ROY COOPER
Governor

MICHAEL S. REGAN
Secretary

NORTH CAROLINA
Environmental Quality

October 12, 2018

Environmental Review Commission
16 West Jones Street
Raleigh, NC 27601

Re: Annual Report from the Drought Management Advisory Council

Dear Chairs of the Environmental Review Commission,

The North Carolina Drought Management Advisory Council (NC DMAC) was established by G.S. 143-355.1. The NC DMAC was created to coordinate drought monitoring, assessment, and response activities between state and federal agencies, public water systems, and the public. The objective of the council is to provide consistent and accurate information on drought conditions so that relevant entities can manage and mitigate its harmful effects.

In accordance with statutory requirements, the NC DMAC is required to submit a report on drought conditions annually. Enclosed is the report covering FY 2017-2018.

Sincerely,

Klaus Albertin, Chair
NC Drought Management Advisory Council

Enclosures

cc: Michael Regan, Secretary
Sheila Holman, Assistant Secretary of the Environment
Linda Culpepper, Division of Water Resources

North Carolina Department of Environmental Quality
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Annual Report to the

North Carolina General Assembly

Drought Management Advisory Council Report

July 1, 2017 – June 30, 2018

Division of Water Resources

NORTH CAROLINA
DEPARTMENT OF ENVIRONMENTAL QUALITY

North Carolina Department of Environmental Quality
Division of Water Resources
Drought Management Advisory Council Annual Report
July 1, 2017–June 30, 2018

Introduction

The North Carolina Drought Management Advisory Council (DMAC), created as required by General Statute 143-355.1, coordinates drought monitoring, assessment, and response activities between state and federal agencies, public water systems, and the public. The objective of the council is to provide consistent and accurate information on drought conditions to the following entities to manage and mitigate the harmful effects of drought: United States Drought Monitor, Environmental Management Commission, the secretary of the state Department of Environmental Quality, the N.C. Environmental Review Commission and the public. In accordance with statutory requirements, the council must submit an annual report to the governor, the secretary of the Department of Environmental Quality and the Environmental Review Commission by Oct. 1 of each year.

Drought Overview 2017–2018

State Climate Office: Climate Summary

Temperature and Precipitation

For the 12-month period from July 1, 2017 to June 30, 2018, North Carolina's precipitation was near normal, averaging 48.90 inches, or 0.42 inches, below the 1901-2000 mean annual precipitation. The driest month in this period was November, which only saw an average of 1.3 inches across the state, or 1.72 inches below the 20th-century mean. For the 12-month period, only October 2017, April 2018, and May 2018 saw above-normal precipitation. These months were marked by amounts more than an inch above the long-term normal. For example, May 2018 saw 2.6 inches above normal precipitation.

Average temperatures for the same period were 1.4°F warmer than the 1901-2000 period mean, with nine of the 12 months having temperatures that were above their historic monthly average. Of note, February 2018 was the warmest February ever recorded in the state at 9.9°F above normal, and May 2018 ranked as the 3rd-warmest May on record with average temperature 5.2°F above normal. Only January, March and April were cooler than normal. February 2018 was 5.6°F warmer than March 2018.

Temperature and Precipitation Rankings

Month	Precipitation (deviation from normal)	Mean Temperature (deviation from normal)
July 2017	4.49 inches (-1.18 inches) 38th Driest / 87th Wettest	78.7°F (+1.8°F) 108th Coolest / 17th Warmest
August 2017	5.15 inches (-0.13 inches) 69th Driest / 55th Wettest	75.9°F (+0.3°F) 67th Coolest / 57th Warmest
September 2017	3.86 inches (-0.43 inches) 58th Driest / 66th Wettest	70.5°F (+0.2°F) 70th Coolest / 54th Warmest
October 2017	4.37 inches (+1.10 inches) 95th Driest / 29th Wettest	62.8°F (+3.2°F) 113th Coolest / 11th Warmest
November 2017	1.30 inches (-1.72 inches) 15th Driest / 109th Wettest	50.3°F (+1.0°F) 76th Coolest / 48th Warmest
December 2017	2.85 inches (-0.82 inches) 39th Driest / 85th Wettest	42.4°F (+0.9°F) 77th Coolest / 47th Warmest
January 2018	3.79 inches (-0.12 inches) 66th Driest / 59th Wettest	35.9°F (-4.1°F) 20th Coolest / 105th Warmest
February 2018	3.07 inches (-0.76 inches) 40th Driest / 85th Wettest	51.8°F (+9.9°F) 124th Coolest / 1st Warmest
March 2018	4.10 inches (-0.19 inches) 61st Driest / 64th Wettest	46.2°F (-3.1°F) 20th Coolest / 105th Warmest
April 2018	5.14 inches (+1.60 inches) 110th Driest / 15th Wettest	56.0°F (-1.8°F) 23rd Coolest / 102nd Warmest
May 2018	6.79 inches (+2.80 inches) 122nd Driest / 3rd Wettest	71.6°F (+5.2°F) 122nd Coolest / 3rd Warmest
June 2018	3.99 inches (-0.58 inches) 50th Driest / 75th Wettest	76.8°F (+3.2°F) 115th Coolest / 10th Warmest
July 2017 - June 2018	48.9 inches (-0.42 inches) 55th Driest / 69th Wettest	59.9°F (+1.4°F) 106th Coolest / 18th Warmest

Precipitation and temperature values and rankings were obtained from the NOAA National Centers for Environmental Information: https://www.ncdc.noaa.gov/cag/statewide/rankings/31
Monthly average values are compared against the 1900-2001 normals.

Summary of Weather Patterns

There was no drought or abnormal dryness present in North Carolina entering the summer of 2017, However, above-normal temperatures combined with slightly below-normal rainfall during the summer contributed to a drying trend across the state, with abnormally dry (Drought Class D0) conditions appearing in early August. The driest conditions were concentrated in North Carolina's Piedmont and persisted into the fall as the region consistently missed out on rains, such as those associated with the remnants of Hurricane Irma in September. Figure 1 shows fall conditions reported by the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS).

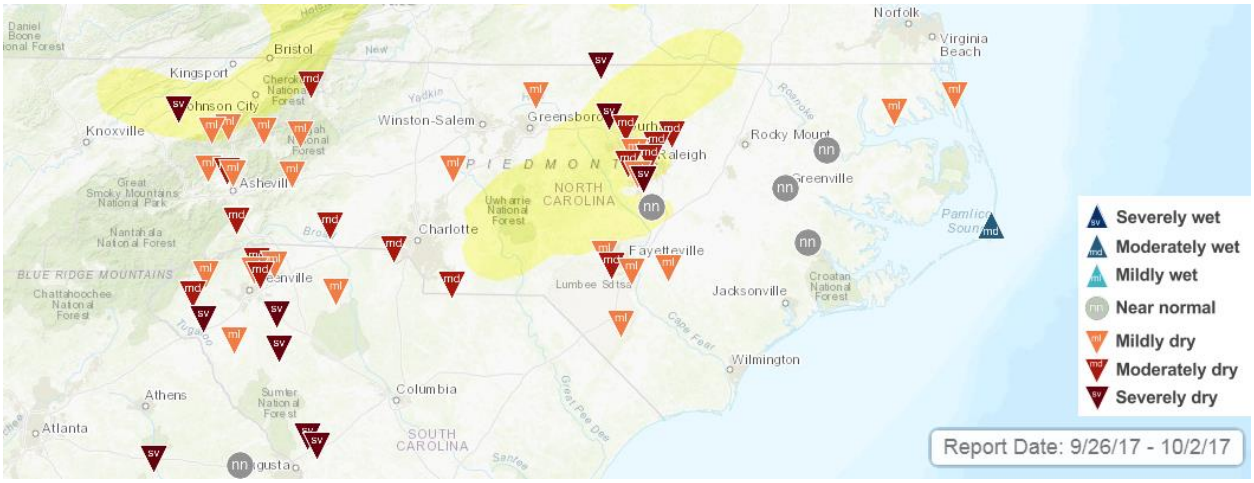

Figure 1. CoCoRaHS condition monitoring reports submitted by observers from September 26 through October 2 reveal drying conditions across much of the state.

By late October, moderate drought (Drought Class D1) appeared in a few parts of North Carolina. A dry November exacerbated conditions across the Piedmont and coastal plain. December saw some relief in the form of precipitation in southeastern North Carolina, but little precipitation in other areas which led to a westward expansion of D0 and D1.

Although our winter was influenced by a moderate La Niña pattern, which often results in drier weather in the southeast United States, enough precipitation fell over drought-affected areas to bring improvements in soil moisture, streamflow, and reservoir levels. By late March, no drought remained in the state, although abnormally dry conditions persisted in areas of the Piedmont and western coastal plain.

In early spring, the driest part of the state shifted east, falling along a north-south line roughly following the I-95 corridor. April saw an active weather pattern, including several tornadoes that damaged buildings and homes in the Piedmont.

May saw a statewide average of 6.79 inches of precipitation, which was 2.8 inches above normal. Much of this precipitation fell in the mountains, leading to swollen rivers, flooding and landslides. These late spring rains removed all drought or dry conditions from the map in early June.

U.S. Geological Survey: Streamflow and Groundwater

At the beginning of the reporting period, USGS WaterWatch streamflow maps depicted a mix of conditions generally in the normal ranges across the state. Below-normal ranges were present at some USGS streamgages across western North Carolina. Streamflow conditions alternating between mostly normal ranges with episodes of expanding below-normal ranges across central North Carolina were characteristic of the late summer and fall seasons until widespread, below-normal conditions became entrenched across the state during December and early January. During these two months, widespread flows at less than 10th percentile, as well as record-low streamflows (for the calendar date), were in effect. Overall streamflow conditions in early February began to vary widely between above- and below-normal cycles with much of the below-normal conditions generally confined to the central parts of the state. In late April, an increasing frequency of storm systems, as well as occurrences of beneficial rainfall amounts across the state, began to improve streamflow conditions, most notably in the Blue Ridge and western piedmont streams. From May into early June, much above-normal streamflow conditions (greater than 90th percentile) were in effect for the western part of the state with mostly normal streamflow ranges elsewhere. At the end of the annual period, the frequency of storm systems declined and streamflows were shifting back towards mostly normal ranges across the state with a small presence of below-normal conditions in the western piedmont.

Figure 2 below indicates the percentage of USGS streamgages in North Carolina with 7-day flows less than the 25th, 10th and 1st percentiles (or record-low for the calendar date) during the annual period.

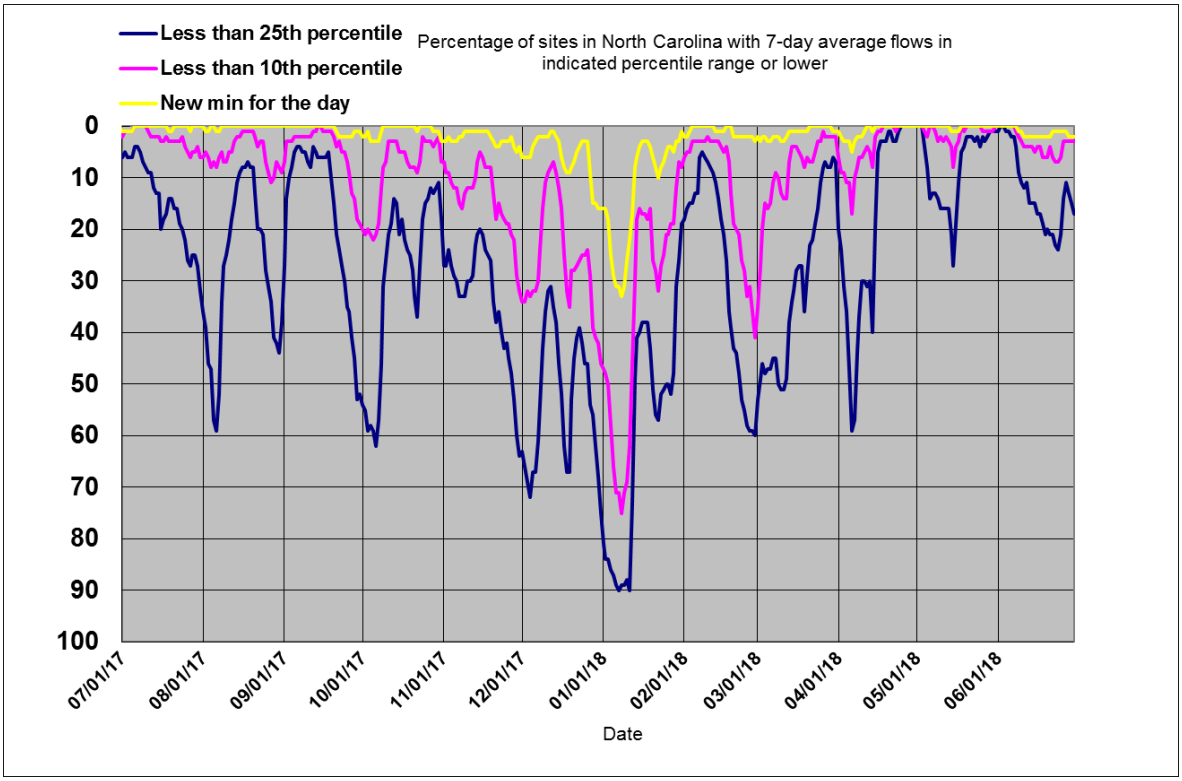

Figure 2. 7-day Flow Percentiles for USGS Streamgages in North Carolina

Below-normal streamflow conditions gradually expanded during the summer and early fall seasons with the percentages of USGS streamgages across North Carolina having 7-day average streamflow percentiles below the 25th and 10th percentiles reaching 90 and 75 percent, respectively, in early January. These percentages are lower than the maximum values (99 and 91 percent, respectively) observed during the previous annual period (2016−2017). Beginning in early February and lasting through mid-April, streamflow conditions varied widely between alternating cycles of above and below-normal conditions. During this late-winter and early-spring period, the percentage of below-normal 7- and 28-day streamflows increased and decreased by 50+ percentage points. However, from late April through end of June, the frequency of storm systems crossing parts of the state were sufficient to improve overall streamflow conditions such that the percentage of below-normal conditions was less than 30 percent during the last two months of the annual period.

Examination of provisional daily discharges indicates no new period of record minimum daily mean discharges were set at USGS streamgages across North Carolina during the annual period. Likewise, no new periods of record minimum monthly average discharge were set for any of the

USGS streamgages within the state. However, provisional new record minimum monthly average discharges were set during December 2017 and January 2018 at four streamgages across the north central piedmont within the upper Roanoke, Cape Fear, and Yadkin River basins. United States drought monitor conditions depicted for North Carolina during December and most of January were D0 across the Blue Ridge and coastal plain regions accompanied by D1 across the piedmont.

Groundwater levels at 16 USGS observation wells within the N.C. Climate Response Network varied widely during July 1, 2017 through June 30, 2018. Water levels in the wells reflect the climate conditions (occurrence of precipitation), but temporal changes are also affected by individual well characteristics (e.g., well depth, surrounding material through which the water moves).

Water levels at the four Blue Ridge observation wells in this network were generally sustained in the normal and above-normal ranges throughout much of the annual period. Brief periods of below-normal water levels were noted during some months. The most notable instance was well below normal ranges (less than 10^{th} percentile) at the USGS well at Marble in Cherokee County during January and early February. A new January monthly minimum water level of 6.95 ft. below land surface was observed at the Marble well on Jan. 27, 2018. Frequent and beneficial rainfalls during May resulted in the Blue Ridge water levels remaining sustained in the above- and much-above normal ranges through the end of June 2018.

Water levels in three piedmont wells (Langtree in Iredell County, Piedmont Research Station in Rowan County, and Mocksville in Davie County) were likewise generally in the normal- or above-normal ranges through much of the annual period. Exceptions to this pattern included below-normal water levels observed at the Langtree and Mocksville wells during parts, or all, of the period from November through early February. No periods of record minimum or maximum water levels were set during the annual period at these three Piedmont wells, but a new monthly maximum water level (6.70 ft. below land surface) for September was set on September 12, 2017.

As with the Blue Ridge and piedmont wells, the water levels in the Marston well (Sand Hills region) also were in the normal ranges throughout the annual period, with exception of April when water levels were in the below-normal ranges for the month. Among the six wells in the coastal plain, water levels varied widely among the above-normal, normal, and below-normal ranges throughout the year. Such wide variations reflect the quick response of water levels to climatic conditions in shallow wells common in the coastal plain. No new record monthly minimum water levels were observed among the six wells during the period, but multiple instances of new record monthly maximum water levels were observed at all six sites.

North Carolina Forest Service: Forest Resources

Weather impacts had a minimal effect on forestry and wildfire operations across the state during the past fiscal year. There were some localized issues with tree planting this winter due to excess moisture that required later planting than normal. However, there were no reports of tracts not being planted due to wet conditions.

From July 1, 2017 to June 30, 2018, the North Carolina Forest Service responded to 4,371 wildfires across the state that burned approximately 12,542 acres on state and private lands. The number of fires decreased by approximately five percent, while the number of acres decreased by approximately 83 percent over the previous year. The number of fires was approximately 10 percent greater than the 10-year average. The total number of acres burned was 38 percent lower than the 10-year average. There were 71,409 acres on state and private lands which were treated with prescribed fire during the past fiscal year, a 10 percent decrease from the previous year. This decrease is most likely due to drier conditions last year that allowed for more burning days.

Initially reported last year, pine bark beetle activity is increasing across the southeastern U.S., including extreme western North Carolina. Pine bark beetles (such as southern pine beetle and *Ips* engraver beetles) are opportunistic. Drought-stressed trees, even years after drought subsides, are more susceptible to attack, especially in over-mature, unmanaged, predominantly southern pine stands. Forest Service field personnel are performing aerial surveys statewide and monitoring outbreaks.

North Carolina Cooperative Extension: Agriculture

June and July 2017 saw good-to-ideal growing conditions across the state with the traditional dryness setting into the Piedmont in early August. By late August, dry conditions were impacting soybeans and some tobacco in the northern piedmont. By late September, most crop harvesting was well underway, even though Hurricane Irma dumped extra rain on parts of the state.

October saw D1 conditions throughout parts of the Piedmont, with agricultural impacts limited primarily to vegetable crops and slowed planting of small grains. Harvest of tobacco was starting to wind down, with soybean and cotton harvest well underway. Across the state, corn and soybean yields were basically average for year over year. By late November, with D0 moving into the northeastern part of the state, soybean and cotton harvest was winding down, so agricultural impacts from the dry weather were minimal.

This year got off to a warm and wet start across most of the state, with a few exceptions at the higher elevations of the northwest mountains. By mid-April many farmers were deep into planting corn, bedding tobacco, and strawberries that escaped the freeze in the east were doing

well. Wet conditions in some southeastern counties were keeping farmers out of the fields. By late April, drier weather was allowing farmers back into the fields to plant or in some cases replant corn. Abnormal dryness reached south to north along the I-95 corridor but with no reported impacts on crops. The end of May saw extensive rain across most of the state, again keeping farmers out of fields and hampering wheat harvest.

By mid-June, only one county, Robeson, identified dry conditions severe enough to impact corn development. Some producers were still struggling to get crops planted and nitrogen applied. By the end of June, sporadic dryness had settled into counties from the foothills to the coast with some counties still reporting wet conditions. Small grain production numbers in areas with increased rain were off from 2017 in some counties. Most crops looked good by the end of this reporting period.

With few exceptions, crop production in North Carolina for 2017 was close to average. Strawberries and some of the other truck crops were reduced slightly by early season freezes, but most crops had enough moisture and growing degree days to overcome any negative impacts. Upland cotton was up 114 percent, winter wheat was up 42 percent and peanuts were up 37 percent.

Drought Condition Summary

The fiscal year period began with no areas of the state in abnormally dry (D0) or drought (D1 to D4) conditions (see Figure 3). Conditions began to worsen in late July 2017. During the past year, the worst drought conditions in the state occurred in the fall and early winter. Over 80 percent of the state was classified as D0 or D1 in January 2018. Drought conditions for the 2017–2018 period peaked during the week of January 23, 2018. Heavy rains across much of the state at the beginning of February 2018 significantly improved conditions. No areas of the state were in drought or an abnormally dry condition by early May. These normal conditions remained through the end of May 2018.

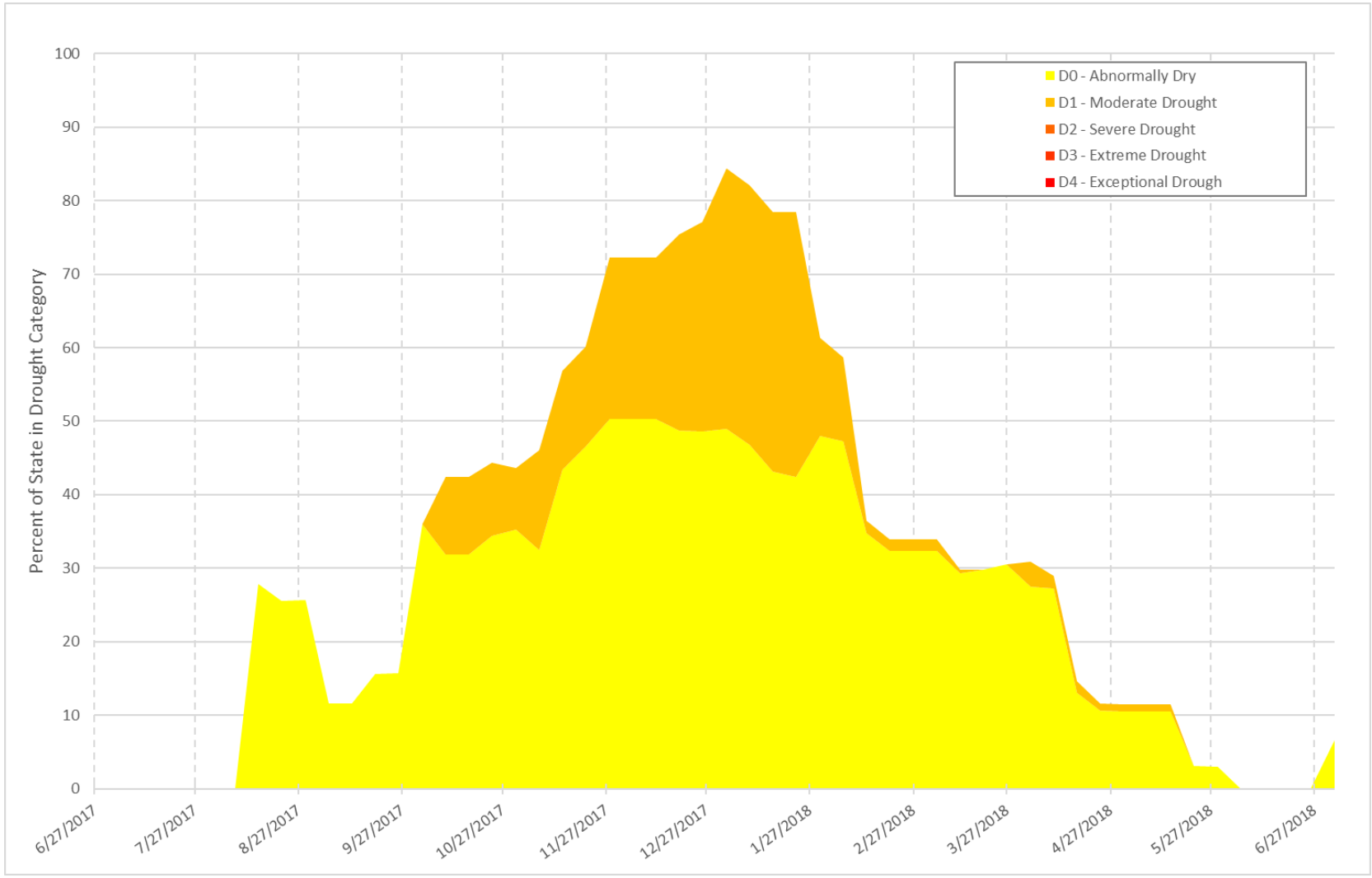

Figure 3. Drought Levels from July 1, 2017 through June 30, 2018

The dry conditions which began in fall 2017 were initially of limited concern. Rainfall is often lowest during this time of the year, residential use is dropping, farmers are generally hoping for dry weather so they can harvest, and critical periods for much of the North Carolina ecosystem is past. However, fall 2017 was much drier than normal. Parts of the Piedmont saw a deficit of eight to 10 inches from Sept. 1 through Nov. 30, 2017. By that time, approximately 50 percent of the state was considered abnormally dry and an additional 22 percent was in moderate drought (see Figure 4).

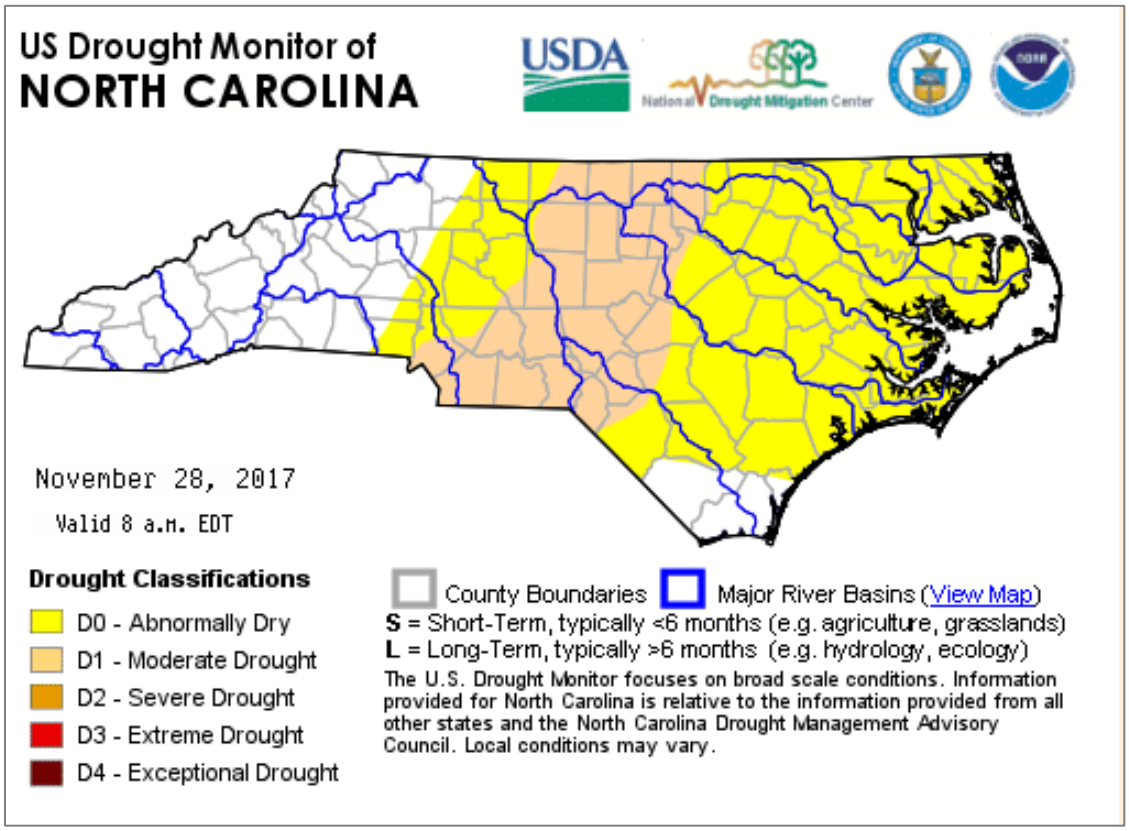

Figure 4. North Carolina Drought Classification (late November)

The dryness continued into the winter, which is usually a wetter time of year. The state did see sporadic, widespread rainfall in December and January, but saw an additional deficit of two inches in all areas except for the central and southern coast. While most water needs are low during the winter, it is an important time for recharge of groundwater and recovery of reservoirs. Reservoir storage was the primary impact seen during the 2017- 2018 moderate drought period. By mid-January, Jordan Lake had only 48 percent of its water quality pool remaining. Falls Lake had about 60 percent of its water quality pool remaining. The water supply pool was near 100 percent at Jordan Lake but down to 73 percent at Falls Lake.

Dry conditions peaked during the week of Jan. 2, 2018. At that time, part or all of 38 counties were experiencing moderate drought conditions. Approximately 50 percent of the state was considered abnormally dry and an additional 35 percent was in moderate drought. No areas in the state reached the severe drought (D2) stage. Other systems in the Piedmont, such as Durham, were also seeing reductions in their water supply availability. The Jordan, Falls, and Kerr reservoirs all reduced flow releases over the winter to maintain water storage. Energy was purchased by the Southeast Power Administration to reduce hydropower production obligations at the Kerr Lake dam.

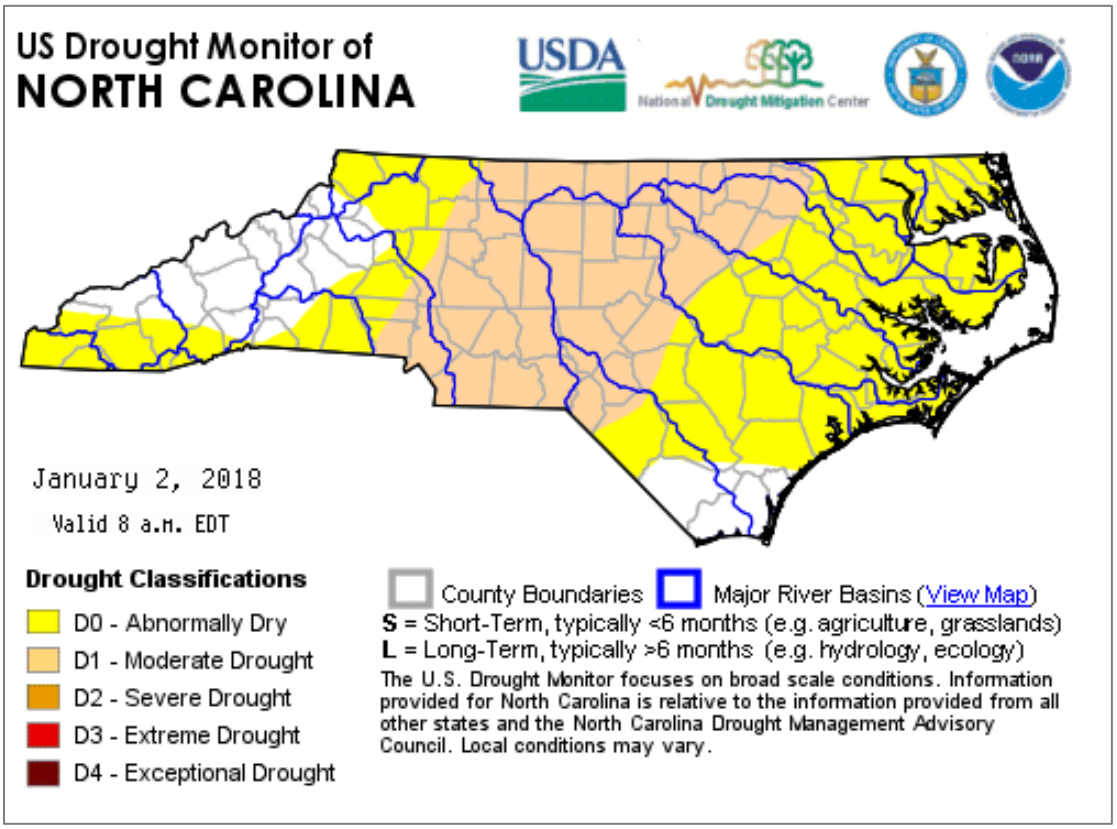

Figure 5. North Carolina Drought Classification (early January)

Conditions saw a significant improvement in February 2018 with less than two percent of the state in moderate drought by Feb. 13, 2018. Further improvements occurred gradually throughout the spring with no drought designations statewide by early June 2018.

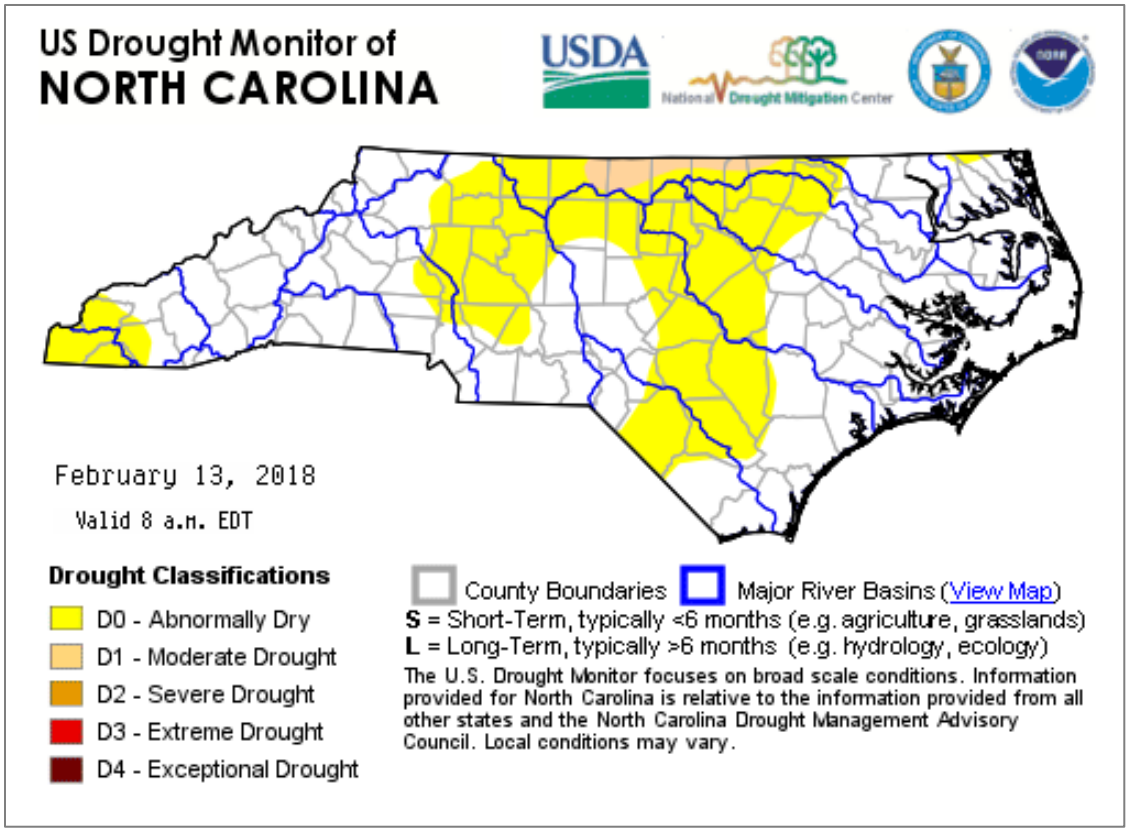

Figure 6. North Carolina Drought Classification (mid-February)

During the worst period of the drought, part or all of 48 counties were abnormally dry and an additional 38 counties were experiencing moderate drought conditions.

Historical Perspective

Due to the natural variability of climate, drought may occur at some locations in the state. In recent history, 2003 was the only year where no drought occurred in any part of the state. More typically, we see a moderate part of the state with abnormally dry conditions and a much smaller area in moderate drought. Severe drought or worse conditions do occur in many years, but the extent is often limited. The areas that are affected also shift throughout the year as localized rainfall either hits or misses locations. In this context, the 2017 – 2018 period was somewhat typical for drought conditions.

Analysis using one of the standard drought assessment metrics, the Palmer Drought Hydrologic Index (PDHI), provides insight into long-term drought conditions for North Carolina (See Figure 7). Similar to the standard deviation of a normal distribution in statistics, PDHI values within +/- 2 reflect typical conditions. Values outside of this range show either very wet (positive) or very dry (negative) conditions. Values above +4 and below -4 reflect very extreme conditions.

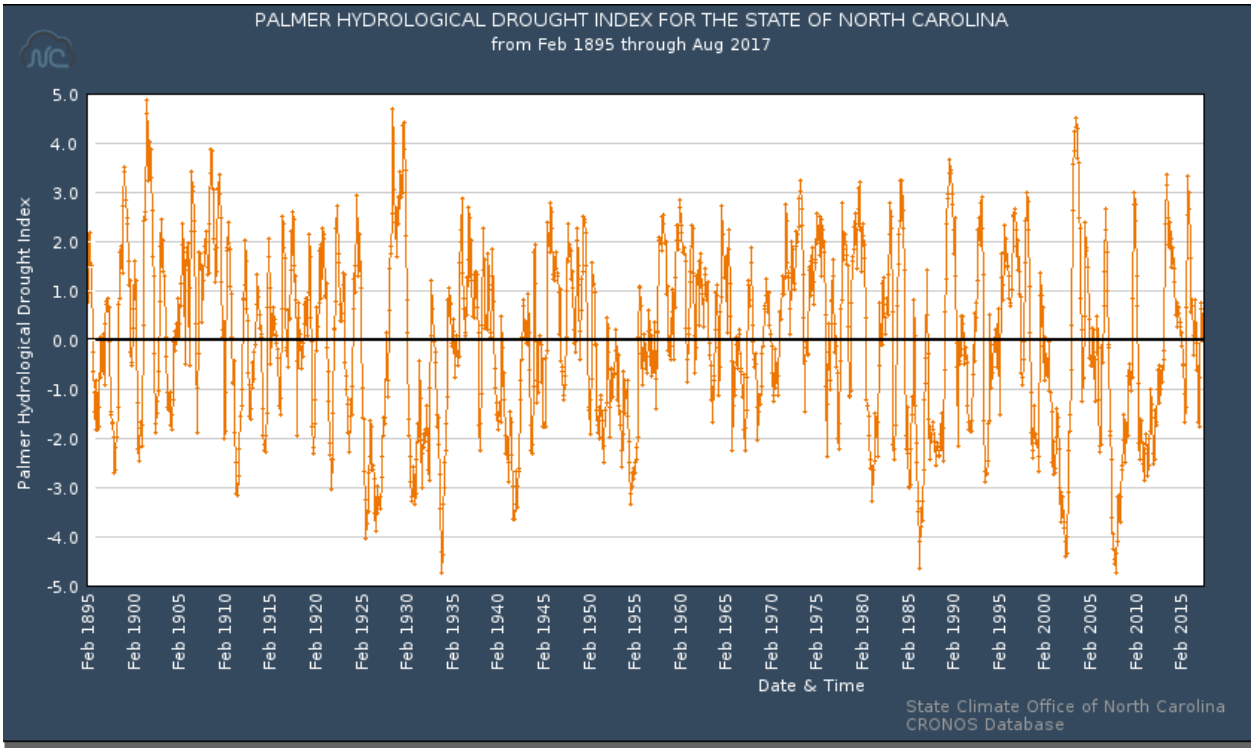

Figure 7. Palmer Hydrologic Drought Index since 1895. Source: NC SCO, 2018

North Carolina experienced extreme drought conditions from 1925 through 1927, with PDHI values reaching -4.1 at one point. A very wet period followed and then an extreme drought occurred in 1932 and 1933. This extreme drought period saw the lowest individual monthly PDHI value of -4.74. Occasional, moderate droughts occur in the 1940s and 1950s but it wasn't until the late 1980s that extreme drought returned. The PDHI reached a low of -4.6 in July 1986. Moderate to wet conditions returned in the 1990s, but two of the most extreme droughts in North Carolina's recorded meteorological history occurred between 2000 and 2010. One of the wettest years also occurred during this period. Since 2010, conditions have been less extreme but highly variable, swinging from moderately wet to moderately dry. No clear trend emerges but it does appear that more extreme swings in conditions are likely.

The southern, central and northern Piedmont reached PDHI values of -3.32, -2.81, and -2.72, respectively, in December 2017 (NOAA, 2018). These same regions reached PDHI values of -3.23, -2.73, and -2.53, respectively, in January 2018. This data places those months, the worst of the dry period, in the moderate category. The 2017-2018 period was moderate in dryness and fairly limited in spatial extent relative to the values shown in Figure 7.

Council Meetings

Drought conditions in North Carolina are updated weekly through an audio-video telecom with a technical drought advisory team, a sub-group of the Drought Management Advisory Council. The team consists of experts on climate, weather, hydrology, water supply, forestry and agriculture that report each week on streams flows, groundwater levels, reservoirs levels, wildfire activity, water supplies and crop conditions. Based on this information, the team makes a recommendation to the U.S. drought monitor author on the state's weekly drought conditions. Those recommendations are used to draw the national drought map each Thursday. To see or download a copy of the current drought map, go to the state's official drought website at: www.ncdrought.org.

The Drought Management Advisory Council is required by law to meet in person at least once each calendar year. The annual council meeting was held 10 a.m. April 12, 2018 with 41 representatives and associates of the council in attendance. Items discussed at the meeting included current conditions on stream flow and ground water levels, lake and reservoir levels, agriculture, forestry and public water systems.

References:

NOAA. 2018. Climate at a Glance. National Oceanographic and Atmospheric Administration. Website: https://www.ncdc.noaa.gov/cag/divisional/mapping/31/phdi/201711/1/value. Accessed July 25, 2018.

NC SCO. 2018. Climate Division Data. North Carolina State Climate Office. Website: http://climate.ncsu.edu/climate/climdiv . Accessed July 25, 2018.