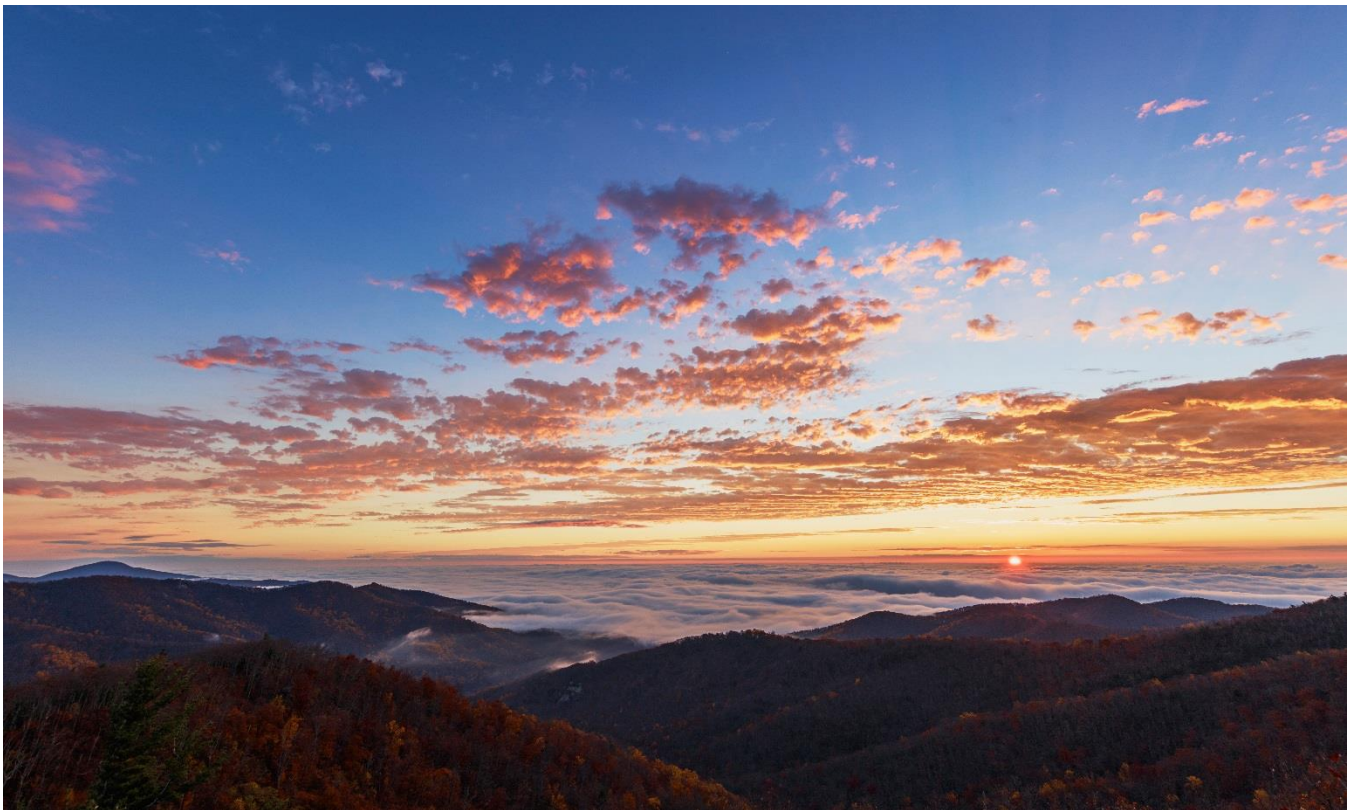




Weather of Shenandoah National Park

Mid-Atlantic Network Summary Report for 2017

Natural Resource Data Series NPS/MIDN/NRR—2018/1170



ON THE COVER

“Fog Ocean Sunrise” — Shenandoah National Park

Image courtesy of NPS/N. Lewis

Weather of Shenandoah National Park

Mid-Atlantic Network Summary Report for 2017

Natural Resource Data Series NPS/MIDN/NRR—2018/1170

John. E.B. Wofford

Mid-Atlantic Network
National Park Service
120 Chatham Lane
Fredericksburg, VA 22405

May 2018

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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 a subject-matter expert who was 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.

This report is available in digital format from the [NPS Mid-Atlantic Network website](#) and the [Natural Resource Publications Management website](#). If you have difficulty accessing information in this publication, particularly if using assistive technology, please email irma@nps.gov.

Please cite this publication as:

Wofford, J. E. B. 2018. Weather of Shenandoah National Park: Mid-Atlantic Network summary report for 2017. Natural Resource Data Series NPS/MIDN/NRR—2018/1170. National Park Service, Fort Collins, Colorado.

Contents

	Page
Figures.....	iv
Tables.....	v
Abstract.....	vi
Introduction.....	1
Methods.....	2
Observing Stations.....	2
Climate Indicators and Climatological Normals	5
Drought Status	7
Data Processing and Quality Assurance	7
Results.....	8
Temperature Summary	8
Precipitation Summary	15
Literature Cited	22

Figures

	Page
Figure 1. Location of weather observing stations around Shenandoah National Park selected as most representative of the parks in 2017	3
Figure 2. Maps showing departure from average monthly maximum temperature in 2017 compared to the 30-year normal (1981–2010).....	9
Figure 3. Maps showing departure from average monthly minimum temperature in 2017 compared to the 30-year normal (1981–2010).....	10
Figure 4. Maps showing percent of average monthly precipitation in 2017 compared to the 30-year normal (1981–2010).....	16
Figure 5. Palmer Drought Severity Index (PDSI) for Northern Virginia, 2015–2017.....	19
Figure 6. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for Virginia in 2017.	20
Figure 7. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for the Southeast in 2017.	21

Tables

	Page
Table 1. List of weather observing stations around Shenandoah National Park selected as most representative of the parks in 2017.	4
Table 2. Summary of 2017 monthly average temperatures for selected stations.	11
Table 3. Summary of 2017 departure from normal temperature based on the 30-year normal (1981-2010) for selected stations.....	12
Table 5. Seasonal and annual temperature and precipitation rankings for 2017 over 123 years for the Western Piedmont (NOAA 2018b).....	14
Table 6. Seasonal and annual temperature and precipitation rankings for 2017 over 123 years for Northern Virginia (NOAA 2018b).....	14
Table 7. Seasonal and annual temperature and precipitation rankings for 2017 over 123 years for the Central Mountains (NOAA 2018b).....	14
Table 8. Summary of 2017 monthly precipitation for selected stations.	17
Table 9. Summary of 2017 percent of normal precipitation based on the 30-year normal (1981-2010) for selected stations.	18
Table 10. Status of 2017 precipitation indicators compared to the 30-year normal (1981-2010) for selected stations.	18
Table 11. Top five wettest days and top five dry spells (consecutive days with a trace of less of liquid precipitation) during 2017 from all stations.	19

Abstract

The Mid-Atlantic Network (MIDN) weather and climate monitoring protocol documents the current status and long-term trends in air temperature and precipitation at multiple temporal and spatial scales in MIDN parks. This report provides a concise weather and climate summary for Shenandoah National Park (SHEN) for the time period of January 1 to December 31, 2017. SHEN is located in the Western Piedmont, Northern Virginia, and Central Mountain Climate Divisions of Virginia. In 2017, a total of eight weather stations were selected to report park weather and climate conditions, and a large suite of precipitation and temperature metrics were summarized. Ultimately, 2017 was a very warm year. It tied as the warmest on record for the Western Piedmont and was the 3rd and 5th warmest for Northern Virginia and the Central Mountains, respectively. All seasons were warmer than normal, particularly the winter (3rd warmest in all divisions since 1895). The year was also drier than normal, ranging from the 34th (in Northern Virginia) to the 48th (in the Central Mountains) driest out of 123 years of records. Moderate drought conditions occurred during the winter, early spring, and fall seasons of 2017.

Introduction

Weather and climate are widely recognized as key drivers of terrestrial and aquatic ecosystems, affecting biotic as well as abiotic ecosystem characteristics and processes. Global and regional scale climatic patterns, trends, and variations are critical to the cycling of elements, nutrients, and minerals through ecosystems and can deliver pollutants from regional and even global sources (National Assessment Synthesis Team 2001). These variations and trends influence the fundamental properties of ecologic systems such as soil-water relationships and plant-soil processes and their disturbance rates and intensity. Information obtained from meteorological monitoring will be useful to interpreting and understanding changes in species composition, community structure, water and soil chemistry, and related landscape processes (Comiskey and Callahan 2008).

The purpose of this report is to provide a concise weather and climate summary for January 1 to December 31, 2017, and to place current patterns and trends in an appropriate historical and regional context (Marshall et al. 2012). It is our intention that this report will satisfy an inherent interest in meteorological phenomena and meet the Mid-Atlantic Network (MIDN) Weather and Climate Monitoring Protocol objective:

- Document current status and long-term trends in air temperature and precipitation at multiple temporal scales (e.g., daily, monthly, seasonal, annual, and decadal) and spatial scales (e.g., individual stations and aggregated stations such as climate divisions) utilizing existing weather and climate monitoring programs and datasets.

To accomplish this objective, a variety of atmospheric data streams were evaluated for their quality, longevity, and applicability to relevant MIDN parks. Since no single weather observing network contains all the pertinent measures of atmospheric phenomena to assess ecosystem health, an objective analysis of the data networks was developed and outlined in the Weather and Climate Monitoring Protocol for the Eastern Rivers and Mountains Network and Mid-Atlantic Network of the National Park Service (Marshall et al. 2012). Through this analysis, a select number of weather/climate observing stations were chosen as representative of each park; these are the primary data sources used in the profile of 2017's climate summary.

In addition to a suite of summary tables, graphs, and narratives, we specifically identify a series of key weather indicators to report status and trends on an annual basis and periodically in separate and more thorough reports (for the most recent trend report, see Knight et al. 2016). These key indicators are summarized in this report and are further described in the protocol (Marshall et al. 2012).

Methods

Observing Stations

A total of eight weather observing stations comprising four weather observing networks were selected as the most representative weather stations around Shenandoah NP in 2017 (Figure 1, Table 1). One historic station (MDSV2) was excluded in 2017 due to low reporting. Representative stations within a 100-km range of each park were chosen based on several criteria, which include proximity to the park, the representativeness of the station to the park elevation profile, the type and frequency of observations, the period of record of the data, and data availability (Marshall et al. 2012). Moreover, the percentage of time a station reports a particular parameter (e.g., temperature) can influence data inclusion. Shenandoah National Park (NP) is located in Virginia Climate Division 3 (Western Piedmont), 4 (Northern Virginia), and Virginia Climate Division 5 (Central Mountain). Most of the park is found within the Northern Virginia Division. A climate division is a region that is reasonably homogenous with respect to climatic and hydrologic characteristics and is frequently used for compiling climate statistics (<http://www.esrl.noaa.gov/psd/data/usclimdivs/data/map.html>).

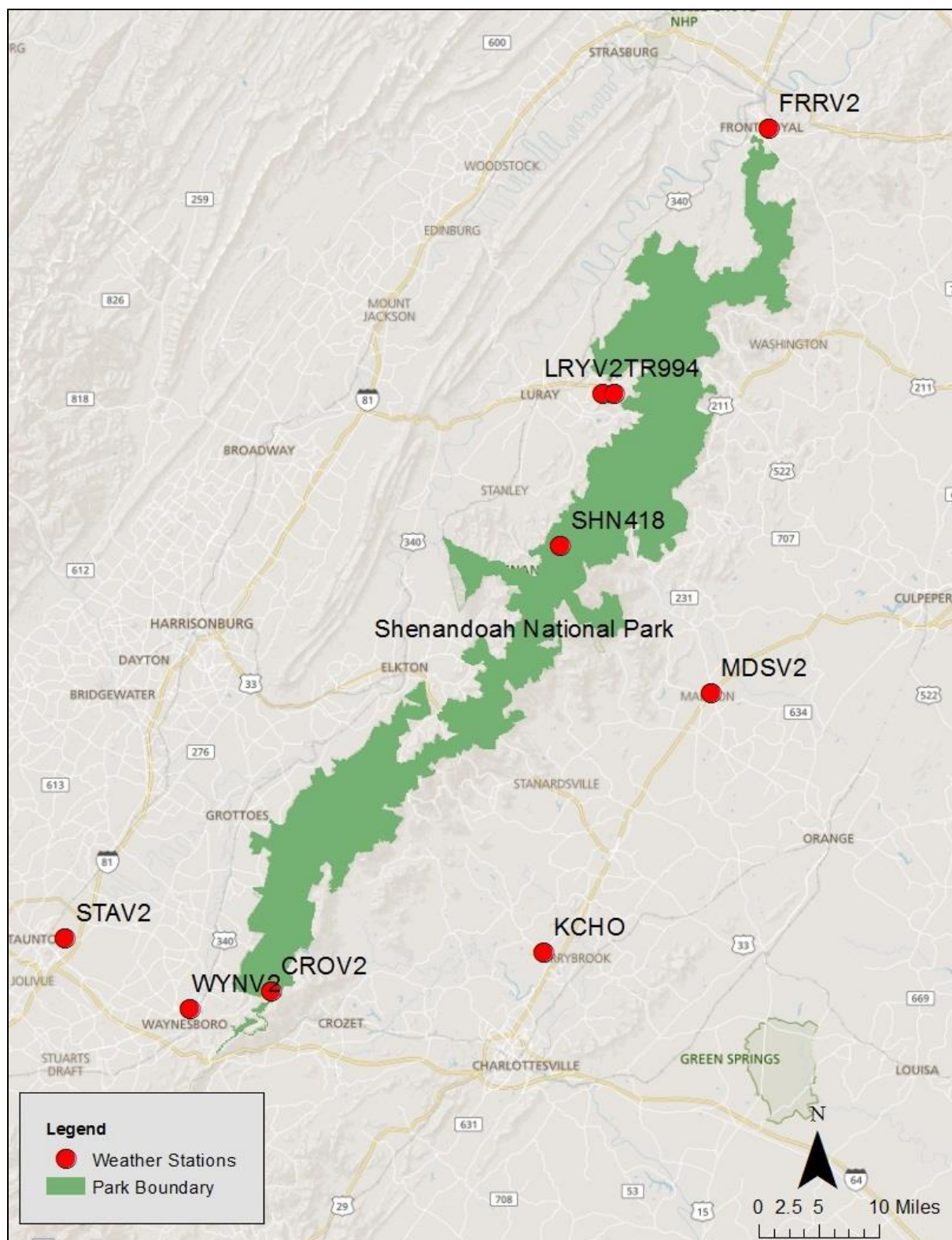


Table 1. List of weather observing stations around Shenandoah National Park selected as most representative of the parks in 2017.

Station Name	Station	Observing Network ^B	Period of Record (POR)	Percentage of Time Reporting Temperature for 2017	Percentage of Time Reporting Precipitation for 2017	Percentage of Time Reporting Temperature for entire POR	Percentage of Time Reporting Precipitation for entire POR
Big Meadows	SHN418	CASTNET	07/01/1988 - Present	97.5	96.7	98.6	98.4
Charlottesville-Albemarle Airport	KCHO	ASOS	01/07/1973 - Present	99.7	100.0	43.1 ^C	36.4 ^C
Front Royal	FRRV2	COOP	12/01/1995 - Present	84.1	97.5	98.8	98.8
Headquarters	TR994	RAWS	11/15/2006 - Present	96.7	96.7	97.5	97.5
Luray 5 E	LRYV2	COOP	03/01/1941 - Present	98.6	98.4	92.8	96.9
Madison ^A	MDSV2	COOP	01/01/1996 - Present	0.0	20.0	63.7	64.7
Sawmill Ridge	CROV2	RAWS	11/15/2006 - Present	100.0	100.0	91.1	91.1
Staunton WTPD	STAV2	COOP	01/01/1893 - Present	100.0	100.0	95.8	92.0
Waynesboro WTP ^D	WYNV2	COOP	10/01/2000 - Present	98.4	98.9	95.4	94.8

^A Data from the Madison station MDSV2 is not included in this report due to low reporting percentages for both temperature and precipitation in 2017.

^B Observing networks are: CASTNET — Clean Air Status and Trends Network, ASOS — Automated Surface Observation System, COOP — National Weather Service Cooperative Observer Program, and RAWS — Remote Automated Weather Stations.

^C The percentage of time reporting temperature and precipitation for KCHO is 99.9 from 2001 through 2010.

^D WTP – Water Treatment Plant

Climate Indicators and Climatological Normals

A suite of indicators were identified to provide a summary of weather and climate conditions (Marshall et al. 2012). The following are the climate indicators selected for each of the parks:

- Average Annual Mean Temperature—A measure of the composite mean temperature (averaging the maximum and minimum on a daily basis) for an entire year
- Average Annual Maximum Temperature—A measure of the average of the daily maximum temperature for an entire year
- Highest Annual Maximum Temperature—A measure of the individual highest maximum temperature each year
- Annual Number of Hot Days (maximum temperature equal to or exceeding 90°F (32°C)—A measure of warm season heat using a threshold of days with a 90°F (32°C) maxima
- Average Annual Minimum Temperature—A measure of the average of the daily minimum temperature for an entire year
- Lowest Annual Minimum Temperature—A measure of the individual lowest minimum temperature each year
- Annual Number of Cold Days (maximum temperature less than or equal to 32°F (0°C))—A measure of cold season chill using a threshold of days with a 32°F (0°C) maxima
- Annual Number of Subfreezing Days (minimum temperature less than or equal to 32°F (0°C))—A measure of cold season chill using a threshold of days with a 32°F (0°C) minima
- Annual Number of Subzero Days (minimum temperature less than or equal to 0°F (-17.8°C))—A measure of cold season chill using a threshold of days with a 0°F (-17.8°C) minima
- Growing Season Length (number of days between last freeze in spring and first freeze in fall)—A measure of the local growing season as tallied by the total number of days between the last 32°F (0°C) in the spring and the first 32°F (0°C) in the fall
- Annual Precipitation—A measure of total liquid (and its equivalent melted snow) for all days
- Autumn Precipitation (October 1 – December 31) - The three month total precipitation including rain and melted snow
- Annual Number of Heavy Precipitation Days (liquid equal to or greater than 1.0 in (25mm))—A measure of the frequency of heavy precipitation events during each year
- Annual Number of Extreme Precipitation Days (liquid equal to or greater than 2.0 in (50mm))—A measure of frequency of extreme precipitation events during each year

- Annual Number of Micro-droughts—A measure of micro-droughts for the year as the number of periods of 7+ days without rain
- Annual Snowfall—A measure of total solid precipitation (includes sleet and hail; does not include freezing rain)
- Annual Number of Measureable Snow Days—A measure of the severity of winter precipitation as the number of days receiving more than or equal to 0.1 in (0.3 cm) of solid precipitation (includes sleet and hail; does not include freezing rain)
- Annual Number of Moderate Snow Days—A measure of the severity of winter precipitation as the number of days receiving more than or equal to 3 in (7.6 cm) of solid precipitation (includes sleet and hail; does not include freezing rain)
- Annual Number of Heavy Snow Days—A measure of the severity of winter precipitation as the number of days receiving more than or equal to 5 in (12.7 cm) of solid precipitation (includes sleet and hail; does not include freezing rain)

The average value of a climate element over 30 years is defined as a climatological normal, which is calculated and established by NOAA’s National Climatic Data Center (NCDC). Every ten years, NCDC computes new thirty-year climate normals for selected temperature and precipitation elements for a large number of U.S. climate and weather stations. The current (as of 2018) normals cover the period 1981–2010. In this report, the 30-year normals established by NCDC are used as the baseline for comparisons (e.g., departures from normal). In cases where data for the 30-year normal period are not available, we use alternative comparisons such as the new pseudo-normal from NCDC or a recent 10-year period. In some cases, sufficient data may simply not be available to calculate normals. For metrics that NCDC may not routinely calculate a normal, such as the number of days with more than 2 in (55 mm) of rain or liquid equivalent, normals are calculated using the same time period (e.g., 1981–2010) as the current NCDC standard. Throughout the report, descriptions of a station’s values as compared to the normals are described as a difference from the “average”, “mean”, “typical”, “long-term value”, as well as “normal”, to improve the readability of the document. However, all of these terms are comparing a value from one year at that station to that station’s normal, whether it be the 30-year normal or the pseudo-normal calculated on a shorter time frame.

For SHEN, nine stations are generally selected for reporting weather and climate status and trends. In 2017, eight were utilized because the Madison station (MDSV2) had very low reporting in 2017 for both temperature and precipitation (see Table 1). For the monthly summaries, with the exception of the RAWs stations due to short period of records (POR), all of the stations are utilized for comparisons with long-term averages. Of the eight stations, three (Luray, Staunton, and Charlottesville-Albemarle) have a Period of Record (POR) sufficiently long for a true 30-year normal (normal calculated from years 1981–2010). However, Charlottesville-Albemarle has a low percentage of time reporting temperature and precipitation over its POR. Therefore, only Luray and Staunton are used for the full suite of metrics found in the climate indicator tables.

Maps of multi-state departures of temperature and precipitation from long-term averages were derived from the Parameter-elevation Regressions on Independent Slopes Model (PRISM). PRISM uses an interpolation scheme for temperature between actual observations and corrects these estimates for changes in topography across the region (Daly et al. 2008). More information can be found at <http://www.prism.oregonstate.edu/>.

Drought Status

There are a number of drought indices used to estimate the severity of drought in an area. These indices use algorithms that incorporate recent temperatures, rainfall, soil moisture, and other information (<http://www.drought.gov>). The main indices we report are the Palmer Drought Severity Index (PDSI) and the United States Drought Monitor (DM) – Drought Intensity Index. While both indices provide excellent summary information on broad-scale conditions, local conditions (such as at the park scale) may vary.

The PDSI is a soil moisture algorithm calibrated for relatively homogeneous regions and is calculated on a monthly basis using precipitation and temperature data, as well as the water content of the soil. The values vary between extremely moist (>4.0) and extreme drought (<-4.0). Positive values indicate periods of above normal precipitation (0 to 2: near normal; 2 to 3: moderate moisture; >3 : very moist) and negative values indicate periods of drought (0 to -2: near normal; -2 to -3: moderate drought; <-3 : severe to extreme drought) (NOAA 2018a).

The DM – Drought Intensity Index is a synthesis of multiple indices (including the PDSI) and impacts, which represents a consensus of federal and academic scientists (NIDIS 2018). The DM produces a summary map of drought intensity for the nation and all states each week. It is on a scale ranging from abnormally dry (D0) to exceptional drought (D4).

Data Processing and Quality Assurance

Data from selected stations are downloaded from relevant data streams (i.e. CASTNET — Clean Air Status and Trends Network, ASOS — Automated Surface Observation System, COOP — National Weather Service Cooperative Observer Program, and RAWS — Remote Automated Weather Stations.). Variables are calculated using simple statistics (e.g. mean, minimum, maximum, etc.).

Each data stream has varying levels of associated quality assurance (from limited to extensive). ASOS and CASTNET data have rigorous and extensive quality assurance beginning at the point of gather (data-logger on site) and at additional levels as described in the respective user's manuals and specification documents. The COOP data quality control is now much more extensive in real-time as the electronically submitted data passes through several levels of quality assurance and is in a final format within a few days of submission. See NOAA (2017) for a summary of ASOS and COOP quality control programs. See Amec Foster Wheeler (2009) and NWCG (2014) for CASTNET and RAWS quality assurance information, respectively. Quality assurance of RAWS data is also performed manually by comparing values with nearby stations.

Data management procedures are fully outlined in Marshall, et al. (2012).

Results

Temperature Summary

Almost all of the temperature metrics calculated from stations around SHEN indicate that 2017 was a warm year. Several months had average temperatures that were much higher than normal (Figures 2 and 3, Tables 2 and 3). As such, average annual temperatures were also above normal at all of the reporting stations (Table 3). In addition, the average annual maximum temperature and average annual minimum temperatures were above average (Table 4). Growing season lengths ranged from one week (Luray) to more than eight weeks longer than average (Staunton; Table 4). Most stations were warmer than average across all seasons. In contrast, the Big Meadows and Luray stations generally showed cooler than average temperatures over a five-month period during the spring and summer (May–September; Table 4). In fact, despite an overall warmer than average year at Big Meadows (due to a few extremely warm months), eight months had cooler than average temperatures. At the climate division scale, across the three climate divisions that encompass Shenandoah National Park, all of the seasons ranked warmer than average with the winter being particularly warm (Tables 5, 6, and 7). The winter of 2017 was a near-record season as the 3rd warmest since 1895 in all divisions. In the Western Piedmont Climate Division, 2017 tied as the warmest year on record. It was the 3rd and 5th warmest year in the Northern Virginia Division and in the Central Mountains Division, respectively.

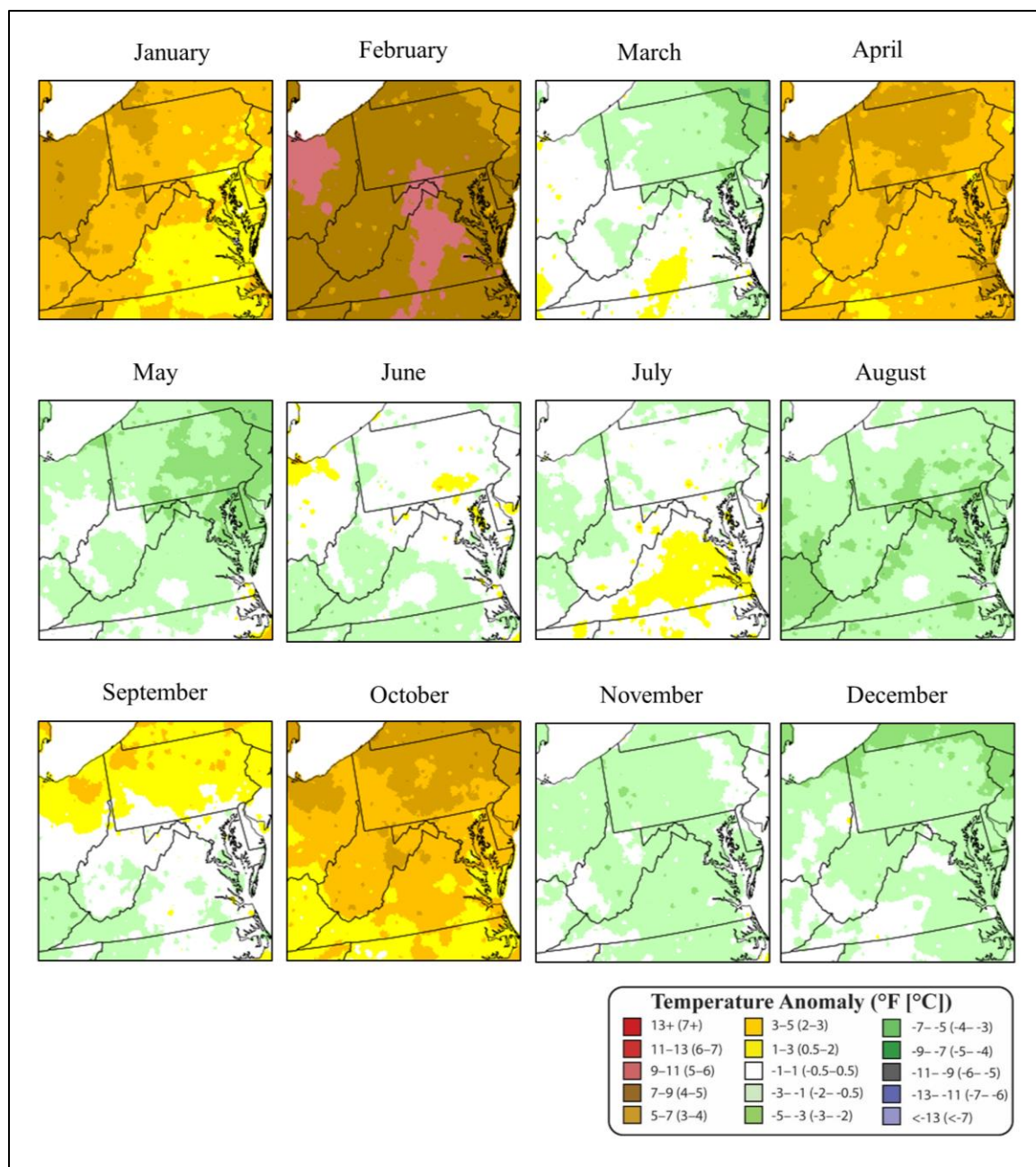


Figure 2. Maps showing departure from average monthly maximum temperature in 2017 compared to the 30-year normal (1981–2010).

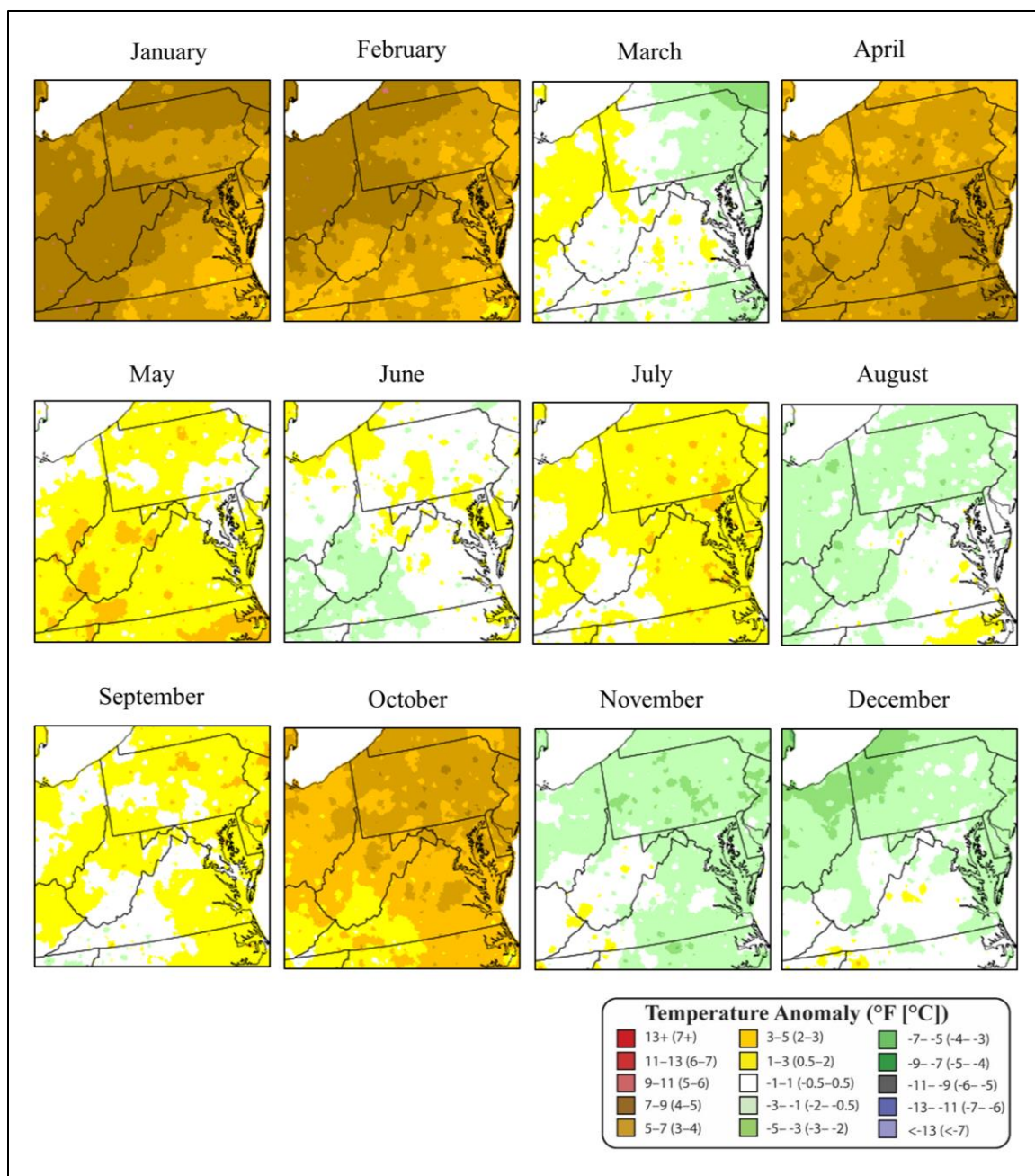


Figure 3. Maps showing departure from average monthly minimum temperature in 2017 compared to the 30-year normal (1981–2010)

Table 2. Summary of 2017 monthly average temperatures for selected stations.

Name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Big Meadows	SHN418	32.1°F 0.1°C	37.9°F 3.3°C	35.1°F 1.7°C	52.4°F 11.3°C	53.7°F 12.1°C	62.7°F 17.1°C	66.6°F 19.2°C	62.5°F 16.9°C	58.6°F 14.8°C	52.9°F 11.6°C	39.2°F 4.0°C	30.2°F -1.0°C	48.7°F 9.3°C
Charlottesville- Albemarle Airport	KCHO	42.0°F 5.6°C	50.2°F 10.1°C	48.6°F 9.2°C	63.7°F 17.6°C	65.5°F 18.6°C	74.5°F 23.6°C	80.0°F 26.7°C	75.8°F 24.3°C	70.1°F 21.2°C	63.3°F 17.4°C	47.8°F 8.8°C	38.7°F 3.7°C	60.0°F 15.6°C
Front Royal	FRRV2	37.9°F 3.3°C	43.8°F 6.6°C	42.2°F 5.7°C	58.5°F 14.7°C	M	M	M	M	M	59.6°F 15.3°C	M	35.8°F 2.1°C	M
Headquarters	TRR994	38.3°F 3.5°C	44.6°F 7.0°C	43.5°F 6.4°C	59.5°F 15.3°C	61.0°F 16.1°C	M	74.0°F 23.3°C	70.5°F 21.4°C	64.5°F 18.1°C	58.6°F 14.8°C	M	33.4°F 0.8°C	55.3°F 12.9°C
Luray 5E	LRYV2	38.3°F 3.5°C	44.5°F 6.9°C	42.8°F 6.0°C	58.5°F 14.7°C	61.3°F 16.3°C	69.3°F 20.7°C	74.5°F 23.6°C	70.9°F 21.6°C	65.8°F 18.8°C	60.0°F 15.6°C	44.6°F 7.0°C	M	56.0°F 13.3°C
Sawmill	CROV2	38.1°F 3.4°C	45.5°F 7.5°C	43.3°F 6.3°C	60.0°F 15.6°C	61.2°F 16.2°C	70.4°F 21.3°C	74.9°F 23.8°C	71.3°F 21.8°C	65.4°F 18.6°C	60.1°F 15.6°C	45.2°F 7.3°C	35.0°F 1.7°C	55.9°F 13.3°C
Staunton WTPD	STAV2	37.8°F 3.2°C	45.2°F 7.3°C	42.9°F 6.1°C	58.2°F 14.6°C	61.3°F 16.3°C	69.8°F 21.0°C	75.2°F 24.0°C	70.5°F 21.4°C	65.3°F 18.5°C	59.9°F 15.5°C	44.2°F 6.8°C	35.2°F 1.8°C	55.5°F 13.1°C
Waynesboro WTP	WYNV2	37.9°F 3.3°C	43.6°F 6.4°C	42.9°F 6.1°C	58.4°F 14.7°C	61.5°F 16.4°C	69.3°F 20.7°C	75.8°F 24.3°C	71.6°F 22.0°C	65.2°F 18.4°C	59.2°F 15.1°C	42.8°F 6.0°C	34.8°F 1.6°C	55.1°F 12.8°C

M = missing data (monthly and annual statistics are reported as "M" if more than 4 or 12 days of data are missing, respectively)

Table 3. Summary of 2017 departure from normal temperature based on the 30-year normal (1981-2010) for selected stations.

Name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Big Meadows ^A	SHN418	4.2°F 2.4°C	7.7°F 4.3°C	-1.6°F -0.9°C	5.6°F 3.1°C	-1.6°F -0.8°C	-1.0°F -0.5°C	-0.3°F -0.2°C	-2.7°F -1.5°C	-0.7°F -0.4°C	3.6°F 2.0°C	-1.6°F - 0.9°C	-0.5°F -0.3°C	0.9°F 0.5°C
Charlottesville- Albemarle Airport	KCHO	6.8°F 3.8°C	12.0°F 6.7°C	2.7°F 1.5°C	8.4°F 4.7°C	2.3°F 1.3°C	2.6°F 1.4°C	4.6°F 2.6°C	1.8°F 1.0°C	3.3°F 1.9°C	7.3°F 4.1°C	0.9°F 0.5°C	0.9°F 0.5°C	4.4°F 2.5°C
Front Royal ^B	FRRV2	5.0°F 2.8°C	7.6°F 4.3°C	-1.0°F -0.5°C	4.2°F 2.3°C	M	M	M	M	M	3.5°F 1.9°C	M	-0.5°F -0.3°C	M
Luray 5E	LRYV2	5.4°F 3.0°C	8.0°F 4.4°C	-1.5°F -0.8°C	3.9°F 2.1°C	-1.5°F -0.8°C	-1.6°F -0.9°C	0.0°F 0.0°C	-2.2°F -1.2°C	-0.7°F -0.4°C	3.5°F 2.0°C	-2.3°F -1.3°C	M	1.2°F 0.6°C
Staunton WTPD	STAV2	5.2°F 2.9°C	9.6°F 5.3°C	-0.3°F -0.1°C	5.3°F 3.0°C	-0.2°F -0.1°C	-0.2°F -0.1°C	1.6°F 0.9°C	-1.8°F -1.0°C	0.1°F 0.1°C	5.7°F 3.2°C	-1.0°F -0.5°C	-0.6°F -0.3°C	1.9°F 1.1°C
Waynesboro WTP ^B	WYNV2	5.1°F 2.9°C	8.7°F 4.8°C	0.6°F 0.4°C	6.9°F 3.9°C	0.6°F 0.3°C	-0.6°F -0.4°C	2.3°F 1.2°C	-0.7°F -0.4°C	0.3°F 0.1°C	5.0°F 2.8°C	-1.7°F -0.9°C	-0.6°F -0.3°C	1.9°F 1.0°C

M = missing data (monthly and annual statistics are reported as "M" if more than 4 or 12 days of data are missing, respectively)

^A Normals for the Big Meadows station represent 1980-2010 normals from the Big Meadows COOP station which was discontinued in 2012.

^BIndicates a station's Period of Record does not cover the period of 1981-2010 but is ten or more years. In these cases, the departure-from-normal values were calculated with normals derived from data spanning the length of the station's Period of Record.

Table 4. Status of 2017 temperature indicators compared to the 30-year normal (1981-2010) for selected stations.

Temperature Indicator	Luray 5 E 2017	Luray 5 E 1981–2010	Staunton WTP 2017	Staunton WTP 1981–2010
Average Annual Temperature	56.0°F 13.3°C	54.7°F 12.7°C	55.5°F 13.1°C	53.6°F 12.0°C
Average Annual Maximum Temperature	67.4°F 19.7°C	67.2°F 19.6°C	65.7°F 18.7°C	64.0°F 17.8°C
Maximum Temperature	93.0°F 33.9°C	97.4°F 36.3°C	92.0°F 33.3°C	94.7°F 34.8°C
Hot Days (days with Tmax≥90°F/32°C)	15	25	7	10
Average Annual Minimum Temperature	44.5°F 6.9°C	42.3°F 5.7°C	45.3°F 7.4°C	43.1°F 6.2°C
Minimum Temperature	3.0°F -16.1°C	-1.9°F -18.8°C	4.0°F -15.6°C	-1.8°F -18.8°C
Cold Days (days with Tmax≤32°F/0°C)	7	10	10	14
Sub-freezing Days (days with Tmin≤32°F/0°C)	96	111	81	105
Sub-zero Days (days with Tmin≤0°F/-18°C)	0	2	0	1
Growing Season Length (days between last spring Tmin 32°F/0°C and first fall Tmin 32°F/0°C)	171	160	232	174

Table 5. Seasonal and annual temperature and precipitation rankings for 2017 over 123 years for the Western Piedmont (NOAA 2018b).

Parameter	VA Climate Division 3 Rankings — Western Piedmont				
	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN	Jan–Dec YEAR
Temperature-2017	3	6-T	36-T	25-T	1-T
Precipitation-2017	107	3	101	111	83

1 = warmest/wettest year and 123 = coldest/driest year. T = Tie between multiple years

Table 6. Seasonal and annual temperature and precipitation rankings for 2017 over 123 years for Northern Virginia (NOAA 2018b).

Parameter	VA Climate Division 4 Rankings — Northern Virginia				
	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN	Jan–Dec YEAR
Temperature-2017	3	5-T	37-T	20-T	3
Precipitation-2017	102	39	60	100	90

1 = warmest/wettest year and 123 = coldest/driest year. T = Tie between multiple years

Table 7. Seasonal and annual temperature and precipitation rankings for 2017 over 123 years for the Central Mountains (NOAA 2018b).

Parameter	VA Climate Division 5 Rankings — Central Mountains				
	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN	Jan–Dec YEAR
Temperature-2017	3	12-T	53-T	29-T	5
Precipitation-2017	105	5	98	89	76

1 = warmest/wettest year and 123 = coldest/driest year. T = Tie between multiple years

Precipitation Summary

Monthly precipitation totals in 2017 were highly variable but annual totals were below normal at all stations (Figure 4, Tables 8 and 9). Most months had less than normal precipitation, with February being particularly dry (Tables 8 and 9). Monthly totals ranged from a low of 0.3 inches (8 mm) at Staunton and Waynesboro in February (and at Sawmill in December) to a high of 10.7 inches (272 mm) at Sawmill in May (Table 8). In all, annual precipitation ranged from 2.6 to 11.0 inches (66 to 279 mm) below average (Table 10). The wettest day occurred on May 5th when 3.0 inches (77 mm) of rain was observed (Table 11). Winter, summer, and fall seasons were all much drier than normal; in contrast, spring was much wetter than normal (Tables 5, 6, and 7). In all, 2017 was a moderately dry year, ranking as the 34th to the 48th driest (i.e. 76th to 90th wettest) year on record, depending on the climate division of interest (Tables 5, 6, and 7). The majority of SHEN is contained in the Northern Virginia Climate Division. That division entered “moderate drought” conditions for February through April and again in November and December, as measured by the Palmer Drought Severity Index (Figure 5). Similarly, the Drought Intensity Index shows “abnormally dry” periods were encountered in 2017 near SHEN and in surrounding states as summer transitioned into fall (Figures 6 and 7).

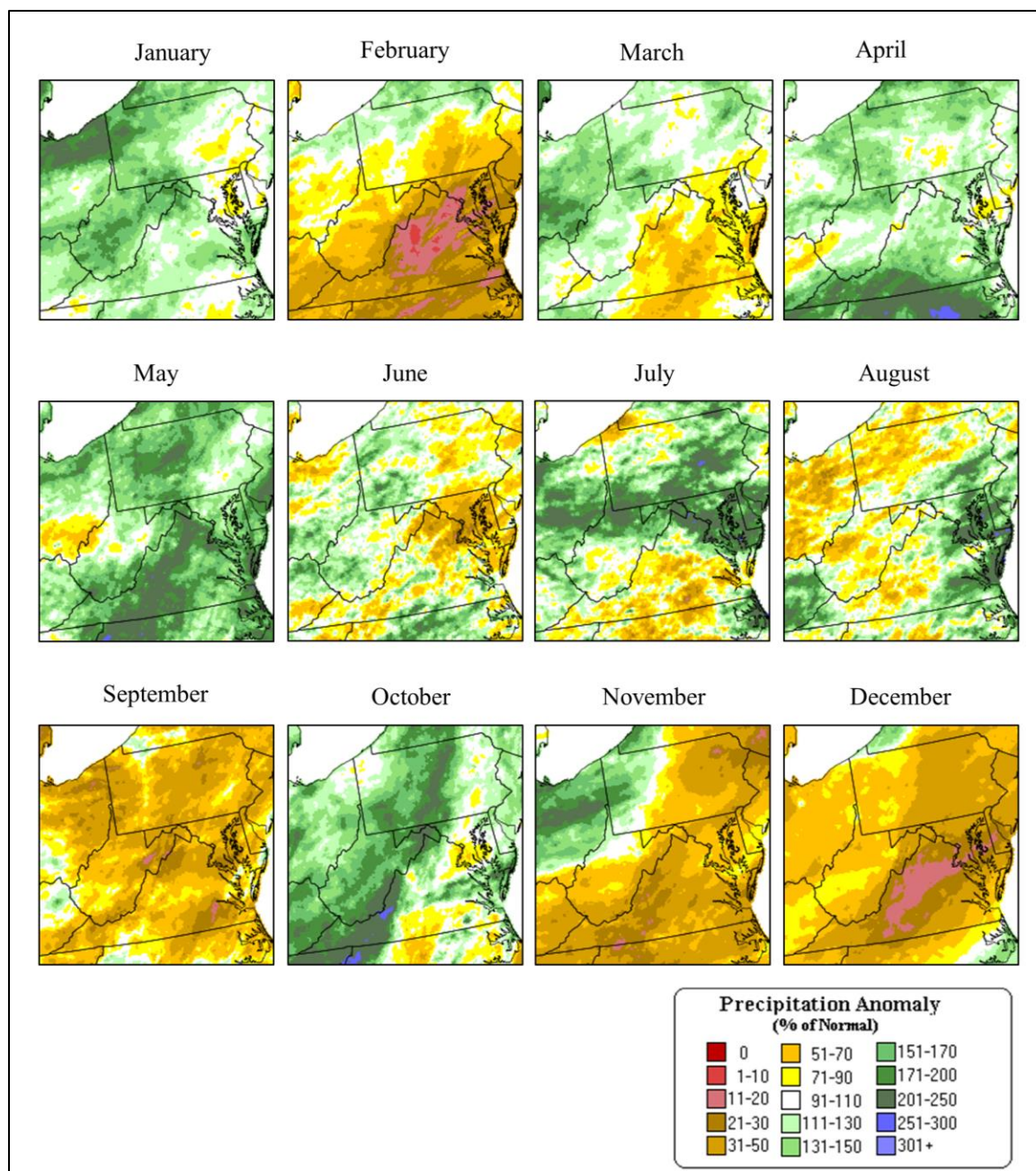


Figure 4. Maps showing percent of average monthly precipitation in 2017 compared to the 30-year normal (1981–2010).

Table 8. Summary of 2017 monthly precipitation for selected stations.

Name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Big Meadows	SHN418	5.1 in 130 mm	0.5 in 13 mm	3.0 in 76 mm	4.9 in 124 mm	10.3 in 262 mm	4.2 in 107 mm	4.4 in 112 mm	1.4 in 36 mm	1.6 in 41 mm	2.4 in 61 mm	M	0.8 in 20 mm	38.9 in 988 mm
Charlottesville- Albemarle Airport	KCHO	2.6 in 66 mm	0.6 in 15 mm	2.7 in 69 mm	2.8 in 71 mm	8.8 in 224 mm	2.8 in 71 mm	3.8 in 97 mm	3.2 in 81 mm	2.0 in 51 mm	3.9 in 99 mm	1.0 in 25 mm	0.4 in 10 mm	34.5 in 876 mm
Front Royal	FRRV2	4.2 in 107 mm	0.5 in 13 mm	1.8 in 46 mm	4.4 in 112 mm	7.8 in 198 mm	0.7 in 18 mm	3.3 in 84 mm	4.7 in 119 mm	1.1 in 28 mm	2.3 in 58 mm	1.4 in 36 mm	2.9 in 74 mm	35.2 in 894 mm
Headquarters	TRR994	4.1 in 104 mm	0.9 in 23 mm	2.3 in 58 mm	3.1 in 79 mm	7.1 in 180 mm	M	2.9 in 74 mm	2.7 in 69 mm	0.9 in 23 mm	4.1 in 104 mm	M	0.5 in 13 mm	32.4 in 823 mm
Luray 5E	LRYV2	3.7 in 94 mm	0.5 in 13 mm	2.2 in 56 mm	3.8 in 97 mm	6.4 in 163 mm	2.5 in 64 mm	3.0 in 76 mm	2.7 in 69 mm	0.9 in 23 mm	4.0 in 102 mm	1.1 in 28 mm	M	31.3 in 795 mm
Sawmill	CROV2	3.5 in 89 mm	0.6 in 15 mm	2.1 in 53 mm	3.9 in 99 mm	10.7 in 272 mm	2.2 in 56 mm	3.9 in 99 mm	3.9 in 99 mm	2.6 in 66 mm	5.2 in 132 mm	1.3 in 33 mm	0.3 in 8 mm	40.2 in 1021 mm
Staunton WTPD	STAV2	3.5 in 89 mm	0.3 in 8 mm	1.6 in 41 mm	4.1 in 104 mm	8.3 in 211 mm	4.5 in 114 mm	2.6 in 66 mm	6.1 in 155 mm	1.4 in 36 mm	2.7 in 69 mm	1.0 in 25 mm	0.4 in 10 mm	36.5 in 927 mm
Waynesboro WTP	WYNV2	3.6 in 91 mm	0.3 in 8 mm	2.1 in 53 mm	4.9 in 124 mm	8.7 in 221 mm	2.7 in 69 mm	1.9 in 48 mm	2.9 in 74 mm	2.3 in 58 mm	5.1 in 130 mm	1.3 in 33 mm	0.5 in 13 mm	36.4 in 925 mm

M = missing data (monthly and annual statistics are reported as "M" if more than 4 or 12 days of data are missing, respectively)

Table 9. Summary of 2017 percent of normal precipitation based on the 30-year normal (1981-2010) for selected stations.

Name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Big Meadows ^A	SHN418	142	17	67	111	206	88	88	37	25	51	M	20	72
Charlottesville-Albemarle Airport	KCHO	93	22	73	82	220	76	88	89	44	126	26	13	81
Front Royal ^B	FRRV2	175	19	47	133	186	18	100	152	24	74	37	104	86
Luray 5E	LRYV2	137	19	56	112	160	62	73	82	20	133	31	M	74
Staunton WTPD	STAV2	130	12	50	132	224	125	67	169	37	90	32	15	93
Waynesboro WTP ^B	WYNV2	129	10	57	140	223	69	45	72	49	159	29	17	82

M = missing data (monthly and annual statistics are reported as “M” if more than 4 or 12 days of data are missing, respectively)

^ANormals for the Big Meadows station represent 1980-2010 normals from the Big Meadows COOP station which was discontinued in 2012.

^BIndicates a station's Period of Record does not cover the period of 1981-2010 but is ten or more years. In these cases, the departure-from-normal values were calculated with normals derived from data spanning the length of the station's Period of Record.

Table 10. Status of 2017 precipitation indicators compared to the 30-year normal (1981-2010) for selected stations.

Precipitation Indicator	Luray 5 E 2017	Luray 5 E 1981–2010	Staunton WTP 2017	Staunton WTP 1981–2010
Annual Precipitation	31.3 in 795 mm	42.3 in 1,074 mm	36.5 in 927 mm	39.1 in 993 mm
Autumn (Oct, Nov, Dec) Precipitation	5.6 in 142 mm	9.7 in 246 mm	4.1 in 104 mm	8.8 in 224 mm
Heavy Precipitation Days (days with ≥ 1.0 in (25 mm) rain)	4	11	7	9
Extreme Precipitation Days (days with ≥ 2.0 in (51 mm) rain)	2	2	3	2
Micro-drought (periods of 7+ days without rain)	10	10	9	9
Annual Snowfall	8.5 in 21.6 cm	17.9 in 45.5 cm	5.0 in 12.7 cm	22.7 in 57.7 cm
Measurable Snow Days (days with ≥ 0.1 in (0.3 cm) snow)	5	6	4	9
Moderate Snow Days (days with ≥ 3.0 in (7.6 cm) snow)	1	3	0	3
Heavy Snow Days (days with ≥ 5.0 in (12.7 cm) snow)	0	1	0	1

Table 11. Top five wettest days and top five dry spells (consecutive days with a trace of less of liquid precipitation) during 2017 from all stations.

Wettest Days in 2017	Dry Spells in 2017
May 05: 3.0 in (77 mm)	Sep 13 - Oct 08
Aug 12: 3.0 in (76 mm)	Nov 16 - Dec 05
Jan 23: 2.6 in (67 mm)	Jan 24 - Feb 08
Oct 29: 2.3 in (59 mm)	Jul 06 - Jul 21
Jul 05: 2.3 in (58 mm)	Dec 09 - Dec 22

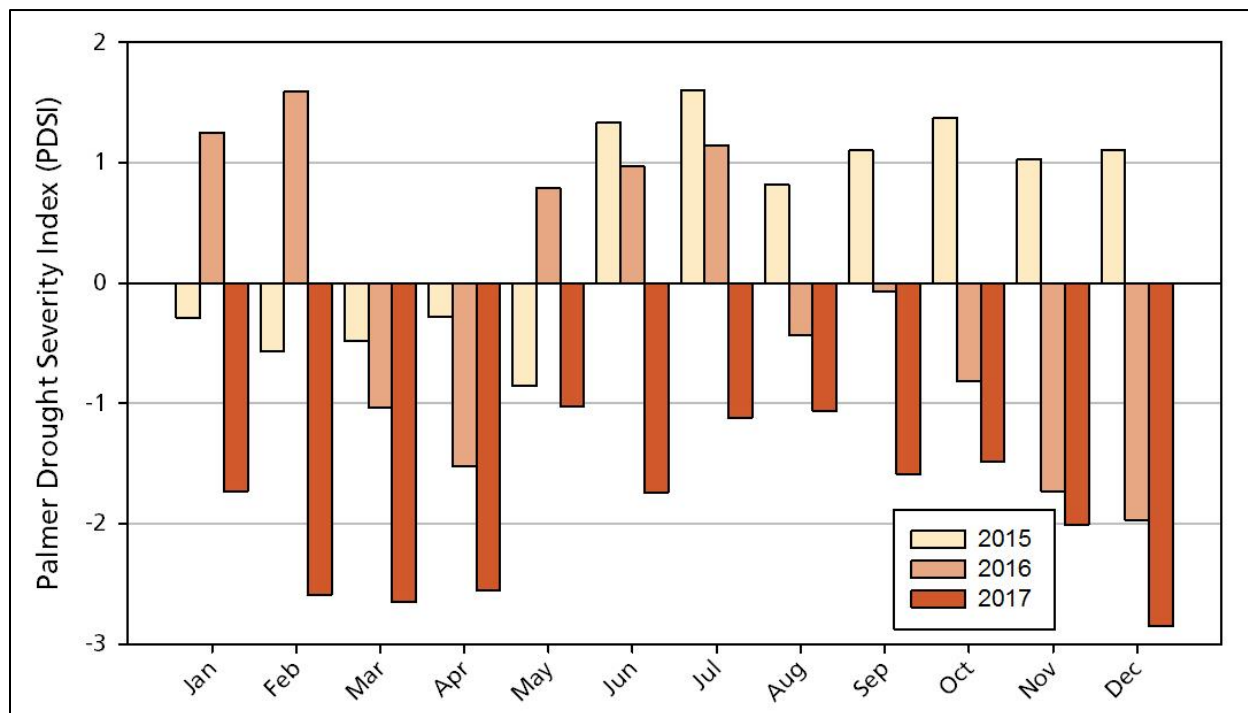


Figure 5. Palmer Drought Severity Index (PDSI) for Northern Virginia, 2015–2017. Positive values indicate periods of above normal precipitation (0 to 2: near normal; 2 to 3: moderate moisture; >3: very moist) and negative values indicate periods of drought (0 to -2: near normal; -2 to -3: moderate drought; <-3: severe to extreme drought).

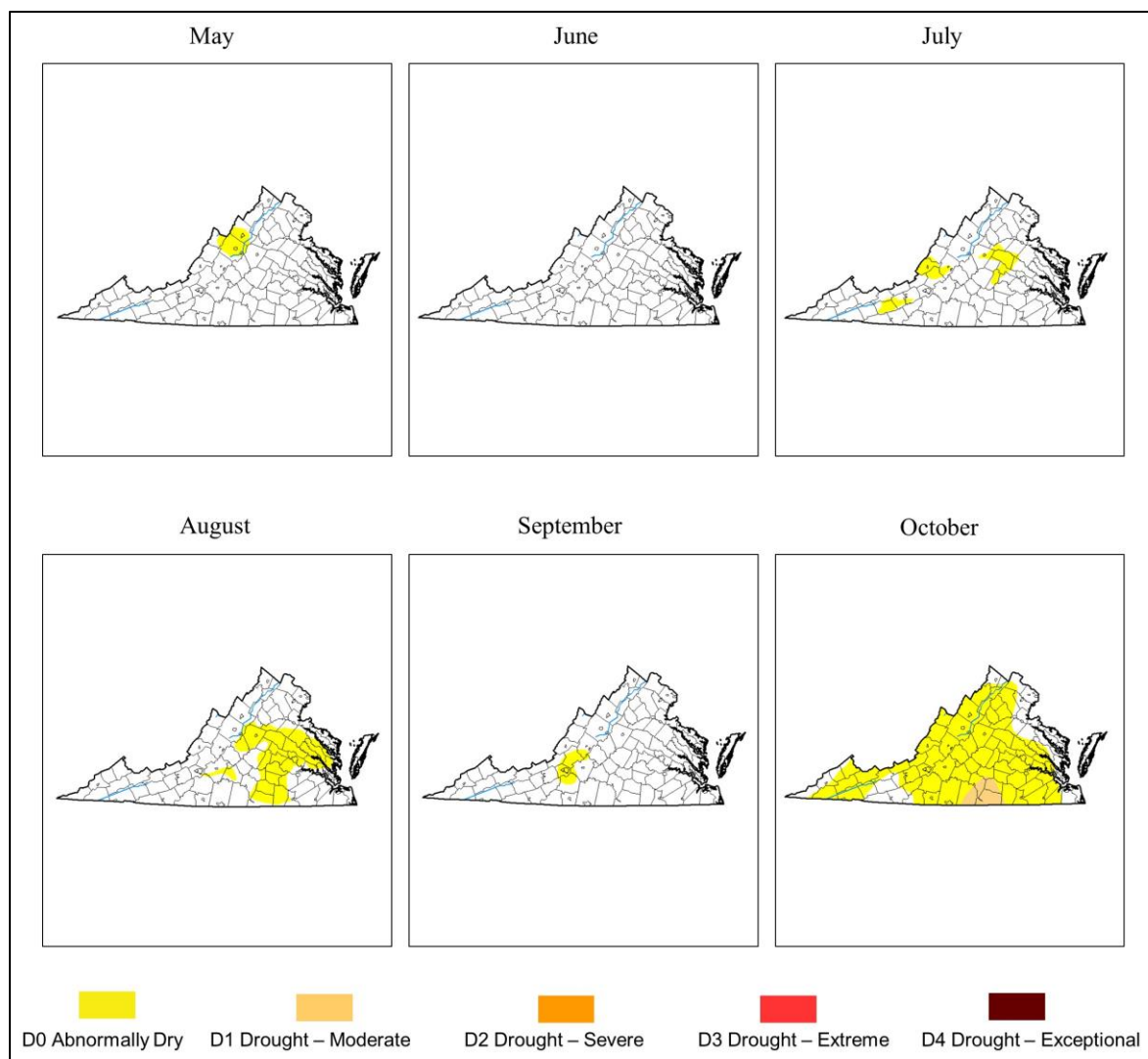


Figure 6. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for Virginia in 2017.

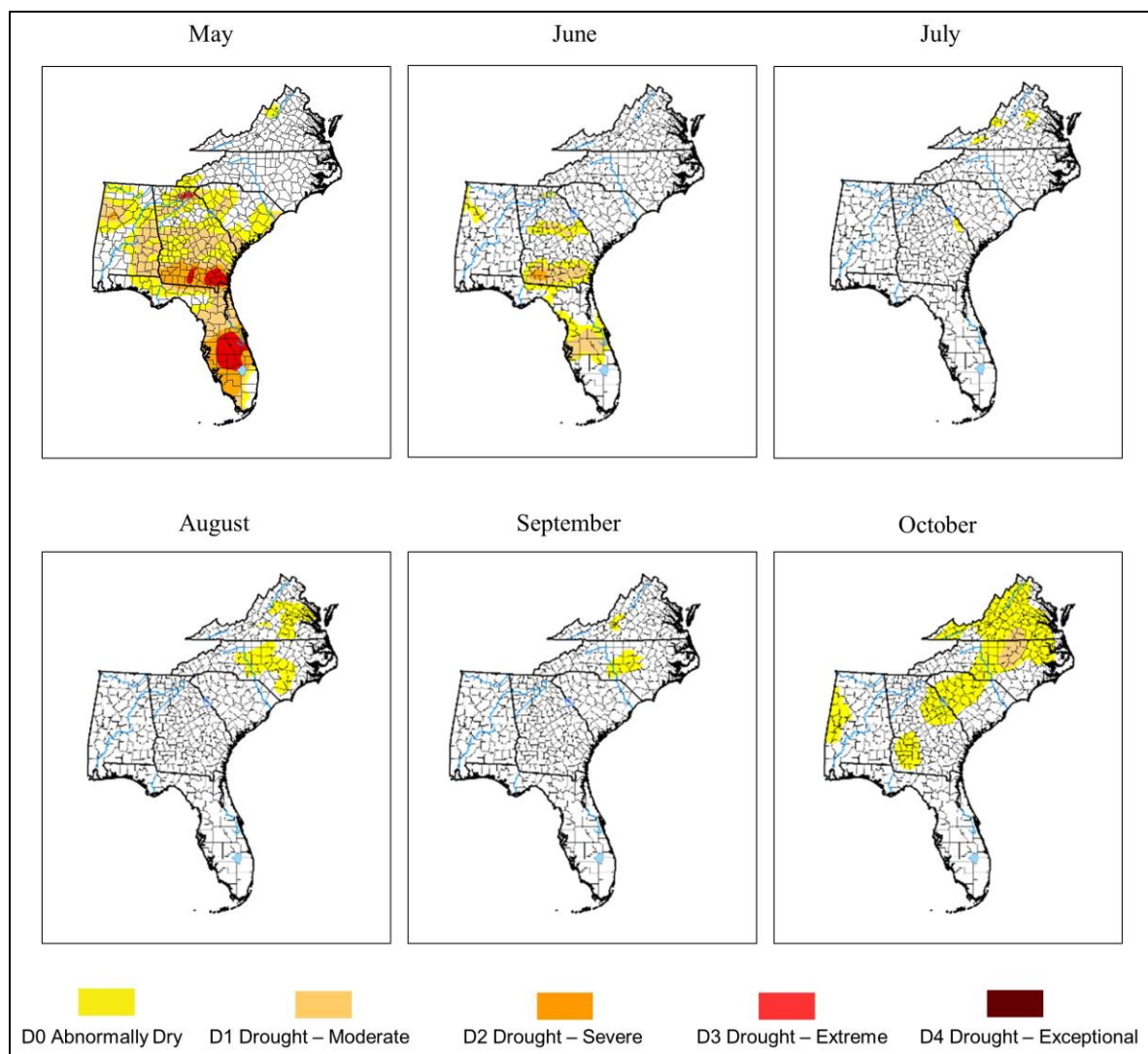


Figure 7. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for the Southeast in 2017.

Literature Cited

- Amec Foster Wheeler. 2016. Clean air status and trends network (CASTNET) quality assurance project plan (QAPP): revision 9.0. Available at <https://java.epa.gov/castnet/documents.do> (accessed 23 April 2018).
- Daly, C., M. Halbleib, J.I. Smith, W.P. Gibson, M.K. Doggett, G.H. Taylor, J. Curtis, and P.P. Pasteris. 2008. Physiographically sensitive mapping of climatological temperature and precipitation across the conterminous United States. *International Journal of Climatology*, 28: 2031-2064.
- Comiskey, J. A., and K. K. Callahan. 2008. Mid-Atlantic Network vital signs monitoring plan. Natural Resource Report NPS/MIDN/NRR—2008/071. National Park Service, Fort Collins, CO.
- Knight, P., K. Imhoff, and A. Person. 2016. Weather of Shenandoah National Park: Mid-Atlantic Network summary report for 2014. Natural Resource Data Series. NPS/MIDN/NRR—2016/1115. National Park Service. Fort Collins, Colorado
- Marshall, M., P. Knight, and J. Comiskey. 2012. Weather and climate monitoring protocol: Eastern Rivers and Mountains Network and Mid-Atlantic Network. Natural Resource Report NPS/ERMN-MIDN/NRR—2012/498. National Park Service, Fort Collins, Colorado.
- National Assessment Synthesis Team. 2001. Climate Change Impacts on United States: The Potential Consequences of Climate Variability and Change. Report for the U.S. Global Change Research Program. Cambridge University Press, Cambridge, UK.
- National Integrated Drought Information System (NIDIS). 2018. National Climate Data Center and United States Department of Agriculture. Available at: <http://droughtmonitor.unl.edu/Maps/MapArchive.aspx> (accessed 16 February 2018).
- National Oceanic and Atmospheric Administration (NOAA). 2017. National Weather Service Instruction 10-1305. Available at <http://www.nws.noaa.gov/directives> (accessed 23 April 2018).
- National Oceanic and Atmospheric Administration (NOAA). 2018a. National Centers for Environmental Information Historical Palmer Drought Indices. Available at: <https://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers/> (accessed 10 April 2018).
- National Oceanic and Atmospheric Administration (NOAA). 2018b. National Centers for Environmental Information Climatological Rankings. Available at: <http://www.ncdc.noaa.gov/temp-and-precip/climatological-rankings/> (accessed 11 April 2018).
- National Wildfire Coordinating Group (NWCG). 2014. Interagency Wildland Fire Weather Station Standards and Guidelines. Report PMS 426-3. Available at: <https://www.nwcg.gov/publications> (accessed 23 April 2018).

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 134/145289, May 2018

National Park Service
U.S. Department of the Interior



[Natural Resource Stewardship and Science](#)

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525