



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

Eastern Rivers and Mountains Network Summary Report for 2013

Natural Resource Data Series NPS/ERMN/NRDS—2014/698



ON THE COVER

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

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

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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, 2013, 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 2013]).

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 Woods, 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. 2012). Moreover, the percentage of time a station reports particular parameters (e.g., temperature) can influence data inclusion. No stations were excluded in 2013 based on this criterion; therefore, 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.

The NCDC 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>.

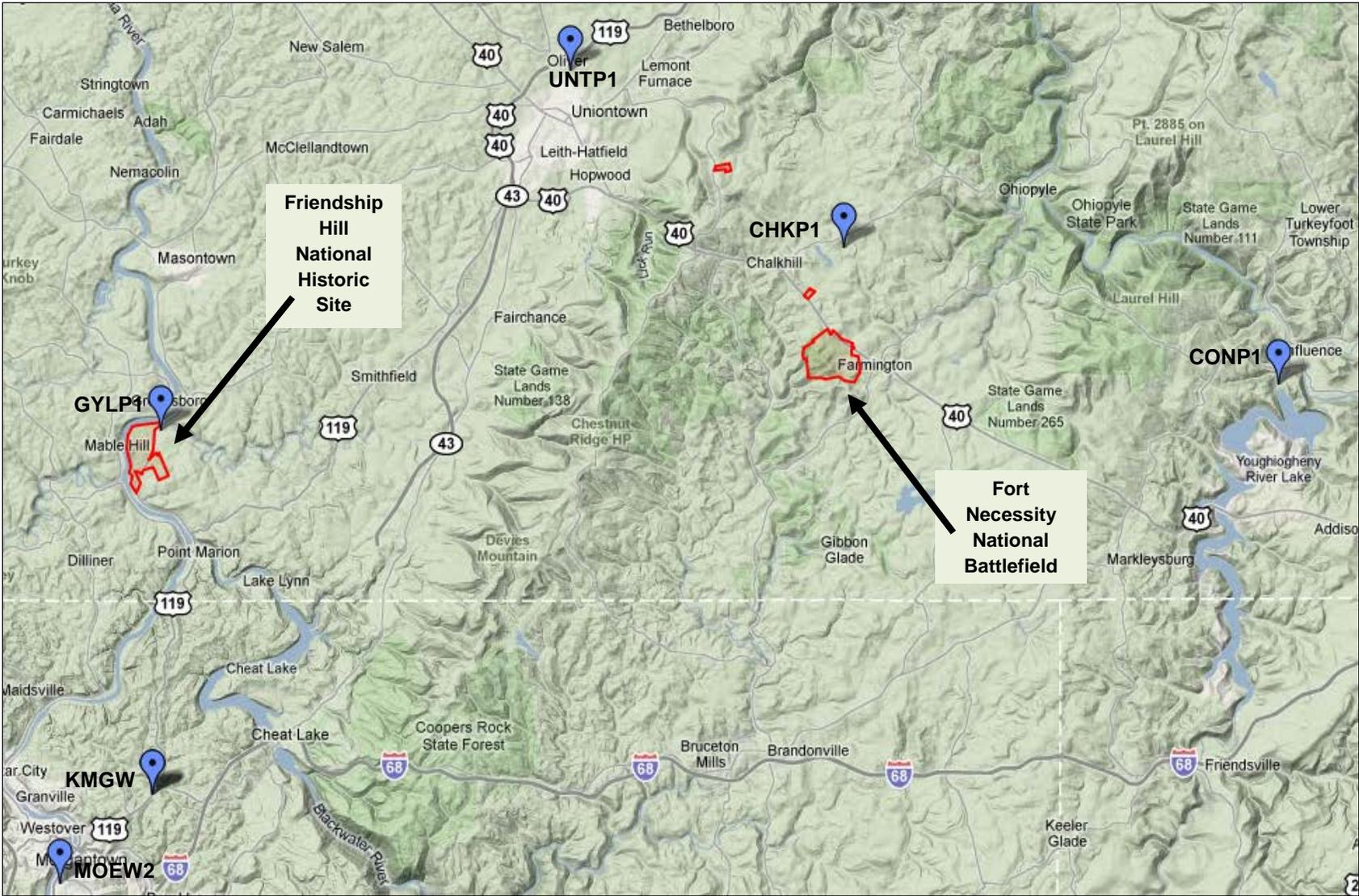


Figure 1. Location of weather observing stations around Friendship Hill National Historic Site and Fort Necessity National Battlefield. See Table 1 for station names.

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 2013.

Station	Observing Network	Station Name	Period of Record (POR)		Percentage of Time Reporting Temperature for 2013	Percentage of Time Reporting Precipitation for 2013	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	89.3	76.2	99.2	98.4
GYLP1	COOP	Grays Landing	10/01/1996	Present	99.4	99.5	96.9	99.2
UNTP1	COOP	Uniontown 1 NE	01/01/1894	Present	97.5	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	62.2	62.2	96.2 ¹	95.6
KMGW	ASOS	Morgantown Municipal Airport -Walter L. Bill Hart Field	12/31/1973	Present	100.0	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

2013 was cooler than normal (Tables 2, 3 and 4), primarily due to chilly conditions that started during February and continued through March and reappeared August and November (Figures 2 and 3). The maps in Figures 2 and 3 were created using estimates 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. 2002). More information can be found at <http://www.prism.oregonstate.edu/>.

The year began rather mild, as January had readings ranging from +1.0 degrees Fahrenheit (°F) (+0.6 degrees Celsius (°C)) to +3.4°F (+1.9°C) above normal (Table 4). The coldest weather of the year occurred January 23-24 when minima of -1°F (-18.3°C) were measured at Chalk Hill, PA, and a value of 7°F (-13.7°C) occurred at Morgantown Lock and Dam (Table 2). February mean temperatures were notably lower (Table 4), averaging as much as 7.4°F (4.1°C) below the long-term average at Chalk Hill. March brought the largest negative anomalies of the year (Figures 2 and 3). Overall, the winter was the 55th coolest in 119 years (59 is the mid-point; Table 5).

The spring ranked the 25th warmest on record since 1895, which was +1.4°F (0.8°C) above normal (Table 5). Two of the spring months had near-average temperatures for all of the reporting stations (Table 4). The largest anomalies were in April at Morgantown, which tallied an anomaly of +3.3°F (1.8°C), mainly due to very mild nights (Figure 3 and Table 4). Daytime temperatures were near the long-term average (Figure 2). The last freeze of the season occurred on May 27th, which led to a much shorter than normal length in the growing season. There were five consecutive days from May 30 through June 3 with readings in the 80's°F (> 27°C).

Summer of 2013 was cooler than normal, ranking as the 47th coolest on record (Table 5). This negative anomaly was persistent, with the majority of the stations averaging below normal for two of the three months (Figures 2 and 3). The largest anomalies were during August, when readings averaged as much as -3.5°F (1.9°C) below normal at Grays Landing, PA (Table 4). The highest temperature of the summer occurred during July, with a reading of 91°F (32.8°C) on July 17-19. Afternoon readings rose to 85°F (29.4°C) on September 11, and the first readings in the 30°F (<4.0°C) range occurred on September 6 at Chalk Hill, PA.

Temperatures in autumn stayed above normal, ranking 41st warmest since records have been kept in 1895 (Table 5). The first widespread 32°F (0°C) readings of the fall occurred on September 24 near Fort Necessity NB (Table 2). November had increasingly large negative anomalies in daytime readings (Figure 2). Nighttime readings fell below 32°F (0.0°C) on all but four days during November. There were a below average number of cold days and notably fewer-than-average number of sub-zero days (Table 2). Overall, 2013 averaged -0.4°F (-0.2°C) below the long-term average around Fort Necessity NB and Friendship Hill NHS (Table 2) and the year ranked as the 42nd warmest in 119 years.

Table 2. Status of 2013 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 2013	Chalk Hill 2 ENE, PA CHKP1 1981–2010	Morgantown Lock and Dam, WV MOEW2 2013	Morgantown Lock and Dam, WV MOEW2 1981–2010
Average Annual Temperature	46.3°F 7.9°C	46.7°F 8.2°C	52.3°F 11.3°C	52.3°F 11.3°C
Average Annual Maximum Temperature	57.4°F 14.1°C	58.3°F 14.6°C	62.6°F 17.0°C	62.6°F 17.0°C
Maximum Temperature	88.5°F 31.4°C	87.0°F 30.6°C	91.0°F 32.8°C	93.0°F 33.9°C
Hot Days (days with Tmax≥90°F/32°C)	0	0	4	5
Average Annual Minimum Temperature	35.3°F 1.8°C	35.1°F 1.7°C	41.9°F 5.5°C	41.9°F 5.5°C
Minimum Temperature	-1.0°F -18.3°C	-10.8°F -23.8°C	7.3°F -13.7°C	-1.1°F -18.4°C
Cold Days (days with Tmax≤32°F/0°F)	38	35	11	22
Sub-freezing Days (days with Tmin≤32°F/0°C)	146	161	74	117
Sub-zero Days (days with Tmin≤0°F/-17.8°C)	6	9	0	2
Growing Season Length (days between last spring Tmin 32°F/0°C and first fall Tmin 32°F/0°C)	118	146	133	181

**Friendship Hill National Historic Site and Fort Necessity National Battlefield
Departure from Average Monthly Maximum Temperature
2013 vs. 1981–2010**

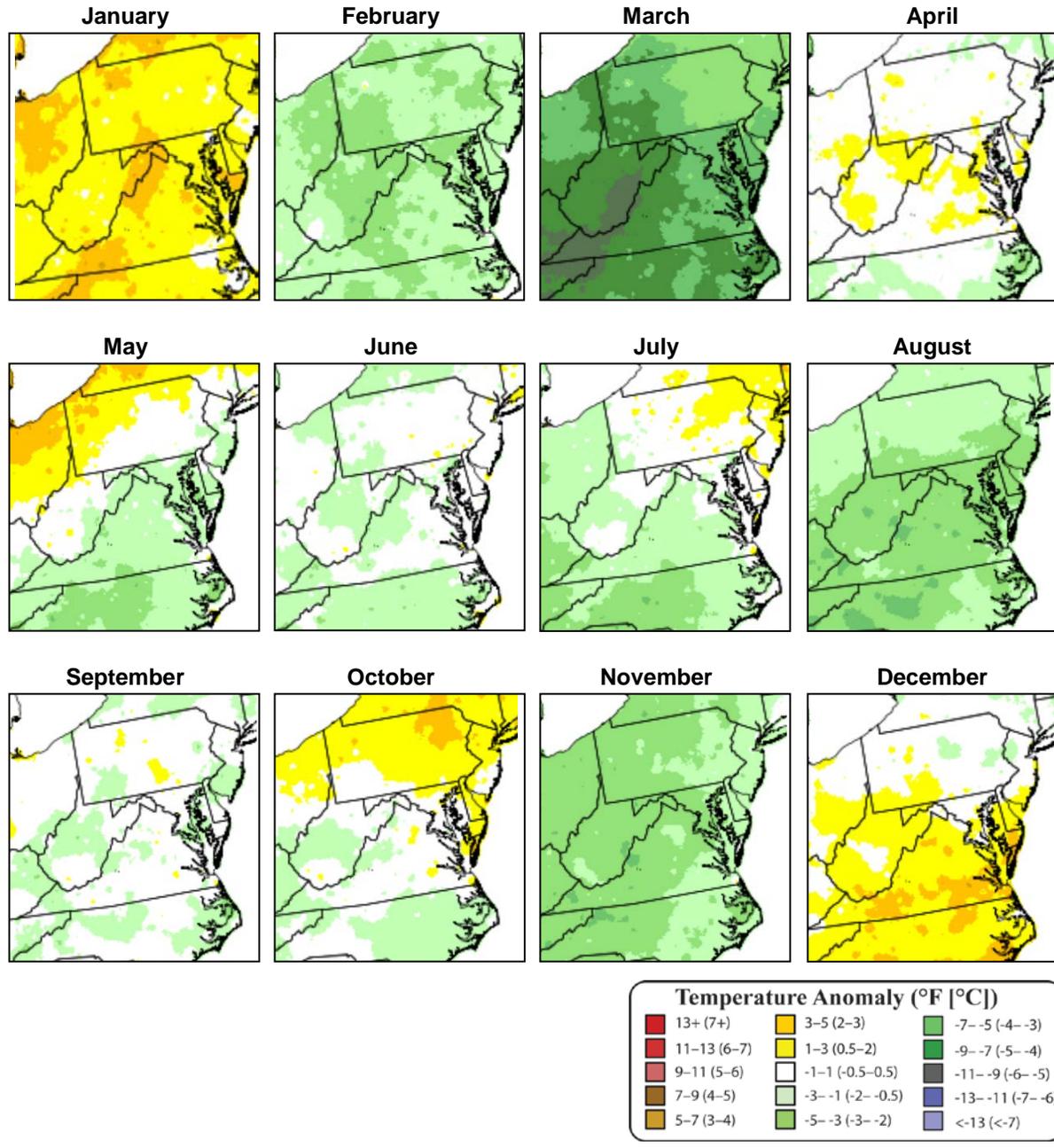


Figure 2. Maps showing departure from average monthly maximum temperature compared to the 30-year normal (1981–2010).

**Friendship Hill National Historic Site and Fort Necessity National Battlefield
Departure from Average Monthly Minimum Temperature
2013 vs. 1981–2010**

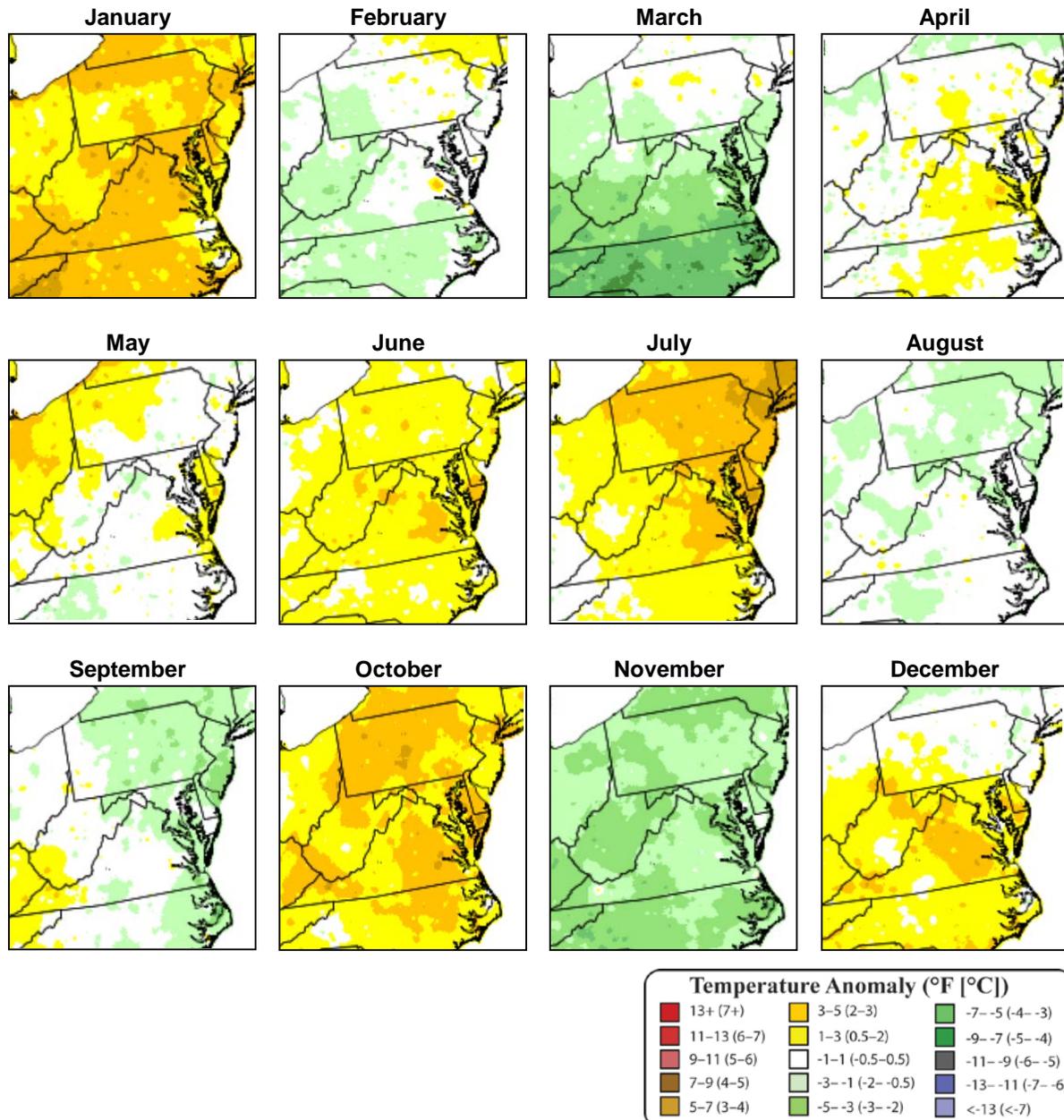


Figure 3. Maps showing departure from average monthly minimum temperature compared to the 30-year normal (1981–2010).

Table 3. Summary of monthly average temperatures for 2013 for the selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Morgantown Airport	KMGW	34.9 °F	32.4 °F	39.5 °F	56.3 °F	63.8 °F	70.0 °F	73.7 °F	70.6 °F	64.9 °F	55.9 °F	40.9 °F	37.8 °F	53.4 °F
		1.6 °C	0.2 °C	4.2 °C	13.5 °C	17.7 °C	21.1 °C	25.2 °C	23.2 °C	18.3 °C	13.3 °C	4.9 °C	3.2 °C	11.9 °C
Chalk Hill 2 ENE	CHKP1	28.4°F	22.3°F	30.3°F	48.3°F	56.1°F	64.5°F	68.8°F	64.3°F	57.6°F	50.1°F	34.3°F	31.1°F	46.3°F
		-2.0 °C	-5.4 °C	-0.9°C	9.1 °C	13.4 °C	18.1 °C	20.4 °C	17.9 °C	14.2 °C	10.1 °C	1.3 °C	-0.5 °C	7.9 °C
Uniontown 1 NE	UNTP1	32.2°F	30.2°F	36.0°F	51.8°F	61.9°F	69.4°F	73.7°F	69.6°F	63.9°F	55.0°F	39.8°F	36.8°F	51.7°F
		0.1 °C	-1.0 °C	2.2 °C	11.0 °C	16.6 °C	20.8 °C	23.2 °C	20.9 °C	17.7 °C	12.8 °C	4.3 °C	2.7 °C	10.9 °C
Confluence 1 SW Dam	CONP1	28.9°F	26.5°F	32.3°F	49.1°F	57.8°F	66.9°F	71.2°F	67.2°F	61.2°F	52.9°F	36.4°F	32.2°F	48.6°F
		-1.7 °C	-3.1 °C	0.2 °C	9.5 °C	14.3 °C	19.4 °C	21.8 °C	19.6 °C	16.2 °C	11.6 °C	2.4 °C	0.1 °C	9.2 °C
Morgantown Lock and Dam	MOEW2	32.5°F	33.3°F	35.4°F	53.4°F	61.8°F	69.2°F	74.1°F	69.1°F	62.3°F	53.2°F	40.4°F	36.0°F	51.7°F
		0.3°C	0.7 °C	1.9°C	11.9 °C	16.6 °C	20.7 °C	23.4 °C	20.6 °C	16.8 °C	11.8 °C	4.7°C	2.2°C	10.9°C
Grays Landing	GYLP1	31.7°F	29.2°F	35.3°F	50.3°F	59.8°F	69.2°F	73.0°F	69.3°F	63.5°F	54.8°F	38.7°F	35.0°F	50.8°F
		-0.2 °C	-1.6 °C	1.8 °C	10.2 °C	15.4 °C	20.7 °C	22.8 °C	20.7 °C	17.5 °C	12.7 °C	3.7 °C	1.7 °C	10.4 °C

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

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Table 4. Summary of 2013 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	3.4 °F	-2.0 °F	-2.8 °F	3.3 °F	2.4 °F	0.3 °F	0.3 °F	-1.7 °F	0.4 °F	1.5 °F	-5.1 °F	2.9 °F	0.2 °F
		1.9 °C	-1.1 °C	-1.5 °C	1.8 °C	1.4 °C	0.2 °C	0.2 °C	-0.8 °C	0.2 °C	0.8 °C	-2.7 °C	1.6 °C	0.1 °C
Chalk Hill 2 ENE	CHKP1	1.6 °F	-7.4 °F	-7.5°F	-0.6 °F	-1.2 °F	-0.6°F	0.3 °F	-3.0 °F	-2.9 °F	-0.1 °F	-6.3 °F	1.2°F	-2.3 °F
		0.9 °C	-4.1 °C	-4.1 °C	-0.3 °C	-0.7 °C	-0.3 °C	0.2 °C	-1.7 °C	-1.6 °C	-0.1 °C	-3.4 °C	0.7 °C	-1.3 °C
Uniontown 1 NE	UNTP1	2.0 °F	-2.0 °F	-3.5 °F	1.9°F	2.5 °F	1.1 °F	1.6 °F	-1.3 °F	0.0 °F	2.8 °F	-3.0 °F	3.5 °F	0.5 °F
		1.1 °C	-1.1 °C	-1.9 °C	1.1 °C	1.4 °C	0.7 °C	0.9 °C	-0.7 °C	0.0 °C	1.6 °C	-1.8 °C	1.9 °C	0.3 °C
Confluence 1 SW Dam	CONP1	2.2 °F	-3.0 °F	-5.0 °F	0.8°F	-0.1 °F	0.1 °F	0.7 °F	-2.6 °F	-1.4 °F	1.9 °F	-4.5 °F	1.7 °F	-0.7 °F
		1.3 °C	-1.7 °C	-2.3 °C	0.4 °C	-0.1 °C	0.1 °C	0.4 °C	-1.4 °C	-0.8 °C	1.1 °C	-2.4 °C	0.9 °C	-0.4 °C
Morgantown Lock and Dam	MOEW2	1.0 °F	-0.7 °F	-6.7 °F	0.6 °F	0.7 °F	-0.4 °F	0.8 °F	-3.2 °F	-3.4 °F	-1.6 °F	-4.2 °F	1.5 °F	-0.9 °F
		0.6 °C	-0.4 °C	-3.7 °C	0.3 °C	0.3 °C	-0.2 °C	0.5 °C	-1.8 °C	-1.9 °C	-0.9 °C	-2.2°C	0.8 °C	-0.5 °C
Grays Landing ¹	GYLP1	1.1 °F	-2.8 °F	-4.6 °F	-0.8 °F	-0.8 °F	-0.5 °F	-0.2 °F	-3.5 °F	-1.9 °F	1.4 °F	-4.5 °F	3.0 °F	-1.6 °F
		0.7 °C	-1.6 °C	-2.6 °C	-0.4 °C	-0.4 °C	-0.2 °C	-0.1 °C	-1.9 °C	-1.1 °C	0.8 °C	-2.4 °C	1.8 °C	-0.9 °C

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

¹Indicates a station's Period of Record is ten or more years but less than 30 years. In these cases, the departures from normal values were calculated with normals derived from data spanning the length of the station's period of record.

Table 5. Seasonal and annual temperature and precipitation rankings for 2013 over 119 years (1 = warmest/wettest year and 119 = 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-2013	64	25	71	41	42
Precipitation-2013	95	55	17	21	24

Precipitation Summary

Overall, 44.92 in (1140 mm) of liquid precipitation (rain plus melted snow, ice, sleet, etc.; hereafter precipitation) fell in Uniontown, PA (near Fort Necessity NB), and 41.16 in (1046 mm) fell in Morgantown Airport, WV (near Friendship Hill NHS), during the year making 2013 the 24th wettest year on record (Tables 5 and 6). These totals ranged from 1.9 in (49 mm) to 2.6 in (66 mm) below the long-term averages. The longest dry spell of the year occurred from April 1-11, when no measurable rain fell at Chalk Hill (Table 7). Conversely, the wettest day in 2013 occurred on July 9, when 2.00 in (52 mm) fell in Chalk Hill (Table 7). Precipitation alternated between moist and dry months during 2013 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 a wetter-than-average January, with 3.5 in (89 mm [107 percent of average]) precipitation falling at Uniontown (Tables 8 and 9). February was notably drier, with precipitation ranging from 1.0 in (25 mm) at Morgantown Lock and Dam, which was 35 percent of normal, to 2.2 in (55 mm) at Chalk Hill (Table 8). March continued drier than normal, with stations averaging 60 percent of normal precipitation (Table 9). Overall, the winter (January, February, and March) ranked as the 14th driest since 1895 (Table 5). Below average seasonal snowfall was recorded near Fort Necessity NB, as Chalk Hill tallied 83 in (210.8 cm) that was approximately 6 in (14cm) below the long-term average (Table 6).

April precipitation was well below normal, ranging from 41 to 60 percent of normal (Table 9). May rainfall ranged from 2.77 in (71 mm) at Grays Landing to 3.87 in (100 mm) at Morgantown (Table 8). June brought more showers, with the region averaging more than 120 percent of long-term normal (Table 9). Overall, spring of 2013 ranked as the 55th wettest in this climate division (Table 5).

Summer of 2013 started much wetter than average (Figure 4); but it turned drier in September. Overall, this season ranked as the 20th wettest (Table 5). The surplus was caused by a wet July which was 17th wettest since 1895. July had as much as 8.7 in (221 mm) of rain falling in Uniontown (199 percent of normal), to as little as 1.09 in (28 mm) at Confluence (30 percent of normal) during September (Tables 8 and 9). Three of the year's wettest days occurred between late June and early August (Table 7).

The autumn of 2013 was another wet season and its ranking was the 21st wettest in 119 years in the Southwest Plateau Pennsylvania Climate Division (Table 5). Precipitation was highly variable during the fall, ranging from 5.11 in (130 mm) at Chalk Hill in December to 1.1 in (28 mm) in Morgantown during October (Table 8). The number of heavy precipitation days was below normal in 2013, and the number of days with moderate and heavy snow was also slightly below average (Table 6).

Table 6. Status of 2013 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 2013	Chalk Hill 2 ENE, PA CHKP1 1981–2010	Morgantown Lock and Dam, WV MOEW2 2013	Morgantown Lock and Dam, WV MOEW2 1981–2010
Annual Precipitation	51.6 in* 1,311 mm*	54.2 in 1,377 mm	41.2 in** 1,046 mm**	43.1 in 1,095 mm
Autumn (Oct, Nov, Dec) Precipitation	10.7 in 272 mm	12.4 in 315 mm	9.9 in 255 mm	9.7 in 246 mm
Heavy Precipitation Days (days with ≥ 1.0 in [25 mm] rain)	8	11	4	7
Extreme Precipitation Days (days with ≥ 2.0 in [51 mm] rain)	1	2	0	1
Micro-drought (strings of 7+ days without rain)	1	3	0	6
Annual Snowfall	83.0 in 210.8 cm	89.0 in 226.1 cm	10.0 in 25.4 cm	33.4 in ² 84.8 cm ²
Measurable Snow Days (days with ≥ 0.1 in [0.3 cm] snow)	44	53	9	20 ²
Moderate Snow Days (days with ≥ 3.0 in [7.6 cm] snow)	10	10	1	3 ²
Heavy Snow Days (days with ≥ 5.0 in [12.7 cm] snow)	5	4	0	1 ²

²MOEW2 1981-2010 normal snowfall data is approximated using Fairmont, WV snowfall data.

*Uniontown data used for annual values **Morgantown Airport data used for annual values

Table 7. Top five wettest days and top five dry spells (consecutive days with a trace or less of liquid precipitation) during 2013 from stations at Chalk Hill (CHKP1) and Morgantown Lock and Dam (MOEW2).

Wettest Days in 2013	Dry Spells in 2013
Jul 9: 2.00 in (52mm)	April 1-11
Aug 8: 1.60 in (41mm)	Sept 4-12
Dec 6: 1.52 in (39mm)	Jan 17-28
Jun 28: 1.33 in (32mm)	Sept 22-29
Jan 31: 1.45 in (36mm)	Nov 28-Dec 4

Table 8. Summary of 2013 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	3.14 in	1.42 in	2.38 in	1.81 in	3.87 in	4.78 in	6.94 in	4.95 in	1.99 in	1.79 in	3.56 in	4.53 in	41.16 in
		79mm	36 mm	61 mm	46 mm	100 mm	122 mm	175 mm	127 mm	51 mm	46 mm	91 mm	118 mm	1046 mm
Chalk Hill 2 ENE	CHKP1	3.74 in	2.20 in	4.37 in	1.95 in	3.77 in	5.90 in	8.52 in	7.50 in	2.47 in	2.19 in	4.30 in	5.11 in	52.66 in
		94 mm	56 mm	112 mm	51 mm	97 mm	150 mm	216 mm	191 mm	64 mm	56 mm	109 mm	130 mm	1311 in
Uniontown 1 NE	UNTP1	3.49 in	1.77 in	2.66 in	1.96 in	3.80 in	5.06 in	7.65 in	7.51 in	2.28 in	1.59 in	3.47 in	3.68 in	44.92 in
		89 mm	46 mm	67 mm	51 mm	97 mm	130 mm	196 mm	191 mm	58 mm	41 mm	89 mm	94 mm	1140 mm
Confluence 1 SW Dam	CONP1	2.86 in	2.23 in	2.52 in	2.31 in	3.01 in	4.36 in	6.97 in	8.65 in	1.09 in	1.60 in	2.14 in	1.93 in	39.67 in
		74 mm	56 mm	64 mm	58 mm	76 mm	112 mm	178 mm	221 mm	28 mm	41 mm	43 mm	48 mm	1008 mm
Morgantown Lock and Dam	MOEW2	3.33 in	1.0 in	0.5 in	1.5 in	3.7 in	4.6 in	8.7 in	3.5 in	1.9 in	1.1 in	1.9 in	1.7 in	34.9 in
		85 mm	25 mm	13 mm	38 mm	94 mm	117 mm	221 mm	89 mm	48 mm	28 mm	48 mm	43 mm	886 mm
Grays Landing	GYLP1	3.07 in	1.86 in	1.69 in	1.59 in	2.77 in	6.55 in	6.95 in	7.35 in	1.51 in	1.63 in	3.13 in	3.47 in	41.57 in
		79 mm	48 mm	43 mm	40 mm	71 mm	168 mm	178 mm	188 mm	38 mm	41 mm	79 mm	89 mm	1057 mm

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Table 9. Summary of 2013 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	101	53	65	52	99	117	149	125	58	65	115	144	105
Chalk Hill 2 ENE	CHKP1	87	61	95	41	71	119	157	177	56	59	101	98	100
Uniontown 1 NE	UNTP1	107	66	71	53	92	114	167	188	67	54	112	119	107
Confluence 1 SW Dam	CONP1	83	78	66	60	68	106	153	226	30	54	68	57	92
Morgantown Lock and Dam	MOEW2	104	35	13	42	88	110	199	91	58	40	63	53	85
Grays Landing ¹	GYLP1	101	83	48	46	62	152	164	204	48	55	104	111	111

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

¹Indicates a station's Period of Record is ten or more years but less than 30 years. In these cases, the departure from normal values was calculated with normals derived from data spanning the length of the station's period of record.

**Friendship Hill National Historic Site and Fort Necessity National Battlefield
Percent of Average Monthly Precipitation
2013 vs. 1981–2010**

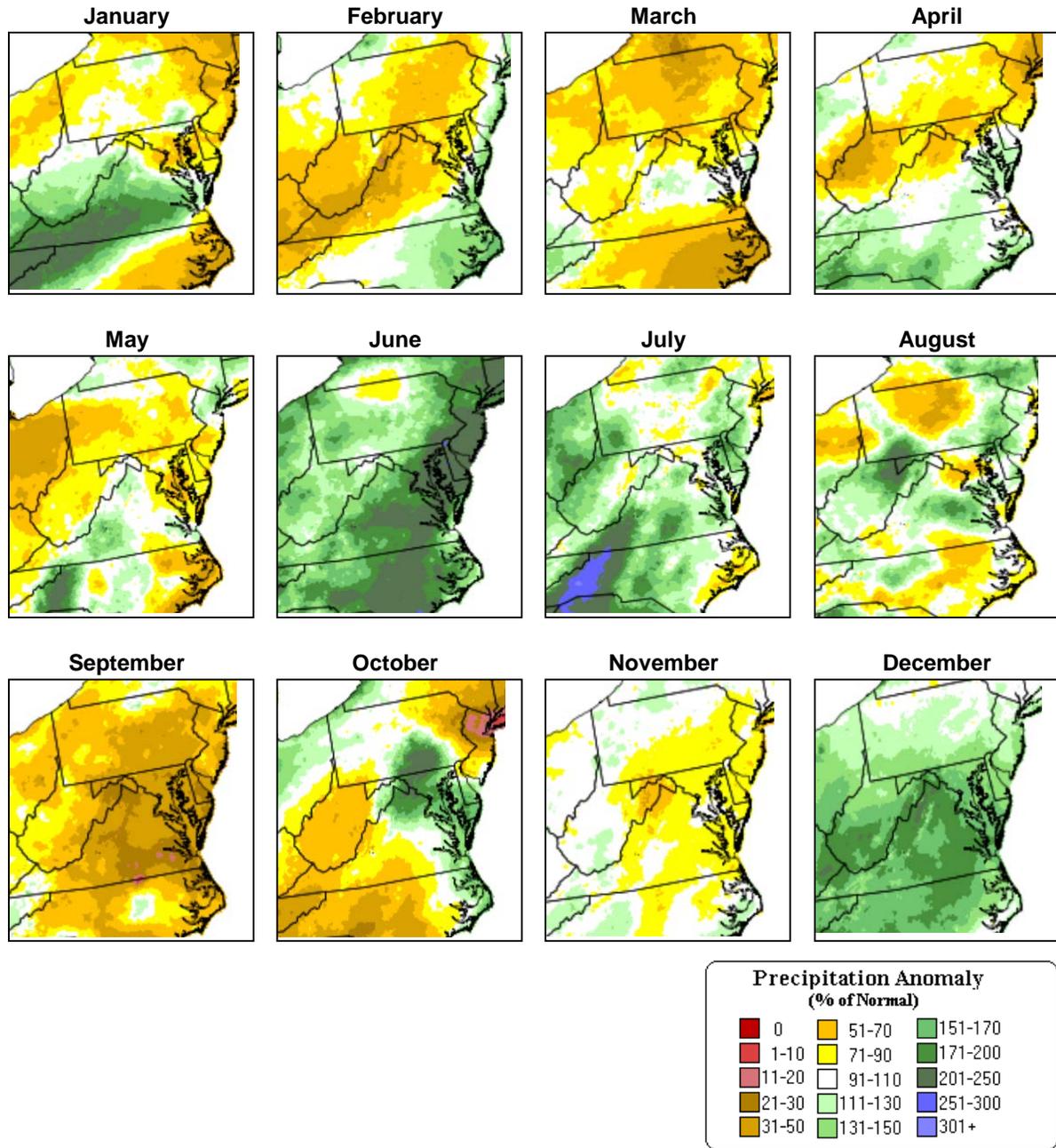


Figure 4. Maps showing percent of average monthly precipitation compared to the 30-year normal (1981–2010).

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 2013 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 2013). 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 2013.

According to the PDSI in Climate Division 9, a persistently dry spring and early summer was bookended by a moist early winter (January) and a wet late summer and autumn. The dry conditions led the drought severity index to approach “moderate drought” level by late May (Figure 5) but it suddenly turned wet and became “moderately moist” by late-August. Heavy rainfall during November and December raised the PDSI values above $+2.5$, moderately moist, by the latter half of December. The calendar year 2013 was most similar to 2012 and most dissimilar to the spring of 2011.

The DM – Drought Severity Index for Pennsylvania (Figure 6) and the Northeast (Figure 7) shows a similar pattern for the growing season (April through September); abnormally to moderately dry (D0) developed during May and June, but dissipated by July in southwestern Pennsylvania.

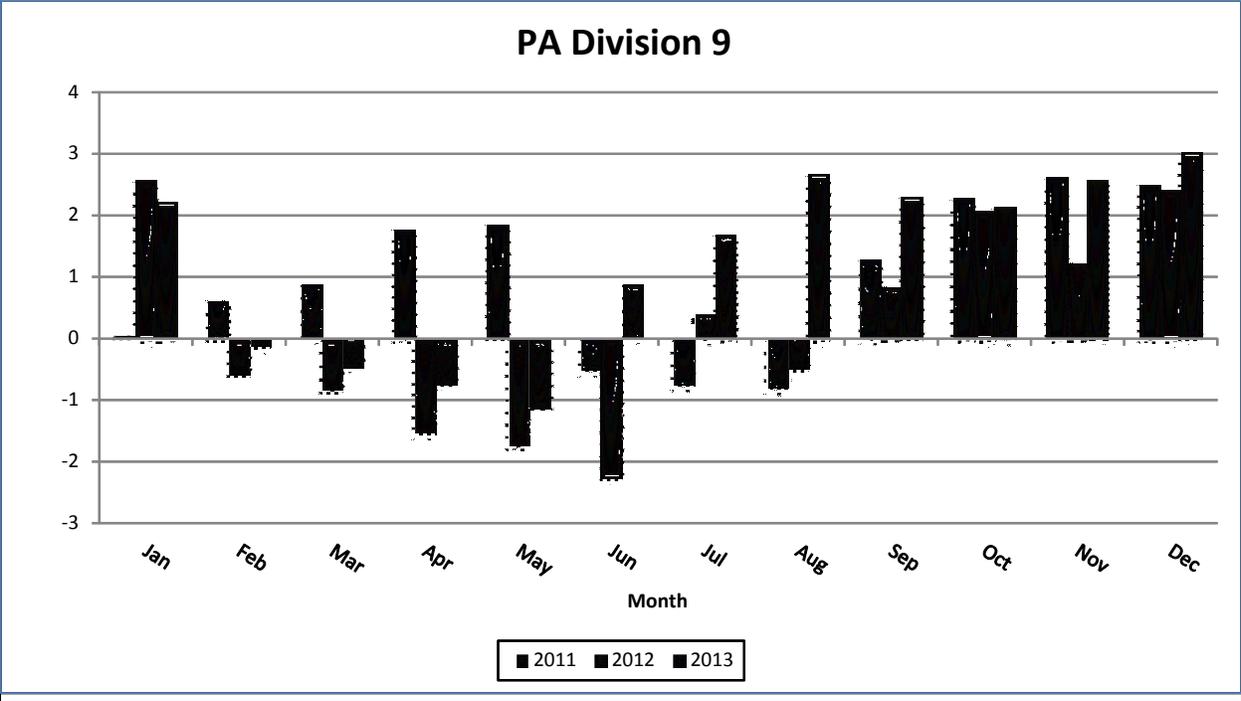


Figure 5. Monthly Palmer Drought Severity Index (PDSI) values for Pennsylvania Climate Division 9, 2011–2013.

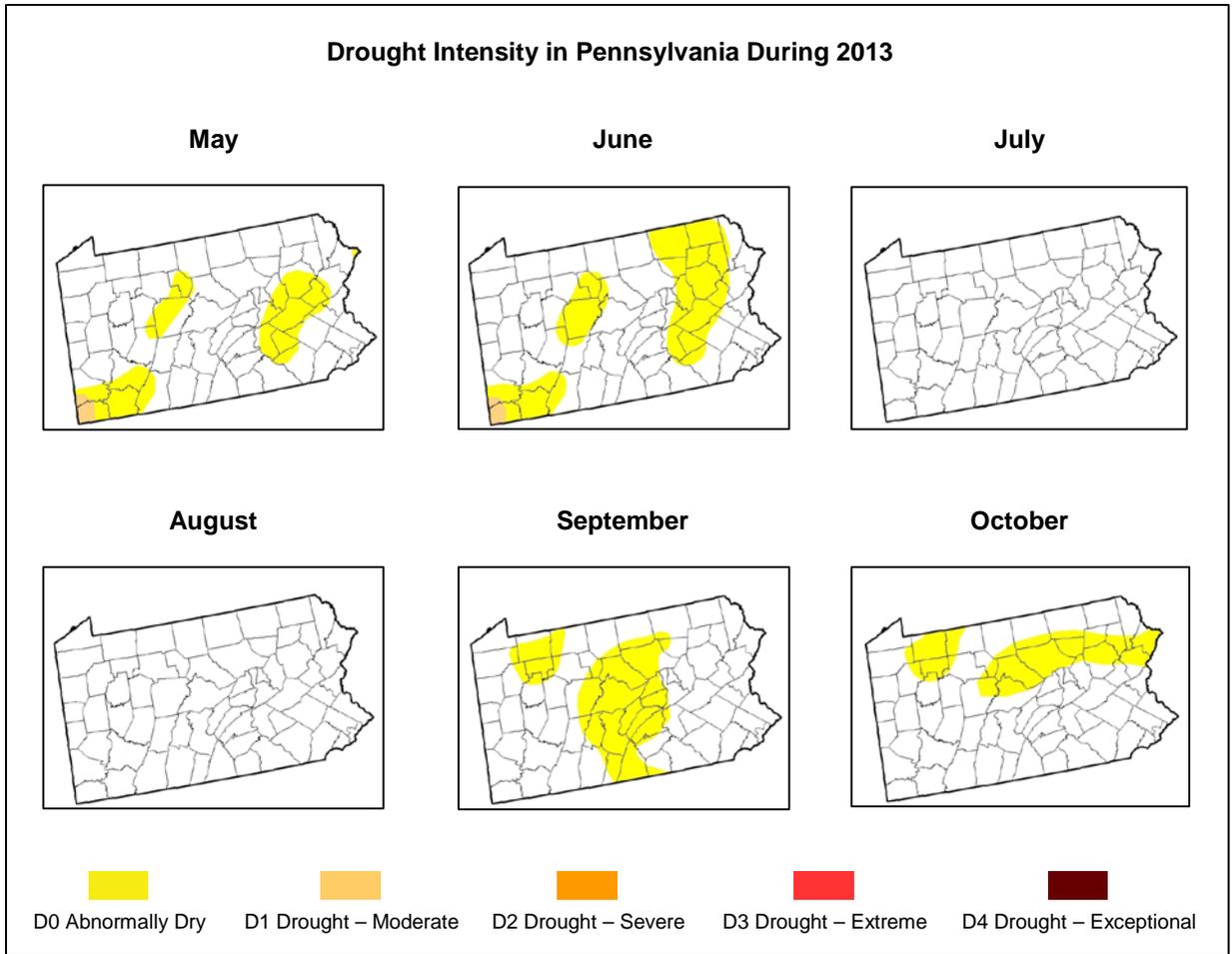


Figure 6. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for Pennsylvania in 2013.

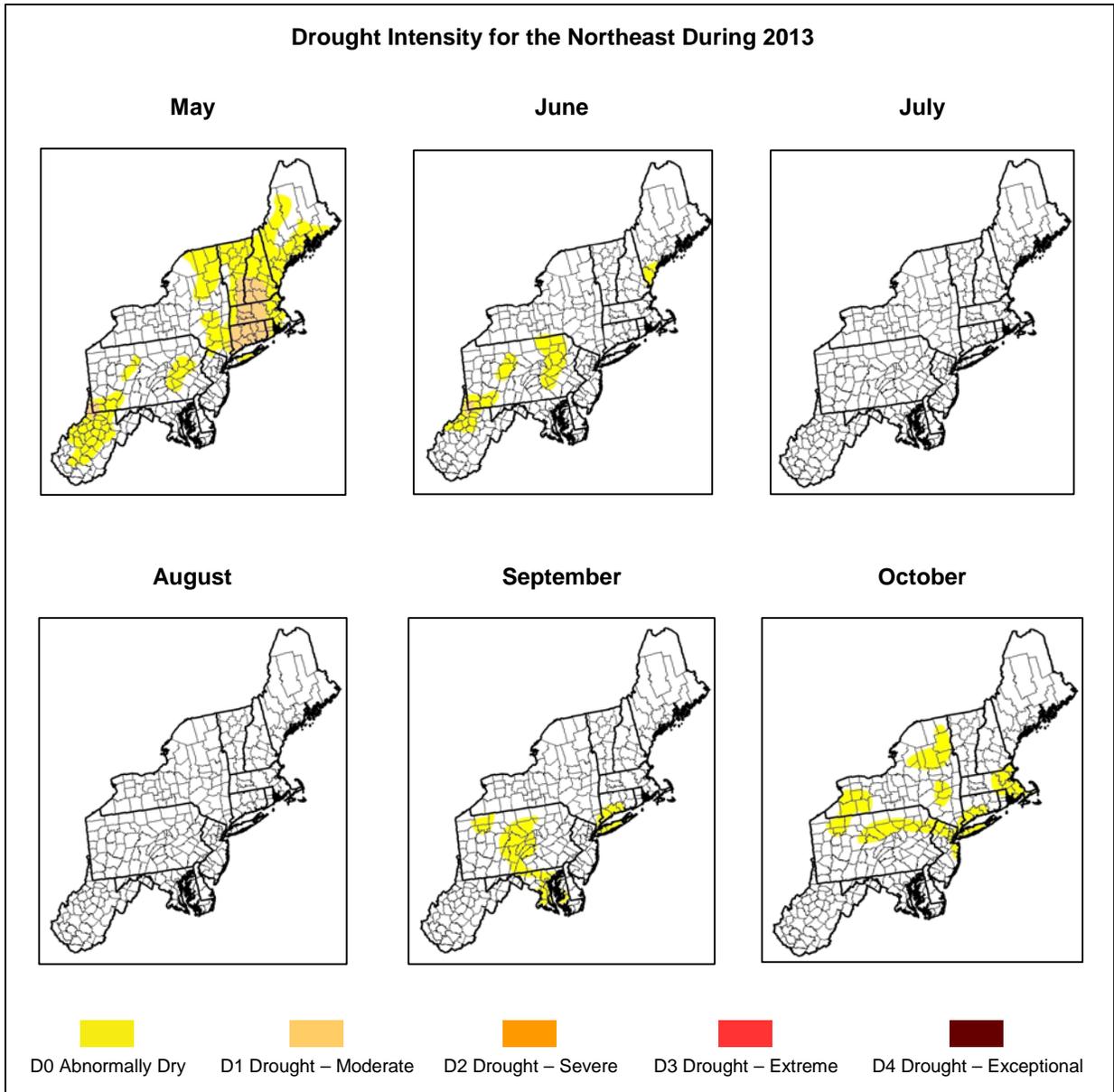


Figure 7. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for the Northeast in 2013.

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