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Weather of Delaware Water Gap National Recreation Area and Upper Delaware Scenic and Recreational River

Eastern Rivers and Mountains Network Summary Report for 2010

Natural Resource Data Series NPS/ERMN/NRDS—2011/292

ON THE COVER
Sunset over West Branch of the Delaware River near Shehawken Creek.
Photograph by: Caleb Tzilkowski.

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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List of Key Acronyms

ASOS	Automated Surface Observing System
COOP	National Weather Service Cooperative Observer Program
CWOP	Citizen Weather Observer Program
DEWA	Delaware Water Gap National Recreational Area
ERMN	Eastern Rivers and Mountains Network
FAA	Federal Aviation Administration
GOES	Geostationary Operational Environmental Satellite
IFLOWS	Integrated Flood Observing and Warning System
NADP	National Atmospheric Deposition Program
NARR	North American Regional Reanalysis
NCDC	National Climatic Data Center
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRA	National Recreation Area
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
SRR	Scenic and Recreational River
UPDE	Upper Delaware Scenic and Recreational River
USDM	United States Drought Monitor
USGS	United States Geological Survey

Introduction

Weather and climate are widely recognized as key drivers of terrestrial and aquatic ecosystems, affecting biotic as well as abiotic ecosystem characteristics and processes. Global and regional scale climatic patterns, trends, and variations are critical to the cycling of elements, nutrients, and minerals through ecosystems and can deliver pollutants from regional and even global sources (National Assessment Synthesis Team 2001). These variations and trends influence the fundamental properties of ecologic systems such as soil-water relationships and plant-soil processes and their disturbance rates and intensity. Information obtained from meteorological monitoring will be useful to interpreting and understanding changes in species composition, community structure, water and soil chemistry, and related landscape processes (Marshall and Piekielek 2007).

The purpose of this report is to provide a concise weather and climate summary for the period from January 1 through December 31, 2010, and to place current patterns and trends in an appropriate historical and regional context (Marshall et al., in review). It is our intention that this report will satisfy an inherent interest in meteorological phenomena and meet a portion of the Eastern Rivers and Mountains Network (ERMN) Weather and Climate Monitoring objective:

- Document current status and long-term trends in air temperature and precipitation at multiple temporal scales (e.g., daily, monthly, seasonal, annual, and decadal) and spatial scales (e.g., individual stations and aggregated stations such as climate divisions) utilizing existing weather and climate monitoring programs and datasets.

To accomplish this objective, a variety of atmospheric data streams were evaluated for their quality, longevity, and applicability to the ERMN parks. Since no single weather observing network contains all the pertinent measures of atmospheric phenomena to assess ecosystem health, an objective analysis of the data networks was developed and outlined in the Weather and Climate Monitoring Protocol for the Eastern Rivers and Mountains Network and the Mid-Atlantic Network of the National Park Service (Marshall et al., in review). Through this analysis, a select number of weather/climate observing stations were chosen as representative of each park; these are the primary data sources used to profile climate summary and trends.

In addition to a suite of summary tables, graphs, and narratives, we specifically identify a series of key weather indicators to report status and trends on an annual basis and periodically in separate and more thorough reports. These key indicators are further described in the protocol (Marshall et al., in review) and summarized in this report.

Climate of the Pocono Mountains and Eastern Plateau

Delaware Water Gap National Recreation Area (NRA) lies in Pennsylvania Climate Division 1 "Pocono Mountains" and New Jersey Climate Division 1 "Northern NJ," while Upper Delaware Scenic and Recreational River (SRR) lies within Pennsylvania Climate Division 1 and New York Climate Division 2 "Eastern 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/usclimdivs/data/map.html [NOAA 2010]). Pennsylvania and New York are each divided into 10 climate divisions; New Jersey has three divisions.

The three climate divisions encompassing Delaware Water Gap NRA and Upper Delaware SRR are generally considered to have a humid, continental type of climate, but the varied physiographic features have a marked effect on the weather and climate of the various parts of the Delaware River valley. The prevailing westerly winds carry most of the weather disturbances that affect the region from the interior of the continent, so that the Atlantic Ocean has limited 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. Also, storms of tropical origin can have the greatest effect within this portion of the Pennsylvania–New Jersey–New York region, causing severe floods in some instances (Gelber 2002).

Temperatures are moderately continental, with the tempering effects of the Great Lakes contributing to cloud production 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 Delaware River valley. The southwest winds gain additional warmth when descending the crest of the Appalachians.

Precipitation is fairly evenly distributed throughout the year. Annual amounts generally range between 34–52 in (864–1,320 mm), while the majority of places receive 38–46 in (965–1,168 mm). Greatest amounts usually occur in the late-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 mountains, 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, ice, and snow may be produced.

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 summer solstice. Hail is relatively infrequent, but flash floods and damaging thunderstorm winds affect parts of the river valley 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 hurricanes and tropical storms have contributed to the region's worst floods. 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 12 weather observing stations comprised of three observing networks were selected around Delaware Water Gap NRA and Upper Delaware SRR. 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 parks' elevation profile, the type and frequency of observations, the period of record of the data, and data availability (Marshall et al., in review). Moreover, the percentage of time a station reports particular parameters (e.g., temperature) can influence its data inclusion. No stations were excluded in 2010 based upon this criterion. Therefore, a total of 12 stations were used for this report (Figure 1, Table 1).

In addition to the summary information available in this report, a near real-time data stream has been made available to the ERMN through a Web interface for the selected stations, along with monthly, seasonal, and annual summaries. The Web interface is accessible through the following link: http://climate.met.psu.edu/gmaps/NPS_DEVELOPMENT/interface.php.

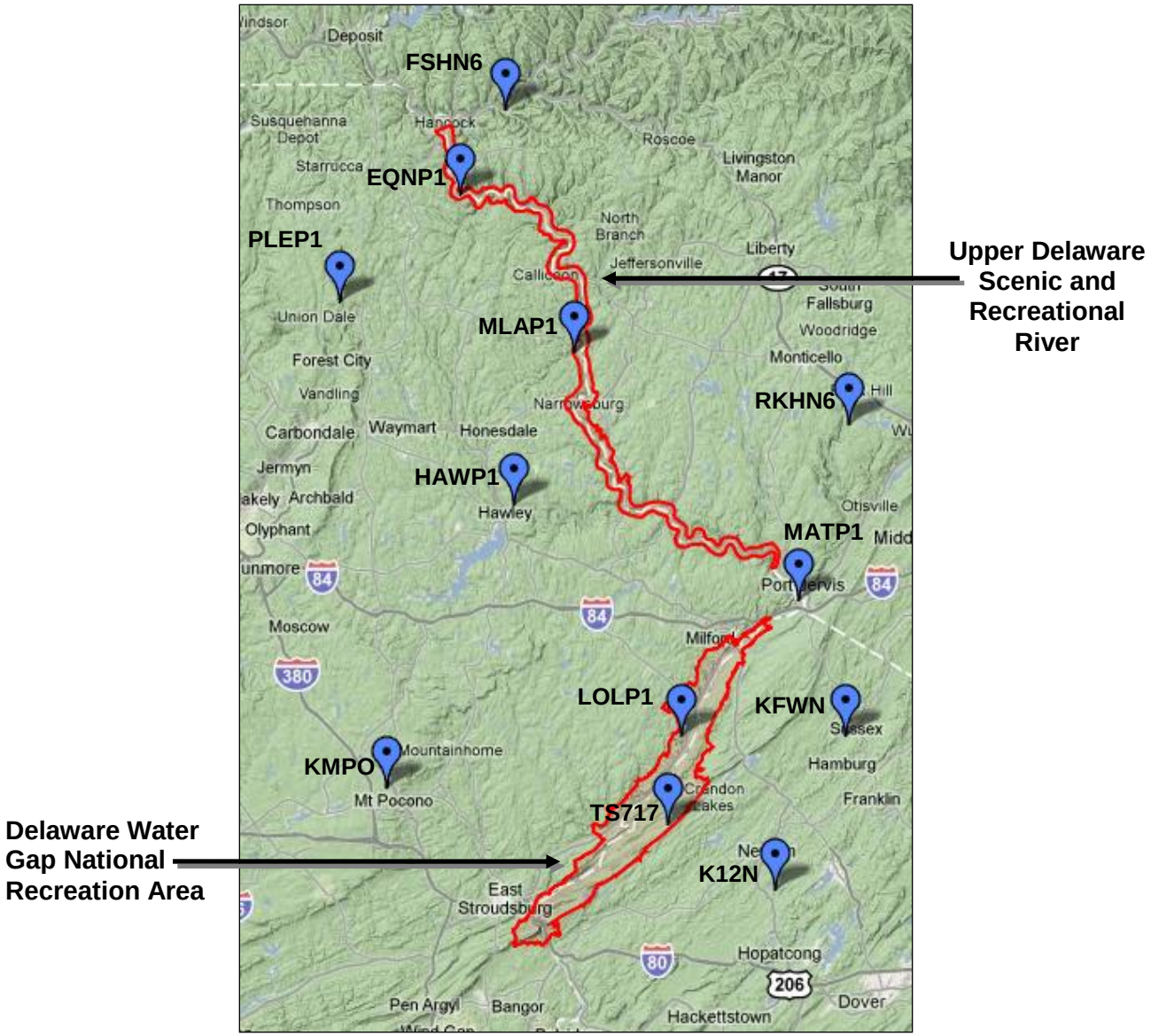

Figure 1. Location of weather observing stations around Upper Delaware Scenic and Recreational River and Delaware Water Gap National Recreation Area. See Table 1 for station names.

Table 1. List of weather observing stations around the Upper Delaware Scenic and Recreational River and Delaware Water Gap National Recreation Area selected as most representative of the parks in 2010.

Station	Observing Network	Station Name	Period of Record (POR)		Percentage of Time Reporting Temperature for 2010	Percentage of Time Reporting Precipitation for 2010	Percentage of Time Reporting Temperature for entire POR	Percentage of Time Reporting Precipitation for entire POR
MATP1	COOP	Matamoras	10/01/1904	Present	100.0	100.0	91.2*	94.4
EQNP1	COOP	Equinunk 2 NW	03/01/1957	Present	-	100.0	-	99.2
HAWP1	COOP	Hawley 1 E	11/01/1897	Present	100.0	100.0	74.5	80.4
RKHN6	COOP	Rock Hill 3 SW	06/01/1963	Present	98.6	99.7	93.3*	98.2
FSHN6	COOP	Fishs Eddy	04/08/1953	Present	-	96.4	-	82.3
KMPO	ASOS	Pocono Mountains Municipal Airport	09/29/1999	Present	100.0	100.0	98.8	98.6
KFWN	ASOS	Sussex Airport	12/27/2000	Present	100.0	100.0	99.5	99.4
K12N	ASOS	Aeroflex-Andover Airport	10/25/2000	Present	100.0	100.0	82.0	81.9
PLEP1	COOP	Pleasant Mount 1W	10/01/1924	Present	100.0	99.2	98.7*	98.0
MLAP1	COOP	Milanville	08/01/1945	Present	100.0	97.8	29.7*	40.5
TS717	RAWS	Blue Mountain Lakes	12/11/2007	Present	92.2	92.2	93.9	93.9
LOLP1	RAWS	Loch Lomond	01/01/2005	Present	93.4	93.4	94.5	94.5

* Matamoras did not start reporting temperature until 07/01/1963. The percentage time of reporting temperature is based upon this por.
* Rock Hill 3 SW did not start reporting temperature until 12/01/2008. The percentage time of reporting temperature is based upon this por.
* Pleasant Mount 1 W did not start reporting temperature until 12/01/1951. The percentage of time reporting temperature is based upon this por.
* Milanville did not start reporting temperature until 06/20/1963. The percentage of time reporting temperature is based upon this por.

Temperature Summary

Calendar year 2010 averaged above the long-term mean temperature (Tables 2 and 3), with maximum temperatures departing between +0.5 and +1.9 degrees Fahrenheit (°F) (+0.2 and +1.1 degrees Celsius [°C]) for the year (Table 2). Minimum temperature readings averaged closer to the 30-year mean (Table2). Only December 2010 was colder than normal at all sites, and March had the largest above-average temperature departures (Table 4).[1]

While January and February 2010 averaged below normal maximum temperatures and near the somewhat above normal minimum temperatures (Figures 2 and 3), it was the unusual warmth in March that turned the tables and allowed the winter months to rank between 12th and 18th warmest in 116 years (Table 5). The mean temperature departures in March ranged from +4.6°F (+2.6°C) at Matamoras, PA to +8.0°F (+4.4°C) in Pleasant Mount (Table 4). A cold episode brought morning readings just below 0°F (-17.8°C) during January, with the lowest values in many sections occurring at before mid-month with minima between +4 and -4°F (-15.6 to -20°C) (Table 2). The number of sub freezing days varied, with Matamoras accruing 19 more than average, but Pleasant Mount tallying four fewer than normal (Table 2).

The spring was one of the warmest on record in the region, with climate division rankings of either 1st or 2nd place (Table 5). In Pennsylvania Climate Division 1 "Pocono Mountains," which encompasses most of Upper Delaware SRR and Delaware Water Gap NRA, ranked as the warmest spring in the past 116 years (58 is the mid-point; Table 5). A remarkable warm spell occurred from April 2nd to 9th when readings rose to 90°F (+32.2°C). Most sections had their last freeze and frost between May 11–12, which contributed to a growing season length which was two weeks shorter than average at Matamoras, PA, and three weeks longer than average at Pleasant Mount, PA (Table 2). Temperatures during each of the three-month periods averaged above normal at all sites, with departures ranging between +1.6 to +7.2°F (+0.9 to +4.0°C) above the 1971–2000 long-term mean (Table 4).

The summer period continued the very warm conditions, with virtually all stations averaging above normal for each of the three months (Table 4), with the exception of Matamoras during August (-0.5°F; -0.3°C). July and September tallied the higher positive anomalies, with July maximum temperatures ranging from +5 to +7°F (+3 to +4°C) (Figure 2). Despite this season being the 2nd to 10th warmest in 116 years (Table 5), few daily records maximum were set.

Autumn temperatures were near average (Tables 3 and 4; Figures 2 and 3). Frosts and freezes occurred near the long-term average date, with most sections noticing sub-freezing readings (<0°C) on October 10–11. Maximum temperatures during December had the largest departures of the year, with readings more than 7°F (4°C) below normal, but December minimums were closer to seasonal readings. Overall, the annual temperature for 2010 averaged above normal (Table 2), ranging from +0.3°F (0.1°C) to +2.4°F (1.2°C).

[1] The maps in Figures 2 and 3 were created using estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM). PRISM uses an interpolation scheme for temperature between actual observations and corrects these estimates for changes in topography across the region (Daly et al. 2002). More information can be found at http://www.prism.oregonstate.edu/.

Table 2. Status of 2010 temperature indicators compared to the 30-year normal (1971–2000) at the Matamoras (MATP1), Hawley 1 E (HAWP1), and Pleasant Mount 1 W (PLEP1) stations.

Temperature Indicator	Matamoras, PA 2010	Matamoras, PA 1971-2000	Hawley 1 E, PA 2010	Hawley 1 E, PA 1971-2000	Pleasant Mount 1 W, PA 2010	Pleasant Mount 1 W, PA 1971-2000
Average Annual Temperature	49.8°F 9.9°C	49.5°F 9.7°C	47.9°F 8.8°C	46.8°F 8.2°C	45.7°F 7.6°C	43.3°F 6.3°C
Average Annual Maximum Temperature	61.0°F 16.1°C	60.5°F 15.8°C	59.0°F 15.0°C	58.1°F 14.5°C	55.4°F 13.0°C	53.5°F 11.9°C
Maximum Temperature	97.0°F 36.1°C	94.6°F 34.8°C	96.0°F 35.6°C	91.0°F 32.8°C	90.0°F 32.2°C	87.9°F 31.1°C
Hot Days (days with Tmax>=90°F/32°C)	13	11	8	4	2	0
Average Annual Minimum Temperature	38.6°F 3.7°C	38.5°F 3.6°C	36.9°F 2.7°C	35.4°F 1.9°C	36.1°F 2.3°C	33.1°F 0.6°C
Minimum Temperature	4.0°F -15.5°C	-5.6°F -20.9°C	-4.0°F -20.0°C	-11.4°F -24.1°C	-3.0°F -19.4°C	-14.6°F -25.9°C
Cold Days (days with Tmax<=32°F/0°C)	36	27	54	37	69	63
Sub-freezing Days (days with Tmin<=32°F/0°C)	149	132	161	159	170	174
Sub-zero Days (days with Tmin<=0°F/-17.8°C)	0	4	2	11	4	16
Growing Season Length (days between last spring Tmin 32°F/0°C and first fall Tmin 32°F/0°C)	151	165	151	145	150	130

Delaware Water Gap National Recreation Area
and Upper Delaware Scenic and Recreational River
Departure from Average Monthly Maximum Temperature
2010 vs. 1971–2000

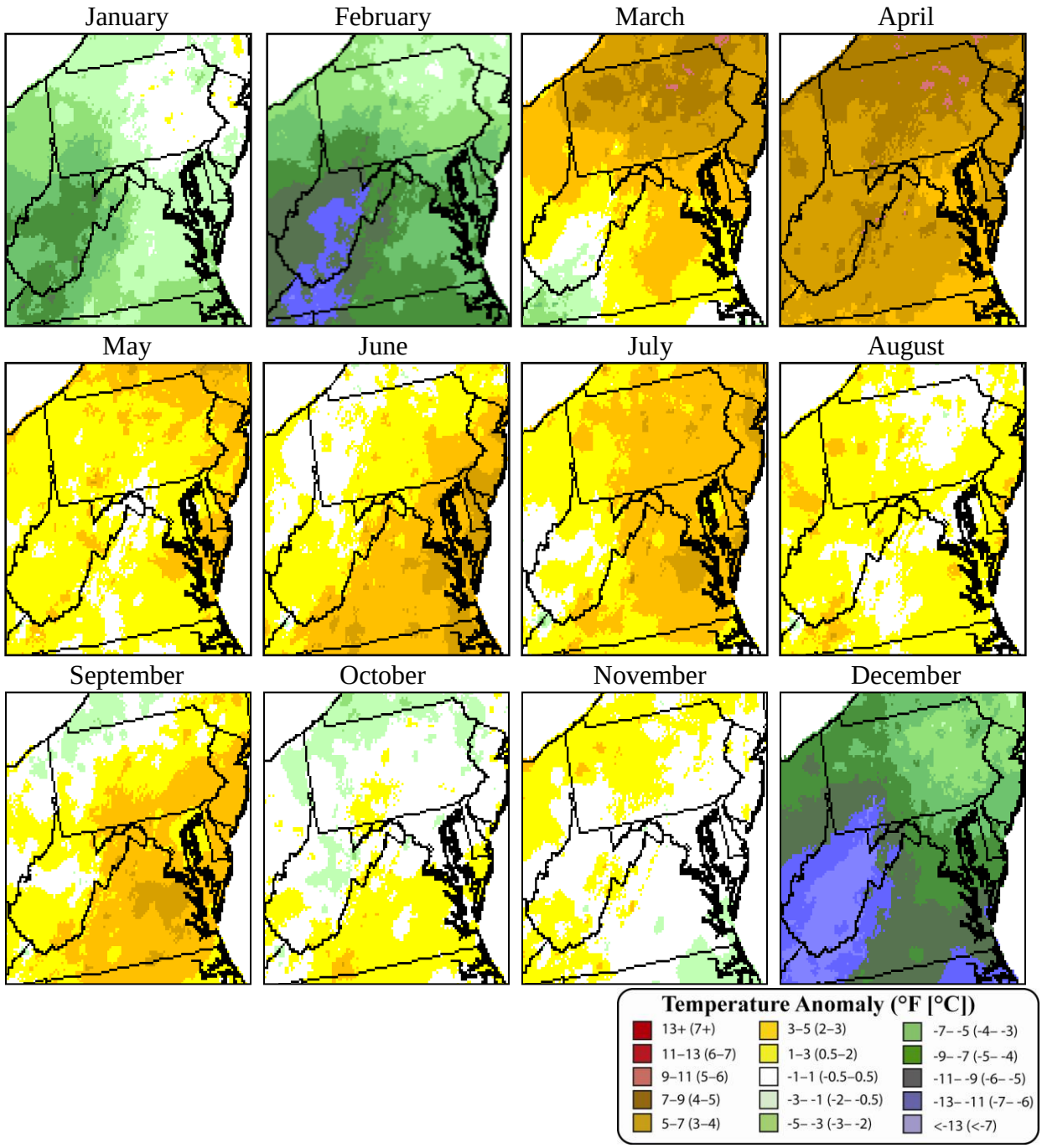

Figure 2. Maps showing departure from average monthly maximum temperature compared to the 30-year normal (1971–2000).

Delaware Water Gap National Recreation Area
and Upper Delaware Scenic and Recreational River
Departure from Average Monthly Minimum Temperature
2010 vs. 1971–2000

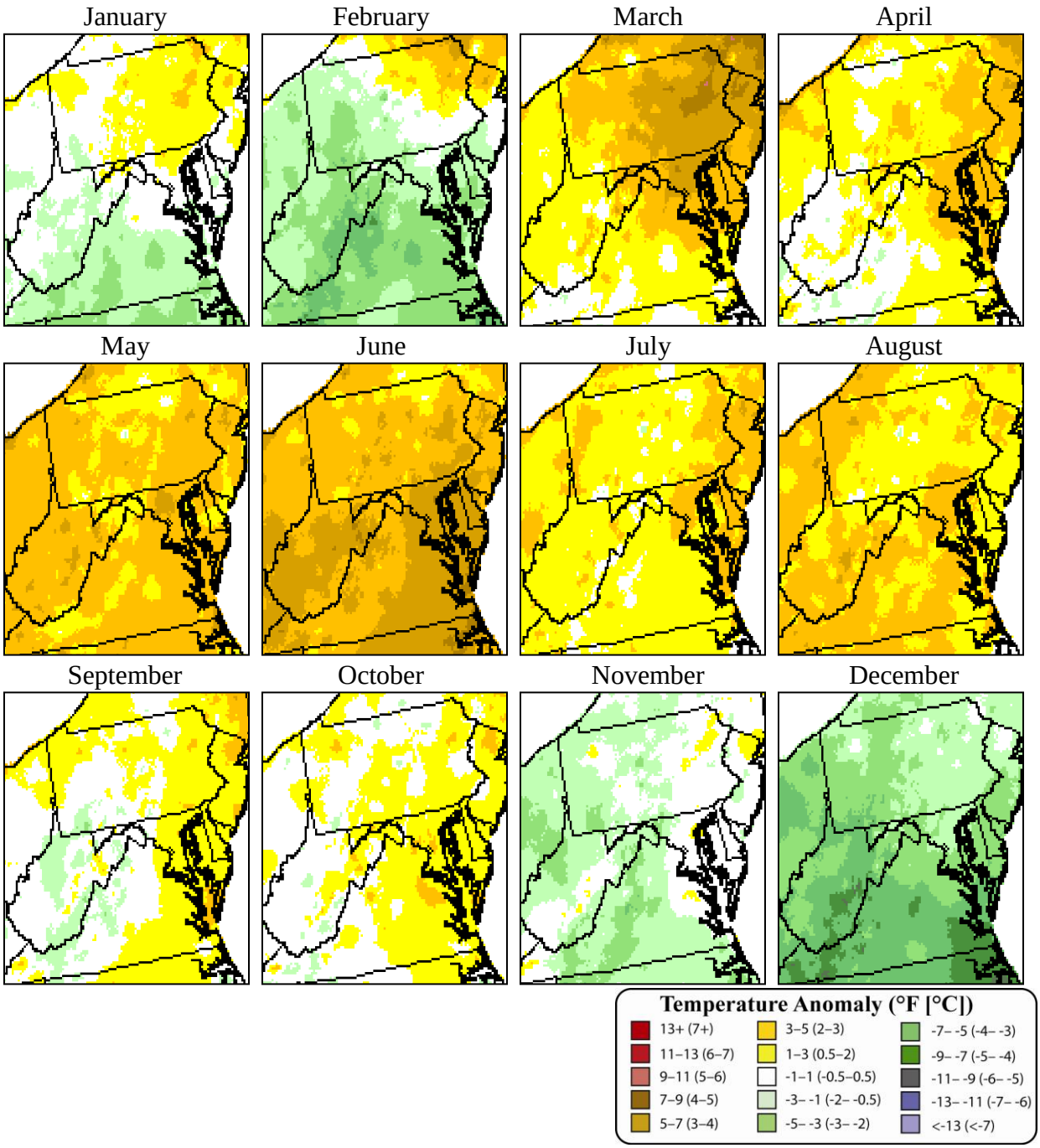

Figure 3. Maps showing departure from average monthly minimum temperature compared to the 30-year normal (1971–2000).

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

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Matamoras, PA	MATP1	26.0°F	27.4°F	41.5°F	51.0°F	60.1°F	69.1°F	72.3°F	69.5°F	63.1°F	50.3°F	40.0°F	26.3°F	49.7°F
		-3.3°C	-2.6°C	5.3°C	10.6°C	15.6°C	20.6°C	22.4°C	20.8°C	17.3°C	10.2°C	4.4°C	-3.2°C	9.8°C
Hawley 1 E, PA	HAWP1	23.3°F	25.2°F	39.8°F	48.7°F	58.3°F	66.2°F	71.5°F	67.5°F	61.1°F	48.7°F	38.4°F	25.0°F	47.8°F
		-4.8°C	-3.8°C	4.3°C	9.3°C	14.6°C	19.0°C	21.9°C	19.7°C	16.2°C	9.3°C	3.6°C	-3.9°C	8.8°C
Rock Hill 3 SW, NY	RKHN6	22.8°F	20.8°F	36.3°F	44.8°F	58.9°F	66.6°F	72.5°F	68.9°F	61.9°F	48.7°F	38.3°F	23.4°F	47.0°F
		-5.1°C	-6.2°C	2.4°C	7.1°C	14.9°C	19.2°C	22.5°C	20.5°C	16.6°C	9.3°C	3.5°C	-4.8°C	8.3°C
Pleasant Mount 1 W, PA	PLEP1	20.4°F	22.3°F	37.4°F	47.1°F	56.6°F	64.2°F	69.6°F	65.5°F	59.1°F	46.8°F	37.1°F	21.2°F	45.6°F
		-6.4°C	-5.4°C	3°C	8.4°C	13.7°C	17.9°C	20.9°C	18.6°C	15°C	8.2°C	2.83°C	-6°C	7.6°C
Milanville, PA	MLAP1	24.0°F	27.5°F	41.5°F	50.4°F	59.6°F	67.8°F	72.6°F	69.1°F	62.3°F	50.3°F	39.5°F	25.0°F	49.1°F
		-4.4°C	-2.5°C	5.3°C	10.2°C	15.3°C	19.9°C	22.6°C	20.6°C	16.8°C	10.2°C	4.2°C	-3.9°C	9.5°C
Mt Pocono Airport, PA	KMPO	23.2°F	25.1°F	39.5°F	50.2°F	58.5°F	66.3°F	71.8°F	68.0°F	61.5°F	49.2°F	39.1°F	23.1°F	48.0°F
		-4.9°C	-3.8°C	4.2°C	10.1°C	14.7°C	19.1°C	22.1°C	20.0°C	16.4°C	9.6°C	3.9°C	-4.9°C	8.9°C
Sussex Airport, NJ	KFWN	26.9°F	29.4°F	43.5°F	53.0°F	61.5°F	69.3°F	74.4°F	71.2°F	64.5°F	51.9°F	41.3°F	27.5°F	51.2°F
		-2.8°C	-1.4°C	6.4°C	11.7°C	16.4°C	20.7°C	23.6°C	21.8°C	18.1°C	11.1°C	5.2°C	-2.5°C	10.7°C
Aeroflex-Andover Airport, NJ	K12N	27.3°F	29.2°F	43.6°F	53.5°F	62.3°F	70.1°F	74.9°F	71.4°F	65.3°F	52.8°F	42.3°F	27.6°F	51.7°F
		-2.6°C	-1.6°C	6.4°C	11.9°C	16.8°C	21.2°C	23.8°C	21.9°C	18.5°C	11.6°C	5.7°C	-2.4°C	10.9°C
Blue Mountain Lakes, NJ	TS717	27.8°F	26.7°F	42.4°F	53.2°F	60.9°F	68.4°F	73.1°F	69.8°F	64.0°F	51.1°F	40.7°F	25.2°F	50.3°F
		-2.3°C	-2.9°C	5.8°C	11.8°C	16.1°C	20.2°C	22.8°C	21°C	17.8°C	10.6°C	4.8°C	-3.8°C	10.2°C
Loch Lomond, PA	LOLP1	27.4°F	28.6°F	43.8°F	54.3°F	62.0°F	69.7°F	74.4°F	70.9°F	65.3°F	52.3°F	41.5°F	27.0°F	51.4°F
		-2.6°C	-1.9°C	6.6°C	12.4°C	16.7°C	20.9°C	23.6°C	21.6°C	18.5°C	11.3°C	5.3°C	-2.8°C	10.8°C

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

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Matamoras, PA	MATP1	1.0°F	0.01°F	4.6°F	3.3°F	1.6°F	2.3°F	0.8°F	-0.5°F	1.0°F	-0.7°F	-0.3°F	-4.0°F	0.7°F
		0.6°C	0.0°C	2.6°C	1.8°C	0.9°C	1.3°C	0.5°C	-0.3°C	0.6°C	-0.4°C	-0.2°C	-2.2°C	0.4°C
Hawley 1 E, PA	HAWP1	0.1°F	0.2°F	5.6°F	3.8°F	2.6°F	2.4°F	3.1°F	0.6°F	1.7°F	0.1°F	-0.6°F	-3.5°F	1.3°F
		0.06°C	0.1°C	3.1°C	2.1°C	1.4°C	1.3°C	1.7°C	0.3°C	0.9°C	0.05°C	-0.3°C	-1.9°C	0.7°C
Pleasant Mount 1 W, PA	PLEP1	1.5°F	1.5°F	8.0°F	6.0°F	4.1°F	3.3°F	4.3°F	1.8°F	3.4°F	1.9°F	2.1°F	-3.0°F	2.9°F
		0.8°C	0.8°C	4.5°C	3.3°C	2.3°C	1.8°C	2.4°C	1.0°C	1.9°C	1.1°C	1.2°C	-1.7°C	1.6°C
Mt Pocono Airport, PA	*KMPO	1.8°F	2.2°F	7.7°F	7.2°F	4.8°F	4.3°F	5.1°F	2.8°F	4.1°F	2.3°F	2.3°F	-3.6°F	3.5°F
		1.0°C	1.2°C	4.3°C	4.0°C	2.7°C	2.4°C	2.8°C	1.6°C	2.3°C	1.3°C	1.3°C	-2.0°C	1.9°C
Sussex Airport, NJ	*KFWN	2.5°F	2.5°F	7.1°F	5.8°F	3.8°F	3.2°F	3.2°F	1.8°F	3.1°F	1.9°F	1.0°F	-2.6°F	2.8°F
		1.4°C	1.4°C	4.0°C	3.2°C	2.1°C	1.8°C	1.8°C	1.0°C	1.7°C	1.1°C	0.6°C	-1.4°C	1.5°C
Aeroflex-Andover Airport, NJ	*K12N	2.4°F	2.0°F	6.9°F	6.0°F	4.3°F	3.5°F	3.6°F	2.1°F	3.9°F	3.0°F	1.8°F	-2.7°F	3.1°F
		1.3°C	1.1°C	3.8°C	3.3°C	2.4°C	1.9°C	2.0°C	1.2°C	2.2°C	1.7°C	1.0°C	-1.5°C	1.7°C

*Indicates a station's period of record is less than 30 years. In these cases, the departure from normal values were calculated with normals derived from data spanning the length of the station's period of record. Stations with a period of record of less than 8 years were not included in this table.

Table 5. Seasonal temperature and precipitation rankings over 116 years (1 = warmest/wettest year and 116 = coldest/driest year) for Pennsylvania Climate Division 1 (top), New Jersey Climate Division 1 (middle), and New York Climate Division 2 (bottom).

PA Climate Division 1 Rankings "Pocono Mountains"	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN
Temperature-2010	14	1	8	70
Precipitation-2010	10	96	68	14

NJ Climate Division 1 Rankings "Northern NJ"	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN
Temperature-2010	12	1	2	50
Precipitation-2010	4	101	89	36

NY Climate Division 2 Rankings "Eastern Plateau"	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN
Temperature-2010	18	2	10	67
Precipitation-2010	5	77	58	9

Precipitation Summary

For the 10th consecutive year, annual precipitation (rain and melted snow, ice, sleet, etc.; hereafter precipitation) for calendar year 2010 averaged above the long-term mean (Table 6). Reverting back to the trend of past years, the majority of the wettest days occurred during the colder half of the year (Table 7). The highest accumulated liquid occurred in October (Table 8). The months of February, March, October, and December averaged above-normal precipitation throughout the region (Figure 4; Table 9). Dry spells were noted in late August and September, which is typical, but also in January, July, October, and December (Table 7). Snowfall was near normal, due, in large part, to a snowy February, March, and December. The number of days with excessive rainfall (>1.0 in [25 mm]) was above the long-term average for northeastern Pennsylvania (Table 6).

The year began with near-normal precipitation during January and then turned much wetter in February and March (Figure 4). The first three months of 2010 were ranked as the fourth to tenth wettest in 116 years of record keeping (Table 5). Essentially, all stations reported above-average precipitation (rain and snow) during the months of February and March, with 271 percent of normal tallied at Hawley, PA, in February (Table 9).

Spring 2010 (April–May–June) was a much drier period, with only one station (Equinunk, PA), during one month (June), averaging more than 100 percent of normal rainfall (Table 9). This three month period ranked between the 15th and 39th driest in 116 years for the three climate divisions encompassing the parks (Table 5).

The summer began with generally above-average rainfall with two of the three months tallying as much as 170 percent of normal (Table 9). September turned quite dry with the longest dry spell of the year beginning on August 27 and persisting until September 7 (Table 7). There was the indirect effect of the remnants of Tropical Storm Nicole that resulted in an historic rainstorm September 30 through October 1. In fact, October 1st brought 5.05 in (128.3 mm) of rain to Matamoras, PA, the wettest day of the year (Table 7).

As has been the case for much of the last decade, the autumn was wetter than normal, with total precipitation ranging from 15.2–17.5 in (386–445 mm) (Table 6). October was the wettest month of 2010, as stations tallied 137–277 percent of normal rainfall (Table 9). Equinunk, PA, measured 9.60 in (244 mm), for the maximum accumulation (Table 8). November was much drier, with most sections averaging less than 80 percent of the normal rainfall (Table 9). A series of wintry coastal storms brought early snowfall to the region during December. Precipitation during the last three months of 2010 ranked between ninth and 36th wettest for the climate divisions surrounding the parks. Snowfall during the year ranged from 41.7 in (105.9 cm) to 63.7 in (161.8 cm), which averaged near normal.

Overall, 2010 had between 84–140 percent of the normal precipitation (Tables 6 and 9).

Table 6. Status of 2010 precipitation indicators compared to the 30-year normal (1971–2000) at the Matamoras (MATP1), Hawley 1 E (HAWP1), and Pleasant Mount 1 W (PLEP1) stations.

Precipitation Indicator	Matamoras, PA 2010	Matamoras, PA 1971-2000	Hawley 1 E, PA 2010	Hawley 1 E, PA 1971-2000	Pleasant Mount 1 W, PA 2010	Pleasant Mount 1 W, PA 1971-2000
Annual Precipitation	48.3 in 1,227mm	42.1 in 1,069 mm	55.0 in 1,397 mm	40.9 in 1,039 mm	54.9 in 1,394 mm	48.4 in 1,229 mm
Autumn (Oct, Nov, Dec) Precipitation	15.7 in 399 mm	9.9 in 251mm	17.5 in 445 mm	9.5 in 241mm	15.2 in 386 mm	12.0 in 305 mm
Heavy Precipitation Days (days with ≥1.0 in (25 mm) rain)	14	11	17	9	13	11
Extreme Precipitation Days (days with ≥2.0 in (51 mm) rain)	2	2	3	1	4	1
Micro-drought (strings of 7+ days without rain)	7	5	6	5	5	5
Annual Snowfall (inches)	41.7 in 105.9 cm	32.1 in 81.5 cm	43.9 in 111.5 cm	43.9 in 111.5 cm	63.7 in 161.8 cm	71.7 in 182.1 cm
Measurable Snow Days (days with ≥0.1 in (0.3 cm) snow)	22	15	21	22	41	31
Moderate Snow Days (days with ≥2.0 in (5.0 cm) snow)	7	5	6	8	11	14
Heavy Snow Days (days with ≥5.0 in (12.7 cm) snow)	1	1	2	2	2	3

Table 7. Top five wettest days and top five dry spells (consecutive days with a trace or less of rainfall) during 2010 from the Matamoras (MATP1) station.

Wettest Days in 2010	Dry Spells in 2010
Oct. 1: 5.05 in (128 mm)	Aug. 27–Sept. 7
Apr. 27: 2.00 (51 mm)	Jun. 30–Jul. 9
Mar. 23: 1.97 in (50 mm)	Dec. 15– 26
Mar. 14: 1.82 in (46 mm)	Jan. 9–17
Oct. 27: 1.67 in (42 mm)	Oct. 17–25
Feb. 26/Jun. 1: 1.62 in (41 mm)	Dec. 3–11

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
Matamoras, PA	MATP1	2.3 in	4.4 in	7.4 in	3.1 in	2.3 in	4.0 in	3.0 in	4.5 in	1.7 in	9.4 in	2.7 in	3.5 in	48.3 in
		58 mm	112 mm	188 mm	79 mm	58 mm	102 mm	76 mm	114 mm	43 mm	239 mm	69 mm	89 mm	1227 mm
Equinunk 2 NW, PA	EQNP1	2.6 in	2.2 in	4.2 in	2.5 in	2.2 in	4.7 in	4.5 in	4.9 in	2 in	9.6 in	2.6 in	2.9 in	44.8 in
		66 mm	56 mm	107 mm	64 mm	56 mm	119 mm	114 mm	124 mm	51 mm	244 mm	66 mm	74 mm	1141 mm
Hawley 1 E, PA	HAWP1	2.9 in	7.1 in	5.1 in	3.6 in	2.7 in	2.9 in	4.1 in	6.2 in	2.9 in	8 in	2.7 in	6.8 in	55.0 in
		74 mm	180 mm	130 mm	91 mm	69 mm	74 mm	104 mm	157 mm	74 mm	203 mm	69 mm	173 mm	1397 mm
Rock Hill 3 SW, NY	RKHN6	2.9 in	5.1 in	4.3 in	2.7 in	3.2 in	3.8 in	2.5 in	5.3 in	2.6 in	7.3 in	3.3 in	5.6 in	48.6 in
		74 mm	130 mm	109 mm	69 mm	81 mm	97 mm	64 mm	135 mm	66 mm	185 mm	84 mm	142 mm	1234 mm
Fish's Eddy, NY	FSHN6	2.6 in	3.4 in	4.3 in	2.0 in	2.3 in	4.6 in	4.3 in	4.7 in	1.7 in	9.3 in	2.8 in	3.3 in	45.2 in
		66 mm	86 mm	109 mm	51 mm	58 mm	117 mm	109 mm	119 mm	43 mm	236 mm	71 mm	84 mm	1148 mm
Pleasant Mount 1 W, PA	PLEP1	3.7 in	6.9 in	4.6 in	3 in	3.5 in	3.8 in	5.6 in	5.8 in	2.9 in	8.7 in	3.0 in	3.5 in	54.9 in
		94 mm	175 mm	117 mm	76 mm	89 mm	97 mm	142 mm	147 mm	74 mm	221 mm	76 mm	90 mm	1397 mm
Milanville, PA	MLAP1	2.1 in	1.8 in	4.3 in	3.2 in	3.0 in	3.5 in	3.4 in	4.9 in	2.9 in	8.6 in	2 in	3.5 in	43.0 in
		53 mm	46 mm	109 mm	81 mm	76 mm	89 mm	86 mm	124 mm	74 mm	218 mm	51 mm	89 mm	1092 mm
Mt Pocono Airport, PA	KMPO	3.5 in	3.3 in	6.4 in	3.5 in	3.2 in	2.5 in	2.2 in	3.5 in	8.6 in	5.9 in	4.3 in	5.8 in	52.8 in
		89 mm	84 mm	162 mm	89 mm	82 mm	65 mm	55 mm	89 mm	219 mm	149 mm	109 mm	148 mm	1341 mm
Sussex Airport, NJ	KFWN	1.8 in	3.1 in	8.1 in	2.8 in	2.7 in	2.6 in	3.1 in	4.1 in	3.1 in	5.1 in	2.2 in	1.7 in	40.4 in
		47 mm	80 mm	206 mm	70 mm	69 mm	65 mm	78 mm	105 mm	78 mm	129 mm	56 mm	43 mm	1025 mm
Aeroflex-Andover Airport, NJ	K12N	2.9 in	4.2 in	6.7 in	3.0 in	3.0 in	3.3 in	5.6 in	2.8 in	3.3 in	6.0 in	2.4 in	3.5 in	46.8 in
		74 mm	107 mm	170 mm	76 mm	76 mm	84 mm	142 mm	71 mm	84 mm	152 mm	61 mm	90 mm	1186 mm
Blue Mountain Lakes, NJ	TS717	3.1 in	1.6 in	6.3 in	3.2 in	3.7 in	3.3 in	M	3.1 in	4.7 in	7.5 in	3.9 in	3.3 in	44.8^{M} in
		79 mm	41 mm	160 mm	81 mm	94 mm	84 mm	28 mm	79 mm	119 mm	191 mm	99 mm	84 mm	1138^{M} mm
Loch Lomond, PA	LOLP1	2.8 in	2.6 in	6.0 in	2.7 in	2.4 in	2.3 in	M	4.0 in	3.6 in	7.6 in	4.3 in	3.5 in	42.9^{M} in
		71 mm	66 mm	152 mm	69 mm	61 mm	58 mm	30 mm	102 mm	91 mm	193 mm	109 mm	89 mm	1090^{M} mm

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

Delaware Water Gap National Recreation Area
and Upper Delaware Scenic and Recreational River
Percent of Average Monthly Precipitation
2010 vs. 1971–2000

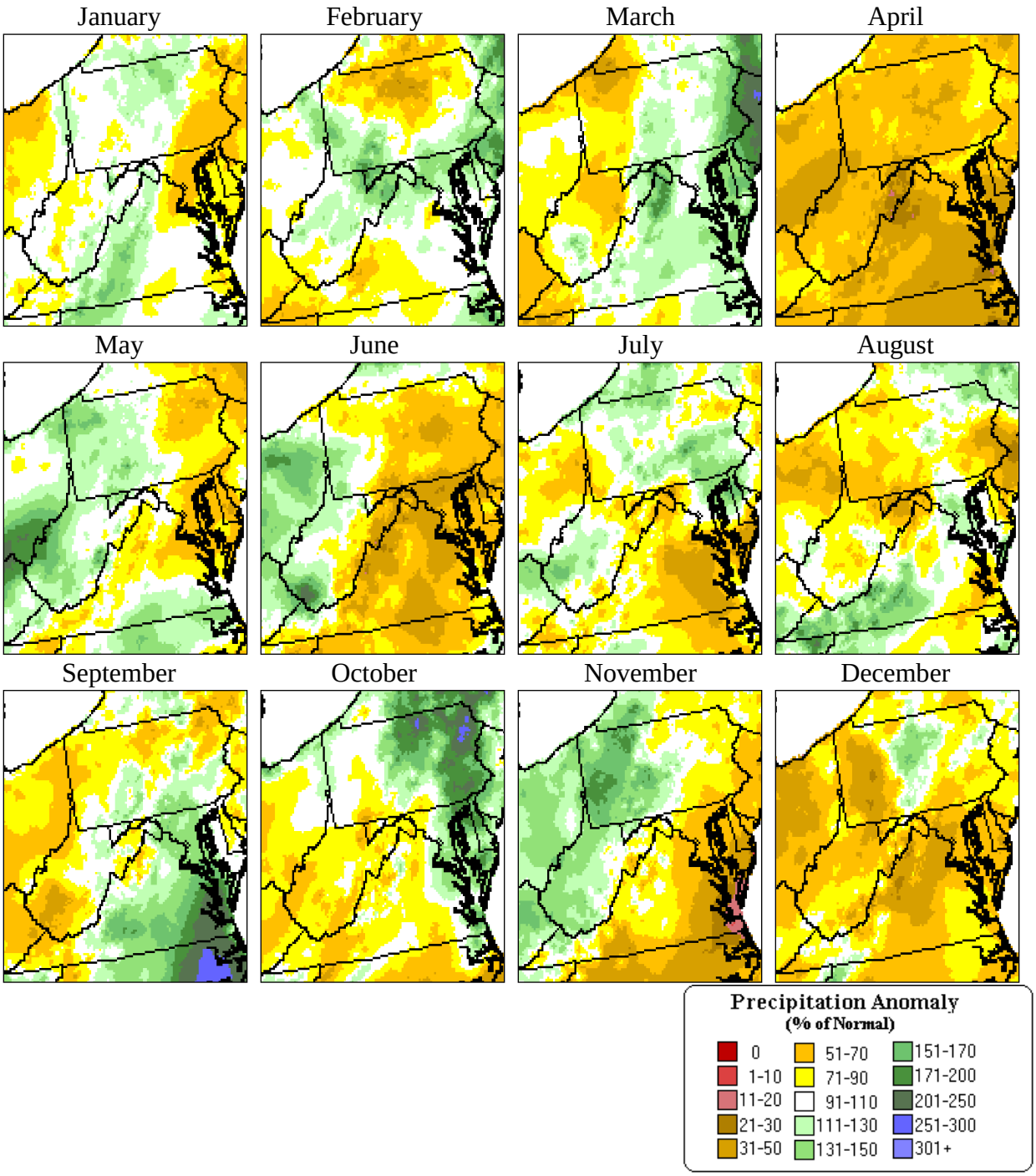

Figure 4. Maps showing percent of average monthly precipitation compared to the 30-year normal (1971–2000).

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

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Matamoras, PA	MATP1	66	155	210	75	55	90	72	123	37	276	73	103	106
Equinunk 2 NW, PA	EQNP1	76	83	116	68	54	117	117	131	50	277	64	81	103
Hawley 1 E, PA	HAWP1	91	271	165	97	67	68	114	179	76	255	75	220	140
Rock Hill 3 SW, NY	RKHN6	77	165	102	63	63	80	63	139	57	193	77	149	102
Pleasant Mount 1 W, PA	PLEP1	109	242	133	72	71	78	128	141	64	209	69	96	118
Mt Pocono Airport, PA*	KMPO	85	101	158	82	69	56	53	89	173	156	102	162	107
Sussex Airport, NJ*	KFWN	47	106	214	62	61	56	73	98	69	137	59	47	84
Aeroflex-Andover Airport, NJ*	K12N	79	155	181	74	68	73	127	63	73	166	63	101	102

*Indicates a station's period of record is less than 30 years. In these cases, the departure-from-normal values were calculated with normals derived from data spanning the length of the station's period of record. Stations with a period of record of less than 8 years were not included in this table.

Drought Status

There are a number of drought indices used to estimate the severity of drought in an area using algorithms that incorporate recent temperatures, rainfall, soil moisture, and other information (http://www.drought.gov). The main indices we report are the Palmer Drought Severity Index (PDSI) and the United States Drought Monitor (DM) – Drought Intensity Index. While both indices provide excellent summary information on broad-scale conditions, local conditions (such as at the park scale) may vary.

The PDSI is a soil moisture algorithm calibrated for relatively homogeneous regions and is calculated on a monthly basis using precipitation and temperature data, as well as the water content of the soil. The values vary between extremely moist (>4.0) and extreme drought (<-4.0), with "normal" values ranging between -1.9 and 1.9. Monthly PDSI values for Pennsylvania Climate Division 1 in 2010 are shown in Figure 5.

The DM – Drought Intensity Index is a synthesis of multiple indices (including the PDSI) and impacts, and represents a consensus of federal and academic scientists. The DM produces a summary map of drought intensity for the nation and all states each week. It is on a scale ranging from abnormally dry (D0) to exceptional drought (D4). Mid-month (i.e., the second or third week) values for Pennsylvania (Figure 6) and the Northeast (Figure 7) are shown for 2010.

According to the PDSI for PA Climate Division 1, a moist winter reversed into an increasingly dry spring and summer (PDSI ~ -2.0 by September; Figure 5). However, an historic rainstorm at the start of October completely alleviated the drought and it remained more "moist" than normal (PDSI >0) for the autumn. When compared with the past few years, 2010 was the first truly dry time during the heart of the growing season from May to September. The DM – Drought Severity Index for Pennsylvania (Figure 6) and the Northeast (Figure 7) shows a similar pattern for the growing season (May through October); abnormally dry (D0) during the period from June until late September.

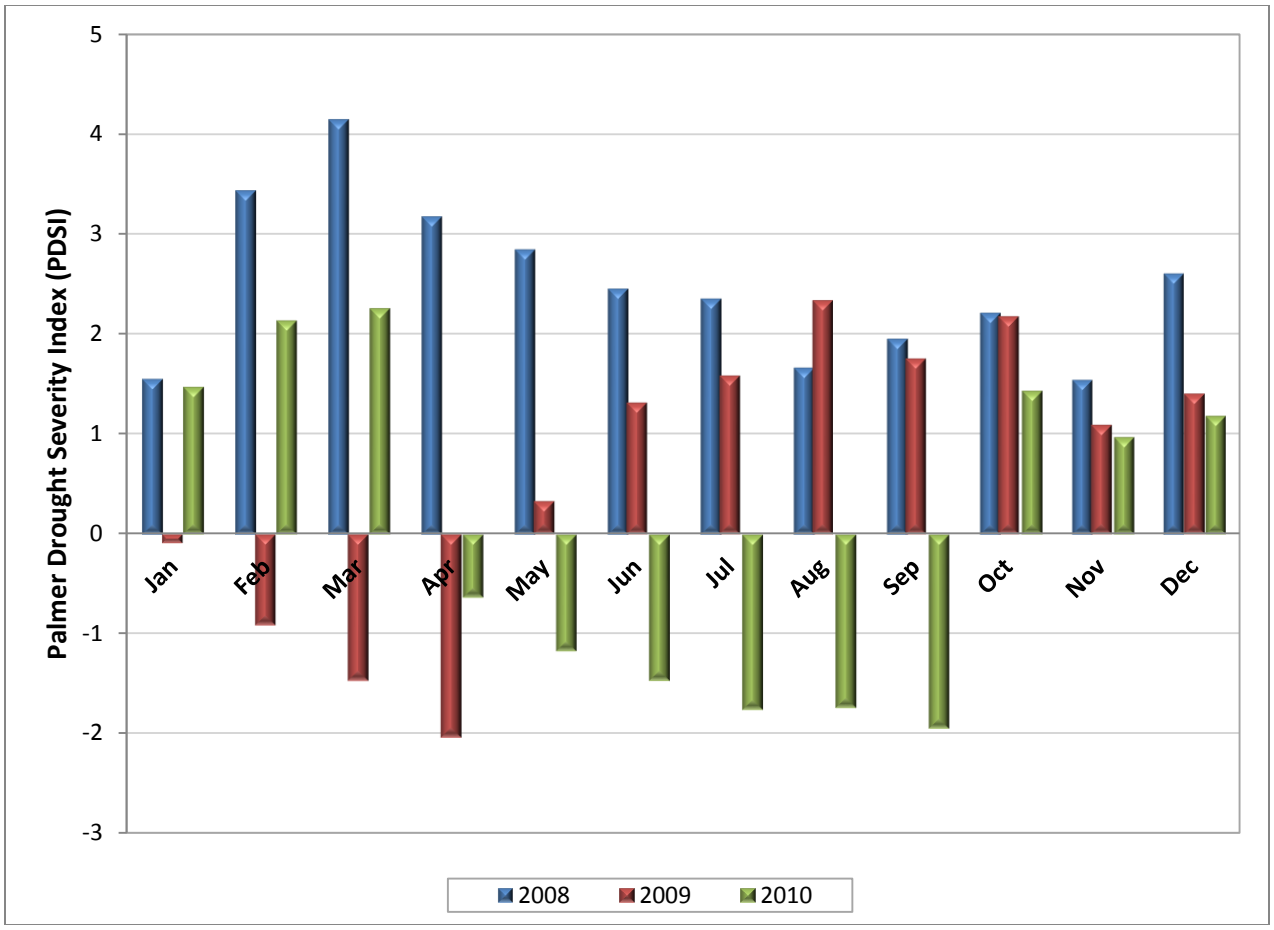

Figure 5. Monthly Palmer Drought Severity Index (PDSI) values for Pennsylvania Climate Division 1, 2008–2010.

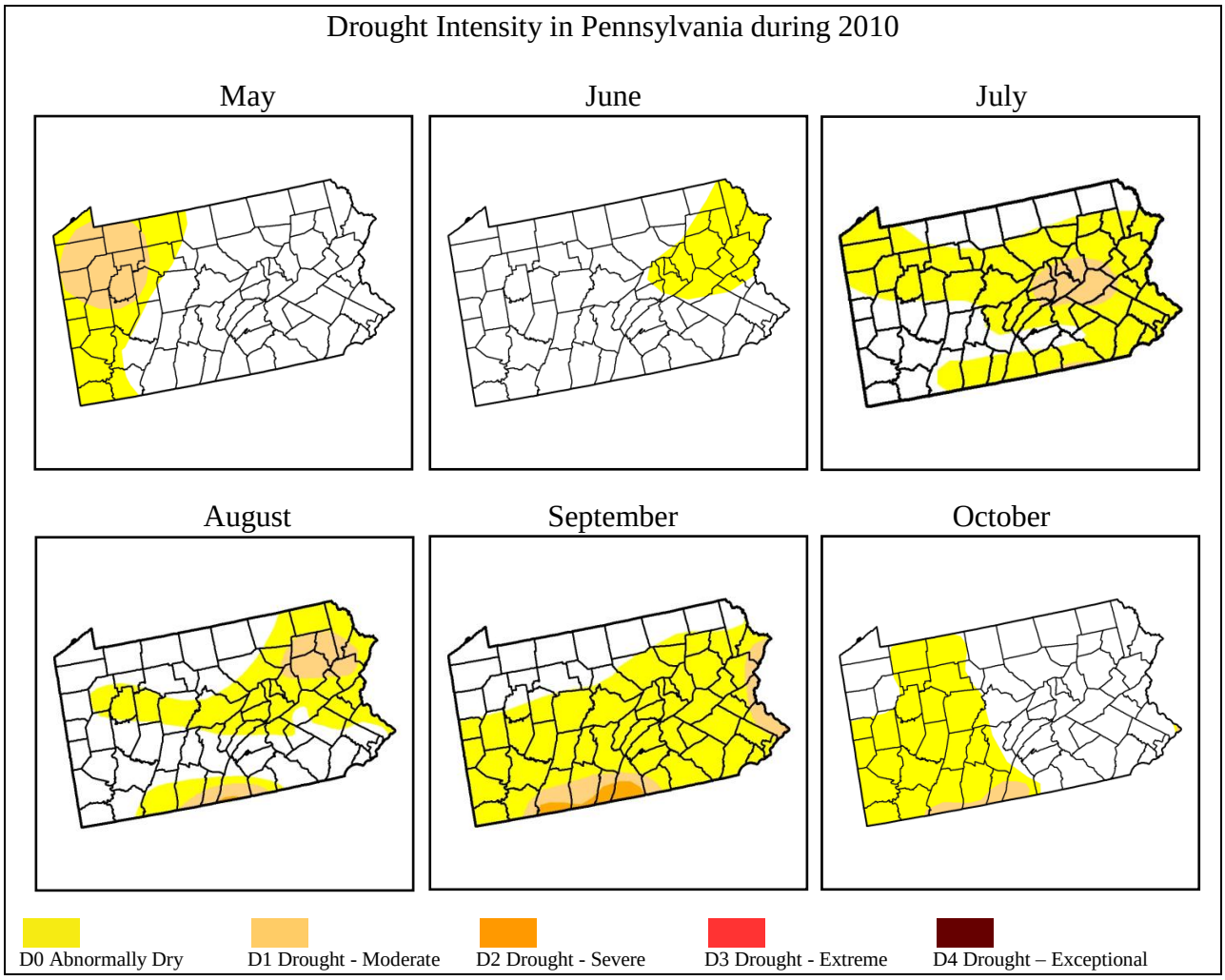

Figure 6. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for Pennsylvania in 2010.

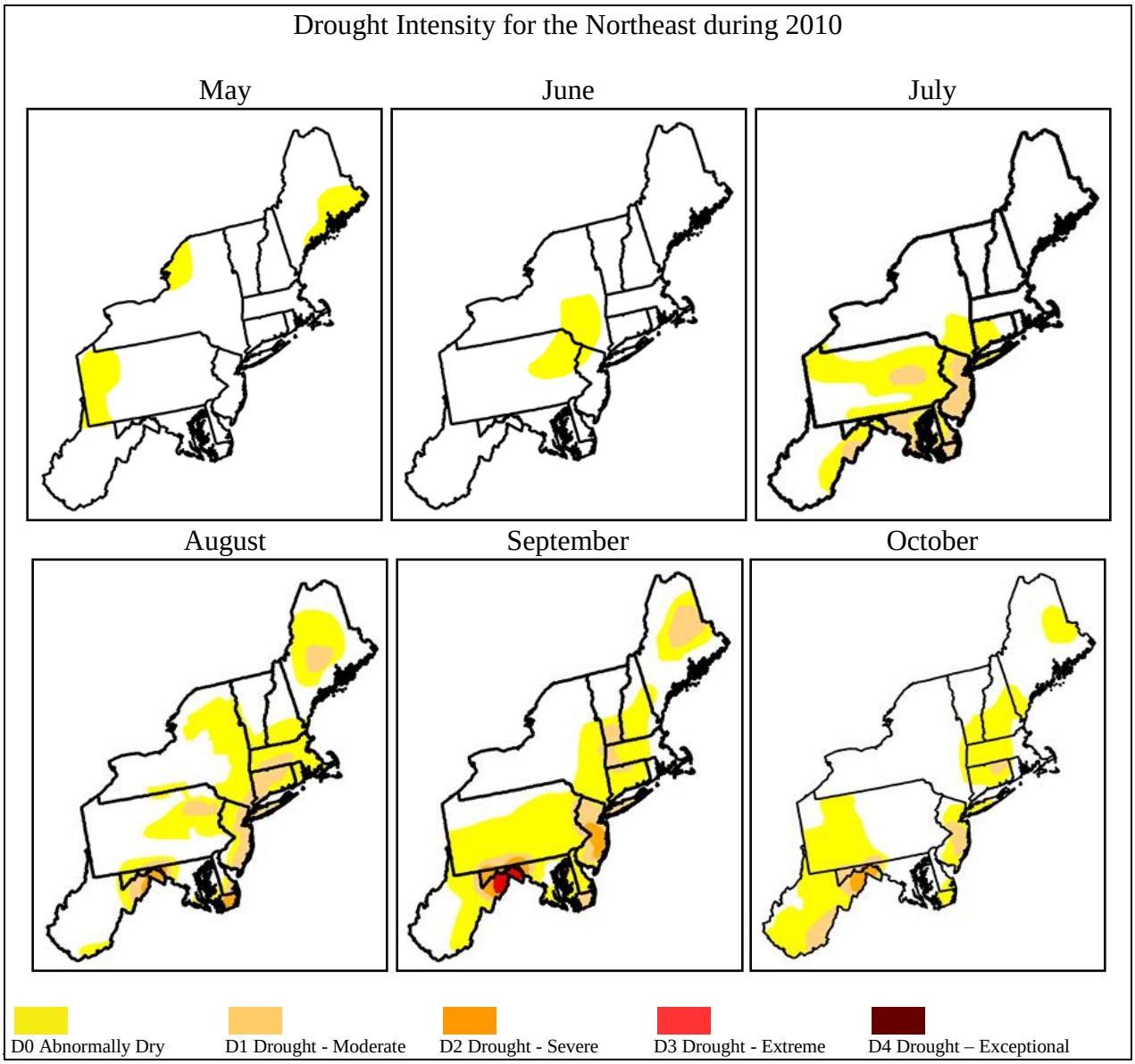

Figure 7. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for the Northeast in 2010.

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