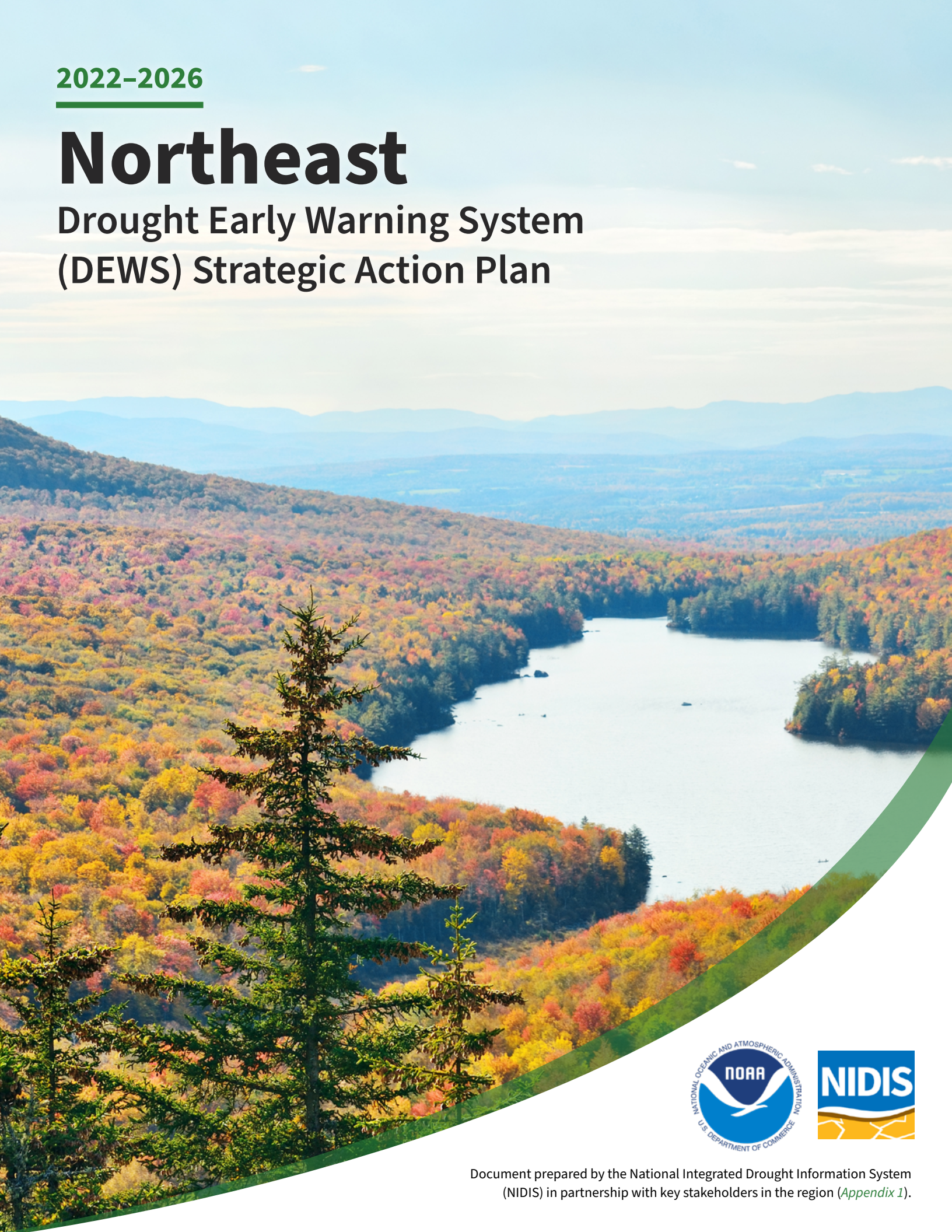
2022–2026

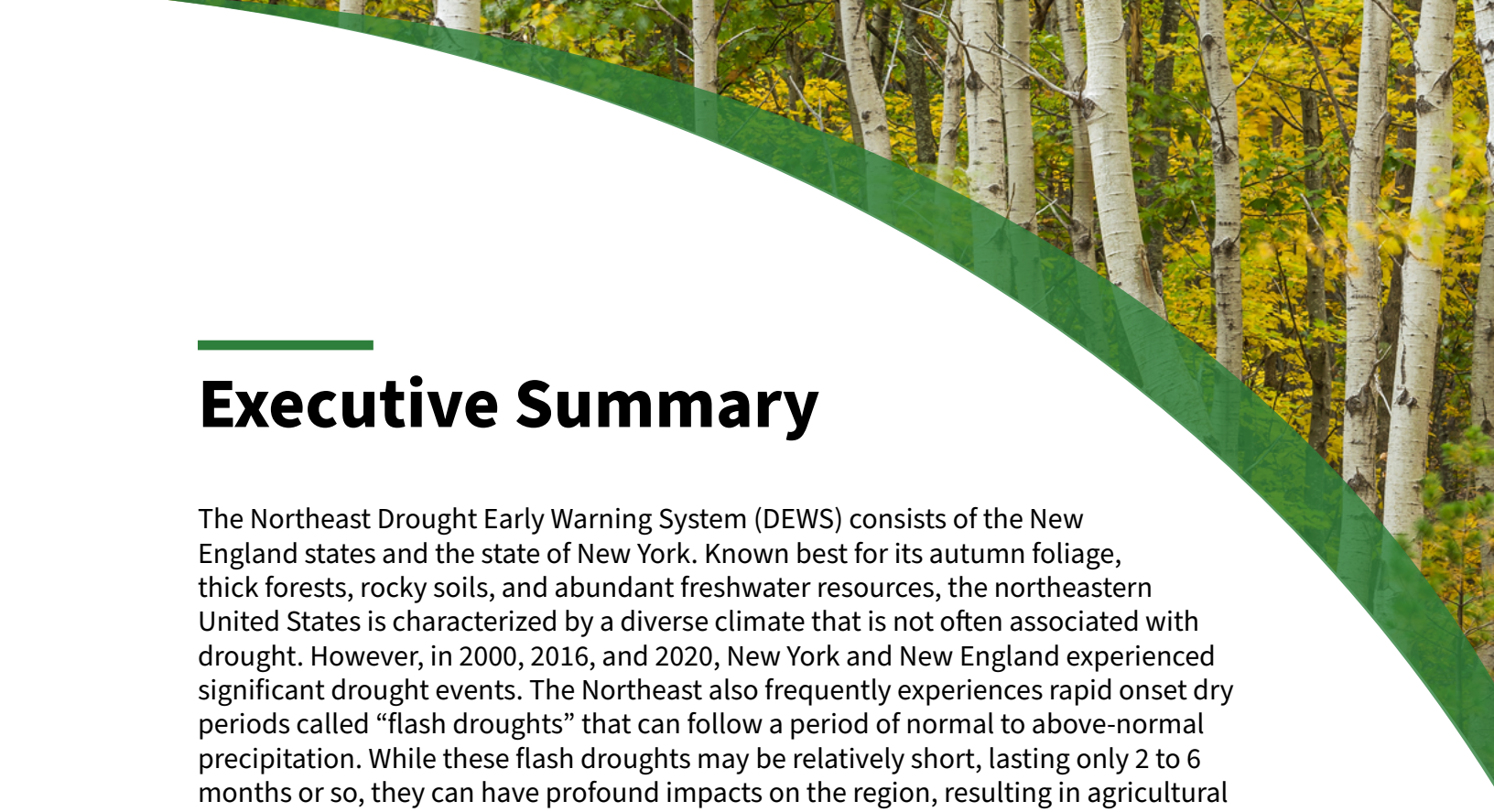
Northeast

Drought Early Warning System (DEWS) Strategic Action Plan



Document prepared by the National Integrated Drought Information System (NIDIS) in partnership with key stakeholders in the region (*Appendix 1*).

On the cover: Lake with autumn foliage near Stowe, Vermont. Credit: Songquan Deng



Executive Summary

The Northeast Drought Early Warning System (DEWS) consists of the New England states and the state of New York. Known best for its 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 2000, 2016, and 2020, New York and New England experienced significant drought events. The Northeast also frequently experiences rapid onset dry periods called "flash droughts" that can follow a period of normal to above-normal precipitation. While these flash droughts may be relatively short, lasting only 2 to 6 months or so, they can have profound impacts on the region, resulting in agricultural losses, increases in wildland fire potential, disruption of typical ecological patterns, low stream flows, below normal groundwater supplies, and challenges to drinking water management.

The Northeast DEWS (NE DEWS) is a collaborative federal, regional, state, and local interagency effort to improve drought early warning capacity and build long-term drought resilience. In the midst of the 2016–2017 northeastern drought, stakeholders from Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont came together to assess the impacts and lay the groundwork for drought resilience through planning and preparedness. This group developed a two year (2018–2019) strategic action plan based on the National Integrated Drought Information System (NIDIS) core components of a Drought Early Warning System: observations and monitoring; interdisciplinary research and applications; prediction and forecasting; communication and outreach; and planning and preparedness. Activities initiated under that plan included the establishment of a NE DEWS Drought Information Dashboard (*nedews.nrcc.cornell.edu*), drought response activities such as regular drought status

WHAT IS NIDIS? The National Integrated Drought Information System (NIDIS) is a multi-agency partnership that coordinates drought monitoring, forecasting, planning, and information at national, state, and local levels across the country with a mission to improve the nation's capacity to proactively manage drought-related risks. Congress created NIDIS in 2006 (Public Law 109-430) 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). The program was reauthorized in 2014 (Public Law 113-86) and again in 2019 (Public Law 115-423).

updates to stakeholders in the region, as well as the launch of a drought monitoring status coordination group where local experts and partners share drought status data and provide regular feedback to US Drought Monitor authors. In 2022, next steps involve the expansion of regional partnerships and the continued identification of the unique characteristics of drought that will help with early warning and mitigation in the region.

WHAT IS A DROUGHT EARLY WARNING SYSTEM (DEWS)? A 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 Strategic Action Plan 2022–2026 is built on the same foundation as the previous plan, and it continues to identify key outcomes and activities that will build drought early warning capabilities and resilience in the region. Partners from across New England and New York attended virtual listening sessions in October and November of 2020 to discuss the progress made and identify next steps. The listening sessions were organized around the following topics:

- Agriculture, Aquaculture, Forestry and Ecosystems
- Expanded Partnerships: Private Sector, Tribal and Federal Emergency Management Agency (FEMA)
- Water Resources Management: surface and groundwater
- Communications, Awareness and Education
- Monitoring and Prediction

Discussions acknowledged the progress made across the NE DEWS network to better communicate and collaborate in preparing for and responding to drought in the region. It also led participants to ask how the DEWS might further advance not only information delivery but also drought impact mitigation. While the 2020 Northeast drought resulted in greater coordination between the states and the application of lessons learned from the previous drought, additional needs emerged. Those needs are integrated into this plan.

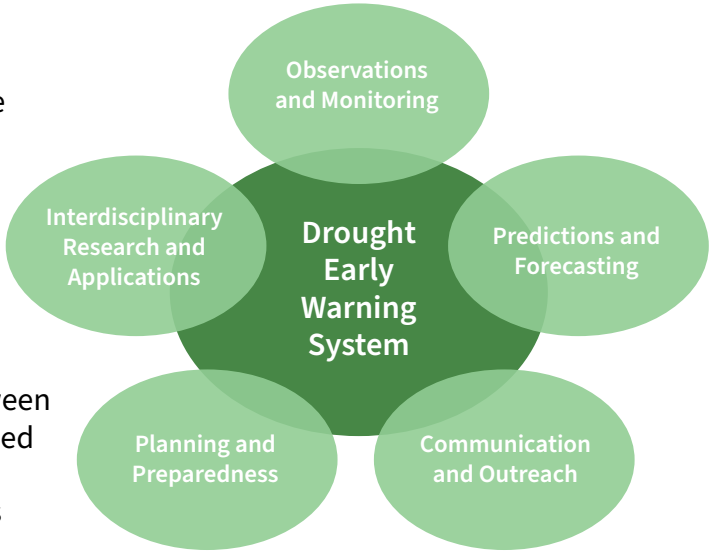


Figure 1: Five components of DEWS.
Credit: NOAA NIDIS, Fiona Martin

Blueberries ripening in an orchard on Cape Cod, Massachusetts. Credit: J.A. Johnson

PRIORITIES AND ACTIVITIES FOR 2022–2026

The following five priorities were identified and confirmed during the 2020 virtual listening sessions and the 2021 meeting of NE DEWS stakeholders:

- Continue to build a comprehensive understanding of drought indicators/indices used in the Northeast, to better demonstrate their value, limitations, business sector relevance, seasonal and geographical application.
- Expand drought observations (such as monitoring dry wells and soil moisture conditions) and utilize data sets (such as snow survey data) that can help build a robust drought impact reporting system. This system should include a citizen science information component and contribute to a regional-scale response framework.
- Expand partnerships with diverse stakeholders, such as local and federal emergency management agencies, Tribal nations, and the private sector, to more effectively build drought resilience and drought response resources across sectors and communities.
- Improve collaboration, coordination, and communication among partners in the NE DEWS network to support information-sharing.
- To support the drought planning and plan evaluation cycle, increase opportunities for planners to share drought-related lessons learned both within and across the DEWS, sectors, tribal, state, and local agencies.

This plan is organized by the five components of a drought early warning system. It prioritizes outcomes and identifies activities that the NE DEWS will focus on over the next several years. Routinely scheduled partner meetings and individual consultations will allow for continuous reassessment of priorities and activities. This plan is not all inclusive. Emerging issues, research applications, and capabilities could shift priorities. More detailed information on the larger suite of activities in the plan can be found in the body of this document.

Focusing Northeast DEWS Priorities, Outcomes, and Activities
NETWORK COORDINATION AND INTEGRATION
Convene in-person and virtual meetings within the region, to foster opportunities for the exchange of experiences and ideas.
Support meetings and workshops related to drought planning—organized by regional partners—to more fully integrate drought planning and preparedness into their plans and policies.
Evaluate the effectiveness of the NE DEWS network and engagement strategies in building collaborations, increasing partners' ability to find and use information for decision-making, and expanding participation in drought planning and preparedness activities.
DROUGHT PREDICTIONS AND FORECASTING
Review the products and tools available that convey the probability of drought expansion or recovery, and determine if we need to develop new tools, improve on existing tools, and/or provide training and raise awareness of tools.
Develop simple, effective communication materials to increase user understanding of forecasts and outlooks. This should include information on uncertainties inherent in the products.
Support work to better understand the timing of drought mitigation decisions for various sectors impacted by drought in the Northeast. Verify that the available products and services contribute to situational awareness and drought early warning.
DROUGHT OBSERVATIONS AND MONITORING
Ensure that new and existing drought-related monitoring networks are interoperable and that partners know what data is available throughout the region.
Leverage existing and new initiatives to increase monitoring in the region (especially soil moisture/ temperature networks and private well monitoring collaborations).
Engage with tribal and federal partners to address in situ weather observation gaps on tribal lands.
DROUGHT PLANNING AND PREPAREDNESS
Communicate drought planning resources that build ecosystem health and drought resilience—especially water management strategies that take advantage of periods of water abundance and flood events.
Develop guidance on what it means to proactively plan and prepare for drought at the local and state levels. This could include checklists that remind planners to consider drought impacts on infrastructure, underserved communities, and health.
Support states and tribes who are updating drought and related plans by sharing practice-based solutions, lessons learned, and technical information utilized by other states and tribes.

Focusing Northeast DEWS Priorities, Outcomes, and Activities
DROUGHT COMMUNICATION AND OUTREACH
Provide opportunities for capacity building of key products and tools that can be applied throughout the DEWS. Develop feedback mechanisms to allow for continuous improvement of those tools and information pathways.
Develop regional displays of drought monitoring networks, observations, and reported impacts that inform local decision-making.
Conduct meaningful engagement and outreach with new partners from the private sector, tribal nations, and emergency management agencies in the Northeast, to better understand their drought related challenges and priorities.
Establish a drought learning network to encourage drought and climate literacy, the exchange of best practices, lessons learned, and peer-to-peer exchanges that foster preparedness and resilience to drought.
INTERDISCIPLINARY RESEARCH AND APPLICATIONS
Determine the appropriate drought indicators for different types of drought (agricultural, ecological, hydrological) in the Northeast. Address seasonal and geographical differences. Use those indicators in communications to DEWS partners and the public when drought potential is increasing.
Identify barriers to the communication of research findings and the implementation of research applications. This includes bridging the gap between the research community and the product/application end users by offering discussion forums at various stages of the development and implementation process.

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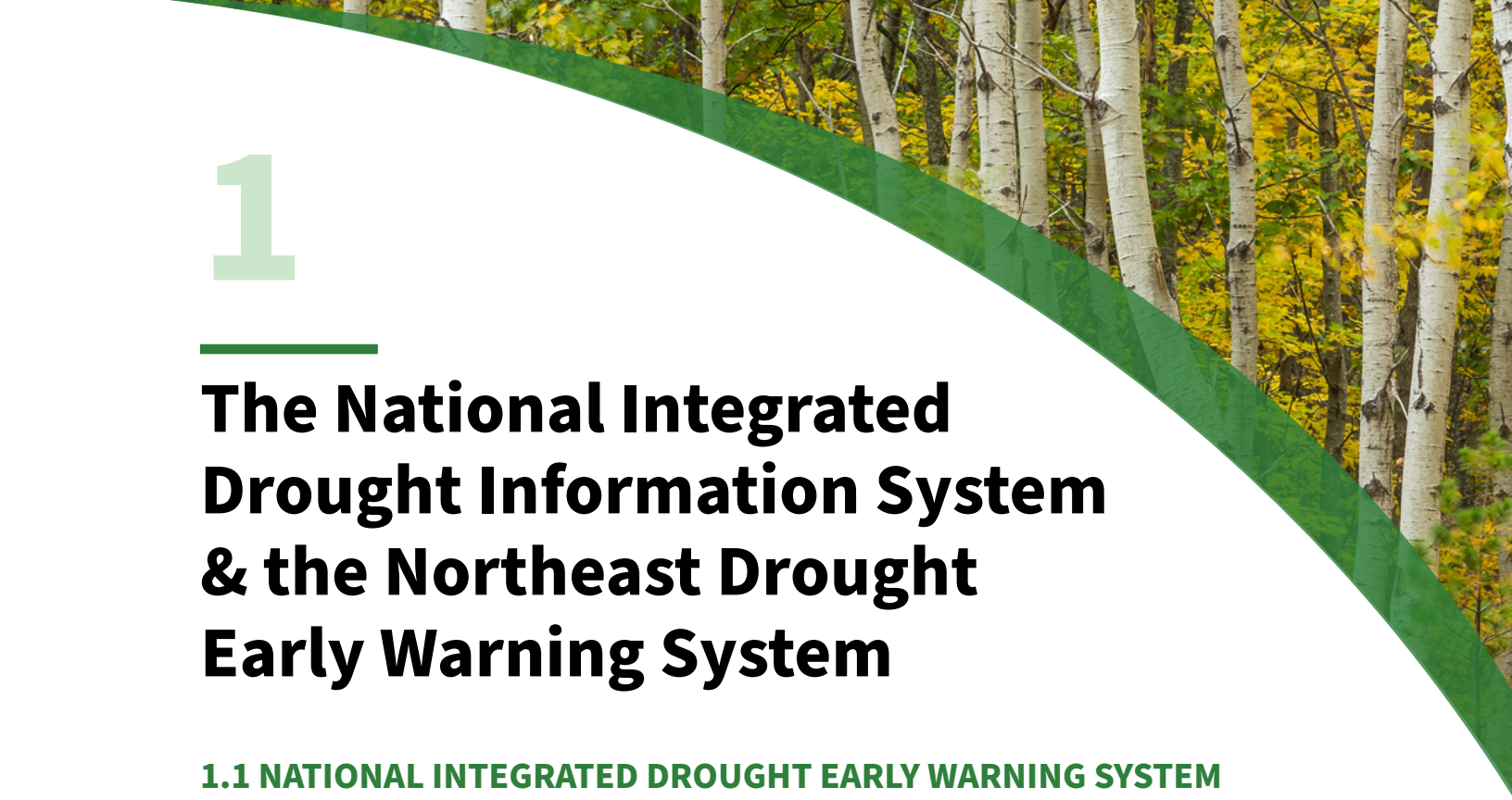


1

The National Integrated Drought Information System & the Northeast Drought Early Warning System

1.1 NATIONAL INTEGRATED DROUGHT EARLY WARNING SYSTEM

Congress created the National Integrated Drought Information System in 2006 (Public Law 109-430) 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). The program has been reauthorized in 2014 (Public Law 113-86) and again in 2019 (Public Law 115-423). NIDIS is working toward this goal by developing a network of regional DEWS. These regional DEWS utilize existing networks to make climate and drought science readily available, easily understandable, and actionable; and to improve regional capacity to respond to and cope with drought.

A regional DEWS is supported by stakeholders, composed 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 regional DEWS that is well networked and responsive to the specific needs of each region.

1.2 COMPONENTS OF A DROUGHT EARLY WARNING SYSTEM

Early warning is the provision of timely and effective information that allows individuals exposed to a hazard to act to avoid or reduce their risk and prepare for effective response. In the case of drought, five components have been identified as necessary for drought early warning (*Figure 1*). In order for these systems to be

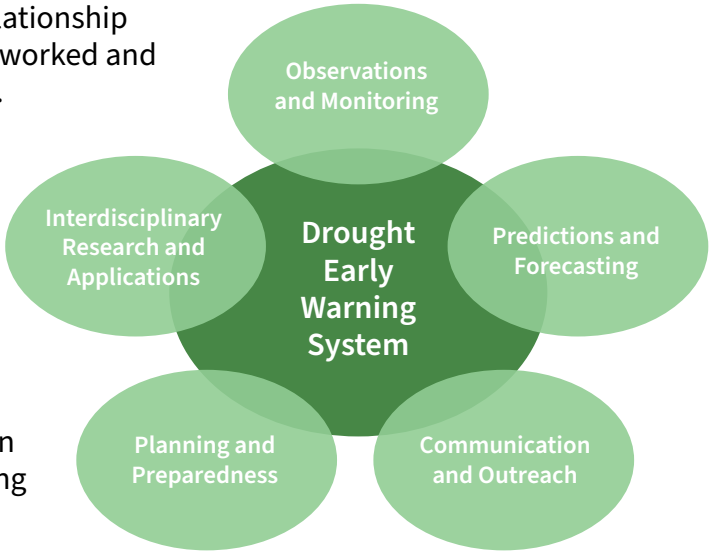


Figure 1: Five components of DEWS.
Credit: NOAA NIDIS, Fiona Martin

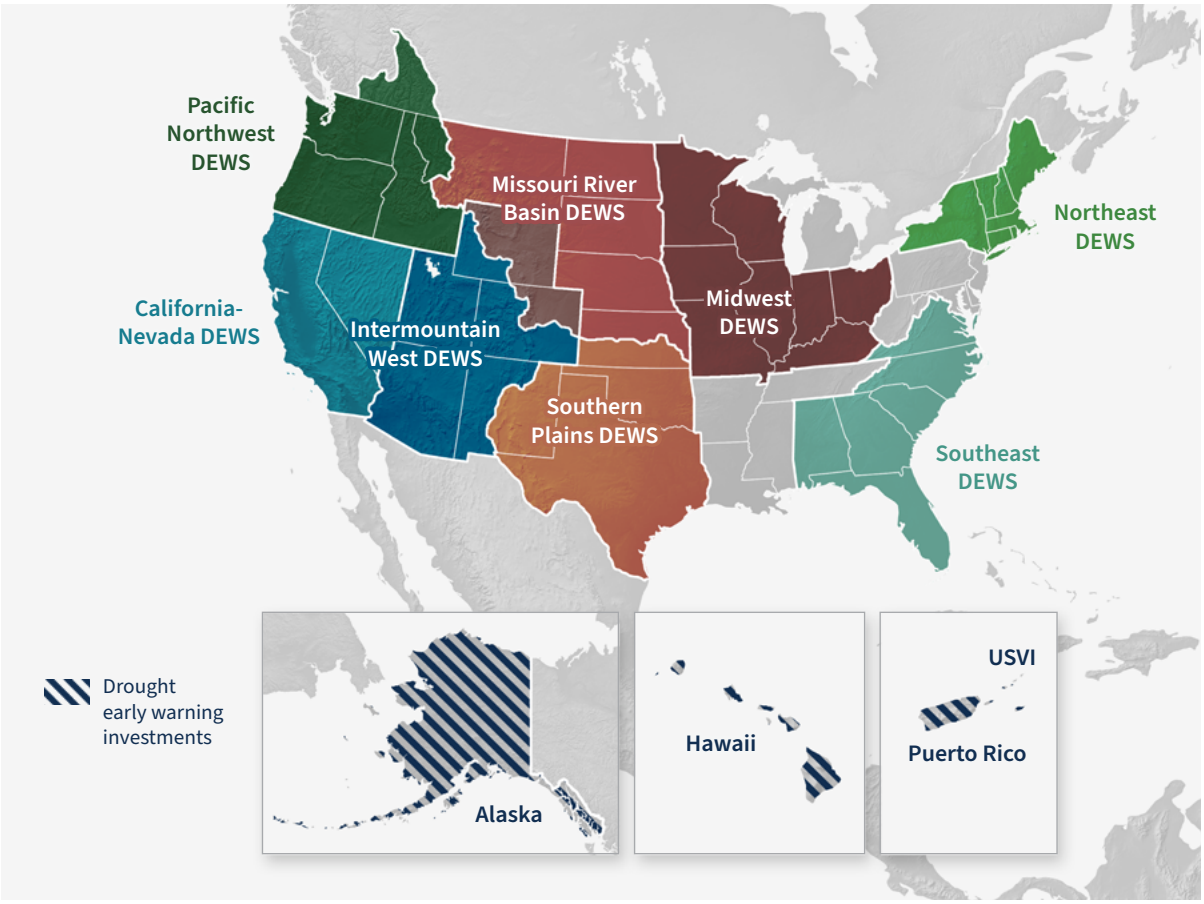


Figure 2: Map of regional Drought Early Warning Systems (DEWS). Credit: NOAA NIDIS, Fiona Martin

successful, they must support efforts to understand past, present, and future conditions and to plan proactively. They must also respond using an adaptive management process that applies learning to improve future outcomes. Activities and actions in one component inform those in other components, and in the early warning system itself there is feedback and learning that informs and improves the system over time.

1.3 BRINGING IT TOGETHER ACROSS SCALES

NIDIS employs a systems—or holistic approach—to identify gaps, foster collaboration, facilitate information flow and informed decisions, and integrate the five components of early warning both across and within regional DEWS. This capitalizes on the strengths in part of the system to address needs in another. The regional DEWS provides a foundation on which a national early warning system rests (*Figure 2*).

Regional gaps, needs, and input are incorporated into national products and processes (*Figure 3, next page*). Initiatives that cross DEWS boundaries, or that are larger than any one regional DEWS, are elevated to be addressed holistically by NIDIS and partners at a national scale. This includes complex issues such as the relationship between drought and

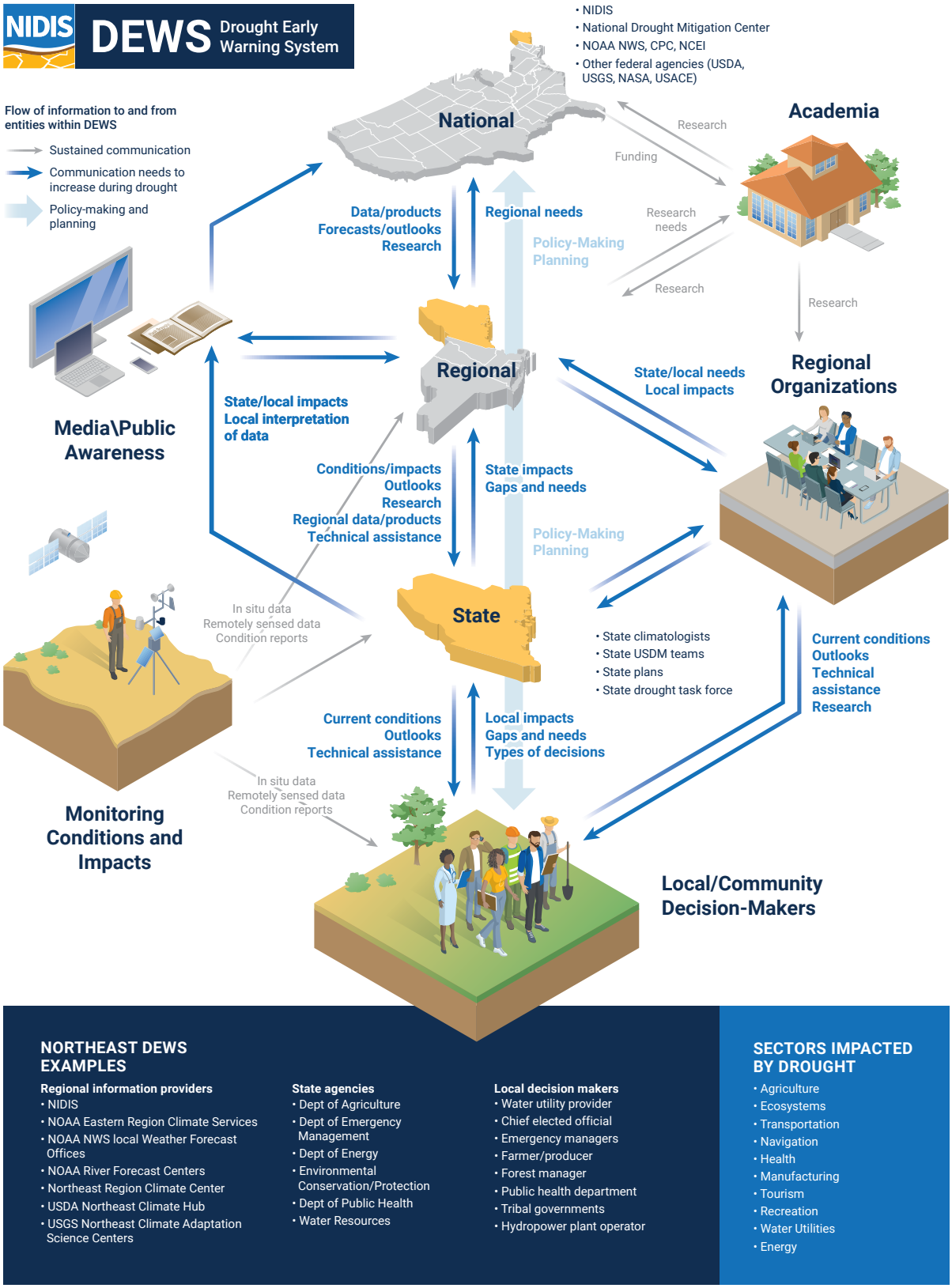


Figure 3: DEWS network. Modeled after the DEWS within the National Integrated Drought Information System (NIDIS). Graphic by Fiona Martin; mushakesa/stock.adobe.com.

wildland fire, or drought and public health, which require larger investments in research and targeted decision support tools. In the same way, these national efforts, products, and learning can be assessed for relevance, validated, tailored, and then incorporated into the regional DEWS. The components of a drought early warning system are necessary and important, but it is this cross-scale exchange of information and learning that has the potential to improve our capacity for national early warning.

A key ingredient to a successful early warning system is the people and partners who are dedicated to making the network function. This aspect of a DEWS network requires sustained commitment and attention in order to ensure drought preparedness and resilience are prioritized in times of drought as well as when drought is not present. Convening and fostering dialogue on drought related priorities is one of NIDIS's primary roles in each regional DEWS.

1.4 LAUNCHING THE NORTHEAST DROUGHT EARLY WARNING SYSTEM

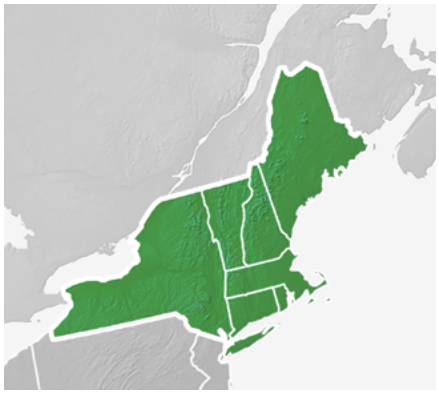


Figure 4: Location and spatial extent of the Northeast Drought Early Warning System (DEWS). Credit: NOAA NIDIS, Fiona Martin

During an historic drought event in 2016–2017 in New England and New York, NIDIS, in partnership with NOAA's Regional Climate Services Director for the Eastern Region, the Northeast Regional Climate Center (NRCC), US 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 (October 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, the impacts of the drought, existing response and preparedness resources, and climate outlooks for the coming seasons. Additional meetings in New York (February 2017) and Massachusetts (March 2017) were convened to assess the drought, understand the additional resources that would have strengthened drought resilience, and identify what drought indicators and early warning capacity could be integrated into the NE DEWS. More than 100 community leaders, representing sectors from water resource management and agriculture to local government and community watershed groups, shared insights on the 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, agricultural interests, utilities, and community watershed groups, launched a regional DEWS in the northeast and outlined a two-year strategic plan.

1.5 NORTHEAST DROUGHT EARLY WARNING SYSTEM PROGRESS TO-DATE

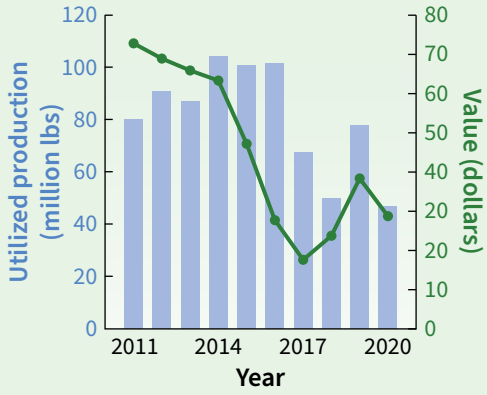
The first NE DEWS Strategic Plan from 2018–2019 focused on four priorities: (1) Enhance Drought Monitoring, Forecasting, and Research; (2) Integrate and Develop Collaborative Networks; (3) Strengthen Decision Making to Improve Drought Planning and Preparedness; and (4) Increase Communication and Application of Drought and Climate Science. Several of the associated activities were initiated and brought to fruition. The most significant activities included:

- The Northeast DEWS Dashboard is maintained by the NRCC and offers at-a-glance drought status maps, precipitation outlooks, mapped indices, and links to other drought tools.
- The NE DEWS drought status discussion group was initiated as a virtual space for local experts and partners to share drought status data and provide weekly feedback to the US Drought Monitor authors. This group was a key part of the effort to monitor the onset and evolution of the 2020 drought.
- NE DEWS partners initiated work to support state drought management efforts and develop decision support information platforms with "one stop" access to key data sets.

All of these activities enhanced regional communication and collaboration. Progress on other activities was impeded by the COVID-19 global pandemic and, as a result,

Of Note: Drought Impacts on Wild Blueberries—A Specialty Crop in Maine

Recent research[1] on wild blueberries (usually considered to be a drought tolerant plant) indicates that sufficient soil moisture over the long term is important for high yields and crop value.



From the USDA National Agricultural Statistics Service (NASS), New England Field Office - 2020 Maine Wild Blueberry Production report of December 27, 2022.

1 Barai, K.; Tasnim, R.; Hall, B.; Rahimzadeh-Bajgiran, P.; Zhang, Y.-J. Is Drought Increasing in Maine and Hurting Wild Blueberry Production? Climate 2021, 9, 178. https://doi.org/10.3390/cli9120178

many of the foundational strategic action plan activities will become a part of the 2022–2026 plan.

The following table summarizes most of the key outcomes and progress that NIDIS and partners in the NE DEWS have made since its inception in 2016 and the first Strategic Action Plan in 2018. This summary is not meant to be an exhaustive list, but to provide a sense of how drought early warning capacity was enhanced in the region.

Key Outcomes and Progress
DROUGHT PREDICTIONS AND FORECASTING
Investments from NOAA RISA/CIRC, NIDIS, NRCC and the US Department of Agriculture (USDA) have been used to build out tools in the Climate Toolbox, to provide climate, drought, and water decision support products for the Northeast region.
DROUGHT OBSERVATIONS AND MONITORING
The NE DEWS Drought Status Discussion Group brings together experts from across the region and a variety of sectors to report on current drought conditions and impacts. A weekly summary of their observations and conclusions is shared with the US Drought Monitor authors.
A snow survey data set is in development by the National Weather Service (NWS) forecast office in Gray, Maine, in collaboration with other Northeastern states, the NRCC and Plymouth State University. An ArcGIS mapping tool is used to visualize the survey elements. Uniquely, the data set includes historical observations.
DROUGHT PLANNING AND PREPAREDNESS
The Northeast DEWS developed a partnership with Boston University's Questrom School of Business to work with students on a 2020–2021 Capstone Project. The students identified a project focused on increasing the dissemination of available drought-related information to agribusinesses in a way that allowed for the development of a drought mitigation strategy. The partnership will be renewed for the 2021–2022 school year and engage a new group of business students in a similar effort.
DROUGHT COMMUNICATION AND OUTREACH
Since 2018, the Northeast DEWS Dashboard has been a portal to regional drought information that includes precipitation maps, surface and groundwater status maps, soil moisture indices, and links to other drought tools.
A monthly climate summary and outlook webinar series (delivered by the NRCC and the Eastern Region Climate Services Director) has been a key mechanism for providing stakeholders with the latest climate and drought information.
Throughout the 2020–2021 drought, the NE DEWS worked with state drought management committees to support information exchange and cross-border awareness of drought conditions and impacts.

Key Outcomes and Progress

Weekly drought status updates (*sample on next page*) were published from June to mid-December in 2020. Monthly updates were delivered during the first half of 2021 as drought persisted in the region. The updates focused on the latest US Drought Monitor conditions in the region and also covered state response status, impacts, and outlooks. The Northeast Region Climate Center, NOAA Eastern Region Climate Services Director, USDA, and USGS offices contributed content and edited these updates.

Quarterly stakeholder meetings with the US Environmental Protection Agency/ Region 1, monthly meetings with the Northeast Region Cohesive Wildland Fire Management team, and other Federal interagency meetings have expanded the NE DEWS network.

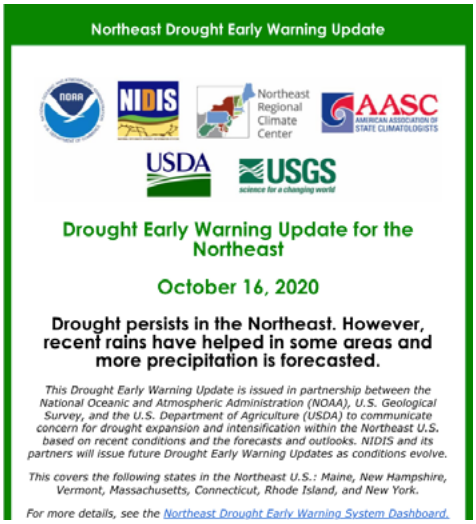
DROUGHT INTERDISCIPLINARY RESEARCH AND APPLICATIONS

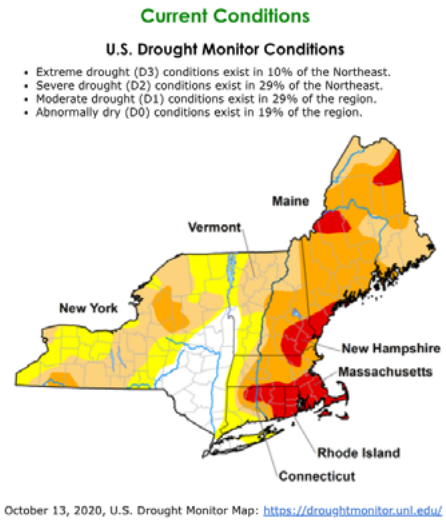
Regional and state decision support information portals are under development. These portals are customized to each state's needs but serve as programming templates for expanded distribution of drought data sets.

Plans to expand the coverage of coastal salinity gauges maintained by the USGS and National Estuarine Research Reserves will be explored. The northeast will benefit from research on the Coastal Salinity Index as it applies to the understanding of salt water intrusion and coastal fresh water supplies impacted by drought.

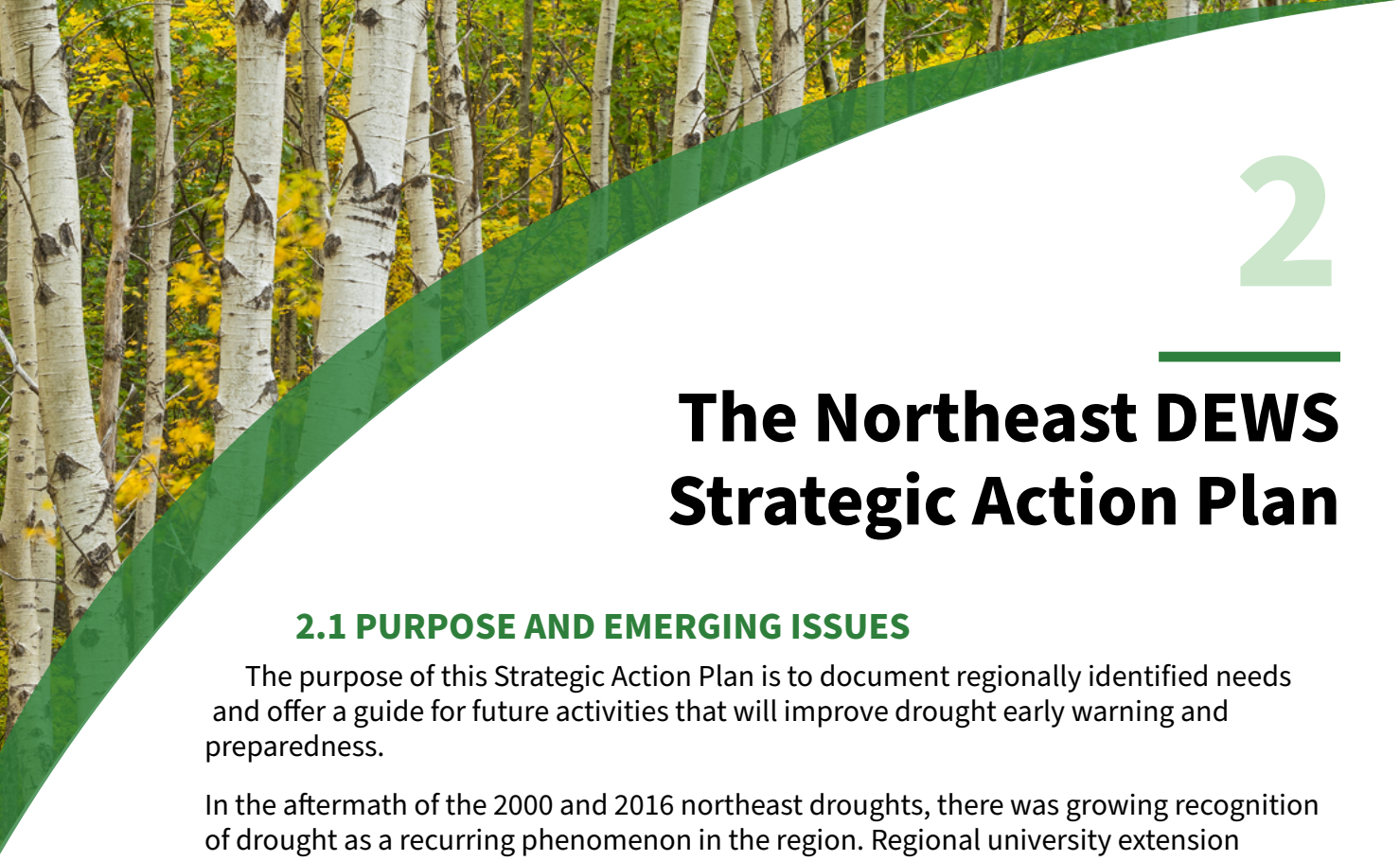
A NIDIS funded collaboration between the Desert Research Institute, University of Colorado, and Cornell University, worked to identify the most effective drought indicators for hydrologic and agricultural drought monitoring in the Northeast. This included the identification of appropriate time scales related to long-term and short-term drought and indicators of flash drought development. This research was completed in the fall of 2021.

Another NIDIS-funded multi-year study underway at the University of Massachusetts, Lowell, looks at the causes of Northeastern heat waves and droughts and how they interact. This research will be completed in 2023.





Screenshots of a *Northeast Weekly Drought Update* on October 13th, 2020.



2

The Northeast DEWS Strategic Action Plan

2.1 PURPOSE AND EMERGING ISSUES

The purpose of this Strategic Action Plan is to document regionally identified needs and offer a guide for future activities that will improve drought early warning and preparedness.

In the aftermath of the 2000 and 2016 northeast droughts, there was growing recognition of drought as a recurring phenomenon in the region. Regional university extension services provided support to the farming community on drought mitigation techniques. Some producers introduced irrigation equipment for crops that previously needed little assistance to maintain good soil moisture. State drought management committees supported producers applying for USDA/FSA disaster assistance loans to recover from drought losses. NE DEWS states also developed and refined comprehensive drought management plans that contained local criteria for mitigation actions. Most recently, many of these plans have become a part of state climate adaptation strategies.

In October and November of 2020, partners from across the NE DEWS attended virtual listening sessions to discuss their drought information needs and next steps for the region. The topic was fresh on the minds of all participants because the region was experiencing drought for the 3rd time in a period of less than twenty years. Meteorological drought appeared in June 2020. Extreme drought (D3) had taken hold in several areas by early fall with wildfire, agricultural, and hydrological impacts evident.

Conditions improved over the winter of 2020 to 2021 with the elimination of extreme drought in early December. Abnormally dry (DO) and moderate drought conditions (D1) persisted in some areas. Surface and groundwater reports showed some improvement with spring rainfall, but concerns remained for summer and the potential for warmer than normal temperatures. Severe drought (D2) returned by mid-summer and validated the need for continued monitoring and improvements to decision support processes.

Through the progress of events over the time period described above, drought has emerged as an issue that will require continuous monitoring in the northeast US. The priorities identified during the five listening sessions of 2020 were supplemented by numerous one-on-one conversations and information gathered from partners and stakeholders. Many of these same partners and stakeholders met in October 2021 to share lessons learned, and validated the five key priorities for this strategic action plan.

2.2 KEY PRIORITIES FOR 2022–2026

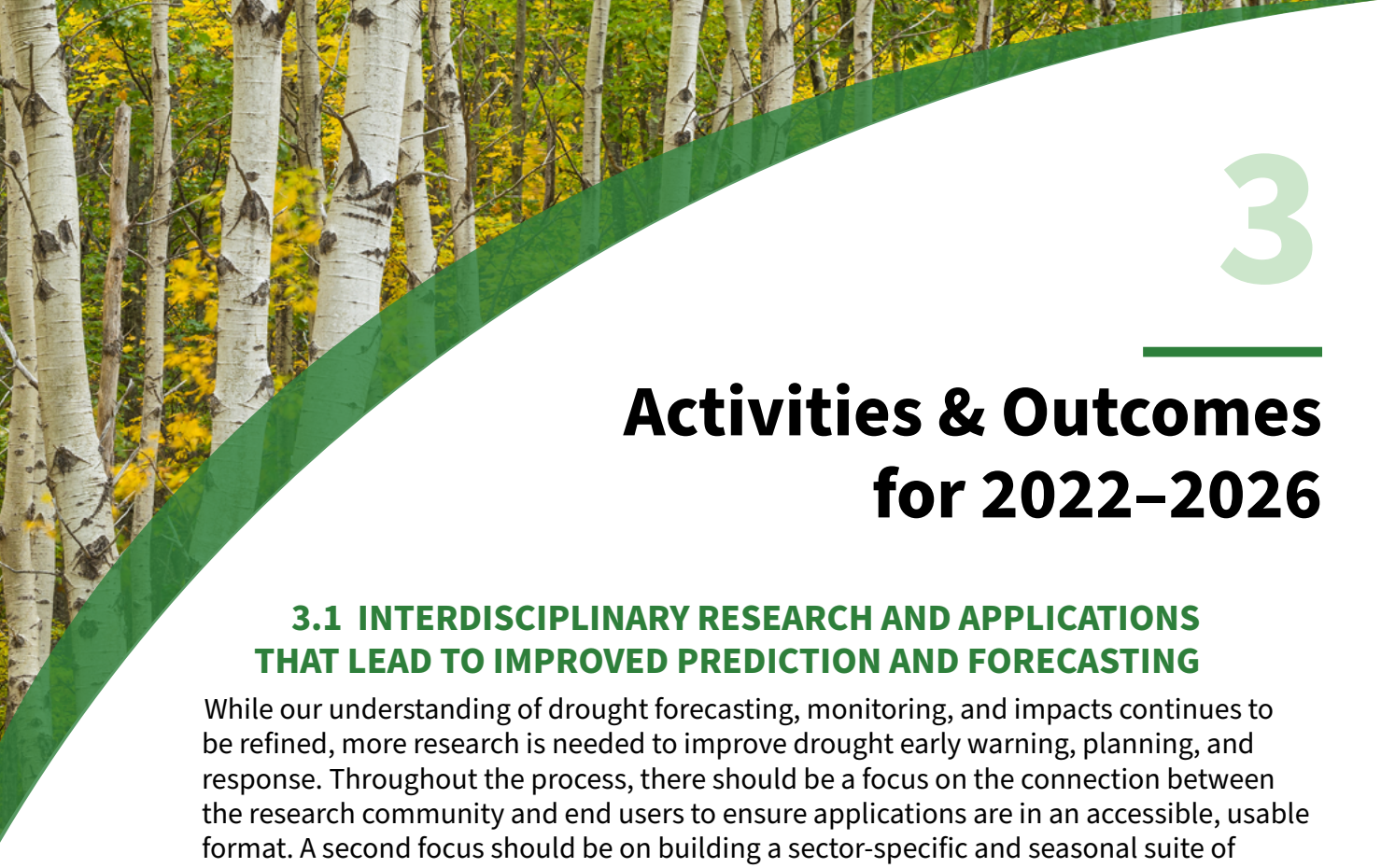
- Continue to build a **comprehensive understanding of drought indicators/indices** used in the Northeast, to better demonstrate their value, limitations, business sector relevance, seasonal and geographical application.
- Expand **drought observations** (such as monitoring dry wells and soil moisture conditions) and **utilize data sets** (such as snow survey data) that can help build a robust drought impact reporting system. This system should include a citizen science information component and contribute to a regional-scale response framework.
- Expand **partnerships with diverse stakeholders**, such as local and federal emergency management agencies, Tribal nations, and the private sector, to more effectively build drought resilience and drought response resources across sectors and communities.
- Improve **collaboration, coordination, and communication among partners** in the NE DEWS network to support information-sharing.
- To support the **drought planning and plan evaluation cycle**, increase opportunities for planners to share drought-related lessons learned both within and across the DEWS, sectors, tribal, state, and local agencies.

Hudson River valley, New York. Credit: Songquan Deng

2.3 UPDATE CYCLE AND PROCESS

This Strategic Action Plan covers four years, with the option of extending to an additional year if the partners agree that the priorities and activities are still relevant, and serve the NE DEWS. The plan is considered a living document, and the need for continuous review and refinement is recognized. A “change log” will be maintained to track updates for plan revisions.

As a part of the plan review cycle, annual meetings within the NE DEWS will focus on drought related lessons learned and cross DEWS applications including feedback from various business sectors, tribal, state, and local agencies.



3

Activities & Outcomes for 2022–2026

3.1 INTERDISCIPLINARY RESEARCH AND APPLICATIONS THAT LEAD TO IMPROVED PREDICTION AND FORECASTING

While our understanding of drought forecasting, monitoring, and impacts continues to be refined, more research is needed to improve drought early warning, planning, and response. Throughout the process, there should be a focus on the connection between the research community and end users to ensure applications are in an accessible, usable format. A second focus should be on building a sector-specific and seasonal suite of drought indicators/indices best suited to the Northeast. Multi-decadal indicators are also needed for long term planning and climate change policy development.

An old stone grist mill in Massachusetts. Credit: Keith J. Finks

1.1 Outcome: Streamflow forecasts are strengthened to improve lead time and accuracy.

1.1a Activity: Support research that will investigate the applicability of stream flow and watershed forecasting techniques from other DEWS while shepherding regionally specific streamflow forecasting techniques into active research.

1.1b Activity: Continue to engage regional river basin associations (e.g., the Susquehanna River Basin Commission and the Delaware River Basin Commission) to understand their needs for predictive stream flow tools.

1.1c Activity: Ensure that water use data (withdrawals for agricultural, industrial, and human needs) are integrated into predictive models so that regional flow forecasts can be improved.

1.2 Outcome: Research and application development opportunities are co-funded through strong regional partnerships.

1.2a Activity: Develop a relationship with the US Army Corps of Engineers (USACE) offices in the Northeast and support research projects related to the retention of excess water for use during periods of drought.

1.2b Activity: Work with reservoir management agencies and utilities to identify their needs for research and tools that support long term (multi-decadal) decision making.

1.3 Outcome: The appropriate suite of early warning data, indices, prediction tools and other long range outlooks are available to decision makers in formats, scales and visualizations that are user validated.

1.3a Activity: Work with the NRCC and wildfire management partners to develop a regional Keetch-Byram Drought Index that can be updated at least weekly, to address forest fire potential.

1.3b Activity: Determine whether the Coastal Salinity Index (CSI) will be helpful to water managers, fisheries managers, and ecologists and if the onset and impacts of drought in Northeastern coastal communities and ecosystems can be predicted by monitoring the CSI. If determined useful, support the expansion of coastal salinity monitoring sites.

1.3c Activity: Support improvements to the Evaporative Demand Drought Index and increase the understanding of its use in the NE DEWS.

1.3d Activity: Investigate the development of a National Weather Service drought "watch" statement. This advisory would alert the public that water conservation actions may be needed within the next few weeks to a month.

Northeast Regional Climate Center. Credit: Cornell University

3.2 OBSERVATIONS AND MONITORING

In order to improve drought early warning and our knowledge of current conditions, we need to increase the variety of drought related data sets and the data density. These data sets should include a robust drought impact reporting and analysis system that promotes citizen science, echoes the concept of water value and addresses local needs. The focus should be on the expansion

of the data available on the NE DEWS dashboard and ensuring the data is available to the widest possible audience.

2.1 Outcome: Snow survey data sets are developed and made available within the region.

2.1a Activity: Work with the NWS in Gray, Maine and Plymouth State University to ensure that the expanded snow survey data set is archived at the NRCC and made widely available to users in several formats—including mapped products.

2.1b Activity: Identify opportunities to use the snow survey data in western snow-to-flow models for water availability. The outcomes of these models may indicate the need to develop models specifically for the Northeast.

2.1c Activity: In addition to the general snow survey data set, support the development of timelines that allow for the identification of analog drought years or climate shifts.

2.2 Outcome: Provide DEWS partners with standards and protocols for sensors and point data collection for new stations and soil moisture networks as a part of the NIDIS National Coordinated Soil Moisture Monitoring Network.

2.2a Activity: Support the efforts of Tribal Nations and community groups that wish to install and maintain observation sites under citizen science methodologies.

2.2b Activity: Support the efforts of regional colleges and universities to install and maintain observation sites that also provide hands-on opportunities for student research in agricultural and ecological sectors.

2.3 Outcome: Dry Well reports, reservoir status, and other water utility decision support data sets are routinely collected and displayed on state and regional dashboards.

2.3a Activity: Develop ArcGIS applications that visualize the dry well reports in relation to USGS groundwater reporting sites and other key data layers (watersheds, crop production areas, forests, etc.)

2.3b Activity: Work with states and water management utilities to routinely update reservoir status information and then map the data on state and regional scales.

2.4 Outcome: Satellite and drone imagery are collected and correlated to ground network observations to begin the determination of whether or not these data can monitor plant life and wildfire potential.

2.4a Activity: Identify and query the appropriate agencies needed to collaborate on the correlation of satellite imagery to surface and groundwater observations with the goal of monitoring crop health.

2.4b Activity: Identify and query the appropriate agencies needed to collaborate on the use of satellite and drone imagery to visualize wildland fire potential in the NE DEWS.

Doubling Point lighthouse, with its wooden bridge or walkway leading to the tower. Kennebec River, Maine. Credit: Allan Wood

3.3 OUTREACH

The NE DEWS seeks to develop a robust and active network of partners across all sectors and at all levels of government in the effort to build early warning capacity. Expanded partnerships with local and federal emergency management agencies, Tribal nations, and the private sector will improve the coordination of drought mitigation efforts and preparedness. Developing relationships with professional societies like the American Meteorological Society and the American Association of State Climatologists will leverage our stakeholder development. Most importantly, the outcomes and activities identified here are key to the improved regional communications and education efforts described in this plan.

3.1 Outcome: Private sector partners are identified and involved in drought mitigation and management.

3.1a Activity: Given the unique vulnerabilities of small and medium sized water utilities to drought conditions, establish a regular dialogue and identify partnership and support opportunities.

3.1b Activity: Develop relationships with hydropower producers to understand their needs for drought data and forecasts.

3.2 Outcome: The NIDIS Tribal Engagement Strategy is implemented in the NE DEWS.

3.2a Activity: Continue to identify tribal partners and define their drought information needs within the context of their ideologies.

3.2b Activity: Support drought planning, preparedness and mitigation efforts within the United South and Eastern Tribes, Inc., Office of Environmental Resource Management alongside EPA Region I, and other federal agencies. Support efforts to mitigate drought impacts on water quality and quantity on tribal lands in the Northeast.

3.3 Outcome: Local, state and federal Emergency Management agencies have expanded access to drought planning tools, as well as exercise materials and workshops to enhance preparedness, mitigation capabilities, and community resilience.

3.3a Activity: Develop workshops on drought, drought forecasts, and indices as components of regional, state, and local emergency management conferences.

3.3b Activity: Develop a library of editable educational materials on water conservation. Some of these materials could be interactive teaching tools that are available on drought.gov.

3.3c Activity: Promote the use of interactive ArcGIS maps from the Drought.gov portal. Highlight selected data layers for download and overlay onto the proprietary maps of critical infrastructure maintained by utilities, states, and other agencies.

3.4 Outcome: Established partnerships with the broadcast media, American Meteorological Society (AMS), NWS Weather Ready Nation (WRN) Ambassador program and/or environmental interest groups to educate the public about drought.

3.4a Activity: Establish a relationship with the AMS, Teacher Professional Development Program office to work toward the development of drought education modules. Use the NE DEWS as a pilot region.

3.4b Activity: Leverage NIDIS's partnership with the WRN program to develop drought preparedness modules, utilizing the NE DEWS as a pilot region.

3.4c Activity: Promote Drought.gov resources to media outlets, regional and national environmental interest groups, and others who have a platform suitable for drought information distribution.

Boston, Massachusetts. Credit: f11photo

3.4 COMMUNICATIONS AND EDUCATION

Strong vertical and horizontal communications channels build a matrix that supports collaboration and resilience. The NE DEWS seeks to expand and strengthen communications between researchers and end users, government and citizen scientists, businesses and environmental interest groups—among others. The communication of drought status information, drought forecasts,

and outlooks not only creates awareness but also broadens the pathway to resilience. This is especially true when that pathway is paved with drought education materials and shared learning opportunities.

4.1 Outcome: Expanded access to drought status information and updates for the region.

4.1a Activity: Support the wider distribution of NWS forecast office drought information statements and River Forecast Center products on the NE DEWS dashboard.

4.1b Activity: In partnership with local weather and climate information providers, continue the NE DEWS drought status updates as appropriate based on drought conditions.

4.2 Outcome: State drought management committees experience regional situational awareness and collaborate on common messaging elements.

4.2a Activity: Develop and share talking points on drought status from the regional perspective.

4.2b Activity: Help states explore the use and effectiveness of a variety of communication tools to convey drought status and hazards, especially when drought is likely to worsen. These may include, but are not limited to, electronic notice boards, social media and email alerts, hazard advisory text messaging, and variable road signage.

4.2c Activity: Prepare standard messaging that addresses state-to-state differences in drought status language or depiction conflicts with the US Drought Monitor.

4.3 Outcome: Improved public education campaigns centered on climate literacy and drought awareness.

4.3a Activity: Build on existing campaigns or develop education materials that teach the value of water in times of abundance and in times of drought. Collaborate with conservation groups in this effort.

4.3b Activity: Expand the use of NCEI products that show how much precipitation it will take to ameliorate the drought.

4.3c Activity: Work with the NIDIS digital communications team to develop a “text to audio” capability for Drought.gov. Similarly, consider a language translation feature for the web site.

3.5 PLANNING AND PREPAREDNESS

An increase in the ability to share planning, preparedness, and mitigation guidance both within and across DEWS, business sectors, tribal, state, and local agencies is key to drought resilience. Emphasis should be placed on drought planning as part of a detailed all-hazard planning process that references decision support tools and gives consideration to impact disparities, environmental justice concerns, and economic implications.

New York dairy cows. Credit: Camera Obscura

5.1 Outcome: The Drought Planning Platform is built, hosted on drought.gov, and supports NE DEWS stakeholders in their drought planning and plan revision processes.

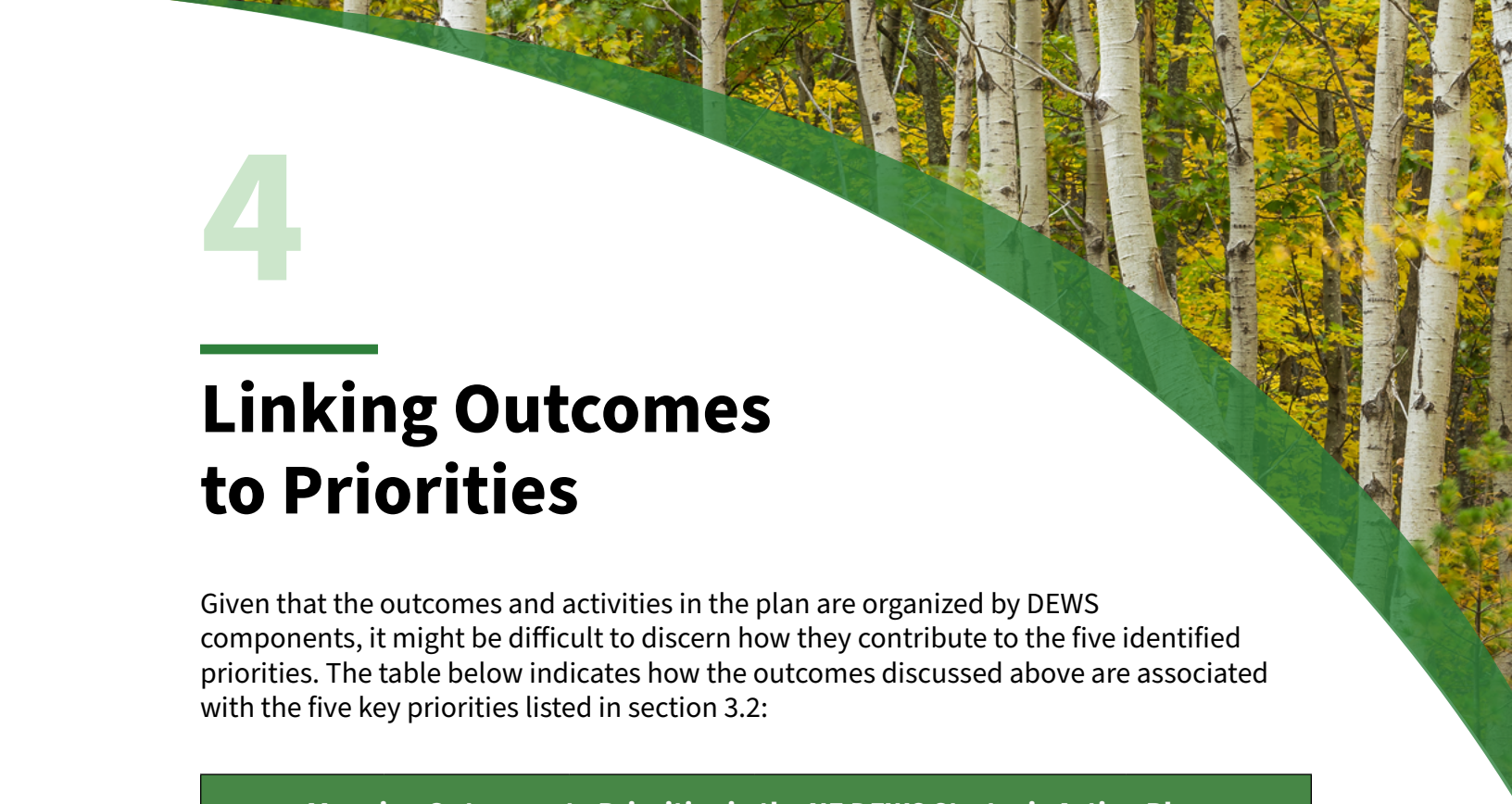
5.1a Activity: Support drought plan review and improvement efforts at all levels. Demonstrate how agencies can connect drought monitoring and mitigation strategies to standard operating procedures as well as broader climate adaptation plans and policies.

5.1b Activity: Support the development of a lessons learned section on the Drought.gov Planning and Preparedness page. Routinely identify and share regionally significant lessons learned with NE DEWS partners.

5.1c Activity: Investigate the use of the Climate Resilience Toolkit to encourage planning considerations related to vulnerable and environmentally disadvantaged populations.

5.2 Outcome: Drought/water availability are considered in infrastructure, zoning, and development planning.

5.2a Activity In partnership with regional climate information providers, develop a dialogue with regional, town and rural planners and planning associations to promote the awareness of drought tools and indices in land use and resource protection.



4

Linking Outcomes to Priorities

Given that the outcomes and activities in the plan are organized by DEWS components, it might be difficult to discern how they contribute to the five identified priorities. The table below indicates how the outcomes discussed above are associated with the five key priorities listed in section 3.2:

Mapping Outcomes to Priorities in the NE DEWS Strategic Action Plan					
OUTCOME	PRIORITY 1	PRIORITY 2	PRIORITY 3	PRIORITY 4	PRIORITY 5
1.1	X				
1.2	X		X		
1.3	X	X	X	X	
2.1		X	X		
2.2		X	X	X	
2.3	X	X	X	X	
2.4	X	X			
3.1			X	X	
3.2			X	X	
3.3			X	X	
3.4			X	X	
4.1			X	X	
4.2				X	
4.3			X	X	
5.1				X	X
5.2			X	X	X

Snow cover over North America in early winter 2001. Credit: NASA MODIS

5 Linking National & Cross-DEWS Initiatives

NIDIS has implemented regional DEWS as the foundation on which to provide national drought early warning in recognition that impacts and early warning information differ across the regions. While each DEWS has the same basic ingredients, they ultimately have their own flavor and reflect the needs of the regions. That said, there are challenges that cross multiple regions or require a coordinated effort at the national level. This includes challenges like accessibility to data and maps for the visually impared or content translations to other languages. Other large-scale challenges include the complex interactions of drought and wildland fire, drought and human health, tribal engagement, drought impact reporting and analysis, linking drought triggers and indicators, the NIDIS Coping with Drought grant program, and soil moisture monitoring. The regional DEWS have the ability to tap into these larger initiatives where there is interest and need, again providing an opportunity for cross regional and scalable (regional-to-national) learning and progress. This table illustrates some of these linkages as they apply in the NE DEWS.

National/Cross-DEWS Initiatives	Northeast DEWS Activities
Drought and Human Health	NIDIS is engaged in developing a Drought and Human Health Strategy. There are opportunities to hold regional workshops on the topic. NIDIS has also partnered with the Heat Risk Team of the Climate Program Office to identify and understand connections between drought events and Urban Heat Island events.
Drought Impact Reporting and Analysis	NIDIS works with NDMC and the National Drought Impact Reporter to improve reporting and use of print and social media reports of drought. In several NE DEWS states dry well reports have been a particular focus. Efforts to collect well reports during drought episodes will continue with an eye toward regional data sharing and analysis. Activities 2.3a, 2.3b will contribute to this national effort.
Improving Indicator Use and Linking to Triggers	A common refrain from partners across the DEWS is the desire to better understand which indicators and indices should be used for a region/state both spatially and temporally as well as for different sectors. There are efforts within the NE DEWS as well as nationally with the Desert Research Institute, NDMC and internationally with the Commission on Environmental Cooperation (CEC) to contribute answers to these questions. Deliberate efforts to share learning across these initiatives will hopefully accelerate this work.
National Drought Forum	The National Drought Forum held in 2019 resulted in ten priority actions, many of which are reflected in this plan. These include, but are not limited to, improvement of flash drought forecasts, enhancements to observations, monitoring, and decision support tools, better quantification of drought impacts, and ecosystem restoration to mitigate drought impacts. The synergies between priorities at the regional and national level should amplify our progress in addressing these complex challenges.
Tribal Engagement Strategy	There are many similarities in the gaps and needs in the NE DEWS, whether the recipient of the information and services be a tribal nation or a state or community. By considering the principles of engagement that are enumerated in the Tribal Engagement Strategy and engaging the tribal nations in the Northeast, many drought mitigation outcomes in the NE DEWS Strategic Action Plan will be realized. Activities 2.2a, 2.2b, 3.2a. 3.2b will provide a regional application to these national initiatives.

National/Cross-DEWS Initiatives	Northeast DEWS Activities
Weather Research and Forecasting Innovation Act of 2017 (Weather Act)	The Weather Act calls for NOAA to prioritize weather research in part to improve forecasts and warnings for protection of life and economy, to improve understanding of forecast capabilities for atmospheric events and their impacts, and to make reliable and timely foundational forecasts of subseasonal (2 weeks to 3 months) to seasonal (3 months to 2 years) forecasts of temperature and precipitation. While there are many other initiatives included in the Weather Act, these are the areas in which NIDIS also has a strong interest—in terms of drought early warning. NIDIS is making and leveraging investments in regards to the same temporal scale as they apply to drought in partnership with the NWS regional and local forecast offices, the Climate Prediction Center (CPC), and the Office for Oceanic and Atmospheric Research (OAR). Activities 2.1a, 3.4b and 4.1a offer a regional perspective on these national initiatives.
Water Prediction Center/ NOAA Water Initiative	NOAA has multiple efforts aimed at water security that NIDIS plays a role in. The Water Initiative aims 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. NOAA will advance this mission primarily through transforming integrated water prediction services in collaboration with decision makers, partners, and users. In addition the Water Prediction Center focuses on collaborative research to inform essential emergency management and water resources decisions across all time scales. NIDIS is involved in efforts to enhance drought prediction and monitoring, looking at applications of the National Water Model to drought early warning and serving as part of these initiatives where they intersect with drought.
National Coordinated Soil Moisture Monitoring Network	There is a clear need in the NE DEWS to fill gaps in the spatial coverage of soil moisture sensors. There is also a need to diversify monitoring sites to include forested environments. The NCSMMN strategy addresses these needs and prioritizes work that will integrate soil moisture data into fire potential indices.
NIDIS Coping with Drought	NIDIS uses the Coping with Drought federal funding opportunity to address research needs gathered through the consultative process within the DEWS. The outcomes of applied research funded through the CWD program will be transferred to the DEWS. For example, the FY20 competition is focused on indicators, impacts, and triggers which aligns with priorities 1 and 2 for this region.

5.1 LINKAGES TO REGIONAL PARTNERS AND INITIATIVES

Spring runoff at Quechee Gorge in Vermont. Credit: Ken Rhodes

NIDIS has a mandate to work across the federal government, coordinating drought related activities with other federal agencies, and to build upon and leverage existing partnerships, networks, and initiatives. This is especially important in the regional DEWS where these partners and regional organizations are key to realizing success in the region. In the NE DEWS, key regional partners include the Northeast Region Climate Center, USGS New England Water Science Center, USDA Northeast Climate Hub, the National Drought Mitigation Center, Northeast EPA Region 1, and the Eastern Region Climate Services Director.

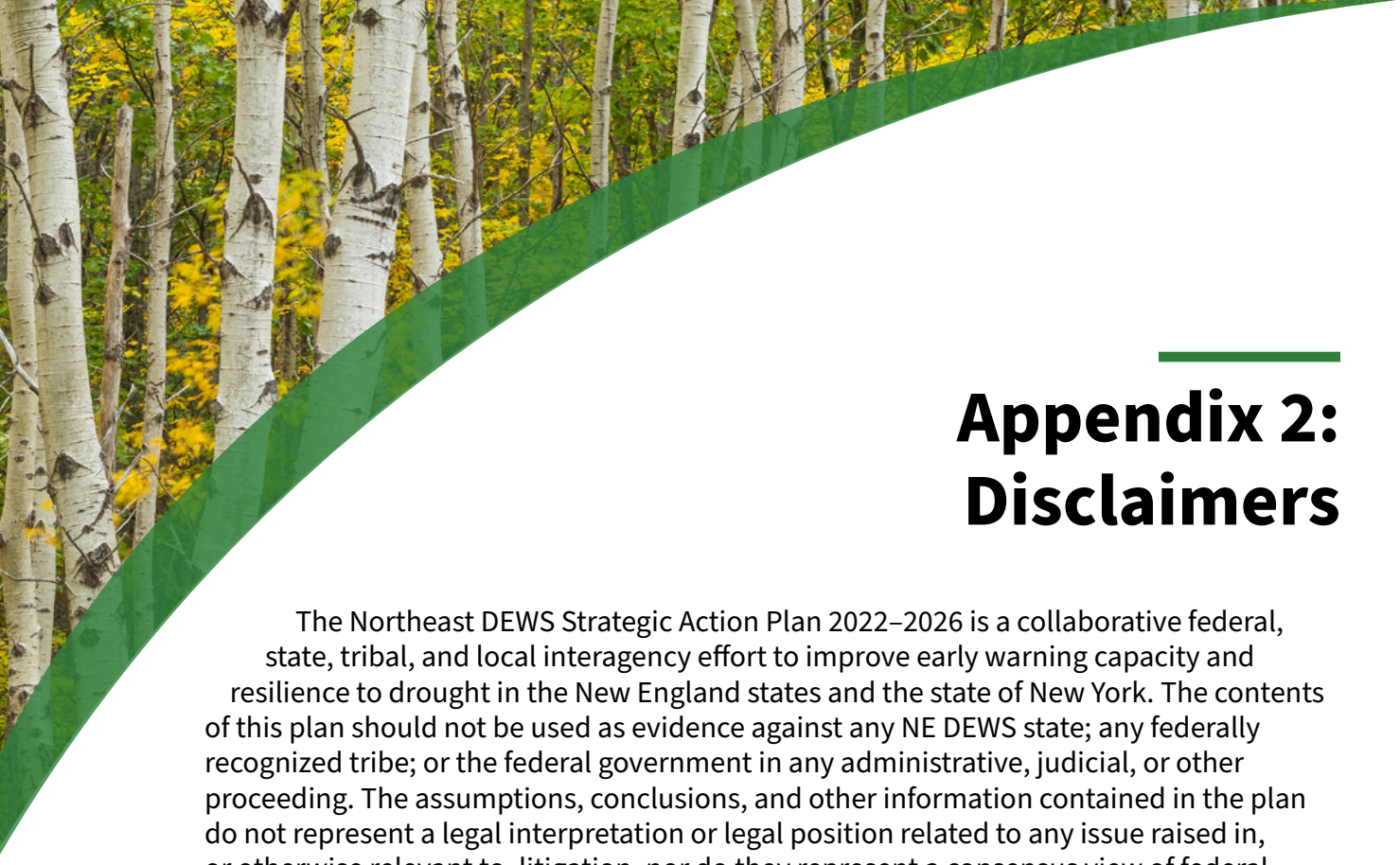
The activities listed in this plan point to many places where linkages are being made with these regional partners and programs. These linkages have been key to past progress and will continue to be key moving forward. Additional partners, programs, assistance, and activities offer additional beneficial linkages that can be developed and built upon to increase efficiency and effectiveness.

Appendix 1: Partners

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

Partner Agencies and Organizations
FEDERAL AGENCIES
US Environmental Protection Agency | Region 1 ***Federal Emergency Management Agency | Region I*** ***NOAA | National Weather Service*** ***NOAA | National Centers for Environmental Information*** ***NOAA | Office of Oceanic and Atmospheric Research*** ***NOAA | Fisheries*** ***USDA | Agricultural Research Service*** ***USDA | Farm Service Agency*** ***USDA | Natural Resources Conservation Service*** ***USDA | Northeast Climate Hub*** ***National Drought Mitigation Center (NDMC)***
REGIONAL AGENCIES/ORGANIZATIONS
Northeast Climate Adaptation Science Center ***Northeast Regional Climate Center*** ***Wildland Fire Executive Council | Northeast Regional Strategy Committee***

Partner Agencies and Organizations
RESEARCH & ACADEMIC AGENCIES/ORGANIZATIONS
Cornell University ***National Drought Mitigation Center*** ***University of Massachusetts Boston*** ***University of Massachusetts Extension*** ***University of Massachusetts Lowell*** ***University of New Hampshire***
STATE CLIMATOLOGISTS
Connecticut State Climate Center ***Maine State Climate Office*** ***Vermont State Climate Office***
STATE, LOCAL, AND TRIBAL AGENCIES/ORGANIZATIONS
City of Worcester | Public Works and Parks ***Connecticut Department of Public Health*** ***Connecticut Department of Energy and Environmental Protection*** ***Maine Department of Environmental Protection*** ***Maine Emergency Management Agency*** ***Massachusetts Division of Fisheries and Wildlife*** ***Massachusetts Executive Office of Energy and Environmental Affairs*** ***Massachusetts Water Resources Authority*** ***New York City Department of Environmental Protection*** ***New York State Water Resources Institute*** ***United South and Eastern Tribes, Inc.***



Appendix 2: Disclaimers

The Northeast DEWS Strategic Action Plan 2022–2026 is a collaborative federal, state, tribal, and local interagency effort to improve early warning capacity and resilience to drought in the New England states and the state of New York. The contents of this plan should not be used as evidence against any NE DEWS state; any federally recognized tribe; or the federal government in any administrative, judicial, or other proceeding. The assumptions, conclusions, and other information contained in the plan do not represent a legal interpretation or legal position related to any issue raised in, or otherwise relevant to, litigation, nor do they represent a consensus view of federal agencies or other stakeholders involved in the plan's development or implementation. The plan is not intended as an attempt to resolve any particular dispute within the NE DEWS. Nothing in the plan is intended to, nor shall the plan be construed so as to, interpret, diminish, or modify the rights of any NE DEWS state, any federally recognized tribe, or the federal government under federal or state law or administrative rule, regulation, or guideline.

Finally, all parties recognize that partners participating in this process may disagree over the appropriate scope, methods, results, or interpretation of technical analyses performed in developing or implementing this DEWS. As such, neither the plan, nor any work performed pursuant to it, shall be attributed to any organizations or individuals by virtue of their participation as a partner in this process. Nor shall any party be deemed to accept or agree with any assumption, conclusion, and other information contained in the plan or its resulting studies, unless explicitly stated by those parties.

The efforts of many NE DEWS partners in the shaping and review of this plan are greatly appreciated. The continued participation of diverse partners who are impacted by drought is critical to proactive drought risk mitigation and management in the Northeast region.

Document prepared by NIDIS in partnership with key stakeholders in the region.