



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

*Eastern Rivers and Mountains Network Summary Report for 2011*

Natural Resource Data Series NPS/ERMN/NRDS—2012/386



**ON THE COVER**

Photo description: Summer sky at Fort Necessity National Battlefield, August 2008.

Photograph by: Jane Clark (NPS photos).

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*Eastern Rivers and Mountains Network Summary Report for 2011*

Natural Resource Data Series NPS/ERMN/NRDS—2012/386

Paul Knight, Kyle Imhoff, Chad Bahrmann, and Sonya Miller

Pennsylvania State Climate Office  
503 Walker Building  
Pennsylvania State University  
University Park, Pennsylvania

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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 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, 2011, 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 2011]). 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 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., in review). Moreover, the percentage of time a station reports particular parameters (e.g., temperature) can influence data inclusion. No stations were excluded in 2011 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 2011) 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.

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/gmaps/NPS\\_DEVELOPMENT/interface.php](http://climate.met.psu.edu/gmaps/NPS_DEVELOPMENT/interface.php).

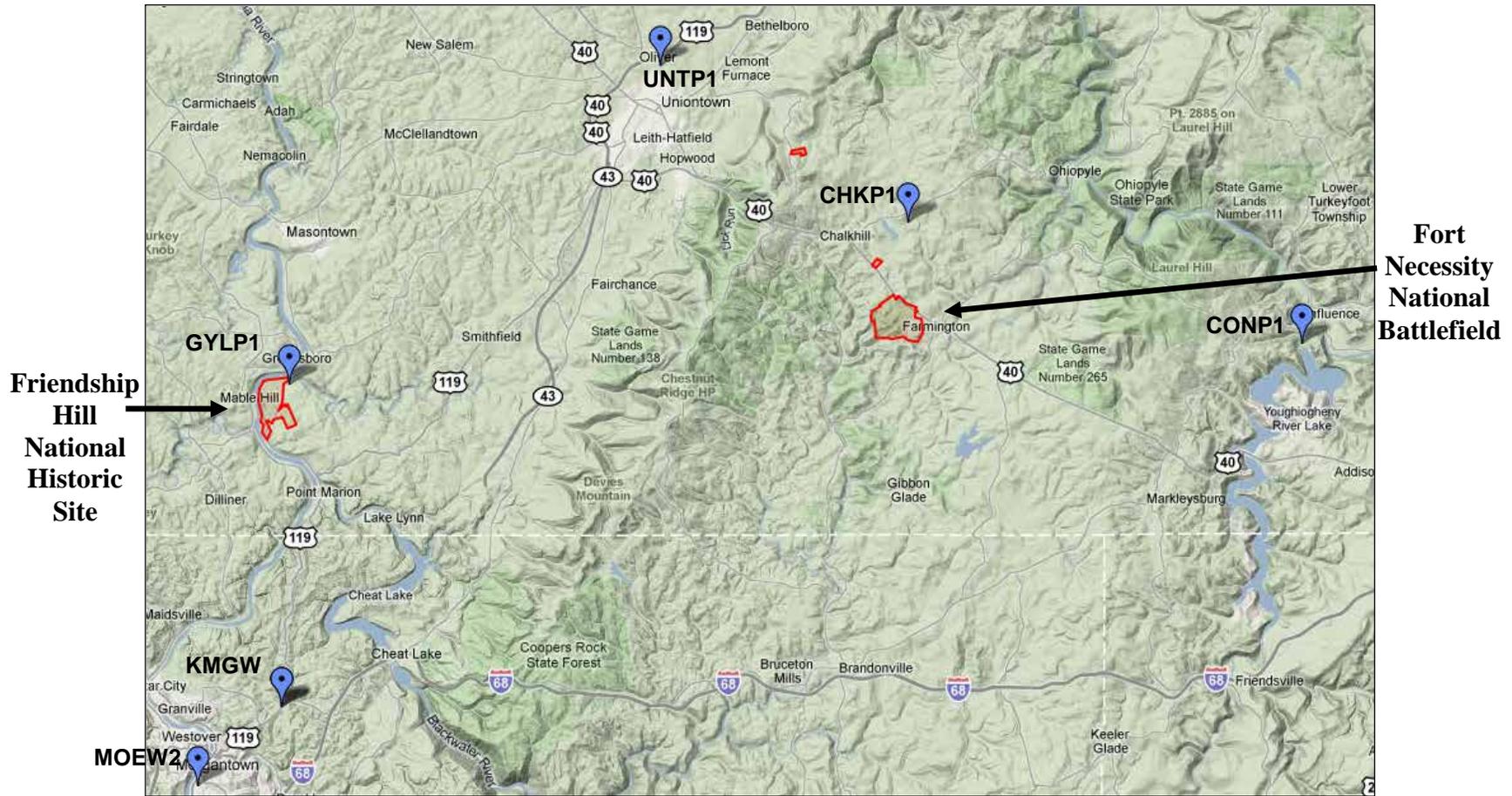


Figure 1. Location of weather observing stations around Friendship Hill National Historic Site and Fort Necessity National Battlefield. See Table 1 for station names.

**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 2011.

Station	Observing Network	Station Name	Period of Record (POR)		Percentage of Time Reporting Temperature for 2011	Percentage of Time Reporting Precipitation for 2011	Percentage of Time Reporting Temperature for entire POR	Percentage of Time Reporting Precipitation for entire POR
			Start Date	End Date				
<b>CHKP1</b>	COOP	Chalk Hill 2 ENE	07/01/1977	Present	93.7	86.3	99.7	99.5
<b>GYLP1</b>	COOP	Grays Landing	10/01/1996	Present	99.7	100.0	96.5	99.2
<b>UNTP1</b>	COOP	Uniontown 1 NE	01/01/1894	Present	100.0	100.0	97.3	95.6
<b>CONP1</b>	COOP	Confluence 1 SW Dam	07/01/1946	Present	100.0	100.0	99.7	99.7
<b>MOEW2</b>	COOP	Morgantown Lock and Dam	09/01/1921	Present	92.1	89.9	96.9 <sup>1</sup>	96.0
<b>KMGW</b>	ASOS	Morgantown Municipal Airport -Walter L. Bill Hart Field	12/31/1973	Present	100.0	100.0	99.0	99.0

<sup>1</sup> 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

2011 was notably warmer than normal (Tables 2, 3 and 4), primarily due to warmth that started during late March and continued through December (Figures 2 and 3)<sup>1</sup>.

The year began rather cold, as January had readings ranging from -4.2 degrees Fahrenheit (°F) (-2.3 degrees Celsius (°C)) to -5.0°F (-2.7°C) below normal (Table 4). The coldest weather of the year occurred January 25 when minima of -15°F (-26.1°C) were measured at Chalk Hill, PA, and a value of 1°F (-17.2°C) occurred at Morgantown Lock and Dam (Table 2). February mean temperatures were higher (Table 4), averaging as much as 2.6°F (1.4°C) above the long-term average at Morgantown. March continued with slightly above-average temperatures (Figures 2 and 3). Overall, the winter was virtually normal ranking 68<sup>th</sup> (58 is the mid-point; Table 5).

The spring ranked the 14<sup>th</sup> warmest on record since 1895, which was +2.3°F (1.2°C) above normal (Table 5). All of the spring months had above-average temperatures for virtually all of the reporting stations (Table 4). The largest anomalies were in May at Uniontown, which tallied an anomaly of +4.1°F (2.2°C), mainly due to very mild nights (Figure 3 and Table 4). Daytime temperatures were generally above the long-term average (Figure 2). The last freeze of the season occurred on May 6<sup>th</sup>, which led to a near normal length in the growing season. There were three days between April 26 and April 28 with readings in the 80's°F (> 27°C).

Summer of 2011 was much warmer than normal, ranking as the 11<sup>th</sup> hottest on record (Table 5). This positive anomaly was persistent, with the majority of the stations averaging above normal for each of the three months (Figures 2 and 3). The largest anomalies were during July, when readings averaged as much as +3.3°F (1.8°C) above normal at Uniontown, PA (Table 4). The highest temperature of the summer occurred during July, with a reading of 94°F (34.4°C) on July 23. Afternoon readings rose to 92°F (33.2°C) on September 4, and the first readings in the 30°F (<4.0°C) range occurred on September 16 and 17 at Chalk Hill, PA.

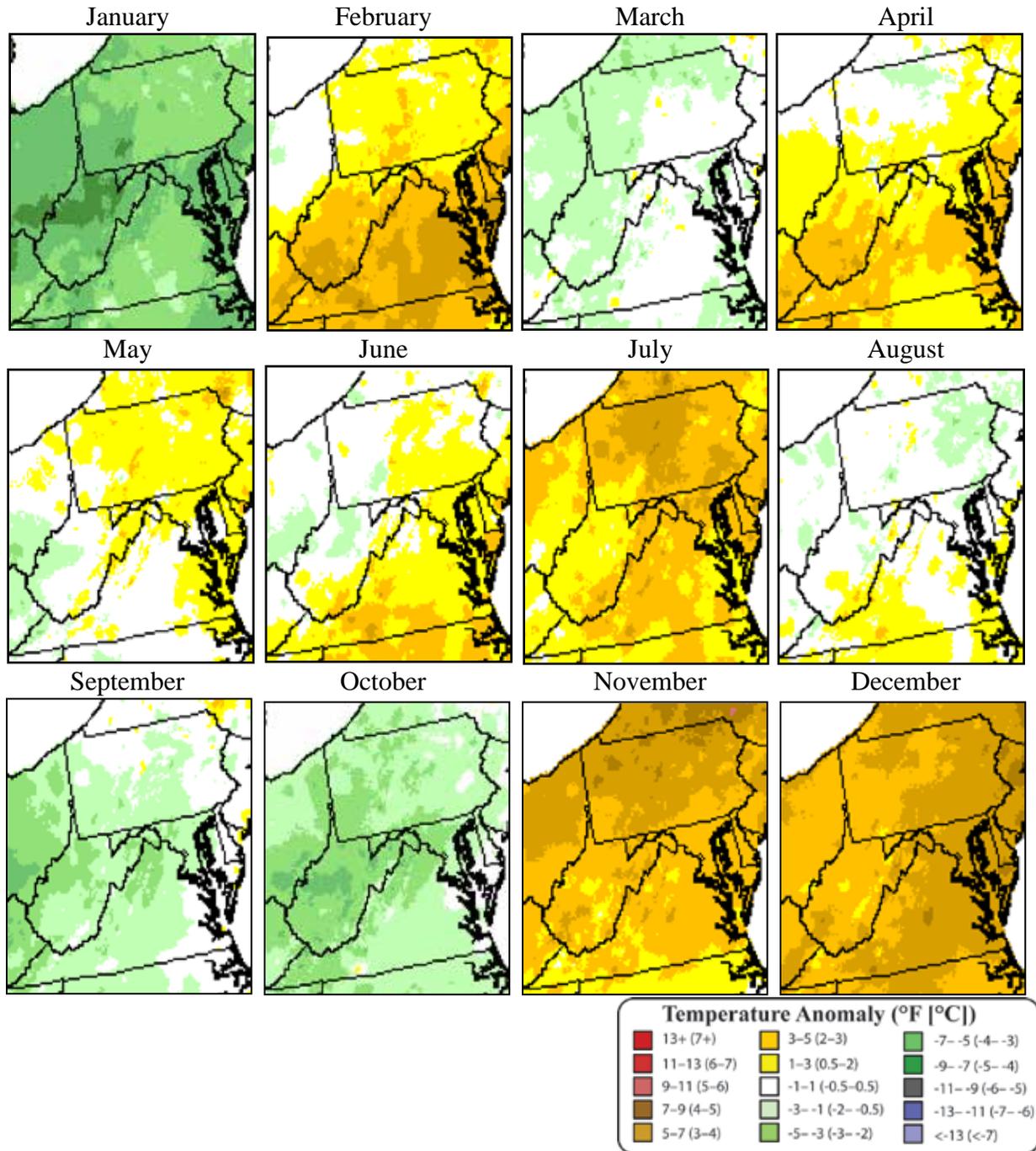
Temperatures in autumn stayed well above normal, ranking 8<sup>th</sup> warmest since records have been kept in 1895 (Table 5). The first widespread 32°F (0°C) readings of the fall occurred on October 28 near Fort Necessity NB (Table 2) and this accompanied by wet snow. November and December had increasingly large positive anomalies in daytime readings (Figure 2). Daytime readings stayed above 32°F (0.0°C) on all but a handful of days during December. There was an average number of cold days and slightly fewer-than-average number of sub-zero days (Table 2). Overall, 2011 averaged between +1.2°F (+0.6°C) and +1.4°F (+0.8°C) above the long-term average around Fort Necessity NB and Friendship Hill NHS (Table 2).

<sup>1</sup> 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/>.

**Table 2.** Status of 2011 temperature indicators compared to the 30-year normal (1981–2010) at the Chalk Hill 2 ENE (CHKP1) and Morgantown Lock and Dam (MOEW2) stations.

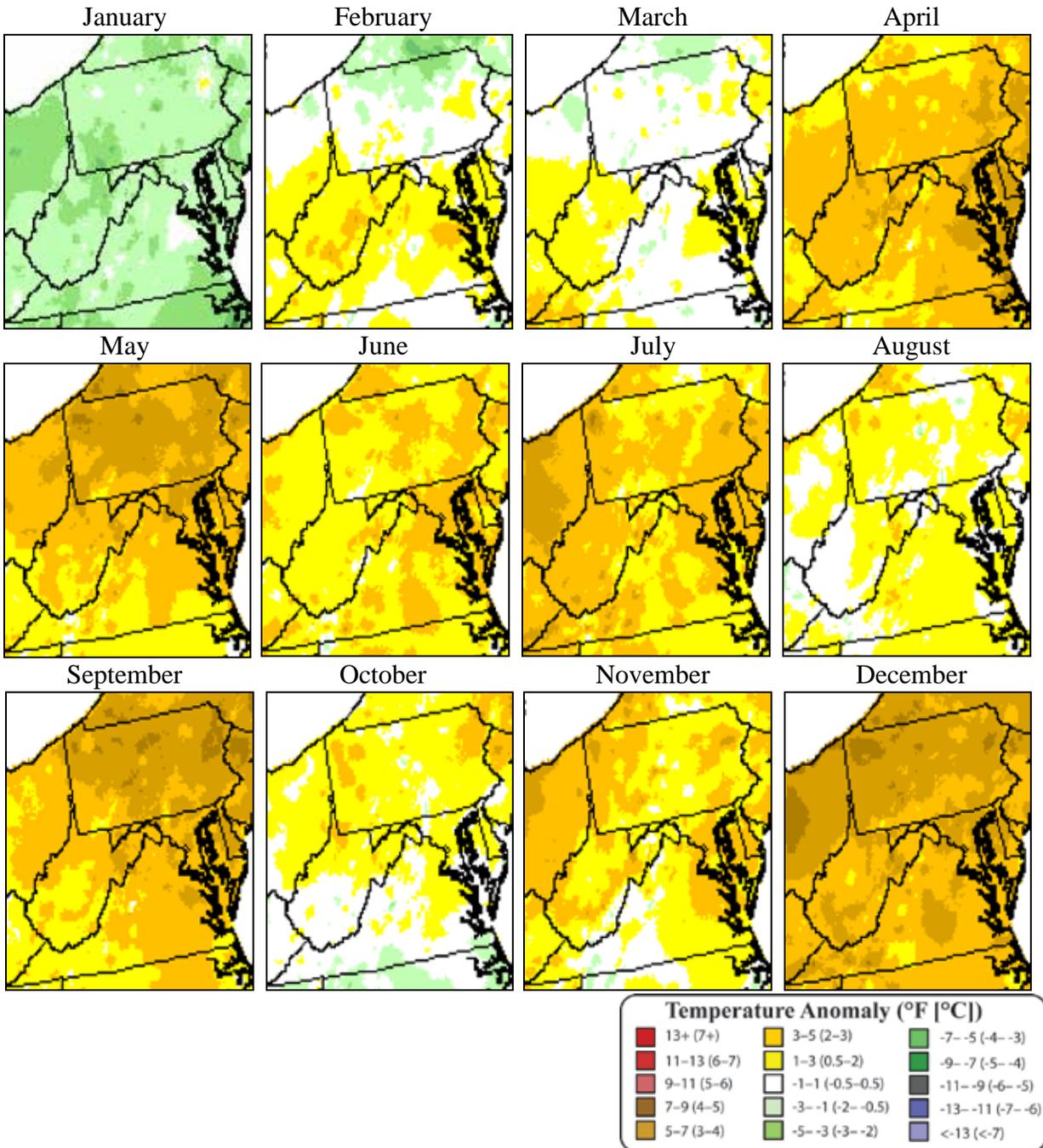
<b>Temperature Indicator</b>	<b>Chalk Hill 2 ENE, PA CHKP1 2011</b>	<b>Chalk Hill 2 ENE, PA CHKP1 1981–2010</b>	<b>Morgantown Lock and Dam, WV MOEW2 2011</b>	<b>Morgantown Lock and Dam, WV MOEW2 1981–2010</b>
Average Annual Temperature	47.9°F 8.8°C	46.7°F 8.2°C	53.7°F 12.1°C	52.3°F 11.3°C
Average Annual Maximum Temperature	58.5°F 14.7°C	58.3°F 14.6°C	63.7°F 17.6°C	62.6°F 17.0°C
Maximum Temperature	91.0°F 32.8°C	87.0°F 30.6°C	94.0°F 34.4°C	93.0°F 33.9°C
Hot Days (days with T <sub>max</sub> ≥90°F/32°C)	1	0	10	5
Average Annual Minimum Temperature	37.2°F 2.9°C	35.1°F 1.7°C	43.7°F 6.5°C	41.9°F 5.5°C
Minimum Temperature	-15.0°F -26.1°C	-10.8°F -23.8°C	1.0°F -17.2°C	-1.1°F -18.4°C
Cold Days (days with T <sub>max</sub> ≤32°F/0°C)	39	35	20	22
Sub-freezing Days (days with T <sub>min</sub> ≤32°F/0°C)	143	161	100	117
Sub-zero Days (days with T <sub>min</sub> ≤0°F/-17.8°C)	9	9	0	2
Growing Season Length (days between last spring T <sub>min</sub> 32°F/0°C and first fall T <sub>min</sub> 32°F/0°C)	132	146	204	181

Friendship Hill National Historic Site and Fort Necessity National Battlefield  
 Departure from Average Monthly Maximum Temperature  
 2011 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  
 2011 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 2011 for the selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Morgantown Airport	KMGW	27.1°F	36.8°F	42.2°F	55.6°F	64.7°F	70.2°F	76.2°F	72.4°F	65.9°F	53.5°F	49.1°F	40.6°F	54.5°F
		-2.7°C	2.6°C	5.6°C	13.1°C	18.1°C	21.2°C	24.5°C	22.4°C	18.8°C	11.9°C	9.5°C	4.7°C	12.5°C
Chalk Hill 2 ENE	CHKP1	19.9°F	28.1°F	35.1°F	47.1°F	59.3°F	64.3°F	69.5°F	66.4°F	60.2°F	47.6°F	42.6°F	32.4°F	47.7°F
		-6.7°C	-2.16°C	1.7°C	8.3°C	15.1°C	17.9°C	20.8°C	19.1°C	15.6°C	8.6°C	5.8°C	0.2°C	8.7°C
Uniontown 1 NE	UNTP1	25.1°F	33.8°F	40.4°F	54.0°F	63.5°F	69.8°F	75.3°F	71.8°F	66.3°F	52.6°F	47.2°F	38.5°F	53.1°F
		-3.8°C	1.0°C	4.6°C	12.2°C	17.5°C	21.0°C	24.0°C	22.1°C	19.0°C	11.4°C	8.4°C	3.6°C	11.7°C
Confluence 1 SW Dam	CONP1	21.5°F	28.6°F	40.0°F	50.5°F	61.2°F	68.2°F	72.5°F	67.5°F	63.5°F	50.6°F	45.3°F	M	51.8°F
		-5.8°C	-1.9°C	4.4°C	10.3°C	16.2°C	20.1°C	22.5°C	19.7°C	17.5°C	10.3°C	7.4°C	M	11.0°C
Morgantown Lock and Dam	MOEW2	25.5°F	33.7°F	40.6°F	52.9°F	62.9°F	69.5°F	76.2°F	71.8°F	65.9°F	53.9°F	M	M	55.2°F
		-3.6°C	0.9°C	4.7°C	11.6°C	17.1°C	20.8°C	24.5°C	22.1°C	18.8°C	12.1°C	M	M	12.9°C
Grays Landing	GYLP1	24.3°F	32.8°F	40.0°F	52.2°F	62.2°F	68.7°F	74.7°F	71.3°F	65.2°F	52.4°F	46.0°F	36.5°F	52.1°F
		-4.2°C	0.4°C	4.4°C	11.2°C	16.7°C	20.3°C	23.7°C	21.8°C	18.4°C	11.3°C	7.7°C	2.5°C	11.2°C

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

**Table 4.** Summary of 2011 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
Chalk Hill 2 ENE	CHKP1	-5.0°F	0.5°F	-0.7°F	0.2°F	3.9°F	1.1°F	2.9°F	1.1°F	1.6°F	-0.6°F	3.9°F	4.0°F	1.0°F
		-2.7°C	0.2°C	-0.3°C	0.1°C	2.1°C	0.6°C	1.6°C	0.6°C	0.8°C	-0.3°C	2.1°C	2.2°C	0.59°C
Grays Landing <sup>1</sup>	GYLP1	-4.7°F	1.2°F	0.9°F	1.9°F	2.4°F	-0.1°F	1.3°F	-0.7°F	0.8°F	-0.2°F	3.7°F	4.1°F	0.8°F
		-2.6°C	0.6°C	0.5°C	1.0°C	1.3°C	-0.1°C	0.7°C	-0.3°C	0.4°C	-0.1°C	2.0°C	2.2°C	0.49°C
Uniontown 1 NE	UNTP1	-4.5°F	1.7°F	1.0°F	4.0°F	4.1°F	1.7°F	3.3°F	1.0°F	2.6°F	0.2°F	4.4°F	5.2°F	2.0°F
		-2.5°C	0.9°C	0.5°C	2.2°C	2.2°C	0.9°C	1.8°C	0.5°C	1.4°C	0.1°C	2.4°C	2.8°C	1.1°C
Confluence 1 SW Dam	CONP1	-4.6°F	-1.0°F	1.4°F	2.7°F	3.1°F	1.5°F	0.6°F	-1.2°F	-0.4°F	-0.1°F	5.4°F	M	2.2°F
		-4.5°C	-0.6°C	0.7°C	1.6°C	1.6°C	0.8°C	0.3°C	-0.7°C	-0.2°C	-0.1°C	3.0°C	M	1.3°C
Morgantown Lock and Dam	MOEW2	-4.5°F	1.1°F	0.1°F	1.4°F	2.3°F	0.3°F	3.1°F	0.1°F	0.7°F	-0.4°F	M	M	0.42°F
		-2.5°C	0.6°C	0.05°C	0.7°C	1.2°C	0.1°C	1.7°C	0.05°C	0.3°C	-0.2°C	M	M	0.23°C
Morgantown	KMGW	-4.2°F	2.6°F	0.1°F	2.9°F	3.6°F	0.8°F	3.0°F	0.4°F	0.7°F	-0.7°F	4.2°F	5.8°F	1.6°F
		-2.3°C	1.4°C	0.05°C	3.6°C	1.6°C	2.0°C	0.4°C	1.6°C	0.2°C	0.3°C	2.3°C	3.2°C	0.8°C

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

<sup>1</sup>Indicates a station's Period of Record is ten or more years but less than 30 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 5.** Seasonal and annual temperature and precipitation rankings for 2011 over 117 years (1 = warmest/wettest year and 117 = coldest/driest year) for Pennsylvania Climate Division 9.

<b>PA Climate Division 9 Rankings "Southwest"</b>	<b>Jan-Feb-Mar WINTER</b>	<b>Apr-May-Jun SPRING</b>	<b>Jul-Aug-Sep SUMMER</b>	<b>Oct-Nov-Dec AUTUMN</b>	<b>Jan - Dec ANNUAL</b>
Temperature-2011	68	14	11	8	10
Precipitation-2011	33	12	15	9	4

## Precipitation Summary

Overall, 58.9 in (1,496 mm) of liquid precipitation (rain plus melted snow, ice, sleet, etc.; hereafter precipitation) fell in Chalk Hill, PA (near Fort Necessity NB), and 61.5 in (1,562 mm) fell in Morgantown Lock and Dam, WV (near Friendship Hill NHS), during the year making 2011 the 4<sup>th</sup> wettest years on record (Tables 5 and 6). These totals ranged from 4.7 in (119 mm) to 18.4 in (457 mm) above the long-term averages. The longest dry spell of the year occurred between May 29 and June 4, when no measurable rain fell at Chalk Hill (Table 7). Conversely, one of the wetter days in 2011 occurred on August 7, when 2.27 in (57 mm) fell in Chalk Hill (Table 7). There were two indirect influences from tropical storms in 2011, with the effects of Hurricane Irene on August 28<sup>th</sup> and Tropical Storm Lee on September 7-8. Precipitation was consistently above normal during 2011 at Fort Necessity NB and Friendship Hill NHS, with the majority of reporting stations averaging 100 percent or more of normal in 11 of the 12 months (Tables 8 and 9).

The winter season began with a drier-than-average January, with 1.6 in (41 mm [45 percent of average]) precipitation falling at Confluence (Tables 8 and 9). February was wetter, with precipitation ranging from 3.3 in (83 mm) at Grays Landing, which was 113 percent of normal, to 4.5 in (114 mm) at Chalk Hill (Table 8). March was also wet, with stations averaging 117 percent of normal precipitation (Table 9). Overall, the winter (January, February, and March) ranked as the 33<sup>rd</sup> wettest since 1895 (Table 5). Near average seasonal snowfall was recorded near Fort Necessity NB, as Chalk Hill tallied 76.8 in (195.1 cm) and Morgantown Lock and Dam measured 15.4 in (39.1 cm) (Table 6).

April precipitation was far above normal, ranging from 164 to 227 percent of normal (Table 9). May rainfall ranged from 4.7 in (119 mm) at Morgantown to 6.3 in (160 mm) at Chalk Hill (Table 8). June brought a similar amount of showers, with the region averaging 125 percent of long-term normal (Table 9). Overall, spring of 2011 ranked as the 12<sup>th</sup> wettest in this climate division, which is the wettest since 2004 (Table 5).

Summer of 2011 started somewhat drier than average (Figure 4); but it turned very wet and ranked as the 15<sup>th</sup> wettest (Table 5). The surplus was caused by a very wet September, which was 3<sup>rd</sup> wettest since 1895. July had as much as 6.9 in (175 mm) of rain falling in Uniontown (140 percent of normal), to as little as 2.7 in (68 mm) at Grays Landing (83 percent of normal) during August (Tables 8 and 9).

The autumn of 2011 was yet another very wet season and its ranking was the 9<sup>th</sup> wettest in 117 years in the Southwest Plateau Pennsylvania Climate Division (Table 5). Precipitation was quite consistent during the fall, ranging from 3.0 in (76 mm) at Confluence in November to 5.6 in (142 mm) in Morgantown Lock and Dam during October (Table 8). The number of heavy precipitation days was notably above normal in 2011, and the number of days with moderate and heavy snow was very close to average (Table 6).

**Table 6.** Status of 2011 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 2011	Chalk Hill 2 ENE, PA CHKP1 1981–2010	Morgantown Lock and Dam, WV MOEW2 2011	Morgantown Lock and Dam, WV MOEW2 1981–2010
Annual Precipitation	58.9 in 1,496 mm	54.2 in 1,377 mm	61.5 in 1,562 mm	43.1 in 1,095 mm
Autumn (Oct, Nov, Dec) Precipitation	14.8 in 376 mm	12.4 in 315 mm	14.1 in 358 mm	9.7 in 246 mm
Heavy Precipitation Days (days with $\geq 1.0$ in (25 mm) rain)	13	11	13	7
Extreme Precipitation Days (days with $\geq 2.0$ in (51 mm) rain)	1	2	2	1
Micro-drought (strings of 7+ days without rain)	1	3	1	6
Annual Snowfall	76.8 in 195.1 cm	89.0 in 226.1 cm	15.4 in <sup>1</sup> 39.1 cm <sup>1</sup>	33.4 in <sup>2</sup> 84.8 cm <sup>2</sup>
Measurable Snow Days (days with $\geq 0.1$ in (0.3 cm) snow)	40	53	9	20 <sup>2</sup>
Moderate Snow Days (days with $\geq 3.0$ in (7.6 cm) snow)	10	10	3	3 <sup>2</sup>
Heavy Snow Days (days with $\geq 5.0$ in (12.7 cm) snow)	3	4	0	1 <sup>2</sup>

<sup>1</sup>MOEW2 snowfall data was missing in Oct, Nov, and Dec - annual totals will reflect this.

<sup>2</sup>MOEW2 1981-2010 normal snowfall data is 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 2011 from stations at Chalk Hill (CHKP1) and Morgantown Lock and Dam (MOEW2).

Wettest Days in 2011	Dry Spells in 2011
August 7: 2.27 in (57 mm)	May 29-June 4
May 14: 2.10 in (53 mm)	July 13-19
July 19: 1.76 in (45 mm)	December 9-15
Sept 7: 1.76 in (45 mm)	Oct 6-11
Sept 5: 1.55 in (39 mm)	Jan 22-27

**Table 8.** Summary of 2011 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	2.0 in	3.8 in	4.3 in	7.2 in	4.7 in	4.8 in	5.4 in	4.9 in	7.4 in	4.6 in	4.3 in	3.9 in	57.7 in
		51 mm	97 mm	109 mm	183 mm	120 mm	123 mm	137 mm	124 mm	188 mm	117 mm	109 mm	100mm	1465 mm
Chalk Hill 2 ENE	CHKP1	2.8 in	4.5 in	5.3 in	M in	6.3 in	6.8 in	2.9 in	M in	M in	5.1 in	3.9 in	3.8 in	37.9in
		71 mm	114 mm	134 mm	M mm	160 mm	172 mm	73 mm	M mm	M mm	129 mm	99 mm	96 mm	963 mm
Uniontown 1 NE	UNTP1	1.9 in	3.5 in	4.1 in	6.8 in	5.0 in	5.9 in	6.9 in	3.1 in	6.9 in	4.9 in	4.9 in	3.5 in	58.1 in
		48 mm	88 mm	104mm	172mm	127 mm	149 mm	175 mm	78mm	175 mm	124 mm	124 mm	88 mm	1474 mm
Confluence 1 SW Dam	CONP1	1.6 in	3.4 in	4.0 in	6.5 in	5.5 in	4.2 in	4.7 in	4.0 in	7.4 in	5.0 in	3.0 in	M	49.3 in
		41 mm	86 mm	102 mm	165 mm	140 mm	107 mm	119 mm	102 mm	188 mm	127 mm	76 mm	M	1252 mm
Morgantown Lock and Dam	MOEW2	1.9 in	3.4 in	5.2 in	8.1 in	5.1 in	4.7 in	5.2 in	5.0 in	8.3 in	5.6 in	M	M	52.9 in
		46 mm	86 mm	132 mm	205 mm	129 mm	119 mm	132 mm	127 mm	210 mm	142 mm	M	M	1343 mm
Grays Landing	GYLP1	1.9 in	3.3 in	4.3 in	6.3 in	5.6 in	5.5 in	4.2 in	2.7 in	7.1 in	4.2 in	5.1 in	3.3 in	53.8 in
		48 mm	83 mm	109 mm	160 mm	141 mm	140 mm	106 mm	68 mm	180 mm	106 mm	129mm	83 mm	1366 mm

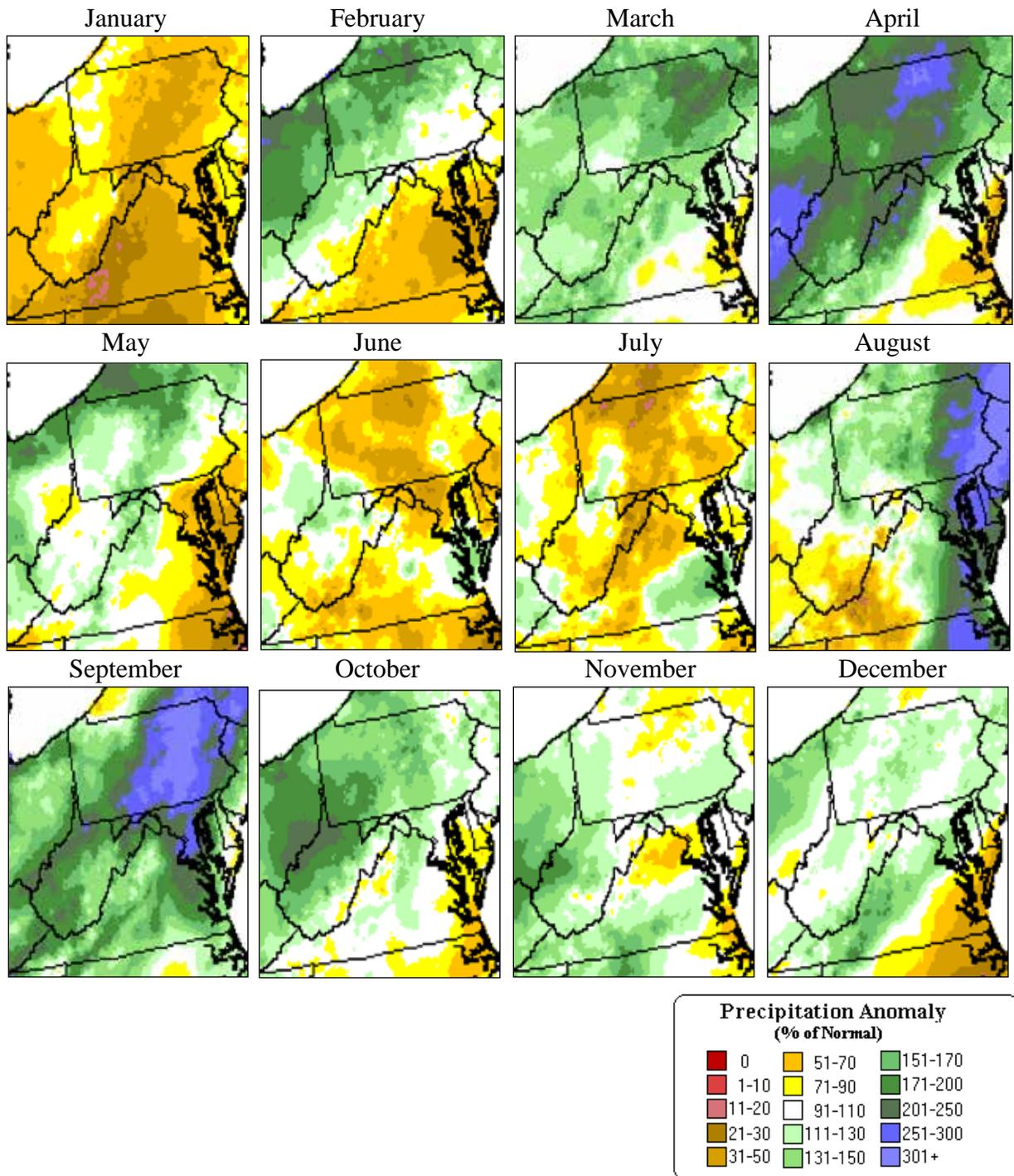
**Table 9.** Summary of 2011 percent of normal precipitation based on 30-year normal (1981–2010) for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Morgantown Airport	KMGW	72	148	118	205	103	118	117	138	232	166	125	136	138
Chalk Hill 2 ENE	CHKP1	66	118	114	M	119	136	55	M	M	M	115	92	102
Uniontown 1 NE	UNTP1	63	126	113	187	113	140	152	90	208	167	135	116	135
Confluence 1 SW Dam	CONP1	45	114	104	164	123	105	99	107	182	166	82	M	109
Morgantown Lock and Dam	MOEW2	57	116	133	227	113	115	119	149	265	200	M	M	146
Grays Landing <sup>1</sup>	GYLP1	67	113	119	195	130	139	114	83	251	169	135	112	136

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

<sup>1</sup>Indicates 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  
 2011 vs. 1981–2010



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

## Drought Status

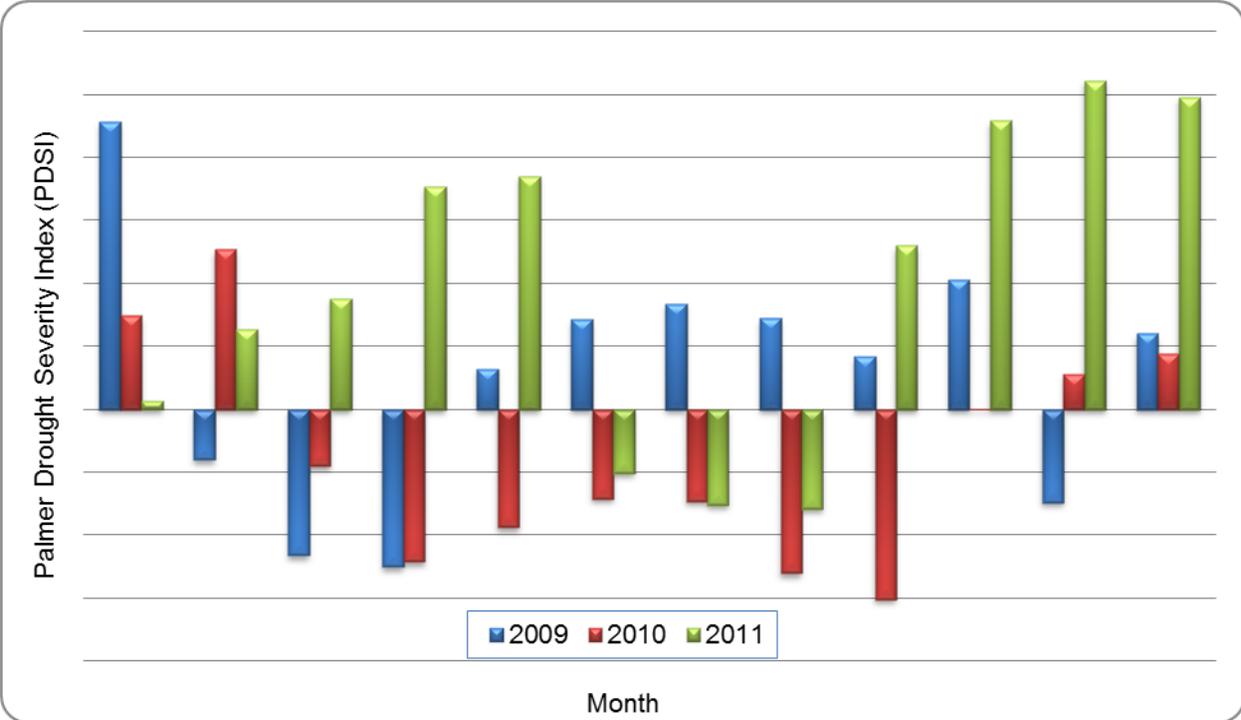
There are a number of drought indices used to estimate the severity of drought in an area using algorithms that incorporate recent temperatures, rainfall, soil moisture, and other information (<http://www.drought.gov>). The main indices we report are the Palmer Drought Severity Index (PDSI) and the United 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 2011 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 2011). 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 2011.

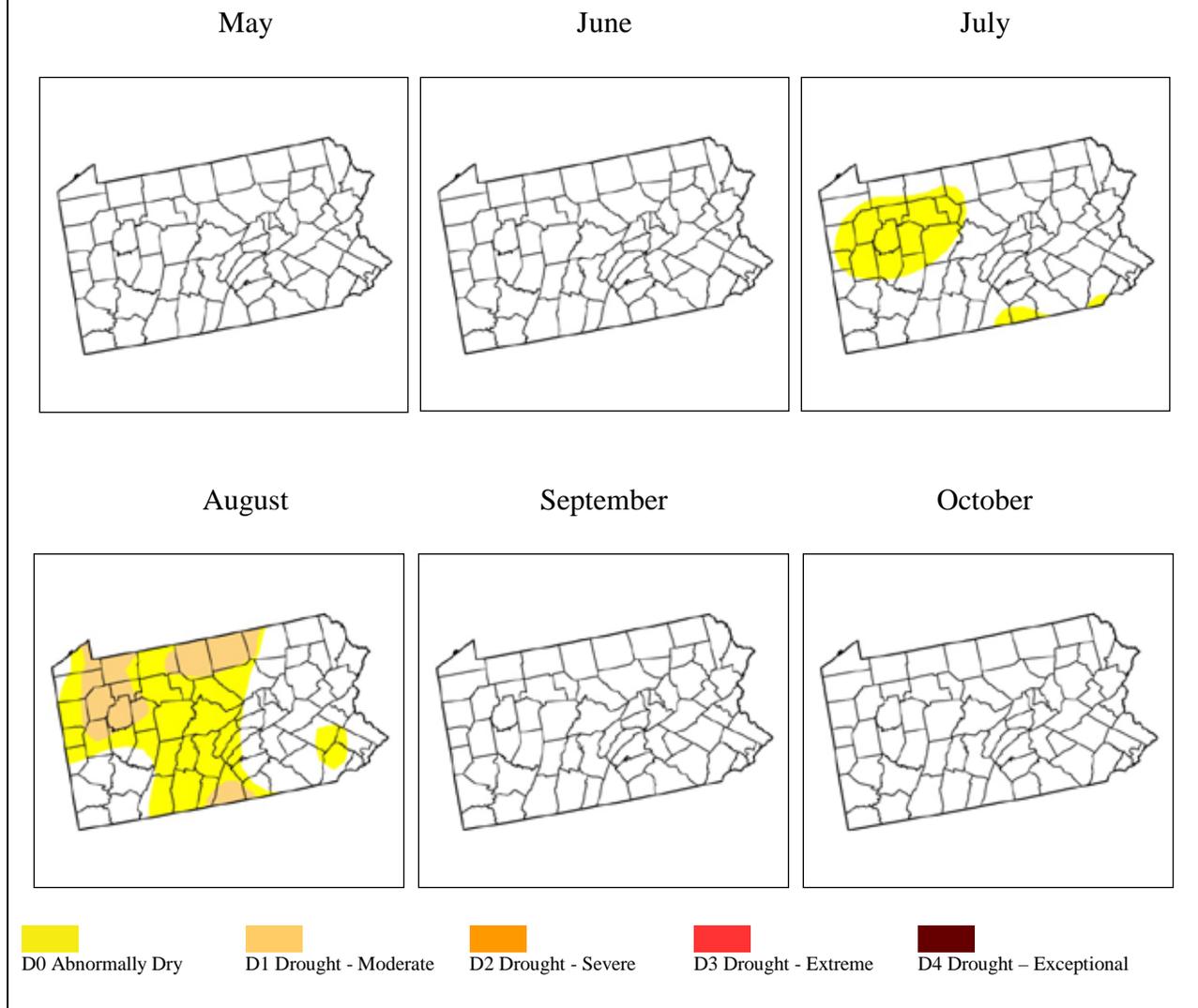
According to the PDSI, after a normal start to the year in Climate Division 9, persistent wet conditions led the drought severity index to approach “moderately moist” level by late May (Figure 5) but it suddenly turned dry and became “near normal” by mid-August. Heavy rainfall during late August and September raised the PDSI values above +2.5, moderately moist, by early November and it remained at this level into December. The calendar year 2011 was most dissimilar to the past two years during the period March-April and May when it was very moist.

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 dry (D0) developed briefly during August in southwestern Pennsylvania.

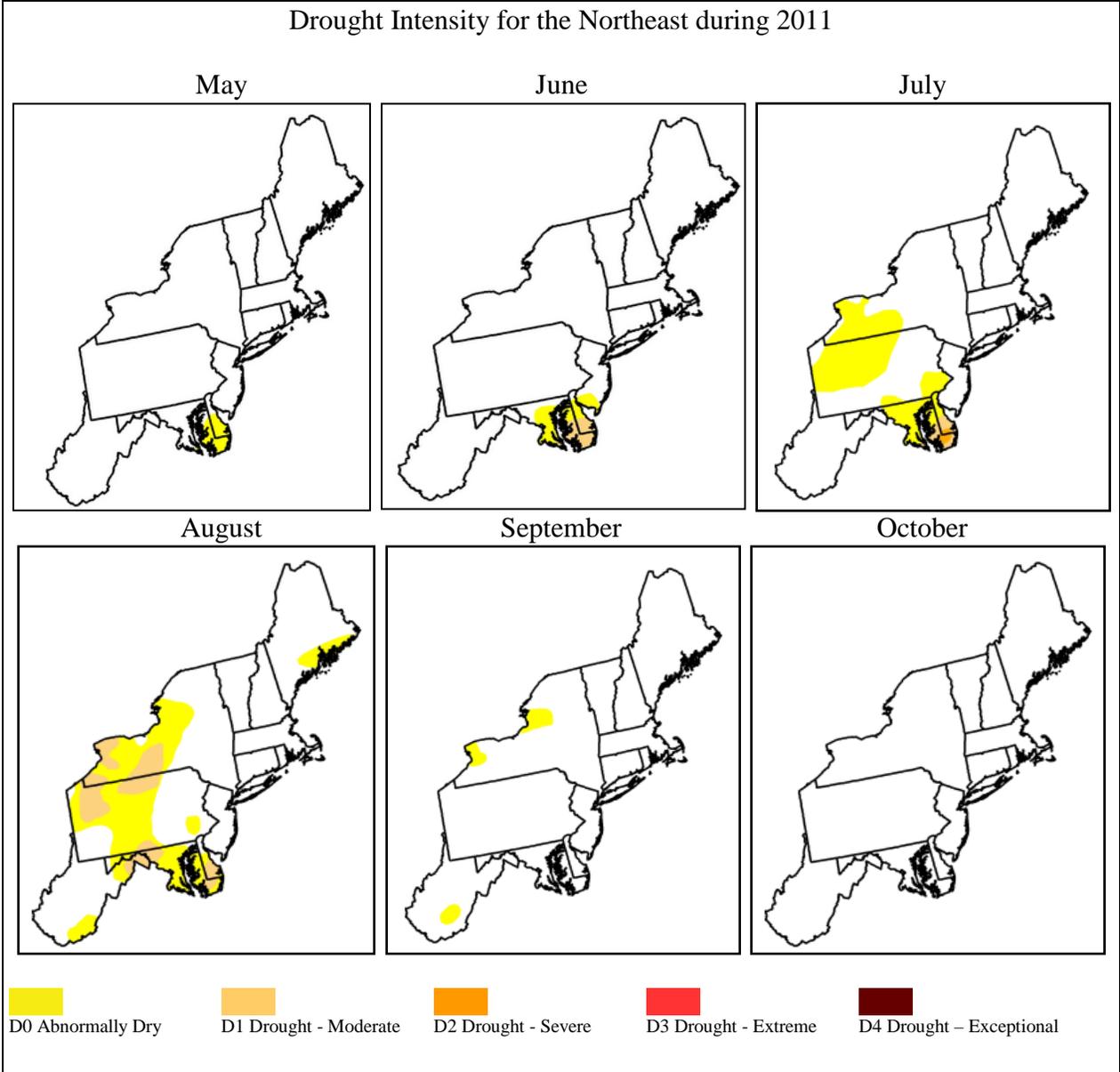


**Figure 5.** Monthly Palmer Drought Severity Index (PDSI) values for Pennsylvania Climate Division 9, 2009–2011.

Drought Severity in Pennsylvania during 2011



**Figure 6.** Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for Pennsylvania in 2011.



**Figure 7.** Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for the Northeast in 2011.

## References

- Daly, C., W. P. Gibson, G. H. Taylor, G. L. Johnson, and P. Pasteris. 2002. A knowledge-based approach to the statistical mapping of climate. *Climate Research* 22:99–113.
- Gelber, B. 2002. *The Pennsylvania Weather Book*. Rutgers University Press. New Brunswick, NJ.
- Kocin, P. J., and L. W. Uccellini. 2004. *Northeast Snowstorms Volume 1: Overview*. Meteorological Monographs. Vol 32. No 54. American Meteorological Society. Boston, MA.
- Marshall, M., Knight, P., 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, CO.
- Marshall, M. R., and N. B. Piekielek. 2007. *Eastern Rivers and Mountains Network Ecological Monitoring Plan*. Natural Resource Report NPS/ERMN/NRR—2007/017. National Park Service. Fort Collins, CO.
- 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 Oceanic and Atmospheric Administration (NOAA). 2011. *National Climatic Data Center. Climate of 2011 – Annual Review, Global and U.S. Summary*. <http://lwf.ncdc.noaa.gov/oa/climate/research/2011/ann/us-summary.html>.
- National Integrated Drought Information System (NIDIS). 2011. *National Climate Data Center and United States Department of Agriculture*. <http://drought.unl.edu/dm/archive.html>.

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