The
Oregon
Weather Book

A State of Extremes

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Drought

Drought is a periodic climate cycle that affects virtually all regions and countries on earth. The natural world has adapted to these dry periods, although not without changes in plant and animal populations. Steadily rising human populations, coupled with increased demands for water for agricultural, domestic, industrial, recreation, and power generation purposes, have made water an increasingly scarce and precious resource.

To study drought and its effects on Oregon, we begin by defining drought, discuss ways to monitor its behavior, and describe ways in which drought has affected Oregon in the past.

Drought Definitions

The *American Heritage Dictionary of the English Language* defines drought as follows:

> *drought (drout) n. Also drouth (drouth). 1. A long period with no rain especially during a planting season 2. A dearth of anything; a scarcity.*

The first definition is a concise statement describing a meteorological phenomenon and includes a major effect of droughts (agriculture), but begs even more questions than it answers:

—What is meant by a long period?

—Does a period with only a little rain qualify as a drought?

—What about other forms of precipitation namely, snow?

—Some areas on earth commonly receive little or no rainfall for extended periods. Are these always drought periods?

Clearly a more precise definition is necessary for our purposes. Van Havel and Carriker (1957) defined drought in terms of its effects on plants - a period with “sufficient moisture not available in the root zone for plant growth and development.”

Palmer (1965), on the other hand, described drought in meteorological terms:

> *An interval of time, generally months or years, when actual moisture supply consistently falls short of the climatically appropriate moisture supply.*

This definition, unlike the dictionary definition, includes a consideration of climatic normals in its description. Thus, a period of very dry weather, which might be common or even “normal” in Death Valley, can be seen as atypical on the Oregon coast, and thus would constitute a drought. Palmer also defined the time scale of a drought as being seasonal annual, or of multiyear duration. Finally, Palmer's definition encompassed all aspects of water supply (precipitation, streamflow, ground water, etc.). It thus serves as a solid, useful definition of meteorological drought.

What remains is to define "climatically appropriate." Clearly this varies from one location to the next and should encompass a sufficient period of time to avoid short-term variations. Climatologists generally define "normal" as a 30-year average of a particular parameter. It is the custom in the United States to use a given 30-year average for 10 years, whereupon the averaging period is moved forward to the most recent 30 year period. Since 1991, for example, the 1961-90 average has represented "normal." In a few years, new normals will be calculated (for the 1971-2000 period).

In addition to "agricultural" and "meteorological" droughts, one might define "regulatory" drought. Drought is one of many natural disasters that may trigger availability of funds or other assistance from Federal or state agencies- Because of this, it is necessary to define drought in a manner that enables responsible agencies to declare a drought situation. The Oregon Drought Plan includes the following statement:

> *The Legislative Assembly finds that an emergency may exist when a severe, continuing drought results in a lack of water resources, thereby threatening the availability of essential services and jeopardizing the peace, health, safety, and welfare of the people of Oregon.*

This definition is the basis for drought declarations or terminations or those declarations by the Governor.

Quantifying Drought

Accurate determination of the existence of a drought an objective criterion for defining the onset, continuation, or end of a drought period. The ideal approach is to develop an established numeric drought index; values above some threshold would indicate near-drought or drought conditions, while values below the threshold would correspond to periods with adequate or surplus water. Various indices exist for defining drought, although some were designed for identifying meteorological drought while others were intended for agricultural or hydrological drought.

One of the earliest drought indices in this country was established in 1905 by the U.S. Weather Bureau, which defined drought as "any period of 21 or more days with rainfall 30% or more below normal." This proved to be a very liberal definition since it identified sixty-two "droughts" in a thirty-three year period in the District of Columbia. Van Bavel and Carriker (1957) defined drought in terms of its effects on agriculture. They identified drought as a period with "sufficient soil moisture not available in the root zone for plant growth and development." This method proved to be fairly sensitive to precipitation; even a few hundredths of an inch of rainfall could be sufficient to end such droughts. In addition, this method completely ignored the effects of low winter precipitation.

The most widely used drought index is that developed by Palmer (1965), who defined "meteorological drought." Palmer's method, which is sill in widespread use, was based on precipitation, runoff, evaporation, and soil moisture. It provided numeric values ranging from -4 (extreme dryness) to +4 (extremely wet), with 0 representing normal conditions. Palmer's method has been shown to work reasonably well in many parts of the country, particularly the Midwest. However, it has several major shortcomings especially when applied to the high-relief areas in the western states. The Palmer index reacts very slowly to changes in water availability and has a persistent time life. It is also very complicated to use and works poorly in areas with significant elevation changes, since it handles snowpack very inadequately. These deficiencies of the Palmer index have given other researchers incentive to develop more effective techniques.

One of these was the method developed by Shear and Steila (1974), which used the same basic input parameters as the Palmer method but which seemed to work more effectively. This index proved to be sensitive to short-term changes in water availability and is much simpler to use and apply than is the Palmer method. In addition, this method yields numeric values which are in the same units as precipitation, and therefore has actual meteorological significance, unlike the non-dimensional values produced by the Palmer index.

The poor performance of the Palmer index in mountainous areas was the incentive for the development of the Surface Water Supply Index (SWSI). Developed jointly by the U.S, Soil Conservation Service and the Colorado Division of Water Resources, SWSI is based on precipitation, reservoir storage, and either snowpack (winter) or stream flow (summer). SWSI produces the same units as the Palmer index, but appears to respond much more appropriately to changes in available moisture.

The Standardized Precipitation Index (SPI) was formulated by Tom McKee, Nolan Doesken and John Kleist of the Colorado Climate Center in 1993. The purpose is to assign a single numeric value to precipitation, for comparison across regions with markedly different climates. Technically, the SPI is the number of standard deviations that the observed value would deviate from the long-term mean, for a normally distributed random variable. Since precipitation is not normally distributed, a transformation is first applied so that the transformed precipitation values follow a normal distribution.

McKee et al. (1993) used the classification system shown in Table 1 to define drought intensities resulting from the SPI; they also defined the criteria for a "drought event" for any of the time scales. A drought event occurs any time the SPI is continuously negative and reaches an intensity where the SPI is -1.0 or less. The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and an intensity for each month that the event continues. The accumulated magnitude of drought can also be measured. McKee et al. (1993) called this the Drought Magnitude (DM), and it is the positive sum of the SPI for all the months within a drought event.

SPI Values	Drought Category	Time in Category
0 to -0.99	Mild Drought	24%
1.00 to -1.49	Moderate Drought	9.2%
1.50 to -1.99	Severe Drought	4.4%
2.00 or less	Extreme Drought	2.3%

Table: SPI Values

The table also shows the percent of time that the SPI is in each of the drought categories based on an analysis of stations across Colorado (McKee et al. 1993). Because the SPI is standardized, these percentages are expected from a normal distribution of the SPI. The 2.3% of SPI values within the "Extreme Drought" category is a percentage that is typically expected for an "extreme" event (Wilhite 1995). In contrast, the Palmer Index reaches its "extreme" category more than 10% of the time across portions of the central Great Plains. This standardization allows the SPI to determine the rarity of a current drought, as well as the probability of the precipitation necessary to end the current drought (McKee et al. 1993).

Other drought indices which are used to assess water availability (drought, floods, or in between) include the following:

Percent of Normal

The percent of normal precipitation is one of the simplest measurements of rainfall for a location. Analyses using the percent of normal are very effective when used for a single region or a single season. It is also easily misunderstood and gives different indications of conditions depending on the location and season. It is calculated by dividing actual precipitation by normal precipitation—typically considered to be a 30-year mean—and multiplying by 100%. This can be calculated for a variety of time scales. Usually these time scales range from a single month to a group of months representing a particular season, to an annual or water year. Normal precipitation for a specific location is considered to be 100%.

One of the disadvantages of using the percent of normal precipitation is that the mean, or average, precipitation is often not the same as the median precipitation, which is the value exceeded by 50% of the precipitation occurrences in a long-term climate record. The reason for this is that precipitation on monthly or seasonal scales does not have a normal distribution. Use of the percent of normal comparison implies a normal distribution where the mean and median are considered to be the same. An example of the confusion this could create can be illustrated by the long-term precipitation record in Melbourne, Australia for the month of January. The median January precipitation is 36.0 mm (1.4 in.), meaning that in half the years less than 36.0 mm is recorded, and in half the years more than 36.0 mm is recorded. However, a monthly January total of 36.0 mm would be only 75% of normal when compared to the mean, which is often considered to be quite dry.

Because of the variety in the precipitation records over time and location, there is no way to determine the frequency of the departures from normal. Therefore, the rarity of an occurring drought is not known and can not be compared with a different location. This makes it difficult to link a value of a departure with a specific impact occurring as a result of the departure, inhibiting attempts to mitigate the risks of drought based on the departures from normal and form a plan of response (Willeke et al. 1994).

Deciles

Arranging monthly precipitation data into deciles is another drought-monitoring technique. It was developed by Gibbs and Maher (1967) to avoid some of the weaknesses within the "percent of normal" approach. The technique they developed divided the distribution of occurrences over a long-term precipitation record into sections for each ten percent of the distribution. They called each of these categories a "decile." The first decile is the rainfall amount not exceeded by the lowest 10% of the precipitation occurrences. The second decile is the precipitation amount not exceeded by the lowest 20% of occurrences. These deciles continue until the rainfall amount identified by the tenth decile is the largest precipitation amount within the long-term record. By definition, the fifth decile is the median, and it is the precipitation amount not exceeded by 50% of the occurrences over the period of record. The deciles are grouped into five classifications, which are shown in Table 2.

The decile method is relatively simple to calculate, requires less data and fewer assumptions than the Palmer index, and provides uniformity in drought classifications. One disadvantage of the decile system is that a long climatological record is needed to calculate the deciles accurately.

Table 2: Decile Classifications for Dry and Wet Periods

Deciles 1-2	lowest 20%	much below normal
Deciles 3-4	next lowest 20 %	below normal
Deciles 5-6	middle 20%	near normal
Deciles 7-8	next highest 20%	above normal
Deciles 9-10	highest 20%	much above normal

Drought Monitoring

At one time, the Oregon Drought Council was the primary drought assessment agency in Oregon. Comprising representatives of various state and Federal agencies, the Council met monthly and reported to the Strategic Water Management Group (SWMG), which in turn reported to the Governor. The Drought Council played an important role in the 1992 drought, when Oregon successfully sought federal relief funds for the statewide drought emergency. Unfortunately, SWMG was disbanded several years later, and with it went the Drought Council.

The National Drought Mitigation Center (NDMC) was founded in 1995, with funds from the Special Grants Program of the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, and the Climate Prediction Center, with additional support from the University of Nebraska-Lincoln and the Institute for Agriculture and Natural Resources. The NDMC is in the Department of Agricultural Meteorology at the University of

Nebraska-Lincoln, also home to the International Drought Information Center. It is the first research and development program to address drought as a national issue in the United States.

Drought in Oregon

A history of drought in Oregon reveals many short-term droughts and a few long-term events. In some cases, droughts have been widespread, affecting virtually the entire state. At other times, regional or local water shortages have occurred.

The attached figure shows monthly Palmer Drought Severity Index for the Willamette Valley from 1895 through early 1998. As was stated earlier, the Palmer Index is not the best water availability indicator for Oregon, but it has the advantage of being available for more than 100 years. In western Oregon, the Palmer Index is a good indicator of precipitation compared with normal (averaged over a period of about 6 months).

The figure shows some significant periods of water shortage:

- 1904-05. A drought period of about 18 months.
- 1917-31. A very dry period, punctuated by brief wet spells in 1920-21 and 1927.
- 1939-41. A three-year intense drought.
- 1965-68. A three-year drought following the big regional floods of 1964-65.
- 1976-77. A brief but very intense statewide drought.
- 1985-94. A generally very dry period, capped by statewide droughts in 1992 and 1994.

Effects of Droughts

Droughts have obvious effects on lake and river levels, cause significant harm to wildlife, and present major problems for farmers and ranchers. The greatest impacts, however, may be to forests. During the 1985-94 drought, trees were weakened by the water shortages, and tree pests proliferated. Spruce budworm and bark beetles ravaged large areas in Oregon, killing many trees. The forests became huge tinderboxes, ripe for major fires. The situation was not unlike what occurred during the long, dry period from the late teens through the early 1930s. In the 1990s, Oregon was fortunate not to have major forest fires. In the 1930s, we were not so lucky.

The Tillamook Burn

Between 1933 and 1951, the Tillamook Forest burned four times, with bizarre regularity, every six years. The fires burned over 350,000 acres of forest, and are collectively known as the Tillamook Burn.

The first fire started a little after one o'clock on the afternoon of August 14, 1933. Stewart Holbrook described the scene for the *American Mercury*:

> *Hundreds of men fought valiantly all night on that August 14, and for all the good they did they might as well have remained in their camps. The fire leaped into the tops of the trees and swept on with fearful speed, making its own wind as it went. Those great trees, many of them 300 feet high, burned like tremendous torches. I saw one great body of Douglas firs, each nearly 500 years old, burn savagely like so many huge columns of fat, spitting, crackling, then roaring like flame under a bellows.*

`Smoke rolled and billowed above the flames. It formed, for two days, a pillar and mushroom that stood clear and white and terrible five thousand feet above the forest. Presently ashes were drifting through the screens of the windows in Portland homes, fifty miles away. The wind over the fire rose at last to a hurricane and the noise was greater than the sea pounding the Oregon shore. It rumbled and thundered and was marked by the deep booming of ancient trees uprooted by the gale and crashing down.

Five hundred more men, then a thousand more, then two thousand were hurried to the lines that now formed a front along a hundred miles, and mariners far at sea saw dead embers fall on the decks of their ships, while the tides piled debris two feet deep along the Oregon beaches. Tillamook County, Oregon's great timbered pride, was going up in flame and smoke. I saw it burn and I never expect to see another sight like it…

A sudden shift of the wind, on the tenth day of the conflagration, brought immediate danger to Camp McGregor, logging headquarters of the Oregon-American Lumber Company. An hour later the main body of the fire was only half a mile from the camp, and spot fires were springing up within a few yards of the buildings. Men fought these near fires, a rear-guard action, while wives and children were loaded aboard a logging train. The train pulled out just as the camp itself started to burn fiercely. It pounded down the mountain, rocked around curves and crossed dizzily high trestles that were beginning to smoulder, while back on the mountain the camp was going up in smoke.

The little hamlet of Elsie, set almost in the middle of this gigantic destruction, was soon surrounded by the fire, and for twenty-four hours it was believed that Elsie and all it contained had been wiped away. But through some quirk in the wind, Elsie survived. Not so another hamlet, Lukarilla. Settlers watched while Lukarilla, with its homes and barns and fences and one store, disappeared entirely. Strangely enough there was no loss of life here. Only one person died in all the fire, Frank Palmer, a CCC boy from Illinois, who was killed instantly when a big fir, uprooted by the wind, crushed him to earth.

The blaze burned itself out on August 24, after a fog blanket drifted in from the coast to smother it. In ten days it had killed twelve and one-half billion feet of fine timber. It burned over some 310,000 acres. How can one described twelve and one-half billion feet of timber? There is no use piling it up, in Sunday-supplement style beside the Empire State Building, which it would put in shadow many times over. But perhaps it will mean something to know that during the year 1932, twelve and one-half billion feet of logs was enough to supply the needs of all the sawmills, lath mills, shingle mills and pulpwood mills in the forty-eight states.

Drought, like floods, will doubtless return every so often to Oregon. During periods of plentiful water (as we find ourselves experiencing in the late 1990s), it is easy to forget that fact. But unless we are prepared for water scarcity, we will encounter problems when drought reappears. Most Oregon state and local agencies have enacted comprehensive drought contingency plans. The only element missing is early assessment or prediction of drought, something at which the Drought Council excelled. If we were to suggest ways to improve Oregon's responsiveness to drought, we would begin by reestablishing the Drought Council!