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PRECIPITATION DISTRIBUTION IN OREGON; PROBABILITY OF DRY YEARS

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Abstract

During the autumn of 1976 and the winter of 1977, the Pacific Northwest section of the United States suffered five months of drought. This paper investigates the monthly rainfall for Oregon from 1900 to 1976. An effort was made to determine if an equivalent dry period had occurred before and whether or not two consecutive dry years were likely to occur.

Oregon is a state which typically has a winter maximum of rainfall. This study considers a "water year" as the annual period of October 1 through September 30.

The analysis of the rainfall data for twenty-seven stations in Oregon shows that the recent drought did not produce the driest "water year" for some locations. Rather, this drought was notable because it occurred in the typical wet months of the year.

Climatology shows that the portion of Oregon west of the Cascade Mountains has never experienced two consecutive dry years. Three scattered locations in Oregon east of the Cascade range have had two consecutive dry years and one has had three consecutive dry years. The probability of such occurrence is almost zero in western Oregon and is under 5% in eastern Oregon. A dry autumn in Oregon is not necessarily followed by a dry winter and spring. Though Oregon is mostly a region of winter maximum precipitation, a dry fall and winter have not historically meant a drastic shortage of water for the crop year.

1. INTRODUCTION

A great shortage of precipitation occurred throughout the Pacific Northwest during the period October 1976 through most of February 1977. Because this region is heavily dependent upon winter-time rainfall for hydropower year-round and for irrigation the following summer, the acute winter rain shortage was of widespread concern. This concern led us to investigate the long term precipitation distribution in Oregon to determine if droughts have been frequent, widespread or of long duration. Our goal was to find statistical probabilities of continued droughts of two or more years, or crop-year cycle droughts using the available rainfall records since 1900. Our results should not be considered a prediction of precipitation or the lack of it in a future crop year.

Although this study was directed toward the state of Oregon, a brief look at a few Washington locations was made. Data were available for the Columbia drainage basin from the River Forecast Center at Portland. That office was able to supply monthly and annual rainfall totals for the region. The period of record extends from 1900 to 1976. The annual cycle used throughout the study is the "water year". The water year is defined as October 1 in one year to September 30 of the following year. This is very useful in a region with a winter maximum precipitation pattern, and it is particularly useful in considering moisture supply and crop water demand for agricultural purposes.

The lack of moisture in its usual period of the year can have a great influence on soil moisture in dryland agriculture as well as on snowpack, runoff and storage for irrigation. Concern about agriculture's need brought many questions regarding the immediate effect of this precipitation deficit and its potential impact for a second year or perhaps longer.

2. DEFINITION

Nearly everyone is affected by severe rainfall shortages. The number of people affected depends on the severity and duration of the anomaly. Nearly all those affected call a dry condition a drought, and among them one finds many definitions of drought. Palmer (1961) says, "Drought can be considered as a strictly meteorological phenomenon. It can be evaluated as a meteorological anomaly characterized by a prolonged and abnormal moisture deficiency." He believes this definition or point of view removes most of the biological complications and arbitrary definitions.

The analysis of annual rainfall data for this study has conformed rather closely to Palmer's view as stated. The amount of precipitation by periods of time has been compared to the long term average for particular reporting stations. Drought in our usage is a condition in which the annual precipitation varies by one standard deviation or more from the local annual average. This objective statement is not encumbered by biological needs or annual distribution of moisture.

3. VARIABILITY OF PRECIPITATION

The time and space variability of precipitation is great over an area so large as the state of Oregon (252,150 sq km). The mountains and high plateaus which cover much of the state enhance the variability.

A cross section of normal annual precipitation versus the 1977 water year precipitation in Oregon at latitude 45°N is shown in Figure 1. The 1977 precipitation is shown as a percentage of normal from west to east at this latitude. It varied from 19% in some "rain shadowed" valleys to 75% or 80% on west mountain slopes. Over the more even terrain, 1977 precipitation ranged downward from about 55% to 33% of normal.

Twenty-seven Oregon rainfall stations were used for the study, but of these, six were selected from Oregon's various climatic areas to show the pattern of precipitation variability. They are:

STATION	MEAN PRECIPITATION	STANDARD DEVIATION
Madras	244.0 mm	65.5 mm
Pendleton	323.8	71.0
Klamath Falls	470.8	91.8
Medford	482.5	129.5
Eugene	1020.3	225.0
Portland	1043.5	182.3

Regions with the greatest annual rainfall may have slightly more stable distribution. But, because the standard deviation from mean precipitation may be one fifth to more than one quarter of the mean, a close analysis of precipitation received related to the normal condition must be made to be sure drought condition exists as opposed to the expected variation about the mean. Graphs of the Eugene and Pendleton (locations in Fig. 4) precipitation for 1977 compared to the average can be seen in Figures 2 and 3.

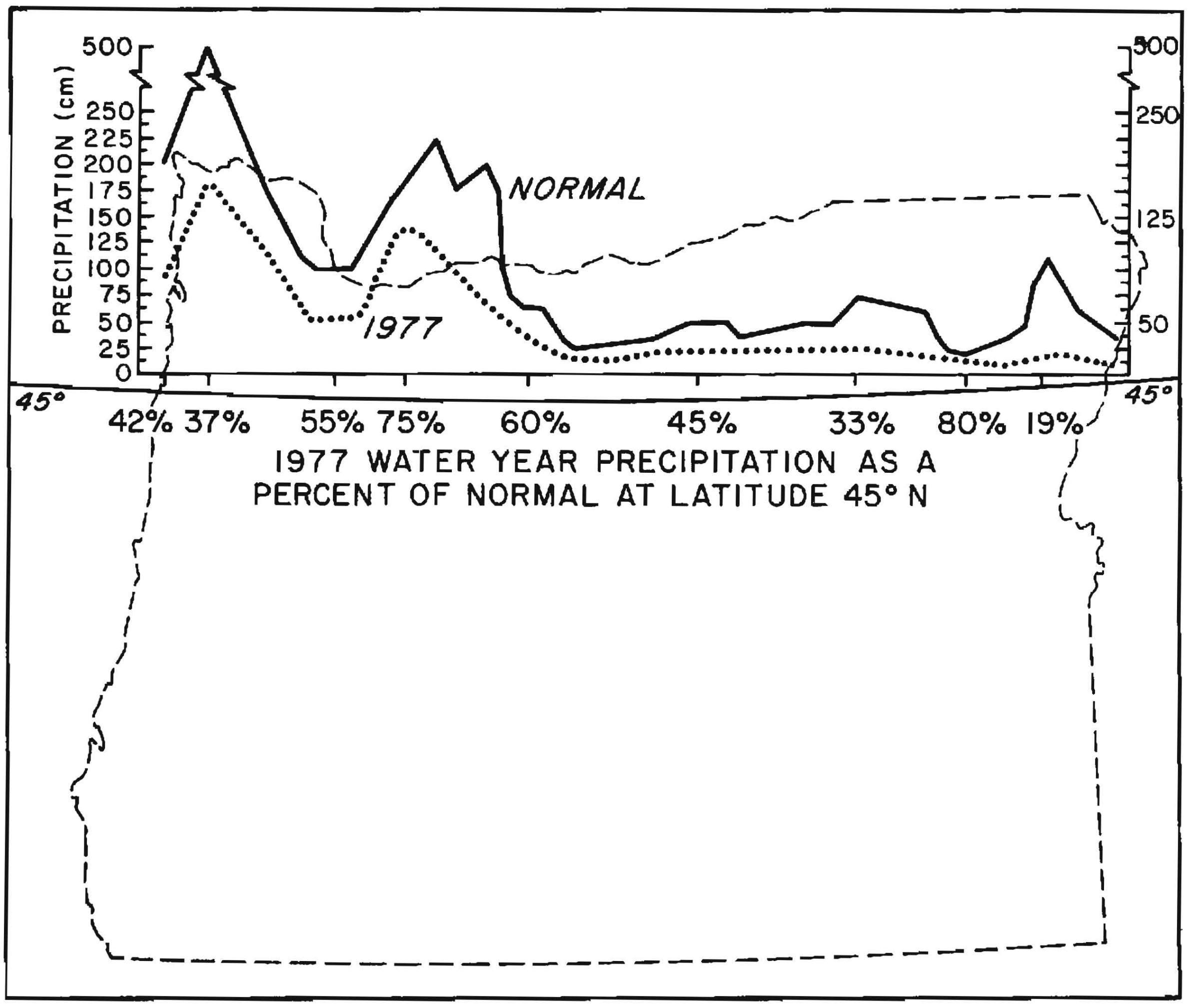

Figure 1. Cross Section at 45°N Latitude in Oregon Showing Normal Precipitation Versus the 1977 Water Year Precipitation.

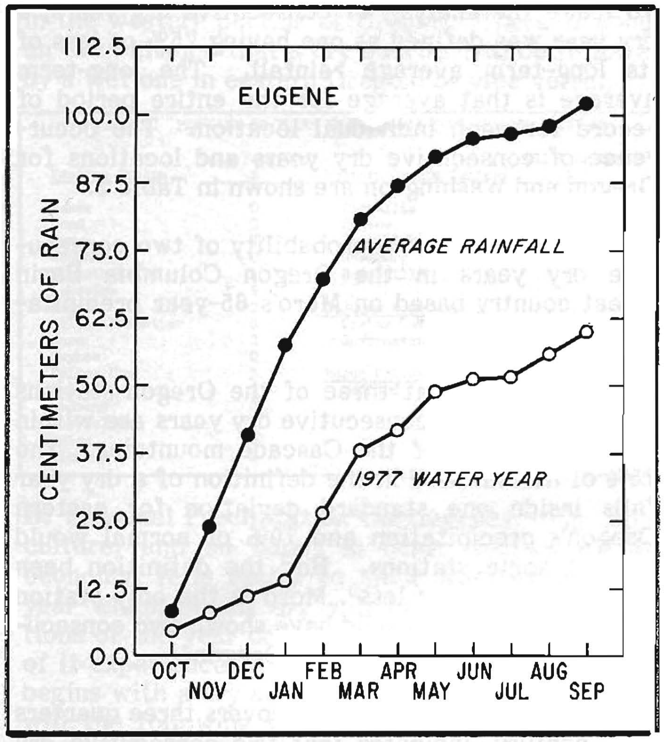

Figure 2. Accumulated 1977 Water Year Precipitation Compared to Average Annual Precipitation at Eugene, Oregon.

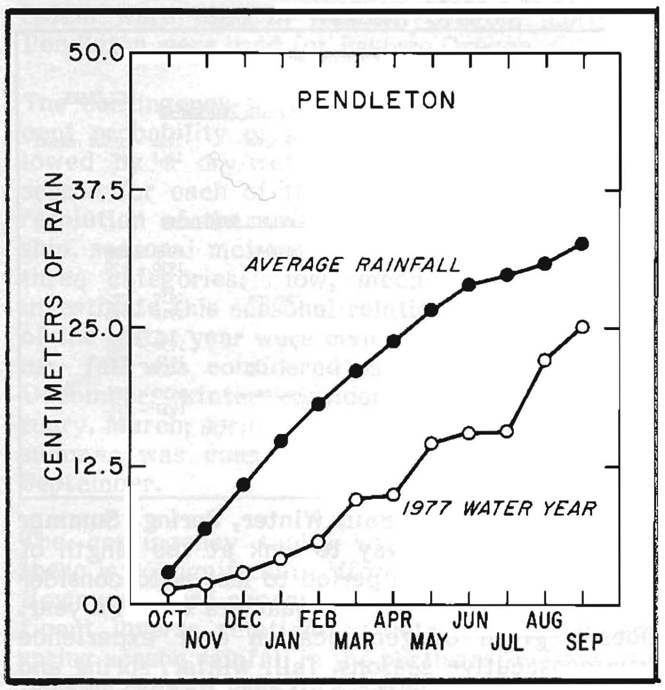

Figure 3. Accumulated 1977 Water Year Precipitation Compared to Average Annual Precipitation at Pendleton, Oregon.

They indicate that 1977 precipitation, in general, both east and west of the oregon Cascades departed more than one standard deviation from average. This would surely place the 1977 water year in the drought category.

4. ANALYSIS OF DATA

Reporting stations in this study have various lengths of record. The period studied is 1900 to 1976. Many stations had records covering 60 or more of these years. The record is of sufficient length to give a stable picture of the climatological condition as it pertains to annual and seasonal rainfall.

The state was divided into 5 climatic areas. They are: Eastern Oregon, Cascade Mountains, Rogue Valley, Western Oregon Valleys and the Coast. Figure 4 shows the geographic position of all precipitation measuring stations of Oregon used in this study.

The water year is designated as October 1 to September 30. For example, the 1921 water year began October 1, 1920 and ended September 30, 1921.

A. Driest Year. The driest year for each of the twenty-seven stations was determined. This varied from 1906 at Government Camp to 1973 at Moro and Astoria. Five locations had the driest year in 1924; four were driest in 1939; and all remaining areas were widely separated in space and time in regard to the driest year. There were a few cases in which a pair of closely situated stations were dry in the same year.

There was some belief that the 1977 water year was the driest year in Oregon in this century. This is only true in some locations and does not seem to be generally true. To investigate this, six stations representing the changes of latitude and elevation and the various climatic sections of the state were selected. Three each were selected for west of the Cascade Mountains and east of the mountains. Of the six stations selected, Portland was the only one at which 1977 was the driest. See Table 1.

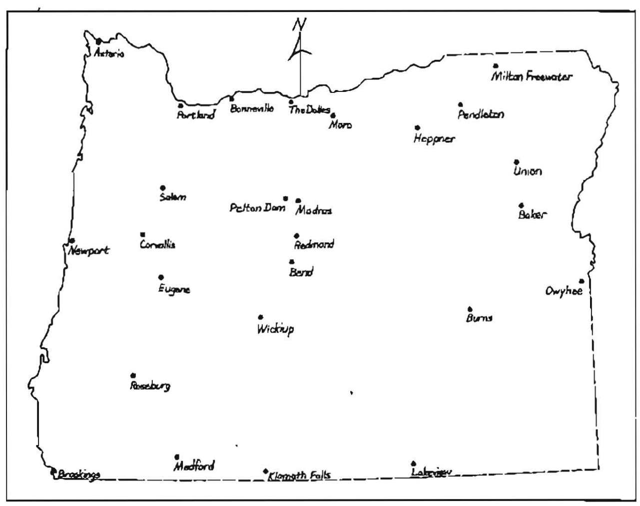

Figure 4. Geographic Position in Oregon of Precipitation Measuring Stations of This Study.

Table 1. DRIEST YEAR AT SIX SELECTED OREGON STATIONS

Station	Mean Precip.	Former Driest Year and Precip. Total		1977 Water Year Precip. Total	1977 Difference from Previous Driest
Portland	1043.5 mm	1944	633.0 mm	596.0 mm	-37.0 mm
Eugene	1020.3	1924	592.0	601.3	+ 9.3
Medford	482.5	1955	213.5	311.3	+97.8
Klamath Falls	470.8	1926	165.3	174.5	+ 9.2
Madras	244.0	1924	110.8	111.8	+ 1.0
Pendleton	323.8	1968	191.8	250.8	+59.0

In 1924, the southwest quarter of the state seemed to be driest; in 1939, it was the northeast quarter. In 1944, the far northwest corner of Oregon, lying north of Newport and Salem was driest. The water year, 1955, had a dry band extending northeastward from Medford to Bend and Redmond in central Oregon. The northern Cascade Mountains showed a tendency for their driest period to have been in 1929, but data are too sparse in the mountains to be certain. Table 2 shows the driest year, prior to the 1977 water year, at all Oregon stations studied. Also, the mean rainfall for the period of record for each individual station is included.

B. Consecutive Dry Years. There was concern that the shortage of rainfall in the 1977 water year might have continued into the water year beginning October 1, 1977. Thus the question arose, "Do any of Oregon's climatic areas ever experience two or more consecutive dry years?"

Table 2. DRIEST YEAR RECORDED - BY REGION

	Year	Amount in mm	Mean Precip. for Entire Period of Record in mm
EASTERN OREGON			
Baker	1919	147.3	274.5
Bend	1955	108.8	299.8
Burns	1939	141.3	289.8
Heppner	1939	206.0	330.8
Klamath Falls	1926	165.3	333.5
Lakeview	1924	141.8	350.8
Madras	1924	110.8	235.0
Milton Freewater	1964	219.8	345.5
Moro	1973	161.5	284.8
Owyhee	1966	97.8	217.8
Pelton Dam	1955	56.0	246.3
Pendleton	1968	191.8	325.3
Redmond	1955	46.3	205.3
The Dalles	1929	197.8	347.0
Union	1939	202.5	338.0
Wickiup	1929	209.5	479.25
WESTERN OREGON VALLEYS			
Bonneville	1944	1323.8	1960.0
Corvallis	1944	624.3	999.8
Eugene	1924	592.0	1020.3
Portland	1944	633.0	953.3
Roseburg	1924	463.0	792.8
ROGUE VALLEY			
Medford	1955	213.5	465.3
CASCADE MOUNTAINS			
Crater Lake	1931	801.5	1692.3
Government Camp	1906	1483.5	2114.0
COAST			
Brookings	1924	971.0	1920.8
Newport	1944	1125.8	1740.8
Astoria	1973	1267.3	1899.5

To make the analysis of consecutive dry years, a dry year was defined as one having 75% or less of its long-term average rainfall. The long-term average is that average for the entire period of record for each individual location. The occurrence of consecutive dry years and locations for Oregon and Washington are shown in Table 3.

There is about a 1.5% probability of two consecutive dry years in the Oregon Columbia Basin wheat country based on Moro's 65-year precipitation record.

It can be seen that three of the Oregon stations with two or more consecutive dry years are within the rain shadow of the Cascade mountains. The 75% of normal used in the definition of a dry year falls inside one standard deviation for eastern Oregon's precipitation and 70% of normal would also at some stations. Had the definition been "70% of normal or less", Moro is the only station in the study which would have shown two consecutive dry years in the state of Oregon.

This period of record, which covers three quarters of a century, indicates that two consecutive dry years in any Oregon or Washington region, though possible, is not very probable. Such a period is very unlikely to encompass more than isolated sections of a state.

Table 3. CONSECUTIVE DRY YEARS

Western Oregon	Dry Years	Western Washington	Dry Years
Western Oregon Valleys	none	Olympic	1944 - 55% of normal
Coast	none		1945 - 69%
Rogue Valley	none		
Cascade Mountains	none		
Eastern Oregon		**Eastern Washington**	
Madras	1933 - 65% of normal	Ephrata	1929 - 55%
	1934 - 71%		1930 - 63%
Moro	1929 - 70%	Spokane	1917 - 72%
	1930 - 70%		1918 - 65%
			- - - - - - -
Owyhee	1954 - 56%		1930 - 69%
	1955 - 72%		1931 - 63%
Wickiup	1933 - 61%	Yakima	1930 - 56%
	1934 - 65%		1931 - 61%
	1935 - 72%		
	- - - - - - - - -		
	1944 - 73%		
	1945 - 69%		

C. Consecutive Dry Fall, Winter, Spring, Summer Seasons. Another way to look at the length of time to expect a dry period to last is to consider consecutive dry seasons or quarters within a year. Does a given Oregon location ever experience four consecutive seasons, fall, winter, spring and summer, of dry weather? Again, a dry season is defined as one having 75% or less of the long-term average precipitation.

With the very small probability, as shown in Table 4, that the four quarters of the year will all be dry, the occurrence of two or three months of dry weather in some part of the state is not likely to spell disaster to Oregon agriculture. There is nearly an even probability that a dry quarter will be followed by a wet one, or the reverse of this, in the western portion of Oregon. There is about an even chance that a dry quarter will be followed by a wet one in eastern Oregon, or vice versa.

Table 4. PER CENT OF YEARS IN WHICH ALL FOUR SEASONS WERE DRY

Eastern Oregon	All Four Dry %	Western Oregon Valleys	All Four Dry %
Baker	0	Corvallis	0
Bend	0	Eugene	1
Burns	3	Portland	1
Heppner	0	Roseburg	2
Klamath Falls	4	Bonneville	0
Lakeview	5		
Madras	2	Cascade Mountains	
Milton Freewater	0	Crater Lake	0
Moro	2	Government Camp	0
Owyhee	0		
Pelton Dam	3	Rogue Valley	
Pendleton	1	Medford	5
Redmond	2		
The Dalles	1		
Union	0		
Wickiup	2		

D. Seasonal Precipitation Contingency. In agriculture, and no doubt in other sectors of the economy, it is useful to know whether or not a year which begins dry will have succeeding portions of the year dry also. If the state or portions of it experiences a crop year or water year which begins with a dry autumn, as was the case in 1976, will the following winter or following spring and summer be dry? Four locations in the state which represent climatic conditions for agricultural regions quite well, both east and west of the Cascade mountains, were selected. Portland and Salem were used in Western Oregon; Moro and Pendleton were used for Eastern Oregon.

The contingency tables in Table 5 show the percent probability of a dry/wet autumn being followed by a dry/wet winter, spring or summer season for each of the locations. Or, for finer resolution of the seasonal precipitation relationship, seasonal moisture is also shown divided into three categories: low, medium and high. To investigate this seasonal relationship, the months of the water year were divided to the four seasons as: fall was considered as October, November, December; winter considered as January, February, March; spring considered as April, May; and summer was considered as June, July, August, September.

The contingency tables show that, in general, there is no significant difference at the 5% level. However, there appears to be a statistically significant inverse relationship between autumn and spring season rainfall in the northwest valleys, the heavier rainfall area, of Oregon. This is shown in the 3-category, spring table for Portland and in the 2-category, spring table for Salem. They indicate that a wet autumn is most likely to be followed by a dry spring or the reverse relationship.

In a practical sense, these differences in precipitation amounts are not impressive. For Portland, the median spring precipitation total is only 113.8 millimeters. The variation from "low" to "high" is

Table 5. CONTINGENCY TABLES FOR PRECIPITATION AT FOUR LOCATIONS

Salem (67 years of record)

Percentages of seasonal precipitation relationship, 2 categories

Winter

Fall	Dry	Wet	Total
dry	51.5	48.5	100
wet	47.1	52.9	100

corrected CHI Sq = .01
significance = .90

Spring

Fall	Dry	Wet	Total
dry	33.3	66.7	100
wet	64.7	35.3	100

corrected CHI Sq = 5.40
significance = .02

Summer

Fall	Dry	Wet	Total
dry	42.4	57.6	100
wet	55.9	44.1	100

corrected CHI Sq = .73
significance = .39

Percentages of seasonal precipitation relationship, 3 categories

Winter

Fall	Low	Medium	High	Total
low	47.6	23.8	28.6	100
medium	39.1	34.8	26.1	100
high	13.1	39.1	47.8	100

raw CHI Sq = 7.12
significance = .12

Spring

Fall	Low	Medium	High	Total
low	23.8	38.1	38.1	100
medium	26.1	26.1	47.8	100
high	43.5	39.1	17.4	100

raw CHI Sq = 5.58
significance = .23

Summer

Fall	Low	Medium	High	Total
low	19.0	28.6	53.4	100
medium	34.8	43.5	21.7	100
high	34.8	34.8	30.4	100

raw CHI Sq = 5.04
significance = .28

(Table 5. continued)

Portland (76 years of record)

Percentages of seasonal precipitation relationship, 2 categories

Winter

Fall	Dry	Wet	Total
dry	52.6	47.4	100
wet	47.4	52.6	100

corrected CHI Sq = .15
significance = .81

Spring

Fall	Dry	Wet	Total
dry	44.7	55.3	100
wet	52.6	47.4	100

corrected CHI Sq = .21
significance = .64

Summer

Fall	Dry	Wet	Total
dry	52.6	47.4	100
wet	47.4	52.6	100

corrected CHI Sq = .05
significance = .81

Percentages of seasonal precipitation relationship, 3 categories

Winter

Fall	Low	Medium	High	Total
low	36.0	36.0	28.0	100
medium	40.0	28.0	32.0	100
high	32.1	43.6	42.3	100

raw CHI Sq = 2.31
significance = .67

Spring

Fall	Low	Medium	High	Total
low	32.0	28.0	40.0	100
medium	20.0	24.0	56.0	100
high	46.2	42.3	11.5	100

raw CHI Sq = 11.46
significance = .02

Summer

Fall	Low	Medium	High	Total
low	32.0	36.0	32.0	100
medium	24.0	40.0	36.0	100
high	42.3	23.1	34.6	100

raw CHI Sq = 2.58
significance = .62

(Table 5 continued)

Pendleton (76 years of record)

Percentages of seasonal precipitation relationship, 2 categories

Winter

Fall	Dry	Wet	Total
dry	44.7	55.3	100
wet	53.8	46.2	100

corrected CHI Sq = .32
significance = .56

Spring

Fall	Dry	Wet	Total
dry	52.6	47.4	100
wet	46.2	53.8	100

corrected CHI Sq = .11
significance = .73

Summer

Fall	Dry	Wet	Total
dry	57.9	42.1	100
wet	41.0	59.0	100

corrected CHI Sq = 1.56
significance = .21

Percentages of seasonal precipitation relationship, 3 categories

Winter

Fall	Low	Medium	High	Total
low	20.0	32.0	48.0	100
medium	38.5	38.5	23.1	100
high	38.5	30.8	30.8	100

raw CHI Sq = 4.48
significance = .34

Spring

Fall	Low	Medium	High	Total
low	48.0	24.0	28.0	100
medium	26.9	42.3	30.8	100
high	23.1	34.6	42.3	100

raw CHI Sq = 4.96
significance = .29

Summer

Fall	Low	Medium	High	Total
low	40.0	40.0	20.0	100
medium	38.5	30.8	30.8	100
high	23.1	26.9	50.0	100

raw CHI Sq = 5.54
significance = .23

(Table 5 continued)

Moro (66 years of record)

Percentages of seasonal precipitation relationship, 2 categories

Winter

Fall	Dry	Wet	Total
dry	40.6	59.4	100
wet	55.9	44.1	100

corrected CHI Sq = .98
significance = .32

Spring

Fall	Dry	Wet	Total
dry	53.1	46.9	100
wet	44.1	55.9	100

corrected CHI Sq = .23
significance = .62

Summer

Fall	Dry	Wet	Total
dry	53.1	46.9	100
wet	41.2	58.8	100

corrected CHI Sq = .52
significance = .46

Percentages of seasonal precipitation relationship, 3 categories

Winter

Fall	Low	Medium	High	Total
low	23.8	33.3	42.9	100
medium	50.0	22.7	27.3	100
high	26.1	39.1	34.8	100

raw CHI Sq = 4.48
significance = .34

Spring

Fall	Low	Medium	High	Total
low	33.3	28.6	38.1	100
medium	27.3	36.4	36.4	100
high	34.8	34.8	30.4	100

raw CHI Sq = .64
significance = .95

Summer

Fall	Low	Medium	High	Total
low	33.3	33.3	33.3	100
medium	36.4	31.8	31.8	100
high	26.1	34.8	39.1	100

raw CHI Sq = .61
significance = .96

as small as 101 mm to 130 mm, yet these are the 33 1/3 percentile and 66 2/3 percentile. For Salem, the median spring value is 97 millimeters. "Dry" and "wet" categories lie either side of this figure and, therefore, the difference from dry to wet cannot be great.

There is no significant relationship of rainfall between seasons for the stations studied in eastern Oregon. If the autumn is dry, at Moro or Pendleton, the winter, spring and summer following are equally likely to be either dry or wet. Also, for Portland and Salem, there is no significant relationship between their autumn precipitation and the following winter or summer. The four stations are representative of climate east and west of the Cascades; also, they are located in and represent important agricultural areas.

In general, no significant relationship has been show between precipitation received in the autumn (or lack of it) and the precipitation of winter, spring or summer seasons. On a shorter period basis, can we find persistence of a wet or dry regime from one period to the next or to a distant period?

The correlation from a given month to each succeeding month from October to May was determined for four stations. The resulting matrixes for Salem and Moro are shown in Table 6. These represent western and eastern Oregon climates and each is in an important agricultural area. The bulk of the annual rain falls in these months. Salem, for example, gets 90% of its rain from October through May. During the other months, irrigation is usually required for commercial agriculture except where summer fallowing is practiced. The correlation coefficients for both Moro and Salem, in Table 6, are very low. It cannot be said that the precipitation regime of one month persists into the next or is reflected in a later month, according to this table.

There are many negative correlation coefficients shown. The largest ones of the table show a negative relationship; however, in only one case, May's relation to April at Salem, does a negative correlation show for an immediate succeeding month.

E. Probability of More Than 2/3 of Mean Precipitation Annually. All Sections of Oregon depend on irrigation in the summer for many crops. However, cereals, grass seed crops, range land, and to some extent pastures and tree fruits produce from natural rainfall only. It is thus good to consider how reliable precipitation is through winter, spring, and early summer. Landsberg (1958) points out that the great droughts of 1934 and 1952-56 had annual rainfall amounts of less than 50% of typical over great areas. It is considered that 2/3 of annual normal precipitation will produce a viable crop. Table 7 shows actual probabilities of getting certain percentage categories of normal precipitation at all Oregon stations sampled.

Climatology from the past 75 years shows that there is an 85% probability of getting 68% or more of normal rainfall in Western Oregon valleys during fall and winter and also in the spring and early summer.

During the fall and winter, the Cascade Mountains have a 91% probability of getting 68% or more of their normal precipitation. The probability is 88% that those mountains will get 68% or more of normal precipitation in spring and early summer. Thus, there is a high probability of storing adequate irrigation water for western and central Oregon.

The Rogue Valley has an 83% probability of getting 68% or more of normal precipitation in fall and winter. The probability is 78% in spring and early summer that the Rogue Valley will get 68% or more of normal precipitation.

The vast region east of the Cascade Mountains has considerable variation in precipitation. During the fall-winter period, probability ranges from 78% up to 92% that the region will get 68% or more of normal precipitation. The probability decreases a little in spring and early summer. At that time, the probability ranges from 72% to 86%. However, half the stations sampled get in excess of 200% of normal in the spring and early summer of some years. This is no doubt due to thunderstorm activity in May and June. The relatively high probability of getting 2/3 or more of annual average rainfall plus the possibility of amounts even exceeding 200% of normal in Eastern Oregon shows that caution must be used in predicting crop shortages and the need of such cultural practices as decreasing fertilizer application because three or four dry months have occurred.

Table 6. MONTHLY PRECIPITATION CORRELATION OCTOBER THROUGH MAY

Salem

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Oct	1.000	.106	-.049	.185	.012	.029	-.118	.066
Nov		1.000	.005	-.079	-.052	.236	-.157	-.218
Dec			1.000	.151	-.012	-.003	-.065	-.199
Jan				1.000	.005	-.132	-.258	.065
Feb					1.000	.133	-.023	.157
Mar						1.000	.189	.043
Apr							1.000	-.096
May								1.000

Moro

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Oct	1.000	.050	-.184	-.085	.124	-.024	.051	.020
Nov		1.000	.068	-.042	-.021	-.000	-.257	-.010
Dec			1.000	.145	-.064	-.162	.003	-.027
Jan				1.000	.117	-.146	.016	.071
Feb					1.000	.064	.109	.233
Mar						1.000	.028	-.024
Apr							1.000	.007
May								1.000

Table 7. PER CENT PROBABILITY OF PRECIPITATION BY CATEGORY (% OF AVERAGE) BY SEASON

	0-25 %	26-67 %	68-133 %	134-200 %	>200% of Average
WESTERN OREGON VALLEYS					
October to February					
Corvallis	0	9.0	82.1	9.0	
Eugene	0	13.0	75.3	10.4	
Portland	0	7.7	82.1	10.3	
Roseburg	0	15.2	71.2	13.6	
Bonneville	0	13.2	78.9	7.9	
March to June					
Corvallis	0	14.9	68.7	16.4	
Eugene	0	11.7	72.7	15.6	
Portland	2.6	7.7	79.5	10.3	
Roseburg	0	13.6	75.8	10.6	
Bonneville	0	5.3	81.6	13.2	
CASCADE MOUNTAINS					
October to February					
Crater Lake	0	8.7	78.3	13.0	
Government Camp	0	7.8	76.6	15.6	
March to June					
Crater Lake	0	8.7	80.4	10.9	
Government Camp	0	11.7	80.5	7.8	
ROGUE VALLEY					
October to February					
Medford	0	16.9	66.2	15.4	1.5
March to June					
Medford	0	21.5	60.0	16.9	1.5

Table 7. (continued)

	0-25 %	26-67 %	68-133 %	134-200 %	>200% of Average
EASTERN OREGON					
October to February					
Baker	0	12.0	74.7	13.3	
Bend	1.5	19.7	60.6	18.2	
Burns	0	13.2	68.4	18.4	
Heppner	0	8.5	78.9	12.7	
Klamath Falls	0	20.0	61.4	17.1	1.4
Lakeview	0	17.2	65.6	17.2	
Madras	0	19.6	62.5	17.9	
Milton Freewater	0	8.3	76.7	15.0	
Moro	0	13.6	74.2	12.1	
Owyhee	0	19.5	58.5	22.0	
Pelton Dam	3.4	10.3	72.4	13.8	
Pendleton	0	10.4	77.9	11.7	
Redmond	2.1	14.6	68.8	14.6	
The Dalles	0	9.3	81.3	9.3	
Union	0	13.8	70.8	15.4	
Wickiup	4.1	18.4	59.2	18.4	
March to June					
Baker	0	17.3	65.3	17.3	
Bend	1.5	18.2	62.1	16.7	1.5
Burns	0	18.4	60.5	21.1	
Heppner	0	18.3	63.4	18.3	
Klamath Falls	0	22.9	61.4	14.3	1.4
Lakeview	1.6	18.8	64.1	14.1	1.6
Madras	1.8	17.9	67.9	7.1	5.4
Milton Freewater	0	20.0	61.7	16.7	1.7
Moro	0	21.2	57.6	21.2	
Owyhee	0	24.4	58.5	12.2	4.9
Pelton Dam	6.9	20.7	51.7	13.8	6.9
Pendleton	0	18.2	64.9	16.9	
Redmond	0	14.6	66.7	18.8	
The Dalles	1.3	25.3	52.0	20.0	1.3
Union	0	13.8	70.8	15.4	
Wickiup	0	20.4	59.2	20.4	

Eastern Oregon usually gets substantial rain from thundershowers in May and June. This is very important to cereals and range land and is also beneficial to crops of hay, potatoes, mint and melons. Probabilities range from 72 percent up to 96.9 percent that Eastern Oregon will get more than .20 inch of May rainfall. The probability of greater than .20 inch of rain in June ranges from 62% to 98.5%. The area around Union has a probability of 98.5%. The northeast mountain area has a tendency for a summer maximum of rainfall; therefore, the high probability in this area during the summer is to be expected.

The Rogue Valley has never recorded a rainless May. That valley has an 89% probability of getting over .20 inch of rain in May. There is a 68% probability of more than .20 inch of rain in the Rogue Valley in June.

The Western Valleys of Oregon get rainfall very consistently in May and June. None of the reporting stations have had a May with no rain and they have a 97% to 100% probability of getting more than .20 inch. Portland and Bonneville have never reported a June with no rain. There is an 89% to 97% probability of more than .20 inch of rain in June.

Though rain occurs in July and August throughout Oregon more years than not, the amounts in all agricultural areas are generally less than an inch and in many places the average is under half an inch per month. Holbrook (1970) shows that long periods of rainless days, or summer drought, do occur in Oregon. In 1970, periods of consecutive dry days in various parts of the state ranged from 60 up to 95 days. Most of the Willamette Valley, the north three quarters of the coast, and most of Eastern Oregon had 95 such days in 1970. Gold Beach, on the south coast, had 84 rainless days. Considering the long period of dry weather reported for 1970 and the characteristically small rain amounts for Oregon summers, a dry summer in the state shouldn't be alarming to anyone and it would usually not fit the definition of drought.

5. WHY THE PRECIPITATION SHORTAGE IN AUTUMN, 1976?

The question has often been asked, "Why was the weather so dry throughout the Pacific Northwest in the autumn and winter of 1976 and 1977?" Such a discussion is beyond the scope of this paper but we offer a few statements by climate researchers.

Some of the many variables which possibly cause climate change are shown in Figure 5. It can be seen that some of these variables would likely have a long-term, subtle influence on climate. It may be that weather or climatic conditions like those in the autumn of 1976 are influenced by shorter period events such as those operating

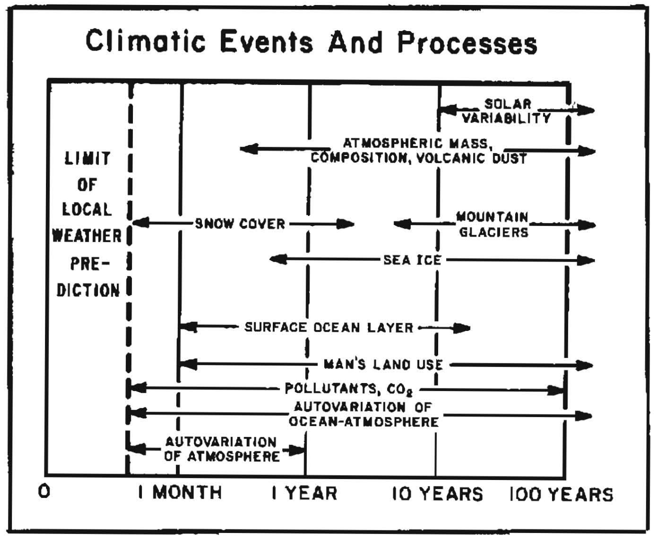

Figure 5. Characteristic Climatic Events and Processes in the Atmosphere, Hydrosphere and Biosphere and Possible Causative Factors of Global Climatic Changes. (From "Understanding Climatic Change.")

from a matter of weeks to perhaps only a few years. There surely is no definite answer, but some interesting hypotheses have been put forth, particularly regarding ocean-atmospheric interaction.

There are no reliable data to connect the drought with sunspot cycles. Some cyclic pattern in dry periods is evident, but there is no long-term evidence to show a relationship betwen the return of dry periods and the cycles of sunspot activity.

Dr. Jerome Namias, a prominent researcher at Scripps Institute at La Jolla, California, has done work in relating sea-surface temperatures to weather conditions. During the period 1971-1975, eastern United States experienced relatively warm weather and the west portion was relatively wet; and through this period, Namias showed Central Pacific waters had above normal surface temperatures, and waters east of 140°W. had below normal surface temperatures. Over the warmer waters, an upper-air ridge persisted, with an upper trough over the cooler waters nearer the west coast.

Namias has pointed out that in the autumn of 1976 and into February 1977, warmer water and a strong upper-air ridge persisted near the west coast. Cooler waters and a persistent trough were located toward the Central Pacific. These patterns as depicted by Snellman (1977) can be seen in Figure 6 for the 1971-1975 period and the autumn-early winter of 1976-1977.

The idea that warm water and cool water areas strongly indicate where the areas of anticyclonic and cyclonic circulation will persist is controversial. It is, however, interesting and worthy of

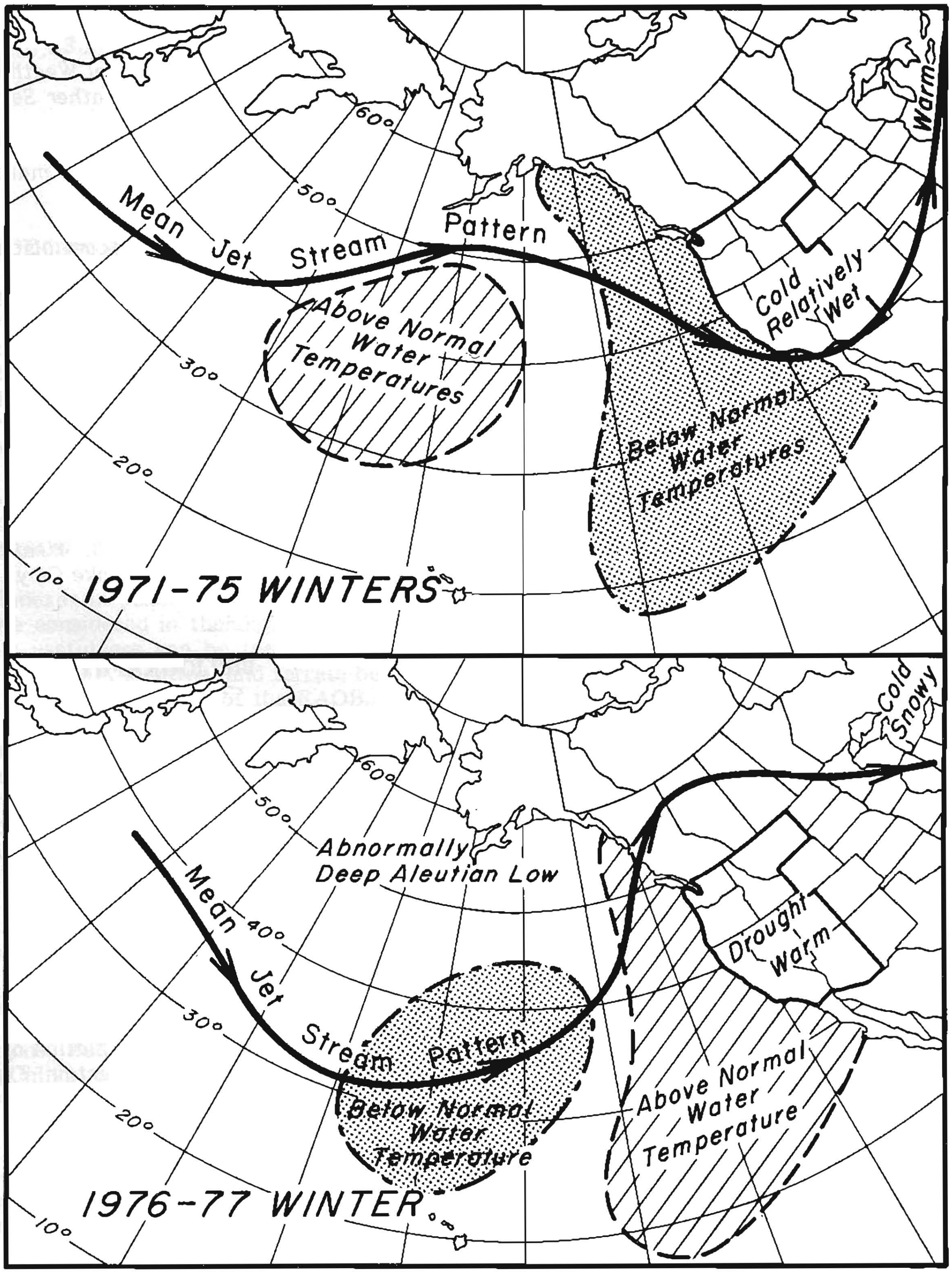

Figure 6. Mean Jet Stream Pattern in Relation to Eastern Pacific Ocean Surface Water Temperatures During a Relatively Wet, Cool Period in Western U.S.A. Compared to the Same Elements During a Warm Drought Period in Western U.S.A. (From WRTA No. 77-8)

consideration, and it is suggested by the conditions found in the autumn of 1976.

Earlier, Pyke (1972) said, "It is concluded from this investigation that aside from the seasonal oscillation of the sun's declination, the Pacific Ocean surface temperatures are probably the most important source of influence upon the precipitation patterns of the region of investigation, with those of the equatorial Pacific perhaps the most influential upon the winter precipitation of the region's subtropical latitudes. It also appears that the importance of sea surface temperatures near the west coast of North America is greatest during the warmer seasons of the year, and that it increases wth decreasing latitude."

6. CONCLUSION

The water year was dry by any standard, but it was notable more because of the unusual distribution of precipitation through the year than for a shortage of water. At some stations, it was only a little drier than the former driest year, and at some stations in agriculturally important areas, it was not the driest year of record.

Oregon is large and has a number of climatic areas. Departures from normal rainfall vary greatly within the State of Oregon. Therefore, it is quite possible for one section to experience a short term drought when other sections have adequate water. This was well demonstrated in the 1977 water year when, in spite of a dry winter, some areas had adequate water and others had short crops due to inadequate precipitation.

Climatology shows us that a dry autumn in Oregon is not necessarily followed by a dry winter and spring. Even though Oregon is mostly a region with a winter maximum of precipitation, a dry fall and winter has not historically meant a drastic shortage of water for the crop year. There is almost zero probability of two successive water years wtih critical water shortage in western Oregon and the probability is under 5% of such occurrence in eastern Oregon.

The cause of drought is ellusive. Namias and Pyke have suggested that sea surface temperatures of the Pacific Ocean may have a strong influence on North American, west coast precipitation amounts.

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REFERENCES

Holbrook, S. G., 1970, "Special Weather Summary Oregon, Sept. 1970", U.S. Weather Service manuscript.

Landsberg, H., 1958, Physical Climatology, Gray Printing Co., Dubois, Penn.

Palmer, W. C., 1961, "Meteorological Drought: Its Measurement and Classification", U.S. Weather Service manuscript.

Pyke, C. B., 1972, "Some Meteorological Aspects of The Seasonal Distribution of Precipitation in The Western United States and Baja, California," a research report based on the author's doctoral dissertation, April, 1972, University of Calif., Los Angeles.

Snellman, L., 1977, Editor, "Western Region Technical Attachment," No. 77-8, Weather Service Western Headquarters, Salt Lake City.

BIBLIOGRAPHY

Kincer, J. B., "Probable Frequency of Serious Nationwide Droughts in the United States," Agriculture Engineering, St. Joseph, Mich. 13 (6): 145-147, 1932.

Shelton, M. L., "The 1976 and 1977 Drought in California: Extent and Severity," Weatherwise: Vol. 30, No. 4, Wash., D.C., Aug. 1977.

Showalter, A. K., "Chance For Successive Dry Years in Southern California," Monthly Weather Review, Washington, D.C., 76: 221-223, 1948.

Starrett, L. G., 1949, "The Relation of Precipitation in North America to Certain Types of Jet Streams At the 300-Millibar Level," J. of Meteorology, 6: 347-352.

Tannehill, H. E., 1962, Drought -- Its Cause and Effects, Princeton, N.J., Princeton University Press, p. 264.

Thomas, H. E., "The Meteorologic Phenomenon Of Drought in The Southwest," U.S. Geol. Survey Prof. Paper 372-A, p. 42, 1962.

Understanding Climatic Change, National Academy of Sciences, Washington, D.C., 1975.

Weekly Weather and Crop Bulletin, U.S. Weather Bureau, Vol. 64, No. 1a, Jan. 1957.

WMO Technical Note No. 138, Drought And Agriculture, Secretariat of WMO, Geneva, Switzerland, 1975.