Governor's
Ad hoc
Executive Water
Emergency Committee

W. B. KINCAID

HISTORY OF DROUGHTS IN WASHINGTON STATE

Prepared by

Governor's Ad Hoc Executive Water Emergency Committee Staff

December 1977

STATE OF
WASHINGTON

Dixy Lee Ray
Governor

OFFICE OF THE GOVERNOR
Legislative Building, Olympia, Washington 98504

Dear Reader:

On February 16, 1977, Governor Dixy Lee Ray established the "Governor's Ad Hoc Executive Water Emergency Committee." Shortly thereafter, I was appointed committee chairman. The Committee was made up of representatives from the state departments of Fisheries, Ecology, Commerce and Economic Development, Natural Resources, Agriculture, Game, Social and Health Services, Emergency Services, State Energy Office, and the Office of Community Development. In addition, representatives from other governmental entities were invited to participate. The Committee coordinated responses as various problems developed during the drought and prepared biweekly reports on drought and drought-related conditions and activities.

In order to better understand the recent drought phenomenon in Washington, the Committee felt it was important to compile information on the historical, economic, environmental, and social effects drought has had in Washington, and to examine how society has adjusted to alleviate the serious effects of drought. Such information will be of value in formulating strategies to deal with drought impacts.

This report briefly describes 19 historical drought occurrences in Washington. Until 1930, agriculture was the activity most susceptible to drought damage due to lack of water, especially in nonirrigated areas such as dryland farms and rangelands. The increase of electric power consumption in the 1930's also began to place a great demand on water supplies. Both the federal and state governments have been active in developing water supply projects, as well as in water management, soil conservation, and drought relief programs, all of which have lessened the drought impacts through the years.

Despite impressive gains in reducing the effects of drought, the trends of increasing population, the demand for food, the scarcity of resources, and the growing competition for water suggests that future droughts will continue to clearly, if not severely, impact society.

Sincerely,

Jason King
Special Assistant to the Governor
Federal/State Liaison

JK:DL:mg

ABSTRACT

According to the United States Weather Service, there have been 19 drought occurrences in the State of Washington since 1900. Various means are used to determine drought periods, such as precipitation records, ground water records, and tree ring studies. The maximum duration of droughts has ranged from 34 to 72 months in the 10 meteorological regions of the state. Until 1930, agriculture was the activity most susceptible to drought damage due to the lack of water, especially in nonirrigated areas such as dryland farms and range lands. The increase of electric power consumption in the 30's also began to place a great demand on water supplies. Various adjustments by society have helped to mitigate drought impacts through the years. Beginning in 1935, a major effort was made to control every fire on State Department of Forestry land. Through better techniques, total acreage burned has continually decreased. Both the federal and state governments have been active in developing water supply projects, water management, soil conservation, and drought relief programs, all of which have lessened the drought impacts through the years.

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HISTORY OF DROUGHTS IN WASHINGTON
Introduction

On February 16, 1977 Governor Ray established an "Ad Hoc Executive Water Emergency Committee" to deal with the problems created by the drought. In order to better understand drought, the committee prepared this historical overview of past droughts in Washington State.

It is important to understand the economic, environmental, and social effects that drought has had upon society and how society has adjusted to alleviate the serious effects of drought. This awareness will help in formulating policies for future water-short years.

While the shortage of moisture may result in drought conditions, "drought is produced basically by human activities, technologies, and institutions. The severity of drought is determined by the degree to which excessive demands are placed on the long-run availability of moisture. The dynamic nature of drought results from the adjustments and adaption man makes to cope with the risks and uncertainties of weather and from continuing changes in human society." 1/ Therefore, a society less dependent on water resources would be less affected by drought conditions.

Since the most direct impact of drought is "economic" as opposed to loss of life or immediate destruction of property, direct accounting of the losses or gains from drought is extremely difficult. The problem is further complicated by the differential impact drought may have on varying sectors of the economy. It may be misleading to relate variations in crop production directly to drought conditions. For example, a crop failure may be due to insect infestation, disease, frost, or human carelessness, although drought conditions may tend to accentuate such problems. Likewise, an area may receive rain at an opportune time during the growing season, resulting in good crop production in spite of drought conditions.

The temptation is to trace each and every drought-affected thread in society and to try to account for all the linking effects which have a way of magnifying the apparent direct effects of the drought. Such a detailed approach exceeds the scope of this report.

The principal newspaper sources of information for this report are the Yakima Herald-Republic, Walla Walla Union, Spokane Spokesman Review, and Tacoma News Tribune (1900-1973). The main government documents used in the report are the Pacific Northwest River Basins Commission's Climatological Handbook and the Biennial Reports from the Washington State Department of Conservation and Development (which went through several organizational changes and is now known as the Department of Ecology).

This report presents general background information on droughts in Washington and briefly examines 19 historical drought periods determined by the U.S. Weather Service. The drought period reviews include: the characteristics of the physical event; the areas subject to drought; the general effects that drought has had on nature, man, and the economy; and the various adjustments which may have mitigated drought impacts through the years.

"A major agricultural drought is generally defined as a period when water is deficient enough to cause serious crop or range damage over a sizeable area. There is general disagreement on the primary meteorological causes of prolonged drought. Possible theories involve sunspots, volcanic dust, terrestrial alterations, ocean currents, and atmospheric pollutants from human sources. Some claims for drought cycles are made, but are discounted by many on the grounds of lack of statistical evidence. Development of prediction or forecast capabilities is hindered by inadequate understanding of causal processes." 2/

Tree Analysis

Because of the relatively short period of time covered by weather records, they are inadequate to document historical climatic fluctuations. Records of fluctuations in lake levels are also either too recent or too indefinite in terms of dates to be of much value. Tree rings, on the other hand, often carry a very old and precise record of climatic fluctuations, provided they can be interpreted.

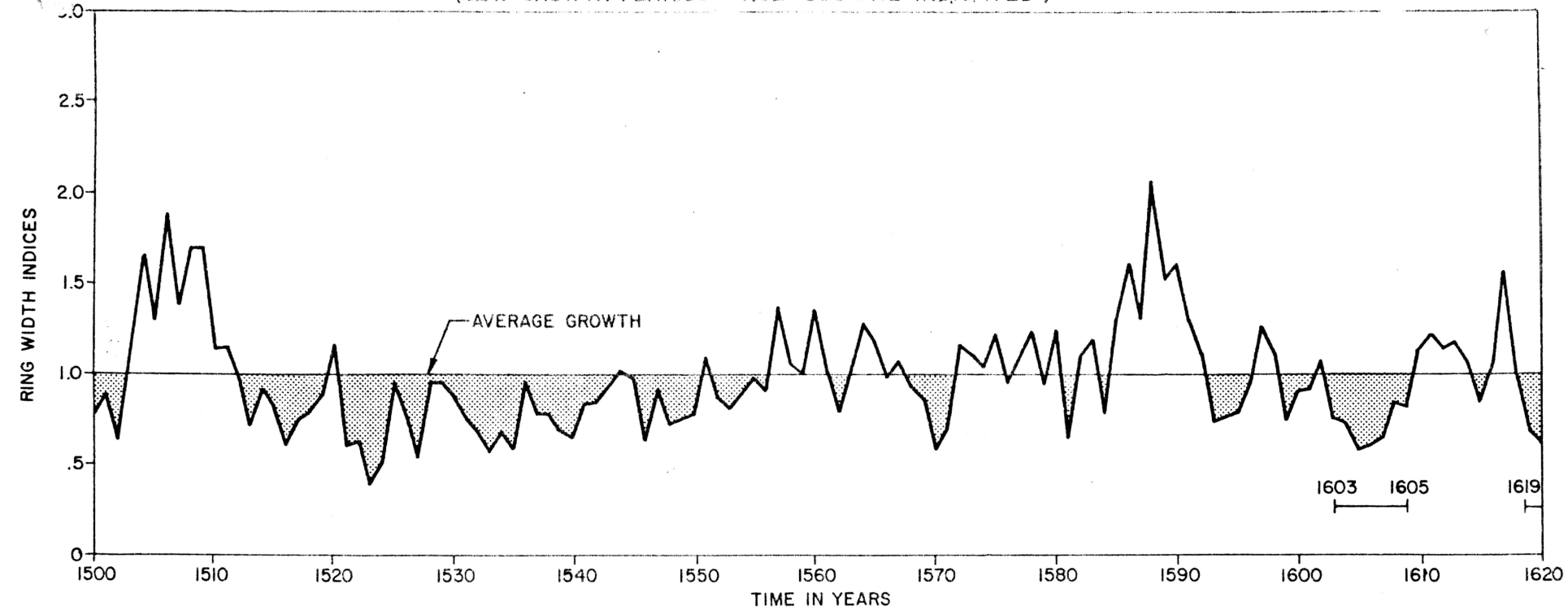
"Tree ring examinations have suggested that there may have been exceptionally dry periods in the State of Washington ranging back over the past three centuries. The data gathered at 23 sites in eastern Washington have not been fully interpreted, but preliminary results do suggest a low growth-drought relationship.

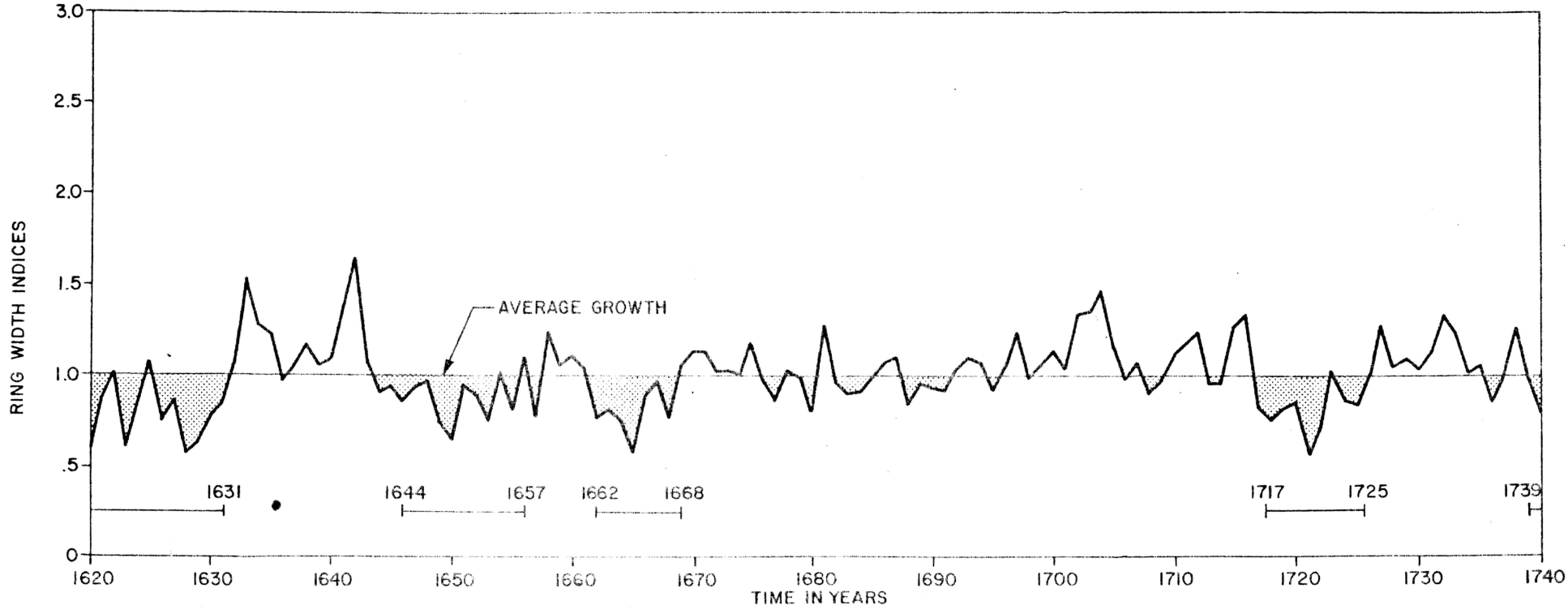
"Figure 1 shows that there is no clear correspondence of individual drought years with years of below average growth. However, there is a striking correspondence between the interval of drought years during the 1920's and 1930's and the extended period of low growth between approximately 1918 and 1940. One might speculate that only extended periods of drought have a noticeable effect on tree growth. The interval between 1918 - 1940 is the longest period (22 years) of below normal growth in the record. Figure 2 shows a general relationship between tree growth and precipitation trends. Table 1 shows that since 1600 there have been 13 low growth periods. The average duration of low growth is approximately 10 years, and the average number of years between such periods is 17 years (ranging from 5 to 49 years)." 3/

In 1960, T. W. Childs, from the U.S. Forest Service, wrote a report on "Drought Effects on Conifers in the Pacific Northwest 1958-59." In the report, Childs states, "The effects of drought are ordinarily most conspicuous in small trees on the poorest sites, where they are of least economic consequence. Tops killed by drought, for example, present an alarming appearance, but occur principally on sites incapable of producing commercial timber. On somewhat better sites, extensive dying of older foliage and lower branches may be so striking as to give the impression of a dying stand, but even in such instances, it is usually only a symptom of temporary retrenchment. On fair to good sites, mortality in young stands is rarely extensive enough to impair stocking . . . .

"Of the economic loss directly attributable to drought, by far the greater part has undoubtedly resulted from inconspicuous but general

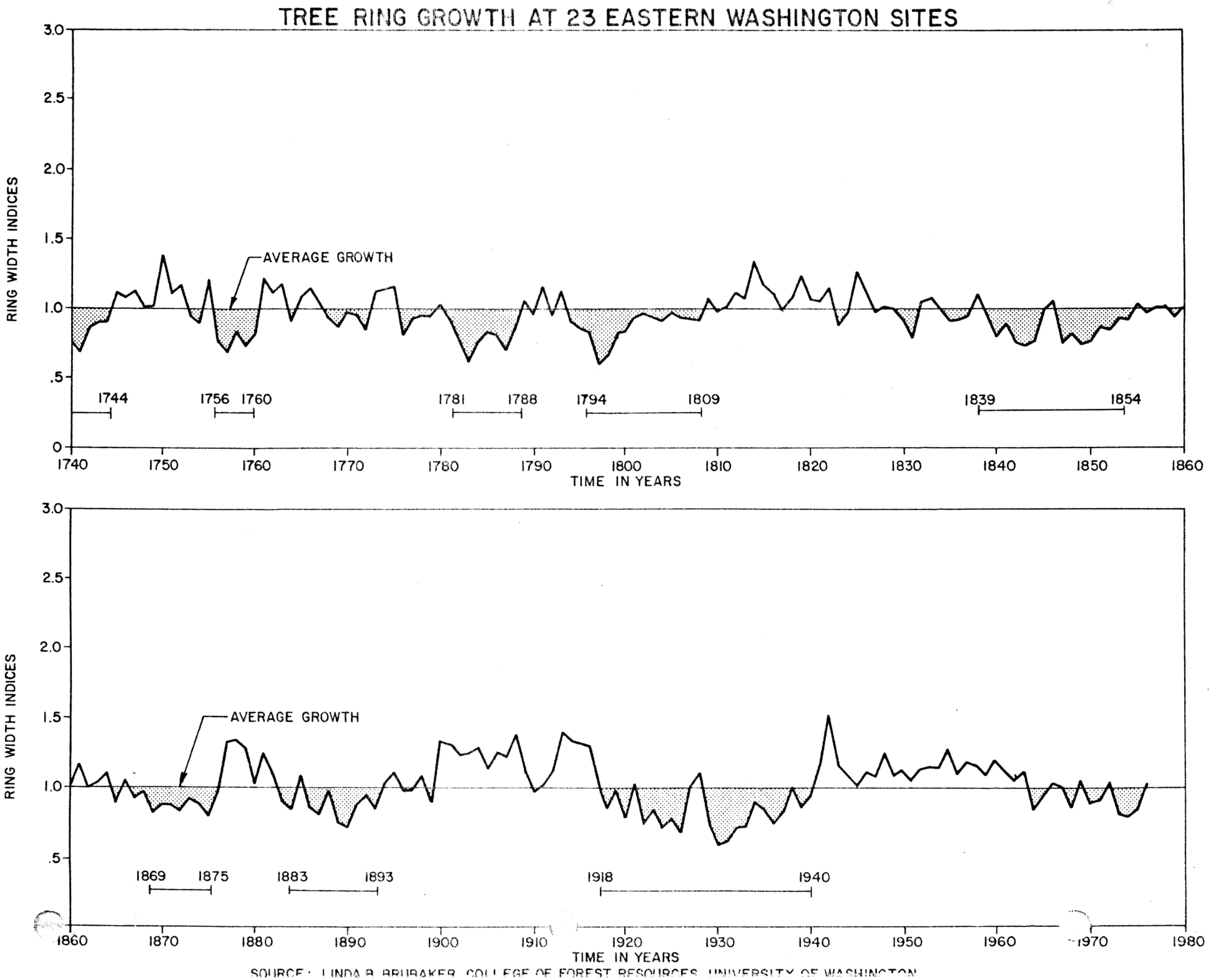
Figure 1. TREE RING GROWTH AT 23 EASTERN WASHINGTON SITES
(LOW GROWTH PERIODS SINCE 1600 ARE INDICATED)





SOURCE: LINDA S. BRUBAKER, COLLEGE OF FOREST RESOURCES, UNIVERSITY OF WASHINGTON

Figure 1-contd.



SOURCE: LINDA B. BRUBAKER, COLLEGE OF FOREST RESOURCES, UNIVERSITY OF WASHINGTON

Figure 2

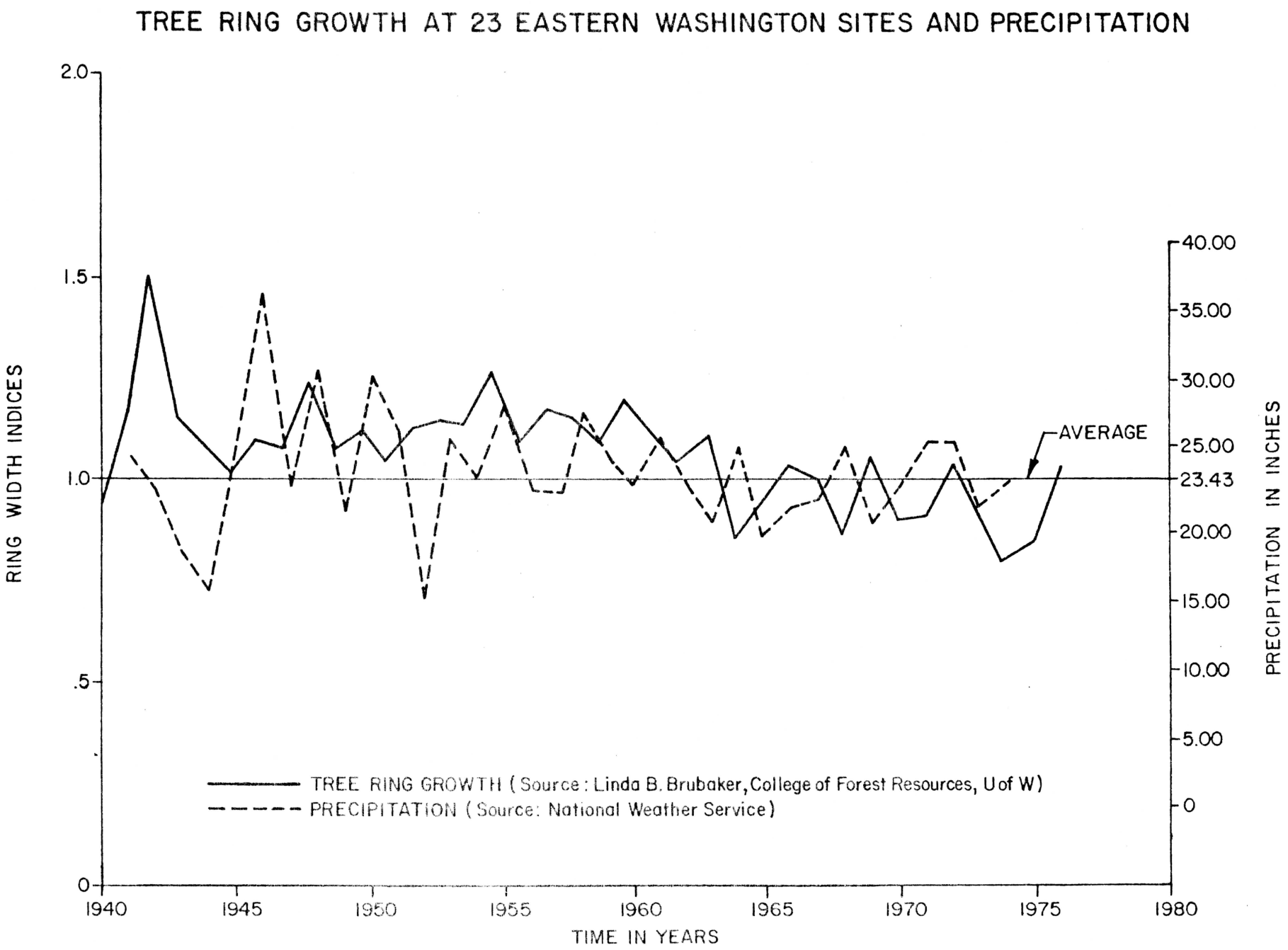

TREE RING GROWTH AT 23 EASTERN WASHINGTON SITES AND PRECIPITATION
RING WIDTH INDICES
2.0
1.5
1.0
.5
0
PRECIPITATION IN INCHES
40.00
35.00
30.00
25.00
23.43
20.00
15.00
10.00
5.00
0
AVERAGE
1940
1945
1950
1955
1960
1965
1970
1975
1980
TIME IN YEARS
TREE RING GROWTH (Source: Linda B. Brubaker, College of Forest Resources, U of W)
PRECIPITATION (Source: National Weather Service)

TABLE 1: PERIODS OF LOW GROWTH SINCE 1600

Dates	Duration	Years Since Last Low Growth Period
1603 - 1609	6	
1619 - 1631	12	10
1644 - 1657	13	13
1662 - 1668	6	5
1717 - 1725	8	49
1739 - 1744	5	14
1756 - 1760	4	12
1781 - 1788	7	21
1794 - 1809	15	6
1839 - 1854	15	30
1869 - 1875	6	15
1883 - 1893	10	8
1918 - 1940	22	25
	$\bar{x}$ = 9.9 yrs	$\bar{x}$ = 17.3 yrs

decrease in current increment throughout most of the region. [In other words, the economic loss to forests due to drought is caused by the general decrease in tree growth.]

"Whether or not the drought continues, additional damage must be expected during the next few years as weakened trees fall prey to root rots, insects, and other enemies."4/

Palmer Drought Index

Meteorological data collected since 1930 (Palmer Drought Index) also indicate the frequency of droughts. The Palmer Drought Index was developed in 1965 by Wayne C. Palmer of the U.S. Weather Bureau. The index is computed from a complex formula taking into account the severity and duration of dry spells using several parameters. These include: (1) temperature, (2) precipitation, (3) evaporation and transpiration, (4) runoff, and (5) soil moisture.

This formula provides monthly index values that permit the comparison of values of a particular period with the average climatic conditions for the area in question. There are 10 climatic divisions for Washington (See Figure 3). As an example, the East Slope Cascade Division has experienced drought conditions 36 percent of the time since 1931. The Puget Sound Lowlands Division has experienced drought conditions 32 percent of the time since 1931. The duration of droughts, as they are identified in this report, has ranged from as little as 1 month to as long as 72 months. As shown in Table 2 and 3, any prolonged period below a Palmer Index Value of -1 constitutes a drought. In general, Palmer Drought Index Values of -1 to -2 do not represent significant departures from normal weather conditions. Figure 4 shows the intensity of drought occurrences during the years 1934, 1936, 1973, and 1977.

Ground Water

The U.S. Geological Survey has gathered data on precipitation and water levels in wells since the early 1900's. The survey has compiled data on 7 areas in the state (see Figure 5). The water level and precipitation lines on each graph clearly indicate that ground water responds to changes in precipitation.

Lakes

An article written by Otis W. Freeman in June, 1929, presents examples of prolonged drought in the past on the Columbia Plateau in eastern Washington. As a result of the great flood during the end of the ice age, a large number of lakes exist on the lava plateau southwest of Spokane.

> "Most of the lakes have no visible outlet. Many are highly alkaline, especially in the drier sections of the Columbia Basin. Typically, the lakes occupy elongated basins with steep cliffs descending abruptly into deep, rock water; but in places along the shores of the lakes, particularly at their heads, material has been deposited making swamps or shallow water. Decreased rainfall

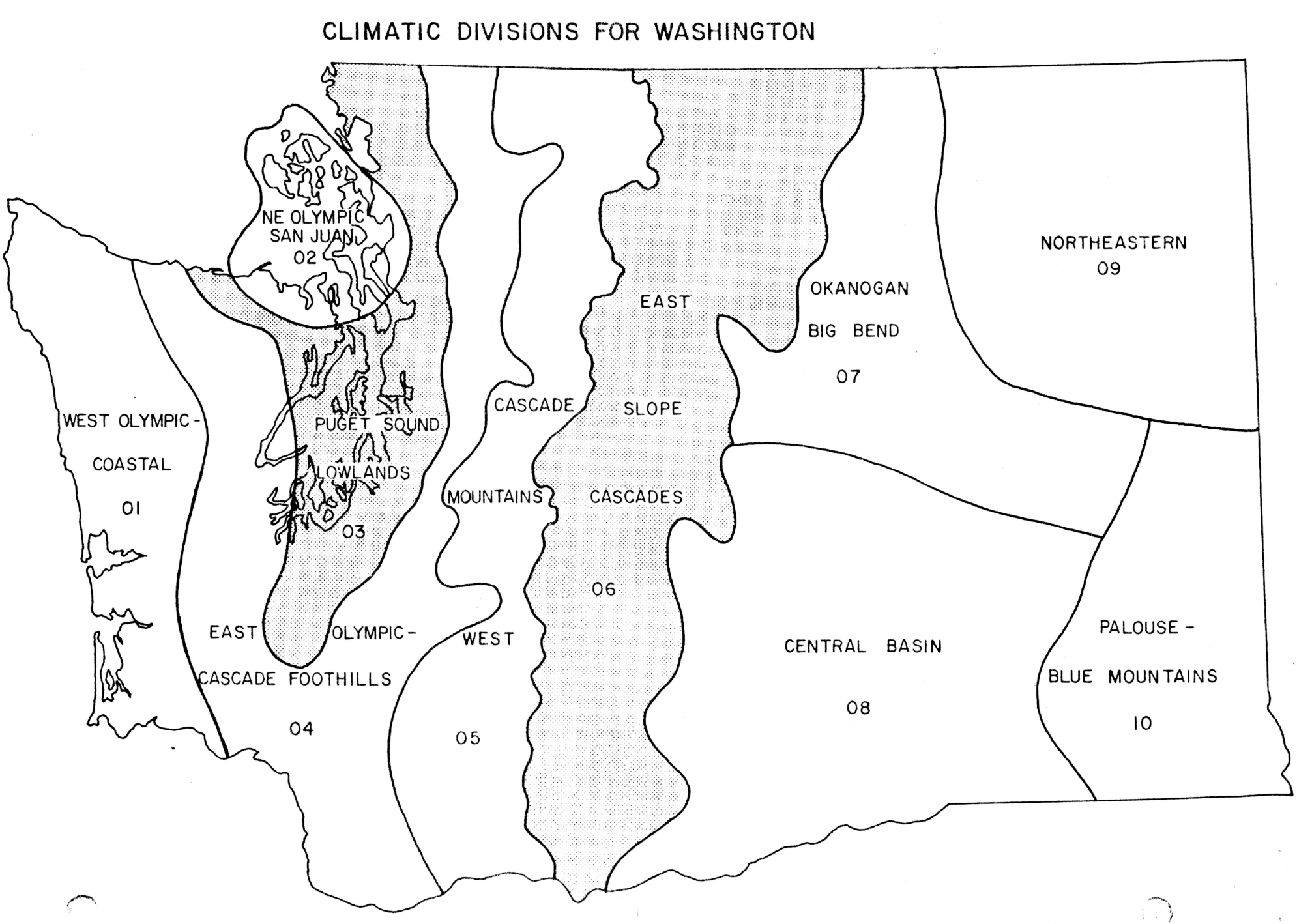

CLIMATIC DIVISIONS FOR WASHINGTON
NE OLYMPIC
SAN JUAN
02
WEST OLYMPIC-
COASTAL
01
PUGET SOUND
LOWLANDS
03
EAST
CASCADE FOOTHILLS
04
OLYMPIC-
WEST
05
CASCADE
MOUNTAINS
EAST
SLOPE
CASCADES
06
OKANOGAN
BIG BEND
07
NORTHEASTERN
09
CENTRAL BASIN
08
PALOUSE-
BLUE MOUNTAINS
10

Figure 3

Table 2

METEOROLOGICAL DROUGHT, SUMMARY, 1931-1977*
(East Slope Cascade Division, 4506)

	BEGAN		ENDED		MAXIMUM SEVERITY			NUMBER OF DROUGHT MONTHS					
No.	Month	Year	Month	Year	Index	Month	Year	Incipient	Mild	Moderate	Severe	Extreme	Total
1	SEP	1932	OCT	1932	-1.37	OCT	1932		2				2
2	FEB	1934	AUG	1934	-3.19	AUG	1934	1	3	1	2		7
3	FEB	1935	FEB	1935	-1.02	FEB	1935		1				1
4	JUN	1935	DEC	1935	-3.02	DEC	1935		5	1	1		7
5	OCT	1936	JAN	1937	-2.75	JAN	1937		1	3			4
6	JUN	1938	MAR	1941	-4.44	NOV	1940		6	16	9	3	34
7	JAN	1942	APR	1942	-2.40	APR	1942		2	2			4
8	NOV	1943	JAN	1945	-3.79	DEC	1944		2	7	6		15
9	MAR	1947	AUG	1947	-1.90	MAY	1947		6				6
10	DEC	1947	JAN	1948	-1.49	DEC	1947		2				2
11	MAY	1949	AUG	1949	-2.21	AUG	1949		2	2			4
12	FEB	1952	DEC	1952	-4.06	DEC	1952		5	3	1	2	11
13	NOV	1953	NOV	1953	-1.08	NOV	1953		1				1
14	JAN	1955	JAN	1955	-1.78	JAN	1955		1				1
15	JUL	1956	JUL	1956	-1.19	JUL	1956		1				1
16	JAN	1957	JAN	1957	-1.74	JAN	1957		1				1
17	NOV	1957	MAR	1958	-1.38	NOV	1958	2	3				5
18	JUN	1958	AUG	1958	-1.72	AUG	1958		3				3
19	JUN	1959	AUG	1959	-1.53	AUG	1959		3				3
20	JAN	1960	JAN	1960	-1.67	JAN	1960		1				1
21	OCT	1960	OCT	1960	-1.04	OCT	1960		1				1
22	DEC	1960	JAN	1961	-1.10	DEC	1960		2				2
23	JAN	1962	FEB	1962	-1.72	FEB	1962		2				2
24	JAN	1963	JAN	1963	-2.03	JAN	1963			1			1
25	DEC	1963	DEC	1963	-1.27	DEC	1963		1				1
26	FEB	1964	MAY	1964	-1.23	MAY	1964		4				4
27	MAR	1965	MAR	1965	-1.72	MAR	1965		1				1
28	OCT	1965	DEC	1967	-2.77	SEP	1967	4	18	4			26
29	MAR	1968	JUL	1968	-1.59	JUL	1968	2	3				5
30	FEB	1969	OCT	1970	-3.74	AUG	1970		5	10	5		20
31	JUL	1971	NOV	1971	-1.18	OCT	1971		3				3
32	OCT	1972	AUG	1973	-4.43	AUG	1973	1	3	1	4	2	11
33	SEP	1974	NOV	1974	-1.83	OCT	1974	1	2				3
34	MAY	1976	-	-	-5.66	APR	1977	2	3	1	1	6	13
NUMBER OF MONTHS								13	99	52	29	13	206
PERCENT OF TIME (558 MONTHS)								2	17	9	5	2	35

*As of June 1977

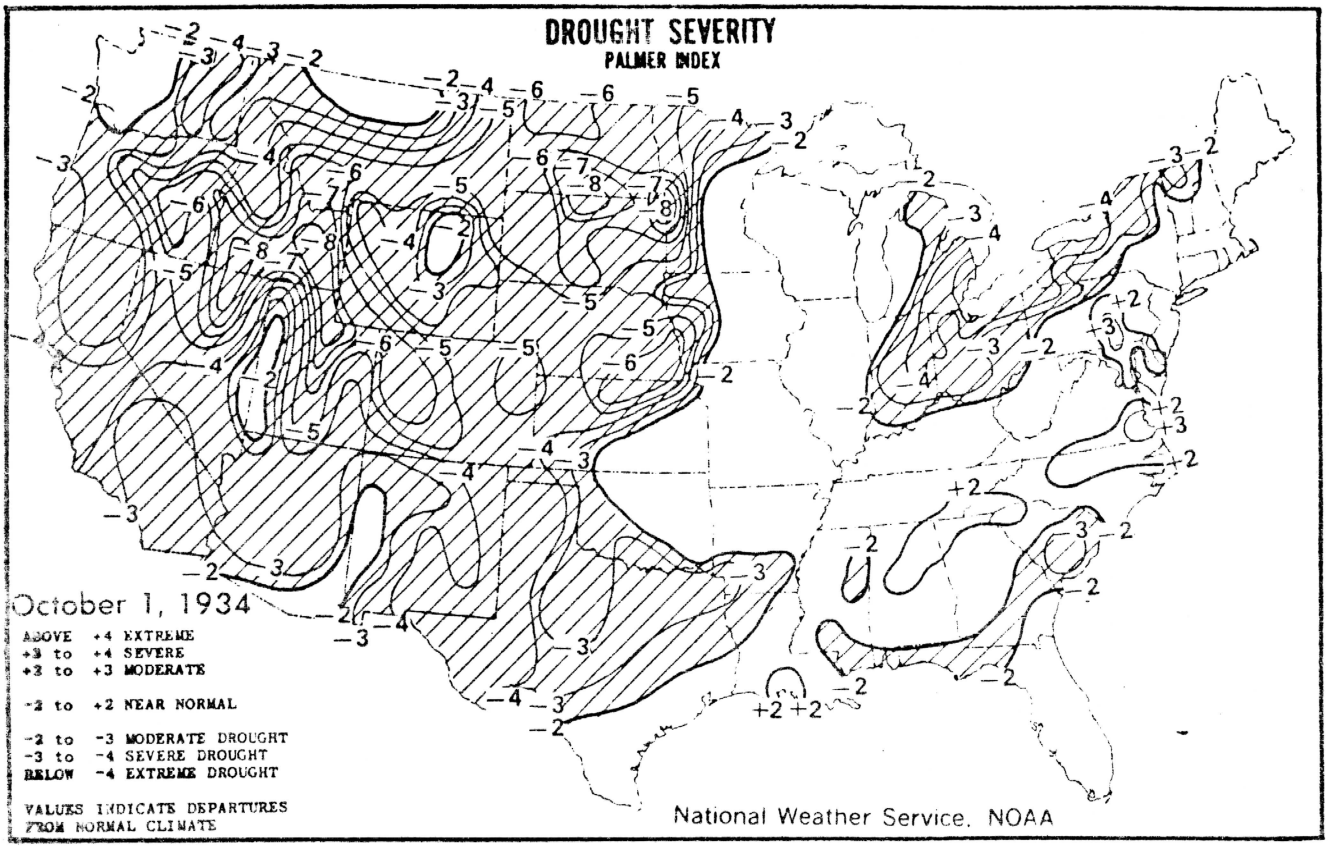
Table 3

METEOROLOGICAL DROUGHT, SUMMARY, 1931-1977*
(Puget Sound Lowlands Division, 4503)

	BEGAN		ENDED		MAXIMUM SEVERITY			NUMBER OF DROUGHT MONTHS					
No.	Month	Year	Month	Year	Index	Month	Year	Incipient	Mild	Moderate	Severe	Extreme	Total
1	FEB	1934	AUG	1934	-2.40	AUG	1934		4	3			7
2	MAY	1935	DEC	1935	-2.75	DEC	1935		6	2			8
3	OCT	1936	JAN	1937	-2.80	JAN	1937		1	3			4
4	FEB	1938	APR	1942	-4.11	APR	1941	8	14	21	6	2	51
5	SEP	1942	JAN	1945	-4.68	DEC	1944	5	8	3	10	2	28
6	AUG	1945	AUG	1945	-1.06	AUG	1945		1				1
7	MAY	1947	MAY	1947	-1.36	MAY	1947		1				1
8	JAN	1949	JAN	1949	-1.26	JAN	1949		1				1
9	MAY	1949	OCT	1949	-1.74	SEP	1949		6				6
10	JUN	1951	DEC	1952	-5.06	DEC	1952		4	12	1	2	19
11	JAN	1955	MAR	1955	-1.38	JAN	1955		3				3
12	MAY	1956	AUG	1956	-1.61	MAY	1956	1	3				4
13	JAN	1957	JAN	1957	-1.46	JAN	1957		1				1
14	SEP	1957	OCT	1958	-3.52	AUG	1958		9	1	4		14
15	SEP	1961	FEB	1962	-2.42	FEB	1962		5	1			6
16	JAN	1963	MAR	1963	-1.59	MAR	1963		3				3
17	FEB	1964	FEB	1964	-1.06	FEB	1964		1				1
18	MAR	1965	FEB	1966	-1.88	FEB	1966	3	9				12
19	MAY	1967	SEP	1967	-2.33	SEP	1967	1	1	2			4
20	JAN	1973	SEP	1973	-2.04	MAR	1973		2	1			3
21	SEP	1974	DEC	1974	-2.01	OCT	1974		1	1			3
22	NOV	1976	-	-	-4.65	FEB	1977	1		1	2	3	7
NUMBER OF MONTHS								19	85	51	23	9	187
PERCENT OF TIME (556 MONTHS)								3	15	9	4	1	32

*As of April 1977

Figure 4


DROUGHT SEVERITY
PALMER INDEX
October 1, 1934
ABOVE +4 EXTREME
+3 to +4 SEVERE
+2 to +3 MODERATE
-2 to +2 NEAR NORMAL
-2 to -3 MODERATE DROUGHT
-3 to -4 SEVERE DROUGHT
BELOW -4 EXTREME DROUGHT
VALUES INDICATE DEPARTURES FROM NORMAL CLIMATE
National Weather Service, NOAA

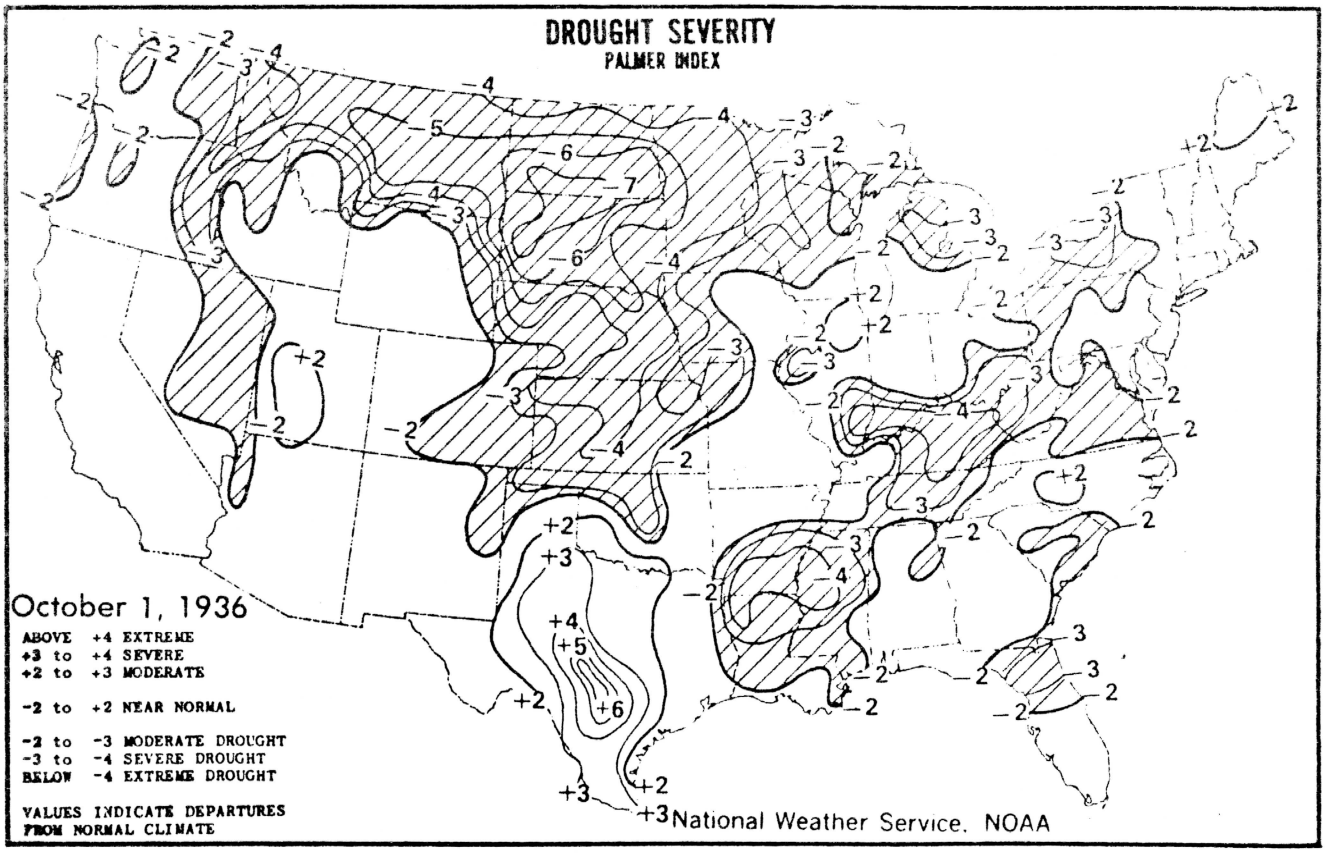
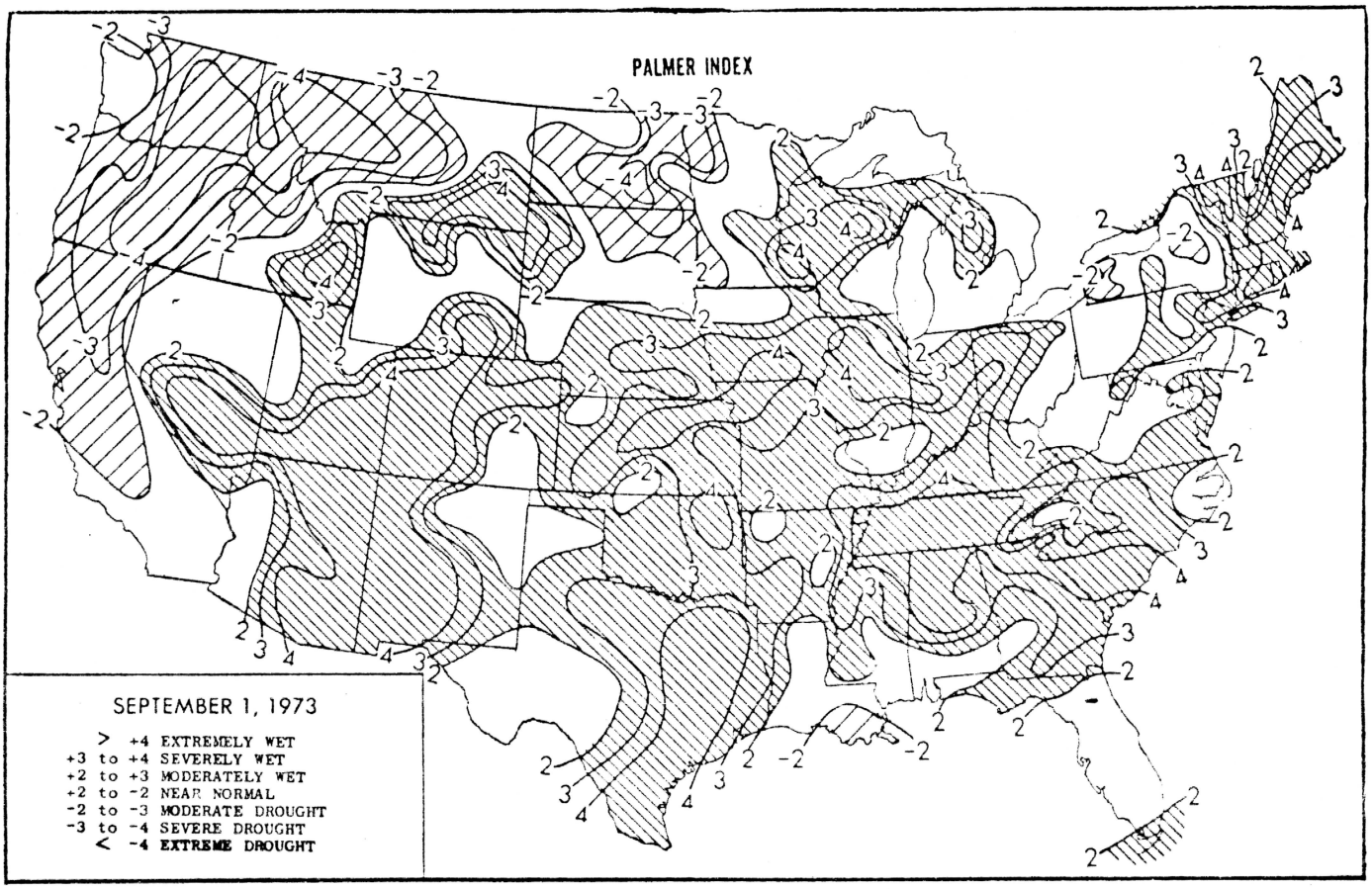

DROUGHT SEVERITY
PALMER INDEX
October 1, 1936
ABOVE +4 EXTREME
+3 to +4 SEVERE
+2 to +3 MODERATE
-2 to +2 NEAR NORMAL
-2 to -3 MODERATE DROUGHT
-3 to -4 SEVERE DROUGHT
BELOW -4 EXTREME DROUGHT
VALUES INDICATE DEPARTURES FROM NORMAL CLIMATE
National Weather Service, NOAA

Figure 4 - contd.



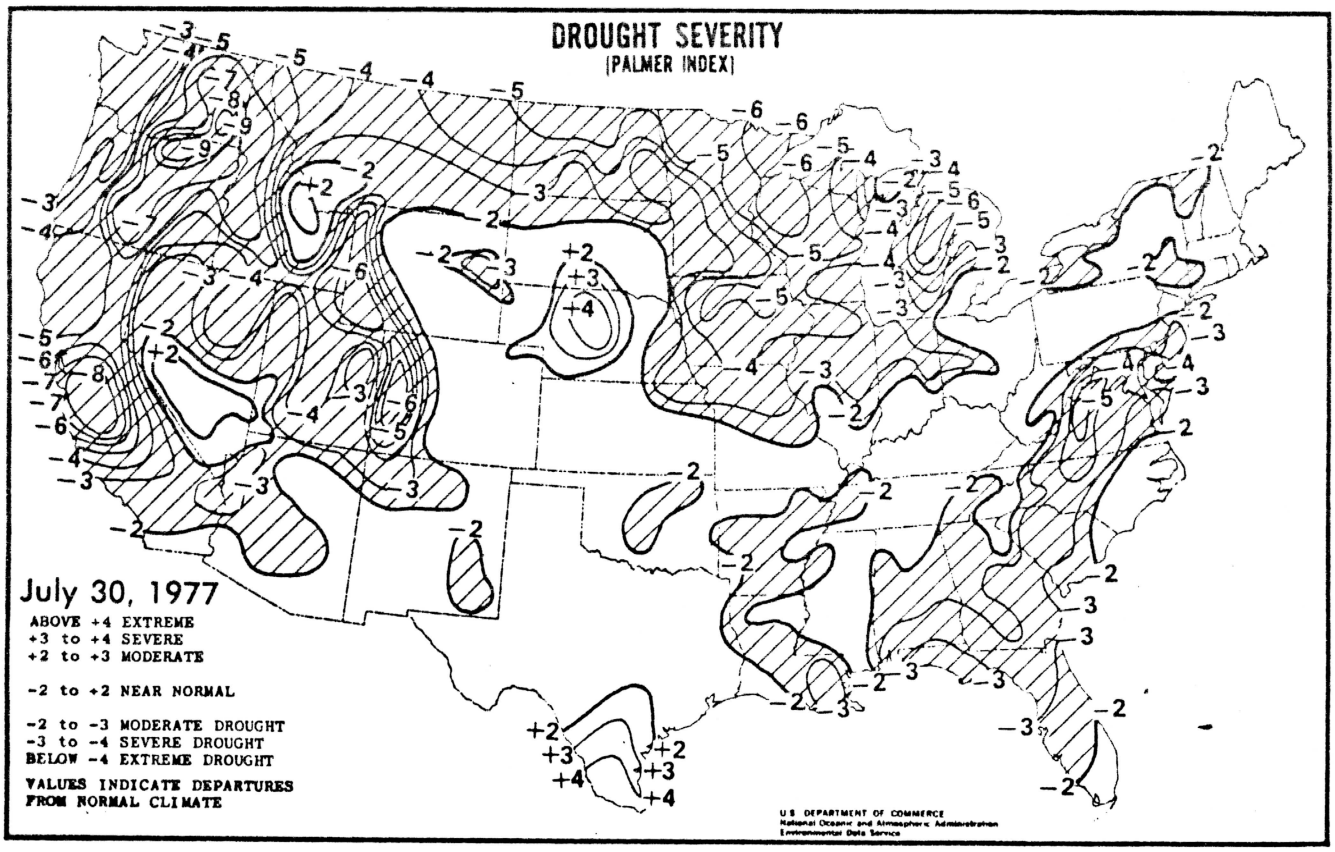
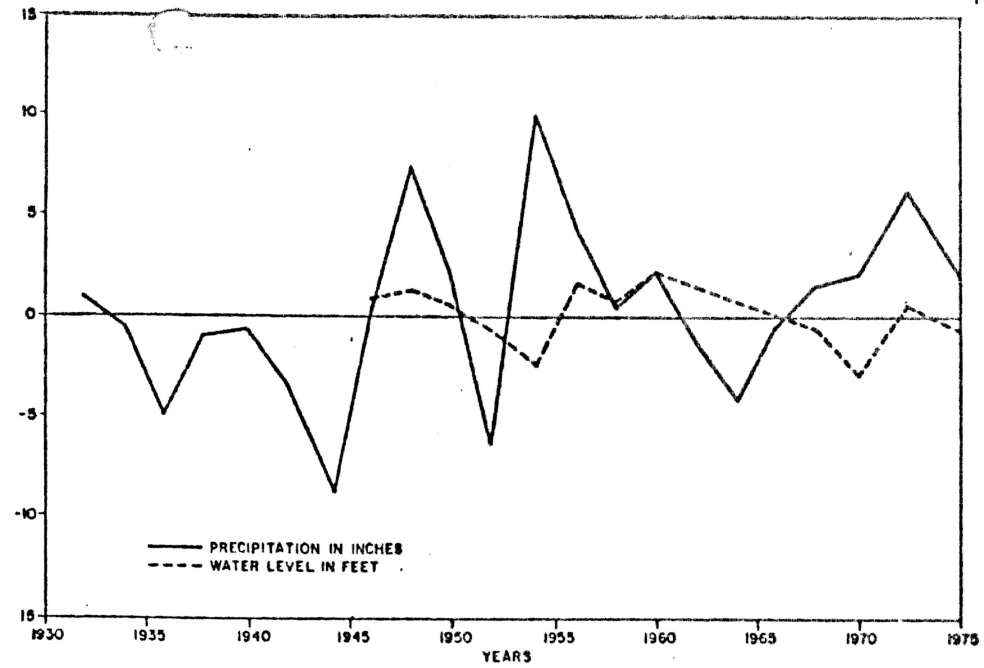
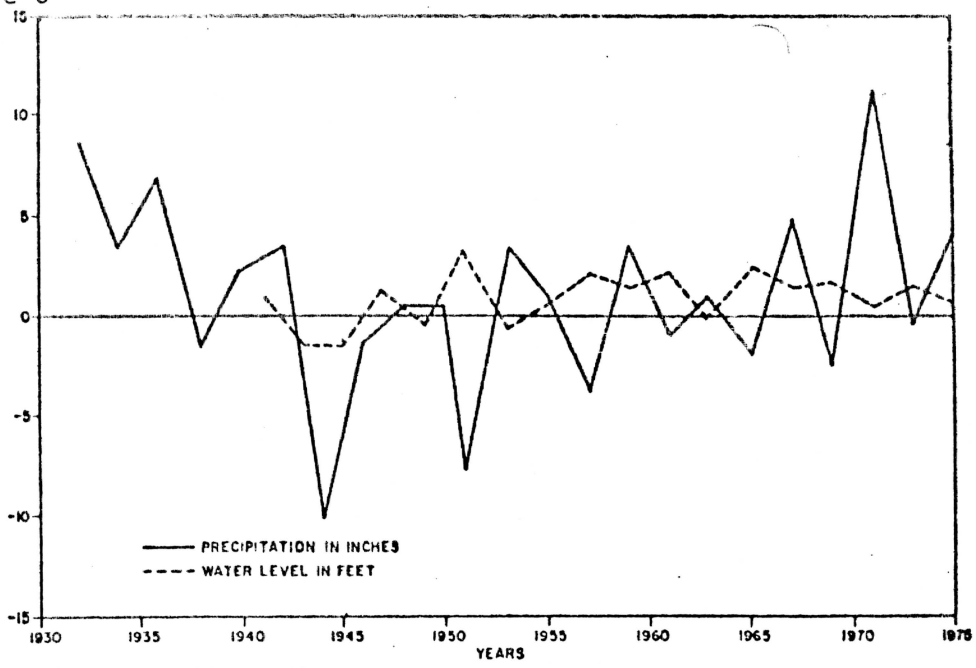


Figure 5



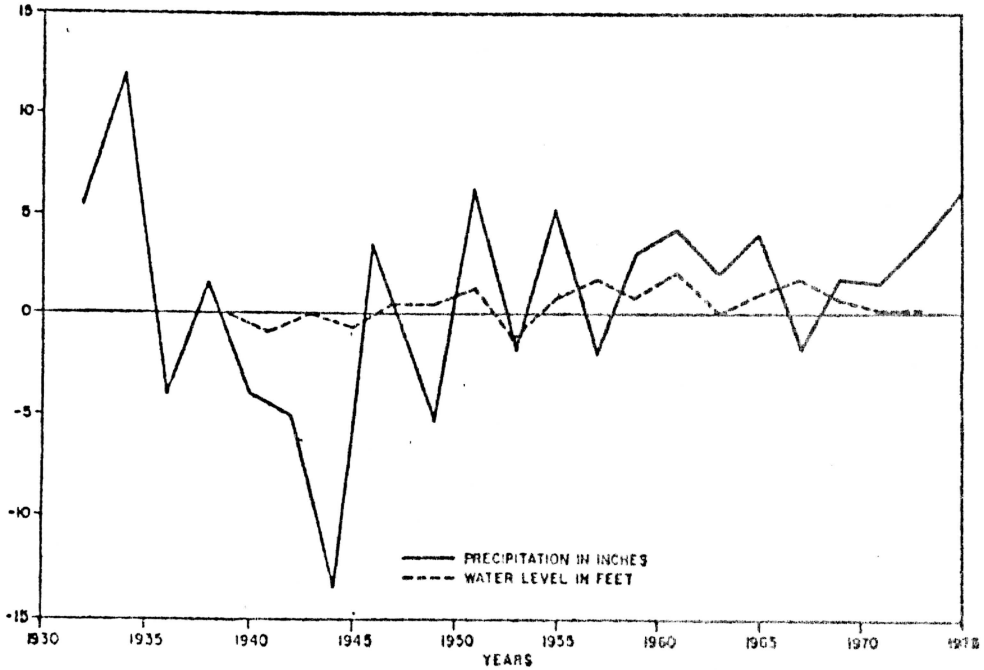
SOURCE: U.S. GEOLOGICAL SURVEY

CUMULATIVE DEPARTURE FROM MEAN ANNUAL PRECIPITATION AT EVERETT COMPARED WITH THE WATER LEVEL IN WELL (TWO YEAR AVERAGE).



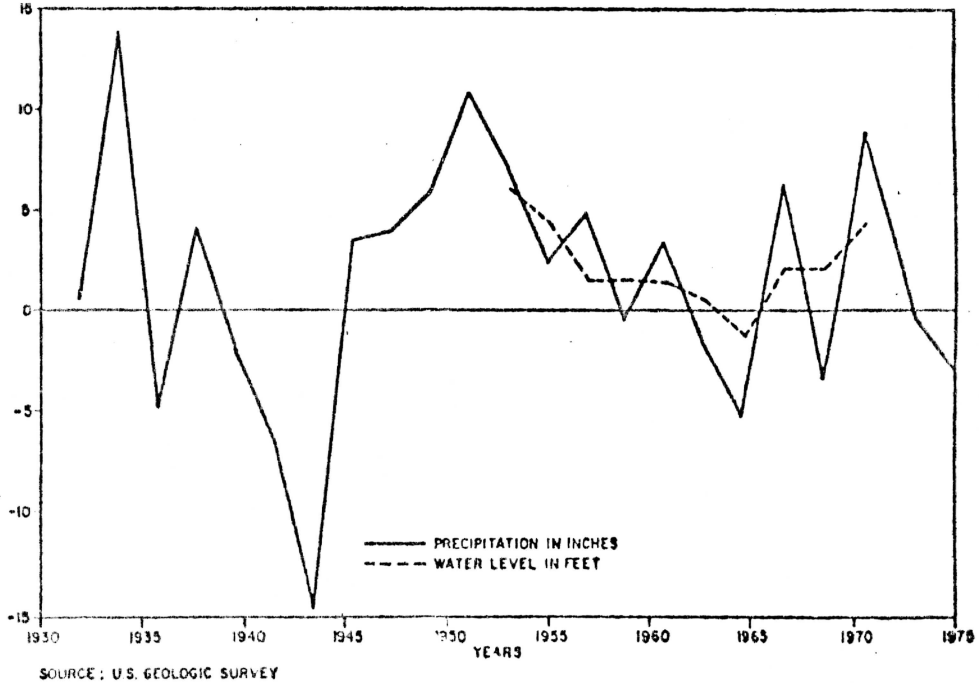
SOURCE: U.S. GEOLOGICAL SURVEY

CUMULATIVE DEPARTURE FROM MEAN ANNUAL PRECIPITATION AT BELLINGHAM COMPARED WITH THE WATER LEVEL IN WELL (TWO YEAR AVERAGE).



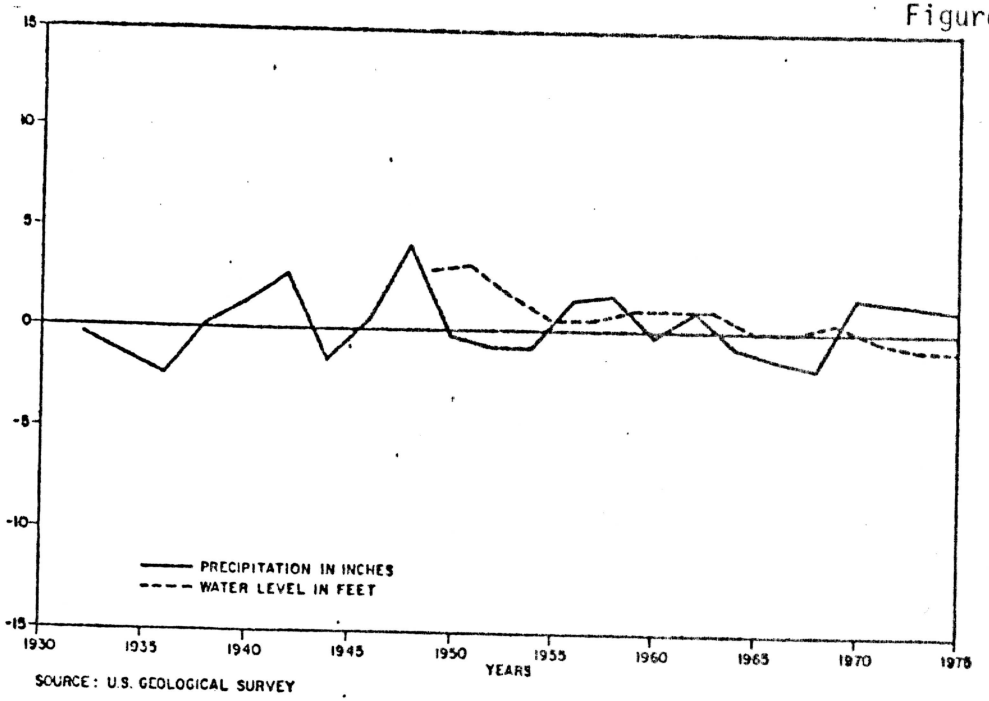
SOURCE: U S GEOLOGICAL SURVEY

CUMULATIVE DEPARTURE FROM MEAN ANNUAL PRECIPITATION AT PUYALLUP COMPARED WITH THE WATER LEVEL IN WELL (TWO YEAR AVERAGE).



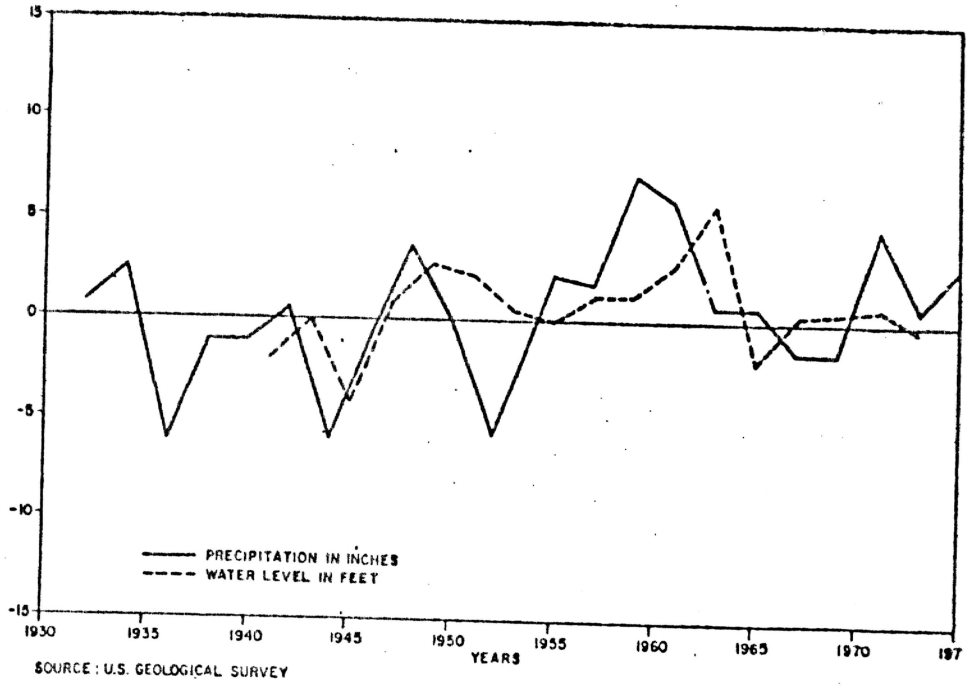
SOURCE: U.S. GEOLOGIC SURVEY

CUMULATIVE DEPARTURE FROM MEAN ANNUAL PRECIPITATION AT OLYMPIA COMPARED WITH THE WATER LEVEL IN WELL (TWO YEAR AVERAGE).



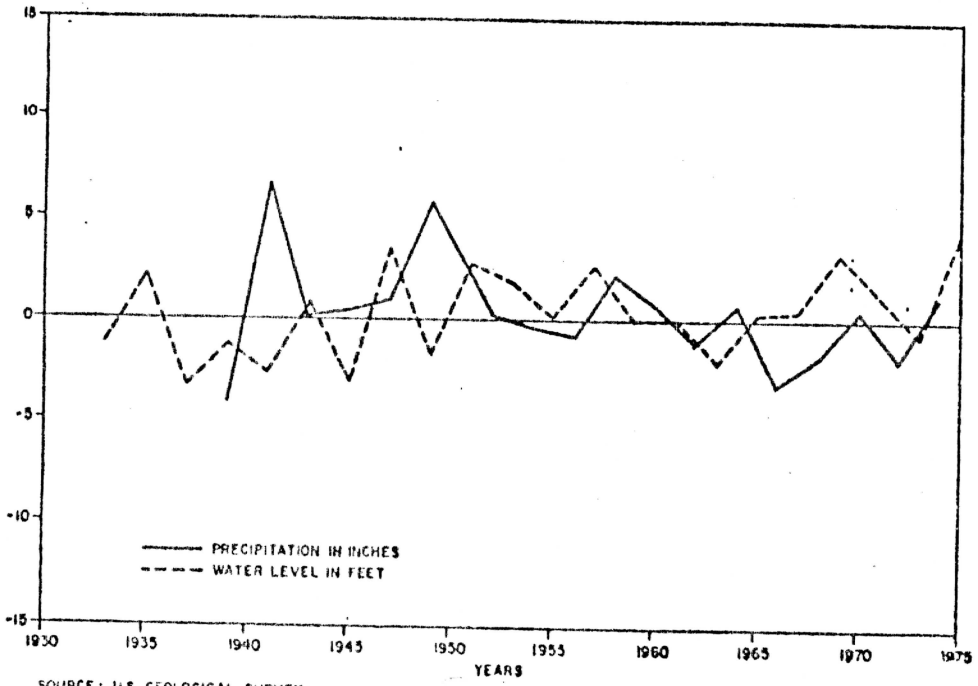
SOURCE: U.S. GEOLOGICAL SURVEY

CUMULATIVE DEPARTURE FROM MEAN ANNUAL PRECIPITATION AT KENNEWICK COMPARED WITH THE WATER LEVEL IN WELL (TWO YEAR AVERAGE).



SOURCE: U.S. GEOLOGICAL SURVEY

CUMULATIVE DEPARTURE FROM MEAN ANNUAL PRECIPITATION AT PULLMAN COMPARED WITH THE WATER LEVEL IN WELL (TWO YEAR AVERAGE).



SOURCE: U.S. GEOLOGICAL SURVEY

CUMULATIVE DEPARTURE FROM MEAN ANNUAL PRECIPITATION AT SPOKANE COMPARED WITH WATER LEVEL IN WELL (TWO YEAR AVERAGE).

causes the water level to sink and trees can grow on the newly exposed land. Increased rainfall causes the lakes to rise and the trees are killed.

"Stumps of dead trees were found standing in Granite Lake, Williams Lake, Medical Lake, Badger Lake, and many other lakes southwest of Spokane during the summers of 1926 and 1927, when after 10 years of deficient rainfall, the level of the lakes was the lowest known since the white man settled the country (see Figure 6). Rings of growth proved some of the trees lived over a century during . . . a prolonged drought period [in which] lake levels were below anything known today. Since most lakes on the Columbia Plateau contain stumps of trees killed by rising water (except where the rainfall was too low for trees to have even growth), it is proof of a widespread drought period lasting over a century. The phenomenon being widespread cannot be accounted for by a local cause that might temporarily have affected the level of one lake alone." 5/

Agriculture

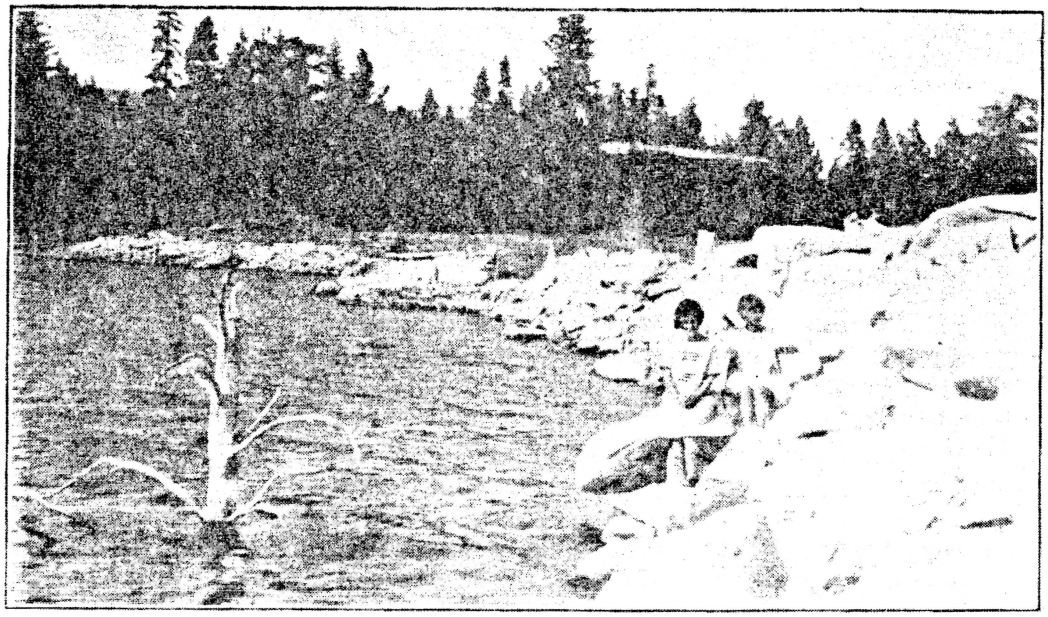
During the turn of the century, agriculture was the activity most susceptible to problems due to the lack of water. The main focus was in obtaining water; it was not until the 1930's that conservation and other relief measures were also emphasized by government. Mentioned below are some of the measures society took in insuring water supply up to the 1970's.

"By the end of the 1800's most of the waters of the small streams in central and eastern Washington had been appropriated and those irrigation systems most easily constructed had been built. Attention was, therefore, turned to larger enterprises, the construction of which was necessarily undertaken by corporations and irrigation districts. The first irrigation district law was enacted in 1890.

"Most of the larger projects were promoted by private groups and corporations; often for land development purposes. In such cases, the irrigation works were constructed with cheap materials and were, consequently, short-lived. As soon as the raw lands had been sold (frequently at fabulous prices), the promoters sold the irrigation system to a water user's association or irrigation district organized for that purpose. In some cases, the capacity of the ditch was inadequate to serve all the lands under it; in others, the available water supply was insufficient for the lands on the project. The settlers on these projects, after taking over the irrigation works, were immediately confronted with the necessity of constructing adequate and more lasting irrigation works. The settlers' financial burden caused many to lose their total investment, a condition which was sufficiently prevalent to reflect severely on the economics of irrigation farming for many years.

"In 1893, the United States Geological Survey established the first gaging stations in the State of Washington, located on the Yakima and Naches rivers. These stations were installed principally for the purpose of determining the quantity of water available for irrigation projects."6/

Figure 6



—Shore of Granite Lake, Spokane County, in 1926. The lake level was the lowest since white settlement about 60 years ago, yet stumps 1 to 2 feet in diameter, with over 100 rings of growth were standing in the lake. The trees are yellow pine which grow on well-drained soil. A further drop of 5 to 10 feet in lake level would be necessary for the pines to again grow in this situation. The climate must have been decidedly drier for over a century to have produced such low-water level

—Shore line of Silver Lake, Spokane County, in 1926. Pines and willows have migrated to the lower shore line which is about 10 feet below that in 1915 before 10 years of drought began. Part of the drop in Silver Lake resulted from pumping water for irrigation and water supply of the city of Medical Lake. The men are standing on deposits of calcareous tufa

—Shore of Silver Lake, Spokane County, in 1928. Willows killed by rising lake water. The level of the lake rose in part because pumping from it for irrigation and other uses ceased in 1926, but more because of heavy rainfall in 1927–28. The change of level shown in these photographs is greater than for other lakes because of the pumping, but all lakes in the "scablands" were at low levels in 1926 from drought and at high levels in 1928 because of abundant rainfall. Silver Lake rose nearly 29 feet in two years. Other lakes rose about one-half or one-third of this amount

—Shore of Granite Lake, summer of 1926. Note the stumps that had been long under water exposed by the shrinking of the lake resulting from more than a decade of dry years. Some of these stumps were again surrounded by water in 1928, by the rising lake water, the result of heavy rains and snows. In 1889, according to George Craig, of Cheney, the large rock at the left of the view was an island whose top was just above the water surface. The point at which the dead pines decayed and broke off leaving the present stumps would be at about the level of the lake in 1889. Wood, of course, decays most readily at the point where it is alternately wet and dry. Young pines are beginning to invade the mud flat beyond the stumps where the drainage is better. A wetter cycle in the future would drown the invaders and the story told by the

The Carey Act of 1894 marked an increase in federal interest in irrigation. It provided donations of up to one million acres of desert land to each public land state in order to stimulate the states' interest in the reclamation of these lands. Over 57,000 acres of land were developed in the Yakima Basin under the Carey Act.

"In 1902, the Bureau of Reclamation was created to carry out an orderly program of planning and construction for full-scale water and land resource development beyond the means of private enterprise. In 1903, preliminary investigations were commenced by the Bureau on the Okanogan, Yakima, and Palouse projects. The Bureau of Reclamation reported on the Yakima Basin in 1905. The essential conclusions of that report were: first, that the natural flow of the Yakima was already appropriated to a degree which exhausted its low water stage in summer and fall; and second, that to carry out any extensive reclamation there must be an extensive reservoir system for storage of flood waters."7/

An act of the State Legislature of March 4, 1905, granted to the United States Reclamation Service the power to exercise the right of Eminent Domain in acquiring lands, water rights, and other property in pursuit of its undertakings, and to withdraw from filing all unappropriated water in the Yakima River for the benefit of the United States.

The act of April 16, 1906, gave the Secretary of the Interior the authority to sell surplus power from reclamaton projects provided the sale did not impair the efficiency of the project.

In the year 1917, the State Water Code was enacted giving central authority over the water resources of the state to the Supervisor of Hydraulics, and providing a means of establishing definite legal title to water rights which is necessary for the successful operation of irrigation projects.

"The State Reclamation Law of 1919 provided that the Reclamation Revolving Fund be used for the purpose of assisting reclamation districts in construction, improvement, and refinancing problems. Each Legislature appropriated money from that fund for other purposes, such as seed wheat, the soldier's settlement at White Bluffs, forestry, an interstate water suit, cooperative activities with the U.S. Geological Survey, and the Columbia Basin project."8/

Historically, the agricultural sector is one of the first human activities to feel the impact of a drought. "The range of possible effects of drought includes financial hardship; bankruptcy and geographic dislocation for the farmer; regional economic disruption and migration; massive government relief and rehabilitation; food shortages; rising prices; and disruptions of social systems. . . .

"In the 1930's, drought struck hard at the farmer and stimulated aid from state and federal sources. Poor farming techniques, falling market prices, and a depressed economy [increased] the problem. Drought prompted the conscious adoption of new drought adjustments and further stimulated the creation of governmental agencies to promote agricultural and regional adjustment; trends already underway. Thereafter, conservation

practices spread; irrigation increased; operations became more flexible with larger farm sizes, diversification, and improved management practices; a federal crop insurance program was established; and credit institutions were liberalized.

"During this period, drought-related research was carried out by the U.S. Department of Agriculture (USDA), the State Agricultural Experiment Station System, and agricultural colleges and universities. Notable accomplishments were technologies for soil erosion control, soil moisture conservation, higher yielding grain varieties, improved fertilizers, and better farm management.

"When drought struck again in the early 1950's, the impact was much less severe. The widespread financial distress and regional disruption characteristic of the Dust Bowl era were largely absent. Though comparable in meteorological severity, the impact was moderated by the adjustments which had been made, as well as by improved farm prices and a healthy economy. Again, attention was directed to drought adjustment and research. Strong emphasis was placed on water conservation and augmentation, weather modification research, weather prediction and control, ground water recharge, irrigation and river basin development, increasing runoff, evaporation control, desalination, phreatophyte control, and irrigation canal lining." 9/

"In 1949, state legislation was passed authorizing the denial of water right applications which might result in lowering the flows of water below that necessary to adequately support fish populations. Since then, two additional laws were passed. The Minimum Water Flows and Levels Act was enacted in 1969 to provide a formal process to establish minimum stream flows and lake levels to protect fish, game, birds, or other wildlife resources, or recreational or aesthetic values. The act also directed that adequate waters be provided for the watering of livestock on riparian grazing lands. The Water Resources Act of 1971 further provides that perennial streams and rivers shall be retained with base flows necessary to provide for the preservation of wildlife, fish, scenic, aesthetic, and other environmental values, and navigational values."10/

Even though there was little direct legislative action during drought periods, the federal and state government continued to develop water resources and soil conservation programs. In addition to state drought relief programs, there are over 40 federal programs available in 1977 that offer drought relief in the form of grants, loans, insurance, and other types of assistance to state and local governments, business, and individuals. See Table 4 for a list of various federal drought-related programs available during the 1977 drought.

Despite impressive gains in reducing the effects of drought, the trends of increasing population, the demand for food, the scarcity of resources, and the growing competition for water suggests that future droughts will continue to clearly, if not severely, impact society.

TABLE 4

Summary Description of Federal Drought-Related Programs

Department of Agriculture
- Farmers Home Administration (FHA)
  - Emergency Loans
  - Emergency Livestock Loans
  - Farm Operating Loans
  - Farm Ownership Loans
  - Soil and Water Loans
  - Irrigation and Drainage Loans
- Agriculture Stabilization and Conservation Service (ASCS)
  - Emergency Conservation Measures Program
  - Emergency Livestock Feed Program
  - Agricultural Conservation Program
  - Disaster Payments Program
  - Hay Transportation Program
  - Cattle Transportation Assistance Program
  - Emergency Feed Program
- Federal Crop Insurance Corporation
- Forest Service
  - Rural Community Fire Protection Program
  - Drought-Related Stewardship
  - Cooperative Forest Insect and Disease Management
  - Cooperative Forest Fire Control
- Soil Conservation Service
  - Great Plains Conservation
  - Resource Conservation and Development

Department of the Interior
- Bureau of Reclamation
  - Emergency Fund
  - Drought Emergency Program
- Bureau of Land Management
  - Grazing Privilege
  - Agency Drought and Stewardship Programs
- Fish and Wildlife Service

Department of Commerce
- Special Economic Development and Adjustment Assistance Program
- Public Works Impact Projects

Small Business Administration
- Emergency Drought Disaster Loans
- Physical Disaster Loans
- Economic Injury Disaster Loans
- Product Disaster Loans

Federal Disaster Assistance Administration (FDAA)
- Hay Transportation Assistance
- Cattle Transportation Assistance
- Emergency Livestock Feed Assistance
- Individual and Family Grants Program

Source: Directory of Federal Drought Assistance: 1977. U.S. Department of Agriculture.

Historical Drought Occurrences

Table 5 presents a brief summary of historical drought periods since 1900. It should be noted that sections relating to drought mitigation measures do not necessarily refer specifically to actions taken in response to droughts. They do, however, refer to actions (taken for a variety of reasons) which have reduced drought impacts. Actions that have occurred over a period of years are grouped to provide continuity. In some cases, additional information on specific droughts is included in the appendix.

TABLE 5

HISTORICAL DROUGHT OCCURRENCES

DATE	WATER SUPPLY CONDITIONS/DROUGHT IMPACTS	SIGNIFICANT MITIGATION MEASURES*
July-August 1901	No measurable rainfall in western Washington from July 23 to August 25 or from July 13 to August 25 in eastern Washington. Economic Impact Vegetable and fruit crops ripened quicker than expected. Pastures lacked moisture and hop crops were down in western Washington. Grain crops were not affected. There were a number of major forest fires. The principal fire damage occurred in the Washington and Rainier forest reserve districts.	
August 1919	Occurred primarily in western Washington. Economic Impact Hot weather most detrimental in the nonirrigated counties. The wheat crop was 64 percent of normal production, oats 76 percent, and barley 76 percent. 762 forest fires occurred consuming 211,095 acres with a loss of 47 million board feet of timber.	
July-August 1921	The drought occurred in all the agricultural sections. Economic Impact Too dry for unirrigated pastures, gardens, corn, late oats, sugar beets, and potatoes. Apples began to sunburn and split. Rains, preceded by severe dust storms, caused extensive damage to fruit trees and hop yards. Large number of forest and grass fires occurred in northwestern Washington during August. Rains ended drought around August 20.	It was necessary to use a large amount of irrigation water in the Yakima Valley because of the heat. The U.S. Forest Service used airplanes to spot smoke during the forest fire season.

* The measures taken were not necessarily implemented as a direct response to drought conditions, but have served to lessen drought impacts.

HISTORICAL DROUGHT OCCURRENCES (Continued)

ATE	WATER SUPPLY CONDITIONS/DROUGHT IMPACTS	SIGNIFICANT MITIGATION MEASURES*
June-August 1922	From June 10 to August 10, the statewide precipitation average was only .10 inch. Economic Impact General wheat yield was less than average Spring wheat was of very poor quality. The stock was in poor condition due to dry ranges and pastures. The price of milk rose 25 percent because of poor pasturage. In western counties, oat production was below average and potato production was fair. 947 fires burned (305,351 acres), destroying 311,483,000 board feet of timber. There were also $870,528 in other fire-related losses.	First time a Governor's proclamation was issued prohibiting fires in the forests.
March-Mid August 1924	Economic Impact In some localities, the germination of spring wheat was retarded by lack of moisture in the soil. A poor second crop of alfalfa came from northeastern counties. In dairying districts, pastures and ranges were dry resulting in a decline in the milk supply. There was a total of 1,532 fires, causing 322,691 acres to burn and destroying 25,301,000 feet of timber. Social Impact Contamination of shallow wells (low water level) caused typhoid in Walla Walla County.	State Hydraulic Division developed (and successfully used) procedures to provide advance warning of changes in stream flows allowing the irrigator to saturate his land during the flood season in anticipation of the dry spell. Power companies started their own water survey's which included measuring snow pack conditions.
July 1925	Economic Impact Decline in hops, hay, apples, potatoes, beets, and other vegetables. Wheat and oat crop production was 73 percent and 81 percent of normal, respectively. Pastures were 67 percent of normal. 1,271 fires burned 142,355 acres which destroyed 69 million board feet of timber. There were $306,000 in other losses (property, buildings, etc.) plus national forest losses.	The Washington Forest Fire Association spent $187,418 in forest fire protection work. The U.S. Weather Bureau was studying fire-weather causes and effects.
June 21 - August 25, 1926	Little or no rainfall was reported. Streams and wells were unusually low in Walla Walla area. 1,553 fires burned 375,010 acres. Fire costs greater than any other year.	2,246,847 acres of forest were closed during the fire season. Special fire weather warning service was developed by U.S. Weather Bureau. Studies conducted by the W.A. ST. Experimental Station on land in the dry belt area subject to to wind erosion.
August 1928 - March 1929	Drought was unusually long and severe. Most stations averaged less than 20 percent of normal rainfall for August and September and less than 60 percent for the entire nine months. Crops generally good. During the fire season more logs were destroyed than in any previous season since 1922.	

* The measures taken were not necessarily implemented as a direct response to drought conditions, but have served to lessen drought impacts.

DATE	WATER SUPPLY CONDITIONS/DROUGHT IMPACTS	SIGNIFICANT MITIGATION MEASURES*
July - August 1930	Driest weather occurred in western part of state, but the drought affected the entire state. Most weather stations averaged 10 percent or less of normal precipitation. Economic Impact Dryland crops made little or no growth. Irrigated vegetation progressed rapidly. Social Impact In the City of Walla Walla, the water consumption rose from a normal use of 200 gallons per day per resident to 500 gallons per day per resident.	December 30, 1930, the Secretary of Agriculture issued a circular describing loans which were available for purchase of up to $2,000 worth of seed for spring planting or fuel and oil for tractors.
April 1934 - March 1937 (For further information see appendix)	The longest drought in the region's history with the Palmer Drought Index maintaining values less than -1. The driest periods were April-August 1934, September-December 1935, and July-January 1936-1937. Economic Impact (1934) Wheat yields less than anticipated. A forest fire in the Colville National Forest destroyed farm homes, livestock, and more than $1 million worth of timber. Social Impact (1934) The City of Pomeroy had no water for fire protection. Pasco residents had to purify their water. Economic Impact (1935) In Walla Walla area, peaches and apples ripened too rapidly and ground water table declined. 1935 fire season was long and severe from April 6 to October 15. Between August 19 and August 27 some 500 fires occurred. Economic Impact (1936) Record high temperatures in southwestern Washington Cherry and prune crops were poor In some areas of southeastern Washington, wheat was burned yellow by the hot, dry weather. 1,272 forest fires reported, burning 44,182 acres, and causing $62,248 in property damage. Economic Impact (1937) 1,058 fires burned over 20,111 acres and caused $58,216 in damages. The average area burned per fire was 19 acres compared with 34.7 for 1936.	Federal government spent massive amounts of money to help alleviate the human distress resulting from moisture deficiency, crop failure, pasture damage, and depletion of livestock. (1934) Federal Emergency Relief Admin. gave $75,000 to rehabilitate distressed farmers on poor lands. Part of Yakima County was designated as a secondary drought area. Mayor of Pomeroy issued an emergency order to limit irrigation and sprinkling. (1935) For the first time, the State Department of Forestry made an effort to control every fire under its protection. There was continued progress in reduction of acreage burned because: 1. Numerous roads, trails, lookouts, and telephone systems constructed by the Civilian Conservation Corps. 2. Availability and mobility of organized fire fighting crews. (1937) State Planning Council obtained information on ground water supplies. There were (No laws at the time requiring permits to use ground water). A number of logging operators voluntarily shut down when weather conditions became hazardous. Legislature advanced the fire season from April 15 to October 15.

* The measures taken were not necessarily implemented as a direct response to drought conditions, but have served to lessen drought impacts.

HISTORICAL DROUGHT OCCURRENCES (Continued)

DATE	WATER SUPPLY CONDITIONS/DROUGHT IMPACTS	SIGNIFICANT MITIGATION MEASURES*
April 1934 - March 1937 (continued)	Social Impact (1937) Electric power market condition changed during 30's. New electrical appliances Increase in power consumption Reduction in electric power rates Expanded role by federal government.	
May - September 1938 (for further information see appendix)	In western Washington, it was the driest growing season ever recorded. Nearly all western stations reported less than half the normal amount of precipitation. Economic Impact Berry and pea production was curtailed. The fire season was the most hazardous since 1922. 2,359 fires burned 144,513 acres of timber.	The Division of Hydraulics and Water Resources proposed that a study be undertaken to examine the necessity for definite reservation of a fixed minimum flow in streams in the interest of fish life. Increasing emphasis on streamflow records and gaging stations. Large increase in applications for water permits, especially from dairy farmers for irrigation of pasture land. All logging operations were closed down from July 14-16.
1944	July temperatures averaged slightly above normal in the west and slightly below in the eastern stations. Economic Impact: High temperatures bleached the coloring or caused apples to sunburn. In Spokane County, tomatoes ripened rapidly. In Clark County, pastures were dry. Bean yield was down in King County. Late spring wheat, oats, and unirrigated gardens in the eastern part of the state suffered. Pastures were dry causing the supply of milk to decline. Unusual number of grain and stubble fires. Social Impact: City of Spokane faced with water shortage. City of Walla Walla had heavier than normal consumption of domestic water.	The City of Spokane took conservation measures to alleviate the water shortage.
1952	Extremely dry year with every month except June below normal in precipitation. Hardest hit areas were Puget Sound and the central Cascades. Tacoma received 41 percent of normal precipitation and Stampede Pass 43 percent of normal. Palmer Drought Index dropped to a low of -5.06 in the Puget Sound lowlands. Economic Impact: Wheat crops came up late. Scorched pastures and thin cattle caused cattle prices to drop. There were 1,794 fires reported, burning 32,352 acres. Because of low hydroelectric reservoirs, users of interruptible power were cut off.	Interruptible power curtailed. Tacoma City Light ordered a 10 percent cut in power use by their industrial users. Many plants were able to achieve 10 percent reduction without any layoffs. Illuminated billboards were reduced by 33 percent. Christmas lights were reduced in many areas. Many farmers in prairie districts had to obtain supplemental water from storage tanks and pumps. Some farmers rented pasturage where water was available for cattle. Logging was banned in western Washington for 2 weeks in September and October.

* The measures taken were not necessarily implemented as a direct response to drought conditions, but have served to lessen drought impacts.

HISTORICAL DROUGHT OCCURRENCES (Continued)

DATE	WATER SUPPLY CONDITIONS/DROUGHT IMPACTS	SIGNIFICANT MITIGATION MEASURES*
January - May 1964	Drought covered basically the southeastern part of the state. Precipitation was less than 40 percent of normal. Considerable wind with blowing dust. Economic Impact: Nonirrigated crops were affected by the dry weather. Some seed grass fields were totally destroyed by winds.	
Spring 1966	Spring of 1966 was dry throughout the entire state. The Palmer Index for June was -5.28 in the Palouse-Blue Mountain area. Economic Impact: Pea crop ripen early. Lack of subsoil moisture damaged grass seed crops. 1,330 fires reported during the year.	
June - August 1967	No rain of importance fell from the third week in June to the first week in September. Economic Impact: In eastern portions of the state the heat caused crops to mature too rapidly thus reducing yields. 1,767 forest fires burned 6,716 acres.	State and National forests were closed, prohibiting logging, mining and recreational uses outside designated campground areas.
January - August 1973 (For further information see appendix)	Occurred mainly in the eastern part of the state. West slope of the Cascades annual precipitation departure was -9.29 inches. The east slope of the Cascades annual precipitation departure was -5.73 inches. Economic Impact: Most crops showed effects of inadequate soil moisture including wheat and barley. Pastures were dry. Large blocks of industrial energy loads were curtailed and as a result, major losses occurred in production and employment.	In July, a voluntary energy conservation program was started by utilities and government agencies. Power managers sought variances of some of the region's environmental standards. Arrangements were set up to conduct cloud-seeding operations by utilities. Outside energy was purchased (over 169 million kilowatt-hours).

* The measures taken were not necessarily implemented as a direct response to drought conditions, but have served to lessen drought impacts.

DATE	WATER SUPPLY CONDITIONS/DROUGHT IMPACTS	SIGNIFICANT MITIGATION MEASURES*
October 1976 - September 1977 (For further information see appendix)	The percentage of normal precipitation for Olympia was 61 percent, Seattle 57 percent and Yakima 43 percent. Stream flows averaged between 30 and 70 percent of normal. With negligible inflow to sustain circulation, temperatures were higher than normal in many lakes, resulting in algal blooms, oxygen depletion, and fish kills. There was minimal ground water recharge during the spring creating a more rapid decline in the the late summer. In eastern Washington, the Palmer Index dropped below -9 during July and August. Economic Impact: Agriculture and the aluminum and ski industries suffered the most. The drought would decrease the forecasted gross production as much as $330 to $410 million, during 1977 and 1978. Many row crops were not planted because of the expected water supply shortage. Dryland wheat only 60 percent of 1976 record harvest. 1,319 forest fires burned nearly 10,800 acres. Social Impact: More than 106 community and municipal water supply systems experienced or anticipated drought related problems. Most of these were associated with dry wells as a result of declining shallow ground water levels.	Governor Ray established an "Ad Hoc Executive Water Emergency Committee" to coordinate responses as the various problem situations developed and prepare biweekly reports on drought conditions. Thirty-four counties were designated as Emergency Drought Impact areas. These counties were eligible to apply for federal drought relief programs. State legislature passed emergency drought legislation (2nd S.S.B. 2620) to ease agricultural and domestic water supply problems ($33 million dollars). 600 temporary emergency authorizations and supplemental ground water permits were issued by the State Department of Ecology. 13 contracts were prepared for grants and loans to public organizations to assist in the construction of emergency agriculture water supply facilities. "Fish Flow '77" consisted of increasing flows at several Columbia River dams and trapping and transporting operations on the Snake River. Similar operations were conducted on smaller streams. Cloud seeding - Total funding, public (Senate Bill No. 2561) and private, for cloud seeding in the State of Washington was approximately $401,000. Governor Ray directed state agencies to cut electric energy by 10 percent. The Governor also urged the public to undertake voluntary savings and a goal of 10 percent was established.

* The measures taken were not necessarily implemented as a direct response to drought conditions, but have served to lessen drought impacts.

SUMMARY

Drought occurrences are not unusual in Washington. There have been 19 drought occurrences since 1901. In every case, agriculture has felt the impact, especially in nonirrigated areas such as dryland farms and range lands. Droughts have left their major impact on individuals (farm owners, tenants, and farm laborers) and on the agricultural industry, and to a lesser extent, on other agriculture-related and nonagricultural sectors. As a result of droughts, new techniques and adaptations have occurred in agriculture. Federal and state governments have also assumed an active role in developing new water projects and soil conservation programs.

Another major impact of droughts is the increased danger of forest fires. Millions of board feet of timber have been lost, and in many cases, erosion occurred which caused serious damage to aquatic life, irrigation, and power development by heavy silting of streams, reservoirs, and rivers. But, through better forest fire protection techniques, total acreage burned has continually decreased.

In the 1930's, a new development occurred. The production of low-cost electricity was a major factor in the Pacific Northwest's transition from a regional economy based on agriculture and lumber to a more balanced, widely diversified economic and social structure, thus placing more demands on the state's water resources. There have been three energy curtailments during drought periods prior to 1977 that have caused temporary unemployment. Both private enterprise and government have taken an active role in developing new sources of energy to meet the continually increasing demand.

Problems of domestic-municipal water supply have historically been corrected (funds permitting) by building another reservoir, larger pipeline, a new well, or some other facility.

Low stream flows have created high temperatures, oxygen depletion, disease, and lack of spawning areas for our fish resources.

Progress is being made in dealing with the impact of droughts through proper management of Washington's water resources. Hopefully, information being collected and shared will assist in the formulation of effective programs for future water short years.

APPENDIX

April 1934 - March 1937

Water Supply Conditions:

"This was probably the longest drought in the region's history with the Palmer Drought Index (PDI) maintaining values less than minus 1 throughout the period. Fortunately, the rain that did come was timely and prevented farmers from suffering extensive losses. The forests were not so fortunate with a number of serious fires reported. The driest areas varied with time, as is shown by the extreme PDI values; Okanogan - Big Bend: - 4.65, July 1934; Central Basin: - 5.38, July 1934; Northeast: - 5.85, January 1937; and Palouse: - 4.91, January 1937. Generally, the driest periods were April-August 1934, September-December 1935, and July-January 1936-1937."11/

Weather Bureau reports compiled by E. M. Keyser for the 50-year period, 1880 to 1930, showed that rainfall in Spokane County gradually decreased and temperatures slowly rose. T. A. Bonser, curator at Grace Campbell Memorial Museum in Spokane, made a graph to explain the decrease of precipitation from 1880 to 1930. This graph divides the 50 years into 10 year averages. The average rainfall for the first 10 years (1880-1890), was 18.91 inches; second 18.28; third 16.13 (1900-1910); fourth 14.03 (1910-1920); and fifth, 13.21. The loss from 1881 to 1930 was 5.70 inches or 30 percent.

Economic Impact (1934):

Because the hot spell in early March did not allow the heads to properly fill, wheat yields were less than anticipated. Nature (droughts, insects, and floods) caused the Agricultural Adjustment Administration's crop reduction program to overshoot its goal. The program, in part to help establish better crop prices, was slowly phased out. One of the worst forest fires in the history of the Colville National Forest destroyed farm homes, livestock, and more than $1 million worth of timber. The fire spread over 18,000 acres. From 1930 to 1934, wheat acreage and production declined in response to lowered domestic and export prices. Also, yields in that period were relatively low because of the extended drought.

Social Impacts (1934):

Municipalities had experienced numerous water problems. Pomeroy, in eastern Washington, had no water for fire protection. The mayor issued an emergency order to limit irrigation and sprinkling. Pasco residents had to purify their water because it was not meeting state standards.

Drought Mitigation Measures (1934):

Labor was provided for a new irrigation well in Weston under the Federal Emergency Relief Administration.

The Federal Emergency Relief Administration gave the Washington Emergency Relief Administration $75,000 to administer land settlement projects as a means of rehabilitating distressed farmers on poor lands.

In 1934, Washington was not designated as a drought state, and thus was not eligible on a statewide basis for emergency funds from the federal government. However, part of Yakima County was classified as a secondary drought area.

Water Supply Condition (1935):

In 1935, the water table dropped in the Walla Walla area causing a number of wells to go dry.

Economic Impact (1935):

In the Walla Walla area, peaches and apples ripened too rapidly.

"The 1935 fire season was long and severe, beginning April 6 and ending October 15. The following quotation [is] from the U.S. Weather Observer in Olympia: 'Rainfall recorded the first 11 months of 1935 was 11.15 inches below average. July and August were practically without precipitation, July's measuring but .25 and August's .26. May was the driest since 1890. . . .'

"From May 2 until October 15 there was nearly continuous fire fighting, with the number of men varying from 500 to 2,000. The most acute period of the entire season occurred between August 19 and August 27, during which some 500 fires were [reported].

"In a number of cases it became necessary to use men from Civilian Conservation Corps (CCC) camps in order to control fires started either in or dangerously near logging operations. In spite of a very long and dry season and a 40 percent increase in the number of fires, the actual acreage burned was less than 1 percent of the total forest area protected by the state. The total loss and damage to property was only $88,696.00. Of a total area of 120,027 acres burned over, there were 6,759 acres of merchantable timber killed, most of which was salvaged."12/

Drought Mitigation Measures (1935):

"For the first time since organized protection began, there was an effort made to control every fire on the 12 million acres under the protection of the Department of Forestry [state] regardless of origin, locality, or ownership. There was continued progress in reduction of acreage burned and loss and damage to property. This may be attributed to the following factors: first, the numerous

roads, trails, lookouts, and telephone systems constructed by men from the CCC camps which enabled crews to reach fires before they gained headway; and second, availability and mobility of organized fire fighting crews. Most of the fire fighting on state and private lands was done by the CCC men who spent 35,204 man-days on fire suppression. The State of Washington realized a net savings of $105,612 in fire fighting wages." 13/

Economic Impact (1936):

In May of 1936, temperatures rose to a new all-time high in southeastern Washington. During June, much of the wheat lands in the southeastern region were burned yellow in spots as the long, dry spell continued and was accompanied by hot weather and drying winds. Cherry and prune crops were poor.

However, in spite of poor conditions in some areas, the rains came and helped a great deal as Washington State harvested the largest wheat and apple crop in the nation. The state also harvested the second largest crop of pears in the nation.

During 1936 there were 1,272 fires reported. The total area burned was 44,182 acres, causing $62,248 in property damage. "The length of fire season, the comparatively small acreage burned, and low property loss indicate continued progress in the forest protective organization. The average area burned per fire in 1935 was 42.7 acres, while for 1936 this was reduced to 34.7 acres."14/ Most of the fire fighting was performed by men from CCC camps and state park camps.

Social Impact (1936):

In Dayton, the municipal water supply had to be conserved. The cannery was running at full capacity, and the city water mains could not carry sufficient water to operate the industry and allow domestic consumers unlimited use. In order to insure that there would be no shortage, each residence district was given certain hours for irrigation of lawns.

Water Supply Conditions (1937):

In 1937, a project conducted by the State Planning Council obtained information on ground water supplies. Because the state was well supplied with surface waters, little attention had been paid to underground water. Up to this time, 45 cities obtained all or portions of their water supply from underground sources. A number of important industries, particularly pulp manufacturers, relied on wells for water of high purity. One pulp mill obtained seven million gallons per day from such a source. Reclamation projects were being watered from ground water sources. There was no information available on the extent of the various basins and the amount of water which may be drawn from them without depletion, or of its quality. There were also no laws, at the time, requiring permits to use ground water.

Economic Impact (1937):

"In 1937 there were 1,058 fires reported that burned over 20,111 acres, with a subsequent loss and damage of $58,216. The average area burned per fire was 19 acres, compared with 34.7 for 1936. Favorable weather and increased caution by the traveling public were largely responsible for such a decided reduction in the number of man-caused fires. A large percentage of the logging operators voluntarily shut down their camps when weather conditions became hazardous and fire risk excessive. The 1937 fire season was officially advanced by legislative action to April 15 and extended to October 15." 15/

Social Impacts/Drought Mitigation Measures:

The electric power market condition changed a great deal during the 1930's. The introduction of many new electrical appliances, the increase of electric power consumption, reduction in electric power rates, and the expanded role of the federal government brought expanded growth and the need for more hydroelectric power, thus placing a greater demand on water.

The problem of drought affected many areas in the United States between 1934 and 1937. The federal government spent massive amounts of money to help alleviate the human distress resulting from moisture deficiency, crop failure, pasture damage, and depletion of livestock. Federal funds were expended by the Federal Emergency Relief Administration (April 1933-June 1936), the Civil Works Administration (November 1933-July 1934), Agriculture Adjustment Administration (May 1933-May 1936), Resettlement Administration (July 1935-June 1936), and Works Progress Administration (April 1933-June 1936).

"In Washington State, an area of 283,000 acres of cutover, burned-over, and second growth timber land, interspersed with about 230 scattered farms, was acquired by the Resettlement Administration. The area was located along the divide between Stevens and Pend Oreille counties and consisted of privately-owned and county lands. Tax delinquencies, foreclosures, and heavy relief and tax burdens seriously drained the resources of the area."16/ The land was restored to its best forest, recreational, and other uses, removing about 135 families from farming.

The Resettlement Administration gave approximately $65,800 in emergency grants to six counties: Adams, Benton, Chelan, Cowlitz, Jefferson, and Stevens.

In an endeavor to examine the social aspects of the drought problem, the Division of Social Research of the Works Progress Administration, the Bureau of Agricultural Economics of the Department of Agriculture, and the Resettlement Administration combined their resources on human problems. The study concentrated on the drought area of the mid-west.

Water Supply Conditions:

"1938 was a dry year at most stations in the state, but especially so from May to September in western Washington where it was then called 'the driest growing season ever recorded.' During this period, nearly all western stations reported less than half the normal amount of precipitation. For example, Tacoma received 1.67 inch or 23 percent of normal, Coupeville 2.05 inch or 38 percent of normal, South Bend 5.70 inch or 42 percent. June was the driest month in the period with a number of stations reporting less than .10 inch. Oddly enough, a majority of eastern stations reported more than normal precipitation the same month."17/

Economic Impact:

The unusual dryness curtailed the yield of many crops, especially berries and peas. The fire season was the most hazardous since 1922. A total of 2,359 fires burned 144,513 acres of timber. "By July 13, the situation had become so critical that, for the first time in Washington, a general order was issued closing down all logging operations on July 14, 15, and 16. Unprecedented drought and critical fire weather were some of the unusual features of the fire season.

"Owing to the almost entire absence of precipitation during the summer of 1938 there was a large increase in the number of applications for water permits, particularly from western Washington. This is particularly true of dairy farmers, many of whom requested permits for irrigation of pasture land."18/

Social Impact:

An editorial written in the Tacoma News Tribune on August 14, 1938 commented on the drought:

Speaking of the Rain

In terms of actual precipitation, the Puget Sound country has experienced a real drouth this summer. A scant inch of rain has fallen in the past three months, a deficiency of moisture that would have meant agricultural ruin in most parts of the United States.

Here, on the contrary, few crops have suffered severly and none has been entirely lost for lack of rain; water has been available to keep lawns fresh and green, flowers have continued to bloom in glorious profusion, and there has been nothing to suggest to the eye the dust bowls of the plains states.

Apparently no drouth in the ordinary sense can really dry up this section. Farmers may have to

pump and irrigate locally, but the fact remains that the water is available with flourishing gardens, loaded fruit trees, filled with hydro-electric reservoirs and running streams all testifying to the fact. Mid-westerners visiting Tacoma after three rainless months find all this hard to believe. Under similar circumstances they would be hauling in their drinking water.

Water is probably the most precious asset of the Pacific Northwest, little as it is appreciated during the winter months when Nature is giving us a year's supply. There are other sections of the country, notably southern California, that are seriously worried over the prospect that future population demands will outstrip potential water supplies. J. B. Priestley makes note of this in his new book, "Midnight on the Desert," when he writes: "Unfortunately, millions of people (in the Los Angeles area), with their houses and factories and fruit farms, need a great deal of rain; and so the ghost of drouth haunts this region. It has room for millions more, but will it have water for them?"

That's one worry we Puget Sounders will never have. As for this summer's "drouth," perhaps Nature has been trying to teach us an appreciation of the showers and mists of winter.

Drought Mitigation Measures:

"Since 1909 successive State Legislatures have made appropriations for "Hydrographic Surveys" which have been matched by the federal government. At the outset, stream flow records were obtained primarily to study feasibility of irrigation projects. Soon, however, the state's predominance in water power possibilities became apparent so that records were started for that purpose. Daily records of stream flow were obtained at 122 gaging stations located on the principal streams in the state. As of 1938, the investment in gaging station structures amounted to about $200,000. Data were published annually in water supply papers of the U.S. Geological Survey, making it possible for engineers in any part of the country to appraise the water resources of the state. A total of eight new gaging stations were placed in operation during the biennium."19/

In July, 1938, a Public Works Administration allotment of $51,000 was made available for improvement of equipment at existing gaging stations.

The Ninth Biennial Report of the Department of Conservation and Development (October 1, 1936 - September 30, 1938) also mentions the concern for the diminishing game and fish life. The Division

of Hydraulics and Water Resources proposed that a study be undertaken to examine the necessity for definite reservation of a fixed minimum flow in the various streams in the interest of fish life.

A Memorandum Regarding the Cause of Dying Douglas Fir In the Prairie Region was written by R. L. Furniss, from the Forest Insect Laboratory in Portland, Oregon. In concluding his report he stated "in regard to the dying Douglas firs in the prairies of western Washington, this condition was primarily brought about by deficient rainfall during the growing season of 1938. The dying trees are most abundant on the Fort Lewis military reservation. The effects of the drought were supplemented by the work of certain bark boring beetles . . . . No insect control measures are necessary. It is believed that, while the insects may do a limited amount of damage in 1939, this will not be appreciable unless there is a recurrence of very dry weather."20/

1973

Water Supply Conditions:

"The 1973 Water Year was one of the driest on record for the Columbia Basin. Moderate to severe drought conditions persisted over all areas. . . . April set many new seasonal high temperature records and was the beginning of the hot summer to follow. Many stations registered in the high 80's and mid-90's in May, exceeding their usual July temperatures, while the temperature in June and July moved into the high 90's and low 100's to exceed long-term records for both daily and consecutive days in excess of 100°F."21/

The drought conditions occurred mainly in the eastern portion of the state. The Palouse-Blue Mountain area received a P.D.I. value of -5.19 for August. The duration of the drought was approximately from January through August. The west slope of the Cascades annual precipitation departure was -9.29 inches and the east slope annual precipitation departure was -5.73 inches.

"The snowpack for the 1973 season was slow in starting to accumulate. On most watersheds it continued to fall behind throughout the entire season. The snowpack, because it was so low, disappeared from the higher elevations about June 1st, a month earlier than usual."22/

Economic Impact:

There were 1,459 fires during 1973 burning a total of 10,126 acres.

"April temperatures were near normal, but continued dry weather hampered the recovery of damaged fall grain stands and slowed the development of early spring crops. Irrigation started earlier than usual. Unstable May temperatures resulted in sporadic plant growth, and most crops showed effects of inadequate soil moisture.

Dry weather was favorable for harvest, but some wheat and barley was badly shriveled from continued shortage of soil moisture. Dry weather continued to have adverse effects on pasture conditions. Most grass seed was harvested during the month with low yields as a result of poor crop growth and development during the season. Haying operations were virtually completed in dryland areas by the end of August with dismal results."23/

Social Impacts:

"The 1973 drought led to the most critical power supply situation in the history of the coordinated power system in the Pacific Northwest. Starting in April, large blocks of industrial loads were curtailed and, as a result, major losses occurred in production and employment. In July the utilities and governmental agencies in the area launched an extensive program to advise the general public of the power shortage and ask for voluntary energy conservation measures. Response to the plea for energy conservation was immediately successful and ranged from the dimming of street lights, stores and public buildings to an official ban on the use of electric signs in Oregon. There had not been power "brownouts" since 1952 in the normally water-rich Pacific Northwest, but the 1973 drought made it necessary again."24/

Drought Mitigation and Management Measures:

"The bleak power outlook and its adverse effect on the regional economy forced power managers to seek variances of some of the region's environmental standards. In August, officials of the Washington Public Power Supply System received a temporary variance on the water temperature standard for the Columbia River reach near the Hanford thermal plant. It was feared that operation of the Hanford plant would cause water temperatures to slightly exceed the 68°F. standard on a few days in August. Later in the year, managers of the coal-fired thermal plant at Centralia also received a short-term variance of the stack emission standards for the plant, allowing generation to be increased to an average of 1200 megawatts.

"Power managers took additional steps to alleviate the situation as the magnitude of the potential power deficit became apparent. The Bonneville Power Administration (BPA) and utilities in the area made arrangements to conduct cloud-seeding operations in several basins in the area if the power situation did not improve. Further, BPA arranged to use its Continuing Fund for direct purchase of energy for use in serving the firm loads of customers of the Federal Columbia River Power System. Nearly $1 million was expended from this fund by September 1973 to purchase over 169 million kilowatt-hours of relatively high-cost energy to bolster the low reservoirs of the Columbia Basin, with a total expenditure of about $2.5 million."25/

"The Washington District, U.S. Geological Survey, in cooperation with Washington Department of Fisheries, had for several years been

engaged in a study of stream hydraulics as related to the spawning of salmon. The study was expanded in cooperation with the Washington Department of Game to include steelhead and other trout. Specifically, the purpose of the study is to determine for many of the major salmon and trout streams in Washington the streamflow necessary for spawning and rearing, according to conditions of velocity and depth preferred by the various species."26/

Through the years the federal role in water management became greater. For example, "the Columbia Basin Inter-Agency Committee (CBIAC) was established in 1946 by the parent Federal Inter-Agency River Basins Commission 'to facilitate progress on the multiple-purpose development projects presently authorized by the Congress for the Columbia River Basin . . . and to implement the coordination of plans . . . for further development of those areas . . . .' In March 1967, CBIAC was replaced by the Pacific Northwest River Basins Commission (PNWRBC) under terms of the Water Resource Planning Act of 1965 (Public Law 89-80, 79 Stat. 244). The new Commission continued the coordinating functions of CBIAC with greater emphasis on resource planning. However, it was not assumed to have operating responsibility for existing projects. Therefore, operating agencies initiated formation of a separate Columbia River Water Management Group (CRWMG) to carry on the functions of the Water Management Sub-committee."27/

"The Columbia River Water Management Group met every month during the 1973 water year except August. At each meeting reports were presented by agency representatives summarizing events of interest over the preceding month for which their agencies have responsibility as follows: Weather, by the National Weather Service; Streamflow, by the Geological Survey; Snow Accumulation, by the Soil Conservation Service; Outlook for Power, by the Bonneville Power Administration; Outlook for Water Supply in Irrigation Reservoirs, by the Bureau of Reclamation; Flood Control Operations and Reservoir Regulations, by the Corps of Engineers; and Water Quality, by the Environmental Protection Agency. Task Forces and Committees report on their activities and submit recommendations to the Water Management Group for approval and further action."28/

October 1976 - September 1977

Water Supply Conditions:

For the water year October, 1976 - September 19, 1977, the percentage of normal precipitation for Olympia was 61 percent, Seattle 57 percent and Yakima 43 percent. Stream flow throughout the state declined during the period averaging from about 30 to 70 percent of normal, while many small streams went dry. With negligible inflow to sustain circulation, temperatures were higher than normal in many lakes resulting in algal blooms, oxygen depletion, and fish kills. There was minimal ground water recharge during the spring, creating a more rapid decline in the late summer. The drought had its greatest impact in eastern Washington where the Palmer Index value dropped to an unprecedented low value of -9 during July and August.

Economic Impact:

Agriculture, aluminum, and the ski industries suffered most, and it was forecast that the drought would decrease gross production in Washington during 1977 and 1978 as much as 330 to 410 million dollars with 80 percent of the loss expected to occur in 1977.

Although irrigated orchard crops fared better than originally anticipated, many row crops were not planted because of the expected water supply shortage, and dryland grains suffered appreciable losses from lack of rainfall during critical periods. The 1977 dryland wheat production, estimated at 86.4 million bushels, will only be about 60 percent of last year's record amount. If poor soil moisture conditions continue, the fall planting of winter wheat will be precluded in much of the Columbia Basin area.

The extreme fire danger from the dry weather was aggravated by heat wave conditions in mid summer, and on state owned lands alone, there was a total of 1,042 fires which had burned nearly 6,600 acres by the end of August. The incidence of fires has been about double the normal rate, but through intensified efforts in prevention and detection, the total area burned has been relatively small.

Social Impact:

As of September 20, 1977, a total of 106 community and municipal water supply systems in Washington were experiencing or anticipating drought related problems. Most of these were associated with dry wells as a result of declining shallow ground water levels. (The state legislature earmarked 15 million dollars for domestic water supply problem relief.)

Drought Mitigation Measures:

To counter the problems created by the drought and coordinate all efforts, Governor Ray established an "Ad Hoc Executive Water Emergency Committee" in February. This group, composed of state,

federal, and local government agency representatives, prepared biweekly reports on drought conditions, held periodic meetings and coordinated responses to the various problem situations as they developed.

Thirty-four counties in the State of Washington were designated as Emergency Drought Impact Areas by an Interagency Drought Coordinating Committee. These counties were eligible to apply for assistance through various federal drought relief programs.

The availability of 33 million dollars in state funds through emergency drought legislation [Second Substitute Senate Bill 2620] helped to ease agricultural and domestic water supply problems. Through August, a total of nearly 600 temporary emergency authorizations and supplemental ground water permits were issued by the State Department of Ecology to individuals and other entities to allow the immediate development of supplemental water supplies. In addition, a total of 13 contracts were prepared for grants and loans to public organizations to assist in the construction of emergency water supply facilities.

Early in the year, the "Fish Flow '77" program was implemented on the Snake and Columbia Rivers in an attempt to preserve migrating fish populations. The program consisted of increasing flows through additional generation and spillage at several Columbia River dams and trapping and transporting operations on the Snake River. Preliminary reports indicate that the program was successful although it is expected that later summer runs will be seriously affected by low flows and high water temperatures. Similar operations were conducted on smaller streams in the state.

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