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 2013

Natural Resource Data Series NPS/ERMN/NRDS—2014/688

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.
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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, 2013, 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 2013]) 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 2013 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 2013) 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.

The NCDC also calculates and provides climatological ranks for selected temperature and precipitation elements (http://www.ncdc.noaa.gov/temp-and-precip/ranks.php). Data and statistics are as of January 1895 providing a substantial period of record to place the current year in historical context.

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/NPS/interface.php.

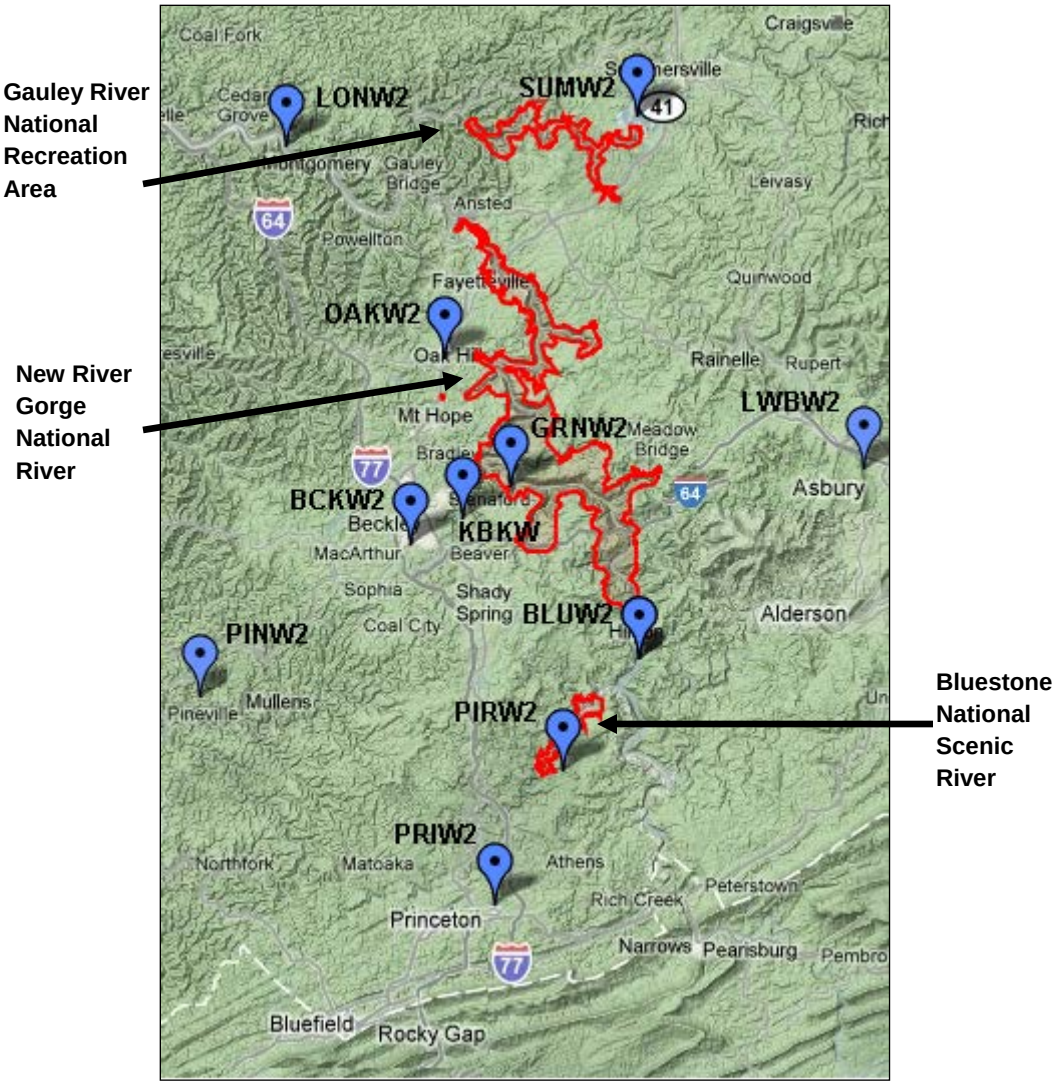

Figure 1. Location of weather observing stations around Bluestone National Scenic River, Gauley River National Recreation Area, and New River Gorge National River. See Table 1 for station names.

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 2013.

Station	Observing Network	Station Name	Period of Record (POR)		Percentage of Time Reporting Temperature for 2013	Percentage of Time Reporting Precipitation for 2013	Percentage of Time Reporting Temperature for entire POR	Percentage of Time Reporting Precipitation for entire POR
BLUW2	COOP	Bluestone Lake	03/01/1943	Present	61.4	100.0	97.9	99.6
OAKW2	COOP	Oak Hill	10/01/1941	Present	-	-	95.8	95.8
LONW2	COOP	London Locks	07/01/1934	Present	96.7	97.3	90.2[1]	89.2
SUMW2	COOP	Summersville Lake	02/01/1967	Present	79.7	83.6	97.3	98.4
PRIW2	COOP	Princeton	07/01/1940	Present	-	97.3	-	98.7
LWBW2	COOP	Lewisburg 3 N	09/11/1852	Present	100.0	100.0	94.3[2]	65.2
BCKW2	COOP	Beckley VA Hospital	12/01/1893	Present	99.7	99.7	79.1[3]	76.9
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	89.6	90.1	62.8	62.8
GRNW2	RAWS	Grandview	01/01/2005	Present	100.0	100.0	97.8	97.6
PIRW2	RAWS	Pipestem	06/09/2005	Present	100.0	100.0	97.6	97.6

[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 2013 calendar year averaged below normal compared with the long-term means for temperature (Tables 2, 3, and 4) and reversed the warming trend noted in 2012. After a mild January, it turned progressively colder during February and March brought the largest negative departures of the year (Figures 2 and 3). 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/.

The lowest readings, which were between 4 and 13 degrees Fahrenheit (°F) (-15.6 to -10.6 degrees Celsius [°C]) during the winter, were measured on January 22 and February 1-2, 2013 at most sections. The lowest value for the year near the parks occurred in Summerville Lake, WV, and was 4.0°F (-15.6°C) (Table 2). The number of sub-freezing days was comparable to the long-term mean and the number of cold nights was above the average (Table 2). The winter ranked as the 35th to 40th coldest in 119 years for the climate divisions encompassing the parks (59 is the mid-point; Table 5).

The spring saw mild conditions return such that the period from April to June of 2013 ranked as the 32nd to 47th warmest in 119 years (Figures 2 and 3; Table 5). Record early warmth was noted during the last week of May as readings rose to 86°F (30°C) in some locations. An outbreak of cold weather preceded the warm spell in the latter part of May and brought most sections their last frost (on May 24-25), so the growing season in parts of each park began later than the average date (Table 2). Most of this spring's warmth can be attributed to very mild nights and mild days during April (Figures 2 and 3).

The summer months of July–August–September were cool due to rather cool August days (Figure 2). July and September averaged very close to normal with both months measuring slightly cooler than average maximums (Figure 3). No record maximums were recorded during the period and the summer ranked as the 38th to 49th coolest in 119 years of records (Table 5). The highest readings of the year, above 90°F (32.2°C) occurred on July 16-18 (Table 2).

Overall, autumn ranked near the average of the last 119 years for temperature; between 46th and 65th with 59 being the long-term mean (Table 5). Frosts and freezes occurred around the average date, with most sections noticing sub-freezing readings (<32°F [<0°C]) on October 20. As a result, the length of the growing season was shorter (by about 1–19 days) (Table 2) than the 1981–2010 normal lengths at two of the primary locations. While October averaged near to above normal (Figures 2 and 3), it was November which had the largest negative departures of the season with as much as -5.9°F (-3.3°C) (Table 4). The average annual temperature ranged from -1.3°F (-0.7°C) to -0.4°F -0.2°C), making 2013 the 44th and 49th coolest since 1895.

Table 2. Status of 2013 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 2013	London Locks, WV 1981-2010	Beckley Airport, WV 2013	Beckley Airport, WV 1981–2010	Summersville Lake, WV 2013	Summersville Lake, WV 1981-2010
Average Annual Temperature	54.9°F 12.7°C	56.2°F 13.4°C	51.5°F 10.9°C	51.9°F 11.1°C	50.5°F 10.3°C	50.8°F 10.4°C
Average Annual Maximum Temperature	64.8°F 18.2°C	67.0°F 19.4°C	60.7°F 15.9°C	61.3°F 16.3°C	61.1°F 16.2°C	61.3°F 16.3°C
Maximum Temperature	90.3°F 32.4°C	94.5°F 34.7°C	86.7°F 30.4°C	88.2°F 31.2°C	91.0°F 32.8°C	89.5°F 31.9°C
Hot Days (days with Tmax≥90°F/32°C)	3	12	0	1	2	2
Average Annual Minimum Temperature	45°F 7.2°C	45.5°F 7.5°C	42.9°F 6.1°C	42.5°F 5.8°C	39.8°F 4.3°C	40.2°F 4.6°C
Minimum Temperature	13.3°F -10.4°C	3.1°F -16.1°C	7.0°F -13.9°C	-4.8°F -20.4°C	4.0°F -15.6°C	-5.3°F -20.7°C
Cold Days (days with Tmax≤32°F/0°F)	13	11	24	25	17	27
Sub-freezing Days (days with Tmin≤32°F/0°C)	109	88	121	107	108	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)	206	207	185	174	150	169

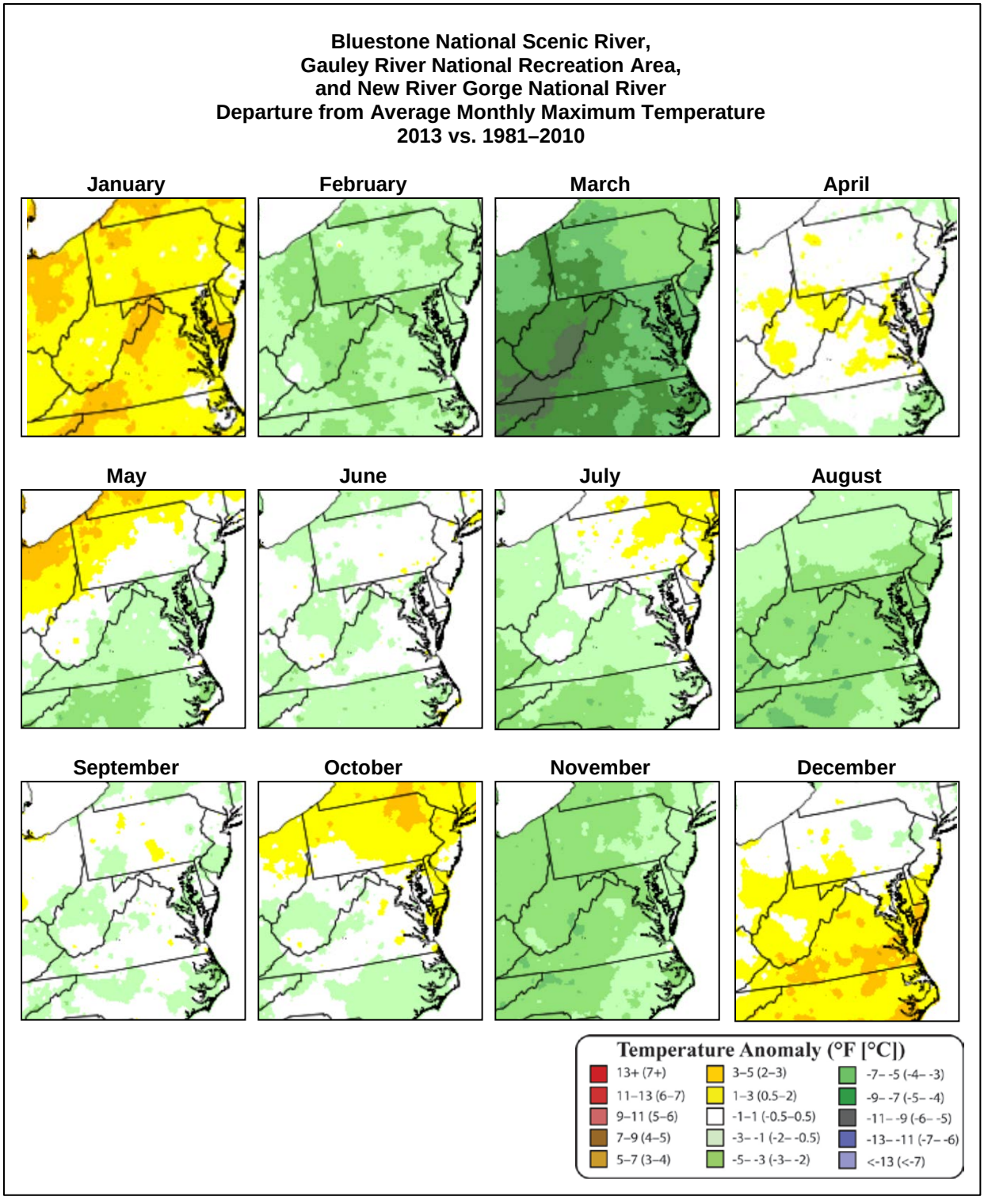

Figure 2. Maps showing departure from average monthly maximum temperature compared to the 30-year normal (1981–2010).

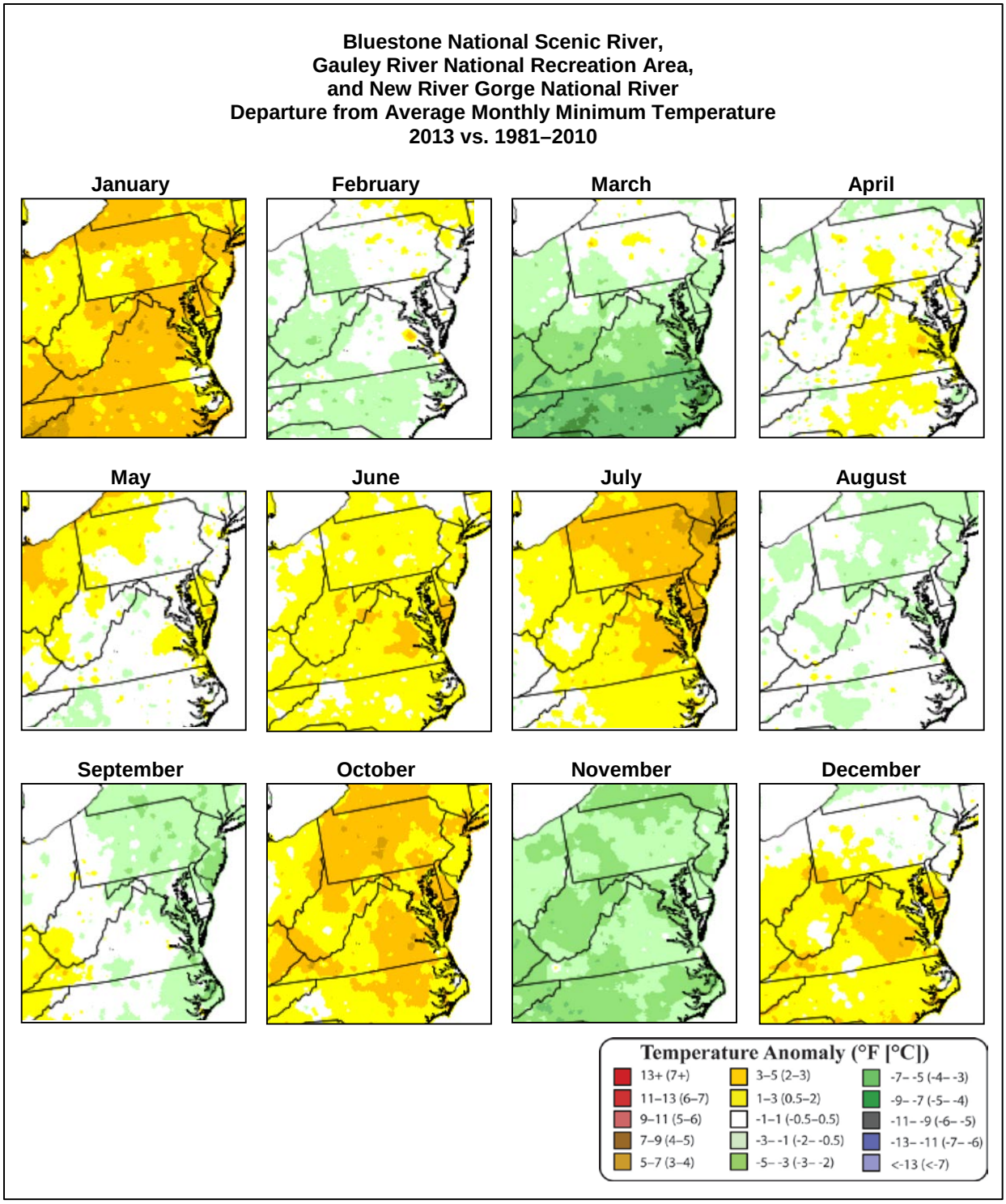

Figure 3. Maps showing departure from average monthly minimum temperature compared to the 30-year normal (1981–2010).

Table 3: Summary of monthly average temperatures for 2013 for the select station.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Oak Hill, WV	OAKW2	M	M	M	M	M	M	M	M	M	M	M	M	M
		M	M	M	M	M	M	M	M	M	M	M	M	M
London Locks, WV	LONW2	36.3°F	35.4°F	39.0°F	55.5°F	63.9°F	72.1°F	74.7°F	72.1°F	68.8°F	59.4°F	43.5°F	38.3°F	54.9°F
		2.38°C	1.88°C	3.88°C	13.0°C	17.7°C	22.2°C	23.7°C	22.2°C	20.4°C	15.2°C	6.4°C	3.5°C	12.7°C
Summersville Lake, WV	SUMW2	36.2°F	33.2°F	32.8°F	49.5°F	57.4°F	69.1°F	71.1°F	67.9°F	63.7°F	53.3°F	49.0°F	33.2°F	46.4°F
		2.33°C	0.66°C	0.44°C	9.72°C	14.1°C	20.6°C	21.7°C	19.9°C	17.6°C	11.8°C	9.44°C	0.67°C	8.0°C
Lewisburg, WV	LWBW2	31.0°F	30.2°F	33.5°F	51.1°F	58.5°F	68.4°F	71.2°F	67.8°F	62.1°F	52.7°F	37.6°F	33.1°F	49.8°F
		-0.55°C	-1.0°C	0.83°C	10.6°C	14.7°C	20.2°C	21.7°C	19.8°C	16.7°C	11.5°C	3.11°C	0.61°C	9.8°C
Beckley VA Hospital, WV	BCKW2	32.6°F	29.8°F	32.1°F	49.3°F	57.2°F	65.7°F	68.3°F	65.5°F	61.3°F	51.2°F	36.9°F	32.9°F	48.7°F
		0.33°C	-1.22°C	0.05°C	9.61°C	14.0°C	18.7°C	20.1°C	18.6°C	16.2°C	10.6°C	2.72°C	0.50°C	9.3°C
Beckley Airport, WV	KBKW	35.9°F	32.7°F	35.3°F	53.2°F	60.7°F	68.7°F	71.2°F	68.9°F	63.8°F	54.8°F	39.8°F	37.0°F	51.8°F
		2.16°C	0.38°C	1.83°C	11.7°C	15.9°C	20.3°C	21.7°C	20.5°C	17.6°C	12.6°C	4.33°C	2.78°C	10.9°C
Pineville,WV	PINW2	35.1°F	34.4°F	37.4°F	55.0°F	61.0°F	70.5°F	73.4°F	71.0°F	65.9°F	56.0°F	44.3°F	37.3°F	53.4°F
		1.72°C	1.33°C	3.00°C	12.78°C	16.11°C	21.39°C	23.00°C	21.67°C	18.83°C	13.33°C	6.83°C	2.94°C	11.9°C
Grandview, WV	GRNW2	34.0°F	31.7°F	34.6°F	53.4°F	60.1°F	67.5°F	69.4°F	67.2°F	62.0°F	53.1°F	38.4°F	34.9°F	50.5°F
		1.1°C	-0.1°C	1.4°C	11.9°C	15.6°C	19.7°C	20.7°C	19.6°C	16.7°C	11.7°C	3.5°C	1.6°C	10.3°C
Pipestem, WV	PIRW2	34.7°F	31.9°F	34.4°F	52.9°F	59.1°F	67.8°F	69.9°F	67.5°F	62.6°F	53.9°F	39.1°F	36.0°F	50.5°F
		1.5°C	0.0°C	1.3°C	11.6°C	15.1°C	19.9°C	21.0°C	19.7°C	17.0°C	12.1°C	3.9°C	2.2°C	10.4°C

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

Table 4. Summary of 2013 departure from normal temperature based on 30-year normal (1981-2010) for the selected stations.

Station name	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Oak Hill, WV	OAKW2	M	M	M	M	M	M	M	M	M	M	M	M	M
		M	M	M	M	M	M	M	M	M	M	M	M	M
London Locks, WV	LONW2	1.52°F	-2.33°F	-6.57°F	-0.13°F	0.08°F	-0.36°F	-1.47°F	-3.34°F	-0.14°F	1.76°F	-4.22°F	0.20°F	-1.2°F
		0.83°C	-1.73°C	-3.67°C	-0.11°C	0.04°C	-0.3°C	-0.85°C	-1.91°C	-0.1°C	0.98°C	-2.34°C	0.10°C	-0.7°C
Summersville Lake, WV	SUMW2	6.56°F	0.78°F	-7.24°F	-0.58°F	-1.27°F	2.57°F	0.85°F	-1.22°F	1.12°F	1.04°F	-5.90°F	0.20°F	-1.4°F
		3.66°C	0.44°C	-4.0°C	-0.33°C	-0.73°C	1.44°C	0.48°C	-0.71°C	0.6°C	0.53°C	-3.28°C	0.11°C	-0.8°C
Lewisburg, WV	LWBW2	2.52°F	-1.54°F	-5.78°F	1.33°F	-0.12°F	1.62°F	0.89°F	-1.34°F	0.12°F	1.48°F	-3.45°F	1.80°F	-0.2°F
		1.39°C	-0.84°C	-3.22°C	0.72°C	-0.07°C	0.87°C	0.43°C	-0.81°C	0.04°C	0.84°C	-1.89°C	0.99°C	-0.1°C
Beckley VA Hospital, WV	BCKW2	4.00°F	-1.75°F	-6.69°F	0.33°F	-0.28F	0.82°F	0.22°F	-1.57°F	0.83°F	0.93°F	-4.10°F	5.10°F	0.4°F
		2.21°C	-0.95°C	-3.72°C	0.17°C	-0.16°C	0.43°C	0.05°C	-0.9°C	0.37°C	0.44°C	-2.28°C	2.83°C	0.5°C
Beckley Airport, WV	KBKW	4.75°F	-1.72°F	-6.84°F	1.07°F	0.88°F	1.30°F	0.64°F	-0.80°F	0.60°F	1.57°F	-4.10°F	2.80°F	0.0°F
		2.66°C	-0.95°C	-3.78°C	0.54°C	0.46°C	0.64°C	0.26°C	-0.44°C	0.27°C	0.83°C	-2.28°C	0.67°C	0.0°C
Pineville, WV	PINW2	2.8°F	-1.4°F	-6.1°F	-1.6°F	1.1°F	-0.1°F	0.5°F	-2.3°F	-0.4°F	1.1°F	-0.3°F	2.3°F	-0.4°F
		1.6°C	-0.8°C	-3.4°C	0.9°C	-0.6°C	0.1°C	-0.3°C	-1.3°C	-0.2°C	-0.6°C	-0.2°C	1.3°C	-0.2°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 2013 over 119 years (1 = warmest/wettest year and 119 = coldest/driest year) for West Virginia Climate Division 4 (top) and 5 (bottom).

WV Climate Division 4 Rankings "Central"	Jan–Feb–Mar WINTER	Apr–Ma20y–Jun SPRING	Jul–Aug–Sep SUMMER	Oct–Nov–Dec AUTUMN	Jan – Dec ANNUAL
Temperature-2013	84	32	70	65	74
Precipitation-2013	87	36	29	30	28
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-2013	79	47	81	46	70
Precipitation-2013	79	19	49	13	12

Precipitation Summary

Liquid precipitation (rain and melted snow, ice, sleet, etc.; hereafter, precipitation) for the region generally averaged below the long-term mean except near Gauley River NRA where there was slightly above normal precipitation (Table 6). Most of the wettest days occurred during the summer and autumn (Table 7). An unusually dry period was noted from May 24 until June 2 when there was no measurable rain (Table 7). Snowfall was markedly below normal (Table 6). The number of days with excessive rainfall (>1.0 in [25 mm]) was at the long-term average for south-central West Virginia (Table 6).

The winter started much above normal (Figure 4), as January averaged approximately 170 percent of normal precipitation in Beckley, WV, and 163 percent in Bluestone Lake, WV (Tables 8 and 9). February was much drier (Figure 4), with between 31 percent and 89 percent of average precipitation (Tables 8 and 9); some fell in the form of snow. Monthly precipitation in March was still below normal, with 2.2–3.4 in (55-87 mm) accumulating across the central and southern districts of West Virginia (Table 8). Winter precipitation, including rain and snow (liquid equivalent), was ranked between 31st and 39th driest in 119 years of record keeping (Table 5).

Spring 2013 brought piecemeal moist conditions during April and May and progressively wetter weather in June (Figure 4), averaging the 36th driest in climate division 4 and 19th driest in climate division 5 (Table 5). By far, April was the driest month of this season, as 36-126 percent of normal rain was reported (Table 9). Three of the year's dry spells occurred between April 4-11, April 29-May 6 and May 24-June 2 (Table 7). May and June brought more frequent and sporadic rainfall. Pineville tallied only 103 percent of average rainfall, while Lewisburg measured 142 percent of normal rainfall; these stations are about 62 miles apart.

The summer months of July, August, and September showed some contrast; the southern valleys averaged near-normal rainfall, but the eastern and central mountains were dry (Figure 4). Two of the wettest days of 2013 occurred during the summer. On July 22, an average of 2.0 in (50.8 mm) was tallied in the region and on September 20, approximately 2.47 in (62.7 mm) fell (Table 7). The summer ranked the 29th wettest in the central West Virginia climate division, and the 49th wettest in the southern division (Table 5).

Autumn brought increasingly wetter than normal precipitation to the region (Figure 4). October was dry with most sections averaging from 59-77 percent of the normal rainfall (Table 9); however, November was notably moister in the central West Virginia climate division. For example, Beckley VA Hospital, WV, had 122 percent of normal rainfall, but Pineville, WV, tallied 49 percent with 1.58 in (40.1 mm) (Tables 8 and 9). December turned wetter with more than 230 percent of normal rain and snow tallied at London Locks, WV (Table 9). Overall, 2013 brought between 146-230 percent of average annual precipitation, which ranged from -3.5 in (-89 mm) to +1.6 in (+56 mm). It was, overall, an average year for much of the region.

Table 6. Status of 2013 precipitation indicators compared to the 30-year normal (1981–2010) at the London Locks (LONW2), Beckley Airport (KBKW), and Summersville Lake (SUMW2) stations.

Precipitation Indicator	London Locks, WV 2013	London Locks, WV 1981-2010	Beckley Airport, WV 2013	Beckley Airport, WV 1981–2010	Summersville Lake, WV 2013	Summersville Lake, WV 1981-2010
Annual Precipitation	44.5 in 1,130 mm	43.8 in 1,112 mm	42.8 in 1,102 mm	41.2 in 1,046 mm	44.4 1,128 mm	47.9 in 1,217 mm
Autumn Precipitation (Oct, Nov, Dec) Precipitation	10.6 in 269 mm	9.2 in 234 mm	8.4 in 213 mm	8.5 in 216 mm	9.3 in 236 mm	10.2 in 259 mm
Heavy Precipitation Days (days with ≥1.0 in (25 mm) rain)	10	9	6	7	8	9
Extreme Precipitation Days (days with ≥2.0 in (51 mm) rain)	2	1	0	1	1	1
Micro-drought (strings of 7+ days without rain)	M	7	2	3	1	5
Annual Snowfall (inches)	M	36.4 in 92.5 cm	43.9 in 111.5 cm	62.0 in 157.5 cm	22.0 in 55.9 cm	38.7 in 98.3 cm
Measurable Snow Days (days with ≥0.1 in (0.3 cm) snow)	M	27	35	38	12	21
Moderate Snow Days (days with ≥3.0 in (7.6 cm) snow)	M	5	2	6	1	5
Heavy Snow Days (days with ≥5.0 in (12.7 cm) snow)	M	1	0	2	0	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.

Table 7. Top five wettest days and top five dry spells (consecutive days with a trace or less of liquid precipitation) during 2013 from stations London Locks (LONW2), Beckley Airport (KBKW), and Summersville Lake (SUMW2).

Wettest Days in 2013	Dry Spells in 2013
Sept. 20: 2.47 in (62.7 mm)	May. 24 - Jun. 2
July 22: 2.00 in (50.8 mm)	Sept. 4-12
Dec. 6: 2.00 in (50.8 mm)	Sept. 29- Oct. 6
Jan. 31: 1.76 in (44.7 mm)	Apr. 29-May 6
Nov. 26: 1.51 in (38.4 mm)	Apr. 4-11

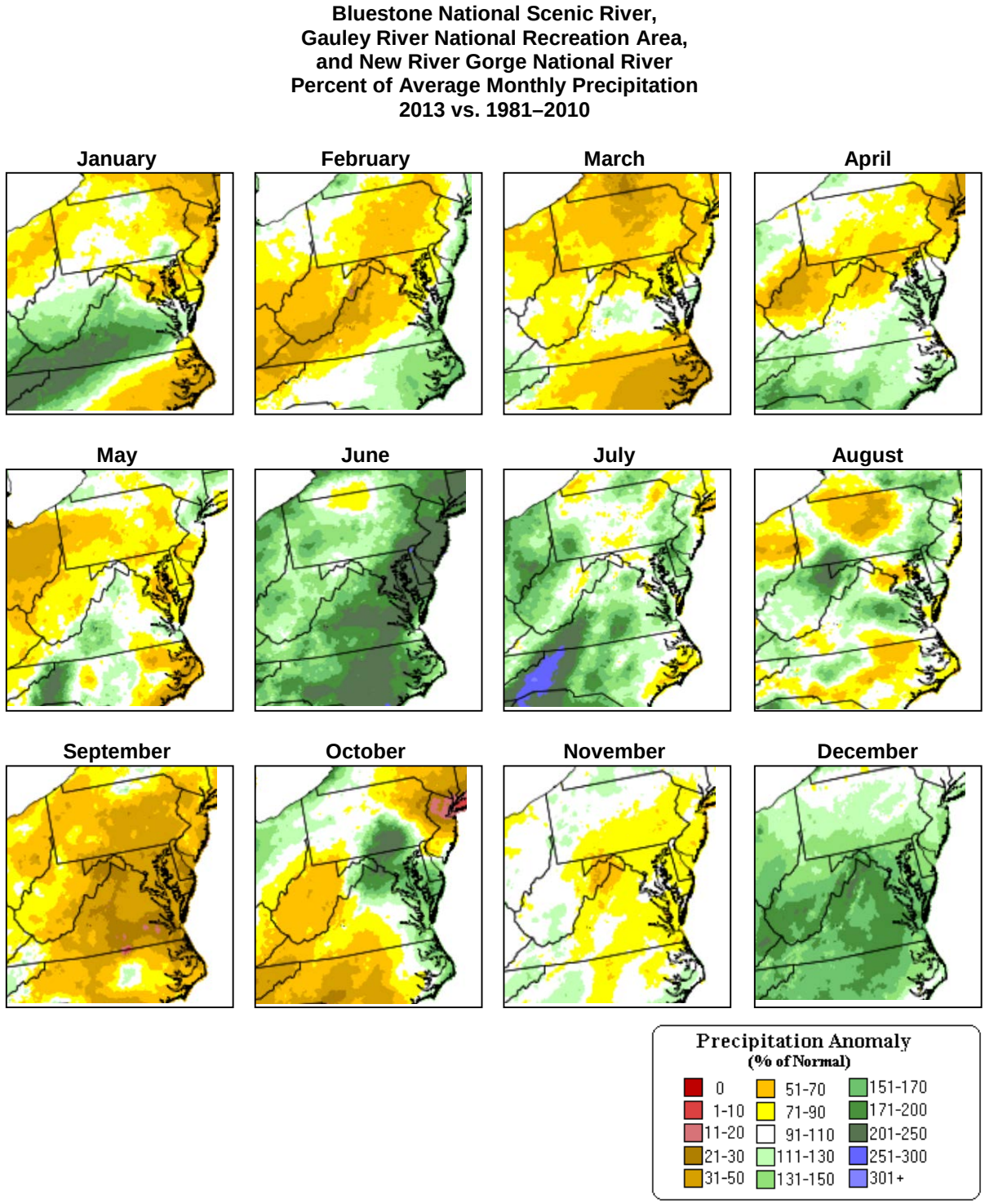

Figure 4. Maps showing percent of average monthly precipitation compared to the 30-year normal (1981–2010).

Table 8. Summary of 2013 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	4.68in	1.37in	2.66in	4.28in	4.76in	4.29in	3.97in	5.22in	2.80in	1.59in	2.56in	5.91in	44.09in
		118.9mm	34.8mm	67.6mm	108.7mm	120.9mm	109.0mm	100.8mm	132.6mm	71.1mm	40.4mm	65.0mm	150.1mm	1119.9mm
Oak Hill	OAKW2	M	M	4.7 in	M	M	M	M	M	M	M	M	M	M
		M	M	120 mm	M	M	M	M	M	M	M	M	M	M
London Locks	LONW2	4.55in	2.47in	2.56in	1.29in	3.62in	4.77in	7.58in	3.14in	0.82in	1.78in	4.37in	7.53in	44.48in
		115.5mm	62.73mm	65.0mm	32.7mm	91.9mm	121.1mm	192.5mm	79.7mm	20.8mm	45.2mm	110.9mm	191.3mm	1129.8mm
Summersville Lake	SUMW2	4.49in	1.30in	3.44in	2.27in	3.11in	5.81in	6.28in	4.29in	3.35in	2.04in	0.86in	4.94in	44.37in
		114.0mm	33.0mm	87.3mm	57.6mm	78.9mm	147.5mm	159.5mm	108.9mm	85.0in	51.8mm	21.8mm	125.5mm	1127.0mm
Princeton	PRIW2	5.03in	1.65in	3.05in	3.55in	4.58in	5.20in	3.36in	2.34in	1.38in	1.84in	3.43in	5.55in	40.96in
		127.8mm	41.9mm	77.5mm	90.2mm	116.3mm	132.1mm	85.3mm	59.4mm	35.1mm	46.7mm	87.1mm	141.0mm	1040.4mm
Lewisburg 3 N	LWBW2	4.75in	0.85in	2.48in	3.05in	4.78in	5.17in	4.15in	5.18in	3.39in	1.68in	2.98in	6.02in	44.48in
		120.6mm	21.59mm	63.0mm	77.5mm	121.4mm	131.3mm	105.4mm	131.6mm	86.1mm	42.7mm	75.7mm	152.9mm	1129.8mm
Beckley VA Hospital	BCKW2	4.47in	1.37in	2.39in	2.65in	4.32in	6.83in	5.33in	4.75in	1.60in	1.87in	3.49in	5.82in	44.89in
		113.5mm	34.8mm	60.7mm	67.3mm	109.7mm	173.5mm	135.5mm	120.7mm	40.64mm	47.5mm	88.7mm	147.8mm	1140.2mm
Beckley Airport	KBKW	4.77in	1.42in	2.15in	2.73in	4.31in	4.82in	4.62in	5.15in	1.72in	1.51in	3.28in	6.36in	42.84in
		121.1mm	36.1mm	54.6mm	69.3mm	109.5mm	122.4mm	117.4mm	130.8mm	43.7mm	38.4mm	83.3mm	161.5mm	1088.1mm
Pineville	PINW2	5.25in	1.00in	2.37in	3.46in	4.30in	4.37in	3.66in	3.29in	1.40in	1.81in	1.58in	5.54in	38.03in
		133.3mm	25.4mm	60.2mm	87.9mm	109.2mm	111.0mm	93.0mm	83.6mm	35.6mm	46.0mm	40.1mm	140.7mm	966.0mm
Grandview	GRANDVIEW	4.59in	1.46in	2.22in	2.60in	4.86in	5.05in	6.06in	4.73in	1.64in	1.59in	3.56in	6.28in	44.64in
		116.5mm	37.1mm	56.4mm	66.0mm	123.4mm	128.3mm	153.9mm	120.1mm	41.7mm	40.4mm	90.4mm	159.5mm	1133.9mm
Pipestem	PIPESTEM	5.83in	1.53in	3.30in	4.82in	4.62in	4.63in	2.54in	3.00in	1.02in	1.89in	2.81in	5.71in	41.70in
		148.1mm	38.9mm	83.8mm	122.4mm	117.3mm	117.6mm	64.5mm	76.2mm	25.9mm	48.0mm	71.3mm	145.0mm	1059.2mm

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

Table 9. Summary of 2013 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	163%	52%	79%	126%	116%	127%	90%	154%	96%	61%	98%	204%	115%
Oak Hill	OAKW2	M	M	118%	M	M	M	M	M	M	M	M	M	M
London Locks	LONW2	154%	89%	68%	36%	75%	110%	151%	84%	26%	72%	129%	230%	104%
Summersville Lake	SUMW2	139%	43%	91%	59%	62%	128%	106%	96%	97%	65%	25%	146%	94%
Princeton	PRIW2	172%	63%	93%	112%	108%	145%	77%	70%	48%	77%	124%	195%	107%
Lewisburg	LWBW2	154%	33%	71%	88%	111%	142%	109%	164%	108%	66%	105%	184%	117%
Beckley VA Hospital	BCKW2	169%	55%	74%	78%	95%	199%	102%	139%	55%	77%	122%	192%	114%
Beckley Airport	KBKW	170%	52%	60%	81%	93%	121%	92%	148%	57%	59%	112%	212%	104%
Pineville	PINW2	148%	31%	62%	91%	85%	103%	70%	88%	44%	63%	49%	159%	84%

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 2012 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 2013). 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 2013 in Figures 7 and 8, respectively.

According to the PDSI for WV Climate Division 4 for 2013, it was "normal to abnormally dry" (PDSI <0; Figure 5) in the winter and spring and "normal to moist" (PDSI>0) in the summer and fall for the West Virginia parks. While the calendar year began normal, dry conditions set in by February and continued until May. As a result, PDSI values fell from near 0 in early February to near -1.3 (approaching "abnormally dry") by the end of May. Regular and occasionally heavy precipitation returned during June and August, raising PDSI values well above 0 (Figure 5). Dry weather returned in October, lowering the PDSI, but wet weather in December boosted PDSI values for the end of 2013. Surprisingly, WV Climate Division 5, which includes parts of Bluestone and New River, was moist throughout the year, despite the trends seen in WV Climate Division 4. When comparing the PDSI values with recent years, 2013 showed more consistency of moist weather during the growing season than in 2011 or 2012.

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) occurred in May 2013.

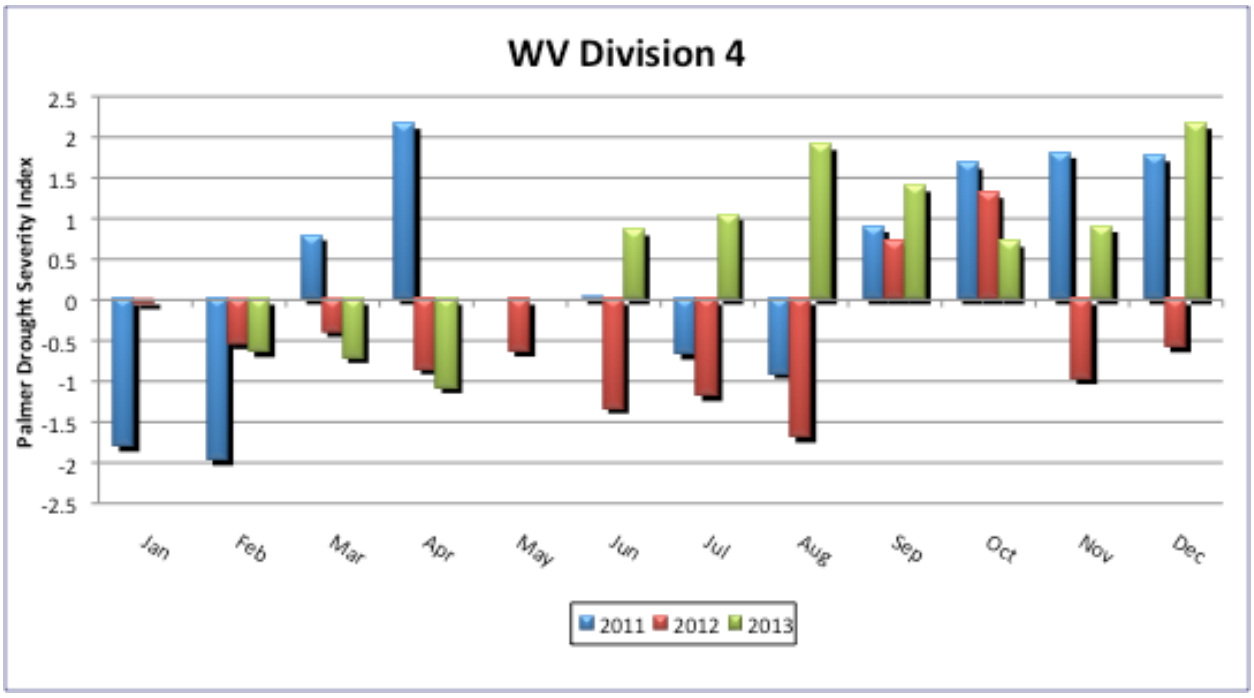

Figure 5. Monthly Palmer Drought Severity Index (PDSI) values for West Virginia Climate Division 4, 2011–2013.

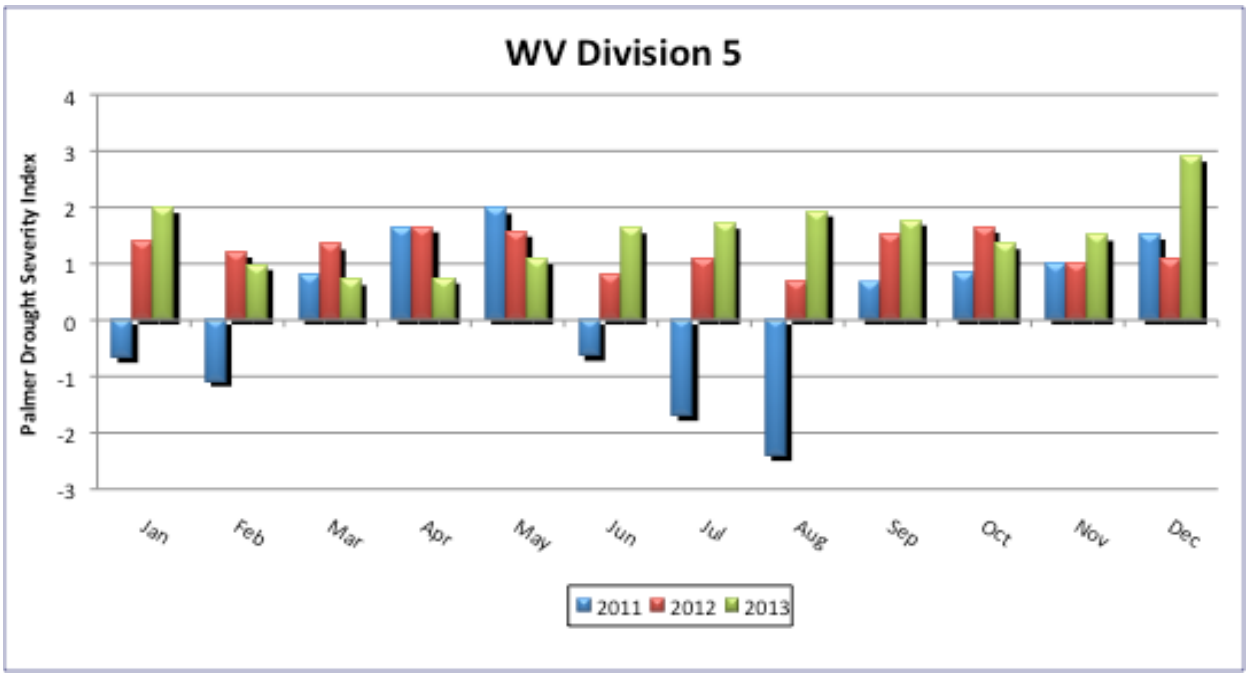

Figure 6. Monthly Palmer Drought Severity Index (PDSI) values for West Virginia Climate Division 5, 2011–2013.

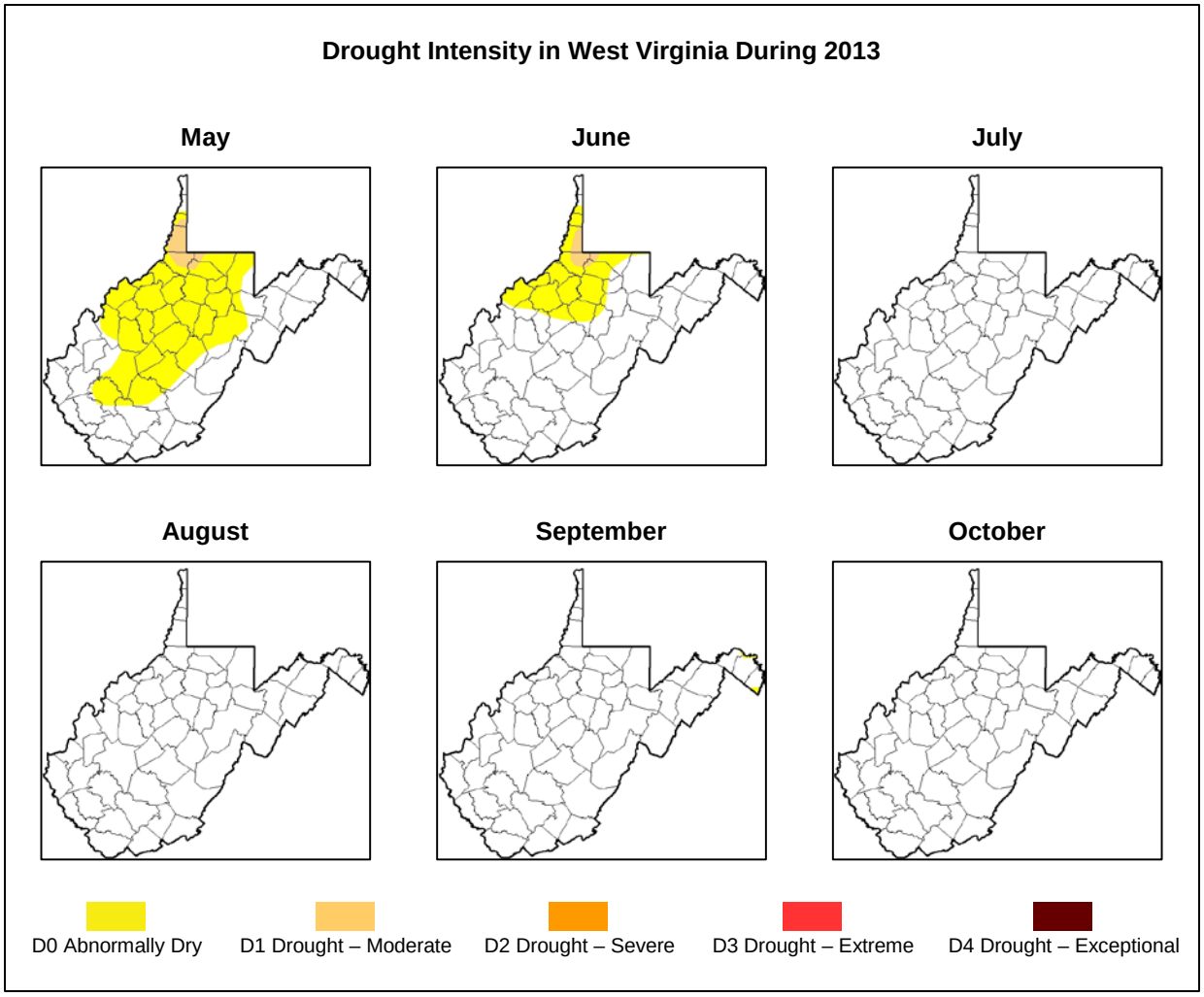

Figure 7. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for West Virginia in 2013.

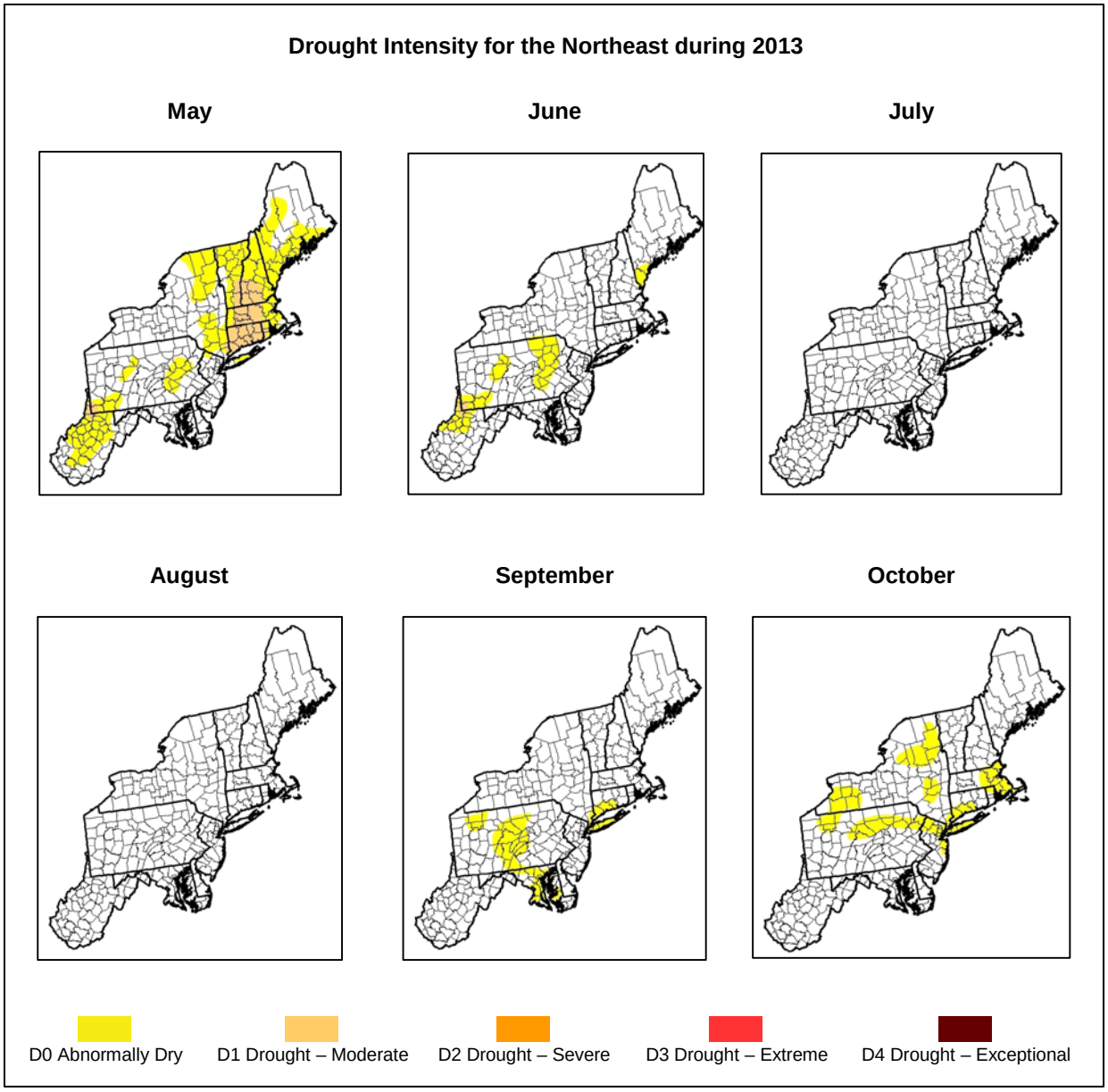

Figure 8. Mid-month values of the United States Drought Monitor (DM) - Drought Intensity Index for the Northeast in 2013.

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