y	36.50	36.36	0.23	25.48	28.04	42.47	45.91	58.87(72)	22.71(77)
4406 LAKE KACHESS									
W	44.18	45.65	0.24	29.02	35.99	51.18	57.86	68.08(72)	23.03(77)
S	7.20	6.70	0.35	4.70	5.66	8.34	9.99	15.21(48)	1.64(67)
Y	51.38	51.55	0.22	36.22	42.27	59.89	65.82	77.81(72)	30.60(79)
4414 LAKE KEECHELUS									
W	56.97	58.61	0.22	39.67	46.62	64.63	74.02	85.78(72)	33.24(41)
S	9.53	9.12	0.32	6.18	7.35	10.93	13.90	17.66(59)	2.53(67)
Y	66.50	66.63	0.20	49.53	53.41	78.26	83.70	99.95(72)	43.90(77)
4446 LAKE WENATCHEE									
W	35.37	37.24	0.24	23.49	27.41	41.37	46.89	53.16(56)	18.97(77)
S	4.78	4.44	0.40	2.56	3.45	6.03	6.90	11.84(48)	1.71(70)
Y	40.14	42.17	0.22	27.76	31.68	46.90	50.41	58.57(56)	25.68(77)
4486 LANDSBURG									
W	43.40	43.38	0.18	32.08	37.45	50.38	54.42	55.99(74)	23.42(77)
S	13.10	12.52	0.30	8.03	10.52	16.06	18.66	23.01(64)	6.01(67)
Y	56.50	56.73	0.16	44.87	48.99	64.36	68.98	74.10(48)	39.53(77)

(WASHINGTON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
4549 LAURIER									
W	11.94	11.60	0.23	9.01	9.81	13.79	15.22	18.09(74)	5.39(77)
S	7.44	7.17	0.36	4.55	5.53	8.87	10.11	16.96(41)	2.30(67)
Y	19.38	19.42	0.20	13.94	16.84	22.40	23.75	30.82(41)	11.94(77)
4572 LEAVENWORTH 3 S									
W	21.29	20.41	0.30	13.33	17.54	23.53	29.25	37.62(56)	7.86(77)
S	3.28	2.90	0.56	1.52	2.17	4.03	4.80	11.26(48)	0.37(70)
Y	24.57	23.15	0.27	16.75	20.34	27.03	34.39	42.51(56)	12.38(77)
4679 LIND 3 NE									
W	6.93	6.65	0.30	4.60	5.38	8.09	10.02	11.83(41)	1.93(77)
S	2.99	2.68	0.58	1.64	1.91	3.34	4.30	11.39(48)	1.13(49)
Y	9.91	9.31	0.31	7.18	8.02	10.85	12.56	22.32(48)	5.96(77)
4769 LONGVIEW									
W	36.59	36.94	0.21	25.73	33.17	41.73	46.02	49.67(74)	14.54(77)
S	8.94	8.36	0.32	5.75	7.08	10.26	14.06	15.69(78)	4.31(67)
Y	45.53	45.35	0.17	34.86	41.00	51.08	55.90	59.78(56)	29.91(77)
4971 MANSFIELD									
W	7.70	7.68	0.29	4.48	6.67	9.09	10.07	13.82(74)	2.74(77)
S	3.43	2.85	0.62	1.74	2.25	4.28	5.00	13.95(48)	0.46(70)
Y	11.13	11.05	0.28	7.72	9.24	12.21	14.65	22.84(48)	5.05(79)
5128 MAZAMA 6 SE									
W	15.25	14.71	0.28	10.05	13.20	17.29	21.71	25.21(72)	5.45(77)
S	4.10	3.79	0.52	2.14	3.05	4.33	6.18	14.16(48)	1.61(70)
Y	19.47	18.85	0.26	13.58	16.17	21.40	27.52	33.25(72)	9.66(77)
5224 McMILLIN RESERVOIR									
W	31.34	30.67	0.21	22.95	26.88	36.17	41.08	42.79(74)	14.31(77)
S	8.75	8.67	0.31	5.23	6.57	11.09	12.33	14.32(48)	3.44(52)
Y	40.09	40.48	0.17	30.58	34.33	46.14	48.78	53.16(72)	25.11(44)
5425 MINERAL									
W	70.35	71.43	0.28	45.13	59.59	81.52	95.66	116.39(74)	22.85(79)
S	12.93	13.17	0.31	7.93	9.95	15.97	18.90	21.26(59)	4.77(70)
Y	83.29	84.36	0.24	58.61	70.70	95.34	108.77	132.49(74)	31.41(79)
5525 MONROE									
W	36.75	36.88	0.17	28.42	32.41	41.37	44.21	51.86(74)	22.35(77)
S	11.07	10.71	0.31	7.24	8.71	12.89	15.95	18.62(77)	4.27(67)
Y	47.82	46.86	0.14	39.16	41.87	53.66	57.86	63.34(48)	36.47(79)

(WASHINGTON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
5613 MOSES LAKE 3 E									
W	5.78	5.62	0.32	3.60	4.50	6.82	7.30	10.66(41)	1.92(77)
S	2.45	2.27	0.49	1.05	1.67	3.22	3.53	6.93(48)	0.74(70)
Y	8.23	8.20	0.30	5.39	6.18	9.63	11.40	14.09(48)	4.29(73)
5659 MOUNT ADAMS RANGER STATION									
W	41.35	42.76	0.28	24.92	33.30	48.29	56.53	66.29(56)	12.45(77)
S	4.84	4.76	0.44	2.23	3.35	5.75	7.80	10.64(48)	1.24(70)
Y	46.18	47.22	0.24	30.34	39.28	53.93	60.58	69.18(56)	20.47(77)
5688 MOXEE CITY 10 E									
W	5.68	5.60	0.37	3.29	4.29	6.72	8.10	11.42(53)	1.20(77)
S	2.33	2.12	0.48	0.94	1.54	2.90	3.82	5.42(48)	0.40(70)
Y	8.00	7.84	0.29	5.22	6.25	9.16	11.20	12.92(53)	3.74(79)
5704 MUD MOUNTAIN DAM									
W	38.98	38.13	0.19	29.13	33.41	44.66	49.60	53.14(74)	24.05(42)
S	15.09	14.55	0.26	9.77	12.45	17.60	20.70	24.05(68)	5.84(67)
Y	54.06	52.42	0.15	45.38	46.81	61.03	67.14	69.48(74)	39.69(52)
5801 NEAH BAY 1 E									
W	84.76	80.90	0.21	63.26	72.89	98.52	107.37	131.44(76)	42.09(79)
S	16.17	16.03	0.26	11.77	13.26	17.82	22.51	30.33(78)	8.32(67)
Y	100.93	99.89	0.19	77.25	86.93	112.26	125.36	148.04(76)	55.82(79)
5832 NESPELEM 2 S									
W	9.00	8.52	0.29	6.19	7.40	10.71	12.66	15.65(74)	2.26(77)
S	4.28	3.54	0.59	2.38	2.87	4.94	6.31	16.37(48)	1.02(49)
Y	13.28	12.02	0.30	9.12	10.74	15.40	18.71	27.94(48)	7.22(77)
5840 NEWHALEM									
W	65.21	63.51	0.20	46.44	56.31	75.68	86.20	92.57(74)	41.32(44)
S	13.54	13.12	0.27	9.69	11.08	15.60	19.53	22.32(59)	6.12(75)
Y	78.75	76.54	0.18	59.12	67.71	88.98	100.47	110.13(59)	55.77(73)
5844 NEWPORT									
W	20.28	20.10	0.21	14.38	18.04	22.64	26.08	31.04(74)	8.67(77)
S	7.54	7.26	0.29	5.09	6.32	8.46	10.26	13.53(48)	3.83(58)
Y	27.82	28.19	0.16	20.18	25.64	30.92	32.71	37.67(74)	16.38(77)
5946 NORTHPORT									
W	12.69	12.61	0.20	9.55	10.91	14.18	15.83	18.67(69)	6.72(77)
S	7.37	7.13	0.35	4.26	5.21	8.99	10.38	15.35(41)	2.85(67)
Y	20.06	19.73	0.17	15.32	17.49	23.08	24.34	29.58(41)	12.31(73)

(WASHINGTON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
6039 ODESSA									
W	7.26	7.54	0.27	4.88	5.78	8.53	9.77	10.98(74)	2.23(77)
S	3.08	2.84	0.57	1.61	1.95	3.70	4.75	10.61(48)	0.62(70)
Y	10.34	10.41	0.28	7.15	8.15	12.14	13.37	19.29(48)	5.13(49)
6096 OLGA 2 SE									
W	22.51	22.05	0.20	16.97	19.26	26.71	28.31	31.52(72)	14.23(79)
S	6.58	6.52	0.26	4.56	5.12	7.58	8.72	12.14(48)	4.39(67)
Y	29.10	28.99	0.18	22.08	25.51	32.38	36.49	38.76(64)	19.09(79)
6114 OLYMPIA WSO AP									
W	41.39	41.23	0.25	27.45	35.35	48.14	56.49	60.57(72)	17.97(77)
S	7.75	6.83	0.38	4.92	5.68	8.86	13.34	14.99(78)	3.13(67)
Y	49.14	48.38	0.22	35.90	41.47	58.54	62.89	69.93(72)	27.01(44)
6123 OMAK 2 NW									
W	8.47	8.65	0.32	5.49	6.33	9.93	11.49	16.13(74)	2.47(77)
S	3.98	3.43	0.56	2.22	2.49	4.52	6.61	12.90(48)	1.00(70)
Y	12.44	12.27	0.30	8.42	9.42	14.00	16.67	23.34(41)	6.90(79)
6295 PALMER 3 ESE									
W	70.63	71.93	0.20	53.84	59.47	83.12	89.58	96.20(61)	36.67(77)
S	21.56	20.81	0.29	13.57	17.69	25.96	29.21	38.47(59)	9.49(67)
Y	92.19	88.59	0.17	74.53	79.87	104.66	114.10	131.05(59)	63.65(77)
6553 PLEASANT VIEW									
W	9.47	9.12	0.27	6.78	7.77	11.12	13.14	16.19(74)	2.51(77)
S	3.44	3.23	0.47	1.84	2.08	4.18	6.11	8.28(48)	1.47(63)
Y	12.91	13.04	0.22	9.75	11.08	14.76	15.79	21.29(48)	6.72(77)
6610 POMEROY									
W	11.58	11.96	0.24	8.14	9.65	13.27	15.10	17.48(48)	4.26(77)
S	4.56	4.14	0.39	2.66	3.42	5.34	6.61	11.39(41)	2.38(67)
Y	16.13	16.18	0.20	11.95	13.48	18.28	19.66	24.49(48)	10.24(77)
6624 PORT ANGELES									
W	20.44	20.65	0.23	14.61	16.64	24.23	26.60	29.84(54)	10.86(44)
S	4.21	4.00	0.31	2.59	3.26	5.06	6.04	7.29(48)	2.36(73)
Y	24.65	25.17	0.21	17.88	20.83	28.36	32.05	34.51(54)	14.99(44)
6678 PORT TOWNSEND									
W	13.52	13.10	0.21	10.01	11.96	15.69	17.13	19.95(71)	7.31(77)
S	5.65	5.64	0.32	3.44	4.24	6.63	7.40	11.98(48)	2.66(52)
Y	19.18	19.36	0.17	15.31	16.63	21.40	23.14	27.70(48)	12.76(73)

(WASHINGTON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
6768 PROSSER 4 NE									
W	5.86	5.87	0.35	3.21	4.54	6.96	8.62	10.62(58)	1.58(77)
S	2.29	1.92	0.46	1.20	1.60	3.11	3.89	4.59(41)	0.65(70)
Y	8.15	8.02	0.28	5.08	6.64	9.26	11.61	12.76(41)	4.27(79)
6789 PULLMAN 2 NW									
W	15.39	15.40	0.25	10.42	12.54	17.96	21.10	23.20(74)	5.15(77)
S	5.48	4.93	0.32	3.57	4.40	6.23	8.71	10.08(41)	2.94(69)
Y	20.87	20.83	0.21	15.31	17.86	23.63	27.69	31.05(59)	13.19(77)
6803 PUYALLUP 2 W EXPERIMENT STATION									
W	32.15	31.29	0.21	23.20	28.15	36.61	42.46	43.50(56)	14.56(77)
S	7.92	7.78	0.33	4.81	5.82	9.38	11.33	14.85(48)	3.52(52)
Y	40.07	40.61	0.17	30.82	35.36	45.92	48.43	51.49(72)	27.18(77)
6846 QUILCENE 2 SW									
W	45.22	44.53	0.23	31.26	38.96	51.56	59.64	66.37(74)	18.41(77)
S	8.99	8.71	0.35	5.31	6.65	10.91	13.45	17.03(48)	3.73(67)
Y	54.22	54.28	0.20	38.12	48.62	61.50	69.26	76.85(56)	31.74(77)
6880 QUINCY 1 S									
W	5.72	5.90	0.35	3.61	4.46	6.66	8.23	11.87(74)	1.22(77)
S	2.26	1.96	0.57	0.99	1.37	2.68	3.69	7.16(48)	0.71(63)
Y	7.98	7.87	0.30	5.07	6.04	9.82	11.14	13.85(48)	3.59(79)
6896 RAINIER-OHANAPECOSH									
W	65.87	67.22	0.23	44.92	57.54	73.34	83.78	100.23(72)	33.45(77)
S	11.07	10.48	0.32	6.79	8.82	12.85	16.59	18.53(78)	4.09(67)
Y	76.94	76.86	0.19	55.44	66.87	87.21	96.36	113.38(72)	49.01(73)
6909 RANDLE 1 E									
W	49.29	49.38	0.22	35.52	43.50	57.19	62.59	69.87(72)	20.47(77)
S	10.74	10.27	0.31	6.72	8.38	13.49	15.57	17.12(41)	4.02(67)
Y	60.03	60.82	0.18	46.16	51.24	67.98	72.04	83.50(72)	37.50(77)
6974 REPUBLIC									
W	9.91	9.51	0.27	7.04	8.32	10.98	14.10	16.77(74)	4.29(77)
S	6.24	5.76	0.41	3.38	4.63	7.34	9.17	15.21(41)	2.77(67)
Y	16.14	15.61	0.20	12.08	13.96	18.75	20.20	23.96(41)	10.10(77)
7038 RIMROCK (TIETON DAM)									
W	21.61	21.72	0.30	13.29	17.15	25.50	30.28	35.35(56)	6.02(77)
S	3.51	3.37	0.40	2.11	2.85	4.06	4.79	9.35(48)	0.73(70)
Y	25.12	25.09	0.28	16.78	18.93	29.43	34.19	39.53(72)	9.53(77)

(WASHINGTON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
7059 RITZVILLE 1 SSE									
W	8.41	8.43	0.25	5.93	7.08	10.12	10.83	13.49(74)	2.45(77)
S	3.30	2.95	0.59	1.69	2.26	3.61	4.64	13.01(48)	1.13(49)
Y	11.71	11.56	0.27	7.66	10.34	12.98	14.73	23.80(48)	5.78(77)
7180 ROSALIA									
W	12.79	12.85	0.24	9.09	10.90	14.58	16.48	19.79(74)	4.66(77)
S	5.23	4.93	0.38	3.05	3.76	6.05	7.44	12.34(48)	2.50(66)
Y	18.02	17.72	0.23	12.93	16.00	20.08	22.54	31.72(48)	9.96(73)
7473 SEATTLE-TACOMA WSO AP									
W	31.13	31.25	0.22	22.55	27.22	35.46	40.42	42.30(51)	12.36(77)
S	7.05	6.82	0.36	4.06	5.16	9.06	10.48	14.10(48)	3.39(67)
Y	38.17	38.39	0.19	28.61	33.55	44.03	48.04	50.83(72)	23.16(77)
7478 SEATTLE-UNIV. OF WASHINGTON									
W	28.62	29.20	0.19	20.63	25.06	33.60	35.08	36.69(56)	13.25(77)
S	6.93	6.08	0.36	4.44	5.00	8.69	10.60	13.78(48)	3.16(58)
Y	35.56	35.73	0.17	27.88	30.93	40.56	43.29	47.57(48)	23.60(79)
7507 SEDRO WOOLEY									
W	34.34	33.77	0.21	23.37	29.85	39.69	43.37	51.39(59)	21.99(77)
S	11.36	11.05	0.27	7.46	9.43	13.50	15.57	18.98(64)	6.53(58)
Y	45.71	44.08	0.18	35.60	38.85	52.18	56.97	68.00(59)	31.18(79)
7538 SEQUIM									
W	11.81	12.19	0.21	7.92	10.61	13.53	15.02	16.29(57)	6.68(44)
S	4.16	3.91	0.35	2.52	3.20	5.05	5.58	9.36(48)	2.06(57)
Y	15.97	16.08	0.18	12.31	13.86	17.41	19.52	23.42(48)	9.11(73)
7584 SHELTON									
W	55.74	54.57	0.22	38.50	46.97	65.66	71.52	76.98(56)	26.40(77)
S	8.50	7.82	0.34	5.85	6.69	9.59	14.04	15.73(48)	4.14(67)
Y	64.24	63.75	0.20	45.29	55.20	74.31	81.22	85.85(72)	41.75(77)
7773 SNOQUALMIE FALLS									
W	48.34	46.44	0.21	34.09	42.73	55.91	61.10	66.95(74)	25.37(77)
S	12.53	11.74	0.30	8.66	9.36	15.45	17.15	21.72(48)	4.76(67)
Y	60.86	59.53	0.18	46.45	53.39	70.84	76.31	82.36(48)	39.50(77)
7938 SPOKANE WSO AP									
W	12.16	12.20	0.27	8.31	9.49	14.85	15.99	18.45(74)	3.96(77)
S	4.84	4.32	0.38	2.87	3.80	5.48	7.22	10.90(48)	2.19(74)
Y	16.99	16.59	0.22	12.23	15.01	19.51	20.49	28.78(48)	10.25(73)

(WASHINGTON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
7956 SPRAGUE									
W	10.97	11.08	0.25	8.10	9.03	12.89	14.37	17.90(74)	3.24(77)
S	4.02	3.59	0.41	2.52	2.90	4.84	5.65	10.26(48)	1.82(49)
Y	14.99	14.83	0.22	11.07	13.52	16.55	19.23	24.85(48)	7.40(77)
7987 SPRUCE									
W	107.91	105.62	0.19	81.56	92.16	123.13	135.43	152.10(76)	67.73(77)
S	20.34	19.70	0.26	13.57	16.35	22.74	28.80	32.93(78)	10.46(67)
Y	128.25	127.35	0.16	101.01	112.93	145.38	151.56	172.12(76)	89.83(44)
8034 STARTUP 1 E									
W	48.86	48.56	0.18	39.08	42.66	55.37	61.48	65.74(74)	29.82(77)
S	16.21	16.40	0.28	9.92	13.44	19.06	22.80	25.57(48)	6.00(67)
Y	65.07	62.55	0.16	53.34	57.39	72.10	80.25	87.85(48)	47.73(73)
8059 STEHEKIN 4 NW									
W	30.19	29.81	0.24	21.66	24.84	34.95	38.93	50.74(51)	13.99(77)
S	4.34	3.78	0.44	2.67	2.97	5.42	6.32	10.63(48)	1.80(67)
Y	34.52	33.78	0.23	25.23	29.67	39.88	45.08	56.42(51)	19.26(77)
8207 SUNNYSIDE									
W	4.96	4.44	0.48	2.73	3.55	5.93	7.05	15.85(74)	1.21(77)
S	1.97	1.55	0.54	0.75	1.20	2.64	3.58	4.60(48)	0.28(70)
Y	6.94	6.89	0.35	4.33	5.18	7.63	9.97	16.72(74)	3.86(79)
8286 TACOMA CITY HALL									
W	30.09	30.69	0.21	21.16	26.56	34.14	38.74	42.84(56)	13.25(77)
S	6.80	6.53	0.40	3.94	4.71	8.17	10.61	14.85(48)	2.22(52)
Y	36.89	36.90	0.18	28.16	33.22	40.88	46.20	50.21(48)	21.66(52)
8348 TEKOA									
W	14.84	15.42	0.22	11.56	12.49	16.65	18.29	22.11(48)	4.57(77)
S	6.23	5.67	0.37	3.91	4.61	7.58	8.85	14.07(48)	2.56(74)
Y	21.07	21.21	0.21	15.89	18.57	23.13	25.31	36.18(48)	10.20(77)
8773 VANCOUVER 4 NNE									
W	32.89	32.84	0.21	25.47	28.51	37.33	41.02	49.85(74)	12.86(77)
S	7.52	7.02	0.34	4.42	5.81	9.34	11.12	15.05(68)	2.52(67)
Y	40.41	39.93	0.17	33.06	35.41	45.90	48.01	56.44(74)	25.72(77)
8931 WALLA WALLA WSO CI									
W	11.69	11.71	0.24	8.07	10.12	13.94	14.86	17.42(74)	5.04(77)
S	4.34	3.88	0.39	2.43	3.38	5.03	6.27	9.63(41)	1.64(74)
Y	16.03	15.84	0.18	12.11	13.89	18.90	19.64	20.02(48)	11.16(77)

(WASHINGTON)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
8959 WAPATO									
W	5.39	5.05	0.38	2.93	3.91	6.50	7.92	11.02(74)	1.05(77)
S	1.91	1.68	0.53	0.81	1.26	2.56	3.35	5.10(48)	0.26(70)
Y	7.30	6.69	0.32	4.95	5.71	8.72	11.14	12.69(56)	3.23(79)
9012 WATERVILLE									
W	7.89	8.00	0.29	5.10	6.64	8.86	10.69	13.66(74)	1.73(77)
S	3.54	3.39	0.61	1.36	2.32	4.33	5.09	13.87(48)	0.28(70)
Y	11.43	11.13	0.29	7.74	9.94	13.07	14.58	23.84(48)	5.27(77)
9058 WELLPINIT									
W	14.19	13.64	0.26	10.01	11.95	16.67	19.23	23.50(74)	5.15(77)
S	5.60	5.23	0.38	3.27	4.27	6.79	8.16	12.85(48)	2.41(67)
Y	19.79	19.19	0.22	14.57	17.24	21.95	25.86	28.81(48)	10.50(77)
9074 WENATCHEE									
W	6.58	6.81	0.28	4.17	5.42	7.46	8.98	10.98(74)	1.28(77)
S	2.33	2.04	0.70	0.73	1.43	3.12	4.44	9.00(48)	0.15(70)
Y	8.91	8.67	0.28	5.80	7.53	9.82	12.40	16.23(48)	3.89(79)
9238 WILBUR									
W	8.54	8.66	0.26	6.02	6.96	10.60	11.21	13.83(74)	2.79(77)
S	4.02	3.73	0.52	1.88	2.80	4.67	6.07	13.69(48)	1.24(49)
Y	12.56	12.51	0.26	9.25	10.23	14.31	15.71	25.26(48)	7.15(73)
9327 WILSON CREEK									
W	6.35	6.67	0.29	4.11	5.16	7.38	8.57	11.98(74)	2.12(77)
S	2.70	2.38	0.59	1.22	1.70	3.24	4.20	10.20(48)	0.78(70)
Y	9.05	8.95	0.28	6.38	7.40	10.46	12.25	17.84(48)	4.91(77)
9342 WIND RIVER									
W	89.81	91.09	0.22	62.48	77.92	103.90	113.90	125.28(72)	45.97(77)
S	11.88	10.92	0.40	5.77	9.35	14.44	18.26	23.52(41)	4.62(67)
Y	101.68	103.04	0.18	77.60	87.56	115.01	126.00	140.16(72)	64.07(44)
9376 WINTHROP 1 WSW									
W	10.80	10.53	0.30	7.45	8.82	13.01	15.22	16.91(72)	2.47(77)
S	3.91	3.57	0.47	2.10	2.79	4.39	6.21	11.16(48)	1.39(70)
Y	14.71	14.16	0.28	10.24	12.24	17.97	19.84	24.49(48)	6.47(77)
9465 YAKIMA WSO AP									
W	5.93	5.85	0.34	3.52	4.67	7.03	8.30	11.76(74)	1.20(77)
S	1.96	1.77	0.53	0.91	1.31	2.58	3.24	6.01(48)	0.28(70)
Y	7.90	7.82	0.28	5.14	6.54	8.72	11.11	14.25(56)	3.92(79)

(IDAHO)

	Mean	Median	CV	Percentiles				Max(year)	Min(year)
				10	25	75	90		
1380 CALDWELL									
W	7.78	8.04	0.26	5.32	6.56	9.03	9.85	12.94(43)	2.33(77)
S	2.92	2.85	0.39	1.42	2.10	3.55	4.26	5.59(41)	0.79(77)
Y	10.70	10.79	0.22	7.07	9.27	12.37	13.67	14.89(43)	5.18(66)
1956 COEUR D'ALENE RANGER STATION									
W	18.98	19.43	0.22	13.79	16.29	21.91	23.61	30.70(74)	6.87(77)
S	7.22	6.78	0.35	4.63	5.29	8.82	10.50	14.20(48)	3.45(66)
Y	26.19	26.38	0.18	19.62	23.71	28.76	32.14	37.68(48)	15.45(77)
3771 GRANGEVILLE									
W	13.21	12.88	0.23	10.02	11.14	15.24	17.30	19.61(48)	6.02(77)
S	10.20	10.20	0.30	6.47	7.60	12.71	14.00	16.04(48)	4.89(66)
Y	23.41	23.39	0.19	18.05	20.14	26.22	28.75	33.65(78)	14.22(73)
6152 MOSCOW-UNIV. OF IDAHO									
W	17.23	16.98	0.24	11.99	15.27	19.90	21.36	30.80(74)	8.12(77)
S	6.52	5.62	0.34	4.25	5.00	8.00	9.29	12.31(48)	2.87(66)
Y	23.75	23.00	0.21	17.59	20.48	27.45	30.06	36.25(74)	13.19(66)
6424 NEZ PERCE									
W	13.00	12.37	0.22	10.15	11.27	14.19	16.74	18.40(59)	4.66(77)
S	8.92	9.13	0.28	5.49	7.56	10.49	11.87	15.26(48)	3.41(51)
Y	21.92	22.11	0.18	16.28	19.59	24.64	27.03	30.44(48)	14.04(73)
6844 PARMA EXPERIMENT STATION									
W	7.64	7.46	0.33	5.11	6.09	9.16	11.59	13.76(78)	2.22(49)
S	3.24	3.03	0.44	1.63	2.12	4.44	5.04	6.25(65)	1.08(49)
Y	10.87	10.29	0.29	7.00	9.00	13.35	15.69	16.55(70)	3.30(49)
6891 PAYETTE									
W	8.22	8.11	0.31	4.79	6.75	10.15	11.79	12.53(40)	1.45(77)
S	2.90	2.90	0.43	1.41	1.90	3.62	4.64	6.20(41)	0.50(66)
Y	11.12	11.41	0.27	7.03	9.17	13.03	15.15	16.95(41)	4.79(66)

(IDAHO)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
7264 PORTHILL									
W	13.37	13.66	0.24	9.49	11.56	15.36	16.77	21.86(74)	5.08(77)
S	7.12	6.72	0.31	4.27	5.69	8.83	9.96	11.65(42)	3.03(73)
Y	20.48	20.97	0.21	14.98	18.43	22.90	25.78	28.97(74)	11.52(44)
7386 PRIEST RIVER EXPERIMENT STATION									
W	23.70	22.96	0.21	17.97	21.38	26.38	29.60	38.52(74)	9.05(77)
S	8.89	8.36	0.28	6.13	7.68	9.84	11.84	16.32(41)	4.68(67)
Y	32.58	32.64	0.16	26.81	30.06	35.46	37.52	46.77(74)	17.40(77)
7706 RIGGINS									
W	10.20	10.18	0.23	7.15	8.12	11.82	13.59	14.79(76)	5.83(77)
S	6.64	6.33	0.30	3.98	5.29	8.13	9.08	11.16(41)	2.77(51)
Y	16.84	17.31	0.20	11.30	15.19	18.82	20.65	24.21(78)	10.95(79)
8062 SAINT MARIES									
W	22.18	22.26	0.22	16.37	18.75	25.30	27.79	34.87(74)	9.30(77)
S	7.82	7.39	0.32	5.34	6.03	9.47	10.87	15.78(48)	3.35(77)
Y	30.00	30.34	0.19	22.79	27.07	32.76	37.42	42.77(48)	17.92(77)

(NEVADA)

	Mean	Median	CV	10	25	75	90	Max(year)	Min(year)
2573 ELKO FAA AP									
W	6.31	6.15	0.30	4.04	5.29	7.44	9.09	9.91(43)	1.71(77)
S	3.33	3.21	0.49	1.52	2.18	4.13	5.90	7.27(70)	0.31(74)
Y	9.64	9.59	0.25	6.27	7.38	11.46	12.68	14.61(41)	5.43(77)
5869 OWYHEE									
W	9.27	9.49	0.21	6.91	8.08	10.27	11.20	14.31(71)	4.32(77)
S	5.07	4.66	0.40	2.68	4.04	6.00	8.05	10.18(63)	0.78(74)
Y	14.35	14.11	0.19	10.90	12.91	15.77	18.56	20.35(63)	9.14(66)
6005 PARADISE VALLEY 1 NW									
W	9.60	6.29	0.33	3.96	5.18	8.48	9.57	11.57(58)	2.07(77)
S	2.60	2.49	0.52	1.02	1.73	3.31	4.83	5.73(52)	0.46(74)
Y	9.20	8.31	0.26	7.03	7.64	10.88	12.57	14.87(52)	4.16(66)
9171 WINNEMUCCA									
W	5.80	6.01	0.33	3.07	4.48	7.30	8.33	9.15(52)	1.72(77)
S	2.69	2.41	0.50	1.00	1.70	3.41	4.85	5.43(63)	0.43(54)
Y	8.49	8.74	0.28	5.22	6.71	9.87	11.06	13.95(52)	3.93(54)

(CALIFORNIA)

	Mean	Median	CV	Percentiles 10	25	75	90	Max(year)	Min(year)
1614 CEDARVILLE									
W	9.83	9.54	0.28	6.52	8.06	11.70	14.05	15.39(63)	3.82(77)
S	3.20	2.96	0.48	1.70	2.03	3.95	5.24	8.17(71)	1.31(77)
Y	13.03	12.74	0.26	9.60	10.54	14.14	17.34	22.96(71)	7.32(66)
2147 CRESCENT CITY 1 N									
W	61.60	60.66	0.23	43.43	52.80	70.86	79.49	91.45(74)	22.36(77)
S	7.67	7.25	0.44	3.99	4.52	10.58	11.42	15.24(53)	2.36(74)
Y	69.27	68.51	0.20	52.64	59.98	79.96	88.43	96.70(43)	35.64(77)
3157 FORT BIDWELL									
W	12.21	12.05	0.28	8.30	9.79	14.62	17.10	18.80(52)	3.82(77)
S	3.55	3.29	0.42	1.91	2.48	4.43	5.64	8.13(71)	1.46(62)
Y	15.76	15.15	0.24	11.25	13.60	18.36	21.17	25.50(71)	9.43(59)
3761 HAPPY CAMP RANGER STATION									
W	51.34	51.03	0.30	33.84	40.28	59.37	67.42	90.42(74)	14.05(77)
S	4.39	4.46	0.48	1.70	2.92	5.79	7.10	9.66(77)	0.38(74)
Y	55.73	55.63	0.27	37.72	45.28	63.55	72.58	90.80(74)	23.71(77)
9053 TULELAKE									
W	7.51	7.30	0.33	4.21	5.73	8.98	11.18	12.51(56)	2.32(77)
S	3.39	2.94	0.47	1.59	2.23	4.74	5.08	6.62(58)	1.21(70)
Y	10.90	10.94	0.26	7.36	9.07	12.54	14.01	16.07(65)	5.88(55)
9866 YREKA									
W	15.49	15.87	0.35	8.85	11.25	19.57	21.81	27.10(74)	4.63(77)
S	3.27	3.06	0.41	1.76	2.38	4.23	4.83	7.19(78)	0.79(74)
Y	18.76	19.53	0.31	11.58	13.40	23.28	23.07	30.94(56)	7.53(55)

DESCRIPTIVE STATISTICS
MONTHLY PRECIPITATION DATA
(1940-1979)

(OREGON)

Mo	Mean	Median	SDev	CV	Percentiles 10	25	75	90	Max	Min	Range
0304	ASHLAND										
Oct	1.74	1.40	1.49	0.86	0.48	0.69	2.36	3.33	7.43	0.23	7.20
Nov	2.59	2.54	1.72	0.66	0.60	1.17	3.46	5.12	7.74	0.00	7.74
Dec	3.12	2.83	2.03	0.65	1.12	1.66	3.90	5.65	11.28	0.68	10.60
Jan	2.76	2.40	1.55	0.56	1.19	1.43	4.12	5.08	6.00	0.50	5.50
Feb	1.91	1.86	0.94	0.49	0.76	1.24	2.45	3.00	4.74	0.25	4.49
Mar	1.90	1.67	1.04	0.55	0.85	1.16	2.48	3.18	5.35	0.13	5.22
Apr	1.37	1.16	0.84	0.61	0.43	0.74	2.01	2.74	3.34	0.33	3.01
May	1.52	1.23	1.28	0.84	0.32	0.56	1.82	3.73	5.31	0.19	5.12
Jun	1.13	0.96	0.98	0.87	0.08	0.30	1.80	2.50	3.68	0.00	3.68
Jul	0.31	0.04	0.51	1.67	0.00	0.00	0.45	0.90	2.52	0.00	2.52
Aug	0.45	0.26	0.61	1.37	0.00	0.03	0.55	1.30	3.08	0.00	3.08
Sep	0.83	0.61	0.82	0.99	0.04	0.30	1.10	1.64	3.74	0.00	3.74
0328	ASTORIA WSO AP										
Oct	7.02	6.13	3.79	0.54	2.48	4.58	8.81	12.16	17.79	1.01	16.78
Nov	10.42	11.28	3.97	0.38	4.86	7.62	13.10	15.30	18.89	1.45	17.44
Dec	12.09	12.37	3.52	0.29	6.66	9.79	14.36	15.84	19.33	4.20	15.13
Jan	10.75	10.36	5.10	0.47	4.98	6.32	14.22	17.56	26.35	1.42	24.93
Feb	8.80	7.98	4.15	0.47	5.26	5.96	10.26	15.64	21.89	2.60	19.29
Mar	7.59	7.42	3.11	0.41	4.34	5.36	9.68	10.56	16.85	0.93	15.92
Apr	5.05	5.18	1.79	0.35	2.63	3.72	6.50	7.42	8.47	1.65	6.82
May	3.04	2.74	1.50	0.49	1.44	1.96	4.06	5.29	6.76	0.75	6.01
Jun	2.57	2.23	1.54	0.60	0.84	1.36	3.22	5.00	6.83	0.37	6.46
Jul	1.19	0.88	1.05	0.88	0.16	0.39	1.84	2.56	4.20	0.01	4.19
Aug	1.61	1.25	1.24	0.77	0.31	0.53	2.52	3.22	5.22	0.02	5.20
Sep	3.25	3.01	1.84	0.57	0.62	1.82	4.62	5.77	6.93	0.04	6.89
0417	BAKER KBKR										
Oct	0.72	0.52	0.68	0.94	0.08	0.31	0.98	1.54	3.15	0.00	3.15
Nov	1.09	1.07	0.61	0.56	0.24	0.71	1.52	1.82	2.54	0.00	2.54
Dec	1.24	1.02	0.78	0.63	0.38	0.64	1.74	2.35	3.46	0.23	3.23
Jan	1.10	1.13	0.65	0.59	0.36	0.68	1.37	1.75	3.29	0.17	3.12
Feb	0.74	0.75	0.38	0.52	0.21	0.42	1.07	1.28	1.51	0.01	1.50
Mar	0.88	0.77	0.62	0.71	0.26	0.44	1.26	1.58	3.28	0.04	3.24
Apr	0.91	0.84	0.71	0.78	0.14	0.50	1.28	1.47	4.27	0.05	4.22
May	1.46	1.16	1.02	0.69	0.48	0.72	1.80	3.14	4.36	0.05	4.31
Jun	1.35	1.08	0.96	0.71	0.20	0.70	2.06	2.84	3.52	0.00	3.52
Jul	0.60	0.32	0.74	1.22	0.03	0.14	0.70	1.75	3.31	0.00	3.31
Aug	0.62	0.40	0.64	1.03	0.00	0.16	1.00	1.36	2.80	0.00	2.80
Sep	0.65	0.41	0.78	1.11	0.03	0.16	0.74	1.52	3.90	0.00	3.90

(OREGON)

Mo	Mean	Median	SDev	CV	Percentiles 10	25	75	90	Max	Min	Range
0471	BANDON 2 NNE										
Oct	4.96	4.13	3.43	0.69	1.28	2.30	7.17	9.08	15.32	0.59	14.73
Nov	8.67	8.85	4.39	0.51	2.88	5.40	11.29	12.98	23.35	1.08	22.27
Dec	10.19	9.84	4.90	0.48	4.44	6.73	13.79	15.41	25.56	1.63	23.93
Jan	10.11	8.91	4.72	0.47	4.26	6.96	13.38	16.98	20.14	2.32	17.82
Feb	7.70	7.30	3.50	0.46	3.79	5.12	9.70	12.67	17.74	2.26	15.48
Mar	7.14	7.82	2.73	0.38	3.14	5.36	8.86	10.66	12.48	1.57	10.91
Apr	4.29	4.24	2.53	0.59	1.46	2.30	5.42	7.69	11.35	0.67	10.68
May	2.80	2.34	1.93	0.69	0.74	1.50	4.08	6.02	7.31	0.27	7.04
Jun	1.26	1.00	0.97	0.77	0.22	0.54	1.92	2.63	4.39	0.07	4.32
Jul	0.45	0.25	0.51	1.14	0.04	0.10	0.75	1.02	2.65	0.00	2.65
Aug	0.80	0.30	1.03	1.30	0.00	0.08	1.18	2.09	4.39	0.00	4.39
Sep	1.81	1.74	1.18	0.65	0.20	0.81	2.50	3.45	4.55	0.00	4.55
0694	BEND										
Oct	0.86	0.53	1.03	1.20	0.12	0.34	0.96	1.94	5.88	0.00	5.88
Nov	1.55	1.32	1.26	0.81	0.18	0.58	2.42	3.38	4.58	0.02	4.56
Dec	1.86	1.52	1.64	0.88	0.41	0.74	2.52	3.82	8.74	0.00	8.74
Jan	1.95	1.97	1.18	0.60	0.63	0.93	2.88	3.48	4.37	0.20	4.17
Feb	1.02	0.98	0.66	0.65	0.16	0.44	1.48	1.86	2.50	0.07	2.43
Mar	0.79	0.66	0.65	0.82	0.10	0.22	1.12	1.60	2.76	0.01	2.75
Apr	0.50	0.34	0.49	1.00	0.06	0.14	0.70	1.01	2.18	0.00	2.18
May	1.01	0.66	0.95	0.94	0.10	0.37	1.47	2.15	3.76	0.00	3.76
Jun	0.99	0.79	0.88	0.89	0.04	0.25	1.56	2.26	3.20	0.00	3.20
Jul	0.41	0.24	0.48	1.16	0.00	0.06	0.66	1.23	1.74	0.00	1.74
Aug	0.60	0.26	0.65	1.07	0.00	0.02	1.14	1.64	2.18	0.00	2.18
Sep	0.40	0.27	0.44	1.11	0.00	0.05	0.58	0.96	1.82	0.00	1.82
1055	BROOKINGS										
Oct	6.64	5.94	4.29	0.65	2.14	3.54	8.74	11.02	21.93	0.16	21.77
Nov	11.51	10.88	6.10	0.53	4.16	6.99	15.60	18.72	26.01	1.86	25.15
Dec	13.19	14.24	5.88	0.45	5.71	8.12	17.78	21.10	23.65	2.10	21.55
Jan	12.79	11.84	5.86	0.46	5.59	8.61	16.40	21.90	25.77	2.07	23.70
Feb	10.27	10.40	4.70	0.46	4.54	6.43	12.20	15.96	24.76	2.82	21.94
Mar	9.25	9.27	3.86	0.42	4.46	6.44	11.64	14.43	17.91	1.59	16.32
Apr	5.43	4.56	3.79	0.70	1.52	2.50	7.08	10.84	17.43	0.46	16.97
May	4.13	3.30	3.23	0.78	0.86	1.93	5.98	8.52	14.15	0.12	14.03
Jun	1.52	1.01	1.53	1.00	0.14	0.59	1.94	3.57	7.72	0.02	7.70
Jul	0.59	0.19	1.09	1.85	0.02	0.08	0.99	1.20	6.40	0.00	6.40
Aug	1.06	0.42	1.50	1.41	0.02	0.07	1.46	3.64	6.97	0.00	6.97
Sep	2.17	1.64	1.86	0.85	0.29	0.64	3.00	5.21	7.38	0.02	7.36
1862	CORVALLIS-STATE UNIVERSITY										
Oct	3.47	2.85	2.16	0.62	1.14	1.68	4.26	6.46	9.70	0.88	8.82
Nov	5.84	5.82	3.28	0.56	2.00	3.12	7.52	9.22	18.28	0.31	17.97
Dec	7.26	6.70	3.89	0.54	3.11	4.17	9.73	12.56	19.16	1.47	17.69
Jan	6.95	6.84	3.82	0.55	2.00	4.36	10.36	11.88	15.51	0.96	14.55
Feb	5.03	5.12	2.46	0.49	1.72	3.38	6.23	8.08	11.84	0.79	11.05
Mar	4.44	4.39	1.92	0.43	1.98	2.90	6.00	7.10	8.87	0.59	8.28
Apr	2.28	2.06	1.18	0.52	0.88	1.56	2.91	4.32	4.94	0.55	4.39
May	1.89	2.02	1.09	0.58	0.57	1.04	2.64	3.44	3.94	0.16	3.78
Jun	1.12	0.91	0.87	0.78	0.30	0.52	1.32	2.52	3.84	0.02	3.82
Jul	0.37	0.19	0.52	1.41	0.00	0.02	0.55	0.66	2.72	0.00	2.72
Aug	0.72	0.30	1.03	1.44	0.00	0.04	0.87	1.98	5.24	0.00	5.24
Sep	1.52	1.40	1.08	0.71	0.03	0.75	2.16	3.25	3.96	0.00	3.96

(OREGON)

Mo	Mean	Median	SDev	CV	Percentiles 10	25	75	90	Max	Min	Range
1946	CRATER LAKE NPS HQ										
Oct	5.50	5.24	3.73	0.68	1.76	3.12	6.76	10.01	19.11	0.31	18.80
Nov	9.79	10.22	5.35	0.55	2.52	5.67	13.10	15.10	24.16	0.14	24.02
Dec	11.70	11.14	6.61	6.55	5.41	6.72	15.03	18.35	38.47	0.90	37.57
Jan	11.00	11.44	4.64	0.42	4.97	7.60	14.24	17.22	20.93	2.43	18.50
Feb	8.24	8.13	3.52	0.43	3.86	4.72	10.92	13.00	17.58	3.31	14.21
Mar	7.82	7.53	3.16	0.40	4.40	5.58	9.80	12.06	15.22	1.24	13.98
Apr	4.58	4.61	2.18	0.48	1.90	2.85	5.88	7.54	9.63	1.29	8.34
May	3.42	2.92	2.11	0.62	1.42	1.84	4.44	6.94	8.70	0.61	8.09
Jun	2.32	1.60	0.50	0.80	0.50	1.14	3.07	4.66	9.25	0.00	9.25
Jul	0.64	0.50	0.74	1.15	0.00	0.04	0.83	1.81	2.87	0.00	2.87
Aug	1.10	0.56	1.25	1.14	0.00	0.06	1.88	2.58	5.34	0.00	5.34
Sep	2.15	1.86	1.77	0.82	0.25	0.66	2.89	4.98	6.83	0.00	6.83
2168	DAYVILLE										
Oct	0.90	0.68	0.66	0.73	0.30	0.42	1.29	1.75	3.11	0.00	3.11
Nov	1.17	1.18	0.71	0.61	0.26	0.64	1.54	1.94	3.41	0.03	3.38
Dec	1.31	1.26	0.73	0.56	0.45	0.68	1.72	2.26	3.58	0.23	3.35
Jan	1.25	1.19	0.70	0.56	0.42	0.70	1.60	2.36	3.27	0.27	3.00
Feb	0.90	0.76	0.58	0.64	0.24	0.53	1.14	1.78	2.78	0.07	2.71
Mar	1.01	0.89	0.55	0.54	0.30	0.65	1.30	1.72	2.55	0.23	2.32
Apr	1.08	0.89	0.69	0.64	0.26	0.59	1.56	2.04	2.78	0.19	2.59
May	1.53	1.39	0.97	0.63	0.30	0.76	2.37	2.77	3.68	0.22	3.46
Jun	1.19	0.92	0.94	0.79	0.18	0.40	1.88	2.30	3.87	0.00	3.87
Jul	0.47	0.28	0.56	1.18	0.00	0.04	0.62	1.42	2.02	0.00	2.02
Aug	0.62	0.38	0.74	1.19	0.02	0.08	0.87	1.59	3.25	0.00	3.25
Sep	0.54	0.52	0.51	0.95	0.00	0.09	0.84	1.03	2.33	0.00	2.33
2997	FOREST GROVE										
Oct	3.76	3.35	2.33	0.62	1.14	2.24	5.32	6.62	10.91	0.53	10.38
Nov	6.80	6.58	3.34	0.49	2.62	4.10	8.44	10.96	15.79	1.90	13.89
Dec	7.71	7.30	3.57	0.46	2.58	4.70	10.94	12.38	13.59	1.57	12.02
Jan	7.60	7.72	3.75	0.49	2.52	4.90	9.94	13.62	15.68	1.38	14.30
Feb	5.56	5.10	2.64	0.48	2.22	3.96	7.26	8.35	13.45	0.77	12.68
Mar	4.89	4.92	2.04	0.42	2.28	3.25	6.39	7.68	8.61	0.58	8.03
Apr	2.39	2.38	1.20	0.50	0.80	1.40	3.45	4.14	4.49	0.39	4.10
May	1.86	1.56	1.08	0.58	0.78	1.02	2.56	3.43	4.86	0.11	4.75
Jun	1.14	1.14	0.72	0.63	0.20	0.57	1.64	2.18	2.77	0.04	2.73
Jul	0.45	0.32	0.42	0.93	0.00	0.06	0.88	1.03	1.51	0.00	1.51
Aug	0.84	0.59	0.89	1.06	0.03	0.12	1.32	1.89	4.02	0.00	4.02
Sep	1.63	1.66	1.11	0.68	0.06	0.70	2.58	3.16	3.41	0.00	3.41
3402	GOVERNMENT CAMP										
Oct	7.74	7.18	4.46	0.58	2.41	4.24	9.25	14.83	20.21	0.67	19.54
Nov	11.46	10.62	5.79	0.51	3.80	7.24	16.48	19.08	23.95	1.60	22.35
Dec	14.24	13.60	6.10	0.43	6.30	9.65	19.06	21.36	28.62	3.87	24.75
Jan	13.06	12.90	6.44	0.49	4.50	7.81	19.24	21.10	24.10	3.20	20.90
Feb	9.94	10.28	4.20	0.42	4.88	6.91	13.32	15.23	20.90	2.45	18.45
Mar	9.22	9.36	3.99	0.43	3.48	6.66	11.35	13.81	22.53	2.37	20.16
Apr	6.78	6.76	3.04	0.45	2.80	4.64	8.84	10.65	14.21	1.62	12.59
May	5.05	4.66	2.21	0.44	2.50	3.69	6.24	8.12	10.82	0.87	9.95
Jun	3.79	3.44	2.16	0.57	1.48	2.39	4.78	7.06	9.60	0.46	9.14
Jul	1.00	0.75	0.94	0.95	0.00	0.18	1.54	2.38	3.39	0.00	3.39
Aug	1.78	1.01	1.68	0.95	0.08	0.62	2.52	4.42	6.48	0.00	6.48
Sep	3.90	3.42	2.65	0.68	0.78	1.88	5.92	7.14	12.71	0.14	12.57

(OREGON)

Mo	Mean	Median	SDev	CV	Percentiles				Max	Min	Range
					10	25	75	90			
3827 HEPPNER											
Oct	1.19	1.07	0.84	0.71	0.25	0.52	1.60	2.28	3.64	0.06	3.58
Nov	1.60	1.68	0.91	0.57	0.42	0.94	2.16	2.64	3.94	0.00	3.94
Dec	1.60	1.65	0.86	0.54	0.65	0.86	2.09	2.48	4.40	0.34	4.06
Jan	1.43	1.30	0.81	0.56	0.60	0.82	1.78	2.67	4.04	0.31	3.73
Feb	1.11	1.10	0.64	0.57	0.31	0.60	1.45	2.10	2.30	0.19	2.11
Mar	1.26	1.16	0.65	0.52	0.62	0.90	1.44	1.89	4.08	0.41	3.67
Apr	1.25	0.96	0.85	0.68	0.26	0.66	1.90	2.46	3.78	0.07	3.71
May	1.44	1.24	0.88	0.61	0.38	0.71	2.24	2.60	3.27	0.02	3.25
Jun	1.15	0.98	0.90	0.78	0.22	0.34	1.74	2.66	2.89	0.06	2.83
Jul	0.37	0.16	0.40	1.08	0.00	0.06	0.72	1.10	1.24	0.00	1.24
Aug	0.63	0.28	0.76	1.21	0.00	0.08	1.01	1.84	2.91	0.00	2.91
Sep	0.77	0.56	0.63	0.81	0.00	0.26	1.22	1.56	2.24	0.00	2.24
4506 KLAMATH FALLS 2 SSW											
Oct	1.17	0.90	1.05	0.90	0.18	0.38	1.66	2.08	4.55	0.00	4.55
Nov	1.72	1.64	1.16	0.67	0.44	0.72	2.63	3.41	4.19	0.00	4.19
Dec	2.37	1.80	1.82	0.77	0.70	1.06	3.30	4.80	8.93	0.22	8.71
Jan	2.12	1.79	1.24	0.58	0.90	1.16	2.64	4.07	4.85	0.56	4.29
Feb	1.36	1.22	0.84	0.62	0.36	0.68	1.92	2.46	3.89	0.08	3.81
Mar	1.26	0.93	0.93	0.74	0.41	0.57	1.80	2.85	3.47	0.08	3.39
Apr	0.72	0.61	0.53	0.74	0.16	0.27	1.10	1.53	2.00	0.08	1.92
May	1.07	0.86	0.92	0.86	0.19	0.38	1.48	1.90	4.75	0.01	4.74
Jun	0.86	0.77	0.70	0.81	0.06	0.25	1.31	1.74	3.09	0.00	3.09
Jul	0.25	0.10	0.35	1.40	0.00	0.01	0.40	0.76	1.60	0.00	1.60
Aug	0.56	0.20	0.79	1.41	0.00	0.04	0.75	1.75	2.93	0.00	2.93
Sep	0.56	0.38	0.66	1.18	0.02	0.17	0.54	1.34	3.06	0.00	3.06
4670 LAKEVIEW 2 NNW											
Oct	1.27	0.94	1.25	0.98	0.18	0.45	1.57	2.45	6.62	0.00	6.62
Nov	1.68	1.34	1.10	0.66	0.32	0.74	2.26	3.00	4.59	0.01	4.58
Dec	2.11	1.79	1.54	0.71	0.74	1.14	2.57	3.54	8.96	0.01	8.95
Jan	2.16	1.85	1.27	0.59	0.88	1.32	2.85	3.72	5.81	0.29	5.52
Feb	1.58	1.40	0.86	0.54	0.48	0.96	2.31	2.74	3.34	0.11	3.23
Mar	1.46	1.34	0.80	0.55	0.48	0.84	1.82	2.62	3.84	0.26	3.58
Apr	1.15	0.90	0.71	0.62	0.34	0.74	1.54	2.22	2.96	0.19	2.77
May	1.59	1.31	1.00	0.63	0.50	0.86	2.30	2.67	4.30	0.32	3.98
Jun	1.44	1.14	1.28	0.89	0.10	0.38	2.09	3.20	5.47	0.00	5.47
Jul	0.28	0.13	0.38	1.37	0.00	0.00	0.38	0.90	1.39	0.00	1.39
Aug	0.43	0.16	0.70	1.63	0.00	0.02	0.44	1.32	3.04	0.00	3.04
Sep	0.59	0.40	0.55	0.92	0.00	0.17	0.86	1.55	1.98	0.00	1.98
5162 MALHEUR REFUGE HDQ											
Oct	0.78	0.46	0.76	0.98	0.08	0.24	1.10	1.80	3.54	0.00	3.54
Nov	1.06	0.82	0.85	0.80	0.12	0.40	1.64	2.36	3.40	0.00	3.40
Dec	0.97	0.89	0.68	0.71	0.33	0.48	1.26	1.62	3.39	0.09	3.30
Jan	1.04	0.93	0.70	0.68	0.31	0.55	1.18	1.87	3.35	0.13	3.22
Feb	0.65	0.52	0.48	0.73	0.11	0.28	1.07	1.24	2.04	0.01	2.03
Mar	0.78	0.62	0.54	0.69	0.22	0.30	1.20	1.64	2.07	0.11	1.96
Apr	0.59	0.50	0.48	0.82	0.09	0.22	0.78	1.18	2.23	0.00	2.23
May	1.04	0.96	0.62	0.60	0.30	0.52	1.34	1.90	2.70	0.00	2.70
Jun	1.00	0.92	0.74	0.74	0.12	0.33	0.92	1.56	2.14	0.00	2.14
Jul	0.29	0.18	0.33	1.16	0.00	0.03	0.43	0.70	1.32	0.00	1.32
Aug	0.51	0.28	0.79	1.56	0.00	0.06	0.58	1.09	4.00	0.00	4.00
Sep	0.58	0.46	0.62	1.07	0.00	0.08	0.82	1.28	3.12	0.00	3.12

(OREGON)

Mo	Mean	Median	SDev	CV	Percentiles 10	25	75	90	Max	Min	Range
5362	MCKENZIE BRIDGE RANGER STATION										
Oct	6.00	5.14	3.84	0.64	1.82	3.22	7.91	10.49	18.28	0.16	18.12
Nov	10.53	11.42	4.72	0.45	4.03	6.04	13.58	15.15	22.54	1.05	21.49
Dec	11.88	11.52	5.88	0.50	4.36	7.38	15.24	19.48	26.94	2.24	24.70
Jan	10.93	11.80	5.39	0.49	4.66	5.51	15.62	17.50	23.62	2.35	21.27
Feb	8.08	8.14	4.09	0.51	3.36	4.20	11.00	13.38	19.07	1.91	17.16
Mar	7.52	7.78	3.13	0.42	3.11	5.04	9.96	11.25	14.33	1.41	12.92
Apr	4.80	4.46	1.92	0.40	2.56	3.42	6.36	7.38	9.27	1.88	7.39
May	3.85	3.48	2.07	0.54	1.40	2.28	5.20	6.86	9.39	0.91	8.48
Jun	2.52	2.48	1.74	0.69	0.51	1.17	3.16	5.04	7.74	0.00	7.74
Jul	0.55	0.38	0.59	1.07	0.00	0.06	0.64	1.51	2.31	0.00	2.31
Aug	1.19	0.74	1.31	1.10	0.00	0.13	1.93	2.80	5.03	0.00	5.03
Sep	2.62	2.52	1.74	0.66	0.30	1.29	3.80	5.14	6.74	0.00	6.74
5429	MEDFORD WSO AP										
Oct	1.80	1.35	1.80	1.00	0.38	0.61	2.19	3.00	9.16	0.01	9.15
Nov	2.92	2.43	1.90	0.65	0.68	1.50	3.99	5.34	7.20	0.06	7.14
Dec	3.44	2.80	2.43	0.71	1.05	1.71	3.95	5.58	12.72	0.36	12.36
Jan	3.25	2.64	1.82	0.56	1.17	1.69	4.80	5.88	6.19	0.51	5.68
Feb	2.15	2.04	1.27	0.59	0.63	1.18	2.74	3.51	5.37	0.21	5.16
Mar	1.83	1.49	1.20	0.65	0.82	1.03	2.08	3.62	5.54	0.29	5.25
Apr	1.11	0.86	0.71	0.64	0.37	0.58	1.64	2.24	3.07	0.16	2.91
May	1.31	1.01	1.08	0.82	0.22	0.45	1.63	2.37	4.22	0.11	4.11
Jun	0.80	0.59	0.75	0.94	0.00	0.15	1.25	1.69	2.90	0.00	2.90
Jul	0.24	0.04	0.42	1.76	0.00	0.00	0.17	0.94	1.63	0.00	1.63
Aug	0.41	0.26	0.56	1.39	0.00	0.03	0.40	1.13	2.83	0.00	2.83
Sep	0.72	0.54	0.78	1.07	0.15	0.23	0.83	1.57	4.22	0.00	4.22
6032	NEWPORT										
Oct	6.02	5.90	3.20	0.53	2.14	3.59	7.58	11.12	14.10	1.01	13.09
Nov	9.75	9.28	4.61	0.47	3.61	6.73	12.92	15.64	22.13	1.99	20.14
Dec	11.98	12.80	4.65	0.39	5.43	8.99	14.82	18.42	22.68	2.88	19.80
Jan	10.89	10.31	5.60	0.51	4.89	5.74	14.86	18.84	24.24	1.79	22.45
Feb	8.44	8.11	3.54	0.42	3.56	6.63	10.62	13.23	16.64	2.66	13.98
Mar	8.06	8.20	3.22	0.40	3.68	6.14	9.63	12.62	14.47	1.35	13.12
Apr	4.81	4.59	2.32	0.48	1.88	2.96	6.40	8.07	10.17	1.12	9.05
May	3.16	2.86	1.61	0.51	1.17	1.93	4.14	5.72	7.13	0.61	6.52
Jun	2.31	1.80	1.63	0.70	0.86	1.22	2.77	4.86	6.88	0.14	6.74
Jul	0.85	0.74	0.68	0.80	0.14	0.26	1.17	1.70	3.30	0.00	3.30
Aug	1.32	0.82	1.38	1.05	0.14	0.39	2.00	2.92	7.60	0.05	7.55
Sep	2.71	2.50	1.81	0.67	0.48	1.45	3.60	5.54	7.25	0.03	7.22
6749	PORTLAND KGW-TV										
Oct	3.71	3.20	2.13	0.57	1.00	2.21	4.26	6.21	9.70	0.48	9.22
Nov	6.33	6.15	3.15	0.50	1.80	3.99	7.60	10.63	14.40	1.13	13.27
Dec	7.25	6.74	3.04	0.42	2.86	4.79	10.04	11.02	12.92	1.36	11.56
Jan	6.84	6.07	3.81	0.56	2.36	4.13	9.07	11.69	15.22	0.90	14.32
Feb	4.64	4.41	2.13	0.46	2.08	3.66	5.63	6.42	10.99	0.43	10.56
Mar	4.56	4.61	1.91	0.42	1.81	2.92	5.94	7.09	8.37	1.31	7.06
Apr	2.63	2.63	1.28	0.49	0.98	1.56	3.35	4.54	5.67	0.50	5.17
May	2.22	1.74	1.19	0.54	0.93	1.19	2.79	3.88	4.97	0.76	4.21
Jun	1.49	1.22	0.92	0.62	0.41	0.77	2.16	2.80	3.42	0.03	3.39
Jul	0.50	0.34	0.50	1.00	0.00	0.09	0.75	1.14	2.27	0.00	2.27
Aug	1.04	0.61	1.07	1.02	0.03	0.15	1.55	2.50	4.25	0.00	4.25
Sep	2.03	1.66	1.43	0.71	0.09	0.93	3.56	3.86	4.87	0.00	4.87

(OREGON)

Mo	Mean	Median	SDev	CV	Percentiles 10	25	75	90	Max	Min	Range
7331	ROSEBURG KQEN										
Oct	2.82	2.13	2.24	0.80	0.94	1.47	3.60	5.47	12.53	0.14	12.39
Nov	4.72	4.48	3.17	0.67	1.06	2.38	6.26	8.41	15.91	0.11	15.80
Dec	5.95	5.76	3.25	0.55	2.13	3.58	7.34	9.29	15.74	0.84	14.90
Jan	5.62	5.73	2.93	0.52	1.90	3.29	6.96	10.35	11.29	1.35	9.94
Feb	3.91	3.52	2.17	0.56	1.34	2.53	4.67	6.75	9.71	1.02	8.69
Mar	3.45	3.33	1.62	0.47	1.25	2.40	4.56	6.00	6.65	0.47	6.18
Apr	2.02	1.85	1.11	0.55	0.75	1.02	2.55	3.60	5.28	0.49	4.79
May	1.70	1.51	0.93	0.54	0.66	0.93	2.40	3.11	3.80	0.30	3.50
Jun	1.05	0.52	1.12	1.07	0.12	0.26	1.55	2.41	4.97	0.00	4.97
Jul	0.24	0.08	0.49	2.00	0.00	0.00	0.32	0.53	2.79	0.00	2.79
Aug	0.53	0.16	0.73	1.37	0.00	0.01	0.84	1.26	3.30	0.00	3.30
Sep	1.08	0.98	0.80	0.74	0.14	0.54	1.38	2.29	3.15	0.01	3.14
8797	VALE										
Oct	0.77	0.50	0.79	1.04	0.10	0.24	0.96	2.15	3.53	0.00	3.53
Nov	0.99	0.78	0.67	0.67	0.22	0.43	1.48	2.03	2.54	0.12	2.42
Dec	1.11	1.14	0.60	0.54	0.32	0.60	1.38	2.04	2.48	0.16	2.32
Jan	1.23	1.14	0.64	0.52	0.44	0.88	1.60	2.02	3.07	0.15	2.92
Feb	0.91	0.90	0.65	0.72	0.14	0.30	1.56	1.84	2.25	0.02	2.23
Mar	0.73	0.59	0.49	0.67	0.19	0.38	1.00	1.40	2.20	0.09	2.11
Apr	0.72	0.54	0.73	1.01	0.10	0.20	0.95	1.35	4.07	0.01	4.06
May	0.98	0.77	0.78	0.79	0.14	0.34	1.40	2.09	3.33	0.04	3.29
Jun	0.79	0.54	0.66	0.83	0.04	0.30	1.35	1.78	2.19	0.00	2.19
Jul	0.21	0.06	0.33	1.59	0.00	0.00	0.24	0.61	1.36	0.00	1.36
Aug	0.44	0.26	0.64	1.47	0.00	0.01	0.50	0.93	3.12	0.00	3.12
Sep	0.53	0.40	0.62	1.15	0.00	0.15	0.58	1.06	2.91	0.00	2.91
8997	WALLOWA										
Oct	1.60	1.52	0.96	0.60	0.34	1.05	2.11	2.64	4.32	0.00	4.32
Nov	2.02	1.97	1.09	0.54	0.84	1.25	2.72	3.54	4.94	0.00	4.94
Dec	2.13	1.94	1.28	0.60	0.64	1.23	2.82	3.50	7.02	0.25	6.77
Jan	1.85	1.57	1.10	0.60	0.68	0.97	2.61	3.52	4.70	0.18	4.52
Feb	1.43	1.38	0.67	0.47	0.63	0.95	1.89	2.13	3.67	0.32	3.35
Mar	1.49	1.46	0.66	0.44	0.80	1.06	1.88	2.62	3.05	0.07	2.98
Apr	1.45	1.48	0.75	0.51	0.38	1.12	1.82	2.14	3.74	0.07	3.67
May	1.88	1.49	0.98	0.52	0.83	1.12	2.66	3.42	3.89	0.38	3.51
Jun	1.66	1.35	1.07	0.64	0.49	0.90	2.18	3.48	4.45	0.18	4.27
Jul	0.68	0.56	0.62	0.91	0.07	0.20	0.84	1.65	2.56	0.00	2.56
Aug	0.82	0.68	0.69	0.84	0.08	0.25	1.28	1.91	2.24	0.00	2.24
Sep	1.30	1.10	1.14	0.88	0.08	0.45	1.82	2.64	4.43	0.00	4.43
9068	WASCO										
Oct	0.99	0.71	0.88	0.89	0.24	0.40	1.34	1.96	3.89	0.00	3.89
Nov	1.74	1.94	0.92	0.53	0.40	0.98	2.24	2.84	3.76	0.06	3.70
Dec	1.60	1.64	0.95	0.60	0.55	0.65	2.30	2.96	3.84	0.35	3.49
Jan	1.78	1.40	1.03	0.58	0.58	1.11	2.49	3.07	4.77	0.18	4.59
Feb	1.19	1.02	0.90	0.76	0.28	0.58	1.48	2.09	4.37	0.01	4.36
Mar	0.96	0.83	0.58	0.60	0.24	0.60	1.26	1.69	3.08	0.09	2.99
Apr	0.69	0.73	0.52	0.75	0.10	0.26	0.95	1.28	2.14	0.02	2.12
May	0.71	0.60	0.58	0.81	0.08	0.26	0.96	1.75	2.07	0.01	2.06
Jun	0.63	0.47	0.56	0.88	0.06	0.18	1.02	1.48	1.98	0.00	1.98
Jul	0.26	0.20	0.31	1.16	0.00	0.00	0.42	0.65	1.36	0.00	1.36
Aug	0.36	0.26	0.43	1.18	0.00	0.00	0.62	0.90	1.54	0.00	1.54
Sep	0.51	0.46	0.42	0.81	0.06	0.21	0.70	1.06	2.08	0.00	2.08

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Mo	Mean	Median	SDev	CV	Percentiles 10	25	75	90	Max	Min	Range
0008	ABERDEEN										
Oct	7.59	6.63	4.06	0.54	2.82	5.25	8.88	13.54	17.84	1.25	16.59
Nov	10.86	10.90	3.87	0.36	5.70	7.96	14.16	15.64	18.78	3.01	15.77
Dec	13.54	13.30	3.83	0.28	8.36	11.32	15.83	18.58	20.77	5.09	15.68
Jan	12.24	12.50	5.56	0.45	5.44	8.37	14.25	19.32	30.46	1.40	29.06
Feb	9.52	8.63	4.08	0.43	4.94	6.80	11.85	15.34	20.60	2.36	18.24
Mar	8.79	8.08	3.50	0.40	4.87	6.34	11.21	13.55	17.17	1.60	15.57
Apr	5.55	5.40	2.13	0.38	2.64	3.92	7.00	8.45	10.28	1.41	8.87
May	3.48	3.42	1.83	0.53	1.28	2.17	4.34	5.81	8.53	0.83	7.70
Jun	2.44	2.47	1.47	0.60	0.76	1.19	3.20	4.90	5.94	0.26	5.68
Jul	1.39	1.00	1.19	0.86	0.19	0.47	2.21	3.00	4.69	0.04	4.65
Aug	2.03	1.66	1.48	0.73	0.32	0.72	3.06	4.14	5.36	0.11	5.25
Sep	3.70	3.30	2.39	0.65	0.82	2.08	5.41	6.91	10.23	0.10	10.13
0564	BELLINGHAM 2 N										
Oct	3.64	3.50	1.61	0.44	1.79	2.50	4.44	5.82	8.73	1.42	7.31
Nov	4.46	4.73	1.75	0.39	2.04	3.08	5.36	6.82	8.05	1.01	7.04
Dec	4.82	4.62	1.53	0.32	2.88	3.66	5.86	7.14	8.34	2.10	6.24
Jan	4.28	4.00	2.56	0.53	1.71	2.68	5.66	7.31	11.23	0.58	10.65
Feb	3.38	3.06	1.46	0.43	1.50	2.30	4.24	5.58	7.08	1.02	6.06
Mar	2.96	2.72	1.23	0.42	1.39	2.09	3.89	4.54	5.53	0.59	4.94
Apr	2.49	2.42	0.93	0.37	1.21	1.98	2.76	4.12	4.42	0.48	3.94
May	2.03	2.08	0.90	0.44	0.92	1.46	2.66	2.98	4.15	0.28	3.87
Jun	1.71	1.49	1.02	0.60	0.52	1.12	2.10	3.10	4.55	0.22	4.33
Jul	1.08	0.94	0.79	0.73	0.08	0.44	1.72	2.24	2.63	0.00	2.63
Aug	1.44	0.91	1.22	0.84	0.28	0.41	2.49	3.36	4.70	0.12	4.58
Sep	2.03	1.87	1.21	0.60	0.81	1.12	2.44	4.10	5.58	0.35	5.23
1233	CEDAR LAKE										
Oct	9.63	9.92	4.35	0.45	3.99	7.06	11.42	16.68	20.57	2.06	18.51
Nov	13.35	13.18	4.66	0.35	7.32	9.52	16.90	19.51	22.15	3.69	18.46
Dec	14.82	15.14	3.90	0.26	9.48	11.20	18.36	19.32	22.64	6.64	16.00
Jan	13.41	14.36	6.55	0.49	5.97	7.73	16.90	22.00	33.35	3.06	30.29
Feb	10.91	10.35	4.28	0.39	5.24	7.67	13.66	16.68	22.16	3.94	18.22
Mar	10.22	10.62	3.51	0.34	5.43	8.12	12.00	15.35	17.43	2.41	15.02
Apr	8.28	8.06	2.74	0.33	4.95	6.52	10.08	12.08	13.70	2.44	11.26
May	5.94	5.22	2.63	0.44	2.80	4.14	7.84	9.58	12.29	1.22	11.07
Jun	5.31	5.06	2.78	0.52	1.96	3.20	6.98	9.44	12.09	0.49	11.60
Jul	2.32	2.24	1.60	0.69	0.16	1.07	3.46	4.24	6.78	0.00	6.78
Aug	2.95	1.87	2.15	0.73	1.08	1.43	4.60	6.60	7.75	0.12	7.63
Sep	5.54	5.03	3.52	0.64	1.14	3.06	7.62	10.80	16.71	0.28	16.43
1395	CHEWELAH										
Oct	1.60	1.17	1.33	0.83	0.19	0.62	2.47	4.00	5.08	0.00	5.08
Nov	2.48	2.40	1.48	0.60	0.68	1.70	3.04	3.98	8.32	0.29	8.03
Dec	2.90	2.58	1.44	0.50	1.02	1.68	4.19	4.82	5.64	0.68	4.96
Jan	2.32	2.30	1.14	0.49	0.85	1.46	3.14	3.88	4.90	0.31	4.59
Feb	1.80	1.80	0.98	0.54	0.70	1.10	2.34	3.04	4.65	0.42	4.23
Mar	1.65	1.61	0.89	0.54	0.52	1.00	2.14	2.79	4.25	0.14	4.11
Apr	1.39	1.12	0.88	0.63	0.42	0.69	2.02	2.48	3.82	0.13	3.79
May	1.87	1.70	1.25	0.69	0.58	0.84	2.46	3.88	5.09	0.41	4.68
Jun	1.44	1.42	0.75	0.52	0.51	0.88	1.74	2.42	3.89	0.30	3.59
Jul	0.76	0.61	0.73	0.96	0.05	0.24	1.18	1.63	3.72	0.00	3.72
Aug	0.95	0.68	0.91	0.96	0.08	0.28	1.36	2.17	3.79	0.00	3.79
Sep	1.10	0.92	0.81	0.74	0.15	0.42	1.56	2.37	2.89	0.00	2.89

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Mo	Mean	Median	SDev	CV	Percentiles 10	25	75	90	Max	Min	Range
1767	COULEE DAM 1 SW										
Oct	0.74	0.49	0.73	0.98	0.10	0.23	1.04	1.85	2.95	0.00	2.95
Nov	1.28	1.28	0.82	0.64	0.30	0.70	1.67	2.02	3.95	0.13	3.82
Dec	1.43	1.42	0.71	0.50	0.52	0.86	1.78	2.40	3.20	0.20	3.00
Jan	1.11	1.08	0.59	0.53	0.38	0.66	1.55	1.89	2.52	0.25	2.27
Feb	0.89	0.90	0.70	0.78	0.14	0.34	1.10	1.52	3.58	0.03	3.55
Mar	0.68	0.60	0.47	0.69	0.10	0.34	0.96	1.28	1.85	0.04	1.81
Apr	0.79	0.68	0.58	0.73	0.10	0.30	1.10	1.66	2.31	0.03	2.28
May	1.16	0.76	1.05	0.91	0.20	0.48	1.70	2.26	5.52	0.15	5.37
Jun	0.88	0.88	0.64	0.73	0.16	0.40	1.18	1.60	3.26	0.05	3.21
Jul	0.46	0.22	0.58	1.27	0.02	0.06	0.72	1.46	2.33	0.00	2.33
Aug	0.55	0.29	0.56	1.02	0.00	0.06	1.04	1.32	1.75	0.00	1.75
Sep	0.55	0.44	0.47	0.86	0.04	0.14	0.84	1.36	1.51	0.00	1.51
2157	DIABLO DAM										
Oct	8.14	7.83	4.28	0.53	3.49	5.01	11.03	13.77	19.61	1.21	18.40
Nov	11.12	10.26	4.75	0.43	5.08	7.38	14.42	17.96	20.68	2.25	18.43
Dec	12.78	12.76	3.87	0.30	8.66	9.91	15.34	17.06	25.83	5.02	20.81
Jan	10.97	10.82	5.76	0.53	4.00	6.12	13.80	18.22	26.48	1.82	24.67
Feb	8.48	8.00	4.71	0.56	3.08	4.44	11.70	13.42	21.30	1.80	19.50
Mar	6.84	6.27	2.97	0.43	3.31	4.54	9.30	10.76	12.54	1.08	11.46
Apr	4.52	3.90	2.55	0.56	2.02	2.88	6.19	7.24	14.05	0.68	13.37
May	2.68	2.86	1.26	0.47	0.78	1.63	3.44	4.42	5.12	0.31	4.81
Jun	2.01	1.98	1.11	0.55	0.69	1.46	2.61	3.01	6.52	0.20	6.32
Jul	1.38	1.39	0.83	0.60	0.31	0.64	1.94	2.30	3.77	0.00	3.77
Aug	1.70	1.52	1.10	0.65	0.38	0.82	2.61	3.28	3.86	0.14	3.72
Sep	3.89	3.52	2.59	0.67	0.85	1.68	5.51	7.44	10.75	0.20	10.55
2914	FORKS 1 E										
Oct	11.47	10.28	5.98	0.52	3.80	7.70	14.12	19.16	29.79	2.08	27.71
Nov	15.56	15.48	6.69	0.43	6.43	11.08	20.10	24.24	31.06	2.91	28.15
Dec	18.77	19.04	5.68	0.30	11.18	14.54	22.48	25.28	31.61	6.62	24.99
Jan	16.93	16.80	7.56	0.45	7.86	11.50	20.92	25.79	41.70	2.31	39.39
Feb	14.33	13.16	5.74	0.40	7.63	9.46	18.30	22.25	28.84	4.95	23.89
Mar	12.57	12.96	4.68	0.37	6.46	9.26	15.28	18.58	24.58	3.62	20.96
Apr	8.14	8.08	3.66	0.45	3.18	5.36	10.84	13.48	15.34	1.54	13.80
May	5.06	4.50	3.02	0.60	1.84	3.03	6.19	9.57	13.40	0.90	12.50
Jun	3.12	2.86	2.14	0.69	0.77	1.54	4.39	6.28	8.89	0.17	8.72
Jul	2.41	2.10	1.94	0.81	0.38	0.76	3.40	5.25	7.99	0.01	7.98
Aug	2.67	2.96	2.07	0.78	0.43	0.76	3.96	4.94	9.57	0.20	9.37
Sep	5.17	3.83	3.10	0.60	1.94	2.71	7.63	9.50	12.24	0.24	12.00
4446	LAKE WENATCHEE										
Oct	3.63	3.15	2.50	0.69	0.87	1.74	4.66	7.38	10.23	0.27	9.96
Nov	6.46	5.98	3.38	0.52	2.24	3.80	8.42	12.40	13.57	1.21	12.36
Dec	7.98	7.87	2.79	0.35	4.24	5.90	10.08	11.07	14.07	2.59	11.48
Jan	7.54	6.88	4.59	0.61	2.50	3.79	10.29	13.52	22.97	1.60	21.37
Feb	4.98	4.51	2.65	0.53	2.53	2.97	6.46	8.71	12.72	0.50	12.22
Mar	3.12	2.76	1.63	0.52	1.32	2.00	4.18	5.02	7.80	0.20	7.60
Apr	1.65	1.50	0.99	0.60	0.48	0.80	2.49	3.10	3.76	0.14	3.62
May	1.23	0.99	1.03	0.84	0.26	0.52	1.49	2.32	5.95	0.10	5.85
Jun	1.03	0.92	0.69	0.67	0.20	0.42	1.60	2.13	2.54	0.04	2.50
Jul	0.45	0.40	0.39	0.87	0.02	0.13	0.66	0.94	1.71	0.00	1.71
Aug	0.76	0.66	0.70	0.92	0.02	0.16	1.02	1.62	2.79	0.00	2.79
Sep	1.31	1.28	0.90	0.68	0.06	0.57	1.78	2.70	3.45	0.04	3.41

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Mo	Mean	Median	SDev	CV	Percentiles 10	25	75	90	Max	Min	Range
4549	LAURIER										
Oct	1.50	1.42	1.14	0.75	0.22	0.66	1.77	3.05	4.81	0.07	4.74
Nov	1.93	1.92	0.89	0.46	0.79	1.26	2.45	2.88	4.83	0.37	4.46
Dec	2.31	2.20	0.82	0.36	1.20	1.76	2.94	3.42	4.26	0.94	3.32
Jan	2.05	2.14	0.80	0.39	1.09	1.33	2.55	3.06	3.82	0.28	3.54
Feb	1.48	1.32	0.76	0.51	0.56	0.90	1.97	2.71	3.21	0.34	2.87
Mar	1.27	1.28	0.54	0.43	0.42	1.03	1.68	1.83	2.57	0.11	2.46
Apr	1.39	1.32	0.81	0.58	0.42	0.72	1.84	2.74	3.18	0.21	2.97
May	1.89	1.58	1.06	0.56	0.78	1.08	2.42	3.40	4.59	0.52	4.07
Jun	2.04	1.88	1.07	0.53	0.78	1.18	2.64	3.39	4.65	0.41	4.24
Jul	1.12	1.04	0.75	0.66	0.13	0.58	1.62	2.21	2.76	0.05	2.71
Aug	1.31	1.06	1.17	0.90	0.15	0.36	2.08	2.91	4.48	0.00	4.48
Sep	1.08	0.68	0.88	0.82	0.22	0.42	1.84	2.27	3.56	0.06	3.50
5128	MAZAMA 6 SE										
Oct	1.38	0.99	1.21	0.87	0.26	0.54	2.10	2.80	5.56	0.15	5.41
Nov	2.93	2.82	1.69	0.58	0.70	1.82	3.63	5.86	6.90	0.15	6.75
Dec	3.54	3.28	1.61	0.46	1.65	2.38	4.54	5.84	7.56	0.88	6.68
Jan	3.15	2.87	2.00	0.63	0.77	1.69	4.57	5.50	8.39	0.43	7.96
Feb	2.28	2.25	1.22	0.53	0.73	1.56	3.08	3.50	5.93	0.48	5.45
Mar	1.28	1.20	0.90	0.70	0.28	0.64	1.80	2.41	4.19	0.12	4.07
Apr	0.92	0.78	0.77	0.84	0.13	0.26	1.35	2.16	2.62	0.00	2.62
May	0.98	0.66	0.90	0.92	0.21	0.44	1.30	1.76	4.93	0.02	4.91
Jun	1.05	0.70	0.90	0.85	0.14	0.42	1.52	2.30	3.70	0.01	3.69
Jul	0.53	0.41	0.53	0.99	0.02	0.09	0.70	1.42	2.21	0.00	2.21
Aug	0.82	0.36	0.90	1.10	0.04	0.11	1.38	2.20	3.78	0.00	3.78
Sep	0.72	0.60	0.67	0.93	0.04	0.18	1.16	1.56	2.74	0.00	2.74
5613	MOSES LAKE 3 E										
Oct	0.80	0.58	0.80	1.00	0.08	0.24	1.16	1.98	3.71	0.01	3.70
Nov	1.21	1.00	1.29	1.07	0.18	0.41	1.60	2.04	7.82	0.00	7.82
Dec	1.29	1.16	1.17	0.91	0.37	0.65	1.62	2.14	7.19	0.08	7.11
Jan	0.92	0.82	0.55	0.60	0.38	0.52	1.24	1.74	2.56	0.04	2.52
Feb	0.78	0.69	0.68	0.88	0.12	0.40	0.98	1.30	4.11	0.03	4.08
Mar	0.62	0.66	0.38	0.61	0.13	0.27	0.88	1.14	1.42	0.02	1.40
Apr	0.56	0.52	0.42	0.74	0.08	0.28	0.78	1.08	1.85	0.00	1.85
May	0.73	0.60	0.60	0.83	0.08	0.26	0.98	1.56	2.79	0.00	2.79
Jun	0.69	0.66	0.53	0.76	0.06	0.28	0.97	1.38	2.09	0.02	2.07
Jul	0.32	0.16	0.44	1.38	0.00	0.01	0.38	0.81	2.24	0.00	2.24
Aug	0.33	0.18	0.38	1.15	0.00	0.04	0.52	0.92	1.35	0.00	1.35
Sep	0.38	0.20	0.48	1.25	0.02	0.08	0.52	1.08	2.07	0.00	2.07
5801	NEAH BAY 1 E										
Oct	10.42	9.93	4.99	0.48	5.77	7.16	12.30	16.06	24.93	2.16	22.77
Nov	14.04	13.88	6.37	0.45	6.12	9.28	17.52	22.44	29.84	4.29	25.55
Dec	16.51	16.98	4.65	0.28	9.86	14.01	19.68	21.99	25.88	5.85	20.03
Jan	14.39	14.66	6.08	0.42	7.78	9.78	17.33	22.05	30.45	2.89	27.56
Feb	12.07	11.14	5.19	0.43	5.72	7.76	15.89	19.20	26.90	4.74	22.16
Mar	10.17	10.08	3.77	0.37	4.79	6.92	13.41	15.39	16.34	3.91	12.43
Apr	7.17	7.03	3.12	0.44	3.07	5.08	9.56	11.30	14.02	0.78	13.24
May	3.95	3.64	2.09	0.53	1.63	2.44	5.15	7.35	9.09	0.50	8.59
Jun	2.86	2.56	1.83	0.64	0.72	1.66	3.94	4.82	7.83	0.33	7.50
Jul	2.42	2.06	1.93	0.80	0.54	0.96	3.49	5.65	7.60	0.00	7.60
Aug	2.52	2.30	1.85	0.73	0.49	1.00	3.49	5.04	8.10	0.10	8.00
Sep	4.42	3.78	2.50	0.57	1.77	2.32	6.57	7.60	10.33	0.74	9.59

(WASHINGTON)

Mo	Mean	Median	SDev	CV	Percentiles 10	25	75	90	Max	Min	Range
6114	OLYMPIA WSO AP										
Oct	4.75	4.60	2.42	0.51	1.67	2.79	6.04	8.79	10.08	0.78	9.30
Nov	7.41	7.42	3.46	0.47	2.72	4.49	9.86	12.26	15.51	1.37	14.14
Dec	8.18	8.54	3.07	0.38	3.76	5.80	10.30	12.24	14.32	2.06	12.26
Jan	7.56	7.48	4.04	0.53	2.84	4.11	5.14	12.32	19.84	0.69	19.15
Feb	5.82	5.18	2.77	0.48	3.10	3.71	7.44	10.08	13.18	1.71	11.47
Mar	4.74	4.32	2.22	0.47	2.46	3.10	6.10	7.85	10.13	0.48	9.65
Apr	2.94	2.84	1.32	0.45	1.22	1.99	4.10	4.64	5.87	0.37	5.50
May	1.93	1.52	1.20	0.62	0.66	1.31	2.66	3.30	5.83	0.25	5.58
Jun	1.40	1.25	0.94	0.67	0.24	0.72	1.82	2.60	4.09	0.05	4.04
Jul	0.81	0.66	0.69	0.85	0.04	0.26	1.30	1.65	2.68	0.00	2.68
Aug	1.27	0.80	1.24	0.98	0.12	0.52	1.60	3.08	5.45	0.01	5.44
Sep	2.33	2.22	1.60	0.69	0.41	1.29	2.94	4.70	7.59	0.00	7.59
6624	PORT ANGELES										
Oct	2.47	2.12	1.55	0.63	0.78	1.50	3.14	4.48	7.75	0.46	7.29
Nov	3.76	3.48	1.76	0.47	1.47	2.74	5.08	6.20	8.44	0.60	7.84
Dec	4.03	4.01	1.46	0.36	1.99	3.30	2.66	5.93	7.70	1.27	6.43
Jan	3.95	3.66	2.25	0.51	1.26	2.29	5.12	7.00	11.06	0.90	10.16
Feb	2.93	2.44	1.54	0.52	1.11	1.78	4.23	4.70	6.97	0.83	6.14
Mar	2.08	1.82	1.10	0.53	0.74	1.38	2.75	3.73	4.64	0.54	4.10
Apr	1.22	1.22	0.60	0.49	0.42	0.82	1.49	2.18	2.70	0.09	2.61
May	0.92	0.94	0.46	0.49	0.31	0.64	1.17	1.41	2.49	0.10	2.39
Jun	0.82	0.70	0.55	0.68	0.19	0.36	1.14	1.58	2.40	0.09	2.31
Jul	0.49	0.49	0.36	0.73	0.06	0.20	0.68	1.04	1.56	0.00	1.56
Aug	0.79	0.56	0.76	0.97	0.07	0.26	1.18	1.70	3.67	0.00	3.67
Sep	1.19	1.14	0.79	0.67	0.20	0.45	1.90	2.30	3.08	0.04	3.04
6896	RAINIER OHANAPECOSH										
Oct	6.99	6.00	3.86	0.55	1.34	4.08	8.20	12.77	16.09	1.18	14.91
Nov	11.55	10.87	5.14	0.44	4.86	6.82	14.76	17.70	25.69	1.22	24.47
Dec	13.48	13.70	5.18	0.38	5.98	9.88	17.31	21.00	23.50	4.43	19.07
Jan	13.01	10.84	7.60	0.58	4.48	6.56	19.06	22.77	31.59	2.35	29.24
Feb	9.21	8.51	4.13	0.45	4.08	6.39	11.31	15.95	18.53	1.93	16.60
Mar	7.13	6.60	3.11	0.44	3.39	4.64	9.36	11.14	14.25	1.23	13.02
Apr	4.49	4.20	2.07	0.46	1.91	3.06	5.74	7.19	9.82	0.69	9.13
May	2.94	2.50	1.53	0.52	1.06	1.96	4.14	4.82	7.09	0.35	6.74
Jun	2.28	2.28	1.18	0.51	0.92	1.50	2.72	3.90	5.41	0.64	4.77
Jul	0.94	0.80	0.76	0.82	0.06	0.37	1.48	2.16	2.60	0.00	2.60
Aug	1.67	1.22	1.52	0.91	0.24	0.46	2.31	4.32	5.66	0.00	5.66
Sep	3.24	2.84	2.38	0.74	0.68	1.60	4.20	6.50	10.95	0.11	10.84
7038	RIMROCK (TIETON DAM)										
Oct	2.08	1.96	1.53	0.74	0.36	0.96	2.88	4.63	6.02	0.15	5.87
Nov	4.03	3.48	2.39	0.59	1.15	2.27	5.82	7.64	9.75	0.59	9.16
Dec	4.89	4.56	2.67	0.55	1.73	2.92	6.08	8.96	12.03	0.91	11.12
Jan	4.41	4.26	3.00	0.68	1.08	1.52	6.54	8.56	11.98	0.22	11.76
Feb	2.89	2.47	1.80	0.62	1.00	1.50	4.12	5.08	7.65	0.26	7.39
Mar	2.07	1.88	1.24	0.60	0.52	1.20	2.90	3.96	5.28	0.20	5.08
Apr	1.23	1.26	0.85	0.69	0.21	0.48	1.73	2.45	3.38	0.06	3.32
May	0.88	0.66	0.73	0.83	0.16	0.32	1.26	1.97	3.56	0.02	3.54
Jun	0.85	0.62	0.71	0.83	0.20	0.33	1.22	1.83	3.11	0.00	3.11
Jul	0.39	0.28	0.44	1.11	0.00	0.07	0.46	0.98	1.76	0.00	1.76
Aug	0.70	0.48	0.78	1.12	0.00	0.08	0.82	1.92	3.07	0.00	3.07
Sep	0.69	0.63	0.60	0.87	0.04	0.14	1.04	1.40	2.36	0.00	2.36

(WASHINGTON)

Mo	Mean	Median	SDev	CV	Percentiles 10	25	75	90	Max	Min	Range
7180	ROSALIA										
Oct	1.49	1.14	1.12	0.75	0.30	0.72	2.18	3.08	4.42	0.02	4.40
Nov	2.18	2.00	1.24	0.41	0.52	1.41	2.74	3.69	5.63	0.38	5.25
Dec	2.40	2.32	0.99	0.57	1.12	1.63	3.04	4.18	4.49	0.78	3.71
Jan	2.16	1.90	1.20	0.56	0.74	1.26	2.84	3.80	5.37	0.44	4.93
Feb	1.70	1.42	1.10	0.65	0.46	1.00	2.14	3.20	5.37	0.31	5.06
Mar	1.53	1.38	0.77	0.50	0.76	0.93	1.87	2.68	3.74	0.34	3.40
Apr	1.33	1.22	0.81	0.61	0.32	0.74	1.79	2.55	3.21	0.17	3.04
May	1.55	1.12	1.17	0.76	0.67	0.84	1.98	2.77	6.22	0.12	6.10
Jun	1.42	1.29	0.70	0.49	0.56	0.89	1.92	2.44	3.10	0.39	2.71
Jul	0.52	0.41	0.55	1.05	0.00	0.12	0.66	1.34	2.26	0.00	2.26
Aug	0.74	0.54	0.61	0.82	0.04	0.26	1.10	1.75	2.37	0.00	2.37
Sep	1.00	0.77	0.89	0.89	0.21	0.34	1.35	2.50	3.52	0.00	3.52
7478	SEATTLE-UNIV. OF WASHINGTON										
Oct	3.30	2.95	1.65	0.50	1.66	2.18	4.09	5.99	7.50	0.54	6.96
Nov	5.12	5.22	2.06	0.40	2.20	3.99	6.48	7.89	9.13	0.55	8.58
Dec	5.45	4.82	2.28	0.42	2.10	4.26	6.78	8.47	10.56	1.15	9.41
Jan	4.92	5.12	2.15	0.44	2.00	3.41	6.26	7.86	9.83	0.89	8.94
Feb	3.98	3.93	1.71	0.43	1.89	2.36	5.36	6.41	7.62	1.58	6.04
Mar	3.46	3.18	1.59	0.46	1.52	2.32	4.46	5.54	7.06	0.43	6.63
Apr	2.40	2.39	0.81	0.34	1.29	1.99	2.91	3.40	4.58	0.59	3.99
May	1.71	1.45	1.00	0.59	0.65	1.03	2.10	2.99	4.72	0.39	4.33
Jun	1.49	1.20	0.93	0.62	0.44	0.68	2.18	2.86	3.58	0.33	3.25
Jul	0.88	0.65	0.80	0.91	0.09	0.28	1.08	2.04	3.77	0.00	3.77
Aug	0.97	0.69	0.89	0.92	0.12	0.32	1.34	2.09	4.00	0.00	4.00
Sep	1.89	1.54	1.30	0.69	0.27	1.13	2.32	3.78	5.49	0.03	5.46
8931	WALLA WALLA WSO CI										
Oct	1.41	1.36	0.92	0.65	0.46	0.66	1.92	2.86	4.20	0.03	4.17
Nov	1.86	1.92	0.94	0.51	0.54	1.20	2.49	3.02	4.13	0.11	4.02
Dec	2.12	2.00	1.01	0.48	0.82	1.36	2.66	3.70	4.31	0.29	4.02
Jan	1.98	1.66	1.21	0.61	0.84	1.12	2.39	3.91	5.86	0.34	5.52
Feb	1.47	1.58	0.77	0.52	0.54	0.86	1.79	2.34	3.99	0.17	3.82
Mar	1.40	1.35	0.62	0.44	0.72	0.89	1.66	2.37	2.94	0.34	2.60
Apr	1.44	1.33	0.81	0.56	0.38	0.87	2.03	2.46	3.26	0.11	3.15
May	1.49	1.14	1.09	0.57	0.46	0.68	1.97	3.48	4.19	0.23	3.96
Jun	1.06	0.87	0.80	0.76	0.30	0.42	1.24	2.57	3.04	0.09	2.95
Jul	0.38	0.14	0.48	1.27	0.00	0.01	0.58	1.10	1.78	0.00	1.78
Aug	0.56	0.35	0.68	1.20	0.00	0.06	0.94	1.36	2.94	0.00	2.94
Sep	0.85	0.76	0.66	0.77	0.07	0.25	1.30	1.86	2.41	0.00	2.41
9465	YAKIMA WSO AP										
Oct	0.54	0.28	0.57	1.05	0.06	0.13	0.82	1.47	2.22	0.00	2.22
Nov	0.99	0.96	0.71	0.71	0.10	0.47	1.26	1.84	2.86	0.00	2.86
Dec	1.18	1.07	0.90	0.76	0.14	0.51	1.46	2.25	4.19	0.07	4.12
Jan	1.31	1.26	0.83	0.63	0.40	0.59	1.74	2.38	3.66	0.13	3.53
Feb	0.81	0.76	0.66	0.81	0.08	0.33	1.14	1.50	3.11	0.00	3.11
Mar	0.60	0.47	0.54	0.91	0.12	0.22	0.80	1.14	2.63	0.01	2.62
Apr	0.50	0.42	0.47	0.94	0.02	0.07	0.82	1.25	1.62	0.00	1.62
May	0.50	0.45	0.50	0.99	0.06	0.14	0.74	1.02	2.76	0.03	2.73
Jun	0.64	0.38	0.64	1.00	0.02	0.18	1.15	1.67	2.10	0.00	2.09
Jul	0.16	0.08	0.19	1.21	0.00	0.01	0.26	0.44	0.71	0.00	0.71
Aug	0.32	0.20	.044	1.37	0.00	0.01	0.42	0.62	2.10	0.00	2.10
Sep	0.34	0.24	0.32	0.95	0.00	0.04	0.62	0.84	0.98	0.00	0.98

APPENDIX C

SKEWNESS STATISTIC
SEASONAL AND ANNUAL PRECIPITATION - 244 STATIONS
MONTHLY PRECIPITATION DATA - 43 STATIONS

SEASONAL SKEWNESS (194Ø-1979)

(OREGON)

Station I.D.	Name	Winter	Summer	Year
Ø197	Antelope	-Ø.28	Ø.Ø9	Ø.Ø1
Ø265	Arlington	-Ø.Ø7	Ø.2Ø	Ø.2Ø
Ø3Ø4	Ashland	-Ø.21	Ø.37	-Ø.31
Ø318	Astor Experiment Station	-Ø.17	Ø.51	-Ø.Ø5
Ø328	Astoria WSO AP	Ø.Ø8	Ø.43	Ø.24
Ø356	Austin 3 S	Ø.23	Ø.43	Ø.23
Ø412	Baker FAA AP	Ø.24	Ø.63	Ø.58
Ø417	Baker KBKR	Ø.3Ø	1.12	Ø.86
Ø471	Bandon 2 NNE	-Ø.Ø4	Ø.63	Ø.15
Ø694	Bend	Ø.12	1.18	Ø.22
Ø723	Beulah	-Ø.19	Ø.46	Ø.Ø3
Ø897	Bonneville Dam	-Ø.2Ø	Ø.31	Ø.Ø3
1Ø55	Brookings	-Ø.79	Ø.43	-Ø.63
1176	Burns WSO CI	-Ø.43	Ø.24	Ø.11
12Ø7	Butte Falls 1 SE	Ø.22	Ø.36	Ø.3Ø
1433	Cascadia	-Ø.Ø1	Ø.97	Ø.28
1546	Chemult	Ø.15	Ø.72	-Ø.Ø3
1552	Cherry Grove 2 S	-Ø.22	Ø.65	Ø.Ø1
1571	Chiloquin 1 E	-Ø.Ø8	Ø.8Ø	Ø.1Ø
1643	Clatskanie 3 W	Ø.Ø2	Ø.8Ø	Ø.27
1765	Condon	Ø.23	Ø.49	Ø.35
1862	Corvallis-State Univ.	Ø.64	1.Ø1	Ø.8Ø
1897	Cottage Grove 1 S	-Ø.Ø5	Ø.35	-Ø.11
19Ø2	Cottage Grove Dam	-Ø.Ø2	Ø.51	-Ø.13
1926	Cove	-Ø.39	Ø.68	-Ø.2Ø
1946	Crater Lake NPS HQ	-Ø.Ø4	Ø.96	Ø.11
2112	Dallas	-Ø.Ø8	Ø.75	-Ø.11
2135	Danner	-Ø.46	-Ø.37	-Ø.29
2168	Dayville	Ø.3Ø	1.16	Ø.61
2277	Detroit	-Ø.Ø3	Ø.64	Ø.25
24Ø6	Drain	Ø.21	Ø.3Ø	Ø.Ø8
244Ø	Dufur	Ø.25	Ø.Ø8	Ø.37
2633	Elkton 3 SW	-Ø.Ø1	Ø.55	-Ø.2Ø
2672	Enterprise	-Ø.Ø4	-Ø.23	Ø.Ø6
2693	Estacada 2 SE	Ø.Ø9	Ø.26	Ø.16
27Ø9	Eugene WSO AP	Ø.78	Ø.71	Ø.7Ø
28Ø5	Falls City 2	-Ø.2Ø	Ø.18	-Ø.25
2997	Forest Grove	-Ø.2Ø	1.Ø2	-Ø.Ø7
3Ø95	Fremont	Ø.36	Ø.55	Ø.73
3121	Friend	Ø.12	Ø.14	Ø.31
3356	Gold Beach Ranger Station	-Ø.43	Ø.58	-Ø.35
34Ø2	Government Camp	Ø.19	Ø.22	Ø.31
3445	Grants Pass	Ø.12	Ø.25	Ø.23
3542	Grizzly	-Ø.45	Ø.45	Ø.Ø5

(OREGON)

Station I.D.	Name	Winter	Summer	Year
3604	Halfway	0.58	1.09	-0.40
3692	Hart Mountain Refuge	0.69	0.60	0.73
3770	Headworks, Portland Water Bureau	0.33	0.17	0.48
3827	Heppner	-0.01	0.64	0.08
3847	Hermiston 2 S	0.86	0.64	0.46
3908	Hillsboro	-0.33	0.77	-0.08
4003	Hood River Experiment Station	-0.20	1.35	-0.14
4098	Huntington	0.04	-0.09	-0.09
4133	Illahe	-0.56	0.68	-0.49
4161	Ione 18 S	-0.05	0.63	0.95
4291	John Day	-0.26	0.42	-0.14
4403	Keno	-0.05	0.78	-0.21
4411	Kent	-0.05	0.88	0.28
4506	Klamath Falls 2 SSW	-0.12	0.74	0.24
4622	LaGrande	-0.63	1.41	-0.41
4670	Lakeview 2 NNW	-0.20	0.48	0.19
4811	Leaburg 1 SW	-0.03	0.27	0.03
5080	Lower Hay Creek	0.09	0.22	0.11
5139	Madras	-0.04	0.39	0.10
5160	Malheur Branch Experiment Station	-0.09	0.55	-0.13
5162	Malheur Refuge HDQ	-0.25	0.63	-0.13
5362	McKenzie Bridge Ranger Station	-0.17	0.51	-0.04
5384	McMinnville	-0.21	0.71	-0.04
5424	Medford Experiment Station	0.70	0.54	0.37
5429	Medford WSO AP	0.14	0.54	0.28
5593	Milton Freewater	-0.18	0.94	-0.08
5734	Moro	-0.05	0.19	0.26
6032	Newport	-0.11	1.05	0.11
6073	North Bend FAA AP	-0.53	0.64	-0.44
6179	Nyssa	0.01	0.71	-0.18
6213	Oakridge Fish Hatchery	-0.01	0.30	0.00
6243	Ochoco Ranger Station	0.08	0.86	0.19
6405	Owyhee Dam	0.29	0.20	0.33
6426	Paisley	0.97	0.45	1.00
6468	Parkdale 2 SSE	-0.18	0.23	-0.21
6546	Pendleton WSO AP	0.20	1.14	0.19
6634	Pilot Rock 1 SE	-0.16	0.87	0.28
6749	Portland KGW-TV	-0.50	0.75	-0.05
6820	Powers	0.04	1.10	0.11
6883	Prineville	0.05	0.23	0.04
6907	Prospect 2 SW	0.06	0.57	0.07

(OREGON)

Station I.D.	Name	Winter	Summer	Year
7052	Redmond 2 W	-0.07	0.59	0.09
7082	Reedsport	0.23	0.34	0.29
7169	Riddle	0.41	0.52	0.47
7208	Riverside	0.06	0.54	0.13
7250	Rock Creek	-0.65	1.18	-0.03
7331	Roseburg KQEN	0.21	0.58	0.21
7354	Round Grove	-0.03	0.50	0.35
7500	Salem WSO AP	-0.01	0.80	0.07
7641	Seaside	-0.32	0.44	0.00
8029	Squaw Butte Experiment Station	0.08	0.68	0.40
8407	The Dalles	0.31	1.22	0.42
8466	Three Lynx	0.01	0.55	0.23
8494	Tillamoook 1 W	-0.45	0.68	0.02
8726	Ukiah	-0.03	1.47	0.48
8746	Union Experiment Station	-0.97	0.99	0.31
8780	Unity	-0.22	0.78	0.41
8797	Vale	0.41	0.21	-0.25
8818	Valley Falls 3 SSE	0.44	0.65	0.41
8833	Valsetz	-0.06	0.47	0.10
8884	Veronica 2	0.01	0.85	0.03
8997	Wallowa	-0.46	1.00	-0.11
9068	Wasco	0.22	0.42	0.26
9316	Wickiup Dam	-0.01	0.33	-0.05

(WASHINGTON)

Station I.D.	Name	Winter	Summer	Year
0008	Aberdeen	-0.16	0.75	0.10
0176	Anacortes	0.06	0.94	0.06
0242	Ariel Dam	0.19	0.43	0.46
0257	Arlington	0.07	0.58	0.98
0482	Battle Ground	-0.29	0.65	0.14
0564	Bellingham 2 N	0.31	0.39	0.22
0668	Bickleton	0.59	0.52	0.88
0729	Blaine	0.27	0.88	0.11
0872	Bremerton	0.26	0.53	0.26
0945	Buckley 1 NE	-0.20	0.33	0.04
1233	Cedar Lake	-0.15	0.01	0.22
1276	Centralia	-0.09	0.44	-0.25
1350	Chelan	0.10	2.62	0.32
1385	Chesaw 4 NNW	0.61	0.82	0.39
1395	Chewelah	0.62	0.81	0.34
1414	Chimacum 4 S	-0.25	0.59	0.02
1484	Clearbrook	0.42	0.58	0.44
1504	Cle Elum	0.57	2.88	0.72

(WASHINGTON)

Station I.D.	Name	Winter	Summer	Year
1586	Colfax 1 NW	-0.41	1.45	-0.04
1650	Colville AP	0.60	0.85	0.43
1666	Conconully	-0.09	2.00	0.75
1679	Concrete	0.27	0.51	0.51
1760	Cougar 6 E	0.28	0.50	0.53
1767	Coulee Dam 1 SW	-0.10	3.02	1.13
1783	Coupeville 1 S	0.18	0.78	0.35
1934	Cushman Dam	-0.58	0.73	-0.53
1968	Dallesport FAA AP	1.52	1.26	1.45
1992	Darrington Ranger Station	0.14	0.44	0.24
2007	Davenport	-0.52	2.67	0.76
2030	Dayton 1 WSW	-0.28	1.34	-0.06
2157	Diablo Dam	0.37	0.69	0.50
2505	Ellensburg	0.01	2.38	0.08
2531	Elma	-0.02	0.83	0.29
2675	Everett	0.01	1.00	0.87
2914	Forks 1 E	0.31	0.59	0.38
3222	Goldendale	-0.25	0.88	-0.08
3284	Grapeview 3 SW	-0.35	1.20	-0.23
3357	Greenwater	0.00	0.65	0.28
3502	Harrington 5 S	0.37	3.27	1.86
3529	Hartline	0.28	2.80	1.06
3546	Hatton 9 ESE	0.23	1.72	1.17
3975	Irene Mt. Wauconda	0.33	1.12	0.40
4077	Kahlotus 5 SSW	0.38	0.96	0.51
4084	Kalama Falls Hatchery	0.46	0.54	0.71
4154	Kennewick	0.82	1.43	1.19
4201	Kid Valley	-0.05	0.38	0.27
4338	La Crosse	0.06	1.70	0.51
4394	Lake Cle Elum	0.14	1.08	0.29
4406	Lake Kachess	-0.09	0.97	0.07
4414	Lake Keechelus	0.09	0.70	0.31
4446	Lake Wenatchee	-0.01	1.26	0.01
4486	Landsburg	-0.23	0.46	0.16
4549	Laurier	0.25	1.19	0.41
4572	Leavenworth 3 S	0.64	2.20	0.79
4679	Lind 3 NE	0.45	3.13	2.23
4769	Longview	-0.60	0.86	-0.16
4971	Mansfield	-0.02	3.14	1.25
5128	Mazama 6 SE	0.37	2.83	0.62
5224	McMillin Reservoir	-0.21	0.17	-0.16
5425	Mineral	-0.38	0.04	-0.28
5525	Monroe	0.08	0.37	0.42
5613	Moses Lake 3 E	0.68	1.29	0.68
5659	Mt. Adams Ranger Station	-0.16	0.62	-0.17
5688	Moxee City 10 E	0.63	0.64	0.33
5704	Mud Mountain Dam	0.01	0.15	0.25

(WASHINGTON)

Station I.D.	Name	Winter	Summer	Year
5801	Neah Bay 1 E	0.30	1.03	0.32
5832	Nespelem 2 S	0.06	2.94	1.33
5840	Newhalem	0.19	0.52	0.48
5844	Newport	-0.19	0.95	-0.50
5946	Northport	0.28	0.65	0.22
6039	Odessa	-0.11	2.25	0.74
6096	Olga 2 SE	0.01	0.91	0.08
6114	Olympia WSO AP	-0.06	1.14	0.06
6123	Omak 2 NW	0.30	2.04	0.96
6295	Palmer 3 ESE	-0.15	0.40	0.35
6553	Pleasant View	0.17	1.13	0.42
6610	Pomeroy	-0.25	1.70	0.48
6624	Port Angeles	-0.13	0.66	0.02
6678	Port Townsend	0.09	1.02	0.31
6768	Prosser 4 NE	0.29	0.64	0.36
6789	Pullman 2 NW	-0.01	1.06	0.26
6803	Puyallup Experiment Station	-0.13	0.59	-0.17
6846	Quilcene 2 SW	-0.12	0.47	-0.11
6880	Quincy 1 S	0.47	1.74	0.44
6896	Rainier Ohanapecosh	-0.12	0.37	0.14
6909	Randle 1 E	-0.47	0.20	-0.10
6974	Republic	0.78	1.56	0.36
7038	Rimrock (Tieton Dam)	-0.06	1.86	0.09
7059	Ritzville 1 SSE	-0.35	3.36	1.32
7180	Rosalia	-0.13	1.54	0.63
7473	Seattle-Tacoma WSO AP	-0.46	0.74	-0.22
7478	Seattle-Univ. of Wash.	-0.61	0.78	-0.12
7507	Sedro Wooley	0.14	0.68	0.52
7538	Sequim	-0.40	1.19	0.10
7584	Shelton	-0.22	1.28	-0.05
7773	Snoqualmie Falls	-0.10	0.28	0.15
7938	Spokane WSO AP	-0.22	1.38	0.61
7956	Sprague	-0.02	1.80	0.53
7987	Spruce	0.16	0.52	0.16
8034	Startup 1 E	-0.05	-0.01	0.46
8059	Stehekin 4 NW	0.20	1.52	0.29
8207	Sunnyside	2.53	0.54	1.79
8286	Tacoma City Hall	-0.38	1.01	-0.07
8348	Tekoa	-0.45	1.18	0.52
8773	Vancouver 4 NNE	-0.14	0.78	0.15
8931	Walla Walla WSO Cl	-0.01	1.29	-0.13
8959	Wapato	0.54	1.05	0.64
9012	Waterville	-0.15	2.89	1.20
9058	Wellpinit	0.13	1.29	0.23
9074	Wenatchee	-0.33	1.95	0.64
9238	Wilbur	-0.08	2.56	1.36
9327	Wilson Creek	0.32	2.70	1.04
9342	Wind River	-0.22	0.74	0.01
9376	Winthrop 1 WSW	-0.17	1.75	0.39
9465	Yakima WSO AP	0.64	1.63	0.77

(IDAHO)

Station I.D.	Name	Winter	Summer	Year
1380	Caldwell	-0.05	0.35	-0.43
1956	Coeur D'Alene Ranger Station	-0.13	0.76	-0.01
3771	Grangeville	0.12	0.08	0.52
6152	Moscow-Univ. of Idaho	0.53	0.93	0.43
6424	Nezperce	-0.41	0.02	0.02
6844	Parma Experiment Station	0.29	0.41	0.00
6891	Payette	-0.35	0.32	-0.23
7264	Porthill	-0.18	0.21	-0.33
7386	Priest River Exper. Sta.	0.02	1.18	-0.35
7706	Riggins	0.09	0.14	-0.07
8062	Saint Maries	-0.16	1.10	0.04

(NEVADA)

2573	Elko FAA AP	-0.09	0.79	0.10
5869	Owyhee	0.13	0.56	0.29
6005	Paradise Valley 1 NW	0.23	0.60	0.46
9171	Winnemucca WSO AP	-0.20	0.38	0.15

(CALIFORNIA)

1614	Cedarville	0.24	1.28	1.06
2147	Crescent City 1N	-0.33	0.34	-0.12
3157	Fort Bidwell	0.03	1.08	0.72
3761	Happy Camp Ranger Station	0.33	0.33	1.44
9053	Tulelake	0.13	0.53	0.09
9866	Yreka	0.06	0.69	-0.01

MONTHLY SKEWNESS (1940-1979)

	Station	Oct	Jan	Apr	Jul
	(OREGON)				
0304	Ashland	2.06	0.57	0.89	2.67
0328	Astoria WSO AP	0.86	0.70	-0.10	1.25
0417	Baker KBKR	1.93	1.51	2.65	1.99
0471	Bandon 2 NNE	1.08	0.52	1.01	2.32
0694	Bend	3.38	0.41	1.91	1.42
1055	Brookings	1.39	0.41	1.38	4.18
1862	Corvallis-St. Univ.	1.12	0.23	0.20	3.06
1946	Crater Lake NPS HQ	1.55	0.11	0.58	1.55
2168	Dayville	1.22	1.00	0.82	1.40
2997	Forest Grove	1.04	0.33	0.08	0.72
3402	Government Camp	0.83	0.06	0.33	0.97
3827	Heppner	1.08	1.27	0.96	1.74
4506	Klamath Falls 2 SSW	1.79	0.86	0.76	2.00
4670	Lakeview 2 NNW	2.49	1.27	0.96	1.74
5162	Malheur Refuge HQ	1.69	1.48	1.41	1.62
5362	McKenzie Bridge R.S.	1.17	0.18	0.57	1.43
5429	Medford WSO AP	2.46	0.37	0.91	2.18
6032	Newport	0.55	0.44	0.43	1.40
6749	Portland KGW-TV	0.92	0.56	0.31	1.40
7331	Roseburg KQEN	2.35	0.44	0.96	4.14
8797	Vale	1.74	0.56	2.68	2.28
8997	Wallowa	0.78	0.81	0.60	1.15
9068	Wasco	1.79	0.83	0.68	1.57
	(WASHINGTON)				
0008	Aberdeen	0.94	0.70	0.13	1.04
0564	Bellingham 2N	1.01	0.82	0.37	0.34
1233	Cedar Lake	0.52	0.73	0.01	0.64
1395	Chewelah	0.99	0.31	0.80	1.90
1767	Coulee Dam 1 SW	1.49	0.58	0.67	1.64
2157	Diablo Dam	0.72	0.64	1.56	0.47
2914	Forks 1 E	1.06	0.74	0.26	0.99
4446	Lake Wenatchee	1.01	1.09	0.41	1.12
4549	Laurier	1.30	-0.03	0.55	0.44
5128	Mazama 6 SE	1.64	0.73	0.78	1.34
5613	Moses Lake 3 E	1.83	1.02	0.96	2.63
5801	Neah Bay 1 E	1.01	0.35	0.11	1.07
6114	Olympia WSO AP	0.50	0.65	0.05	0.83
6624	Port Angeles	1.42	1.06	0.49	0.93
6896	Rainier-Ohanapecosh	0.70	0.59	0.37	0.68
7038	Rimrock (Tieton Dam)	0.99	0.57	0.58	1.72
7180	Rosalia	1.03	1.00	0.55	1.61
7478	Seattle-Univ. of Wash.	0.75	0.19	0.04	1.64
8931	Walla Walla WSO CI	0.93	1.30	0.36	1.49
9465	Yakima WSO AP	1.36	0.83	0.95	1.53

APPENDIX D

CONFIDENCE INTERVAL OF MEAN PRECIPITATION
(all data in inches)

Confidence Interval of Mean Precipitation (inches)

(OREGON)

I.D.		Season	Mean	95%	99%
0304	Ashland	W	15.38	13.96 - 16.80	13.47 - 17.29
		S	4.23	3.57 - 4.89	3.35 - 5.11
		Y	19.61	17.94 - 21.08	17.40 - 21.62
0328	Astoria	W	61.73	57.44 - 66.02	55.96 - 67.50
	WSO AP	S	11.67	10.52 - 12.82	10.12 - 13.22
		Y	73.39	69.02 - 77.76	67.52 - 79.26
0417	Baker KBKR	W	6.69	6.08 - 7.29	6.42 - 6.94
		S	4.68	4.14 - 5.22	3.96 - 5.40
		Y	11.37	10.48 - 12.26	10.17 - 12.57
0471	Bandon	W	53.06	49.63 - 56.43	48.45 - 57.67
	2 NNE	S	7.11	6.27 - 7.95	5.98 - 8.24
		Y	60.18	56.84 - 9.42	55.69 - 64.67
0694	Bend	W	8.53	7.55 - 9.51	7.21 - 9.85
		S	3.42	2.82 - 4.01	2.61 - 4.23
		Y	11.94	10.74 - 12.14	10.33 - 13.55
1055	Brookings	W	69.07	64.93 - 73.21	68.80 - 70.34
		S	9.49	8.23 - 10.75	7.79 - 11.19
		Y	78.55	74.53 - 82.57	73.16 - 83.94
1862	Corvallis	W	35.25	32.38 - 38.12	31.40 - 39.10
	State	S	5.62	4.92 - 6.32	4.68 - 6.56
	Univ.	Y	40.86	38.02 - 43.70	37.05 - 44.67
1946	Crater	W	58.63	54.35 - 62.91	52.88 - 64.38
	Lake	S	9.63	8.57 - 10.69	8.20 - 11.06
	NPS HQ	Y	68.26	64.32 - 72.20	62.97 - 73.55
2168	Dayville	W	7.61	6.88 - 8.34	6.63 - 8.59
		S	4.35	3.76 - 4.94	3.56 - 5.14
		Y	11.96	10.92 - 13.00	10.57 - 13.35
2997	Forest	W	38.71	35.99 - 41.43	35.05 - 42.37
	Grove	S	5.92	5.24 - 6.60	5.00 - 6.84
		Y	44.63	42.04 - 47.22	41.16 - 48.10
3402	Government	W	72.45	67.19 - 77.71	65.38 - 79.52
	Camp	S	15.52	14.27 - 16.77	13.84 - 17.20
		Y	87.96	82.74 - 93.18	80.95 - 94.97
3827	Heppner	W	9.45	8.68 - 10.22	8.42 - 10.48
		S	4.35	3.81 - 4.89	3.62 - 5.08
		Y	13.80	12.94 - 14.66	12.64 - 14.96

I.D.		Season	Mean	95%	99%
4506	Klamath Falls 2 SSW	W	10.72	9.60 - 11.84	9.22 - 12.22
		S	3.30	2.78 - 3.82	2.60 - 4.00
		Y	14.02	12.82 - 15.22	12.40 - 15.64
4670	Lakeview 2 NNW	W	11.41	10.36 - 12.46	10.00 - 12.82
		S	4.33	3.81 - 4.85	3.63 - 5.03
		Y	15.74	14.51 - 16.95	14.09 - 17.37
5162	Malheur Refuge HDQ	W	5.87	5.23 - 6.51	5.01 - 6.73
		S	3.42	3.03 - 3.81	2.89 - 3.95
		Y	9.28	8.57 - 9.99	8.33 - 10.23
5362	McKenzie Bridge R. S.	W	59.32	55.16 - 63.48	53.73 - 64.91
		S	10.73	9.68 - 11.78	9.32 - 12.14
		Y	70.05	66.16 - 73.94	64.82 - 75.28
5424	Medford WSO AP	W	16.49	14.89 - 18.09	14.33 - 18.65
		S	3.48	2.91 - 4.05	2.72 - 4.24
		Y	19.97	18.31 - 21.63	17.73 - 22.21
6032	Newport	W	59.96	55.66 - 64.26	54.18 - 65.74
		S	10.35	9.09 - 11.61	8.65 - 12.05
		Y	70.31	65.99 - 74.63	64.50 - 76.12
6749	Portland KGW-TV	W	35.99	33.35 - 38.63	32.43 - 39.55
		S	7.28	6.40 - 8.16	6.10 - 8.46
		Y	43.26	40.73 - 45.49	39.86 - 46.66
7331	Roseburg KQEN	W	28.49	26.19 - 30.79	25.40 - 31.58
		S	4.60	4.00 - 5.22	3.79 - 5.43
		Y	33.10	30.80 - 35.40	30.01 - 36.19
8797	Vale	W	6.46	5.83 - 7.09	5.61 - 7.31
		S	2.95	2.57 - 3.33	2.43 - 3.47
		Y	9.41	8.67 - 10.15	8.42 - 10.40
8997	Wallowa	W	11.98	11.05 - 12.91	10.72 - 13.24
		S	6.35	5.80 - 6.90	5.61 - 7.09
		Y	18.32	17.28 - 19.36	16.92 - 19.72
9068	Wasco	W	8.95	8.10 - 9.80	7.81 - 10.09
		S	2.48	2.18 - 2.78	2.07 - 2.89
		Y	11.43	10.54 - 12.32	10.23 - 12.63

(WASHINGTON)

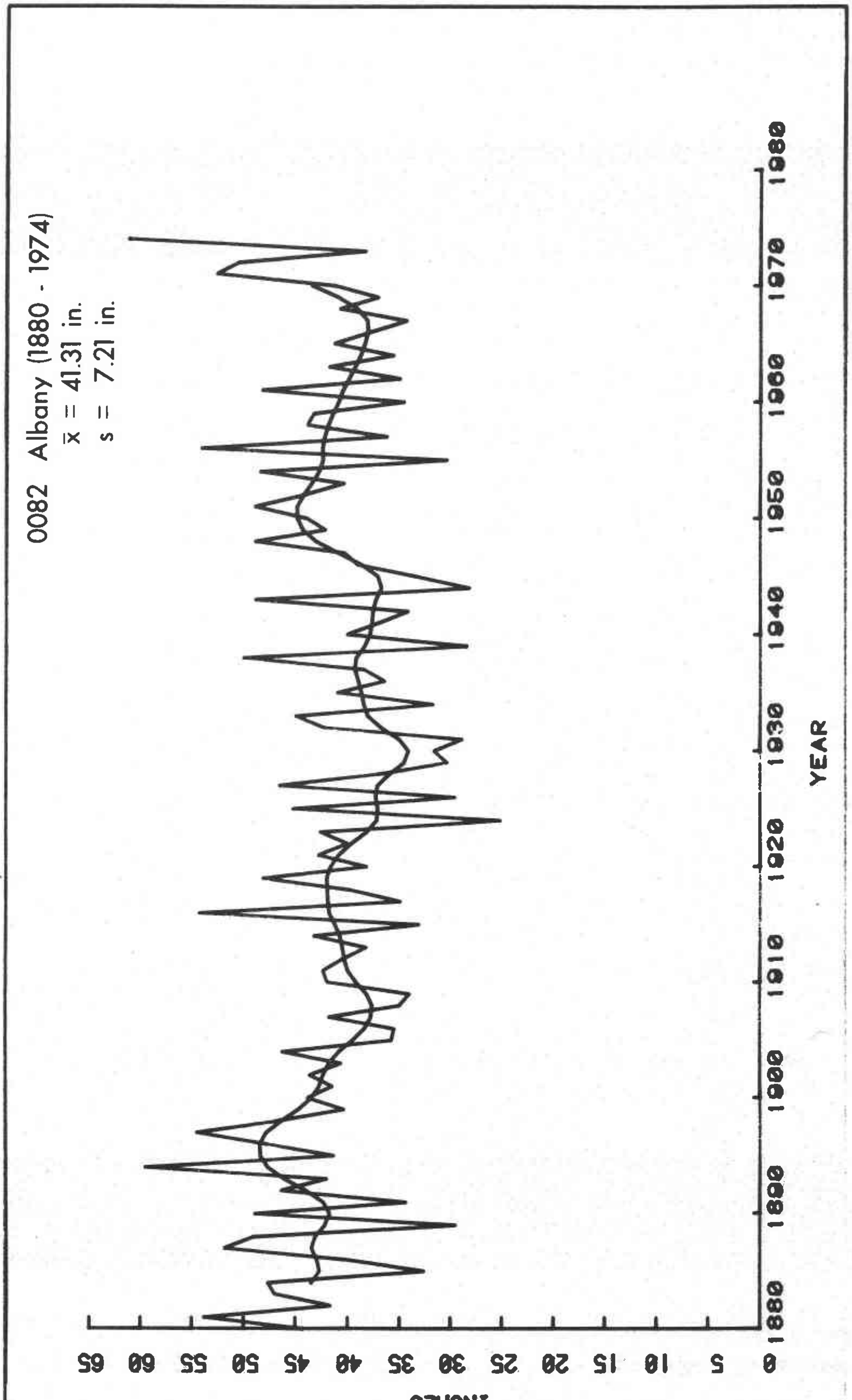
I.D.		Season	Mean	95%	99%
0008	Aberdeen	W	68.10	63.97 - 72.23	62.54 - 73.66
		S	13.04	11.77 - 14.31	11.33 - 14.75
		Y	81.14	76.99 - 85.29	75.56 - 86.72
0564	Bellingham 2 N	W	26.03	24.29 - 27.77	23.70 - 28.36
		S	8.29	7.51 - 9.05	7.25 - 9.31
		Y	34.32	32.28 - 36.36	31.57 - 37.07
1233	Cedar Lake	W	80.63	75.87 - 85.39	74.24 - 87.02
		S	22.07	20.11 - 24.03	19.44 - 24.70
		Y	102.70	97.45 -107.95	95.65 -109.75
1395	Chewelah	W	14.15	13.01 - 15.64	12.62 - 15.68
		S	6.11	5.43 - 6.79	5.19 - 7.03
		Y	20.26	18.98 - 21.54	18.54 - 21.98
1767	Coulee Dam 1 SW	W	6.91	6.27 - 7.55	6.05 - 7.77
		S	3.60	2.93 - 4.27	2.65 - 4.55
		Y	10.50	9.52 - 11.48	9.18 - 11.82
2157	Diablo Dam	W	68.85	58.12 - 67.58	56.50 - 69.20
		S	11.67	10.55 - 12.79	10.17 - 13.17
		Y	74.52	69.43 - 79.61	67.68 - 81.36
2914	Forks 1 E	W	97.78	91.52 -104.04	96.67 -101.89
		S	18.42	16.80 - 20.04	16.24 - 20.60
		Y	116.20	109.71 -122.69	107.48 -124.92
4446	Lake Wenatchee	W	35.37	32.54 - 38.20	31.57 - 39.17
		S	4.78	4.16 - 5.40	3.94 - 5.62
		Y	40.15	37.26 - 43.02	36.27 - 44.01
4549	Laurier	W	11.94	11.05 - 12.83	10.75 - 13.13
		S	7.44	6.57 - 8.31	6.27 - 8.61
		Y	19.38	19.10 - 20.66	17.66 - 21.10
5128	Mazama 6 SE	W	15.24	13.88 - 16.60	13.41 - 17.07
		S	4.23	3.41 - 4.79	3.18 - 5.02
		Y	19.47	17.85 - 21.09	16.90 - 21.64
5613	Moses Lake 3 E	W	5.78	5.19 - 6.37	4.98 - 6.58
		S	2.45	2.07 - 2.83	1.97 - 2.93
		Y	8.23	7.45 - 9.01	7.19 - 9.27
5801	Neah Bay 1 E	W	84.76	78.84 - 90.68	76.80 - 92.72
		S	16.17	14.79 - 17.55	14.32 - 18.02
		Y	100.93	94.68 -107.18	92.53 -108.93

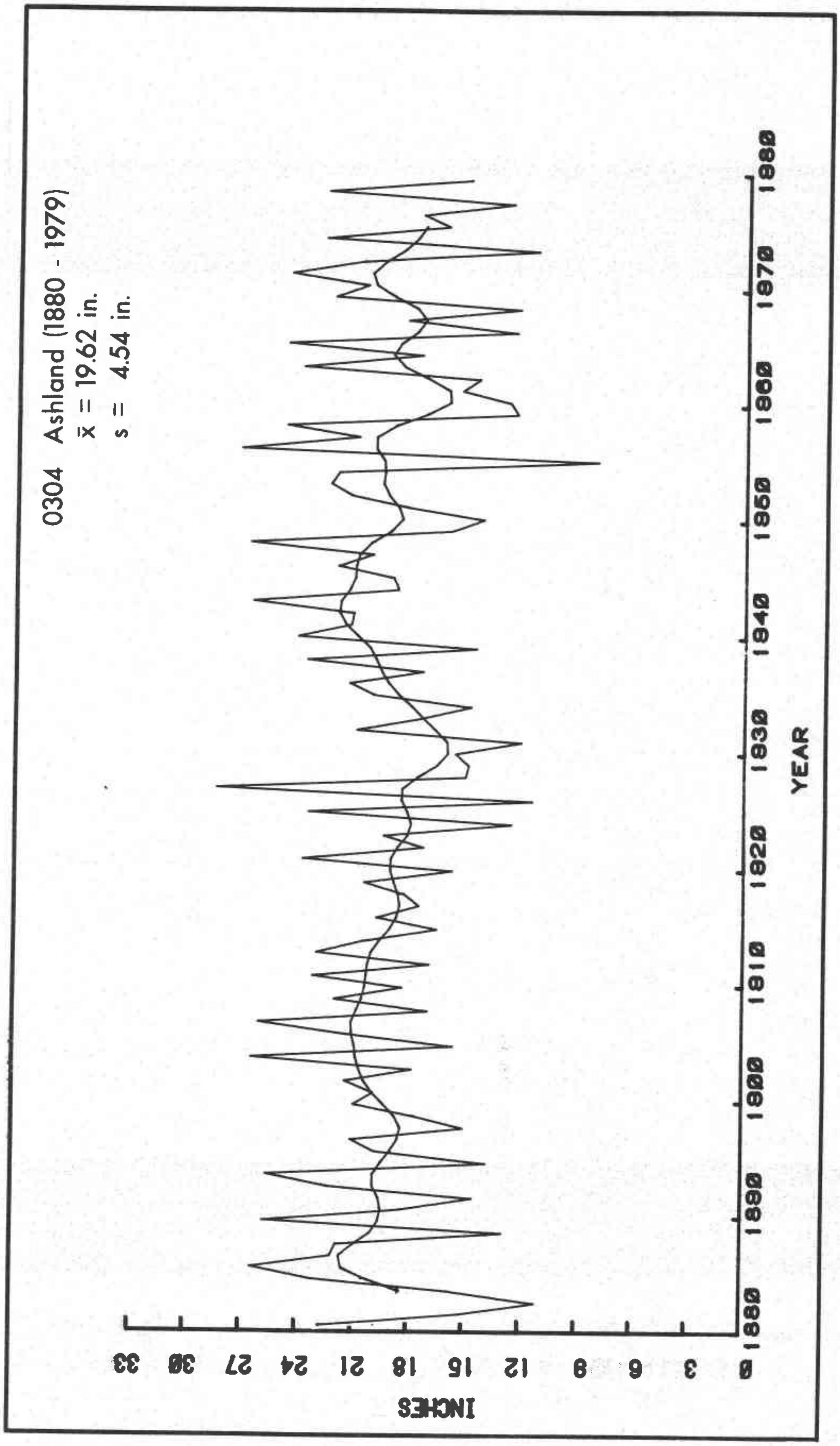
I.D.		Season	Mean	95%	99%
6114	Olympia	W	41.39	38.06 - 44.73	36.93 - 45.87
	WSO AP	S	7.75	6.81 - 8.69	6.48 - 9.02
		Y	49.14	45.75 - 52.53	44.59 - 53.95
6624	Port	W	20.44	18.90 - 21.98	18.38 - 22.50
	Angeles	S	4.21	3.79 - 4.63	3.65 - 4.77
		Y	24.65	23.02 - 26.28	22.46 - 26.84
6896	Rainier	W	65.87	61.09 - 70.65	59.45 - 72.29
	Ohanapecosh	S	11.07	9.94 - 11.20	9.55 - 12.59
		Y	76.94	72.15 - 81.73	74.80 - 79.08
7038	Rimrock	W	21.61	19.51 - 23.61	18.79 - 24.43
	(Tieton Dam)	S	3.51	3.06 - 3.96	3.45 - 4.12
		Y	25.12	22.87 - 27.37	22.09 - 28.15
7180	Rosalia	W	12.79	11.80 - 13.78	11.46 - 14.12
		S	5.23	4.59 - 5.87	4.37 - 6.09
		Y	18.02	16.72 - 19.32	16.27 - 19.77
7478	Seattle-	W	28.62	26.86 - 30.38	26.26 - 30.98
	Univ. of	S	6.93	6.12 - 7.01	5.85 - 7.01
	Wash.	Y	35.56	33.62 - 37.50	32.96 - 38.16
8931	Walla Walla	W	11.69	10.81 - 12.57	10.51 - 12.87
	WSO Cl	S	4.34	3.79 - 4.89	3.60 - 5.08
		Y	16.03	15.12 - 16.94	14.81 - 17.25
9465	Yakima	W	5.93	5.28 - 6.58	5.05 - 6.81
	WSO AP	S	1.96	1.63 - 2.29	1.51 - 2.41
		Y	7.90	7.19 - 8.61	6.94 - 8.86

APPENDIX E

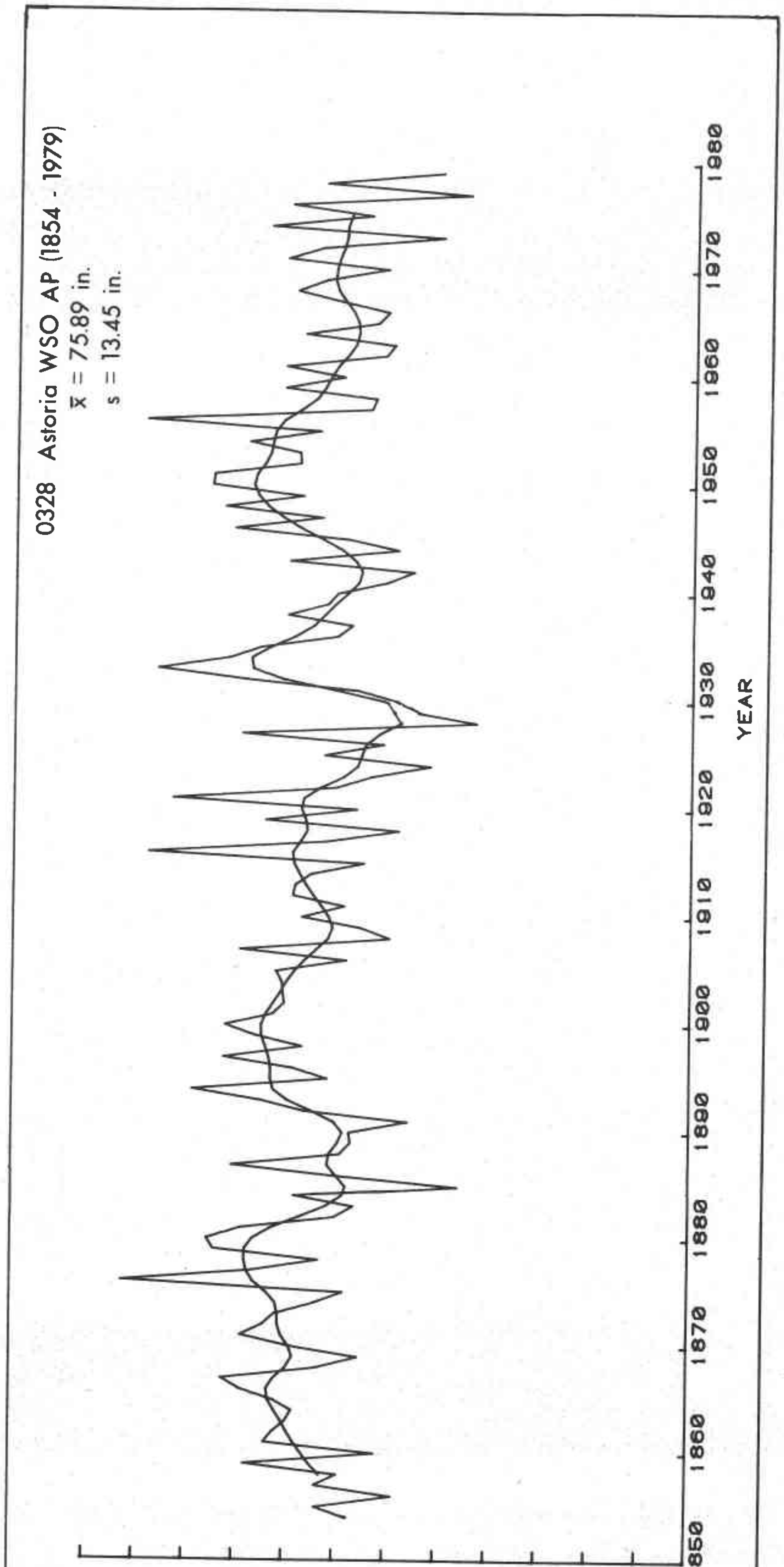
PRECIPITATION DATA SERIES FOR LONG-TERM STATIONS
DATA ARE ANNUAL TOTALS
SERIES ARE SMOOTHED WITH 9-TERM WEIGHTED MEAN

Western Oregon

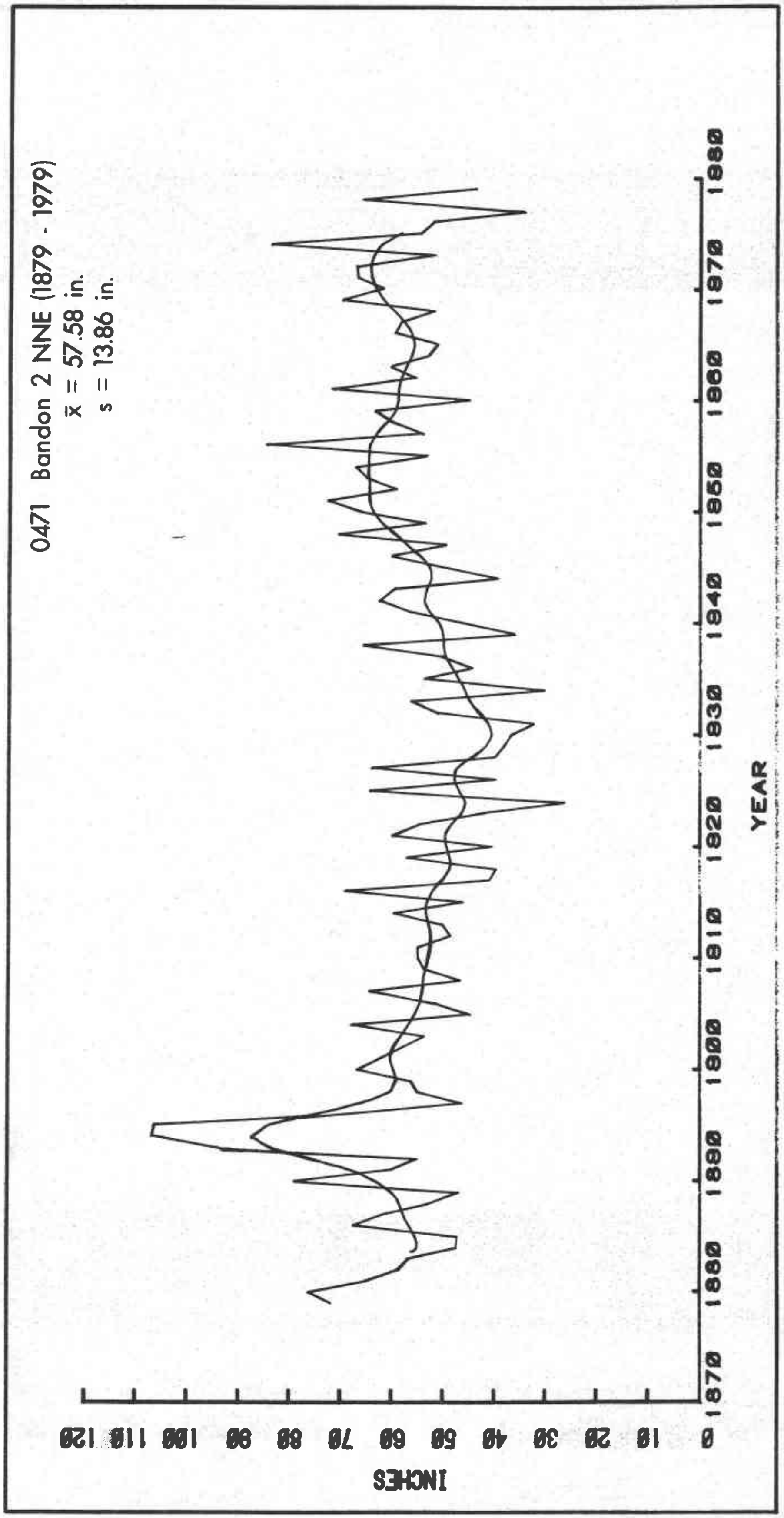

0082 Albany (1880 - 1974)
x̄ = 41.31 in.
s = 7.21 in.
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
INCHES
0 5 10 15 20 25 30 35 40 45 50 55 60 65

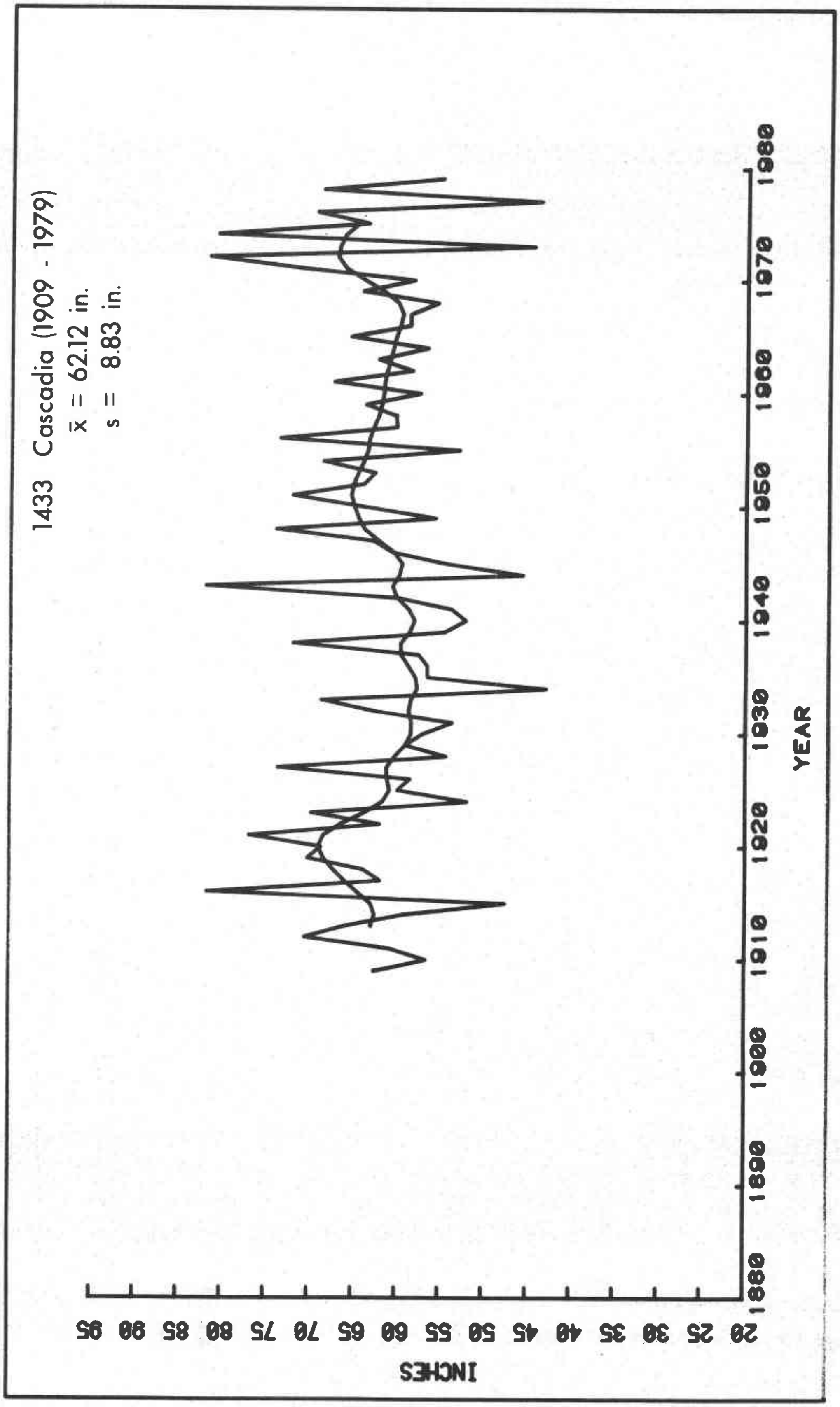


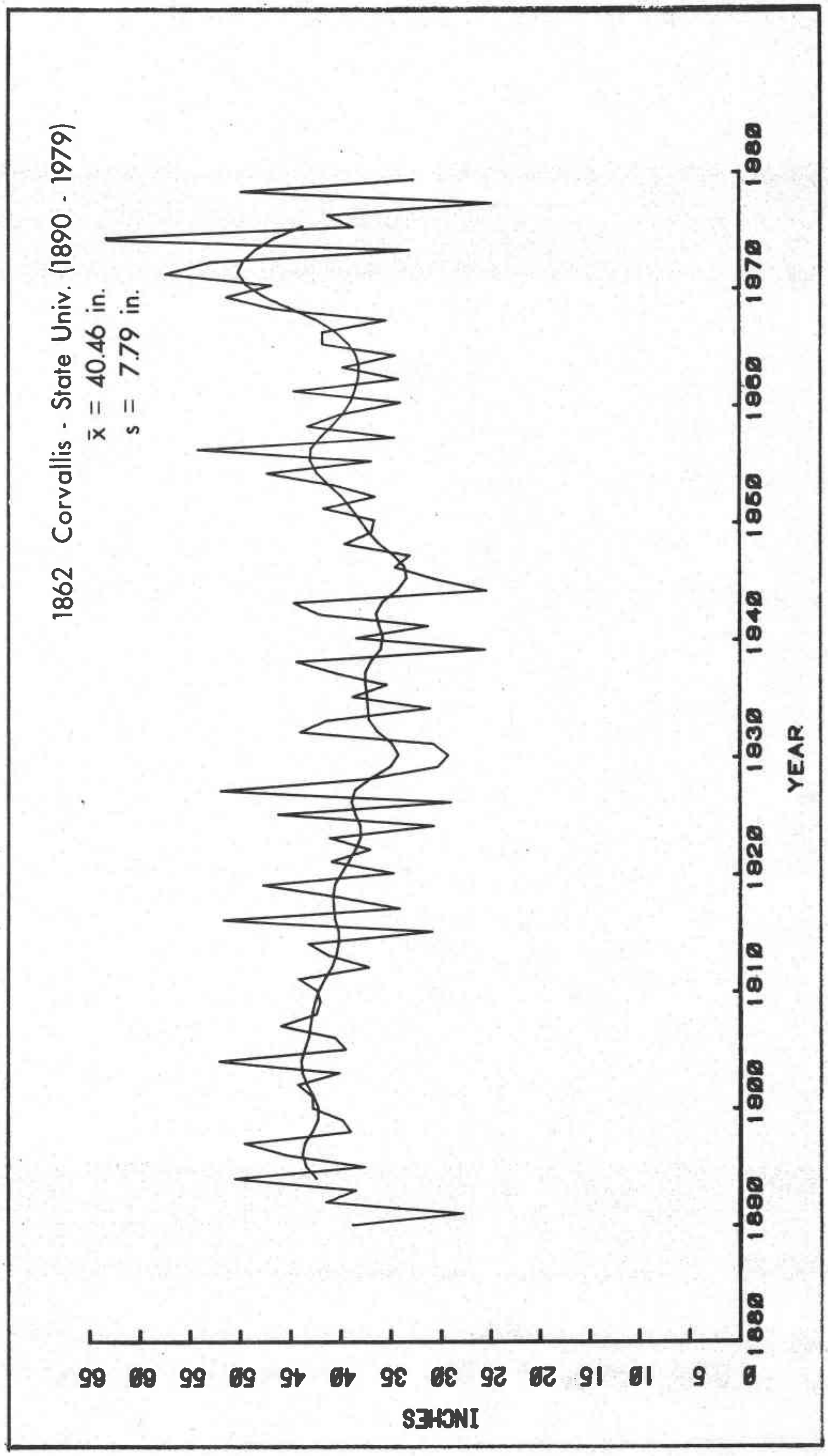
0304 Ashland (1880 - 1979)
x̄ = 19.62 in.
s = 4.54 in.
INCHES
0
3
6
9
12
15
18
21
24
27
30
33
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

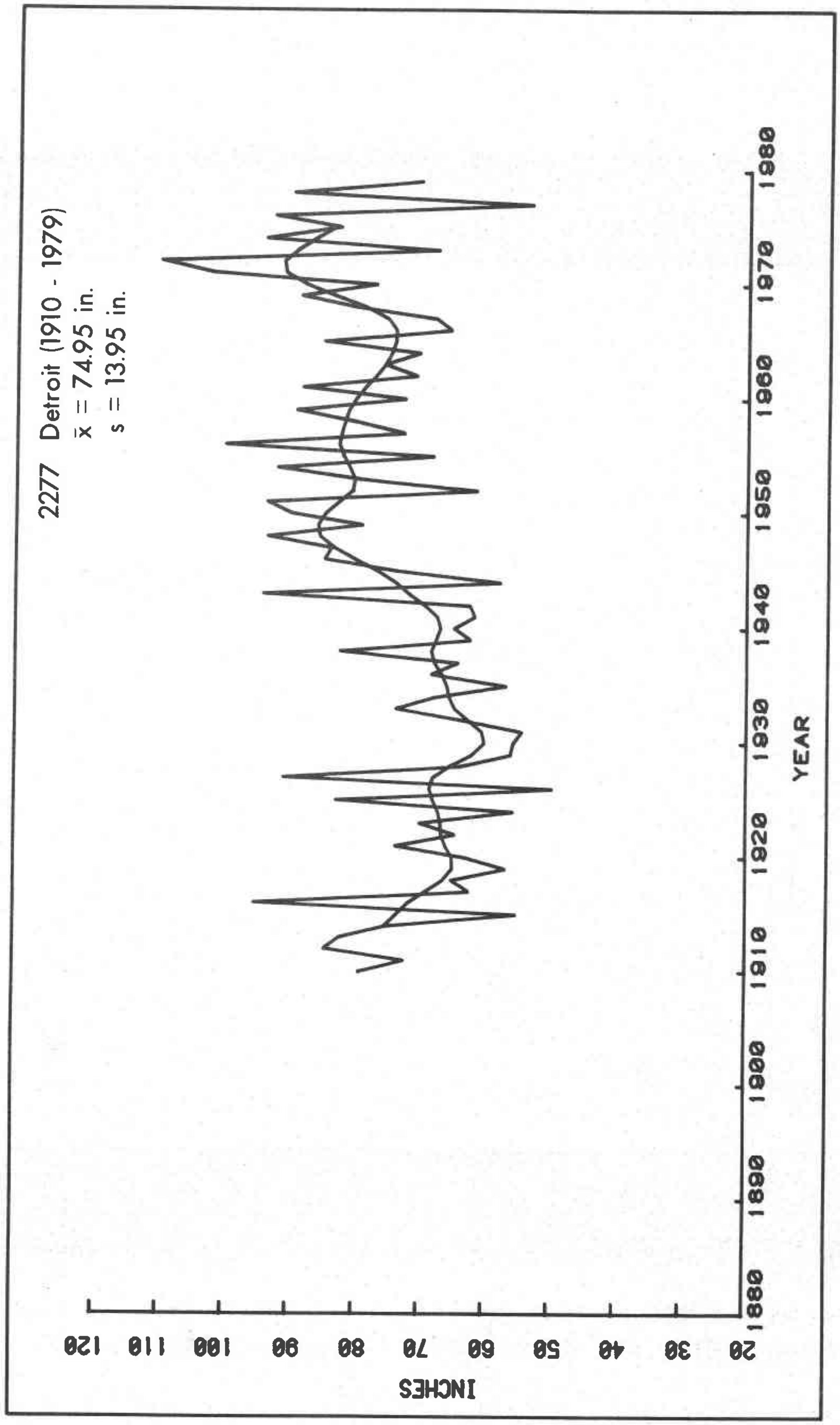


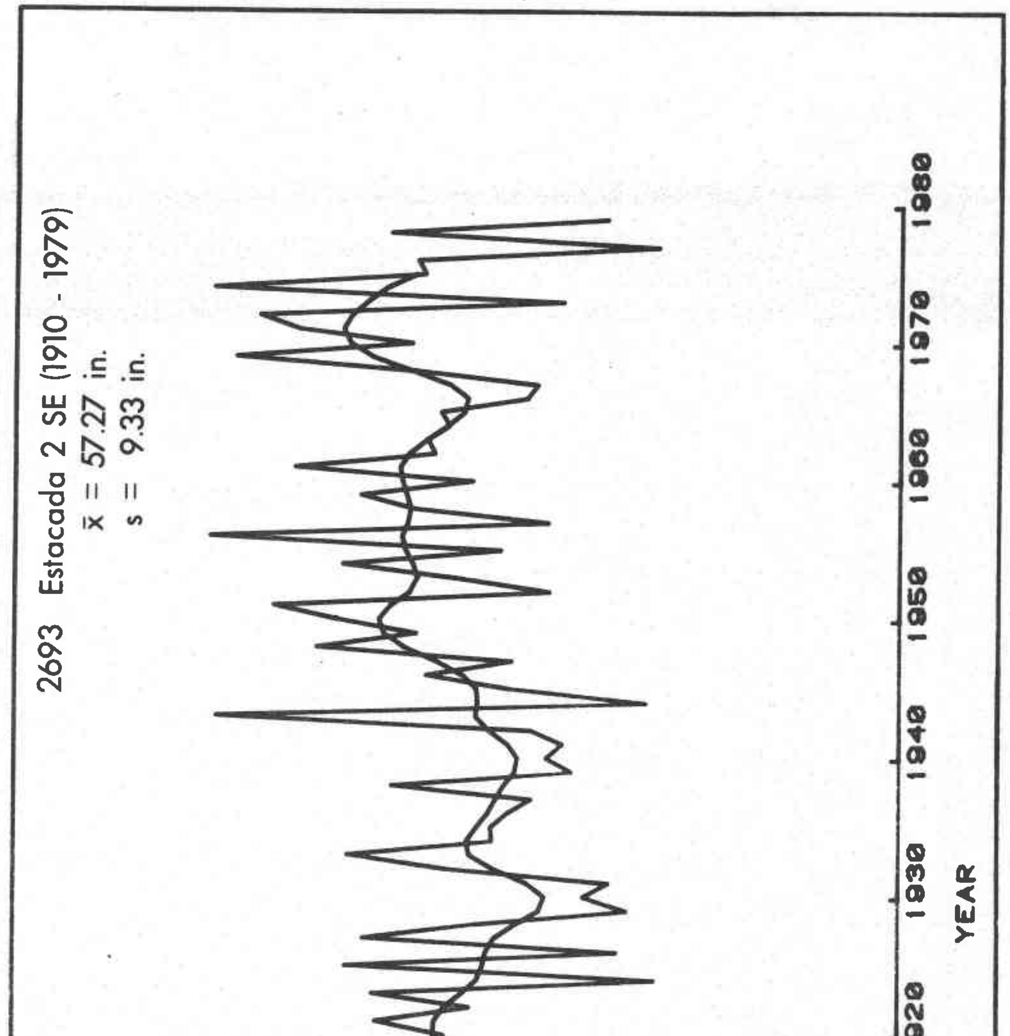
0328 Astoria WSO AP (1854 - 1979)
x̄ = 75.89 in.
s = 13.45 in.
YEAR
INCHES
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
0
10
20
30
40
50
60
70
80
90
100
110
120


0471 Bandon 2 NNE (1879 - 1979)
x̄ = 57.58 in.
s = 13.86 in.
YEAR
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
INCHES
0
10
20
30
40
50
60
70
80
90
100
110
120

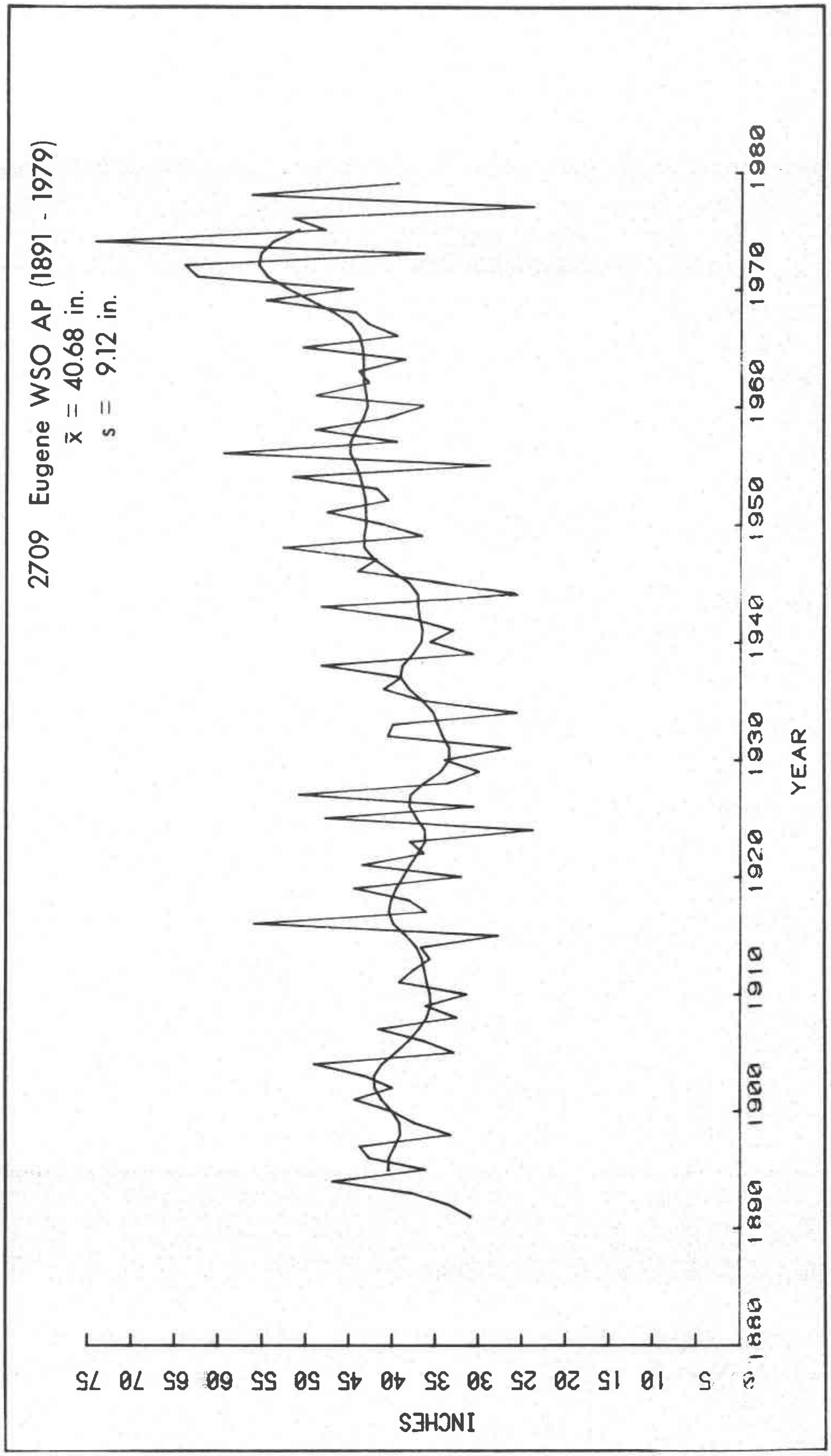

1433 Cascadia (1909 - 1979)
$\bar{x}$ = 62.12 in.
s = 8.83 in.
INCHES
20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980

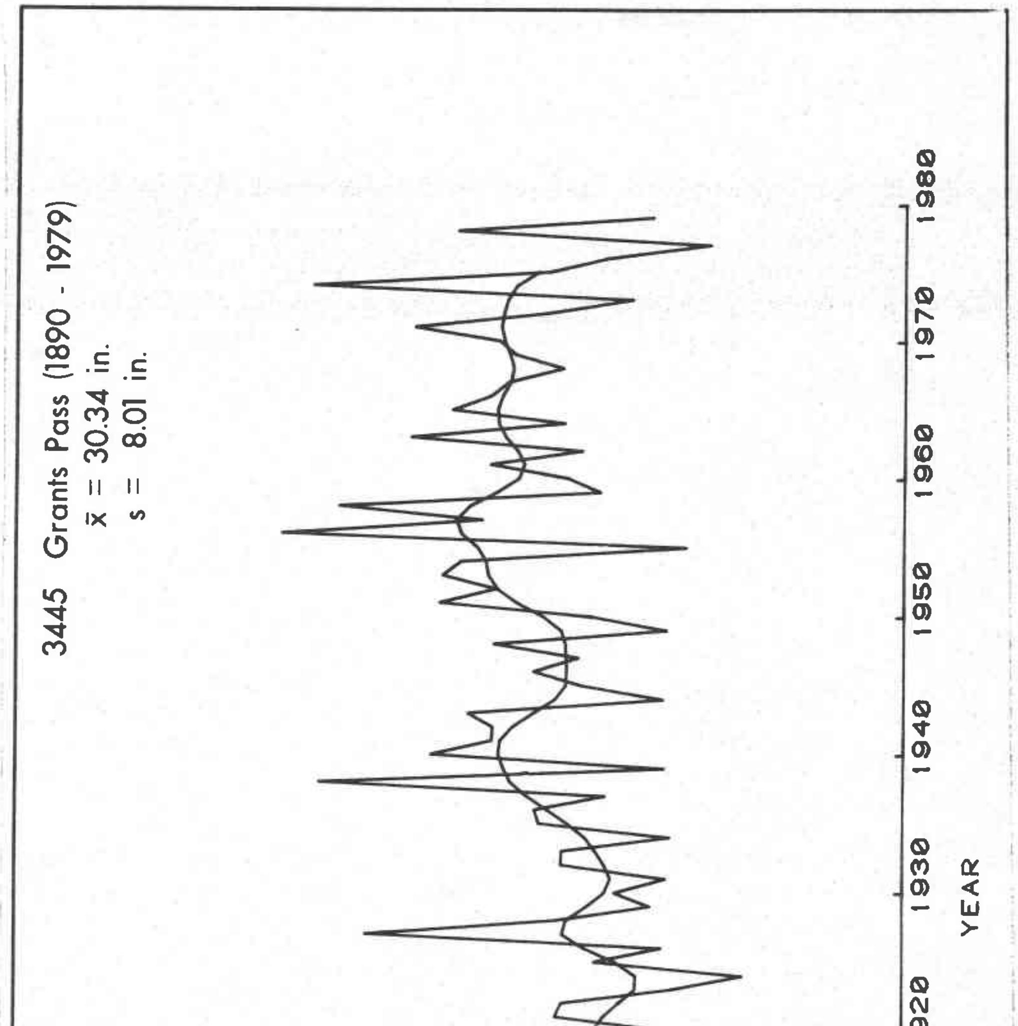

1862 Corvallis - State Univ. (1890 - 1979)
x̄ = 40.46 in.
s = 7.79 in.
INCHES
0 5 10 15 20 25 30 35 40 45 50 55 60 65
YEAR
1860 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980

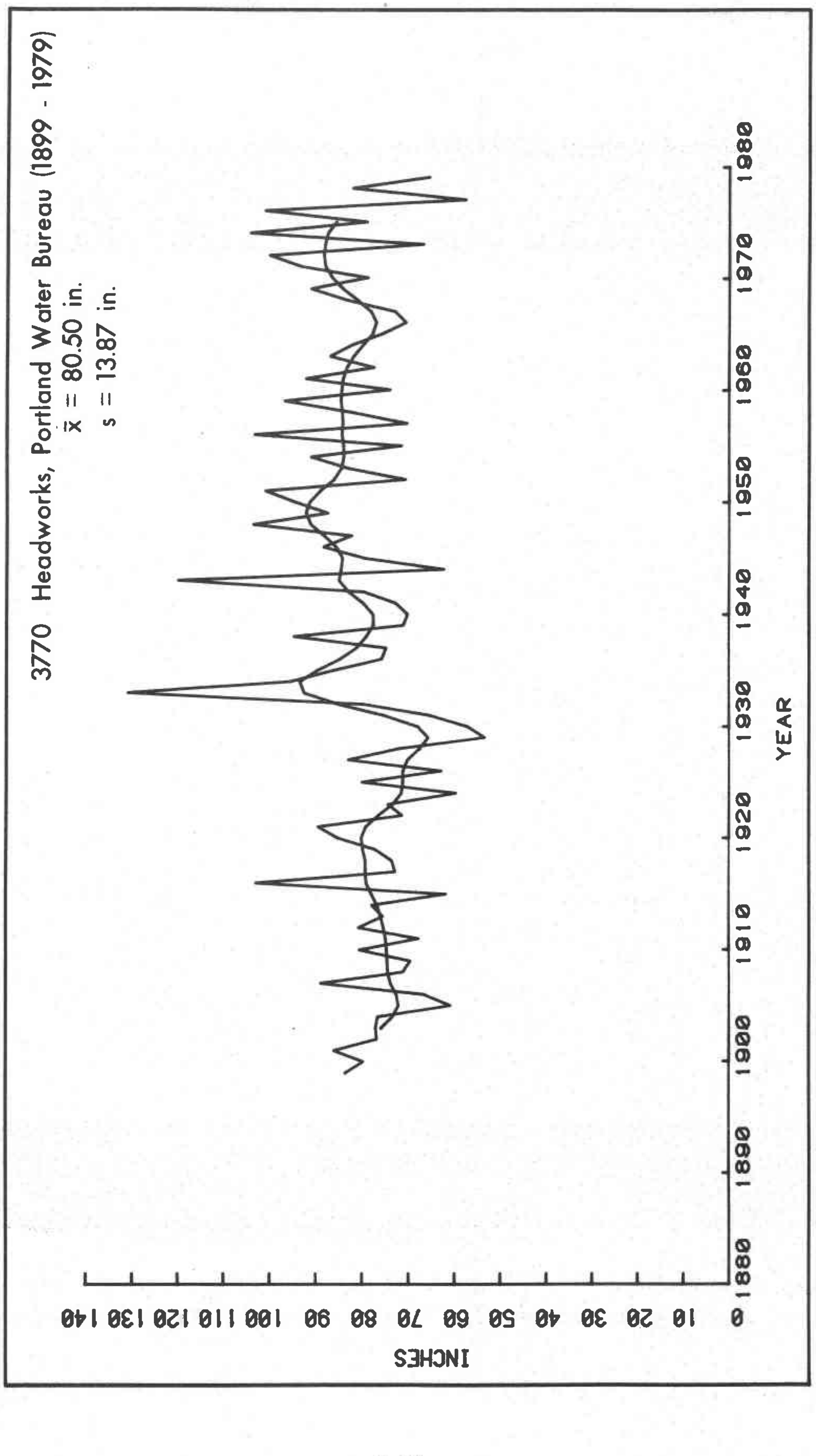

2277 Detroit (1910 - 1979)
x̄ = 74.95 in.
s = 13.95 in.
INCHES
20
30
40
50
60
70
80
90
100
110
120
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980



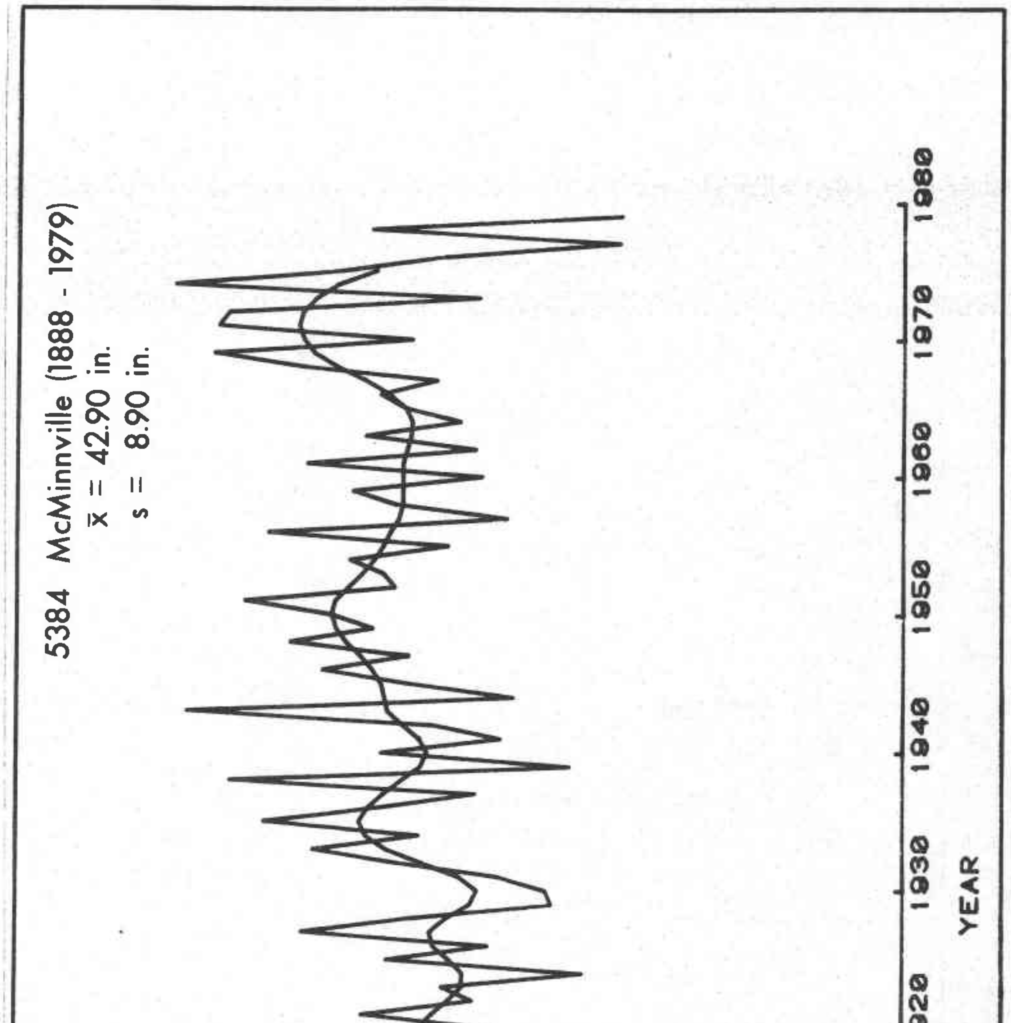
2693 Estacada 2 SE (1910 - 1979)
x̄ = 57.27 in.
s = 9.33 in.
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
INCHES
20 25 30 35 40 45 50 55 60 65 70 75 80 85

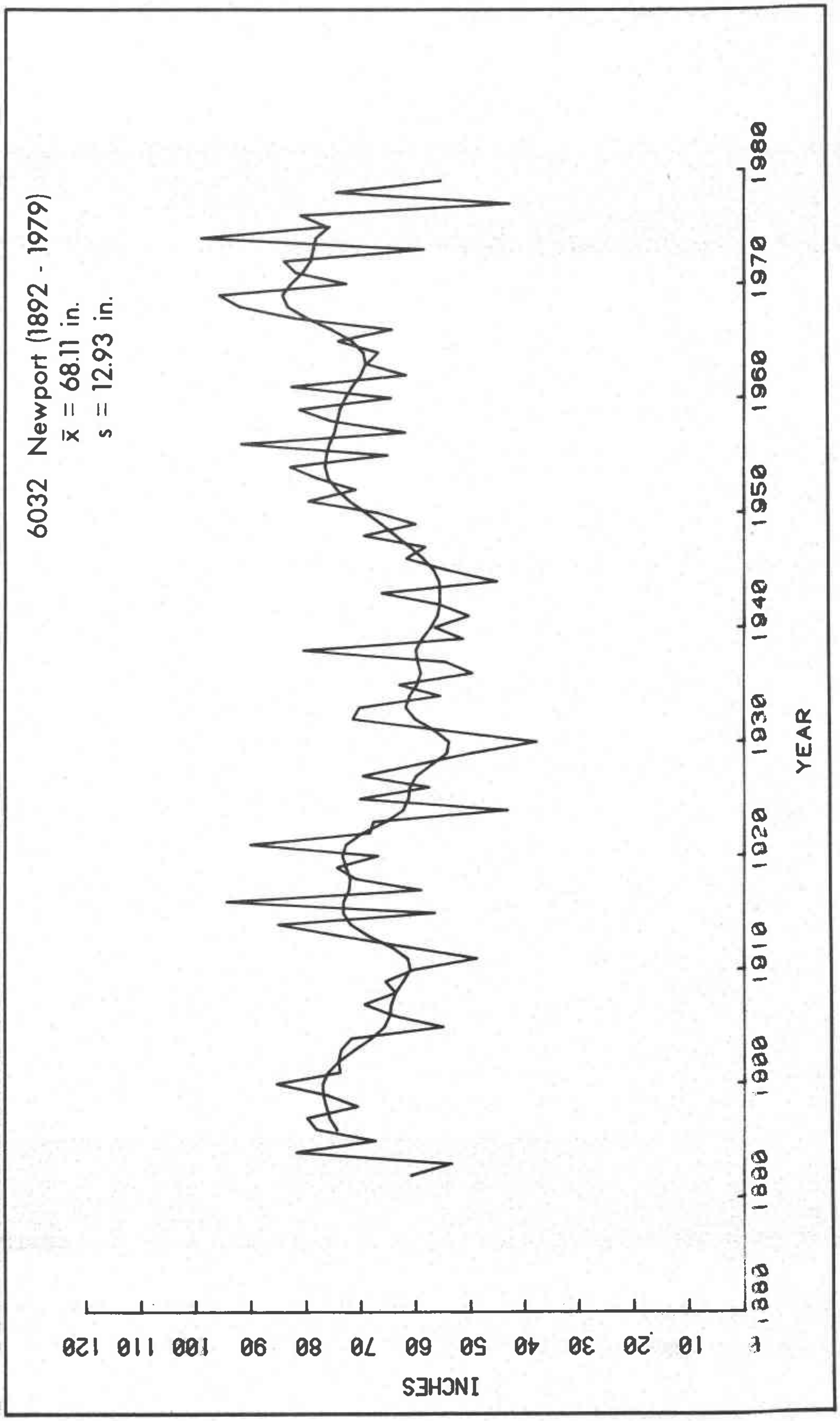

2709 Eugene WSO AP (1891 - 1979)
x̄ = 40.68 in.
s = 9.12 in.
INCHES
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980


3445 Grants Pass (1890 - 1979)
x̄ = 30.34 in.
s = 8.01 in.
YEAR
INCHES
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
0 5 10 15 20 25 30 35 40 45 50 55 60 65

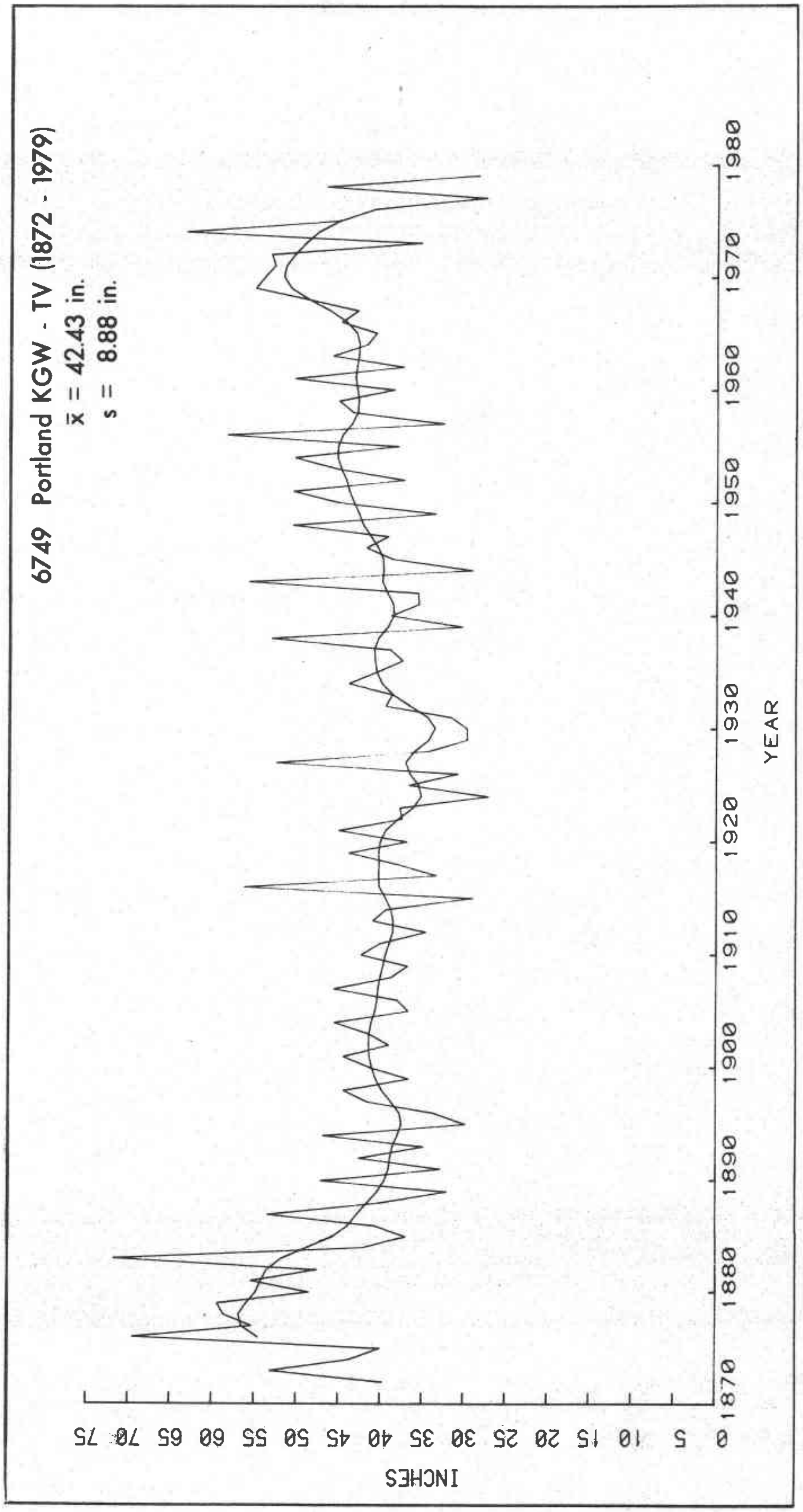


3770 Headworks, Portland Water Bureau (1899 - 1979)
$\bar{x}$ = 80.50 in.
s = 13.87 in.
INCHES
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

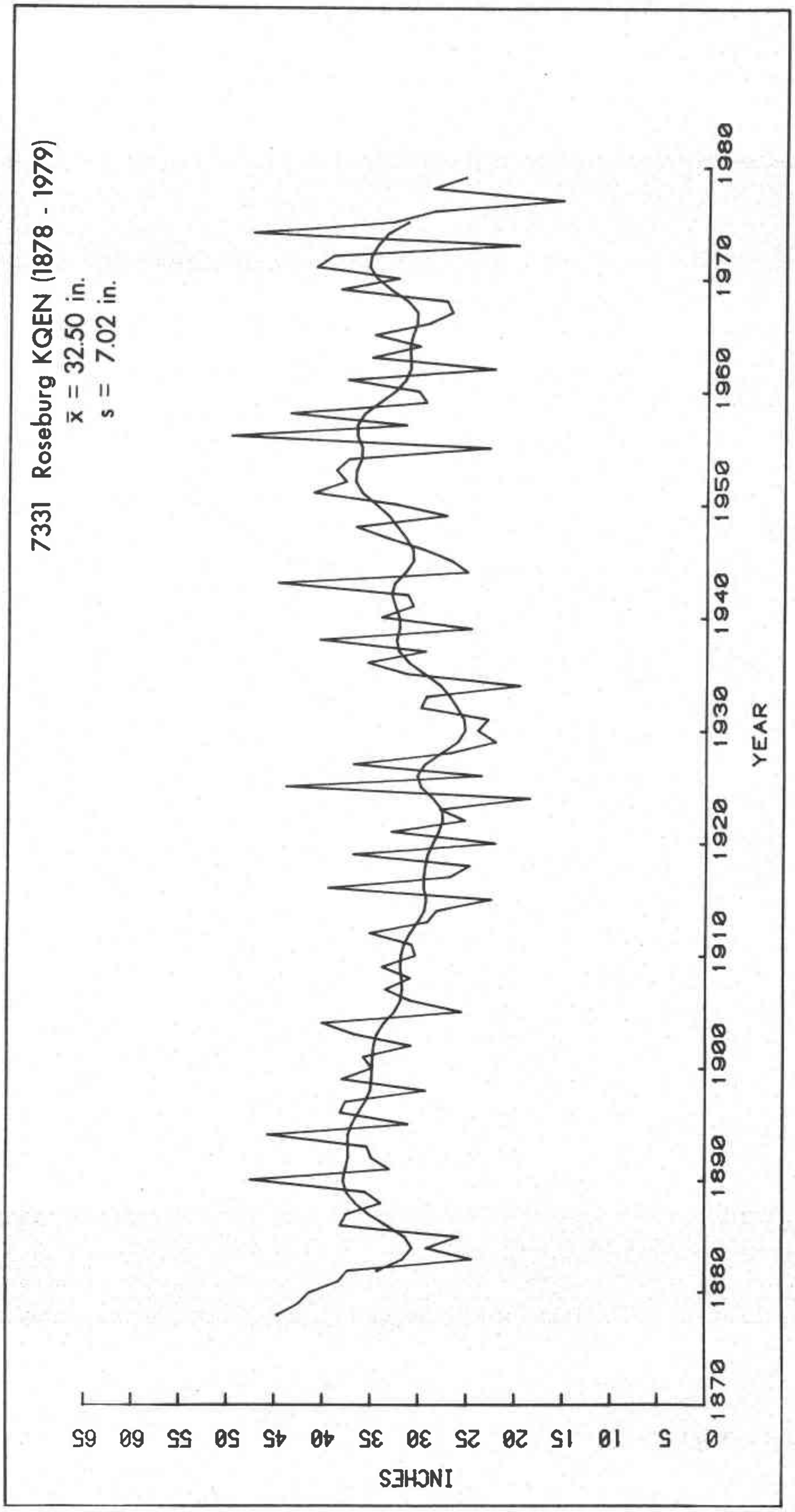

5384 McMinnville (1888 - 1979)
x̄ = 42.90 in.
s = 8.90 in.
INCHES
0 5 10 15 20 25 30 35 40 45 50 55 60 65
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980

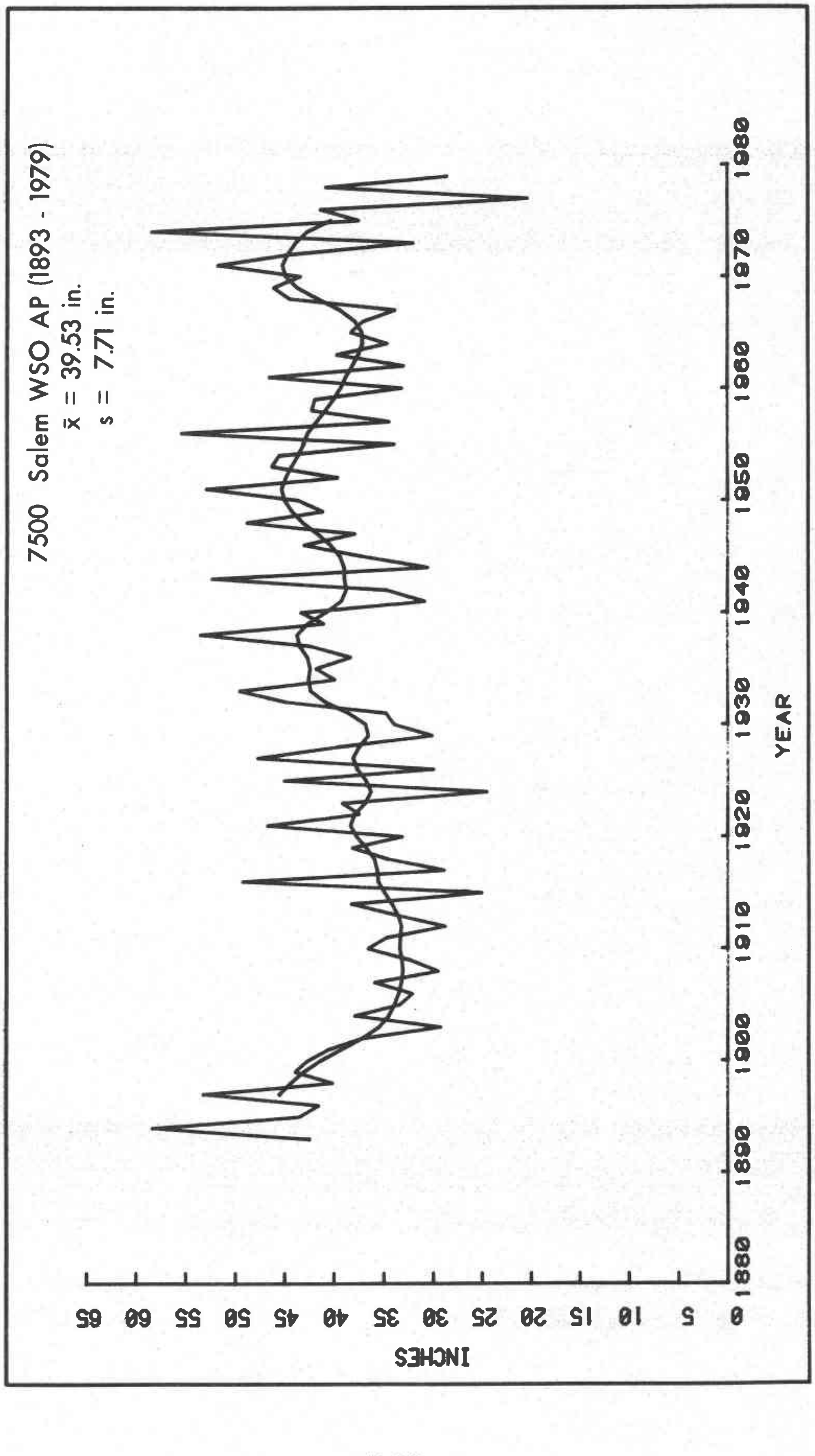


6032 Newport (1892 - 1979)
$\bar{x}$ = 68.11 in.
s = 12.93 in.
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
INCHES
0 10 20 30 40 50 60 70 80 90 100 110 120

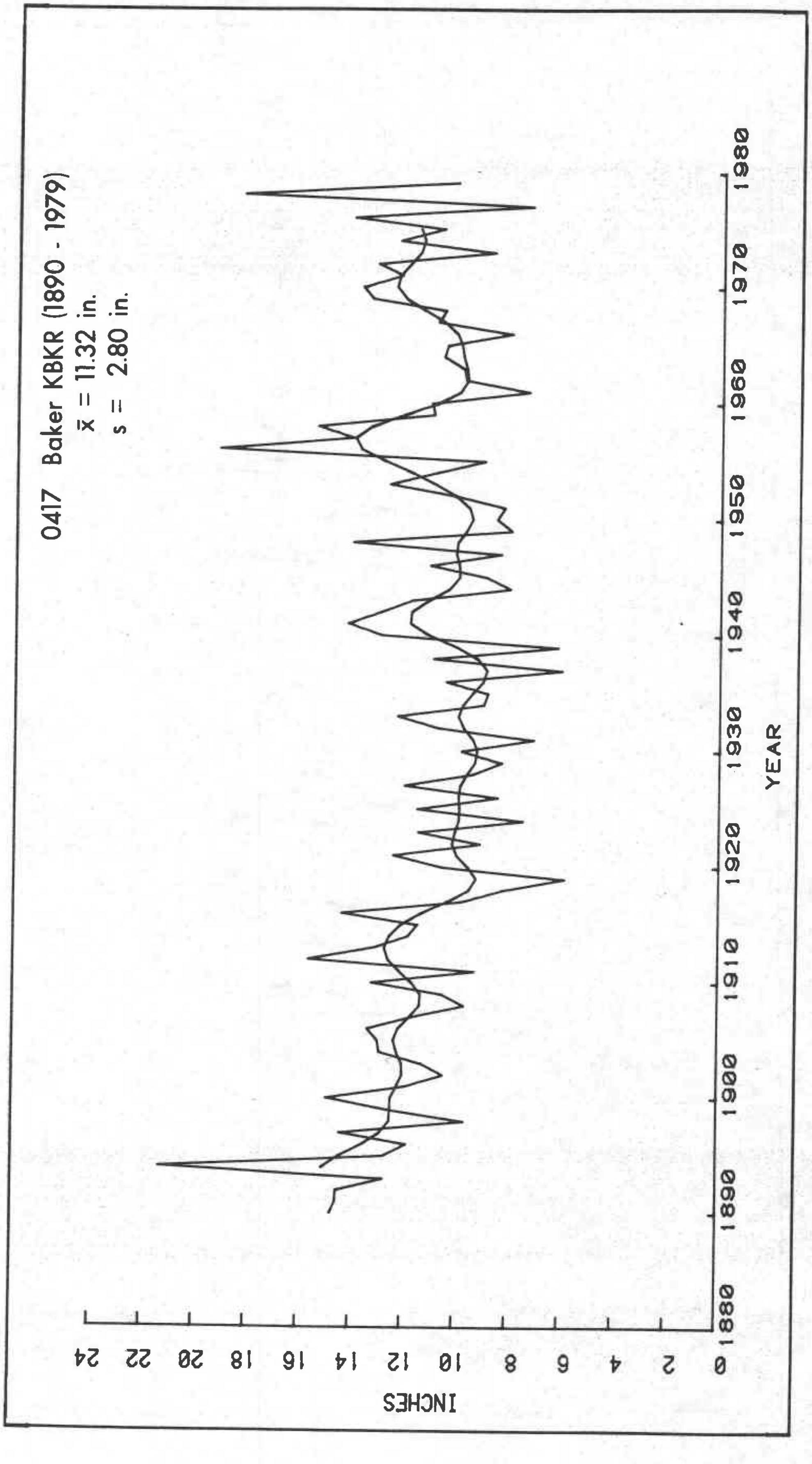


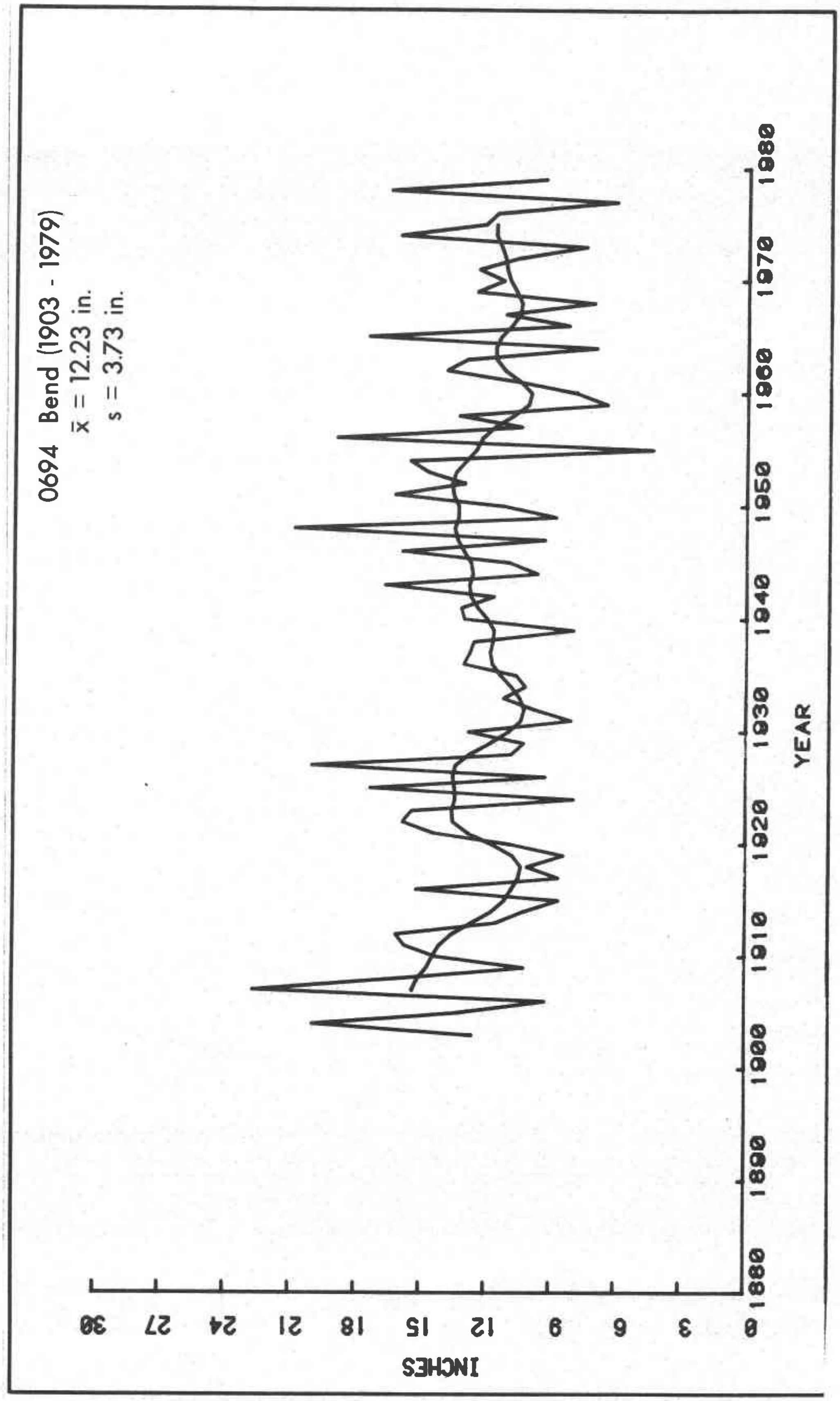
6749 Portland KGW - TV (1872 - 1979)
x̄ = 42.43 in.
s = 8.88 in.
YEAR
1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
INCHES
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75

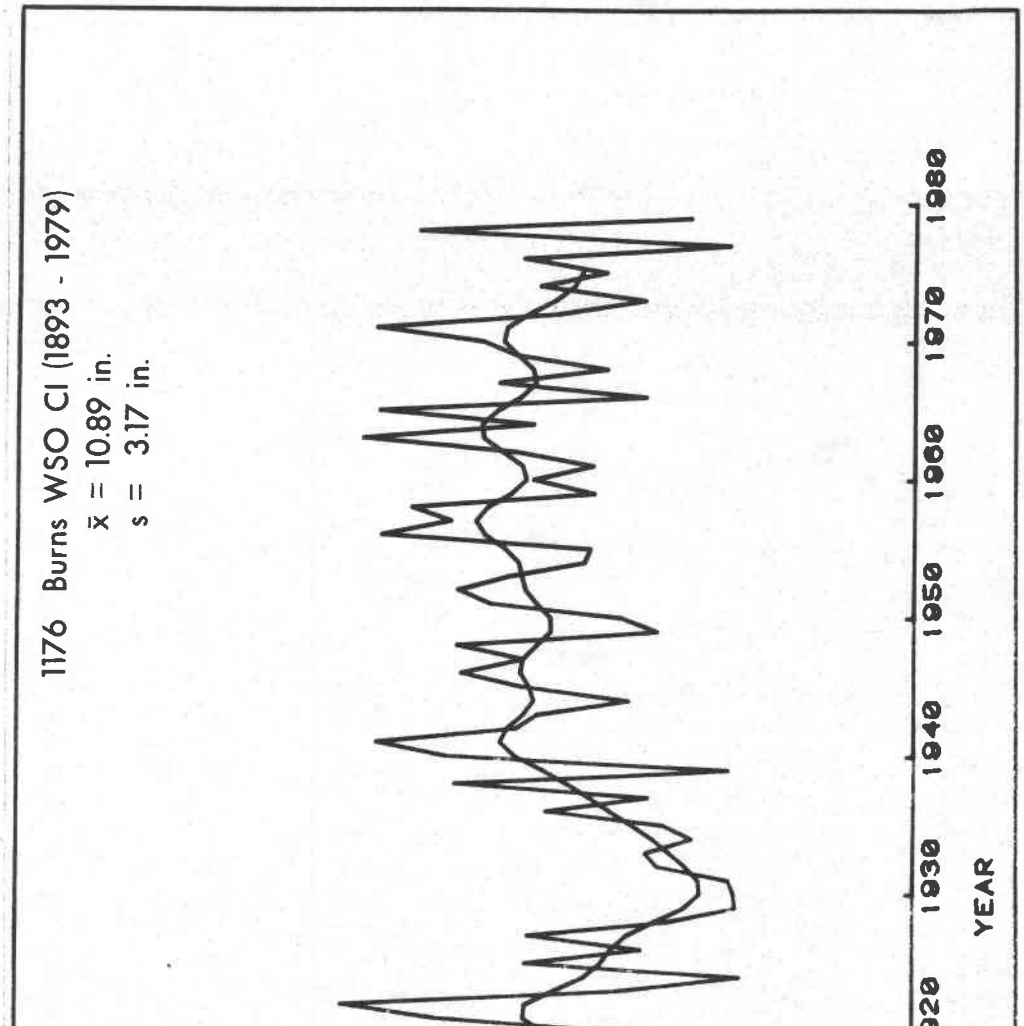

7331 Roseburg KQEN (1878 - 1979)
$\bar{x}$ = 32.50 in.
s = 7.02 in.
INCHES
0
5
10
15
20
25
30
35
40
45
50
55
60
65
YEAR
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

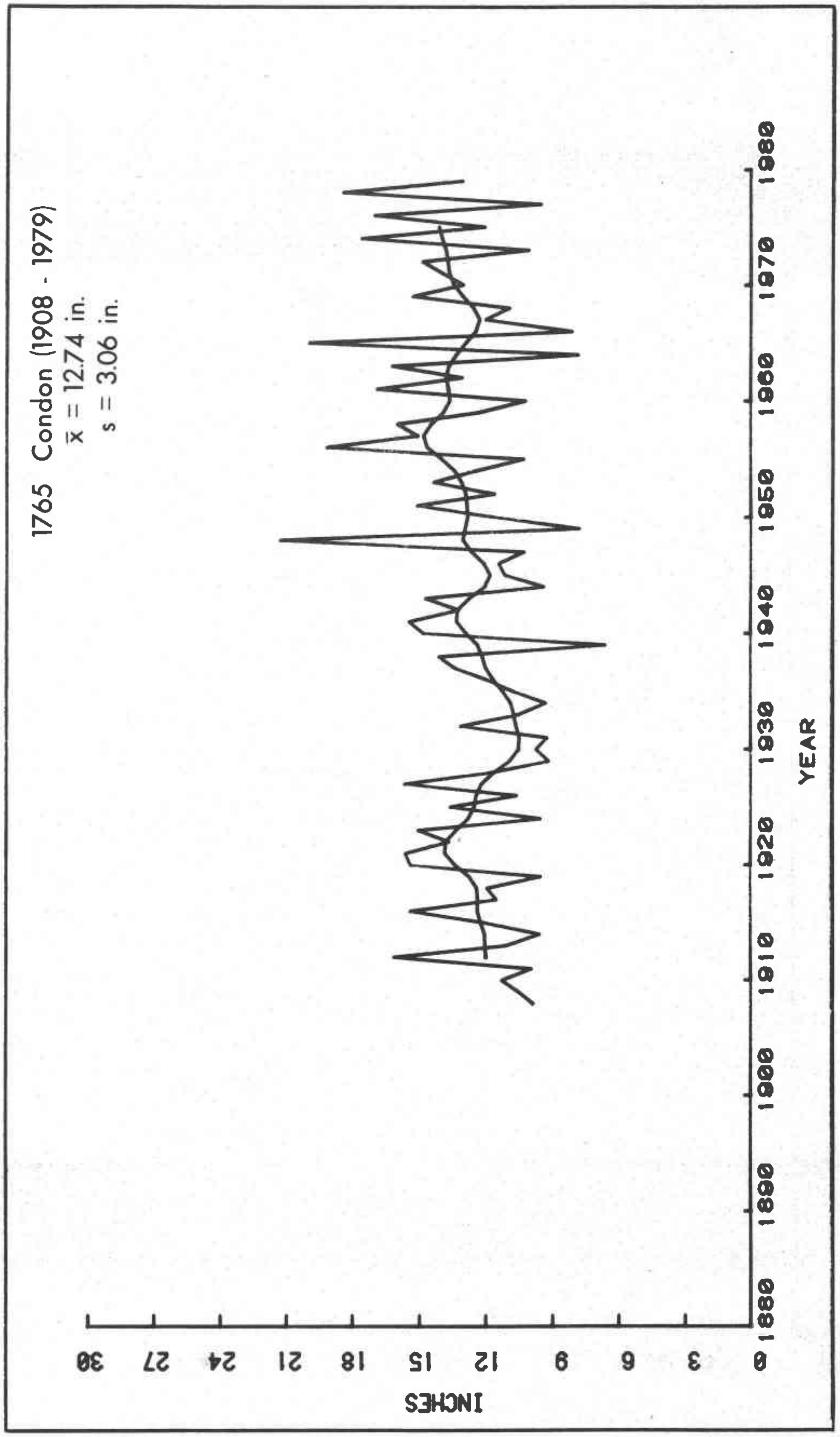

7500 Salem WSO AP (1893 - 1979)
x̄ = 39.53 in.
s = 7.71 in.
INCHES
0 5 10 15 20 25 30 35 40 45 50 55 60 65
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980

Eastern Oregon

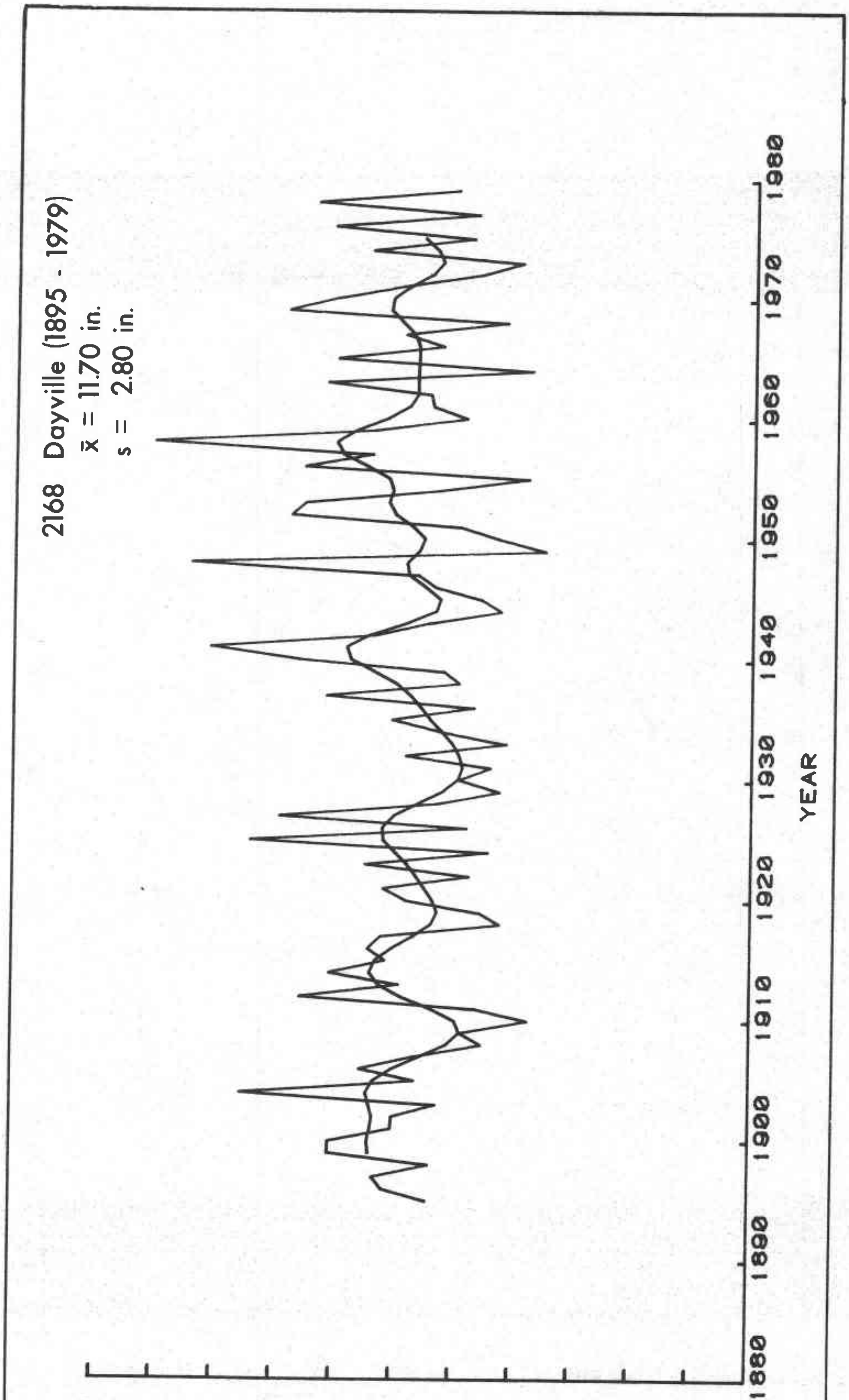

0417 Baker KBKR (1890 - 1979)
x̄ = 11.32 in.
s = 2.80 in.
INCHES
0
2
4
6
8
10
12
14
16
18
20
22
24
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980


0694 Bend (1903 - 1979)
x̄ = 12.23 in.
s = 3.73 in.
INCHES
0
3
6
9
12
15
18
21
24
27
30
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

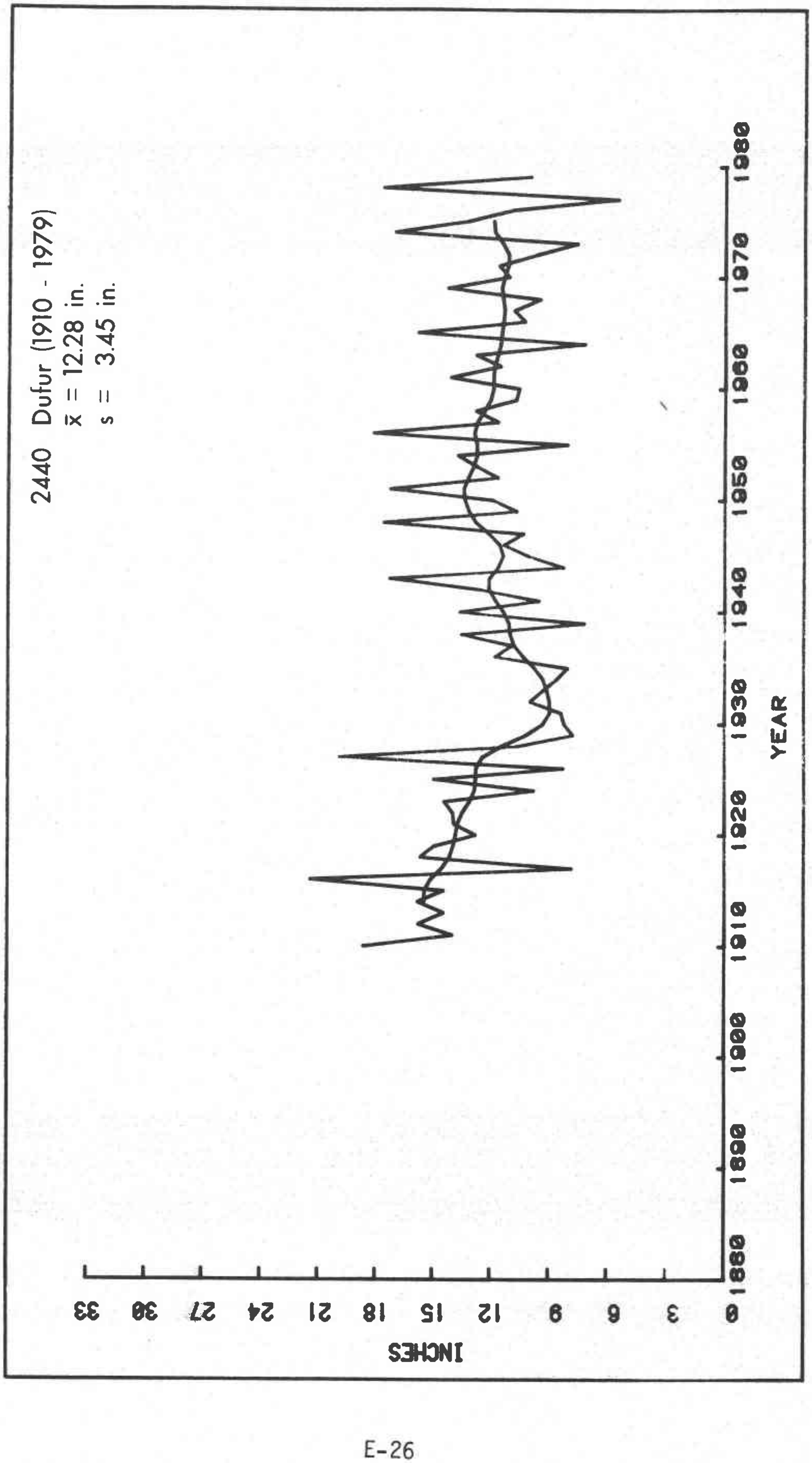

1176 Burns WSO CI (1893 - 1979)
$\bar{x}$ = 10.89 in.
s = 3.17 in.
INCHES
0
2
4
6
8
10
12
14
16
18
20
22
24
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

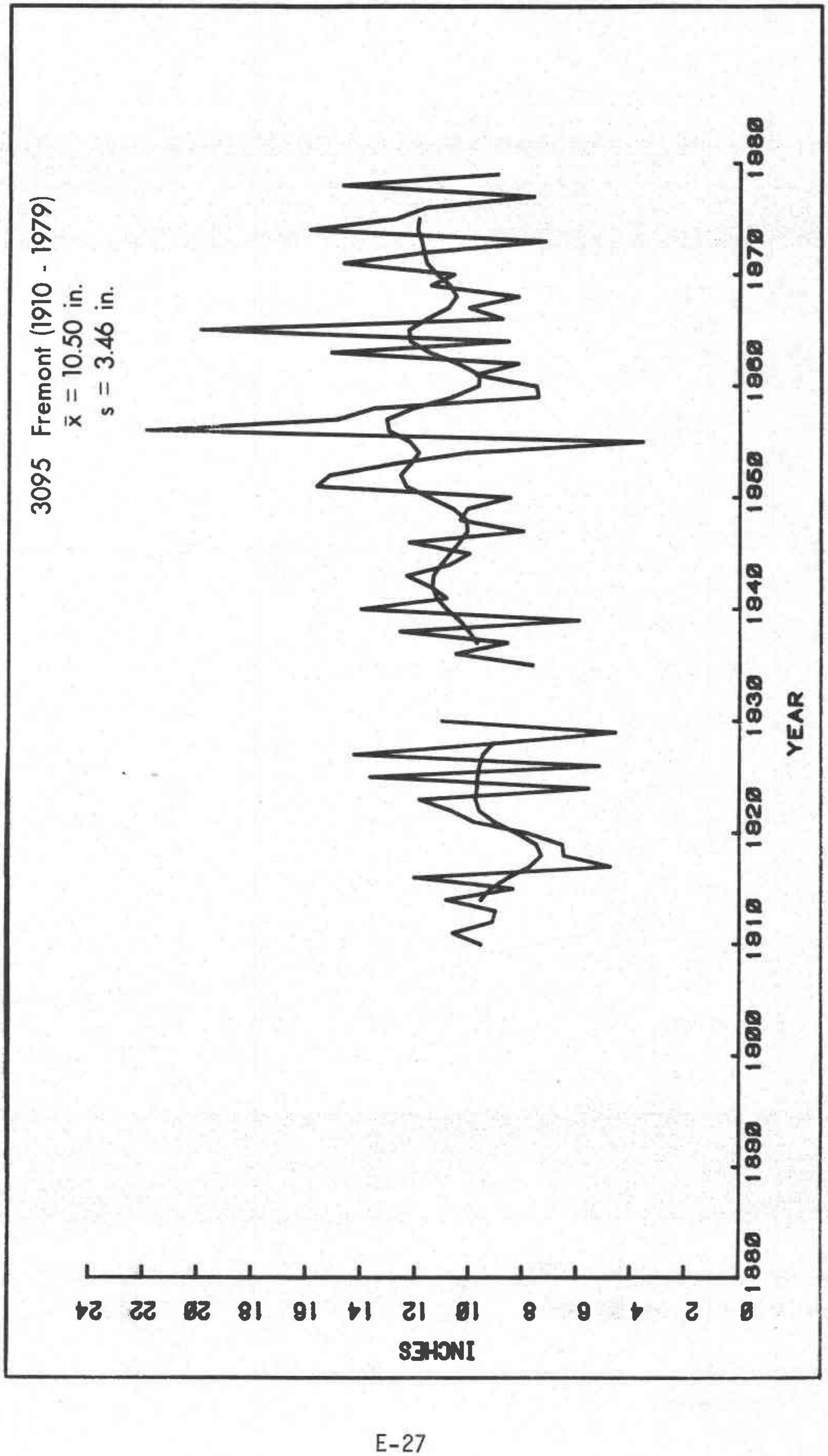


1765 Condon (1908 - 1979)
x̄ = 12.74 in.
s = 3.06 in.
INCHES
0
3
6
9
12
15
18
21
24
27
30
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

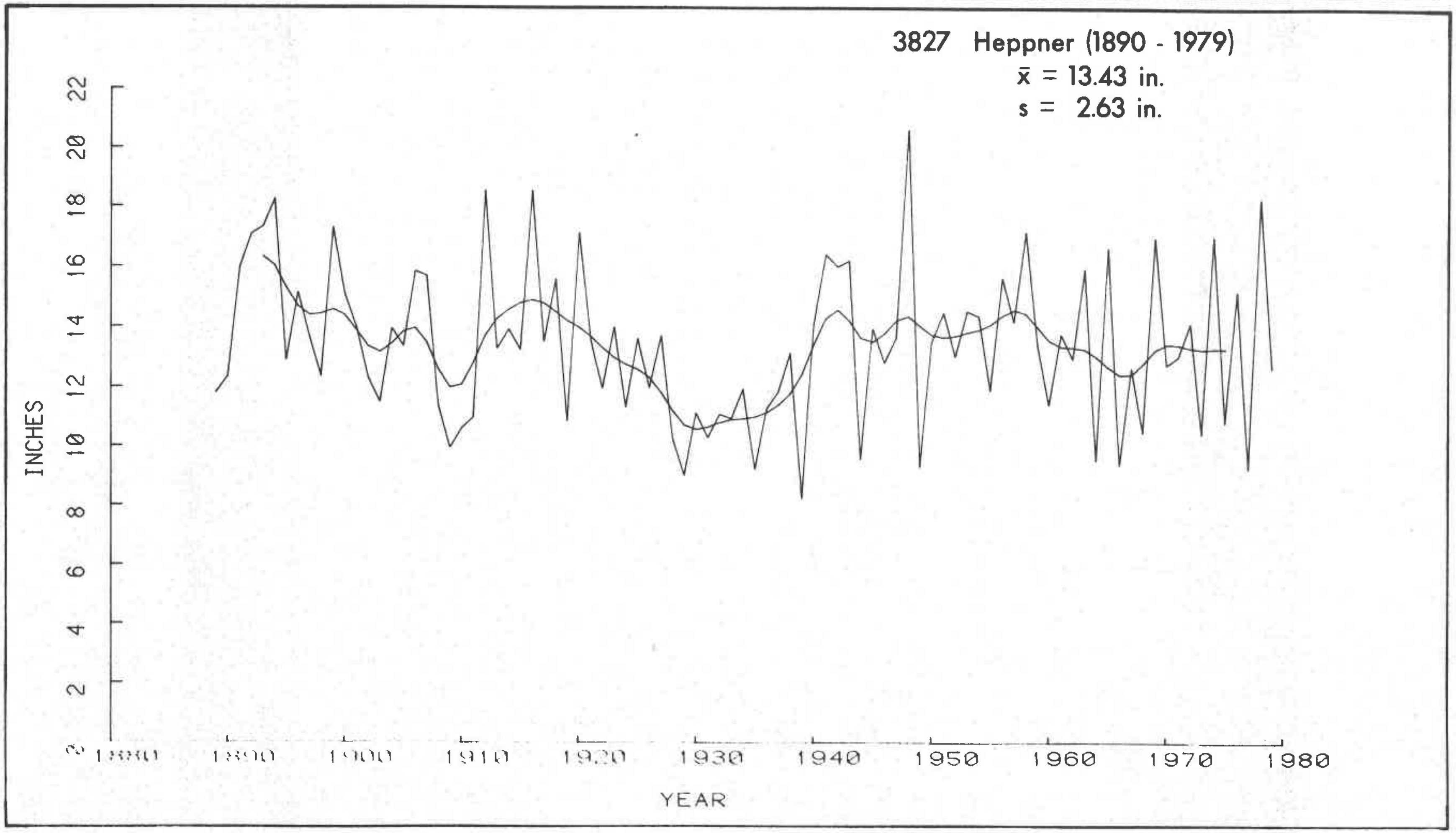


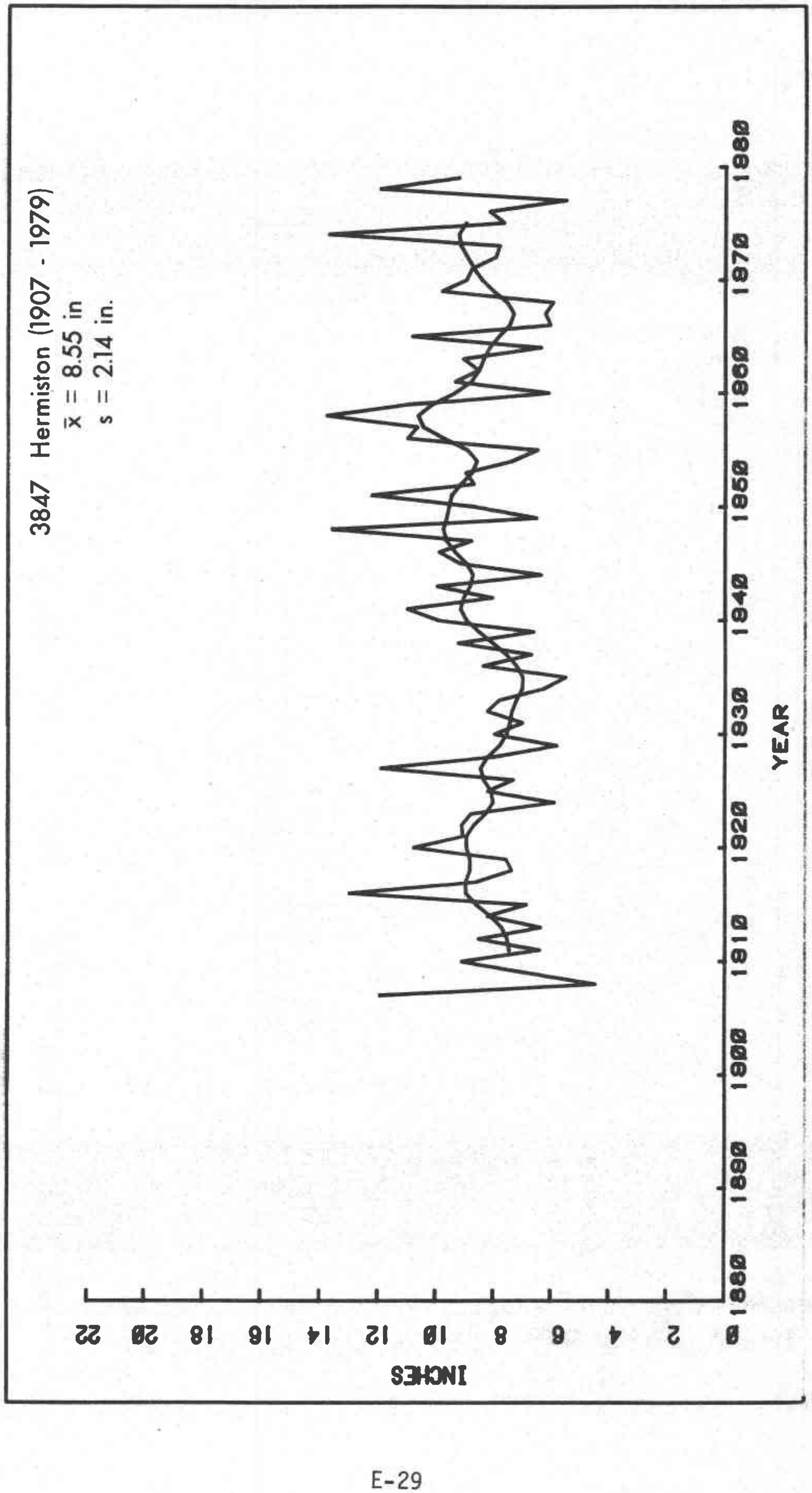
2168 Dayville (1895 - 1979)
x̄ = 11.70 in.
s = 2.80 in.
INCHES
0
2
4
6
8
10
12
14
16
18
20
22
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980


2440 Dufur (1910 - 1979)
$\bar{x}$ = 12.28 in.
s = 3.45 in.
INCHES
0
3
6
9
12
15
18
21
24
27
30
33
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

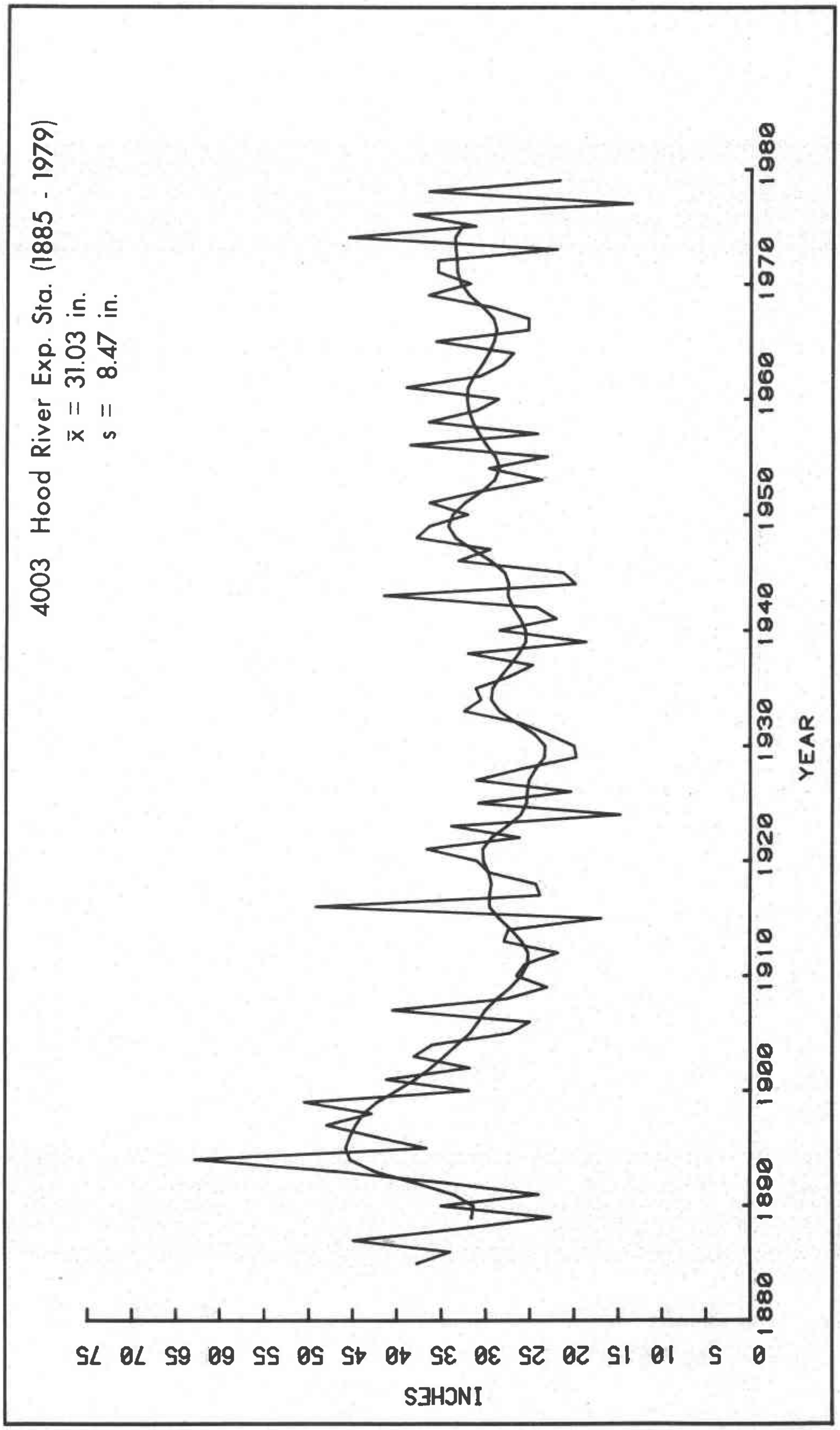


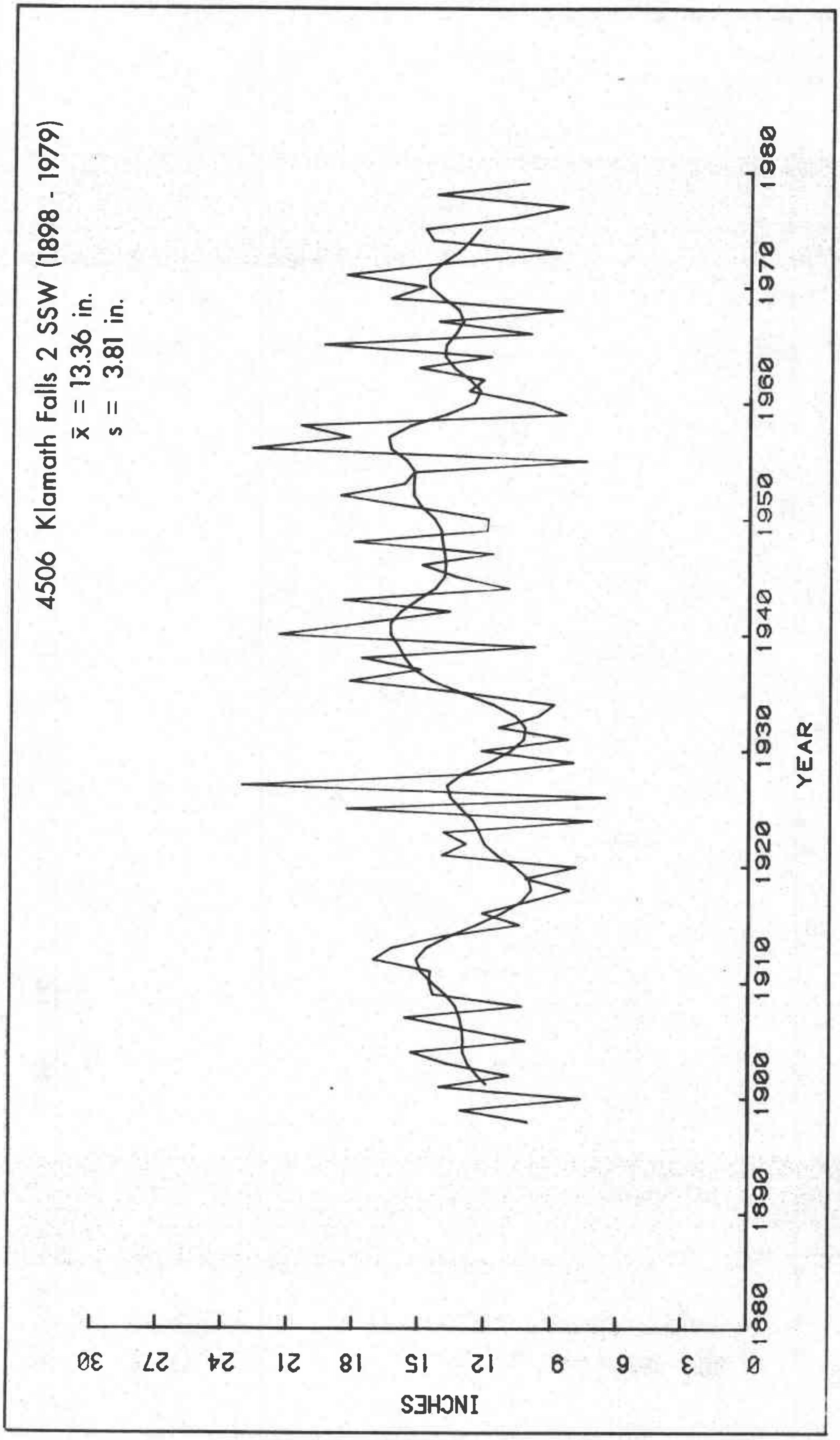
3095 Fremont (1910 - 1979)
$\bar{x}$ = 10.50 in.
s = 3.46 in.
INCHES
0 2 4 6 8 10 12 14 16 18 20 22 24
YEAR
1860 1880 1900 1910 1920 1930 1940 1950 1960 1970 1980


3827 Heppner (1890 - 1979)
x̄ = 13.43 in.
s = 2.63 in.
INCHES
22
20
18
16
14
12
10
8
6
4
2
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
YEAR

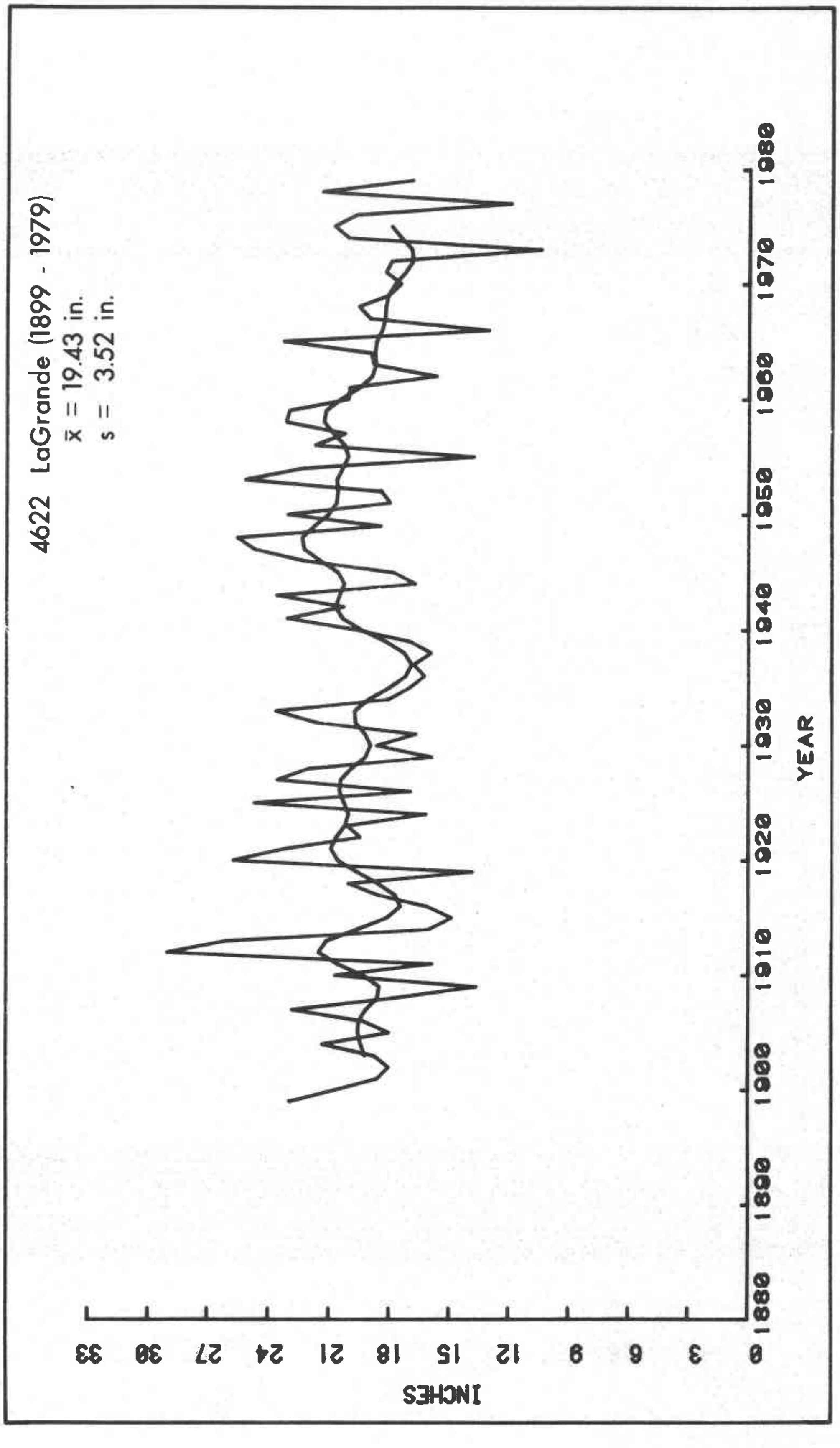


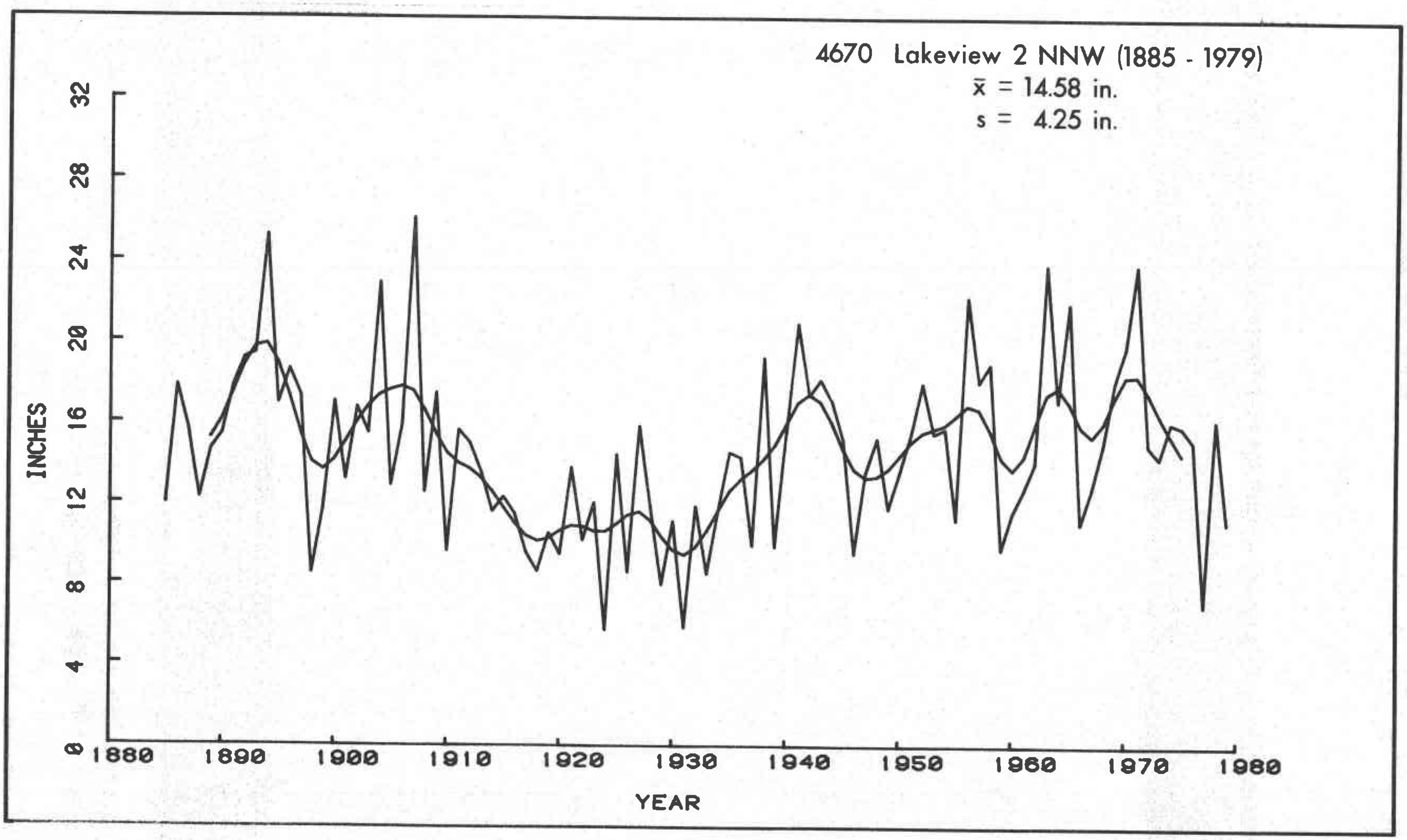
3847 Hermiston (1907 - 1979)
$\bar{x}$ = 8.55 in
s = 2.14 in.
INCHES
0
2
4
6
8
10
12
14
16
18
20
22
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980


4003 Hood River Exp. Sta. (1885 - 1979)
$\bar{x}$ = 31.03 in.
s = 8.47 in.
INCHES
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980

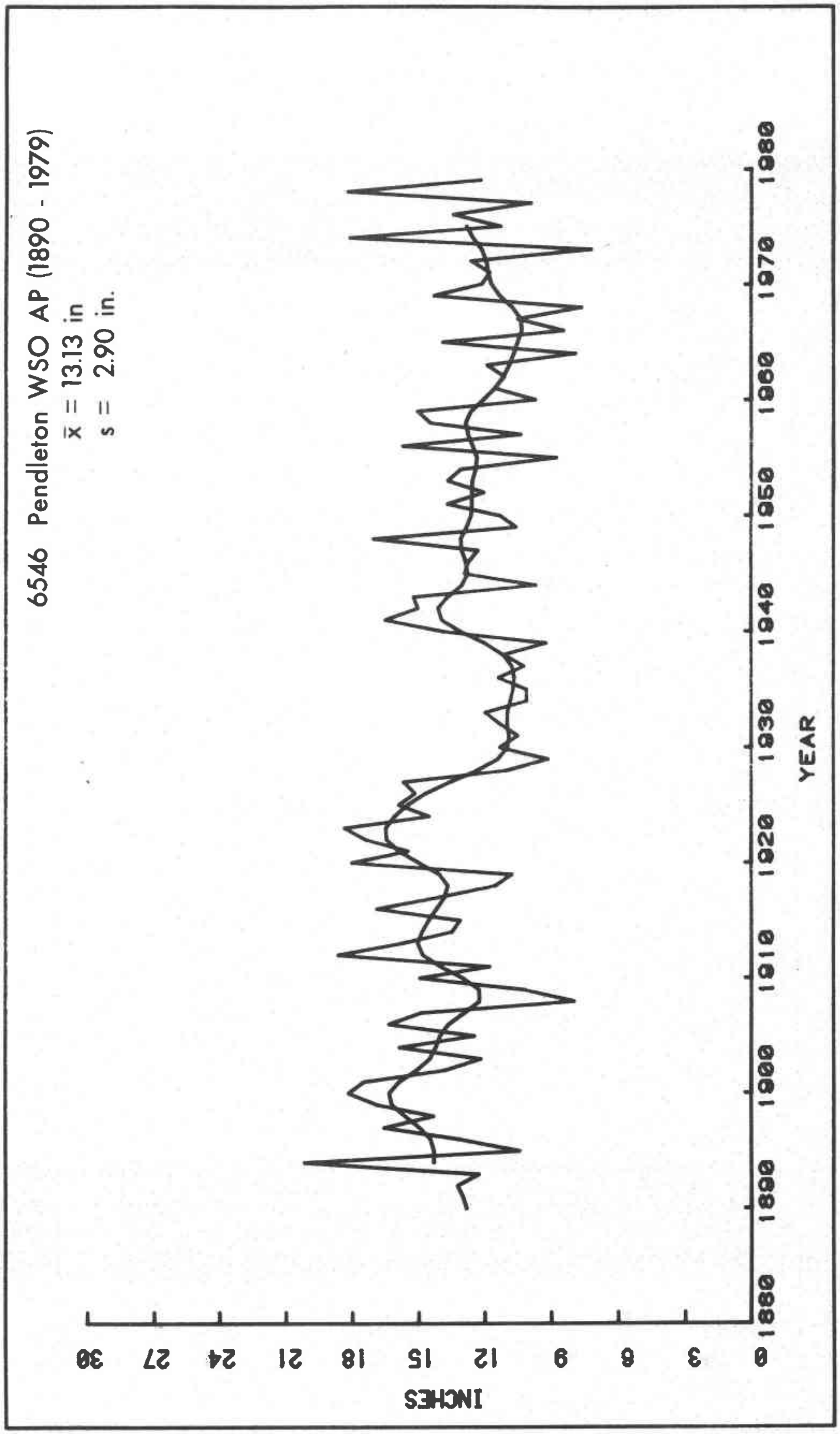


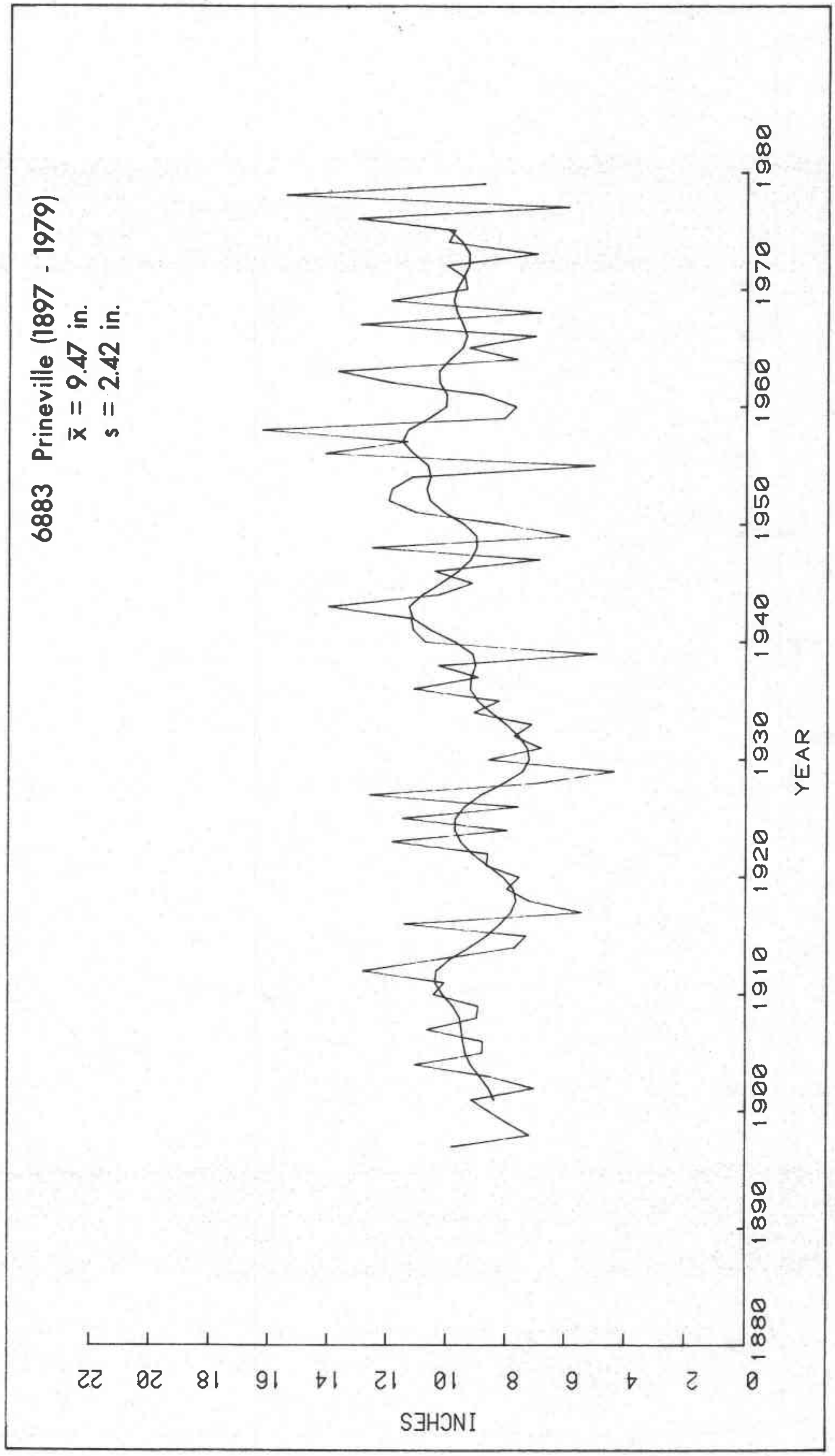
4506 Klamath Falls 2 SSW (1898 - 1979)
x̄ = 13.36 in.
s = 3.81 in.
INCHES
0
3
6
9
12
15
18
21
24
27
30
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

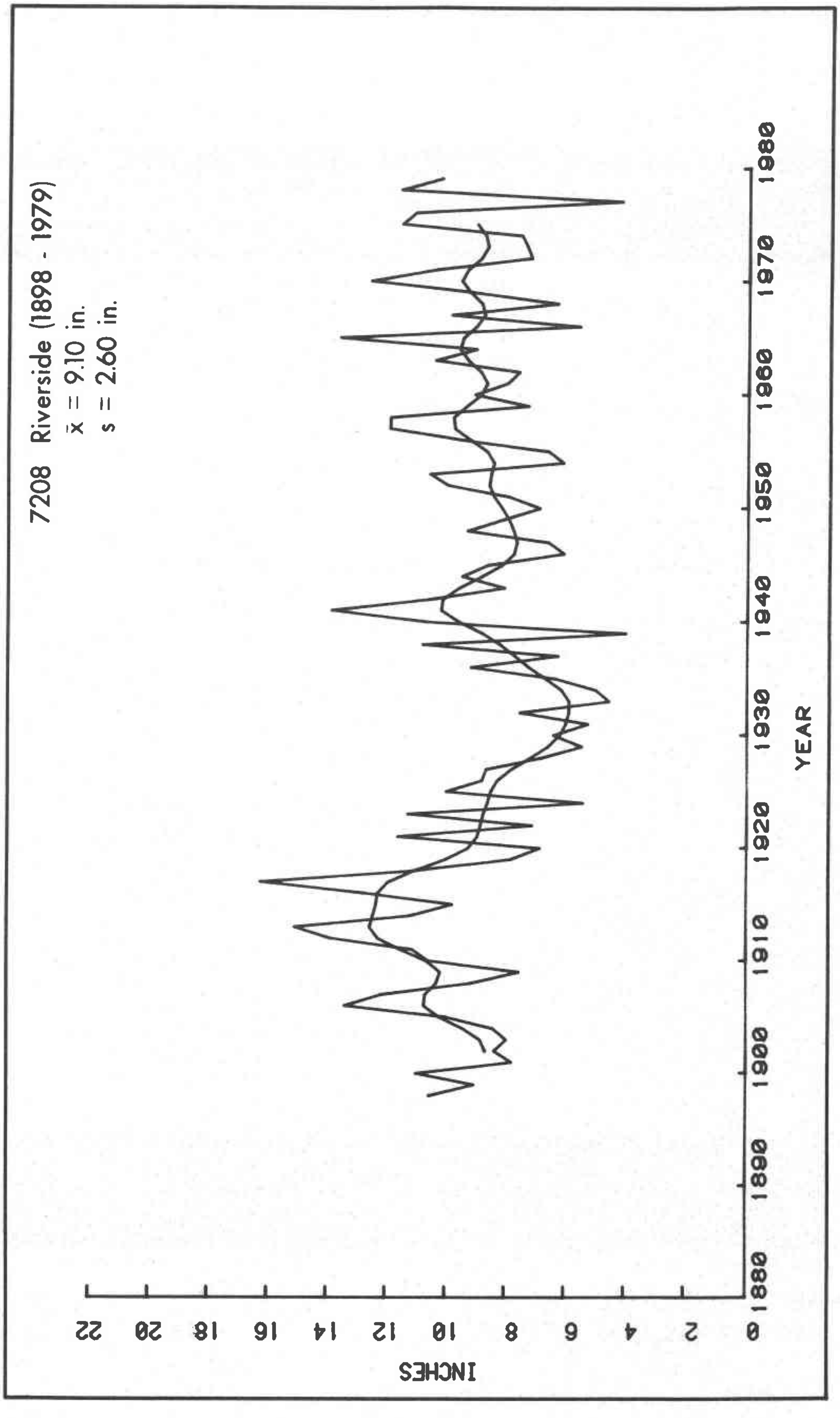

4622 LaGrande (1899 - 1979)
$\bar{x}$ = 19.43 in.
s = 3.52 in.
INCHES
0
3
6
9
12
15
18
21
24
27
30
33
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

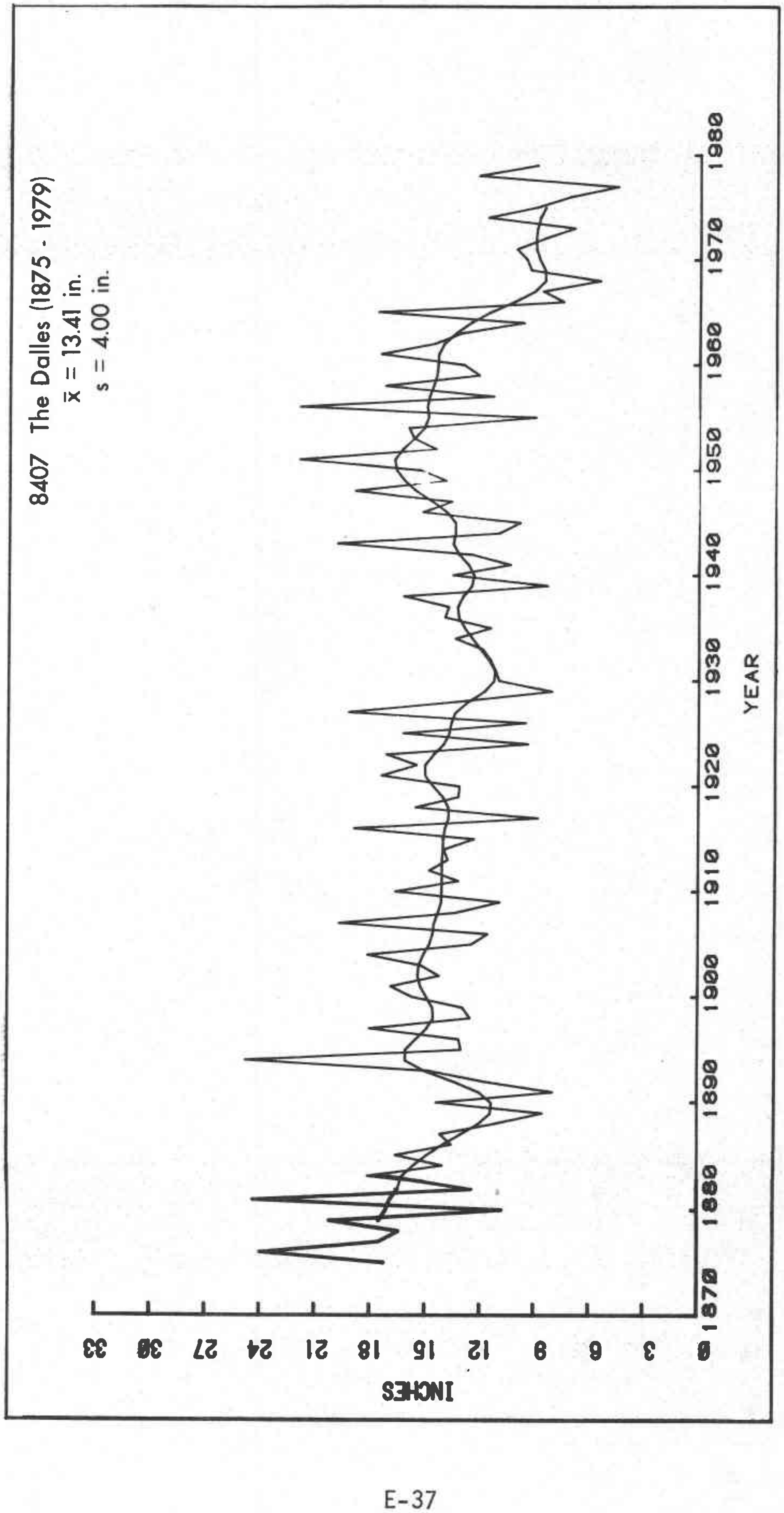


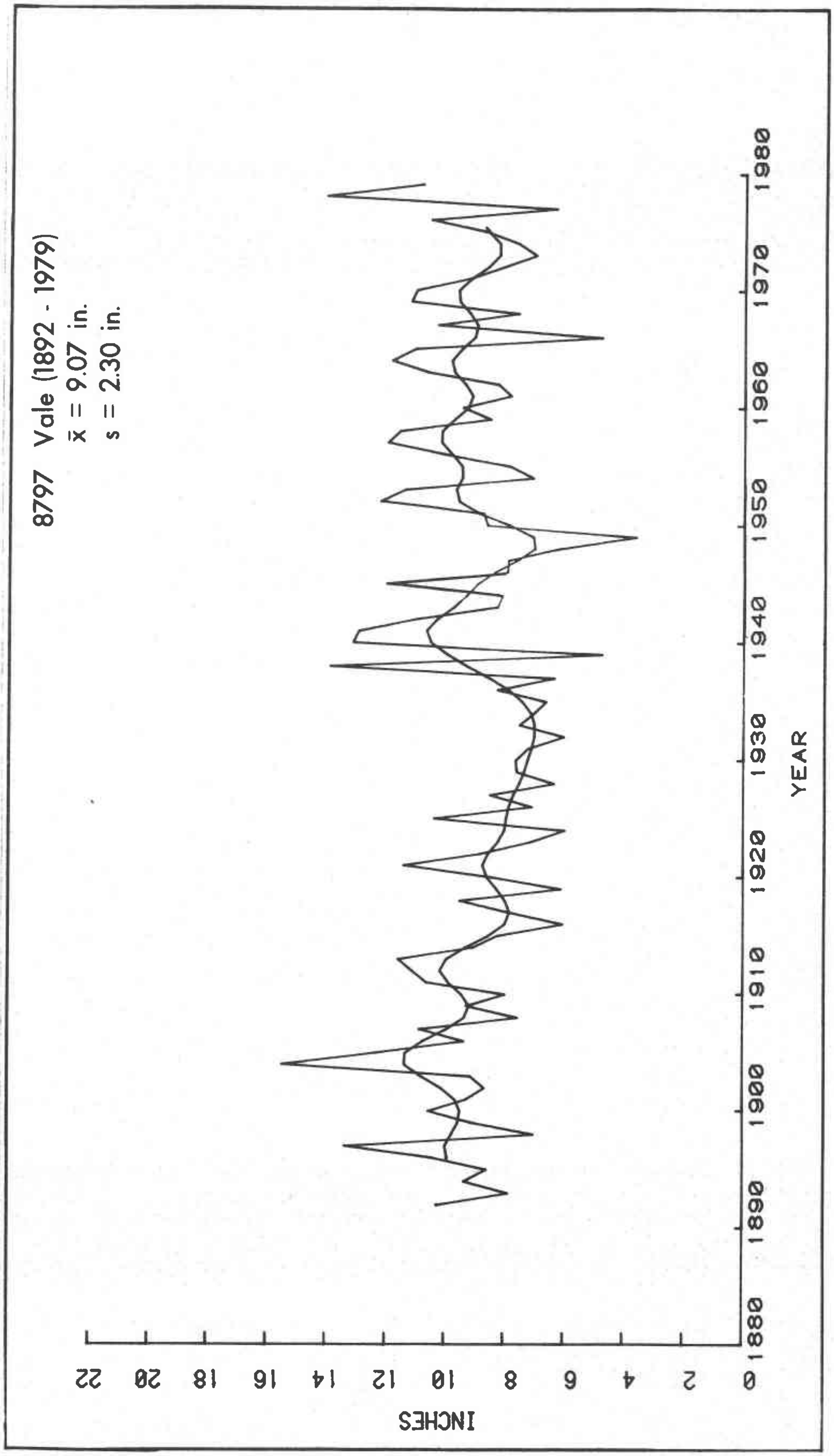
4670 Lakeview 2 NNW (1885 - 1979)
x̄ = 14.58 in.
s = 4.25 in.
INCHES
0
4
8
12
16
20
24
28
32
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

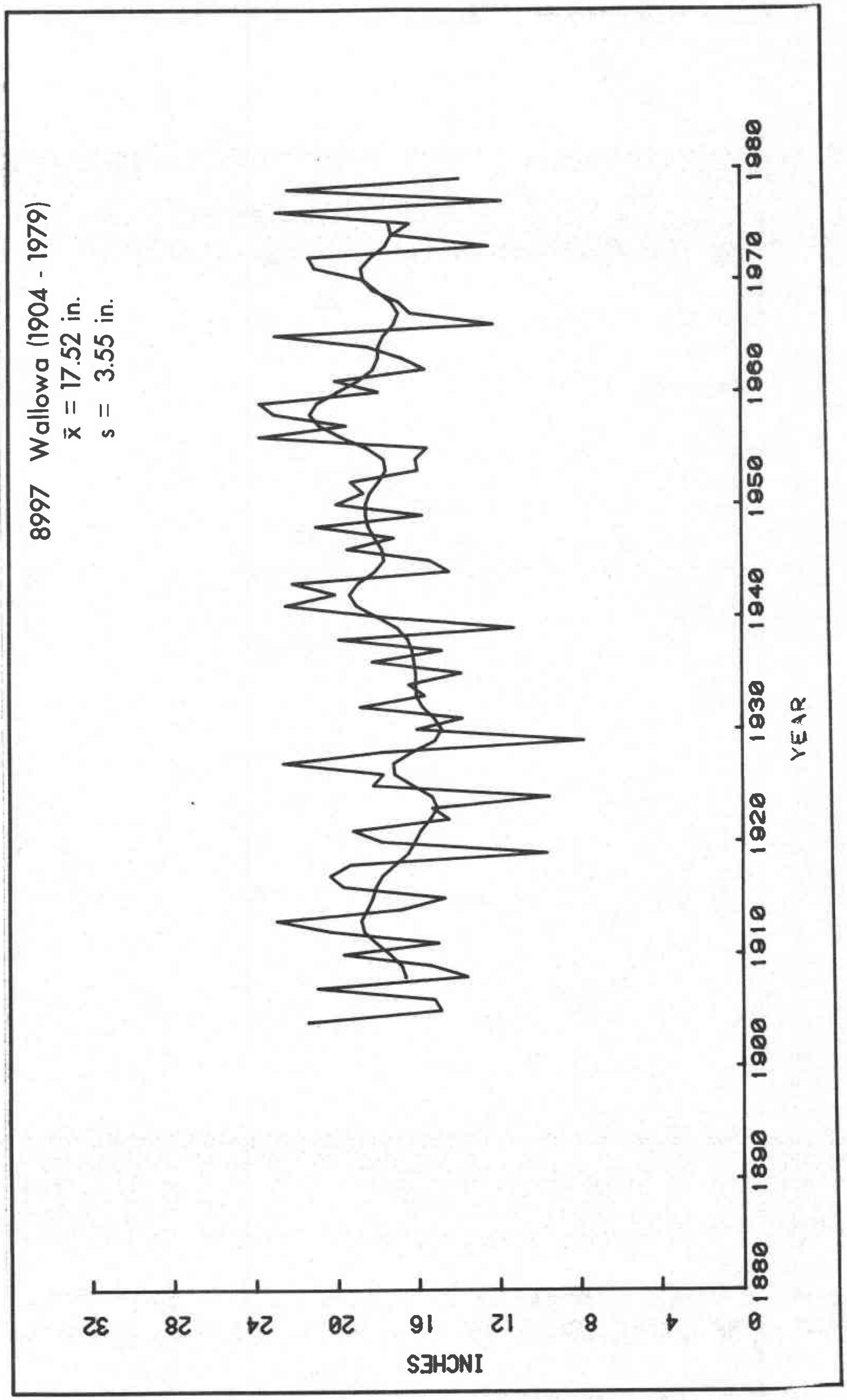

6546 Pendleton WSO AP (1890 - 1979)
$\bar{x}$ = 13.13 in
s = 2.90 in.
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
INCHES
0
3
6
9
12
15
18
21
24
27
30


6883 Prineville (1897 - 1979)
$\bar{x}$ = 9.47 in.
s = 2.42 in.
INCHES
0
2
4
6
8
10
12
14
16
18
20
22
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

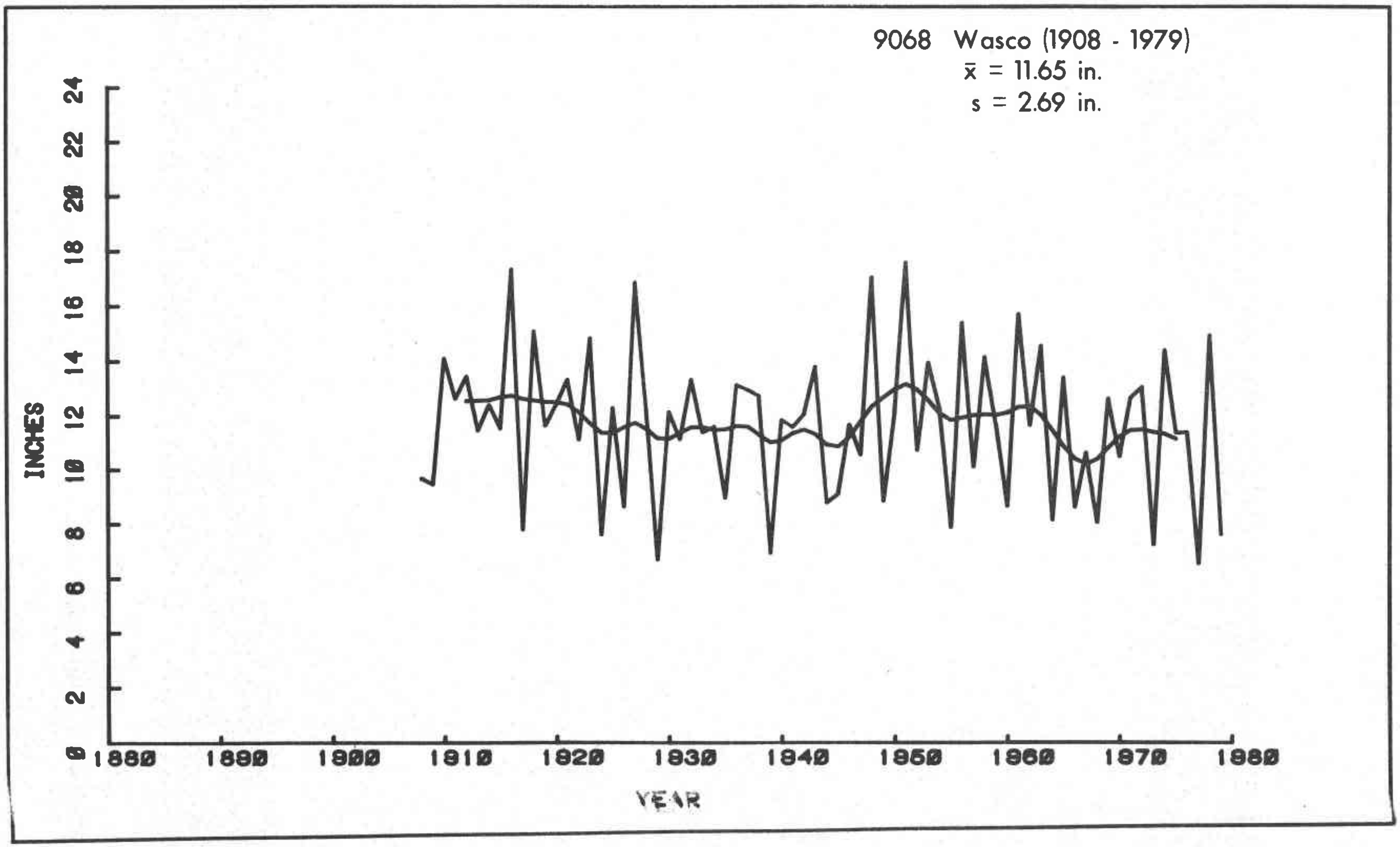

7208 Riverside (1898 - 1979)
$\bar{x}$ = 9.10 in.
s = 2.60 in.
INCHES
0
2
4
6
8
10
12
14
16
18
20
22
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

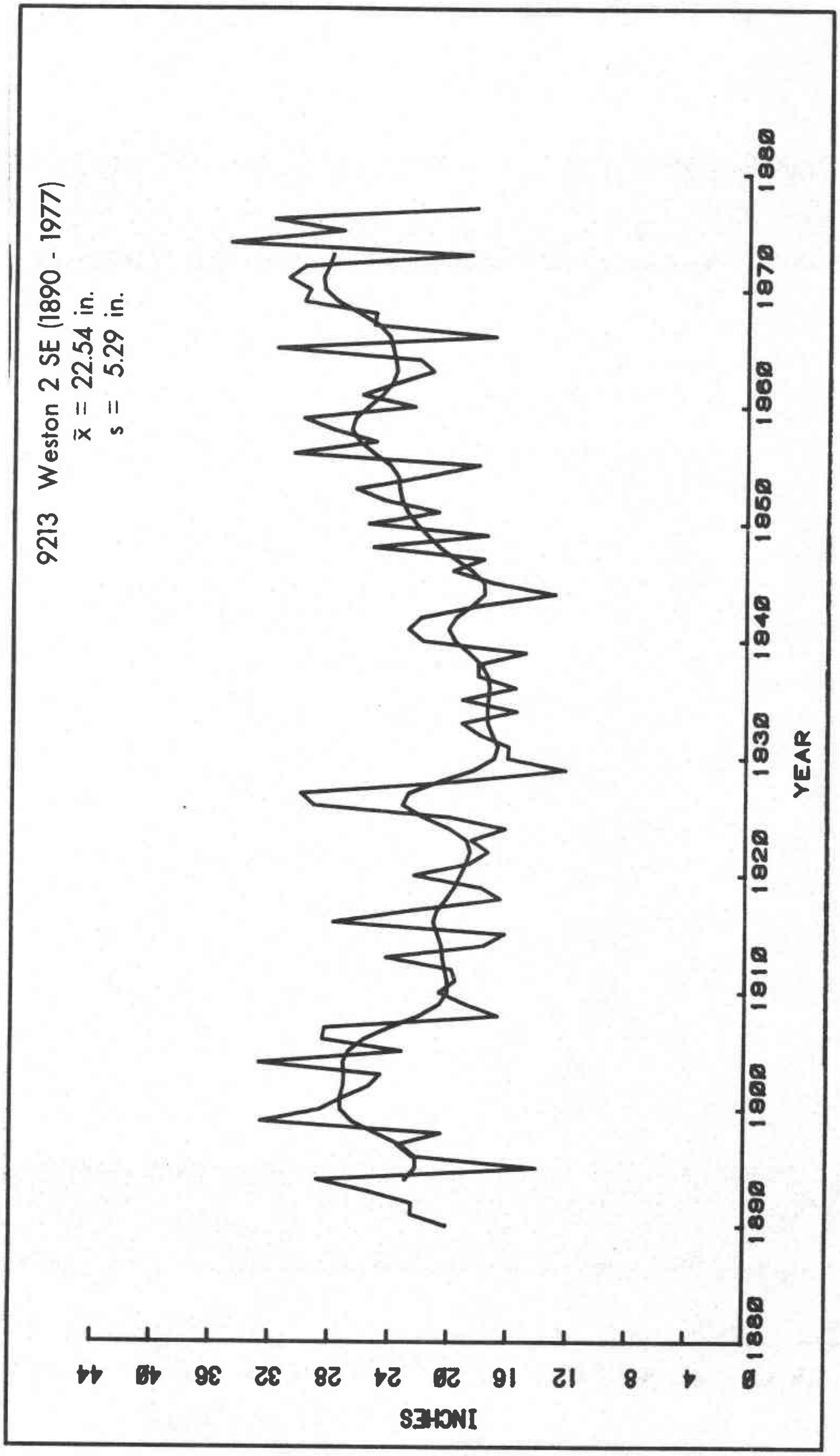

8407 The Dalles (1875 - 1979)
x̄ = 13.41 in.
s = 4.00 in.
INCHES
0
3
6
9
12
15
18
21
24
27
30
33
YEAR
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980


8797 Vale (1892 - 1979)
x̄ = 9.07 in.
s = 2.30 in.
INCHES
0
2
4
6
8
10
12
14
16
18
20
22
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

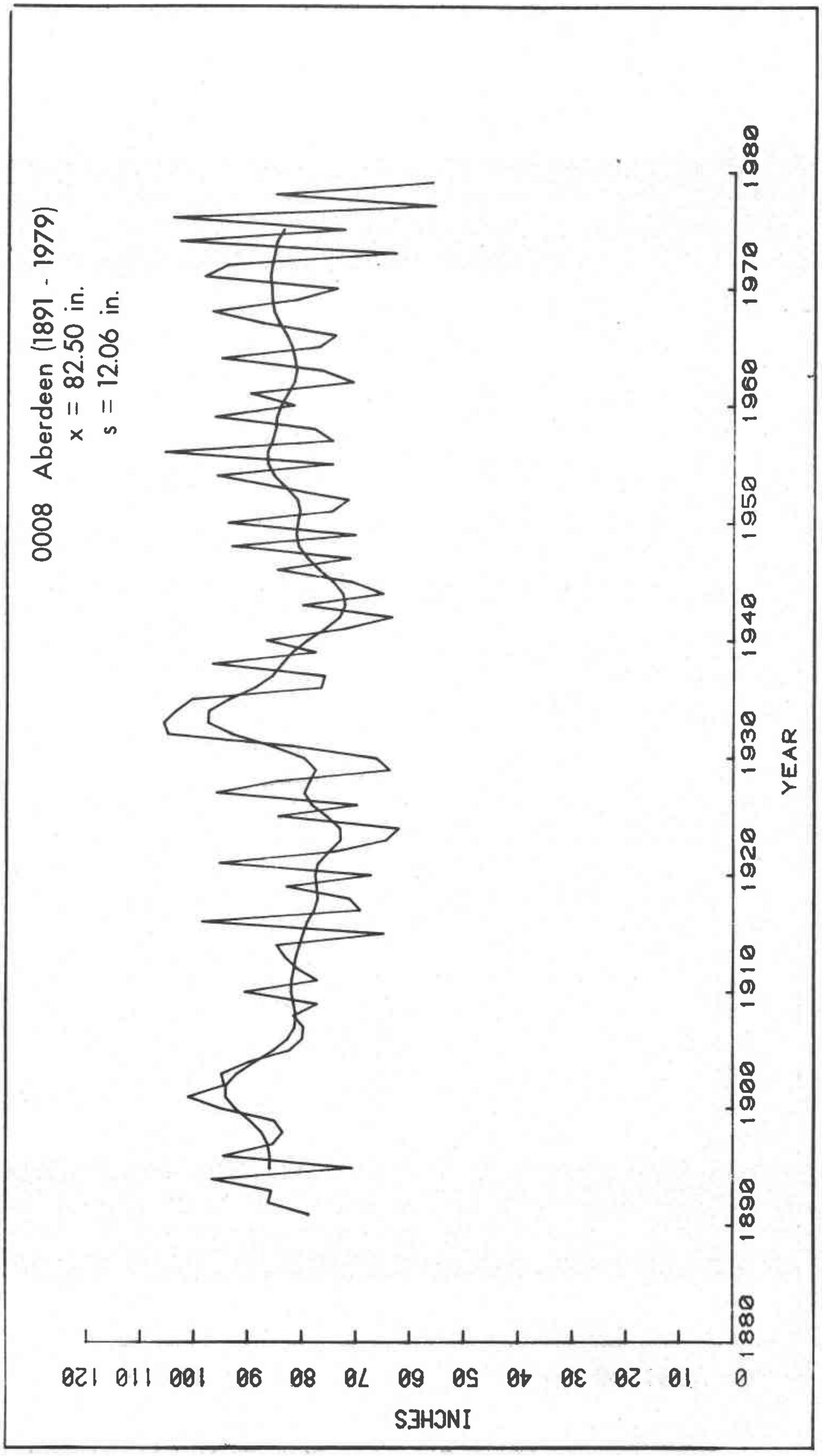


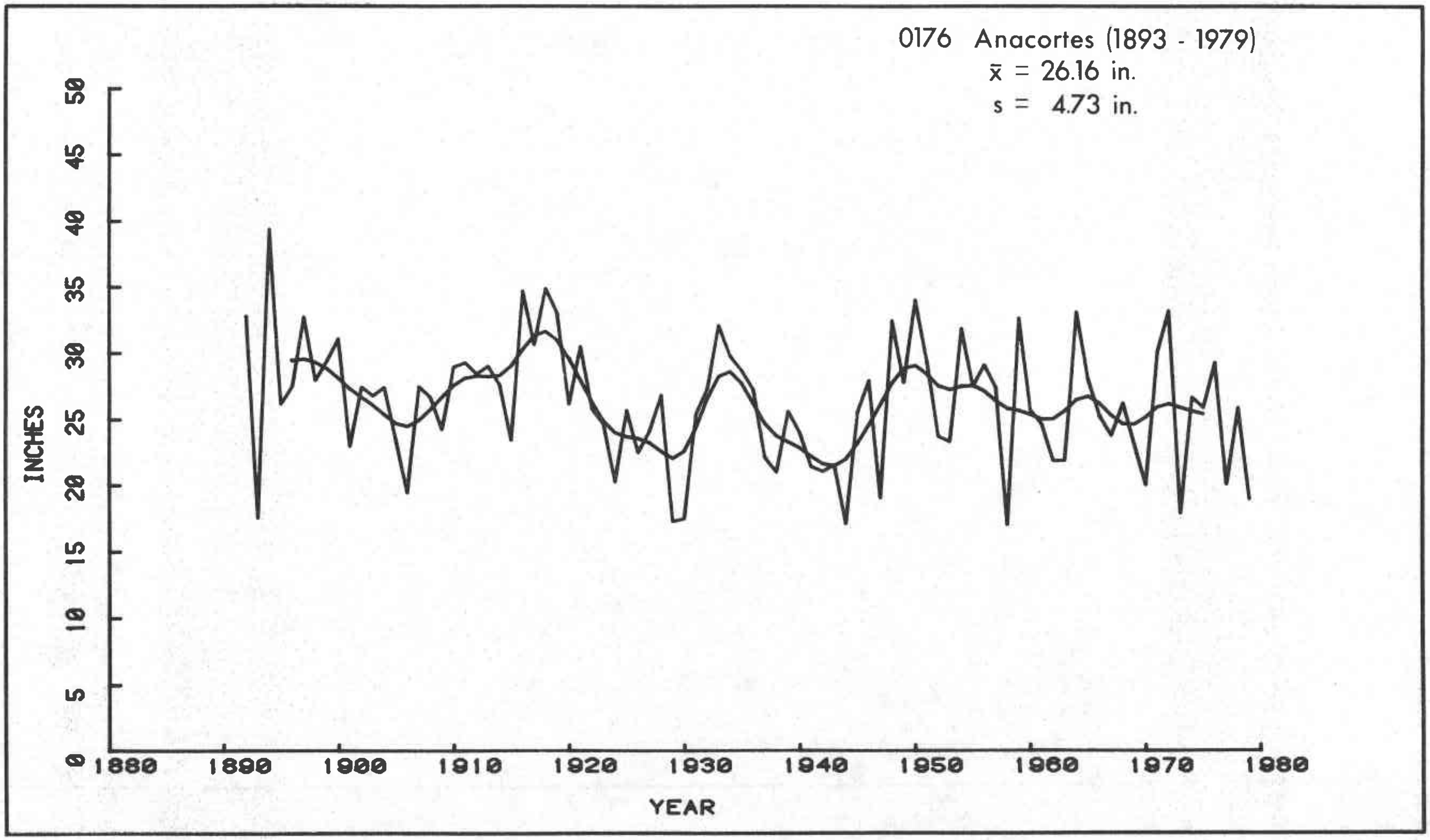
8997 Wallowa (1904 - 1979)
x̄ = 17.52 in.
s = 3.55 in.
YEAR
INCHES
0
4
8
12
16
20
24
28
32
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980


9068 Wasco (1908 - 1979)
$\bar{x}$ = 11.65 in.
s = 2.69 in.
INCHES
0
2
4
6
8
10
12
14
16
18
20
22
24
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
YEAR

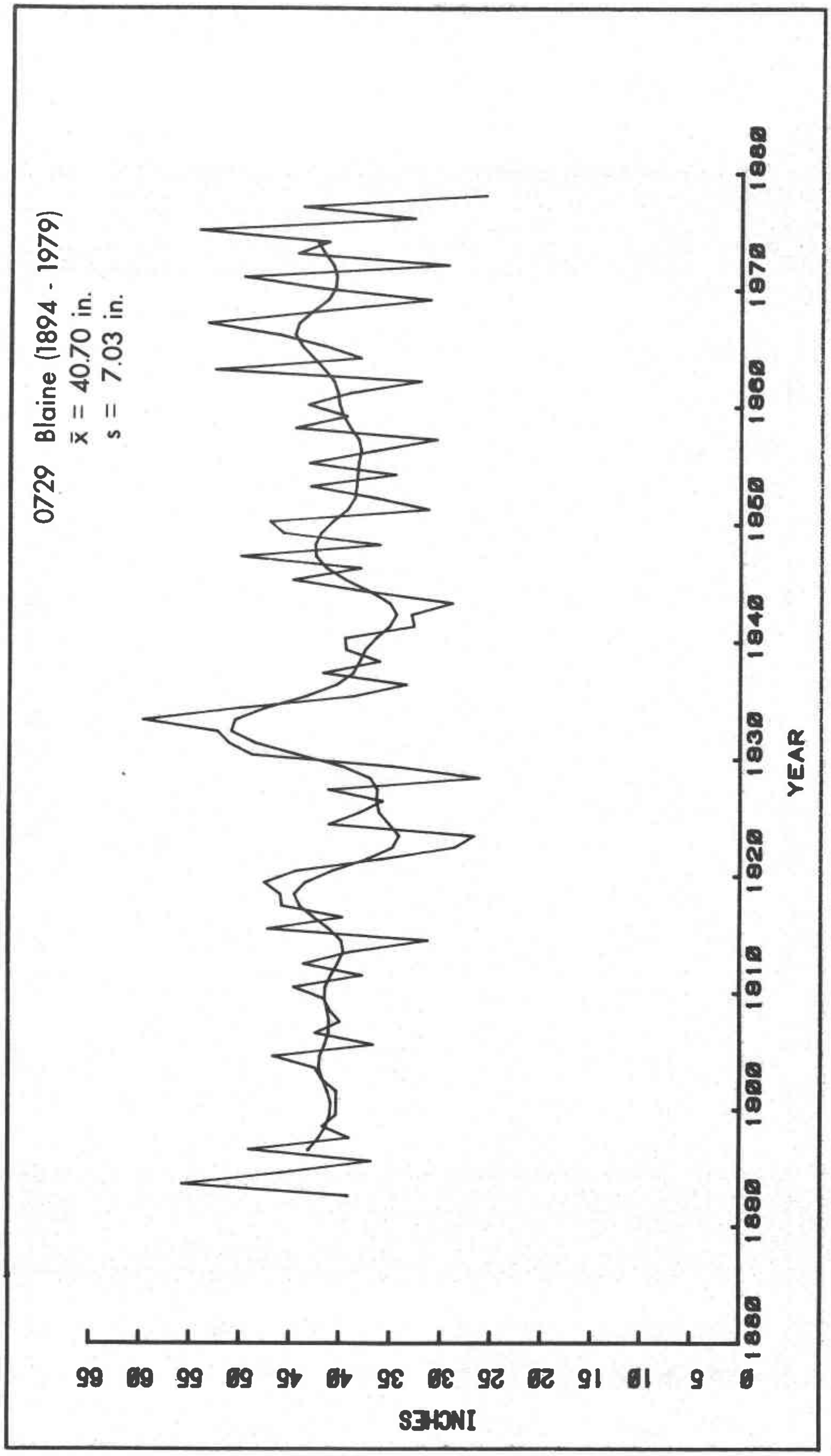

9213 Weston 2 SE (1890 - 1977)
x̄ = 22.54 in.
s = 5.29 in.
INCHES
0
4
8
12
16
20
24
28
32
36
40
44
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
YEAR

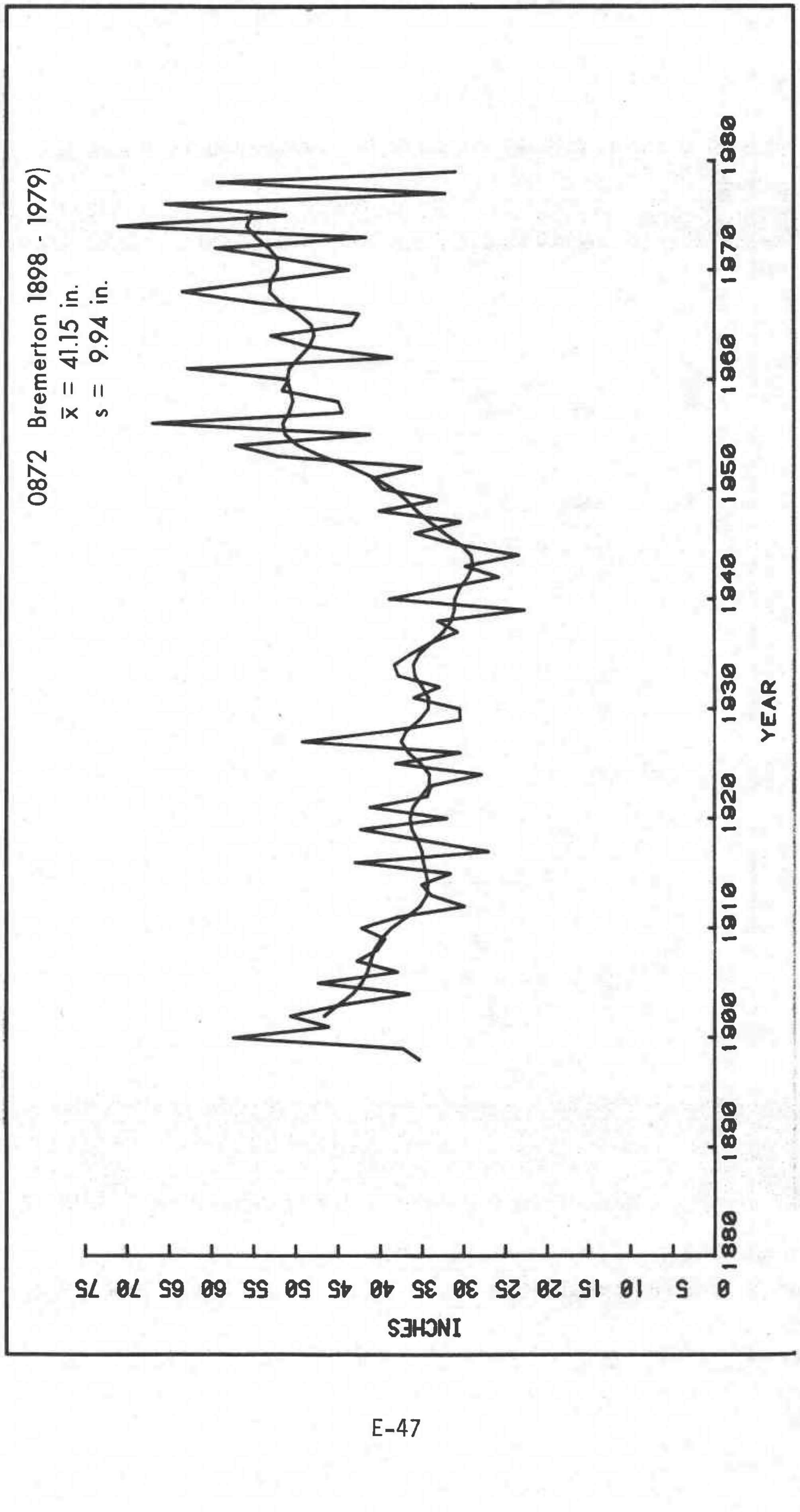
Western Washington

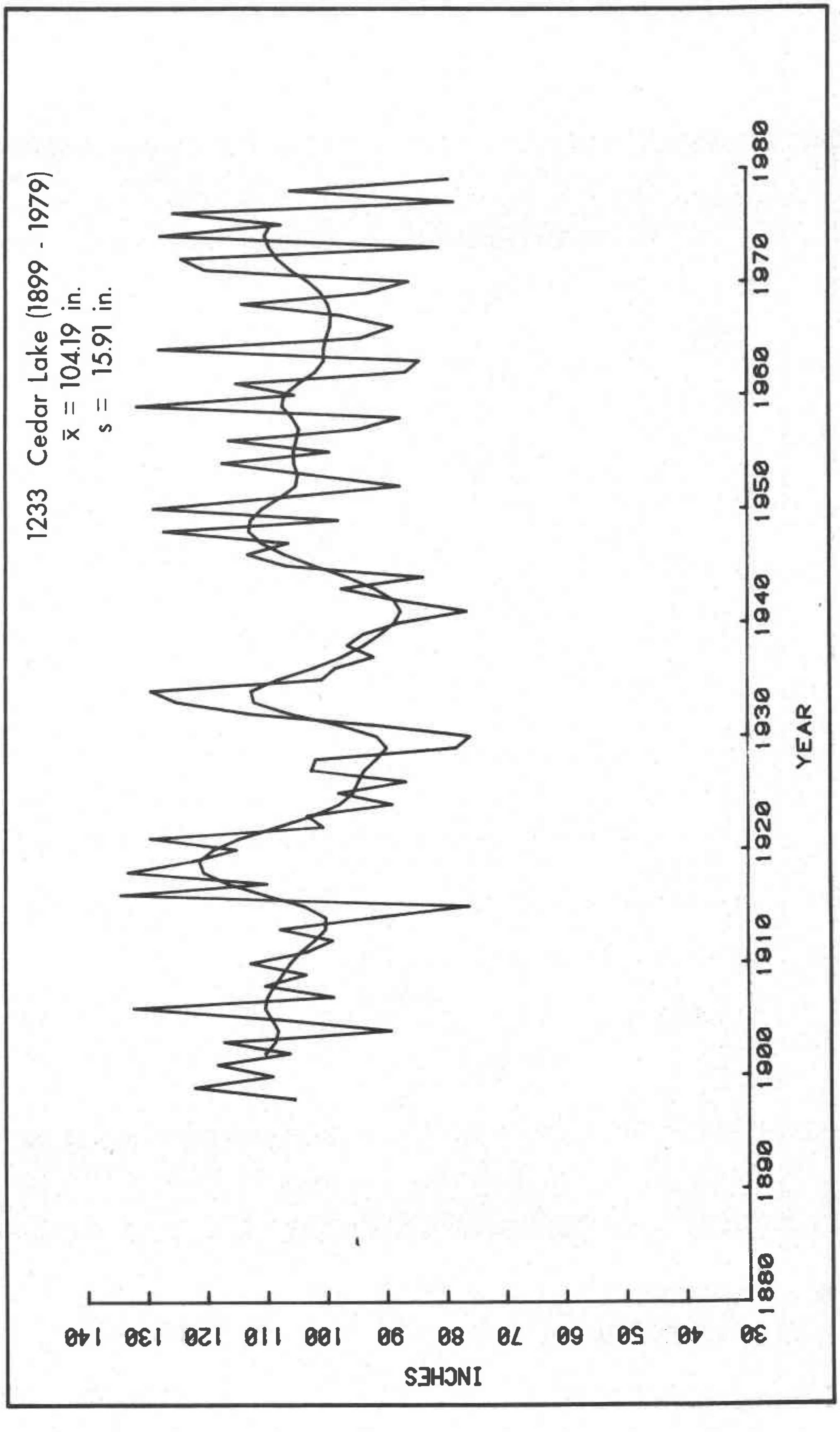

0008 Aberdeen (1891 - 1979)
x = 82.50 in.
s = 12.06 in.
YEAR
INCHES
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
0 10 20 30 40 50 60 70 80 90 100 110 120

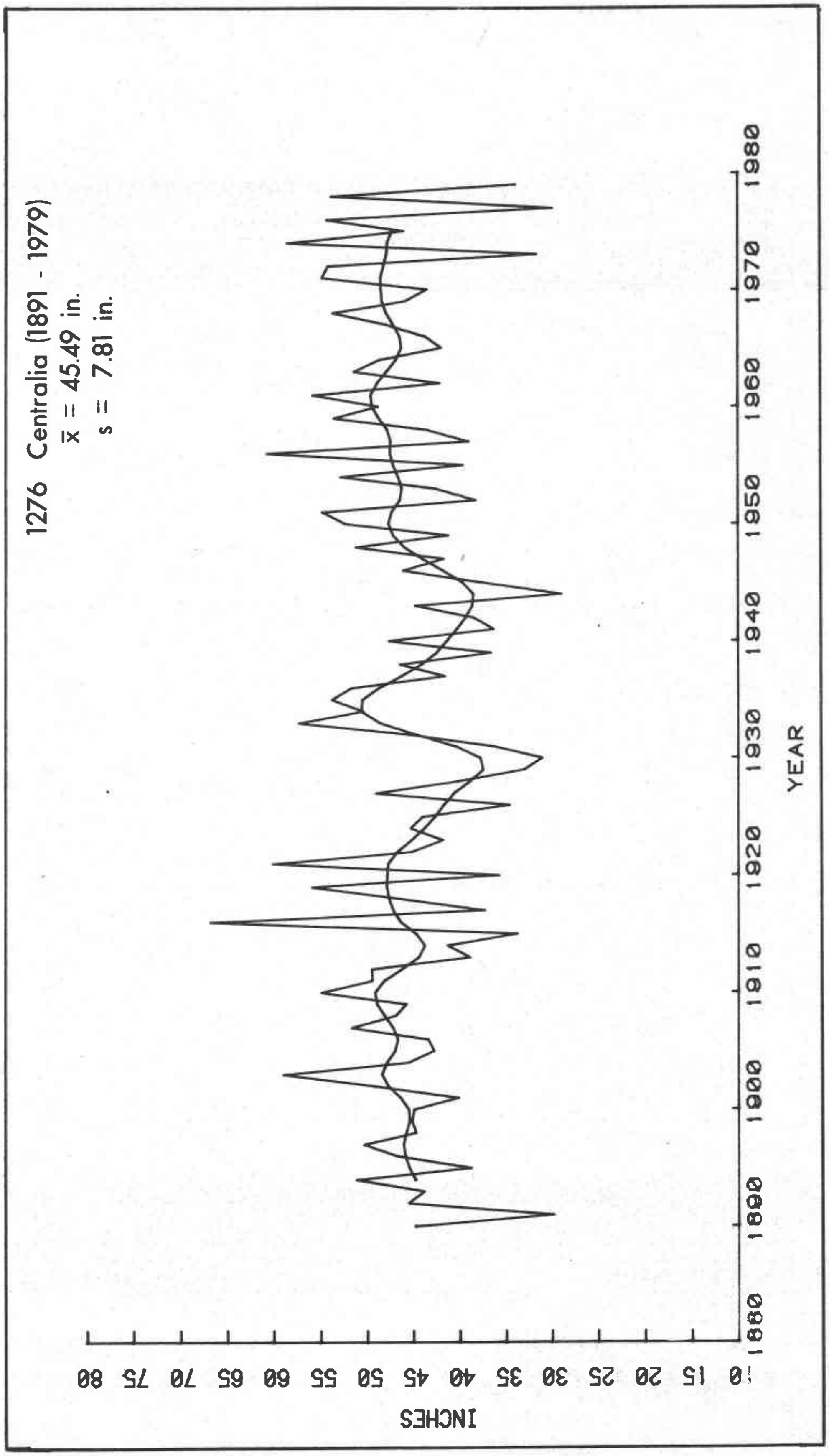


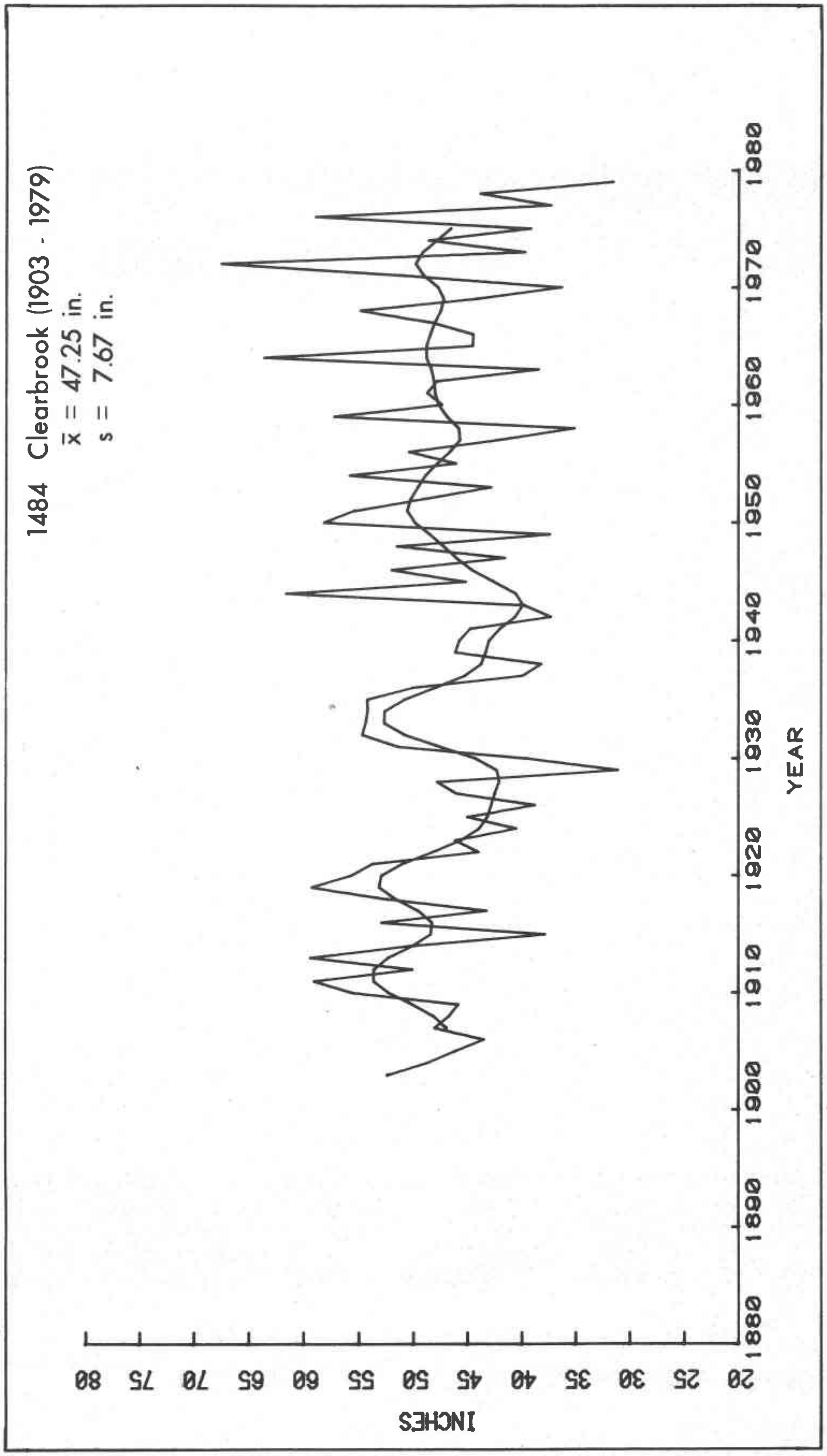
0176 Anacortes (1893 - 1979)
x̄ = 26.16 in.
s = 4.73 in.
INCHES
0
5
10
15
20
25
30
35
40
45
50
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
YEAR

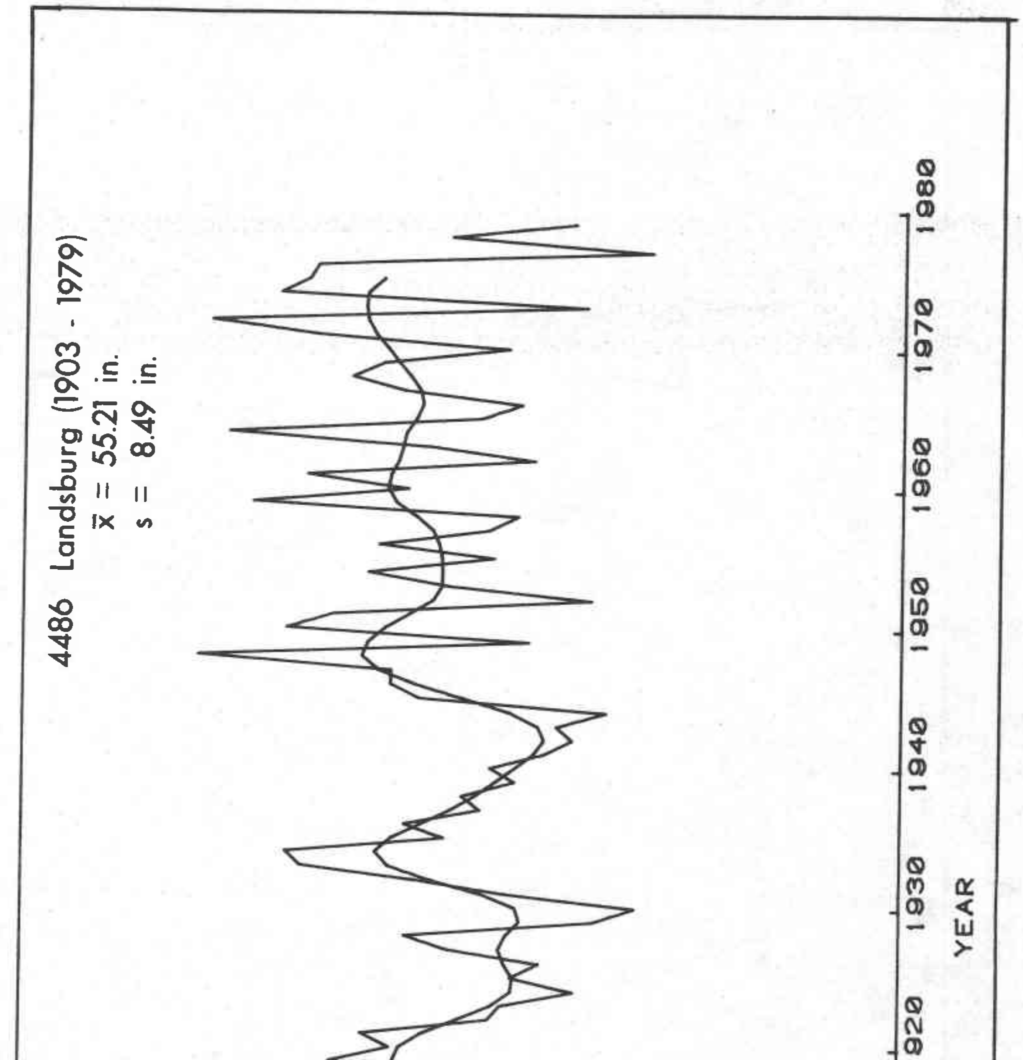

0729 Blaine (1894 - 1979)
$\bar{x}$ = 40.70 in.
s = 7.03 in.
YEAR
INCHES
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
0
5
10
15
20
25
30
35
40
45
50
55
60
65

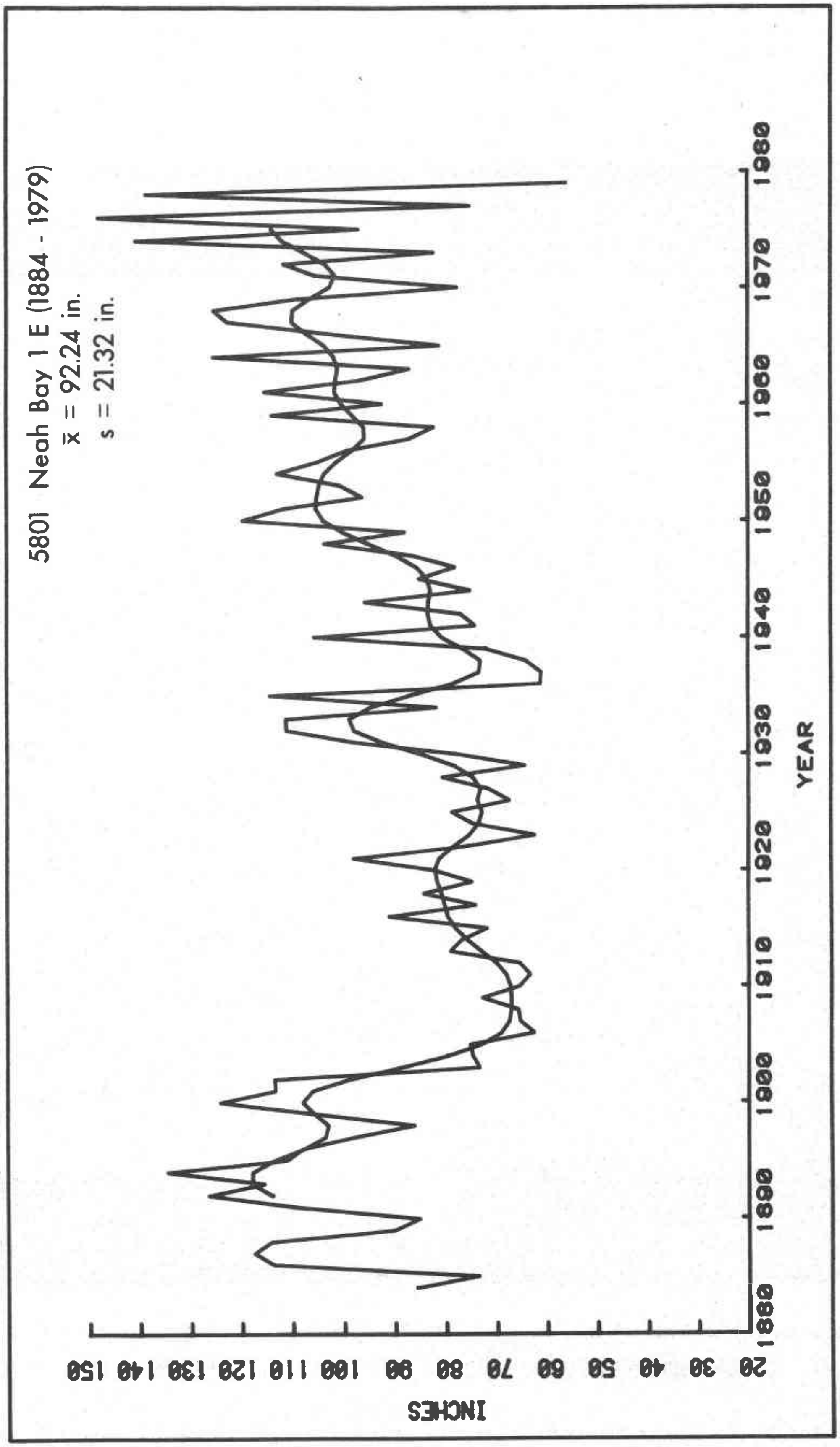

0872 Bremerton 1898 - 1979)
x̄ = 41.15 in.
s = 9.94 in.
INCHES
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
YEAR

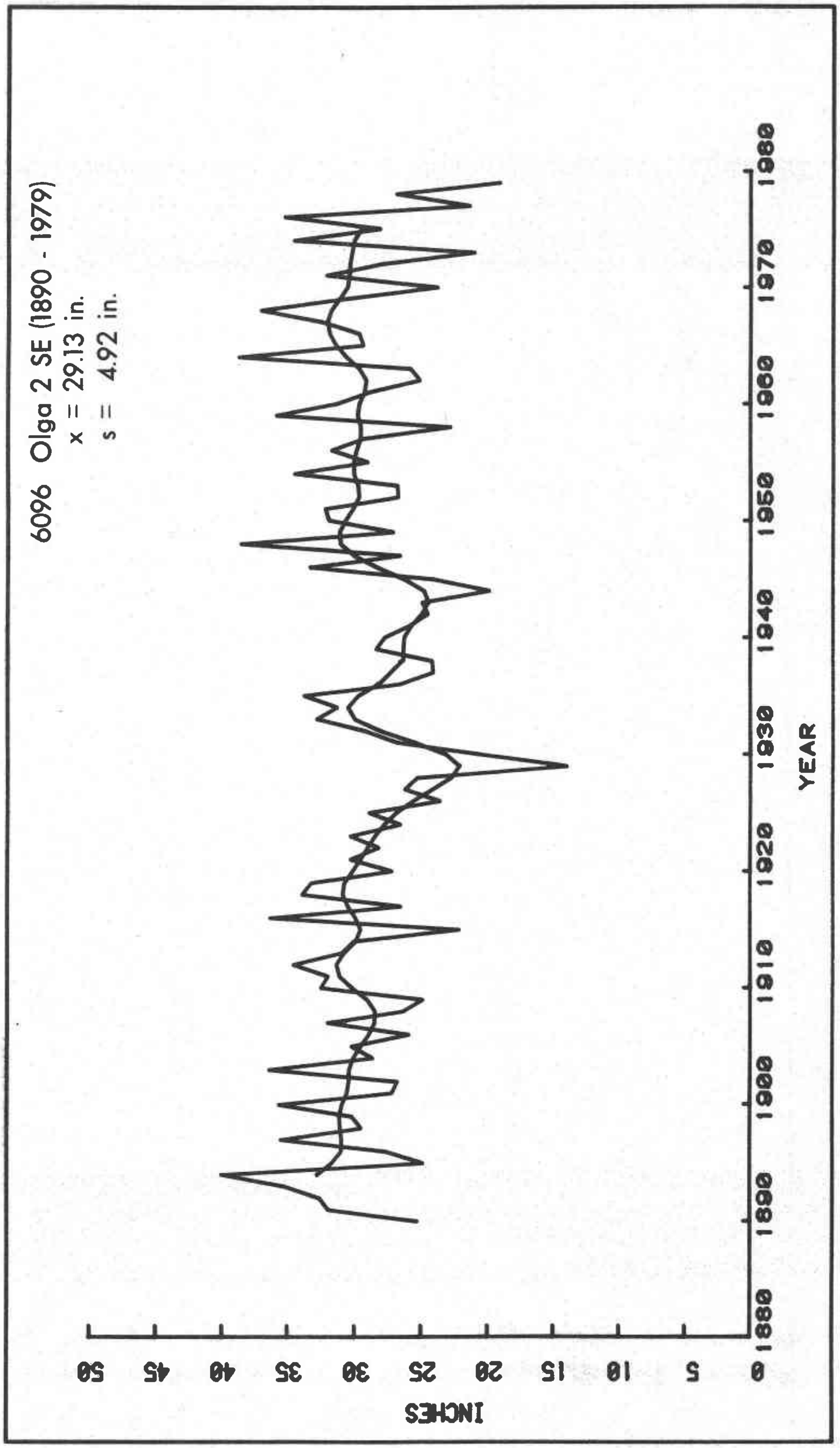

1233 Cedar Lake (1899 - 1979)
x̄ = 104.19 in.
s = 15.91 in.
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
INCHES
30
40
50
60
70
80
90
100
110
120
130
140

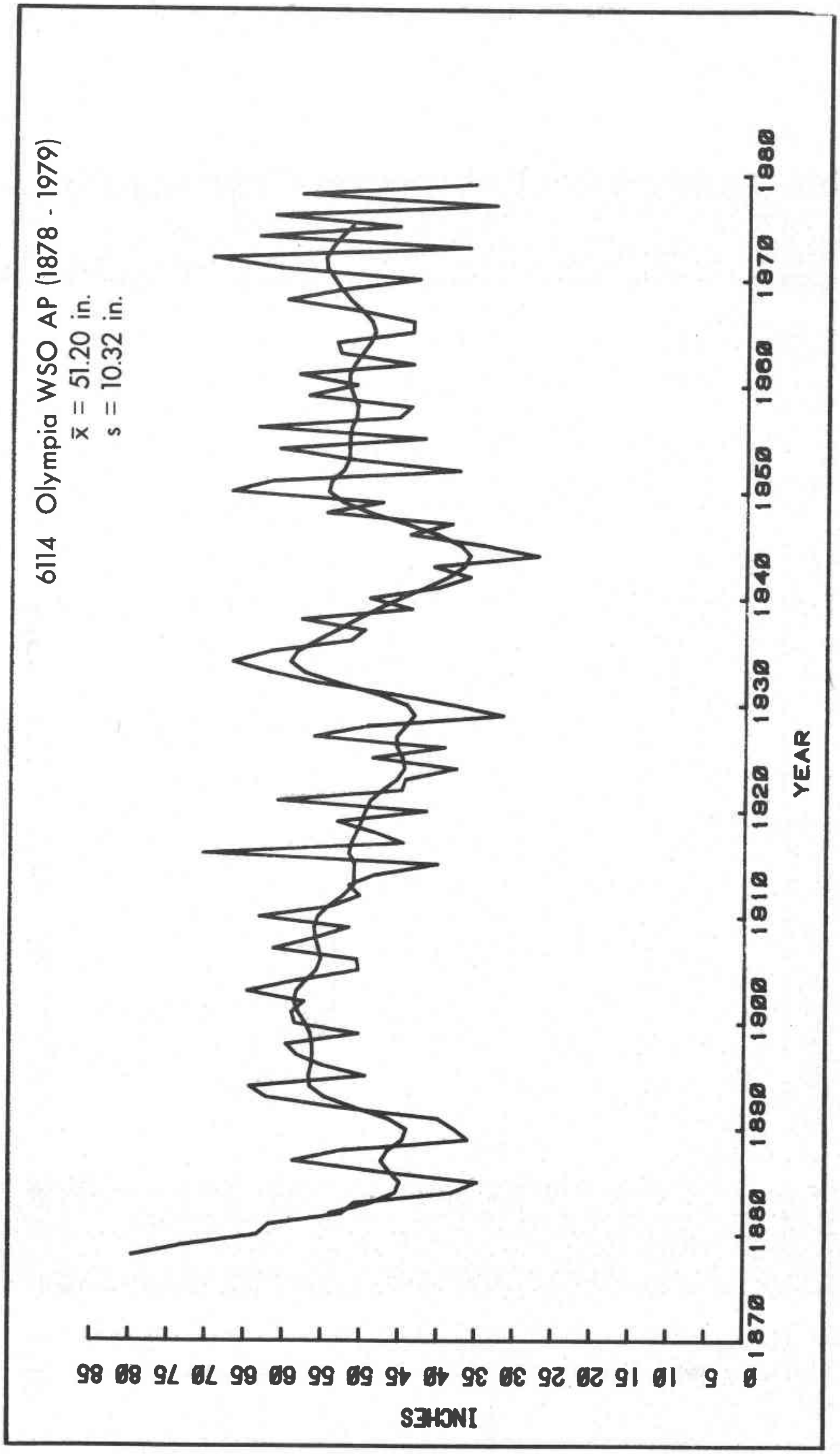

1276 Centralia (1891 - 1979)
$\bar{x}$ = 45.49 in.
s = 7.81 in.
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
INCHES
0 15 20 25 30 35 40 45 50 55 60 65 70 75 80

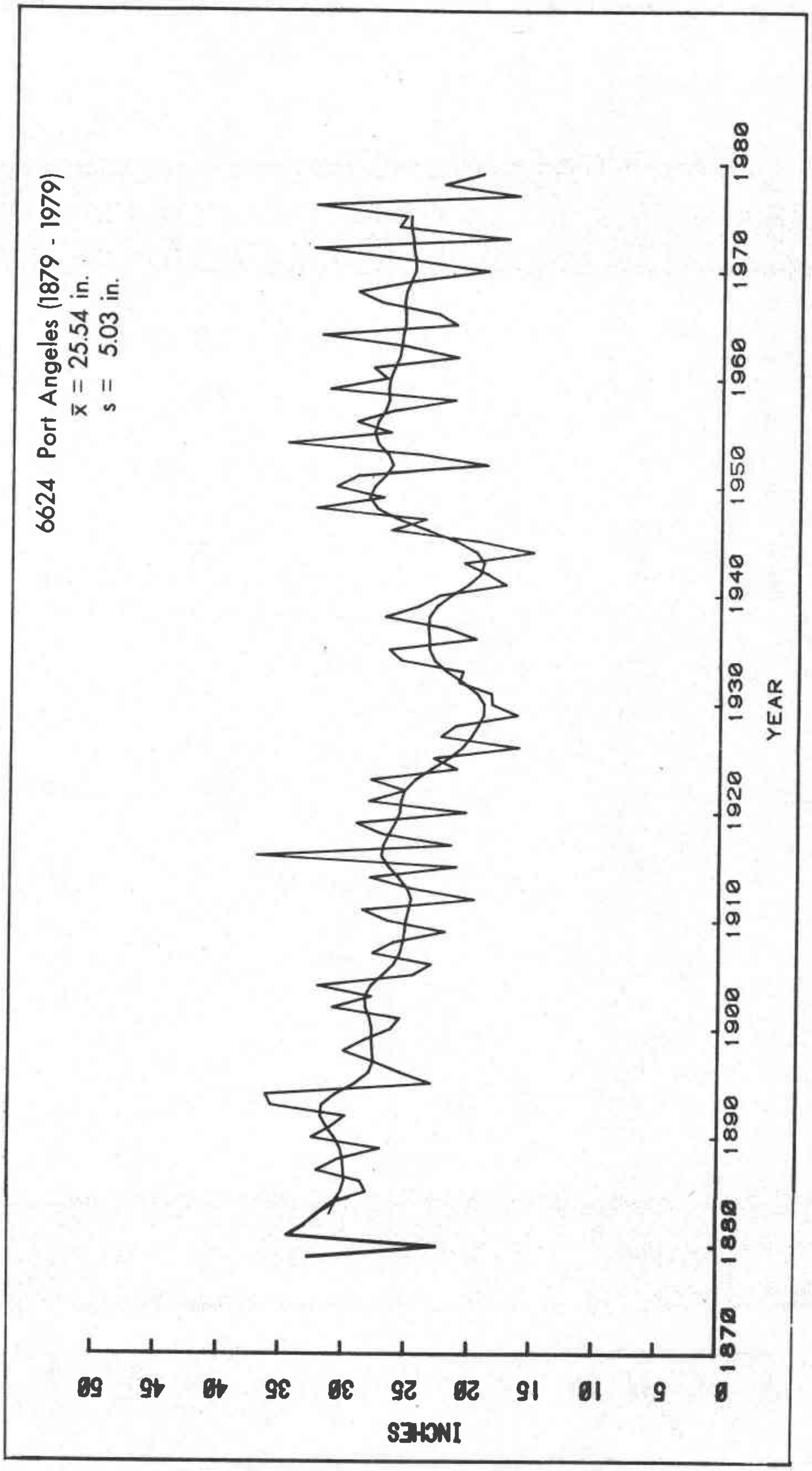

1484 Clearbrook (1903 - 1979)
$\bar{x}$ = 47.25 in.
s = 7.67 in.
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
INCHES
20 25 30 35 40 45 50 55 60 65 70 75 80

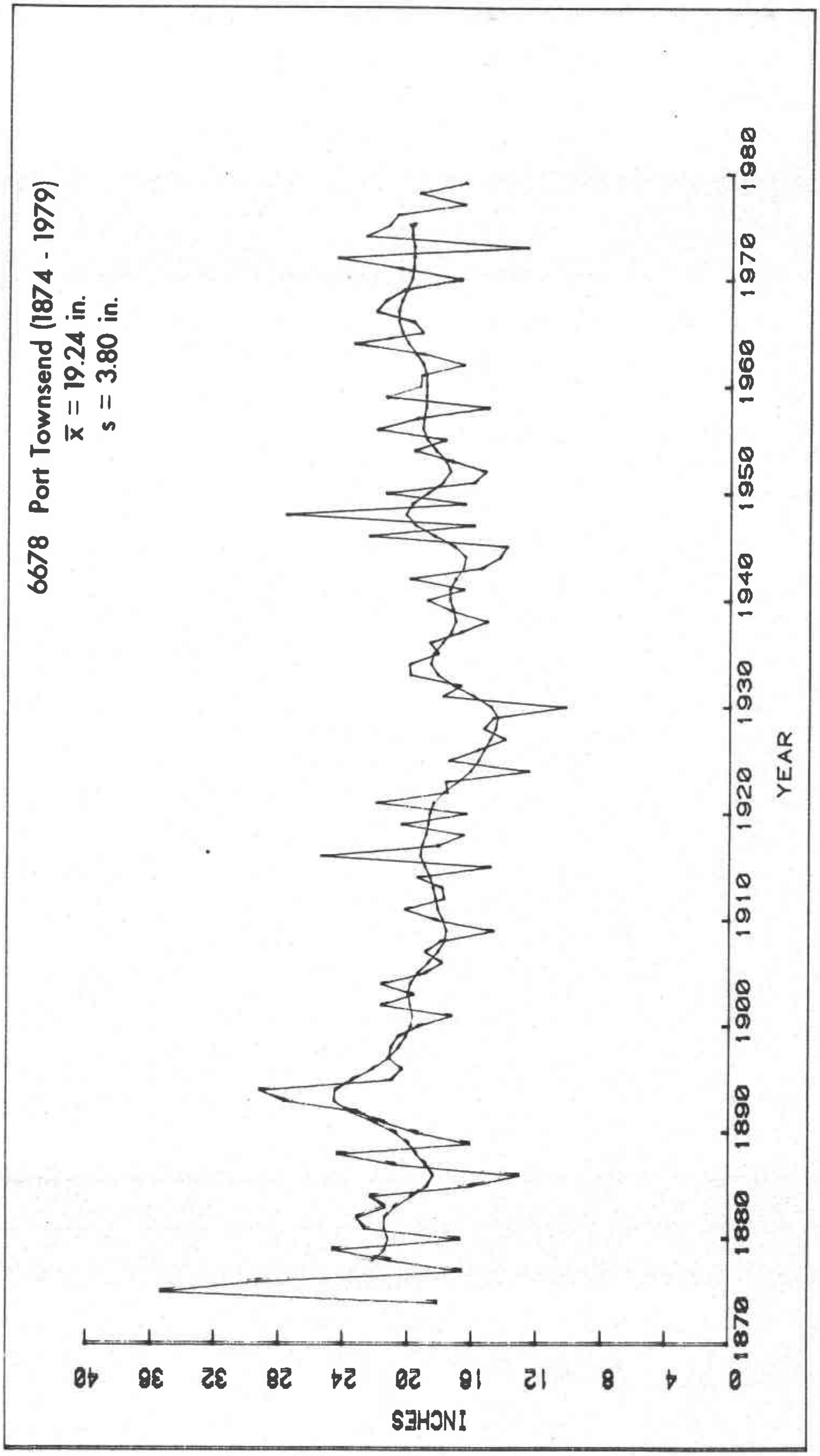

4486 Landsburg (1903 - 1979)
$\bar{x}$ = 55.21 in.
s = 8.49 in.
YEAR
INCHES
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
20 25 30 35 40 45 50 55 60 65 70 75 80


5801 Neah Bay 1 E (1884 - 1979)
$\bar{x}$ = 92.24 in.
s = 21.32 in.
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
INCHES
20 30 40 50 60 70 80 90 100 110 120 130 140 150

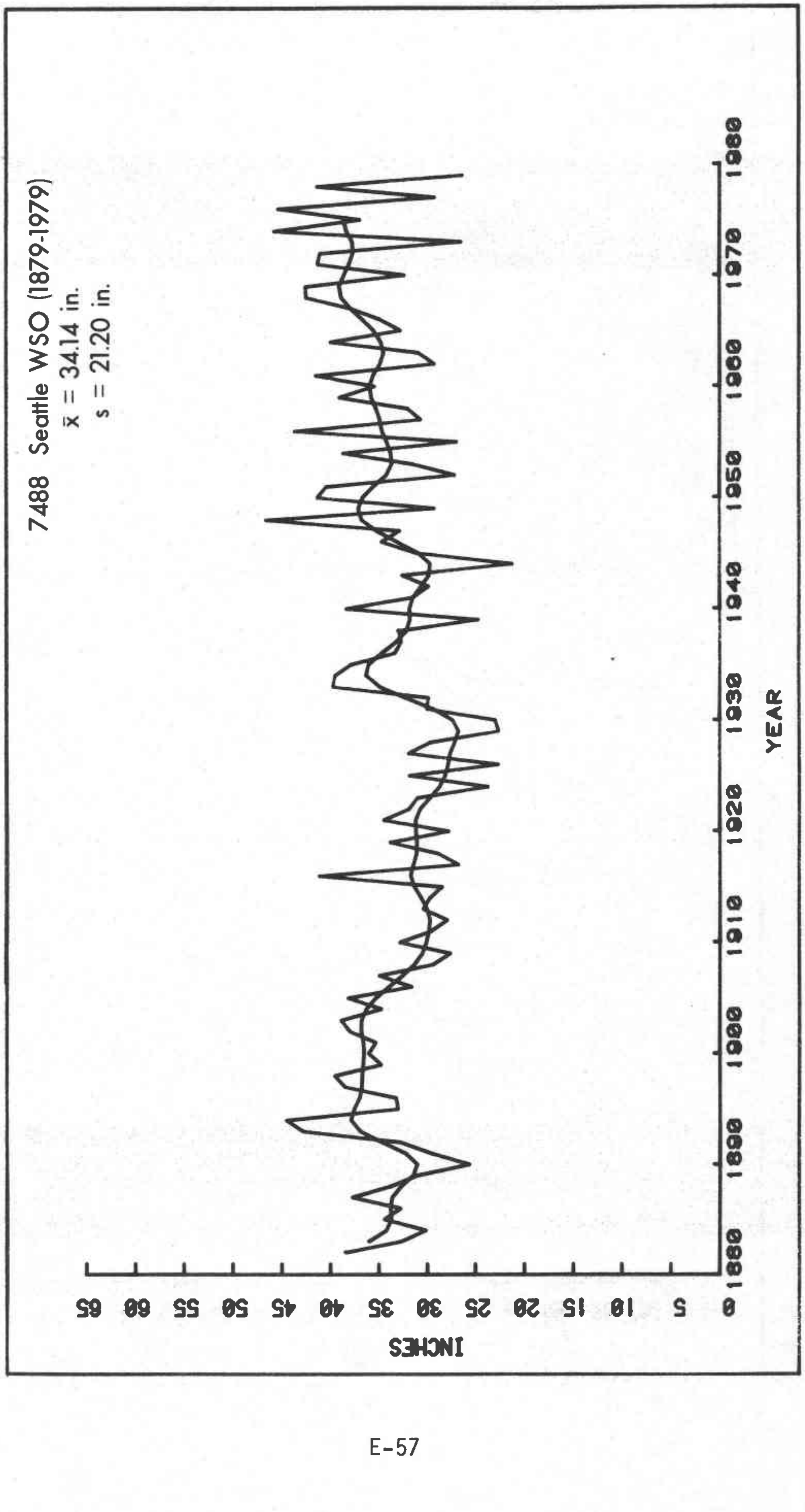

6096 Olga 2 SE (1890 - 1979)
x = 29.13 in.
s = 4.92 in.
INCHES
0
5
10
15
20
25
30
35
40
45
50
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
YEAR

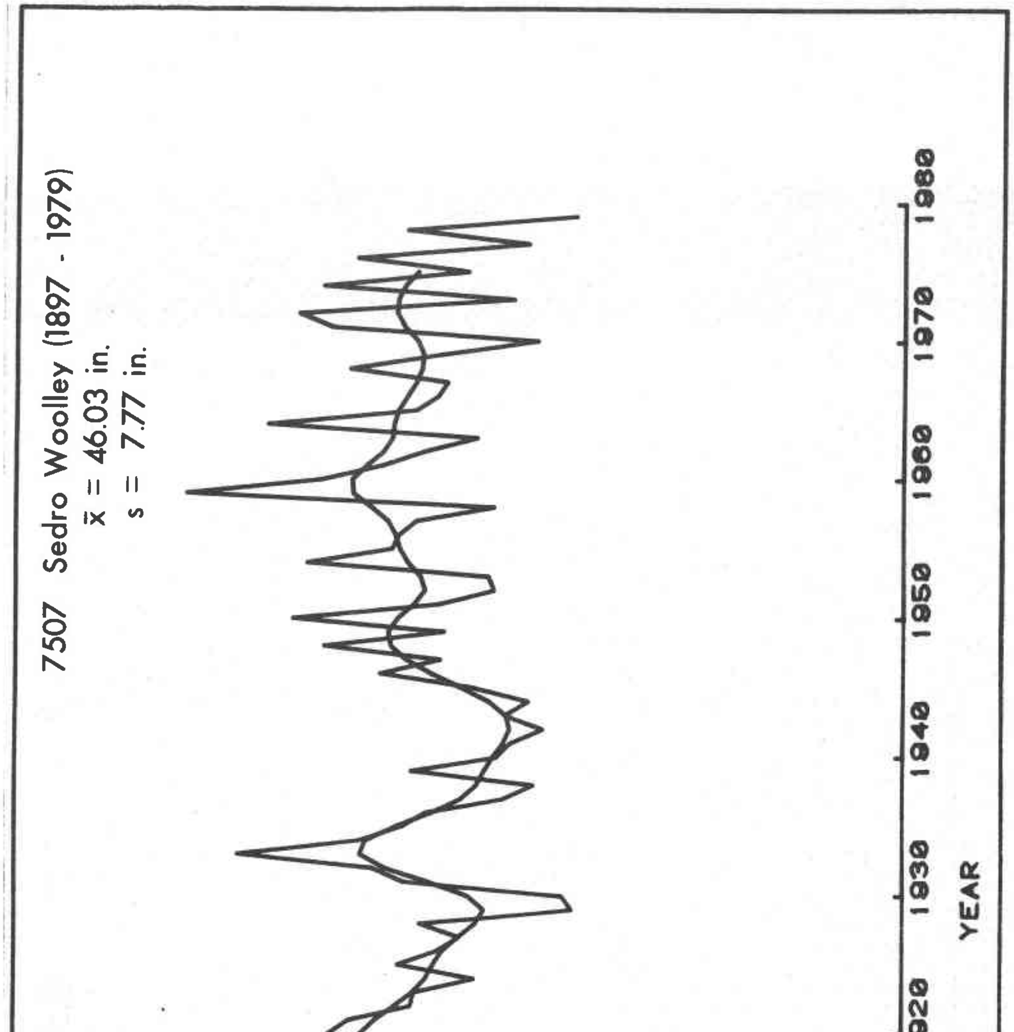

6114 Olympia WSO AP (1878 - 1979)
x̄ = 51.20 in.
s = 10.32 in.
INCHES
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
YEAR
1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980

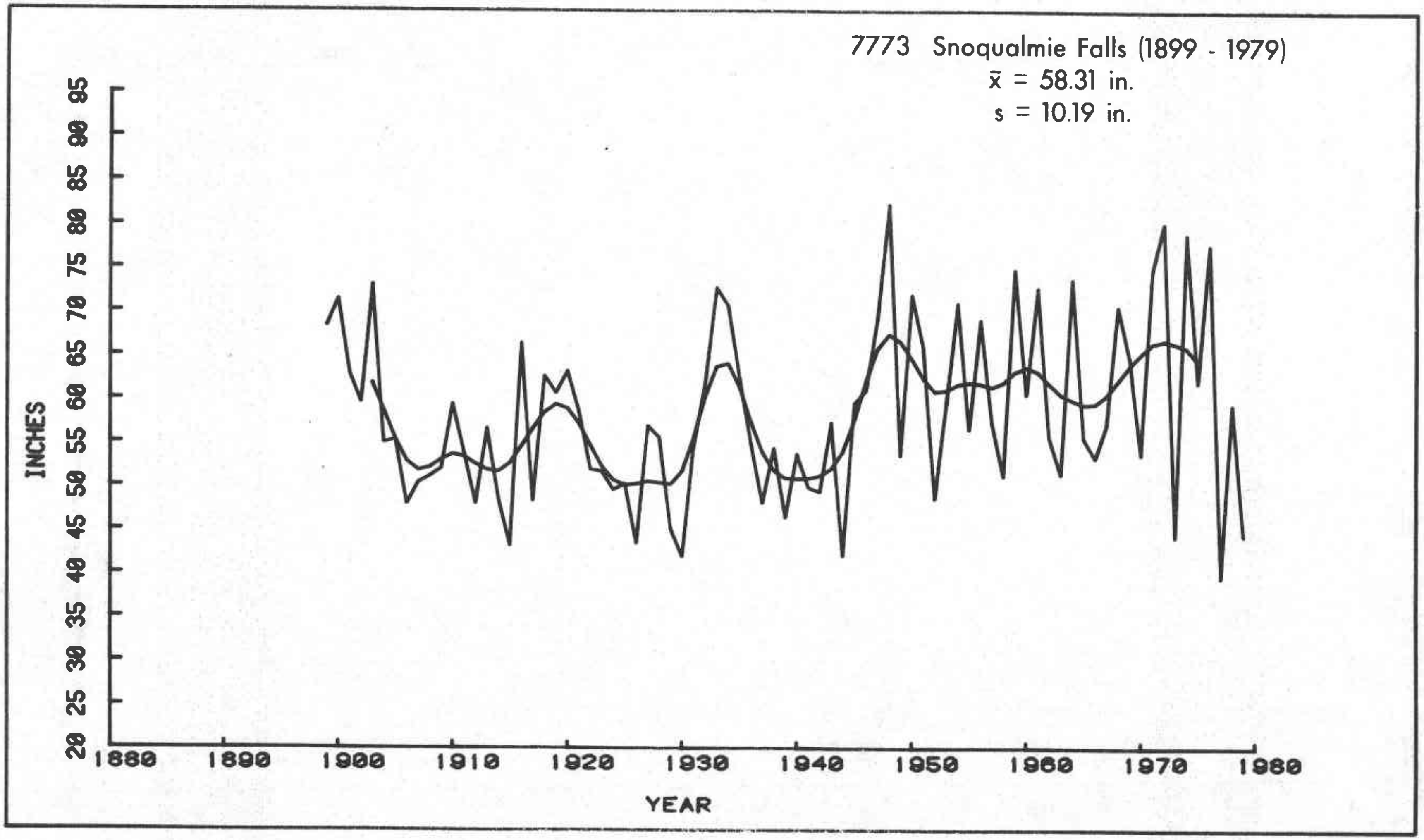

6624 Port Angeles (1879 - 1979)
$\bar{x}$ = 25.54 in.
s = 5.03 in.
INCHES
0
5
10
15
20
25
30
35
40
45
50
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
YEAR

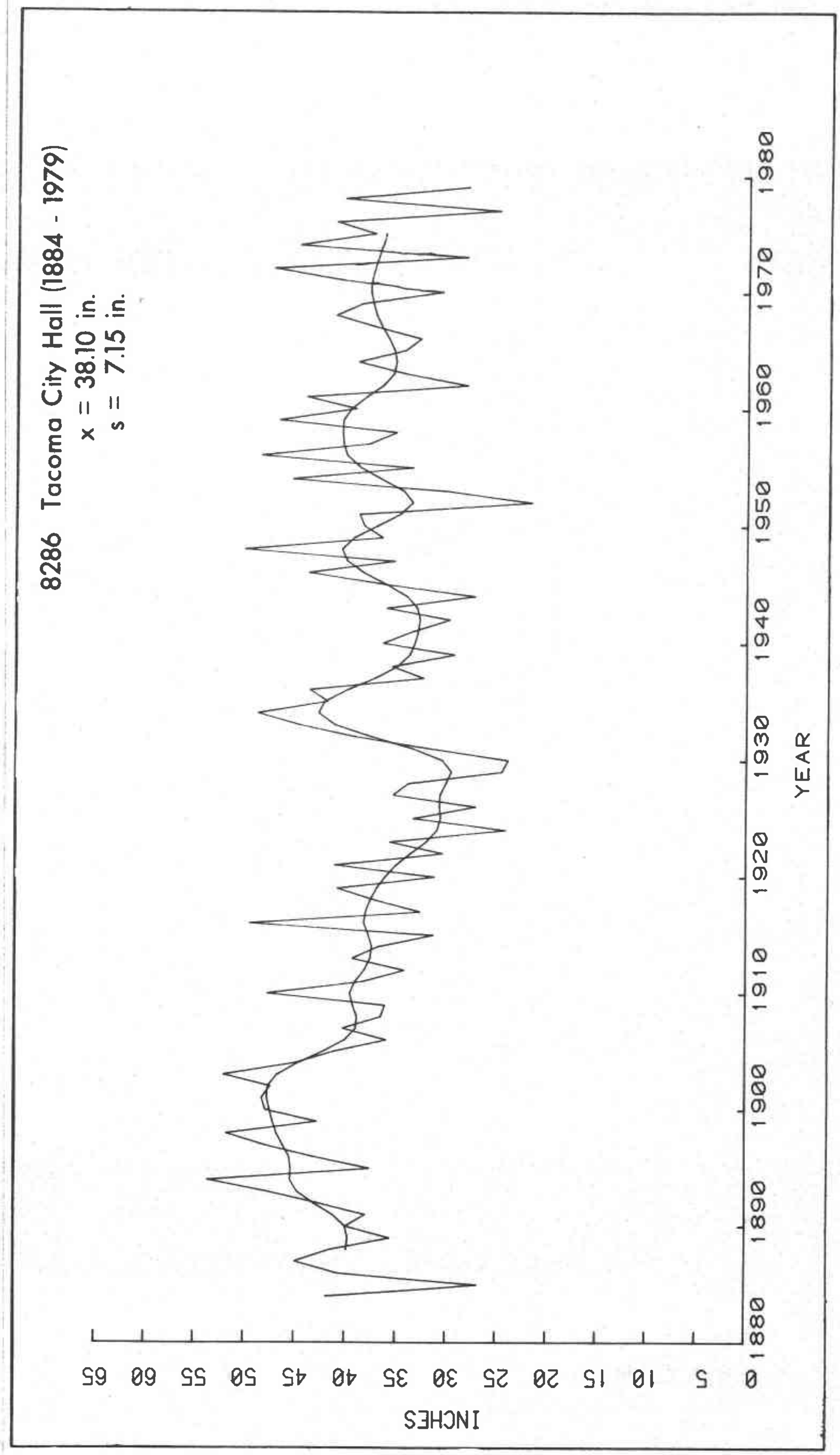


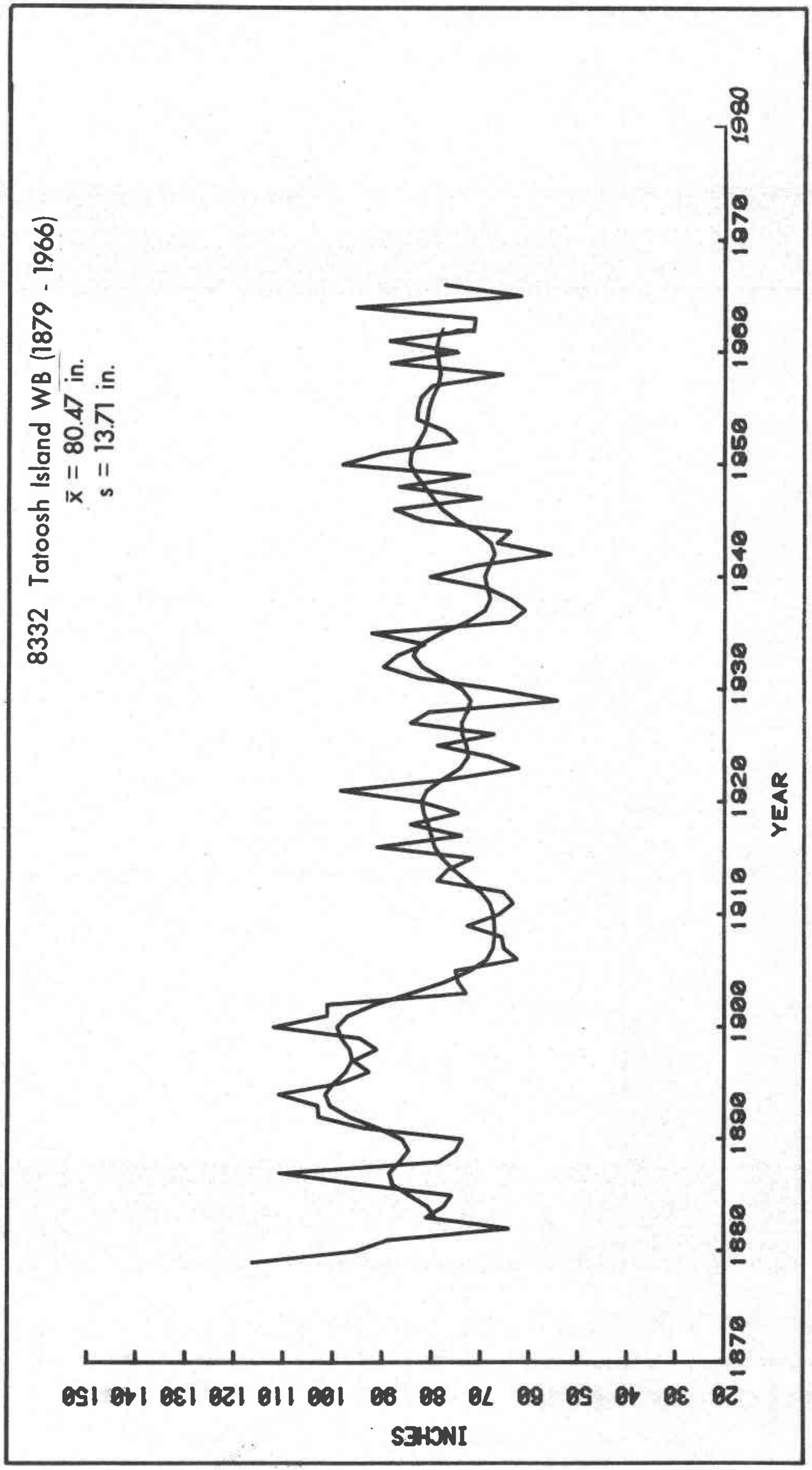
6678 Port Townsend (1874 - 1979)
$\bar{x}$ = 19.24 in.
s = 3.80 in.
YEAR
1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
INCHES
0 4 8 12 16 20 24 28 32 36 40

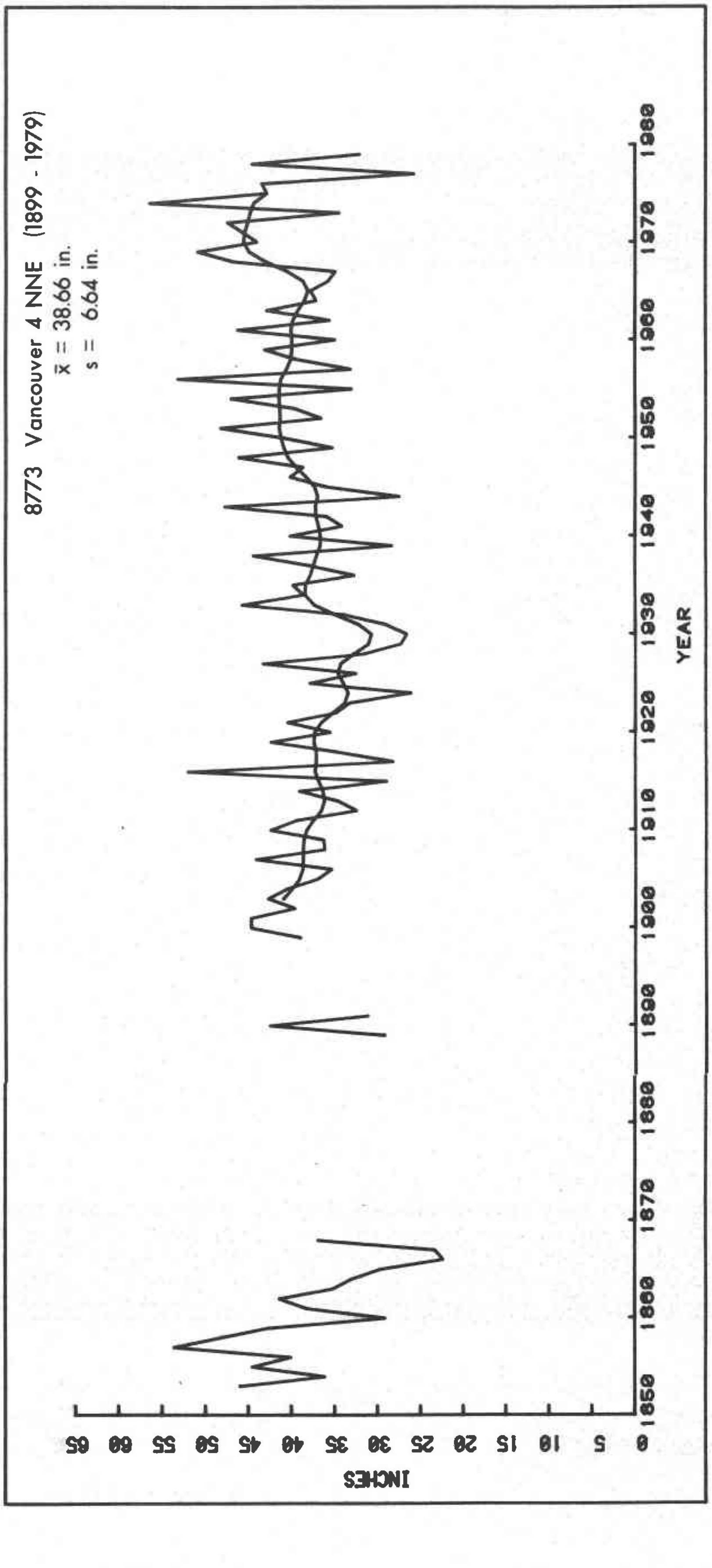

7488 Seattle WSO (1879-1979)
$\bar{x}$ = 34.14 in.
s = 21.20 in.
INCHES
0
5
10
15
20
25
30
35
40
45
50
55
60
65
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980


7507 Sedro Woolley (1897 - 1979)
x̄ = 46.03 in.
s = 7.77 in.
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
INCHES
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75

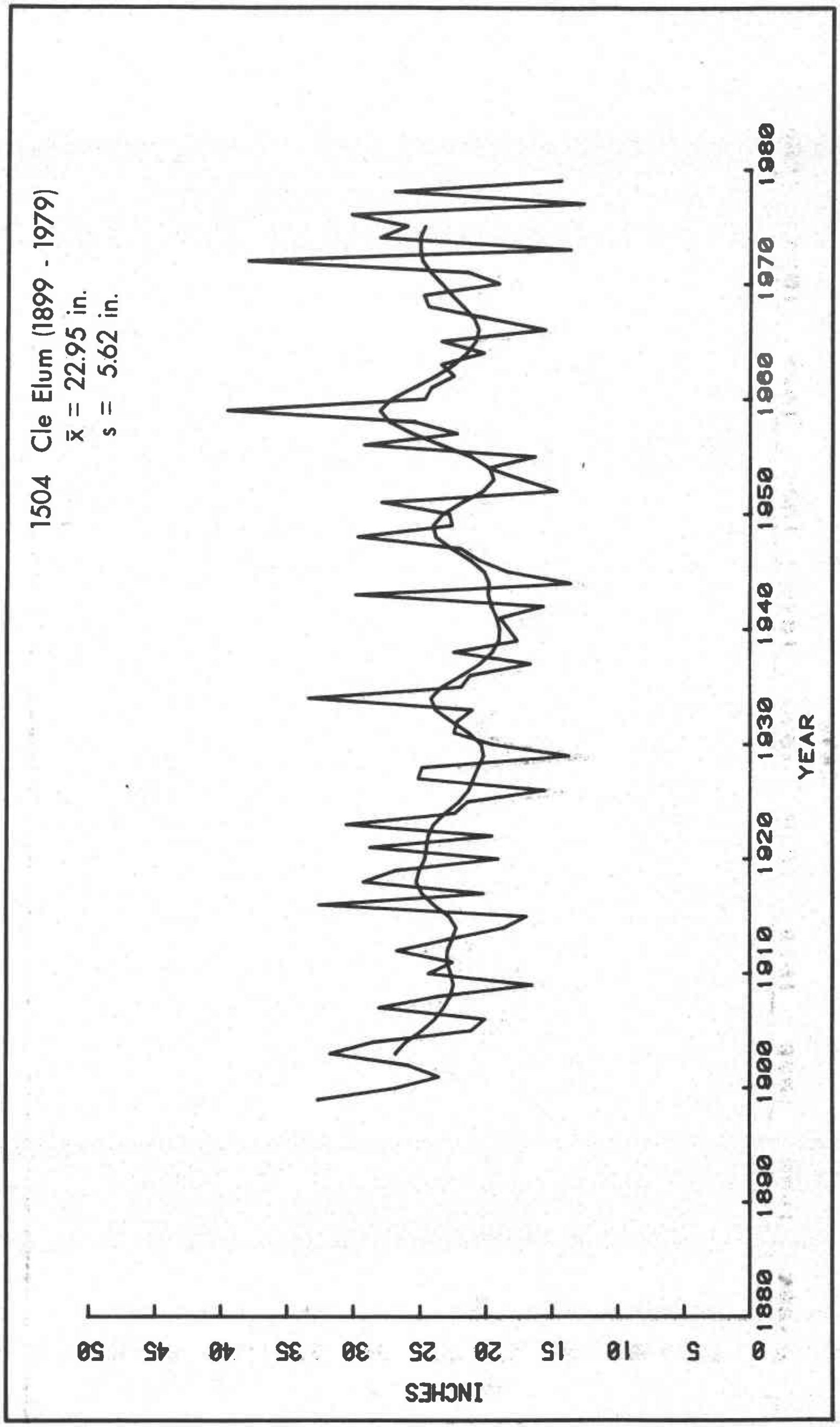

7773 Snoqualmie Falls (1899 - 1979)
x̄ = 58.31 in.
s = 10.19 in.
INCHES
20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
YEAR

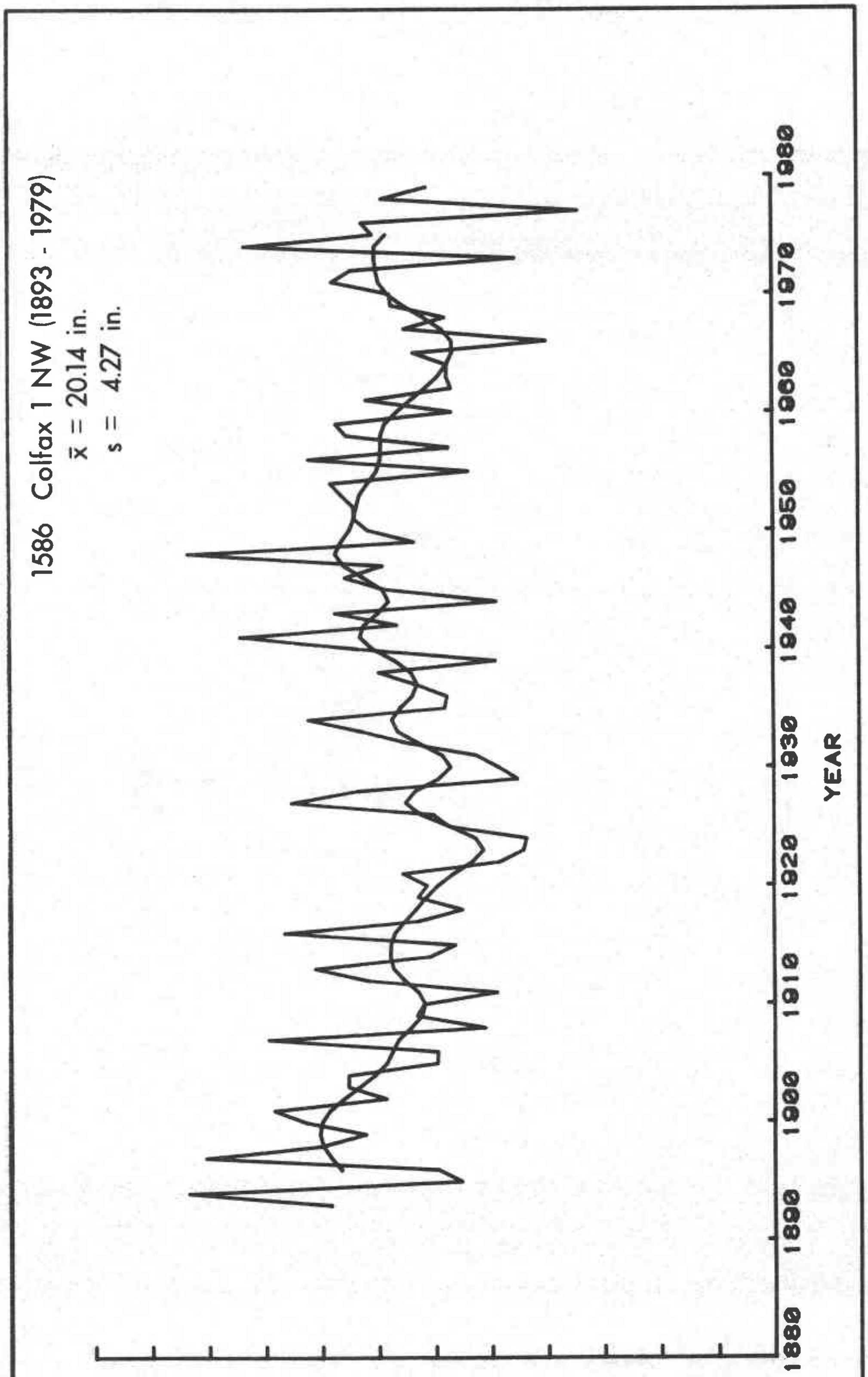

8286 Tacoma City Hall (1884 - 1979)
x = 38.10 in.
s = 7.15 in.
INCHES
0 5 10 15 20 25 30 35 40 45 50 55 60 65
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980

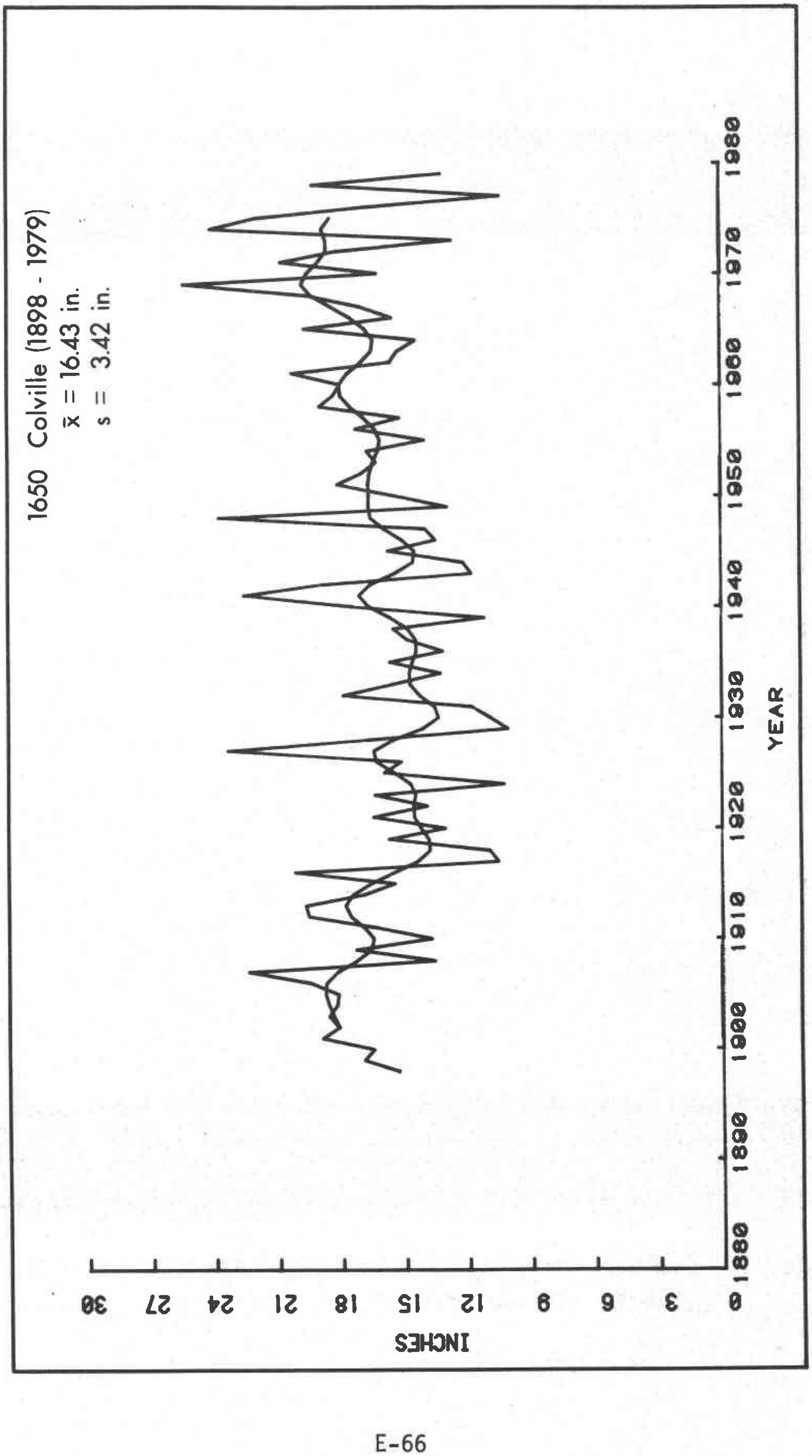

8332 Tatoosh Island WB (1879 - 1966)
x̄ = 80.47 in.
s = 13.71 in.
INCHES
20 30 40 50 60 70 80 90 100 110 120 130 140 150
YEAR
1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980

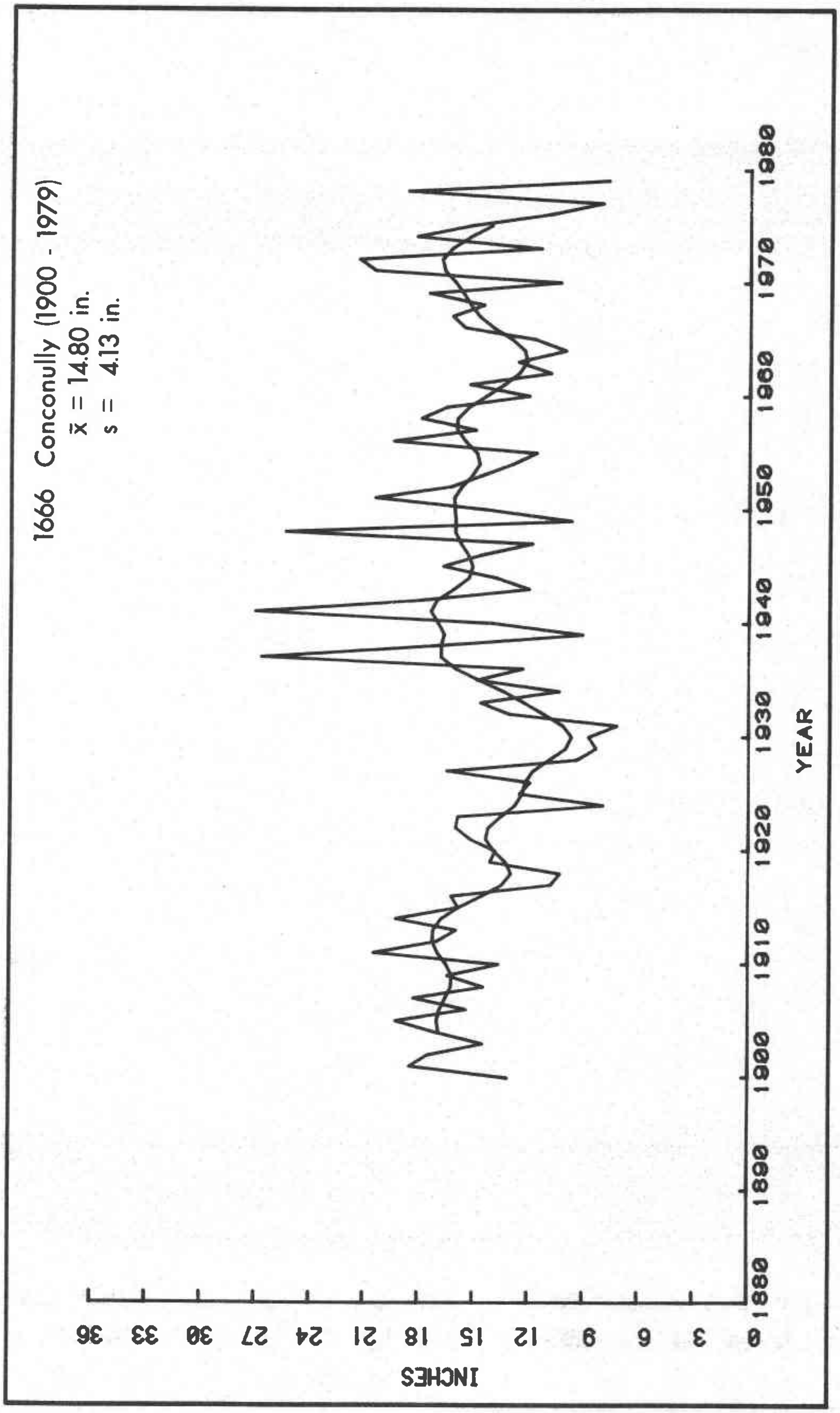

8773 Vancouver 4 NNE (1899 - 1979)
x̄ = 38.66 in.
s = 6.64 in.
YEAR
1850 1860 1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
INCHES
0 5 10 15 20 25 30 35 40 45 50 55 60 65

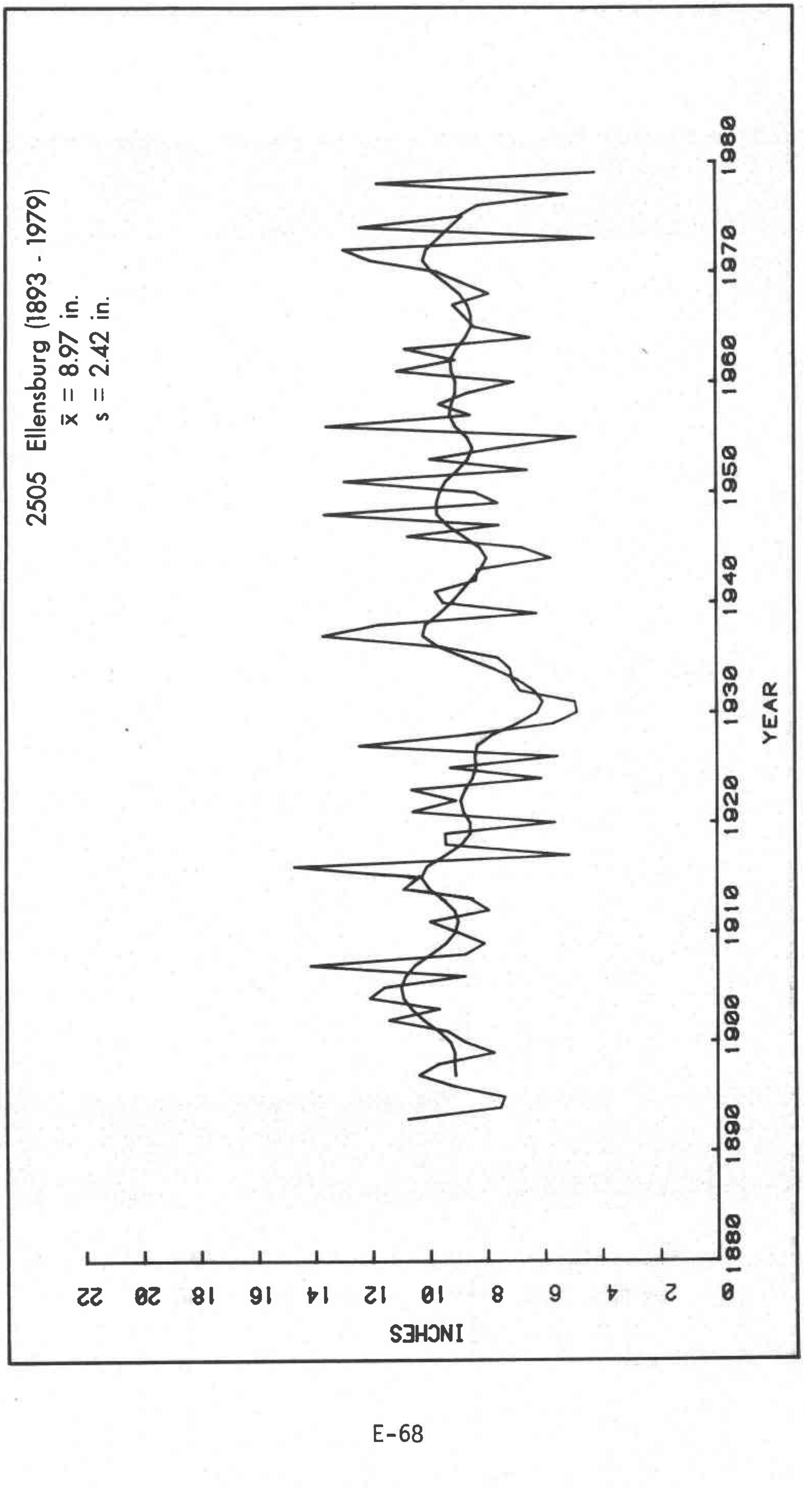
Eastern Washington

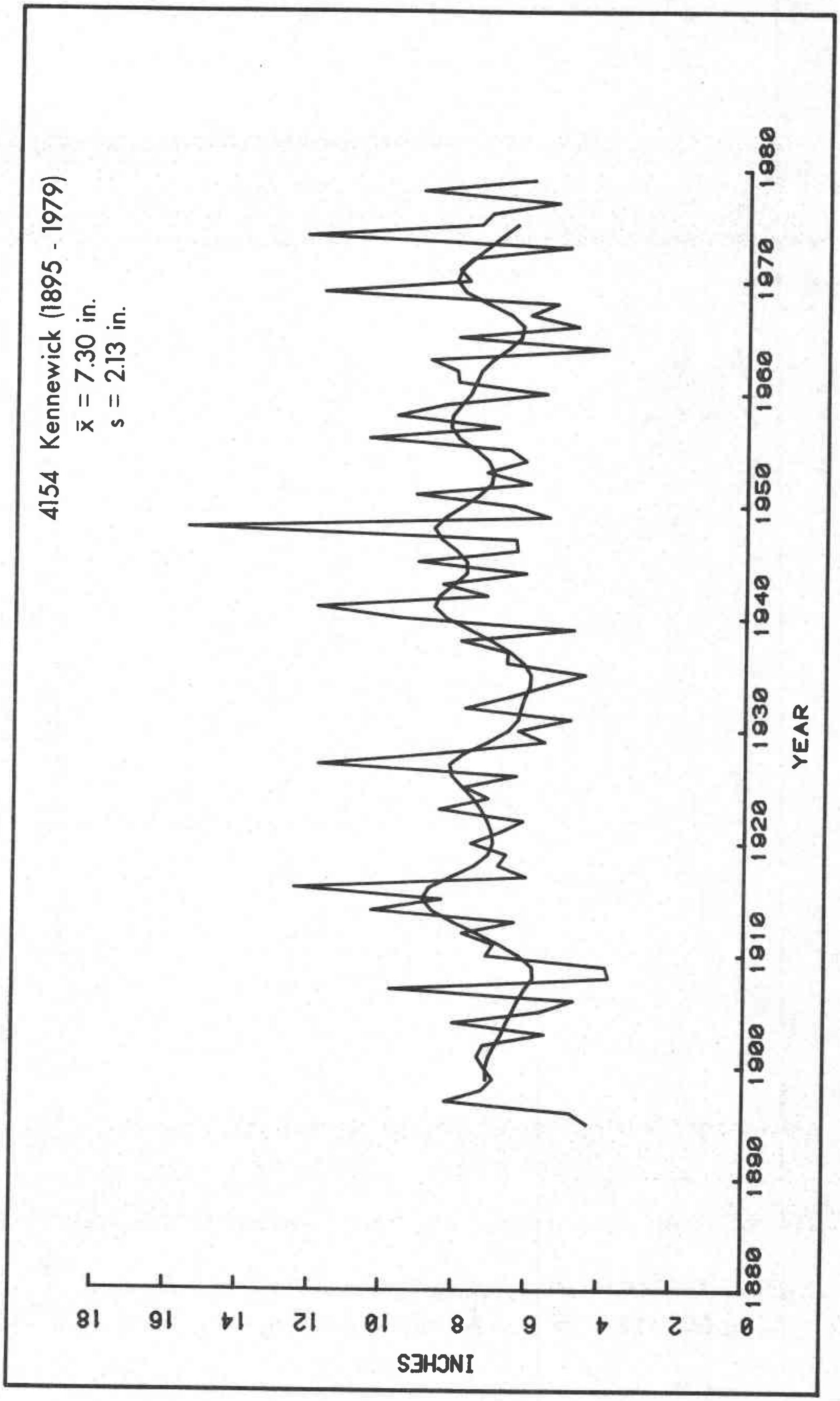

1504 Cle Elum (1899 - 1979)
$\bar{x}$ = 22.95 in.
s = 5.62 in.
INCHES
0 5 10 15 20 25 30 35 40 45 50
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980

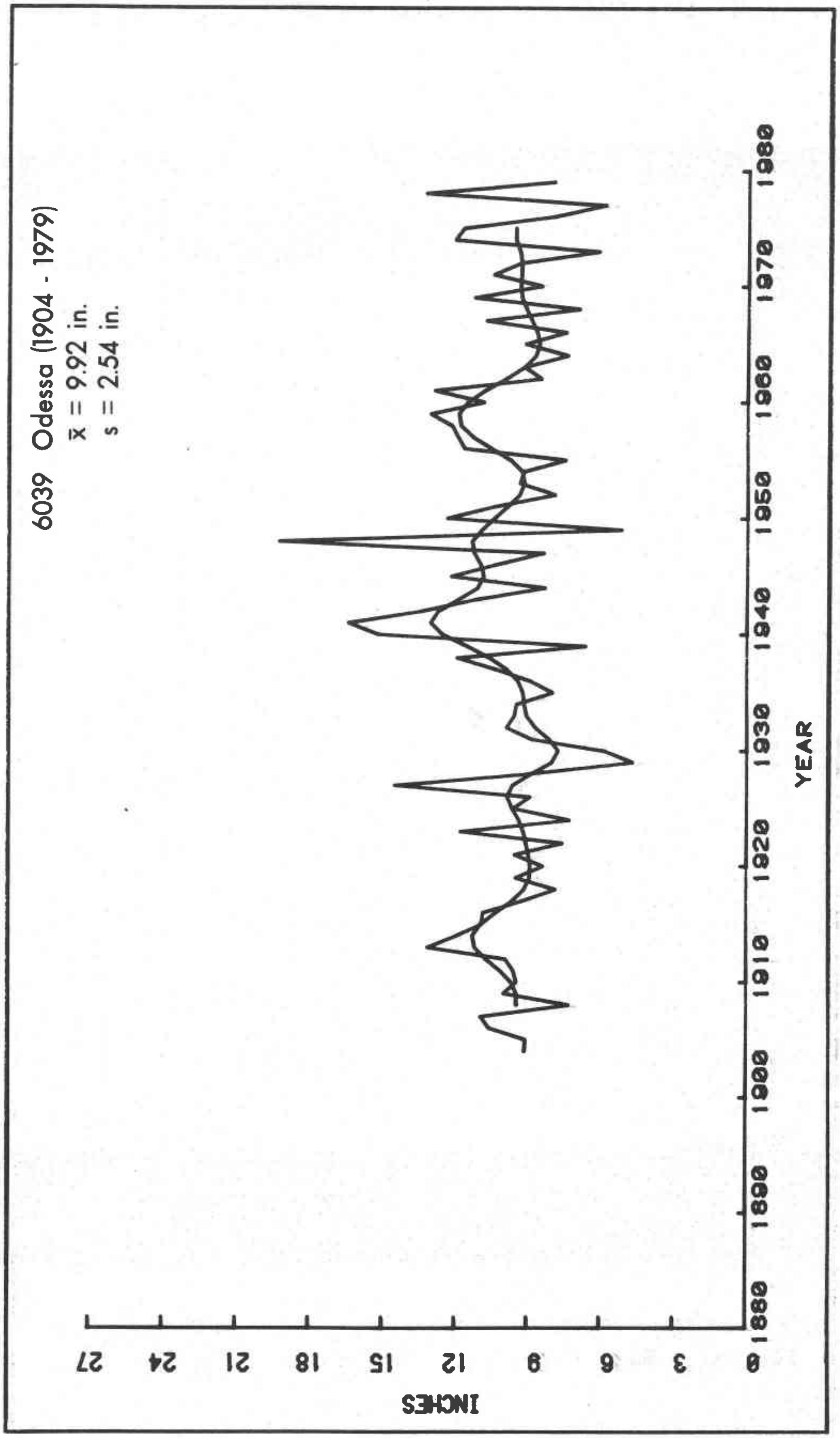

1586 Colfax 1 NW (1893 - 1979)
x̄ = 20.14 in.
s = 4.27 in.
INCHES
0 3 6 9 12 15 18 21 24 27 30 33 36
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980

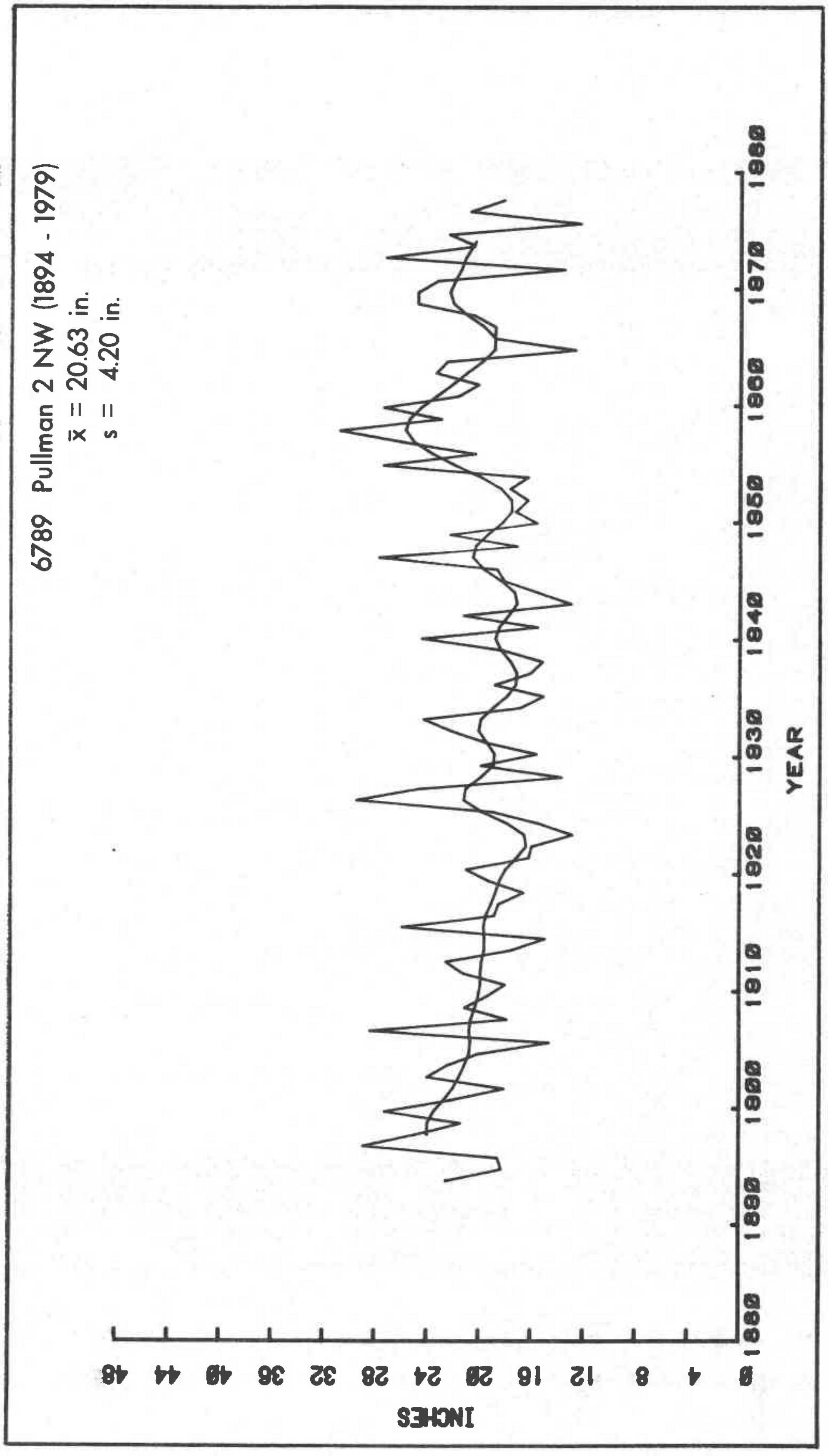

1650 Colville (1898 - 1979)
x̄ = 16.43 in.
s = 3.42 in.
INCHES
0
3
6
9
12
15
18
21
24
27
30
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

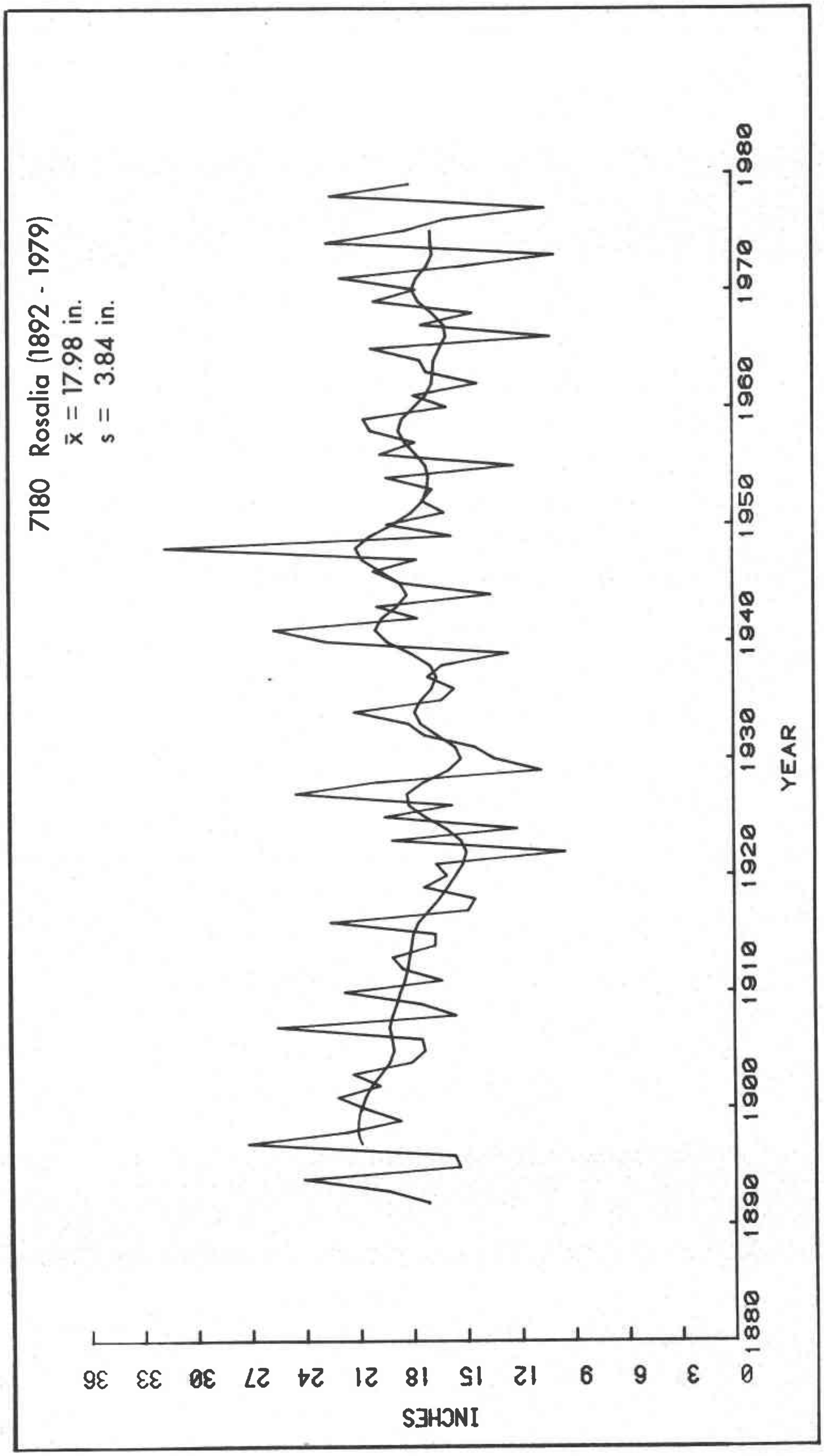

1666 Conconully (1900 - 1979)
x̄ = 14.80 in.
s = 4.13 in.
INCHES
0
3
6
9
12
15
18
21
24
27
30
33
36
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

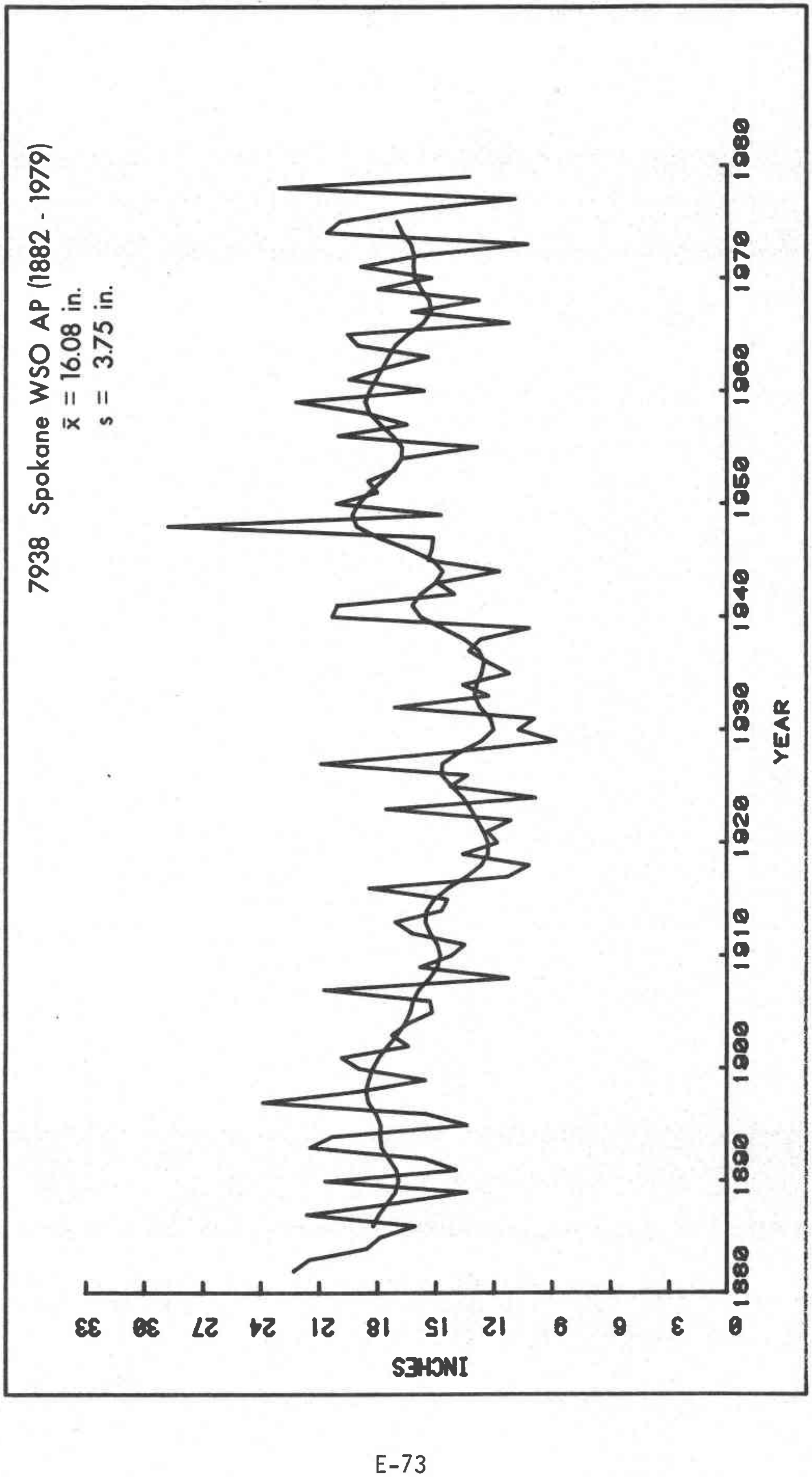

2505 Ellensburg (1893 - 1979)
x̄ = 8.97 in.
s = 2.42 in.
INCHES
0
2
4
6
8
10
12
14
16
18
20
22
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

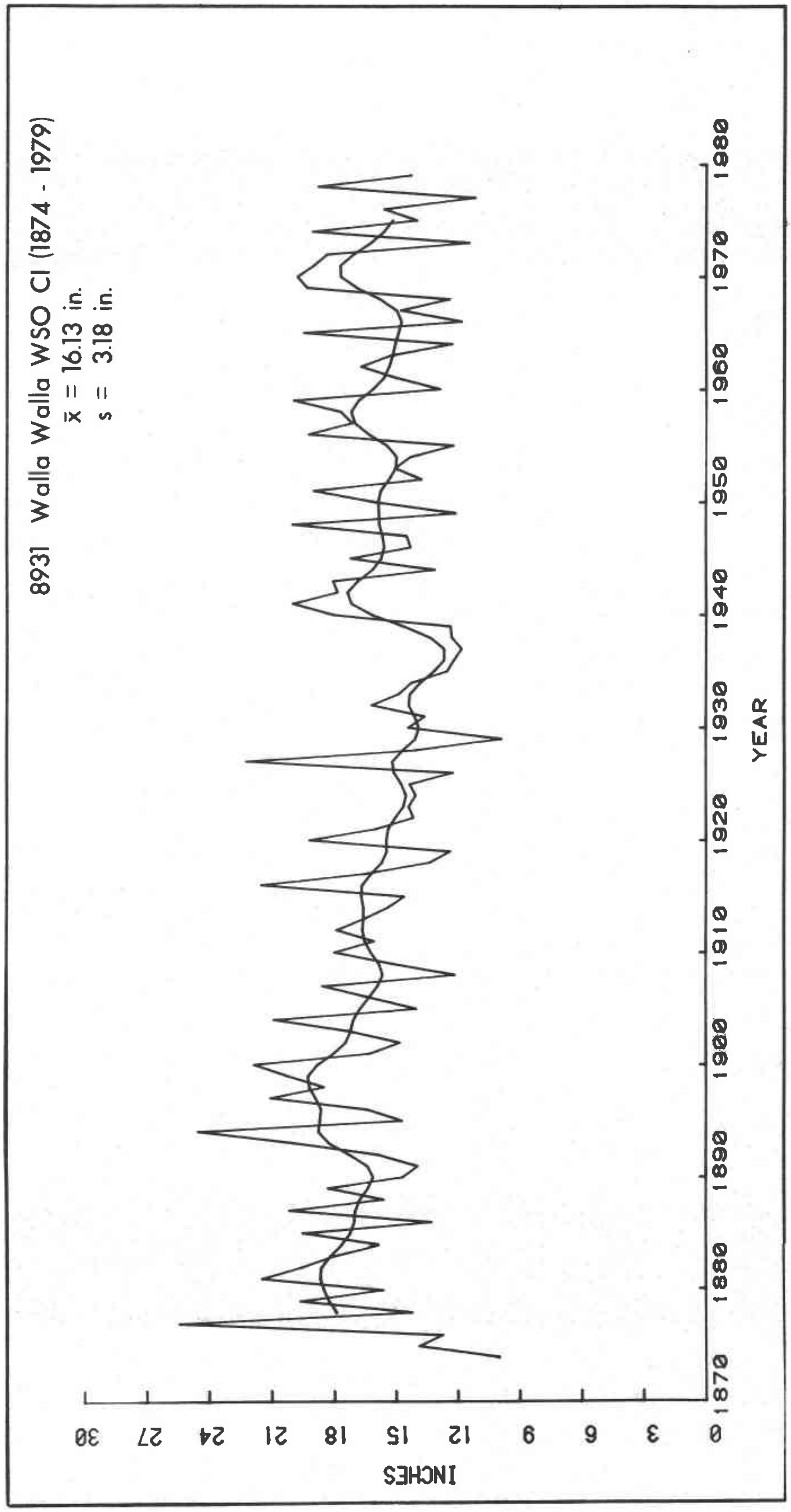

4154 Kennewick (1895 - 1979)
x̄ = 7.30 in.
s = 2.13 in.
INCHES
0
2
4
6
8
10
12
14
16
18
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

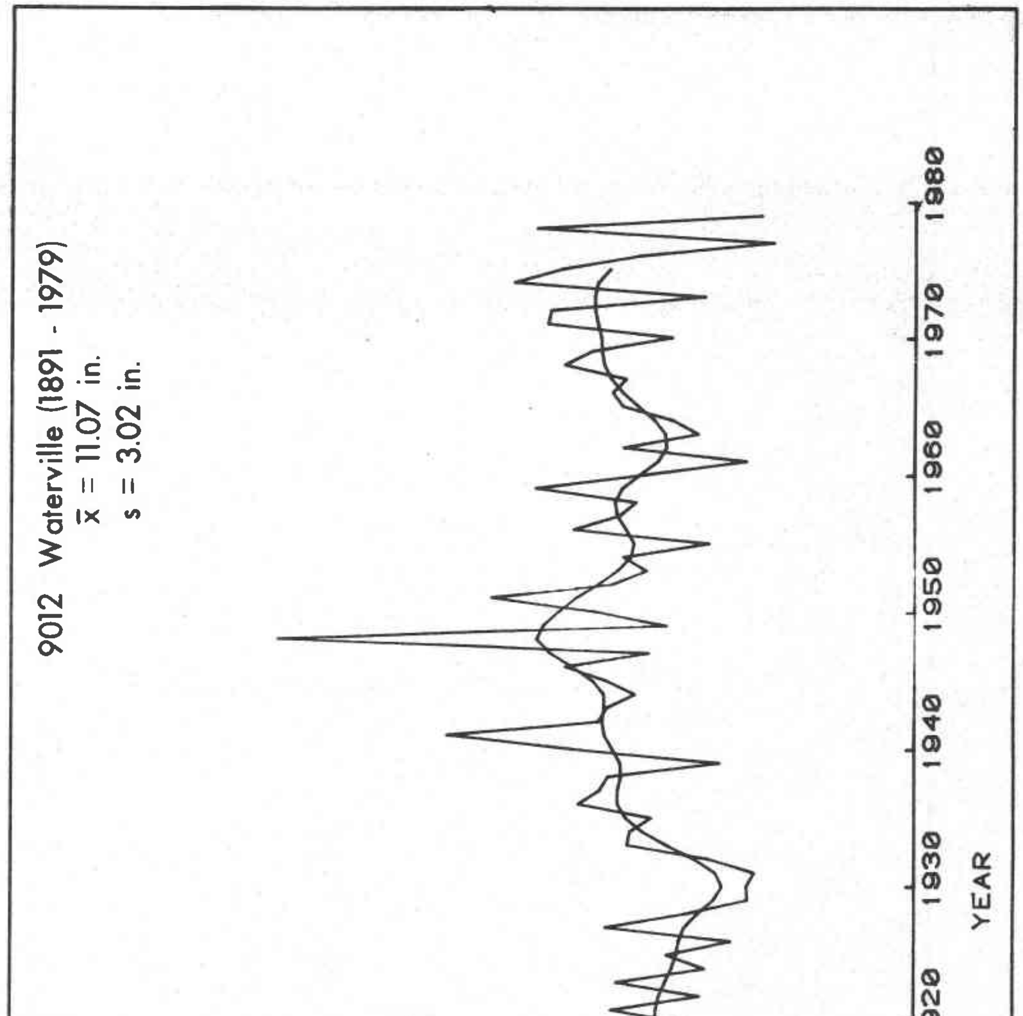

6039 Odessa (1904 - 1979)
x̄ = 9.92 in.
s = 2.54 in.
INCHES
YEAR
0
3
6
9
12
15
18
21
24
27
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

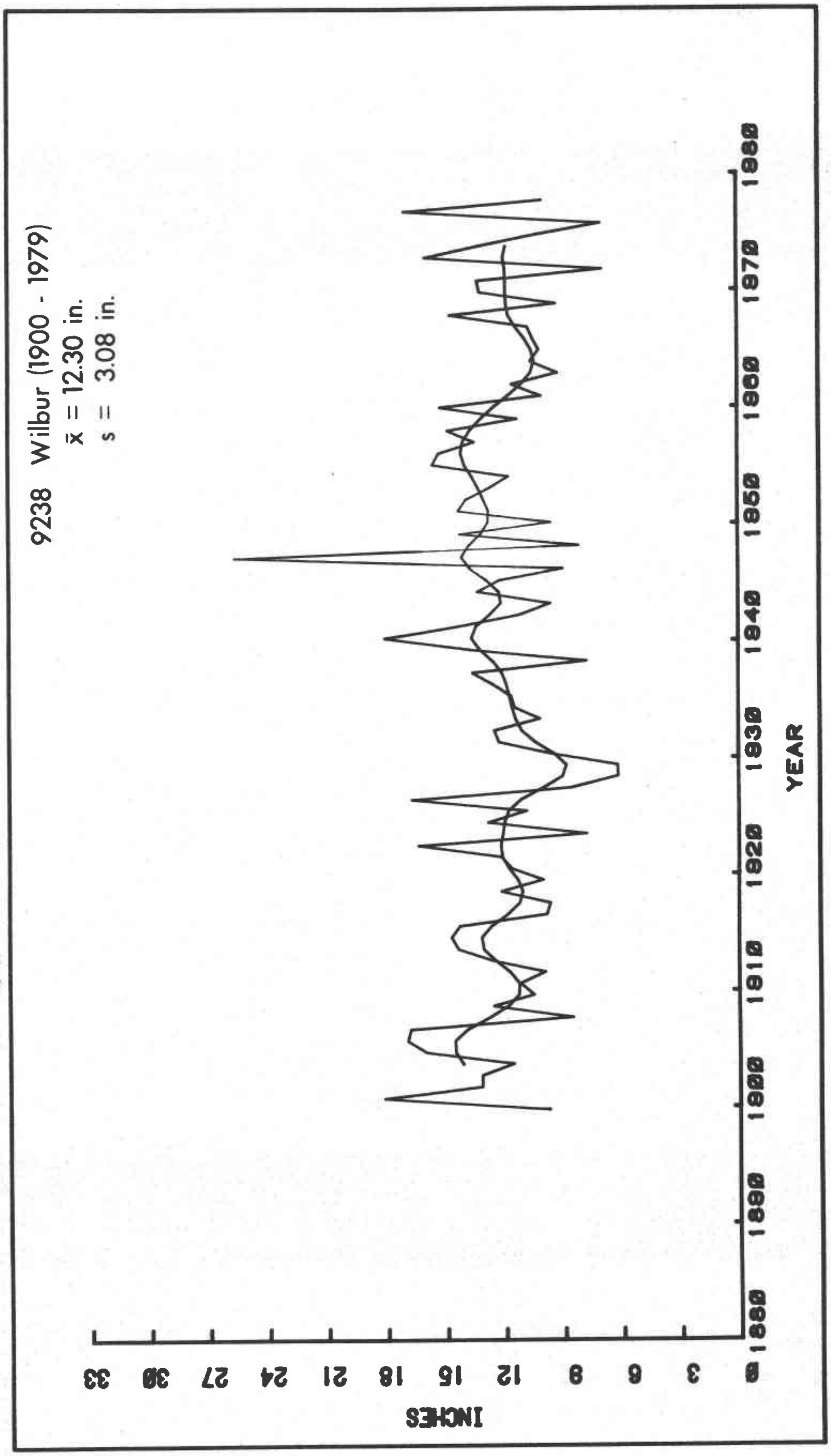

6789 Pullman 2 NW (1894 - 1979)
x̄ = 20.63 in.
s = 4.20 in.
INCHES
0
4
8
12
16
20
24
28
32
36
40
44
48
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

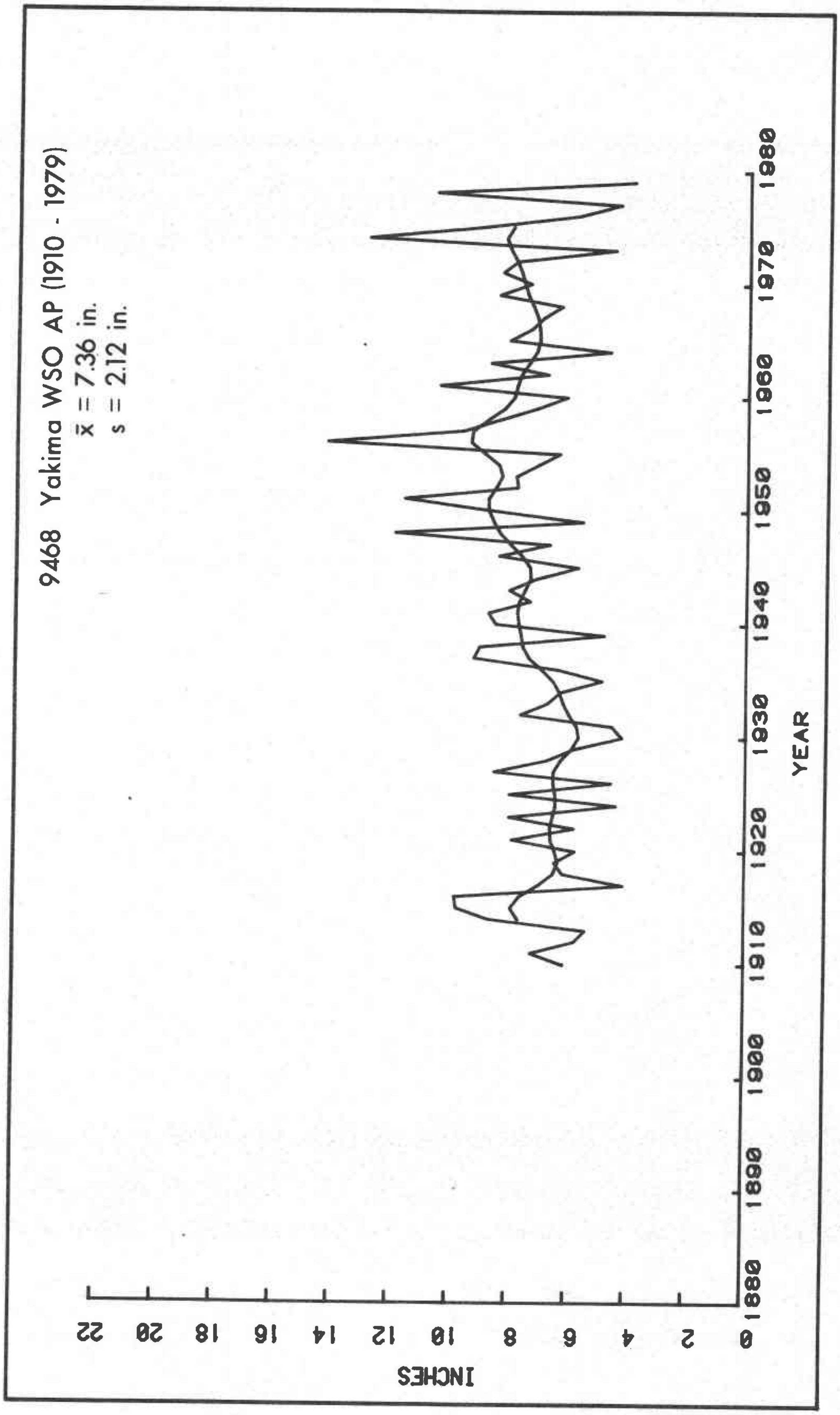

7180 Rosalia (1892 - 1979)
$\bar{x}$ = 17.98 in.
s = 3.84 in.
INCHES
0 3 6 9 12 15 18 21 24 27 30 33 36
YEAR
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980


7938 Spokane WSO AP (1882 - 1979)
x̄ = 16.08 in.
s = 3.75 in.
INCHES
0
3
6
9
12
15
18
21
24
27
30
33
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980


8931 Walla Walla WSO CI (1874 - 1979)
x̄ = 16.13 in.
s = 3.18 in.
INCHES
0
3
6
9
12
15
18
21
24
27
30
YEAR
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980


9012 Waterville (1891 - 1979)
$\bar{x}$ = 11.07 in.
s = 3.02 in.
YEAR
INCHES
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980
0 3 6 9 12 15 18 21 24 27 30


9238 Wilbur (1900 - 1979)
x̄ = 12.30 in.
s = 3.08 in.
INCHES
0
3
6
9
12
15
18
21
24
27
30
33
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980


9468 Yakima WSO AP (1910 - 1979)
x̄ = 7.36 in.
s = 2.12 in.
INCHES
0
2
4
6
8
10
12
14
16
18
20
22
YEAR
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980