



# Friendship Hill National Historic Site and Fort Necessity National Battlefield

## *Weather of 2008*

Natural Resource Data Series NPS/ERMN/NRDS—2010/080



**ON THE COVER**

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

Photograph by: Jane Clark (NPS photos).

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September 2010

U.S. Department of the Interior  
National Park Service  
Natural Resource Program Center  
Fort Collins, Colorado

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Please cite this publication as:

Knight, P., T. Wisniewski, C. Bahrmann, and S. Miller. 2010. Fort Necessity National Battlefield and Friendship Hill National Historic Site: Weather of 2008. Natural Resource Data Series NPS/ERMN/NRDS—2010/080. National Park Service, Fort Collins, Colorado.

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## List of Key Acronyms

COOP	National Weather Service Cooperative Observer Program
CWOP	Citizen Weather Observer Program
FAA	Federal Aviation Administration
FONE	Fort Necessity National Battlefield
FRHI	Friendship Hill National Historic Site
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
NWS	National Weather Service
PDSI	Palmer Drought Severity Index
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RAWS	Remote Automated Weather Stations
USDM	United States Drought Monitor
USGS	United States Geological Survey

## 2008 Climate Summary

The calendar year began with above-average temperatures for the first two months. Temperatures reached above 60°F (15.6°C) from January 7–9, which was 25°F (13.9°C) above average. Despite the positive anomalies, a reading of -7°F (-21.2°C) occurred in Chalk Hill on February 21, which was the lowest value of the year. Below-average temperatures dominated the month of May, which was the 11<sup>th</sup> coldest May on record since 1895. This cold anomaly, however, did not stop the spring from averaging slightly warmer-than-normal with temperatures of 3°F (1.7°C) and 1.5°F (1.4°C) above normal in April and June, respectively. The last quarter of the year was the 26<sup>th</sup> coldest on record since 1895, despite a very warm December when daytime maximum temperatures climbed above 60°F (15.6°C) on December 27 and 28 (almost 30°F [16.7°C] above average). Overall, 2008 averaged as the 44<sup>th</sup> coldest year since 1895 and 1.0°F (0.6°C) lower than 2007. Concerning precipitation, the summer was the driest season, ranking 38<sup>th</sup> driest on record. This was reflected in the Monongahela River's below-normal discharge beginning in the late summer and extending into autumn. Despite a dry summer, the Palmer Drought Severity Index remained positive throughout the year, indicating the presence of abnormally moist conditions. The autumn began dry with October averaging barely 50% of the normal precipitation. A very wet December more than made up for the deficit. More than 200% of normal precipitation fell in this month, making December one of the wettest on record.

### Long-term Trends

The temperature for the Southwest Plateau in 2008 averaged 49.4°F (9.7°C), which was the coldest year since 2003 (Table 1) and well below the trend of the last 10 years. The cool weather caused a near- to above-normal number of days with temperature maximums below 32°F (0°C). The growing season in the region was shorter than the long-term average. The winter months were quite wet and ranked as the 14<sup>th</sup> wettest since records began in 1895. The wettest single month of the year occurred during December when precipitation was over 200% above normal. Dry spells of more than seven days occurred most frequently during the late summer and early fall. A major severe weather outbreak occurred on June 16 when hail up to 1.8 in (44 mm) in diameter fell in Edenborn, PA, and winds toppled trees and power lines.

**Table 1.** Summary of 2008 climate indicators for Friendship Hill NHS and Fort Necessity NB. Data from the COOP stations at Chalk Hill, PA (CHKP1) and Grays Landing, PA (GYLP1) compared to the 30-year normal from Elkins, WV (KEKN).

Indicator	2008 Statistics	Comments on Trends
Average Annual Maximum Temperature	57.9–62.6°F 14.4–17.0°C	Near the 30-year mean of 62.4°F 16.9°C
Average Annual Minimum Temperature	39.3–40.3°F 4.1–4.6°C	Above the 30-year mean of 37.9°F 3.3°C
Hot Days (days with Tmax≥90°F /32°C)	0–10	Near the 30-year mean of 3 days
Cold Days (days with Tmax≤32°F /0°C)	24–38	Near the 30-year mean of 27 days
Winter Minimum (Lowest Temp)	-7.0°F -22.0°C	Below the long-term average of -4.0°F -20.0°C
Sub-freezing Nights (days with Tmin≤32°F/0°C)	125–130	Below the long term average of 145.3
Cold Winter Nights (days with Tmin≤0°F/-17.8°C)	0–4	Below the long term mean of 8.5
Growing Season Length (Days between last spring 32°F/0°C and first fall 32°F/0°C)	155–174	Below the 30-year mean of 175–200 days
Annual Precipitation	44.9–62.6 in 1141–1590 mm	Above the average of 46.1 in 1171 mm
Autumn (Oct, Nov, Dec) Precipitation	9.3–13.6 in 236–345 mm	Below the long-term mean of 11.0 in 270 mm
Moderate Rain (days with ≥1.0 in (25 mm) rain)	6–11	Above the 30-year mean of 6.7 days
Micro-drought (strings of 7+ days without rain)	3–4	Near the long-term mean of 3–6
Annual Snowfall	56–104 in 140–264 cm	Above the 30-year mean of 81 in 205 cm

## 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 the 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, 2008, and to place current patterns and trends in an appropriate historical and regional context (Knight et al., in preparation). It is our intention that this report will satisfy an inherent interest in meteorological phenomena and meet the Eastern Rivers and Mountains Network (ERMN) Weather and Climate Monitoring objectives:

- Document long-term trends in weather and climate through seasonal and annual summaries of selected parameters (e.g., multiple forms of precipitation, temperature).
- Identify and document extremes and averages of climatic conditions for common parameters (e.g., precipitation, air temperature), and other parameters where sufficient data are available (e.g., wind speed and direction, solar radiation).
- Provide information on near real-time weather parameters, historical climate patterns, and climate station metadata from a single, easy-to-use Internet portal.

To accomplish these objectives, a variety of atmospheric data streams were evaluated for their quality, longevity, and applicability to 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 Network and Mountains and Mid-Atlantic Network of the National Park Service (Knight et al., in preparation). Through this analysis, a select number of weather/climate observing stations were chosen as representative of each park and 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 climatological 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 (Knight et al., in preparation) and summarized in the body of this report.

## The Climate of the Southwest Plateau

Fort Necessity National Battlefield and Friendship Hill National Historic site are located in Pennsylvania Climate Division 9, also known as 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 (<http://www.esrl.noaa.gov/psd/data/usclimate/map.html>). 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 an 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 the 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 during 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 winter and mountain-valley circulation induced clouds reducing the heat during summer. The lowest readings in 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 first frosts appear in late September or October.

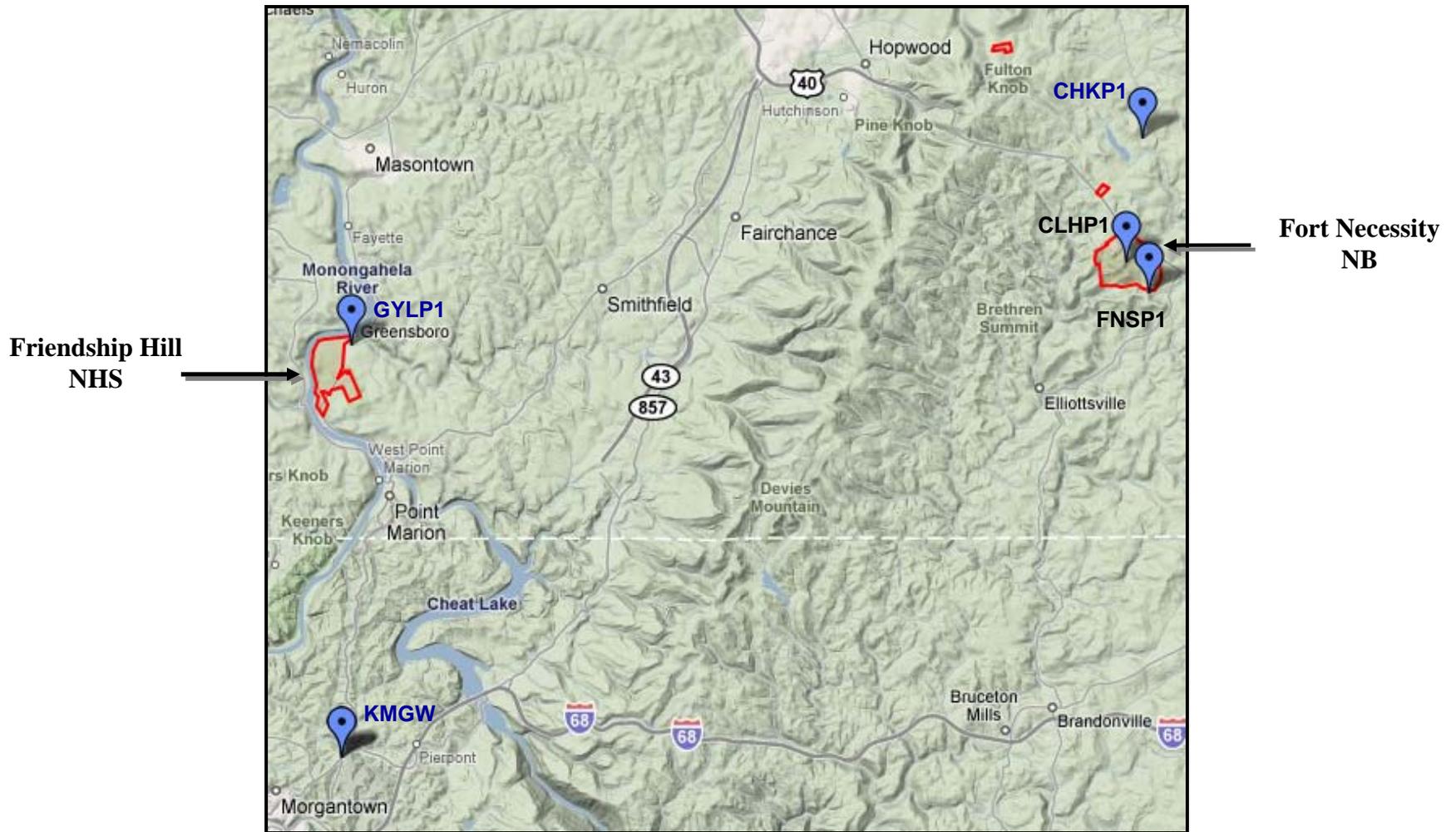
Precipitation is fairly evenly distributed throughout the year. Annual amounts generally range between 36–54 in (914–1,372 mm), while the majority of places receive 40–46 in (1,016–1,372 mm). Greatest amounts usually occur in the spring and summer months, while February is the driest month, having about 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 reaching 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 four observing networks were selected around Fort Necessity NB and Friendship Hill NHS (Figure 1). Representative stations within a 100-km range of each park were chosen based on several criteria which include, proximity to the park, the representativeness of the station to the park elevation profile, the type and frequency of observations, the period of record of the data, and data availability (Knight et al., in preparation). A subset of these observing networks (IFLOWS and GOES; two total weather stations) are not yet utilized for these reports due to limited data availability and/or lack of data quality assurance (Bureau of Land Management 1997). Moreover, the percentage of time a station reports particular parameters (e.g., temperature) can influence data inclusion. No stations were excluded in 2008 based on this criterion. Therefore, a total of four stations were used for this report (Table 2).

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. Not shown is the CASTNET station at Laurel Hill.

**Table 2.** List of weather observing stations around Friendship Hill National Historic Site and Fort Necessity National Battlefield. These stations have been selected as best representative of the parks in 2008.

<b>Station</b>	<b>Observing Network</b>	<b>Station Name</b>	<b>Period of Record (POR)</b>		<b>Percentage of Time Reporting Temperature for 2008</b>	<b>Percentage of Time Reporting Precipitation for 2008</b>	<b>Percentage of Time Reporting Temperature for entire POR</b>	<b>Percentage of Time Reporting Precipitation for entire POR</b>
<b>CHKP1</b>	COOP	Chalk Hill 2 ENE	07/01/1977	Present	99.5	99.5	26.9	26.9
<b>GYLP1</b>	COOP	Grays Landing	10/01/1996	Present	100.0	99.5	93.7	98.1
<b>KMGW</b>	FAA	Morgantown	01/01/1974	Present	99.5	99.5	26.9	26.9
<b>LRL117</b>	CASTNET	Laurel Hill	01/01/1988	Present	100.0	100.0	100.0	100.0

## Temperature Summary

Variable temperature trends dominated calendar year 2008 at Fort Necessity NB and Friendship Hill NHS. Although six months were above normal, and six below, the average temperature was 0.4°F (0.2°C) below the long-term average and the year ranked as the 44<sup>th</sup> coldest in the Southwest Plateau Climate Division since records began in 1895 (ranking of 57 is average). Positive temperature anomalies began the year with the 44<sup>th</sup> warmest January (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/>.

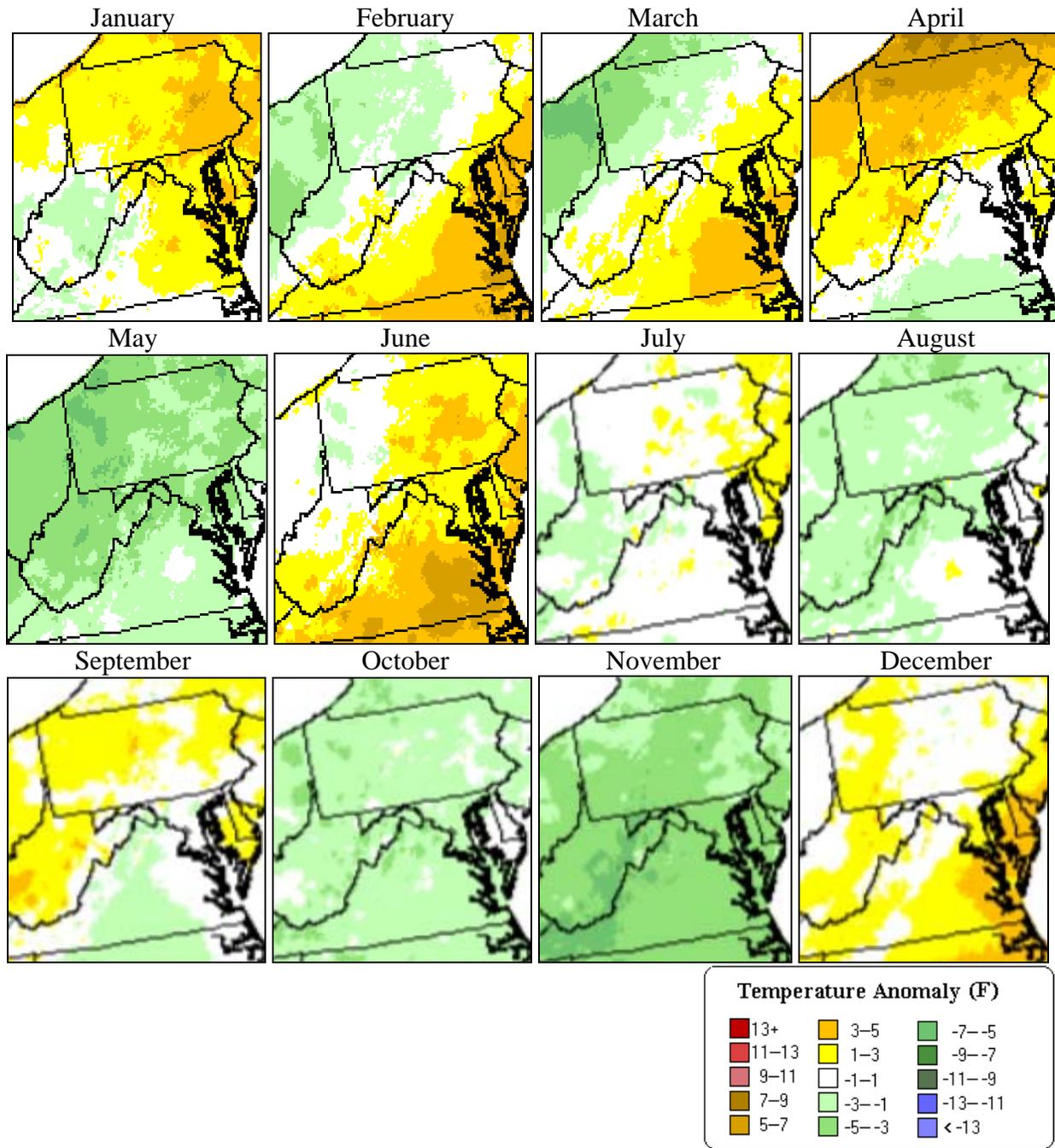
Daytime maximums reached above 60.0°F (15.6°C) from the January 7–9, which was 25.0°F (13.9°C) above average. February temperatures were also above average with a +0.1°F (+0.06°C) temperature anomaly in Chalk Hill, PA, a site near Fort Necessity NB (Table 3). Very chilly nighttime air dominated throughout the month, with the lowest reading of the year occurring on February 21 at -7.0°F (-21.7°C). The first month with below-average temperatures was March, which ranked as the 46<sup>th</sup> chilliest March on record since 1895. Overall, the winter was nearly average with an anomaly of only +0.1°F (+0.06°C).

Spring began with the 13<sup>th</sup> warmest April on record. Temperatures averaged 3.3°F (1.8°C) above normal during the month, with a daytime maximum of 82.0°F (27.8°C) on April 19, 20.0°F (11.1°C) above average. The temperature anomaly completely reversed in May, which was the 11<sup>th</sup> coldest May on record and the chilliest since 2005. The last frost of the spring occurred on May 5. Above-average readings returned in June with daytime maximums rising to 85.0°F (29.4°C) on four consecutive days (June 6–9). The spring ranked the 52<sup>nd</sup> warmest on record since 1895, which is very close to normal (Table 4).

Summer of 2008 was cooler than normal. This negative anomaly was due, in part, to the 19<sup>th</sup> coldest August on record. The other two months consisted of opposite temperature anomalies. July was below average with Morgantown, WV reporting a -0.4°F (-0.2°C) temperature departure (Table 3). The highest temperature of the year also occurred during July with a reading of 86.0°F (30.2°C) on the July 18. As mentioned, August was very chilly with temperatures nearly 2.0°F (1.1°C) below normal. Readings in September were above normal with a high temperature of 82.0°F (27.8°C) on the September 4, which was 18.0°F (10.0°C) above the long-term mean.

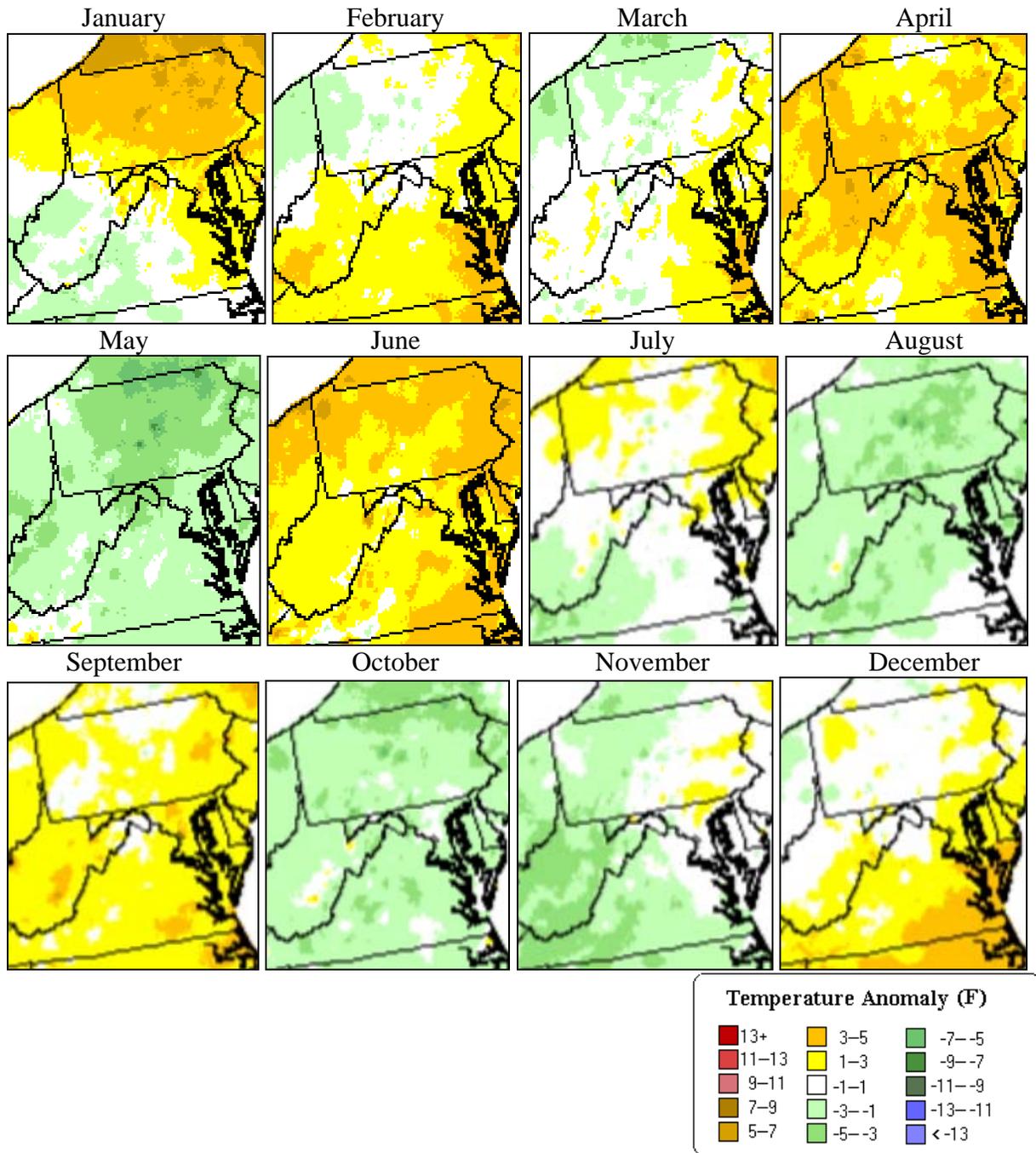
Temperatures in October were a bit below normal, which is a large contrast with 2007 when the month ranked as the 5<sup>th</sup> warmest on record at 5.7°F (3.2°C) above normal. The first 32°F (0°C) reading of the fall occurred on October 7 throughout the region, leading to a shorter-than-normal length of the growing season (Table 5). November was the 20<sup>th</sup> coldest November since 1895 and also the chilliest since 2000. December was slightly above normal. This positive anomaly was aided by daytime maximums greater than 60.0°F (15.6°C) on the December 27 and 28. As a whole, 2008 was slightly cooler than average (~-49.4°F [9.7°C]) and the chilliest since 2003 (Table 6). The 30-year trend for soil temperatures is still on the rise, which is consistent with the overall warming trend noted in the atmosphere during the past 30 years (Figure 4).

Friendship Hill NHS and Fort Necessity NB  
 Departure from Average Monthly Maximum Temperature  
 2008 vs. 1971–2000



**Figure 2.** Maps showing maximum daily temperature (°F) departure from the 30-year normal (1971–2000) for each month in calendar year 2008.

Friendship Hill NHS and Fort Necessity NB  
 Departure from Average Monthly Minimum Temperature  
 2008 vs. 1971–2000



**Figure 3.** Maps showing minimum daily temperature (°F) departure from the 30-year normal (1971–2000) for each month in calendar year 2008.

**Table 3.** Summary of 2008 departure from normal temperature based on 30-year normal (1971–2000) for the selected stations.

Station Location	ID	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chalk Hill, PA	CHKP1	2.9°F	0.1°F	-0.5°F	3.0°F	-3.1°F	1.4°F	-0.1°F	-2.2°F	2.0°F	-1.4°F	-2.7°F	2.4°F
		1.6°C	0.06°C	-0.3°C	1.7°C	-1.7°C	0.8°C	-0.1°C	-1.2°C	1.1°C	-0.8°C	-1.5°C	1.3°C
Grays Landing, PA	GYLP1	1.8°F	0.4°F	-1.2°F	4.3°F	-3.6°F	1.9°F	0.01°F	-0.6°F	3.2°F	-0.5°F	-1.5°F	1.1°F
		1.0°C	0.2°C	-0.7°C	2.4°C	-2.0°C	1.0°C	0.01°C	-0.3°C	1.8°C	-0.3°C	-0.8°C	0.6°C
Morgantown, WV	KMGW	3.0°F	0.5°F	-0.5°F	3.6°F	-3.4°F	1.7°F	-0.4°F	-1.2°F	3.0°F	-0.7°F	-2.6°F	1.7°F
		1.7°C	0.3°C	-0.3°C	2.0°C	-1.9°C	0.9°C	-0.2°C	-0.7°C	1.7°C	-0.4°C	-1.4°C	0.9°C

**Table 4.** Seasonal temperature and precipitation rankings over 114 years for Pennsylvania Climate Division 9. The values show wetter than normal weather in the winter and spring and a quite cool summer and autumn.

PA Climate Division 9 Rankings "Southwest"	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN
Temperature-2008	60	52	82	88
Precipitation-2008	14	21	76	26

1 = Warmest or Wettest      114 = Coldest or Driest

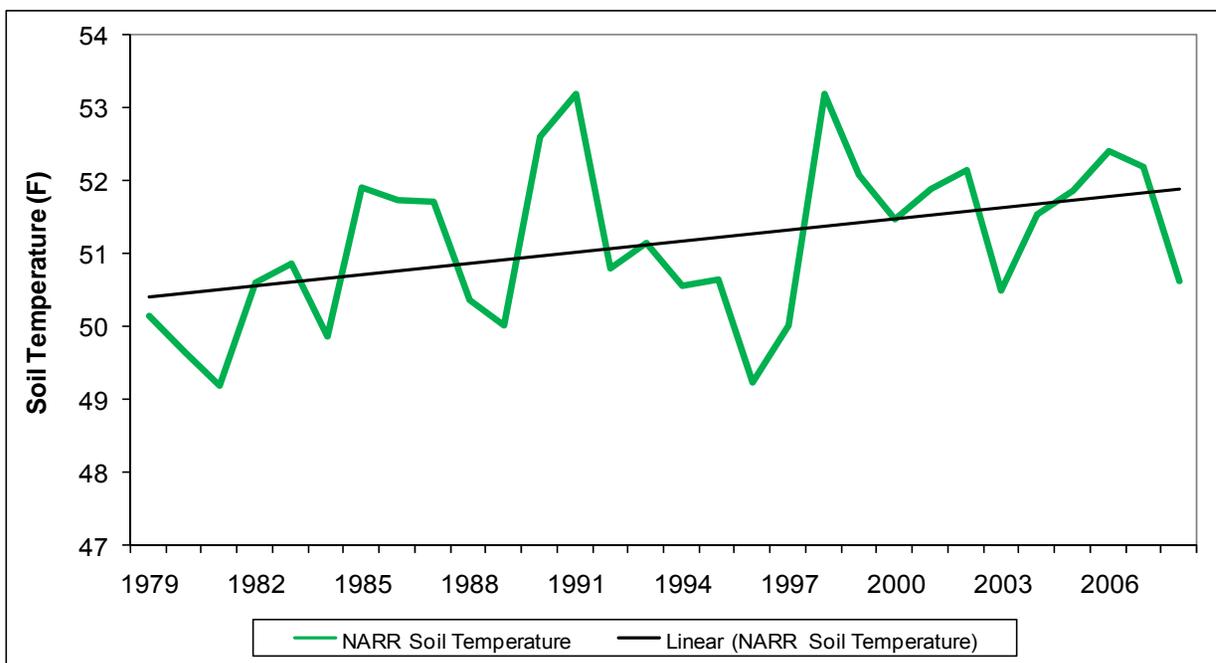
**Table 5.** Status of 2008 temperature indicators using the Chalk Hill and Grays Landing, PA, stations compared the 30-year normal at Elkins, WV. While the elevation does vary, the trend in 2008 showed near to slightly above average number of cold winter days, but fewer sub-freezing nights.

Temperature Indicator	Chalk Hill, PA CHKP1 2008	Grays Landing, PA GYLP1 2008	Elkins, WV KEKN 1971–2000
Average Annual Maximum Temperature	57.9°F 14.4°C	62.6°F 17.0°C	62.4°F 16.9°C
Average Annual Minimum Temperature	39.3°F 4.1°C	40.3°F 4.6°C	37.9 °F 3.3°C
Cold Days (days with Tmax≤32°F /0°C)	38	24	27.3
Sub-freezing Nights (days with Tmin≤32°F /0°C)	130	125	145.3
Cold Winter Nights (days with Tmin≤0°F /-17.8°C)	4	0	8.5
Hot Days (days with Tmax≥90°F /32°C)	0	10	3.1
Winter Minimum (lowest temperature)	-7.0°F -21.7°C	5.0°F -15.0°C	-4.0°F -20°C
Growing Season Length (days between last spring 32°F/0°C and first fall 32°F/0°C)	154	174	175–200

**Table 6.** Summary of monthly average temperatures for 2008 for the selected stations.

Station Location	ID	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Chalk Hill, PA	CHKP1	29.0°F	29.4°F	37.8°F	51.4°F	54.5°F	66.4°F	68.6°F	64.9°F	62.2°F	48.3°F	37.0°F	33.0°F	48.5°F
		-0.7°C	-1.5°C	3.2°C	10.8°C	12.5°C	19.1°C	20.3°C	18.3°C	16.8°C	9.0°C	2.8°C	0.6°C	9.2°C
Morgantown, WV	KMGW	33.2°F	34.0°F	42.0°F	55.7°F	58.0°F	70.7°F	72.5 <sup>b</sup> °F	70.3°F	67.6°F	52.8°F	41.2°F	36.5°F	52.9°F
		0.7°C	1.1°C	5.5°C	13.1°C	14.4°C	21.5°C	22.5 <sup>b</sup> °C	21.3°C	19.8°C	11.6°C	5.1°C	2.5°C	11.6°C
Grays Landing, PA	GYLP1	30.7°F	31.9°F	38.9°F	54.0°F	56.1°F	70.1°F	72.1°F	69.8°F	66.5°F	51.1°F	40.7°F	34.7°F	51.4°F
		-0.7°C	-0.1°C	3.8°C	12.2°C	13.4°C	21.2°C	22.3°C	21.0°C	19.2°C	10.6°C	4.8°C	1.5°C	10.8°C
Laurel Hill, PA	LRL117	26.4°F	30.0°F	35.6°F	49.3°F	52.7°F	64.4°F	66.3°F	68.3°F	59.1°F	45.4°F	35.7°F	30.0°F	46.7°F
		-3.1°C	-2.8°C	2.0°C	9.6°C	11.5°C	18.0°C	19.1°C	20.2°C	15.0°C	7.4°C	2.0°C	-1.1°C	8.2°C

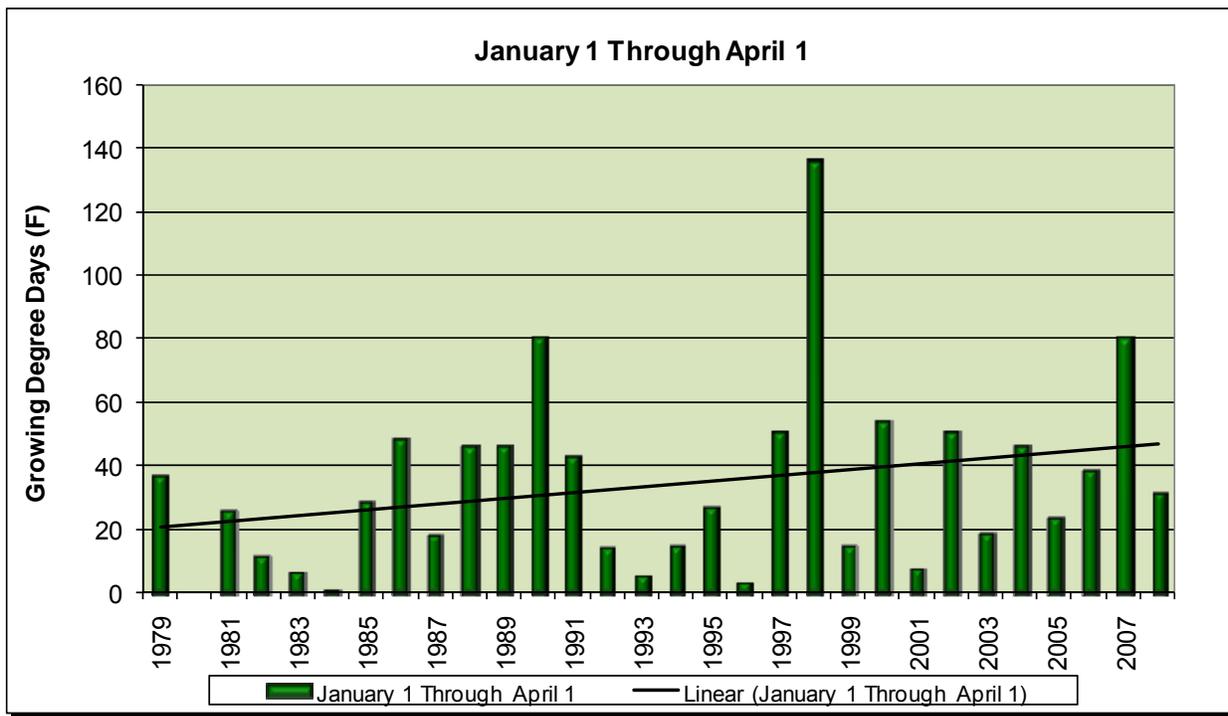
<sup>a</sup>1 day missing; <sup>b</sup>2 days missing; <sup>c</sup>3 days missing; <sup>d</sup>4 days missing.  
 Monthly statistics not reported if more than 4 days are missing.



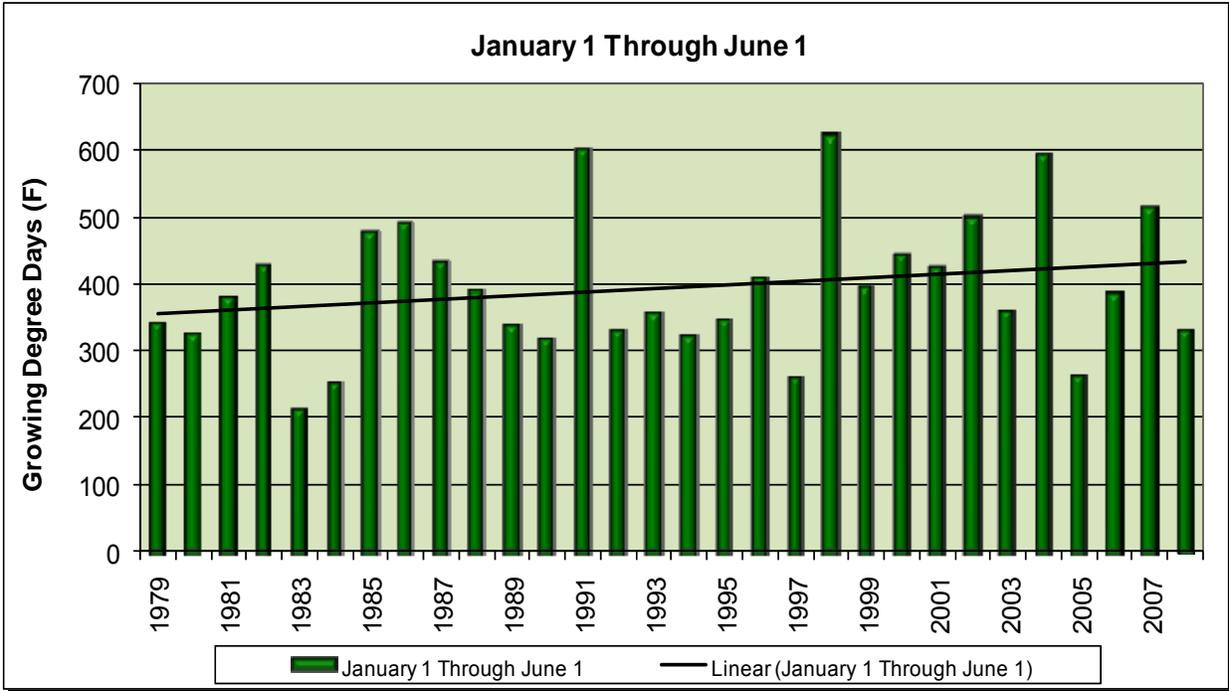
**Figure 4.** Annual soil temperature trends for Friendship Hill National Historic Site and Fort Necessity National Battlefield as derived from the North American Regional Reanalysis (NARR) data set. The black line is the soil temperature trend for a 32-km square box centered within Friendship Hill National Historic Site. The steady rise is consistent with the warming trend noted in the atmosphere during the past 30 years.

## Growing Degree Days

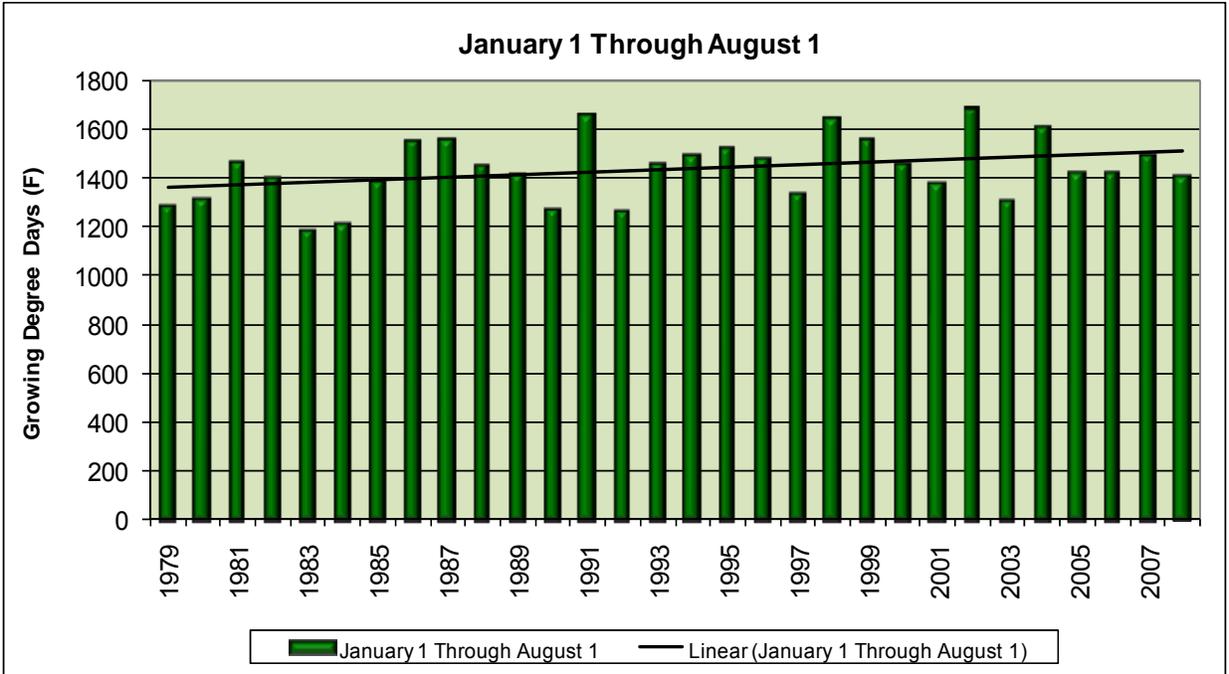
The derived quantity, growing degree days – base 55°F (12.8°C), is shown for its accumulation and long-term trend during several important intervals of the annual growing season. The accumulation of growing degree days is directly related to the phenological cycle of the flora and fauna and its related pests and diseases. Trends in the growing degree days can signal changes in the exposure of the region’s fauna to native and invasive pests. For Fort Necessity NB and Friendship Hill NHS, the trend shows a progressively earlier start to the growing season (Figures 5, 6, and 7). Data in Figures 5–7 are from the Chalk Hill 2 ENE (CHKP1) COOP station.



**Figure 5.** Trend in growing degree day accumulation (90 days) for Friendship Hill National Historic Site and Fort Necessity National Battlefield 1979–2008. There is a steady increase showing a progressively earlier start to the growing season.



**Figure 6.** Trend in growing degree day accumulation (150 days) for Friendship Hill National Historic Site and Fort Necessity National Battlefield 1979–2008. There is gradual increase of about 20% during the last 30 years.



**Figure 7.** Trend in growing degree day accumulation (215 days) for Friendship Hill NHS and Fort Necessity NB 1979–2008. There has been a 10% increase during this period.

## Precipitation Summary

Precipitation was highly variable during calendar year 2008 at Fort Necessity NB and Friendship Hill NHS with above-normal precipitation during five months, below-normal in five months, and near-normal in two months (Figure 8). Overall, 62.6 in (1,590 mm) of precipitation fell in Chalk Hill, PA (near Fort Necessity NB), and 44.9 in (1,141 mm) fell in Grays Landing (near Friendship Hill NHS) during the year, which featured two very wet months (Table 7).

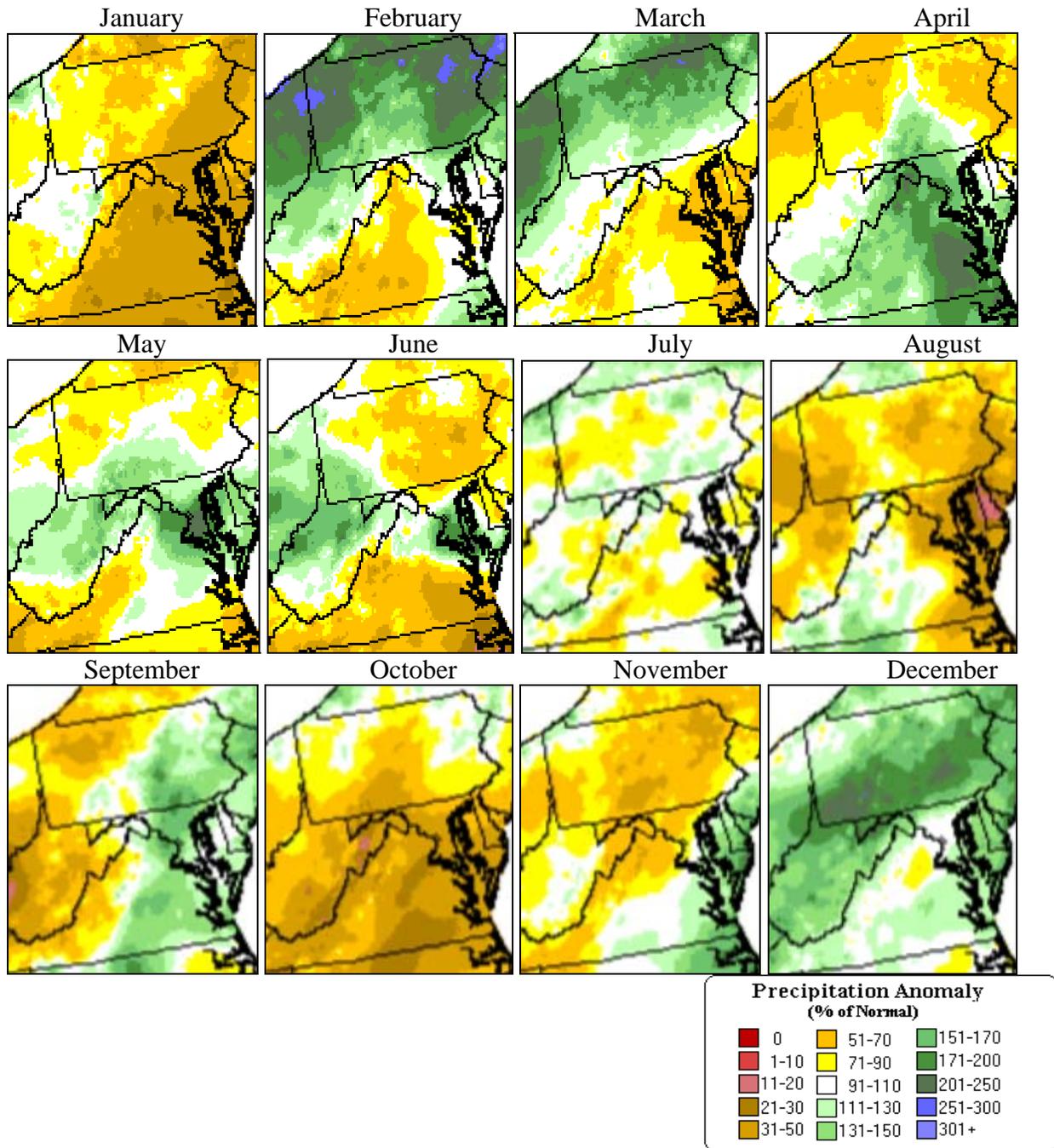
The winter season began with near-normal precipitation in January. During the month, 4.2 in (106 mm) fell at Chalk Hill, which was 96% of average (Tables 8 and 9). Positive anomalies continued in February, which was the 5<sup>th</sup> wettest in the Southwest Plateau Climate Division of Pennsylvania (#9) since records began in 1895. This was also the soggiest February since 1956. March was close to the long-term mean in Fort Necessity with 106% of normal precipitation falling on Chalk Hill. However, precipitation was above normal in Friendship Hill NHS with 114% of normal precipitation falling in Grays Landing, PA. Due, in part, to a very wet February, the winter (January-February-March) ranked as the 14<sup>th</sup> wettest since 1895 (Table 4). Snowfall in Fort Necessity NB was above normal with 104 in (2,647 mm) falling in Chalk Hill, which was more than the average of 80.5 in (2,045 mm) (Table 7).

April precipitation was near normal throughout the region, with 4.2 in (107 mm) falling on Chalk Hill and 4.5 in (114 mm) falling on Gray's Landing (Table 8). May was the soggiest 5<sup>th</sup> month of the year since 2004 with 5.2 in (133 mm) falling in Climate Division #9. Positive anomalies persisted in June, which ranked the 13<sup>th</sup> wettest since 1895. The 6.5 in (165 mm) of rain that fell in the Southwest Plateau was the most since June of 1989. Overall, the spring ranked as the 21<sup>st</sup> wettest in this climate division (Table 4).

Summer of 2008 was the driest season of the year. It ranked as the 38<sup>th</sup> driest (Table 4). The deficit was caused by a very dry August which was the 9<sup>th</sup> driest since 1895 and a vast difference from 2007 which was the wettest August for the period of record. July was above average with 6.9 in (176 mm) of rain falling in Chalk Hill, which was 126% of normal, and 6.5 in (165 mm) falling in Grays Landing (Tables 8 and 9). September featured two of the wettest days of the year (2.5 in [63 mm] on September 9 and 1.5 in [38 mm] on September 14). Conversely, the month also had a long dry spell from September 16–25 (Table 10). Overall, below-average precipitation occurred during September.

Negative precipitation anomalies occurred during the first two months of the fall, with October and November ranking as the 35<sup>th</sup> and 41<sup>st</sup> driest, respectively. October saw 2.1 in (52 mm) of precipitation in the climate division and November saw 2.2 in (57 mm). October was the driest since 1997. It is interesting to note that more precipitation fell in December (6.0 in [154 mm]) than October and November combined (4.3 in [109 mm]). The last month of 2008 was the 2<sup>nd</sup> wettest December since 1895. As a whole, 2008 was the 16<sup>th</sup> wettest and similar to 2007. Despite 2008 being a wet year, annual soil moisture trends have been on the decline during the past 30 years (Figure 9).

Friendship Hill NHS and Fort Necessity NB  
 Percent of Average Monthly Precipitation  
 2008 vs. 1971–2000



**Figure 8.** Maps showing percent of average precipitation compared to the 30-year normal (1971–2000) for each month in the calendar year 2008.

**Table 7.** Status of 2008 precipitation indicators using the Chalk Hill and Grays Landing, PA stations compared the 30-year normal at Elkins, WV. While elevation does vary, trends in 2008 showed an increase in annual rainfall and the number of excessively wet days.

Precipitation Indicators	Chalk Hill, PA CHKP1 2008	Grays Landing, PA GYLP1 2008	Elkins, WV KEKN 1971–2000
Annual Precipitation	62.6 in 1,590 mm	44.9 in 1,141 mm	46.1 in 1,171 mm
Autumn (Oct, Nov, Dec) Precipitation	13.6 in 345 mm	9.3 in 236 mm	-
Annual Snowfall	104 in 265 cm	56 in 142 cm	81 in 205 cm
Micro-drought (strings of 7+ days without rain)	3	4	-
Moderate Rain (days with $\geq 1.0$ in (25 mm) rain)	11	6	6.7
Heavy Rain (days with $\geq 2.0$ in (51 mm) rain)	3	0	-
Heavy Snow (days with $\geq 6.0$ in (15.3 cm) snow)	2	1	-

**Table 8.** Summary of 2008 monthly total rainfall for selected stations.

Station Location	ID	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Chalk Hill, PA	CHKP1	4.2 in	4.5 in	5.0 in	4.2 in	7.2 in	9.7 in	6.9 in	2.0 in	5.3 in	1.8 in	3.1 in	8.6 in	62.2 in
		107 mm	114 mm	127 mm	107 mm	183 mm	246 mm	175 mm	51 mm	135 mm	46 mm	79 mm	218 mm	1580 mm
Morgantown, WV	KMGW	2.5 in	4.1 in	3.3 in	3.4 in	6.0 in	6.7 in	7.8 in	2.3 in	2.3 in	1.3 in	2.4 in	5.5 in	47.7 in
		64 mm	104 mm	84 mm	86 mm	152 mm	170 mm	198 mm	58 mm	58 mm	33 mm	61 mm	140 mm	1212 mm
Grays Landing, PA	GYLP1	2.1 <sup>b</sup> in	3.6 in	4.0 in	4.5 in	5.3 in	6.1 in	6.5 in	1.8 in	1.8 in	1.4 in	2.3 in	5.6 in	41.0 in
		53 <sup>b</sup> mm	91 mm	102 mm	114 mm	135 mm	155 mm	165 mm	46 mm	46 mm	36 mm	58 mm	142 mm	1041 mm

<sup>a</sup>1 day missing; <sup>b</sup>2 days missing; <sup>c</sup>3 days missing; <sup>d</sup>4 days missing.

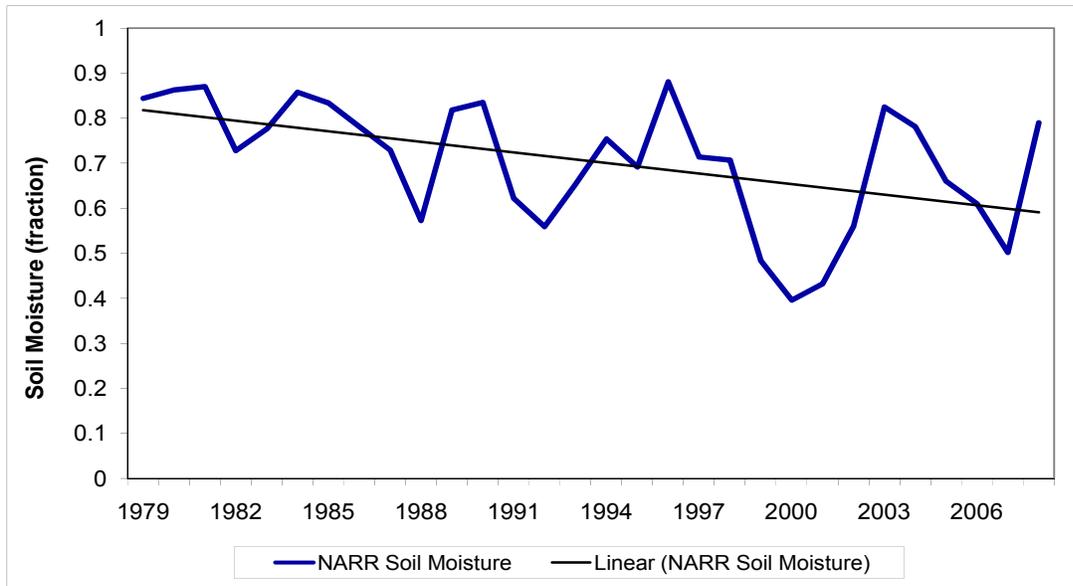
Monthly statistics not reported if more than 4 days are missing.

**Table 9.** Summary of 2008 percent of normal rainfall based on 30-year normal (1971–2000) for selected stations.

Station Location	ID	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Chalk Hill, PA	CHKP1	96	115	106	84	138	204	126	46	117	50	75	219	115
Morgantown, WV	KMGW	88	147	90	95	143	162	185	58	65	47	70	187	113
Grays Landing, PA	GYLP1	70	136	114	101	127	169	162	45	57	53	72	209	113

**Table 10.** Top four wettest days and top four dry spells (consecutive days with a trace or less of rainfall) during 2008 (Data from the Chalk Hill 2 ENE COOP station).

Wettest Days in 2008	Dry Spells in 2008
Sep. 9: 2.5 in (63 mm)	Aug. 7–27
Jun. 1: 2.1 in (54 mm)	Sep. 16–25
Jul. 23: 2.0 in (52 mm)	Oct. 30–Nov.7
Sep. 13: 1.5 in (38 mm)	Sep. 1–Sep. 8

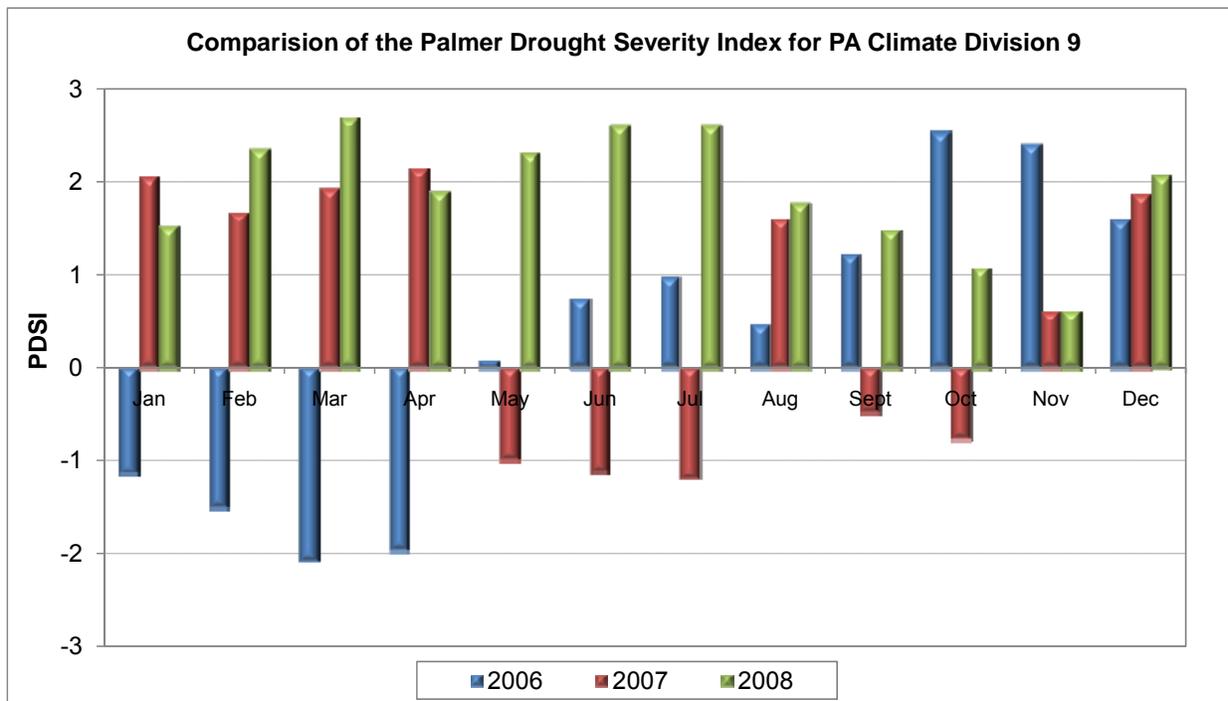


**Figure 9.** Annual soil moisture trends for Fort Necessity National Battlefield and Friendship Hill National Historic Site as derived from the North American Regional Reanalysis (NARR) data set. The black line is the soil moisture trend for a 32-km square box within Fort Necessity National Battlefield. There has been a steady decline in the soil moisture content during the last 30 years.

## Drought Status

The U.S. Drought Monitor (USDM; <http://www.drought.unl.edu/dm/monitor.html>) tracks drought conditions across the nation on a weekly basis and it incorporates data and expert input from a wide variety of state and federal agencies. The USDM is designed to represent a “broad brush,” regional perspective (e.g., summarized by climate division, state, or region) on drought, and therefore provides an ideal tool for tracking generalized drought conditions across the Delaware River valley parks and surrounding areas. One index used to track drought conditions, the Palmer Drought Severity Index (PDSI), uses temperature and rainfall information to determine dryness (the long-term average is “zero”). Since the PDSI responds to long-term effects, including evaporation, there is usually a lag between both long, dry spells and episodes of heavy rain and changes in the index value.

According to the USDM, there was no time during the year when it was drier than normal (Figures 10–12). In fact, despite some dry periods in April, August into November, most of the time the region was abnormally moist ( $>+2$ ). When compared with the past few years, 2008 was noticeably moister than 2007 and similar to the second half of 2006.



**Figure 10.** Palmer Drought Severity Index (PDSI) for Pennsylvania Climate Division 9, 2006–2008.

Drought Severity in Pennsylvania during 2008

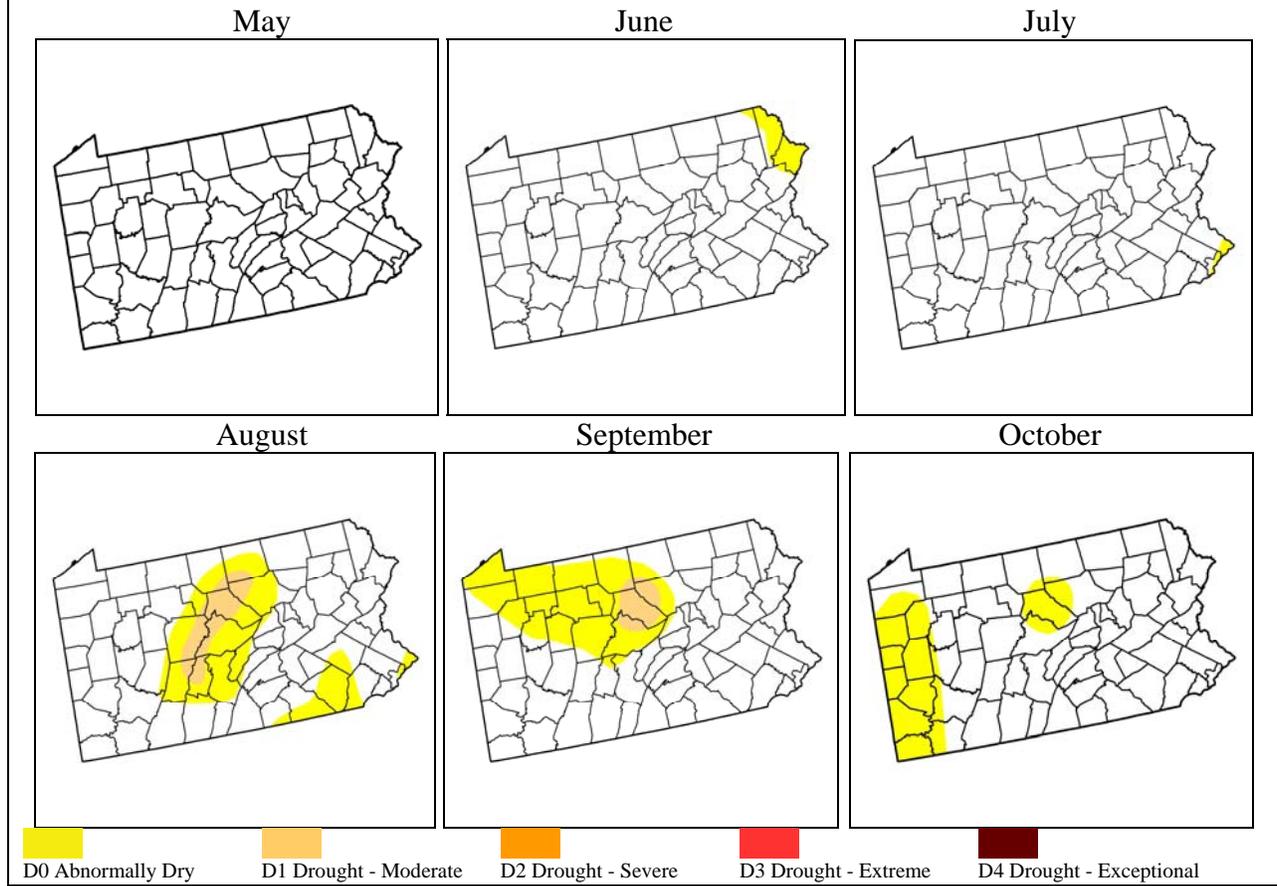
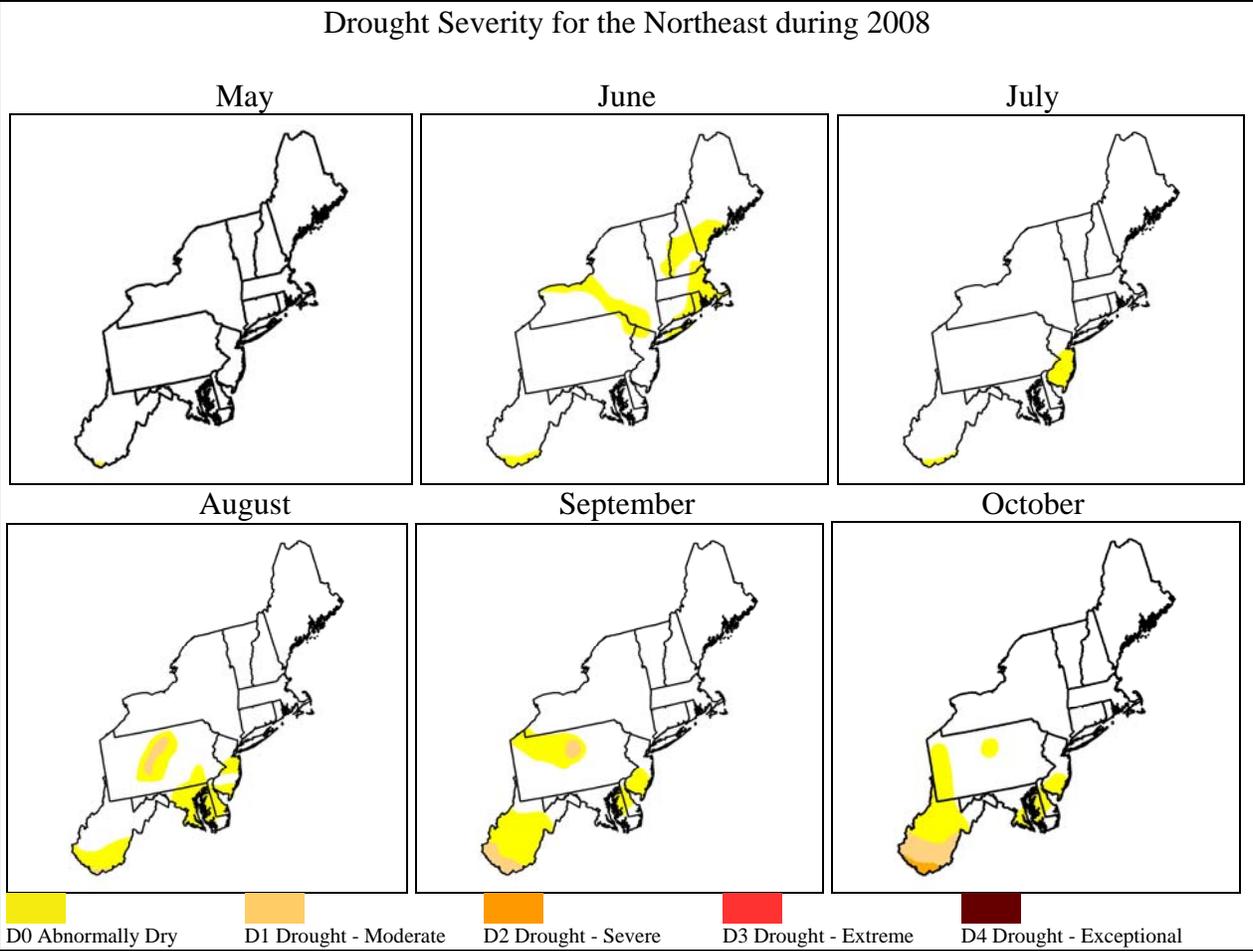


Figure 11. Mid-month values of the Palmer Drought Severity Index (PDSI) for Pennsylvania in 2008.



**Figure 12.** Mid-month values of the Palmer Drought Severity Index (PDSI) for the Northeast in 2008.

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## Appendix. Summary of Severe Weather

The following table summarizes all reports of severe weather during 2008 in the county that encompasses Fort Necessity NB and Friendship Hill NHS. These storm events were provided by the National Climatic Data Center (NCDC). NCDC receives this storm data from the National Weather Service, who acquire their information from a variety of sources. These sources include, but are not limited to: county, state, and federal emergency management officials, local law enforcement officials, skywarn spotters, NWS damage surveys, newspaper clipping services, the insurance industry, and the general public. This Storm Data is an official publication of the National Oceanic and Atmospheric Administration (NOAA [2008]) which documents the occurrence of storms and other significant weather phenomena having sufficient intensity to cause loss of life, injuries, significant property damage, and/or disruption to commerce. Each table contains the location, date, time, description of the severe event, its magnitude, and number of deaths, injuries, and property/crop damage associated with the event. The property and crop damage should be considered as a broad estimate.

### Fayette County

Location or County	Date	Time	Type	Mag	Dth	Inj	PrD	CrD
PAZ007>009 - 030 - 032	01/01/2008	07:00 AM	Heavy Snow	N/A	0	0	0K	0K
PAZ023 - 030 - 032	01/30/2008	04:00 AM	High Wind	50 kts.	0	0	50K	0K
PAZ013 - 022>023 - 030 - 032	02/01/2008	01:00 AM	Winter Storm	N/A	0	0	10K	0K
PAZ032	02/27/2008	02:00 AM	Heavy Snow	N/A	0	0	0K	0K
Connellsville	03/04/2008	21:15 PM	Thunderstorm Wind	50 kts.	0	0	25K	0K
PAZ032	05/11/2008	11:44 AM	High Wind	50 kts.	0	0	50K	0K
Brownsville	06/16/2008	19:05 PM	Hail	1.00 in.	0	0	0K	0K
Woodside	06/16/2008	19:15 PM	Thunderstorm Wind	50 kts.	0	0	50K	0K
Uniontown	06/16/2008	19:21 PM	Hail	0.75 in.	0	0	0K	0K
Leith	06/16/2008	19:22 PM	Hail	1.00 in.	0	0	0K	0K
Oliphant Furnace	06/16/2008	19:30 PM	Thunderstorm Wind	50 kts.	0	0	50K	0K
Leith	06/16/2008	19:50 PM	Flash Flood	N/A	0	0	100K	0K
Edenborn	06/16/2008	20:01 PM	Hail	1.75 in.	0	0	0K	0K
Deffenbaugh	07/20/2008	14:40 PM	Thunderstorm Wind	50 kts.	0	0	40K	0K
Smithfield	07/20/2008	15:45 PM	Thunderstorm Wind	50 kts.	0	0	50K	0K
Whitsett	07/21/2008	20:00 PM	Thunderstorm Wind	50 kts.	0	0	50K	0K
Cottier	07/21/2008	20:20 PM	Thunderstorm Wind	51 kts.	0	0	300K	0K
Ohiopyle	07/21/2008	20:40 PM	Thunderstorm Wind	50 kts.	0	0	10K	0K
Leckrone	07/30/2008	15:50 PM	Hail	0.75 in.	0	0	0K	0K
Leith	07/30/2008	16:10 PM	Thunderstorm Wind	50 kts.	0	0	50K	0K
Fiketown	07/30/2008	16:35 PM	Tornado	F0	0	0	5K	0K
PAZ032	10/28/2008	16:00 PM	Winter Weather	N/A	0	0	0K	0K
PAZ007>009 - 032	11/20/2008	20:00 PM	Heavy Snow	N/A	0	0	0K	0K
PAZ032	11/25/2008	14:00 PM	Heavy Snow	N/A	0	0	0K	0K
Pennsville	12/19/2008	23:50 PM	Flood	N/A	0	0	5K	0K
<b>TOTALS:</b>					0	0	845K	0

Mag: Magnitude; Dth: Deaths; Inj: Injuries; PrD: Property Damage; CrD: Crop Damage



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