



Weather of Fort Necessity National Battlefield and Friendship Hill National Historic Site

Eastern Rivers and Mountains Network Summary Report for 2015

Natural Resource Data Series NPS/ERMN/NRDS—2016/1050



ON THE COVER

Summer sky at Fort Necessity National Battlefield, August 2008.
Photograph by: Jane Clark (NPS photos).

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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.

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List of Key Acronyms

ASOS	Automated Surface Observing System
COOP	National Weather Service Cooperative Observer Program
CWOP	Citizen Weather Observer Program
ERMN	Eastern Rivers and Mountains Network
FAA	Federal Aviation Administration
FONE	Fort Necessity National Battlefield
FRHI	Friendship Hill National Historic Site
GOES	Geostationary Operational Environmental Satellite
IFLOWS	Integrated Flood Observing and Warning System
NADP	National Atmospheric Deposition Program
NARR	North American Regional Reanalysis
NB	National Battlefield
NCDC	National Climatic Data Center
NHS	National Historic Site
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NWS	National Weather Service
PDSI	Palmer Drought Severity Index
POR	Period of Record
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RAWS	Remote Automated Weather Stations
USDM	United States Drought Monitor
USGS	United States Geological Survey

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 (Marshall and Piekielek 2007).

The purpose of this report is to provide a concise weather and climate summary for January 1 to December 31, 2015, 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 portions of the Eastern Rivers and Mountains Network (ERMN) Weather and Climate Monitoring 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 the ERMN 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 the 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 to profile climate summary and trends.

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. These key indicators are further described in the protocol (Marshall et al. 2012) and summarized in the body of this report.

The Climate of the Southwest Plateau

Fort Necessity National Battlefield (NB) and Friendship Hill National Historic Site (NHS) are located in Pennsylvania Climate Division 9, the “Southwest Plateau.” 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. Pennsylvania is divided into 10 climate divisions (<http://www.esrl.noaa.gov/psd/data/usclimdivs/data/map.html> [NOAA 2015]). Pennsylvania is divided into 10 climate divisions.

The Southwest Plateau is generally considered to have a humid, continental type of climate, but the elevated terrain and rolling hills keep temperatures a bit lower than surrounding areas. The prevailing westerly winds carry most of the weather disturbances that affect the region from the interior of the continent, with the Atlantic Ocean having only occasional influence on the climate of the area (Davey et al. 2006). Coastal storms do, at times, affect the day-to-day weather, especially in winter, though the air circulating southeastward from the Great Lakes dominates in the winter. Seldom do storms of tropical origin have a direct effect in this part of Pennsylvania, but the rough terrain has led to memorable floods in the warm half of the year (Gelber 2002).

Temperatures are moderately continental, with the tempering effects of the Great Lakes contributing to cloud production in the winter, and mountain-valley circulation-induced clouds reducing the heat during the summer. The lowest readings in the winter occur with polar air masses of Canadian origin settling over the Northeast after a fresh snowfall. The highest readings of summer happen when the sub-tropical fair weather system, the Bermuda high, pushes westward into the Carolinas; its clockwise circulation will direct hot, humid air from the Gulf region into the Laurel Highlands. Annual maximum and minimum temperatures tend to be greater in Friendship Hill NHS than in Fort Necessity NB. The average annual maximum temperature in Chalk Hill, PA, is 54.4°F (12.4°C), while the annual maximum temperature in Grays Landing, PA, is 63.4°F (17.4°C). The last freeze in the region typically occurs in early May and the first frosts appear in late September or October.

Precipitation is fairly evenly distributed throughout the year. Annual amounts generally range between 36–54 in (914–1,372 mm), while the majority of places receive 40–46 in (1,016–1,372 mm). Greatest amounts usually occur in the spring and summer months, while February is the driest month, having about 2.0 in (51 mm) less than the wettest months. Precipitation tends to be somewhat greater in the higher terrain due to uplift and additional moisture from the Great Lakes. Annual snowfall amounts are much greater for Fort Necessity NB than Friendship Hill NHS.

Surface winds blow from the west and northwest in the cold season and from the southwest during the warm half of the year. Thunderstorms follow a frequency that matches the solar cycle between the equinoxes and reaches a peak near the summer solstice. Hail is relatively infrequent, but flash floods and damaging thunderstorm winds affect parts of the region each summer. On average, tornadoes pass through the area about once every two years. Ice storms, which can cause significant disruption, occur at irregular intervals and are primarily confined to the months between December and March (Kocin and Uccellini 2004).

Observing Stations

A total of six weather observing stations comprised of two observing networks were selected around Fort Necessity NB and Friendship Hill NHS. 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 park elevation profile, the type and frequency of observations, the period of record of the data, and data availability (Marshall et al., in review). Moreover, the percentage of time a station reports particular parameters (e.g., temperature) can influence data inclusion. Two stations, Chalk Hill 2 ENE and Mogantown Lock and Dam, had sufficiently high levels of missing data during 2015 to warrant using proxy stations for the indicator tables (Tables 2 and 6). A total of six stations were used for this report (Figure 1, Table 1).

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 2013) 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 will be 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.

NOAA's National Centers for Environmental Information (NCEI) also calculates and provides climatological ranks for selected temperature and precipitation elements (<http://www.ncdc.noaa.gov/temp-and-precip/ranks.php>). Data and statistics are as of January 1895 providing a substantial period of record to place the current year in historical context.

In addition to the summary information available in this report, a near real-time data stream has been made available to the ERMN through a Web interface for the selected stations, along with monthly, seasonal, and annual summaries. The Web interface is accessible through the following link: <http://climate.met.psu.edu/NPS/interface.php>.

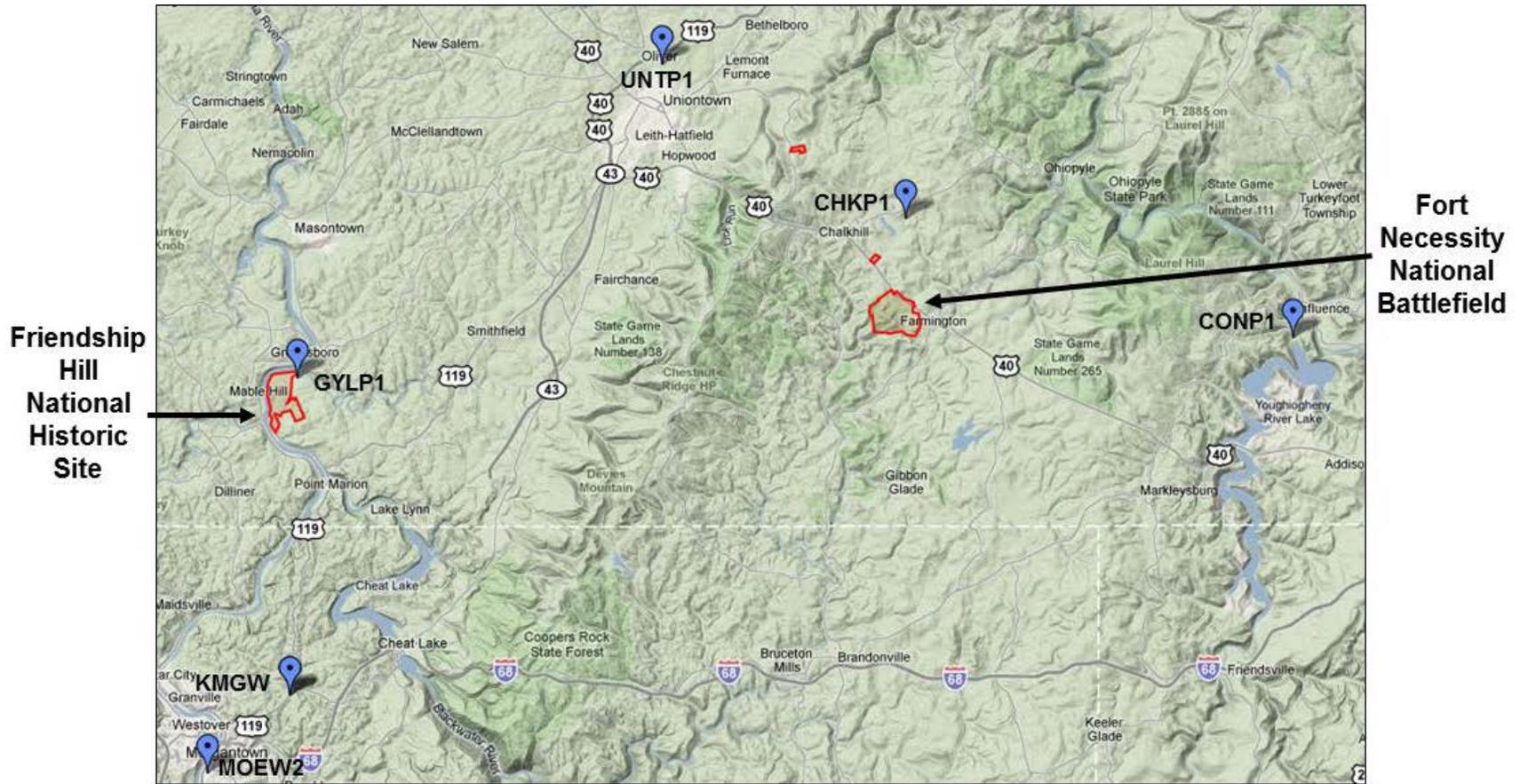


Figure 1. Location of weather observing stations around Friendship Hill National Historic Site and Fort Necessity National Battlefield. See Table 1 for station names.

Table 1. List of weather observing stations around Friendship Hill National Historic Site and Fort Necessity National Battlefield selected as best representative of the parks in 2015.

Station	Observing Network	Station Name	Period of Record (POR)		Percentage of Time Reporting Temperature for 2015	Percentage of Time Reporting Precipitation for 2015	Percentage of Time Reporting Temperature for entire POR	Percentage of Time Reporting Precipitation for entire POR
CHKP1	COOP	Chalk Hill 2 ENE	07/01/1977	Present	2.2	-	96.7	95.8
GYLP1	COOP	Grays Landing	10/01/1996	Present	99.5	99.7	97.0	99.2
UNTP1	COOP	Uniontown 1 NE	01/01/1894	Present	99.2	99.7	97.3	95.6
CONP1	COOP	Confluence 1 SW Dam	07/01/1946	Present	100.0	100.0	99.7	99.7
MOEW2	COOP	Morgantown Lock and Dam	09/01/1921	Present	67.4	63.3	95.8 ¹	95.3
KMGW	ASOS	Morgantown Municipal Airport -Walter L. Bill Hart Field	12/31/1973	Present	99.7	100.0	99.0	99.0

¹ Percentage of time reporting temperature for Morgantown Lock and Dam is based upon a period of record beginning on 06/01/1944. This station did not report temperature prior to this date.

Temperature Summary

The calendar year 2015 was warmer than normal (Tables 2 – 4), primarily due to mild weather spanning from spring through autumn (Figures 2 and 3)¹. Annual average temperatures were between 0.1°F to 2.0°F (0.1°C to 1.1°C) above normal across the reporting stations near Fort Necessity NB and Friendship Hill NHS (Table 4).

The year began rather cool across the region with temperatures averaging below normal in all three winter months of January, February, and March (Tables 3 and 4). February was an exceptionally cold month, with temperature departures between 11.2 and 12.8°F (6.2 and 7.1°C) below the long-term average (Table 4). The very cold air during the month provided for an above average number of sub-zero days for the calendar year (Table 2). Winter 2015 ranked as the 4th coldest in 121 years of records in Southwest Pennsylvania (Table 5).

The turn to milder weather began during the month of spring as positive temperature departures were reported across all stations for all three months of April, May, and June, with the exception of Grays Landing during the month of April (Tables 3 and 4). May was the warmest month of the three (Figures 2 and 3, Tables 3 and 4). Average temperatures reached 67.7°F (19.8°C) at Morgantown Airport, which is 6.6°F (3.7°C) above the long-term mean for the month of May. The season, as a whole, ranked 6th warmest over the period of record (Table 5).

The mild weather would persist during summer, though July and August were generally closer to normal than much of the spring (Tables 3 and 4). Some stations even had slightly negative temperature anomalies during the month of August (Table 4). The warmest temperature of the year, 93.0°F (33.8°C), was observed on August 17th (Table 2). The last month of the season was another very mild month, with September departures between 3.3 and 5.7°F (1.8 and 3.2°C) above normal (Table 4). Due to the mild September primarily, summer 2015 ranked as the 24th warmest since 1895 (Table 2).

While the entire autumn season was warmer than average, the largest temperature departures from normal occurred during the last month of the year (Figures 2 and 3). In fact, December 2015 was the warmest on record since 1895 across the region. Temperature departures reached as high as 14.0°F (7.8°C) above normal at Connellsville (Chalk Hill proxy station, Table 4). Because of the exceptionally mild December, the autumn season was the warmest on record in Southwestern Pennsylvania (Table 5). As a result of the mild spring, summer, and autumn combined, the growing season was three to four weeks longer than the long-term average (Table 2).

Table 2. Status of 2015 temperature indicators compared to the 30-year normal (1981–2010) at the Chalk Hill 2 ENE (CHKP1) and Morgantown Lock and Dam (MOEW2) stations.

Temperature Indicator	Chalk Hill 2 ENE, PA CHKP1 ¹ 2015	Chalk Hill 2 ENE, PA CHKP1 1981–2010	Morgantown Lock and Dam, WV MOEW2 ² 2015	Morgantown Lock and Dam, WV MOEW2 1981–2010
Average Annual Temperature	52.9°F 11.6°C	46.7°F 8.2°C	54.6°F 12.6°C	52.3°F 11.3°C
Average Annual Maximum Temperature	63.9°F 17.7°C	58.3°F 14.6°C	64.0°F 17.8°C	62.6°F 17.0°C
Maximum Temperature	93.0°F 33.8°C	87.0°F 30.6°C	87°F 30.5°C	93.0°F 33.9°C
Hot Days (days with Tmax≥90°F/32°C)	18	0	2	5
Average Annual Minimum Temperature	41.3°F 5.4°C	35.1°F 1.7°C	45.2°F 7.3°C	41.9°F 5.5°C
Minimum Temperature	-9.0°F -22.8°C	-10.8°F -23.8°C	-6°F -21.1°C	-1.1°F -18.4°C
Cold Days (days with Tmax≤32°F/0°F)	32	35	24	22
Sub-freezing Days (days with Tmin≤32°F/0°C)	102	161	83	117
Sub-zero Days (days with Tmin≤0°F/-17.8°C)	13	9	5	2
Growing Season Length (days between last spring Tmin 32°F/0°C and first fall Tmin 32°F/0°C)	175	146	202	181

¹ Chalk Hill 2 ENE (CHKP1) was missing data for all of 2015. Connellsville 2 SSW, PA (CNLP1) was used as a proxy location for this data.

² Morgantown Lock and Dam was missing data for most of 2015. Fairmont, WV (FRTW2) was used as a proxy location for this data

Friendship Hill National Historic Site and Fort Necessity National Battlefield
 Departure from Average Monthly Maximum Temperature
 2015 vs. 1981–2010

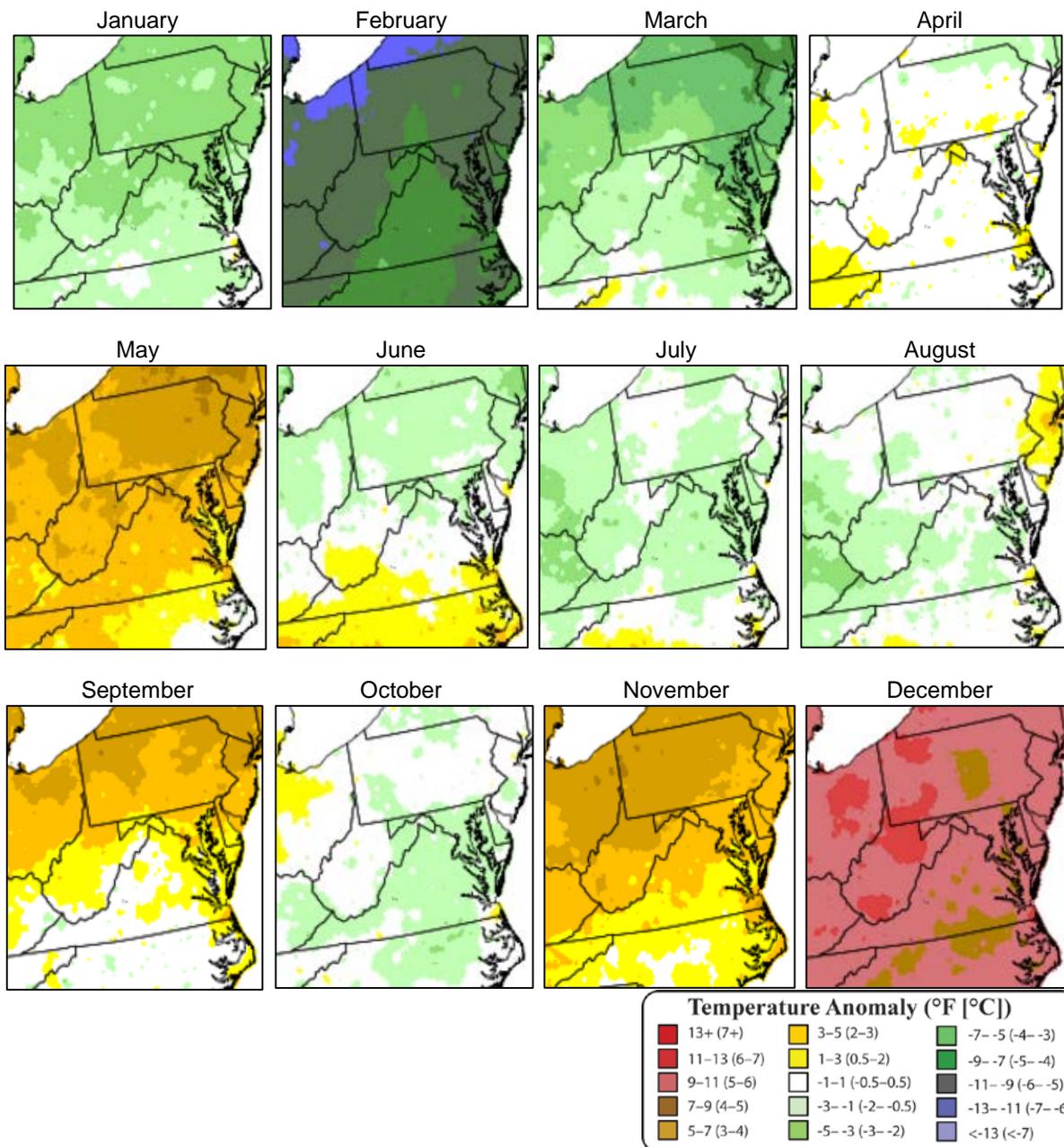


Figure 2. Maps showing departure from average monthly maximum temperature compared to the 30-year normal (1981–2010).

Friendship Hill National Historic Site and Fort Necessity National Battlefield
 Departure from Average Monthly Minimum Temperature
 2015 vs. 1981–2010

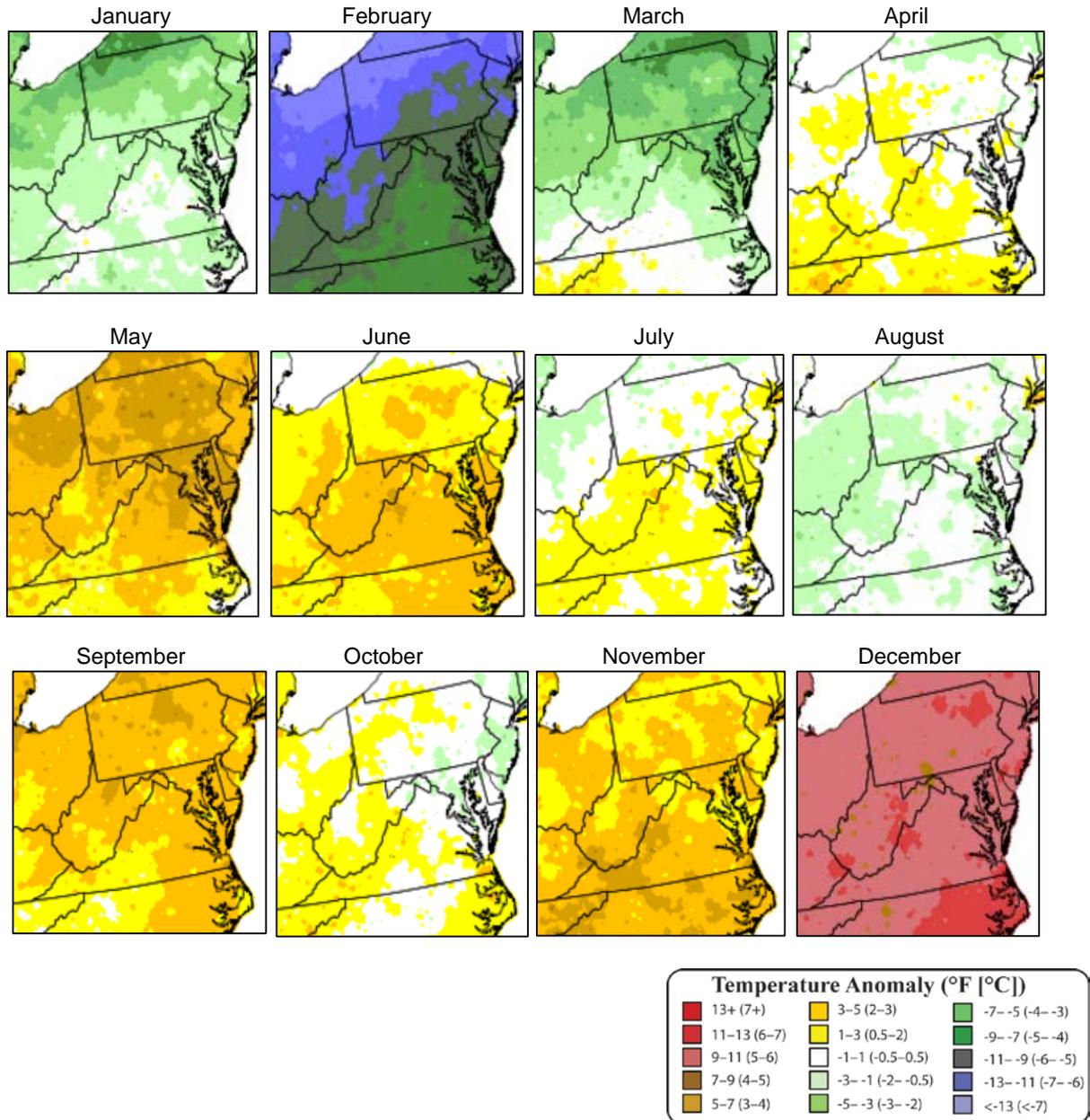


Figure 3. Maps showing departure from average monthly minimum temperature compared to the 30-year normal (1981–2010).

Table 3. Summary of monthly average temperatures for 2015 for the selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Morgantown Airport	KMGW	28.4°F	22.4°F	40.3°F	54.6°F	67.7°F	71.7°F	75.5°F	73.4°F	70.9°F	55.6°F	50.5°F	48.0°F	54.9°F
		-2.0°C	-5.3°C	4.6°C	12.6°C	19.8°C	22.1°C	24.2°C	23°C	21.6°C	13.1°C	10.3°C	8.9°C	12.7°C
Chalk Hill 2 ENE ¹	CHKP1 ¹	27.3°F	20.0°F	35.6°F	53.0°F	65.6°F	70.5°F	72.9°F	71.1°F	69.2°F	53.9°F	48.3°F	47.3°F	52.9°F
		-2.6 °C	-6.7°C	2.0°C	11.7°C	18.7°C	21.4°C	22.7°C	21.7°C	20.7°C	12.2°C	9.1°C	8.5°C	11.6°C
Uniontown 1 NE	UNTP1	27.4°F	20.0°F	36.3°F	52.0°F	65.2°F	70.4°F	72.6°F	69.7°F	69.3°F	53.5°F	47.9°F	46.0°F	52.5°F
		-2.6°C	-6.7°C	2.4°C	11.1°C	18.4°C	21.3°C	22.6°C	20.9°C	20.7°C	11.9°C	8.8°C	7.8°C	11.4°C
Confluence 1 SW Dam	CONP1	24.1°F	17.6°F	33.9°F	49.3°F	61.8°F	67.3°F	70.5°F	67.3°F	66.0°F	50.6°F	45.3°F	43.1°F	49.7°F
		-4.4°C	-8°C	1.1°C	9.6°C	16.6°C	19.6°C	21.4°C	19.6°C	18.9°C	10.3°C	7.4°C	6.2°C	9.8°C
Morgantown Lock and Dam ²	MOEW2 ²	29.4°F	22.7°F	40.5°F	55.7°F	67.1°F	70.8°F	73.7°F	71.8°F	69.1°F	55.1°F	50.9°F	48.1°F	54.6°F
		-1.4°C	-5.2°C	4.7°C	13.2°C	19.5°C	21.6°C	23.2°C	22.1°C	20.6°C	12.8°C	10.5°C	8.9°C	12.6°C
Grays Landing	GYLP1	26.6°F	18.8°F	35.2°F	49.9°F	63.8°F	69.4°F	72.1°F	69.8°F	67.8°F	52.6°F	46.9°F	44.0°F	51.4°F
		-3.0°C	-7.3°C	1.8°C	9.9°C	17.7°C	20.8°C	22.3°C	21.0°C	19.9°C	11.4 °C	8.3°C	6.7°C	10.8°C

M = missing data (Monthly statistics are reported as ' M' if greater than 4 days of data are missing).

¹ Indicates that Chalk Hill 2 ENE had no data in 2015. Connellsville 2 SSW, PA (CNLP1) was used as a proxy location for this data.

² Indicates that Morgantown Lock and Dam had no data in 2015. Fairmont, WV (FRTW2) was used as a proxy location for this data.

Table 4. Summary of 2015 departure from normal temperature based on 30-year normal (1981–2010) for the selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Morgantown	KMGW	-2.9°F	-11.8°F	-1.8°F	1.9°F	6.6°F	2.3°F	2.3°F	1.4°F	5.7°F	1.4°F	5.6°F	13.2°F	2.0°F
		-1.6°C	-6.6°C	-1.0°C	1.1°C	3.7°C	1.3°C	1.3°C	0.8°C	3.2°C	0.8°C	3.1°C	7.3°C	1.1°C
Chalk Hill 2 ENE ¹	CHKP1 ¹	-2.3°F	-12.1°F	-3.8°F	3.0°F	6.2°F	2.4°F	0.9°F	0.3°F	5.5°F	1.5°F	5.5°F	14.0°F	1.8°F
		-1.3°C	-6.7°C	-2.1°C	1.7°C	3.4°C	1.3°C	0.5°C	0.2°C	3.1°C	0.8°C	3.1°C	7.8°C	1.0°C
Uniontown 1 NE	UNTP1	-2.2°F	-12.1°F	-3.1°F	2.0°F	5.8°F	2.3°F	0.6°F	-1.1°F	5.6°F	1.1°F	5.1°F	12.7°F	1.4°F
		-1.2°C	-6.7°C	-1.7°C	1.1°C	3.2°C	1.3°C	0.3°C	-0.6°C	3.1°C	0.6°C	2.8°C	7.1°C	0.8°C
Confluence 1 SW Dam	CONP1	-2.4°F	-11.7°F	-3.0°F	1.2°F	4.2°F	0.9°F	0.2°F	-2.2°F	3.6°F	-0.3°F	4.5°F	12.7°F	0.6°F
		-1.3°C	-6.5°C	-1.7°C	0.7°C	2.3°C	0.5°C	0.1°C	-1.2°C	2.0°C	-0.2°C	2.5°C	7.1°C	0.3°C
Morgantown Lock and Dam ²	MOEW2 ²	-1.8°F	-11.2°F	-1.8°F	2.3°F	5.1°F	0.6°F	0.0°F	-0.9°F	3.3°F	0.5°F	5.8°F	13.2°F	1.3°F
		-1.0°C	-6.2°C	-1.0°C	1.3°C	2.8°C	0.3°C	0.0°C	-0.5°C	1.8°C	0.3°C	3.2°C	7.3°C	0.7°C
Grays Landing	GYLP1	-2.4°F	-12.8°F	-3.9°F	-0.4°F	4.0°F	0.6°F	-1.3°F	-2.2°F	3.4°F	0.0°F	4.6°F	11.6°F	0.1°F
		-1.3°C	-7.1°C	-2.2°C	-0.2°C	2.2°C	0.3°C	-0.7°C	-1.2°C	1.9°C	0.0°C	2.6°C	6.4°C	0.1°C

14

M = missing data (Monthly statistics are reported as ' M' if greater than 4 days of data are missing).

¹ Indicates that Chalk Hill 2 ENE had no data in 2015. Connellsville 2 SSW, PA (CNLP1) was used as a proxy location for this data.

² Indicates that Morgantown Lock and Dam had no data in 2015. Fairmont, WV (FRTW2) was used as a proxy location for this data.

Table 5. Seasonal and annual temperature and precipitation rankings for 2015 over 121 years (1 = warmest/wettest year and 121 = coldest/driest year) for Pennsylvania Climate Division 9.

PA Climate Division 9 Rankings "Southwest"	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN	Jan - Dec ANNUAL
Temperature-2015	118	6	24	1	24
Precipitation-2015	69	4	65	48	20

Precipitation Summary

Overall, 44.7 in (1137 mm) of liquid precipitation (rain plus melted snow, ice, sleet, etc.; hereafter precipitation) fell in Confluence, PA (near Fort Necessity NB), and 40.8 in (1037 mm) fell in Morgantown Airport, WV (near Friendship Hill NHS), during the year making 2015 the 20th wettest year on record (Tables 5 and 8). Both station's annual totals were exactly 98 percent of their respective long-term averages (Table 9). Precipitation alternated between moist and dry months during 2015 at Fort Necessity NB and Friendship Hill NHS, with all of the reporting stations averaging less than 75 percent of normal in 4 of the 12 months (Tables 8 and 9).

The winter season began with near normal precipitation during the month of January, with 2.9 in (72 mm [101 percent of average]) precipitation falling at Grays Landing (Tables 8 and 9). There was some variability during this month, however, as Confluence reported just 1.8 in (44mm), less than half of its monthly normal total. February was consistently dry across the region, as precipitation ranged from 54 to 67 percent of normal. The last month of the season turned wetter, as every station reported at least 4.5 in of rain (114 mm) and had totals that were over 110 percent of normal (Tables 8 and 9). Overall, the winter (January, February, and March) ranked as the 53rd driest since 1895, near the long-term average (Table 5).

The wet weather continued into April, with precipitation ranging from 132 to 185 percent of normal (Table 9). May ended exceptionally dry across the region encompassing Fort Necessity NB and Friendship Hill NHS, with as little as 0.9 in (24 mm) of rain falling at Grays Landing (Table 8). Concerns for development of drought over the summer sprung up at this time last year. June erased any of these concerns, however, as Confluence reported 10.0 in (255 mm [239 percent of normal]) of rain and all reporting stations saw at least 146 percent of their normal monthly precipitation (Tables 8 and 9). The remnants of Tropical Storm Bill, along with a slow-moving frontal boundary, in the middle of the month played a role in the exceptionally wet month. Due to such a wet June, spring of 2015 ranked as the 4th wettest in Southwest Pennsylvania (Table 5).

Summer of 2015 started relatively dry, continuing the back-and-forth of moist and dry months across the region (Figure 4); but it turned wetter in September (Figure 4). The wettest day of the year occurred during the month of September when 2.30 in (58 mm) fell on the 11th (Table 7). In contrast, four of the five longest dry spells during 2015 occurred in the period July through September (Table 7). Overall, this season ranked as the 57th driest in 121 years of records (61 is the mid-point; Table 5).

The autumn of 2015 was bookended by relatively wet months in October and December, but November was very dry across the region (Figure 4, Tables 8 and 9). For the entire season, 10.0 in (254 mm) fell at Connellsville, a proxy for Chalk Hill, which was about 2.4 in (61 mm) below the long-term average (Table 6). The season ranked 48th wettest since records began in 1895 (Table 6).

Table 6. Status of 2015 precipitation indicators compared to the 30-year normal (1981–2010) at the Chalk Hill 2 ENE (CHKP1) and Morgantown Lock and Dam (MOEW2) stations.

Precipitation Indicator	Chalk Hill 2 ENE, PA CHKP1 2015 ¹	Chalk Hill 2 ENE, PA CHKP1 1981–2010	Morgantown Lock and Dam, WV MOEW2 2015 ²	Morgantown Lock and Dam, WV MOEW2 1981–2010
Annual Precipitation	48.8 in 1,240 mm	54.2 in 1,377 mm	44.6 in 1,133 mm	43.1 in 1,095 mm
Autumn (Oct, Nov, Dec) Precipitation	10.0 in 254 mm	12.4 in 315 mm	8.06 in 205 mm	9.7 in 246 mm
Heavy Precipitation Days (days with ≥1.0 in (25 mm) rain)	9	11	7	7
Extreme Precipitation Days (days with ≥2.0 in (51 mm) rain)	1	2	0	1
Micro-drought (strings of 7+ days without rain)	3	3	4	6
Annual Snowfall	24.4 in 62 cm	89.0 in 226.1 cm	23.8 in 60.5 cm	33.4 in 84.8 cm
Measurable Snow Days (days with ≥0.1 in (0.3 cm) snow)	22	53	14	20 ³
Moderate Snow Days (days with ≥3.0 in (7.6 cm) snow)	1	10	4	3 ³
Heavy Snow Days (days with ≥5.0 in (12.7 cm) snow)	0	4	1	1 ³

¹ Chalk Hill 2 ENE (CHKP1) was missing data for all of 2015. Connellsville 2 SSW, PA (CNLP1) was used as a proxy location for this data.

² Morgantown Lock and Dam (MOEW2) was missing data for most of 2015. Fairmont, WV (FRTW2) was used as a proxy location for this data

³ MOEW2 1981-2010 normal snowfall data are approximated using Fairmont, WV snowfall data.

Table 7. Top five wettest days and top five dry spells (consecutive days with a trace or less of liquid precipitation) during 2015 from stations at Chalk Hill (CHKP1) and Morgantown Lock and Dam (MOEW2)*.

Wettest Days in 2015	Dry Spells in 2015
Sep 11: 2.30 in (58 mm)	Jul 16 – 26
Jun 15: 1.70 in (43 mm)	Aug 21 – 30
Jun 20: 1.67 in (42 mm)	Sept 20 – 27
Mar 5: 1.39 in (35 mm)	July 23 – 29
Jul 6: 1.33 in (34 mm)	May 2 – 8

*This table uses data from proxy stations CNLP1 and FRTW2 in replacement of CHPK1 and MOEW2, respectively.

Table 8. Summary of 2015 monthly total precipitation for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Morgantown Airport	KMGW	2.6 in	1.7 in	6.2 in	5.6 in	1.2 in	6.2 in	3.6 in	2.1 in	3.6 in	2.5 in	1.8 in	3.8 in	40.8 in
		65 mm	43 mm	157 mm	141 mm	30 mm	156 mm	91 mm	53 mm	91 mm	64 mm	47 mm	97 mm	1037 mm
Chalk Hill 2 ENE ¹	CHKP1 ¹	3.1 in	1.6 in	6.4 in	5.5 in	2.3 in	8.9 in	3.8 in	1.2 in	6.0 in	3.9 in	2.1 in	4.1 in	48.8 in
		79 mm	40 mm	163 mm	138 mm	57 mm	226 mm	97 mm	31 mm	152 mm	99 mm	52 mm	104 mm	1239 mm
Uniontown 1 NE	UNTP1	2.7 in	1.5 in	5.7 in	5.9 in	2.4 in	7.7 in	2.9 in	1.9 in	4.2 in	3.2 in	2.0 in	3.4 in	43.3 in
		68 mm	39 mm	144 mm	149 mm	62 mm	196 mm	74 mm	47 mm	106 mm	80 mm	50 mm	87 mm	1101 mm
Confluence 1 SW Dam	CONP1	1.8 in	1.7 in	4.3 in	5.2 in	2.6 in	10.0 in	4.3 in	1.6 in	3.9 in	3.7 in	2.1 in	3.6 in	44.7 in
		44 mm	44 mm	108 mm	131 mm	66 mm	255 mm	110 mm	40 mm	99 mm	93 mm	54 mm	92 mm	1137 mm
Morgantown Lock and Dam ²	MOEW2 ²	2.7 in	1.8 in	5.0 in	6.7 in	2.9 in	6.9 in	4.6 in	1.8 in	4.3 in	3.2 in	1.6 in	3.3 in	44.6 in
		68 mm	44 mm	127 mm	170 mm	73 mm	174 mm	116 mm	46 mm	110 mm	82 mm	40 mm	84 mm	1133 mm
Grays Landing	GYLP1	2.9 in	1.4 in	4.6 in	5.6 in	0.9 in	5.8 in	3.7 in	1.2 in	6.2 in	2.6 in	2.1 in	4.1 in	41.1 in
		72 mm	36 mm	117 mm	142 mm	24 mm	148 mm	94 mm	30 mm	157 mm	66 mm	53 mm	105 mm	1043 mm

¹ Indicates that Chalk Hill 2 ENE had no data in 2015. Connellsville 2 SSW, PA (CNLP1) was used as a proxy location for this data.

² Indicates that Morgantown Lock and Dam had no data in 2015. Fairmont, WV (FRTW2) was used as a proxy location for this data.

Table 9. Summary of 2015 percent of normal precipitation based on 30-year normal (1981–2010) for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Morgantown Airport	KMGW	91	67	170	158	26	150	78	59	112	90	53	130	98
Chalk Hill 2 ENE ¹	CHKP1 ¹	114	61	186	138	48	200	81	30	160	130	54	138	110
Uniontown 1 NE	UNTP1	86	54	154	160	54	181	64	53	124	106	53	112	101
Confluence 1 SW Dam	CONP1	49	56	111	132	54	239	97	45	102	124	57	101	98
Morgantown Lock and Dam ²	MOEW2 ²	78	59	124	185	57	155	94	49	122	103	42	95	97
Grays Landing	GYLP1	101	58	127	173	22	146	99	37	216	103	55	139	104

M = missing data (Monthly statistics are reported as 'M' if greater than 4 days of data are missing).

¹ Indicates that Chalk Hill 2 ENE had no data in 2015. Connellsville 2 SSW, PA (CNLP1) was used as a proxy location for this data.

² Indicates that Morgantown Lock and Dam had no data in 2015. Fairmont, WV (FRTW2) was used as a proxy location for this data.

Friendship Hill National Historic Site and Fort Necessity National Battlefield
 Percent of Average Monthly Precipitation
 2015 vs. 1981–2010

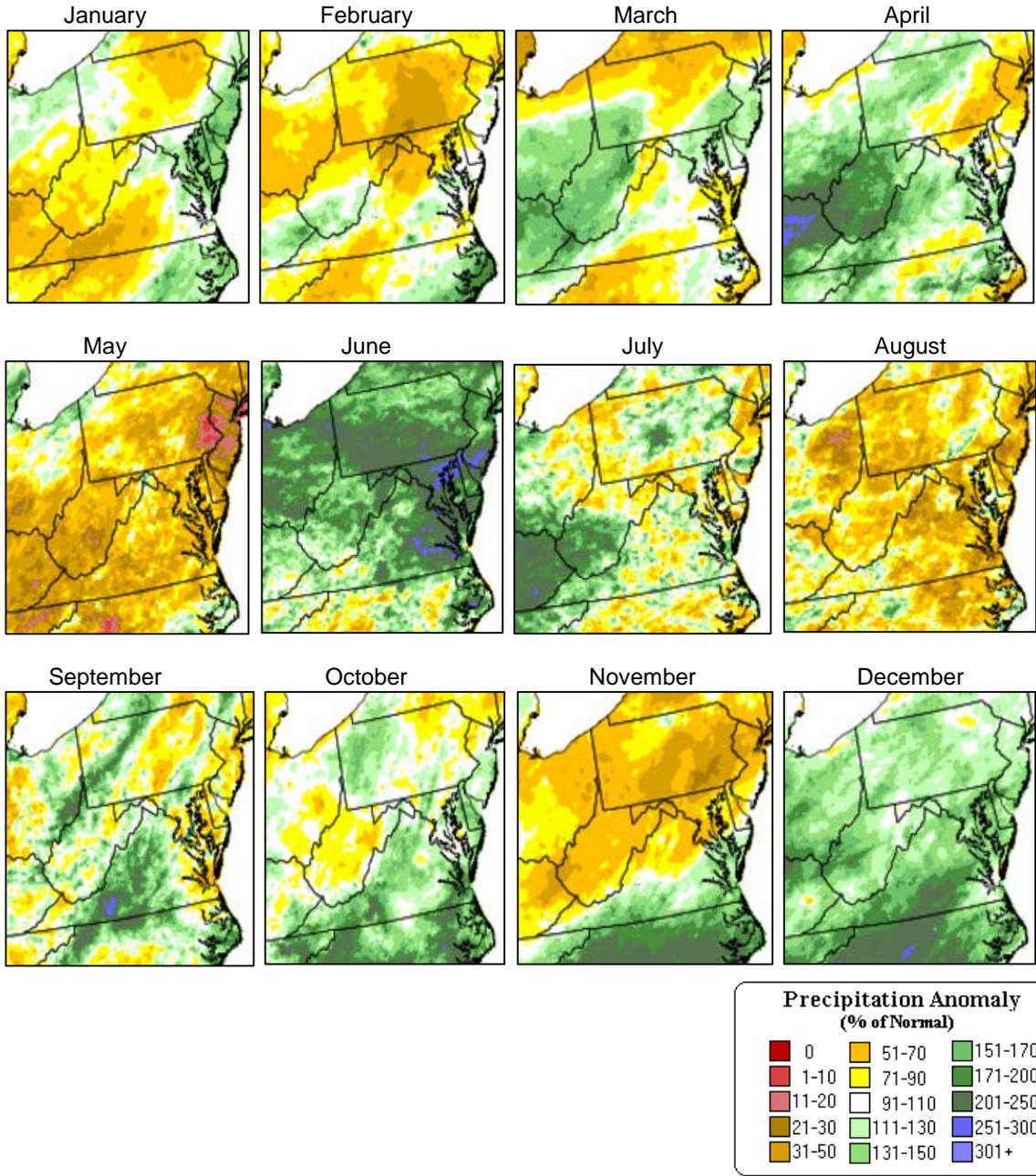


Figure 4. Maps showing percent of average monthly precipitation compared to the 30-year normal (1981–2010).

Drought Status

There are a number of drought indices used to estimate the severity of drought in an area using 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), with “normal” values ranging between -1.9 and 1.9 . Monthly PDSI values for Pennsylvania Climate Division 9 in 2015 are shown in Figure 5.

The DM – Drought Intensity Index is a synthesis of multiple indices (including the PDSI) and impacts, and represents a consensus of federal and academic scientists (NIDIS 2015). 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). Mid-month (i.e., the second or third week) values for Pennsylvania are shown in Figure 6 and the Northeast are shown in Figure 7 for 2015.

According to the PDSI in Climate Division 9, conditions meandered between just above and just below normal across the region through the first half of the year. A very wet June brought PDSI values above 2.0 for the only time throughout the year, indicating “moderately moist” conditions. The remainder of the year brought near normal precipitation to the area. The calendar year 2015 was consistently drier than 2014 in the first half of the year, but was similar toward the latter half of the year with precipitation levels near normal.

The DM – Drought Severity Index for Pennsylvania (Figure 6) and the Northeast (Figure 7) shows a similar pattern for the growing season (May through October); with the only dry (D0) conditions during this period in August and September.

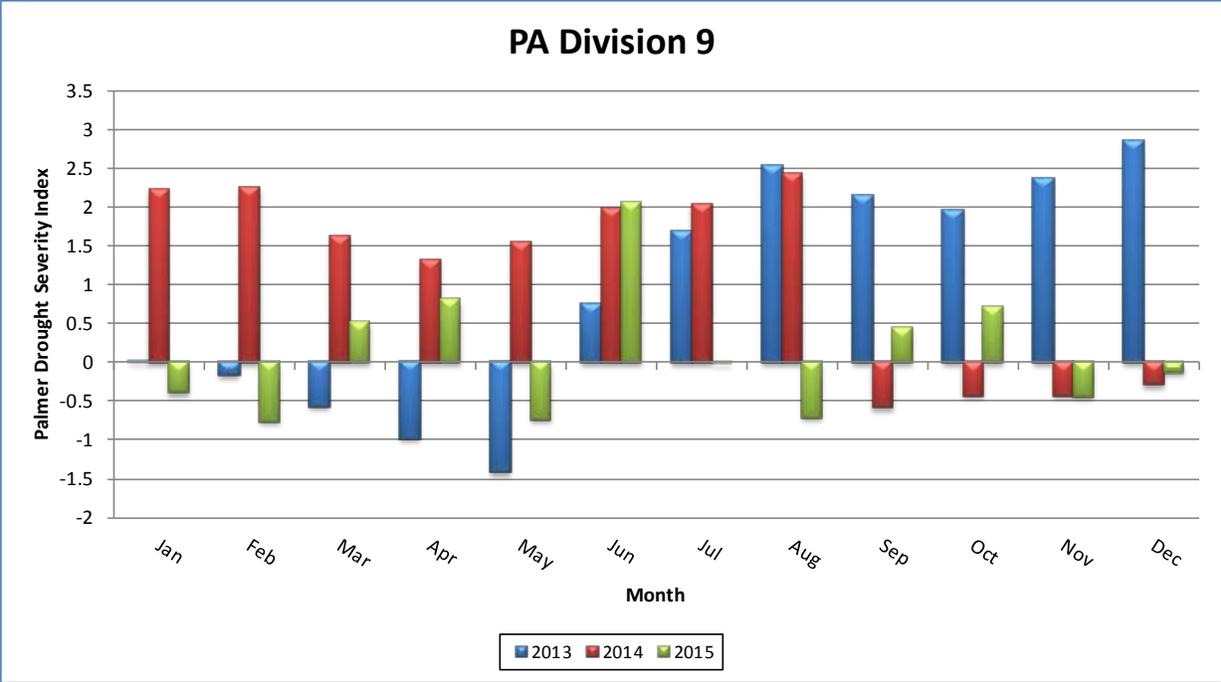


Figure 5. Monthly Palmer Drought Severity Index (PDSI) values for Pennsylvania Climate Division 9, 2013–2015.

Drought Intensity in Pennsylvania During 2015

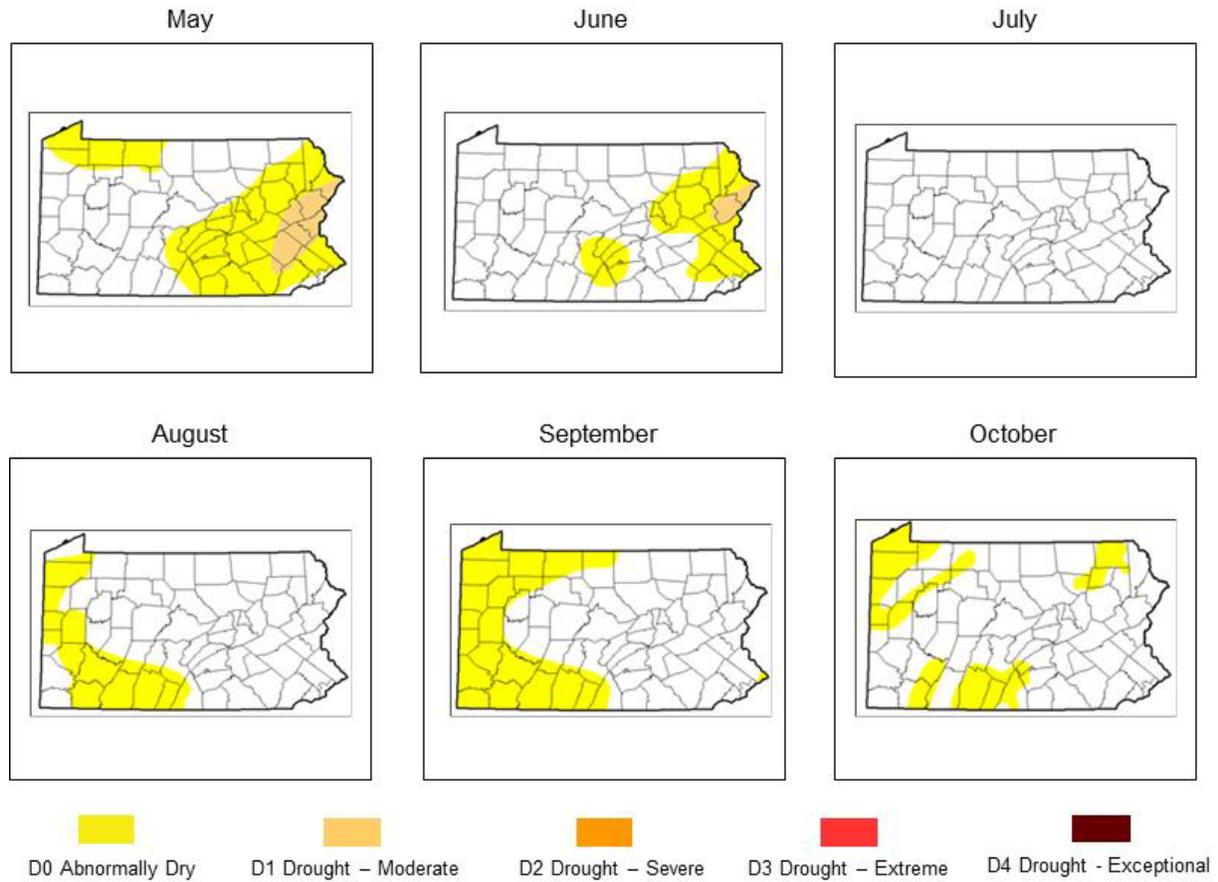


Figure 6. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for Pennsylvania in 2015.

Drought Intensity in Pennsylvania During 2015

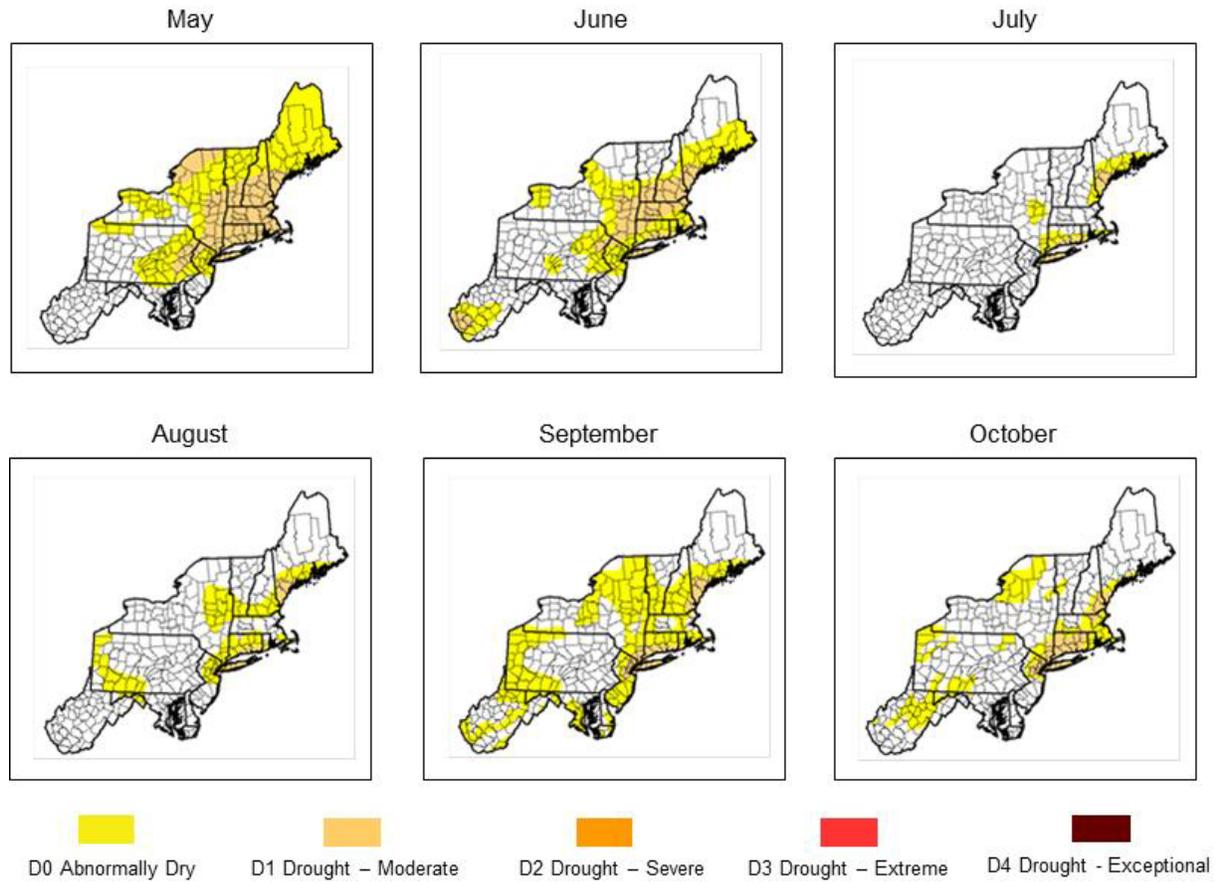


Figure 7. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for the Northeast in 2015.

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