NORTHEAST DROUGHT EARLY WARNING SYSTEM

2018-2019 Strategic Plan

Document prepared by the National Integrated Drought Information System (NIDIS) in partnership with key stakeholders including the Northeast Regional Climate Center (NRCC) and NOAA's Regional Climate Services Director, Eastern Region.

2018-2019 NORTHEAST DEWS STRATEGIC PLAN

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Introduction to the Northeast Drought Early Warning System

The National Integrated Drought Information System and Drought Early Warning Systems

In 2006, Congress authorized the National Integrated Drought Information System (NIDIS) with a mandate for interagency coordination and integrated drought research that builds upon existing federal, tribal, state, and local partnerships to create a national drought early warning system (DEWS). NIDIS is working toward this goal by developing a network of regional DEWS (see map, below). These regional DEWS utilize existing networks to make climate and drought science readily available, easily understandable, and usable; and to improve regional capacity to respond to and cope with drought.

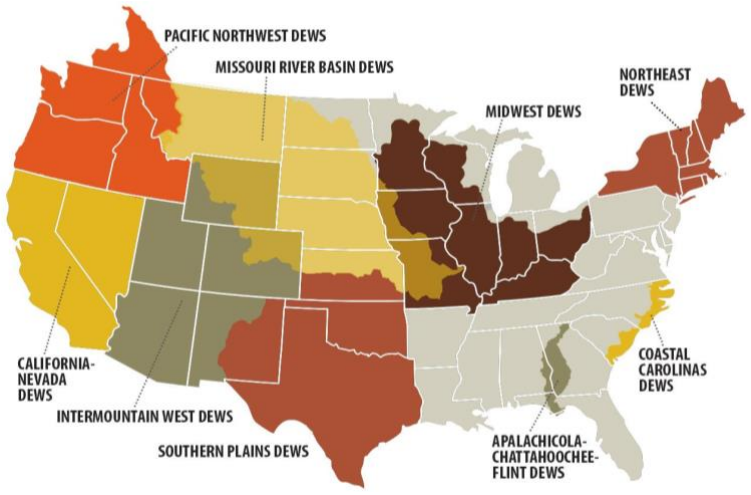

Figure 1 Network of NIDIS Drought Early Warning Systems (DEWS)
Note: While the colored shading denotes the DEWS regions, where the majority of DEWS actions focus, activities may extend beyond the shaded area when needed. The overlapping edges in so some regions reflect the permeability of the DEWS boundaries.

A regional DEWS is supported by stakeholders, comprised of relevant partners and community members across the region, including universities, the private sector, and federal, tribal, state, and local entities. Stakeholders participate in the NIDIS consultation process, and they support NIDIS priorities by leveraging existing resources, programs, and partnerships. This relationship ensures a robust, "ground-up" regional DEWS that is well-networked and responsive to the specific needs of each region. NOAA and the NIDIS program did not establish the DEWS and do not control or manage the DEWS functions or operations; rather, the DEWS constitute the continuation, and leveraging, of existing partnership networks.

WHAT IS NIDIS?

The National Oceanic and Atmospheric Administration's (NOAA) National Integrated Drought Information System (NIDIS) was authorized by Congress in 2006 (Public Law 109-430) with an interagency mandate to develop and provide a national drought early warning information system, by coordinating and integrating drought research, and building upon existing federal, tribal, state, and local partnerships.

WHAT IS A DEWS?

A Drought Early Warning System (DEWS) utilizes new and existing networks of federal, tribal, state, local and academic partners to make climate and drought science accessible and useful for decision makers; and to improve the capacity of stakeholders to monitor, forecast, plan for, and cope with the impacts of drought.

The Northeast DEWS

The Northeast DEWS consists of the areas including New England and the state of New York. Known best for the autumn foliage, thick forests, rocky soils, and abundant freshwater resources, the northeastern United States is characterized by a diverse climate that is not often associated with drought. However, in 2016, New York and New England experienced historic drought conditions not seen since the 1960s. In the hardest-hit areas of western and central New York, Massachusetts, Connecticut, Rhode Island, and southern New Hampshire, drought conditions intensified during the summer of 2016, with extreme drought (D3) introduced for the first time since U.S. Drought Monitor (USDM) data began in 2000. The Northeast also frequently experiences "flash" droughts - short-term intense dry periods that can follow a period of normal to above-normal precipitation. These flash droughts have profound impacts on a local region and can last only 2-4 months; but they result in shortages in public water supplies and very low streamflows.

NIDIS, in partnership with NOAA's Regional Climate Services Director for the Eastern Region, the Northeast Regional Climate Center (NRCC), U.S. Representative Seth Moulton's (MA-6) office, and the American Association of State Climatologists (AASC), hosted a Northeast Drought and Climate Outlook Forum in Boston, Massachusetts on October 11, 2016. The forum brought together nearly 100 stakeholders from around the region and across federal, state, local, private, and nonprofit sectors to discuss drought conditions in New England and New York, the impacts of drought, existing response and preparedness resources, and climate outlooks for the coming seasons.

As the drought continued and expanded into Connecticut and Rhode Island, NOAA, NIDIS, and the NRCC hosted two more meetings in New York (February 2017) and Massachusetts (March 1, 2017). The purpose of these follow-up meetings was to assess the 2016 drought, understand the additional resources that would have strengthened drought resilience, and identify what drought indicators and early warning capacity could be integrated into a Northeast DEWS. More than 100 community leaders, representing sectors from water resource management and agriculture to local government and community watershed groups, shared insights on information gaps they experienced.

What we heard from these stakeholder-driven events was clear: building drought early warning capacity in the Northeast region is vital to proactively managing drought risk and building resilience to future drought and extreme weather events in the region. In November 2017, stakeholders from each of the New England states and New York, including representatives from state government, federal agencies, utilities, and community watershed groups, came together to outline a two-year strategic plan for a regional DEWS in the Northeast. Agenda items included: a history of drought and extreme weather in the region; an overview of current conditions and outlooks; state and local drought planning, policies, and activities; strategies for enhancing drought early warning capacity; identification of data and information needs, gaps, and vulnerabilities; and identifying and prioritizing actions towards a regional DEWS.

Purpose of the Northeast DEWS

The Northeast DEWS is a collaborative federal, regional, state, and local interagency effort to improve drought early warning capacity and long-term drought resilience throughout New England and New York. Early warning activities are driven by the needs of local and state stakeholders for data collection and monitoring; research to improve forecasting of droughts; planning for and adapting to extreme weather events; and communication, education, and outreach.

Figure 2 Key components of NIDIS Regional Drought Early Warning Systems

The Northeast DEWS Strategic Plan

Plan Purpose and Development

The Northeast DEWS Strategic Plan (Plan) outlines priority tasks and activities that build upon existing stakeholder networks to improve drought early warning capacity and long-term resilience in New England and New York. This is a "living document" to which additional actions and partners may be added as needs and opportunities arise. The Plan includes a list of current partners (in Appendix A), outcomes, and key milestones for present activities. Also included are areas where NIDIS is seeking additional partners or working to finalize details of some activities.

Dedicated partners across the Northeast region contributed to the development of the Plan, including federal, regional, state, academic, and local entities, and in particular the Northeast Regional Climate Center (NRCC) and NOAA's Regional Climate Services Director, Eastern Region. A strategic planning workshop was held on November 28, 2017 in Hartford, CT, to receive input on priority needs and actions to be addressed through this Plan. Participants included 28 federal, state, and academic partners with a diverse range of interests and expertise. Information obtained from this workshop, as well as the Northeast Post-Drought Assessment meetings held in February/March 2017 (noted above), have all informed this Plan.

Northeast DEWS Priorities and Activities

The Northeast DEWS prioritizes the following objectives as necessary for building drought early warning capacity and long-term resilience to extremes throughout New England and New York:

- **Priority 1 - Enhance Drought Monitoring, Forecasting, and Research**: Expand access to data and information for drought risk management through enhanced monitoring and forecasting, as well as improved tools and indices for tracking, understanding, and anticipating drought-related impacts.
- **Priority 2 - Integrate and Develop Collaborative Networks**: Coordinate across networks to get drought information disseminated to the widest audience. This coordination includes leveraging existing networks as well as identifying new information resources and networks in the region.
- **Priority 3 - Strengthen Decision Making to Improve Drought Planning and Preparedness**: Investigate decision-making processes and corresponding tools needed to plan and prepare for drought across various sectors, user groups, and geographic areas in the Northeast region.
- **Priority 4 - Increase Communication and Application of Drought and Climate Science**: Coordinate communication, outreach, and training across the region to strengthen the understanding and use of drought and climate science.

For each priority, some of the associated activities outlined in this plan have been started, while others may be initiated over the next two years, depending on designated leaders and funding sources. The corresponding schedule summarizes the appropriate timeframe for each activity's implementation (Appendix B). Milestone dates are based on the following calendar year quarters,

designated by seasons: Winter (Jan, Feb, Mar); Spring (Apr, May, Jun); Summer (July, Aug, Sep); and Fall (Oct, Nov, Dec).

Additionally, some of the activities are funded while other activities will require efforts to acquire funding. Funding sources may include NIDIS and DEWS partners. As the Northeast DEWS continues to develop, it will be important to continue to identify and leverage resources and available funding among DEWS partners.

Coordination with NIDIS Working Groups

Six interagency Working Groups are vital to the mission of NIDIS, each focused on a different component of NIDIS activities within and across agencies and throughout the country. These six areas of focus are: (1) education and public awareness, (2) monitoring and observations, (3) predictions and forecasting, (4) interdisciplinary research and applications for risk assessment, (5) planning and preparedness, and (6) the U.S. Drought Portal for improving accessibility to usable drought risk information. More information on these Working Groups is provided in the NIDIS Implementation Plan December 2016.

Coordination, communication, and transferability of information and actions between the NIDIS Working Groups and the DEWS are essential for the overall process of building an integrated drought information system. The NIDIS Program Office maintains a network of regular communication and exchange of information between these entities to ensure meaningful engagement and effective collaboration on priorities and activities. Appendix B illustrates how each of the activities in this Plan correlates with the Working Group(s).

Priority 1 - Enhance Drought Monitoring and Research

The Northeast DEWS works to expand access to data and information for drought risk management through enhanced real-time monitoring and forecasting, as well as improved usability of tools and indices. Associated activities under this priority include developing robust groundwater monitoring networks, planning for improvements in soil moisture monitoring, providing input to the USDM, and strengthening collaboration with mesonets and citizen science networks. Adequate stream flow monitoring is also an ongoing need in parts of the region to be addressed.

Activity 1.1 Enhance Groundwater Monitoring Networks in the Northeast for Monitoring Private Well Impacts

About 2.3 million New Englanders, or nearly 20 percent of the New England population, and as many as 4 million New York State residents, get their water from private wells (EPA, 2017; NYS, 2017). In Maine, 42 percent of the state's population relies on private wells for drinking water, the highest in the country and well above the national average of 14 percent (USGS, 2014). In some states, private wells are often regulated by local health departments and districts, who capture information on private wells requesting replacement wells or well repair when existing private wells have been impacted by drought. Drought conditions can have wide-ranging impacts on groundwater supply, and shallow wells placed along water tables can fail as a result. Because these local water systems lack coordinated monitoring infrastructure, drought impacts are hard to collect or assess, and drought planning to account for private well water supply is challenging.

The U.S. Geological Survey (USGS) is working with the federal Advisory Committee on Water Information's (ACWI) Subcommittee on Ground Water (SOGW) to develop and administer the National Ground-Water Monitoring Network (NGWMN). This network is designed as a cooperative groundwater-data collection, management, and reporting system that will be based on data from selected wells and springs in existing federal, state, tribal, and local groundwater-monitoring networks. The USGS is currently working to populate and classify wells in this network to help define how each well can be used for drought characterization. This effort will be completed at the end of 2018. Additional USGS data on groundwater drought conditions can be found at the USGS Groundwater Watch page, and data for below-normal water levels at wells can be found here.

The Northeast DEWS will work in consultation with Northeastern states and other partners to integrate well data into USGS groundwater current observations and impacts surveys, with the goals of providing timely drought information to those who rely on private wells and reporting those conditions and impacts to the National Drought Mitigation Center (NDMC)'s Drought Impact Reporter as well as to state-level decision makers. Key partners in this effort include: NOAA's Regional Climate Services, USGS, the U.S. Department of Agriculture (USDA)'s Natural Resources Conservation Service (NRCS) and Agricultural Research Service (ARS), U.S. Environmental Protection Agency (EPA), Massachusetts River Alliance, and individual states.

Activity 1.1 Outcomes

- In collaboration with the NGWMN, conduct an inventory of gauged groundwater monitoring wells for state and local decision makers to utilize, and define priority locations that need additional monitoring
- Conduct research to classify the drought responsiveness of particular USGS wells, including an assessment and characterization of key monitoring wells in the Northeast as drought indicator sites (similar to the 2004 USGS report of monitoring wells and streams on Long Island, NY, an area whose 3 million people rely on groundwater as the sole source of water supply)
- Produce report on Drought Vulnerability and Private Wells in the Northeast and post to U.S. Drought Portal
    - Compile existing USGS Water Use Program data and refine to map municipal, ground water-based water supplies , by population served, and determine drought vulnerability
    - Explore data on new well drilling activities (permits issued, citizen science reporting, etc.)
    - Use the Empire State Poll to assess groundwater failures (e.g. dry wells, depth of well, etc.) in drought conditions
    - Survey of wells use in Agriculture (see Activity 3.2)

Activity 1.2 Develop Regional Data Entry Portal for Surface Water and Groundwater Capacity

The State of Connecticut Department of Public Health Drinking Water Section (the Section, CT DPH) is developing an Excel-based surface water and groundwater capacity database. The Section will ask public water systems to submit their data into an online portal. Collecting and monitoring these data will allow the Section to initiate communication with these water utilities prior to an emergency drought situation. Time constraints associated with the data entry of hundreds of disparate datasheets on a weekly basis beg the need for a centralized online portal. A similar database and online portal would be beneficial to other Northeast states as well.

In order to ensure early warning of critical water supply issues in times of drought, an online information portal hosted by NRCC will be developed to capture regional, relevant data on water supply and groundwater capacity for public water systems. Key partners include: NRCC, the State of Connecticut Department of Public Health, and other interested state partners, including the Commonwealth of Massachusetts.

Activity 1.2 Outcomes

- Develop scoping document for website requirements from CT DPH
- Beta version of Web data entry portal is launched and tested with DEWS stakeholders, in collaboration with NRCC
- Host workshop/meeting to discuss beta portal with other states in the Northeast DEWS, in order to engage interested partners
- Modification and initial launch of web portal
- Final interface to display collected data on the NRCC's Northeast Drought Dashboard executed

Activity 1.3 Expand Soil Moisture Monitoring in the Northeast Region

Soil moisture is an important component of the water budget in the Northeast, yet an accurate depiction of this variable has been a serious challenge. Although, nationally, the U.S. has many platforms on which we can measure soil moisture, integrating those systems in a way that improves our knowledge of soil moisture, and its status across multiple spatial and temporal scales and over multiple soil depths, has only added to this challenge. The federal government, state networks, tribes, the private sector, and citizen science networks have valuable contributions to make in helping to meet these challenges.

At the national level, NIDIS and USDA are co-leading an effort to build a National Coordinated Soil Moisture Monitoring strategy, along with USGS, the National Aeronautics and Space Administration (NASA), NOAA, and wide coalition of federal, state, local, tribal agencies, along with universities and private sector companies. Its goal is to establish a national network that integrates a multitude of soil moisture data sources, develops consistent methodology for data collection, and builds a national multi-platform soil moisture gridded product. In 2017, the Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS), with NIDIS support, launched a soil moisture reporting option for citizen scientists, which will ultimately benefit the expansion

Within the Northeast region, the activity to expand soil moisture monitoring entails adding real-time soil moisture and temperature sensors to existing observation networks in the region, and ensuring the use of standard depths - a valuable measurement for fire managers, watershed managers, and agriculture specialists. This data will be useful input for NWS forecasting models and will be valuable under both extreme dry and wet conditions in the region.

As part of this activity, many mesonet stations across the region that currently measure soil moisture and temperature will be connected, at a regional level, in coordination with Cornell University. The Northeast DEWS network will also work to incorporate existing soil moisture data, such as from state mesonets, NRCS/Soil Climate Analysis Network (SCAN) - (including tribal SCAN partnerships in the region, in development), USGS streamflow and groundwater monitoring sites, GOES satellite, and cooperative sites, into a National Coordinated Soil Moisture Monitoring Network or database. The New England Federal Partners (NEFP) has a sub-team led by USGS that will conduct New England-wide inventory and assessment of soil moisture monitoring efforts, and has proposed a regional monitoring network that includes multiple sensors, standard depths, and data storage. Accompanying applied

research may also be conducted to investigate the effect of different soil types on moisture availability, as well as climatologies and time series of the data. Key partners include: USGS, NRCC, and NRCS.

Activity 1.3 Outcomes

- Develop and execute an inventory of soil moisture monitoring activities and needs for New England, and consider expanding effort to New York (Fall 2018)
- Create a strategy for expanding soil moisture monitoring in the Northeast (Summer 2019)
- Identify existing USGS groundwater and surface water stations to be supplemented with soil moisture sensors at sites where data collection and GOES telemetry already exist (Summer 2019)
- Create soil moisture climatologies based on existing data sets
- Display soil moisture measurements infographic in maps from the Mesonet and the Network for Environmental and Weather Applications (NEWA) on the NRCC drought dashboard (see Activity 3.1)
- Link soil moisture measurements with soil metadata (i.e. type) allowing conversion among units (e.g. volumetric vs. tension)
- Explore using the nascent NRCC soil moisture budget model as a means of producing a gridded soil moisture product

Activity 1.4 Enhance the Usability of Mesonet Networks and Remotely-Sensed Data

On-the-ground agricultural and water-resource-focused monitoring is essential to drought early warning, as it provides the basis on which many other drought and water resource monitoring tools are built and calibrated. Mesonet networks in the Northeast are well positioned to track the weather conditions that influence evaporation and water demand, but they currently don't inform the production of the USDM, nor are they captured in other national information networks.

In the Mid-Atlantic and Northeast region, Pennsylvania State University, the University at Albany-SUNY, the University of Massachusetts, Rutgers University, and the University of Delaware all participate in the National Mesonet Program (NMP). Private sector partners Earth Networks, WeatherFlow, Panasonic, and Weather Telematics also provide critical data to the NMP during high impact weather events, including intense summer convection, severe winter storms, and significant coastal and inland flooding events (such as Hurricane Irene in 2011 in Vermont). The northeast corridor is one of the nation's most populated urban areas, and there remain significantly data-sparse areas which hinder forecast accuracy, emergency response, and other initiatives.

WHAT IS A MESONET?

A mesonet is a regional network of observing stations (usually surface stations) designed to diagnose mesoscale weather features and their associated processes. The National Mesonet Program (NMP) brings non-federal meteorological data sources to NOAA for use in operations at Weather Forecast Offices (WFO) and numerical modelling at the National Centers for Environmental Prediction (NCEP).

Activity 1.4a Foster regional coordination of mesonet networks to better coordinate data access and value-added tools.

Northeast DEWS stakeholders have recognized the need for more drought observations and data access. Since much of this data is collected through state mesonets, NRCC, with support from NIDIS, will host a Regional Mesonet workshop in 2019 to identify mechanisms for better coordination of mesonet data and value-added tools, and opportunities to launch a mesonet in New England. Key partners may include: NRCC, SUNY-Albany Mesonet, and NEWA for data in CT and NY, and other Northeastern state mesonets.

Activity 1.4a Outcomes

- Host a workshop to convene mesonet programs across the Northeast to discuss issues and opportunities for collaboration, including the development of regional monitoring tools, pulling data from various mesonets in the region, updated daily (Summer 2019).
- Conduct research to ground-truth remotely sensed information based on mesonet observations (Fall 2019)

Activity 1.4b Improve the application of remote sensing technology to drought monitoring and early warning

Remotely sensed data can provide valuable observations of drought conditions. For instance, polar orbiting satellite datasets and new products coming from the GOES-16 satellite may assist with monitoring of current conditions with respect to soil moisture, vegetation evolution, etc. The Northeast DEWS will assess and review a wide range of existing datasets from remote sensing technologies to determine the best products for drought monitoring, and make recommendations for further improvement for use in early warning drought monitoring, prioritizing operational systems and research results that show promise for application. The Northeast DEWS will also support the development of capacity to centrally process datasets (and/or value added products) and provide in a user-ready format on the U.S. Drought Portal for stakeholder use on a regular basis (e.g., weekly or monthly). Partners may include: NRCC, NESDIS/NCEI and STAR, NDMC, and NASA/DEVELOP.

Activity 1.4b Outcomes

- Develop a regional prototype blended product(s) that will overlay satellite observations with ground-truth observations in the field
- Conduct validation research into how satellites perform in the region and recommended steps for improvement

Activity 1.5 Strengthen Existing Citizen Science Networks

Citizen scientists help collect drought and climate impact information while simultaneously increasing awareness of community-level drought impacts that are foundational to any drought early warning system. A variety of national citizen science monitoring and data collection programs are useful in collecting drought impact information, including:

- Drought Impact Reporter - collects and reports drought impacts throughout the nation, produced by the NDMC in collaboration with the USDA and NOAA

- Cooperative Observer Network (COOP) - through the National Weather Service, more than 10,000 volunteers take daily weather observations at National Parks, seashores, mountaintops, and farms as well as in urban and suburban areas. COOP data consists of daily maximum and minimum temperatures, snowfall, and 24-hour precipitation totals, and may include additional hydrological or meteorological data such as evaporation or soil temperature
- CoCoRaHS - collects and reports precipitation and climate monitoring reports sponsored by NOAA, NWS, Bureau of Land Management (BLM) and other state and local agencies.
- Global Learning and Observations to Benefit the Environment (GLOBE) Program - an international science and education program that provides students and the public worldwide with the opportunity to participate in data collection sponsored by NASA with support from NSF and NOAA.
- Crowd-sourced observations
- State-by-state drought impact reporters in the Northeast region

The following activities will leverage and expand upon existing citizen science networks.

Activity 1.5a Improve the Network of CoCoRaHS Observers in the Northeast

In coordination with the NWS Weather Forecast Offices (WFOs) in the Northeast, NIDIS, NRCC, and other DEWS partners will support the CoCoRaHS coordinators in the six New England states and New York by co-producing informational handouts and presentation materials that illustrates the value of CoCoRaHS data, especially in sparsely-populated areas.

Activity 1.5a Outcomes

- Analyze the density and gaps within existing CoCoRaHS observation networks, in partnership with state CoCoRaHS leads and NWS/WFO/COOP program leads
- Conduct recruitment effort to engage additional observers in data sparse regions
- Identify new funding sources for rain gauges in key underserved regions

Activity 1.5b Improve Collection and Reporting of Drought Impacts to the U.S. Drought Impact Reporter (DIR)

Upon conducting a review of existing processes used to collect drought impacts for submission to the DIR, including challenges in collecting such information, the Northeast DEWS will develop a strategy to increase and streamline impact information exchange processes, including an analysis of current gaps and needs. Impacts to be considered include: freshwater and marine organisms, drinking water supplies, agriculture, forests and wildfires (suppression supplies), tourism, and recreation (ski-industry, 'camp' wells-springs, rafting). Northeast DEWS stakeholders will also submit suggestions for methods and improvements to the impact information collected by the DIR, including better incorporation of the rich groundwater data in the region. Key partners may include: Northeast regional Climate Services, NDMC, NWS, and USDA Cooperative Extension.

Activity 1.5b Outcomes

- NRCC hosted webinar about the DIR and the value of information exchange between regional stakeholders and the NDMC
- Partner with CoCoRaHS to develop a strategy for communicating the regional value of participating in the DIR to CoCoRaHS observers

- Targeted advertisement of DIR when USDM starts to show D0, including NWS website headlines section, emails to Soil & Water Conservation Districts, etc. (Summer 2018 - ongoing)
- Prominently display DIR on the NRCC Dashboard
- Measure baseline and increase of DIR participation by Northeastern state and local governments, citizens, watershed groups, and media

Activity 1.6 Assessing Impacts of Extreme Hydrological Events (Drought and Flood) on Freshwater Species

During the Northeast Climate Adaptation Science Center's (NE CASC) workshop, "Ecological Drought in the Northeast United States" in the Fall of 2016, participants raised concerns about the risks of ecological drought on forests, freshwater systems, coastal ecosystems, working landscapes, and, in particular, the impacts of flooding and drought on coastal marine environments and diadromous fishes. Over the last century, the relatively wet and stable climate in the Northeast has contributed to an increase in the abundance and dominance of drought-tolerant species and has motivated particular forestry and agricultural practices. Consequently, the ecosystems, livelihoods, and species reliant on this water regime are vulnerable to extreme changes in precipitation. The Northeast DEWS will prioritize impact assessments on the role of extreme hydrological events on the health of freshwater species.

Activity 1.6a Northeast CASC Research on Phenological Drivers for River Herring

In partnership with the Massachusetts Division of Marine Fisheries (MA DMF), the Northeast CASC is conducting research on the phenological drivers for river herring, which includes temperature, flow, NAO, seasonal transitions, local habitat characteristics, etc. As part of this study, a regional evaluation of 12 coastal river systems will determine environmental factors influencing the timing and strength of river herring movements. In addition, two or three Massachusetts river systems of high management and conservation concern will be identified to evaluate specific questions regarding environmental drivers at a river scale, including the impact of extreme hydrological events (e.g., flooding, drought, dam removal, etc).

Activity 1.6a Outcomes

- Conduct research on the impact of extreme hydrological events on river herring and other diadromous fishes; publish and share at NRCC Webinar featuring impacts of Ecological Drought on aquatic species migration and population dynamics
- Research informs the development of MA DMF operational monitoring product for river herring, along with educational tools for related adaptation strategies and actions

Activity 1.6b Mapping Climate Change Resistant Vernal Pools in the Northeastern U.S.

Vernal pools are small, seasonal wetlands that provide critically important seasonal habitats for many amphibian species of conservation concern. Natural resource managers and scientists in the Northeast, as well as the Northeast Refugia Research Coalition (https://www.climaterefugia.org/), coordinated by the Northeast CASC, have identified vernal pools as a priority ecosystem to study drought impacts. Researchers will combine information on vernal pool hydrology with data on targeted amphibian species (e.g., wood frogs and spotted

salamanders), and the ranavirus and chytrid diseases that impact amphibians to provide a preliminary assessment of the resistance of particular vernal pools to changes in climate.

Activity 1.6b Outcomes

- Collect hydrology data over the course of a year for 70 vernal pools in the Northeast
- Map the hydrology of vernal pools across the Northeast to inform land management and conservation decision-making related to targeted amphibian species.
- Model key aspects of vernal pool hydrology (inundated areas in spring, spring-to-summer changes in water cover etc.) based on climate and landscape drivers
- Relate vernal pool hydrology to amphibian occupancy and prevalence of disease
- Share research results as part of NE CASC webinar series

Activity 1.6c River flood seasonality in the Northeast United States and Trends in Annual Timing

The New England and Mid-Atlantic regions of the Northeast have experienced climate-associated increases in both the magnitude and frequency of floods. However, a detailed understanding of flood seasonality across these regions, and how flood seasonality may have changed over the instrumental record, have not been established.

This research, conducted by NOAA's National Marine Fisheries Service, on river flood seasonality in the Northeast and trends in annual timing, may have some implications for migratory fish and the ecological impact of extreme weather events on the region's aquatic and riparian organisms. Through the application of this research in partnership with stakeholders across the Northeast DEWS, a better understanding of flood timing during the year will inform operational monitoring products to support freshwater habitats and species.

Activity 1.6c Outcomes

- Share published research at NRCC Monthly Webinar featuring Ecological Drought

Activity 1.7 Develop Forecast Tools to Predict Future Hydrologic Conditions during Periods of Drought or Potential Drought

This activity calls for the development of tools in the Northeast U.S. to forecast future drought potential or conditions. Although future air temperature and precipitation forecasts are made by NOAA, these forecasts are not easily transferable to future hydrologic conditions such as streamflow or ground water levels/availability. At the October 2016 NIDIS Drought and Climate Outlook Forum in Boston, a number of federal and state participants supported the development of new tools to help characterize potential future drought conditions.

Activity 1.7a. Pilot Northeast Region Drought Forecast Science Development

USGS studies regionally and nationally on determining the probability of future streamflow and groundwater levels provide valuable context for this activity. Austin and Nelms (2017) have created a probabilistic approach for estimating future streamflow conditions. Dudley, Hodgkins, and Dickinson (2017) have developed a probabilistic approach for forecasting groundwater levels going below a selected threshold. Both of these studies utilized water monitoring sites through the nation to develop and apply their techniques.

References:

Austin, Samuel H. and David L. Nelms, , 2017, Modeling Summer Month Hydrological Drought Probabilities in the United States Using Antecedent Flow Conditions, Journal of the American Water Resources Association (JAWRA) 1-14.

Dudley, Robert W., Glenn A. Hodgkins, and Jesse E. Dickinson, 2017, Forecasting the Probability of Future Groundwater Levels Declining Below Specified Low Thresholds in the Conterminous U.S., Journal of the American Water Resources Association (JAWRA) 1-13.

Using results for the USGS Northeast region (from Virginia northward to Maine) from these two techniques can serve as the basis for capability assessment of drought forecasting and the further development of drought forecasting techniques and tools. It is hoped that this pilot work will lead to more discussion on how to improve our ability to forecast future hydrologic conditions under a variety of climatic scenarios that could occur. The long-term goal of this pilot activity is to give water managers the best possible forecasts for water and drought risk management options during future droughts or other periods of water stress.

Activity 1.7a Outcomes

- USGS factsheet the two techniques being applied is disseminated to Northeast DEWS stakeholders, showcasing how it can be used for future probabilistic forecasting of hydrologic condition, where the forecasts can be obtained, and strength and weaknesses of the approaches (Fall 2018)
- USGS will provide monthly updates on future stream flow and groundwater level conditions using the referenced techniques on a USGS web site that will be publicly accessible (Winter 2019)
- USGS will meet will state drought committees/task forces in the Northeast Region to discuss the forecasting done, solicit feedback, and identify opportunities to further develop/enhance these techniques.

Activity 1.7b Support the development of the National Water Model

NOAA's Water Initiative and Five Year Plan has a mission "to improve the Nation's water security by providing science-based information and services that address vulnerability to water risks and enabling greater efficiency and effectiveness in the management of water resources." In the plan are 4 specific outcomes:

(1) build strategic partnerships for water information services;
(2) strengthen water decision support tools and networks;
(3) revolutionize water modeling, forecasting, and precipitation prediction;
(4) accelerate water information research and development (R&D); and
(5) enhance and sustain water-related observation

The National Water Model, a major part of this Initiative, can play a key role in the Northeast DEWS. The Model produces an 18 hour forecast updated hourly, a 10 day forecast updated 4 times day based off the GFS (Global Forecast System), and a 30 day forecast run daily composed of a 16 member ensemble of the downscaled and biased corrected Climate Forecast System temperature and precipitation forcings. Outputs include streamflow forecasts at 2.7 million watersheds, streamflow anomaly forecasts, and most importantly analyzed and forecast near-

surface soil moisture. Graphical output is available at: http://water.noaa.gov/tools/nwm-image-viewer.

The Northeast DEWS will begin testing the usefulness of the streamflow anomaly and near-surface soil moisture forecasts as an early indicator for drought onset, drought relieve, and flash drought commencement. This, combined with existing monitoring activities (above) could set the stage for a true "forecast" of drought evolution backed by 1 km resolution hydrologic modeling provided by the National Water Model. Key partners in this effort include NOAA's National Weather Service Northeast River Forecast Center.

Activity 1.7b Outcomes

- Evaluate the National Water Model analyses and predictions of the streamflow anomaly and near-surface soil moisture as an early indicator for drought/flash drought onset, drought persistence, and drought recovery.

Priority 2 - Integrate and Develop Collaborative Networks

The Northeast DEWS seeks to coordinate across networks to disseminate drought information to the widest audience. Coordination will center on leveraging existing networks as well as identifying new information resources and networks in the region. The NRCC hosts a monthly webinar with NOAA affiliates to address timely weather and climate concerns. These webinars are a strong existing opportunity to invite new partners to the table and exchange drought and water information with a wide variety of regional stakeholders.

Activity 2.1 Improve Coordination and Exchange of Drought and Water Information among DEWS Stakeholders

Activity 2.1a Quarterly Stakeholder Calls

The Northeast DEWS consists of a diverse group of federal, tribal, state, local, and academic partners. On a quarterly basis, a conference call will be held, bringing together active DEWS partners in the region to discuss progress and updates to the Northeast DEWS Strategic Plan, agency and partner activities, and opportunities to leverage resources. Efforts will be made on these calls, and in other stakeholder coordination efforts, to integrate lessons learned and related activities from other DEWS regions. These calls may be held according to the release of the quarterly regional outlook produced by NOAA. NIDIS, along with NOAA's Regional Climate Services Director, Eastern Region, will convene these quarterly calls.

These calls will also be a forum to engage in new partnership building, as a mechanism for inviting new stakeholders to contribute to effective drought early warning in the Northeast. This outreach will include strategic engagement with private sector equities in drought early warning, as well as with partners such as NOAA Regional Integrated Sciences Assessment (RISA)'s Consortium for Climate Risk in the Urban Northeast (CCRUN). This outreach will also happen at the state-level, engaging fire managers and agriculture agencies to ensure adequate engagement in the DEWS network.

Finally, as a supplemental activity associated with quarterly coordination calls, regular (quarterly) webinars to the Northeast DEWS stakeholders will be provided by NIDIS and its partners, including the NIDIS Working Groups, to exchange information on drought research updates, advances in drought forecasting, educational resources, and other topics. These informational presentations may take place regardless of current drought status.

Activity 2.1a Outcomes

- Ongoing Quarterly calls with active DEWS partners, becoming monthly during drought conditions, call notes distributed within one week of call
- Webinars by NIDIS Working Groups for Northeast DEWS stakeholders

Activity 2.1b Briefings to Northeastern State Drought Task Forces

NOAA/National Weather Service employees, along with other Federal agencies like USGS, regularly attend and brief on conditions to Northeastern state drought task forces in times of drought. Information should be presented with unified content for these briefings. This activity consists of creating a centralized template for task force briefings, along with content testing with WFO/BOX, GYX, and ALY.

Activity 2.1b Outcomes

- Produce unified briefing materials, referencing same products and information sites, and auto-updating slide deck
- Outreach material related to atmospheric circulation patterns (AMO, El Nino, etc. relation to drought in the Northeast. Drought 101-like two-pagers geared to state drought officials.

Activity 2.2 Provide Input from the Northeast Region to the U.S. Drought Monitor

A challenge identified by stakeholders in the region is the accuracy of the USDM in some agricultural areas where existing drought observation networks are not available. The Northeast DEWS will work with stakeholders to identify where additional observations near agricultural lands would be helpful to inform the USDM, and improve the resolution of the observation. The NDMC can provide a USDM orientation to the new NRCC user group of contributors. Key partners include: the NRCC, along with State Climate Offices and NWS field offices, and others.

Activity 2.2 Outcomes

- Weekly drought listserv posts on Mondays, led by NRCC, to coordinate regional USDM input and provide resulting drought information to USDM authors/listserv (ongoing, weekly).

Priority 3 - Strengthen Decision Making to Improve Drought Planning and Preparedness

The Northeast DEWS seeks to investigate decision-making processes, tools, and resources needed to plan and prepare for drought across various sectors, user groups, and geographic areas in the Northeast region. The Northeast is home to several “home rule states” where local towns may self-govern so long as they remain within the boundaries of state and federal constitutions; towns rather than counties are

the primary unit of local government. Therefore, strong municipal governments and water districts are central to drought response in the region.
The decisions made by these local entities, however, can be based on a myriad of factors. Towns or water districts may act independently, or in conjunction with state agencies, in managing water resources during droughts. States declare drought levels which may be associated with voluntary or mandatory water conservation. In addition, specific state agencies may require municipal water departments to comply with flow-based, calendar-based, or drought-based water use restrictions. However, water systems may implement voluntary water conservation at any time, unless limited by contractual agreement with customers.

Activity 3.1 Develop Drought/Water Information Dashboard for the Northeast DEWS

A well-curated dashboard of information that features current content can provide benefits to the network of stakeholders engaged in addressing drought in the Northeast. A challenge identified at the Outlook Forum as well as the Assessment meetings was a lack of a centralized communications hub for consistent information on current conditions; impacts to sectors, communities, and those who rely on private wells; forecasts; and resources and assistance. At times, agencies tasked with drought response and recovery can struggle to provide the appropriate response given the particular type of drought presented with its varied climatological factors affecting different sectors (i.e., agricultural drought; groundwater drought; public water supply drought, etc). For instance, the large precipitation deficits in 2015 and 2016 on Long Island caused groundwater declines to peak in 2017; since then, wells have been slow to recover and are still below normal in many parts of the Island.

This activity entails the establishment of a dashboard to provide a centralized communications hub for water resource status (drought and excessive water) information in New England and New York. The target audience includes: state drought management task force members, agricultural producers, resource managers, decision-makers, as well as members of the public. Key partners include the NRCC, which will host the dashboard on its webpage.

Activity 3.1 Outcomes

- Develop and host Northeast Drought and Water Information Online Dashboard, and coordinate with the U.S. Drought Portal on content development
- User testing webinars with stakeholders and Assessment Workshop participants, to determine key data resources, presentation preferences, and geographic scales
- Launch version 1 of Northeast Drought and Water Information online dashboard

Activity 3.2 Facilitate the Development of Sustainable Water Supplies for Agriculture in New England

The 2016-17 drought in the Northeast had notable impacts on agriculture operations throughout the region. Although New England typically receives adequate precipitation and has enough water for societal and industrial needs like agriculture, farms may have limited access to water during periods of drought, leaving these farms highly vulnerable due to their location, soil type, and the reliability, quality, and variety of water resources available. While irrigation is not as common in New England as it is in other agricultural areas of the country, farms in this region must improve the capture and use of water during wetter and/or high runoff periods of the year and consider new techniques, including changes in crop type, in order to maintain sustainable water supplies now and in the future.

This activity, led by the USGS, includes the testing of enhanced farm-level water data collection to assist water management decision-making through the year (e.g., types of crops to plant, when to plant and harvest, when to start irrigating, estimate water supplies relative to forecasts and crop or livestock needs). This includes digital measurements of precipitation and water in streams, ponds, soil, and groundwater so that water can be managed in a way to optimize use and ensure sustainability. Activities may also include the development of a document that details best practices for water sustainability based on farm characteristics. The Northeast DEWS network can support this effort by providing data and analysis that lead to robust on-farm water management decisions. Key partners include: USGS, NIDIS, and the USDA Northeast Climate Hub. Possible future partnership opportunities with New England Water Innovation may also advance smart water systems for Northeastern farmers or other unique and innovative ways to collect and analyze data for farm-level management of water sources during droughts.

Activity 3.2 Outcomes

- Identify vulnerable farms, based on access to water (available ponds, proximity to streams, location relative to other farms), and tie level of vulnerability to different drought magnitudes. Incorporate consideration of water diversion permitting requirements and/or restrictions and related consequences for the agricultural sector.
- Map streams that serve as both municipal and agriculture water sources.
- Work with a small group of farms to develop a sustainable water supply plan utilizing an enhanced farm hydrologic monitoring plan, a total farm water budget, and an optimization water use plan.
- Produce a best practices resource for farmers in the Northeast region

Activity 3.3 Provide Sector-Based Drought Information & Resources

This activity aims to build upon existing partnerships to provide tailored, accessible, sector-based drought information and resources to support decision-making. Additional engagement is necessary to further understand the needs and information gaps of specific sectors, including agriculture, forestry, and outdoor recreation. Associated activities include inviting sector representatives to Northeast DEWS forums and activities, interviews with key representatives from designated sectors, and engagement in sector-based professional dialogues and services to reach the widest audiences (planning commissions, extension services, agricultural industry representatives, well drilling companies, and watershed associations). Key partners include: the Northern Institute of Applied Climate Science, and the USDA Northern Forests Climate Hub.

Activity 3.3 Outcomes

- Through the forum of quarterly Northeast DEWS calls, identify drought vulnerable sectors not represented in strategic planning process, including fisheries, fire risk, public health, recreation, and forestry
- Host a workshop to identify decision-making information needs, how information can be tailored appropriately by sector

Activity 3.4 Map Northeast State and Sub-state, Tribal, Watershed Level Drought Plan Activities

The NDMC, in partnership with NIDIS, is developing a centralized resource to map and provide information about planning activities that address drought, and monitoring activities conducted by states, tribes, and various local and regional agencies. To address the lack of awareness of existing drought planning activities in New England and New York, this activity will establish a pilot for providing current localized information (sub-state, tribal, watershed-level) to the NDMC to populate the tool. Localized information on vulnerability assessments (when looking for historical information) may also be part of this effort. Key partners include: the NDMC, FEMA, the National Association of Counties (NACo), American Water Resources Association (AWRA), American Planning Association (APA), and others.

Activity 3.4 Outcomes

- Northeast DEWS partners, in coordination with NIDIS and the NDMC, will identify resources to support the gathering of regional information needed to populate the database and web interface tool.

Activity 3.5 Expand Drought Planning and Preparedness to Include Zoning and Engineering Practices

Planning for drought means not only preparing for a current drought's response, but also adaptation. Long-term drought preparedness may include the re-engineering of structures, review of structure needs, land use planning, including better wetland protection, and changes in landscape character (more native plans, less lawn), all to help facilitate and enhance recharge of water close to its place of origin.

This activity involves a collaboration between the State of Massachusetts and the EPA Region 1 in integrating green infrastructure (GI), with a focus on drought resilience, into State Hazard Mitigation Plans. This project is underway, and can serve as a model for how EPA Regional offices can collaborate with states and FEMA to optimize the use of GI to mitigate drought, as well as other hazards. This effort builds upon existing work in Massachusetts to promote low-impact development and GI practices to comply with state stormwater performance standards and National Pollutant Discharge Elimination System (NPDES) Phase II permit requirements. Additional research is needed to determine optimal GI specifications for drought mitigation. The Northeast DEWS will bring together local subject-matter experts, the NIDIS Interdisciplinary Research and Applications and Planning and Preparedness Working Groups, and others to discuss knowledge to date and additional research needs to determine GI specification for drought mitigation and identify potential conflicts with GI for stormwater and flooding management. Key partners in this effort include the EPA with support from FEMA.

Activity 3.5 Outcomes

- Support the development of updated best management practices and hazard mitigation plans for cities, towns, and states in the Northeast region, and conduct education/outreach to landowners.

Activity 3.6 Incorporate the Coastal Salinity Index (CSI) as an indicator for drought in the Northeast

Droughts affect coastal areas uniquely because of changes in salinity resulting from decreases in freshwater inflows and precipitation. The CSI emerged from stakeholder needs in the Coastal Carolinas DEWS in 2012. Using real-time and historical salinity data sets and methodologies similar to the

Standardized Precipitation Index (SPI), the CSI characterizes drought conditions in coastal systems. The CSI is computed for various time scales to capture short- and long-term conditions. The continued application and enhancement of the CSI is in the interest of many agencies and organizations in DEWS regions, including the Northeast.

Significant efforts being led by USGS and the Carolinas Integrated Sciences & Assessments (CISA), a NOAA RISA team, are underway to make the computation of the CSI operational, to inform the drought community of climatologists and coastal resource managers such as marine fisheries, water utilities, and forestry managers. Priority actions also focus around computing the CSI for other locations along the Gulf and Atlantic coasts. The Northeast DEWS will contribute to the CSI Working Group (CSIWG) to provide guidance and input on different components of the CSI project, in order to improve the CSI and its use in resource monitoring and management in the Northeast. Key partners in this effort may include: USGS, CISA, and the University of New Hampshire.

Activity 3.6 Outcomes

- Contribute to the CSIWG and discuss the application of CSI for particular agency needs, to share potential data sets on coastal drought, and to provide or identify potential funding resources for CSI research and applications activities.
- Improve information and conduct additional research to further develop and validate the CSI for use in the Northeast region

Priority 4 - Increase Communication and Utilization of Drought and Climate Science

The Northeast DEWS seeks to coordinate communication, outreach, and training across the region to strengthen the understanding and utilization of drought and climate science.

Activity 4.1 Update and Maintain the Northeast DEWS Information on the U.S. Drought Portal

The Northeast DEWS Pages on the U.S. Drought Portal (drought.gov) provide the public with background information on the DEWS and its development, as well as reports on recent and current drought conditions, discussion of climate forecasts, and other information resources. The Northeast DEWS pages on drought.gov also serve as an information portal for an explanation of past, current, and upcoming Northeast DEWS activities, including upcoming workshops and webinars, research, and other tools and resources. The Portal can also serve as a platform to showcase new monitoring tools and drought indices and can also facilitate impact collection. NIDIS will work with its partners to update and maintain this web portal with current content to meet the needs of this DEWS. NIDIS will solicit regular feedback from Northeast DEWS stakeholders to review and provide content for Northeast DEWs specific pages.

Activity 4.1 Outcomes

- Stakeholder review of Northeast DEWS pages on drought.gov
- Initial update to Northeast DEWS pages on drought.gov completed
- Routine enhancements to the Northeast DEWS webpage, to include timely updates, relevant content, and visual improvements in layout and formatting

Activity 4.2 Develop Integrated Drought Messaging

This activity entails developing a centralized, consistent starting point for integrating drought messaging at the Northeast regional level, employing social media, app technology, highway signage, text messaging, and/or other partner communication vehicles to define drought in actionable terms for the public. The Northeast DEWS will host a Regional Drought Communications Workshop to engage with state and local public information officers, trade associations, and other environmental messaging professionals to better understand regional information needs and effective drought messaging, and to deliver strategic communications best practices to be posted to the U.S. Drought Portal. Lessons learned from other DEWS, including the CA-NV DEWS, will be transferred. Key partners may include: NRCC, USGS, Cornell University Media Relations and other academic institutions, and NOAA's National Centers for Environmental Information (NCEI).

Activity 4.2 Outcomes

- Develop drought-related educational and communication best practices document for Northeast audiences that addresses effective methods for pre-drought/current drought response/post-drought messaging; post to the U.S. Drought Portal.
- Develop sample information packages for broadcast media in partnership with Cornell University Media Relations
- Promote drought messaging best practices document into existing Ag Extension newsletters

Activity 4.3 Provide Climate and Drought Outlook Briefings and Webinars

NOAA, in collaboration with the NCEI (lead), NIDIS, the NRCC, and many other climate information providers, issues and distributes a Quarterly Climate Impacts and Outlook briefing for the Northeast region. These briefings have been distributed since 2013 and are posted on the NRCC's website as well as the U.S. Drought Portal. They provide information on recent (last three months) temperature and precipitation anomalies, regional impacts, and a regional climate outlook for the next three months. They are created for decision makers who want to be informed of recent climate trends and impacts in their region.

Activity 4.3 Outcomes

- Continue to publish quarterly outlooks for Northeast, Great Lakes and Gulf of Maine
- Develop timely products for use by stakeholders in informing drought management task forces and other managers (e.g., within 1-2 weeks of end of month).

Activity 4.4 Leverage State-Based Tools and Resources to Disseminate Regional Drought Information

The State of Maine's Department of Environmental Protection supports the Maine Climate Clearinghouse and Adaptation Toolkit, launched in 2016. These sites are co-developed to cultivate best Maine-specific resources on climate-related topics and provide a directory of climate information for Maine communities. Resources will be updated on an ongoing basis in coordination with Maine DEPs Climate Program, through interagency coordination with the Maine Interagency Climate Adaptation Work Group (MICA), and with user groups.

This activity includes integrating the information and presentations available on the state of Maine's website with regional and other New England states' information. Climate Trends & Data and Adaptation Actions pages can help disseminate regional drought information resources, support sector-

based adaptation planning actions, and cross-promote utilization of drought and climate science. Direct outreach on drought specific planning and integration of best practices could also be available upon request to connect inquiries about DEWS materials to technical experts in the network. This activity also includes gathering information on other existing state-level web-based toolkits and assistance materials and determining how these sources of drought information may also help disseminate regional information, support sector-based adaptation planning actions, and cross-promote utilization of drought and climate science.

Activity 4.4 Outcomes

- On-going promotion of State-based Solutions and Resources, like the State of Maine's Climate Clearinghouse and Adaptation Toolkit, to leverage outlets for disseminating cross-border, sector-based, and regional drought-related information

Activity 4.5 Northeast Climate Adaptation Science Center (CASC) Research and Adaptation Tools

The Department of Interior's NE CASC recognizes ecological drought as a key stressor in the Northeast and works with natural and cultural resource managers to gather scientific information and build the tools needed to help fish, wildlife, and ecosystems adapt to the impacts of climate change. The NE CASC has devoted resources to the development of a number of research projects and adaptation tools that support decision making related to drought in the region including:

- NorEaST – Stream Temperature Web Portal Demonstration and Application (https://ccviewer.wim.usgs.gov/noreast/)
- The Massachusetts Climate Action Tool (http://climateactiontool.org/)
- Science to Inform Management of Floodplain Conservation Lands under Non-Stationary Conditions
- Ecological and hydrological impacts of invasive species, fire frequency and other disturbances on Northeast forests
- Improving downscaling climate model for impacts assessments including assessments of climate projections and extremes, snowfall and other precipitation
- Structured decision-making approaches in headwater stream ecosystems that support management across multiple agencies
- Reducing Vulnerability to Extreme Flows and Providing Multiple Ecological Benefits in a Non-Stationary Climate
- Reconnecting Floodplains and Restoring Green Space as a Management Strategy to Minimize Risk and Increase Resilience in the Context of Climate and Landscape Change
- Designing Sustainable Landscapes (DSL): (http://necsc.umass.edu/projects/designing-sustainable-landscapes)

Activity 4.5 Outcomes

- Continue to support the development of adaptation tools and research on the impacts of changes in precipitation and hydrological regimes on natural resources
- Provide access to the technical reports, publications, tools, and data resulting from research activities to the scientific and management communities
- Communicate results as part of NE CASC website (http://necsc.umass.edu), newsletter and webinar series, and cross-post to the U.S. Drought Portal

Appendix A: Northeast DEWS Partners

The development of this Northeast DEWS Strategic Plan and its associated implementation reflects the knowledge and expertise of dedicated individuals, organizations, and partners. Collaboration is key to improving drought early warning capacity and long-term resilience through implementation of the Northeast DEWS. This list of partners is not exhaustive and will evolve as new regional partnerships form.

Aquarion Water Company
Charles River Watershed Association
City of Worcester, Public Works and Parks
Connecticut Department of Energy and Environmental Protection
Connecticut Department of Forestry
Connecticut Department of Public HealthCornell Cooperative Extension
Cornell University Atkinson Center for a Sustainable Future
Delaware River Basin Commission
Department of Homeland Security, Office of Infrastructure Protection
Environmental Protection Agency, Region 1
Federal Emergency Management Agency, Region 1, Mitigation Division
Massachusetts Department of Conservation and Recreation
Massachusetts Division of Fisheries and Wildlife
Massachusetts Executive Office of Energy and Environmental Affairs
Massachusetts Rivers Alliance
Massachusetts Water Resources Authority
Maine Department of Environmental Protection
Maine Emergency Management Agency
Maine Public Utilities Commission
National Drought Mitigation Center
New Hampshire Department of Environmental Services
New York City Department of Environmental Protection
New York State Department of Environmental Conservation, Hudson River Estuary Program
New York State Water Resources Institute
NOAA/National Integrated Drought Information System
NOAA/National Weather Service
NOAA/NESDIS/National Centers for Environmental Information
NOAA/Office of Oceanic and Atmospheric Research
NOAA/Fisheries
Northeast Climate Adaptation Science Center
Northeast Regional Climate Center
Northeast Region State Climatologists
Susquehanna River Basin Commission
Town of Ipswich, MA
Town of Sudbury, MA
University of Massachusetts Boston

University of Massachusetts Extension
University of Maine, Climate Change Institute
University of New Hampshire
U.S. Department of Agriculture/NRCS, Forest Service, FSA, ARS, and Northeast Climate Hub
U.S. Geological Survey/New England Water Science Center
U.S. Geological Survey/New York Water Science Center
U.S. Representative Seth Moulton
Village of New Paltz, NY
Worcester Polytechnic Institute
York Water District

Appendix B: Working Groups

Coordination, communication, and transferability of information and actions between the NIDIS Working Groups and the Northeast DEWS is essential the overall process of building a collaborative information system. The table below highlights how each of the activities in the Plan correspond with the individual Working Groups. As the Northeast DEWS and Working Groups continue to develop, activities among each of these groups will be leveraged and coordinated.

Activity	Education and Public Awareness	Monitoring and Observations	Predictions and Forecasting	Interdisciplinary Research and Applications	Planning & Preparedness	U.S. Drought Portal
Priority 1 – Enhance Drought Monitoring and Research						
Activity 1.1 Enhance Groundwater Monitoring Networks, Private Well Impacts		X				
Activity 1.2 Develop Regional Data Entry Portal for Surface Water and Groundwater		X				
Activity 1.3 Expand Soil Moisture Monitoring in the Northeast		X		X		
Activity 1.4 Enhance the Usability of Mesonet Networks and Remotely-sensed Data		X		X		
Activity 1.5 Strengthen Existing Citizen Science Networks		X				
Activity 1.6 Assessing Impacts of Extreme Hydrological Events on Freshwater Species				X		
Activity 1.7 Develop Forecast Tools to Predict Future Hydrologic Conditions during Periods of Drought			X			

Activity	Education and Public Awareness	Monitoring and Observations	Predictions and Forecasting	Interdisciplinary Research and Applications	Planning & Preparedness	U.S. Drought Portal
Priority 2 – Integrate and Develop Collaborative Networks						
Activity 2.1 Improve Coordination and Exchange of Drought and Water Information among DEWS stakeholders	X				X	
Activity 2.2 Provide Input from the Northeast Region to the U.S. Drought Monitor		X				
Priority 3 – Strengthen Decision Making to Improve Drought Planning and Preparedness						
Activity 3.1 Develop Drought/Water Information Dashboard for the Northeast	X				X	X
Activity 3.2 Facilitate Development of Sustainable Water Supplies for Agriculture				X		X
Activity 3.3 Provide Sector-Based Drought Information & Resources	X				X	X
Activity 3.4 Map Northeast State, Sub-State, Tribal, Watershed Level Drought Plan Activities					X	
Activity 3.5 Expand Drought Planning and Adaptation to Include Zoning and Engineering Practices				X	X	
Activity 3.6 Incorporate Coastal Salinity Index as an Indicator for Drought in the Northeast		X			X	

Activity	Education and Public Awareness	Monitoring and Observations	Predictions and Forecasting	Interdisciplinary Research and Applications	Planning & Preparedness	U.S. Drought Portal
Priority 4 – Increase Communication and Utilization of Drought and Climate Science						
Activity 4.1 Update and Maintain the Northeast DEWS Information on the U.S. Drought Portal						X
Activity 4.2 Develop Integrated Drought Messaging	X					
Activity 4.3 Provide Climate and Drought Outlook Briefings and Webinars	X					
Activity 4.4 Leverage State-Based Tools and Resources to Disseminate Regional Drought Information					X	
Activity 4.5 Northeast Climate Adaptation Science Center Research and Adaptation Tools				X	X	