

**Report to Governor Roy Cooper and the
North Carolina General Assembly
Environmental Review Commission**



***North Carolina Drought
Management Advisory Council***

Annual Report

October 1, 2023

Division of Water Resources

**NORTH CAROLINA DEPARTMENT
OF ENVIRONMENTAL QUALITY**

Pursuant to G.S. 143-355.1

**N.C. Department of Environmental Quality
Division of Water Resources**

**N.C. Drought Management Advisory Council Annual Report
July 1, 2022 – June 30, 2023**

Introduction

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

Drought Overview 2022 - 2023

Climate Summary – State Climate Office (Corey Davis)

Overall Summary

The past 12 months from July 2022 through June 2023 ranked as the 10th warmest (1.9°F above normal) and 60th driest (0.06 inches below normal) statewide based on records dating back 128 years from the National Centers for Environmental Information.

While this year was very slightly drier than normal on average, the timing of our rainfall, particularly from fall tropical storms and heavy rain events in the spring and early summer of 2023, generally kept drought and dryness in check.

There was some notable activity during the fall and spring fire seasons, but both could have been more widespread or impactful, particularly on the shoulders of a La Niña winter. The 2023 growing season also started with adequate moisture levels in most areas, and there were rarely any water supply concerns thanks to the regular rain events during the summer months in both 2022 and 2023.

Summer 2022

Entering July 2022, 53% of the state was classified in drought by the US Drought Monitor, including 14% in Severe Drought (D2) within the Coastal Plain. The beginning of that month saw widespread rainfall from Tropical Storm Colin at the southern coast and other timely showers and thunderstorms elsewhere. Newport recorded 16.57 inches of rain and its wettest July in the past 25 years.

August saw more rain from frequent showers and thunderstorms that finally eroded drought conditions across the state by the middle of the month. That ended a stretch of 43 consecutive weeks with drought present in parts of North Carolina, which was the fifth-longest such streak since the US Drought Monitor officially began tracking conditions in 2000.

By the end of August, about 29% of the state was classified as Abnormally Dry (D0), primarily from the central Piedmont through the northern Coastal Plain. These areas were slightly drier than average during the summer, with seasonal precipitation deficits of 2.62 inches in Fayetteville and 3.84 inches in Roanoke Rapids.

Fall 2022

The three months from September through November 2022 featured several periods of dryness on either end of the state that were bookended by remnant tropical systems. By late September, Moderate Drought (D1) had re-emerged in the northeastern corner of the state, but the remnants of Hurricane Ian brought 4 to 8 inches of rain in this area, which led to widespread improvements.

The Mountains received little to no rain from Hurricane Ian, and they continued drying out in October. Asheville had just 0.68 inches of rain all month, tied for its 18th-driest October on record, and Murphy had only 1.00 inches that month.

In mid-November, the remnants of Hurricane Nicole moved across western North Carolina, with local totals of more than 4 inches. Some areas again missed out on this rainfall, including Bryson City, which had only 0.85 inches of rain from the storm. That kept Moderate to Severe Drought in place across the far western Mountains, and impacts included the Hurricane Ridge wildfire that burned 700 acres in northern Haywood County.

November also saw the re-emergence of Moderate Drought across the Sandhills and southern Coastal Plain, which had each been dry since Hurricane Ian. Wilmington received 2.56 inches of rainfall in October and November combined, which was more than 4 inches below normal.

Winter 2022-23

For the third consecutive year, a La Niña pattern was in place during the winter, which tends to favor warm and dry weather for North Carolina. Indeed, this ended up as our 4th-warmest winter on record statewide, along with the 65th-driest, with an average precipitation 0.12 inches below the 30-year average.

During the winter, frozen precipitation was mostly limited to the Mountains, and even there, it was a snowless season in places like Asheville. However, December and January did bring several rain events from cold fronts moving in from the west, which helped eliminate lingering drought and dryness across the Mountains and Piedmont.

This rain mostly missed the far eastern end of the state, so Moderate Drought remained there for much of the season. Eventually, a short-lived pattern change in mid-January saw more low pressure systems tracking up the coast, which aided some of those dry areas especially in the northeast.

In some parts of the southern and central Coastal Plain, seasonal precipitation and deeper soil moisture deficits remained. These areas were classified as Abnormally Dry at the end of February. In Wilmington, it finished as the 20th-driest winter on record in Wilmington out of the past 89 years, with a deficit of 2.93 inches.

Spring 2023

The spring started with generally drier conditions across the state in our 27th-driest March on record. In eastern North Carolina, which had been dry dating back to the fall, the onset of spring brought the re-emergence of impacts, particularly several large wildfires on Camp Lejeune and the Pocosin Lakes Wildlife Refuge. These coastal areas were classified in Moderate Drought by the end of March.

April's showers then lived up to their billing, and a combination of cold fronts, low pressure systems, and springtime thunderstorms made for the 8th-wettest April on record statewide, along with the 3rd-wettest in Raleigh, the 4th-wettest in New Bern, and the 6th-wettest in Hatteras. As a result of that rainfall, by the beginning of May, the US Drought Monitor map for North Carolina was clear of any drought or dryness for the first time since April 13, 2021.

May was slightly drier than normal for parts of the state, including in Elizabeth City, which was more than 2 inches below normal in its 12th-driest May on record. However, unseasonably cool temperatures slowed the emergence of any widespread dryness, and most of the state finished the spring at or above their normal springtime

precipitation, such as Greensboro (2.33 inches above normal) and Wilmington (3.31 inches above normal).

June 2023

The cooler pattern from May carried over into June, and some areas such as the Triad had yet to hit 90°F through the end of the month. June started drier in many areas, and Abnormally Dry conditions covered up to 35% of the state on the US Drought Monitor assessment for June 20. That was followed by a week of heavy rain associated with a slow-moving upper-level low pressure system parked over the Carolinas, which brought more than 9 inches of rain to parts of the Mountains and Foothills.

By the end of June, the only areas still classified as Abnormally Dry were in the northern Coastal Plain, including Roanoke Rapids – which had only 1.68 inches of rain all month – and Elizabeth City, which had 2.40 inches and its 19th-driest June on record.

Streamflow and Groundwater – USGS (Curtis Weaver)

Streamflow conditions during the annual period (July 1, 2022, through June 30, 2023) were characterized by four periods during which below-normal to normal flows (25th-75th percentiles) were observed across parts of the State. These below-normal periods were noted during the first half of July 2022, the end of October through latter November 2022, mid-March through mid-April 2023, and the first half of June 2023.

Figure 1 shown below indicates the percentage of U.S. Geological Survey streamgages in North Carolina with 7-day average streamflows (or 7-day flows) less than the 25th, 10th, and 1st percentiles (or record-low for the calendar date) during the annual period. The percentages of USGS streamgages across North Carolina having 7-day flow percentiles below the 25th and 10th percentiles reached maximum values of 68 percent (March 25, 2023) and 28 percent (March 26, 2023), respectively. By comparison, the maximum percentages observed during the previous annual period (2021–2022) were 90 and 39 percent, respectively, for these two streamflow indicators.

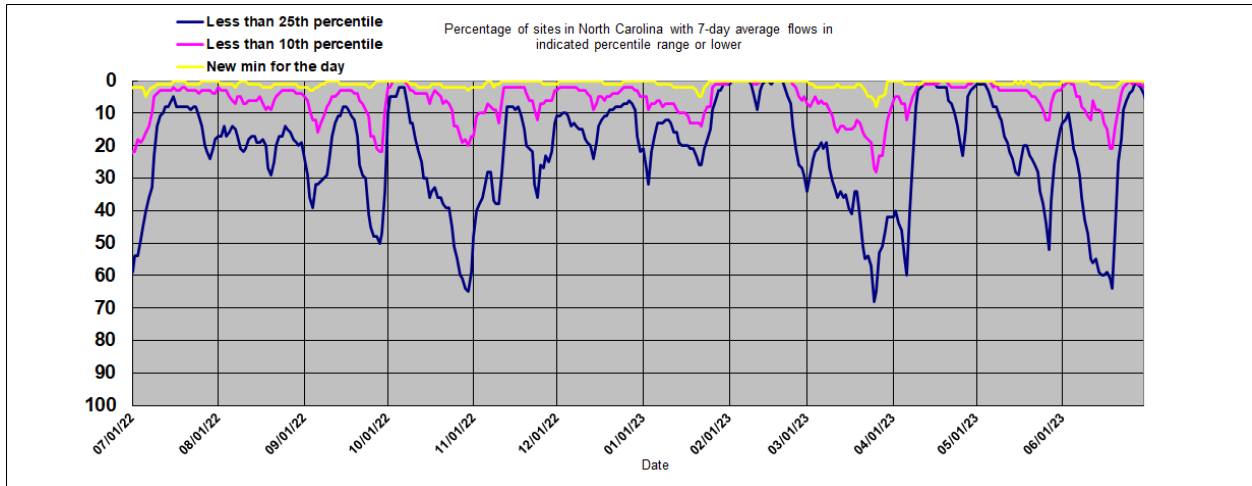


Figure 1. 7-day Flow Percentiles for USGS Streamgages in North Carolina

The extent of below-normal streamflows across North Carolina at the beginning of the 2023 spring season was further echoed with 75 percent of the streamgages across the State having 28-day average streamflows (or 28-day flows) less than the 25th percentile during the latter half of December (Figure 2, similarly structured as Figure 1 but for 28-day flows).

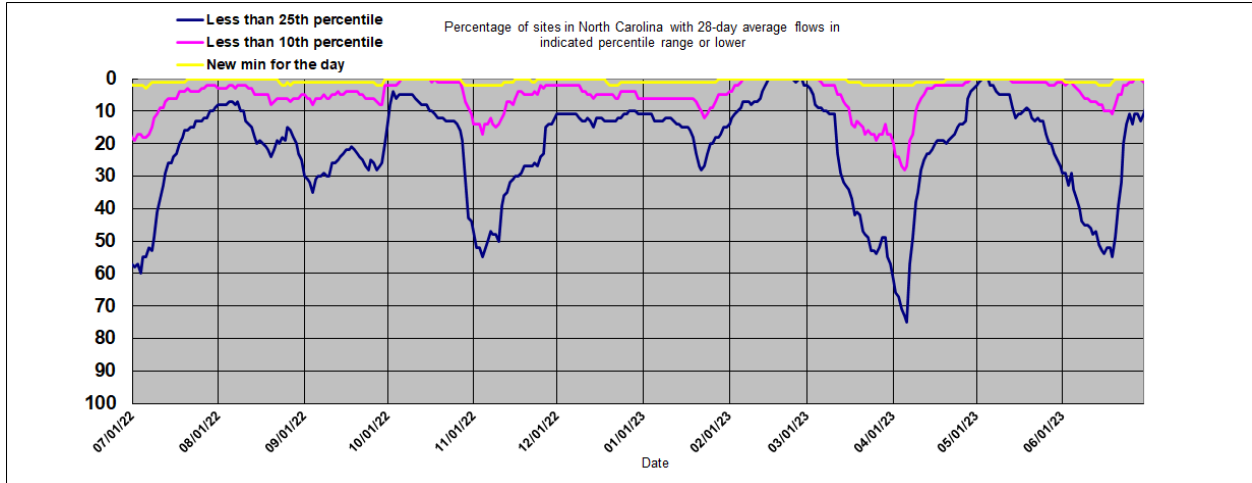


Figure 2. 28-day Flow Percentiles for USGS Streamgages in North Carolina

Examination of approved (2022 water year) and provisional (2023 water year) daily discharge data indicates no period of record minimum daily mean discharges were set at any USGS streamgage in North Carolina during the annual period. However, varying numbers of zero- or minimal-flow occurrences were observed at 7 streamgages during

the period meeting the previous record “zero flow” daily discharges set at these streamgages:

- USGS 0208111310 - Cashie River at SR 1257 near Windsor in Bertie County (40 days during the period between July 3 and October 31, 2022)
- USGS 02084160 - Chicod Creek at SR 1760 near Simpson in Pitt County (25 days during the period between July 1 and August 11, 2022)
- USGS 02084557 – Van Swamp near Hoke in Washington County (one day of zero-flow occurrence on September 29, 2022)
- USGS 02101800 – Tick Creek near Mount Vernon Springs in Chatham County (61 days during the period between August 20 and November 10, 2022)
- USGS 02134480 – Big Swamp near Tarheel in Robeson County (one day of zero-flow occurrence on September 29, 2022)
- USGS 02142900 – Long Creek near Paw Creek in Mecklenburg County (one day of 0.03 ft³/s on September 4, 2022)
- USGS 02146470 – Little Hope Creek at Seneca Place near Charlotte in Mecklenburg County (two days during September 2-3, 2022).

No period of record minimum 7-day flows was observed at any of the USGS streamgages in North Carolina, with exception of three of the seven streamgages identified above (0208111310, 02084160, and 02101800) where the previous record “zero flow” 7-day average streamflows were again observed within parts of the above-indicated periods. Minimum monthly average streamflows were observed at seven other USGS streamgages widely scattered across the eastern half of North Carolina during the annual period, but none of the new provisional monthly minimum averages were low enough to surpass the period of record minimum monthly average flow in effect at these streamgages.

Groundwater levels at the 16 observation wells within the USGS Climate Response Network (Figure 3) varied widely during the annual period from July 1, 2022, through June 30, 2023. The water levels in these 16 wells reflect the climate conditions (occurrence of precipitation), but changes in water levels are also affected by individual well characteristics (e.g., well depth, surrounding material through which the water moves).

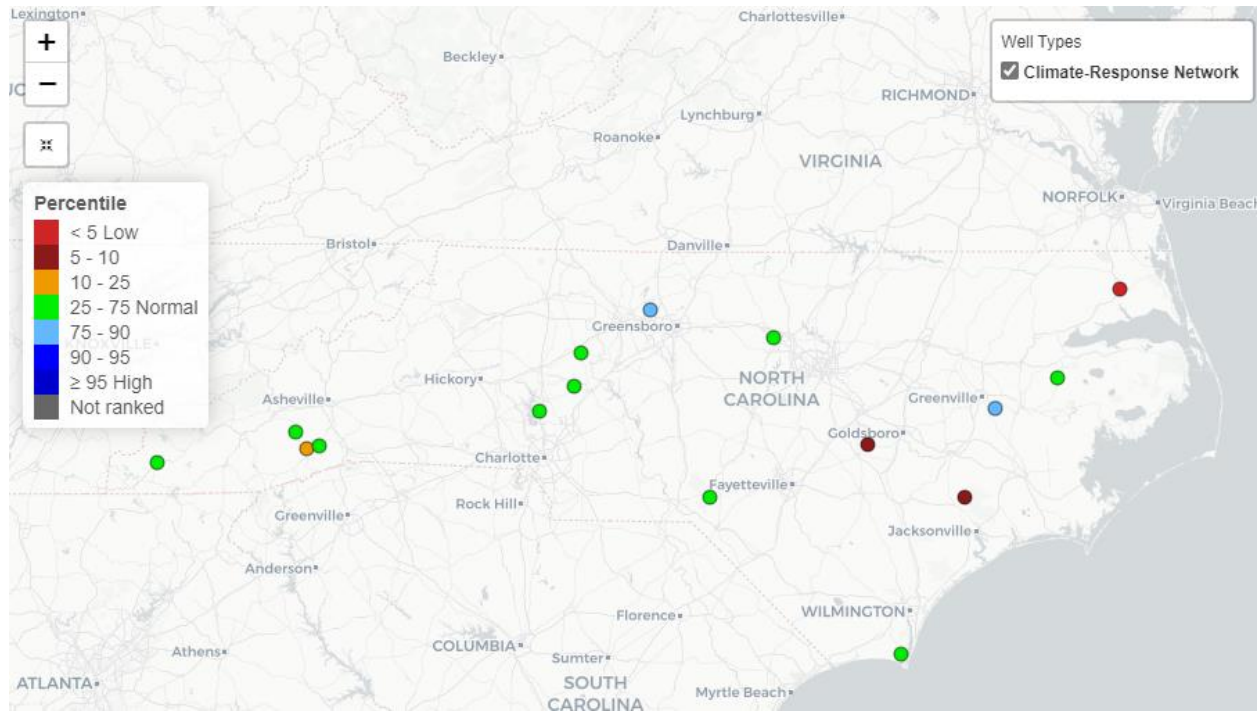


Figure 3. Groundwater levels at 16 observation wells across North Carolina within the USGS Climate Response Network

Observed water levels at the four Blue Ridge observation wells in this network generally were in the normal ranges throughout the annual period at the Marble well in Cherokee County and the Blantyre well in Transylvania County. While the water levels for the Pisgah Forest well in Transylvania County and the Champion well in Haywood County were likewise generally in the normal ranges during the first 9 months of the annual period, the levels eventually descended into or close to the below-normal ranges during the period from April 2022 through June 2023. No period of record or monthly record minimum water levels were noted among any of these four Blue Ridge wells during the period.

Similar to the Blue Ridge wells, water levels at the five Piedmont observation wells in this network generally were in the normal ranges throughout the annual period. No period of record or monthly record minimum water levels were noted among any of these Piedmont wells during the period. Analogous to water levels in the Blantyre well in the Blue Ridge region, water level changes in the Duke Forest well in Orange County have been observed to be from extremely slow to seemingly almost nonresponsive to the occurrence of precipitation events.

Water levels in the Marston observation well in Scotland County (Sand Hills region) were sustained solely within the normal ranges throughout the annual period. No period

of record or monthly record minimum water levels were noted for this well. Similar to water levels in the Blantyre well in the Blue Ridge region and the Duke Forest well in the Piedmont region, water levels in the Marston well are characterized by slow responses to the occurrence of precipitation events.

Among the six observation wells in the Coastal Plain, water levels varied widely during the annual period. Given the shallow depths of the Coastal Plain wells, water levels are typically quick to respond to the occurrence of precipitation. Hence a wide range of conditions can be in effect at a given point in time, as was noted for this annual period. With exception of the Southport well in Brunswick County and Hoke well in Washington County where water levels at the beginning of the annual period were in the normal ranges, the water levels at the beginning of the period were in the below-normal ranges for the remaining four Coastal Plain wells (Grantham well in Wayne County, Comfort Research Station (RS) well in Jones County, Simpson well in Pitt County, and Elizabeth City in Pasquotank County). Water levels remained in the below-normal ranges throughout most of the annual period at the Grantham well, Comfort RS well, and the Elizabeth City well. The water levels fluctuated more widely across the normal and below-normal ranges in the Southport well and Simpson well while water levels remained in the normal ranges throughout most of the annual period (except for below-normal levels during March 2023). No period of record water levels were noted for any of the six Coastal Plain wells, but provisional monthly record minimums were observed water levels during the seven months from November 2022 through May 2023 at the Grantham well, during March and April 2023 at the Comfort RS well, and during April and May 2023 at the Elizabeth City well.

Forestry – NC Forest Service (Jamie Dunbar)

From July 1, 2022, to June 30, 2023, the N.C. Forest Service responded to 4,670 wildfires across the state that burned approximately 35,019 acres on state and private lands. The number of wildfires decreased by approximately 32 percent, while the number of acres increased by 30 percent over the previous year. The number of wildfires was 8 percent more than the 10-year average. The total number of acres burned was 58 percent above the 10-year average.

Dry periods aligning with normal seasonal influences increased overall wildfire activity across the state, also leading to significantly higher acreage burned versus the 10-year average. Several larger wildfires occurred in late spring and into the summer of 2022, including the Juniper Road Two Fire (1,228 acres) in Pender County. November also saw the Hurricane Ridge Fire (792 acres on both state and federally protected lands) in Haywood County. Activity increased again going into the spring and summer of 2023

with several larger project fires that necessitated multiple deployments of incident management teams and various out-of-area resources. These fires included the Last Resort Fire (5,280 acres on both state and federally protected lands) in Tyrrell County, the Great Lakes Fire (32,156 acres on both state and federally protected lands) in Craven/Jones County, and the Pulp Road Fire (15,642 acres) in Pender County.

Figure 4 shows wildfire activity by month for the fiscal year 2023.

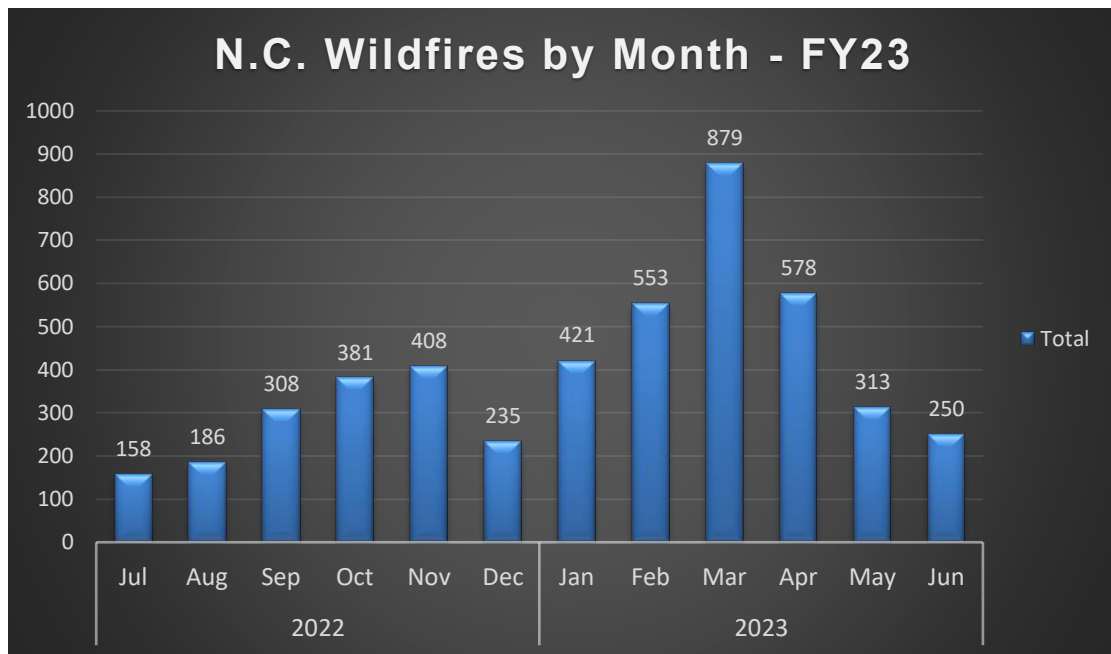


Figure 4. Wildfire activity by month for fiscal year 2023

Agriculture - North Carolina Cooperative Extension (Mike Yoder)

For the year 2022 – 2023, drought condition impacts on agriculture in North Carolina were generally minimized by the timing and amounts of precipitation across the state. Agriculture production for those crops monitored by the DMAC were near the five-year averages. Crop conditions were generally in the Good to Fair range throughout most of the year which resulted in matching or exceeding those long-term averages.

Mid-August 2022 saw widespread but spotty dryness, ranging from Abnormally Dry in the Piedmont to Very Dry in the northern coastal plain and north-eastern North Carolina. Central and the southeast were spotty regarding drought impacts. At the same time, most mountain counties reported adequate to above normal soil saturation. By mid-October, most crops with the exception of sorghum were equal to or higher than the 5-year averages, in terms of crop progress.

Early winter provided enough moisture that harvest was progressing well and small grains were emerging at a rate significantly above the 5-year averages. Soil moisture positioned agriculture for a good winter in most parts of the state. The only exceptions being counties like Wilson, Bertie, Washington, and Carteret, where Moderate to Extreme dryness was reported. The Craven-Carteret area reported Moderate and above dryness most of the spring, summer, and fall months.

Early Spring 2023 found similar conditions with Johnston, Bertie, Washington, Duplin, Vance, Pasquotank counties reporting Abnormal to Moderate dryness. As the spring progressed, some counties reported conditions on early versus late planted crops, determined by a period of dryness that caused farmers to wait for moisture before planting.

Late April saw spotty reports with Mitchell, Pasquotank and Carteret counties being the only counties that reported Abnormal to Moderate dryness. The Pasquotank and Carteret areas had become long-standing reporters of dryness. Pasquotank County's dryness was a matter of low topsoil moisture, yet a high-water table seemed to supply water to the root systems of plants, minimizing the impact of that dryness.

Mid-May saw a lessening of dryness in Carteret County but Abnormal Conditions persisted in Pasquotank, Bladen, Forsyth, Stokes, Pitt and down into Union County. Surry and Yadkin counties reported "increased dryness" but not enough to drop to Abnormal Dryness. By mid-summer, Pitt, Johnston, Vance, Pasquotank, and Mitchell counties were the only reports of abnormal dryness. Crops were on a healthy progression towards maturity, the tobacco harvest was just starting and crop quality was heavily "Good" to "Fair."

Drought Condition Summary – Division of Water Resources (Klaus Albertin)

The July 1, 2022, to June 30, 2023, period began with 95 percent of the state in Abnormally Dry (D0) or in drought (D1 to D4) conditions following the dry conditions which essentially began in October 2021. Conditions in the following year were highly variable with extended dry periods followed by periods of heavy rains (see Figure 5).

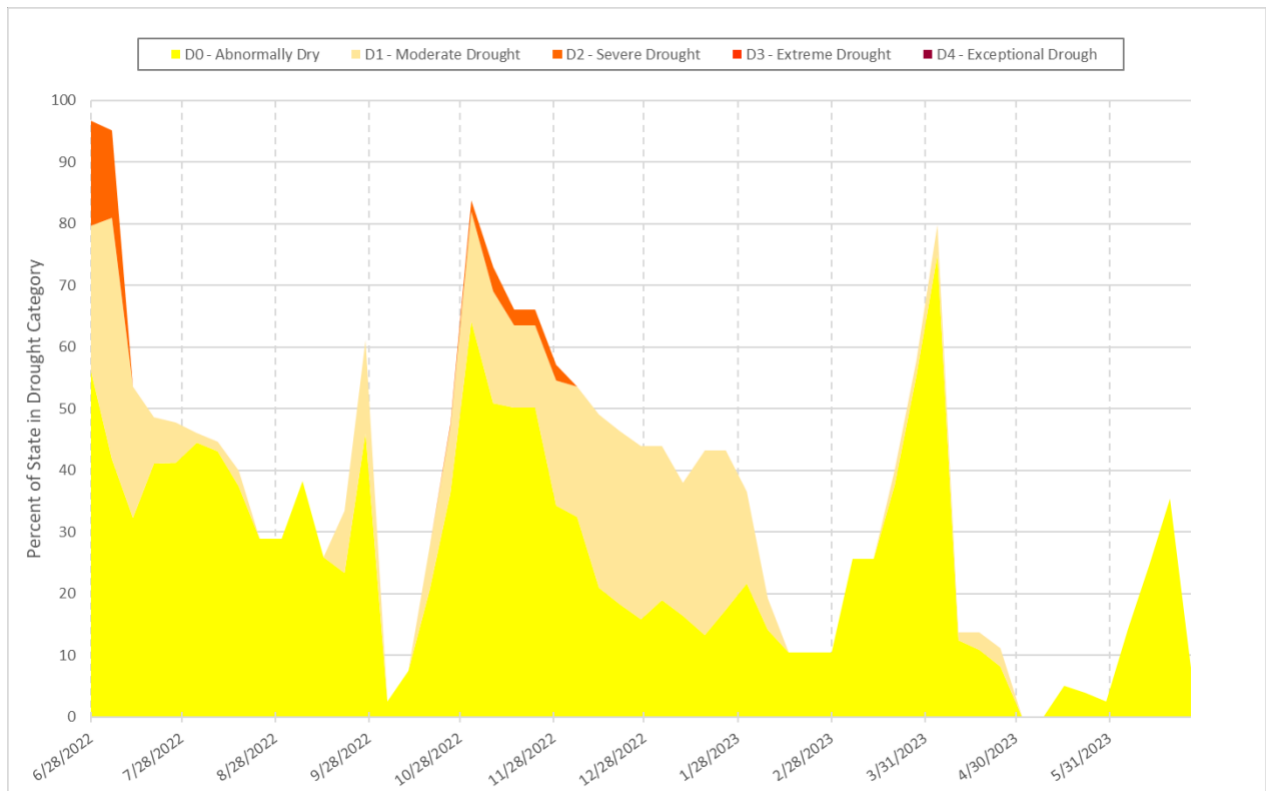


Figure 5. Drought Levels from July 1, 2022 through June 30, 2023

Summer 2022

Following a dry spring in 2022, almost the entire state was still considered to be Abnormally Dry or in drought. The exception was a small area between the Albemarle and Pamlico Sounds which had received heavy rainfall in late-May (see Figure 6). The dryness of the summer was at a high in mid-July but had decreased by mid-August (Figure 7) and then was almost completely gone by the beginning of October due to heavy rains statewide (Figure 8).

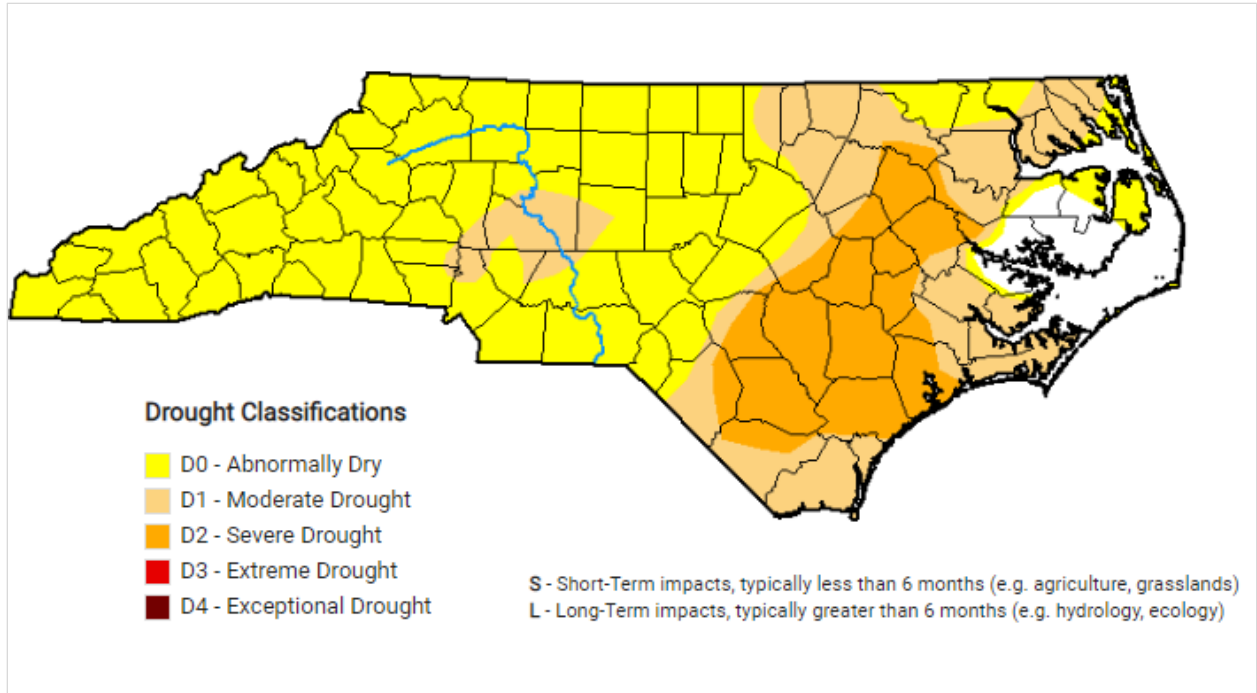


Figure 6. North Carolina Drought Classification (mid-July 2022)

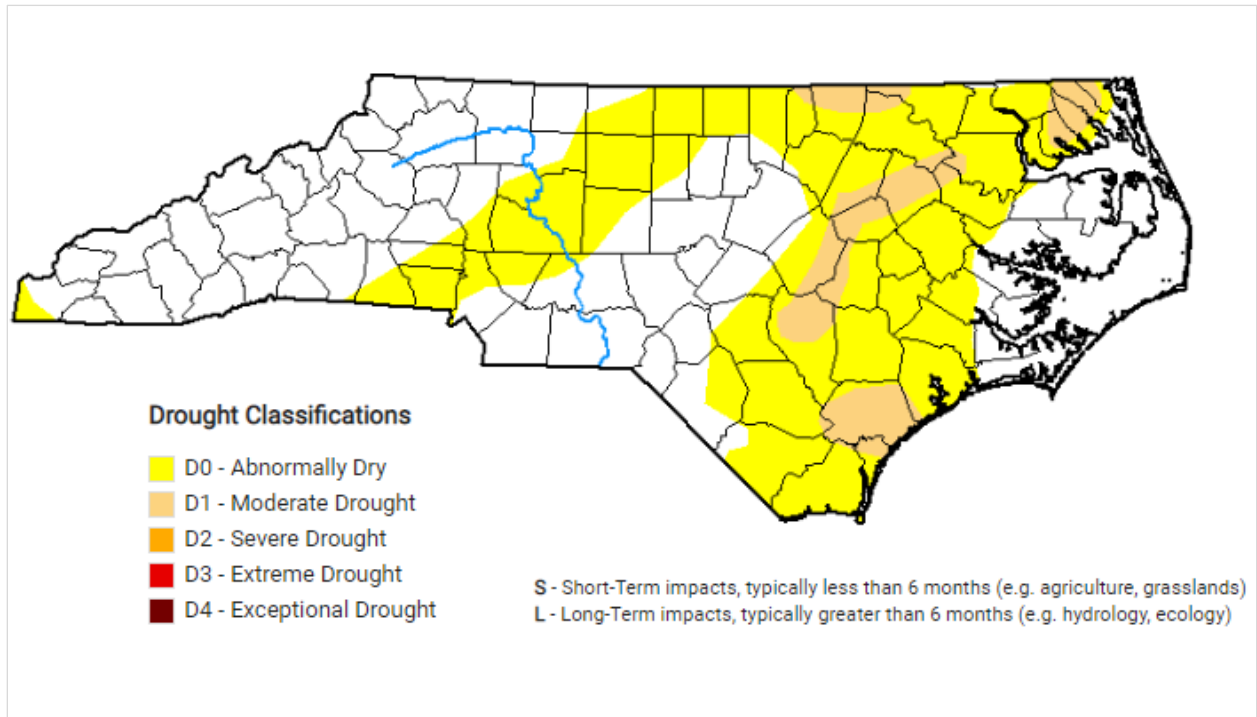


Figure 7. North Carolina Drought Classification (mid-August 2022)

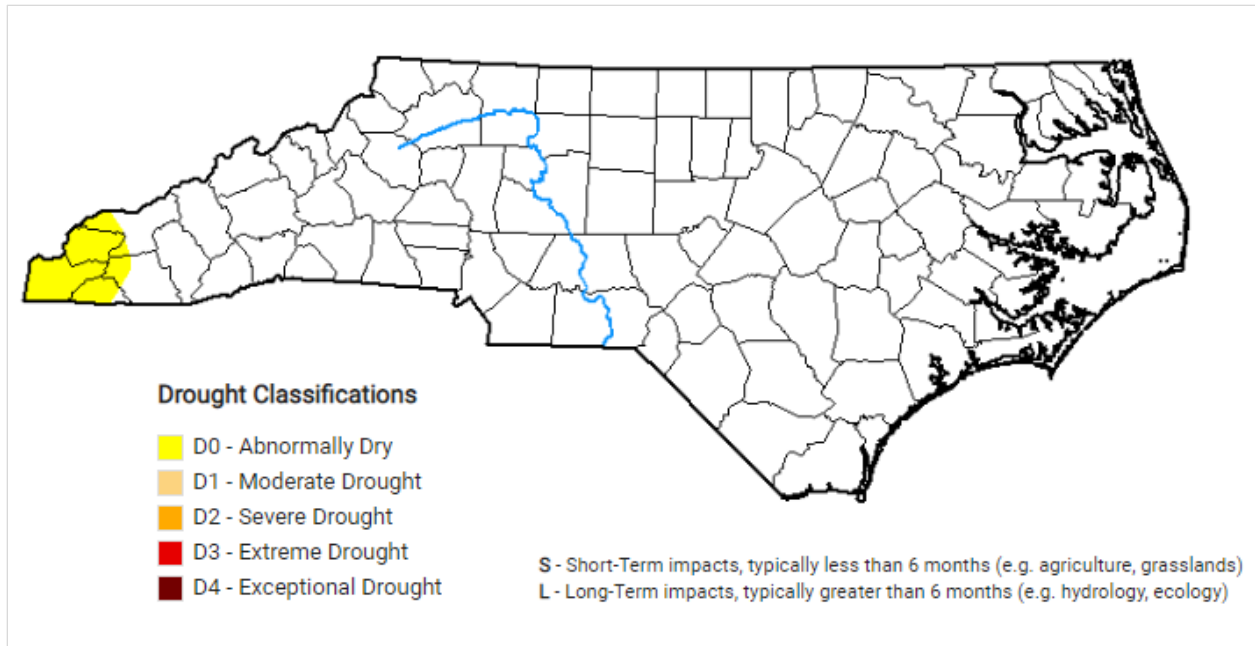


Figure 8. North Carolina Drought Classification (October 4, 2022)

The dry conditions quickly returned in the fall, however. While the heavy rains had removed the short-term rainfall deficits, depleted soil storage and limited rainfall through October resulted in a return to abnormally dry conditions by November 1, 2022 (Figure 9).

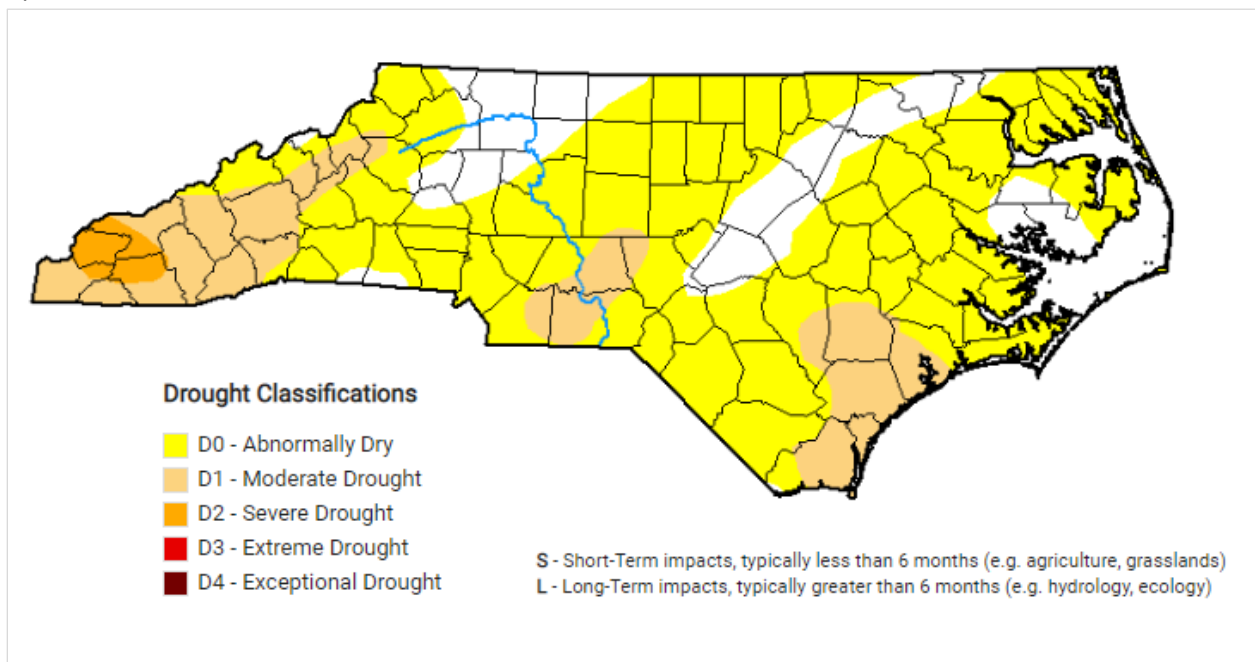


Figure 9. North Carolina Drought Classification (November 1, 2022)

Conditions gradually improved throughout the winter and all drought was removed in early February 2023 (Figure 10).

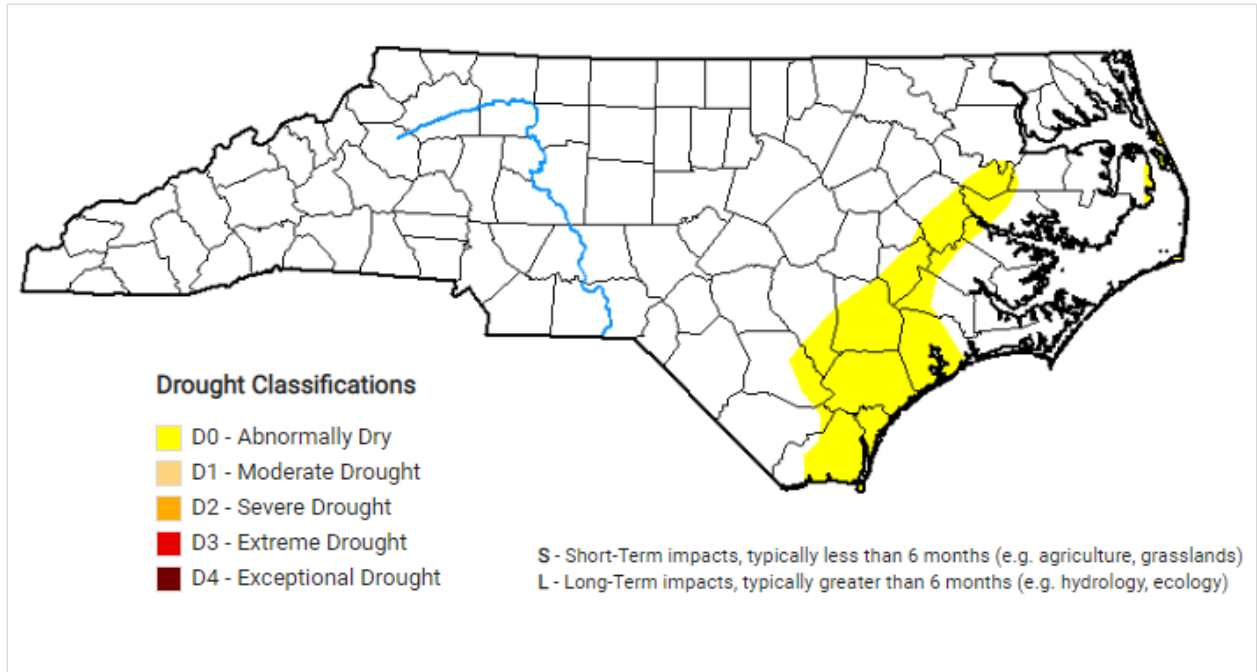


Figure 10. North Carolina Drought Classification (early February 2023)

Unfortunately, the period from late-February to early-April saw limited rain and widespread dryness was seen almost statewide (Figure 11).

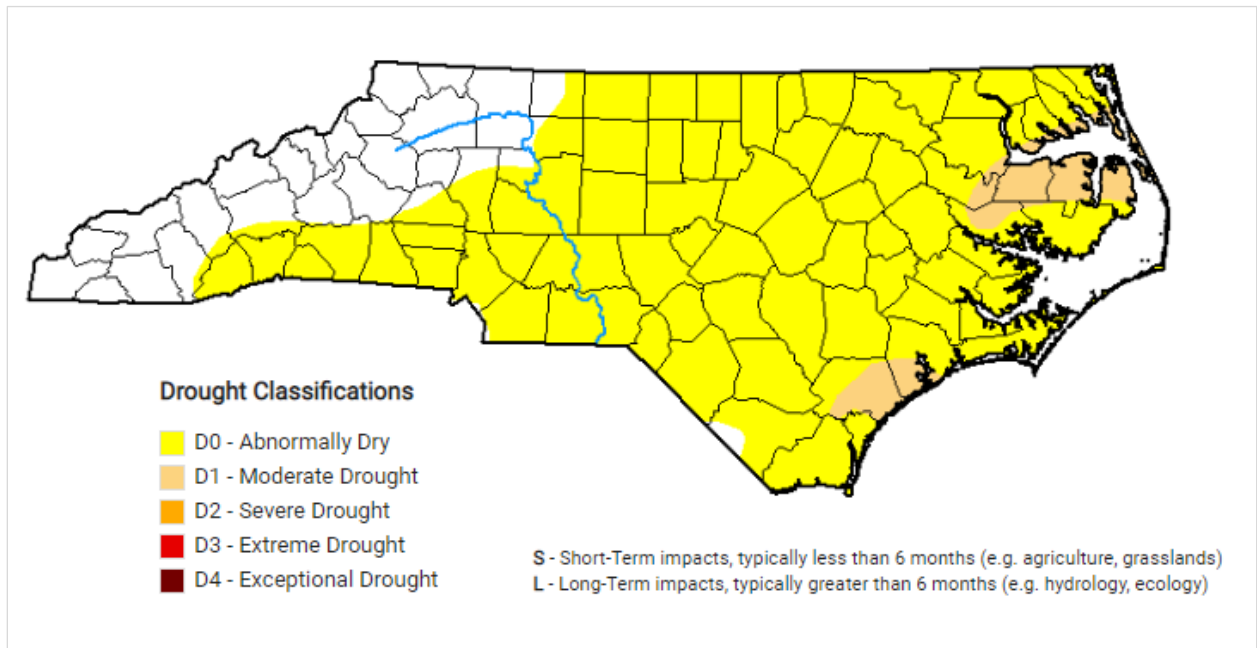


Figure 11. North Carolina Drought Classification (April 4, 2023)

Once again, heavy rains relieved the dryness statewide shortly thereafter (Figure 12). The drought map from May 2, 2023, showed no areas in the Abnormally Dry or Drought status. This was the first time North Carolina had a “clear map” in over two years.

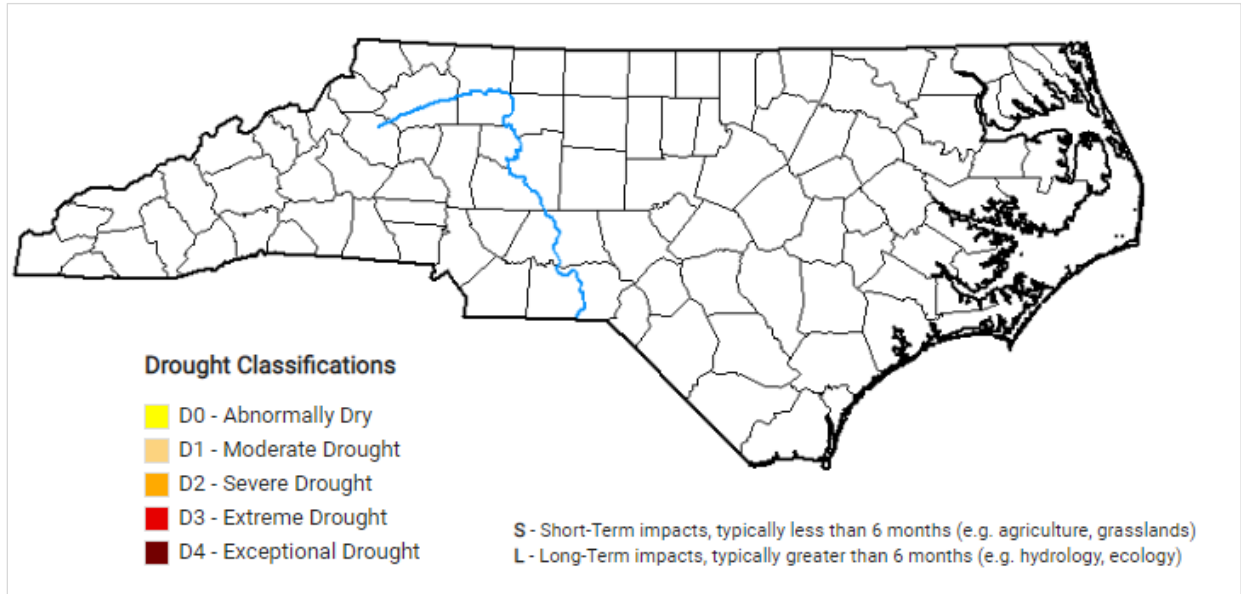


Figure 12. North Carolina Drought Classification (May 2, 2023)

Rainfall since then has been generally localized but almost all of North Carolina has received near normal rainfall, on average, through May and June 2023. The northeast corner of the state has missed out on the heavier rainfalls and remains the driest area at the end of period covered by this report as seen in Figure 13.

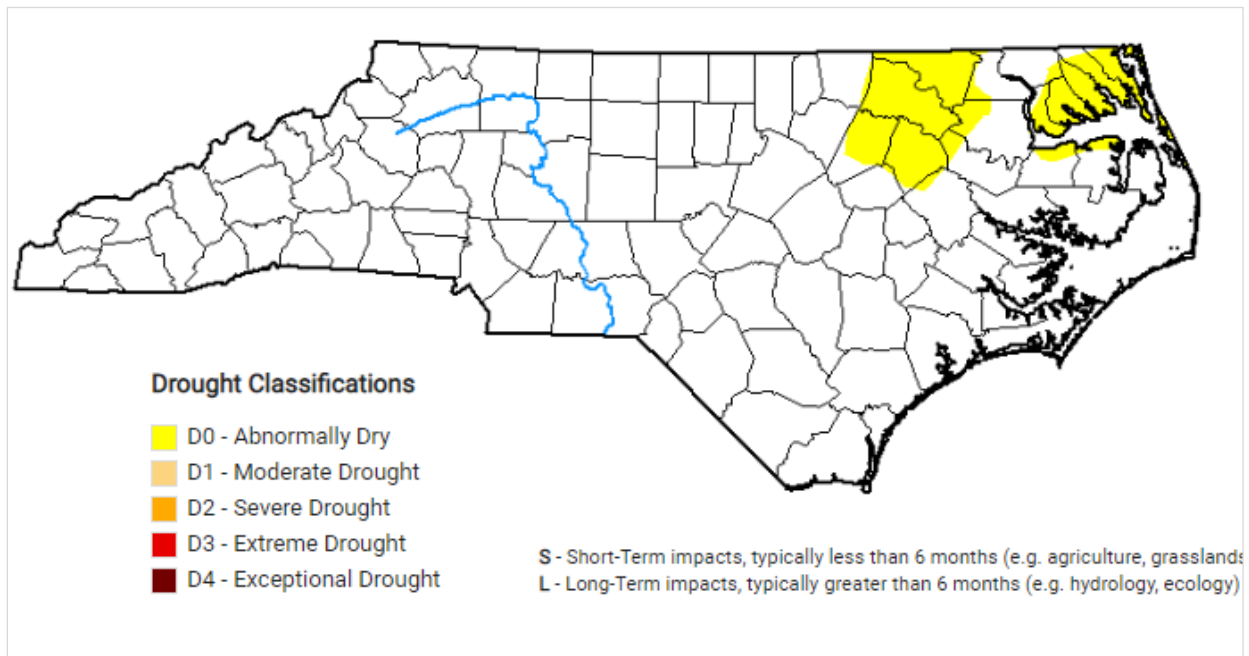


Figure 13. North Carolina Drought Classification (June 27, 2023)

Historical Perspective

Due to the natural variability of climate, drought may occur at any location in the state and at any time of the year. 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 at some point in the year. 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 2022 – 2023 period was a moderate year for drought conditions. Much of the state saw Abnormally Dry or Moderate Drought at some point during the year but the severity and impacts were very limited.

Analysis using one of the standard drought assessment metrics, the Palmer Hydrologic Drought Index (PHDI), provides insight into long-term drought conditions for North Carolina (Figure 14). Similar to the standard deviation of a normal distribution in statistics, PHDI 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.

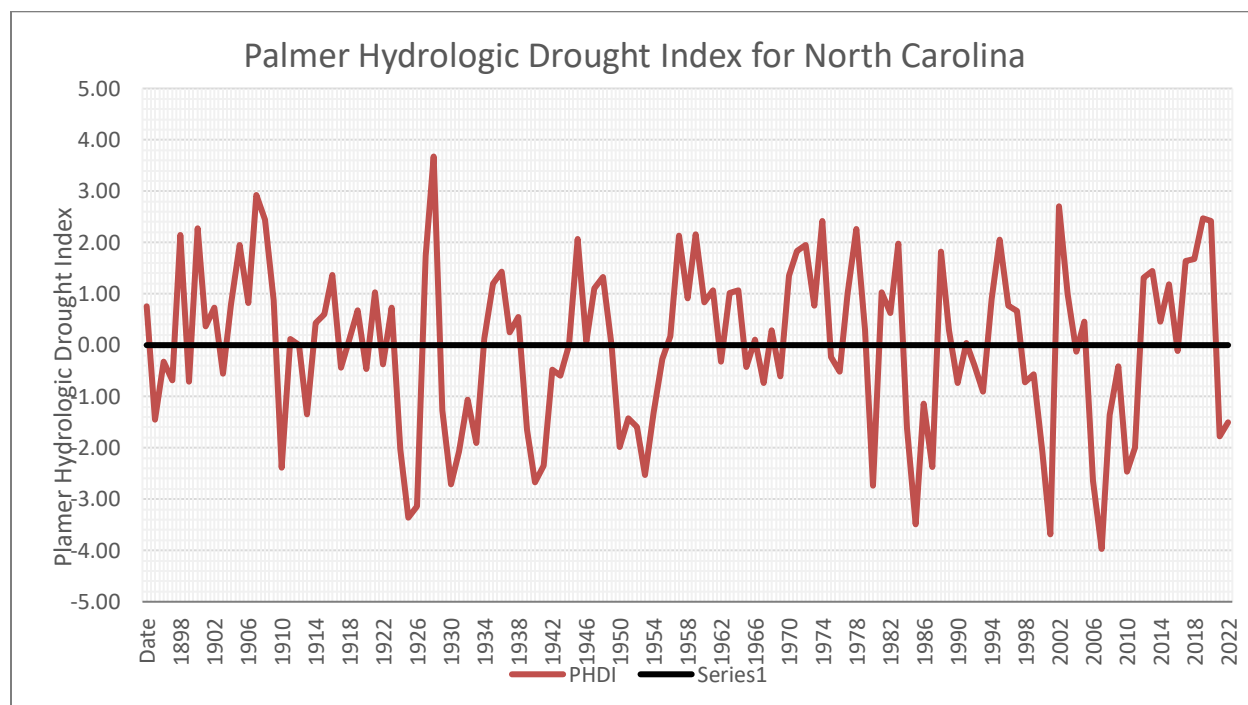


Figure 14. *Palmer Hydrologic Drought Index since 1895* Source: NOAA, 2023

North Carolina experienced extreme drought conditions from 1925 through 1927 with PHDI values reaching -4.1 at one point. A very wet period followed and then an extreme

drought occurred in 1932 - 1933. This extreme drought period saw the lowest individual monthly PHDI value of -4.74. Occasional, Moderate Droughts occur in the 1940's and 1950's but it wasn't until the late 1980's that extreme drought returned. The PHDI reached a low of -4.6 in July 1986. Moderate to wet conditions returned in the 1990's 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 is seen but it does appear that more extreme swings in conditions are likely. The North Carolina PHDI values for the report period averaged -1.76 (NOAA, 2023). These values reflect the very wet winter period and a moderately dry spring. Since the 2007 to 2008 drought, conditions had been trending wetter than normal. However, conditions over the last year swung back to below normal in recent years.

The 2020 North Carolina Climate Science Report (Kunkel et. Al., 2020) found that based on historical observations and projected changes to temperature and rainfall it is likely that future droughts in North Carolina will be more frequent and intense due to higher temperatures leading to increased evaporation. The total annual precipitation is not expected to change significantly but variability is expected to increase with more frequent intense rain events and more severe dry periods.

DMAC Meetings

Drought conditions in North Carolina are updated weekly through an audio-video telecom with a Technical Drought Advisory Team, which is a sub-group of the N.C. DMAC. 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 drought conditions for that week. Those recommendations are used to draw the national drought map (<https://droughtmonitor.unl.edu/CurrentMap.aspx>) each Thursday. To see or download a copy of the current drought map for North Carolina, visit the State's official drought website at: www.ncdrought.org.

The DMAC is required by law to meet in person at least once each calendar year. The 2023 annual council meeting is scheduled for September 21 at 1pm. Items to be discussed at the meeting include a recap of stream flow and ground water levels, lake and reservoir levels, agriculture, forestry, and public water systems conditions over the July 2022 through June 2023 period.

References:

NOAA. 2023. Climate at a Glance. National Oceanographic and Atmospheric Administration. Website: <https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/statewide/time-series/>. Accessed July 29, 2023.

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