



Weather of Petersburg National Battlefield and Richmond National Battlefield Park

Mid-Atlantic Network Summary Report for 2012

Natural Resource Data Series NPS/MIDN/NRDS—2013/503



ON THE COVER

Petersburg National Battlefield .

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Natural Resource Data Series NPS/MIDN/NRDS—2013/503

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June 2013

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

Knight, P., K. Imhoff, C. Bahrmann, A. Person, and S. Miller. 2013. Weather of Petersburg National Battlefield and Richmond National Battlefield Park: Mid-Atlantic Network summary report for 2013. Natural Resource Data Series NPS/MIDN/NRDS—2013/503. National Park Service, Fort Collins, Colorado.

Table of Contents

	Page
Figures.....	iv
Tables.....	v
List of Key Acronyms.....	vi
Introduction.....	1
Climate of the Tidewater and Eastern Piedmont Region of Virginia	2
Observation Stations	3
Temperature Summary.....	6
Precipitation Summary.....	12
Drought Status	16
References	20

Figures

	Page
Figure 1. Location of weather observing stations around Petersburg National Battlefield and Richmond National Battlefield Park selected as most representative of the parks in 2012.....	4
Figure 2. Maps showing departure from average monthly maximum temperature compared to the 30-year normal (1981–2010).....	8
Figure 3. Maps showing departure from average monthly minimum temperature compared to the 30-year normal (1981–2010).....	9
Figure 4. Maps showing percent of average monthly precipitation compared to the 30-year normal (1981–2010).....	14
Figure 5. Palmer Drought Severity Index (PDSI) for the Eastern Piedmont, 2010–2012.....	17
Figure 6. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for Virginia in 2012.	18
Figure 7. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for the Southeast in 2012.	19

Tables

	Page
Table 1. List of weather observing stations around Petersburg National Battlefield and Richmond National Battlefield Park selected as most representative of the parks in 2012.....	5
Table 2. Status of 2012 temperature indicators compared to the 30-year normal (1981–2010) at the Richmond Airport (KRIC) and Hopewell (HOPV2) weather observing stations.	7
Table 3. Summary of 2012 monthly average temperatures for selected stations.....	10
Table 4. Summary of 2012 departure from normal temperature based on the 30-year normal (1981–2010) for selected stations.....	10
Table 5. Seasonal and annual temperature and precipitation rankings for 2012 over 118 years for the Tidewater (NOAA 2012).	11
Table 6. Seasonal and annual temperature and precipitation rankings for 2012 over 118 years for the Eastern Piedmont (NOAA 2012).	11
Table 7. Status of 2012 precipitation indicators compared to the 30-year normal (1981–2010) at the Richmond Airport (KRIC) and Hopewell (HOPV2) weather observing stations.	13
Table 8. Top five wettest days and top five dry spells (consecutive days with a trace or less of liquid precipitation) during 2012 from the weather observing stations at Richmond Airport (KRIC) and Hopewell (HOPV2).	15
Table 9. Summary of 2012 monthly total precipitation for selected stations.	15
Table 10. Summary of 2012 percent of normal total precipitation based on the 30-year normal (1981–2010) for selected stations.....	15

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
IFLOWS	Integrated Flood Observing and Warning System
MIDN	Mid-Atlantic Network
NADP	National Atmospheric Deposition Program
NARR	North American Regional Reanalysis
NB	National Battlefield
NBP	National Battlefield Park
NCDC	National Climatic Data Center
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PASC	Pennsylvania State Climatologist
PDSI	Palmer Drought Severity Index
PETE	Petersburg National Battlefield
POR	Period of Record
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RAWS	Remote Automated Weather Stations
RICH	Richmond National Battlefield Park
USDM	United States Drought Monitor
USEPA	United States Environmental Protection Agency
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 (Comiskey and Callahan 2008).

The purpose of this report is to provide a concise weather and climate summary for January 1 to December 31, 2012, and to place current patterns and trends in an appropriate historical, regional, and global 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 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 these objectives, 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. 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 2012'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. 2012) and summarized in this report.

Climate of the Tidewater and Eastern Piedmont Region of Virginia

Petersburg National Battlefield (NB) and Richmond National Battlefield Park (NBP) lie in VA Climate Division 1 (Tidewater) and VA Climate Division 2 (Eastern 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/usclimdivs/data/map.html>). Virginia is divided into six climate divisions. These divisions of Virginia are generally considered to have a humid, continental type of climate, but the rolling hills and valleys have a marked effect on the weather and climate of the parks. 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, 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 significant effect within this part of Virginia, causing severe floods in some instances.

Temperatures are moderately continental with the tempering effects due to nearby mountains that contribute to cloud production in the summer and onshore winds modifying the chill at times during the winter. 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 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 area. The southwest winds gain additional warmth when descending the crest of the Appalachians. The last freeze and first frost typically occur in mid-April and late October or early November, respectively.

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 40–45 in (1,016–1,143 mm). Greatest amounts usually occur during 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 years with more 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. On average, annual snowfall amounts tend to be slightly greater in Richmond NBP than Petersburg NB.

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, occurring about once every other year, but flash floods and damaging thunderstorm winds affect parts of the parks each summer. On average, tornadoes pass through the area about once every three years. The direct effects of an Atlantic hurricane are irregular, 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 and are primarily confined to the months between December and March (Kocin and Uccellini 2004).

Observing Stations

A total of four weather observing stations, comprising three weather networks, were selected around Petersburg NB and Richmond NBP. Representative stations within a 100-km range of each park were chosen based on several criteria, which include proximity to the park, representativeness of the station to the park elevation profile, 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. A total of three stations were ultimately used for this 2012 report: Richmond, Petersburg, and Hopewell. (Figure 1, Table 1).

The average value of a climate element over 30 years is defined as a climatological normal, which is 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 be the 30-year normal or the pseudo-normal calculated on a shorter time frame

Of the four stations, Richmond and Hopewell have a Period of Record (POR) sufficiently long for a 30-year normal (1981–2010). A normal was also calculated for Petersburg based on a POR from 1996–2010. Monthly averages and deviations from normal are presented for all stations for precipitation and temperature except for I-295 Over Meadow Road which only has six years of data.

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 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.

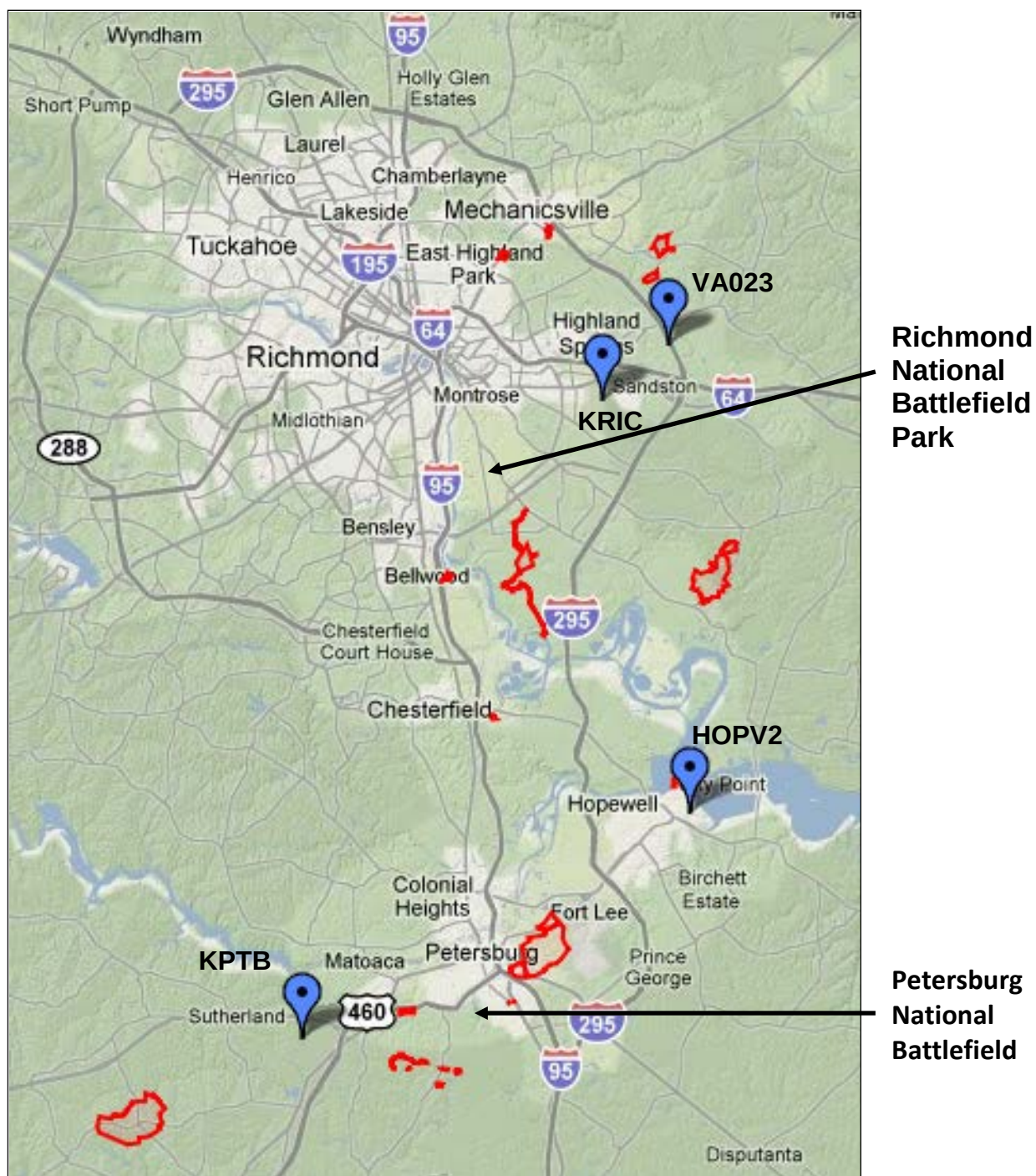


Figure 1. Location of weather observing stations around Petersburg National Battlefield and Richmond National Battlefield Park selected as most representative of the parks in 2012. See Table 1 for station names.

Table 1. List of weather observing stations around Petersburg National Battlefield and Richmond National Battlefield Park selected as most representative of the parks in 2012.

Station	Observing Network ¹	Name	Period of Record (POR)		Percentage of Time Reporting Temperature for 2012	Percentage of Time Reporting Precipitation for 2012	Percentage of Time Reporting Temperature for entire POR	Percentage of Time Reporting Precipitation for entire POR
KRIC	ASOS	Richmond International Airport	02/01/1949	Present	100.0	100.0	96.0	88.7
KPTB	ASOS	(Petersburg) Dinwiddie County Airport	01/01/1996	Present	98.6	98.6	81.0	63.5
HOPV2	COOP	Hopewell	01/01/1960	Present	98.9	98.9	97.5	97.7
VA023	RWIS	I-295 Over Meadow Road ²	08/24/2005	Present	-	-	83.6	57.8

¹ Observing networks are: ASOS — Automated Surface Observation System, COOP — National Weather Service Cooperative Observer Program, and RWIS — Road Weather Information System.

² No data available for this station in 2012.

Temperature Summary

It was the warmest year on record for the area around Petersburg NB and Richmond NBP (Table 2, Figures 2 and 3). Only June, September and November in 2012 had widespread below normal readings, leaving nine months warmer than average (Figure 3)¹.

January was mild with monthly departures ranging from 4.5 to 7.2°F (2.5 to 3.9°C) above normal (Tables 3 and 4). The lowest readings of 2012 occurred on January 4th when minimum temperatures fell to 17°F (-8.3°C) at Richmond and 20°F (-6.7°C) at Hopewell, both about 8-10°F (4.4-5.6°C) above the average annual minimum (Table 2). February stayed mild with daytime and nighttime readings above average (Figures 2 and 3). The mild spell culminated in March as readings ranged from 9.2°F (5.1°C) to 10.6°F (5.9°C) above the long-term mean (Table 4). Overall, the winter was the warmest in the Tidewater since records began in 1895 (Table 5).

Spring began cool. In fact, March's mean temperatures were actually higher than April at Hopewell. April's monthly temperatures ranged from 58.5°F (14.7°C) at Richmond to 60.8°F (15.9°C) at Petersburg (Table 3). May turned warm, as mean temperatures were between 0.9°F to 4.1°F (0.4°C to 2.3°C) above normal (Table 4; Petersburg was nearly normal). June brought negative anomalies (Figure 2) ranging from 1.3°F to 2.7°F (0.7°C to 1.5°C) below normal (Table 4). The spring season ranked as the 18th to 19th warmest in the Tidewater and in the Eastern Piedmont since records began in 1895 (Tables 5 and 6).

Summer of 2012 started very warm, but August and September departures were near to below normal (Figures 2 and 3). Hot days and warm nights during July resulted in mean temperatures ranging from 2.0°F to 3.6°F (1.1°C to 2.0°C) above the normal at the stations (Table 4). Readings during August varied from 78.2 °F (25.7°C) at Richmond to 79.1°F (26.2°C) in Hopewell (Table 3). Slightly cooler-than-average days during September contributed to below-normal temperatures across the region (Table 4). The persistent heat in July and early August raised the tally of hot days to 45 days compared with a long-term average of 42 to 46 days (Table 2). The highest reading of 2012 was 104°F (40°C) on July 7th, above the normal (Table 2), with 4 days rising to or above 100°F (37.8°C). The summer season ranked the 13-17th hottest in 118 years in both the Tidewater and the Eastern Piedmont (Tables 5 and 6).

The autumn began with cool daytime and mild nighttime readings in October (Figures 2 and 3). October was near seasonal levels with monthly mean temperatures ranging from -0.7°F to +1.8°F (-0.3 to +1.0°C) below the 1981–2010 means (Table 4). November turned much cooler and brought the largest negative departures of the year. And December was much milder such that its mean temperatures were higher than November. The number of sub-freezing days was well below the 30-year average (Table 2) and the first freeze of the fall occurred on November 3rd (Table 2). The annual maximum temperatures averaged 2.2°F (1.2°C) above normal and minimum readings averaged as much as 2.5°F (1.4°C) above normal (Table 2).

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

Table 2. Status of 2012 temperature indicators compared to the 30-year normal (1981–2010) at the Richmond Airport (KRIC) and Hopewell (HOPV2) weather observing stations.

Temperature Indicator	Richmond Airport 2012	Richmond Airport 1981–2010	Hopewell 2012	Hopewell, 1981–2010
Average Annual Temperature	61.1°F 16.2°C	58.9°F 14.9°C	63.2°F 17.3°C	61.5°F 16.4°C
Average Annual Maximum Temperature	71.8°F 22.1°C	69.6°F 20.9°C	73.2°F 22.9°C	71.6°F 22.0°C
Maximum Temperature	104.0°F 40.0°C	99.8°F 37.7°C	102.0°F 38.9°C	100.3°F 37.9°C
Hot Days (days with Tmax ≥90°F/32°C)	45	42	40	46
Average Annual Minimum Temperature	50.6°F 10.3°C	48.1°F 8.9°C	53.0°F 11.7°C	51.4°F 10.8°C
Minimum Temperature	17.0°F -8.3°C	9.6°F -12.4°C	20.0°F -6.7°C	11.3°F -11.5°C
Cold Days (days with Tmax ≤32°F/0°F)	0	5	0	2
Sub-freezing Days (days with Tmin ≤32°F/0°C)	55	74	32	52
Sub-zero Days (days with Tmin ≤0°F/-18°C)	0	0	0	0
Growing Season Length (days between last spring Tmin 32°F/0°C and first fall Tmin 32°F/0°C)	238	218	242	214 ¹

¹Normal growing season length for Hopewell (1981-2010) was approximated using temperature data from Petersburg, VA (KPTW).

Petersburg National Battlefield
and Richmond National Battlefield Park
Departure from Average Monthly Maximum Temperature
2012 vs. 1981–2010

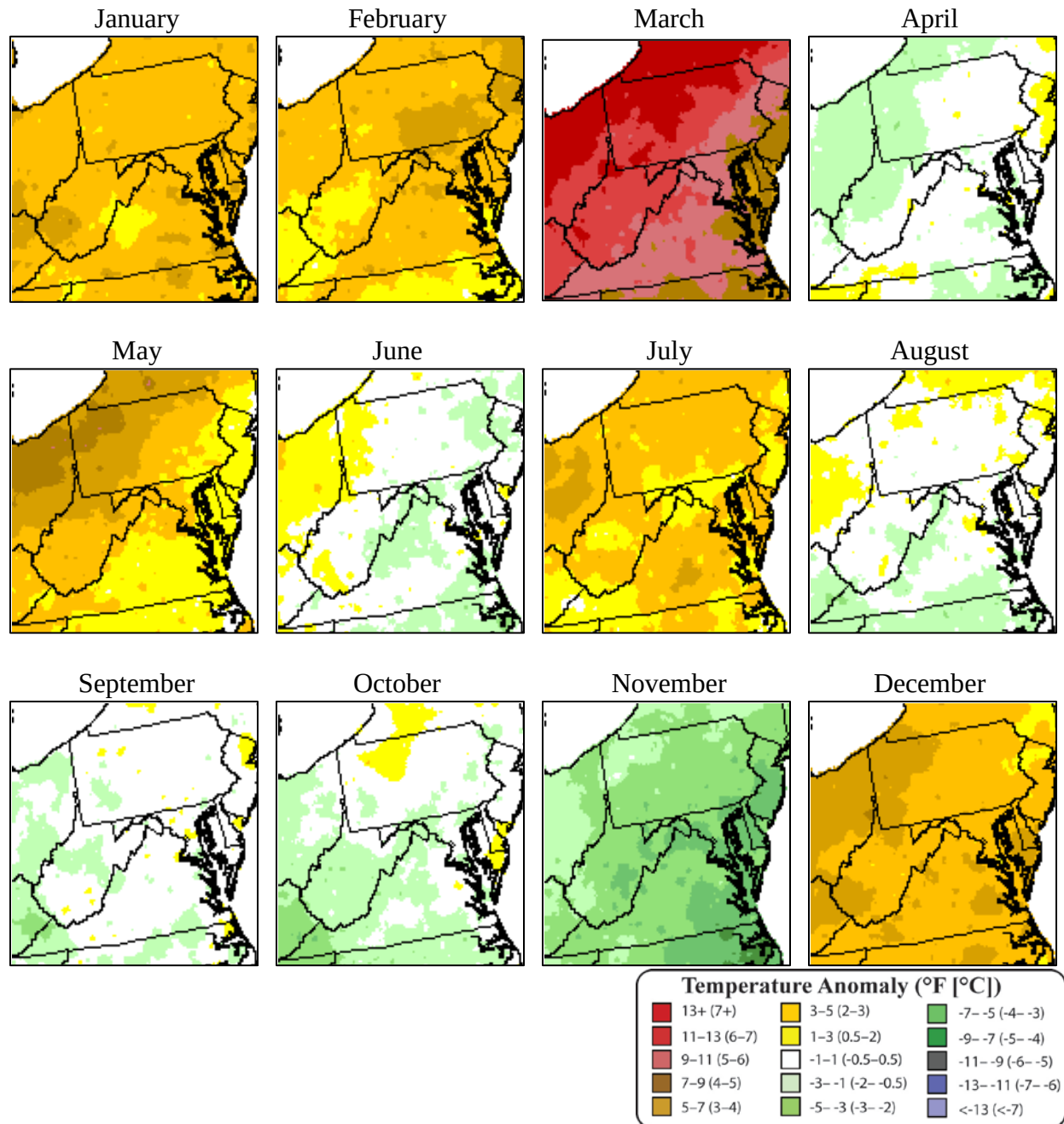


Figure 2. Maps showing departure from average monthly maximum temperature compared to the 30-year normal (1981–2010).

Petersburg National Battlefield
and Richmond National Battlefield Park
Departure from Average Monthly Minimum Temperature
2012 vs. 1981–2010

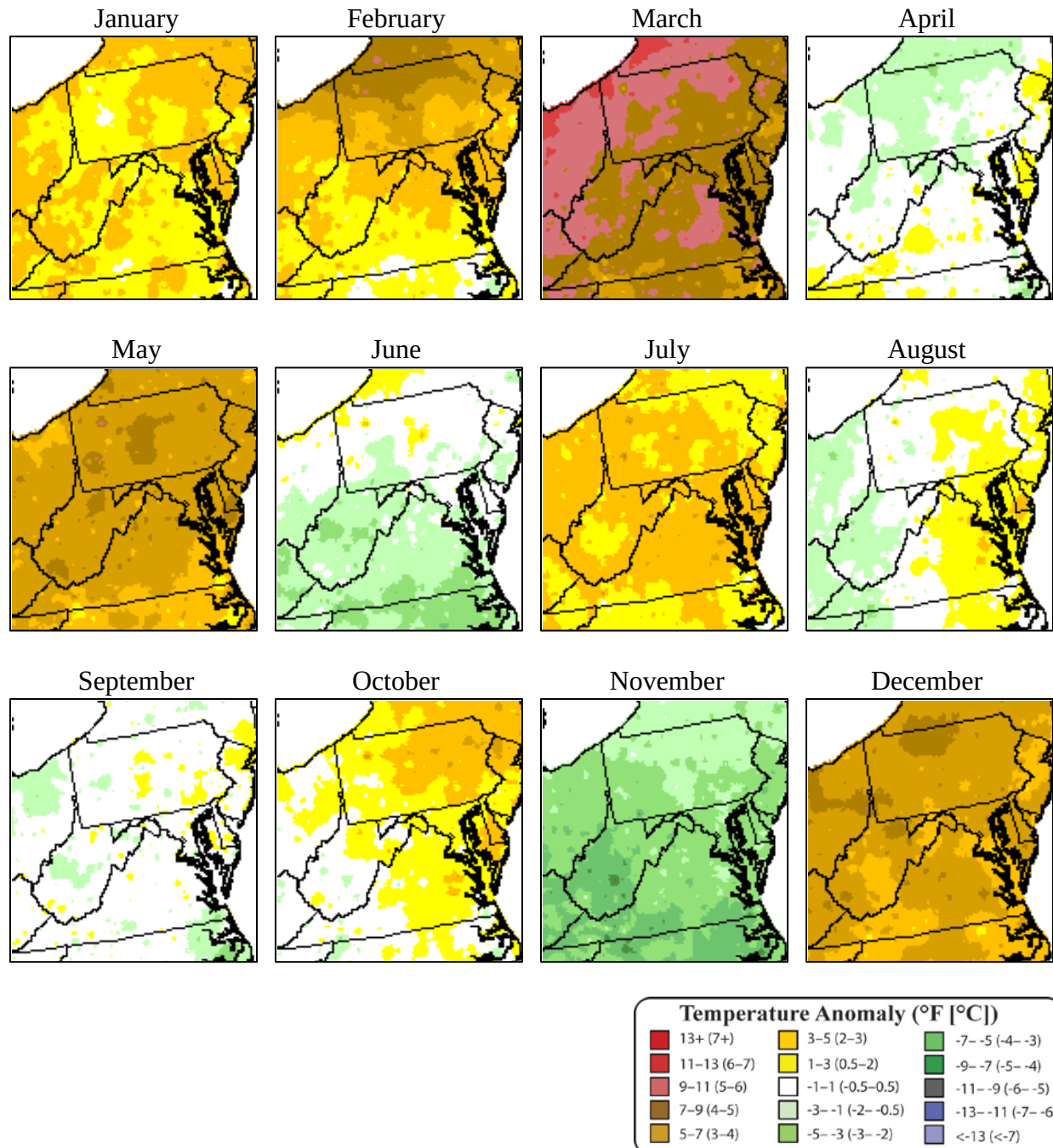


Figure 3. Maps showing departure from average monthly minimum temperature compared to the 30-year normal (1981–2010).

Table 3. Summary of 2012 monthly average temperatures for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Richmond Airport	KRIC	42.6°F	44.7°F	58.3°F	58.5°F	70.5°F	74.1°F	82.7°F	78.2°F	70.3°F	60.4°F	46.3°F	46.7°F	61.1°F
		5.9°C	7.1°C	14.6°C	14.7°C	21.4°C	23.4°C	28.2°C	25.7°C	21.3 °C	15.8°C	7.9°C	8.2°C	16.2°C
Petersburg Airport	KPTB	45.6°F	46.1°F	60.4°F	60.8°F	70.0°F	77.5 °F	81.2°F	79.1°F	72.6°F	61.3°F	48.8°F	47.9°F	61.2°F
		7.6°C	7.8°C	15.8°C	15.9°C	21.1°C	25.3°C	27.3°C	26.2°C	22.6°C	16.3°C	9.3°C	8.8°C	16.2°C
Hopewell	HOPV2	45.7°F	47.8°F	62.2°F	60.8°F	70.9°F	75.5 °F	84.0°F	79.1°F	72.0°F	62.6°F	48.3°F	49.3°F	63.2°F
		7.6°C	8.8°C	16.8°C	16.0°C	21.6°C	24.2°C	28.9°C	26.2°C	22.2°C	17.0°C	9.1°C	9.6°C	17.3°C

Table 4. Summary of 2012 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
Richmond Airport	KRIC	4.7°F	4.0°F	9.7°F	0.2°F	4.1°F	-1.3 °F	3.6°F	0.7°F	-0.2°F	-0.7°F	-4.1°F	5.8°F	2.3°F
		2.6°C	2.2°C	5.4°C	0.1°C	2.3°C	-0.7°C	2.0°C	0.4°C	-0.1°C	-0.4°C	-2.3°C	3.2°C	1.3°C
Petersburg Airport ¹	KPTB	7.2°F	1.4°F	9.2°F	-4.5°F	0.9°F	-2.7°F	2.0°F	-1.3°F	-3.1°F	1.8°F	-6.5°F	-0.5°F	0.4°F
		3.9°C	0.8°C	5.1°C	-2.5°C	0.5°C	-1.5°C	1.1°C	-0.7°C	-1.7°C	1.0°C	-3.6°C	-0.3°C	0.2°C
Hopewell	HOPV2	4.5°F	-0.1°F	10.6°F	-0.4°F	1.8°F	-1.6°F	3.2°F	-0.1°F	-0.9°F	0.2°F	-4.9°F	5.2°F	1.7°F
		2.5°C	-0.0°C	5.9°C	-0.2°C	1.0°C	-0.9°C	1.8°C	-0.0°C	-0.5°C	0.1°C	-2.7°C	2.9°C	0.9°C

¹Indicates a station's Period of Record does not cover the period of 1981-2010 but is ten or more 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 10 years were not included in this table.

Table 5. Seasonal and annual temperature and precipitation rankings for 2012 over 118 years for the Tidewater (NOAA 2012).

	Climate Division 1 Rankings — Tidewater				
	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN	Jan–Dec YEAR
Temperature-2012	1	19	T-17	T-32	1
Precipitation-2012	105	63	T-54	20	65

1 = warmest/wettest year and 118 = coldest/driest year. T = tie between two or more years.

Table 6. Seasonal and annual temperature and precipitation rankings for 2012 over 118 years for the Eastern Piedmont (NOAA 2012).

	Climate Division 2 Rankings — Eastern Piedmont				
	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN	Jan–Dec YEAR
Temperature-2012	2	18	T-13	T-22	1
Precipitation-2012	90	95	T-57	95	107

1 = warmest/wettest year and 118 = coldest/driest year. T = tie between two or more years.

Precipitation Summary

The year was characterized by notably drier conditions than 2011 at Petersburg NB and Richmond NBP, as both stations recorded below normal rainfall of between 2.5 -7.2 in (63-183 mm) (Table 7). Overall, a normal summer was more than offset by a dry winter and autumn (Tables 5 and 6).

Similar to other locations across the region, the winter months for Petersburg NB and Richmond NBP were the driest in the last five years. The Tidewater, which encompasses most of Petersburg NB and Richmond NBP, reported the 13th driest winter in 118 years of records (Table 5). There was one long dry spell during the winter, from January 1-8 (Table 8). As a result, January was notably drier with 30 to 57 percent of normal precipitation falling (Tables 9 and 10). Annual snowfall totals for 2012 were well below the long-term average as only 4.5 in (11.3 cm) was tallied at Richmond and a mere 1.5 in (3.8 cm) at Hopewell (Table 7).

The precipitation deficit grew in the spring, despite being a bit moister. The month of April was still drier than average with 1.5 in (38 mm) of rain reported in Petersburg and 2.9 in (74 mm) in Hopewell, and all locations tallying less than 80 percent of the normal values (Tables 9 and 10). There was one long dry spell during the spring and when combined with a seasonably moist May and June, it was the 24th driest spring recorded in the Eastern Piedmont (Table 5).

Summer rainfall was relatively uniform across the Petersburg NB and Richmond NBP region. As an example, the Tidewater, which encompasses most of Richmond NBP, reported the 54th wettest summer in 118 years of records, while the adjacent Eastern Piedmont only tallied its 57th wettest summer of record (Tables 5 and 6), that is, normal. None of the selected representative weather stations measured less than 85 percent of average rainfall (Table 10) during all three months. No direct effects of tropical cyclones were noted during this quarter of 2012, but two of the wettest days of the year occurred, one during August and one in September. One dry spell occurred in this period from September 20-27 (Table 8).

The final three months of the year ranged from rather moist in the Tidewater to somewhat dry in the Eastern Piedmont region (Tables 5 and 6). October had precipitation ranging from 109 to 134 percent of normal (Table 10) as the effects of Hurricane Sandy were noticed at the end of the month. November was parched with totals ranging from 15 to 18 percent of normal and Petersburg tallying only 0.3 in (8 mm) during this month (Tables 9 and 10). December brought near-average precipitation. The most notable dry spell in 2012 occurred from November 14 -26 (Tables 8 and 10). Overall, 2012 featured a near-average number of micro-droughts and slightly below normal number of extreme precipitation days (Table 7). For the Eastern Piedmont, this was the 12th driest on record.

Table 7. Status of 2012 precipitation indicators compared to the 30-year normal (1981–2010) at the Richmond Airport (KRIC) and Hopewell (HOPV2) weather observing stations.

Precipitation Indicator	Richmond Airport 2012	Richmond Airport 1981–2010	Hopewell 2012	Hopewell 1981–2010
Annual Precipitation	36.6 in 930 mm	43.8 in 1,113 mm	43.8 in 1,113 mm	46.3 in 1,176 mm
Autumn (Oct, Nov, Dec) Precipitation	7.1 in 180 mm	9.5 in 241 mm	7.0 in 178 mm	10.3 in 262 mm
Heavy Precipitation Days (days with ≥ 1.0 in (25 mm) rain)	10	11	10	13
Extreme Precipitation Days (days with ≥ 2.0 in (51 mm) rain)	2	2	2	3
Micro-drought (strings of 7+ days without rain)	10	4	8	8
Annual Snowfall	4.5 in 11.4 cm	10.3 in 26.2 cm	1.5 in 3.8 cm	3.9 in 9.9 cm
Measurable Snow Days (days with ≥ 0.1 in (0.3 cm) snow)	3	6	1	1
Moderate Snow Days (days with ≥ 3.0 in (7.6 cm) snow)	1	1	0	1
Heavy Snow Days (days with ≥ 5.0 in (12.7 cm) snow)	0	1	0	0

Petersburg National Battlefield
and Richmond National Battlefield Park
Percent of Average Monthly Precipitation
2012 vs. 1981–2010

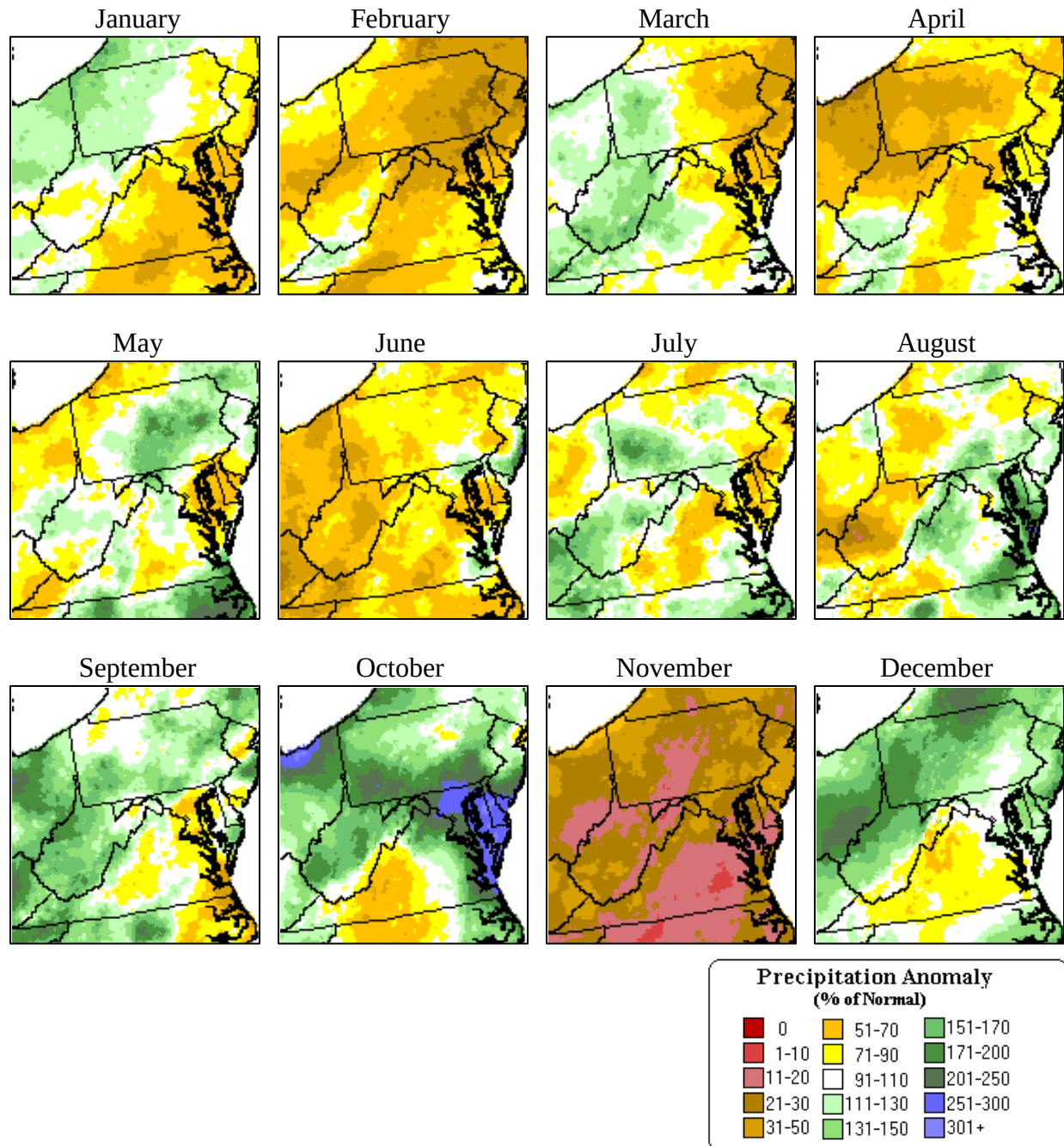


Figure 4. Maps showing percent of average monthly precipitation compared to the 30-year normal (1981–2010).

Table 8. Top five wettest days and top five dry spells (consecutive days with a trace or less of liquid precipitation) during 2012 from the weather observing stations at Richmond Airport (KRIC) and Hopewell (HOPV2).

Wettest Days in 2012	Dry Spells in 2012
Oct. 29: 1.96 in (49.8 mm) ¹	April 1-April 13
June 22: 1.85 in (47 mm)	Nov. 14-Nov 26
Aug. 25: 1.75 in (44.5 mm)	Sep. 20-Sep 27
April 22: 1.59 in (40.4 mm)	Jan 1-Jan 8
Sept. 2: 1.57 in (39.9 mm)	Oct. 1-Oct 8

¹ Hurricane Sandy

Table 9. Summary of 2012 monthly total precipitation for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Richmond Airport	KRIC	1.7 in	3.2 in	2.5 in	2.4 in	2.5 in	4.3 in	5.3 in	3.5 in	4.1 in	4.0 in	0.3 in	2.8 in	36.6 in
		43 mm	81 mm	64 mm	61 mm	64 mm	109 mm	134 mm	89 mm	105 mm	102 mm	8 mm	71 mm	930 mm
Petersburg Airport	KPTB	1.4 in	1.0 in	2.1 in	1.5 in	2.5 in	4.0 in	5.9 in	4.6 in	5.4 in	3.6 in	0.3 in	1.7 in	37.9 in
		36 mm	25 mm	54 mm	38 mm	63 mm	102 mm	150 mm	122 mm	139 mm	92 mm	8 mm	43 mm	962 mm
Hopewell	HOPV2	1.9 in	3.7 in	2.1 in	2.9 in	5.5 in	2.9 in	7.4 in	5.4 in	5.1 in	3.9 in	0.2 in	2.9 in	43.8 in
		48 mm	94 mm	54 mm	74 mm	141 mm	74 mm	188 mm	137 mm	130 mm	100 mm	5 mm	74mm	1,113 mm

Table 10. Summary of 2012 percent of normal total 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
Richmond Airport	KRIC	57	117	62	73	88	109	117	85	98	134	18	87	83.5
Petersburg Airport ¹	KPTB	30	65	75	66	73	97	141	110	119	109	15	51	79
Hopewell	HOPV2	54	115	50	77	124	86	158	107	111	119	16	83	94

¹Indicates a station's Period of Record does not cover the period of 1981-2010 but is 10 years or more. 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 10 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. The long-term average is “zero”. Monthly PDSI values for the Eastern Piedmont in 2012 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 2011). 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 Virginia (Figure 6) and the Southeast (Figure 7) are shown for 2012.

According to the PDSI, 2012 in the Eastern Piedmont, it was quite dry throughout the year. The dry pattern intensified through the end of the growing season. The very dry weather during the autumn resulted in the drought index remaining at moderate drought levels through the end of the year. An exceptionally wet period in late October kept the PDSI from falling below moderate drought levels, but drier weather returned in November. Compared to previous years, 2012 was notably drier than 2010 and 2011, especially during the late autumn. However, the majority of the growing season was dry for the third consecutive year.

The DM – Drought Severity Index for Virginia (Figure 6) and the Southeast (Figure 7) shows a pattern similar to the PDSI for the growing season (May through October); with July to September being the depths of the drought during the growing season (D1-D2).

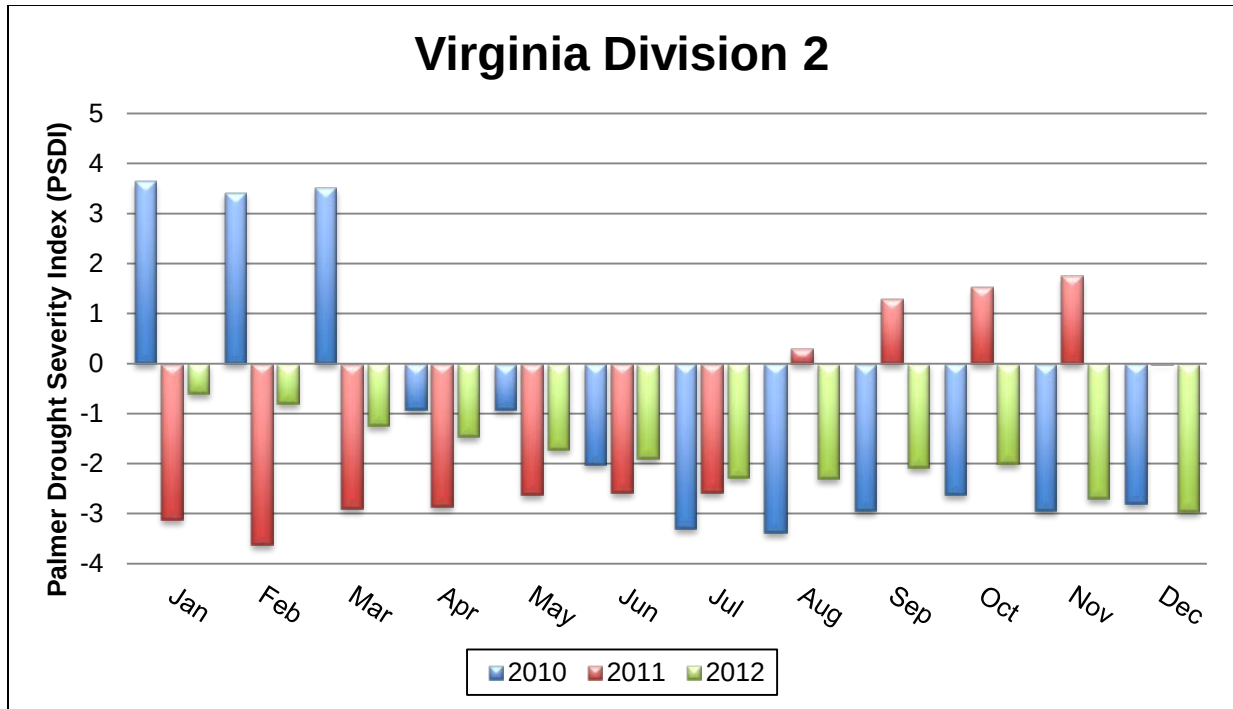


Figure 5. Palmer Drought Severity Index (PDSI) for the Eastern Piedmont, 2010–2012.

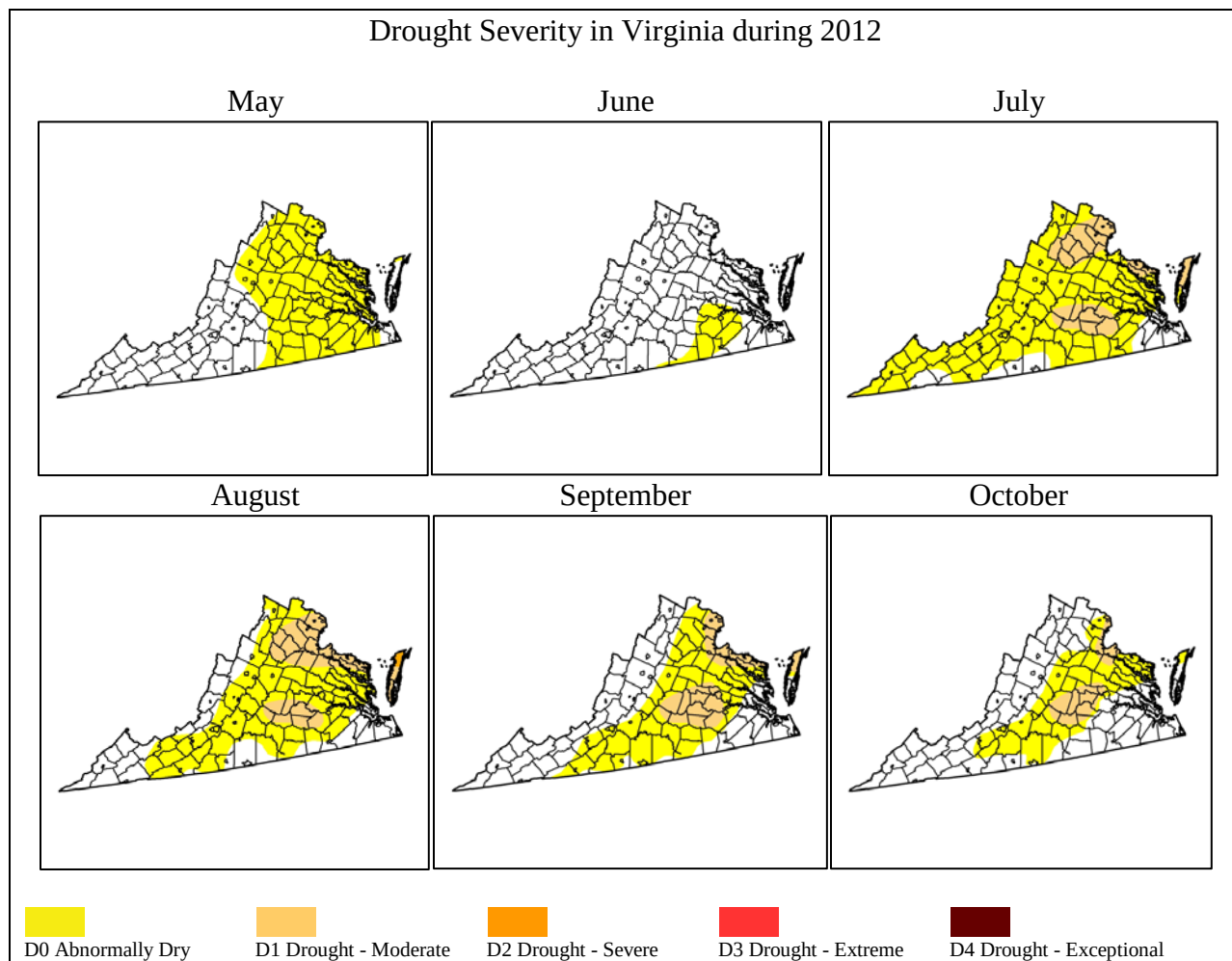


Figure 6. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for Virginia in 2012.

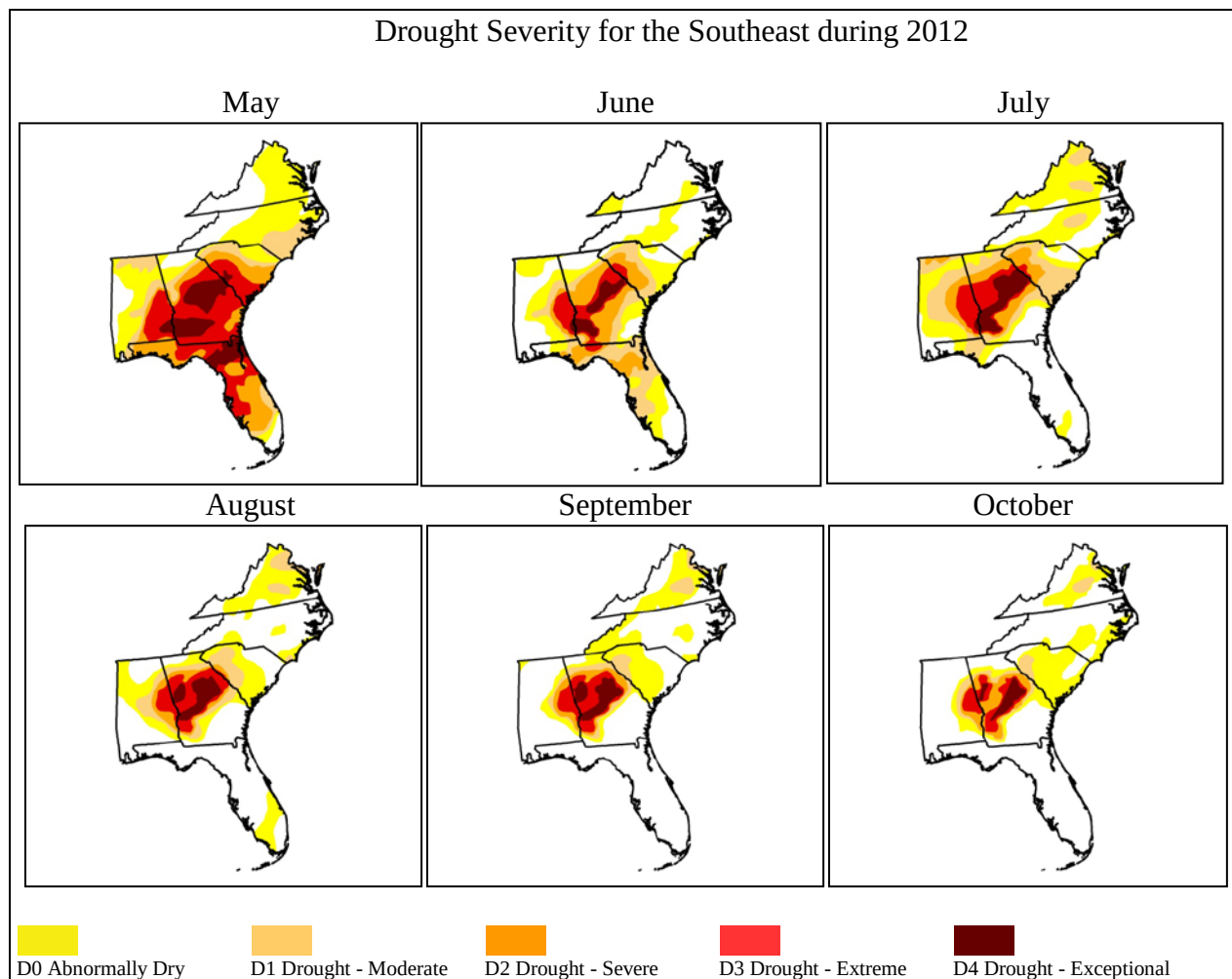


Figure 7. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for the Southeast in 2012.

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NPS 325/121326, 367/121326, June 2013

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