



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

Eastern Rivers and Mountains Network Summary Report for 2010

Natural Resource Data Series NPS/ERMN/NRDS—2011/293



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

Eastern Rivers and Mountains Network Summary Report for 2010

Natural Resource Data Series NPS/ERMN/NRDS—2011/293

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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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Table of Contents

	Page
Figures.....	v
Tables.....	vii
List of Key Acronyms.....	ix
The Climate of the Southwest Plateau	3
Observing Stations	5
Temperature Summary.....	9
Precipitation Summary.....	15
Drought Status	19
References.....	23

Figures

	Page
Figure 1. Location of weather observing stations around Friendship Hill National Historic Site and Fort Necessity National Battlefield. See Table 1 for station names.	6
Figure 2. Maps showing departure from average monthly maximum temperature compared to the 30-year normal (1971–2000).....	11
Figure 3. Maps showing departure from average monthly minimum temperature compared to the 30-year normal (1971–2000).....	12
Figure 4. Maps showing percent of average monthly precipitation compared to the 30-year normal (1971–2000).	18
Figure 5. Monthly Palmer Drought Severity Index (PDSI) values for Pennsylvania Climate Division 9, 2008–2010.....	20
Figure 6. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for Pennsylvania in 2010.	21
Figure 7. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for the Northeast in 2010.....	22

Tables

	Page
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 2010.	7
Table 2. Status of 2010 temperature indicators compared to the 30-year normal (1971–2000) at the Chalk Hill 2 ENE (CHKP1) and Morgantown Lock and Dam (MOEW2) stations.	10
Table 3. Summary of monthly average temperatures for 2010 for the selected stations.	13
Table 4. Summary of 2010 departure from normal temperature based on 30-year normal (1971–2000) for the selected stations.	13
Table 5. Seasonal temperature and precipitation rankings over 116 years (1 = warmest/wettest year and 116 = coldest/driest year) for Pennsylvania Climate Division 9.	14
Table 6. Status of 2010 precipitation indicators compared to the 30-year normal (1971–2000) at the Chalk Hill 2 ENE (CHKP1) and Morgantown Lock and Dam (MOEW2) stations.	16
Table 7. Top five wettest days and top five dry spells (consecutive days with a trace or less of rainfall) during 2010 from stations at Chalk Hill (CHKP1) and Morgantown Lock and Dam (MOEW2).	16
Table 8. Summary of 2010 monthly total precipitation for selected stations.	17
Table 9. Summary of 2010 percent of normal precipitation based on 30-year normal (1971–2000) for selected stations.	17

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, 2010, and to place current patterns and trends in an appropriate historical and regional context (Marshall et al., in review). 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., in review). 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., in review) 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 2010]). 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 2010 based on this criterion; therefore, a total of six stations were used for this report (Figure 1, Table 1).

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.

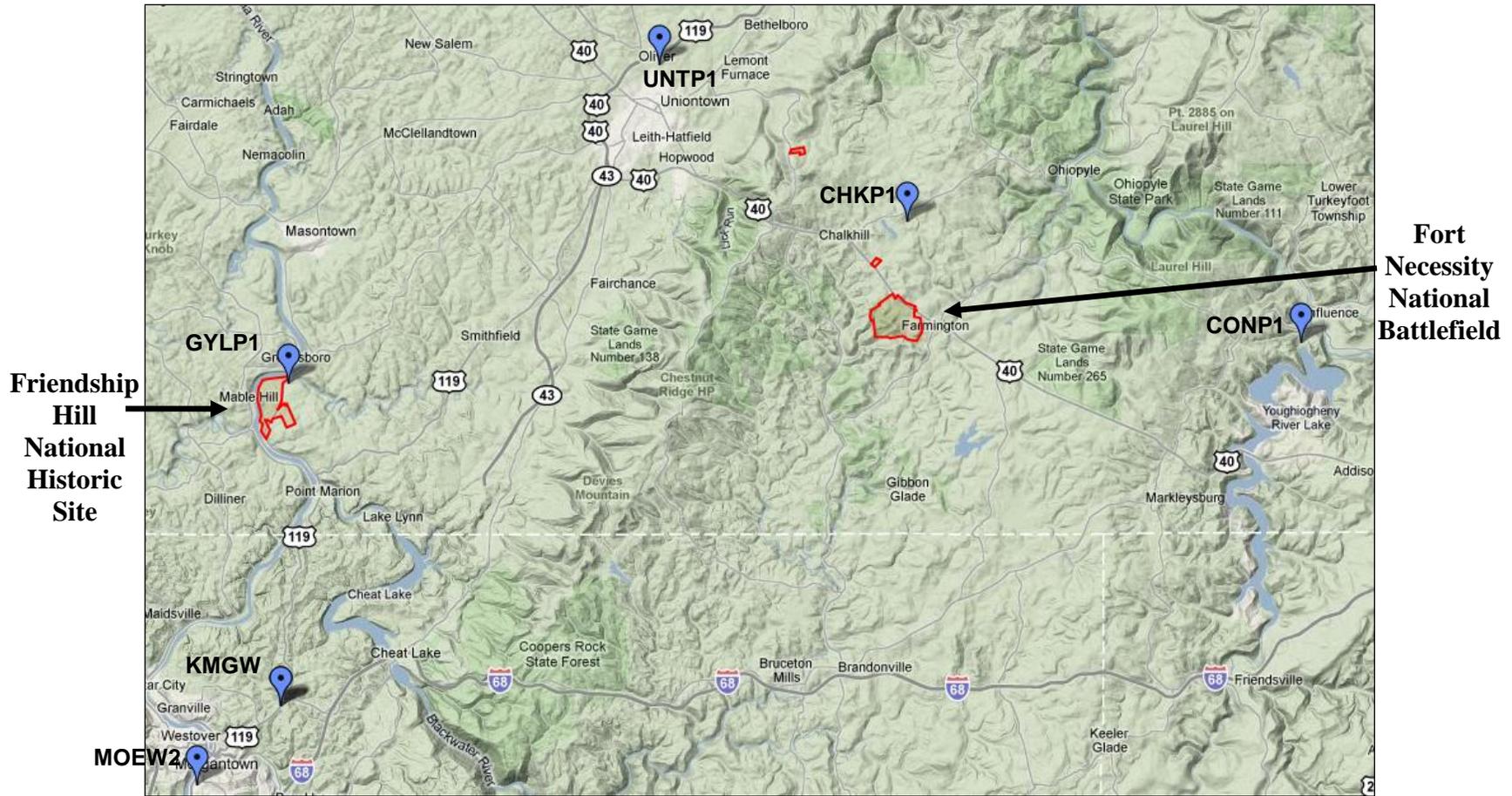


Figure 1. Location of weather observing stations around Friendship Hill National Historic Site and Fort Necessity National Battlefield. See Table 1 for station names.

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 2010.

Station	Observing Network	Station Name	Period of Record (POR)		Percentage of Time Reporting Temperature for 2010	Percentage of Time Reporting Precipitation for 2010	Percentage of Time Reporting Temperature for entire POR	Percentage of Time Reporting Precipitation for entire POR
			Start Date	End Date				
CHKP1	COOP	Chalk Hill 2 ENE	07/01/1977	Present	98.6	98.6	99.9	99.9
GYLP1	COOP	Grays Landing	10/01/1996	Present	100.0	99.7	96.3	99.1
UNTP1	COOP	Uniontown 1 NE	01/01/1894	Present	100.0	100.0	97.3	95.6
CONP1	COOP	Confluence 1 SW Dam	07/01/1946	Present	100.0	99.7	99.7	99.7
MOEW2	COOP	Morgantown Lock and Dam	09/01/1921	Present	100.0	98.6	97.4*	96.1
KMGW	ASOS	Morgantown Municipal Airport -Walter L. Bill Hart Field	12/31/1973	Present	100.0	100.0	99.0	99.0

* 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

Calendar year 2010 was cooler than normal (Tables 2, 3 and 4), primarily due to a very cold February and December (Figures 2 and 3)¹.

The year began seasonably cold, as January had readings ranging from -0.9 degrees Fahrenheit (°F) (-0.5 degrees Celsius (°C)) to -4.1°F (-2.3°C) below normal (Table 4). The coldest weather of the year occurred January 30 to February 1 when minima of -5°F (-20.6°C) were measured at Chalk Hill, PA, and a value of 3°F (-16.1°C) occurred at Morgantown Lock and Dam (Table 2). February mean temperatures were even lower (Table 4), averaging as much as -8.4°F (-4.7°C) below the long-term average at Morgantown Lock and Dam. The first month with above-average temperatures was March, which ranked as the 22nd warmest on record since 1895 (Figures 2 and 3). Overall, the winter was the 42nd chilliest on record (58 is the mid-point; Table 5).

The spring ranked the seventh warmest on record since 1895, which was +2.6°F (1.4°C) above normal (Table 5). All of the spring months had above-average temperatures for all of the reporting stations (Table 4). The largest anomalies were in April at Morgantown, which tallied an anomaly of +6.5°F (3.6°C), mainly due to very mild days (Figure 3 and Table 4). Nighttime temperatures were consistently above the long-term average (Figure 3). The last freeze of the season occurred on May 10th, which led to a virtually normal length in the growing season. There were five days between April 1 and April 8 with readings in the 80's°F (> 27°C).

Summer of 2010 was much warmer than normal, ranking as the 16th hottest on record (Table 5). This positive anomaly was persistent, with nearly every station averaging above normal for each of the three months (Figures 2 and 3). The largest anomalies were during August, 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 93°F (33.9°C) on the July 7. Afternoon readings rose to 92°F (33.2°C) on September 3, and the first readings in the 30°F (<4.0°C) range occurred on September 6 and 7 at Chalk Hill, PA.

Temperatures in autumn reverted to below normal, ranking 14th coolest since records have been kept in 1895 (Table 5). The first 32°F (0°C) reading of the fall occurred on October 8 near Fort Necessity NB (Table 2). November and December had increasingly large negative anomalies in nighttime readings (Figure 3). Readings dropped to or below 10°F (-12.2°C) several times during December. There was a more-than-average number of cold days and fewer-than-average number of sub-zero days (Table 2). Overall, 2010 averaged between -1.2°F (-0.7°C) and -2.3°F (-1.2°C) below the long-term average around Fort Necessity NB and Friendship Hill NHS (Table 2).

¹ 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 2010 temperature indicators compared to the 30-year normal (1971–2000) at the Chalk Hill 2 ENE (CHKP1) and Morgantown Lock and Dam (MOEW2) stations.

Temperature Indicator	Chalk Hill 2 ENE, PA CHKP1 2010	Chalk Hill 2 ENE, PA CHKP1 1971–2000	Morgantown Lock and Dam, WV MOEW2 2010	Morgantown Lock and Dam, WV MOEW2 1971–2000
Average Annual Temperature	46.1°F 7.8°C	48.4°F 9.1°C	51.7°F 10.9°C	52.9°F 11.6°C
Average Annual Maximum Temperature	57.1°F 13.9°C	58.5°F 14.7°C	61.9°F 16.6°C	63.5°F 17.5°C
Maximum Temperature	87.0°F 30.6°C	87.3°F 30.7°C	93.0°F 33.9°C	93.3°F 34.1°C
Hot Days (days with Tmax≥90°F/32°C)	0	1	14	8
Average Annual Minimum Temperature	35.0°F 1.7°C	39.2°F 4.0°C	41.5°F 5.3°C	41.8°F 5.4°C
Minimum Temperature	-5.0°F -20.6°C	-11.0°F -23.9°C	3.0°F -16.1°C	-4.4°F -20.2
Cold Days (days with Tmax≤32°F/0°F)	67	40	54	22
Sub-freezing Days (days with Tmin≤32°F/0°C)	169	133	133	116
Sub-zero Days (days with Tmin≤0°F/-17.8°C)	6	7	0	3
Growing Season Length (days between last spring Tmin 32°F/0°C and first fall Tmin 32°F/0°C)	150	145	173	172

Friendship Hill National Historic Site and Fort Necessity National Battlefield
 Departure from Average Monthly Maximum Temperature
 2010 vs. 1971–2000

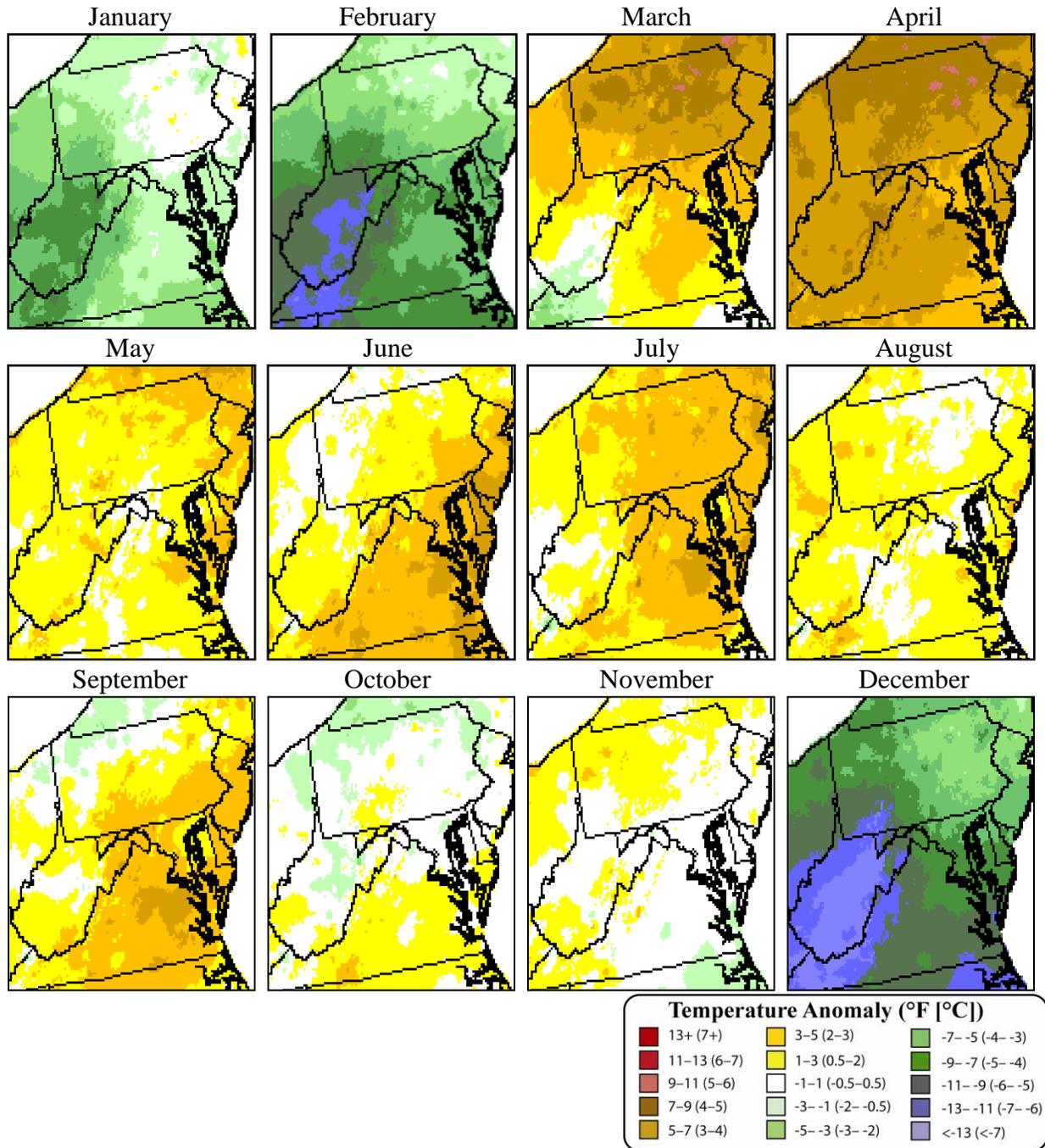


Figure 2. Maps showing departure from average monthly maximum temperature compared to the 30-year normal (1971–2000).

Friendship Hill National Historic Site and Fort Necessity National Battlefield
 Departure from Average Monthly Minimum Temperature
 2010 vs. 1971–2000

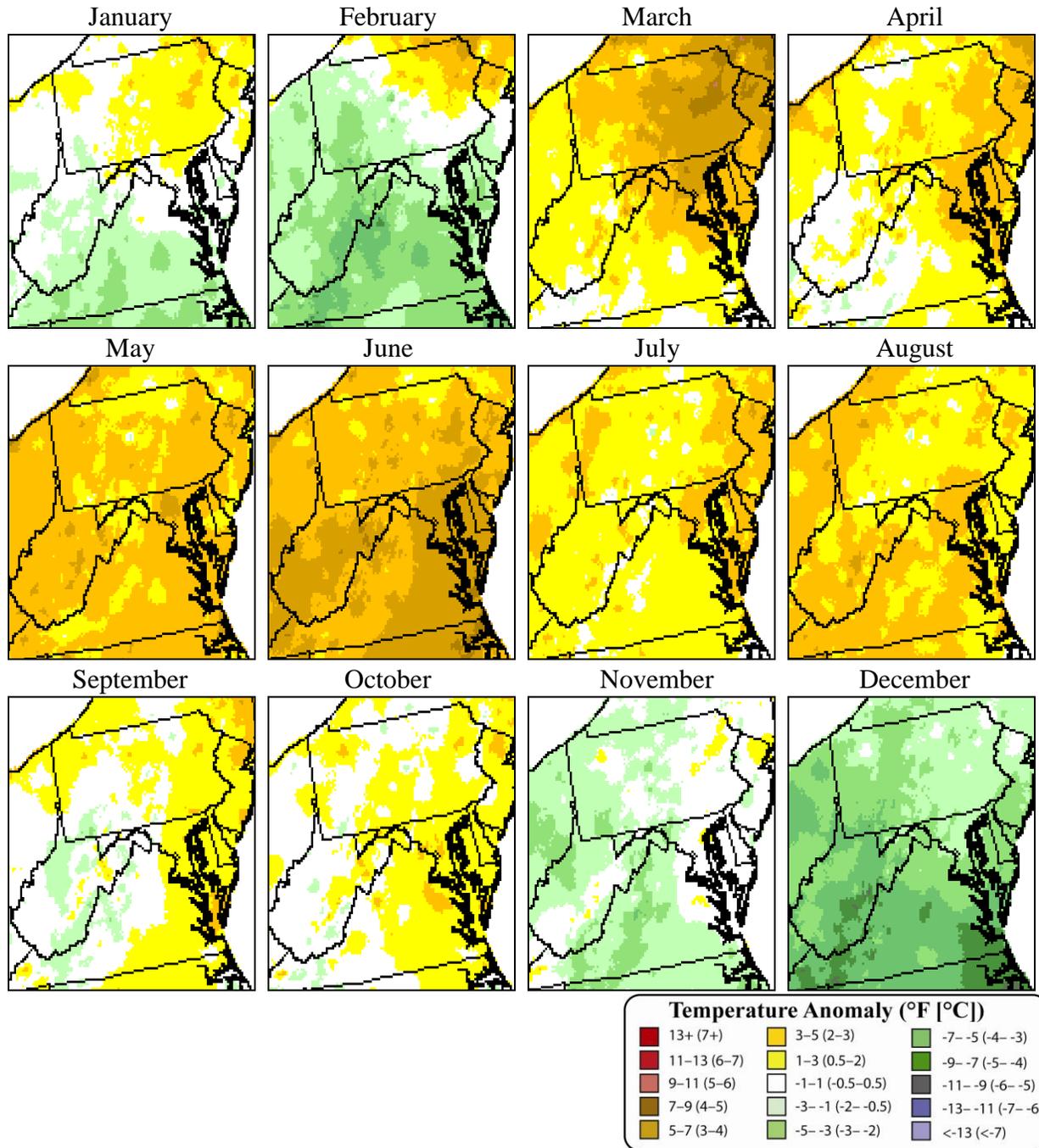


Figure 3. Maps showing departure from average monthly minimum temperature compared to the 30-year normal (1971–2000).

Table 3. Summary of monthly average temperatures for 2010 for the selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Morgantown Airport, WV	KMGW	29.3°F	28.8°F	45.8°F	58.2°F	65.7°F	73.2°F	76.1°F	74.8°F	67.4°F	54.9°F	44.9°F	27.1°F	53.9°F
		-1.5°C	-1.8°C	7.7°C	14.5°C	18.7°C	22.9°C	24.5°C	23.8°C	19.7°C	12.7°C	7.2°C	-2.7°C	12.1°C
Chalk Hill 2 ENE, PA	CHKP1	22.0°F	20.9°F	36.9°F	49.1°F	57.5°F	65.6°F	68.3°F	66.5°F	59.2°F	48.2°F	37.0°F	20.7°F	46.0°F
		-5.6°C	-6.2°C	2.7°C	9.5°C	14.2°C	18.7°C	20.2°C	19.2°C	15.1°C	9.0°C	2.8°C	-6.3°C	7.8°C
Uniontown 1 NE, PA	UNTP1	27.6°F	25.6°F	42.9°F	54.2°F	62.5°F	71.7°F	74.7°F	73.8°F	65.7°F	52.3°F	41.6°F	26.2°F	51.6°F
		-2.4°C	-3.6°C	6.1°C	12.3°C	16.9°C	22.0°C	23.7°C	23.2°C	18.7°C	11.3°C	5.3°C	-3.2°C	10.9°C
Confluence 1 SW Dam, PA	CONP1	23.9°F	22.8°F	39.0°F	50.8°F	60.0°F	69.0°F	72.1°F	70.8°F	63.2°F	51.0°F	39.6°F	23.2°F	48.8°F
		-4.5°C	-5.1°C	3.9°C	10.4°C	15.6°C	20.6°C	22.3°C	21.6°C	17.3°C	10.6°C	4.2°C	-4.9°C	9.3°C
Morgantown Lock and Dam, WV	MOEW2	26.9°F	25.3°F	42.5°F	54.3°F	62.9°F	71.7°F	74.3°F	73.2°F	65.7°F	53.7°F	42.3°F	25.7°F	51.5°F
		-2.8°C	-3.7°C	5.8°C	12.4°C	17.1°C	22.0°C	23.5°C	22.9°C	18.7°C	12.1°C	5.7°C	-3.5°C	10.9°C
Grays Landing, PA	GYLP1	26.3°F	25.1°F	42.1°F	53.0°F	61.7°F	71.4°F	74.1°F	72.9°F	65.5°F	53.0°F	41.2°F	25.2°F	51.0°F
		-3.1°C	-3.8°C	5.6°C	11.7°C	16.5°C	21.9°C	23.4°C	22.7°C	18.6°C	11.7°C	5.1°C	-3.8°C	10.5°C

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

Table 4. Summary of 2010 departure from normal temperature based on 30-year normal (1971–2000) for the selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Chalk Hill 2 ENE, PA	CHKP1	-4.1°F	-8.2°F	-1.0°F	1.0°F	0.2°F	0.7°F	-0.3°F	-0.7°F	-1.3°F	-1.8°F	-3.0°F	-10.1°F	-2.4°F
		-2.3°C	-4.6°C	-0.6°C	0.6°C	0.1°C	0.4°C	-0.2°C	-0.4°C	-0.7°C	-1.0°C	-1.7°C	-5.6°C	-1.3°C
Grays Landing, PA*	GYLP1	-2.6°F	-6.3°F	2.3°F	3.6°F	2.3°F	3.4°F	2.0°F	2.4°F	1.8°F	1.0°F	-1.3°F	-8.5°F	0.05°F
		-1.4°C	-3.5°C	1.3°C	2.0°C	1.3°C	1.9°C	1.1°C	1.3°C	1.0°C	0.6°C	-0.7°C	-4.7°C	0.03°C
Uniontown 1 NE, PA	UNTP1	-1.3°F	-5.8°F	3.1°F	4.8°F	3.1°F	3.7°F	2.6°F	3.3°F	2.0°F	0.3°F	0.9°F	-7.5°F	0.6°F
		-0.7°C	-3.2°C	1.7°C	2.6°C	1.7°C	2.1°C	1.4°C	1.8°C	1.1°C	0.2°C	-0.5°C	-4.2°C	0.3°C
Confluence 1 SW Dam, PA	CONP1	-2.2°F	-6.8°F	0.4°F	3.0°F	1.9°F	2.3°F	0.2°F	2.1°F	-0.7°F	0.3°F	-0.3°F	-9.3°F	-0.8°F
		-1.2°C	-3.8°C	0.2°C	1.7°C	1.0°C	1.3°C	0.1°C	1.2°C	-0.4°C	0.2°C	-0.2°C	-5.1°C	-0.4°C
Morgantown Lock and Dam, WV	MOEW2	-3.9°F	-8.4°F	-0.1°F	2.0°F	1.6°F	2.3°F	0.8°F	1.1°F	-0.1°F	-0.7°F	-2.0°F	-9.7°F	-1.5°F
		-2.2°C	-4.7°C	-0.1°C	1.1°C	0.9°C	1.3°C	0.4°C	0.6°C	-0.1°C	-0.4°C	-1.1°C	-5.4°C	-0.8°C
Morgantown, WV	KMGW	-0.9°F	-4.5°F	3.7°F	6.5°F	4.6°F	4.4°F	3.2°F	3.2°F	2.5°F	1.1°F	0.8°F	-7.8°F	1.4°F
		-0.5°C	-2.5°C	2.1°C	3.6°C	2.6°C	2.4°C	1.8°C	1.8°C	1.4°C	0.6°C	0.4°C	-4.3°C	0.8°C

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

*Indicates a station's period of record is 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. Stations with a period of record of less than 5 years were not included in this table.

Table 5. Seasonal temperature and precipitation rankings over 116 years (1 = warmest/wettest year and 116 = 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
Temperature-2010	74	7	16	102
Precipitation-2010	37	53	79	29

Precipitation Summary

Overall, 49.3 in (1,252 mm) of liquid precipitation (rain plus melted snow, ice, sleet, etc.; hereafter precipitation) fell in Chalk Hill, PA (near Fort Necessity NB), and 39.0 in (991 mm) fell in Morgantown Lock and Dam, WV (near Friendship Hill NHS), during the year (Table 6). These totals for 2010 ranged from 3.1 in (79 mm) to 5.4 in (137 mm) below the long-term averages. The longest dry spell of the year occurred between August 27 and September 11, when no measurable rain fell at Chalk Hill (Table 7). Conversely, one of the wetter days in 2010 occurred on July 14, when 2.25 in (57 mm) fell in Chalk Hill (Table 7). There were no direct influences from tropical storms in 2010, though moisture from the remnants of Tropical Storm Nicole did add to rainfall on October 1. Precipitation varied during 2010 at Fort Necessity NB and Friendship Hill NHS, with precipitation above normal at the majority of reporting stations in only three months, below normal in five months, and near normal in four months (Tables 8 and 9).

The winter season began with a wetter-than-average January, with 4.6 in (117 mm [106 percent of average]) precipitation falling at Chalk Hill (Tables 8 and 9). February was even wetter, with precipitation ranging from 2.6 in (66 mm) at Grays Landing, which was 93 percent of normal, to 6.8 in (173 mm) at Chalk Hill (Table 8). March was noticeably drier, with station's averaging 74 percent of normal precipitation (Table 9). Overall, the winter (January, February, and March) ranked as the 37th wettest since 1895 (Table 5). Record seasonal snowfall was recorded near Fort Necessity NB, as Chalk Hill tallied 178.5 in (4,534 mm) and nearby Laurel Summit measured a state monthly record 117.8 in (3,525 mm) during February alone (Table 6).

April precipitation was well below normal, ranging from 46 to 64 percent of normal (Table 9). May rainfall ranged from 4.2 in (107 mm) at Uniontown to 6.8 in (173 mm) at Confluence (Table 8). June brought a virtually normal amount of showers, with the region averaging exactly 100 percent of long-term normal (Table 9). Overall, spring of 2010 ranked as the 53rd wettest in this climate division, which is just five less than perfectly normal (Table 5).

Summer of 2010 was somewhat drier than average (Figure 4); it ranked as the 37th driest (Table 5). The deficit was caused by a very dry August, which was 20th driest since 1895. July had as much as 5.3 in (135 mm) of rain falling in Morgantown Lock and Dam (125 percent of normal), to as little as 1.9 in (48 mm) at Uniontown (48 percent of normal) during August (Tables 8 and 9).

The autumn of 2010 was drier than recent years, but its ranking was still the 29th wettest in 116 years in the Southwest Plateau Pennsylvania Climate Division (Table 5). Precipitation was quite variable during the fall, ranging from 1.2 in (31 mm) at Morgantown Airport in December to 4.8 in (122 mm) in Chalk Hill during November (Table 8). The second wettest day of the year occurred on December 1, when 1.98 in (50 mm) fell at Chalk Hill. The number of heavy precipitation days was slightly above normal in 2010, and the number of days with moderate and heavy snow was well above average (Table 6).

Table 6. Status of 2010 precipitation indicators compared to the 30-year normal (1971–2000) at the Chalk Hill 2 ENE (CHKP1) and Morgantown Lock and Dam (MOEW2) stations.

Precipitation Indicator	Chalk Hill 2 ENE, PA CHKP1 2010	Chalk Hill 2 ENE, PA CHKP1 1971–2000	Morgantown Lock and Dam, WV MOEW2 2010	Morgantown Lock and Dam, WV MOEW2 1971–2000
Annual Precipitation	49.3 in 1,252 mm	54.7 in 1,389 mm	39.0 in 991 mm	42.1 in 1,069 mm
Autumn (Oct, Nov, Dec) Precipitation	11.2 in 284 mm	12.2 in 310 mm	8.9 in 226 mm	9.7 in 246 mm
Heavy Precipitation Days (days with ≥ 1.0 in (25 mm) rain)	12	11	10	8
Extreme Precipitation Days (days with ≥ 2.0 in (51 mm) rain)	0	1	1	1
Micro-drought (strings of 7+ days without rain)	8	3	9	6
Annual Snowfall	178.5 in 4,534 mm	88.7 in 2,253 mm	38.1 in 968 mm	22.6 in 574 mm
Measurable Snow Days (days with ≥ 0.1 in (0.3 cm) snow)	57	54	29	19
Moderate Snow Days (days with ≥ 2.0 in (5.0 cm) snow)	27	17	6	3
Heavy Snow Days (days with ≥ 5.0 in (12.7 cm) snow)	12	4	1	1

Table 7. Top five wettest days and top five dry spells (consecutive days with a trace or less of rainfall) during 2010 from stations at Chalk Hill (CHKP1) and Morgantown Lock and Dam (MOEW2).

Wettest Days in 2010	Dry Spells in 2010
Jul. 14: 2.25 in (57 mm)	Aug. 27–Sept. 11
Dec. 1: 1.98 in (50 mm)	Jun. 30–Jul. 9
Sept. 17: 1.95 in (50 mm)	Mar. 31–Apr. 8
Feb. 6: 1.94 in (49 mm)	Jun. 14–22
Jul. 10: 1.87 in (48 mm)	Apr. 18–25

Table 8. Summary of 2010 monthly total precipitation for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Morgantown Airport, WV	KMGW	2.4 in	3.0 in	3.1 in	1.9 in	4.6 in	4.3 in	5.0 in	3.0 in	4.3 in	2.3 in	4.3 in	1.2 in	39.4 in
		60 mm	75 mm	80 mm	49 mm	118 mm	110 mm	127 mm	77 mm	108 mm	57 mm	109 mm	31 mm	1001 mm
Chalk Hill 2 ENE, PA	CHKP1	4.6 in	6.8 in	3.6 in	2.7 in	5.3 in	3.8 in	5.2 in	2.5 in	3.6 in	2.7 in	4.8 in	3.8 in	49.4 in
		117 mm	173 mm	91 mm	69 mm	135 mm	97 mm	132 mm	64 mm	91 mm	69 mm	122 mm	97 mm	1255 mm
Uniontown 1 NE, PA	UNTP1	2.4 in	3.4 in	2.5 in	2.4 in	4.2 in	3.7 in	5.1 in	1.9 in	3.7 in	3.1 in	3.3 in	2.5 in	38.2 in
		61 mm	86 mm	64 mm	61 mm	107 mm	94 mm	130 mm	48 mm	94 mm	79 mm	84 mm	64 mm	970 mm
Confluence 1 SW Dam, PA	CONP1	3.4 in	5.4 in	2.8 in	2.3 in	6.8 in	4.0 in	3.1 in	2.7 in	2.6 in	2.8 in	3.1 in	3.3 in	42.2 in
		86 mm	137 mm	71 mm	58 mm	173 mm	102 mm	79 mm	69 mm	66 mm	71 mm	79 mm	84 mm	1072 mm
Morgantown Lock and Dam, WV	MOEW2	2.9 in	2.3 in	2.1 in	1.7 in	4.9 in	5.1 in	5.3 in	2.4 in	3.4 in	2.8 in	3.5 in	2.6 in	39.0 in
		74 mm	58 mm	53 mm	43 mm	125 mm	130 mm	135 mm	61 mm	86 mm	71 mm	89 mm	66 mm	991 mm
Grays Landing, PA	GYLP1	3.1 in	2.6 in	3.2 in	2.1 in	4.4 in	4.5 in	3.8 in	2.1 in	2.6 in	3.8 in	3.1 in	3.2 in	38.5 in
		79 mm	66 mm	81 mm	53 mm	112 mm	114 mm	97 mm	53 mm	66 mm	97 mm	79 mm	81 mm	978 mm

Table 9. Summary of 2010 percent of normal precipitation based on 30-year normal (1971–2000) for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Morgantown Airport, WV	KMGW	81	112	83	54	110	104	118	74	123	81	128	39	93
Chalk Hill 2 ENE, PA	CHKP1	106	180	77	54	101	80	94	59	80	74	114	93	91
Uniontown 1 NE, PA	UNTP1	81	121	68	64	96	86	110	48	104	107	96	81	88
Confluence 1 SW Dam, PA	CONP1	96	182	73	58	152	100	65	72	64	93	85	94	93
Morgantown Lock and Dam, WV	MOEW2	89	80	55	46	112	126	125	61	101	98	99	80	90
Grays Landing, PA*	GYLP1	104	93	87	56	101	105	82	54	73	131	91	103	89

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

*Indicates a station's period of record is 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. Stations with a period of record of less than 5 years were not included in this table.

Friendship Hill National Historic Site and Fort Necessity National Battlefield
 Percent of Average Monthly Precipitation
 2010 vs. 1971–2000

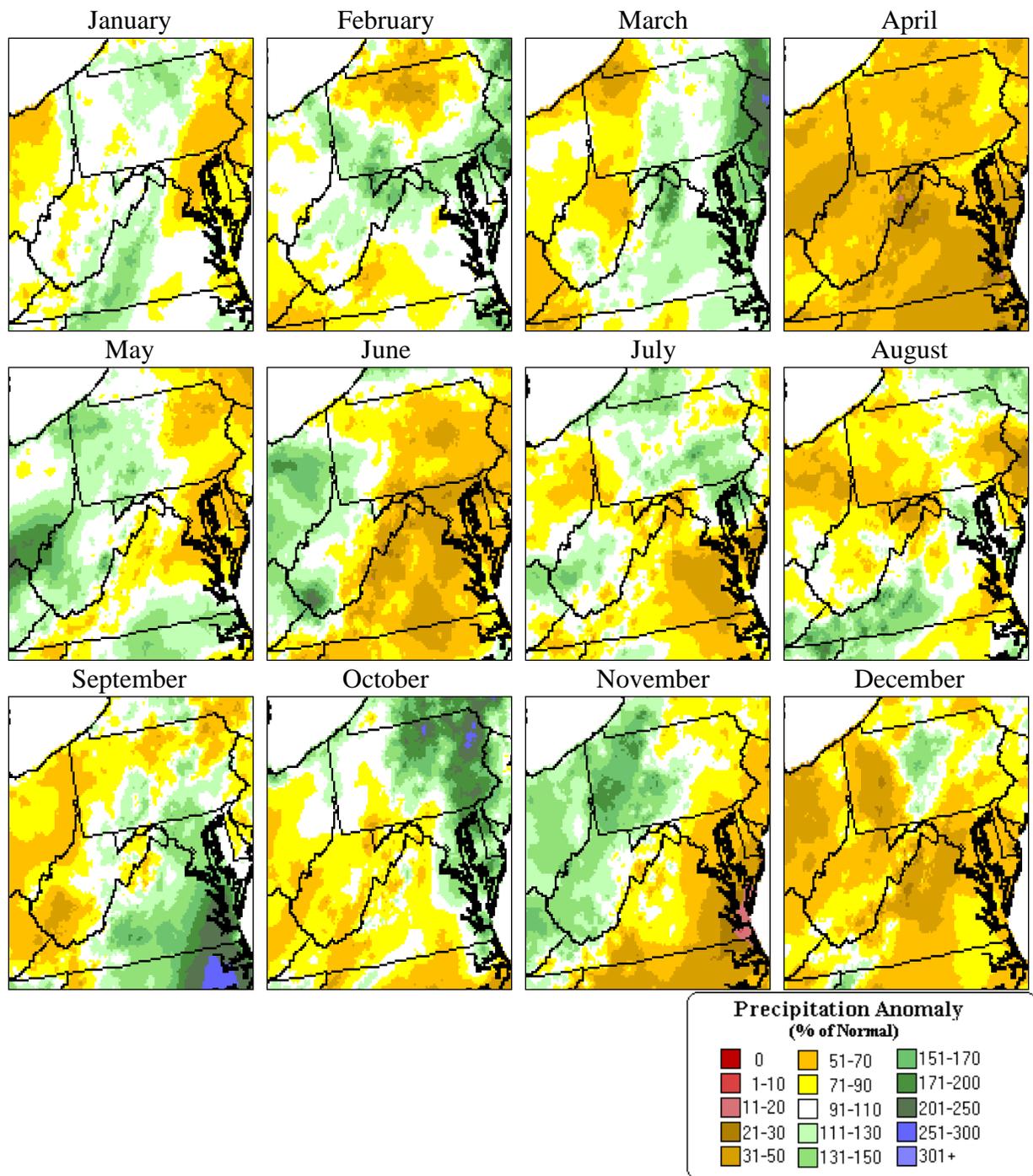


Figure 4. Maps showing percent of average monthly precipitation compared to the 30-year normal (1971–2000).

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 2010 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. 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 2010.

According to the PDSI, after a moist start to the year in Climate Division 9, persistent dry conditions led the drought severity index to approach “moderate drought” level by late August (Figure 5) but it remained in the “normal” range. Heavy rainfall during October brought the PDSI values to zero (that is why the green bar cannot be seen); however, a dry November and December caused values to drop to negative (“dry”) levels. Calendar year 2010 was dissimilar to the past two years, as the dry period in this year occurred during the growing season. 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) became more widespread as the summer progressed.

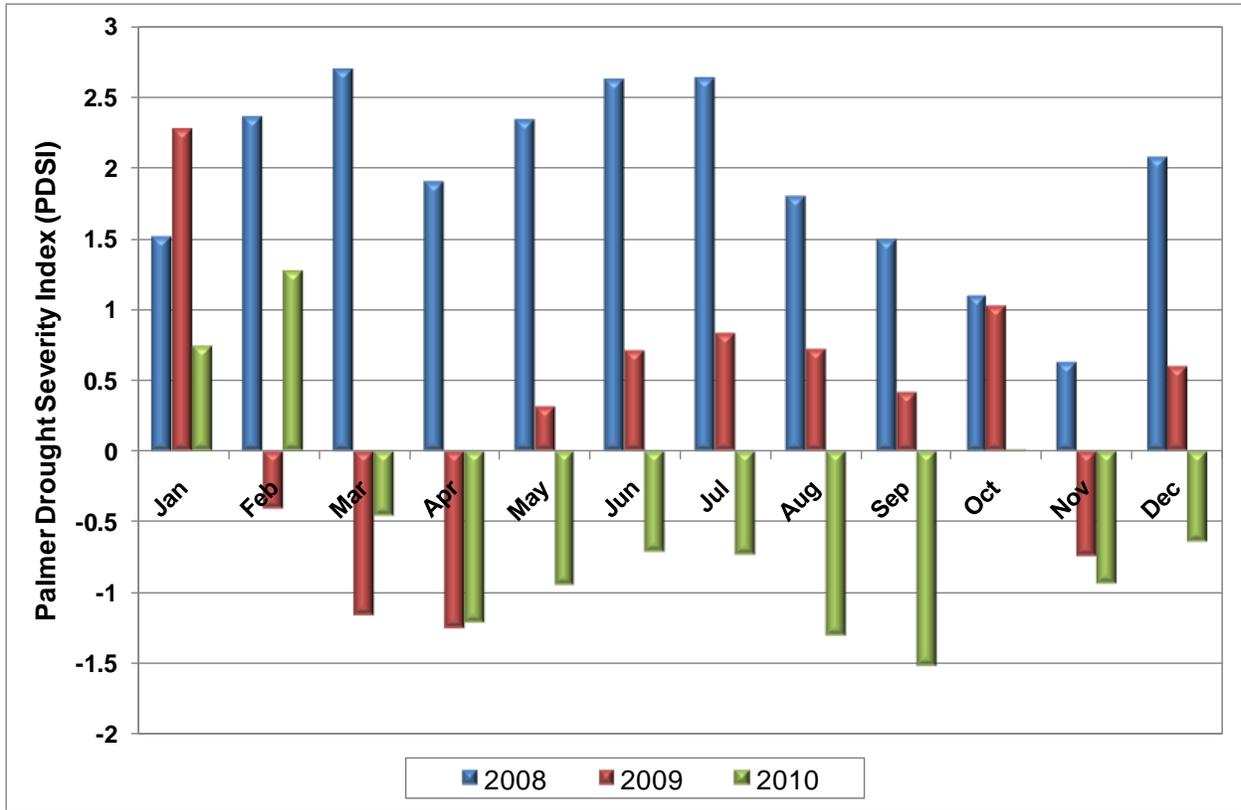


Figure 5. Monthly Palmer Drought Severity Index (PDSI) values for Pennsylvania Climate Division 9, 2008–2010.

Drought Intensity in Pennsylvania during 2010

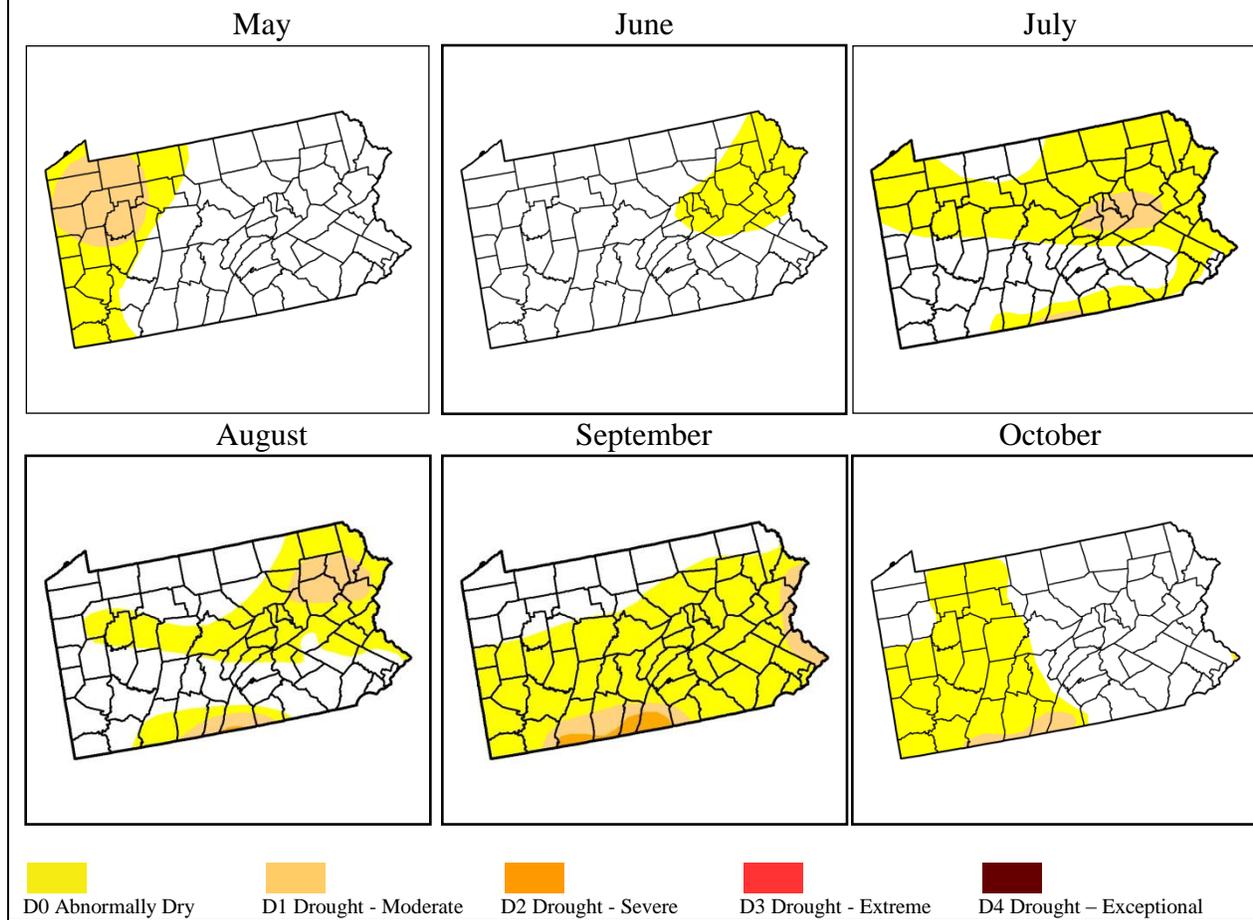


Figure 6. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for Pennsylvania in 2010.

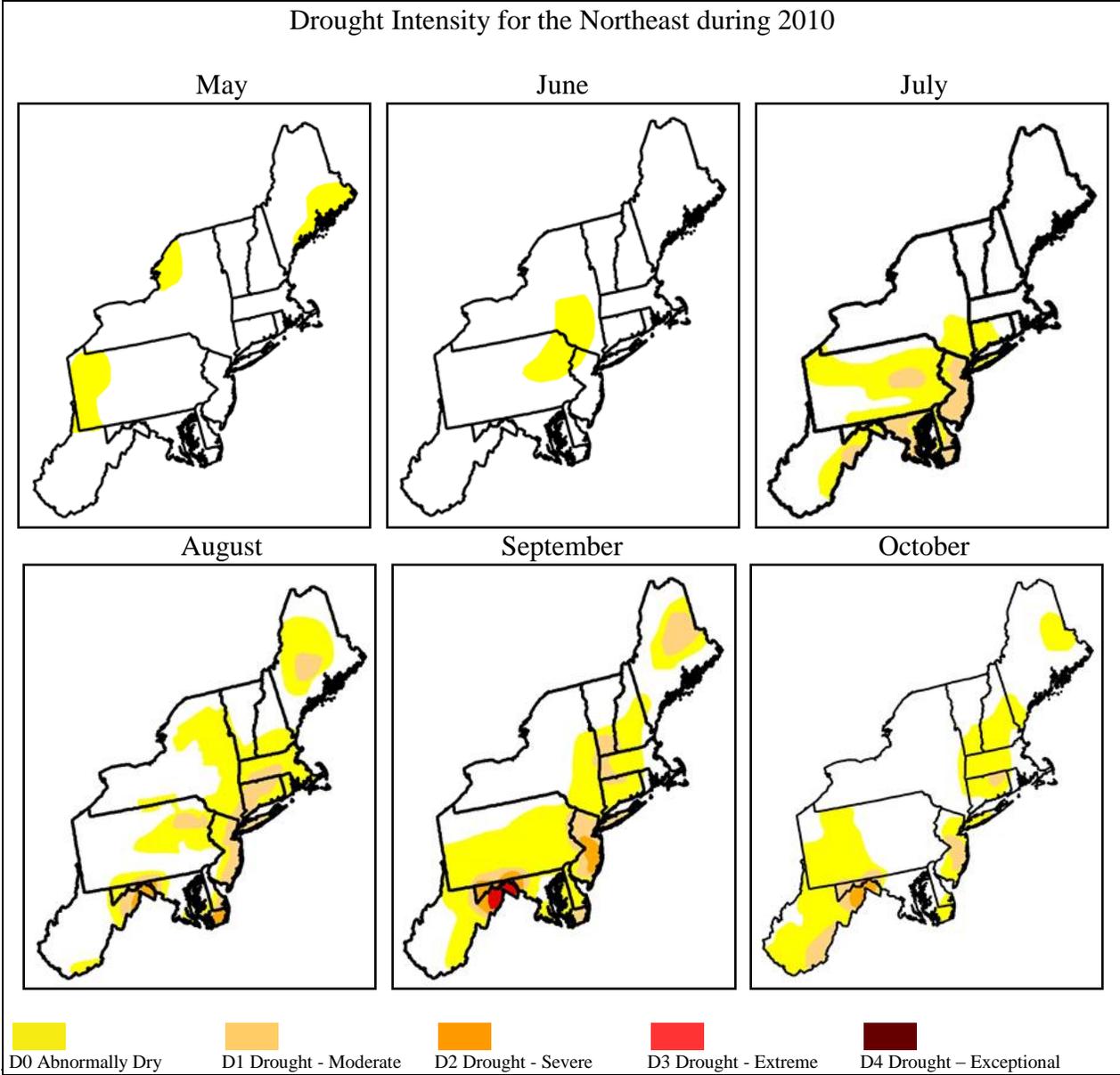


Figure 7. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for the Northeast in 2010.

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.
- Marshall, M. R., Knight, P. and J. A. Comiskey. In review. Weather and Climate Monitoring Protocol for the Eastern Rivers and Mountains and Mid-Atlantic Networks. Natural Resource Report Series NPS/ERMN/NRR—2011/###. National Park Service. Fort Collins, CO.
- 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. 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). 2010. National Climatic Data Center. *Climate of 2010 – Annual Review, Global and U.S. Summary*. <http://lwf.ncdc.noaa.gov/oa/climate/research/2010/ann/us-summary.html>.

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