



Weather of Eisenhower National Historic Site and Gettysburg National Military Park

Mid-Atlantic Network Summary Report for 2016

Natural Resource Data Series NPS/MIDN/NRDS—2017/1099



ON THE COVER

“[Foggy Gettysburg Morn](#)” – Gettysburg National Military Park

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Mid-Atlantic Network Summary Report for 2016

Natural Resource Data Series NPS/MIDN/NRDS—2017/1099

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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.

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Abstract

The Mid-Atlantic Network (MIDN) weather and climate monitoring protocol supports the documentation of current status and long-term trends in air temperature and precipitation at multiple temporal and spatial scales in MIDN parks. The purpose of this report is to provide a concise weather and climate summary for Eisenhower National Historic Site (EISE) and Gettysburg National Military Park (GETT) for the time period of January 1 to December 31, 2016. EISE and GETT are located in the Lower Susquehanna Climate Division of Pennsylvania. In 2016, a total of two weather stations were selected to report park weather and climate conditions, and a large suite of precipitation and temperature metrics were summarized. Ultimately, 2016 was a very warm year and tied as the 4th warmest on record for the Lower Susquehanna. All of the seasons were warmer than normal with the summer of 2016 being the warmest summer ever recorded. In terms of precipitation, most seasons were drier than normal. Winter was the only season with greater than average precipitation. In total, 2016 was the 95th wettest (i.e. 28th driest) year out of 122 years of records. In addition, by the end of 2016, abnormally dry to severe drought conditions were occurring across much of Pennsylvania.

List of Acronyms

ASOS	Automated Surface Observation System
CASTNET	Clean Air Status and Trends Network
COOP	National Weather Service Cooperative Observer Program
EISE	Eisenhower National Historic Site
GETT	Gettysburg National Military Park
MIDN	Mid-Atlantic Network
NADP	National Atmospheric Deposition Program
NCDC	National Climatic Data Center
NM	National Monument
NOAA	National Oceanic and Atmospheric Administration
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

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, 2016, and to place current patterns and trends in an appropriate historical and regional context (Marshall et al. 2012). It is our intention that this report will satisfy an inherent interest in meteorological phenomena and meet the Mid-Atlantic Network (MIDN) 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 MIDN 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 Mid-Atlantic Network of the National Park Service (Marshall et al. 2012). Through this analysis, a select number of weather/climate observing stations were chosen as representative of each park; these are the primary data sources used in the profile of 2016's climate summary.

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 (for the most recent trend report, see Knight et al. 2016). These key indicators are further described in the protocol (Marshall et al. 2012) and are summarized in this report.

Methods

Observing Stations

A total of two weather observing stations comprised of two weather observing networks were selected as the most representative around Eisenhower NHS and Gettysburg NMP in 2016 (Figure 1, Table 1). 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's elevation profile, the type and frequency of observations, the period of record of the data, and data availability (Marshall et al. 2012). Moreover, the percentage of time a station reports a particular parameter (e.g., temperature) can influence data inclusion.

Eisenhower National Historic Site (NHS) and Gettysburg National Military Park (NMP) are located in Pennsylvania Climate Division 4, known as the "Lower Susquehanna." 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/usclimdivs/data/map.html>).

Climate Indicators and Climatological Normals

A suite of indicators were identified to provide a summary of weather and climate conditions (Marshall et al. 2012). The following are the climate indicators selected for each of the parks:

- Average Annual Mean Temperature – A measure of the composite mean temperature (averaging the maximum and minimum on a daily basis) for an entire year
- Average Annual Maximum Temperature – A measure of the average of the daily maximum temperature for an entire year
- Highest Annual Maximum Temperature – A measure of the individual highest maximum temperature each year
- Annual Number of Hot Days (maximum temperature equal to or exceeding 90°F (32°C)) – A measure of warm season heat using a threshold of days with a 90°F (32°C) maxima
- Average Annual Minimum Temperature – A measure of the average of the daily minimum temperature for an entire year
- Lowest Annual Minimum Temperature – A measure of the individual lowest minimum temperature each year
- Annual Number of Cold Days (maximum temperature less than or equal to 32°F (0°C)) – A measure of cold season chill using a threshold of days with a 32°F (0°C) maxima
- Annual Number of Subfreezing Days (minimum temperature less than or equal to 32°F (0°C)) – A measure of cold season chill using a threshold of days with a 32°F (0°C) minima
- Annual Number of Subzero Days (minimum temperature less than or equal to 0°F (-17.8°C)) – A measure of cold season chill using a threshold of days with a 0°F (-17.8°C) minima
- Growing Season Length (number of days between last freeze in spring and first freeze in fall) – A measure of the local growing season as tallied by the total number of days between the last 32°F (0°C) in the spring and the first 32°F (0°C) in the fall

- Annual Precipitation – A measure of total liquid (and its equivalent melted snow) for all days
- Autumn Precipitation (October 1 – December 31) - The three month total precipitation including rain and melted snow
- Annual Number of Heavy Precipitation Days (liquid equal to or greater than 1.0 in (25mm) – A measure of the frequency of heavy precipitation events during each year
- Annual Number of Extreme Precipitation Days (liquid equal to or greater than 2.0 in (50mm)) – A measure of frequency of extreme precipitation events during each year
- Annual Number of Micro-droughts – A measure of micro-droughts for the year as the number of periods of 7+ days without rain
- Annual Snowfall – A measure of total solid precipitation (includes sleet and hail; does not include freezing rain)
- Annual Number of Measureable Snow Days – A measure of the severity of winter precipitation as the number of days receiving more than or equal to 0.1 in (0.3 cm) of solid precipitation (includes sleet and hail; does not include freezing rain)
- Annual Number of Moderate Snow Days– A measure of the severity of winter precipitation as the number of days receiving more than or equal to 3 in (7.6 cm) of solid precipitation (includes sleet and hail; does not include freezing rain)
- Annual Number of Heavy Snow Days– A measure of the severity of winter precipitation as the number of days receiving more than or equal to 5 in (12.7 cm) of solid precipitation (includes sleet and hail; does not include freezing rain)

The average value of a climate element over 30 years is defined as a climatological normal, which are calculated and established by NOAA’s National Climatic Data Center (NCDC). Every ten years, NCDC computes new thirty-year climate normals for selected temperature and precipitation elements for a large number of U.S. climate and weather stations. The current (as of 2011) normals cover the period 1981–2010. In this report, the 30-year normals established by NCDC are used as the baseline for comparisons (e.g., departures from normal). In cases where data for the 30-year normal period are not available, we use alternative comparisons such as the new pseudo-normals from NCDC or a recent 10-year period. In some cases, sufficient data may simply not be available to calculate normals. For metrics that NCDC may not routinely calculate a normal, such as the number of days with more than 2 in (55 mm) of rain or liquid equivalent, normals are calculated using the same time period (e.g., 1981–2010) as the current NCDC standard. Throughout the report, descriptions of a station’s values as compared to the normals are described as a difference from the “average”, “mean”, “typical”, “long-term value”, as well as “normal”, to improve the readability of the document. However, all of these terms are comparing a value from one year at that station to that station’s normal, whether it is the 30-year normal or the pseudo-normal calculated on a shorter time frame.

Of the two stations, only Biglerville has a Period of Record (POR) sufficiently long for a 30-year normal (normal calculated from years 1981–2010). However, for Arendtsville, a normal was calculated based on a POR from 1988–2010. Monthly averages and deviations from normal are presented for all stations for precipitation and temperature.

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). Positive values indicate periods of above normal precipitation (0 to 2: near normal; 2 to 3: moderate moisture; >3 : very moist) and negative values indicate periods of drought (0 to -2: near normal; -2 to -3: moderate drought; <-3 : severe to extreme drought).

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 2017). 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).

Data Processing and Quality Assurance

Data from selected stations are downloaded from relevant data streams (ASOS, RAWS, CASTNET, etc). Variables are calculated using simple statistics (e.g. mean, minimum, maximum, etc.).

Each data stream has varying levels of associated quality assurance (from none to extensive). ASOS, RAWS, and CASTNet data have rigorous and extensive quality assurance beginning at the point of gather (data-logger on site) and at additional levels as described in the respective user's manuals and specification documents.

The COOP data quality control is now much more extensive in real-time as the electronically submitted data passes through several levels of quality assurance and is in a final format within a few days of submission.

Data management procedures are fully outlined in Marshal, et al (2012).

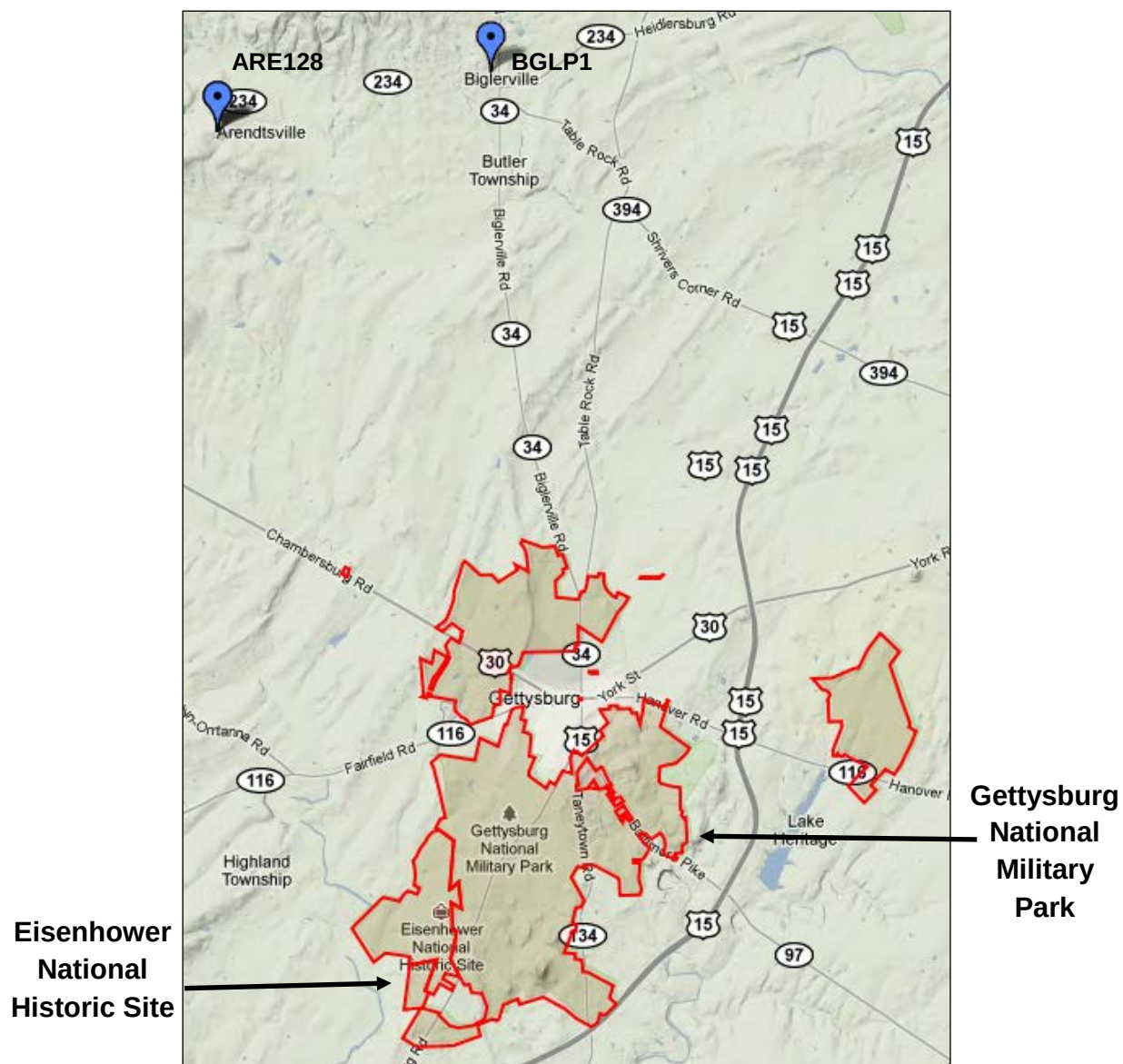


Figure 1. Location of weather observing stations around Eisenhower National Historic Site and Gettysburg National Military Park that were selected as most representative of the parks in 2016. See Table 1 for station names.

Table 1. List of weather observing stations around Eisenhower National Historic Site and Gettysburg National Military Park selected as most representative of the parks in 2016.

Station	Observing Network ^A	Station Name	Period of Record (POR)	Percentage of Time Reporting Temperature for 2016	Percentage of Time Reporting Precipitation for 2016	Percentage of Time Reporting Temperature for entire POR	Percentage of Time Reporting Precipitation for entire POR
ARE128	CASTNET	Arendtsville	07/01/1988 – Present ^B	100.0	84.9	96.4	93.2
BGLP1	COOP	Biglerville	02/02/1972 - Present	100.0	100.0	99.9	99.6

^A Observing networks are: CASTNET — Clean Air Status and Trends Network, COOP — National Weather Service Cooperative Observer Program.

^B Arendtsville POR for precipitation ends 1/1/2012. Precipitation data for 2016 was taken from the NADP/NTN site co-located with the CASTNET site.

Results

Temperature Summary

Almost all of the temperature metrics calculated from stations around EISE and GETT indicate that 2016 was a warm year. Throughout the year, most months had higher than average temperatures (Figures 2 and 3, Table 2 and 3). Average annual temperatures were also above normal at both of the reporting stations (Tables 2 and 3). In addition, the number of hot days, average annual maximum temperatures, and average annual minimum temperatures were all above average (Table 4). The number of hot days was more than two times above normal. In addition, the growing season length was three weeks longer than normal (Table 4). All of the seasons ranked warmer than average, and the summer of 2016 was the warmest ever recorded in the Lower Susquehanna climate division of Pennsylvania (Table 5). In all, 2016 tied with 1990 as the 4th warmest since the year 1895 (Table 5).

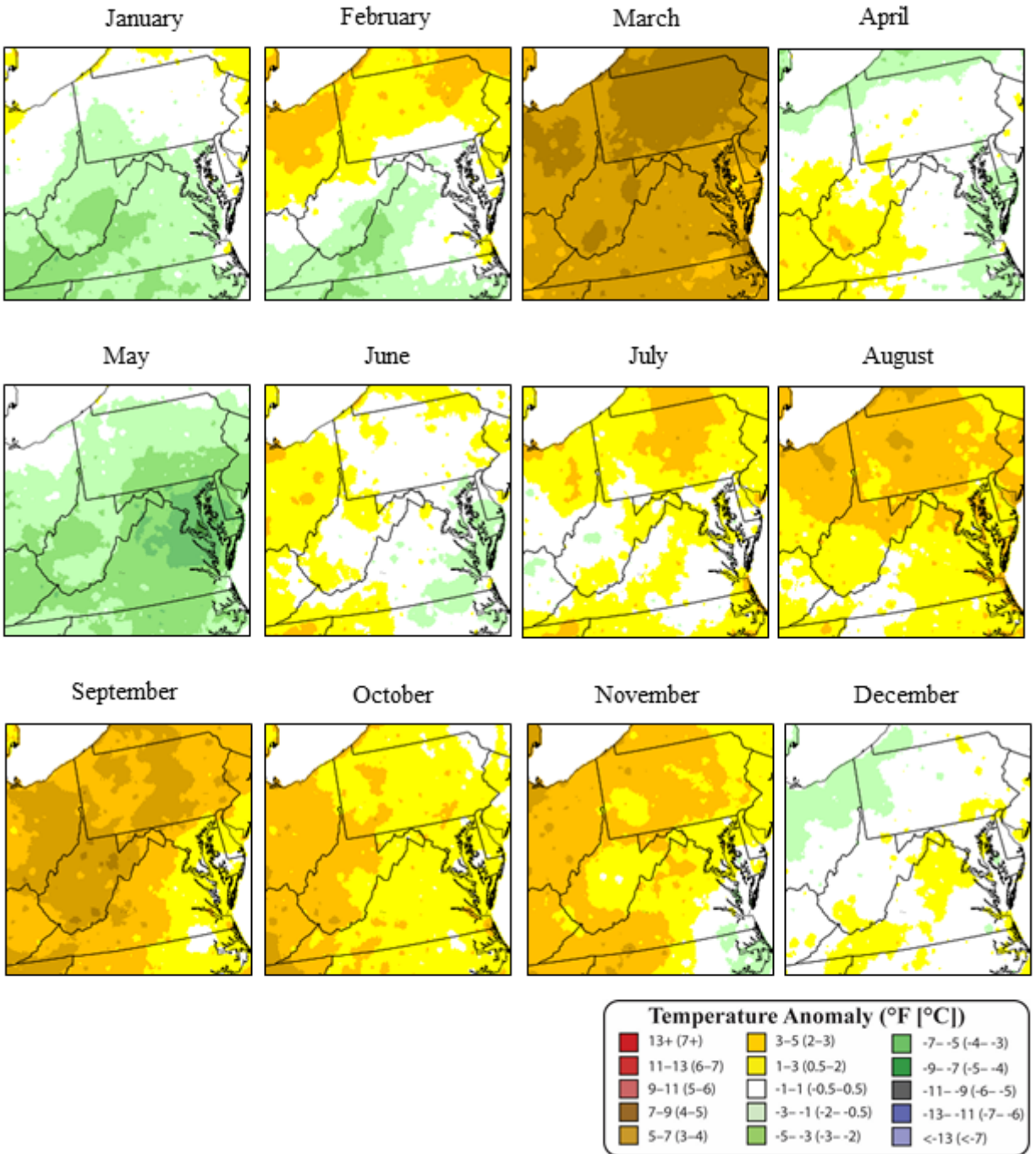


Figure 2. Maps showing departure from average monthly maximum temperature in 2016 compared to the 30-year normal (1981–2010).

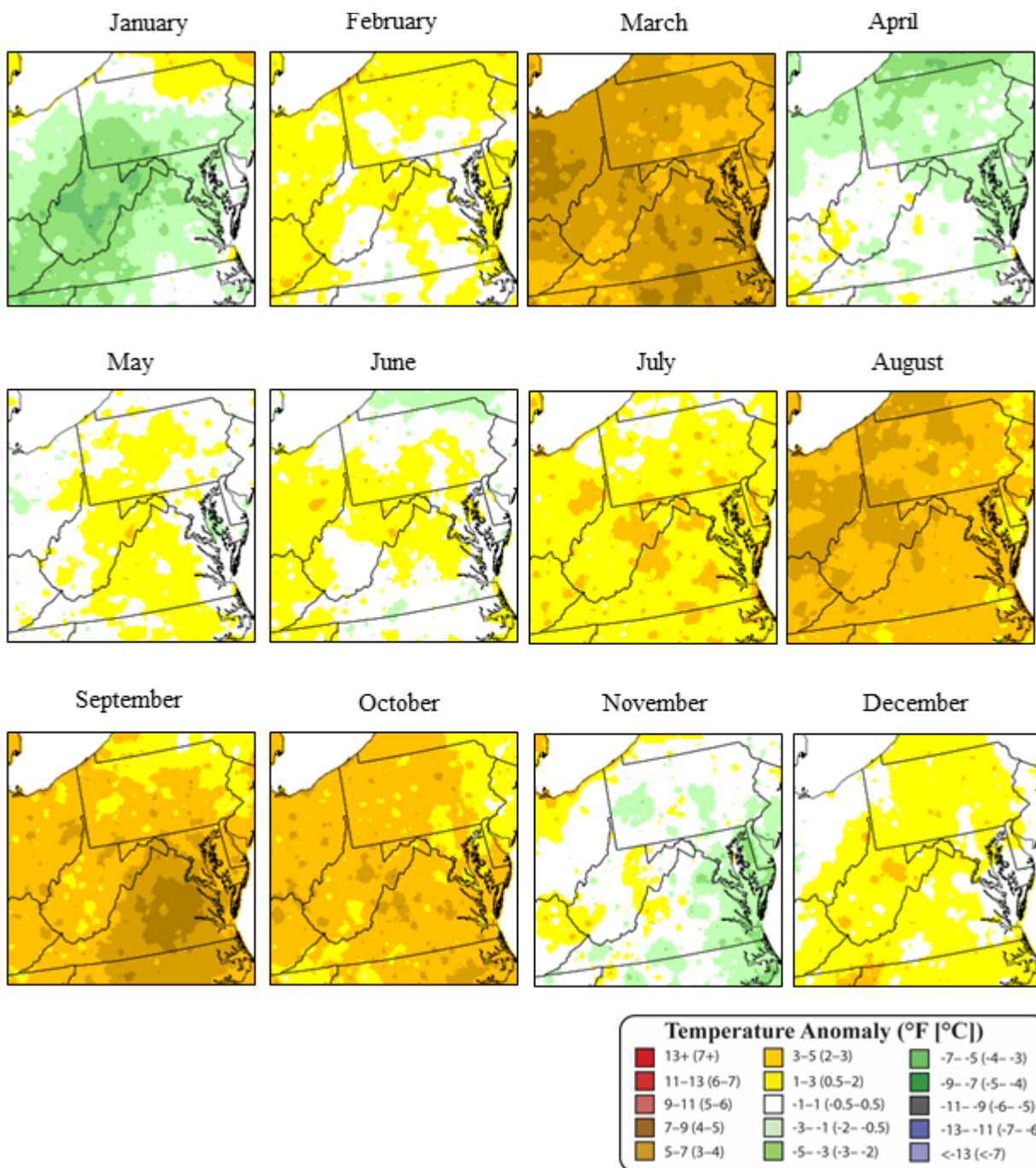


Figure 3. Maps showing departure from average monthly minimum temperature in 2016 compared to the 30-year normal (1981–2010).

Table 2. Summary of 2016 departure from normal temperature based on the 30-year normal (1981–2010) for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Arendstville*	ARE128	-1.6°F	0.8°F	7.4°F	-0.4°F	-0.7°F	1.0°F	3.0°F	3.7°F	5.0°F	2.6°F	3.6°F	0.4°F	2.2°F
		-0.9°C	0.4°C	4.2°C	-0.2°C	-0.3°C	0.6°C	1.7°C	2.0°C	2.8°C	1.4°C	2.0°C	0.2°C	1.3°C
Biglerville	BGLP1	-1.3°F	0.9°F	6.5°F	-0.2°F	-1.3°F	0.6°F	3.0°F	4.4°F	5.6°F	3.7°F	2.0°F	-0.3°F	2.4°F
		-0.7°C	0.5°C	3.6°C	-0.1°C	-0.8°C	0.3°C	1.7°C	2.5°C	3.2°C	2.1°C	1.1°C	-0.2°C	1.3°C

*Indicates a station's Period of Record does not cover the period of 1981-2010 but is five or more years. In this case, departures from normal values were calculated with normals derived from 1989 - 2010.

Table 3. Summary of 2016 monthly average temperatures for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Arendstville	ARE128	29.7°F	33.7°F	48.3°F	51.6°F	60°F	70.7°F	76.6°F	75.8°F	70.1°F	57.2°F	48.3°F	34.4°F	54.8°F
		-1.3°C	0.9°C	9.1°C	10.9°C	15.6°C	21.5°C	24.8°C	24.3°C	21.2°C	14.0°C	9.1°C	1.3°C	12.7°C
Biglerville	BGLP1	27.9°F	32.7°F	46.3°F	50.4°F	59.6°F	70.9°F	77.9°F	77.7°F	70.8°F	57.3°F	45.7°F	33.1°F	54.7°F
		-2.3°C	0.4°C	7.9°C	10.2°C	15.3°C	21.6°C	25.5°C	25.4°C	21.6°C	14.1°C	7.6°C	0.6°C	12.6°C

Table 4. Status of 2016 temperature indicators compared to the 30-year normal (1981–2010) for selected stations.

Temperature Indicator	Biglerville, PA 2016	Biglerville, PA 1981–2010
Average Annual Temperature	54.7°F 12.6°C	52.3°F 11.3°C
Average Annual Maximum Temperature	64.8°F 18.2°C	63.8°F 17.7°C
Maximum Temperature	98.0°F 36.7°C	97.0°F 36.1°C
Hot Days (days with Tmax≥90°F/32°C)	47	21
Average Annual Minimum Temperature	44.5°F 6.9°C	40.4°F 4.7°C
Minimum Temperature	4.0°F -15.6 °C	-0.5°F -18.1°C
Cold Days (days with Tmax≤32°F/0°C)	21	16
Sub-freezing Days (days with Tmin≤32°F/0°C)	100	130
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)	195	174

Table 5. Seasonal and annual temperature and precipitation rankings for 2016 over 122 years for the Lower Susquehanna (NOAA 2017).

Parameter	PA Climate Division 4 Rankings — Lower Susquehanna				
	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN	Jan–Dec YEAR
Temperature-2016	14	50-T	1	13-T	4-T
Precipitation-2016	45	71	64-T	110	95

1 = warmest/wettest year and 122 = coldest/driest year. T = Tie between multiple years

Precipitation Summary

Although monthly precipitation totals were variable, annual totals at Biglerville were below average (Figure 4 and Table 6). In all, annual precipitation was 6.3 inches (160 mm) below normal (Table 7). Monthly totals ranged from a low of 1.2 inches (30 mm) at Biglerville in October to a high of 6.9 inches (175 mm) at Arendstville in September (Table 8). The wettest day occurred on September 8th when 2.8 inches (71 mm) of rain was recorded (Table 9). In all, 2016 was the 95th wettest (i.e. 28th driest) year out of 122 years of records. By the end of 2016, severe drought conditions were occurring across Pennsylvania and the Northeast (Figures 5, 6, and 7).

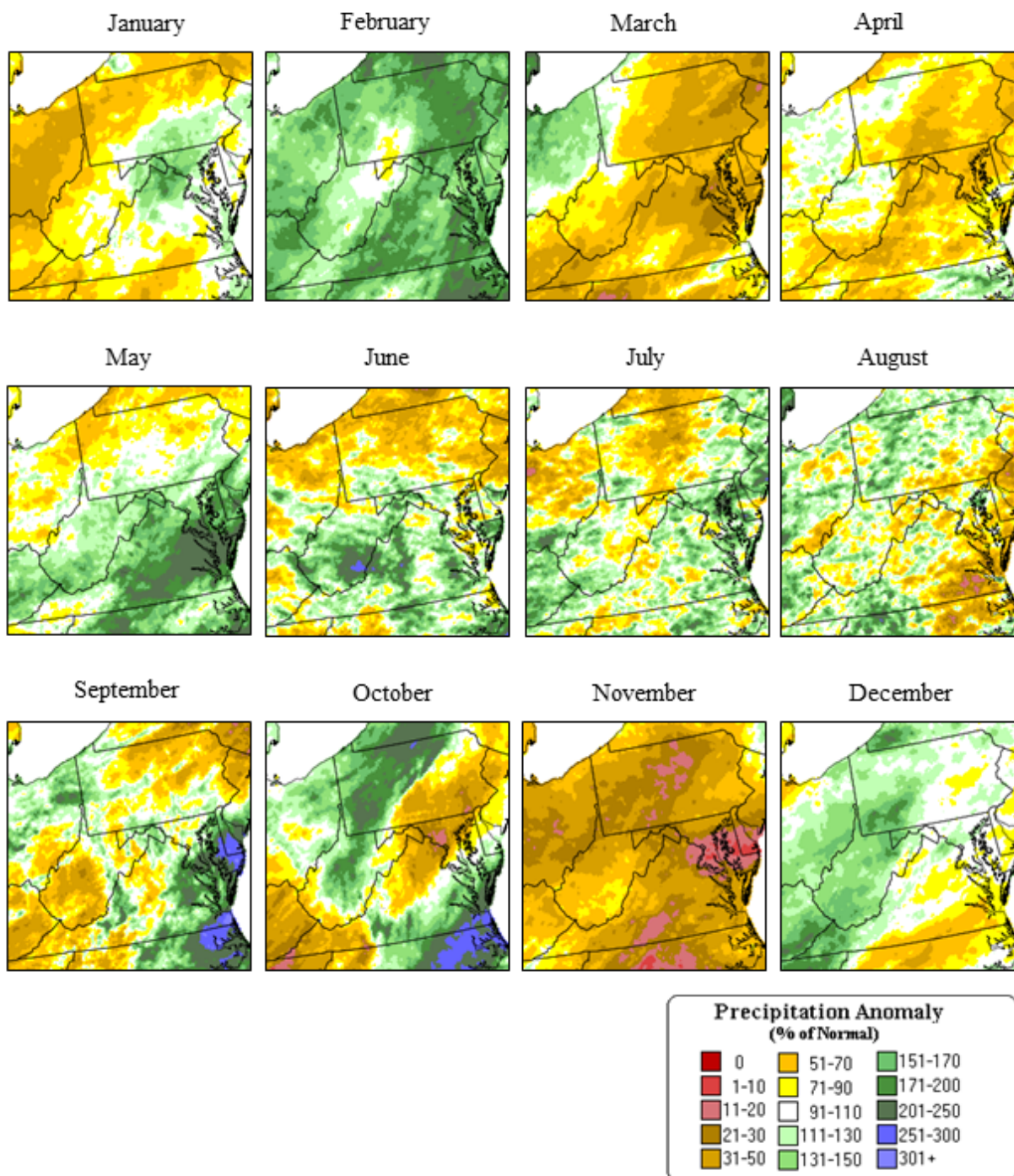


Figure 4. Maps showing percent of average monthly precipitation in 2016 compared to the 30-year normal (1981–2010).

Table 6. Summary of 2016 percent of normal precipitation based on the 30-year normal (1981–2010) for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Arendstville*	ARE128	115	M	M	M	122	100	47	65	98	35	68	60	M
Biglerville	BGLP1	142	159	44	44	114	79	37	80	157	43	36	85	85

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

*Indicates a station's Period of Record does not cover the period of 1981-2010 but is five years or more. In this case, the departures from normal values were calculated with normals derived from 1989-2010.

Table 7. Status of 2016 precipitation indicators compared to the 30-year normal (1981–2010) at Biglerville.

Precipitation Indicator	Biglerville, PA 2016	Biglerville, PA 1981–2010
Annual Precipitation	37.0 in 940 mm	43.3 in 1,100 mm
Autumn (Oct, Nov, Dec) Precipitation	5.6 in 142 mm	10.3 in 262 mm
Heavy Precipitation Days (days with ≥ 1.0 in (25 mm) rain)	10	11
Extreme Precipitation Days (days with ≥ 2.0 in (51 mm) rain)	1	2
Micro-drought (periods of 7+ days without rain)	14	9
Annual Snowfall	33.5 in 85.1 cm	25.9 in 65.8 cm
Measurable Snow Days (days with ≥ 0.1 in (0.3 cm) snow)	9	11
Moderate Snow Days (days with ≥ 3.0 in (7.6 cm) snow)	3	3
Heavy Snow Days (days with ≥ 5.0 in (12.7 cm) snow)	2	1

Table 8. Summary of 2016 monthly total precipitation for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Arendtsville*	ARE128	4.4 in	4.6 in	1.6 in	1.6 in	5.0 in	3.1 in	1.3 in	2.8 in	6.9 in	1.5 in	1.3 in	2.8 in	37.0 in
		112 mm	117 mm	41 mm	41 mm	127 mm	79 mm	33 mm	71 mm	175 mm	38 mm	33 mm	71 mm	940 mm
Biglerville	BGLP1	3.1 in	M	M	M	5.5 in	3.6 in	1.4 in	2.0 in	4.6 in	1.2 in	2.1 in	1.8 in	M
		79 mm	M	M	M	140 mm	91 mm	36 mm	51 mm	117 mm	30 mm	53 mm	46 mm	M

M = missing data (Monthly statistics are reported as 'M' if more than 7 days of data are missing).

*Arendtsville precipitation data for 2016 was taken from the NADP/NTN site co-located with the CASTNET site.

Table 9. Top five wettest days and top five dry spells (consecutive days with a trace or less of liquid precipitation) during 2016 from the weather observing stations at Biglerville (BGLP1).

Wettest Days in 2016	Dry Spells in 2016
Sept. 8: 2.8 in (71 mm)	Nov. 11 – Nov. 28
Sept. 29: 2.0 in (51 mm)	Aug. 3 – Aug. 14
Aug. 2: 1.8 in (56 mm)	March 16 – March 25
Jan 10: 1.8 in (46 mm)	April 13 – April 22
June 6: 1.5 in (38 mm)	June 25 – July 4

Drought Status

The monthly Palmer Drought Severity Index (PDSI) indicates that 2016 began near normal but later became very dry (Figure 5). According to the PDSI, drought began to occur in October and by December, “severe drought” conditions were observed. Similarly, the Drought Intensity Index shows that from late spring and into fall much of the Commonwealth of Pennsylvania was experiencing “abnormally dry” conditions (Figure 6). Many locations across Pennsylvania experienced moderate to severe drought. Across the Northeast, a number of states experienced severe to extreme droughts during the late summer and fall (Figure 7).

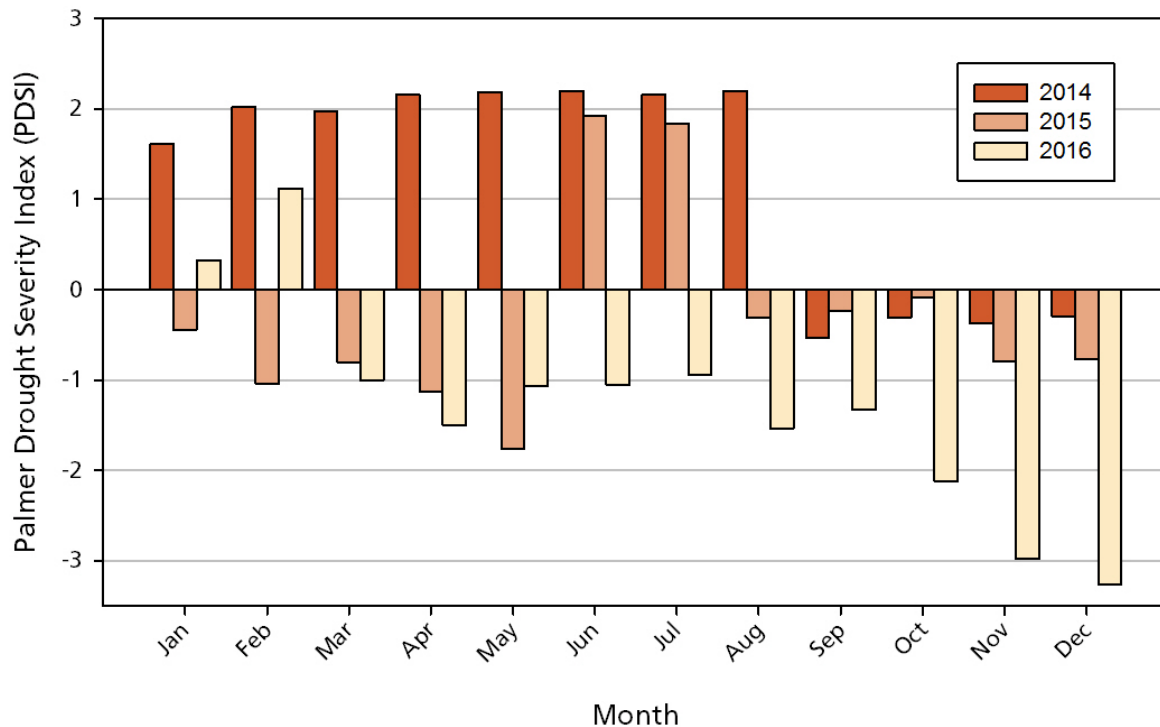


Figure 5. Palmer Drought Severity Index (PDSI) for the Lower Susquehanna, 2014–2016. Positive values indicate periods of above normal precipitation (0 to 2: near normal; 2 to 3: moderate moisture; >3: very moist) and negative values indicate periods of drought (0 to -2: near normal; -2 to -3: moderate drought; <-3: severe to extreme drought).

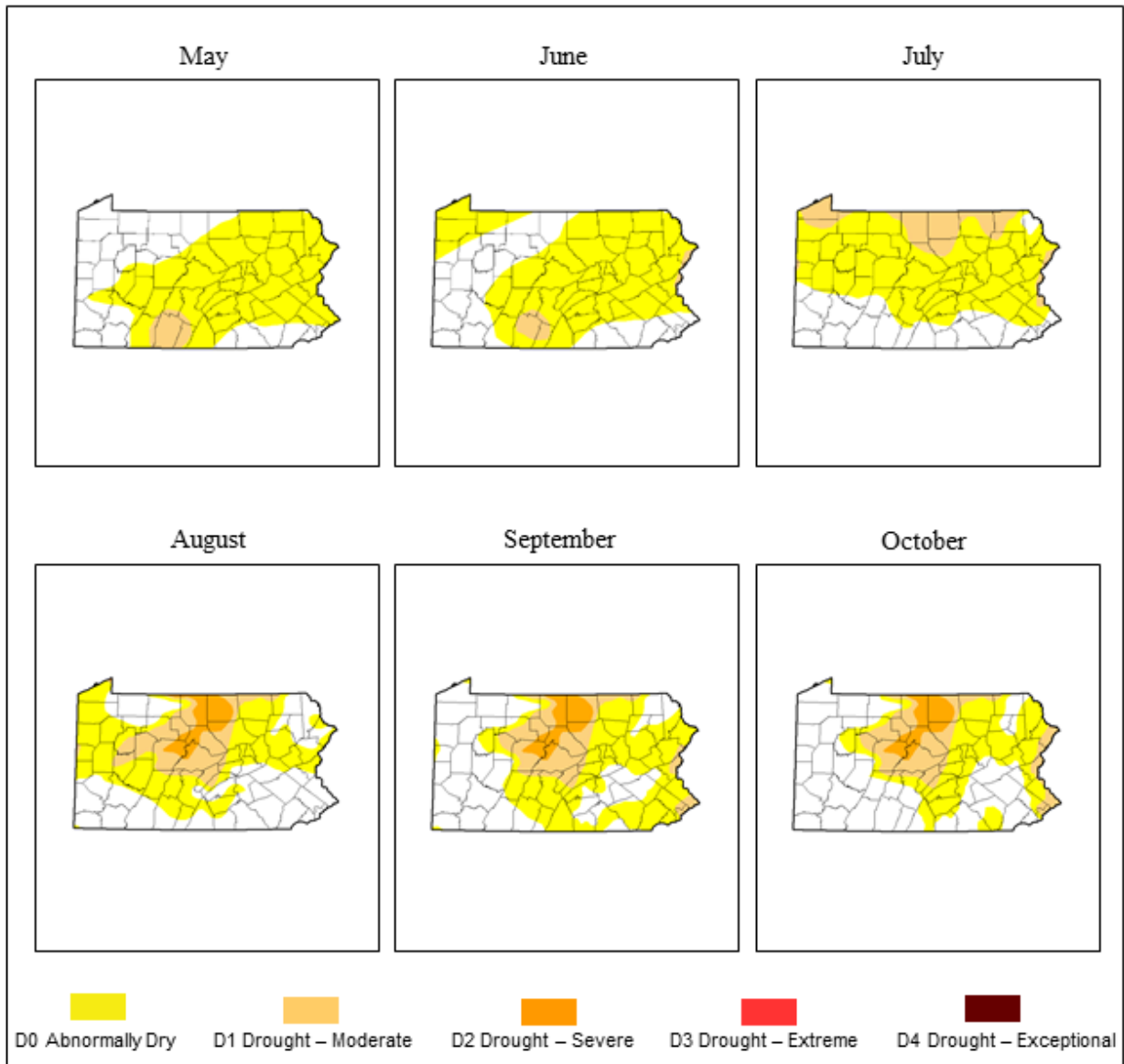


Figure 6. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for Pennsylvania in 2016.

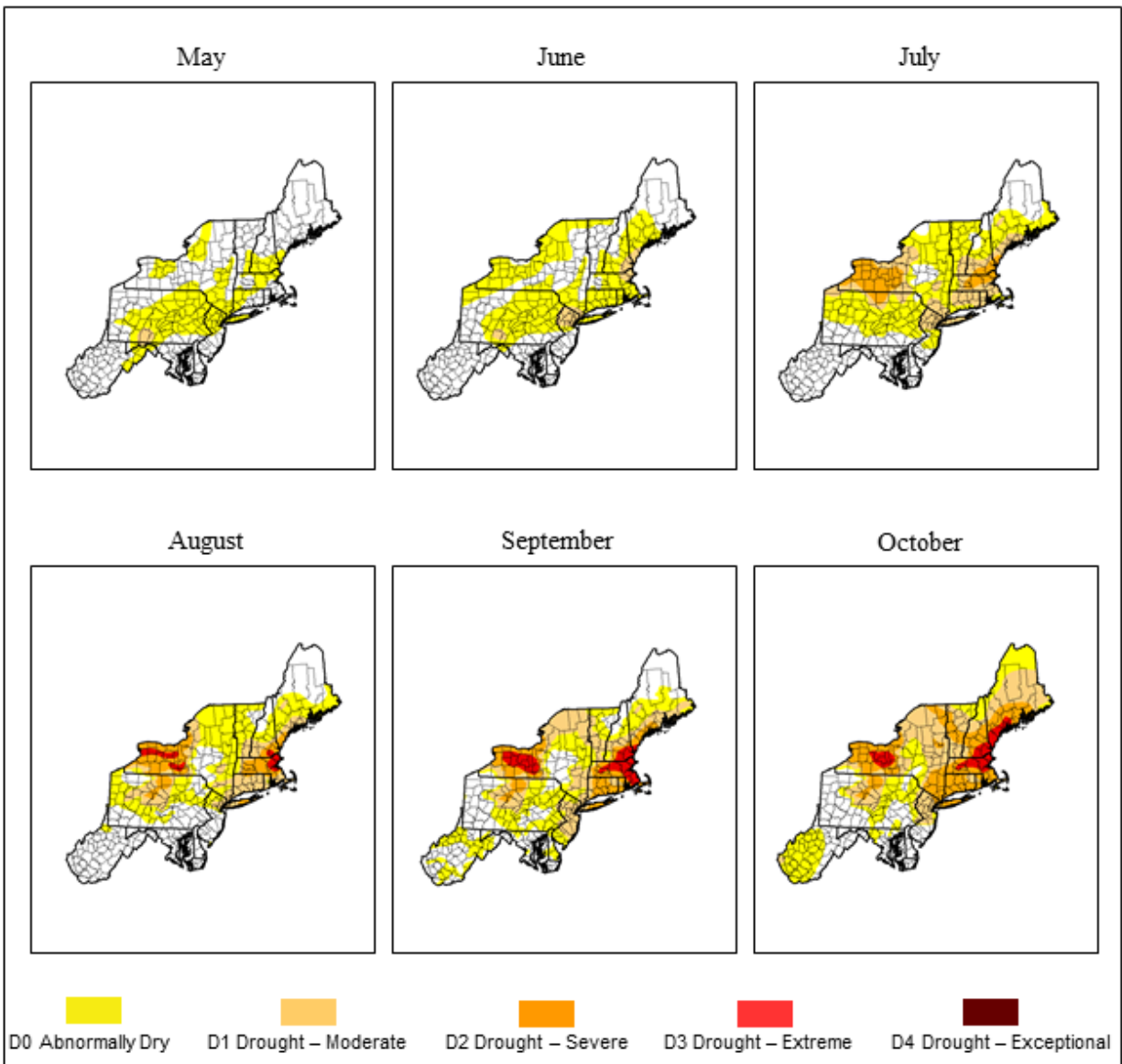


Figure 7. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for the Northeast in 2016.

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The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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