Drought

Drought	Frequency	50+ yrs	10-50 yrs	1-10 yrs	Annually
	People	<1,000	1,000-10,000	10,000-50,000	50,000+
	Economy	1% GDP	1-2% GDP	2-3% GDP	3%+ GDP
	Environment	<10%	10-15%	15%-20%	20%+
	Property	<$100M	$100M-$500M	$500M-$1B	$1B+
	Hazard scale	< Low to High >			

Risk Level[1]

- Frequency – Based on the 100-year history of drought in Washington, the state as a whole can expect severe or extreme drought conditions at least every five years, with most of eastern Washington experiencing severe or extreme drought more frequently.
- People – While people are definitely affected by a drought, lives are usually not lost due to this hazard.
- Economy – The two worst droughts in the state's history (1977 and 2001) resulted in thousands of job losses to the power and agricultural industries as well as job losses in the mining, recreation, and fishing industries. In addition, the estimated losses to the state's economy due to these two drought events were close to $500 million.
- Environment – While the presence of drought can increase the likelihood of wildfires and result in significant damage to the environment, this damage is not expected to completely alter 10% of a habitat or eradicate 10% of a single species, and therefore does not meet the minimum threshold for this category.
- Property – During Washington's last drought in 2005, the Washington State Department of Agriculture (WSDA) made a preliminary estimate of the potential impact of this drought on Washington's agriculture industry. Assuming a worst-case scenario of below average precipitation throughout the growing season, WSDA anticipated that crop losses would be between $195 and $299 million, or 5 to 8% of the Washington harvest.

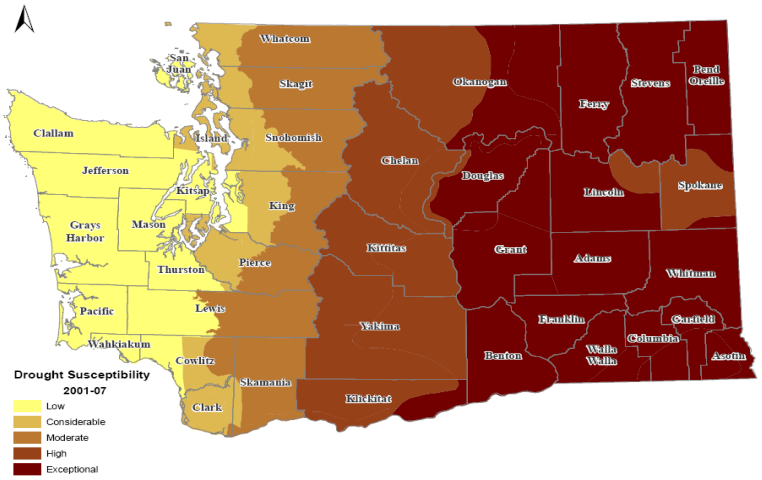


Figure 5.4-1 Drought Susceptibility for Washington State 2001-2007

Summary

- The hazard – Drought is a prolonged period of low precipitation severe enough to reduce soil moisture, water and snow levels below the minimum necessary for sustaining plant, animal, and economic systems. A natural part of the climate cycle, droughts can reduce water supply, threaten crops that rely on natural precipitation, and increase the threat of wildfires.

- Previous occurrences – Washington has a history of drought, including several that lasted more than a single season. The worst two on record occurred in 1977 and 2001; the most recent event was in 2005.

- Probability of future events – At this time, reliable forecasts of drought are not attainable for temperate regions of the world more than a season in advance. However, based on a 100-year history with drought, the state as a whole can expect severe or extreme drought at least 5 percent of the time in the future, with most of eastern Washington experiencing severe or extreme drought about 10 to 15 percent of the time.

- Jurisdictions at greatest risk – Nine counties meet criteria including percentage of time in drought, water use for crop irrigation or due to growth, and potential inability to deal with financial impacts of drought on their communities.

- Special note – This profile will not attempt to estimate potential losses to state facilities due to drought. This hazard poses little threat to people and the built environment, but can pose significant damage to the state's economy.

The Hazard[2, 3, 4, 5, 6, 7, 8]

Drought is a prolonged period of reduced precipitation severe enough to reduce soil moisture, water and snow levels below the minimum necessary for sustaining plant, animal, and economic systems. Droughts are a natural part of the climate cycle. In the past century, Washington State has experienced a number of drought episodes, including several that lasted for more than a single season – 1928 to 1932, 1992 to 1994, and 1996 to 1997.

Unlike most states, Washington has a statutory definition of drought (Revised Code of Washington Chapter 43.83B.400). According to state law, an area is in a drought condition when:

- The water supply for the area is below 75 percent of normal.
- Water uses and users in the area will likely incur undue hardships because of the water shortage.

Drought can have a widespread impact on the environment and the economy, depending upon its severity, although it typically does not result in loss of life or damage to real property, as do other natural disasters.

The National Drought Mitigation Center at the University of Nebraska-Lincoln uses three categories to describe likely drought impacts:

- Agricultural – Drought threatens crops that rely on natural precipitation.
- Water supply – Drought threatens supplies of water for irrigated crops and for communities.
- Fire hazard – Drought increases the threat of wildfires from dry conditions in forest and rangelands.

Additionally, drought threatens the supply of electricity in our state. Hydroelectric power plants generated nearly three-quarters of the electricity produced in Washington State in 2000. When supplies of locally generated hydropower shrink because of drought, utilities seek other sources of electricity, which can drive up prices even as supply is reduced.

Unlike most disasters, droughts occur slowly but may last a long time. On average, the nationwide annual economic impacts of drought – between $6 billion and $8 billion annually in the United States – are greater than the impacts of any other natural hazard. They occur primarily in the agriculture, transportation, recreation and tourism, forestry, and energy sectors. Social and environmental impacts are also significant, although it is difficult to put a precise cost on these impacts.

Drought affects groundwater sources, but generally not as quickly as surface water supplies, although groundwater supplies generally take longer to recover. This can lead to a reduction in groundwater levels and problems such as reduced pumping capacity or wells going dry; shallow wells are more susceptible than deep wells. About 16,000 drinking water systems in Washington State get water from the ground; these systems serve about 5.2 million people.

Reduced replenishment of groundwater affects streams. Much of the flow in streams comes from groundwater, especially during the summer when there is less precipitation and after snowmelt ends. Reduced groundwater levels mean that even less water will enter streams when steam flows are lowest.

The Washington State's climate and ecology are largely shaped by the interactions that occur between seasonally varying weather patterns and the region's mountain ranges. Approximately two-thirds of the region's precipitation occurs in October-March. Much of this precipitation is captured in the region's mountains. Unlike other parts of the country, snow- rather than man –made reservoirs- is the dominant form of water storage, storing water from the winter and releasing it in spring and early summer, when economic, environmental, and recreational demands for water are greatest throughout the state.

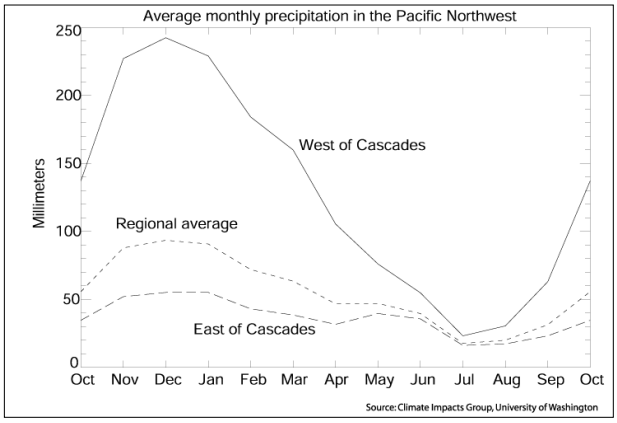


Figure 4-6 Average Monthly Precipitation in the Pacific Northwest for 1900-1998

The amount of snow that collects in Washington's mountains largely depends on both precipitation and the temperature during winter months. The El Niño – Southern Oscillation (El Niño/ La Niña) events that occur in the Pacific Ocean affect Washington's winter weather and play a role in whether the region experiences a drought. In El Niño years, winters tend to be drier and temperatures tend to be warmer, the result is lower springtime snowpack and lower stream flow during spring and summer in snowmelt driven rivers.

A drought directly or indirectly affects all people and all areas of the state. A drought can result in farmers not being able to plant crops or the failure of the planted crops. This results in loss of work for farm workers and those in related food processing jobs. Other water or electricity-dependent industries commonly shut down all or a portion of their facilities, resulting in further layoffs. A drought can spell disaster for recreational companies that use water (e.g., swimming pools, water parks, and river rafting companies) and for landscape and nursery businesses because people will not invest in new plants if water is not available to sustain them. Also, people could pay more for water if utilities increase their rates. With much of Washington's energy coming from hydroelectric plants, a drought can mean more expensive electricity from other resources than dams and probably higher electric bills.

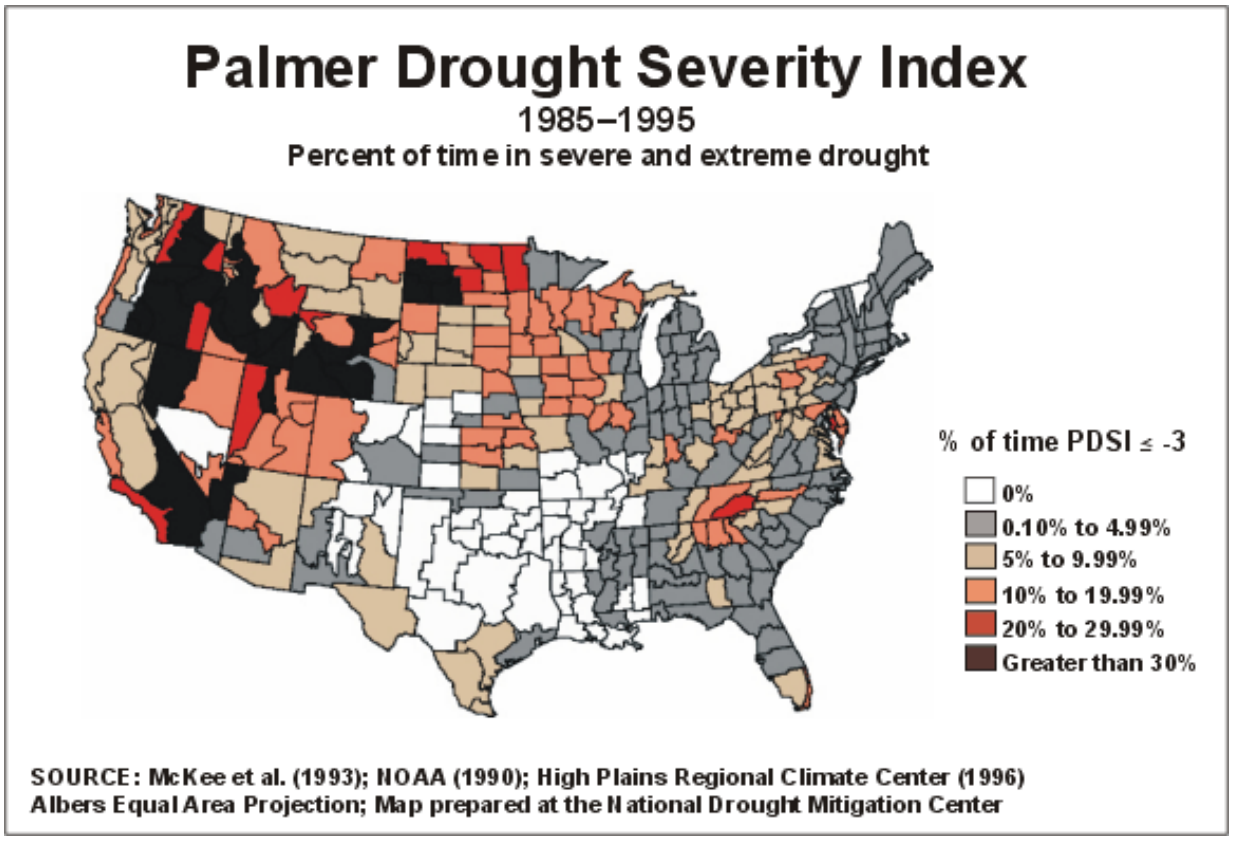
Previous Occurrences[9]

Empirical studies conducted over the past century have shown that meteorological drought is never the result of a single cause. It is the result of many causes, often synergistic in nature; these include global weather patterns that produce persistent, upper-level high-pressure systems along the West Coast with warm, dry air resulting in less precipitation.

Scientists at this time do not know how to predict drought. Predicting drought depends on the ability to forecast precipitation and temperature. Anomalies of precipitation and temperature may last from several months to several decades. How long they last depend on interactions between the atmosphere and the oceans, soil moisture and land surface processes, topography, and the accumulated influence of weather systems on a global scale.

The U.S. Drought Monitor is produced in partnership between the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. One of the key tools used is the Palmer Drought Severity

Index. Drought intensity categories are based on five key indicators and numerous supplementary indicators. Additional indicators are often needed in the West, where winter snowfall has a strong bearing on water supplies. The weekly produced Drought Monitor is intended to provide a general and up-to-date summary of current drought conditions across the 50 states, Puerto Rico, and the Pacific possessions. This national product is designed to provide the "big picture".



In temperate regions, including Washington State, current long-range forecasts of drought have limited reliability. In the tropics, empirical relationships have been demonstrated between precipitation and El Niño events, but few such relationships have been demonstrated above the 30º north latitude; Washington State sits between 45.30º and 49º north latitude. Meteorologists do not believe that reliable drought forecasts are attainable a season or more in advance for temperate regions.

Based on the state's history with drought from 1895 to 1995, the state as a whole can expect severe or extreme drought at least 5 percent of the time in the future. All of eastern Washington, except for the eastern foothills of the Cascade Mountains, can expect severe or extreme drought 10 to 15 percent of the time. The east slopes of the Cascades and much of western Washington can expect severe or extreme drought from 5 to 10 percent of the time.

Comparing the droughts of 1977 and 2001[10, 11]

The Northwest typically has a dry summer with very little summer rainfall. In Seattle, the average rainfall for July is less than one inch while it is nearly six inches in November. Most of the state's annual precipitation occurs during the winter. Precipitation in the Cascade Mountains is normally stored as snow that slowly melts during the spring and summer, maintaining stream and river flows. This is the

primary source of water for irrigation and municipal use. The major causes of droughts in Washington are either low snow accumulations from either low precipitation or warm winter temperatures; or by warm weather in the late winter-early spring that causes early melt of the snowpack.

Where the snow falls affects the nature of a drought. The Columbia River provides most of the energy for hydroelectric power and irrigation for the Columbia Basin Project and farms in the basin. The Columbia receives large amounts of its flow from mountainous areas in British Columbia. In the southern Cascade Mountains of Washington, the Yakima River basin is particularly influenced by fluctuating snow levels.

The 1977 drought was the worst on record, but the 2001 drought came close to surpassing it in some respects. The table below has data on how the two droughts affected Washington by late September of their respective years.

Table 1. Comparison of Impacts of 1977 Drought and 2001 Drought Events

	1977 Drought	2001 Drought
Precipitation	Precipitation received at most locations ranged from 50 to 75 percent of normal levels, and in parts of Eastern Washington as low as 42 to 45 percent of normal.	Precipitation was 56 to 74 percent of normal. US Bureau of Reclamation – Yakima Project irrigators received only 37 percent of their normal entitlements. At the end of the irrigation season, the U.S. Bureau of Reclamation's five reservoirs stored only 50,000 acre-feet of water compared with 300,000 acre-feet typically in storage.
Wildland Fire	1,319 wildland fires burned 10,800 acres. State fire-fighting activities involved more than 7,000-man hours and cost more than $1.5 million.	1,162 wildland fires burned 223,857 acres. Firefighting efforts cost the state $38 million and various local, regional and federal agencies another $100 million.
Fish	In August and September 1977, water levels at the Goldendale and Spokane trout hatcheries were down. Fish had difficulties passing through Kendall Creek, a tributary to the north fork of the Nooksack River in Whatcom County.	A dozen state hatcheries took a series of drought-related measures, including installing equipment at North Toutle and Puyallup hatcheries to address low water flow problems.
Emergency Water Permits	Department of Ecology issued 517 temporary ground-water permits to help farmers and communities drill more wells.	Department of Ecology issued 172 temporary emergency water-right permits and changes to existing water rights.

Economic Impacts	The state's economy lost an estimated $410 million over a two-year period. The drought hit the aluminum industry hardest, with major losses in agriculture and service industries, including a $5 million loss in the ski industry. 13,000 jobs were lost because of layoffs in the aluminum industry and in agriculture.	The Bonneville Power Administration paid more than $400 million to electricity-intensive industries to shut down and remain closed for the duration of the drought. Thousands lost their jobs for months including 2,000-3,000 aluminum smelter workers at the Kaiser and Vanalco plants. Federal agencies provided more than $10.1 million in disaster aid to growers. More than $7.9 million in state funds paid for drought-related projects; these projects enabled the state to provide irrigation water to farmers with junior water rights and to increase water in fish-bearing streams.

In examining the impact of the 2001 drought, the Washington Department of Agriculture determined the potential long-term economic impact of cutting off water to a group of irrigators was five times the value of the lost harvest. The analysis examined the production of 330 farmers that irrigated and harvested nearly 38,000 acres of cropland in the Columbia-Snake River region. The analysis assumed: The farms would not receive sufficient water to maintain their plants for one year; Annual crop farmers, representing about 70 percent of the acres, suffered a single year loss; and Perennial-crop farmers (apples, cherries, grapes, etc.) lost production for three to seven years.

Table 2, below, shows the value of the economic loss for these farmers was projected at $1.2 billion, with projected annual job losses ranging from 2,144 the first year to 643 in subsequent years; each $1 million in lost economic activity represents approximately 15 jobs.

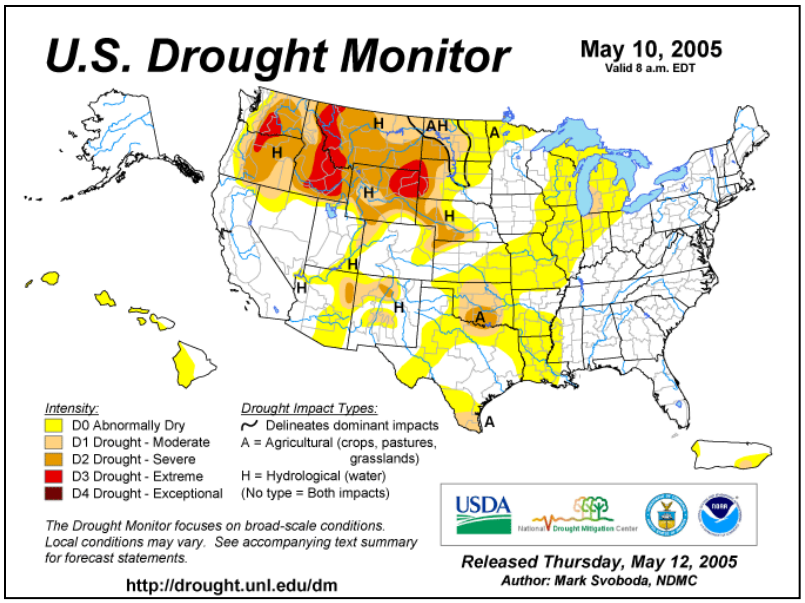
Table 2. Economic Impact of Drought on 330 Irrigators in Columbia-Snake System

Year	Acres Affected	Value Lost Harvest		Replanting Cost		Total Direct Loss (millions)	Job Loss			Total Economic Loss (millions)
		Harvest/ Acre	Value (millions)	Cost/ Acre	Value (millions)		On Farm	Related Jobs	Annual Total	
2001	37,806	$1,755	$66.3	$350	$4.0	$70.3	991	1,153	2,144	$331.7
2002	11,342	$4,000	$45.4	$9,638	$109.3	$154.7	297	346	643	$226.8
2003	11,342	$4,000	$45.4	$858	$9.7	$55.1	297	346	643	$226.8
2004	11,342	$4,000	$45.4	$750	$8.5	$53.9	297	346	643	$226.8
2005	11,342	$4,000	$45.4	$184	$2.1	$47.5	297	346	643	$226.8
Total Harvest Loss			**$247.8**		**$133.6**	**$381.4**				**$1,239.1**

Source: Washington Department of Agriculture, *The Impact of the 2001 Drought on Washington Agriculture*.

2005 Drought[12]

October precipitation ranged between normal to well-above normal for all but the north Puget Sound region. However, precipitation was below or much below average November through February for much of the state, and the fall and winter months were extremely warm, which adversely affected the state's mountain snow pack. A warm mid-January storm removed much of the remaining snow pack. February turned out to be warm and dry. By early March, projections showed Washington might be facing a drought as bad as or worse than the 1977 drought, the worst on state record.



Governor Christine Gregoire authorized the Department of Ecology to declare a statewide drought emergency on March 10, 2005.

Consequently, the state legislature approved a $12 million supplemental budget request that provided funds for buying water, improving wells, implementing other emergency water-supply projects, and hiring temporary state staff to respond to the drought emergency, conduct public workshops and undertake drought-related studies.

In March, the water supply forecast was 66 percent of normal, signaling an extremely poor water year and a possible reduction in electricity production. By late spring, due to record precipitation in March and April, water filled reservoirs to about 95 percent of capacity, more than enough to meet projected electricity demands. Despite projected drought impacts of up to $300 million, unexpected spring rains combined with reallocation of water and conservation measures by farmers largely mitigated the drought's impacts. Harvest of most crops was near normal levels. While statewide harvests were near normal, local farmers who did not receive the spotty rains experienced poor harvests. The number of wildfires was about 75 percent of average for the previous five years, but the acreage burned was three times greater. The largest – the School fire – burned 52,000 acres of state-protected lands, 109 homes and 106 other buildings, and cost more than $15 million to extinguish. The fire also destroyed half of the elk and bighorn sheep and a third of the deer in the Tucannon Game Management Unit.

In October, Governor Gregoire requested agricultural disaster designations from the U.S. Secretary of Agriculture because of significant crop damage from drought. The following counties were included in the disaster request: Asotin, Benton, Chelan, Clark, Columbia, Cowlitz, Douglas, Franklin, Kittitas, Klickitat, Lincoln, Skamania, Walla Walla, Wahkiakum, and Yakima. The emergency proclamation for the drought expired on December 31, 2005.

Impact of Drought on the Washington's Agriculture Industry[13, 14, 15]

Agriculture is the industry most heavily affected by drought. Most of Washington's crops grow in near-desert conditions in Eastern Washington and depend on irrigation; three-quarters of the water consumed in Washington State is used for irrigating crops, according the U.S. Geological Survey.

The state's food and agriculture industry support more than 180,000 jobs around the state and generates 13 percent of the state's economy. Almost 70 percent of Washington's crop value – about $3.6 billion – comes from the 27 percent of harvested cropland that is irrigated. This includes the most valuable crops: apples, cherries, other tree fruit, vegetables, onions and potatoes. Per acre, irrigated crops are worth almost seven times more than crops from non-irrigated land. The tree fruit industry is the largest single user of irrigation water.

According to the 2005 and 2006 production estimates from the U.S. Department of Agriculture (USDA), Washington State was the top producer of apples and pears in the nation, was the number-two producer of sweet cherries, plums, prunes and potatoes, and the seventh-ranked producer of vegetables. In 2011 USDA reported that Washington State was the top producer of apples in the nation, valued at $1.83 billion. Milk was ranked second, wheat third, potatoes fourth, and hay was the fifth leading agricultural commodity produced in Washington State. Overall, field crops were valued at $3.24 billion, fruit and nut crops at $2.50 billion, livestock at $2.39 billion, commercial vegetables at $481 million and specialty products at $378 million. Specifically, blueberries had the highest value per harvested acre in 2011 at $17,429, followed by sweet cherries at $15,500. Apples had a value per harvested acre of $12,542.

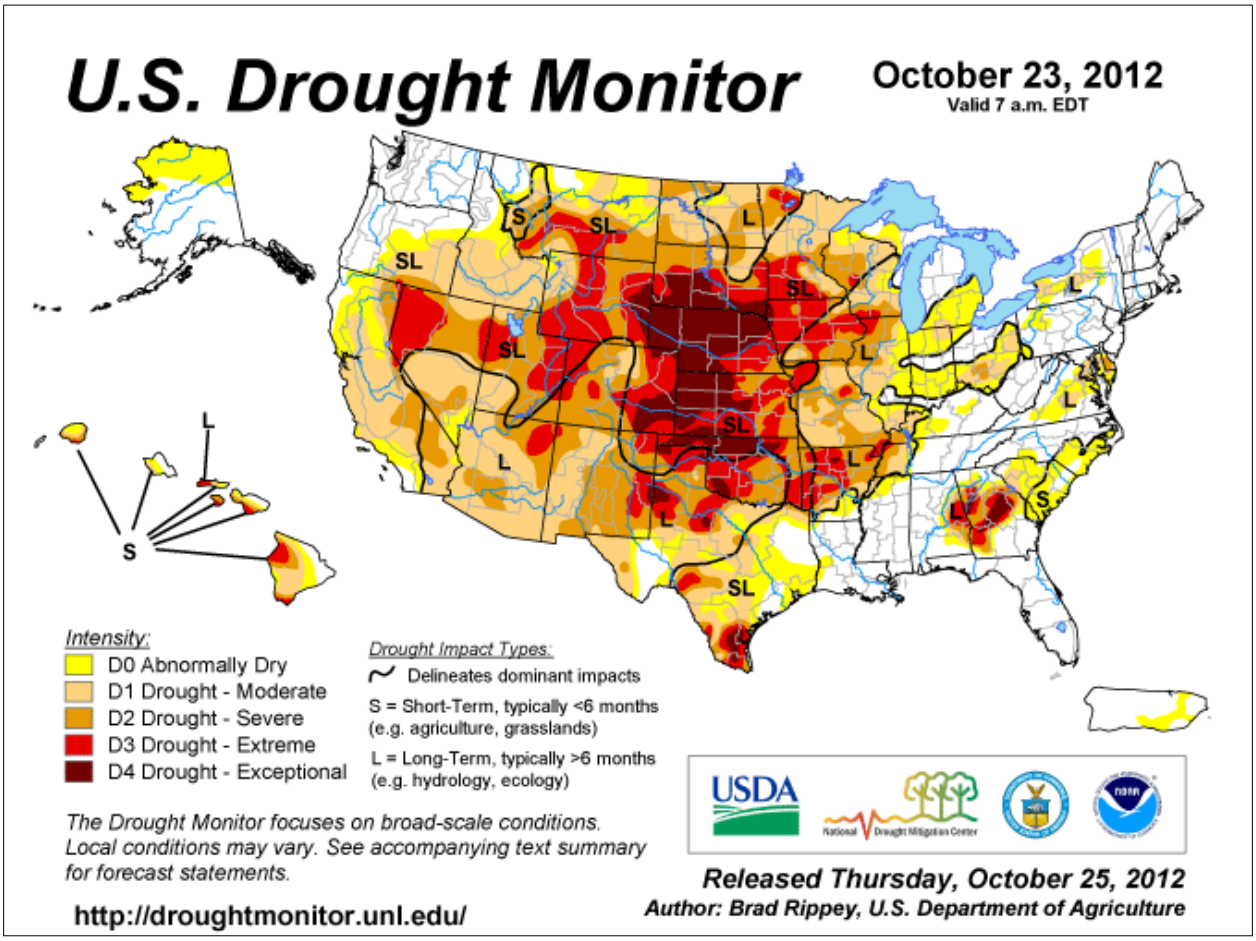
According to the Washington State Department of Agriculture, drought reduces crop production, sometimes for several years, reduces availability of food on rangeland for grazing animals and eliminates jobs in the field, at food processing plants and in affiliated facilities. Surprisingly, drought also reduces availability of relatively inexpensive hydropower for farmers, processors, and storage facilities, removing their competitive edge. Plus, drought increases shipping costs for some segments of the industry. For example, wheat growers may have to use truck and rail transport for a portion of their crop if the level of the Snake and Columbia Rivers become too low for barge traffic. Sixty percent of Washington wheat moves down these rivers.

The impact of drought varies by region, by crop, and by the status of the irrigation water right holder (junior or senior). Loss of water is far more damaging to perennial crops, such as fruit trees, grapes, hops, and asparagus, than to annual crops because it takes perennials a number of years to return to normal production.

Jurisdictions Most Vulnerable to Drought[16]

Vulnerability to drought is affected by (among other things) population growth and shifts, urbanization, demographics, technology, water use trends, government policy, social behavior, environmental awareness, and economic ability to endure a drought. These factors evolve, and a community's vulnerability to drought may rise or fall in response to these changes. For example, increasing and shifting populations put greater pressure on water and other natural resources – more people need more water.

According to the National Drought Mitigation Center at the University of Nebraska-Lincoln, the Pacific Northwest region (Columbia, Willamette, and Snake River basins of Idaho, Oregon, and Washington, and portions of Montana and Wyoming) experienced drought more frequently than most other regions of the nation. The Palmer Drought Severity Index, a measure of moisture supply, is used to determine drought conditions. Figures produced by the National Drought Mitigation Center show that the Pacific Northwest had 10 percent or more of its area in severe or extreme drought during 61 years of the 100-year period of 1895-1995. Only the Missouri basin of the north-central United States and the Great Basin of Nevada and Utah had more years with 10 percent or more of its area experiencing severe or extreme drought, 70 years and 65 years, respectively. Furthermore, only two other regions had a third of their areas in drought more often than the Pacific Northwest – the Great Basin (37 years) and the Upper Colorado (34 years). The Missouri basin also was in this condition 33 years out of the 100-year period. The continental United States is broken into eighteen basins for drought study.



During 1895-1995, much of the state was in severe or extreme drought at least 5 percent of the time. All of Eastern Washington, except for the Cascade Mountain's eastern foothills, was in severe or extreme drought 10 to 15 percent of the time. The east slopes of the Cascades and much of Western Washington was in severe or extreme drought from 5 to 10 percent of the time.

For the State Hazard Mitigation Plan, a county is most vulnerable to drought if it meets at least five of the following seven criteria:

- History of severe or extreme drought conditions:
  - The county must have been in serious or extreme drought at least 10-15 percent of the time from 1895 to 1995.
- Demand on water resources based on:
  - Acreage of irrigated cropland. The acreage of the county's irrigated cropland must be in top 20 in the state.
  - Percentage of harvested cropland that is irrigated. The percentage of the county's harvested cropland that is irrigated must be in top 20 in the state.
  - Value of agricultural products. The value of the county's crops must be in the top 20 in the state.
  - Population growth greater than the state average. The county's population growth in 2000-2006 must be greater than state average of 8.17 percent.
- A county's inability to endure the economic conditions of a drought, based on:
  - The county's median household income less than 75 percent of the state median income of $51,749 in 2005.
  - The county classified as economically distressed in 2005 because its unemployment rate was 20 percent greater than the state average from January 2002 through December 2004.

The following nine counties meet the above criteria: Adams, Benton, Chelan, Franklin, Grant, Kittitas, Klickitat, Okanogan, and Yakima.

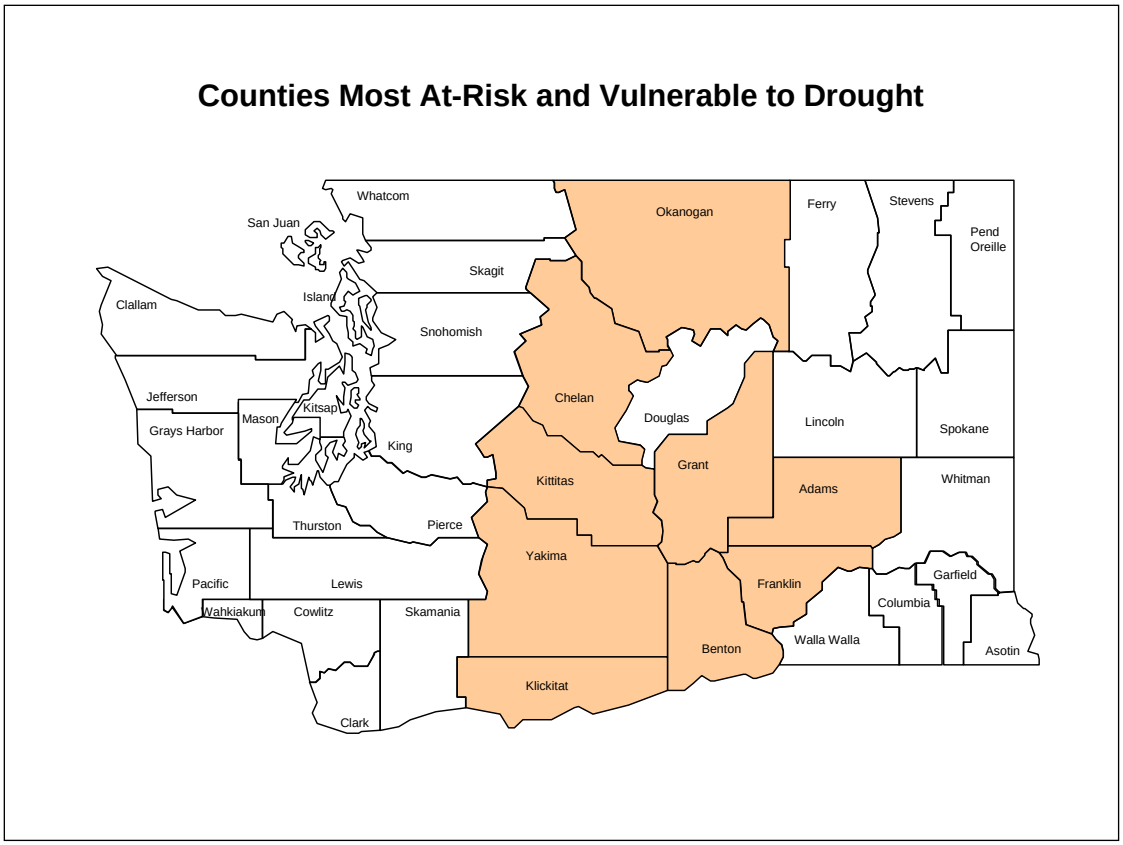


Table 3. County Median Household Income, County Unemployment Rates, County Market Value of Crops, County Population Growth and Time in Drought. The nine counties most vulnerable to drought are highlighted in yellow.

County	2011 Projected Median Household Income, dollars	Median Household Income ≤ 75% of State Average or $41,625	2012 Unemployed Rate, Percent	economically distressed unemployment rates ≥ 120% of state average or 9.24%	Market value of crops 2011	Census 1990	Census 2000	Census 2010	1990 to 2000 Percent Pop Growth	2000 to 2010 Percent Pop Growth	% Time in Drought 1985 - 1995
Washington	55,500		7.7%			4,866,663	5,894,143	6,724,540	21.1	14.1	5-10%
Adams	41,068	■	7.0		$344M	13,603	16,428	18,728	20.8	14.0	20-30%
Asotin	40,171	■	7.0		$13M	17,605	20,551	21,623	16.7	5.2	20-30%
Benton	60,608		8.1		$526M	112,560	142,475	175,177	26.6	23.0	> 30%
Chelan	46,275		6.3		$209M	52,250	66,616	72,453	27.5	8.8	> 30%
Clallam	38,886	■	9.1		$11M	56,204	64,179	71,404	14.2	11.3	
Clark	54,951		8.3		$53M	238,053	345,238	425,363	45.0	23.2	
Columbia	38,916	■	9.3	■	$40M	4,024	4,064	4,078	1.0	0.3	20-30%
Cowlitz	41,406	■	10.6	■	$26M	82,119	92,948	102,410	13.2	10.2	> 30%
Douglas	46,723		6.2		$193M	26,205	32,603	38,431	24.4	17.9	5-10%
Ferry	36,921	■	12.0	■	$3M	6,295	7,260	7,551	15.3	4.0	20-30%
Franklin	53,644		7.8		$467M	37,473	49,347	78,163	31.7	58.4	20-30%
Garfield	44,608		6.6		$26M	2,248	2,397	2,266	6.6	-5.5	> 30%
Grant	42,994		7.7		$1,190M	54,798	74,698	89,120	36.3	19.3	> 30%
Grays Harbor	39,836	■	12.0	■	$33M	64,175	67,194	72,797	4.7	8.3	
Island	54,206		7.8		$14M	60,195	71,558	78,506	18.9	9.7	
Jefferson	44,348		9.0		$9M	20,406	26,299	29,872	28.9	13.6	
King	66,294		6.9		$127M	1,507,305	1,737,046	1,931,249	15.2	11.2	
Kitsap	55,400		7.1		$7M	189,731	231,969	251,133	22.3	8.3	
Kittitas	41,601	■	7.5		$61M	26,725	33,362	40,915	24.8	22.6	> 30%
Klickitat	43,104		8.0		$57M	16,616	19,161	20,318	15.3	6.0	> 30%
Lewis	38,325	■	11.8	■	$110M	59,358	68,600	75,455	15.6	10.0	
Lincoln	43,936		6.7		$126M	8,864	10,184	10,570	14.9	3.8	20-30%

Mason	47,724		10.2	■	$37M	38,341	49,405	60,699	28.9	22.9	
Okanogan	35,161	■	7.4		$209M	33,350	39,564	41,120	18.6	3.9	> 30%
Pacific	37,420	■	10.6	■	$35M	18,882	20,984	20,920	11.1	-0.3	
Pend Oreille	37,234	■	10.3	■	$3M	8,915	11,732	13,001	31.6	10.8	5-10%
Pierce	56,114		8.5		$83M	586,203	700,818	795,225	19.6	13.5	
San Juan	53,916		5.3		$4M	10,035	14,077	15,769	40.3	12.0	
Skagit	55,085		8.5		$256M	79,545	102,979	116,901	29.5	13.5	
Skamania	51,223		8.6		$3M	8,289	9,872	11,066	19.1	12.1	
Snohomish	62,687		7.4		$126M	465,628	606,024	713,335	30.2	17.7	
Spokane	46,846		8.2		$117M	361,333	417,939	471,221	15.7	12.7	20-30%
Stevens	40,282	■	10.6		$25M	30,948	40,066	43,531	29.5	8.6	5-10%
Thurston	60,621		7.4		$118M	161,238	207,355	252,264	28.6	21.7	
Wahkiakum	45,083		11.5		$3M	3,327	3,824	3,978	14.9	4.0	
Walla Walla	44,606		6.4		$344M	48,439	55,180	58,781	13.9	6.5	20-30%
Whatcom	49,775		7.0		$326M	127,780	166,826	201,140	30.6	20.6	
Whitman	31,396	■	6.2		$254M	38,775	40,740	44,776	5.1	9.9	20-30%
Yakima	41,164	■	8.2		$1,200M	188,823	222,581	243,231	17.9	9.3	> 30%
Washington	55,500		7.7%			4,866,663	5,894,143	6,724,540	21.1	14.1	5-10%

Source: Office Financial Management, OFM Census 2010 Data Products, http://ofm.wa.gov/pop/census2010/default.asp#summary accessed 25 October 25, 2012 and National Drought Mitigation Center, http://drought.unl.edu/; OFM Median Household Income, Updated October 25, 2011. Accessed 25 October 2012. http://www.ofm.wa.gov/economy/hhinc/; Source: ESD Map of County Unemployment Rates, Accessed 25 October 2012, https://fortress.wa.gov/esd/employmentdata/reports-publications/economic-reports/monthly-employment-report/map-of-county-unemployment-rates; Agriculture-A Cornerstone of Washington's Economy, Accessed 29 October 2012, http://agr.wa.gov/AgInWa/docs/126-CropProductionMap11-11.pdf

Potential Climate Change Impacts[17,,18]

Washington State is particularly vulnerable to a warming climate: especially our snow-fed water supplies that provide our drinking water, irrigation for agriculture and nearly three-fourths of the electrical power we produce. Close to 40 communities including some of the state's largest population centers along our 2,300 miles of shoreline are threatened by rising sea levels. Ocean acidification, which is created when carbon dioxide reacts with seawater and reduces the water's pH, threatens our abundant shellfish.

According to a 2005 Governor's report prepared by the Climate Impacts Group titled *Uncertain Future: Climate Change and its Effects on Puget Sound*, from "paleoclimatological evidence, we know that over the history of the earth high levels of greenhouse gas concentrations have correlated with, and to a large extent caused, significant warming to occur, with impacts generated on a global scale." While the report also indicates that the "ultimate impact of climate change on any individual species or ecosystem cannot be predicted with precision," there is no doubt that Washington's climate has demonstrated change.

In July 2007, the Climate Impacts Group launched an unprecedented assessment of climate change impacts on Washington State. *The Washington Climate Change Impacts Assessment* (WACCIA) involved developing updated climate change scenarios for Washington State and using these scenarios to assess the impacts of climate change on the following sectors: agriculture, coasts, energy, forests, human health, hydrology and water resources, salmon, and urban stormwater infrastructure. The assessment was funded by the Washington State Legislature through House Bill 1303.

In 2009, the Washington State Legislature approved the *State Agency Climate Leadership Act* Senate Bill 5560. The Act committed state agencies to lead by example in reducing their greenhouse gas (GHG) emissions to: 15 percent below 2005 levels by 2020; 36 percent below 2005 by 2035; and 57.5 percent below 2005 levels (or 70 percent below the expected state government emissions that year, whichever amount is greater.). The Act, codified in RCW 70.235.050-070, directed agencies to annually measure their greenhouse gas emissions, estimate future emissions, track actions taken to reduce emissions, and develop a strategy to meet the reduction targets. Starting in 2012 and every two years thereafter, each state agency is required to report to Washington State Department of Ecology the actions taken to meet the emission reduction targets under the strategy for the preceding biennium.

Recognizing Washington's vulnerability to climate impacts, the Legislature and Governor Chris Gregoire directed state agencies to develop an integrated climate change response strategy to help state, tribal and local governments, public and private organizations, businesses and individuals prepare. The state Departments of Agriculture, Commerce, Ecology, Fish and Wildlife, Health, Natural Resources and Transportation worked with a broad range of interested parties to develop recommendations that form the basis for a report by the Department of Ecology: *Preparing for a Changing Climate: Washington State's Integrated Climate Change Response Strategy*.

Over the next 50 - 100 years, the potential exists for significant climate change impacts on Washington's coastal communities, forests, fisheries, agriculture, human health, and natural disasters. These impacts could potentially include increased annual temperatures, rising sea level, increased sea surface temperatures, more intense storms, and changes in precipitation patterns. Therefore, climate change

has the potential to impact the occurrence and intensity of natural disasters, potentially leading to additional loss of life and significant economic losses.

Multiple droughts since 1971 have resulted in dry streams, withered and abandoned crops, dead fish, record low rivers, declining ground water levels, more forest fires, less summer water for farms, cities and forests plus less water for city municipal water sources affecting industries, businesses and homeowners. Between 2000 and 2005, Washington experienced two drought emergencies, resulting in drought declarations by Governors Locke and Gregoire.

The Yakima River Basin produces crops worth about $1 billion annually, mostly from perennial crops. Many of the Yakima Basin perennial crop growers face water shortages. In the low water year of 2001, reduced water allocation resulted in economic losses of $140 - $195 million. High river flows occurring earlier in the year will result in a 20-40% reduction in water availability by 2050. One potential solution is more reservoir storage, but this is expensive: the proposed Black Rock Reservoir would cost $3.5 to $4 billion.

Federal and state costs of fighting wildfires may exceed $75 million per year by the 2020's which is 50% higher than current expenditures. Economic impacts from fires include: lost timber value, lost recreational expenditures, human health costs, and air pollution and habitat loss.

With a warming climate, the growing season for some plants may be extended. The last frost would come earlier in the spring and first frost would come later in the fall. However, this advantage can be erased if there is limited water to nourish forests and crops during hot weather. Studies in Washington wine country conclude that more frequent series of extreme hot or cold days can result in damage and loss, even if the rest of the season is more moderate. Warmer winters allow forest and crop pests to reproduce longer and suffer less winter die offs, so pest populations can boom. This is already happening in Canada and even northeast Washington forests where pine bark beetles are rapidly devastating large tracts of forests.

Ecosystem changes from shifting seasons can:

- break historic linkages between predator and prey migrations
- shift timing of bloom times and necessary pollinators
- cause population booms or crashes that affect the rest of the system
- allow invasive plants, animals and insects to move into new territory
- stress native species with unusual weather and water conditions

At Risk State Facilities

This profile will not attempt to estimate potential losses to state facilities due to drought. This hazard poses little threat to people and the built environment, but can pose significant damage to the state's economy.

References

[1] "Washington State Hazard Mitigation Plan," *WA State Military Dept. – Emergency Management Division*, January 28, 2008, <http://www.emd.wa.gov/plans/washington_state_hazard_mitigation_plan.shtml> (November 18, 2008)

[2] *Washington State 2001 Hazard Identification and Vulnerability Assessment*, Washington State Military Department, Emergency Management Division, April 2001.

[3] Curt Hart, et al., *2001 Drought Response, Report to the Legislature*, Washington Department of Ecology Water Resources Program, Publication No. 01-11-017, December 2001.

[4] *Planning for Drought: Why Plan for Drought*, National Drought Mitigation Center, University of Nebraska – Lincoln, <http://www.drought.unl.edu/plan/whyplan.htm>, (April 2, 2003).

[5] *Science of Drought*, Washington Department of Ecology Water Resources Program, <http://www.ecy.wa.gov/programs/wr/drought/droughtscience.html>, (April 2, 2003).

[6] *Focus: Drought in Washington State*, Washington Department of Ecology, 2001, <http://www.ecy.wa.gov/pubs/0111003.pdf>, (June 20, 2003).

[7] *2003 Biennial Energy Report – Energy Strategy Update: Responding to the New Electricity Landscape*, Washington Department of Community Trade and Economic Development, Energy Policy Division, February 2003.

[8] "About Pacific Northwest Climate," *Climate Impacts Group – University of Washington*, n.d. <http://cses.washington.edu/cig/pnwc/pnwc.shtml> (February 20, 2008).

[9] *What is Drought: Predicting Drought*, National Drought Mitigation Center, University of Nebraska – Lincoln, *<http://www.drought.unl.edu/whatis/predict.htm>, (April 2, 2003).*

[10] *Mary Getchell, Drought Update: Final Review of the 2001 Drought*, Washington Department of Ecology, news release 01-168, September 25, 2001, <http://www.ecy.wa.gov/news/2001news/2001-168.html>, (April 2, 2003).

[11] Curt Hart, et al., *2001 Drought Response, Report to the Legislature*, Washington Department of Ecology Water Resources Program, Publication No. 01-11-017, December 2001.

[12] *2005 Drought Response – Report to the Legislature*, Washington Department of Ecology, Publication # 06-11-001, February 2006

[13] Ibid.

[14] *Estimated Use of Water in the United States in 1995,* Circular 1200, U.S. Geological Survey, 1998.

[15] William E. Brookreson and Linda Crerar, *The Impact of the 2001 Drought on Washington Agriculture*, Washington Department of Agriculture, April 3, 2001.

[16] *Planning for Drought: Why Plan for Drought*, National Drought Mitigation Center, University of Nebraska – Lincoln, <http://www.drought.unl.edu/plan/whyplan.htm>, (April 2, 2003).

[17] Snover, A.K., P.W. Mote, L. Whitely Binder, A.F. Hamlet, and N.J. Mantua. (2005) *Uncertain Future: Climate Change and its Effects on Puget Sound. A report for the Puget Sound Action Team* by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of Atmosphere and Oceans, University of Washington, Seattle).

[18] Washington State Department of Ecology, Climate Change, *Extreme Weather*. <http://www.ecy.wa.gov/climatechange/extremeweather_more.htm>, (25 October 2012)