The Climate of the State of Washington

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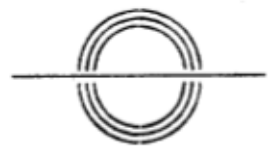
The Climate of Washington

A Careful and Elaborate Treatise on the Climatic Conditions, with Reference to Temperature, Winds, Rainfall and Snowfall.



Great care has been exercised in the compilation of statistics from the records of the Weather Bureau, and temperature and wind, and rainfall maps of the state have been reproduced from the Weather Bureau Annual Summaries. The Eastern and Western sections of the State are considered separately. The information herein contained, and the discussion of *causes* are of value alike to the student of the climate of any section of Washington, or to the teacher who teaches the geography of the state.

THE
Climate of Washington

"For equability and mildness of climate, absence of either very hot or very cold waves, and freedom from destructive tornadoes or cyclones, Washington stands foremost among the favored states of the American Union."—H. F. Alciatore, U. S. Weather Bureau.

The Climate of Washington is much more equable than that of other states situated in corresponding latitudes. The daily and seasonal range of temperature which so greatly affects climate everywhere, is not great in this state. The mean temperature for the month of January, which is usually the coldest month in the year, is 35.2 degrees. This is the aver age of the mean January temperature for ten years, taken at stations well distributed throughout the entire state. A similar average for July, usually the hottest month, gives 64.6 degrees. These averages cannot be far from the true or normal temperature for January and July. The difference between these is 29.4 degrees, the seasonal range. A comparison of the difference between the winter and summer temperature in Idaho, Montana, North Dakota, Wisconsin or Michigan, all of

which are in the same latitude as Washington, with the seasonal range in this state will show that it is comparatively low. To this fact may be attributed the entire absence of sudden changes or violent disturbances of the atmosphere within the state. The average of these two extremes, the temperature of January and July, gives a little less than 50 degrees for the mean annual temperature of the state. This is, however, about one degree above the true or normal temperature.

The daily range, or the difference between the daily maximum and minimum temperatures, is likewise comparatively low throughout the year. The climate of Washington is free from extreme variations of heat or cold. The highest temperature of the summer months gradually lowers to the lowest of the winter months. The change is almost imperceptible, especially west of the Cascade mountains, where the flowers bloom and the gras is green all the year.

This equability of climate or this range in the daily and seasonal change of temperature is due chiefly to the influence of the ocean, the direction of the prevailing winds, and the relative position and direction of the mountain ranges.

The Pacific ocean and Puget Sound are great equalizers of temperature. Their tendency is to retard the movements of the mercury either up or down—to preserve or establish an equilibrium. The larger the ocean or body of water that borders or enters a state, the less subject it is to perturbing influences of local character. The influence of northern latitudes upon the climate of Washington is somewhat neutralized by the effect

of the Pacific ocean where the climatic conditions are nearly constant, where both air and water move with a constancy that overcomes all local or temporary variations. Especially is this true along the course of the Japan current.

The Cascade mountains divide the state into two sections which differ as much in climatic conditions as in topographical aspects. They extend through the state from north to south at an average elevation of about 8,000 feet, and with numerous peaks rising to nearly twice that height. These mountains are paralleled by other ranges upon the eastern and western borders of the state. Generally speaking, it might be said they stand at an angle of about 45 degrees to the direction of the prevailing winds. The great mass of atmosphere filling the basins between these parallel ranges of mountains is well protected upon either side by their high summits and loftier peaks. This air, therefore, is not easily disturbed or affected in any way by outside influences. This, then, partially explains why the climate of Washington is so equable, why there are no violent storms or great extremes of heat or cold. Nature has designed it to be so; it cannot be otherwise.

Having stated in a general way the climatic conditions of the state at large, especially in reference to its position, topography and surroundings, it remains now to note in detail the climate of each section, both east and west of the mountains. In this will be considered separately the three primary factors in climate, viz., the temperature, the humidity, and the movements of the atmosphere, also the modifications produced by latitude, alti-

tude, character of surface, and the influence of the ocean.

EASTERN WASHINGTON.

The Columbia river basin slopes to the south, with numerous streams, shallow lakes, a sandy soil, high mountains bordering on either side, and broken ridges lying to the north; it is well protected from outside influences, admirably arranged and suitably inclined to receive the solar heat, and to have a moderately equable climate, although as compared with the western section of the state, the range of temperature and the velocity of the wind are much greater, while the amount of rainfall is much less.

Temperature.

The mean annual temperature of the whole of the Columbia river basin, deduced from official reports from fourteen stations well distributed over the basin, is 48.25 degrees. As might reasonably be expected, the lowest and most southern portion of this basin has the highest mean annual temperature of any part of the state. This condition results from a high summer temperature, followed by a moderate winter temperature, both of which are easily accounted for, when the direction of slope, the peculiarity of soil and the lack of moisture are taken into account. Kennewick, which is situated near the confluence of the Yakima and Columbia Rivers, may be regarded as the center of this district of highest temperature. The station has a mean annual temperature of 54.7 degrees, the highest in the state. The mean for July is 76.3 degrees,

that for January 34.3 degrees, over 2 degrees above freezing point. The range between these two extremes is 42 degrees. The variation at Walla Walla, some forty-five or fifty miles to the southeast, is somewhat greater. The mean temperature for January is given at 31 degrees, or one degree below freezing point. The temperature for July is 74.6 degrees. These two extremes give a difference of 43.6 degrees for the seasonal range at Walla Walla.

Passing from the southern and lowest part of the eastern section, northward, there is a gradual lowering of the annual temperature. At Hunters, an elevated station in Stevens County, the minimum is reached. This is 41.2 degrees, the lowest mean, not only in Eastern Washington, but in the entire state. The extremes, however, at this place are not so great as might be expected. The normal for January is 22.2 degrees, while that of July is 59.8 degrees. These give a difference of 38.2 degrees for the range between the coldest and hottest months in the year. This range is much less than the average for the entire basin. The intervening stations, situated mostly in the central part of the Columbia River valley, have a temperature ranging between the two extremes, that of Hunters in the north, and Kennewick in the south. In the following tabulated statement of temperature, three stations are arranged according to their latitude from south to north, with the exception of the first and last. Walla Walla is south as well as east of Kennewick. Loomis is north and east of Hunter's. It is observable that there is a gradual decrease in the temperature from south to north. This is in accordance with the

general law that temperature decreases as latitude and altitude increase. The range of temperature between summer and winter is not greatly affected by the above law. The differences exhibited in the table are due to local conditions, such as direction of slope or winds, character of soil and the quantity of moisture evaporated or precipitated. Other conditions being equal, the seasonal range of temperature is a fair measure of the life of a country. It varies with the range of temperature.

Temperature in Eastern Washington.

	Annual Mean.	January Mean.	July Mean.	Seasonal Range.
Kennewick	58.7	34.2	76.3	42.0
Walla Walla.....	53.2	30.9	74.6	43.7
Sunnyside	51.3	30.2	73.1	42.9
Fort Simcoe.....	51.6	30.2	72.6	42.4
Pomeroy	51.5	34.6	72.8	38.2
North Yakima...	50.2	30.0	72.0	42.0
Pullman	46.7	28.6	65.6	37.0
Colfax	46.8	28.8	63.2	34.4
Ellensburg	45.6	23.6	64.9	41.3
Rosalia	47.9	27.5	64.0	36.5
Waterville	44.2	21.6	65.5	43.9
Spokane	47.6	24.8	69.1	44.3
Loomis	49.0	22.6	70.4	47.8
Hunters	41.2	19.5	61.4	41.9
Averages	48.3	27.7	69.3	41.3

2. Winds.

The wind of the Columbia River Basin may be classified under three heads, viz.: The east,

or Walla Walla winds, the Chinook or southwest winds, and the winds that are variable. The cause of wind or the movement of the atmosphere is the difference in the temperature of two places. The movement is always in the direction of the warmer place. The rapidity of the movement depends upon the range of temperature, either the daily or seasonal. This range is not great in Eastern Washington, therefore the winds are rarely high and never violent. Destructive storms, such as cyclones, tornadoes or hurricanes, are not known.

The east or Walla Walla wind, as the Indians called it, is from the east and northeast. It is not a good wind. The cause is a difference in the temperature of the lower Columbia River Basin, and the high mountain ranges toward the north and northeast. This difference in temperature or atmospheric pressure is brought about by a difference in altitude and latitude. Temperature decreases as altitude and latitude increase. These winds are cold and dry. They sweep over the northern hills and plains, and down the Columbia Valley with much force sometimes. They are usually unpleasant and often odious. During the winter season they are cold, chilling or freezing in their effects. In the summer they are dry and often pinching. Their duration, however, is short, usually lasting not more than three or four days at a time. It might be remarked in this connection that all winds from the north, northeast or northwest are dry and comparatively cold winds. The reason is they come from the north, and moving south the temperature increases, which causes a relative decrease in the amount of moisture

they contain; hence evaporation takes place rather than precipitation.

The Chinook winds, which is a pretty Indian name, given to the warm, moist winds from the Pacific ocean, are the deadly enemy of the northeast or Walla Walla winds. These winds cross the ocean freighted with the delightful odors of tropical climes. They enter the state near the mouth of the Columbia River, and follow the course of the valley its entire length, even to Idaho, Montana and sometimes as far east as the Dakotas. They are always welcomed. With them comes spring, warm sunshine, beautiful flowers and pleasant weather. In summer, these winds from the ocean are cooler than the surface of the valley, hence they have a refreshing influence upon all forms of life. They are in fact that part of the general atmospheric circulation known as the prevailing westerlies. They are the rain bearers of Washington. In fact all winds from the southern points of the compass are likely to cause rain, as they move north, for the temperature is gradually decreasing while the relative humidity is gradually increasing, which if continued soon reaches the point of saturation, and precipitation takes place. This is particularly the case of winds moving over water surfaces, as the winds along the coast of Washington.

Variable Winds.—These winds occur mostly during the spring and autumn months, when the area of low atmospheric pressure or comparatively high temperature is moving up or down the valley. This causes the wind to shift in its effort to follow the low area. Sometimes these winds are caused by an intermingling or meeting of different currents, that is,

currents from different directions. This usually takes place near the area of low pressure. In the Columbia River Basin variable winds result from cententions between the Walla Walla and Chinook winds for supremacy. Each rushes in from opposite directions, to fill up the low pressure area. The contest is not usually long, yet the battle is often fierce. The onsets and retreats are marked by the swaying of branches, and the whirling of leaves. The falling of snow means victory to the Walla Walla winds. The descending rain, the opening buds, and the fragrance of the flowers indicate the triumph of the gentle Chinooks. At their approach the Winter King unbinds his ice-bound captives, and retires to the north, where he remains until late in autumn. He then returns with his companion, the Walla Walla wind, to bind once more the rippling brooks and placid lake, to silence for a time the hum of the bee and the cricket's chirp, to reign supreme until the springtime, when the gentle Chinooks return from the ocean to drive him once more to his home in the northland.

Mountain and Valley Winds.—These winds are quite noticeable in Eastern Washington, especially during the summer and autumn. It is during these seasons that the difference in temperature between the low valley lands and the high mountain summits covered with snow becomes the greatest, and causes the atmosphere to move from places of high to places of low pressure, as streams plow from high to low altitude. These winds are most pronounced upon the western side of the Columbia, or the eastern slope of the Cascade range. There are two reasons for this fact. First, it is the leaward side of the mountains.

as regards the prevailing southwesterly winds; second, the slope is much greater, hence the distance between areas of high and low presure would be much less, and the movement of the air greater. The prevailing winds in the Yakima Valley are from the mountains. They are productive of the clear, dry weather so characteristic of the Yakima country in particular, and the eastern slope of the Cascades in general. This is due to the fact that the temperature of the wind increases with a lowering of altitude, and the relative humidity increases. Winds blowing from the mountains should clear the sky and bring about fine weather. Winds moving in the direction of mountains produce clouds, which in turn cause rain and bad weather.

3. Rainfall.

The annual rainfall in Eastern Washington is 14.66 inches. This is the average of sixteen stations well distributed throughout the basin. As compared with the average annual rainfall in the state, it is much less than one-half. This fact is due to the peculiar physical features of Eastern Washington, as well as to the direction of the prevailing winds. There seems to be a gradual increase in the rainfall with the increase of latitude and altitude, that is, the dryest section of the basin is in the lowest and most southern half. From this district, which is made up mostly of Yakima County, with the adjacent parts of the counties adjoining, the rainfall increases with the slope upon either side, likewise toward the north. Kennewick seems to be the center of this district of minimum rainfall, averaging 8.25 inches. The station itself, situated near the confluence of the Yakima and Columbia

Rivers, has an average of 6.45 inches, the least quantity of any station in the state. Sunnyside, which is almost directly west, but some 434 feet higher, has an average rainfall of 7.04 inches, an increase of over one-half an inch. North Yakima, which is situated some distance to the northwest of Sunnyside, comes next, with an average of 8.54 inches, a little more than the average for the southern district. Fort Simcoe, which is higher up the slope than either Yakima or Sunnyside, has 9.3 inches. At Ellensburg, which may be regarded as the northern limit of this district, the rainfall averages 9.81 inches. North from

Rainfall in Eastern Washington.

West Columbia River		East Columbia River	
STATIONS	INCHES	STATIONS	INCHES
Kennewick ...	6.45	Walla Walla.	17.43
Sunnyside	7.04	Pomeroy	16.54
Fort Simcoe ..	9.30	Pullman.	21.62
North Yakima	8.54	Colfax	25.18
S. Ellensburg.	10.32	Rosalia.....	21.00
Ellensburg ...	9.81	Fort Spokane	13.86
Waterville ...	16.17	Hunters	20.38
Lakeside	12.64	Spokane	18.40
Average..	10.04	Average..	19.30

Ellensburg there is a gardual increase in the rainfall as may be observed in the following table. It may be observed also, that the increase in rainfall is much more rapid in ascending the eastern than the western slope. To illustrate, Walla Walla is about the same distance east as Sunnyside is west of Kennewick, the station of least rainfall, but the rainfall at Walla Walla is 17.43 inches, or more than twice that at Sunnyside. The same fact

may be further illustrated by comparing Fort Simcoe with Pomeroy, or Colfax and Pullman with Ellensburg. In the table the stations are arranged according to latitude from north to south. A gradual increase in the rainfall is quite noticeable. The explanation of the fact is found in the general law that the relative humidity of the atmosphere increases as the temperature decreases, and the temperature decreases as latitude and altitude increase. This general statement will explain why the rainfall increases northward as well as east and west of the lowest and most southern part of the Columbia River Basin. The reason why there is more rainfall east than west of the Columbia River is due to the fact that the prevailing winds are from the southwest. They come from the ocean heavily laden with moisture. They follow the course of the river to the confluence of the Snake River, where the Columbia bends somewhat abruptly toward the north. The winds, however, continue to move eastward or northeast. The increase in the altitude from sea level as well as the slight increase in latitude, cause a lowering of the temperature, which in turn increases the relative humidity and brings about precipitation all the way from the mouth of the Columbia to the western slopes of the Blue mountains, and those north of them. The rainfall at the different stations along the course described shows that there is a gradual decrease eastward; that as the distance from the sea increases the rainfall decreases. The facts in this instance well illustrate the general law. In this particular case, however, the fact is due largely to the interception of the Cascade range, which forms a great obstruction to the

movement of the atmosphere eastward. The most of the moisture, as might be expected, is deposited upon the western or seaward side. In the following table the stations are arranged along the course of the wind from the mouth of the Columbia eastward.

Rainfall from the mouth of the Columia River eastward in inches.

Fort Canby	64.14
Vancouver	38.00
Pine Hill	29.92
Dayton	25.18
Pullman	21.62
Rosalia	21.00

There is still another reason why the western and southwestern slopes of the Columbia River Basin are the dryest parts of the state. It is because the distance from the summit of the Cascade range to the Columbia River, or the lowest parts of the basin, is much less than the distance from the Columbia River to the mountain summits east. The difference in elevation is great; that of temperature correspondingly great. Perpetual snow upon the mountains and almost continual sunshine in the valley. Thus conditions give rise to a steep barometric gradient. The local winds move with the slope from the mountains to the river, from the high cold altitude to the warm valley. These winds from the mountains are comparatively cold and dry as all mountain winds are. They absorb rather than dispense moisture in their course. The prevailing winds of Ellensburg are from the northwest; further south at Yakima and Fort Simcoe, they are from the west, and may be regarded as regular mountain winds.

4. Time of Rainfall.

One of the most interesting features of the rainfall of a country is the time in which it occurs. The annual rainfall may be sufficiently great to supply all the requirements of agriculture, yet the distribution in time be such as to render agriculture impossible. It is well known that little rain at the right time is of greater service than much rain at other times. The rainfall in Eastern Washington is well distributed in this respect. An inspection of the monthly reports shows that July and August are the dryest months, and that there is a gradual increase from September to January, when precipitation is greatest. From January to July there is a gradual decrease. This might seem to be the reverse of what it should be for agricultural purposes. It would be in corn growing regions, or places where crops grow in summer and mature in autumn. The Columbia River Basin is a district best suited to the growth of small grain and grasses. This is due to the peculiarity of its soil and climate. Grain is sown in the autumn about the time the rains begin. It remains in the ground during the period of greatest precipitation, which is usually in the form of snow, matures and ripens with the decreasing rainfall of spring and early summer, and is harvested, and threshed during the dryest part of the year. This kind of distribution of rainfall is certainly of great value to the agriculturist. It does not necessitate the storing of grain or hay, either before or after it has been threshed. Hundreds of thousands of bushels of grain may be seen sacked in the harvest fields during the summer months, or waiting

at the railway stations for shipment, with nothing over it, save the clear blue sky.

There is another fact which should not be omitted in the consideration of the climate of this district, and that is the character of its soil. Much depends upon it both from a climatic and agricultural standpoint. If it be loose, sandy and porous, the solar heat and rain penetrate it to a great depth, and are retained longer than if it were compact, clayey and hard. The soil in the agricultural sections of the Columbia River Basin, is mostly of a loose volcanic ash, which receives a large quantity of heat and moisture readily, and retains them for a comparatively long time.

5. Serenity of Sky.

Eastern Washington is a land of sunny rather than cloudy weather. The state, for the

Serenity of the Sky.

STATIONS	CLEAR DAYS	PARTLY CLOUDY	CLOUDY DAYS	RAINY DAYS
Kennewick	204	80	81	40
Sunnyside	188	83	94	33
Fort Simcoe.....	146	201	18	39
North Yakima	159	84	122	48
Ellensburg	206	65	94	39
Lakeside	182	85	98	42
Walla Walla.....	143	162	60	109
Pomeroy	183	98	84	96
Pullman	160	143	62	84
Colfax	163	80	122	90
Rosalia.....	123	103	139	106
	131	97	137	110

year 1898, averaged 138 clear, 114 partially cloudy, and 113 cloudy days. The greatest number of clear days was 206, at Ellensburg. The least number of rainy days was 33, at Sunnyside. The least number of cloudy days was 18, at Fort Simcoe. The maximum clear sky prevailed in the Yakima Valley, the real sunnyside of Washington. This valley ranges in elevation from 330 feet at Kennewick to 1700 feet near Ellensburg. The prevailing winds are from the mountains. They are dry, salubrious, rarely high, although the valley proper is treeless.

6. Snowfall.

The snowfall in Eastern Washington averaged 30 inches, for the year 1898. This is somewhat less than the true or normal. It fell mostly during the months of November and December. This afforded the winter wheat, meadows and pastures good protection during the coldest part of the year.

CLIMATE OF WESTERN WASHINGTON.

General Conditions.

This section is noted for the mildness and equability of its climate. This is due primarily to the nearness of the ocean, and the direction of the mountain ranges, and finally to the liberation of heat through the processes of condensation and precipitation of water-vapor. The temperature of the air over the ocean between the parallels of 45 and 50 degrees north, remains sensibly the same through the year. The prevailing winds, both in winter and summer, are from the ocean, from off the Japan current, which flowes southward just off the coast. These winds are comparatively warm

during the winter, and retard the lowering of the mercury. During the summer, they have the opposite effect. They are comparatively cool and prevent very high temperature. Besides the close proximity to the ocean proper, there are at least 2000 square miles of water surface within the confines of this part of the state. This great arm of the ocean, commonly known as Puget Sound, stretches far to the south, and extends numerous projections inland in almost every direction. Twice a day the ebb and the flow of the tide, the coming and going of the water from and to the sea, cause an interchange of air from sea to land and from land to sea again. All of these influences tend to equalize the temperature and maintain an equilibrium.

The second great influence in the climate of Western Washington, is the relative direction of the mountains to the course of the prevailing winds. The Cascade range extends north and south and forms the eastern border. This range is sufficiently high to intercept the cold Walla Walla or east winds which as a result move down the Columbia river basin. The Olympic range, following the ocean beach from the mouth of the Columbia river to the Straits of Juan de Fuca, forms the western border. These mountains are not so high or as compact as the Cascades. Were it so, this section would not be noted for its great rainfall. Their elevation is such, however, as to break the force of the winds from the ocean, without obstructing to any marked degree the passage of the clouds eastward. Over this great inland sea, lying between these two ranges of mountains, the air is seldom disturb-

ed by outside influences. Its movements are moderate, never violent.

These conditions are favorable to great condensation and precipitation of moisture. These processes liberate immense quantities of heat, which prevent the temperature from falling, and gives this section of the state a winter average far above most places situated in corresponding latitudes. In summer the process of evaporation is great, especially in the sunshine. This converts sensible heat into latent, and prevents the thermometer from rising. During the same season, the relative humidity of the air is great on account of the presence of large bodies of water and snow upon the mountain summits. This fact explains why it is always cool in the shade or when the sun has set.

TEMPERATURE.

The variation of heat or the rising and falling of the mercury in the thermometer is not as great west as east of the Cascade mountains. The seasonal range or the difference between the January and July mean temperature is only 22.85 degrees west of the mountains. On the east side, the difference is 41.3 degrees, or nearly twice as much. The reasons for this have been stated heretofore. The mean annual temperature in Western Washington is 50.37 degrees. This is a fraction over 2 degrees higher than in Eastern Washington. The mean temperature for January, the coldest part of the year, is 38.85 degrees. This is 6.85 degrees above freezing point. This means that Jack Frost does not visit the Sound country often, that the streams are not obstructed by him, and are open for navigation during the win-

ter. The grass is green and flowers bloom the year around out of doors.

The mean temperature for July, the hottest month, is 61.7 degrees. This is 7.6 degrees less than the mean temperature for the same month east of the mountains.

In the following tables are given the mean temperature for January and July, the difference between those extreme temperatures, or the seasonal range, and also the mean annual temperature. In all cases the normal temperature has been given. By this is meant not the average temperature of any one January, July or year, but the average of a number of Januarys, Julys and years, as many, in fact, as have been recorded. In some cases as many as 14, 21 and 30 years have been averaged to get the mean or normal. In other cases, the time or length of records has been shorter, but in most cases sufficiently long to bring the average very near the true normal.

Stations Along Pacific Coast.

	January. Mean.	July. Mean.	Seasonal Range.	Annual Mean.
Fort Canby	40.9	59.8	18.9	50.8
South Bend	41.9	63.1	21.2	53.3
Aberdeen	40.4	60.9	20.5	49.6
Clearwater	39.4	61.5	22.1	51.1
Lapush	41.2	57.6	16.4	48.2
Neah Bay	41.6	56.7	15.1	48.9
Pysht	38.6	59.8	21.2	48.7
Port Angeles	35.8	56.8	21.0	47.0
Port Townsend	38.7	61.3	22.6	49.8
Coupeville	39.9	59.8	19.9	48.8
Averages	39.8	59.7	19.9	49.6

In the first table only stations along the Pacific Coast and the Straits of Juan de Fuca, from the mouth of the Columbia river to Puget Sound, are given. In the second are arranged those stations which are entirely within the Sound Basin.

Stations Within Sound Basin.

	January. Mean.	July. Mean.	Seasonal Range.	Annual Mean.
Vancouver	36.8	67.4	30.6	52.1
La Center	37.4	65.4	28.0	51.1
Mayfield	37.3	64.7	27.4	50.1
Chehalis	36.2	64.6	28.4	51.2
Grand Mound	38.7	64.6	25.9	50.2
Olympia	38.1	62.3	24.2	51.1
Tacoma	38.4	64.2	25.8	50.0
Vashon Island	36.1	63.1	27.0	50.2
Union City	38.3	65.4	27.1	51.1
Seattle	40.4	64.1	23.7	51.5
Madrone	39.7	62.8	23.1	50.9
Snohomish	39.4	62.5	23.1	50.8
Sedro	38.6	63.6	25.0	51.6
New Whatcom	39.1	60.3	21.2	50.0
Blaine	34.4	60.0	25.6	55.0
Averages	37.9	63.7	25.8	51.1

A comparison of the first with the second table will reveal the fact that the mean January temperature of the stations along the Coast is two degrees higher than the mean temperature for the same month of the stations situated within the Sound Basin. It will also show that the July mean of stations along the Coast is nearly four degrees lower than the July mean of the Sound stations. This makes a difference of nearly six degrees between the seasonal ranges of the two sets of

stations. The temperature of the Coast being more nearly equable than that of the Sound.

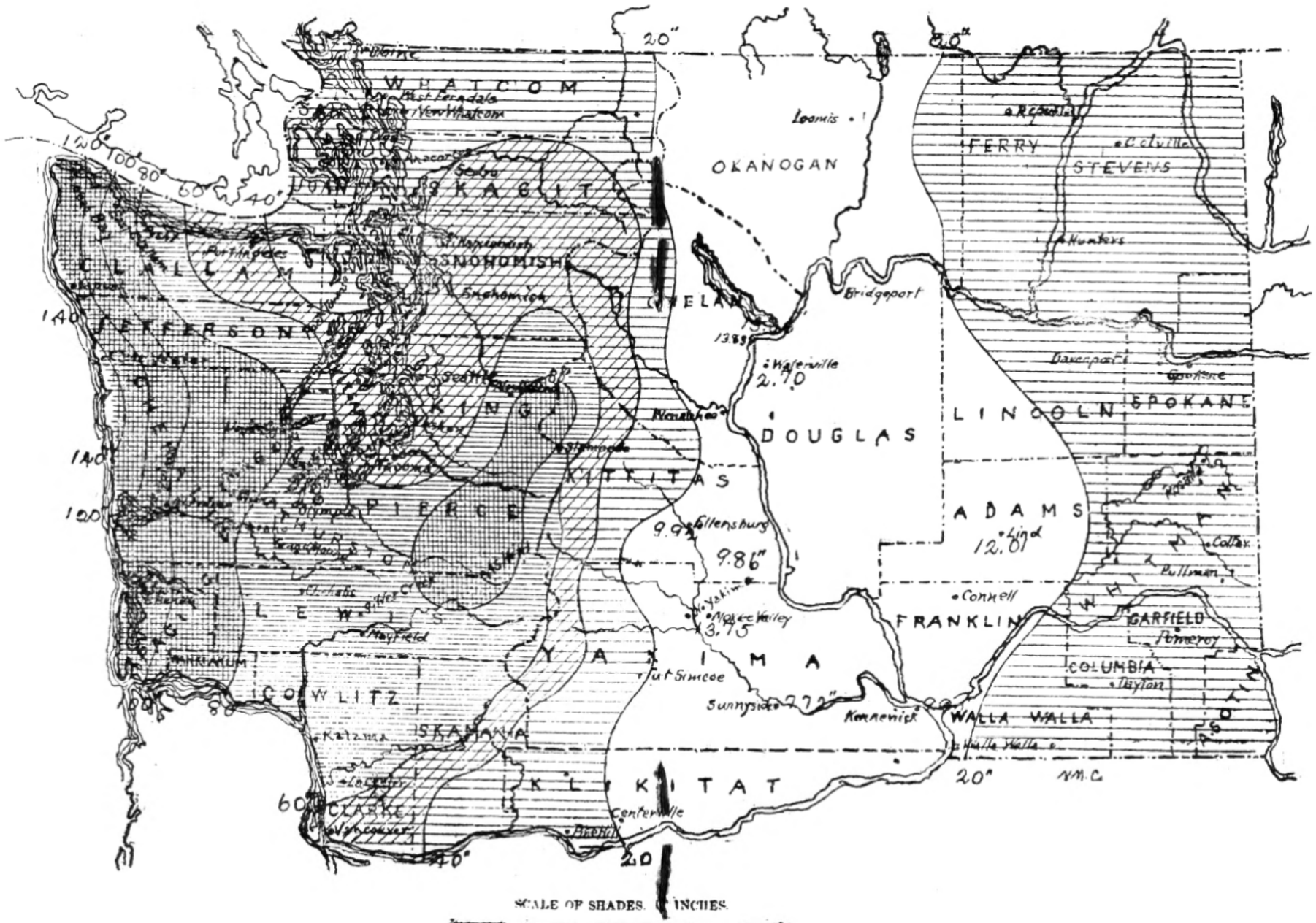
These facts illustrate the general statement made at the beginning of this chapter, viz.: That the presence of a large body of water tends to establish and preserve an equilibrium. It also illustrates the converse. The range of temperature increases as the distance from the sea increases. Places remote from the influence of the ocean have hotter summers and colder winters than places near. Compare Vancouver with New Whatcom, Eastern with Western Washington.

Comparative Table.

	January. Mean.	July. Mean.	Seasonal Range.	Annual Mean.
Coast Stations...	39.8	59.7	19.9	49.6
Sound Stations..	37.9	63.7	25.8	51.1
Differences	1.9	4.0	5.9	1.5
Eastern Wash...	27.7	69.3	41.3	48.3
Western Wash...	38.9	61.7	22.9	50.4
Differences	11.2	7.6	18.4	2.1
Entire States....	33.3	65.5	32.1	49.3

There is also a difference in the annual mean of one and one-half degrees. The annual mean of the Coast stations being 49.6 degrees, while that of the Sound stations is 51.1 degrees. The mean of those two averages is 50.37 degrees, the normal annual temperature of Western Washington. The change from January to July, as far as it relates to temperature, is very gradual, in fact almost imperceptible. The seasonal range is so slight as to affect but little the appearance of vegetation or the occupations and every-day life of the people. Food

Rainfall Map for 1899, Reproduced from the Weather Bureau Summary, and Reduced in Size.



SCALE OF SHADES. INCHES.

0 to 20 20 to 40 40 to 60 60 to 80 80 to 140

shelter and clothing are about the same the year round.

It will be understood that the twenty-five stations in Western Washington where official records are kept are practically on sea-level, that the slight differences in the temperature of stations even in the same section are due to the influence of the water, wind and the character of the immediate surroundings. The element of altitude has not entered into these calculations. As the mountain slopes are ascended on either side and their summits approached, there is a gradual decrease in the temperature, and the snow line may be reached anywhere between five and six thousand feet.

2. Winds.

The winds of Western Washington are not as variable nor their movements as great as those east of the Cascade Range. This fact is due to the comparatively slight variation in the temperature. It is the difference in the temperature of two places that causes the air to move. The difference in the altitude of two places causes water to flow. Substituting the barometer for the measuring line, air as well as water moves from high to the low. In countries that are comparatively level water flows slowly. In countries where the rise and fall of the mercury is slight the movements of the air are necessarily slow. This is particularly the case in the Puget Sound basin, where the daily and seasonal ranges are not great.

The prevailing winds in this section are from the ocean. That is to say, they come from the southwest, west, northwest and the inter-

vening points. The eastward bend in the coast line of North America at Puget Sound and the high mountains that border it, prevent a directly south or north wind in this section. These winds are regular. They are a part of the general circulation of the atmosphere, commonly known as the prevailing westerlies. The zone of those winds moves north and south with the vertical rays of the sun. When the sun is upon the Tropic of Capricorn, the zone of the westerlies reaches its southern limits. At that time, December 21st, they sweep along the coast of California, Oregon and Washington, from the southwest. As the sun moves northward, supplanting winter by spring and spring by summer, these winds come more and more from a westerly direction, until finally when the sun reaches the Tropic of Cancer in June they are directly from the northwest. There are several reasons for this changing of direction. The first is, as the zone of westerlies moves northward, its progress is retarded and finally checked by the cold polar currents flowing southward. In the next place, the decrease in the velocity of the earth's rotation, with an increase of latitude, causes a more nearly direct westerly movement of the air. Finally, the direction and character of the North American coast north of Puget Sound, have their influence upon the direction of these winds. The coast extends to the northwest by high snow-capped mountains, which form a barrier over which no ocean winds can pass. Hence they follow the path of least resistance along the curvature of the coast toward the south and

southeast. There is one other factor that might be mentioned in this connection, and that is the influence of the Japan stream. It has been thought that the latitude of this stream varies somewhat with the seasons, that it follows to some extent the movements of the sun north and south of the equator. If this be true, then the movements of the Japan stream might influence the direction of the prevailing westerlies.

Regarding the relative time and direction of these winds, it might be said that they follow the seasons. In the latter part of December they are as nearly from the south as the contour of the coast will permit them to move. From December until the later part of March they swing more and more toward the west. About April 1st they move north of west, and continue bearing more and more toward the north until midsummer, when they reach their most northern latitude. From July to December they swing back to the south, describing as they go almost a semi-circle, and passing through nearly all the points on the western half of the compass. Then as to direction, Western Washington would have southwest winds during the winter season. These southwest winds are familiarly known as the "chinooks." They are the rain bearers of the northwest coast. During the spring and autumn months the winds are mostly from the west. They veer occasionally a little to the south or north, bringing rain or sunshine, clouds or fair weather, as they move toward one direction or the other. From June to September, the winds

are from the northwest. This means a clear, blue sky and dry weather, so characteristic of Washington climate during the summer months.

The other atmospheric movements of this region may be termed mountain and valley winds, and land and sea breezes. During the summer and early autumn, these winds are the most pronounced. It is then that the difference in temperature between mountain and valley, and land and sea, is greatest. They are diurnal, usually lasting from 9 or 10 o'clock a. m. until 5 or 6 p. m. They move landward or upward during the fore part of the day, and return back the latter part. The summits of the mountains above timber line have little or no vegetation to cover them or protect them from the heat of the sun. The surface becomes heated, and the air above it warm and light. The air in the low valleys or canyons, on the contrary, is sheltered by dense forests or precipitous slopes. The sunshine in many cases seldom or ever penetrates to the surface. During the day the air upon the mountain slopes and summits becomes heated, expands and rises, making room for that which is underneath to expand and rise in the same way, as the day advances and the heat of the sun reaches it. This upward movement, as experienced upon the slopes and peaks of the Cascade and Olympic mountains, is similar to the rising of smoke above a city. It is not in currents, but diffused, yet with sufficient strength to carry with it insects, such as butterflies, to an altitude of 12,000 or 14,000 feet. The heating of the upper

portion of the atmosphere relieves the pressure and causes the lower to rise gradually. These valley winds are warm and pleasant. They are not strong.

The mountain winds are different. When the sun disappears beyond the horizon, the upper rarefied air cools rapidly and falls with great rapidity into the lower but warmer valleys of the foothills. It is sometimes impossible to stake a tent in the presence of these winds. If the canyon or valley below be deep or exposed to the afternoon sun, the force of the wind is likely to be increased. Mountain winds are cold, dry and unpleasant. When they mingle with the warm, humid air of the valleys, they lower the temperature, raise the relative humidity and produce fogs, which gradually cover the low lands and rise upon the mountain sides. These winds well illustrate the general principle of winds, i. e., where the distance between two places is not great, but where the difference in temperature is great, the wind moves very rapidly.

The land and sea breezes are more uniform in their movements. The difference between their coming and going is not as great as in the mountain and valley winds. This is due to the fact that the difference in temperature between the land and water, in this state, is never great. During the day the effect of heat upon the land is greater than upon the water. The air moves from the colder to the warmer surface, that is from the sea to the land. This movement usually begins about 10 o'clock a. m. and continues until about 5 or 6 p. m., when

the land cools rapidly by radiation, and the wind turns toward the sea. The campfire upon the beach is a good indicator of the comparative temperature of land and water. Early in the morning the smoke rises skyward, indicating an equilibrium of heat upon land and sea. After breakfast, the wind veers and the smoke blows into the tent or landward, showing that the land is becoming warmer than the water. At night the reverse is true. The smoke blows over the water and settles along the shore line. These land and sea breezes are noticeable along the Pacific Coast, especially near the mouth of the Columbia River, Gray's Harbor, and through the Strait of Juan de Fuca. Along the shores of the Sound they are not as prominent. These winds are always soft, balmy and spring-like, even during the winter months.

Occasionally the northeast wind makes its way across the mountains into Western Washington. This is seldom, however. It is never welcomed, without it is by small boys, for it is cold and unpleasant. When it mingles with the warm, humid air of the Sound basin, it causes snow, which seems much out of place in the lowlands of Western Washington.

As a general thing, the winds west of the Olympic Range, along the Pacific Coast, are stronger than those in the Sound basin. The reasons for this have already been stated.

Rainfall in Western Washington.

The third factor in the make up of climate is that of moisture. All air contains more or less of it in the form of vapor. The amount present depends largely upon local conditions, such

as the nearness of large bodies of water, the direction of winds, mountains, ocean currents, character of surface, temperature, etc.

Western Washington borders upon the largest of oceans, and has an interior water-surface of over 2000 square miles. Its low mountains are upon the west or windward side. The Cascades form the eastern boundary. The prevailing winds and ocean currents are landward and at nearly a right angle to the mountain ranges. The average temperature is about 50 degrees. Its location is in the path of low barometric pressure. A large per cent. of the "lows" enter the United States from the west and pass eastward through Washington. Such are the general climatic conditions of this section. They are conducive to much rainfall. The quantity, however, is not uniform as to distribution. It varies according to local conditions. For the purpose of better understanding these conditions, Western Washington might be divided into at least two districts. The first of these consists of a comparatively narrow strip of territory extending along the Pacific Coast from the mouth of the Columbia River to Cape Flattery and inland back from the coast as far as the summits of the Olympic mountains. This portion might be termed the Pacific slope. The second district is that trough-like formation lying between two parallel mountain ranges, the Olympic on the west and the Cascades on the east. It extends through the entire width of the state from Blaine to Vancouver. This section is known as the Puget Sound basin. These two districts differ climatically, especially in re-

spect to rainfall. It is worth while to consider each of them separately.

The Pacific slope district comprises much of the counties of Clallam, Jefferson, Chehalis and Pacific. All these border the ocean and slope toward the west and northwest, that is in the direction of the prevailing winds and ocean currents. Here, then, is to be found what might be reasonably expected, from the relative direction of winds and mountain slopes, the belt of greatest rainfall in the state. The average annual rainfall of this slope is 91.75 inches, the greatest average of any district within the United States, if not in all North America. The area of the slope is comparatively small, however, containing only about six per cent. of the total area of the state.

Rainfall Along Pacific Slope.

Fort Canby	64.14	inches
South Bend	91.03	"
Aberdeen	85.72	"
Clearwater	132.09	"
Lapush	85.79	"
Average	91.75	"

It will be noticed from the first table that the average annual rainfall at Fort Canby, near the mouth of the Columbia, is 64.14 inches, while at South Bend, a short distance north, and just inside the Willapa Harbor, it is 91.03 inches. This makes a difference of 26.89 inches between the two places. The explanation of this difference is to be found in the relative position of the places. Fort Canby is at the mouth of the Columbia River. The river

is wide and opens in the direction of the prevailing winds. The moisture meets no obstruction at Fort Canby and is carried eastward along the course of the river before condensation takes place. There is a gradual increase in the rainfall along the course of the Columbia for some distance. This is due to a gradual increase in the elevation. At the Cascade Locks, the rainfall is given at 79.30 inches, over 15 inches more than at Fort Canby. Back of South Bend, there are high hills or mountains covered with dense forests which cause greater precipitation than at Fort Canby. A similar illustration of the effect of altitude upon rainfall is to be found in the difference between Aberdeen and Clearwater. Aberdeen is situated on Gray's Harbor, near the mouth of the Chehalis River, some distance back from the ocean. At this station, the rainfall averages 85.72 inches yearly, or a little over 5 inches less than at South Bend. At Clearwater, a station nearer the coast and about midway between Gray's Harbor and Cape Flattery, occurs the greatest annual rainfall in the state, 132.09 inches. This means an average of about eleven feet yearly or about eleven inches per month. The chief difference for this great difference between the quantity of rainfall at Aberdeen and Clearwater is found in the fact that immmediately back of Clearwater is the highest and most compact portion of the Olympic range. The slope is abrupt. The difference between the temperature of sea-level and the summits of the mountains is great. The moist winds from the ocean move landward. They strike the snow-

covered mountains which cause condensation and precipitation in great profusion. East from Aberdeen, the country is comparatively level and low. The rain clouds move in that direction without much obstruction, and the distribution of rainfall is more nearly uniform, that is it is distributed over a greater area. It is interesting, in this connection, to compare the rainfall at Clearwater with that at Port Townsend. These two stations are not far apart, yet the difference in the annual fall amounts to 110.40 inches, or over nine feet. This comparison illustrates the simple fact that the rain falls mostly on the windward side of the mountains. When the wind and rain are from the southwest that part of the tree or building facing the northeast is dryest. Clearwater is on the rainy side while Port Townsend is on the sheltered side of the Olympic mountains. From Clearwater northward there is a decrease in the rainfall, also in the altitude of the mountains back of the stations. At Lapush, the fall is 85.79 inches. Much of the moisture passes over toward the northeast before falling as rain.

It will be seen from the second table that there is a gradual decrease in the fall of rain from Cape Flattery eastward along the south shore of the Straits of Juan de Fuca to Port Townsend. At Neah Bay, just inside the Cape, the fall is 109.37 inches. At Pysht, it is 68.28 inches. Further east, at Port Angeles, it is 29.64 inches, while at Port Townsend the eastern extremity of the strait upon the south side, it is only 21.69 inches. This means a de-

crease of 87.68 inches in about as many miles.

Fainfall Along the Strait of Fuca.

Neah Bay	109.37	inches
Pysht	68.28	"
Port Angeles	29.64	"
Port Townsend	21.69	"
Average	57.25	"
Decrease	87.68	"

This eastward decrease in the rainfall is largely due to the fact that the stations along the strait are somewhat sheltered from the southwest winds by the mountains along the Pacific coast. The shore line of the strait bears somewhat to the southeast. The clouds move northeast across the strait and are condensed by coming in contact with the mountains of Vancouver Island. It would be interesting, as well as instructive, to compare the rainfall along the southern side of the strait with that along the northern were the data at hand. It is very probable that the rainfall is much greater along the northern coast. A comparison between the rainfall at Port Townsend with that at stations east or northeast, such as Blaine, New Watcom, Sedro and Snohomish shows a decided increase. The average of the above named places is 43.18 inches, or nearly twice as much as at Port Townsend.

The Puget Sound basin lies between the Olympic and Cascade ranges. This section is much larger than the narrow belt along the Pacific Coast. It extends north and south through the entire width of the state and far up the mountain slopes upon either side. In the

north central part of this basin is situated Puget Sound and most of the large cities of Western Washington.

The mean annual rainfall, taken at ten stations in this district, is 47.95 inches. These stations are quite equally distributed from Blaine near the northern line, to La Center in Clarke County on the southern border. In elevation they range from 15 to 300 feet above sea level. The length of their records extends from one to twenty years. The average then cannot be far from the true normal.

An inspection of the following table shows that Mayfield, situated in the southern part,

Rainfall in Puget Sound Basin.

Blaine	45.90	inches
New Watcom	31.26	"
Sedro	47.87	"
Snohomish	47.67	"
Seattle	36.17	"
Average	41.78	"
Difference	12.34	"
Tacoma	42.87	"
Olympia	54.33	"
Chehalis	48.43	"
Mayfield	66.54	"
La Center	58.42	"
Average	54.12	"
General Average	47.95	"

has an average of 66.54 inches, the greatest in the Basin. This is largely due to the fact that Mayfield has an altitude of 300 feet, the highest of the ten stations. The prevailing winds are from the west and southwest. Much of the

moisture that would be condensed near Fort Canby, were it upon higher ground, passes eastward up the Columbia and Cowlitz Rivers, and falls near Mayfield. The least quantity of rain falls at New Whatcom in the northern part, a short distance south of Blaine. There the mean annual amounts to 31.26 inches, much less than half the quantity that falls at Mayfield. An explanation of this great difference in the rainfall at two stations in the same belt, is found in the fact that at New Whatcom the prevailing winds are from the southwest, that is angling across the Olympic mountains and Vancouver Island. It will be remembered that much of the moisture of those winds is left at Clearwater on the Pacific slope. The same reason will apply to the fact that the average rainfall at the stations north beginning with Seattle, is 12.34 inches less than the average of the same number of stations south, beginning with Tacoma. The law is, however, that rainfall increases as latitude or altitude increases, other conditions not preventing. The mountains interfere in this case.

It may be noted that Chehalis, situated a short distance northwest of Mayfield, has a rainfall of only 48.43 inches, while Ashford, some distance northeast, has an average of 71,74 inches. Ashford has an altitude of 1775 feet and is situated on the western slope of the Cascade range. This station illustrates the effect of altitude, within certain limits upon rainfall. The precipitation, on the mountain slopes and summits, is indeed greater than in the valleys, but a quantitative statement of the annual fall

has not yet been determined. Much, however, especially near the summits, falls in form of snow during the winter season.

No two stations will have exactly the same amount of rainfall. The difference is due entirely to local influences, such as altitude, direction of winds, slopes, etc. The fact should serve as a guard against judging the amount of rainfall in the state, or even in a part of it, by the quantity which may happen to fall at any one place.

An examination of the last table will be instructive in this respect. It shows there are at least eight states in the Union where the mean annual rainfall is 5.25 inches more than that of the Puget Sound Basin, and over 13 inches more than the average for the state.

Rainfall in Other States.

Florida	54.9	inches
Louisiana	53.9	"
North Carolina	53.7	"
Alabama	53.6	"
Mississippi	53.0	"
Georgia	51.4	"
Tennessee	50.7	"
Arkansas	50.6	"
Average	53.2	"

Rainfall in Washington.

Pacific Slope	91.75	inches
Strait of Fuca	57.25	"
Puget Sound	47.95	"
Western Washington	65.65	"
Eastern Washington	14.67	"
Enetire State	40.16	"

Time of Rainfall.

A study of the rainfall of a country is not complete without the time in which it falls has been considered. The rainfall of a country may be comparatively slight, yet the time of its fall be such as to make it sufficient for the requirements of agriculture. On the contrary, the quantity of rain may be great, more than is necessary, yet the time of its distribution such as to render it useless or injurious. The time of rainfall is very important, especially when considered in connection with the character of the soil. By this is meant its power to absorb and retain moisture. A few inches of rainfall upon a loose, sandy loam would be of more service than much more upon a compact clay soil. The quantity that is retained as compared with the quantity that flows off, is an important item.

In Western Washington, there are two classes of soils, the rich alluvial deposits of the low valleys, and the less fertile soils of the uplands. Both classes absorb and retain moisture well, especially when under cultivation. For this reason the apparent lack of rain during the summer months is not harmful. Crops grow and mature as they would not in countries where the soil is of a different character, and the relative humidity of the air less.

A table showing the monthly average rainfall in this section might be graphically represented by a bow resting upon its back and its two ends pointing upwards. The beginning and ending of the year, the periods of greatest rainfall, would be represented by the ends of the bow or the parts highest above the ground, and mid-

summer, the dryest part of the year, by the part of the bow resting upon the ground.

There is a gradual decrease in the quantity of rainfall from January to July. As the temperature increases, the rainfall decreases. From July or August, there is a gradual increase in the quantity of rain, and a general decrease in the temperature. December, January and February are the months during which the greatest quantity of rain falls. June, July and August are the months of least rainfall. A little more than one-half of the annual fall occurs during the first six months of the year. There is more rain during June than July, more during May than August, and so on, to the beginning and end of the year. This means that more rain falls during the growing than during the maturing season.

This peculiar type of rainfall has its advantages. About fifty per cent of the rain in Western Washington falls during November, December, January and February. This is when it is needed least for agricultural purposes, and most for logging. These are the months when the temperature would be very low in this latitude were it not for the rain. The immense quantity of heat that is required to evaporate thirty or more inches of water in the tropics, is transported in cloud formations by the prevailing westerlies to Western Washington, where it is liberated and becomes sensitive. This heat, thus liberated by the precipitation of moisture, keeps the temperature from falling, makes it possible for flowers to bloom and the grass to keep green even during the coldest months.

The low hanging clouds, too, act as a covering which prevents this liberated heat from escaping, keeps the temperature from lowering and makes winter on Puget Sound more like spring in most countries.

Should the greater part of the rainfall fall during the summer, spring or autumn months, the effect would be ruinous indeed. Agriculture would be impossible. The summers would be cold, wet and without much sunshine. As it is, the heavy rain occurs in winter, showers in spring and autumn, and dry, warm sunshiny weather during summer, a delightful climate for so high a latitude.

In conclusion, a word might be said regarding the fall of the rain, that it is never abrupt or violent in its descent. Nor is it so heavy or constant as to interfere with the every day life and business of the people. Being so near the ocean, the atmosphere is always pure, spring-like and balmy. Another fact regarding the rain is that it falls mostly during the nights. This is due to the fact that relative humidity increases with a decrease of the temperature. The temperature lowers and rises with the sun, besides the nights in winter are long, especially in this latitude.

Snowfall.

There is comparatively little snowfall in Western Washington. This is due to the fact that the prevailing winds, during the winter season, are from the southwest. When the snow does fall, it is soft, and of short duration. It comes with the Walla Walla winds, from the

east or northeast. This occurs when the area of low pressure lies west of the state and a corresponding area of high pressure is situated somewhere east or northeast of it. The movement of the atmosphere is from the high to the low area. The heavy cold air moves toward the warm light air, just as the cold draft moves in the direction of the fire. The low pressure area being west, is over a comparatively warm water surface. The vapor in the air is thoroughly chilled and often crystalized by being brought in contact with the cold east or northeast winds. The result is that near the eastern border of the area of low pressure there may occur heavy cold rains while still further east where the northeast wind is stronger, there will be snow. The rain and snow often alternate. This condition of weather indicates the relative strength of the contending winds. When the prevailing westerlies retreat, the northeast winds follow them closely, scattering snowflakes in their rear. It is then the small boy is happy, and his clear voice rings out the familiar warning, "track! track!" This condition of weather, however, is of short duration, usually lasting but a few weeks in January or February. The area of low pressure soon changes its position, leaving the "westerlies" to pursue their accustomed course. The snow vanishes, and with it a multiplicity of unique sleds. The grass remains green and flowers continue to bud and blossom.

Serenity of Sky.

As might be expected from what has already been said, the number of clear days increase

from January to July and decrease from July to January. By a clear day is meant a day during which there is over thirty per cent of sunshine. During the winter there are many bright, pleasant days during which the sun does not shine over thirty per cent of the time. In weather reports they are considered as cloudy days. In summer the sky is azure; sometimes draped here and there with heaps of snow-white clouds, and often reflected in the placid waters of the Sound with an accuracy of detail that is marvelous to behold. There is always a balmy softness about it that is indescribable.

The map on the following page shows the annual mean isotherms and prevailing wind directions, year 1898. (Reproduced from Weather Bureau Map.)


WHATCOM
SKAGIT
OKANOGAN
FERRY
STEVENS
SNOHOMISH
CLALLAM
JEFFERSON
KING
CHELAN
DOUGLAS
LINCOLN
SPOKANE
KITITAS
PIERCE
ADAMS
LEWIS
YAKIMA
FRANKLIN
WHITMAN
GARFIELD
COLUMBIA
COWLITZ
WALLA WALLA
SKAMANIA
KLICKITAT
CLARKE

Pacific

Teachers

Agency

Seattle, Wash.