



Weather of Hopewell Furnace National Historic Site and Valley Forge National Historical Park

Mid-Atlantic Network Summary Report for 2010

Natural Resource Data Series NPS/MIDN/NRDS—2011/187



ON THE COVER

Hopewell Furnace National Historic Site.
Photograph by: Steven R. Schuetz.

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Natural Resource Data Series NPS/MIDN/NRDS—2011/187

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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 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 Observation System
CASTNet	Clean Air Status and Trends Network
COOP	National Weather Service Cooperative Observer Program
CWOP	Citizen Weather Observer Program
FAA	Federal Aviation Administration
HOFU	Hopewell Furnace National Historic Site
IFLOWS	Integrated Flood Observing and Warning System
MIDN	Mid-Atlantic Network
NADP	National Atmospheric Deposition Program
NARR	North American Regional Reanalysis
NCDC	National Climatic Data Center
NHP	National Historical Park
NHS	National Historic Site
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PASC	Pennsylvania State Climatologist
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
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VAFO	Valley Forge National Historical Park

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 (Comiskey and Callahan 2008).

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, regional, and global context (Marshall et al., in review). It is our intention that this report will satisfy an inherent interest in meteorological phenomena and meet the Mid-Atlantic Network (MIDN) Weather and Climate Monitoring objectives:

- 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 MIDN parks. Since no single weather 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 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 in the profile of 2010's 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 this report.

Climate of the Southeastern Piedmont

Hopewell Furnace National Historic Site (NHS) and Valley Forge National Historical Park (NHP) are located in Pennsylvania Climate Division 3, known as the “Southeastern Piedmont”. 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 ten climate divisions. The Southeastern Piedmont region of Pennsylvania is generally considered to have a humid, continental type of climate, but the rolling hills and valleys have an effect on the weather and climate of the various parts of the region. The prevailing westerly winds carry most of the weather disturbances that affect the area from the interior of the continent, with the Atlantic Ocean having only an occasional influence on the climate of the region (Davey et al. 2006, Gawtry and Stenger 2007). Coastal storms do, at times, affect the day-to-day weather, especially in the winter. Also, storms of tropical origin can have the greatest effect within this portion of Pennsylvania, causing severe floods in some instances (Gelber 2002).

Temperatures are moderately continental, with the tempering effects of the Appalachians contributing to cloud dissipation in the winter and onshore winds reducing the heat at times 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 the 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 Piedmont plateau. The southwest winds gain additional warmth when descending the crest of the Appalachians. On average, maximum annual temperatures are greater in Valley Forge NHP (63.8°F [17.7°C]) than Hopewell Furnace NHS (62.1°F [16.7°C]). The last freeze for the parks typically occurs in early May and the first frosts appear in October.

Precipitation is fairly evenly distributed throughout the year. Annual amounts generally range between 38–48 in (965–1,219 mm), while the majority of places receive 42–45 in (1,067–1,143 mm). Greatest amounts usually occur in the late spring and summer months, while February is the driest month, having about 2 in (51 mm) less than the wettest months. Precipitation tends to be somewhat greater in the hilly terrain due, primarily, to coastal storms which occasionally frequent the area. During the warm season these storms can bring heavy rain, while in winter heavy snow or a mixture of rain and snow may be produced. Due to its location and higher elevation, annual snowfall totals tend to be greater in Hopewell Furnace NHS than in Valley Forge NHP.

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, occurring between the equinoxes and reaching a peak near the 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 three years. The direct effects of an Atlantic hurricane are uncommon, though remnant rains from tropical storms have contributed to the region’s worst floods. Ice storms, which can cause significant disruption, occur at irregular intervals, but 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 three weather observing networks were selected around Hopewell Furnace NHS and Valley Forge NHP. Representative stations within a 100-km range of each park were chosen based on several criteria, which include proximity to the parks, 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 (Marshall et al., in preparation). Moreover, the percentage of time a station reports a particular parameter (e.g., temperature) can influence data inclusion. A total of six stations were ultimately used for this 2010 report: Glenmore, West Chester, Morgantown, Pottstown, Reading, and Valley Creek (Figure 1, Table 1)

Of the six stations, Glenmore, West Chester, and Morgantown have a Period of Record (POR) sufficiently long for a 30-year normal (1971–2000). However, Morgantown stopped recording temperature in 1986 and also has a low percent of time reporting precipitation over its POR. Only West Chester was used for the temperature indicator analysis, as Glenmore does not report temperature. Glenmore and West Chester are used in the precipitation indicator analysis. Monthly temperature averages and departures from normal are presented for West Chester, Pottstown, and Reading; all stations are used for monthly precipitation averages. Due to a short Period of Record, precipitation departures are not calculated for Valley Creek.

In addition to the summary information available in this report, a near real-time data stream has been made available to the MIDN through a Web interface for the selected weather observing 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.

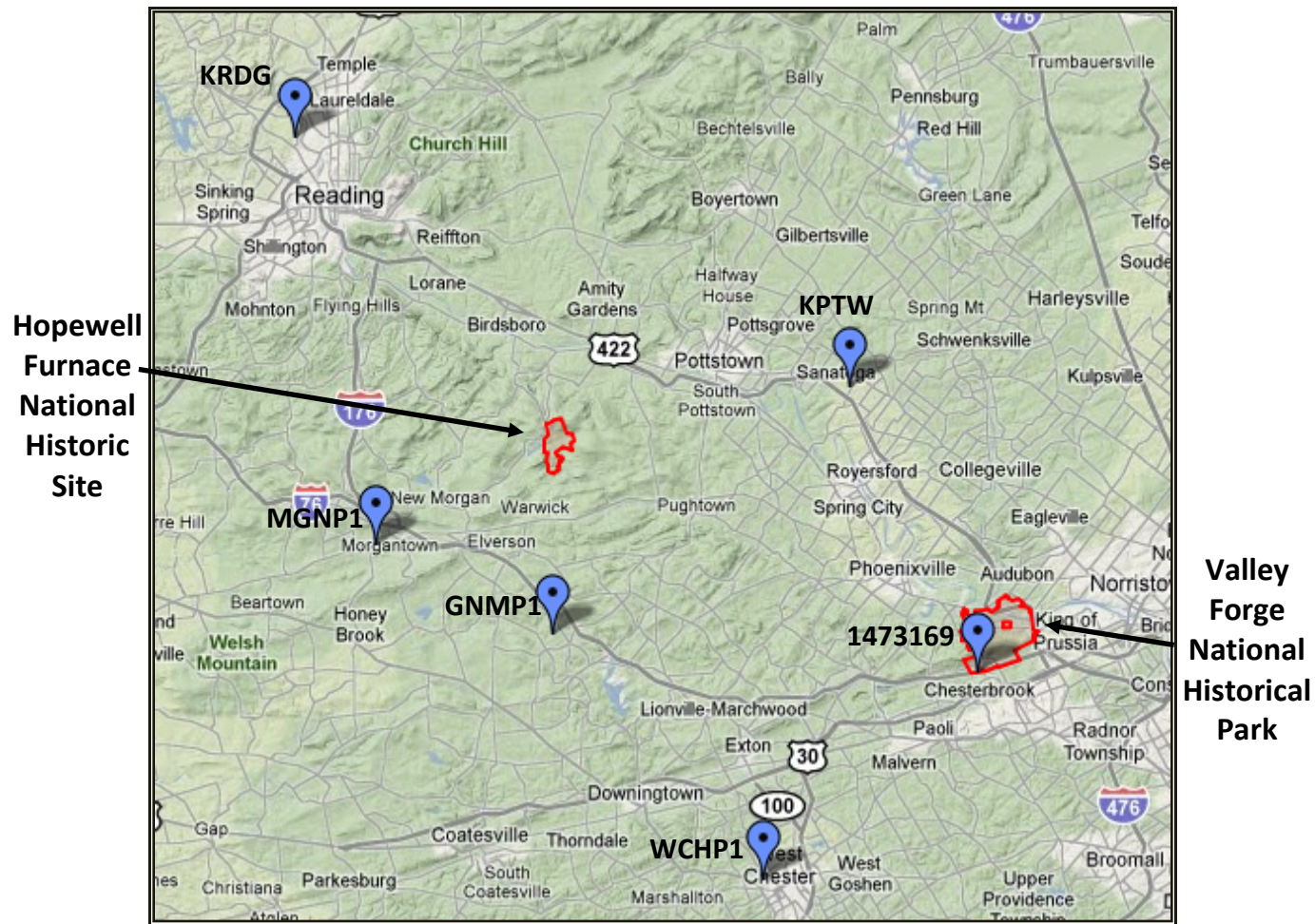


Figure 1. Location of weather observing stations around Hopewell Furnace National Historic Site and Valley Forge National Historical Park selected as most representative of the parks in 2010. See Table 1 for station names.

Table 1. List of weather observing stations around Hopewell Furnace National Historic Site and Valley Forge National Historical Park selected as most representative of the parks in 2010.

Station	Observing Network ¹	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
GNMP1	COOP	Glenmoore	04/01/1959	Present	-	99.7	-	99.3
WCHP1	COOP	West Chester 2 NW	01/01/1893	Present	100.0	98.6	89.8	88.6
MGNP1	COOP	Morgantown	06/01/1951	Present	-	100.0	86.4*	59.9
KPTW	ASOS	(Pottstown) Heritage Field Airport	01/01/1999	Present	100.0	98.6	97.1	97.1
KRDG	ASOS	Reading Regional Airport/Carl A. Spaatz Field	01/01/1973	Present	100.0	100.0	97.7	31.1
1473169	USGS	Valley Creek	10/01/2005	Present	-	98.6	-	98.1

*Percentage of time reporting temperature for Morgantown is based upon a Period of Record ending on 03/01/1986 because the station stopped reporting temperature after this date.

¹ Observing networks are: ASOS — Automated Surface Observation System, COOP — National Weather Service Cooperative Observer Program, and USGS — United States Geological Survey.

Temperature Summary

The year of 2010 in Hopewell Furnace NHS and Valley Forge NHP was warmer than the long-term mean, with annual temperatures 0.8°F (0.4°C) above average (Table 2). Daytime maximum temperatures were consistently higher than normal from March through September with only two months experiencing below average readings at night (Figures 2 and 3)¹.

January was a seasonable month, but February produced the largest negative departures (Figures 2 and 3) for the winter of 2009-2010. Temperatures averaged between 1.3°F to 3.8°F (0.7°C to 2.1°C) below the norm (Tables 3 and 4). The lowest readings of the year occurred on February 8th with a value of 2.0°F (-16.7°C), which is slightly above the normal value (Table 2). Above-average temperatures returned in March which ranged from 3.7°F to 6.6°F (2.1°C to 3.7°C) warmer than normal (Table 4). The number of cold days, where maximum temperatures do not reach 32°F (0°C), was near the long-term average with 19 days compared with an average of 20 (Table 2). The winter months ranked as the 29th warmest in 116 years based in the Southeastern Piedmont which encompasses both parks (Table 5).

The spring was very warm with April tallying the largest positive departures (Figures 2 and 3). May had only slightly above-normal days and milder-than-normal nights, resulting in temperatures that ranged from 1.9°F to 4.1°F (1.1°C to 2.3°C) from normal across the region (Table 4). June was decidedly warmer than average with a mean temperature of 75.5°F (24.2°C) in Pottstown. The spring months ranked as the warmest in 116 years (Table 5).

The summer months were dominated by a hot July, leading to the 6th warmest in 116 years in the Southeastern Piedmont (Table 5). Readings in July varied from 2.2°F to 4.5°F (1.2°C to 2.5°C) above average (Table 4), and the number of hot days tallied 42 days compared with an average of 19 occurrences in a typical year (Table 2). August was not as torrid as July, as mean temperatures ranged from 75.8°F (24.3°C) at Reading to 73.8°F (23.2°C) at West Chester (Table 3). September was another month with above-average days and milder-than-normal nights and averaged somewhat above the long-term values (Figures 2 and 3). The highest reading of the year was 102.0°F (38.9°C), which is higher than the average of 96.0°F (35.6°C) (Table 2).

Autumn featured temperatures lower than average, ranking 35th coolest (Table 5). Temperatures in October varied from 0.5°F to 2.3°F (0.3°C to 1.3°C) (Table 4) above normal due to several warm nights (Figure 2). November was virtually normal with positive and negative anomalies offsetting each other (Table 4). December had the largest negative departures of 2010 with chilly days and frigid nights (Figures 2 and 3). The monthly anomalies during December ranged from 2.7°F to 5.0°F (1.5°C to 2.8°C) below the long-term average. The total growing season length was 165 days, or 9 days shorter than the 30-year average.

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 is at <http://www.prism.oregonstate.edu/>.

Hopewell Furnace National Historic Site
and Valley Forge National Historical Park
Departure from Average Monthly Maximum Temperature
2010 vs. 1971–2000

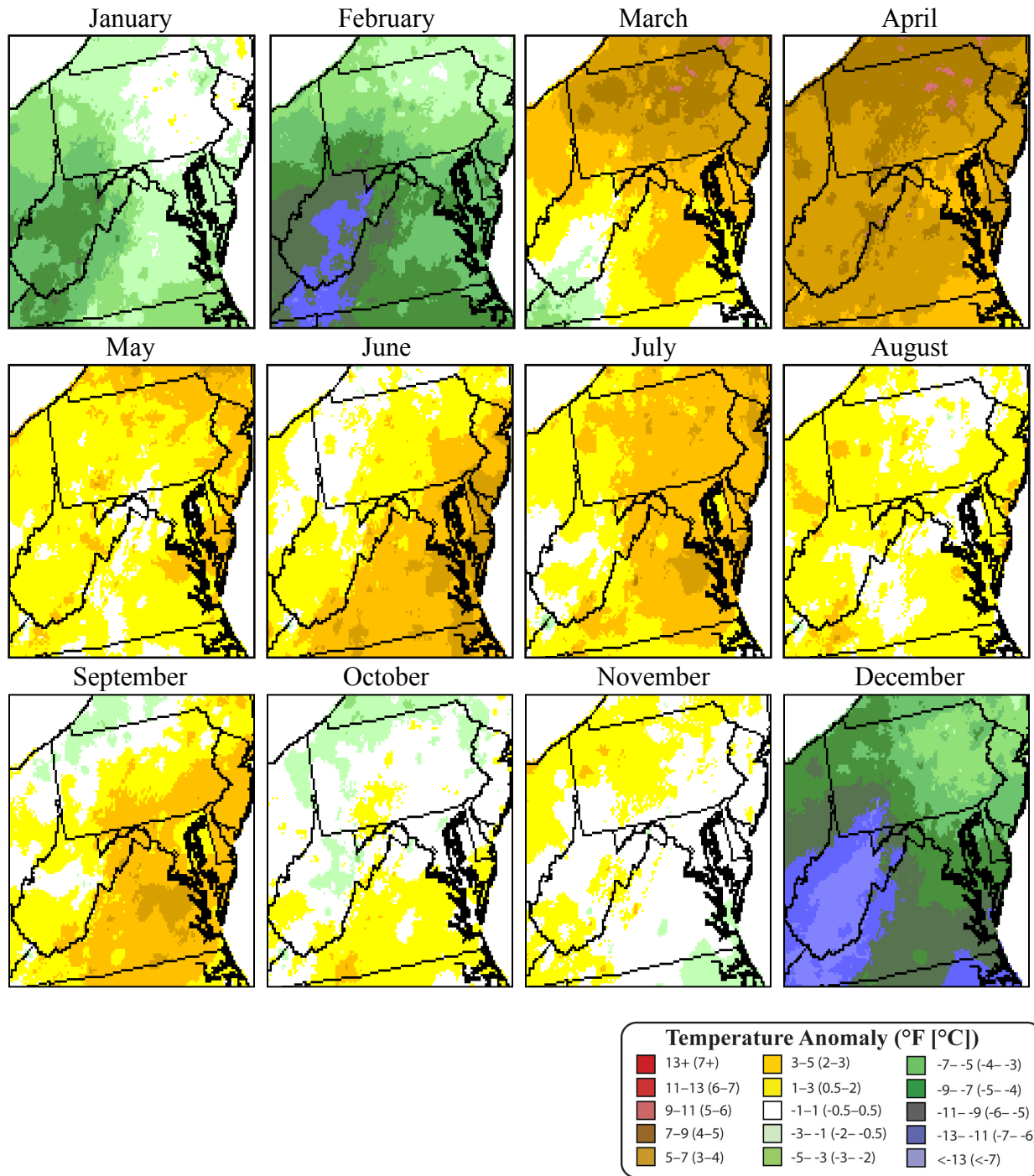


Figure 2. Maps showing departure from average monthly maximum temperature compared to the 30-year normal (1971–2000).

Hopewell Furnace National Historic Site
and Valley Forge National Historical Park
Departure from Average Monthly Minimum Temperature
2010 vs. 1971–2000

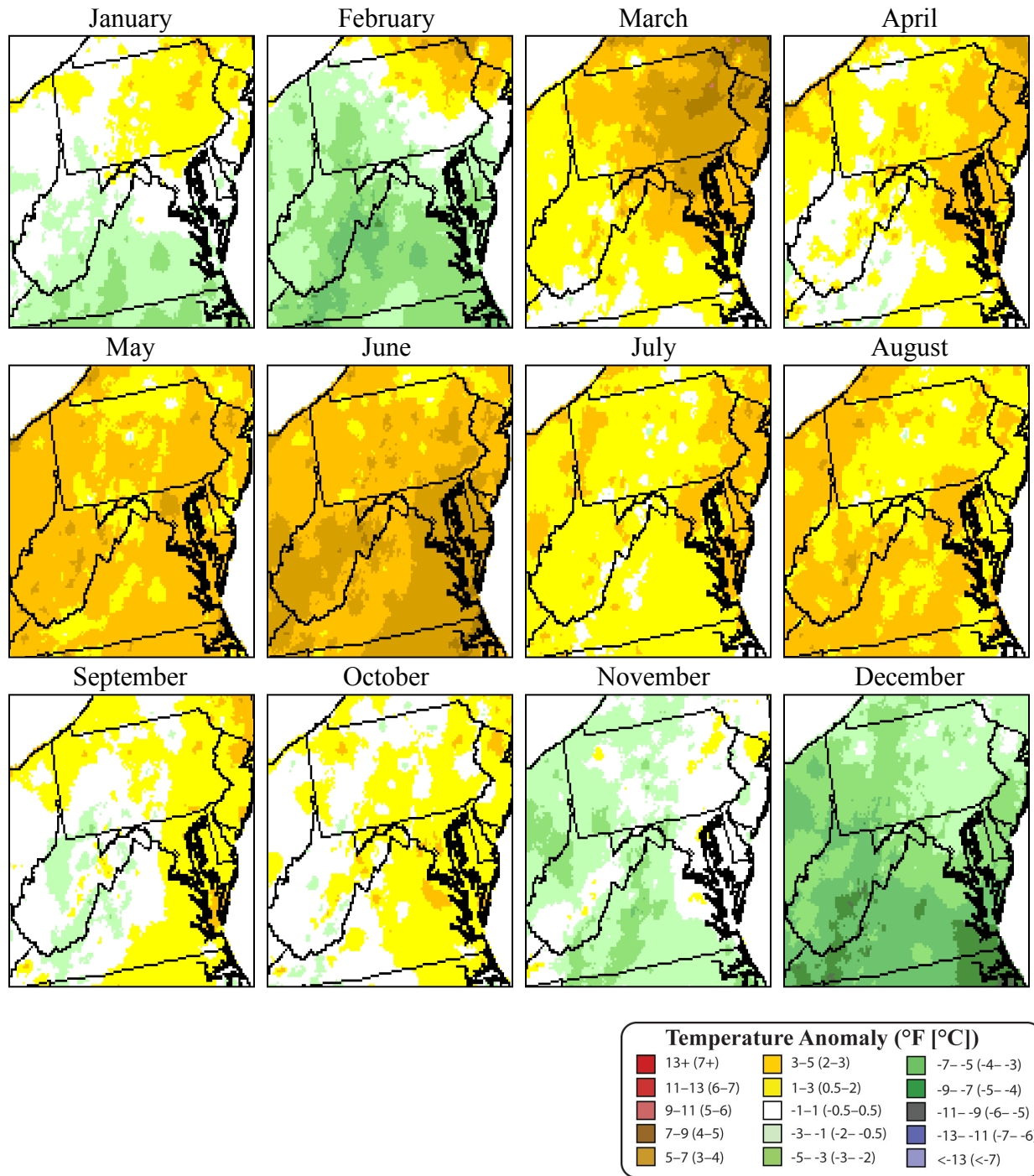


Figure 3. Maps showing departure from average monthly minimum temperature compared to the 30-year normal (1971–2000).

Table 2. Status of 2010 temperature indicators compared to the 30-year normal (1971–2000) at the West Chester 2 NW (WCHP1) weather observing station.

Temperature Indicator	West Chester 2 NW 2010	West Chester 2 NW 1971–2000
Average Annual Temperature	53.6°F 12.0°C	52.8°F 11.6°C
Average Annual Maximum Temperature	65.0°F 18.3°C	63.8°F 17.7°C
Maximum Temperature	102.0°F 38.9°C	96.0°F 35.6°C
Hot Days (days with Tmax≥90°F/32°C)	42	19
Average Annual Minimum Temperature	42.3°F 5.7°C	41.9°F 5.5°C
Minimum Temperature	2.0°F -16.7°C	-0.6°F -18.1°C
Cold Days (days with Tmax≤32°F/0°F)	19	20
Sub-freezing Days (days with Tmin≤32°F/0°C)	127	115
Sub-zero Days (days with Tmin≤0°F/-18°C)	0	2
Growing Season Length (days between last spring Tmin 32°F/0°C and first fall Tmin 32°F/0°C)	165	174

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

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
West Chester 2 NW	WCHP1	30.4 °F	28.9 °F	45.0 °F	54.3 °F	63.3 °F	74.1 °F	76.9 °F	73.8 °F	67.7 °F	54.3 °F	43.5 °F	29.9 °F	53.5 °F
		-0.9 °C	-1.7 °C	7.2 °C	12.4 °C	17.4 °C	23.4 °C	24.9 °C	23.2 °C	19.8 °C	12.4 °C	6.4 °C	-1.2 °C	11.9 °C
Pottstown Airport	KPTW	32.0 °F	31.3 °F	47.9 °F	57.0 °F	66.0 °F	75.5 °F	79.6 °F	76.4 °F	70.4 °F	56.8 °F	46.1 °F	32.2 °F	55.9 °F
		0.0 °C	-0.4 °C	8.8 °C	13.9 °C	18.9 °C	24.2 °C	26.4 °C	24.7 °C	21.3 °C	13.8 °C	7.8 °C	0.1 °C	13.3 °C
Reading Airport	KRDG	30.9 °F	30.3 °F	47.4 °F	56.2 °F	65.6 °F	74.6 °F	78.8 °F	75.8 °F	69.3 °F	55.6 °F	44.6 °F	30.6 °F	55.0 °F
		-0.6 °C	-0.9 °C	8.6 °C	13.4 °C	18.7 °C	23.7 °C	26.0 °C	24.3 °C	20.7 °C	13.1 °C	7.0 °C	-0.8 °C	12.8 °C

Table 4. Summary of 2010 departure from normal temperature 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
West Chester 2 NW	WCHP1	0.3 °F	-3.8 °F	3.7 °F	2.8 °F	1.9 °F	4.2 °F	2.2 °F	1.0 °F	2.4 °F	0.5 °F	-1.2 °F	-5.0 °F	0.7 °F
		0.2 °C	-2.1 °C	2.1 °C	1.6 °C	1.1 °C	2.3 °C	1.2 °C	0.6 °C	1.3 °C	0.3 °C	-0.7 °C	-2.8 °C	0.4 °C
Pottstown Airport*	KPTW	1.8°F	-1.7°F	6.2°F	5.2°F	3.8°F	4.7°F	4.5°F	3.2°F	4.5°F	2.3°F	1.5°F	-2.7°F	2.7°F
		1.0°C	-0.9°C	3.4°C	2.9°C	2.1°C	2.6°C	2.5°C	1.8°C	2.5°C	1.3°C	0.8°C	-1.5°C	1.5°C
Reading Airport*	KRDG	1.7°F	-1.3°F	6.6°F	5.2°F	4.1°F	4.6°F	4.2°F	2.9°F	3.9°F	1.7°F	0.3°F	-3.7°F	2.5°F
		0.9°C	-0.7°C	3.7°C	2.9°C	2.3°C	2.6°C	2.3°C	1.6°C	2.2°C	0.9°C	0.2°C	-2.1°C	1.4°C

*Indicates a station's Period of Record is five 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 temperature and precipitation rankings over 116 years for the Southeastern Piedmont (NOAA 2010).

	Climate Division 3 Rankings — Southeastern Piedmont			
	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN
Temperature-2010	29	1	6	81
Precipitation-2010	14	92	58	17

1 = warmest/wettest year and 116 = coldest/driest year

Precipitation Summary

Precipitation varied significantly across the Hopewell Furnace NHS and Valley Forge NHP region in 2010 (Table 6). Two of the four seasons finished with much-above-average precipitation after a very dry spring (Table 5).

The first three months of 2010 raised concerns about spring flooding (Figure 4). In fact, the Palmer Drought Severity Index (PDSI) was approaching excessively wet (4) by late March (see next section, Figure 5). While January's rain and snowfall was below normal ranging from 42-81 percent of average, the small deficit was erased quickly by a snowy February and a wet March (Table 9). Surprisingly, none of the year's wettest days occurred during the cold seasons in 2010, though snowfall was excessive averaging between 48in to 53 in (121.9 cm to 136.4 cm) compared with a normal value of 27 in (69 cm) (Tables 6 and 7).

Spring became progressively drier with all three months averaging below normal rainfall (Figure 4 and Table 9). April brought rainfall tallies ranging from 2.0 in (51 mm) at Pottstown to 2.8 in (71 mm) at West Chester, but May had closer to average rainfall (Tables 8 and 9). By June, rain was only 35-66 percent of normal (Table 9). Overall, this season ranked as the 24th driest in 116 years of records in the Southeastern Piedmont.

Summer's rainfall was very irregular. Long dry spells ended with excessive precipitation on two occasions. June 26-July 9 had no measurable rain, but the region was inundated with 1.9 in (48 mm) on July 10 and then 2.1 in (51 mm) on July 13. No rain was measured from July 27-August 12, but a total of 2.06 in (52 mm) was registered on August 13 (Table 7). There were the indirect effects from tropical storm Nicole at the end of this period in southeastern Pennsylvania. On September 30, 2.28 in (58mm) was tallied and October 1 was the wettest day of the year with 5.59 in (142 mm), both of which occurred as the remnants of Nicole moved northward along a stalled front (Table 7). The end result was that the three month rainfall from July-September was perfectly normal, ranked 58th in 116 years of records (Table 5).

Yet another wet autumn was tallied around Hopewell Furnace NHS and Valley Forge NHP in 2010. Total precipitation during October-November and December exceeded the 30-year mean by 3.5 in (88 mm) at West Chester, PA (Table 6). Despite being a wet fall, there were three long dry spells, one in November and two in December (Table 7). Thirteen days with more than 1 in (25.4 mm) of rain were noted in 2010; matching the long-term mean of 13 days. However, the occurrence of extreme rainfall, more than 2 in (51 mm), was a bit above average with four days at West Chester (Table 6). The autumn ranked as the 17th wettest for the Southeastern Piedmont (Table 5). The number of days with measurable snow in 2010 totaled from 15-18 days, above the average of 12 days and the occurrence of moderate and heavy snow was also well above normal (Table 6).

Table 6. Status of 2010 precipitation indicators compared to the 30-year normal (1971–2000) at the West Chester 2 NW (WCHP1) and Glenmoore (GNMP1) weather observing stations.

Precipitation Indicator	West Chester 2 NW 2010	West Chester 2 NW 1971–2000	Glenmoore 2010	Glenmoore 1971–2000
Annual Precipitation	53.6 in 1,361 mm	47.9 in 1,217 mm	46.1 in 1,171 mm	48.6 in 1,234 mm
Autumn (Oct, Nov, Dec) Precipitation	14.7 in 373 mm	11.2 in 285 mm	14.1 in 358 mm	11.2 in 285 mm
Heavy Precipitation Days (days with ≥ 1.0 in (25 mm) rain)	13	13	9	14
Extreme Precipitation Days (days with ≥ 2.0 in (51 mm) rain)	4	3	1	2
Micro-drought (strings of 7+ days without rain)	8	8	8	9
Annual Snowfall	53.0 in 134.6 cm	27.2 in 69.1 cm	48.0 in 121.9 cm	27.3 in 69.3 cm
Measurable Snow Days (days with ≥ 0.1 in (0.3 cm) snow)	15	12	18	12
Moderate Snow Days (days with ≥ 2.0 in (5.0 cm) snow)	7	5	6	5
Heavy Snow Days (days with ≥ 5.0 in (12.7 cm) snow)	4	1	3	1

Hopewell Furnace National Historic Site
and Valley Forge National Historical Park
Percent of Average Monthly Precipitation
2010 vs. 1971–2000

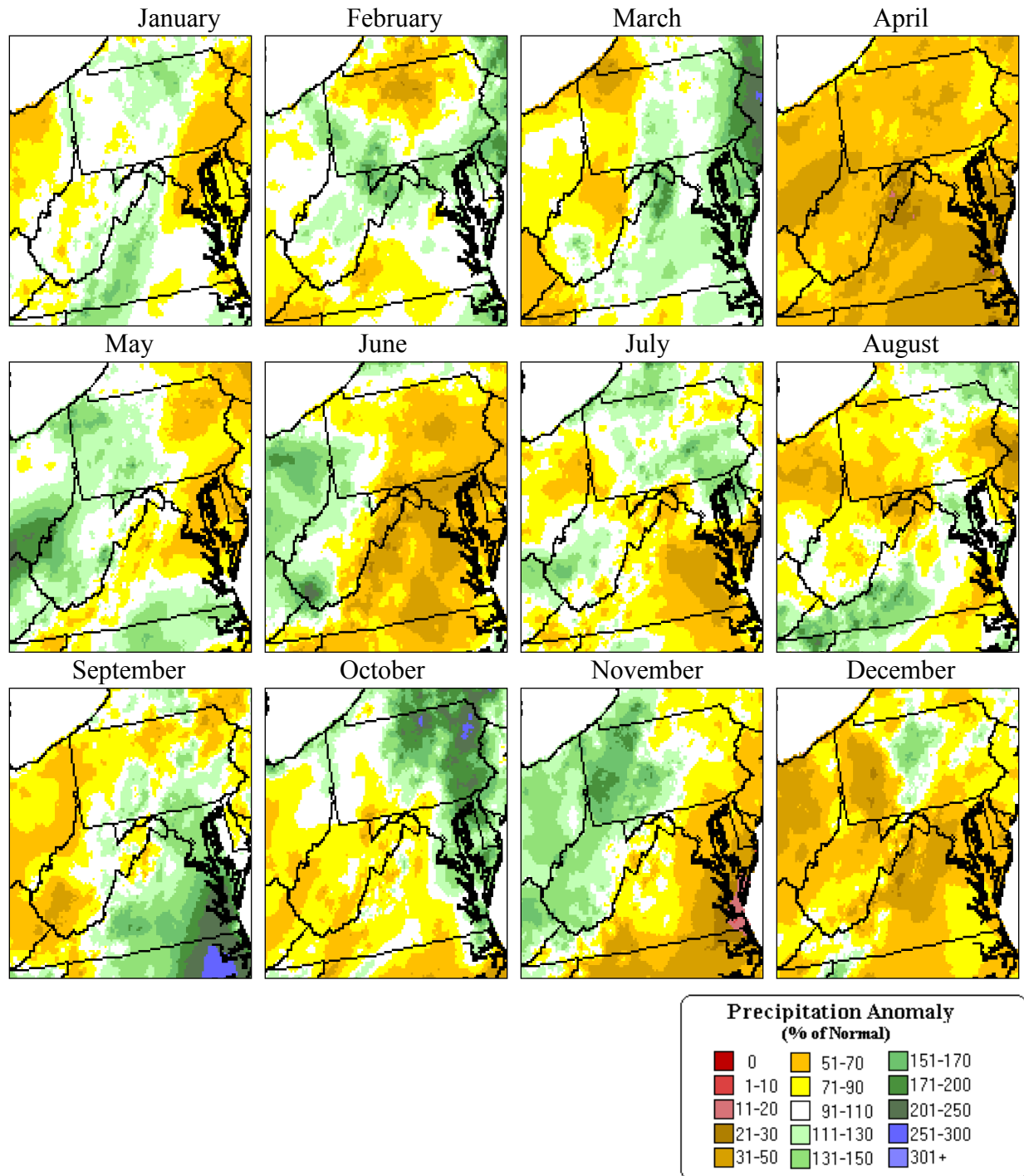


Figure 4. Maps showing percent of average monthly precipitation compared to the 30-year normal (1971–2000).

Table 7. Top five wettest days and top five dry spells (consecutive days with a trace or less of rainfall) during 2010 from weather observing stations at West Chester 2 NW (WCHP1) and Glenmoore (GNMP1).

Wettest Days in 2010	Dry Spells in 2010
Oct. 1: 5.59 in (142 mm)	Aug. 26–Sep. 11
Sep. 30: 2.28 in (58 mm)	Jul. 27–Aug. 12
Jul. 13: 2.10 in (53 mm)	Jun. 26–Jul. 9
Aug. 13: 2.06 in (52 mm)	Nov. 6–15
Jul. 10: 1.90 in (48 mm)	Dec. 3–11
	Dec. 18–26

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
Glenmoore	GNMP1	2.8 in	4.9 in	6.2 in	2.2 in	3.1 in	2.4 in	3.8 in	3.4 in	3.2 in	7.9 in	2.7 in	3.5 in	46.1 in
		71 mm	124 mm	157 mm	56 mm	79 mm	61 mm	97 mm	86 mm	81 mm	201 mm	69 mm	89 mm	1,171 mm
West Chester 2 NW	WCHP1	3.2 in	4.9 in	6.8 in	2.8 in	3.7 in	1.9 in	8.3 in	3.1 in	4.1 in	9.0 in	2.3 in	3.5 in	53.6 in
		81 mm	124 mm	173 mm	71 mm	94 mm	48 mm	211 mm	79 mm	104 mm	229 mm	58 mm	89 mm	1,361 mm
Morgantown	MGNP1	2.4 in	4.5 in	5.4 in	2.1 in	2.9 in	2.8 in	5.0 in	1.9 in	3.1 in	8.3 in	2.4 in	3.4 in	44.2 in
		61 mm	114 mm	137 mm	53 mm	74 mm	71 mm	127 mm	48 mm	79 mm	211 mm	61 mm	86 mm	1,123 mm
Pottstown Airport	KPTW	2.1 in	2.8 in	5.4 in	2.0 in	3.6 in	1.3 in	5.9 in	2.3 in	5.9 in	5.7 in	2.5 in	1.4 in	40.9 in
		53 mm	71 mm	137 mm	51 mm	91 mm	33 mm	150 mm	58 mm	150 mm	145 mm	64 mm	36 mm	1,039 mm
Reading Airport	KRDG	1.6 in	3.0 in	3.9 in	2.8 in	4.4 in	2.8 in	3.5 in	1.4 in	6.7 in	3.7 in	2.5 in	2.0 in	38.3 in
		41 mm	76 mm	99 mm	71 mm	112 mm	71 mm	89 mm	36 mm	170 mm	94 mm	64 mm	51 mm	973 mm
Valley Creek	1473169	2.9 in	3.1 in	7.0 in	2.1 in	2.6 in	2.9 in	1.5 in	2.6 in	7.1 in	7.9 in	2.5 in	3.0 in	45.2 in
		74 mm	79 mm	178 mm	53 mm	66 mm	74 mm	38 mm	66 mm	180 mm	201 mm	64 mm	76 mm	1,148 mm

Table 9. Summary of 2010 percent of normal total 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
Glenmoore	GNMP1	67	157	150	53	69	57	81	84	72	218	71	93	95
West Chester 2 NW	WCHP1	81	161	167	76	81	45	179	84	86	268	57	92	112
Morgantown	MGNP1	58	144	130	51	65	66	106	47	70	229	63	90	91
Pottstown Airport*	KPTW	58	102	135	57	85	35	143	65	137	185	71	39	93
Reading Airport*	KRDG	42	108	108	76	97	64	86	39	154	113	71	60	85

*Indicates a station's Period of Record is five years or more 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.

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 . The long-term average is “zero”. Monthly PDSI values for the Southeastern Piedmont in 2010 are shown in Figure 5.

The DM – Drought Intensity Index is a synthesis of multiple indices (including the PDSI) and impacts, which represents a consensus of federal and academic scientists (NIDIS 2010). 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 (Figure 6) and the Northeast (Figure 7) are shown for 2010.

According to the USDM, 2010 had bookends of moist conditions with rather dry weather during much of the growing season (Figure 5). The winter was abnormally moist due in large part to record snowfall. Then starting in April and the remainder of the growing season was moderately dry (values between 0 and -1.5). When compared to previous years, 2010 had the wettest winter, a dry spring, an even drier summer, and a moist autumn.

The DM – Drought Severity Index for Pennsylvania (Figure 6) and the Northeast (Figure 7) shows a pattern similar to the PDSI for the growing season (May through October); with July and September being the driest.

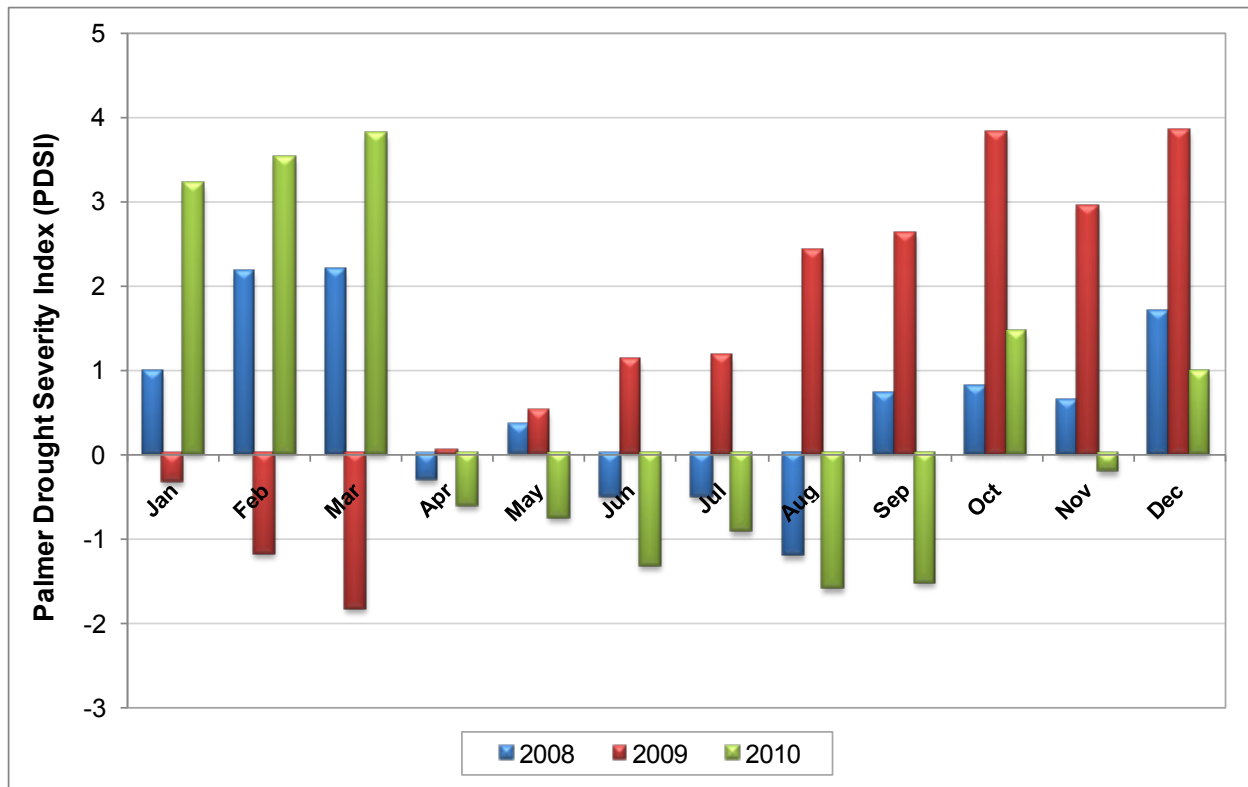


Figure 5. Palmer Drought Severity Index (PDSI) for the Southeastern Piedmont, 2008–2010.

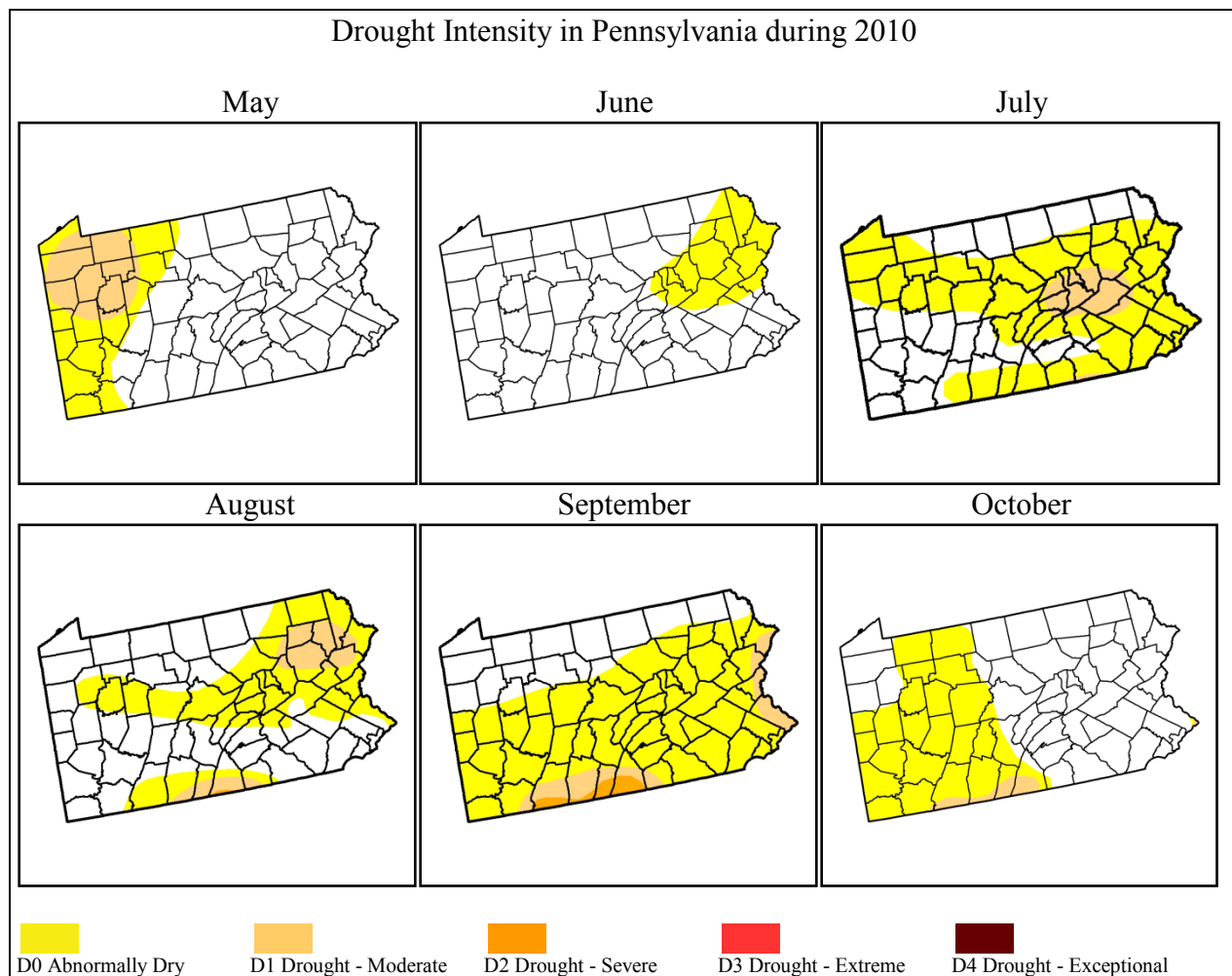


Figure 6. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for Pennsylvania in 2010.

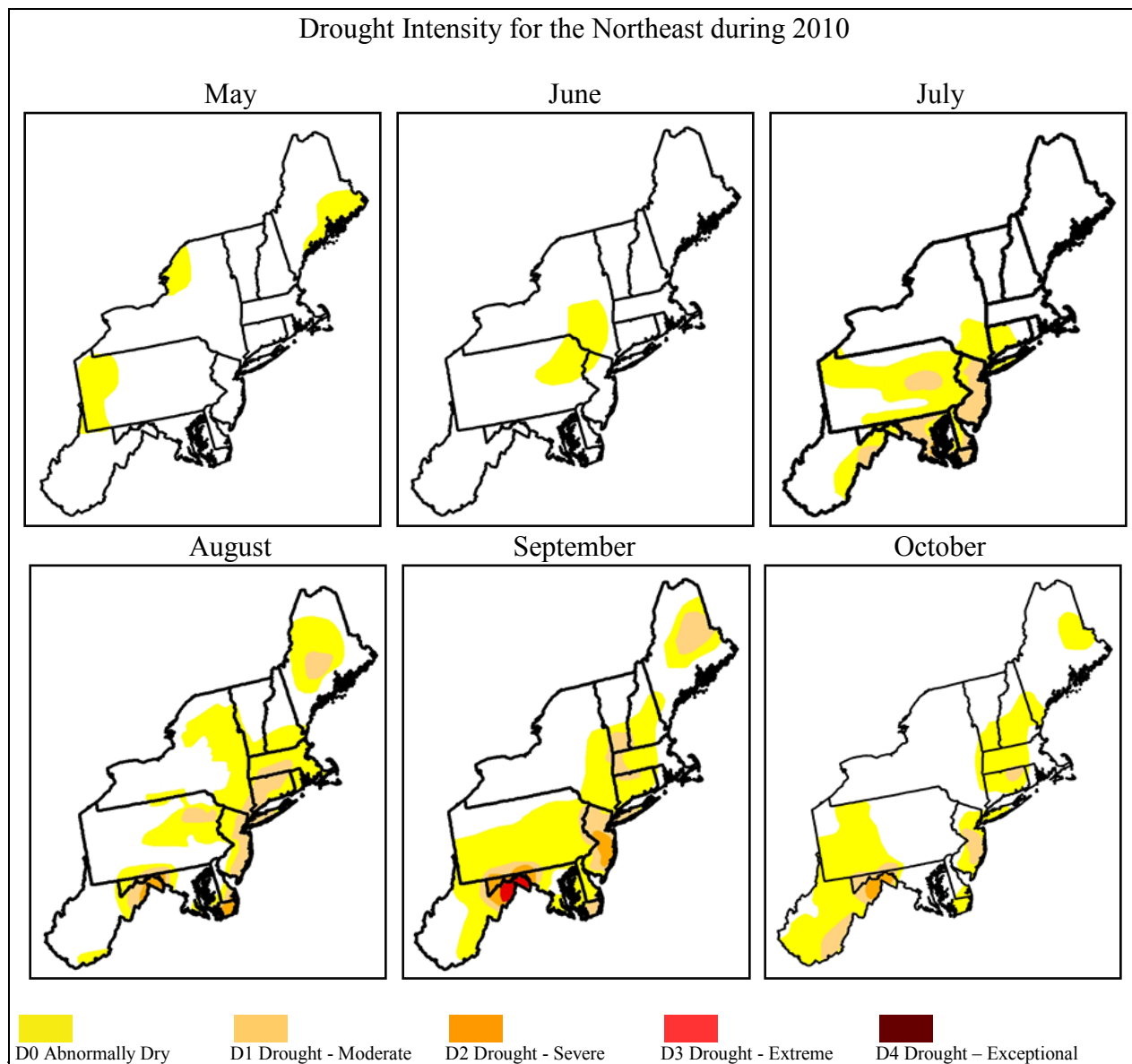


Figure 7. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for the Northeast in 2010.

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