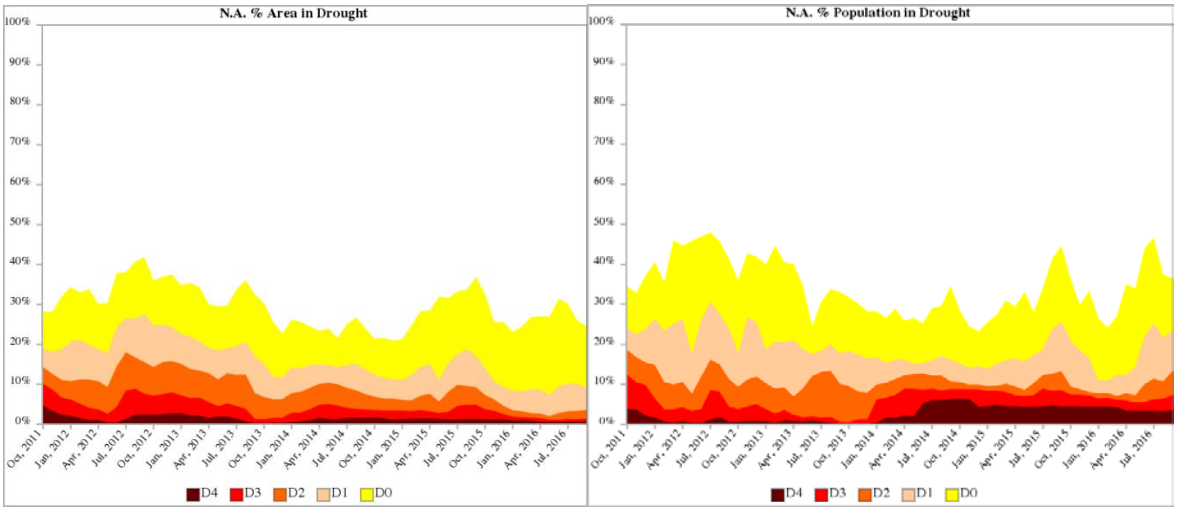
North American Drought Monitor – September 2016

At the end of September 2016, moderate to exceptional drought (D1-D4) affected approximately 9.0% of the area and 23.3% of the population of North America. The percent area value is 1.0% less than the value for the end of August 2016, while the percent population value is 1.7% more than the value for the end of August.



CANADA: September brought variable amounts of precipitation and changes in temperature across the nation. Southern Ontario and Quebec continued to experience drought conditions as a prolonged precipitation deficit continued. The Pacific region benefitted from a relatively wet month, reducing the effects of dryness in many areas of northern British Columbia. However, southwest British Columbia continued to be affected by long term effects of drought. The Atlantic, especially Nova Scotia and New Brunswick, suffered from abnormally dry conditions which resulted in a low water supply. The Prairie region experienced a varied level of precipitation. Western Saskatchewan and eastern Alberta experienced dry conditions.

Western: The province of British Columbia had a cool month with above normal precipitation. This was especially noticeable in the Northern Interior, where areas that were in Severe Drought (D2) such as Dease Lake and Meziadin Lake were able to be brought down to Moderate Drought (D1) conditions. The extent of D1 conditions in the north was slightly pulled back towards the southeast. Southern British Columbia experienced less precipitation than the north during the month of September. There was no precipitation south of Kelowna, so the Abnormally Dry (D0) pockets around Cranbrook and Vancouver were extended to include this area. Vancouver and Vancouver Island saw above average precipitation and streamflow levels this month, but both continued to experience long-term Moderate Drought (D1) conditions.

The prairie region experienced varied amounts of precipitation, with many regions drier than previous months. This helped to alleviate concern regarding excess moisture seen throughout the growing season. Precipitation analysis showed that dryness in western Alberta around Canmore had diminished, so the Abnormally Dry (D0) pocket in this region

was removed. Northwestern Alberta continued to experience dry conditions and the D0 pocket near High Level was extended north up to the Northwest Territories' border. The area surrounding Fort Chipewyan received 50% less precipitation than its fourteen-year normal which resulted in a Moderate Drought (D1) pocket. The Abnormally Dry (D0) pocket around Weyburn, Saskatchewan shrunk due to above average levels of precipitation. Northeast Manitoba received varying levels of precipitation. Due to wet conditions around Fort Churchill the Moderate Drought (D1) pocket was removed and the area was classified as Abnormally Dry (D0). North of Fort Churchill saw a healthy amount of precipitation this month and the extent of the Abnormally Dry (D0) area reduced away from the Nunavut border. The Abnormally Dry (D0) pocket was also reduced around Split Lake due to a near-normal amount of precipitation. The dryness in northern Manitoba moved eastward towards northern Ontario, and the Abnormally Dry (D0) pocket was extended to the border.

Central: Southern Ontario and southern Quebec received very little precipitation this month, continuing their trend of dryness over the past few months. The area around Peawanuck in northern Ontario experienced up to 75% less precipitation than its fourteen-year normal this month, and was classified as Abnormally Dry (D0). The Moderate Drought (D1) pocket in southeastern Ontario was expanded to include Brockville and Perth as well as the majority of the Southern Niagara peninsula north of Lake Erie. These regions have experienced very low levels of precipitation throughout the growing season. Bracebridge and South River were improved from Moderate Drought (D1) to Abnormally Dry (D0) because these regions have experienced less dry conditions than the rest of southeast Ontario. North of Lake Superior, precipitation led to the shrinking of the Abnormally Dry (D0) layer around Homepayne, while the D0 pocket directly west of this was increased in size. Dryness also led to an Abnormally Dry (D0) pocket appearing around Peawanuck in Northern Ontario. Southwestern Quebec also continued to experience dry conditions this month, contributing further to its dry growing season. The Abnormally Dry (D0) pocket in southern Quebec was extended to include Mont-Tremblant, southeast Montreal, and Victoriaville. The Moderate Drought (D1) pockets in this region were also extended to include Lachute and Granby. Northern Quebec's Abnormally Dry (D0) conditions were worsened in September, with up to 75% below normal levels of precipitation in eastern regions.

Atlantic: The month of September brought very little rain to Atlantic Canada. Several areas in southern Nova Scotia continued to experience severe drought that resulted in very low water supply across the province. The southernmost tip of Nova Scotia continued to see the worst of the drought, with many farms reporting dry wells. Abnormally Dry (D0) conditions in New Brunswick expanded to include Oromocto due to the precipitation deficit in this region, which was more than 75% below the fourteen-year average. Central Prince Edward Island, including the city of Charlottetown, experienced less dry conditions throughout the growing season and was brought down from Moderate Drought (D1) to D0. Several areas in Newfoundland saw above average precipitation this month, shrinking the abnormally dry D0 conditions to the southwestern and southeastern regions of the province.

Northern: Drought conditions present in Canada's North have been similar to previous months. Areas that were dry continued to experience less precipitation while places not already in drought in the North did not deteriorate. Severe Drought (D2) is still present near

the town of Watson Lake. From Watson Lake east just past Yukon's border with the Northwest Territories and west to Teslin Moderate Drought (D1) continues to persist. Both of these areas are in southern Yukon. From the Yukon Territory past the Great Bear Lake in the Northwest Territories Abnormally Dry (D0) conditions also continue.

UNITED STATES: During September 2016, the influence of the warm and dry North Pacific and North Atlantic (Bermuda) subtropical highs was challenged by cooler and wetter troughs and lows in the jet stream flow. The Bermuda High, along with persistent upper-level ridging at the jet stream level, resulted in above-normal temperatures across the Lower 48 States (CONUS) east of the Rocky Mountains, while troughs were dominant over western North America, bringing cooler-than-normal air over the West. As they migrated across the CONUS, the troughs dragged cold fronts and surface lows along with them which provided a lifting mechanism that produced areas of precipitation. The monthly precipitation pattern was also affected by tropical moisture dropped by hurricanes and tropical storms along the East Coast, or that was entrained into the Southwest monsoon. The end result was a monthly precipitation pattern that was drier than normal across the Far West, Central Rockies to High Plains, Lower Mississippi Valley to Central Appalachians, and much of the Northeast, and wetter than normal from the interior West to Northern Plains, Southern High Plains to Upper Midwest, and along the coast from Florida to the Mid-Atlantic States. The unusually warmer-than-normal temperatures in the eastern U.S. enhanced evapotranspiration which exacerbated conditions, especially where it was unusually dry. This month's precipitation anomaly pattern resulted in expansion of drought in the South and New England and contraction in parts of the West and Midwest. September was wetter than normal over much of Alaska, which wasn't suffering from drought or abnormal dryness, and Hawaii, where drought conditions improved, and parts of Puerto Rico, where drought also shrank.

The combination of lifting along the frontal boundaries and dynamical support from the upper-level troughs and lows triggered severe weather, mostly east of the Rockies, but the overall dominance of the Bermuda High kept the tornado count below average. According to preliminary data, 36 tornadoes occurred during September 2016, which is about half of the September average of 74. Most occurred in the Southwest to Central Plains and Midwest in association with fronts and low pressure systems along the storm track.

Five named tropical cyclones (Tropical Storms Ian, Julia, Karl, and Lisa, and Hurricane Matthew) formed in the Atlantic Basin in September. Three tropical cyclones which formed in August (Hurricanes Gaston and Hermine and Tropical Depression 8) were also active to some degree into early September. The Bermuda High steered Gaston, Ian, Karl, and Lisa into the central North Atlantic, keeping them away from the CONUS. Tropical Depression 8 brushed the North Carolina coast before being deflected out to sea. Hurricane Hermine tracked across northern Florida on September 2 after developing in the Gulf of Mexico in late August. It joined with a cold front along the Southeast coast and transformed into a frontal low, then tracked just offshore along the Eastern Seaboard during the next several days, dropping tropical moisture along the coast from Florida to the Mid-Atlantic States. Tropical Storm Julia developed along the Atlantic Coast near Jacksonville, Florida in mid-September and slowly meandered just off the Florida to North Carolina coast for the next

several days, occasionally interacting with a passing cold front. The languid motion of Hermine and Julia was influenced by a complex interaction between the Bermuda High, which wanted to swing them out into the North Atlantic, and troughs in the mid-latitude jet stream, which kept pulling them back to the coast. Hurricane Matthew developed near the end of the month in the vicinity of the Lesser Antilles and was steered westward into the Caribbean by easterly Trade Winds, until being drawn north by an upper-level trough dipping southward from the westerlies.

Drought contraction and expansion roughly balanced each other out, so the USDM-based national moderate-to-exceptional drought footprint decreased only slightly across the CONUS from 19.5 percent at the end of August to 19.4 percent at the end of September (from 16.3 percent to 16.2 percent for all of the U.S.). According to the Palmer Drought Index, which goes back to the beginning of the 20th century, about 21.6 percent of the CONUS was in moderate to extreme drought at the end of September, about the same as last month.

Historical Perspective: According to preliminary information provided by the National Centers for Environmental Information (NCEI), when precipitation is integrated across the CONUS, September 2016 ranked as the 40th wettest September in the 1895-2016 record with 2.70 inches (68.6 mm) of precipitation. Two states – North Dakota and South Carolina – had the tenth wettest September on record, while Maine had the fifth driest September.

NCEI statistics indicated that September 2016 ranked as the ninth warmest September in the 1895-2016 record, averaging 62.7°F (17.1°C) nationwide. Twenty-six states along and east of the Mississippi River had a top-ten warmest September, including Ohio which ranked record warmest. Temperatures averaged above normal across the Great Plains states and near to below normal in the West.

The dryness in the Northeast and Southeast extends back roughly to the beginning of the year. Connecticut had the fifth driest January-September on record and Massachusetts the seventh driest. For Georgia, July-September 2016 ranked as the sixth driest such 3-month period.

For the last 12 months, all of the states in the CONUS, except Arizona and Nevada, had a top-ten warmest October-September. The last 12 months (October 2015-September 2016) ranked as the warmest such period on record for Alaska and ten states in the Southeast to Mid-Atlantic – Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The last four October-September 12-month periods in California ranked in the top nine warmest such periods, including the warmest (2014-2015) and second warmest (2013-2014). This persistent and widespread warmth has increased evapotranspiration, which has exacerbated drought. According to the Palmer Drought Index, 20% or more of the West has been in moderate to extreme drought for about three-fourths of the months since January 2000.

Agricultural and Hydrological Highlights: By September 27th, 14% of the nation's cattle inventory, 15% of the nation's hay, 8% of winter wheat production, and 2% of corn and

soybean production were in drought. These percentages were within a percent or two of the values for the end of August. According to October 3rd U.S. Department of Agriculture (USDA) reports, only 8% of the nation's corn crop and 7% of soybeans were rated in poor to very poor condition, but 15% of the cotton crop and 18% of the pasture and rangeland were so rated, which were about the same as at the end of August. And 25% of the nation's topsoil moisture and 25% of the subsoil moisture were rated short to very short (dry to very dry), both also about the same as last month. On a regional basis, conditions varied and were more extreme.

Large wildfires continued across parts of the West and dry conditions were evident in several drought indicators, with areas having low soil moisture, groundwater, and streamflow levels, and impacts on vegetation. Reservoirs were low in Arizona, California, Idaho, New Mexico, Oregon, Utah, and Washington. According to USDA statistics, topsoil moisture was short or very short (dry or very dry) in 50% or more of California (80%), Nevada (65%), Oregon (62%), and New Mexico (59%); subsoil moisture was short or very short in 50% or more of California (80%), Nevada (70%), Oregon (65%), and Wyoming (51%); and pasture and rangeland was in poor to very poor condition in 40% or more of Oregon (55%) and California (45%).

The unusually warmer-than-normal temperatures increased evaporative stress which exacerbated the drought conditions in the Northeast. Soils were dry, vegetation stressed, and groundwater and streamflow levels low. According to USDA statistics, topsoil moisture was short or very short (dry or very dry) in 50% or more of Rhode Island (100%), Massachusetts (78%), Connecticut (76%), New Hampshire (65%), and Vermont (53%); subsoil moisture was short or very short in 50% or more of Rhode Island (100%), Massachusetts (91%), Connecticut (80%), New Hampshire (63%), and Vermont (52%); and pasture and rangeland was in poor to very poor condition in 50% or more of Massachusetts (81%), New Hampshire (65%), Rhode Island (60%), Maine (59%), and Connecticut (56%).

In the Southeast, drought impacts were seen in low streamflows and dry soils, with some areas reporting low groundwater levels. Water conservation measures were implemented in many communities. According to USDA statistics, topsoil moisture was short or very short (dry or very dry) in 50% or more of Mississippi (71%), Georgia (65%), Alabama (63%), Arkansas (61%), and Tennessee (57%); subsoil moisture was short or very short in 50% or more of Mississippi (64%), Alabama (60%), Georgia (58%), Tennessee (54%), and Arkansas (51%); and pasture and rangeland was in poor to very poor condition in 40% or more of Georgia (45%).

MÉXICO: Two tropical cyclones (Newton and Paine), six tropical waves and two cold fronts were the main weather systems that affected the climate in September 2016. The rain from these tropical cyclones was concentrated from the west coast to the northwest, mainly in the Peninsula of Baja California and Sonora; wetness associated with these systems also came up to northern Chihuahua. In Coahuila, the passage of a cold front left heavy rain between September 10 and 11, and a second cold front reached the north of this state with lower rainfall at the end of the month. Temperatures continued above average in a corridor

from the central-west to the north-east parts of Mexico, as well as in the Yucatan Peninsula, and below normal in the north and northwest. Nationally, the country experienced a slightly dry September (29th driest, 89% of normal), based on the period 1941-2016, and the third warmest based on 1971-2016 records.

Hurricane Newton reached Category-1 on the Saffir-Simpson scale and occurred from September 4 to 7. It affected the western part of the country, from the coasts of Guerrero and Michoacan to Baja California Sur where it made landfall for the first time, and then in Sonora where it dissipated. During its track, Newton brought considerable rains in the coast of Guerrero, Colima and Jalisco (165.0 mm in Coyuca de Benitez, 280.0 mm in Cihuatlán and 179.2 mm in Manzanillo). It then moved to Baja California Sur where it dropped 280.0 mm of rain in Santa Rosalia. Hurricane Paine occurred September 18-20. It formed in the Pacific and reached Category-1 strength. Even though Paine dissipated off the coast of Baja California, its remnants reached northern Baja California by September 20. Precipitation from these two tropical cyclones and the two frontal systems in the north of the country resulted in a decrease in moderate to extreme (D1-D3) drought coverage of 5%, going from 11.5% at the end of August to 6.5% at the end of September, while the abnormally dry areas decreased 3.4% to cover 15% of the country by September 30.

At the state level, the most notable change was drought recovery in Guerrero which, due to the rains, went from the 12th driest quarter (June-August) to the 21st wettest (July-September). Baja California Sur improved two ranks, from 20th to 18th wettest, and Coahuila from 4th to 2nd wettest, for these three-month periods. For September, only Baja California and Morelos had monthly ranks in the top wettest (7th and 8th wettest September, respectively). However, the Yucatan Peninsula has begun to dry, with Quintana Roo dropping from the 7th wettest quarter (June-August) to the 30th driest (July-September), Yucatan from 24th to 16th driest, and Campeche from 23rd wettest to the 25th driest. This resulted in an increase of moderate drought (D1) in that region.

Monthly temperatures were cooler than normal in the northern states – the Californias, Sonora, Chihuahua, Sinaloa and northern Tamaulipas – as well as the central region (between Michoacan, Mexico State, Morelos and Puebla). The rest of the country was warmer than normal in September. This resulted in the third warmest September for the nation as a whole, based on records from 1971 to 2016, with a national mean temperature of 25.0 °C, 2.0 °C above normal. On a statewide basis, it was the third warmest September for Aguascalientes, Nayarit, Queretaro and Tlaxcala; second warmest in Michoacán and Nuevo Leon; and the warmest September in Campeche, Colima, Mexico City, Durango, Hidalgo, Jalisco, Quintana Roo and Tamaulipas.

The Ministry of the Interior issued nine emergency declarations in eight states that affected about 52 municipalities during September 2016. The main declarations were due to Hurricane Newton which caused severe floods and rains. The SIAP (The Agri-food Information Service and Fisheries) reported that 2.1% less area was planted during the spring-summer season this year than last year due to erratic rainfall at the beginning of the season and delays in the sowing due to changes in crops planted; this amounted to 78.1 thousand hectares, which represented one-fifth of that reported last year. On the other hand, for the first three quarters of the year, poultry has been the most dynamic sector of the

livestock industry, due to competitive prices and few threats of epidemics. The production of poultry meat experienced a growth of 3.9%, while egg production grew 2.9%. Pork production maintained a significant rate of growth (3.5%), prompted by a substantial level of demand, since its price to the consumer was comparable with beef.