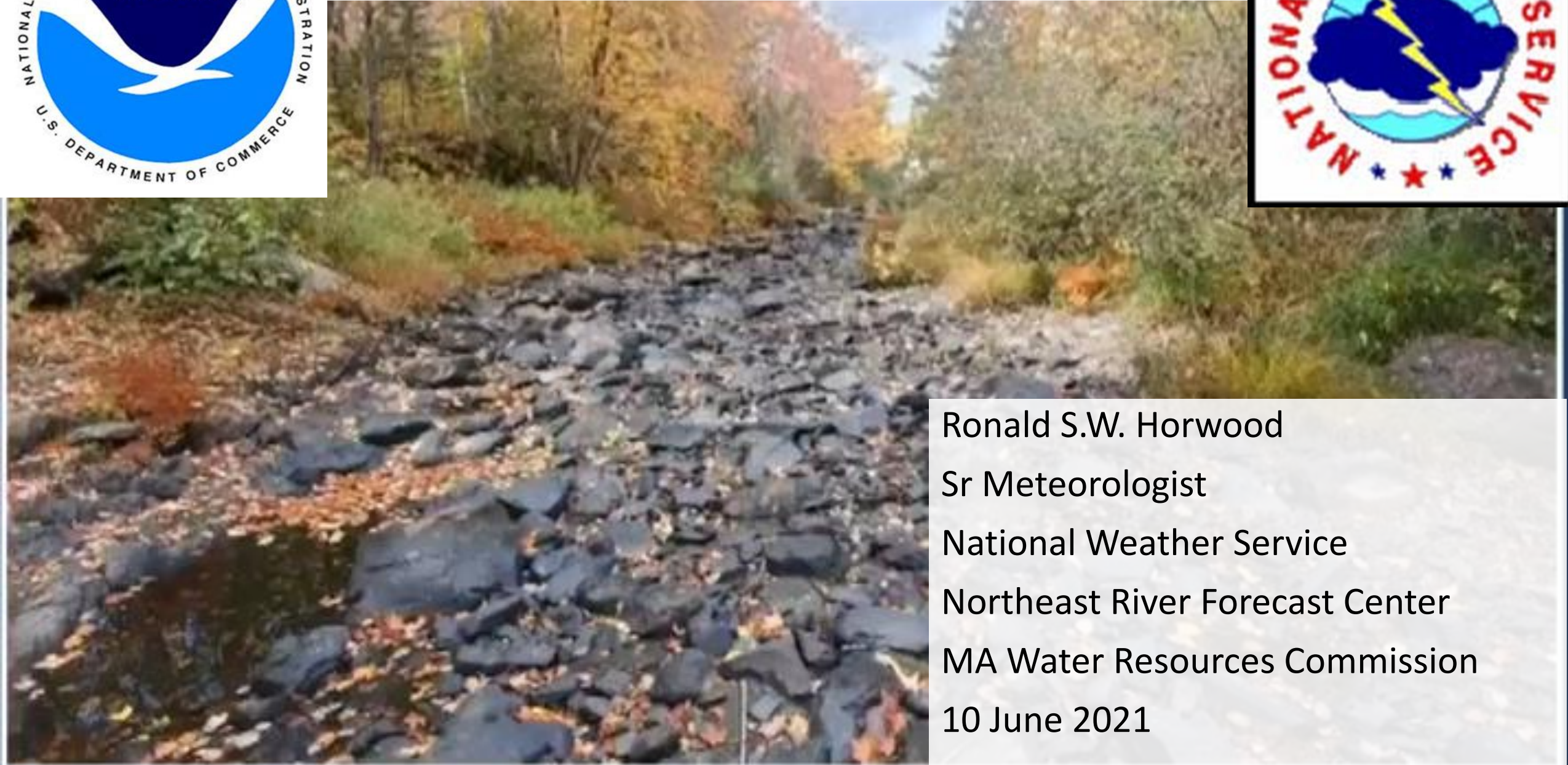


2020 Drought in New England



Ronald S.W. Horwood
Sr Meteorologist
National Weather Service
Northeast River Forecast Center
MA Water Resources Commission
10 June 2021

OUTLINE

- BIO
- 2020 New England Drought Onset and Evolution (Big Picture)
- 2020 Drought Impacts
 - Southern New England
- Flash Drought
- Challenges Predicting Drought in New England
- Remainder of 2021 Drought Outlook

BIO

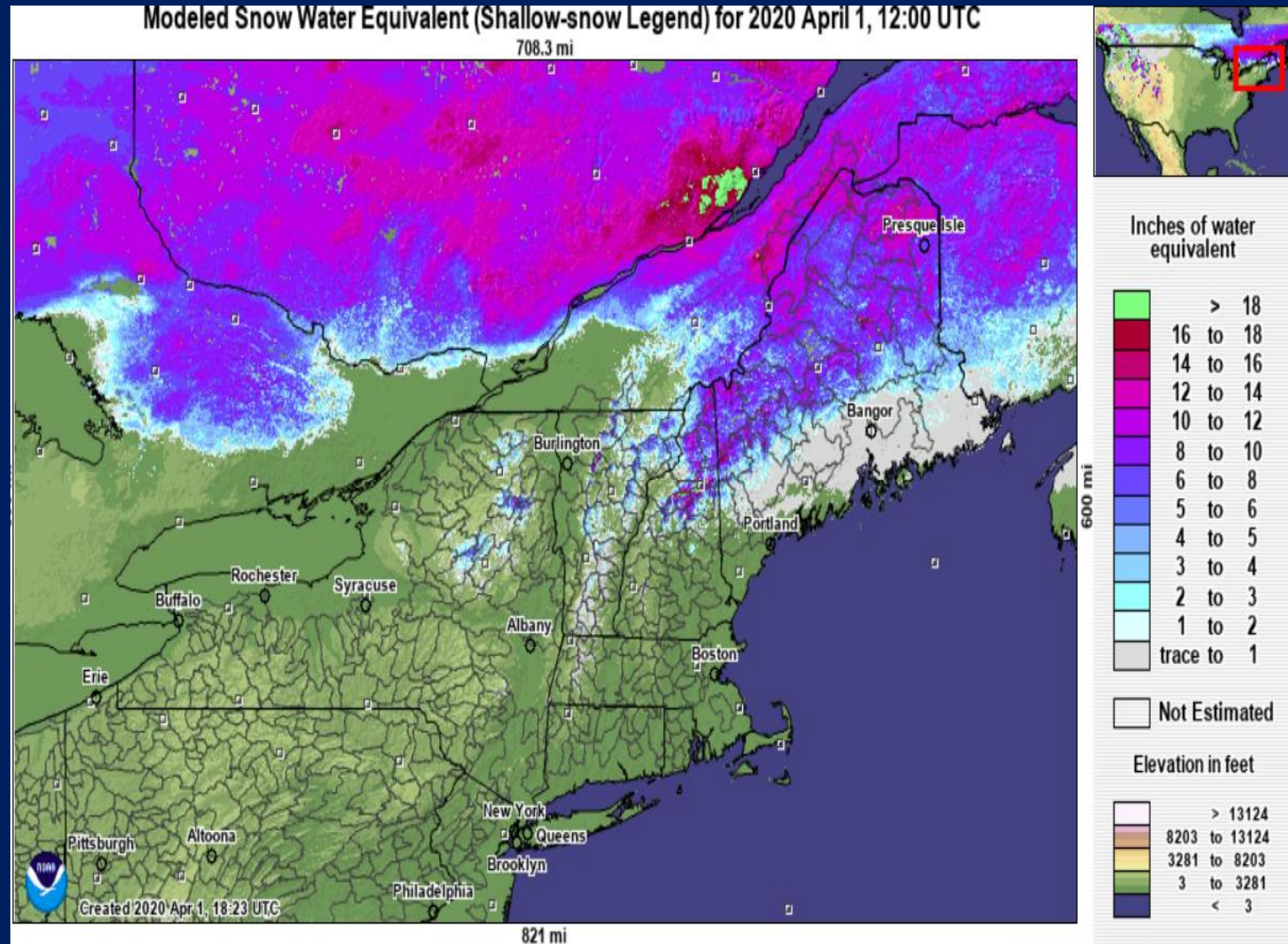
- Grew up in Northeast Massachusetts fascinated by snowstorms
- Graduated from Penn State in 1990 (B.S. Meteorology)
- Joined NOAA/NWS in December 1990
 - Bristol TN (1990 – 1994)
 - Boston – Logan Airport Weather Observer (1994 – 1996)
 - Pittsburgh PA (1996 – 1999)
 - Northeast River Forecast Center (1999 – Present)
- Focus areas include QPF and Flood Forecasting
- Awarded the U.S. Dept of Commerce Gold Medal in 2012 for role in the development and implementation of the Community Hydrologic Prediction System

2020 New England Drought Onset and Evolution

- We will look at onset conditions prior to the 2020 drought and then advance through monthly regional conditions.

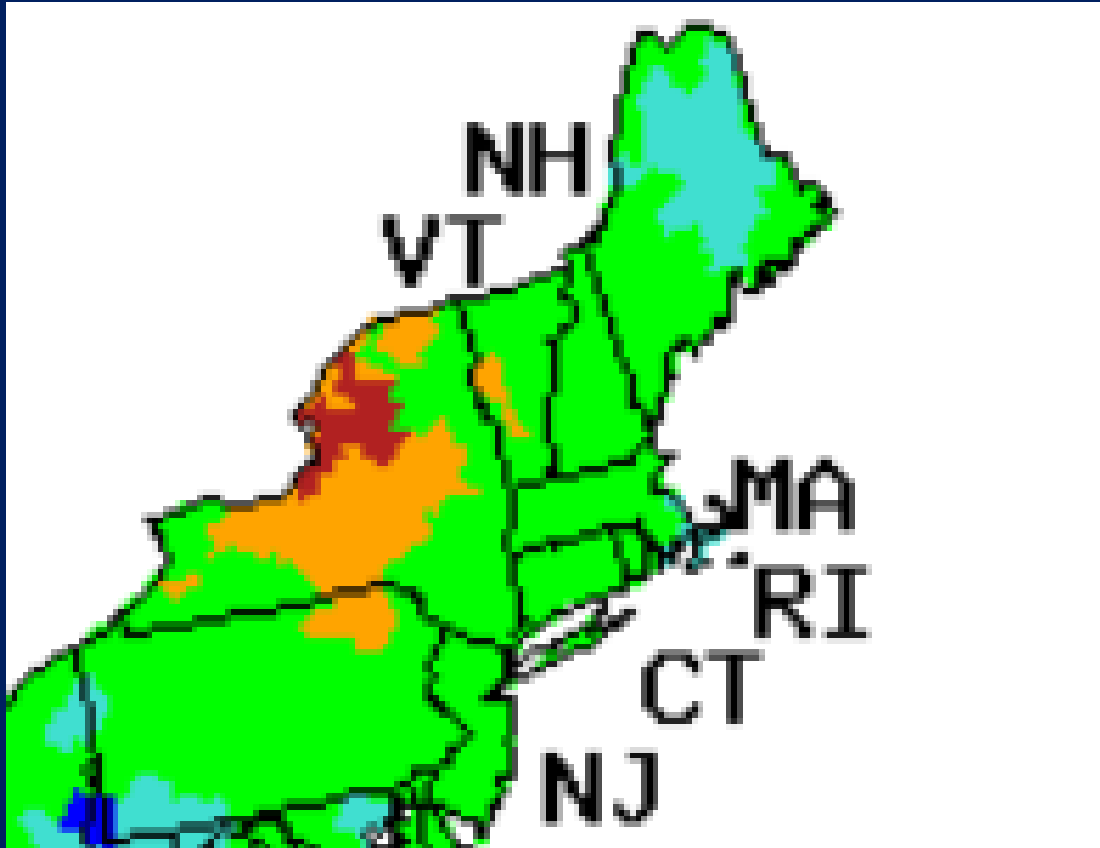
2020 Drought Evolution - cont

- Heading into April 2020...a deep...fairly water laden snowpack remained in place across northern New Hampshire and interior Maine
- Most other areas of New England were either bare of snow or saw it confined to the mountains.

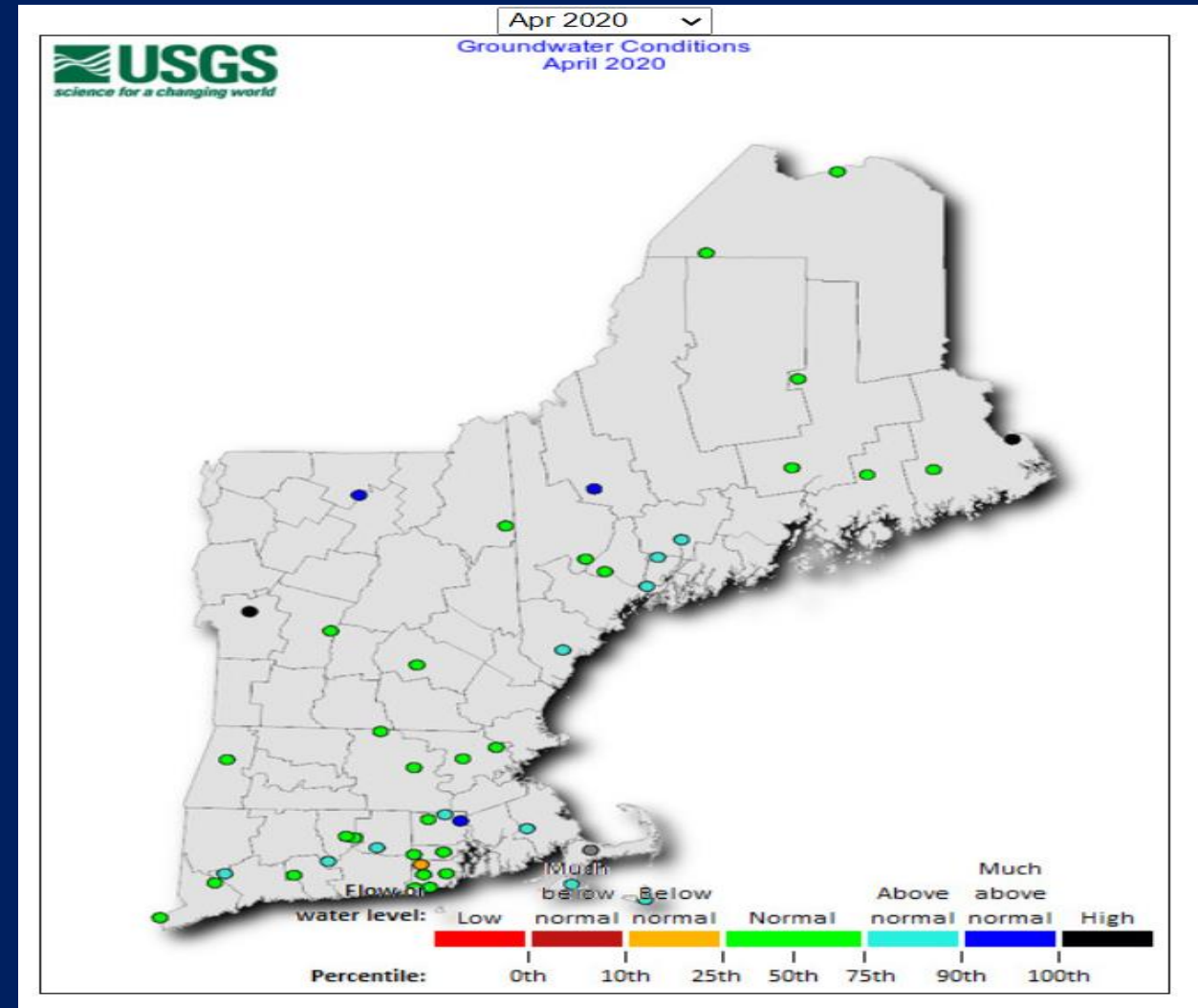


2020 Drought Evolution - cont

At the end of April 2020...streamflow and groundwater levels were near to above normal across New England



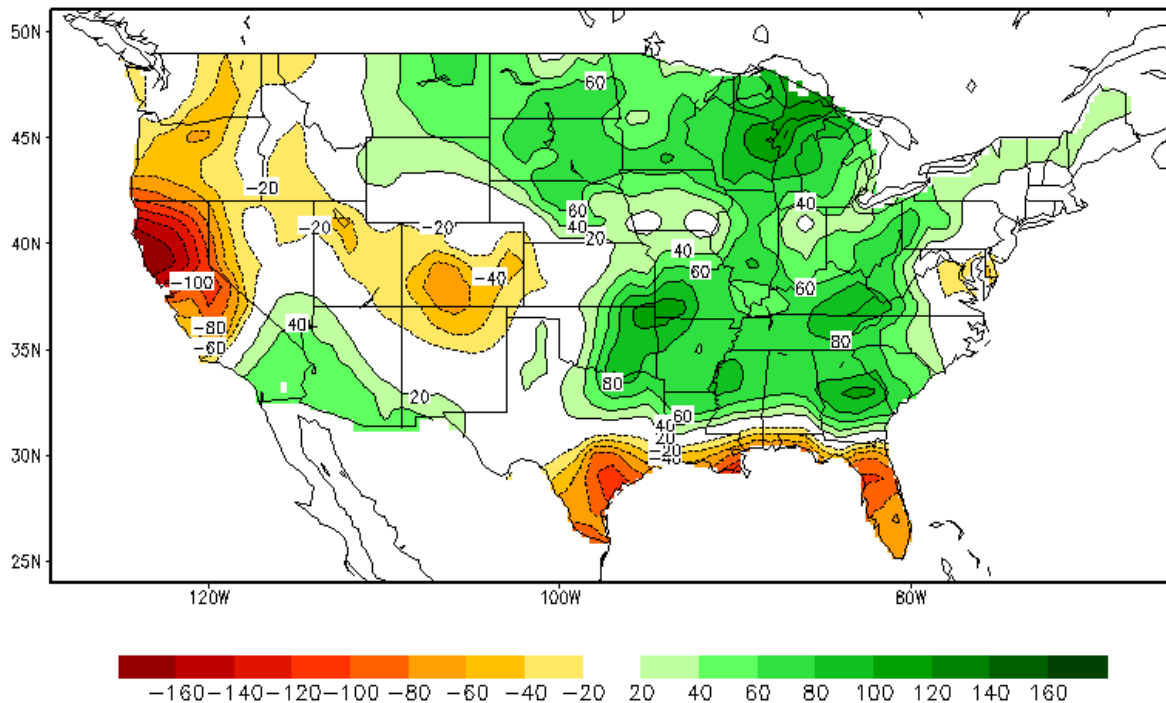
| Explanation - Percentile classes | | | | | | |
|----------------------------------|-------------------|--------------|--------|--------------|-------------------|---------|
| Low | <10 | 10-24 | 25-75 | 76-90 | >90 | High |
| | Much below normal | Below normal | Normal | Above normal | Much above normal | No Data |



2020 Drought Evolution - cont

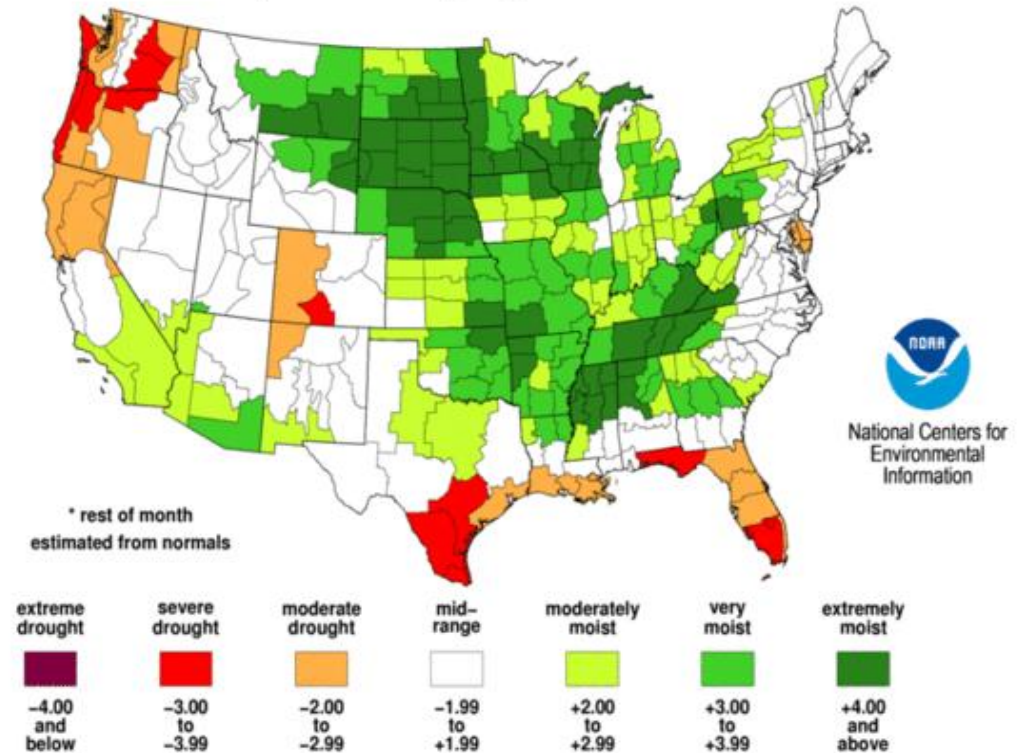
As of the end of April 2020...soil moisture states were at or above normal and there was no indication of long term lingering drought

Calculated Soil Moisture Anomaly (mm)
APR, 2020



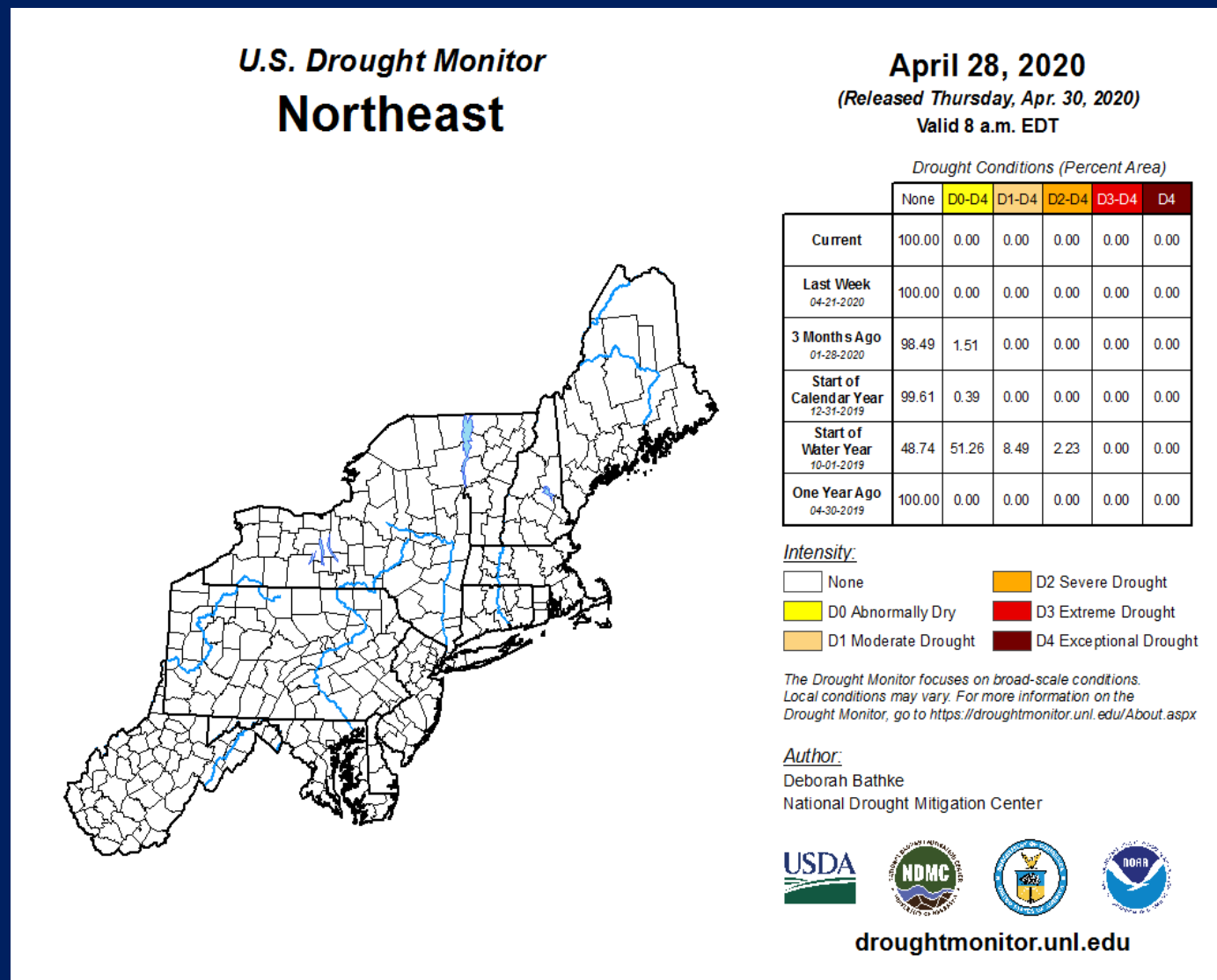
Palmer Hydrological Drought Index
Long-Term (Hydrological) Conditions

April 2020: through April 25 2020*



2020 Drought Evolution - cont

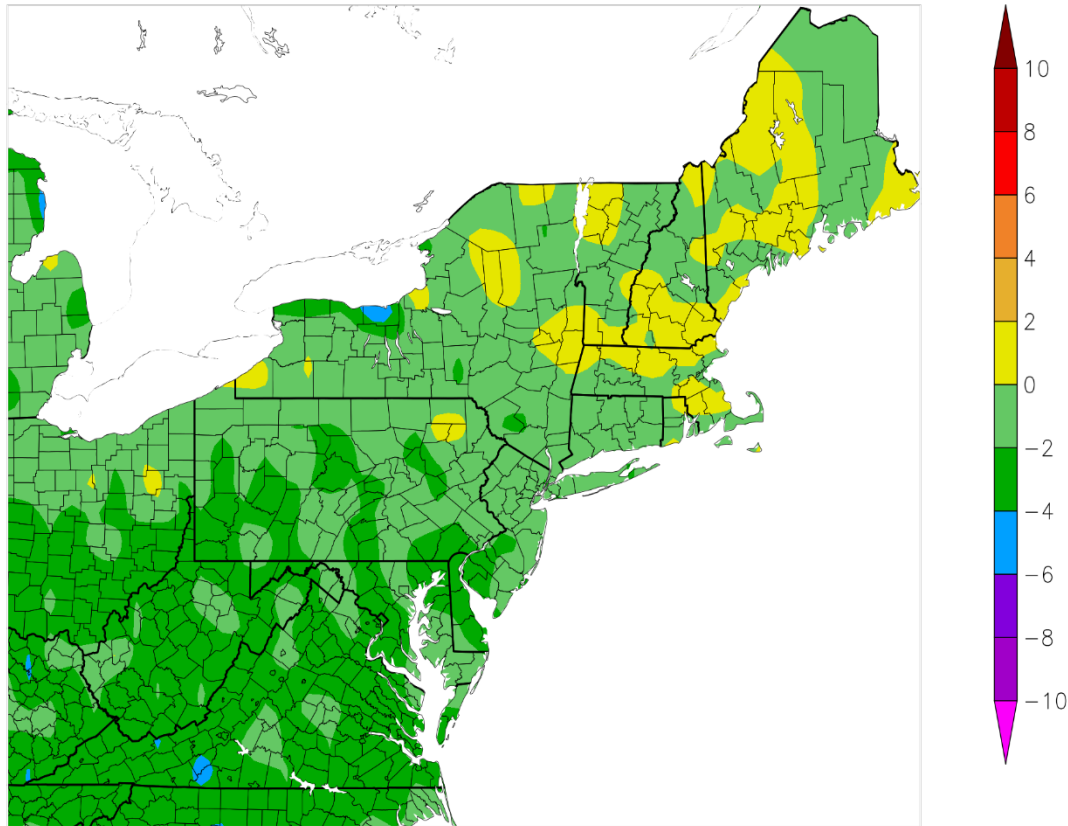
- Hopefully I have convinced everyone there was no hint of drought across New England as of the end of April 2020. Indeed...things looked excessively moist across northern New Hampshire into interior Maine with a lot of snow left to melt and high river flows.
- Now lets follow the monthly progression.



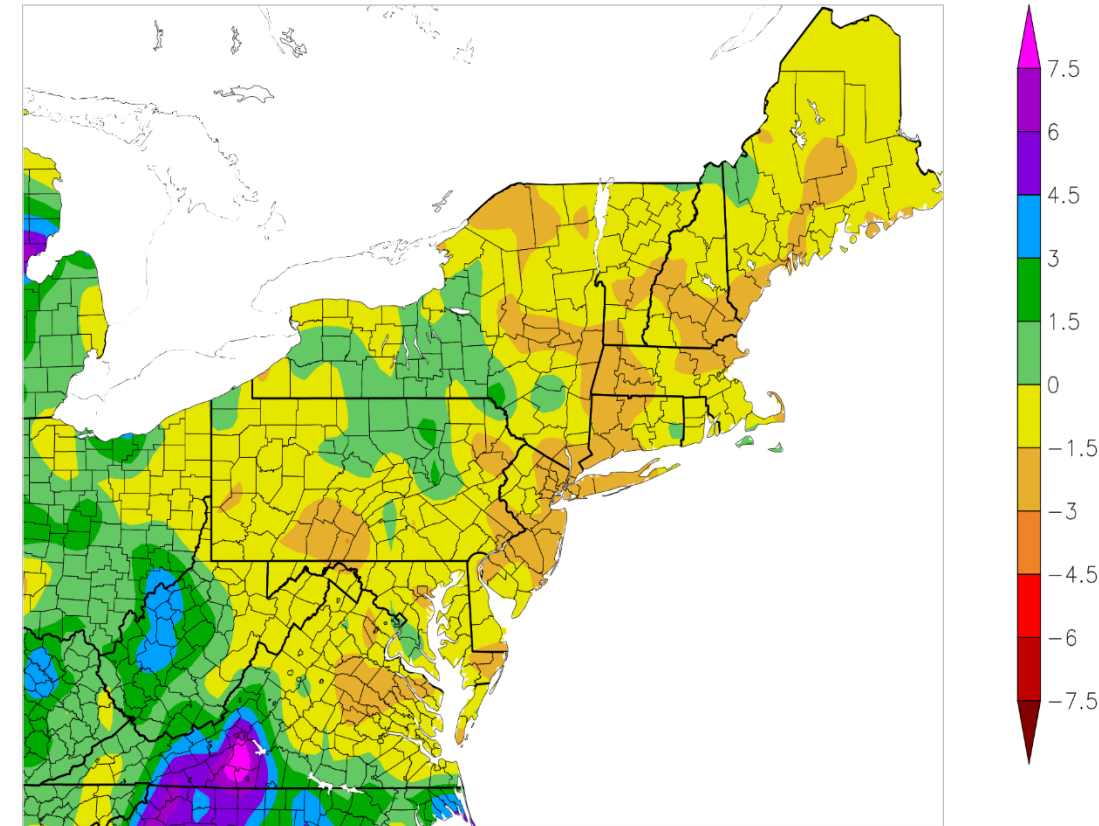
2020 Drought – May 2020

May 2020 featured near normal temperatures but dry conditions emerged especially across central and southern New England where rainfall averaged 1 to 3 inches below normal

Departure from Normal Temperature (F)
5/1/2020 – 5/31/2020

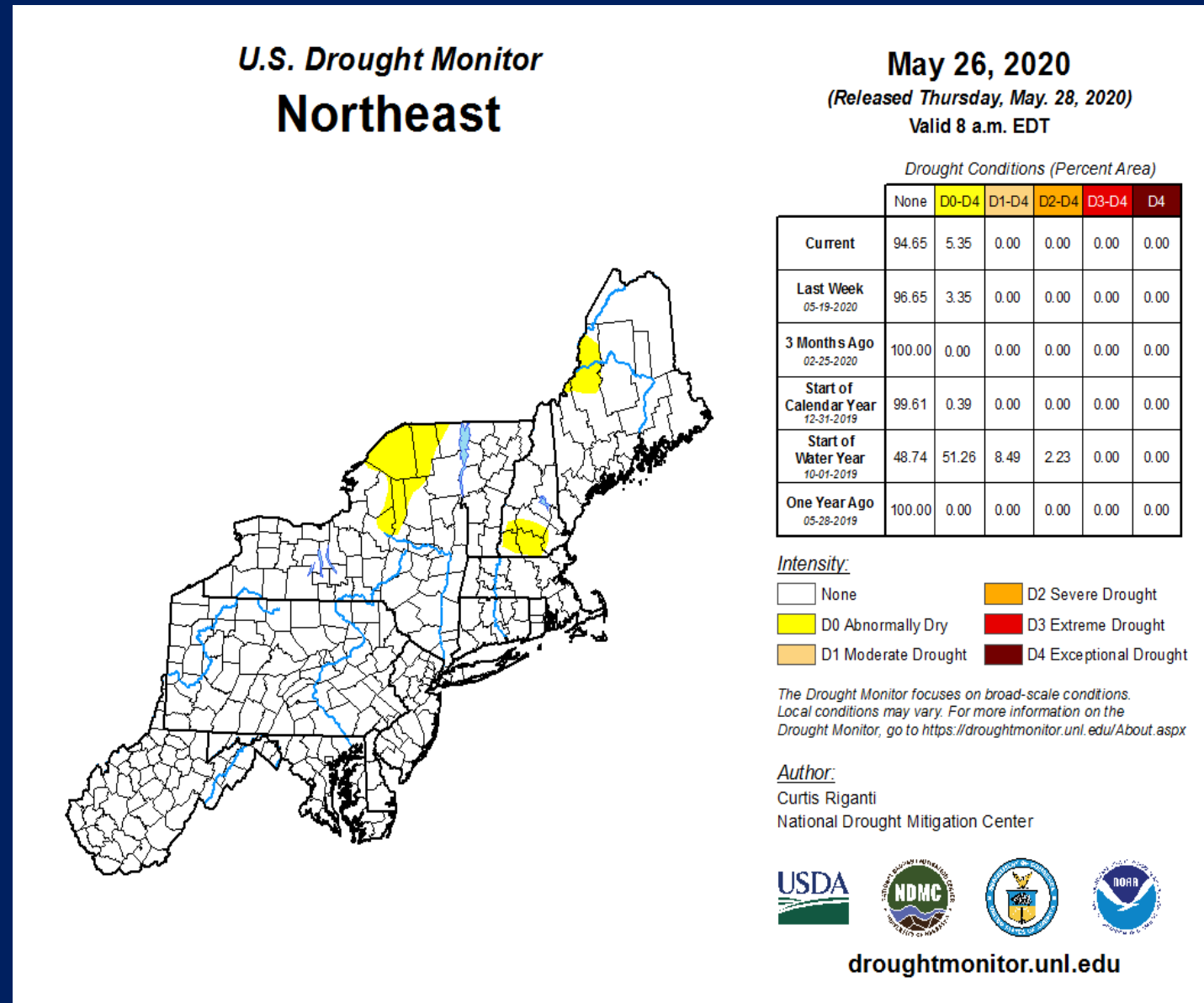


Departure from Normal Precipitation (in)
5/1/2020 – 5/31/2020



2020 Drought – May 2020

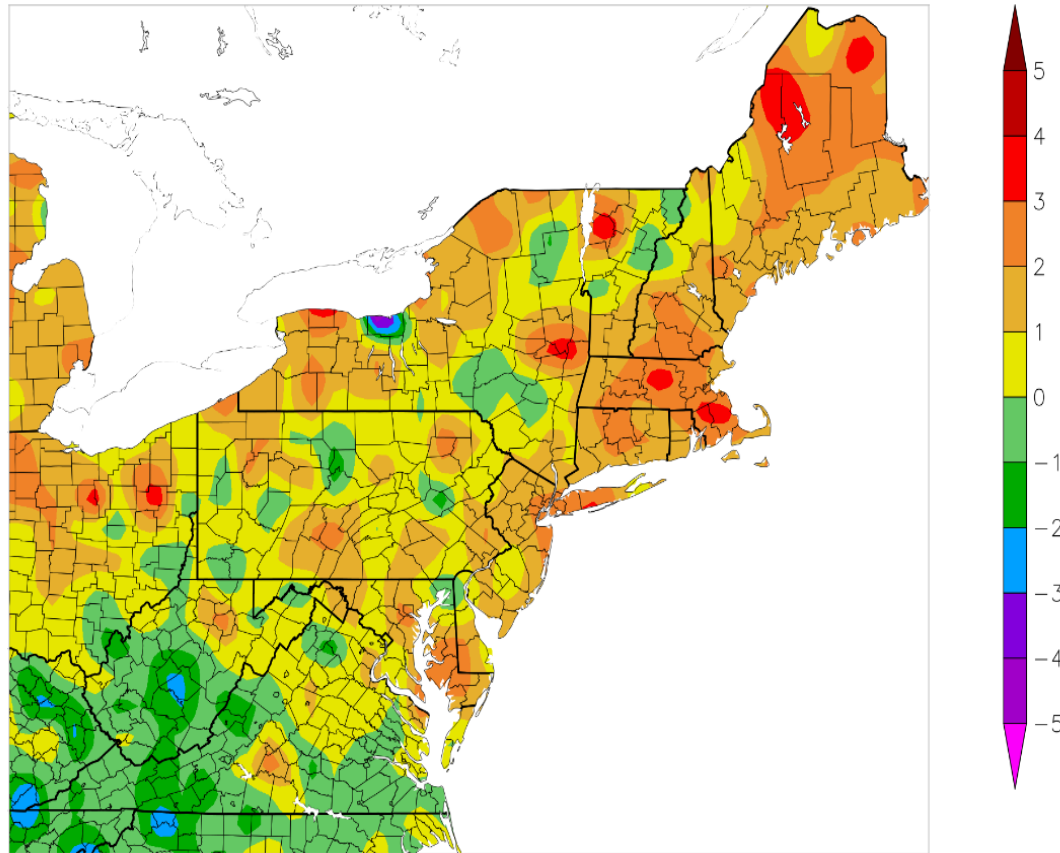
- As a result of the low precipitation amounts in May 2020...pockets of abnormal dryness emerged by the end of the month.



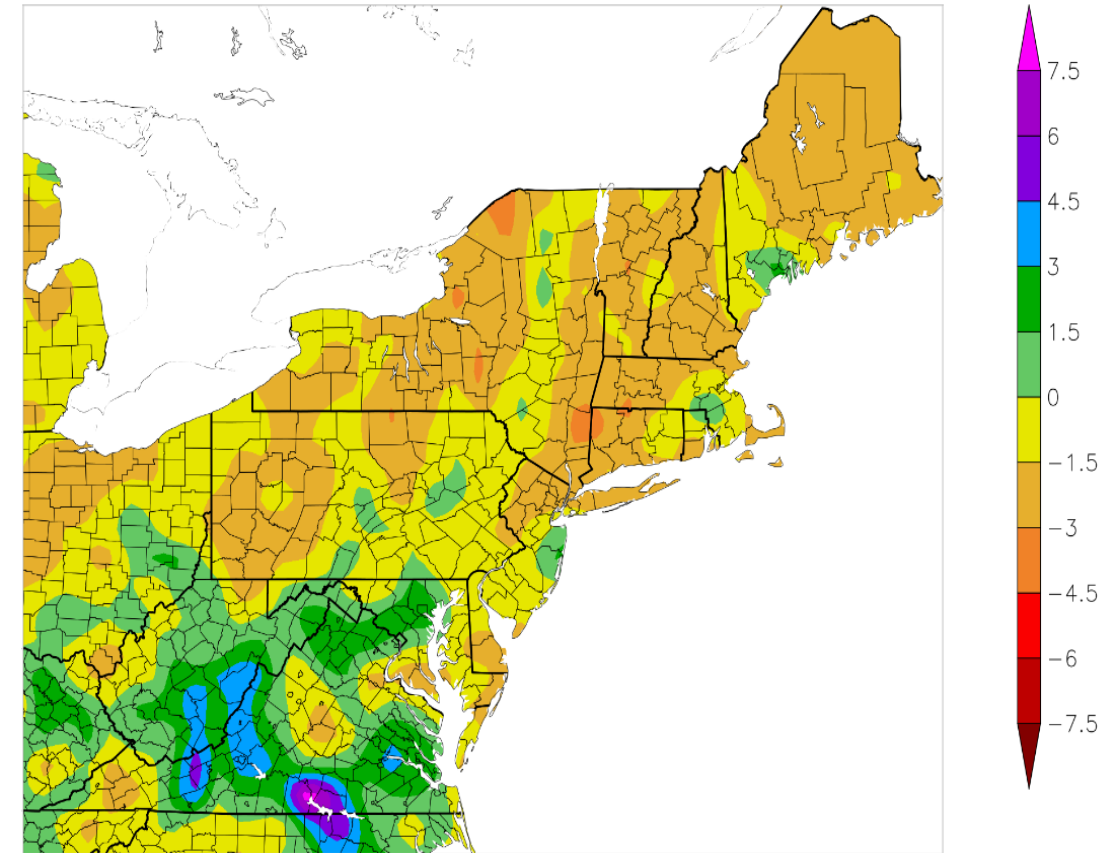
2020 Drought – June 2020

June 2020 was quite warm and dry across most of New England. Much of eastern/southern New England was 1-4 degrees F above normal with rainfall 1 to 3 inches below normal.

Departure from Normal Temperature (F)
6/1/2020 – 6/30/2020

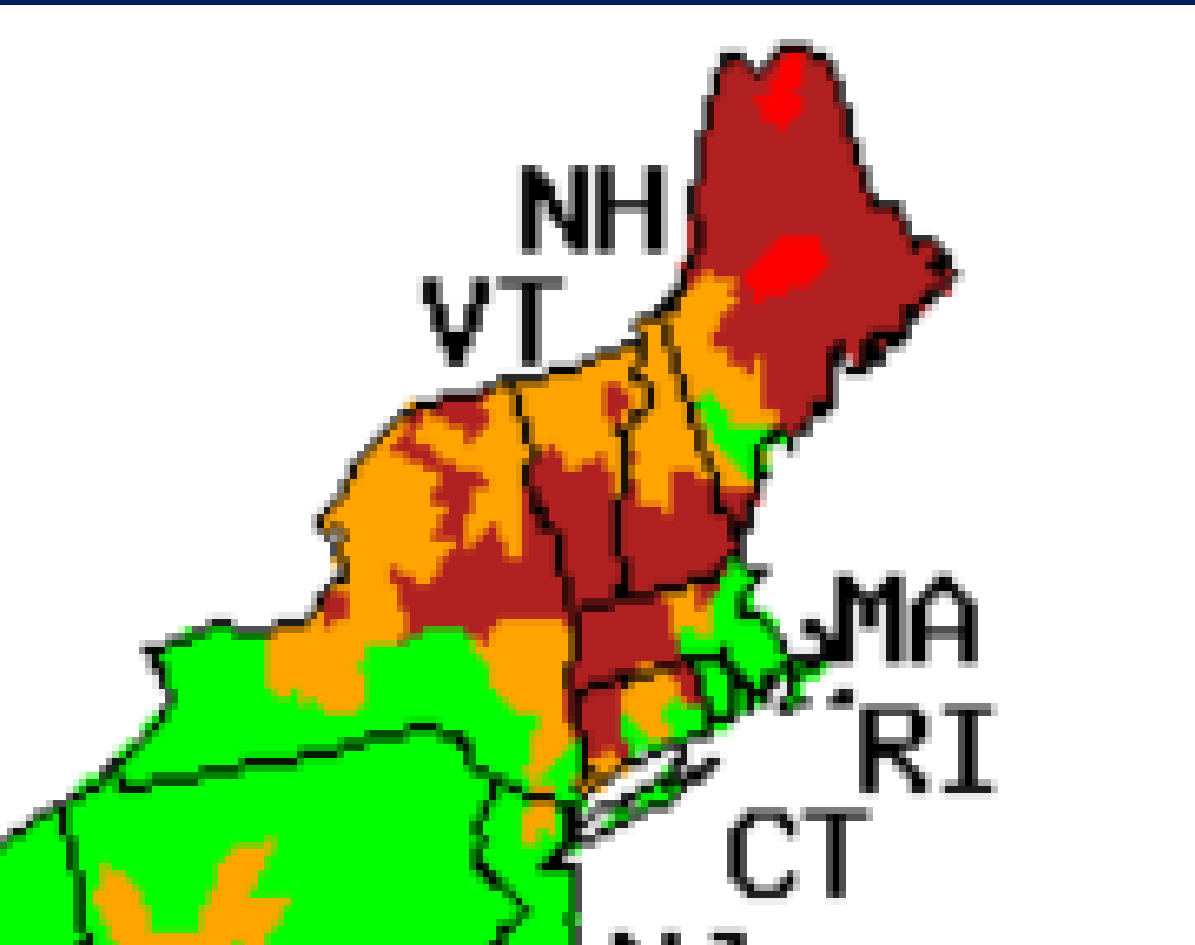


Departure from Normal Precipitation (in)
6/1/2020 – 6/30/2020



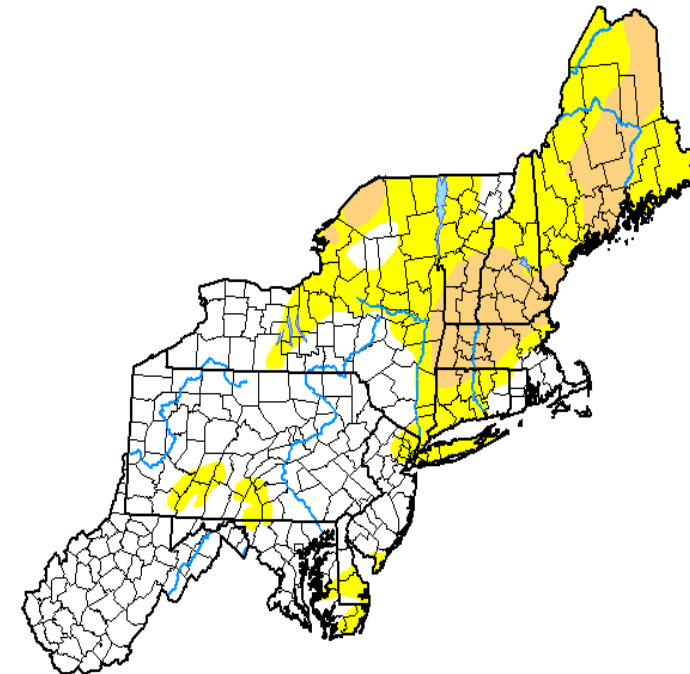
2020 Drought – June 2020

During June 2020...streamflow drops sharply in Maine with moderate drought taking hold in some of the dry areas by the end of the month.



| Explanation - Percentile classes | | | | | | | |
|----------------------------------|-------------------|--------------|--------|--------------|-------------------|------|---------|
| Low | <10 | 10-24 | 25-75 | 76-90 | >90 | High | No Data |
| | Much below normal | Below normal | Normal | Above normal | Much above normal | | |

U.S. Drought Monitor Northeast



June 30, 2020

(Released Thursday, Jul. 2, 2020)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|--------------------------------------|--------|-------|-------|-------|-------|------|
| Current | 54.45 | 45.55 | 14.23 | 0.00 | 0.00 | 0.00 |
| Last Week 06-23-2020 | 57.80 | 42.20 | 16.15 | 0.00 | 0.00 | 0.00 |
| 3 Months Ago 03-31-2020 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Calendar Year 12-31-2019 | 99.61 | 0.39 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Water Year 10-01-2019 | 48.74 | 51.26 | 8.49 | 2.23 | 0.00 | 0.00 |
| One Year Ago 07-02-2019 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Intensity:

| | |
|---------------------|------------------------|
| None | D2 Severe Drought |
| D0 Abnormally Dry | D3 Extreme Drought |
| D1 Moderate Drought | D4 Exceptional Drought |

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

Author:

Adam Hartman
NOAA/NWS/NCEP/CPC

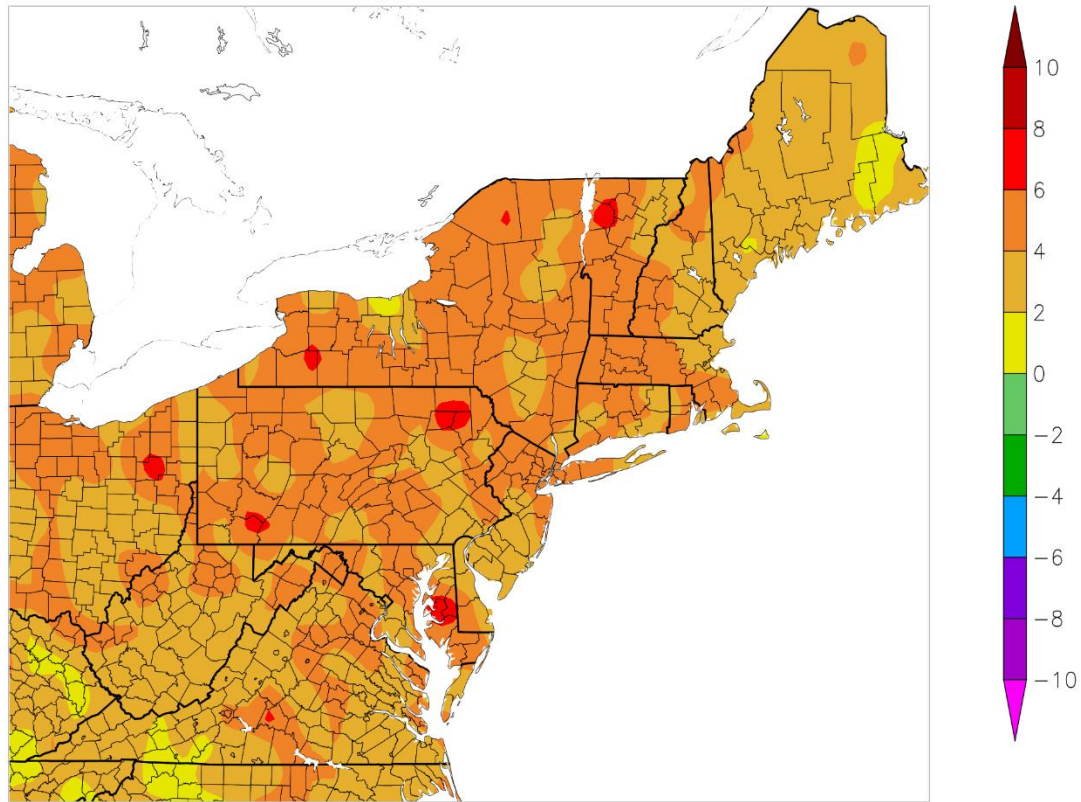


droughtmonitor.unl.edu

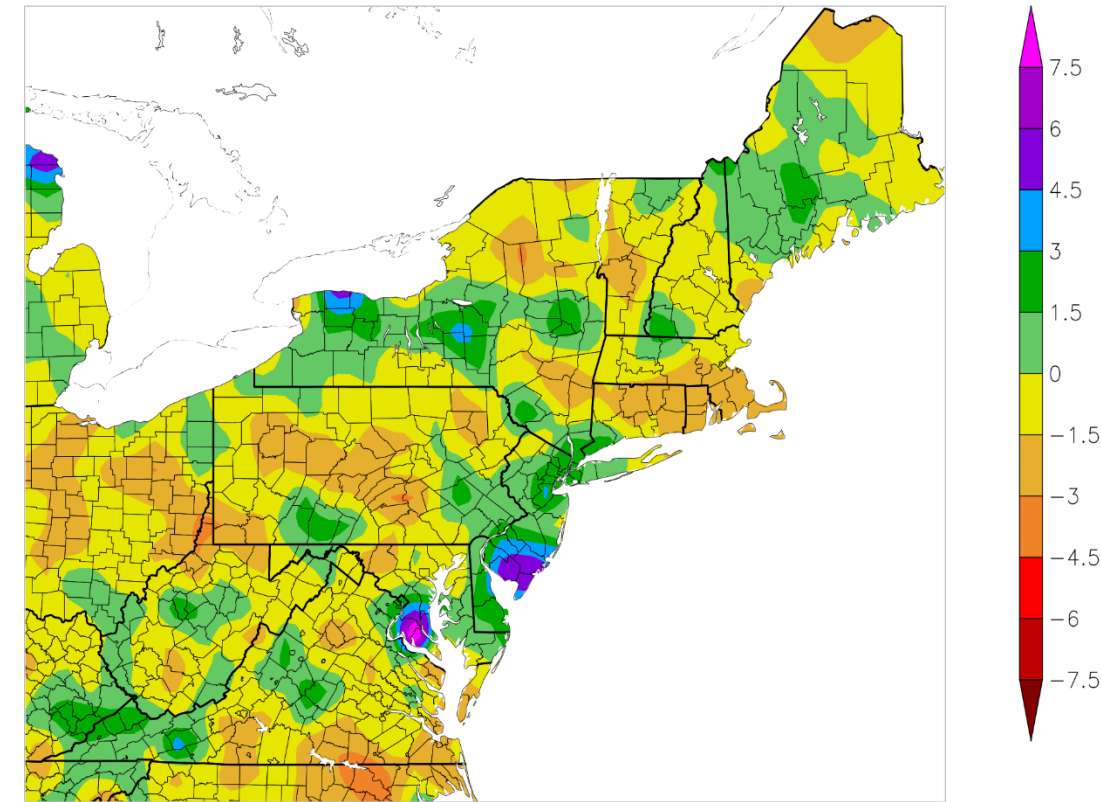
2020 Drought – July 2020

July 2020 is hot with most of New England 2 to 6 degrees F above normal. Areas of northern Maine...southern New England and central Vermont see rainfall amounts 1.50 – 3.00 inches below normal combined with heat

Departure from Normal Temperature (F)
7/1/2020 – 7/31/2020

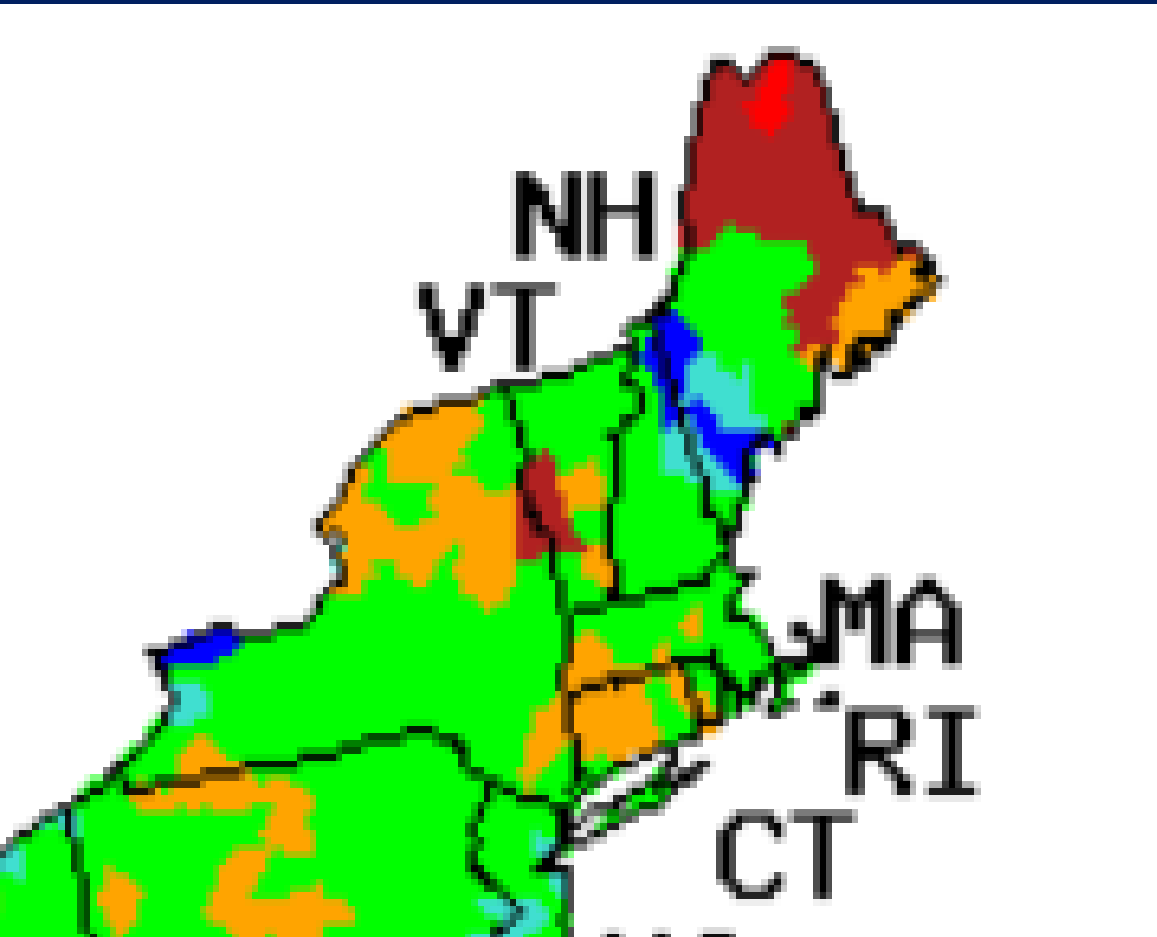


Departure from Normal Precipitation (in)
7/1/2020 – 7/31/2020



2020 Drought – July 2020

A 3rd straight month of below normal rainfall combined with warm temperatures results in the development of severe drought conditions across northern Maine by the end of July



| Explanation - Percentile classes | | | | | | | |
|----------------------------------|-------------------|--------------|--------|--------------|-------------------|------|---------|
| | <10 | 10-24 | 25-75 | 76-90 | >90 | | |
| Low | Much below normal | Below normal | Normal | Above normal | Much above normal | High | No Data |

U.S. Drought Monitor Northeast

July 28, 2020

(Released Thursday, Jul. 30, 2020)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|---|--------|-------|-------|-------|-------|------|
| Current | 28.92 | 71.08 | 28.65 | 1.71 | 0.00 | 0.00 |
| Last Week 07-21-2020 | 30.12 | 69.88 | 25.98 | 1.71 | 0.00 | 0.00 |
| 3 Months Ago 04-28-2020 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Calendar Year 12-31-2019 | 99.61 | 0.39 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Water Year 10-01-2019 | 48.74 | 51.26 | 8.49 | 2.23 | 0.00 | 0.00 |
| One Year Ago 07-30-2019 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

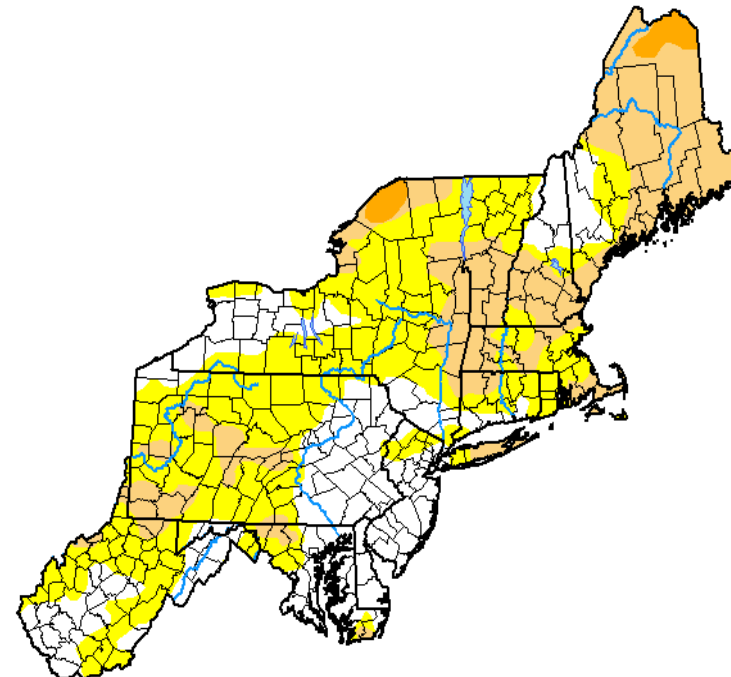
Intensity:

| | |
|---------------------|------------------------|
| None | D2 Severe Drought |
| D0 Abnormally Dry | D3 Extreme Drought |
| D1 Moderate Drought | D4 Exceptional Drought |

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

Author:

Richard Heim
NCEI/NOAA

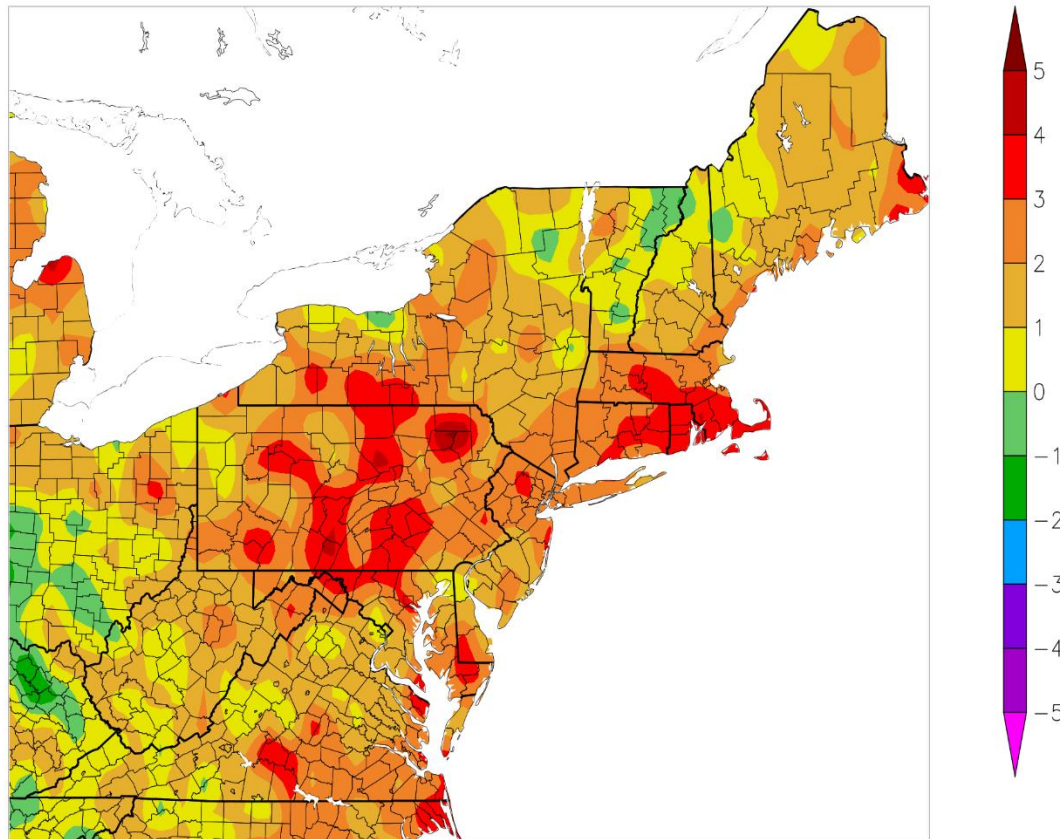


droughtmonitor.unl.edu

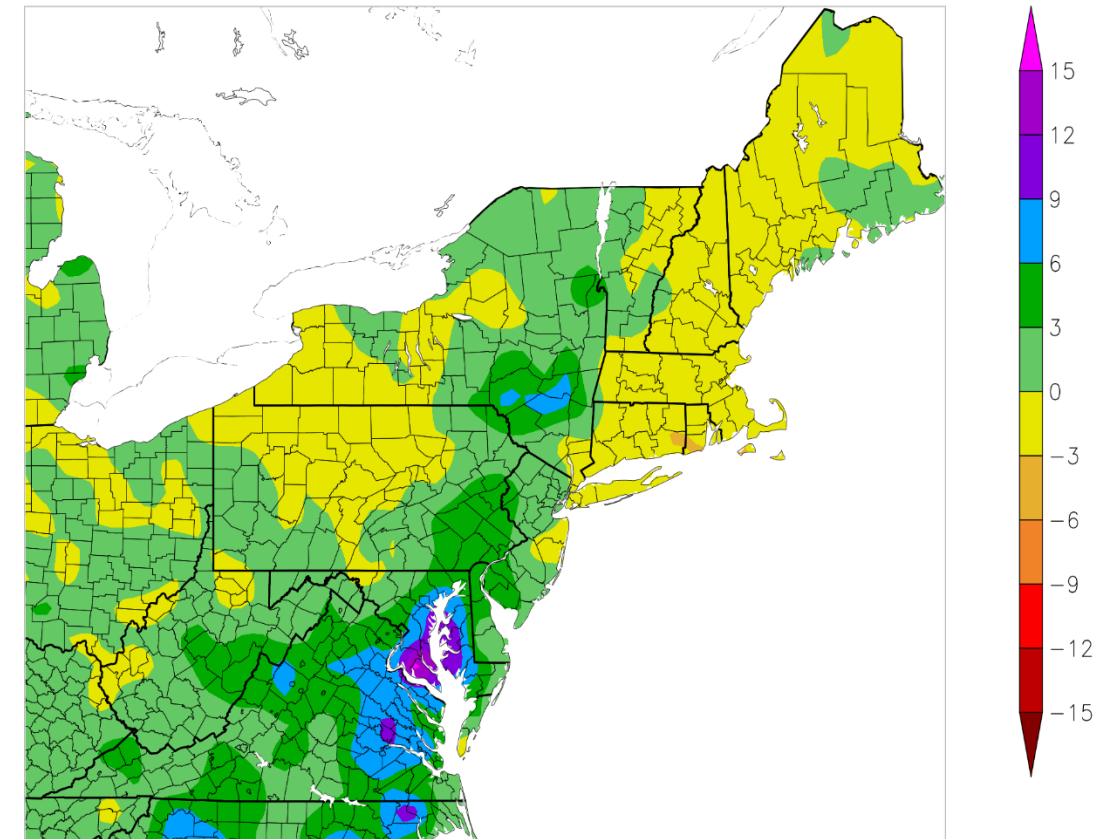
2020 Drought – August 2020

August 2020 continues warm across eastern/southern New England (1-4 degrees F above normal) with net dry conditions continuing

Departure from Normal Temperature (F)
8/1/2020 – 8/31/2020

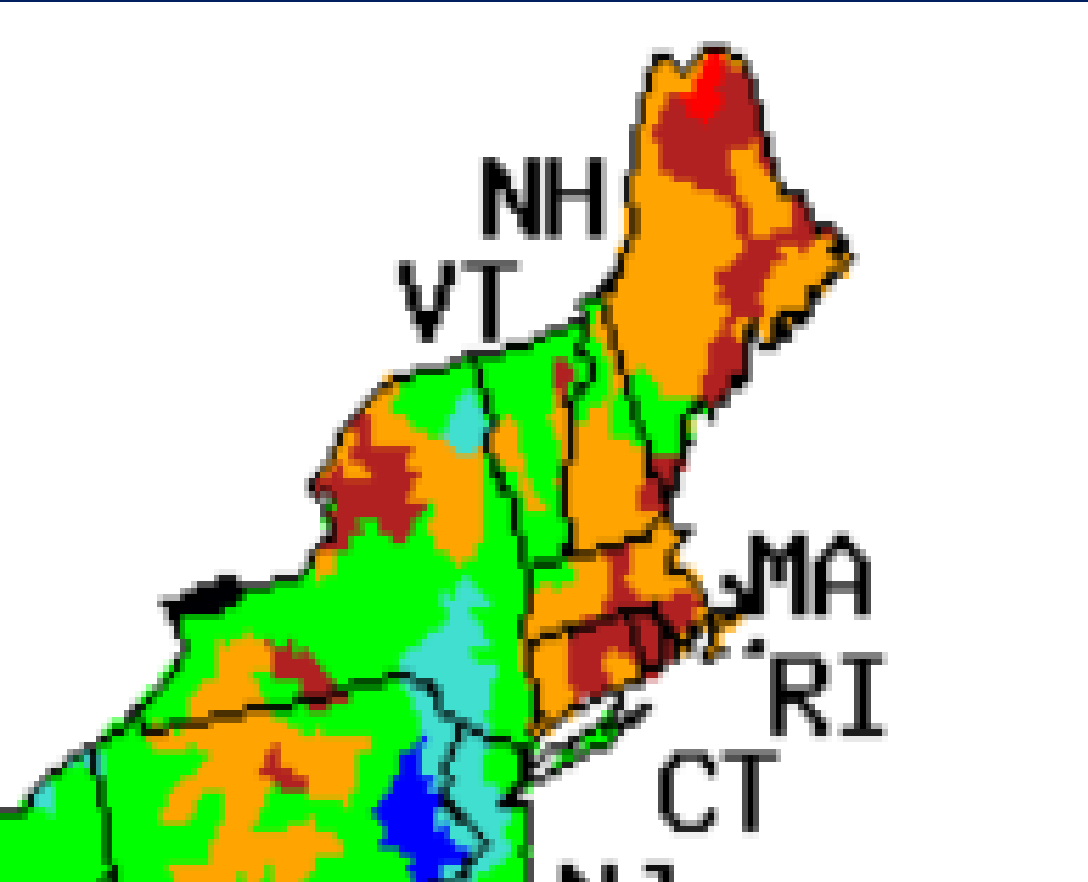


Departure from Normal Precipitation (in)
8/1/2020 – 8/31/2020



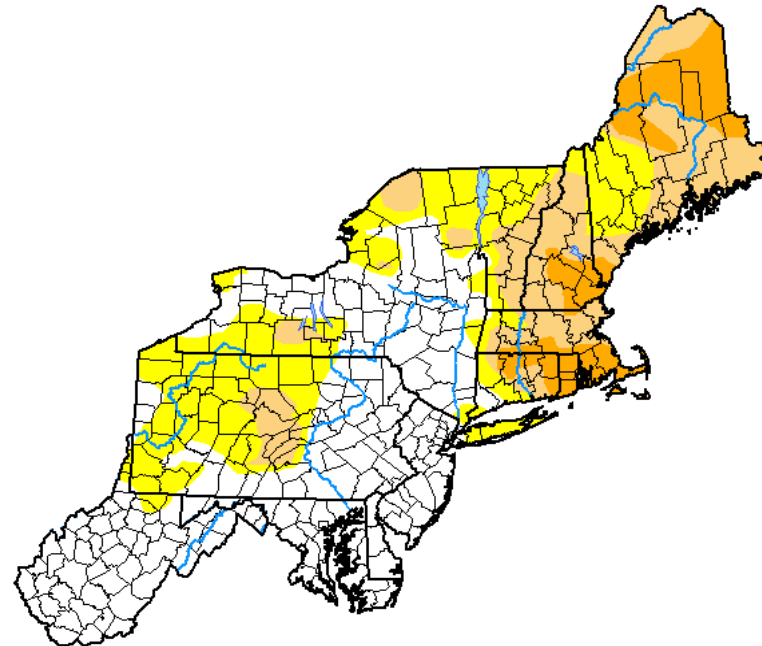
2020 Drought – August 2020

Streamflows continue to degrade in Maine and decline rapidly across southern New England. By the end of August...severe drought expands across northern Maine and is introduced in southeastern New Hampshire and portions of southern New England



| Explanation - Percentile classes | | | | | | | |
|----------------------------------|-------------------|--------------|--------|--------------|-------------------|------|---------|
| | <10 | 10-24 | 25-75 | 76-90 | >90 | High | No Data |
| Low | Much below normal | Below normal | Normal | Above normal | Much above normal | | |

U.S. Drought Monitor Northeast



September 1, 2020
(Released Thursday, Sep. 3, 2020)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|--------------------------------------|-------|-------|-------|-------|-------|------|
| Current | 46.04 | 53.96 | 27.98 | 9.25 | 0.00 | 0.00 |
| Last Week 08-25-2020 | 39.80 | 60.20 | 37.20 | 9.70 | 0.00 | 0.00 |
| 3 Months Ago 06-02-2020 | 91.24 | 8.76 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Calendar Year 12-31-2019 | 99.61 | 0.39 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Water Year 10-01-2019 | 48.74 | 51.26 | 8.49 | 2.23 | 0.00 | 0.00 |
| One Year Ago 09-03-2019 | 93.31 | 6.69 | 0.00 | 0.00 | 0.00 | 0.00 |

Intensity:

| | |
|---------------------|------------------------|
| None | D2 Severe Drought |
| D0 Abnormally Dry | D3 Extreme Drought |
| D1 Moderate Drought | D4 Exceptional Drought |

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

Author:

Richard Tinker
CPC/NOAA/NWS/NCEP

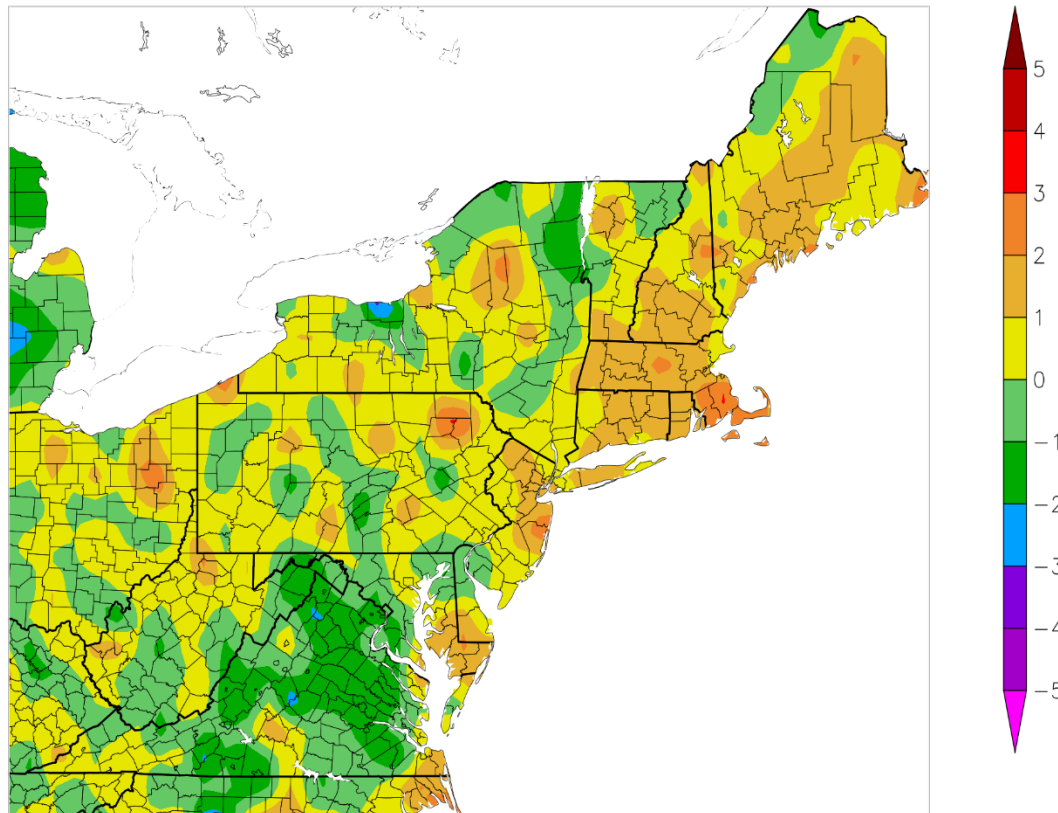


droughtmonitor.unl.edu

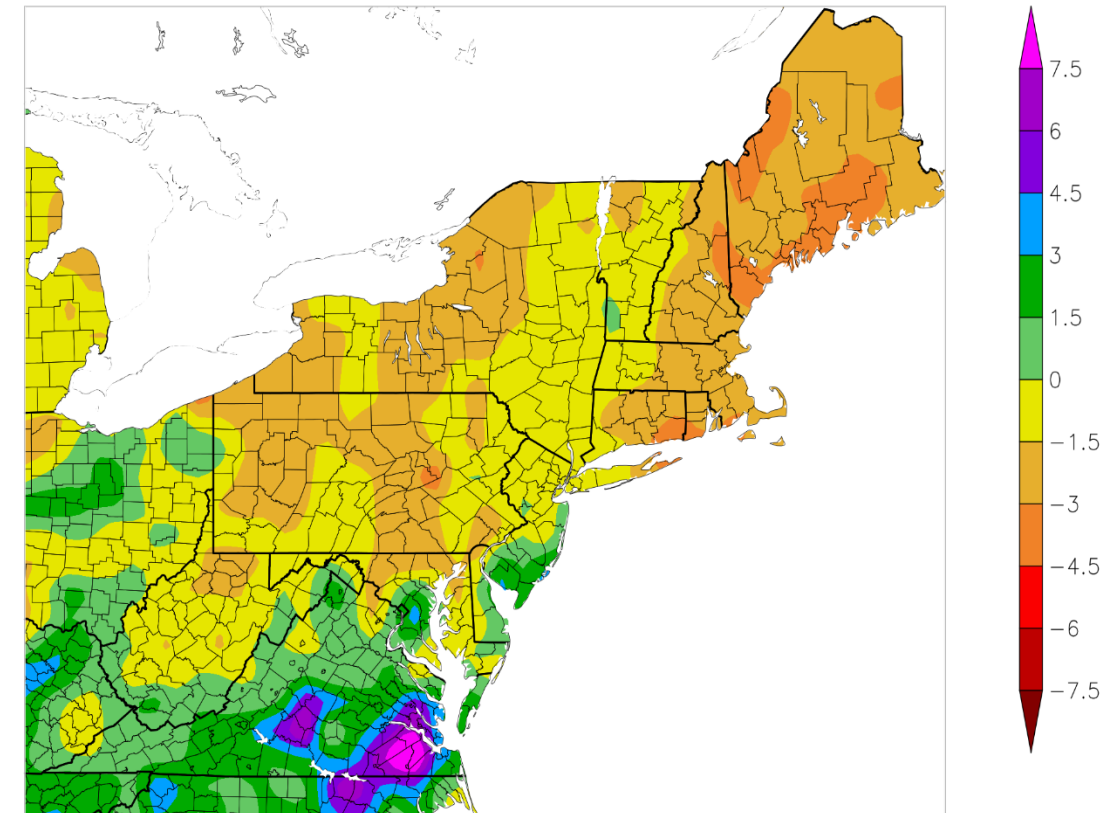
2020 Drought – September 2020

A lot of eastern/southern New England stays warm (1-2+ degrees F above normal). Very dry conditions cover New England east of the Connecticut River with departures of 1.50 - 3+ inches

Departure from Normal Temperature (F)
9/1/2020 – 9/30/2020

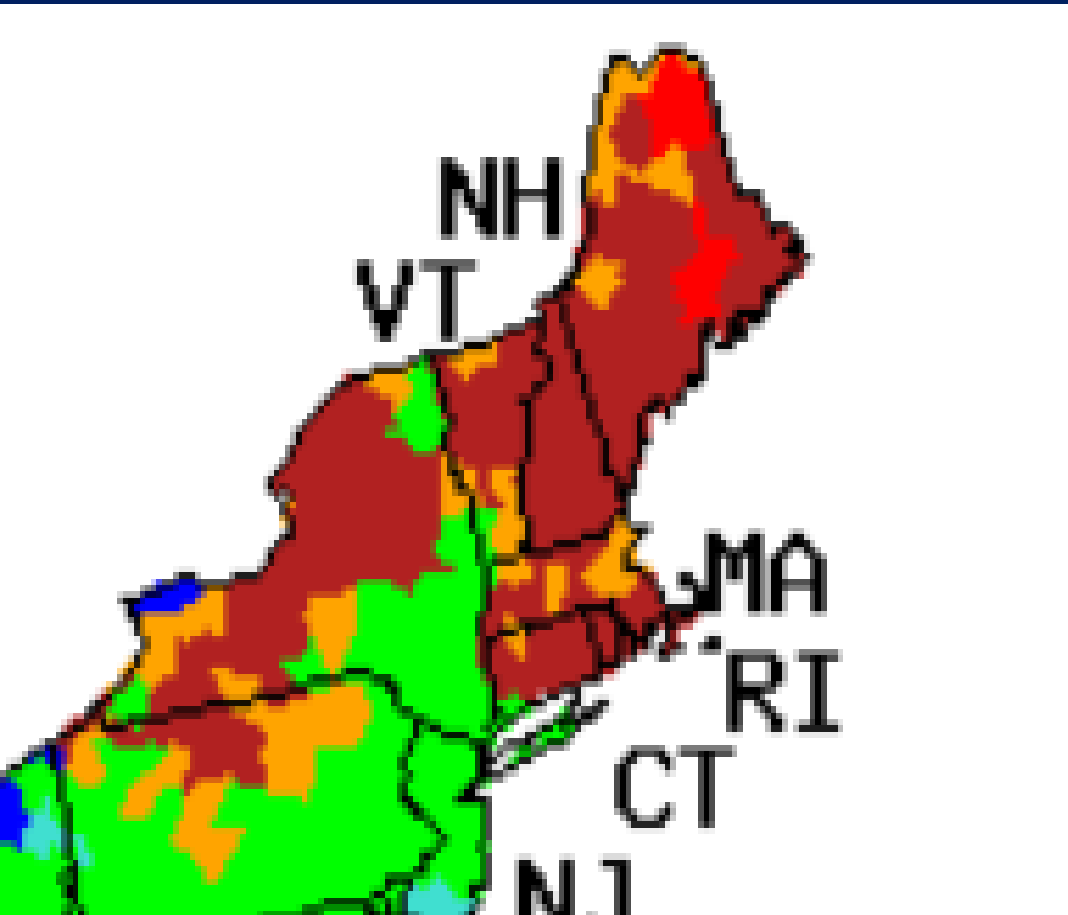


Departure from Normal Precipitation (in)
9/1/2020 – 9/30/2020

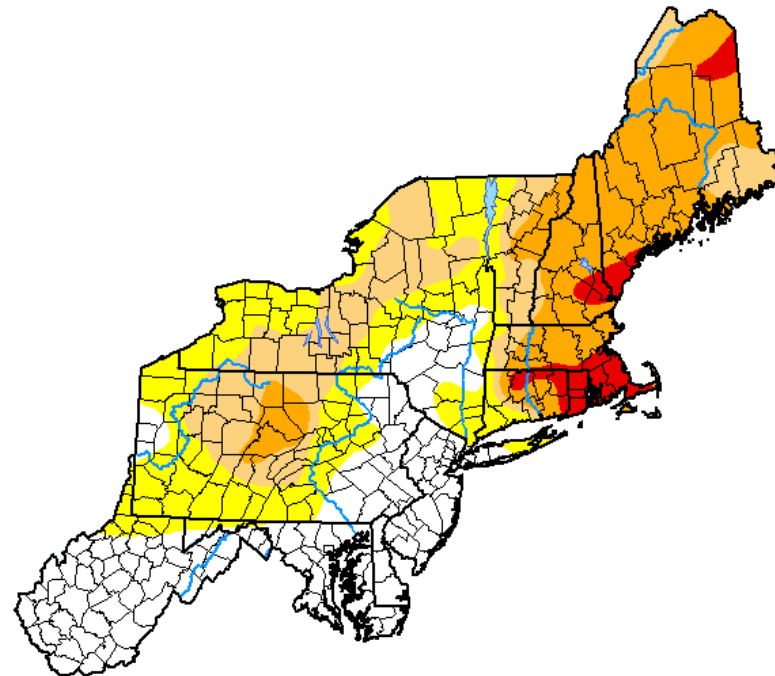


2020 Drought – September 2020

Streamflow declines intensify across most of New England and Extreme Drought is declared across portions of eastern/southern New England for the first time in 2020.



U.S. Drought Monitor Northeast



September 29, 2020

(Released Thursday, Oct. 1, 2020)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|---|-------|-------|-------|-------|-------|------|
| Current | 29.83 | 70.17 | 45.34 | 26.30 | 3.91 | 0.00 |
| Last Week 09-22-2020 | 42.11 | 57.89 | 36.70 | 21.94 | 2.71 | 0.00 |
| 3 Months Ago 06-30-2020 | 54.45 | 45.55 | 14.23 | 0.00 | 0.00 | 0.00 |
| Start of Calendar Year 12-31-2019 | 99.61 | 0.39 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Water Year 10-01-2019 | 48.74 | 51.26 | 8.49 | 2.23 | 0.00 | 0.00 |
| One Year Ago 10-01-2019 | 48.74 | 51.26 | 8.49 | 2.23 | 0.00 | 0.00 |

Intensity:

| | |
|---------------------|------------------------|
| None | D2 Severe Drought |
| D0 Abnormally Dry | D3 Extreme Drought |
| D1 Moderate Drought | D4 Exceptional Drought |

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

Author:

Brad Rippey
U.S. Department of Agriculture



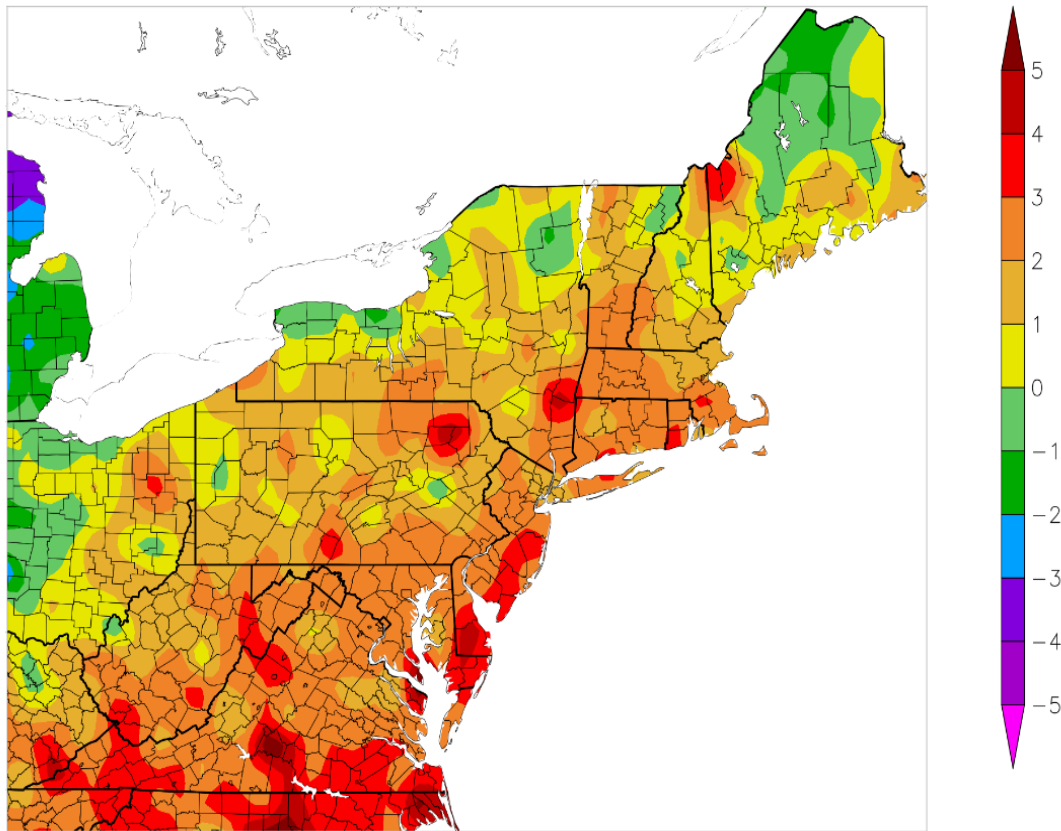
droughtmonitor.unl.edu

| Explanation - Percentile classes | | | | | | | |
|----------------------------------|-------------------|--------------|--------|--------------|-------------------|------|---------|
| Low | <10 | 10-24 | 25-75 | 76-90 | >90 | High | No Data |
| | Much below normal | Below normal | Normal | Above normal | Much above normal | | |

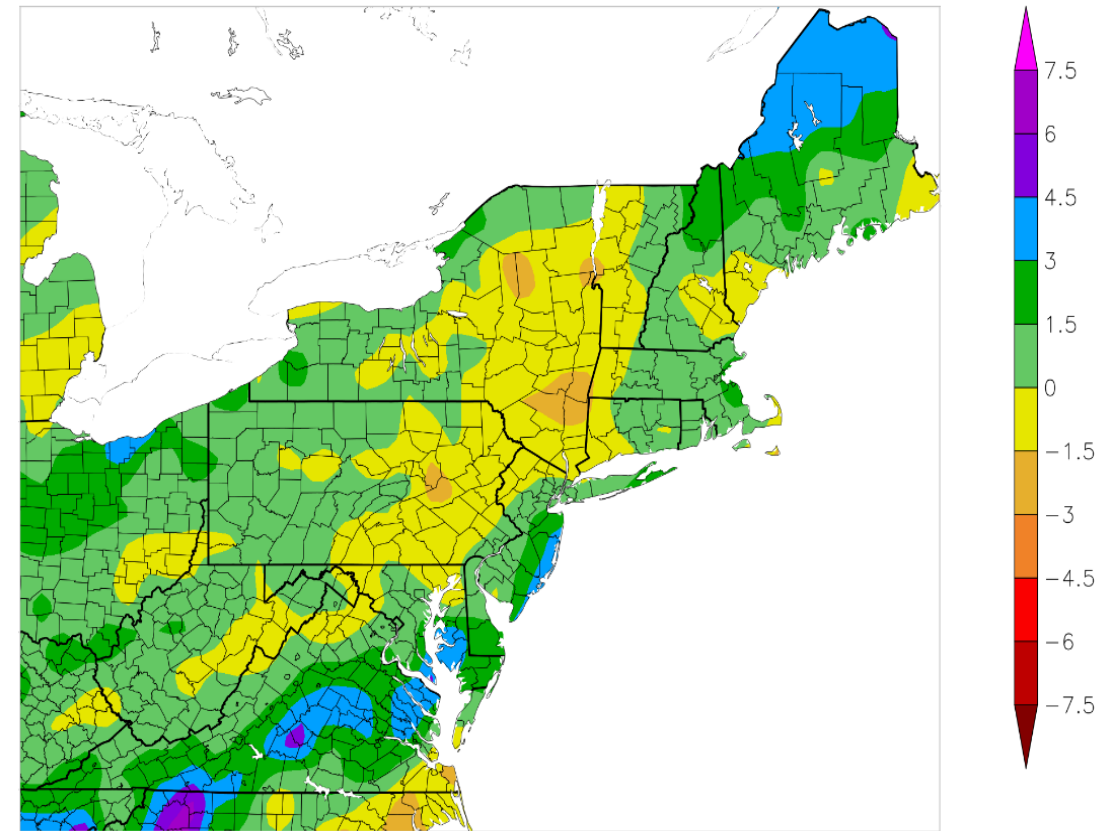
2020 Drought – October 2020

Northern Maine finally sees cooler than normal temperatures and precipitation 3.00 – 4.50 inches above normal during October. Warm temperatures and near normal precipitation occurs across southern New England

Departure from Normal Temperature (F)
10/1/2020 – 10/31/2020

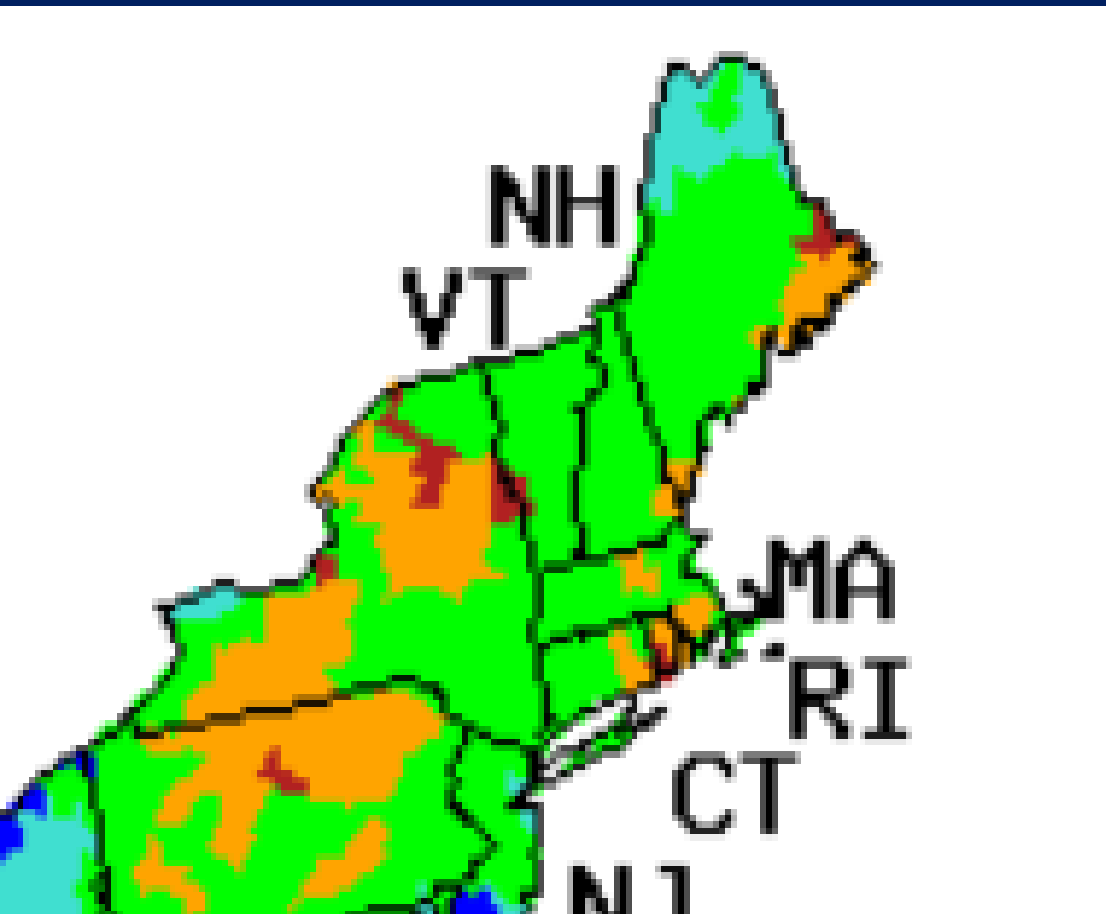


Departure from Normal Precipitation (in)
10/1/2020 – 10/31/2020

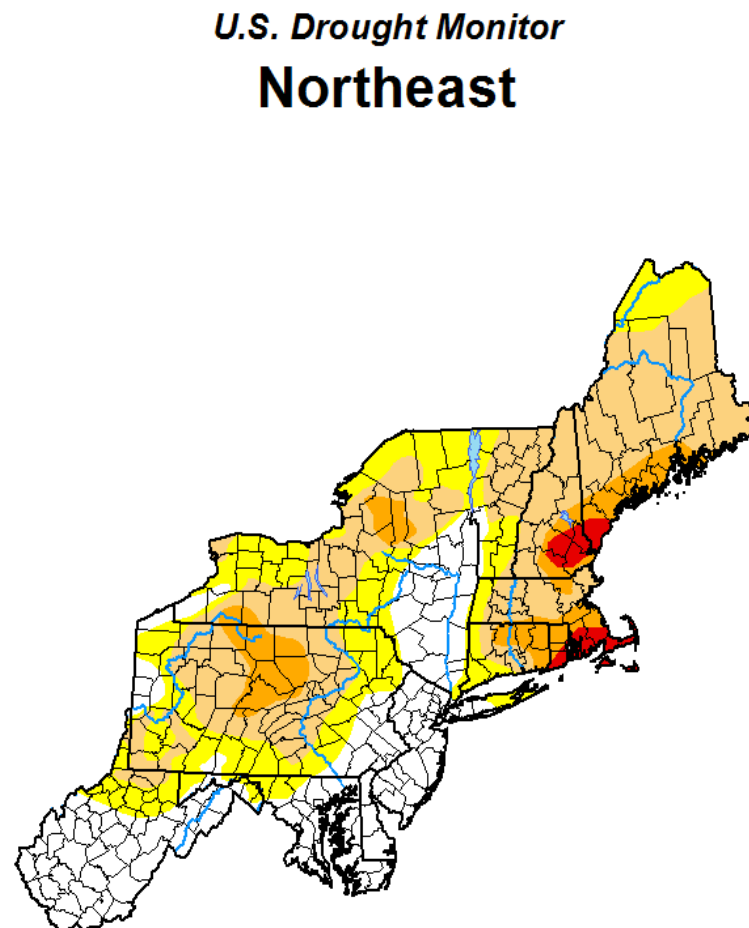


2020 Drought – October 2020

River flows show improvement across New England in October with drought improving across most areas away from the coast.



| Explanation - Percentile classes | | | | | | | |
|----------------------------------|-------------------|--------------|--------|--------------|-------------------|------|---------|
| Low | <10 | 10-24 | 25-75 | 76-90 | >90 | High | No Data |
| | Much below normal | Below normal | Normal | Above normal | Much above normal | | |



U.S. Drought Monitor Northeast

October 27, 2020

(Released Thursday, Oct. 29, 2020)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|--------------------------------------|-------|-------|-------|-------|-------|------|
| Current | 28.92 | 71.08 | 47.18 | 10.94 | 2.02 | 0.00 |
| Last Week 10-20-2020 | 29.23 | 70.77 | 50.06 | 10.70 | 2.02 | 0.00 |
| 3 Months Ago 07-28-2020 | 28.92 | 71.08 | 28.65 | 1.71 | 0.00 | 0.00 |
| Start of Calendar Year 12-31-2019 | 99.61 | 0.39 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Water Year 09-29-2020 | 29.83 | 70.17 | 45.34 | 26.30 | 3.91 | 0.00 |
| One Year Ago 10-29-2019 | 70.13 | 29.87 | 0.00 | 0.00 | 0.00 | 0.00 |

Intensity:

| | |
|---------------------|------------------------|
| None | D2 Severe Drought |
| D0 Abnormally Dry | D3 Extreme Drought |
| D1 Moderate Drought | D4 Exceptional Drought |

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

Author:

David Miskus
NOAA/NWS/NCEP/CPC

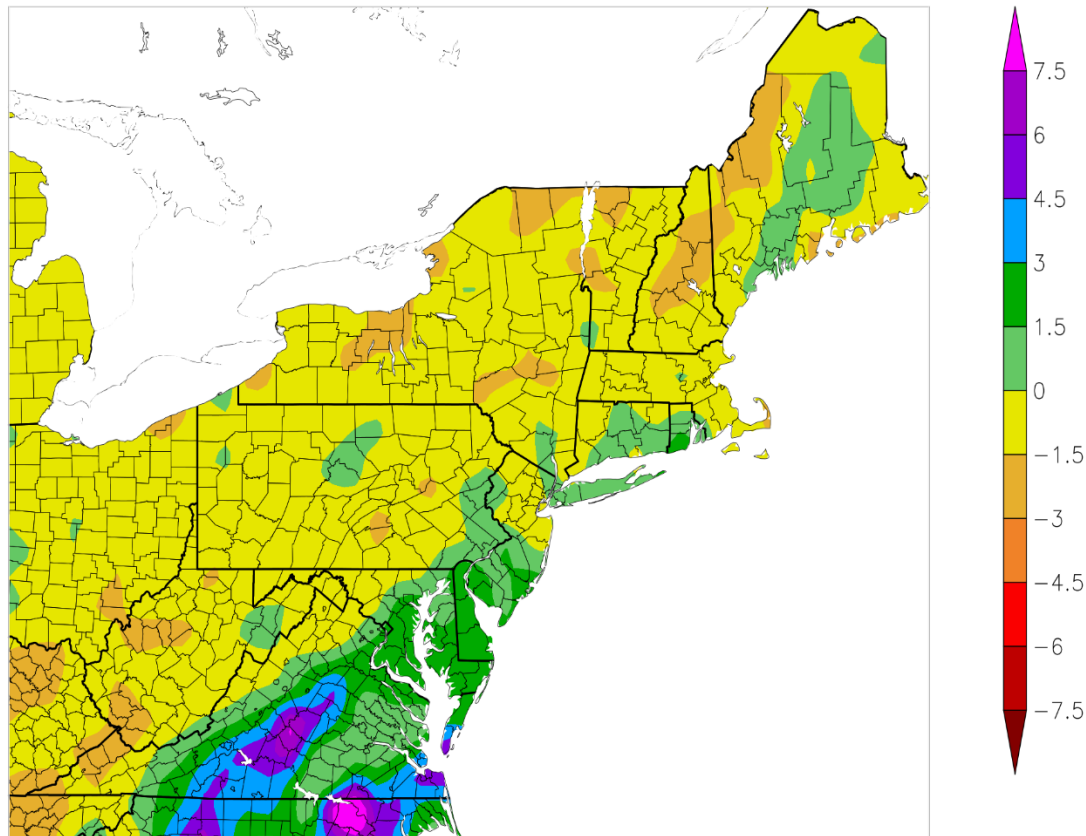


droughtmonitor.unl.edu

2020 Drought – November 2020

Cooler weather and loss of evapotranspiration help to improve drought across all but southeastern New Hampshire and southwest Maine during November despite areas of dryness.

Departure from Normal Precipitation (in)
11/1/2020 – 11/30/2020



U.S. Drought Monitor Northeast

December 1, 2020

(Released Thursday, Dec. 3, 2020)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|---|-------|-------|-------|-------|-------|------|
| Current | 45.89 | 54.11 | 21.09 | 1.72 | 0.43 | 0.00 |
| Last Week 11-24-2020 | 43.78 | 56.22 | 33.42 | 4.07 | 0.75 | 0.00 |
| 3 Months Ago 09-01-2020 | 46.04 | 53.96 | 27.98 | 9.25 | 0.00 | 0.00 |
| Start of Calendar Year 12-31-2019 | 99.61 | 0.39 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Water Year 09-29-2020 | 29.83 | 70.17 | 45.34 | 26.30 | 3.91 | 0.00 |
| One Year Ago 12-03-2019 | 98.03 | 1.97 | 0.00 | 0.00 | 0.00 | 0.00 |

Intensity:

| | |
|---------------------|------------------------|
| None | D2 Severe Drought |
| D0 Abnormally Dry | D3 Extreme Drought |
| D1 Moderate Drought | D4 Exceptional Drought |

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Local conditions may vary. For more information on the
Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

Author:

Richard Heim
NCEI/NOAA

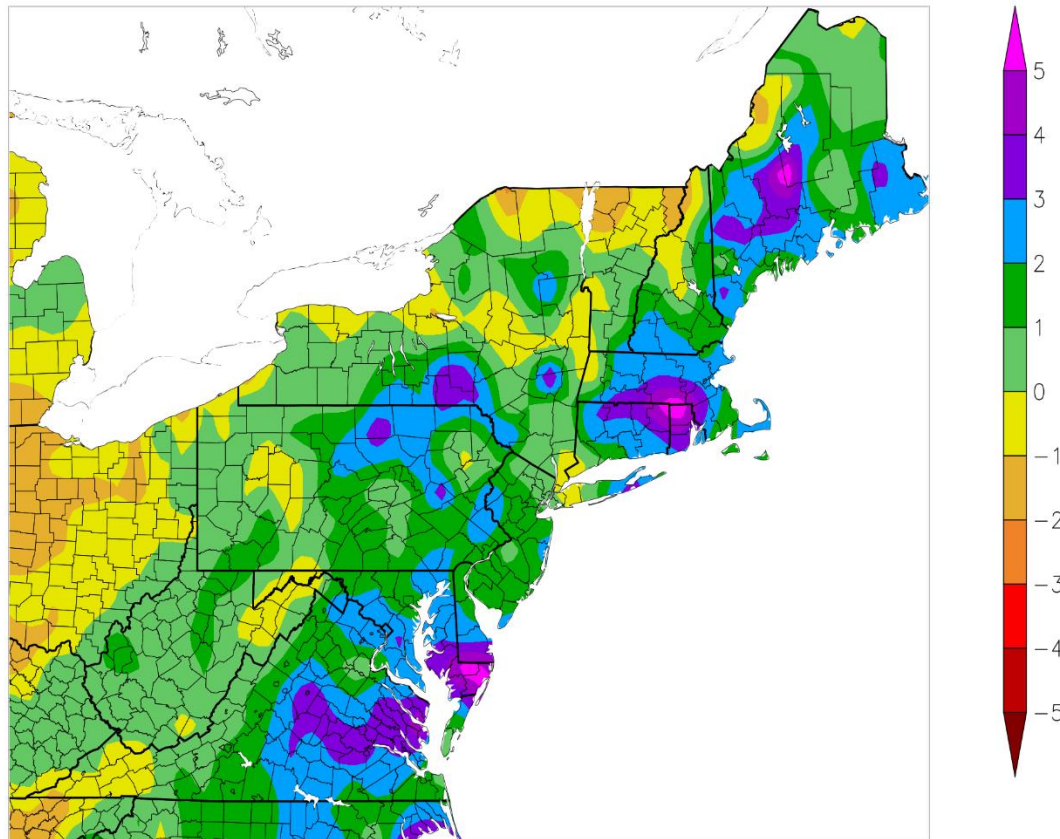


droughtmonitor.unl.edu

2020 Drought – December 2020

Much of eastern/southern New England receive markedly above normal precipitation in December and by the end of the month...most areas are free of drought

Departure from Normal Precipitation (in)
12/1/2020 – 12/31/2020



U.S. Drought Monitor Northeast

January 5, 2021

(Released Thursday, Jan. 7, 2021)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|--------------------------------------|-------|-------|-------|-------|-------|------|
| Current | 79.51 | 20.49 | 3.63 | 0.00 | 0.00 | 0.00 |
| Last Week 12-29-2020 | 77.61 | 22.39 | 3.63 | 0.00 | 0.00 | 0.00 |
| 3 Months Ago 10-06-2020 | 32.76 | 67.24 | 49.35 | 27.27 | 5.85 | 0.00 |
| Start of Calendar Year 12-29-2020 | 77.61 | 22.39 | 3.63 | 0.00 | 0.00 | 0.00 |
| Start of Water Year 09-29-2020 | 29.83 | 70.17 | 45.34 | 26.30 | 3.91 | 0.00 |
| One Year Ago 01-07-2020 | 99.61 | 0.39 | 0.00 | 0.00 | 0.00 | 0.00 |

Intensity:

| | |
|---------------------|------------------------|
| None | D2 Severe Drought |
| D0 Abnormally Dry | D3 Extreme Drought |
| D1 Moderate Drought | D4 Exceptional Drought |

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

Author:

Deborah Bathke
National Drought Mitigation Center



droughtmonitor.unl.edu

2020 Drought – State by State

| STATE | MAXIMUM EXTENT OF DROUGHT | | MAXIMUM EXTENT OF SEVERE OR GREATER DROUGHT | |
|---------------|---------------------------|---------------------|---|--------------------|
| Connecticut | 73.03% | 25 August 2020 | 57.60% | 15 October 2020 |
| Vermont | 76.65% | 29 September 2020 | 29.39% | 6 October 2020 |
| Rhode Island | 100% | 18 Aug – 2 Nov 2020 | 100% | 6 Oct – 3 Nov 2020 |
| Massachusetts | 95.9% | 29 September 2020 | 83.17% | 13 October 2020 |
| New Hampshire | 100% | 29 September 2020 | 95.06% | 29 September 2020 |
| Maine | 100% | 29 September 2020 | 83.86% | 29 September 2020 |

2020 New England Drought Summary

- Drought commences in late June 2020 across central New England and Maine due to consecutive dry months and increasing heat.
- Warm to hot temperatures and continued dryness allows severe drought to become commonplace east of the Connecticut River by the end of August 2020.
- Warm and extremely dry conditions east of the Connecticut River in September 2020 result in most areas experiencing severe to extreme drought.
- Drought eases across northern Maine in October due to heavy rainfall...across southern New England in November and across southeast New Hampshire during early December.
- A 4 to 5 month event for most areas.

2020 Drought Impacts

- Southern New England Drought Particulars
 - Temperature
 - Precipitation
 - Streamflow
 - Groundwater
 - Water Supply
 - Agricultural Impacts

2020 Southern New England Drought - Temperature

- Summer of 2020 was quite warm across far southern New England
 - Boston +1.8F
 - Providence +3.1F
 - Hartford – Windsor Locks +3.1F
- Additional temperatures stats
 - There were 39 days of 90F or above at Hartford – Windsor Locks which was 26 more than normal.
 - There were 23 days of 90F or above at Providence which was 15 more than normal.

2020 Southern New England Drought - Precipitation

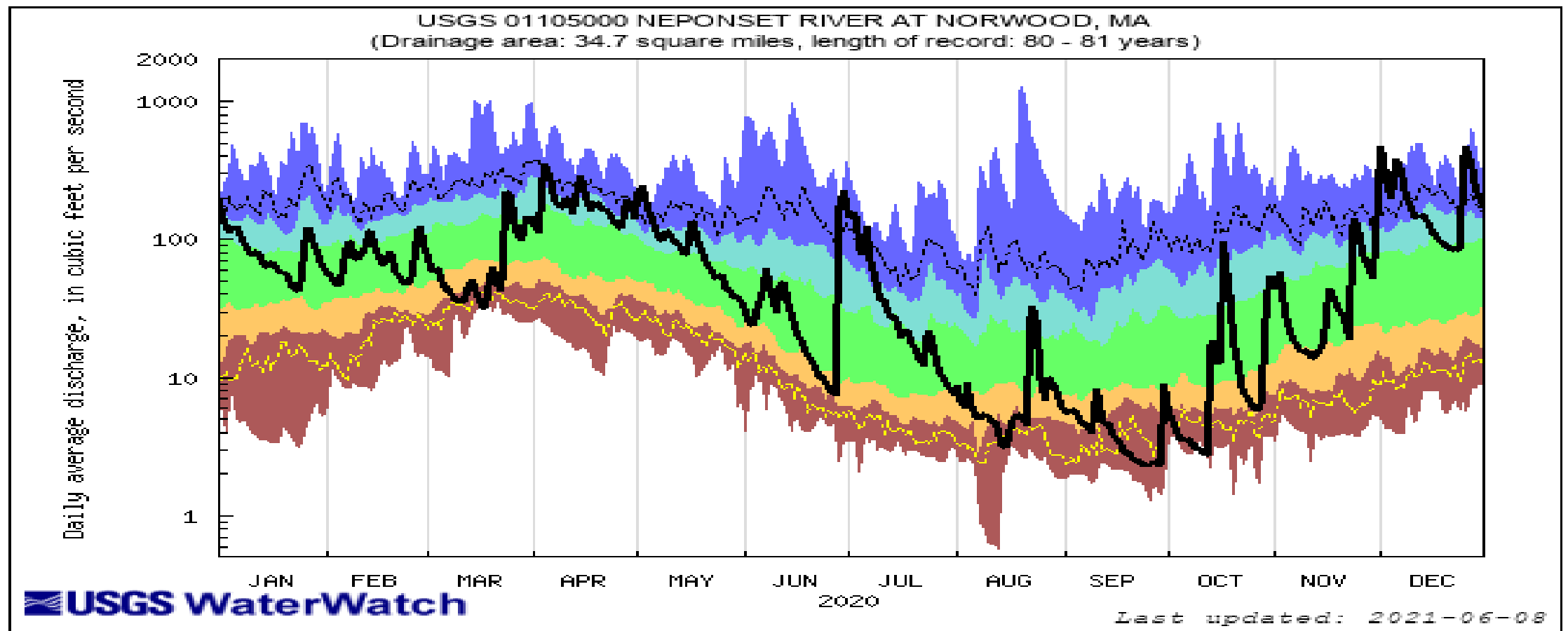
- Very dry conditions persisted across southern New England during the summer of 2020 (June – August)
 - Boston 6.89” was 3.57 inches below normal.
 - Providence 5.99” was 4.54 inches below normal.
 - Hartford – Windsor Locks 4.42” was the driest summer in the 116 year period of record and 8.04 inches below normal.
- Dryness continued through September 2020 averaging an additional 1.75 – 2.75 inches below normal at these 3 climate sites.








2020 Southern New England Drought - Streamflow

- The extremely warm and dry summer and early fall of 2020 led to some historical record low flows.
 - Several smaller streams went completely dry.
- Larger rivers and streams did not deteriorate quite as much as across northern Maine

2020 Southern New England Drought - Streamflow

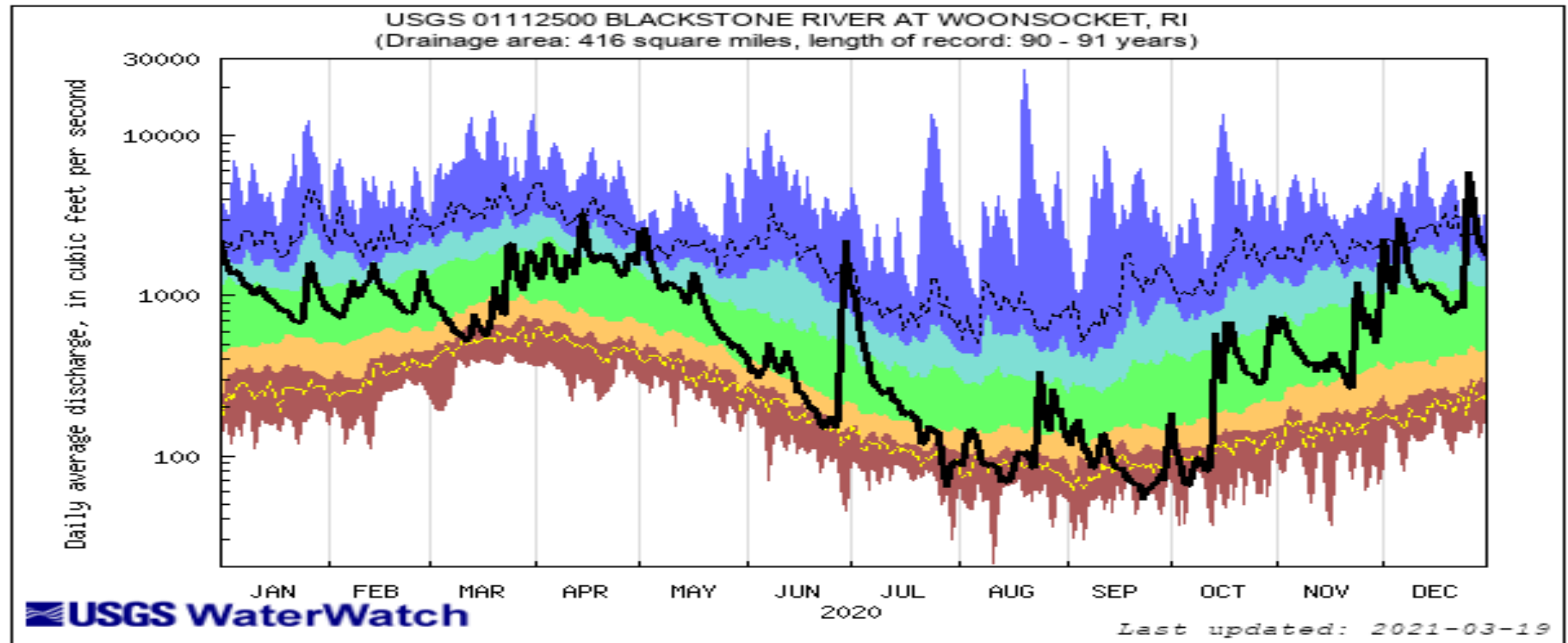
Neponset River at Norwood Massachusetts



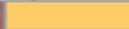






| Explanation - Percentile classes | | | | | | |
|---|---|--|---|---|---|---|
|  |  |  |  |  |  |  |
| lowest-10th percentile | 5 | 10-24 | 25-75 | 76-90 | 95 | 90th percentile - highest |
| Much below Normal | | Below normal | Normal | Above normal | Much above normal | Flow |

2020 Southern New England Drought - Streamflow

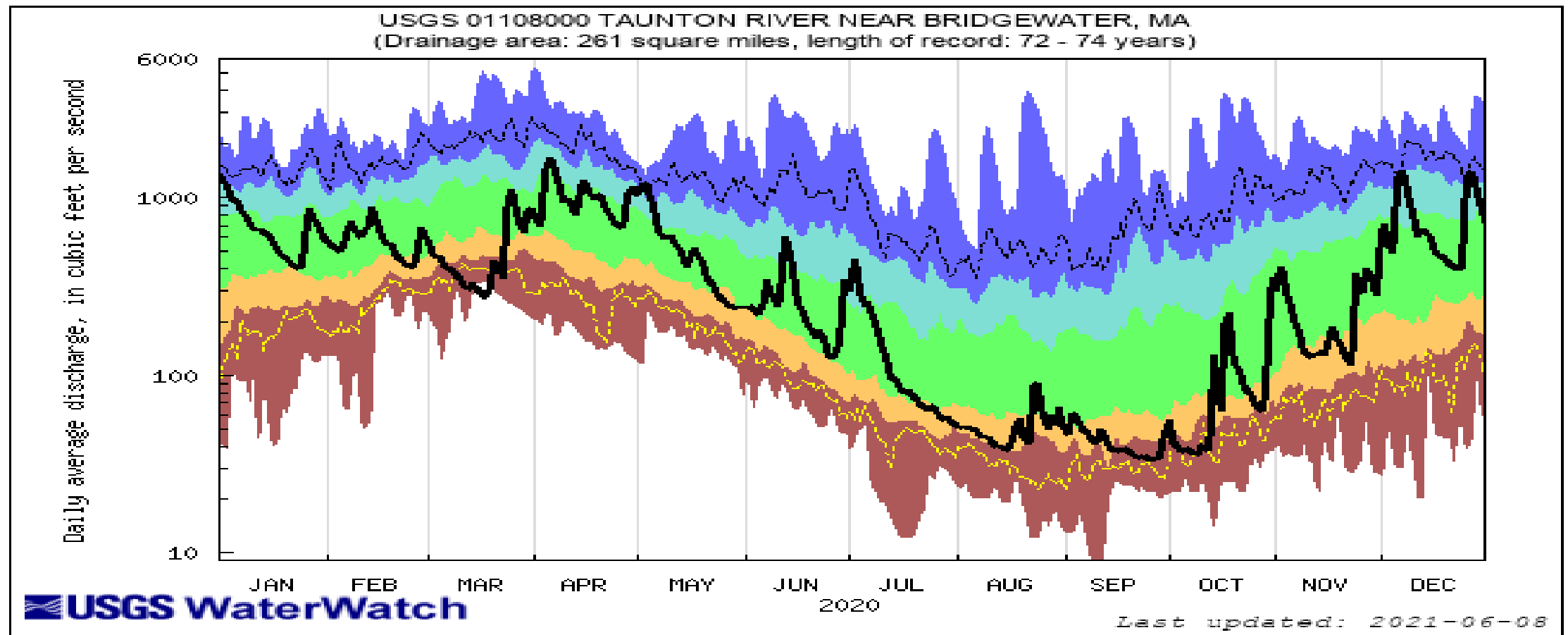
Blackstone River at Woonsocket Rhode Island










| Explanation - Percentile classes | | | | | | |
|---|---|--|---|---|---|---|
|  |  |  |  |  |  |  |
| lowest-10th percentile | 5 | 10-24 | 25-75 | 76-90 | 95 | 90th percentile - highest |
| Much below Normal | | Below normal | Normal | Above normal | Much above normal | Flow |

2020 Southern New England Drought - Streamflow

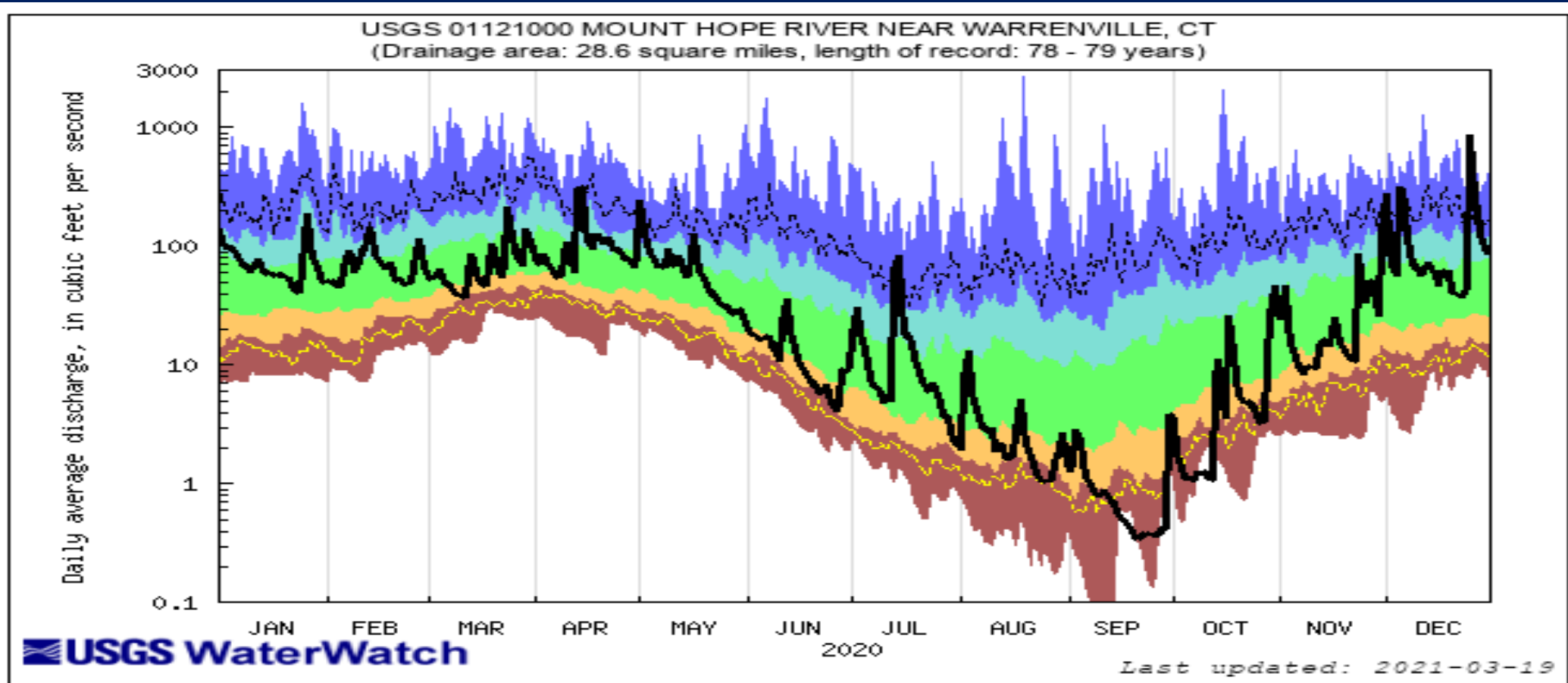
Taunton River at Bridgewater Massachusetts





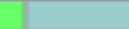




| Explanation - Percentile classes | | | | | | | Flow |
|---|---|--|---|---|---|---|------|
|  |  |  |  |  |  |  | |
| lowest-10th percentile | 5 | 10-24 | 25-75 | 76-90 | 95 | 90th percentile - highest | |
| Much below Normal | | Below normal | Normal | Above normal | Much above normal | | |

2020 Southern New England Drought - Streamflow

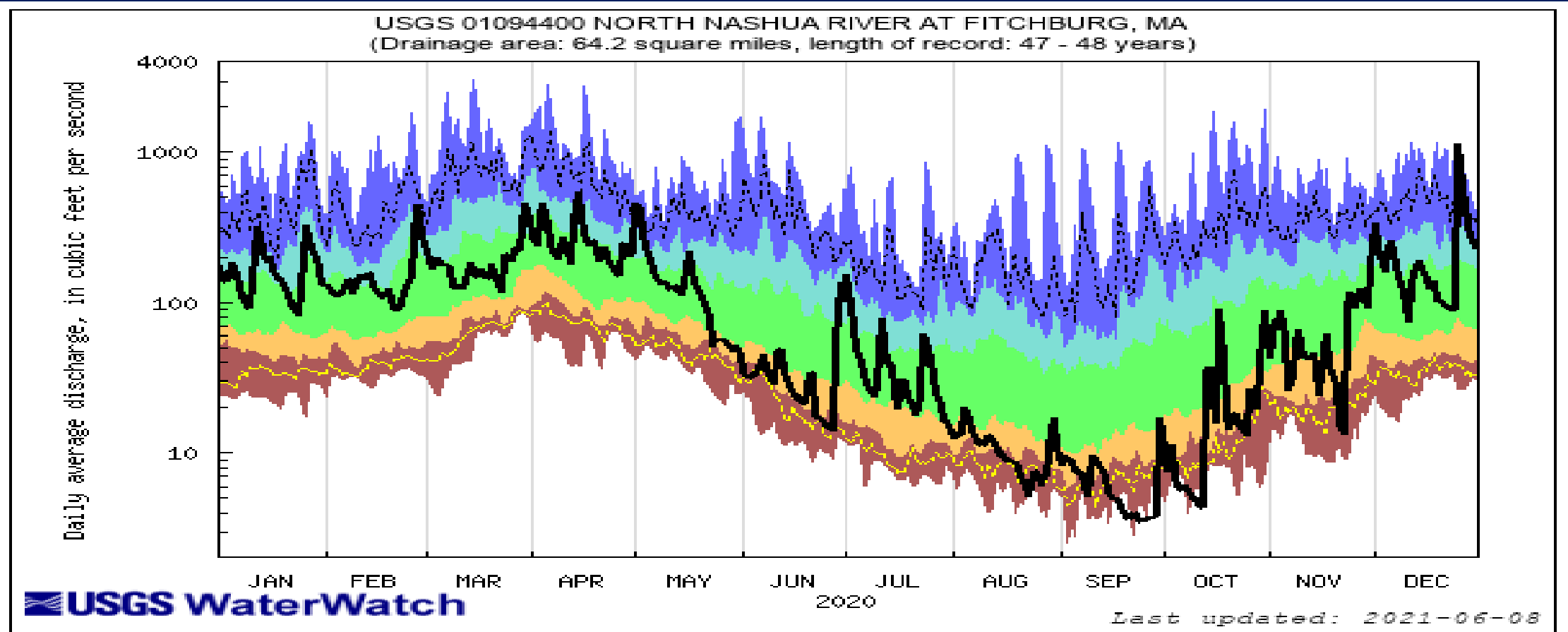
Mount Hope River near Warrenville Connecticut










| Explanation - Percentile classes | | | | | | | Flow |
|---|--|---|---|---|---|---|------|
|  |  |  |  |  |  |  | |
| lowest-10th percentile | 5 | 10-24 | 25-75 | 76-90 | 95 | 90th percentile -highest | |
| Much below Normal | | Below normal | Normal | Above normal | Much above normal | | |

2020 Southern New England Drought - Streamflow

North Nashua River at Fitchburg Massachusetts



| Explanation - Percentile classes | | | | | | | Flow |
|---|--|---|---|---|---|---|------|
|  |  |  |  |  |  |  | |
| lowest-10th percentile | 5 | 10-24 | 25-75 | 76-90 | 95 | 90th percentile -highest | |
| Much below Normal | | Below normal | Normal | Above normal | Much above normal | | |

2020 Southern New England Drought - Streamflow

Mill River at Cheshire Connecticut - USGS



Segreganset River near Dighton Massachusetts - USGS



01109070— Segreganset River near Dighton, MA - 9/17/2020

2020 Southern New England Drought – Streamflow

3rd Herring Brook Scituate Massachusetts



Image courtesy of Boston Globe

A river gauge in the Third Herring Brook showed the lower water level. JOHN TLUMACKI/GLOBE STAFF

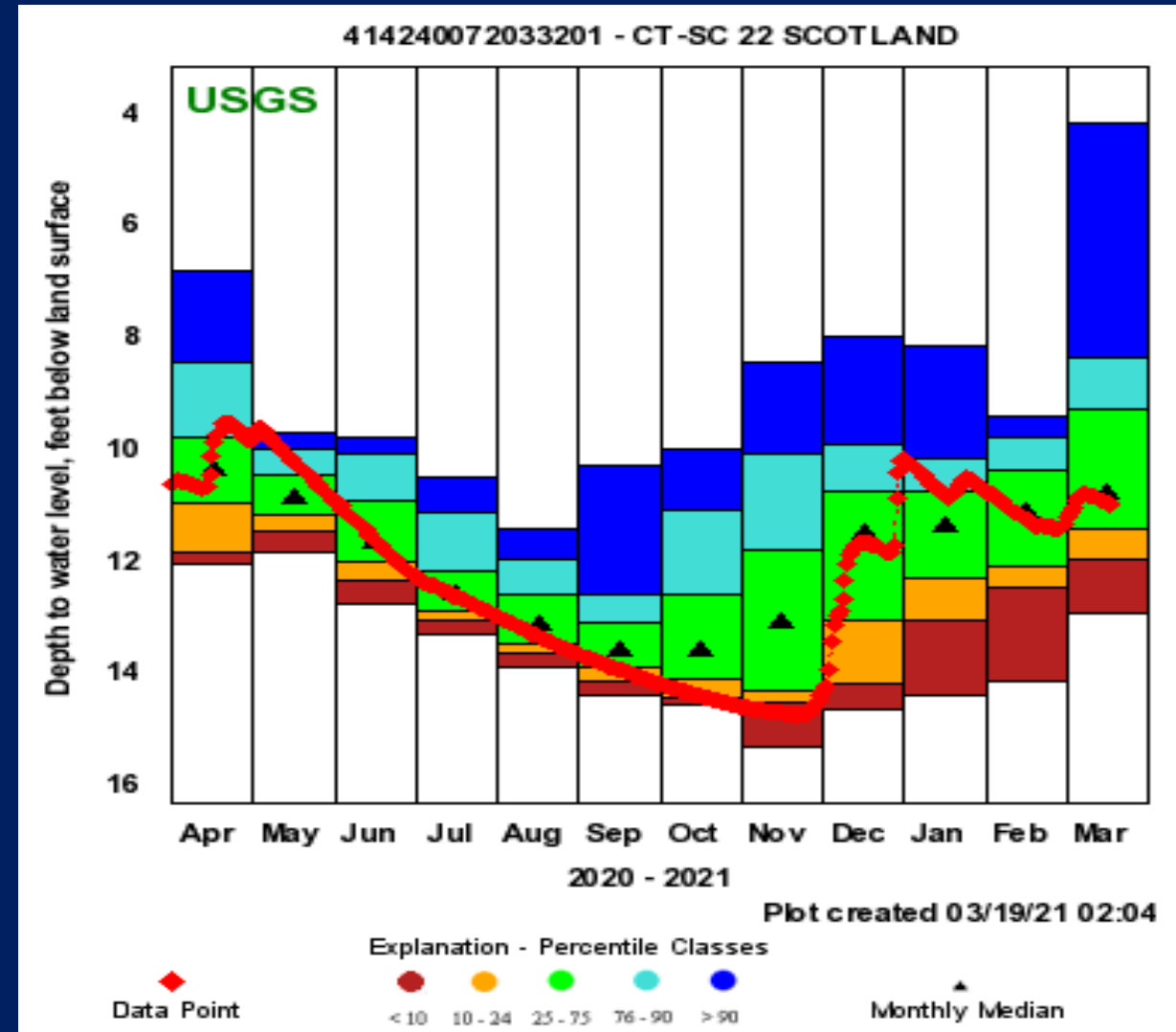
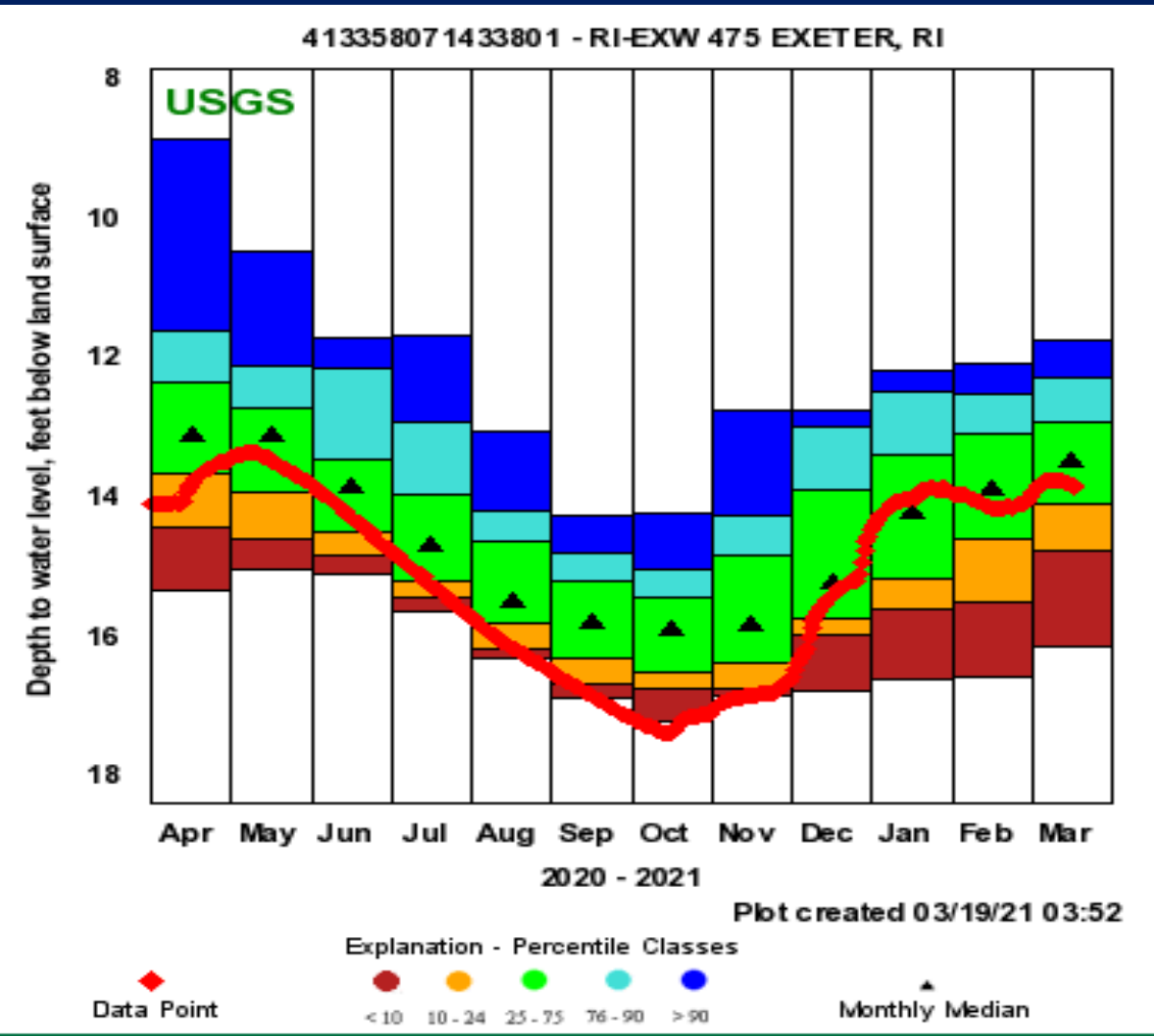
3rd Herring Brook Scituate Massachusetts



Image courtesy of Boston Globe

2020 Southern New England Drought - Groundwater

- Historically low groundwater levels were observed across southern New England by September and October 2020



2020 Southern New England Drought – Water Supply

- Large scale reservoirs remained fine during the relatively short term drought however communities relying on smaller scale wells and reservoirs had issues.
 - Mandatory water restrictions were widespread across southern New England...partly due to population density.

2020 Southern New England Drought – Water Supply

Quabbin Reservoir - Massachusetts

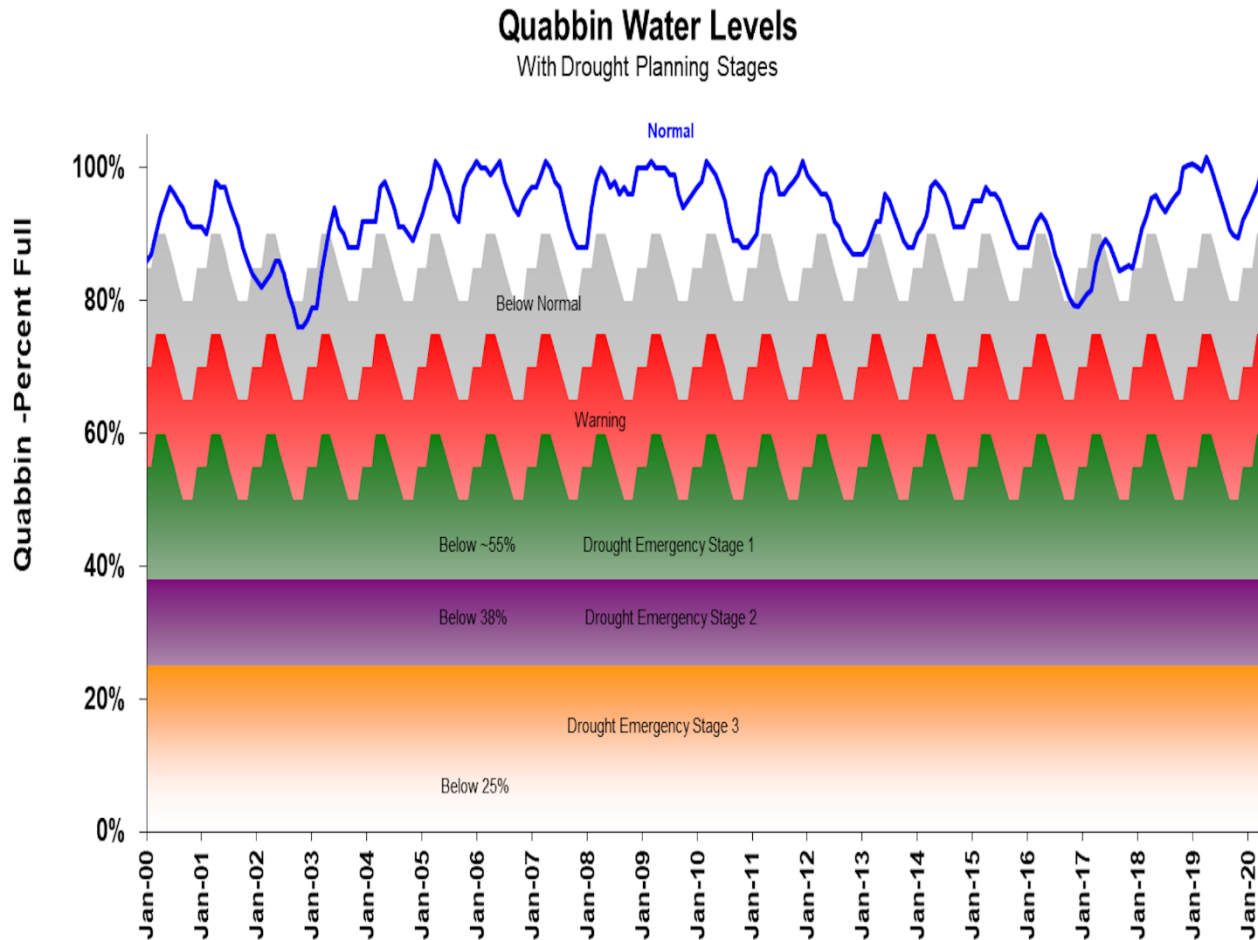


Image Courtesy of Massachusetts Water Resources Authority

Scituate Massachusetts Water Supply Reservoir



Image courtesy of Boston Globe

The town of Scituate's public water supply reservoir is very low. JOHN I LUMACKI/GLOBE STAFF

2020 Southern New England Drought - Agriculture

- Farms without irrigation suffered in southern New England due to the hot...dry weather.
 - Clarks Christmas Tree Farm in Tiverton Rhode Island suffered too much damage to open in 2020 (USNews.com 3 Nov 2020)
- Most of southern New England was also declared a Drought Disaster Area by the U.S. Dept. of Agriculture



Image Courtesy of Boston Globe

wing. JOHN TLUMACKI/GLOBE

Flash Drought

- Drought.gov defines Flash Drought as simply “the rapid onset or intensification of drought. It is set in motion by **lower than normal rates of precipitation...accompanied by abnormally high temperatures...winds and radiation**. Together...these changes in weather can rapidly alter the local climate.
 - Higher temperatures increase evapotranspiration which further lowers soil moisture which decrease rapidly as drought conditions continue. In effect...a vicious feedback cycle can develop.
 - Chen et al, 2020 found that all Flash Droughts studied were preceded by sudden increases in evapotranspiration rates caused by heat...wind and radiation.
 - Significant negative impacts to the agricultural sector have been better documented than impacts to other sectors of the environment.
- *** More research is needed to better define Flash Drought ***

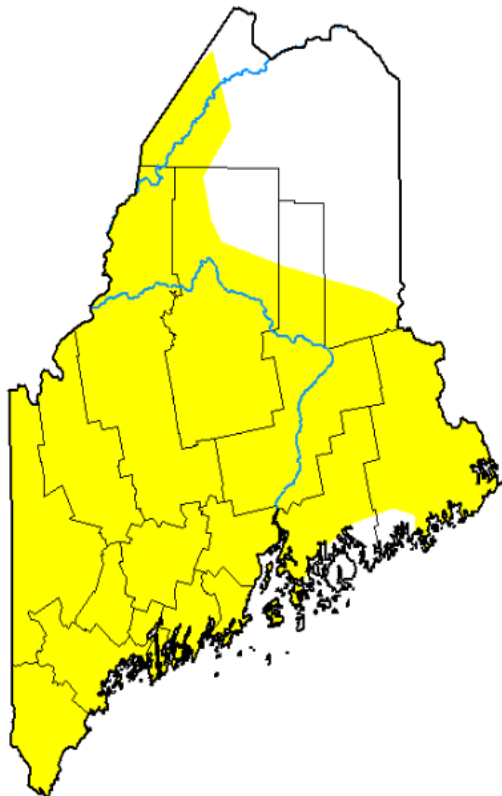
Flash Drought – cont

- So...was there Flash Drought in New England in 2020???
 - Lower than normal rates of precipitation
 - Abnormally high temperatures
 - Significant negative impacts to agriculture
- We will use Chen et al (2019) which defines flash drought as...
 - “ a drought event with greater than or equal to two categories degradation in a four-week period based on USDM “

Flash Drought - Maine

Remember June in Caribou Maine had record low precipitation for the month and tied an all-time record high temperature of 96F.

U.S. Drought Monitor Maine



June 16, 2020

(Released Thursday, Jun. 18, 2020)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|---|--------|-------|-------|-------|-------|------|
| Current | 22.32 | 77.68 | 0.00 | 0.00 | 0.00 | 0.00 |
| Last Week 06-09-2020 | 45.38 | 54.62 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 Months Ago 03-17-2020 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Calendar Year 12-31-2019 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Water Year 10-01-2019 | 87.45 | 12.55 | 0.00 | 0.00 | 0.00 | 0.00 |
| One Year Ago 06-18-2019 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Intensity:

| | |
|---------------------|------------------------|
| None | D2 Severe Drought |
| D0 Abnormally Dry | D3 Extreme Drought |
| D1 Moderate Drought | D4 Exceptional Drought |

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

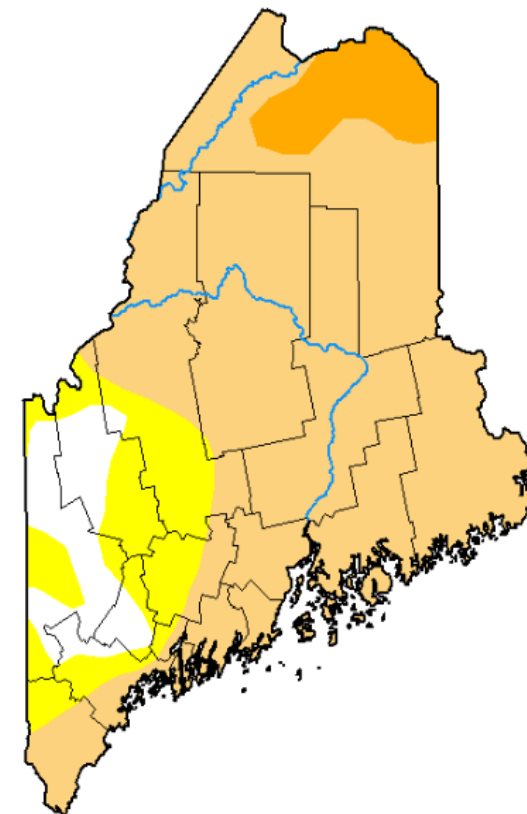
Author:

Richard Tinker
CPC/NOAA/NWS/NCEP



droughtmonitor.unl.edu

U.S. Drought Monitor Maine



July 14, 2020

(Released Thursday, Jul. 16, 2020)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|---|--------|-------|-------|-------|-------|------|
| Current | 8.43 | 91.57 | 77.76 | 6.33 | 0.00 | 0.00 |
| Last Week 07-07-2020 | 6.60 | 93.40 | 80.44 | 8.40 | 0.00 | 0.00 |
| 3 Months Ago 04-14-2020 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Calendar Year 12-31-2019 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Water Year 10-01-2019 | 87.45 | 12.55 | 0.00 | 0.00 | 0.00 | 0.00 |
| One Year Ago 07-16-2019 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Intensity:

| | |
|---------------------|------------------------|
| None | D2 Severe Drought |
| D0 Abnormally Dry | D3 Extreme Drought |
| D1 Moderate Drought | D4 Exceptional Drought |

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Author:

David Miskus
NOAA/NWS/NCEP/CPC



droughtmonitor.unl.edu

Flash Drought – Southern New England

Areas of southeast Massachusetts...Rhode Island and Connecticut see rapid deterioration due to dryness and very hot conditions.

U.S. Drought Monitor Boston/Norton, MA WFO

July 21, 2020

(Released Thursday, Jul. 23, 2020)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|--------------------------------------|--------|-------|-------|-------|-------|------|
| Current | 14.70 | 85.30 | 32.69 | 0.00 | 0.00 | 0.00 |
| Last Week 07-14-2020 | 14.70 | 85.30 | 32.69 | 0.00 | 0.00 | 0.00 |
| 3 Months Ago 04-21-2020 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Calendar Year 12-31-2019 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Water Year 10-01-2019 | 49.77 | 50.23 | 0.00 | 0.00 | 0.00 | 0.00 |
| One Year Ago 07-23-2019 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Intensity:

| | |
|---------------------|------------------------|
| None | D2 Severe Drought |
| D0 Abnormally Dry | D3 Extreme Drought |
| D1 Moderate Drought | D4 Exceptional Drought |

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

Author:

Richard Heim
NCEI/NOAA



droughtmonitor.unl.edu

U.S. Drought Monitor Boston/Norton, MA WFO

August 18, 2020

(Released Thursday, Aug. 20, 2020)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|--------------------------------------|--------|--------|-------|-------|-------|------|
| Current | 0.00 | 100.00 | 91.66 | 33.82 | 0.00 | 0.00 |
| Last Week 08-11-2020 | 0.00 | 100.00 | 72.16 | 0.00 | 0.00 | 0.00 |
| 3 Months Ago 05-19-2020 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Calendar Year 12-31-2019 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Start of Water Year 10-01-2019 | 49.77 | 50.23 | 0.00 | 0.00 | 0.00 | 0.00 |
| One Year Ago 08-20-2019 | 99.09 | 0.91 | 0.00 | 0.00 | 0.00 | 0.00 |

Intensity:

| | |
|---------------------|------------------------|
| None | D2 Severe Drought |
| D0 Abnormally Dry | D3 Extreme Drought |
| D1 Moderate Drought | D4 Exceptional Drought |

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

Author:

David Simeral
Western Regional Climate Center



droughtmonitor.unl.edu

Flash Drought – cont

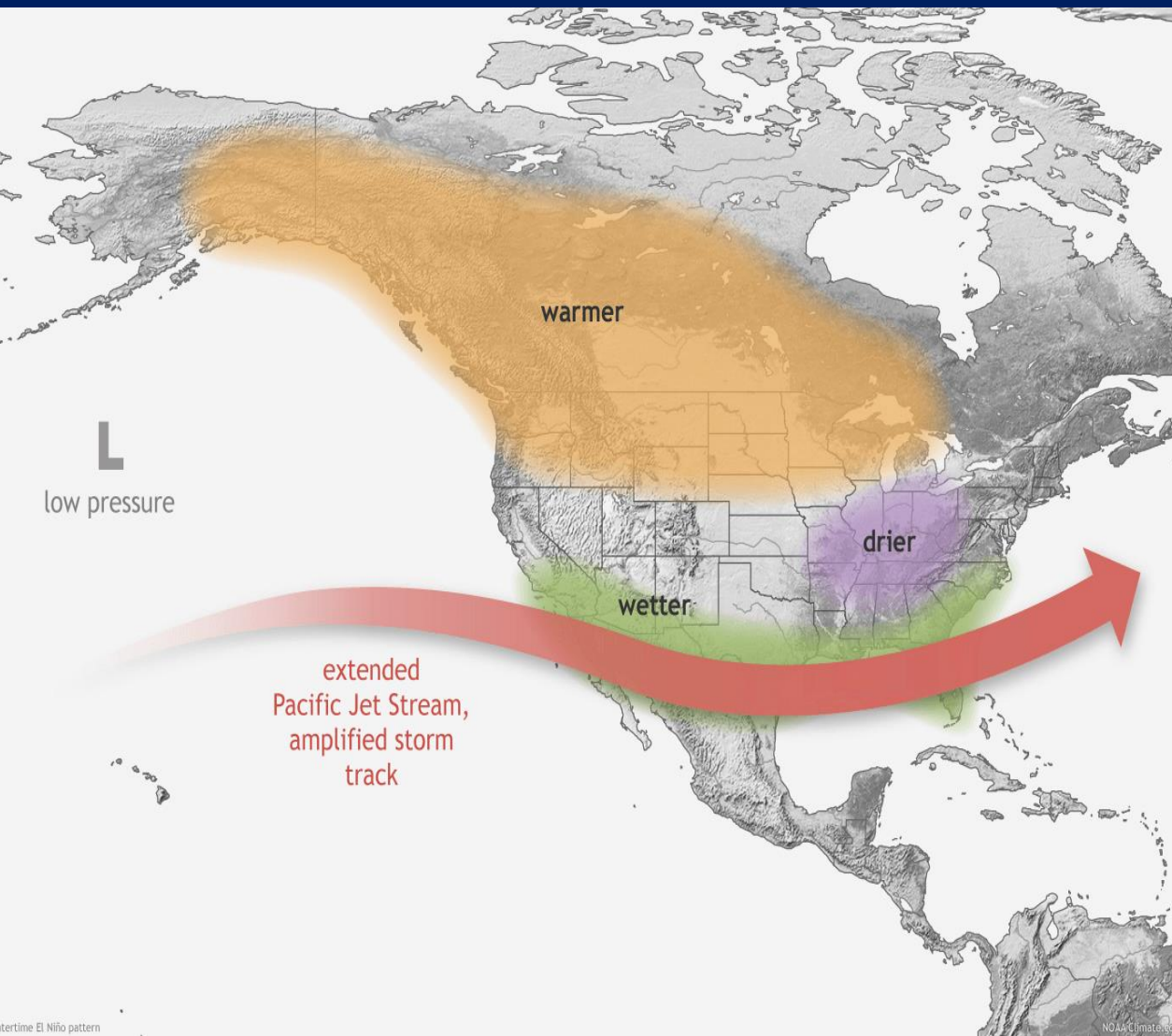
- Flash drought is still an evolving science. Other authors (Pendergrass et al, 2020) propose defining Flash Drought as a...
 - “two-category change in the U.S. Drought Monitor (USDM) in 2 weeks, sustained for at least another 2 weeks”
- Flash drought is less common in the Eastern U.S. than western U.S. due to more humid antecedent conditions.

Challenges Predicting Drought in New England

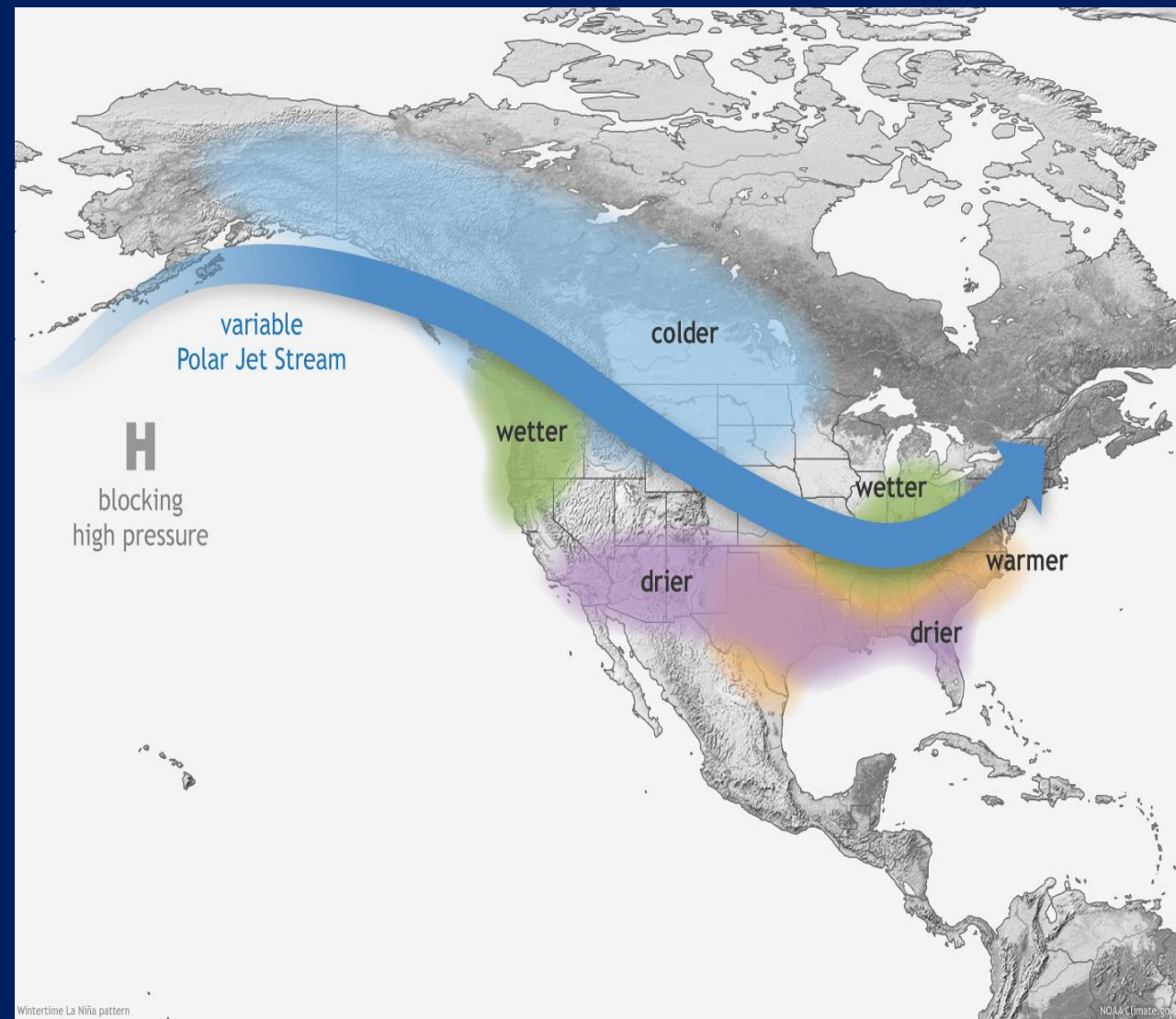
- New England is a unique region in that it is subject to receive precipitation from a wide variety of sources.
 - Storms moving southeast from Canada
 - Storms riding east from the Rockies
 - Storms moving northeast from the Gulf of Mexico
 - Storms/Tropical systems moving north from the Atlantic
- Dependable Climate Indices (El Nino...La Nina) are not very effective for predicting temperature and precipitation in New England.

Drought Prediction in New England - cont

El Nino Pattern



La Nina Pattern



Drought Prediction in New England - cont

- The orientation/position of the Bermuda High in summer can actually have more influence on the rainfall/temperature pattern in New England than other climate indices

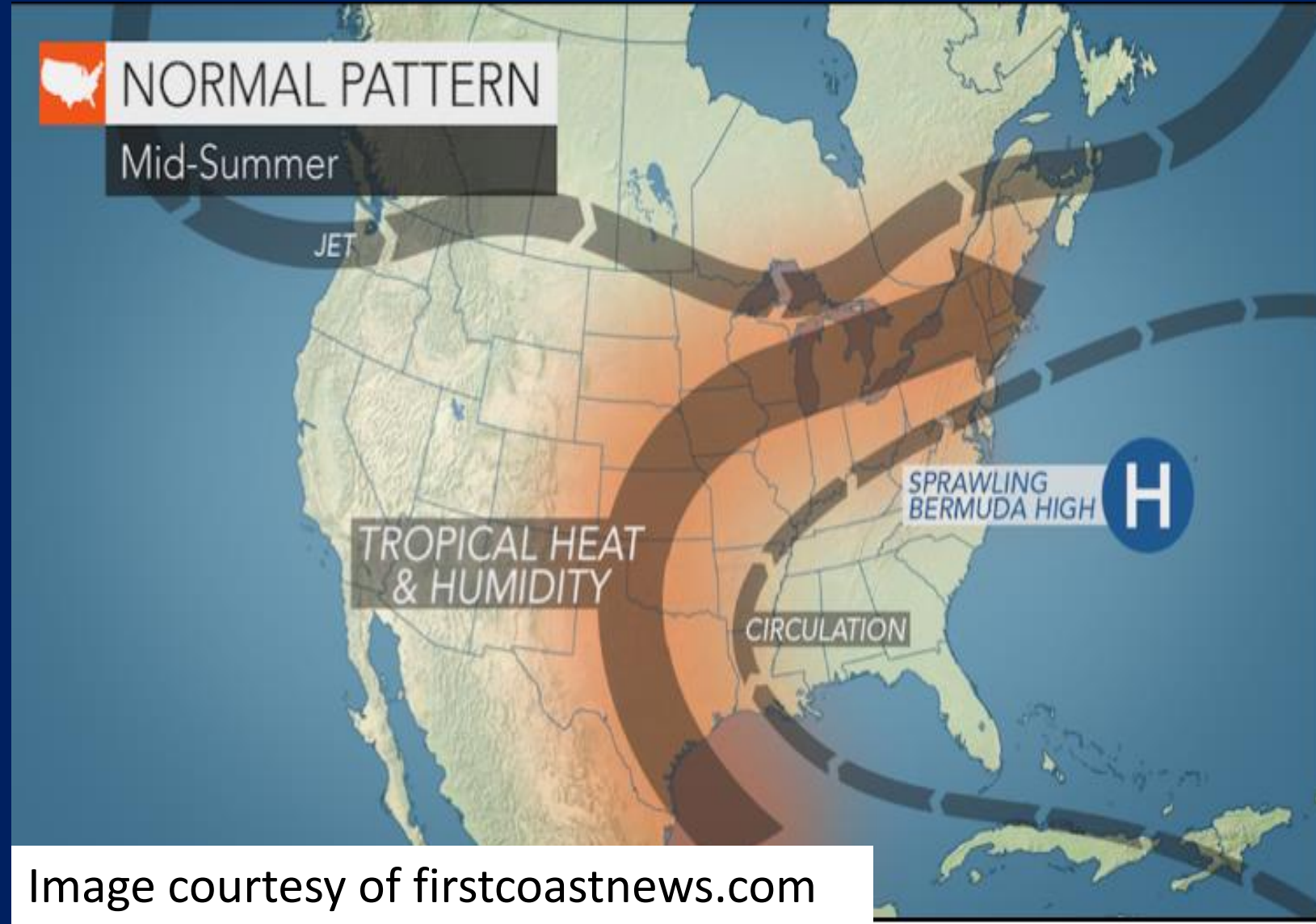
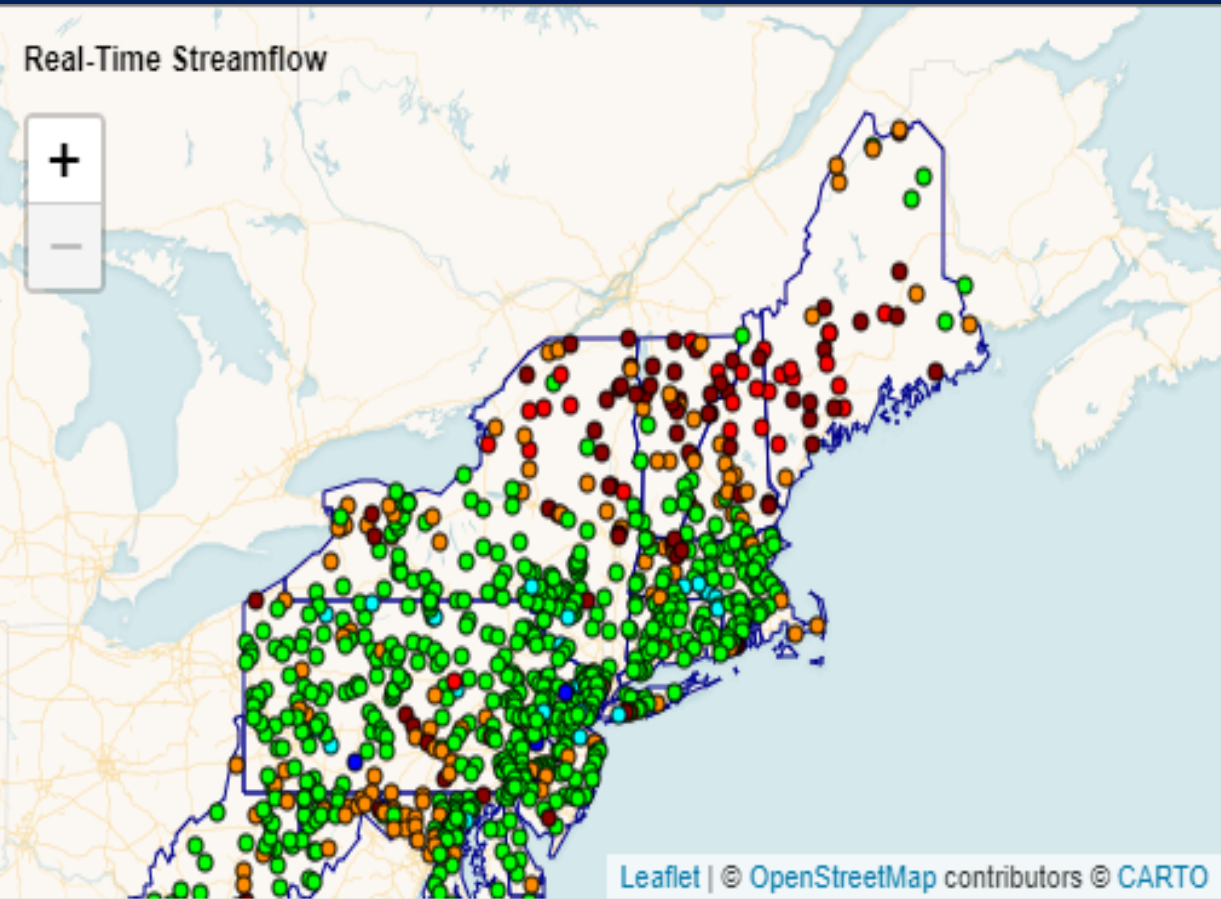


Image courtesy of firstcoastnews.com

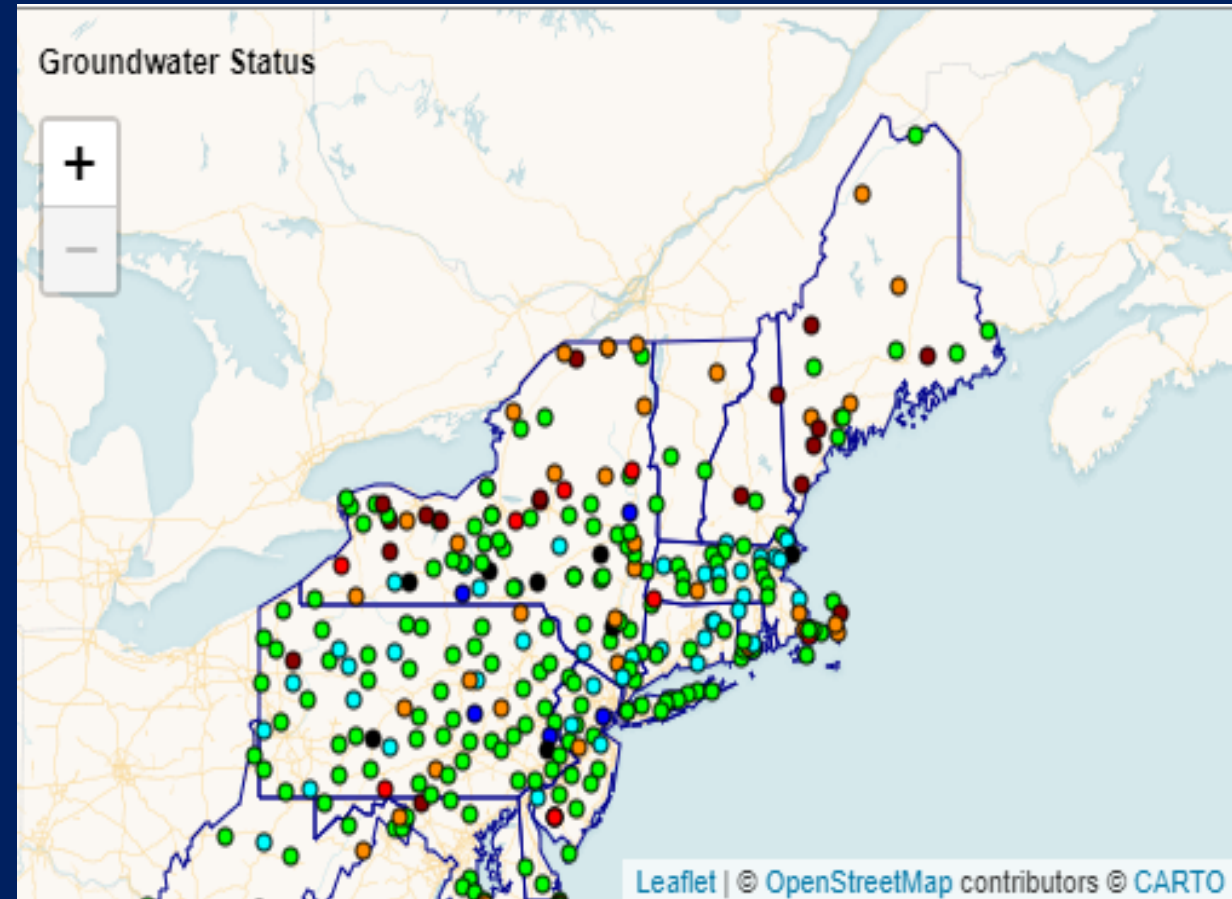
2021 Drought Outlook

Current river flows a bit low in northwest Massachusetts and Cape Cod. Groundwater low on Cape Cod. Massachusetts faring much better than northern New England.



| Explanation - Percentile Classes | | | | | | |
|----------------------------------|-------------------|--------------|--------|--------------|-------------------|------|
| | | | | | | |
| Low | Much below normal | Below normal | Normal | Above normal | Much above normal | High |
| | <10% | 10-24% | 25-75% | 76-90% | >90% | |

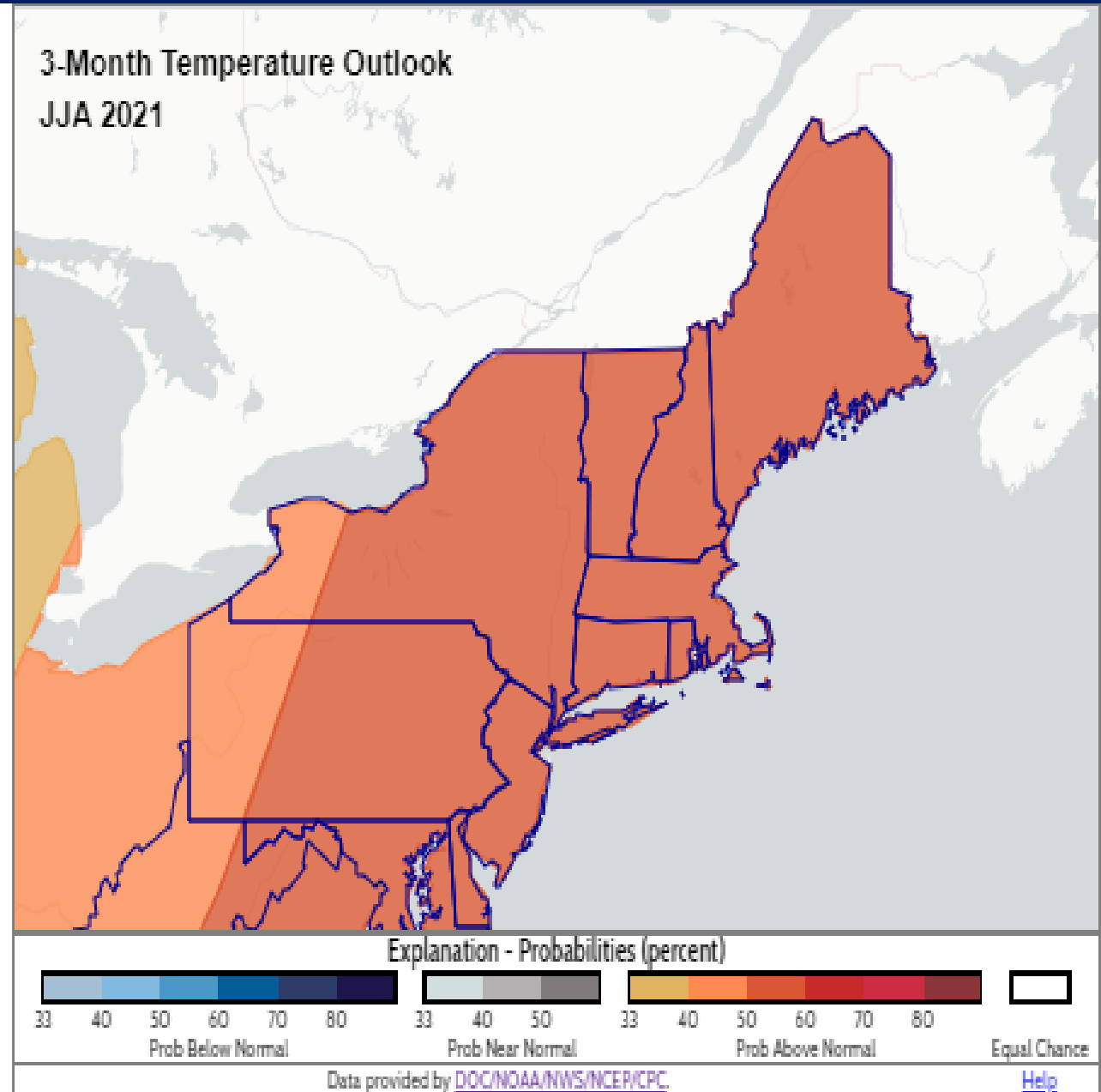
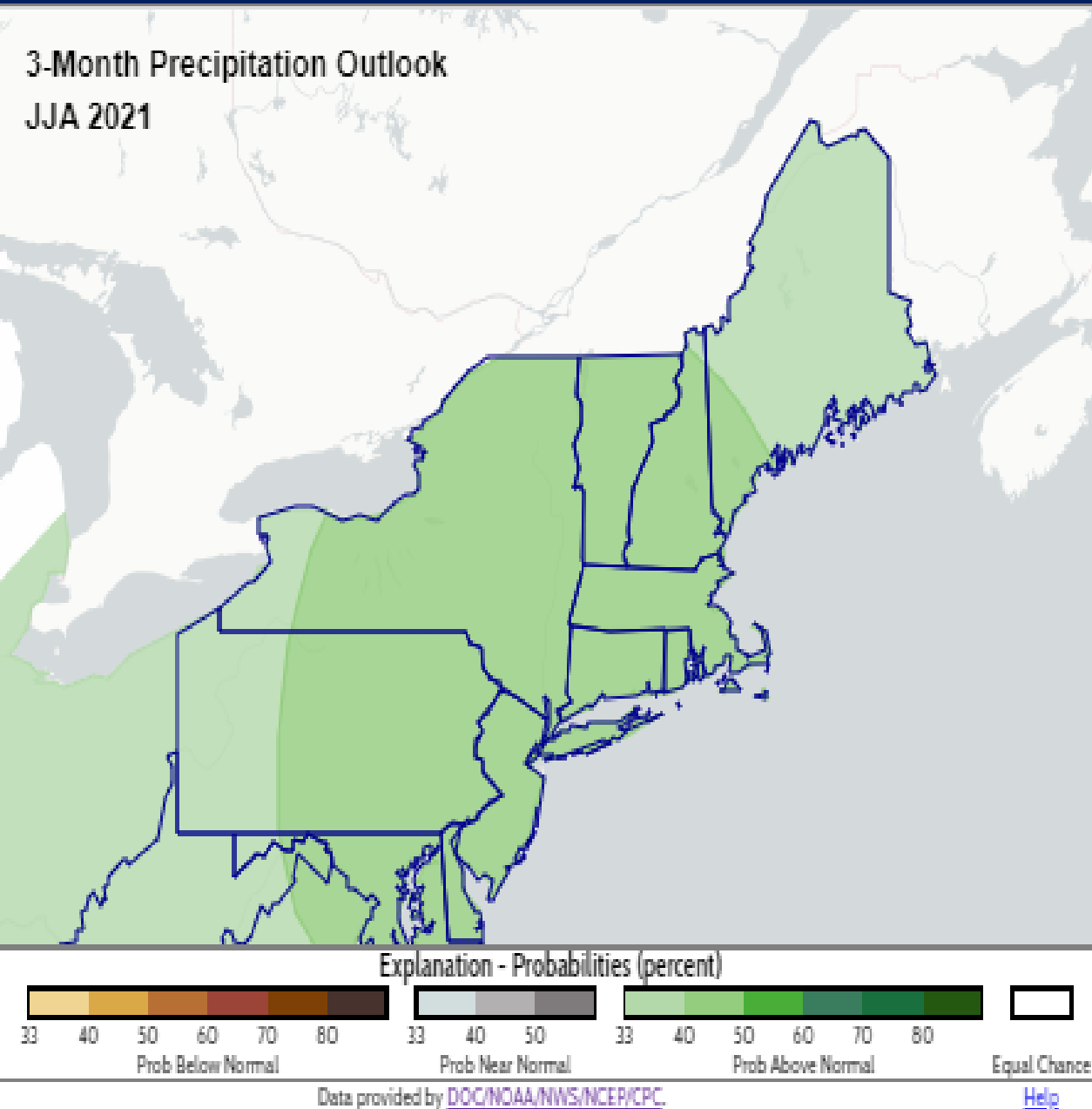
Data provided by [USGS WaterWatch - Streamflow](#); updated 2021-06-08.



| Explanation - Percentile Classes | | | | | | |
|----------------------------------|-------------------|--------------|--------|--------------|-------------------|------|
| | | | | | | |
| Low | Much below normal | Below normal | Normal | Above normal | Much above normal | High |
| | <10% | 10-24% | 25-75% | 76-90% | >90% | |

Data provided by [USGS Groundwater Watch - AGLN](#); updated 2021-06-08.

2021 Drought Outlook - cont

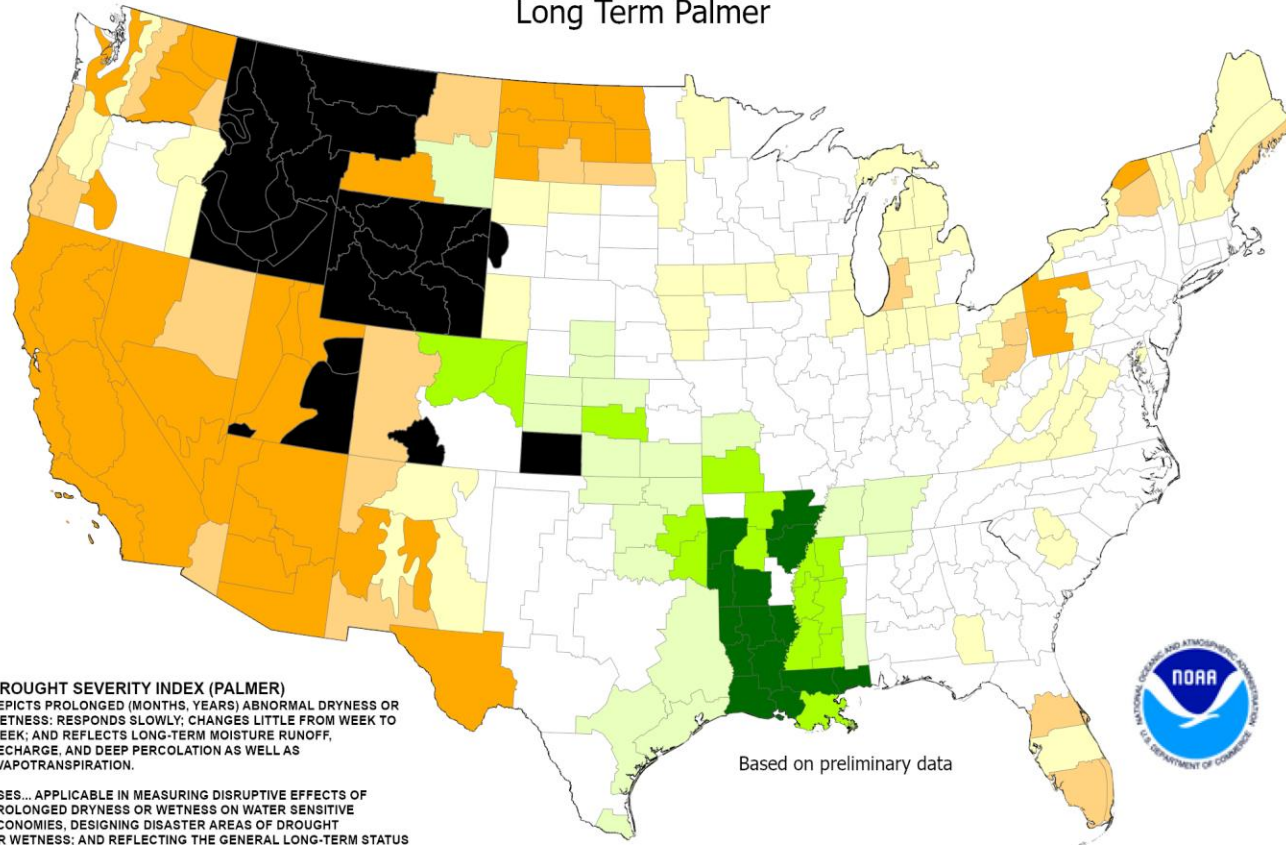


2021 Drought Outlook - cont

Palmer Drought Severity Normal

Latest USDM

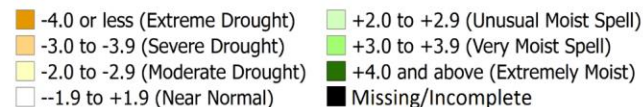
Drought Severity Index by Division
Weekly Value for Period Ending Jun 05, 2021
Long Term Palmer



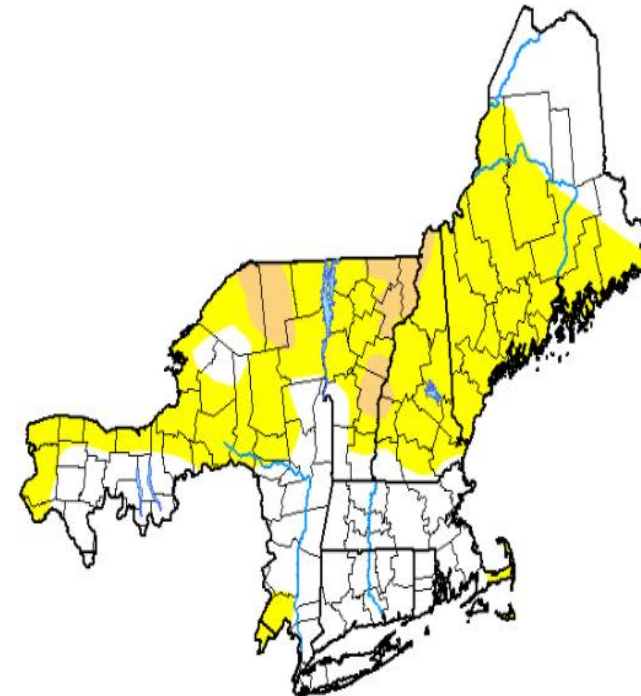
DROUGHT SEVERITY INDEX (PALMER)
DEPICTS PROLONGED (MONTHS, YEARS) ABNORMAL DRYNESS OR WETNESS; RESPONDS SLOWLY; CHANGES LITTLE FROM WEEK TO WEEK; AND REFLECTS LONG-TERM MOISTURE RUNOFF, RECHARGE, AND DEEP PERCOLATION AS WELL AS EVAPOTRANSPIRATION.

USES... APPLICABLE IN MEASURING DISRUPTIVE EFFECTS OF PROLONGED DRYNESS OR WETNESS ON WATER SENSITIVE ECONOMIES, DESIGNING DISASTER AREAS OF DROUGHT OR WETNESS; AND REFLECTING THE GENERAL LONG-TERM STATUS OF WATER SUPPLIES IN AQUIFERS, RESERVOIRS AND STREAMS.

LIMITATIONS... IS NOT GENERALLY INDICATIVE OF SHORT-TERM (FEW WEEKS) STATUS OF DROUGHT OR WETNESS SUCH AS FREQUENTLY AFFECTS CROPS AND FIELD OPERATIONS (THIS IS INDICATED BY THE CROP MOISTURE INDEX).



U.S. Drought Monitor Northeast RFC



June 1, 2021

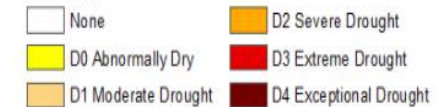
(Released Thursday, Jun. 3, 2021)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|---|-------|-------|-------|-------|-------|------|
| Current | 43.99 | 56.01 | 5.57 | 0.00 | 0.00 | 0.00 |
| Last Week 05-25-2021 | 44.63 | 55.37 | 5.57 | 0.00 | 0.00 | 0.00 |
| 3 Months Ago 03-02-2021 | 66.86 | 33.14 | 7.67 | 0.00 | 0.00 | 0.00 |
| Start of Calendar Year 12-29-2020 | 67.52 | 32.48 | 7.15 | 0.00 | 0.00 | 0.00 |
| Start of Water Year 09-29-2020 | 5.17 | 94.83 | 72.42 | 47.96 | 7.66 | 0.00 |
| One Year Ago 06-02-2020 | 82.77 | 17.23 | 0.00 | 0.00 | 0.00 | 0.00 |

Intensity:



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Author:

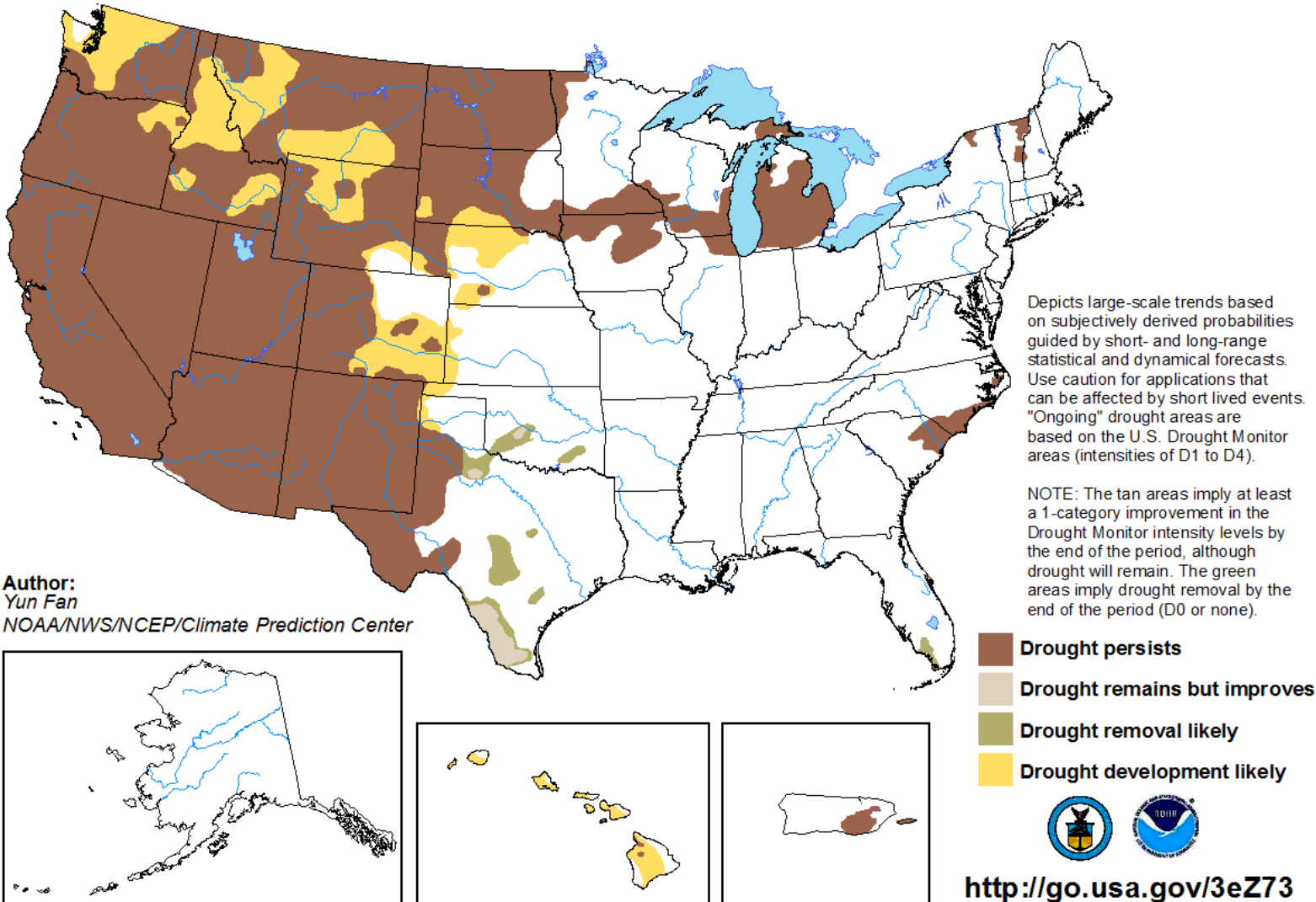
Brian Fuchs
National Drought Mitigation Center



2021 Drought Outlook - cont

U.S. Seasonal Drought Outlook Drought Tendency During the Valid Period

Valid for May 20 - August 31, 2021
Released May 20



- Despite the calls for no drought in northern New England...locally we see drought expanding in northern New England.
- Still watching Cape Cod for local drought expansion as well.

THANK YOU

