National Park Service
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Natural Resource Stewardship and Science

Weather of Bluestone National Scenic River, Gauley River National Recreation Area, and New River Gorge National River

Eastern Rivers and Mountains Network Summary Report for 2011

Natural Resource Data Series NPS/ERMN/NRDS—2012/384

ON THE COVER
Mist over insignificant rapid, Gauley River, Gauley River National Recreation Area.
Photograph by: Jim Vanderhorst.

Weather of Bluestone National Scenic River, Gauley River National Recreation Area, and New River Gorge National River

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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. These reports are 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
BLUE	Bluestone National Scenic River
COOP	National Weather Service Cooperative Observer Program
CWOP	Citizen Weather Observer Program
ERMN	Eastern Rivers and Mountains Network
GARI	Gauley River National Recreational Area
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
NERI	New River Gorge National River
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NR	National River
NRA	National Recreation Area
NSR	National Scenic River
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
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, 2011, 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 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 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 and these are the primary data sources used to profile climate summary and trends.

In addition to a suite of summary tables, graphs, and narratives, we specifically identify a series of key 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 the body of this report.

Climate of the Central and Southern West Virginia Region

Bluestone National Scenic River (NSR) is located in West Virginia (WV) Climate Division 5, "Southern," while Gauley River National Recreation Area (NRA) is located in WV Climate Division 4, "Central." New River Gorge National River (NR) is located within both. A climate division is a region that is reasonably homogenous with respect to climatic and hydrologic characteristics (http://www.esrl.noaa.gov/psd/data/usclimdivs/data/map.html [NOAA 2011]) and is frequently used for compiling climate statistics. West Virginia is divided into six climate divisions.

The two climate divisions encompassing these parks 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 this region. The prevailing westerly winds carry most of the weather disturbances that affect the region from the interior of the continent, with the Atlantic Ocean having only an occasional influence on the climate of the area (Davey et al. 2006). Coastal storms do, at times, affect the day-to-day weather, especially in the winter. Infrequently, storms of tropical origin can have a significant effect, causing severe floods in some instances.

Temperatures are moderately continental, with the tempering effects of the Great Lakes contributing to cloud production in the winter and mountain-valley circulation clouds 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 region 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 Ohio Valley and West Virginia. The humid southwest winds ascending the crest of the Appalachians can produce widespread afternoon thunderstorms. On average, Gauley River National Recreational Area tends to have a greater number of hot days (temperatures above or equal to 90.0°F/32.0°C) than New River Gorge National River and Bluestone National Scenic River. The last freeze typically occurs in mid-May and the first frosts appear in October.

Precipitation is fairly evenly distributed throughout the year. Annual amounts generally range between 36–52 in (914–1,321 mm), while the majority of places receive 38–44 in (965–1,118 mm). Greatest amounts usually occur in the late spring and summer months, while February is the driest month, having about 2 in (51 mm) less than the wettest months. During the warm season, the uneven heating over the irregular terrain leads to numerous thunderstorms which typically form over the mountains.

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 region each summer. On average, tornadoes pass through the area about once every three years. The direct effects of an Atlantic hurricane are uncommon, though remnant rains from 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

Eleven weather observing stations, comprising three observing networks, were selected around Bluestone NSR, Gauley River NRA, and New River Gorge NR. Representative stations within a 100-km range of each park were chosen based on several criteria, including proximity to the park, the representativeness of the station to the park elevation profile, the type and frequency of observations, the period of record of the data, and data availability (Marshall et al. 2012). Moreover, the percentage of time a station reports particular parameters (e.g., temperature) can influence data inclusion. No stations were excluded in 2011 due to this criterion; therefore, all 11 stations were used for this report (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-normal 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 will be 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.

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.

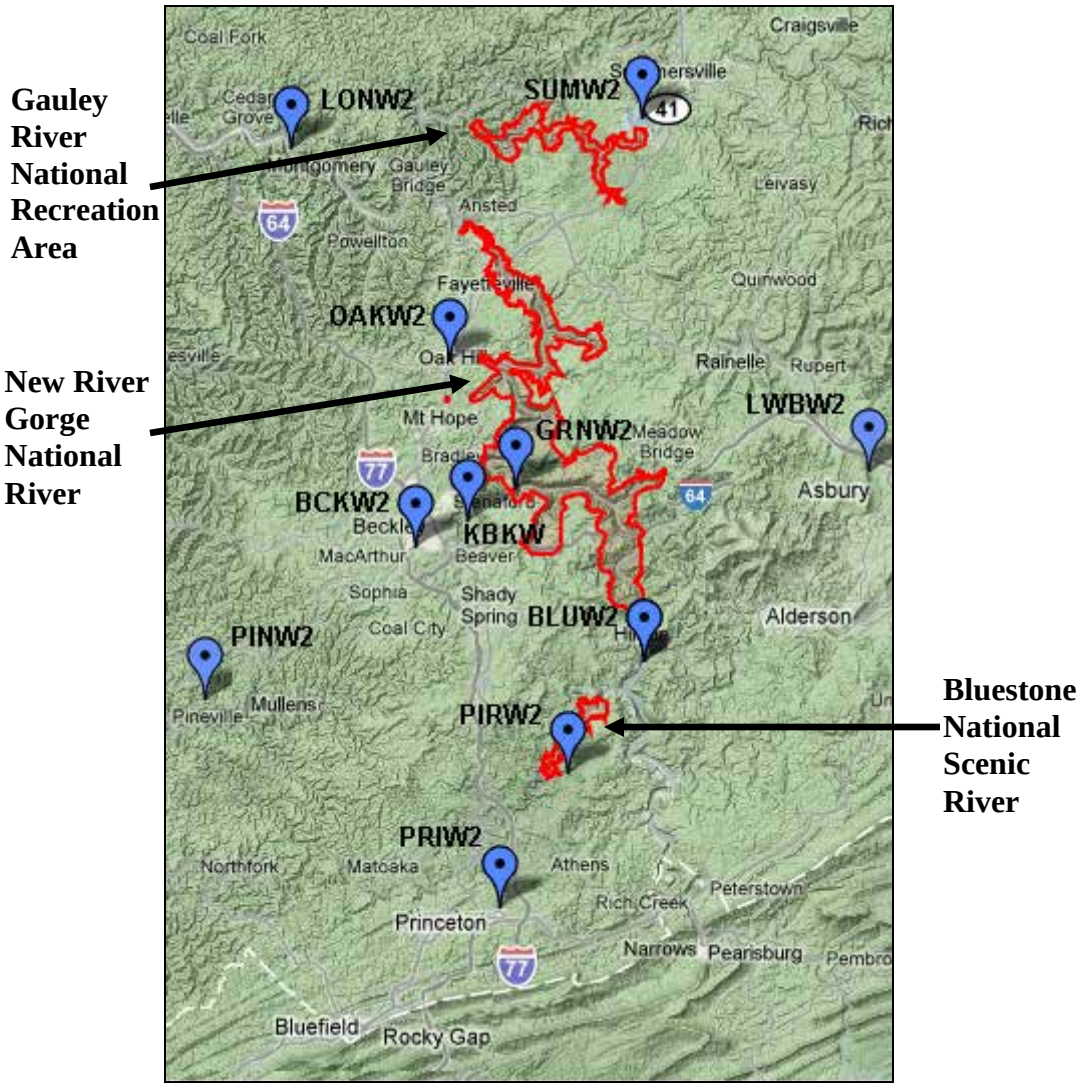

Figure 1. Location of weather observing stations around Bluestone National Scenic River, Gauley River National Recreation Area, and New River Gorge National River. See Table 1 for station names.

Table 1. List of weather observing stations around Bluestone National Scenic River, Gauley River National Recreation Area, and New River Gorge National River selected as best representative of the parks in 2011.

Station	Observing Network	Station Name	Period of Record (POR)		Percentage of Time Reporting Temperature for 2011	Percentage of Time Reporting Precipitation for 2011	Percentage of Time Reporting Temperature for entire POR	Percentage of Time Reporting Precipitation for entire POR
BLUW2	COOP	Bluestone Lake	03/01/1943	Present	100.0	100.0	98.4	99.6
OAKW2	COOP	Oak Hill	10/01/1941	Present	79.7	62.5	97.4	97.3
LONW2	COOP	London Locks	07/01/1934	Present	98.6	98.4	90.1[1]	89.0
SUMW2	COOP	Summersville Lake	02/01/1967	Present	95.6	95.6	98.0	98.9
PRIW2	COOP	Princeton	07/01/1940	Present	-	100.0	-	98.7
LWBW2	COOP	Lewisburg 3 N	09/11/1852	Present	99.7	100.0	94.2[2]	64.8
BCKW2	COOP	Beckley VA Hospital	12/01/1893	Present	99.5	99.5	78.7[3]	76.5
KBKW	ASOS	(Beckley) Raleigh County Memorial Airport	05/15/1963	Present	100.0	100.0	99.9	99.9
PINW2	COOP	Pineville	01/06/1908	Present	97.0	97.5	62.2	62.2
GRNW2	RAWS	Grandview	01/01/2005	Present	100.0	100.0	98.8	98.5
PIRW2	RAWS	Pipestem	06/09/2005	Present	100.0	100.0	96.9	96.9

[1]LONW2 began reporting temperature on 8/4/1936.
[3]BCKW2 began reporting temperature on 4/1/1896.
[2]LWBW2 began reporting temperature on 4/17/1900.

Temperature Summary

The 2011 calendar year averaged above normal compared with the long-term means for temperature (Tables 2, 3, and 4) and departed from the slight cooling trend noted in 2009 and 2010. After a chilly January, February was much warmer, but March saw a return to seasonal temperatures (Figures 2 and 3).[1]

The lowest readings, which were between 3 and 12 degrees Fahrenheit (°F) (-16.1 to -11.1 degrees Celsius [°C]) during the winter, were measured on February 12, 2011 at most sections. The lowest value for the year near the parks occurred in Summerville Lake, WV, and was 3.0°F (-16.1°C) (Table 2). The number of sub-freezing days was noticeably below the long-term mean, but the number of cold nights was very close to the average (Table 2). The winter ranked as the 58th to 59th coldest in 117 years for the climate divisions encompassing the parks (59 is the mid-point; Table 5).

The spring brought a turnaround as warmth returned quickly, such that the period from April to June of 2011 ranked as the 6th to 9th warmest in 117 years (Figures 2 and 3; Table 5). Record early warmth was noted during the last week of May as readings rose above 86°F (30°C) in some locations. An outbreak of cold weather in the early part of April brought most sections their last frost (on April 7–8), so the growing season in parts of each park began earlier than the average date (Table 2). Most of this spring's warmth can be attributed to very mild nights from April through June (Figures 2 and 3).

The summer months of July–August–September were warm due to hot July days (Figure 2) and warm September nights (Figure 3). A few record maximums were recorded during the period and the summer ranked as the 10th to 23rd warmest in 117 years of records (Table 5). The highest readings of the year, above 90°F (32.2°C) occurred on either July 23 or August 6 (Table 2).

Overall, autumn ranked as one of the top 25 warmest of the last 117 years for temperature (Table 5). Frosts and freezes occurred later than in recent years, with most sections noticing sub-freezing readings (<32°F [<0°C]) on November 6, but a few spots saw frost on October 3. As a result, the length of the growing season was longer (by about 5–24 days) (Table 2) than the 1981–2010 normal lengths. While October averaged near to slightly below normal (Figures 2 and 3), it was November and December which had departures of about +4°F (+2.2°C) that made this season so mild (Table 4). The average annual temperature ranged from +1.0°F (0.6°C) to +2.2°F (+1.2°C), making 2011 the warmest since 2007.

[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 2011 temperature indicators compared to the 30-year normal (1981–2010) at the London Locks (LONW2), Beckley Airport (KBKW), and Summersville Lake (SUMW2) stations.

Temperature Indicator	London Locks, WV 2011	London Locks, WV 1981-2010	Beckley Airport, WV 2011	Beckley Airport, WV 1981–2010	Summersville Lake, WV 2011	Summersville Lake, WV 1981-2010
Average Annual Temperature	57.2°F 14.0°C	56.2°F 13.4°C	54.1°F 12.3°C	51.9°F 11.1°C	52.9°F 11.6°C	50.8°F 10.4°C
Average Annual Maximum Temperature	68.5°F 20.3°C	67.0°F 19.4°C	63.7°F 17.6°C	61.3°F 16.3°C	63.3°F 17.4°C	61.3°F 16.3°C
Maximum Temperature	98.0°F 36.7°C	94.5°F 34.7°C	93.0°F 33.9°C	88.2°F 31.2°C	92.0°F 33.3°C	89.5°F 31.9°C
Hot Days (days with Tmax≥90°F/32°C)	40	22	5	1	4	2
Average Annual Minimum Temperature	45.9°F 7.7°C	45.5°F 7.5°C	44.5°F 6.9°C	42.5°F 5.8°C	42.4°F 5.8°C	40.2°F 4.6°C
Minimum Temperature	12.0°F -11.1°C	3.1°F -16.1°C	4.0°F -15.6°C	-4.8°F -20.4°C	3.0°F -16.1°C	-5.3°F -20.7°C
Cold Days (days with Tmax≤32°F/0°F)	9	11	16	25	20	27
Sub-freezing Days (days with Tmin≤32°F/0°C)	84	88	101	107	115	126
Sub-zero Days (days with Tmin≤0°F/-17.8°C)	0	1	0	2	0	3
Growing Season Length (days between last spring Tmin 32°F/0°C and first fall Tmin 32°F/0°C)	212	207	198	174	177	169

Bluestone National Scenic River,
Gauley River National Recreation Area,
and New River Gorge National River
Departure from Average Monthly Maximum Temperature
2011 vs. 1981–2010

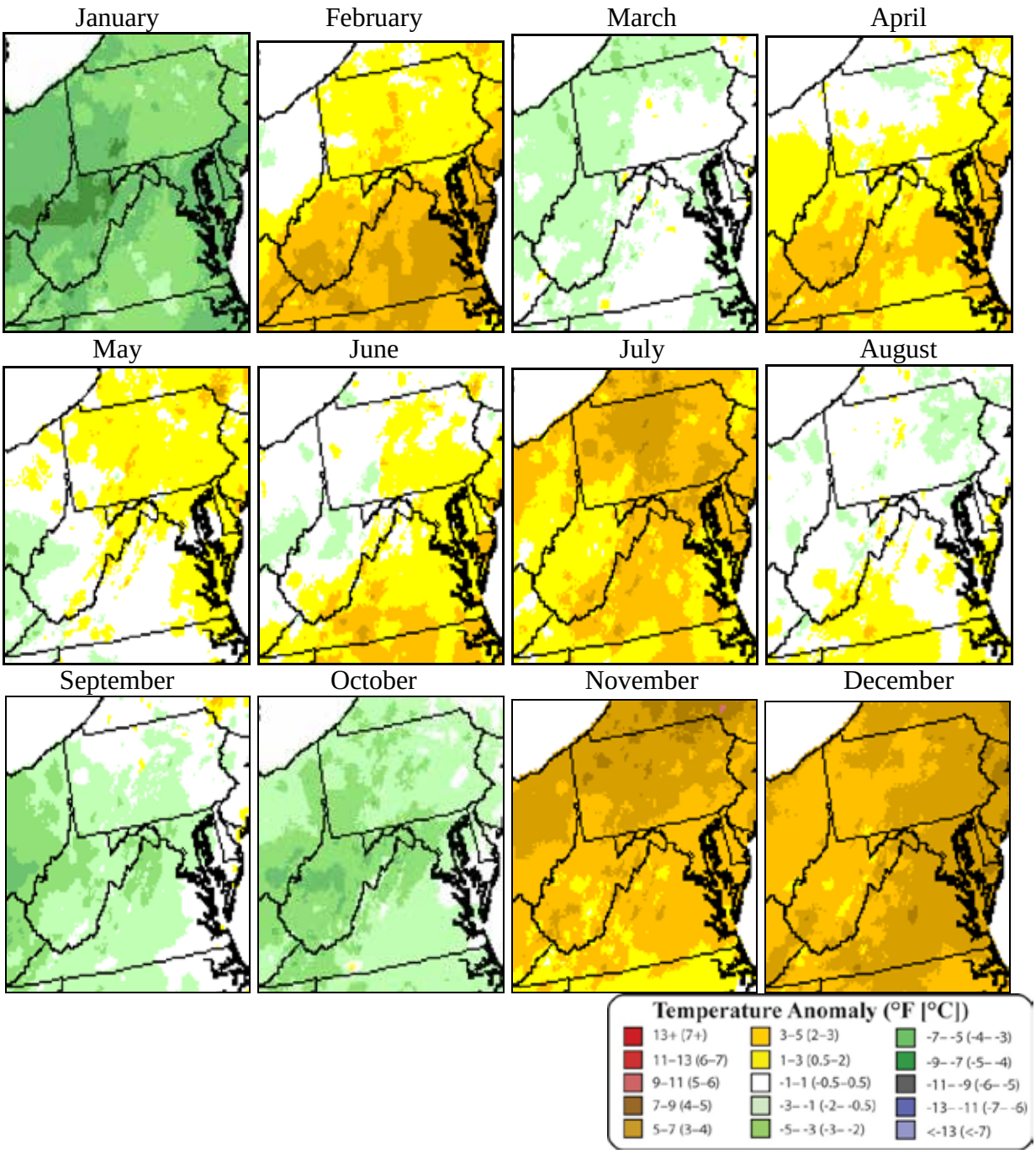

Figure 2. Maps showing departure from average monthly maximum temperature compared to the 30-year normal (1981–2010).

Bluestone National Scenic River,
Gauley River National Recreation Area,
and New River Gorge National River
Departure from Average Monthly Minimum Temperature
2011 vs. 1981–2010

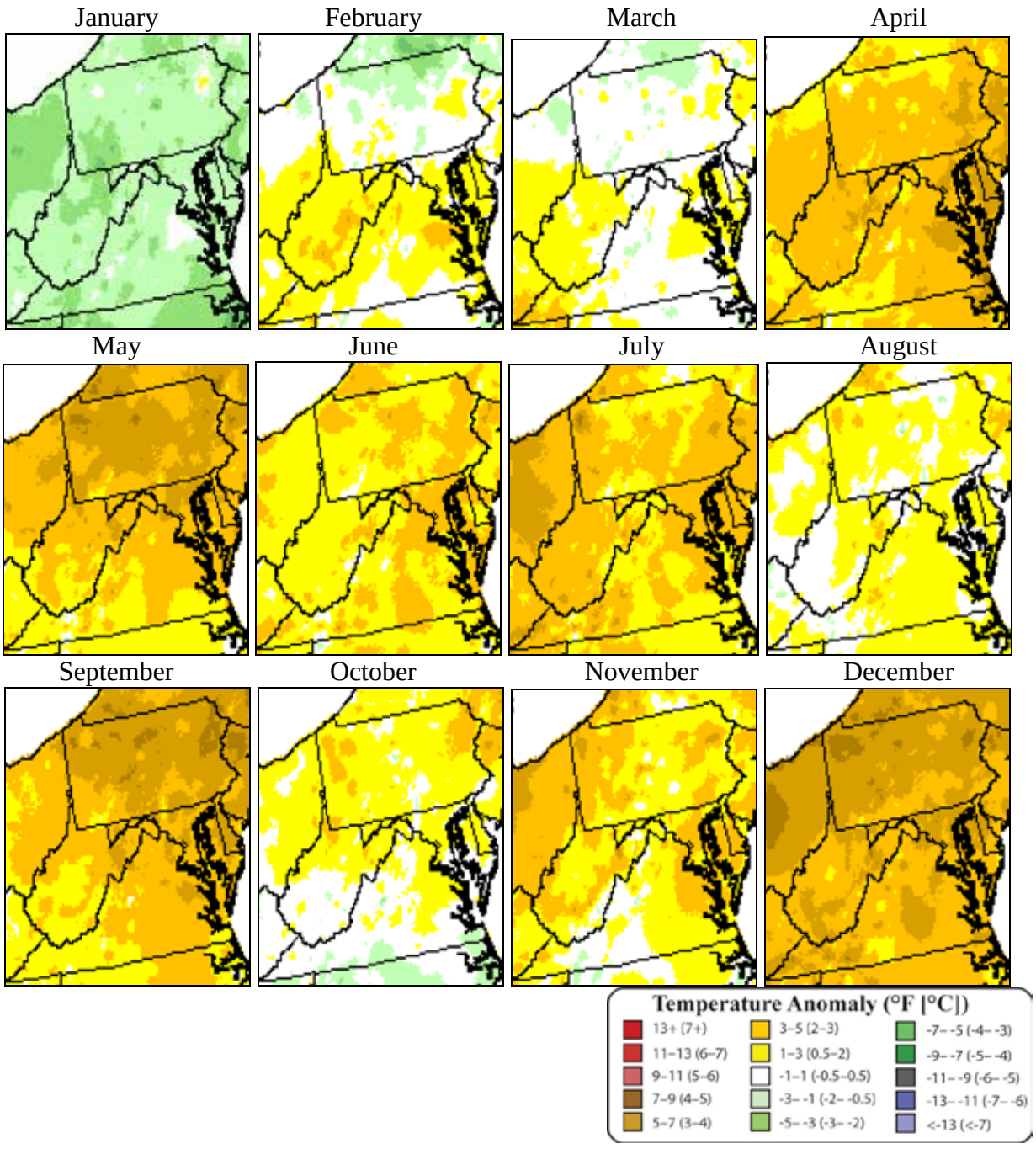

Figure 3. Maps showing departure from average monthly minimum temperature compared to the 30-year normal (1981–2010).

Table 3. Summary of monthly average temperature for 2011 for the selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Bluestone Lake	BLUW2	29.9°F	39.0°F	45.2°F	57.4°F	63.9°F	73.4°F	78.4°F	74.7°F	68.3°F	54.0°F	45.9°F	39.1°F	55.8°F
		-1.2°C	3.9°C	7.3°C	14.1°C	17.7°C	23.0°C	25.8°C	23.7°C	20.2°C	12.2°C	7.7°C	3.9°C	13.2°C
Oak Hill	OAKW2	M	37.9°F	40.9°F	54.7°F	M	M	74.9°F	71.2°F	66.3°F	M	48.0°F	39.5°F	54.2°F
		M	3.3°C	4.9°C	12.6°C	M	M	23.8°C	21.8°C	19.1°C	M	8.9°C	4.2°C	12.3°C
London Locks	LONW2	31.5°F	40.4°F	46.1°F	58.1°F	64.4°F	72.9°F	78.4°F	76.2°F	68.8°F	56.1°F	49.9°F	42.6°F	53.9°F
		-0.3°C	4.7°C	7.8°C	14.5°C	18.0°C	22.7°C	25.8°C	24.6°C	20.4°C	13.4°C	9.9°C	5.9°C	14.0°C
Summersville Lake	SUMW2	24.3°F	34.9°F	40.6°F	54.1°F	60.1°F	67.4°F	72.9°F	70.6°F	64.5°F	50.9°F	M	M	54.3°F
		-4.3°C	1.6°C	4.8°C	12.3°C	15.6°C	19.7°C	22.7°C	21.4°C	18.1°C	10.5°C	M	M	12.2°C
Lewisburg 3 N	LWBW2	25.7°F	35.1°F	40.5°F	54.2°F	60.9°F	68.6°F	74.1°F	70.5°F	63.9°F	49.9°F	43.0°F	35.1°F	51.8°F
		-3.5°C	1.7°C	4.7°C	12.3°C	16.1°C	20.3°C	23.4°C	21.4°C	17.7°C	9.9°C	6.1°C	1.7°C	11.0°C
Beckley VA Hospital	BCKW2	25.4°F	35.3°F	39.8°F	52.4°F	57.9°F	65.3°F	71.2°F	67.5°F	61.9°F	48.2°F	44.1°F	35.8°F	50.4°F
		-3.7°C	1.8°C	4.3°C	11.3°C	14.4°C	18.5°C	21.8°C	19.7°C	16.6°C	9.0°C	6.7°C	2.1°C	10.2°C
Beckley Airport	KBKW	27.5°F	38.7°F	42.4°F	57.3°F	61.8°F	69.3°F	74.8°F	72.0°F	64.7°F	51.8°F	48.5°F	39.9°F	54.1°F
		-2.5°C	3.7°C	5.8°C	14.1°C	16.6°C	20.7°C	23.8°C	22.2°C	18.2°C	11.0°C	9.2°C	4.4°C	12.3°C
Pineville	PINW2	29.2°F	M	44.3°F	57.4°F	63.0°F	71.5°F	76.5°F	72.9°F	66.1°F	52.7°F	45.7°F	38.8°F	56.2°F
		-1.6°C	M	6.8°C	14.1°C	17.2°C	21.9°C	24.7°C	22.7°C	18.9°C	11.5°C	7.6°C	3.8°C	13.4°C
Grandview	GRNW2	26.8°F	37.4°F	41.6°F	56.1°F	60.4°F	67.9°F	73.0°F	70.1°F	62.5°F	50.4°F	46.4°F	38.4°F	52.6°F
		-2.9°C	3.0°C	5.3°C	13.4°C	15.8°C	19.9°C	22.8°C	21.2°C	16.9°C	10.2°C	8.0°C	3.6°C	11.4°C
Pipestem	PIRW2	27.4°F	38.0°F	41.7°F	56.0°F	60.6°F	68.7°F	73.2°F	70.6°F	62.8°F	51.3°F	47.0°F	39.4°F	53.1°F
		-2.6°C	3.3°C	5.4°C	13.3°C	15.9°C	20.4°C	22.9°C	21.4°C	17.1°C	10.7°C	8.3°C	4.1°C	11.7°C

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

Table 4. Summary of 2011 departure from normal temperature based on 30-year normal (1981–2010) for the selected stations. Stations with a Period of Record less than 10 years were not included in this table.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Bluestone Lake	BLUW2	-2.6°F	2.8°F	1.2°F	3.6°F	1.7°F	2.8°F	4.2°F	1.4°F	1.4°F	-1.8°F	0.7°F	3.7°F	1.6°F
		-1.4°C	1.6°C	0.7°C	2.0°C	0.9°C	1.6°C	2.3°C	0.8°C	0.8°C	-1.0°C	0.4°C	2.1°C	0.9°C
Oak Hill	OAKW2	M	3.7°F	-1.0°F	2.6°F	M	M	4.0°F	1.1°F	2.6°F	M	3.6°F	5.3°F	2.7°F
		M	2.1°C	-0.6°C	1.4°C	M	M	2.2°C	0.6°C	1.4°C	M	2.0°C	3.1°C	1.5°C
London Locks	LONW2	-3.3°F	2.7°F	0.5°F	2.5°F	0.6°F	0.4°F	2.2°F	0.8°F	-0.1°F	-1.5°F	2.2°F	4.5°F	1.0°F
		-1.8°C	1.5°C	0.3°C	1.4°C	0.3°C	0.2°C	1.2°C	0.4C	-0.1°C	-0.8°C	1.2°C	2.5°C	0.5°C
Summersville Lake	SUMW2	-5.3°F	2.5°F	0.6°F	4.0°F	1.4°F	0.9°F	2.7°F	1.5°F	1.9°F	-1.4°F	M	M	0.9°F
		-2.9°C	1.4°C	0.3°C	2.2°C	0.8°C	0.5°C	1.5°C	0.8°C	1.1°C	-0.8°C	M	M	0.5°C
Beckley VA Hospital	BCKW2	-3.2°F	3.8°F	1.0°F	3.4°F	0.4°F	0.4°F	3.1°F	0.4°F	1.4°F	-2.1°F	3.1°F	4.0°F	1.3°F
		-1.8°C	2.1°C	0.6C	1.9°C	0.2°C	0.2°C	1.7°C	0.2°C	0.8°C	-1.2°C	1.7°C	2.2°C	0.7°C
Lewisburg 3 N	LWBW2	-2.8°F	3.4°F	1.2°F	4.4°F	2.3°F	1.8°F	3.8°F	1.4°F	1.9°F	-1.3°F	2.0°F	3.8°F	1.8°F
		-3.6°C	1.9°C	0.7°C	2.4°C	1.3°C	1.0°C	2.1°C	0.8°C	1.1°C	-0.7°C	1.1°C	2.1°C	1.0°C
Beckley Airport	KBKW	-3.6°F	4.3°F	0.3°F	5.2°F	2.0°F	1.9°F	4.2°F	2.3°F	1.5°F	-1.4°F	4.6°F	5.7°F	2.3°F
		-2.0°C	2.4°C	0.2°C	2.9°C	1.1°C	1.1°C	2.3°C	1.3°C	0.8°C	-0.8°C	2.6°C	3.2°C	1.3°C
Pineville	PINW2	-2.4°F	M	1.5°F	4.5°F	1.2°F	1.4°F	2.8°F	-0.1°F	0.1°F	-1.8°F	1.5°F	4.3°F	1.2°F
		-1.3°C	M	0.8°C	2.5°C	0.7°C	0.8°C	1.6°C	-0.1°F	0.1°F	-1.0°C	0.8°C	2.4°C	0.7°C

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

Table 5. Seasonal and annual temperature and precipitation rankings for 2011 over 117 years (1 = warmest/wettest year and 117 = coldest/driest year) for West Virginia Climate Division 4 (top) and 5 (bottom).

WV Climate Division 4 Rankings "Central"	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN	Jan – Dec ANNUAL
Temperature-2011	59	9	23	22	12
Precipitation-2011	68	12	46	20	12

WV Climate Division 5 Rankings "Southern"	Jan–Feb–Mar WINTER	Apr–May–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN	Jan – Dec ANNUAL
Temperature-2011	68	6	10	24	5
Precipitation-2011	67	23	73	17	22

Precipitation Summary

Liquid precipitation (rain and melted snow, ice, sleet, etc.; hereafter, precipitation) for the region averaged very near the long-term mean except near Gauley River NRA where there was well above normal precipitation (Table 6). The majority of the wettest days occurred during the warmer half of the year, with only two excessively damp days in the fall (Table 7). An unusually dry period was noted from October 5 until November 9 when there were two long spells without any measurable rain (Table 7). Snowfall was somewhat below normal and far below the record tallies in 2010 (Table 6). The number of days with excessive rainfall (>1.0 in [25 mm]) was a bit below the long-term average for south-central West Virginia (Table 6).

The winter was very near to normal (Figure 4), as January averaged approximately 67 percent of normal precipitation in Beckley, WV, and only 49 percent in Bluestone Lake, WV (Tables 8 and 9). February was equally dry (Figure 4), with between 50 percent and 113 percent of average precipitation (Tables 8 and 9); some fell in the form of snow. Monthly precipitation in March was above normal, with 3.9–6.1 in (99–155 mm) accumulating across the central and southern districts of West Virginia (Table 8). Winter precipitation, including rain and snow (liquid equivalent), was ranked between 49th and 50th driest in 117 years of record keeping (Table 5).

Spring 2011 brought wetter conditions during April and progressively drier weather in June (Figure 4), averaging the 12th wettest in climate division 4 and 23rd wettest in climate division 5 (Table 5). By far, April was the wettest month of this season, as 146–198 percent of normal rain was reported (Table 9). One of the year's wettest days occurred on June 20th, when 2 in (>50mm) of rain fell (Table 7). May and June brought more sporadic rainfall. Pineville tallied only 50 percent of average rainfall, while Summersville Lake measured 154 percent of normal rainfall; these stations are only about 40 miles apart.

The summer months of July, August, and September showed a dramatic contrast; the southern valleys averaged below-normal rainfall, but the eastern and central mountains were wet (Figure 4). Two of the wettest days of 2011 occurred during the summer. On July 20, as an average of 2.0 in (50.8 mm) was tallied in the region, and on September 5, approximately 1.95 in (49.5 mm) fell (Table 7). The summer ranked the 46th wettest in the central West Virginia climate division, and the 45th driest in the southern division (Table 5).

Autumn brought wetter than normal precipitation (Figure 4). October was damp with most sections averaging from 82–207 percent of the normal rainfall (Table 9); however, November still brought above-average precipitation to most sites. For example, Beckley VA Hospital, WV, had 133 percent of normal rainfall, but Lewisburg, WV, tallied 91 percent with 2.6 in (66 mm) (Tables 8 and 9). December stayed moist, with more than 130 percent of normal rain and snow tallied at Beckley, WV (Table 9). Overall, 2011 brought between 85–131 percent of average annual precipitation, which ranged from +1 in (+25.4 mm) to +13 in (+330.2 mm). It was, overall, a wet year for much of the region.

Table 6. Status of 2011 precipitation indicators compared to the 30-year normal (1981–2010) at the London Locks (LONW2), Beckley Airport (KBKW), and Summersville Lake (SUMW2) stations.

Precipitation Indicators	London Locks, WV 2011	London Locks, WV 1981-2010	Beckley Airport, WV 2011	Beckley Airport, WV 1981–2010	Summersville Lake, WV 2011	Summersville Lake, WV 1981-2010
Annual Precipitation	45.3 in 1,151 mm	43.8 in 1,113 mm	42.2 in 1,072 mm	41.2 in 1,046 mm	60.9 in 1,547 mm	47.9 in 1,217 mm
Autumn Precipitation (Oct, Nov, Dec) Precipitation	10.9 in 277 mm	9.2 in 234 mm	10.5 in 267 mm	8.5 in 216 mm	15.8 in 401 mm	10.2 in 259 mm
Heavy Precipitation Days (days with ≥1.0 in (25 mm) rain)	10	9	5	7	14	9
Extreme Precipitation Days (days with ≥2.0 in (51 mm) rain)	0	1	0	1	2	1
Micro-drought (strings of 7+ days without rain)	5	7	3	3	4	5
Annual Snowfall (inches)	M[1]	36.4 in 92.5 cm	53.6 in 136.1 cm	62.0 in 157.5 cm	35.1 in[3] 89.2 cm[3]	38.7 in 98.3 cm
Measurable Snow Days (days with ≥0.1 in (0.3 cm) snow)	M[1]	27[2]	31	38	14[3]	21
Moderate Snow Days (days with ≥3.0 in (7.6 cm) snow)	M[1]	3[2]	7	6	6[3]	5
Heavy Snow Days (days with ≥5.0 in (12.7 cm) snow)	M[1]	1[2]	4	2	1[3]	1

[1]London Locks snowfall data is denoted with an M (missing) because the station did not report snowfall for the entire period.
[2]London Locks 1981-2010 snowfall data is represented by Charleston – Yeager Airport's 1981-2010 snowfall normal values.
[3]Summersville did not report snowfall for much of October, November, and December – which will be reflected in the annual snow-related category totals.

Table 7. Top five wettest days and top five dry spells (consecutive days with a trace or less of liquid precipitation) during 2011 from stations London Locks (LONW2), Beckley Airport (KBKW), and Summersville Lake (SUMW2).

Wettest Days in 2011	Dry Spells in 2011
Oct. 2: 2.13 in (54.1 mm)	Feb. 11–Feb. 20
Jul. 20: 2.00 in (50.8 mm)	Jul. 27–Aug. 5
Sept. 5: 1.95 in (49.5 mm)	Oct. 31–Nov. 9
Jun. 20: 1.90 in (48.3 mm)	May 28 – Jun. 4
Nov. 17: 1.86 in (47.2 mm)	Oct. 5 - 11

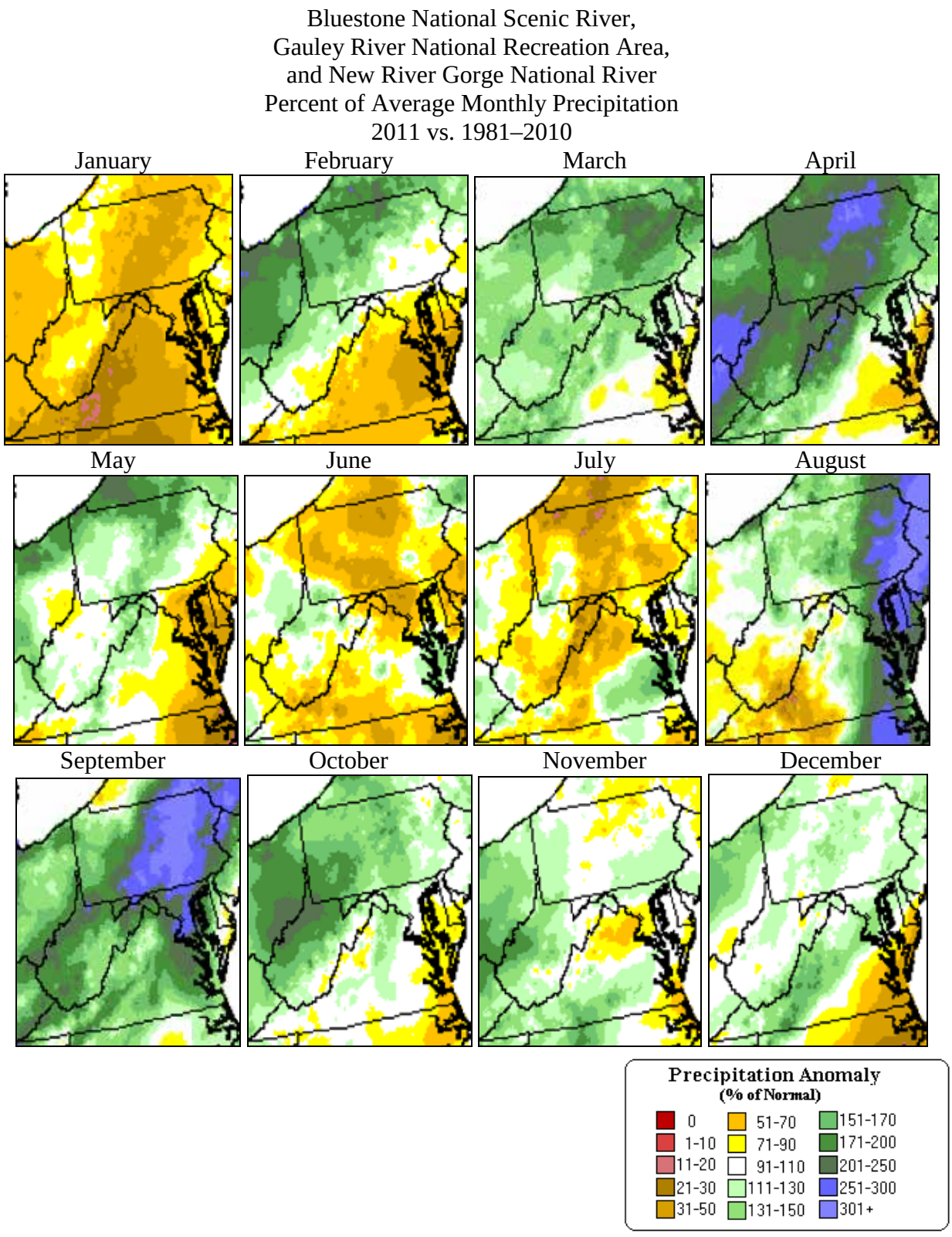

Figure 4. Maps showing percent of average monthly precipitation compared to the 30-year normal (1981–2010).

Table 8. Summary of 2011 monthly total precipitation for selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Bluestone Lake	BLUW2	1.4 in	1.3 in	4.5 in	5.0 in	5.0 in	1.7 in	2.4 in	1.1 in	4.9 in	3.0 in	3.3 in	3.7 in	37.3 in
		36 mm	33 mm	114 mm	127 mm	127 mm	43 mm	61 mm	28 mm	124 mm	76 mm	84 mm	94 mm	947 mm
Oak Hill	OAKW2	M	M	M	M	M	M	5.1 in	3.0 in	7.7 in	M	3.1 in	3.9 in	M
		M	M	M	M	M	M	130 mm	76 mm	196 mm	M	79 mm	99 mm	M
London Locks	LONW2	1.4 in	3.2 in	4.8 in	6.3 in	4.2 in	3.6 in	2.9 in	2.3 in	5.6 in	4.2 in	4.2 in	2.4 in	45.1 in
		36 mm	81 mm	122 mm	60 mm	107 mm	91 mm	74 mm	58 mm	142mm	107 mm	107 mm	61 mm	1,046 mm
Summersville Lake	SUMW2	4.5 in	2.0 in	6.1 in	6.5 in	4.9 in	7.0 in	4.3 in	4.1 in	5.9 in	6.6 in	M	M	M
		114 mm	51 mm	155 mm	165 mm	124 mm	178 mm	109 mm	104 mm	150 mm	168 mm	M	M	M
Princeton	PRIW2	1.9 in	2.7 in	5.0 in	5.9 in	3.9 in	2.0 in	1.5 in	1.3 in	4.9 in	3.0 in	3.2 in	3.1 in	38.4 in
		48 mm	69 mm	127 mm	105 mm	99 mm	51 mm	38 mm	33 mm	124 mm	76 mm	81 mm	78 mm	976 mm
Lewisburg 3 N	LWBW2	0.9 in	1.6 in	5.7 in	5.5 in	4.1 in	3.1 in	2.2 in	2.8 in	4.1 in	2.1 in	2.6 in	4.3 in	39.0 in
		23 mm	41 mm	145 mm	140 mm	104 mm	78 mm	56 mm	71 mm	104 mm	53 mm	66 mm	109 mm	990 mm
Beckley VA Hospital	BCKW2	1.8 in	1.6 in	5.3 in	5.1 in	4.4 in	2.3 in	3.7 in	1.8 in	7.3 in	3.0 in	3.8 in	3.9 in	44.0 in
		45 mm	61 mm	135 mm	130 mm	112 mm	58 mm	94 mm	45 mm	185 mm	76 mm	96 mm	99 mm	1,136 mm
Beckley Airport	KBKW	1.9 in	2.7 in	4.5 in	5.3 in	4.3 in	2.6 in	3.1 in	1.8 in	5.6 in	2.7 in	3.8 in	4.0 in	42.3 in
		48 mm	69 mm	114 mm	135 mm	109 mm	66 mm	79 mm	45 mm	142 mm	69 mm	97 mm	102 mm	1,075 mm
Pineville	PINW2	2.3 in	M	5.5 in	7.5 in	6.0 in	2.1 in	2.9 in	4.8 in	6.5 in	3.3 in	3.9 in	4.3 in	M
		58 mm	M	140 mm	191 mm	152 mm	53 mm	74 mm	121 mm	165 mm	82 mm	99 mm	109 mm	M
Grandview	GRNW2	2.3 in	2.9 in	5.4 in	4.9 in	5.1 in	2.5 in	4.3 in	1.4 in	6.9 in	3.4 in	4.5 in	4.5 in	47.9 in
		58 mm	72 mm	137 mm	123 mm	129 mm	62 mm	110 mm	35 mm	174 mm	87 mm	114 mm	115 mm	1215 mm
Pipestem	PIRW2	1.6 in	2.5 in	3.9 in	4.9 in	3.8 in	1.9 in	2.5 in	0.8 in	4.1 in	2.8 in	3.5 in	4.3 in	36.5 in
		40 mm	63 mm	99 mm	125 mm	96 mm	48 mm	64 mm	21 mm	104 mm	71 mm	89 mm	108 mm	927 mm

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

Table 9. Summary of 2011 percent of normal precipitation based on 30-year normal (1981–2010) for selected stations. Stations with a Period of Record less than 10 years not included in this table.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Bluestone Lake	BLUW2	49	50	133	146	122	50	54	32	168	113	125	128	85
Oak Hill	OAKW2	M	M	M	M	M	M	98	77	224	M	94	111	121
London Locks	LONW2	45	113	129	171	86	83	57	61	181	167	122	76	108
Summersville Lake	SUMW2	134	65	159	163	98	154	73	91	170	207	M	M	131
Princeton	PRIW2	65	100	156	184	93	56	34	38	173	125	116	107	104
Lewisburg	LWBW2	29	54	166	161	96	82	55	87	126	82	91	133	97
Beckley VA Hospital	BCKW2	63	67	160	149	97	63	70	51	247	122	133	131	113
Beckley Airport	KBKW	67	96	126	159	91	64	61	50	185	107	128	134	106
Pineville	PINW2	64	M	144	198	117	50	55	128	200	116	122	118	119

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 West Virginia Climate Division 4 in 2011 are shown in Figure 5 and Climate Division 5 values are seen in Figure 6.

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 (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 West Virginia and the Northeast are shown for 2011 in Figures 7 and 8, respectively.

According to the PDSI for WV Climate Division 4 for 2011, it was "normal to moderate drought" (PDSI <0; Figure 5) in the winter and summer and "normal to moist" (PDSI>0) in the spring and fall for the West Virginia parks. While the calendar year began dry, wet conditions set in by mid-March and continued until early May. As a result, PDSI values rose from near -2.0 in early February to near +2.0 (approaching "moderately moist") by the end of April. Regular precipitation returned during May and June, lowering PDSI values toward 0 (Figure 5). Wet weather returned in August, keeping the PDSI positive for the remainder of 2011. Not surprisingly, WV Climate Division 5, which includes parts of Bluestone and New River, mimicked the same trends as seen in WV Climate Division 4, though with less magnitude. When comparing the PDSI values with recent years, 2011 showed a blend wetter than 2010, but drier than 2009.

The DM – Drought Severity Index for West Virginia (Figure 7) and the Northeast (Figure 8) indicated a near average year, with the only widespread drought conditions near the parks during the growing season (May through September) occurring in August and September in 2011.

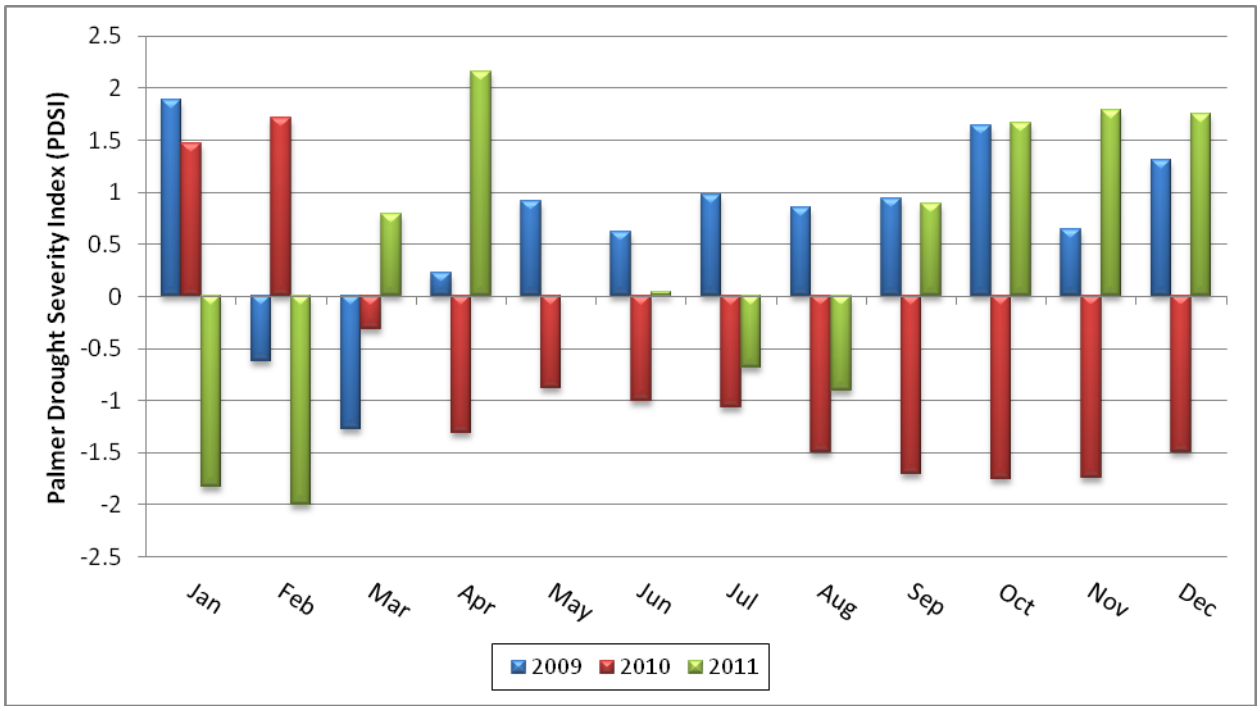

Figure 5. Monthly Palmer Drought Severity Index (PDSI) values for West Virginia Climate Division 4, 2009–2011.

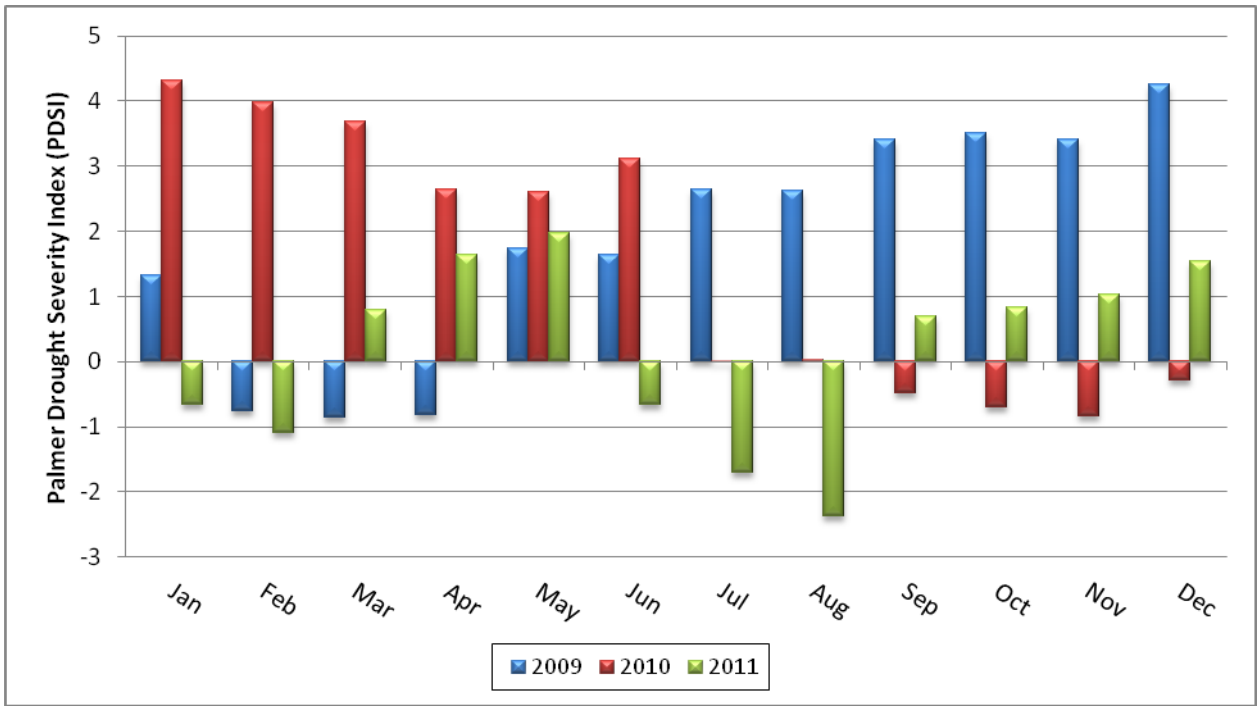

Figure 6. Monthly Palmer Drought Severity Index (PDSI) values for West Virginia Climate Division 5, 2009–2011.

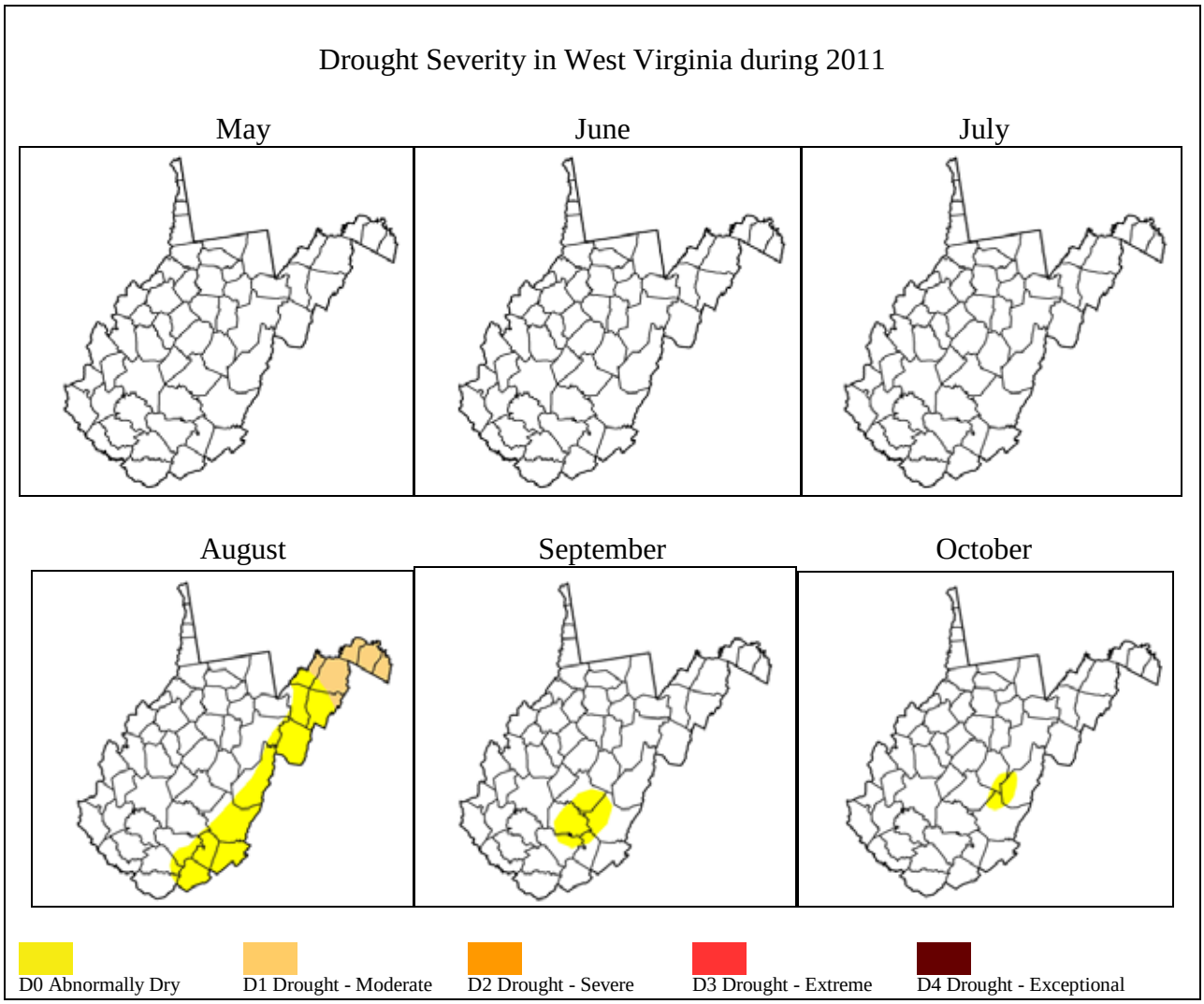

Figure 7. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for West Virginia in 2011.

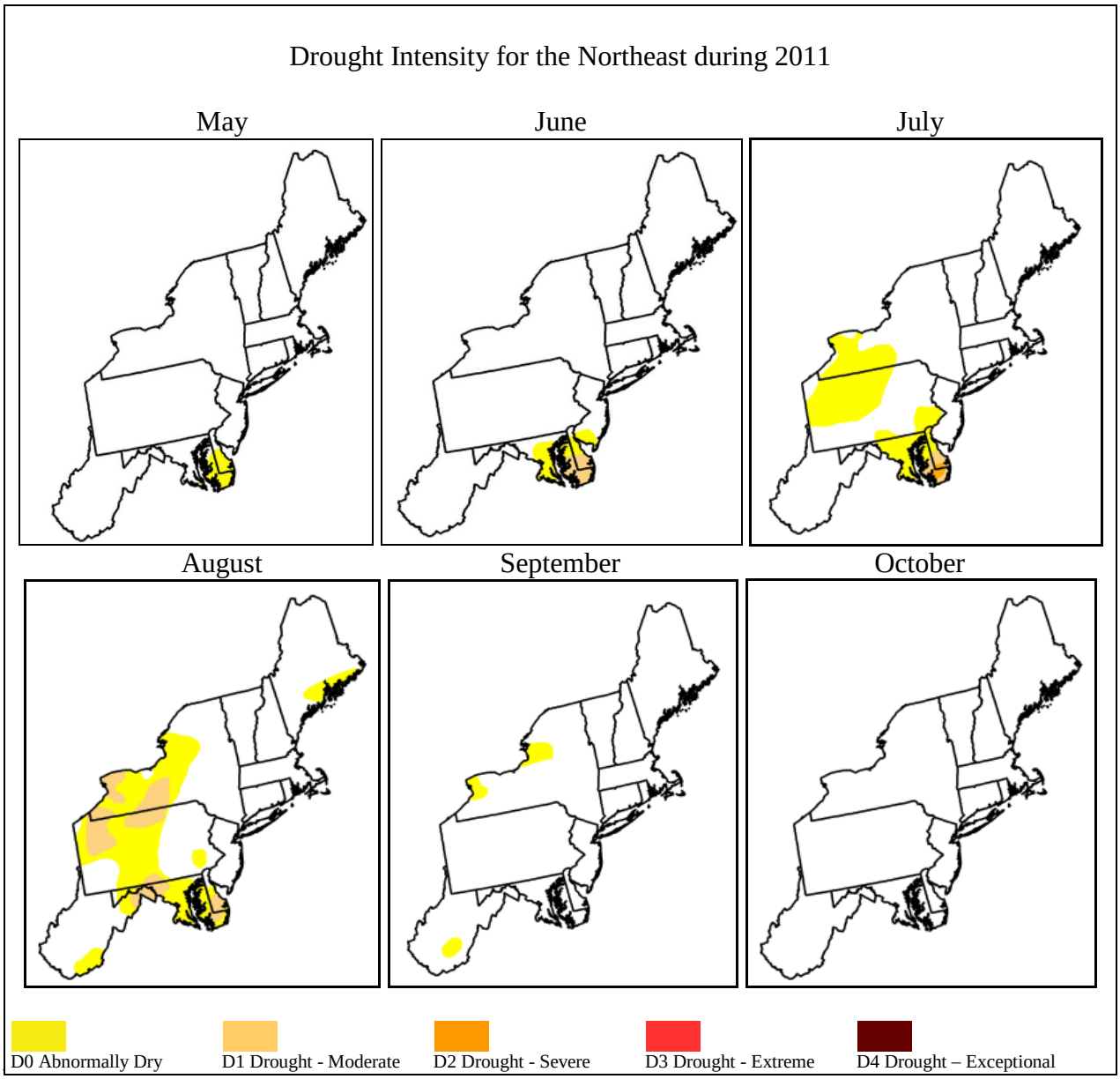

Figure 8. Mid-month values of the United States Drought Monitor (DM) – Drought Intensity Index for the Northeast in 2011.

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