National Park Service
U.S. Department of the Interior
Natural Resource Stewardship and Science

North Coast and Cascades Network Climate Monitoring Report

Mount Rainier National Park; Water Year 2017

Natural Resource Data Series NPS/NCCN/NRDS—2018/1175

ON THE COVER
Above normal spring snowpack at Camp Schurman (Elevation 9,440’) nearly buried a toilet structure.
Photograph: Climbing Rangers, NPS

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Ben Wright and Rebecca Lofgren

National Park Service
North Coast and Cascades Network
Mount Rainier National Park
55210 238th Ave E.
Ashford, WA 98304

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

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Contents

Figures

Page

Tables

Page

Executive Summary

Climate and weather events define the ecological characteristics found in national parks and are key to understanding and interpreting changes in natural resources. Everyday park operations including; fire management, search and rescue, maintenance of park infrastructure, and visitor use are influenced by weather. Collecting weather data and maintaining climate records provides essential information needed to support park operations and to monitor park resources.

This report summarizes climate data collected in Mount Rainier National Park during the 2017 water year, and is part of a set of climate summary reports from seven national and historic parks in the North Coast and Cascades Network. Published in the National Park Service's Natural Resource Data Series, annual climate summary reports are intended to provide basic data sets and data summaries in a timely manner, with minimal interpretation and analyses. We intend that the primary audience for this document will be National Park staff, especially decision makers, planners, and interpreters; partners; and interested public.

Temperature and precipitation data are presented from eight weather stations located within Mount Rainier National Park: Camp Muir (10,100' elevation), Carbon River (1,735'), Cayuse (5,200'), Longmire (2,760'), Ohanapecosh (1,950'), two stations at Paradise (5,550' and 5,120'), and Sunrise (6,420'). Data were recorded using automated and manual instruments operated by the National Park Service and other collaborators, including the National Weather Service, National Interagency Fire Center, Natural Resources Conservation Service, and Northwest Avalanche Center. Monthly averages of daily average temperatures and monthly total precipitation are reported for all stations. Comparisons are made to the 30-year normal (1981-2010) for Longmire and Paradise, two stations with long term climate records. Snow water equivalent (SWE) is reported and compared to the 30-year normal for one SNOTEL station within the park and monthly snow depth is reported for four stations within the park.

Average annual temperatures and precipitation were both near to above normal for Water Year 2017. However, significant monthly departures from normal were recorded throughout the year. Overall conditions in winter were colder and wetter than normal, with a shift to warmer and drier conditions from May through September. Snowpack was slightly below normal during the winter months, but due to a cool and wet spring shifted to above normal conditions in March lasting through June. A significant shift in weather patterns occurred in June to above normal temperatures and below normal precipitation for the remainder of the water year. Most notably a 52-day drought where no precipitation fell and two heat waves in August resulting in the second hottest August on record at Paradise.

Acknowledgments

Mount Rainier National Park relies on several cooperating agencies to help support and maintain a long-term climate monitoring program as part of the North Coast and Cascades (NCCN) climate monitoring program. These agencies include:

- National Interagency Fire Center – Remote Automated Weather Stations Program
- National Weather Service – National Weather Service Cooperative Observer Program
- Natural Resources Conservation Service – National Water and Climate Center, SNOTEL and Snow Survey Program
- Northwest Avalanche Center – High Elevation Climate Stations
- Desert Research Institute – Data management and publication

Data management is critical to provide for the availability and analysis of climate data. We depend on the NCCN Data Managers; the Western Regional Climate Center; and the National Climate Data Center for climate data management.

Acronyms

COOP	Cooperative Observer Station
DRI	Desert Research Institute
I&M	Inventory and Monitoring
NCCN	North Coast and Cascades Network
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
RAWS	Remote Automated Weather Stations
SNOTEL	Snowpack Telemetry
SWE	Snow Water Equivalent

Glossary

Climate: Complete and entire ensemble of statistical descriptors of temporal and spatial properties comprising the behavior of the atmosphere. These descriptors include means, variances, frequency distributions, autocorrelations, spatial correlations and other patterns of association, temporal lags, and element-to-element relationships. The descriptors have a physical basis in flows and reservoirs of energy and mass. Climate and weather phenomena shade gradually into each other and are ultimately inseparable (Davey et al. 2006).

Climate Normals: A long-term average value of a meteorological parameter (i.e. temperature) measured at a specific station. For example, "temperatures are normal for this time of year" means that temperatures are at or near the average climatological value for a given time period. Climate normals are usually taken from data averaged over a 30-year period (e.g., 1981-2010), and are concerned with the distribution of data within limits of common occurrence.

NWS-COOP: An extensive network of manually operated weather stations overseen by the National Weather Service. Many Cooperative Observer Program weather sites were established in the late 1800's and as such, provide the best long term climate data. At each station, an observer records daily maximum and minimum temperature, as well as total rain and snowfall.

Period of Record: The total span of time that climate data have been collected at a specific location. The longer the period of record, the more likely the climate data will not be biased by singular weather events or cyclic climate anomalies such as those associated with the Pacific Decadal Oscillation and the El Niño/La Niña-Southern Oscillation.

RAWS: A network of Remote Automated Weather Stations overseen by the National Interagency Fire Center. RAWS stations provide real-time weather data to assist land management agencies in monitoring wildland fire fuels, rating fire danger and predicting fire behavior. RAWS stations all operate during summer months and many at lower elevations operate on a year round basis.

SNOTEL: An automated network of snowpack data collection sites operated by the Natural Resources Conservation Service (NRCS). A standard SNOTEL station consists of a snow pillow, snow depth sensor, a storage type precipitation gage and air temperature sensor. Enhanced sites also measure soil moisture.

Snow Course: A permanent site where trained observers manually measure snow depth, snow water equivalent and density at a series of points along an established transect. Measurements are taken the last week of each month during winter and early spring. Values are recorded as the first of the month.

Snow Water Equivalent (SWE): A measurement describing the amount of water contained within the seasonal snowpack. It can be thought of as the depth of water that would theoretically result if you melted the entire snowpack instantaneously.

Water Year: The Water Year (or Hydrologic Year) is most often defined as the period from October 1st to September 30 of the following year. It is called by the calendar year in which it ends. Thus,

Water Year 2017 is the 12-month period beginning 01 October 2016 and ending 30 September 2017. The period is chosen so as to encompass a full cycle of precipitation accumulation.

Weather: Instantaneous state of the atmosphere at any given time, mainly with respect to its effects on biological activities. As distinguished from climate, weather consists of the short-term (minutes to days) variations in the atmosphere. Popularly, weather is thought of in terms of temperature, precipitation, humidity, wind, sky condition, visibility, and cloud conditions (Davey et al. 2006).

Introduction

Climate is a dominant driver of the physical and ecologic processes of the North Coast and Cascades Inventory and Monitoring Network Parks (NCCN, Figure 1) (Davey et al. 2006). Trends in rainfall and temperature influence how an ecosystem and its organisms function. The quantity and timing of rainfall and snow can influence the productivity and health of forests (Nakawatase and Peterson 2006), the amount of water flowing in streams and rivers (Hamlet et al. 2007) and the increase or decrease in size and terminus position of mountain glaciers. Likewise, temperature can influence the quantity and timing of plant growth and stream runoff, or the extent and duration of winter snowpack and lake ice (Thompson et al. 2009). Through direct and indirect methods, climate affects the behavior and reproduction of terrestrial and aquatic animal species (Crozier et al 2008). Climate is one of the primary causes of disturbance events such as forest fires (Littell and Gwozdz 2011) avalanches, windstorms, debris flows and floods. These events can have a major impact on park landscapes and their associated ecosystems.

Given the importance of climate, it has been identified as a primary vital sign by all 32 Inventory and Monitoring (I&M) networks within the NPS (Gray 2008). The NCCN monitors climate in order to understand variations in other park resources being monitored; to compare current and historic data to understand long-term trends; and to provide data for modeling impacts to park facilities and resources in the future (Lofgren et al. 2010). Climate data, derived from the NCCN climate network will play an important role in understanding and interpreting the physical and ecological Vital Signs monitored within NCCN parks.

The NCCN climate monitoring program capitalizes on climate stations operated by partnering agencies. The NCCN climate monitoring program compiles data from over 60 weather stations in and adjacent to the parks, of which 15 are operated by the National Park Service. While a wide variety of climate parameters are measured as part of the NCCN climate program, this report focuses on two key parameters: precipitation and air temperature, while providing supplemental information on snowpack.

This report summarizes climate data collected from eight weather stations located in Mount Rainier National Park during the 2017 water year, and is part of a set of climate summary reports from seven national and historic parks in the NCCN (Figure 1). Temperature, precipitation, and snow data from the eight weather stations are summarized in the results section of this report.

Annual climate summary reports are intended to provide basic data sets and data summaries in a timely manner, with minimal interpretation and analyses. National Park staff, especially decision makers, planners, and resource educators; partners; and interested public are the primary audience.

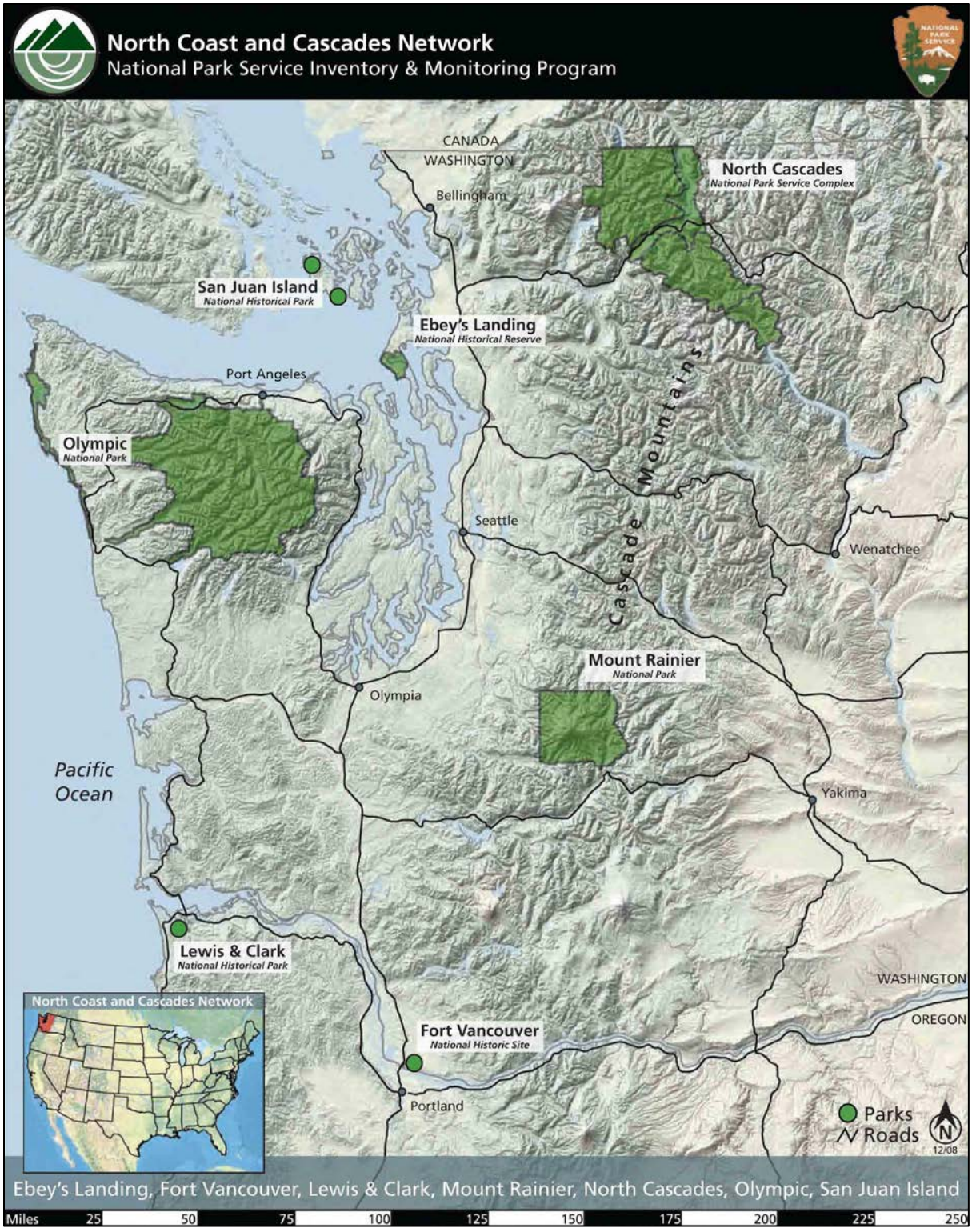

Figure 1. North Coast and Cascades Network suite of National Parks (NCCN).

Methods

Station Locations

This report incorporates data collected from weather stations operated by the National Park Service (NPS), the Natural Resource and Conservation Service (SNOTEL), the National Weather Service (COOP), and the National Interagency Fire Center (RAWS) (Table 1). All stations are located within Mount Rainier National Park (Figure 2).

Table 1. Weather stations referenced in this report.

Station Name	Station Type	Location	Elevation (ft)	Forest Zone	Period of Record
Camp Muir	NPS	Interior	10,100	Alpine	2006 to Present
Carbon River	NPS	Northwest	1,735	Forest	2008 to Present
Cayuse Pass	SNOTEL	Southwest	5,200	Subalpine	2006 to Present
Longmire	COOP	Southwest	2,760	Forest	1909 to Present
Ohanapecosh	RAWS	Southeast	1,950	Forest	2003 to Present
Paradise	COOP	Southwest	5,550	Subalpine	1916 to Present
Paradise	SNOTEL	Southwest	5,120	Subalpine	1981 to Present
Sunrise	NPS	Northeast	6,420	Subalpine	2004 to Present

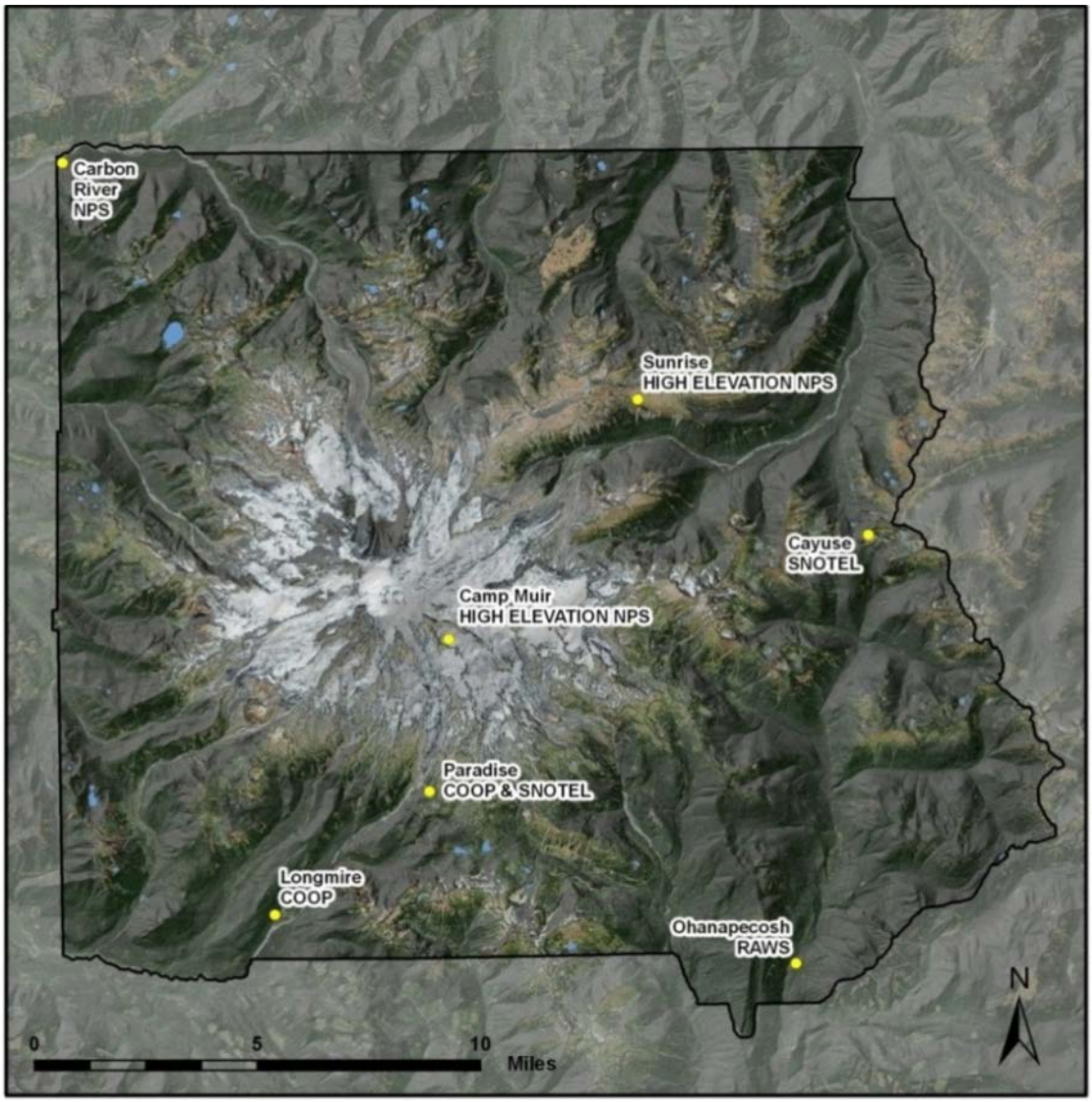

Figure 2. Location of weather stations referenced in this report. The Paradise SNOTEL and Paradise COOP stations are in two separate locations within the same general area.

Weather Station Measurements

Weather stations within the NCCN are managed by a variety of different agencies, each with a specific primary purpose. For this reason, instrumentation, method and period of collection may vary between sites. Table 2 describes the parameters measured at each station, highlights the data presented in this report, and indicates additional data that are available by request from Mount Rainier National Park.

Table 2. Parameters measured at weather stations included in this report. X indicates the parameter is measured and data are presented in this report; ✓ indicates parameter is measured and data are available on request.

Station Name	Managing Agency – Station Type	Air Temp.	Relative Humidity	Precip.	Snow Depth	Snowfall	Snow Water Equivalent	Solar Radiation	Wind Speed & Direction	Soil Temp.	Soil Moisture
Camp Muir	NPS-High Elevation[1]	X	✓	—	—	—	—	✓	✓	—	—
Carbon River	NPS[1]	X	✓	X	✓	—	—	—	—	✓	✓
Cayuse Pass	NRCS-SNOTEL[2]	X	—	X	X	—	✓	—	—	✓	✓
Longmire	NWS-COOP[3]	X	—	X	X	✓	—	—	—	—	—
Ohanapecosh	NIFC-RAWS[4]	X	✓	X	✓	—	—	✓	—	—	—
Paradise	NWS-COOP[3]	X	—	X	X	✓	—	—	—	—	—
Paradise	NRCS-SNOTEL[2]	✓	—	✓	✓	—	X	—	—	✓	✓
Sunrise	NPS-High Elevation[1]	X	✓	—	X	—	—	✓	✓	✓	✓

[1]NPS stations utilize a standard array of automated weather instruments. Parameters are measured at 5 minute intervals and output as hourly averages.

[2]SNOTEL utilize a standard array of automated weather instruments in support of water supply forecasting. Parameters are measured every 60 seconds, and output as hourly averages.

[3]NWS stations rely on a standard array of manually operated weather instruments. Parameters are measured and recorded daily.

[4]RAWS utilize a standard array of automated weather instruments in support of fire weather, which are measured at 10 minute intervals and output as hourly averages.

Data Management

NWS COOP station and NRCS SNOTEL station data used in this report are acquired directly from the managing agencies. Quality assurance and control is provided by these agencies and is described in the NCCN Climate Monitoring Protocol (Lofgren et al. 2010).

The daily data used in this report from NPS and RAWS stations are derived from hourly data which have been evaluated through automated queries and manual display and graphing. Hourly data flagged or identified as suspect are omitted from daily summaries. If more than two hours of data are missing on a given day, no daily values are presented. These calculations and data corrections were performed for NPS and RAWS stations by DRI.

Monthly values are generated and presented for stations where five or fewer daily values are missing. In the case of missing precipitation values, daily quantities may be substituted from another nearby weather station for the purposes of reporting monthly and annual totals. This will only occur when nearby data are available and a known correlation exists between these sites. In these cases where estimates are generated from nearby stations, data are footnoted and a description of the quantity and source of data replacement is given.

Data Quality

Due to problems associated with equipment failure and access to these remote sites, data gaps exist at several stations.

Gaps exist in the Carbon data during April totaling eleven days due to theft of the station battery.

Temperature data are missing from the Sunrise High Elevation site for 28 days in May and 19 days in June due to sensor malfunction.

The Ohanapecosh RAWS precipitation gauge is not heated and can result in missing data during winter months. However, an adjacent NPS climate station is equipped with a precipitation gauge that measures frozen precipitation. These precipitation data were substituted for the months of December through February, and monthly data are footnoted in summary tables.

Precipitation data are missing from Paradise COOP for more than five days in October, November, December, March and April, totaling seven, nineteen, five, ten and twenty six days, respectively. Due to the multiple day accumulated precipitation measurement at the end of April occurring across the change in months, April 20-May 3, Paradise SNOTEL data was substituted to eliminate shifting precipitation that fell in April from being counted towards the May total. April and May totals were included in the tables and footnoted. For the remainder of the year, accumulated precipitation was collected and recorded as multiple day totals when daily observations were missed. When annual precipitation totals from the Paradise COOP station are compared with the adjacent SNOTEL site, the total annual precipitation values are within 2.6 inches or 1.8%. Since values are within standard error for many electronic gauges, multiple day accumulated precipitation data are included in monthly totals and analysis.

The Longmire COOP station was missing observations for six days in October, ten days in November and six days in December. Missing temperature data was substituted with adjacent automated NPS weather station data and footnoted in the table. Accumulated precipitation was collected and recorded as multiple day totals when daily observations were missed. Multiple day accumulated precipitation data are included in monthly totals and analysis.

The wind speed sensor at the Camp Muir and Sunrise High Elevation stations are not heated and can become ice encrusted during cold, wet conditions. Periods of known ice encrusted sensors were removed from the dataset.

Data Reporting

Data in this report are based on the hydrologic or water year and organized by month and seasons. Ecosystems in the Pacific Northwest are dominated by two distinct hydrological periods, a wet season generally beginning in late October and ending in June, and a drought season that generally extends from July to September. While a calendar year divides the wet winter season, the use of a water year closely reflects the timing and seasonality of many physical and ecological processes that are driven by climate, such as soil saturation and forest evapotranspiration, onset and breakup of lake ice, glacial accumulation and ablation balances, magnitude and timing of stream flow, emergence and flowering of plants and migratory timing of bird species.

Seasons in this report are distinguished based on National Weather Service (NWS) standards for the Northern Hemisphere. The NWS defines December, January, and February as winter; March, April, and May as spring; June, July, and August as summer, and September, October, and November as fall.

The main report provides monthly averages of daily average temperatures and monthly total precipitation for all stations listed in Tables 2 and 3. While routinely collected in metric units, data are presented in Fahrenheit and inches to facilitate use and interpretation by the public and park staff. Two stations with long term records; Paradise and Longmire, are compared to the 30-year climate normal. Snow water equivalent is reported and compared to the 30-year climate normal for one SNOTEL within the park, and monthly snow depth at the first of each month is reported for Cayuse, Longmire, Paradise and Sunrise stations. Available upon request are hourly, daily, or monthly weather data from each station noted in Tables 1 and 2.

Results

Temperature

Temperatures were below average at all sites from October through April, with the exception of above normal temperatures in November (Table 3; Figures 3 and 4). In May, a significant shift in the weather pattern occurred with all stations recording warmer than average temperatures from May through September (Figures 3 and 4). August exhibited the most extreme deviation from normal with temperatures 6.9 °F above normal at Paradise and 5.2 ºF at Longmire. Despite the unusually warm summer, average water year temperatures were near normal to slightly above normal across all sites due to the colder than normal winter and early spring months.

Table 3. Average monthly air temperatures (°F) from weather stations within Mount Rainier National Park in Water Year 2017.

Season	Month & Year	Camp Muir NPS	Carbon River NPS	Cayuse Pass SNOTEL	Longmire NWS COOP	Ohanapecosh RAWS	Paradise NWS COOP	Sunrise NPS
Fall	October 2016	22.3	45.6	38	43.9[b]	45.9	36.6	34.7
	November 2016	20.0	42.3	36	40.7[b]	41.9	35.2	32.7
Winter	December 2016	9.2	30.3	23	26.4[b]	29.24	20.8	19.4
	January 2017	12.3	29.7	26	26.8	26.92	25.0	22.5
	February 2017	12.4	33.3	28	31.1	31.9	26.0	23.6
Spring	March 2017	15.2	38.1	31	34.2	35.4	28.6	27.3
	April 2017	15.6	– [a]	32	39.1	40.4	30.8	29.1
	May 2017	28.7	50.7	44	49.9	51.7	43.1	– [c]
Summer	June 2017	36.1	55.9	49	55.6	59.3	48.3	– [c]
	July 2017	44.4	61.3	55	61.9	65.2	55.2	53.6
	August 2017	47.7	63.7	60	65.2	67.3	61.1	58.4
Fall	September 2017	37.7	55.7	51	56.3	58.1	52.1	47.9
Water Year		25.1	– [a]	39.4	44.3	46.1	38.6	– [c]

[a] 11 days of temperature data are missing in April.

[b] October, November and December are missing more than 5 days of temperature. Daily average values were substituted from a co-located NPS site (see Data Quality).

[c] More than five days of temperature data missing in May and June.

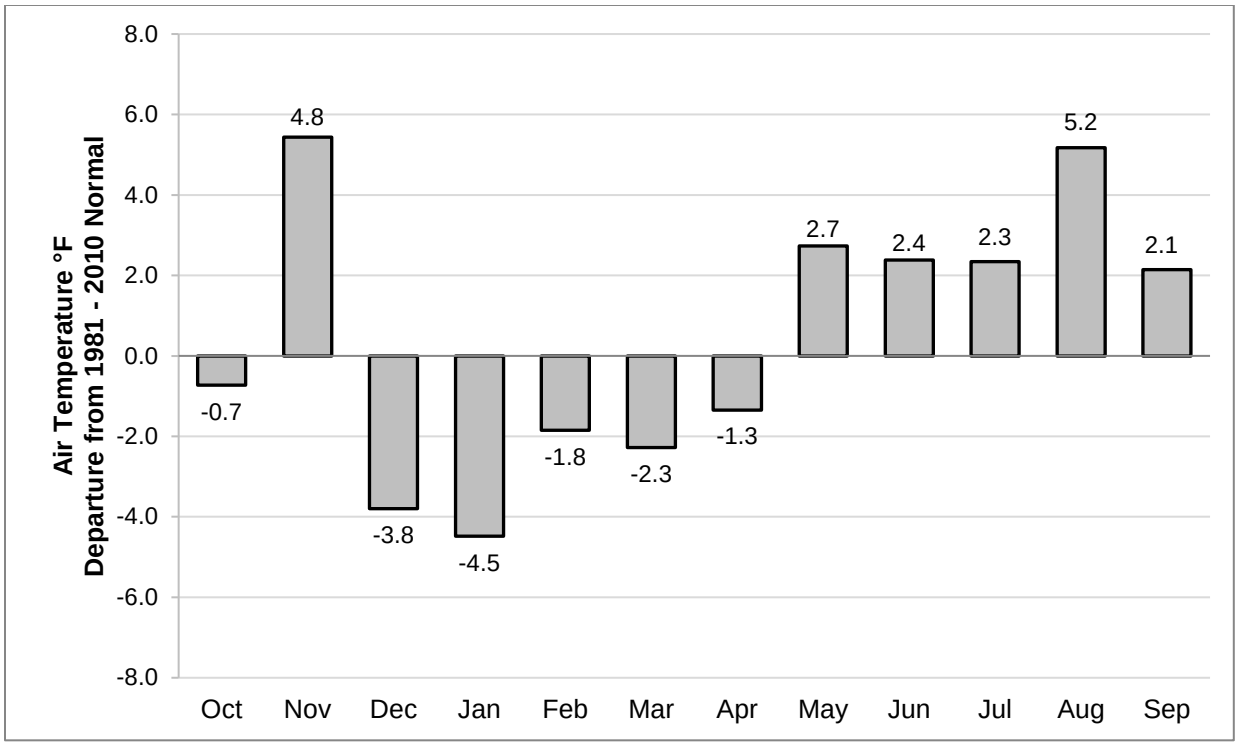

Figure 3. Comparison of average monthly temperature (°F) for Longmire (COOP) in Water Year 2017 against monthly averages for the climatological normal 1981-2010.

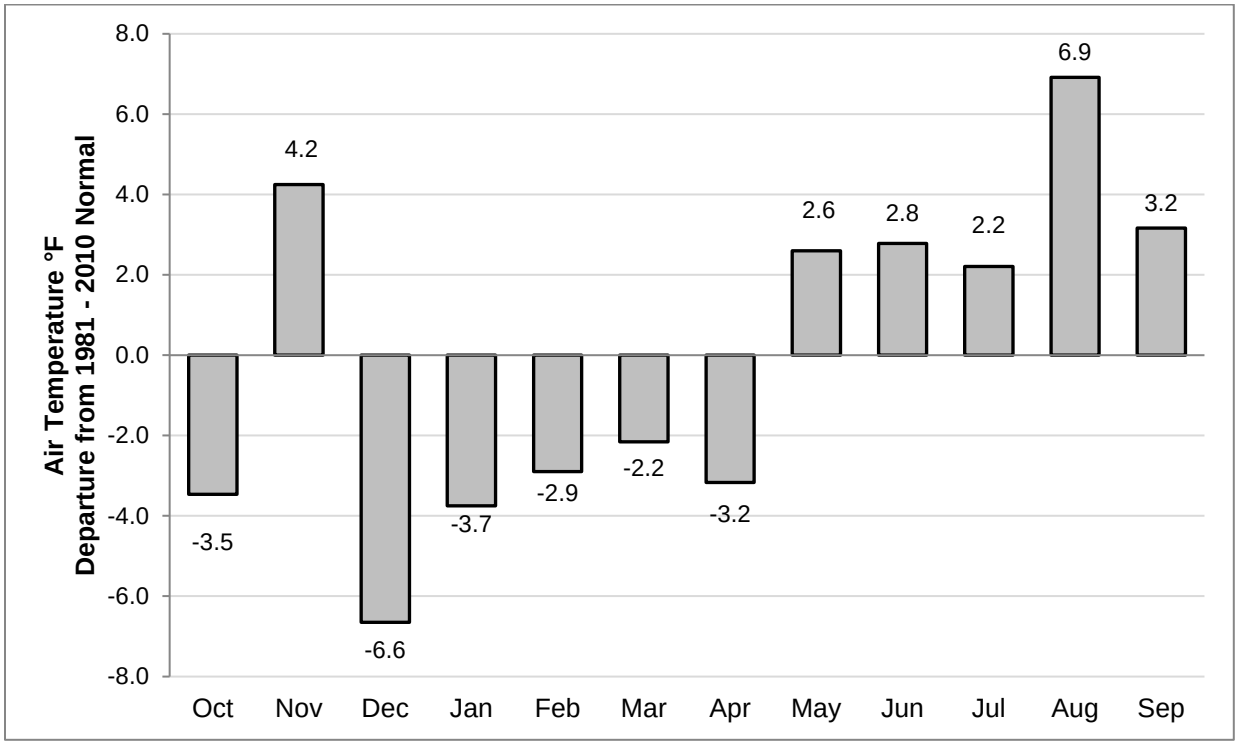

Figure 4. Comparison of average monthly temperature (°F) for Paradise (COOP) in Water Year 2017 against monthly averages for the climatological normal 1981-2010.

Precipitation

Annual precipitation in Water Year 2017 was near normal, however varied significantly by season (Table 4). October recorded the largest departure from normal with precipitation 252% of normal at the Longmire COOP station and 256% of normal at the Paradise COOP station (Figures 5 and 6). November to January experienced near to significantly below normal precipitation. Precipitation for February through April was between 130-224% of normal at the Longmire and Paradise COOP stations (Figures 5 and 6). Wet conditions continued in May with slightly more precipitation than normal. June and July were significantly drier than normal. The notable exceptions were Carbon River and Paradise, which were both above normal in June due to receiving nearly half of their monthly precipitation, 2.67 and 2.91inches respectively, on June 15th and 16th from thunderstorms. July was notably dry with no precipitation falling across the park, only the fifth time that has occurred since 1916. Below normal precipitation conditions continued in August and September.

Table 4. Total Monthly precipitation (inches) from weather stations within Mount Rainier National Park in Water Year 2017.

Season	Month & Year	Carbon River NPS	Cayuse Pass SNOTEL	Longmire NWS COOP	Ohanapecosh RAWS	Paradise NWS COOP
Fall	October 2016	16.7	17.0	19.9	16.7	26.7
	November 2016	8.8	8.7	9.6	9.3	18.7
Winter	December 2016	7.2	7.5	10.3	7.2[b]	18.8
	January 2017	3.7	5.2	5.2	3.7[b]	9.4
	February 2017	9.8	12.4	11.6	10.2[b]	16.5
Spring	March 2017	14.6	13.0	16.7	16.7	24.4
	April 2017	– [a]	7.6	8.6	7.4	11.0[c]
	May 2017	5.9	2.9	5.1	3.2	6.1[c]
Summer	June 2017	6.0	3.1	3.2	3.5	6.2
	July 2017	0.0	0.0	0.0	0.0	0.0
	August 2017	0.4	0.1	0.3	0.1	0.6
Fall	September 2017	3.1	1.6	1.6	2.2	3.3
Water Year		– [a]	79.1	92.0	80.3	141.7

[a] 11 days of precipitation data are missing in April.

[b] Precipitation gauge unheated, co-located NPS station values substituted December, January and February.

[c] Paradise SNOTEL data substituted April 20th through May 3rd.

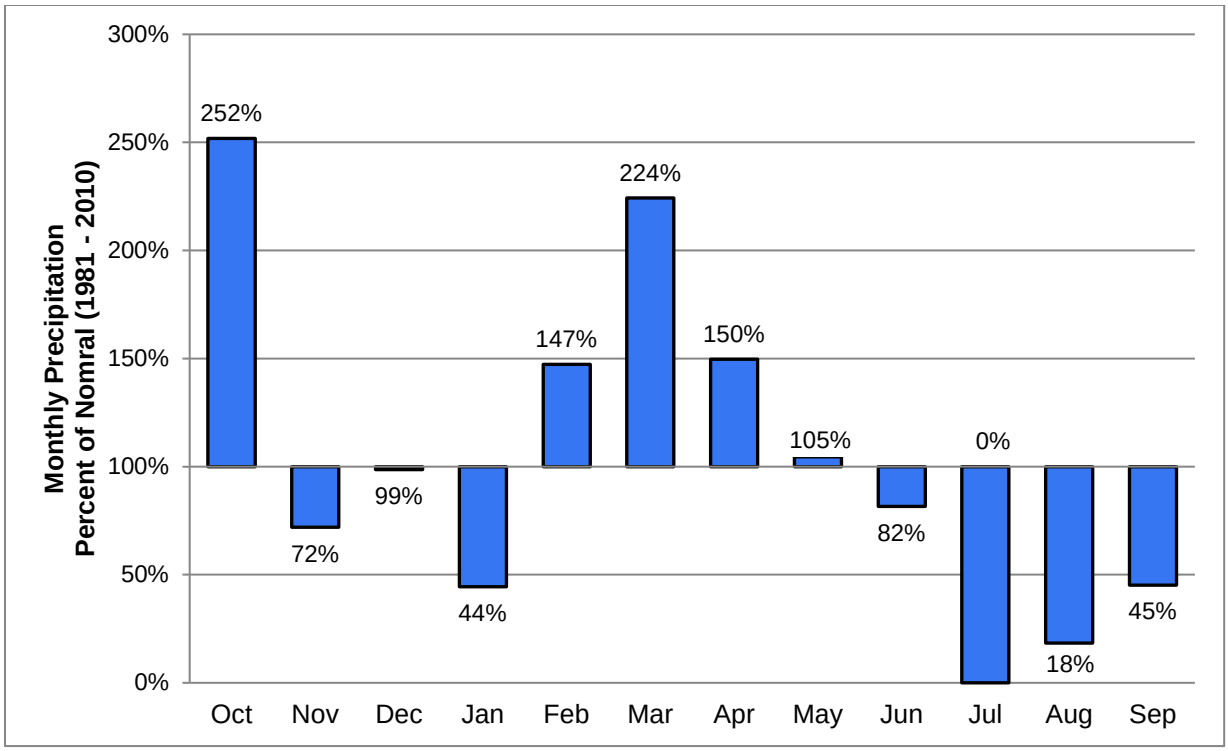

Figure 5. Comparison of total monthly precipitation (inches) at Longmire (COOP) in Water Year 2017 against the climatological normal 1981-2010.

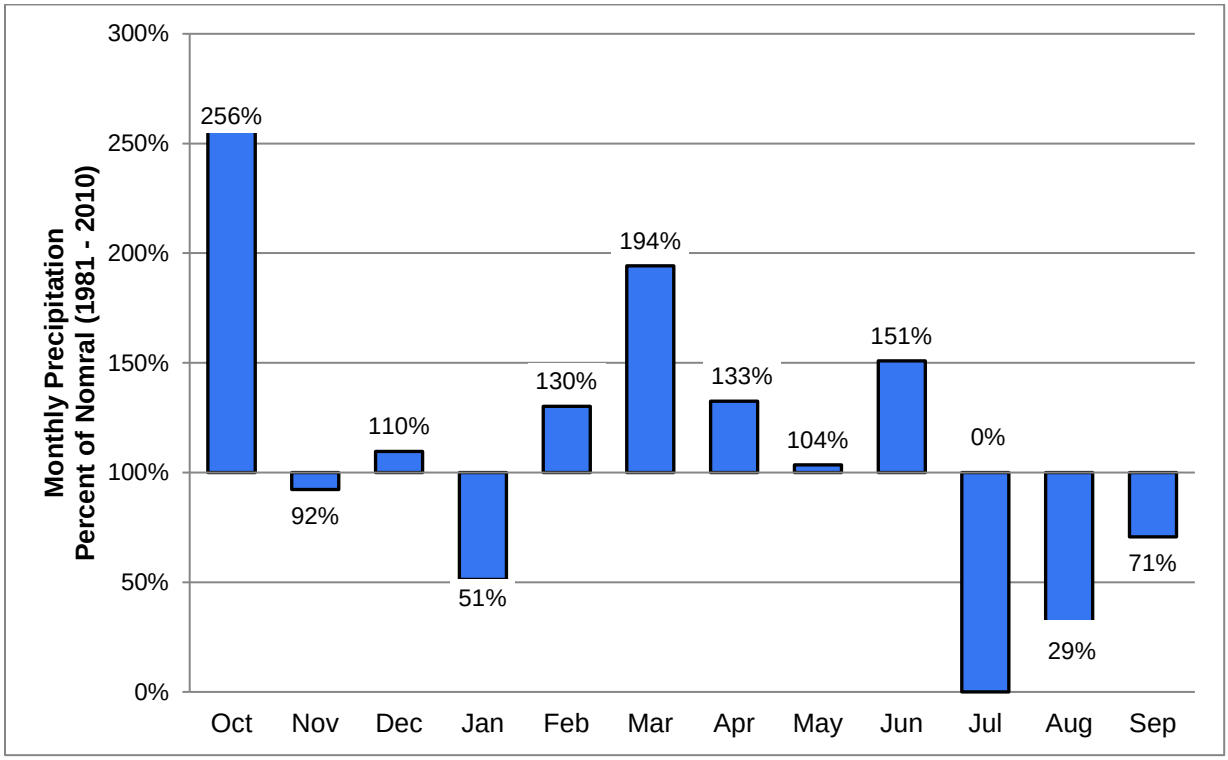

Figure 6. Comparison of total monthly precipitation (inches) at the Paradise (COOP) in Water Year 2017 against the climatological normal 1981-2010.

Snowpack

Due to the warmer than normal temperatures in November, the snowpack was late to develop in early December (Table 5, Figure 7). Cold temperatures in December combined with near normal precipitation to create 99% of normal snowpack by early January. Below normal precipitation in January resulted in a snowpack 88% of normal through early February. Below normal temperatures, combined with abundant precipitation in March, resulted in substantial snowpack growth to 118% of normal SWE by the beginning of April (Figure7, Figure 8). Continued cool and wet conditions through April and early May maintained above normal spring snowpack conditions. However, a shift to warm weather in late May and June rapidly melted the snowpack leading to melt out by July 19th at Paradise only six days later than normal (Figure 7, Figure 8).

Table 5. Snow Depth (inches) measured on the first day of the month at SNOTEL, COOP, and NPS stations within Mount Rainier National Park during Water Year 2017.

Month & Year	Cayuse Pass SNOTEL	Longmire NWS COOP	Paradise NWS COOP	Sunrise High Elevation
October 1st 2016	0	0	0	0
November 1st 2016	2.0	0	0	16.9
December 1st 2016	42.0	0	47.0	45.7
January 1st 2017	96.0	39.0	106.0	63.8
February 1st 2017	85.0	20.0	102.0	69.1
March 1st 2017	132.0	30.0	153.0	93.9
April 1st 2017	149.0	12.0	174.0	115.8
May 1st 2017	160.0	0	178.0	128.8
June 1st 2017	93.0	0	124.0	78.7
July 1st 2017	0	0	44.0	4.0
August 1st 2017	0	0	0	0

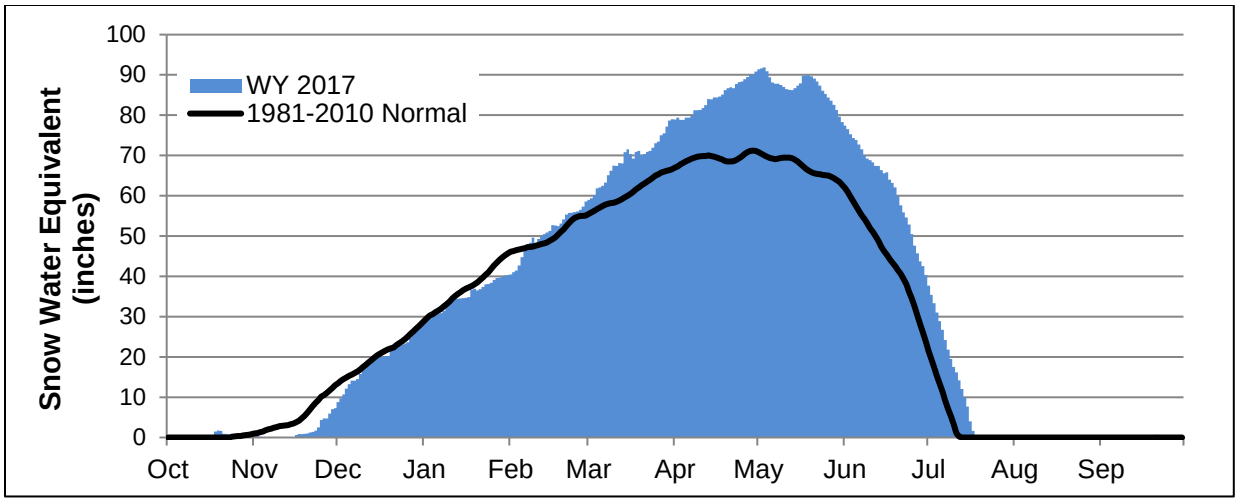

Figure 7. Comparison of snow water equivalent at the Paradise SNOTEL in Water Year 2017 against the 1981-2010 normal.

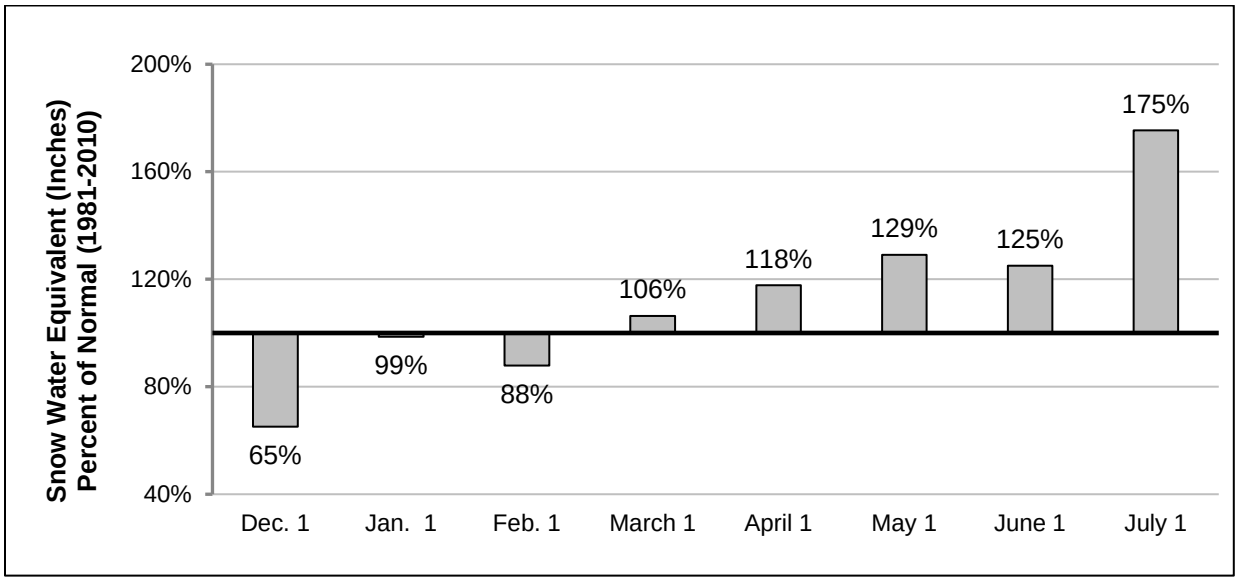

Figure 8. Comparison of snow water equivalent (inches) on the first day of each month at the Paradise Snow Course in Water Year 2017 against the climatological normal 1981-2010.

2017 Water Year in Review

Significant Weather Events and Patterns

Overall the year was characterized by extremes. Winter through spring was considerably colder and wetter than normal with a transition in June to considerably warmer and drier than normal through the end of the water year. Averaged over WA State, the June through August average temperatures ranked as the 4th warmest in the historical record (OWSC 2017). Total monthly June through August precipitation was the 7th driest for WA State (OWSC 2017).

The 2017 water year started off wet, with precipitation being recorded at Carbon River every day of October. Seven days in October saw over an inch of rain recorded each day. On October 14th we

measured 2.71 inches at Carbon River and 3.36 inches at Paradise the wettest day of October in the wettest month of the water year 2017 across all sites in the park. November was considerably warmer and drier than October in comparison to normal resulting in below normal snowpack heading into December.

A series of strong storms moved through the park from November 24th-December 12th bringing over twelve feet of snowfall to the higher elevations of the park, while also contributing the first snowfall of the year at Longmire. These early December storms brought significantly below average temperatures. There were 13-days in December with average daily temperatures 10-20 °F. The coldest temperatures across nearly all sites for the year occurred January 4th with recorded temperatures of 3°F at Paradise. The exception was Camp Muir, which recorded -8.4 °F two days earlier, on January 2rd. An early February storm dumped 5 feet of snowfall over 3 days at Paradise followed by the wettest day of the year February 9th when 3.97 inches of precipitation was recorded at Paradise. March was extremely wet, as Carbon River recorded precipitation on 29 of 31 days. Precipitation at Longmire and Paradise was around 200% of normal in March. Overall, the winter and early spring was characterized by periods of heavy snowfall and cold temperatures with a few rain events to high elevation sites and 707 inches of snowfall at Paradise.

Temperatures during the months of June, July, August and September were well above normal in water year 2017. Temperatures in Longmire reached above 90°F 14 times during that period with two days June 26th and August 4th hitting 99°F (the warmest days of the water year for all sites excluding Camp Muir). These extreme temperatures came in three significant heat waves, June24th - 26th, August 1st -12th and August 28th- September 7th. August was the second hottest month at Paradise and third hottest at Longmire since 1916 and 1909, respectively. With the arrival of the hot weather in late June also came a drought; for example, no precipitation was recorded at Longmire from June 21st through August 11th, 52 days. July tied the record of no measurable precipitation in Longmire with 1922, 1929, 1967 and 1984. The drought was broken by lightning storms on August 11th that ignited 13 wildfires just east of the Cascade Crest in the Norse Peak wilderness outside the park. These fires merged and burned over 55,000 acres outside park boundaries by mid-October when the fire was finally contained. Unusual fire behavior following the early September heat wave, forced Mount Rainier to close and evacuate the White River Entrance, Chinook Pass and Sunrise areas of the park from September 5-13th. Air quality was particularly bad at Mount Rainier in late summer 2017, due for the most part to the effects of the Norse Peak Fire (Figure 9).

Figure 9. Wildfire smoke over the east side of the park on August 22, 2017 (photo NPS).

Also of note was the near total eclipse that occurred on August 21, 2017. Figure 10 shows the effect on air temperature of the eclipse at sunrise where a temperature drop of over 4 °F occurred for 2 hours while the moon blocked the sun during the 9 and 10 am readings.

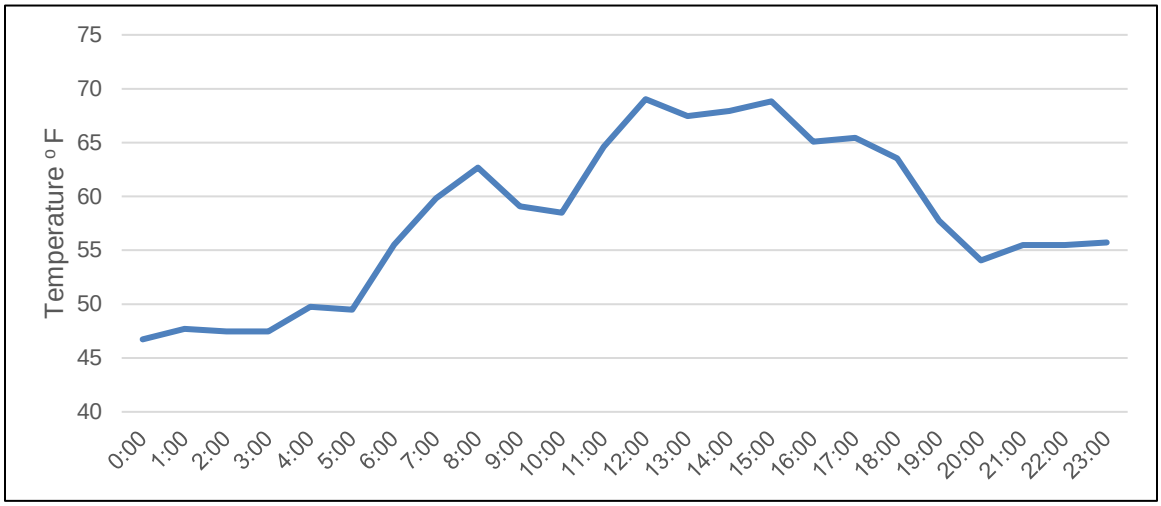

Figure 10. Temperature drop at Sunrise High Elevation site created by solar eclipse on August 21, 2017.

Parkwide Precipitation Summary

Orographic effects produce heavy precipitation on the upper elevation, west-facing slopes of Mount Rainier National Park. The northeastern and eastern sides of the mountain receive less precipitation due to the rain shadow effect and prevailing southwesterly winds (Hemstrom and Franklin 1982). For Water Year 2017, precipitation at upper elevation weather stations neared 140 inches, while lower elevation weather stations ranged between 80.3 and 92.0 inches. The highest recorded amount of

precipitation, 141.7 inches, occurred on the southwest slopes at Paradise (5,400 ft.), whereas on the eastern slopes of Mount Rainier, 79.1 inches was recorded at Cayuse Pass (5,100 ft.) (Figure 11).

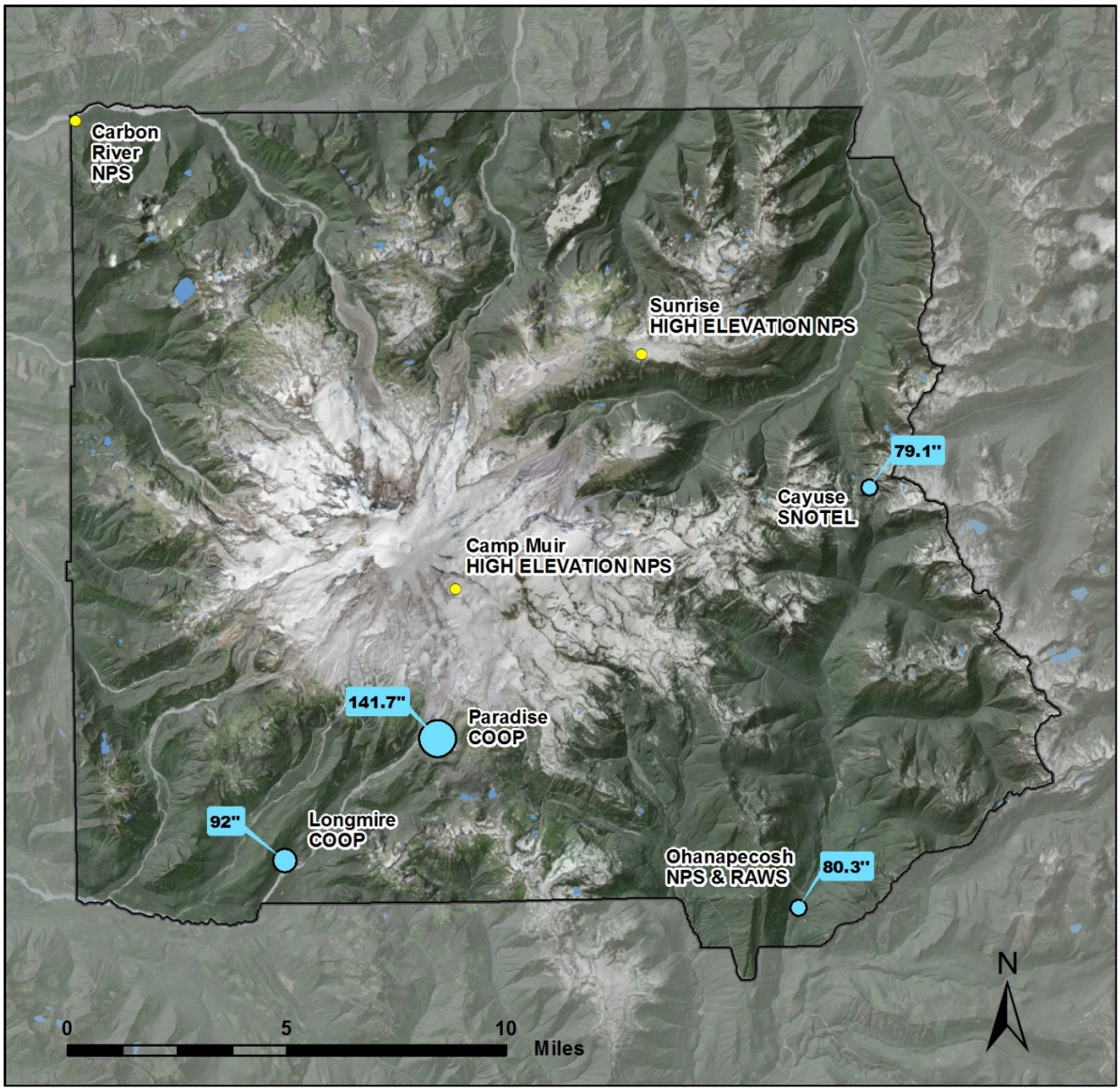

Figure 11. Total precipitation measured at weather stations located within Mount Rainier National Park during Water Year 2017. Blue circles are proportional to the total amount of precipitation measured at each site.

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Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525