DRY TIMES

NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM NEWSLETTER

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Fire without rain

Exploring the drought-wildfire nexus in the West

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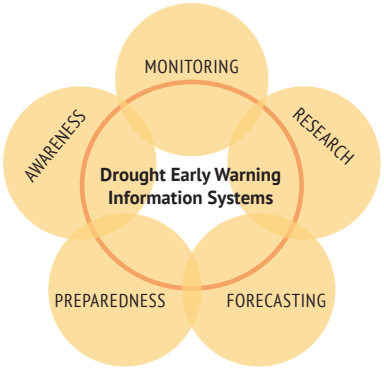


Inside this edition

On the cover

Aftermath of the Mad River Complex fire, Mad River, California, taken in November 2015. Andrew Williams photo. http://www.awilliamsmedia.com/ Learn more about this fire: http://inciweb.nwcg.gov/incident/4436/ and http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=86486

Drought.gov features new navigation, design, content

BY KATHLEEN BOGAN / NIDIS

On April 6, a new look, new navigation and some new features debuted on the U.S. Drought Portal. Over the years, the Portal has undergone seven iterations in response to user feedback.

Some of the motivations behind the most recent change included:

- Simplified navigation, through clearer labeling and more pathways to get to different parts of the site
- Higher prominence for information on regional NIDIS Drought Early Warning Systems
- More filters for the search tools
- Responsive design (contents realign according to screen size)

A new FAQs page (https://www.drought.gov/drought/faqs), together with the enhanced search tools, helps new and returning users find specific information.

A research team from CIRES is conducting usability testing on the revised site, with a report due in the latter half of 2016. NIDIS will use feedback from the testing to help determine future development priorities on the site. After a demonstration of the new site, attendees at the NIDIS Working Group meeting in April (see story on next page) offered some ideas on how to further enhance www.drought.gov:

- Reduce the number of headings/topics on the home page.
- It takes time to find information. Simplify!
- Add Tribal land resources
- Include recent publications from various contributors and/or those who are consuming/using the information.
- Add the ability to bookmark pages on the site that are used frequently and display them in a list on one margin.

Your thoughts are welcome as well. E-mail Kathleen.bogan@noaa.gov with comments.

What's next for NIDIS

Working Groups eye upcoming milestones

BY KATHLEEN BOGAN / NIDIS

Co-chairs of the six NIDIS Working Groups gathered in Lincoln, Nebraska, at the end of April, to take a critical look at the 2007 NIDIS Implementation Plan and begin envisioning ways to update the document. NIDIS and the National Drought Mitigation Center hosted the meeting, which included representatives of the Drought Early Warning Systems (DEWS) as well as the Chairs and other NIDIS partners.

Since its inception in 2006 through Congress' creation of Public Law 109-430, NIDIS has been growing into its ultimate goal: to provide "an effective drought early warning system" for the United States. The 34-page Implementation Plan outlines the goals and tasks of NIDIS, as they were seen in 2007. Since then, NIDIS has organized ten regional DEWS, which are the building blocks of the national system anticipated by Congress; developed the U.S. Drought Portal, drought.gov; provided support for drought research and assessment through multiple initiatives; and undertook other interagency efforts at drought planning, forecasting, assessment, and impact reduction. (For an overview of NIDIS' accomplishments during its first five years, see the NIDIS Report to Congress 2016, https://www.drought.gov/drought/sites/drought.gov.drought/files/media/whatisnidis/Documents/rpt_FINAL_NIDIS%20CongReport_Jan2016.pdf .

Meeting participants discussed the potential goals, priorities and scope of NIDIS activities in the next few years, and efforts necessary for accomplishing those goals. The Working Groups will be revising the language in the plan to reflect the lessons learned since 2007 and to set targets for future activities.

Puneet Srivastava, Director of the Water Resources Center at Auburn University in Alabama, makes a point at the working group meeting in Lincoln, Nebraska, on April 26.

NIDIS Working Groups

The six NIDIS Working Groups help to coordinate activities in their areas of expertise. These groups and their co-chairs are:

PREDICTION AND FORECASTS

Hailan Wang, NASA

Jon Gottschalck, National Weather Service Climate Prediction Center

OBSERVATIONS AND MONITORING

Dennis Todey, South Dakota State Climatologist, SD State University

Art Degaetano, Northeast Regional Climate Center, Cornell University

INTERDISCIPLINARY RESEARCH AND APPLICATIONS

Mark Shafer, Southern Climate Impacts Planning Program, University of Oklahoma

Matt Rollins, U.S. Forest Service

DROUGHT PORTAL

Mike Brewer, NOAA/National Centers for Environmental Information (NCEI)

Kelly Smith, National Drought Mitigation Center at the University of Nebraska-Lincoln

Kathleen Bogan, NOAA/NIDIS

ENGAGING PREPAREDNESS COMMUNITIES

Deborah Bathke, National Drought Mitigation Center

Beth Freeman, Federal Emergency Management Agency (FEMA)

Kirsten Lackstrom, Carolinas Integrated Sciences and Assessments; University of South Carolina

PUBLIC AWARENESS AND EDUCATION

Doug Kluck, NOAA/National Centers for Environmental Information (NCEI)

Jim Angel, Illinois State Climatologist

President outlines goals for National Drought Resilience Partnership

White House makes drought a priority, sets goals for coping

BY NIDIS STAFF

On March 21, President Obama issued the Memorandum and Action Plan, "Building National Capabilities for Long-Term Drought Resilience." These documents discuss in detail the role of the National Drought Resilience Partnership (NDRP), a team of federal agencies, to help communities manage the impact of drought. The NDRP seeks to link information, such as forecasts and early warnings, with drought preparedness strategies in critical sectors like agriculture, municipal water systems, tourism, and transportation.

Since 2007, NIDIS' work on drought information, mitigation, planning and recovery has helped develop the groundwork for the NDRP. NIDIS' networks of government agencies and organizations within its regional Drought Early Warning System initiatives, its drought outlook events and forums, and its online portal to drought data and information, drought.gov, provide many building blocks for the NDRP. NIDIS continues to work across agencies and sectors to link drought monitoring, forecasting, and early warning with risk planning and management. President Obama signed the reauthorization of the NIDIS Act in 2014, commending Congress for passing bipartisan legislation to ensure timely, effective drought early warning.

The Department of Agriculture is to provide funding and administrative support for the NDRP. Agencies included in the Partnership are the Department of Defense; Department of the Interior; the Department of Agriculture; the Department of Commerce; Department of Energy; Department of Homeland Security; Environmental Protection Agency; Office of Management and Budget; Office of Science and Technology Policy; National Economic Council; Council on Environmental Quality; National Security Council staff; the Army; and others as partnership members may deem appropriate. Co-

continued on next page

For more information on the NDRP

- About the National Drought Resilience Partnership https://www.drought.gov/drought/what-nidis/national-drought-resilience-partnership
- The Presidential Memorandum, issued March 21, 2016 https://www.whitehouse.gov/the-press-office/2016/03/21/presidential-memorandum-building-national-capabilities-long-term-drought
- The Action Plan (pdf) https://www.whitehouse.gov/sites/default/files/docs/drought_resilience_action_plan_2016_final.pdf
- Overview of the White House drought campaign resources https://www.whitehouse.gov/campaign/drought-in-america

Chairs of the NDRP are to be the Secretary of Agriculture (or designated representative) and Co-Chair, starting with the Secretary of Commerce and rotating among the agencies every two years thereafter.

The President's Action Plan lays out these goals for the NDRP, to be undertaken in Fiscal Year (FY) 2016 or FY 2017, intended to help build national drought-resilience capabilities. The actions will be carried out using existing resources and under existing authorities. The goals are:

1. **Data Collection and Integration**
   Objective: Agencies shall share data and information related to drought, water use, and water availability, including data on snowpack, groundwater, stream flow, and soil moisture with State, regional, Tribal, and local officials to strengthen decision making to support more adaptive responses to drought and drought risk.
2. **Communicating Drought Risk to Critical Infrastructure**
   Objective: Agencies shall communicate with state, regional, tribal, local, and critical infrastructure officials, targeted information about drought risks, including specific risks to critical infrastrucutre
3. **Drought Planning and Capacity Building**
   Objective: Agencies shall assist State, regional, tribal, and local officials in building local planning capacity for drought preparedness and resilience.
4. **Coordination of Federal Drought Activity**
   Objective: Agencies shall improve the coordination and integration of drought-related activities to enhance the collective benefits of Federal programs and investments.
5. **Market-Based Approaches for Infrastructure and Efficiency**
   Objective: Agencies shall support the advancement of innovative investment models and market-based approaches to increase resilience, flexibility, and efficiency of water use and water-supply systems
6. **Innovative Water Use, Efficiency, and Technology**
   Objective: Agencies shall support efforts to conserve and make efficient use of water by carrying out relevant research, innovation, and international engagements.

WEBINARS: Keep up with conditions in your area

Several of NIDIS' partner organizations offer regular live reports on drought conditions in their regions, through webinars. Upcoming and past webinar listings are at https://www.drought.gov/drought/calendar/webinars. Sign up for future events, or view past sessions:

Upper Colorado River Basin Webinar

The Colorado Climate Center conducts Climate, Water and Drought Assessment briefings detailing events in the basin states of Colorado, Utah, and Wyoming. To register, please visit: http://ccc.atmos.colostate.edu/drought_webinar_registration.php

Water Supply Briefings for the Eastern Great Basin and Colorado River Basin

The Colorado Basin River Forecast Center (CBRFC) produces water supply forecasts for the Colorado River and eastern Great Basin. Briefings explaining these forecasts and the current conditions within the basins are typically conducted monthly between December and June. Additional briefings are scheduled as interest and/or conditions merit. Please contact greg.smith@noaa.gov or 801-524-5130 for more information.

North Central United States Monthly Climate and Drought Summary and Outlook

Sign up at https://attendee.gotowebinar.com/register/7395763081104006913 for the monthly North Central United States Climate Summary and Outlook webinar series. The focus of these presentations is the north central portion of the U.S. that generally stretches from the Great Lakes to the Rockies.

Mountain and lower elevation snowpack are updated along with precipitation and temperature anomalies, river and stream flow trends, and current conditions on the Great Lakes. At the end of the session presenters take questions

Apalachicola-Chattahoochee-Flint (ACF) River Basin Drought Assessment Webinar

The Southeast Climate Consortium organizes a drought assessment webinar that includes current conditions and outlooks for the ACF basin.

Currently the webinars are held monthly, and will increase in frequency if drought conditions warrant. Webinar partners include the U.S. Army Corps of Engineers, National Weather Service, Southeast River Forecast Center, the Florida Climate Center, USGS South Atlantic Water Science Center, Florida Department of Environmental Protection, and Apalachicola National Estuarine Research Reserve. To receive webinar announcements, send a request to reuteem@auburn.edu to get on the email list.

Managing Drought in the Southern Plains

The Southern Climate Impacts Planning Program (SCIPP) hosts webinars and posts briefings on drought and other hazards and their impacts. States covered include Oklahoma, Texas, and New Mexico. To join in upcoming sessions, please register at http://www.southernclimate.org/. You can view past webinars at http://www.southernclimate.org/resources/videos.

The Centers for Disease Control, Cooperative Institute for Climate and Satellites, and the National Drought Mitigation Center are teaming up to learn more about drought's impacts on human health

Drought's fallout: Human health

BY JESSE BELL
Cooperative Institute for Climate and Satellites - NC

SHERRY BURRER
National Center for Environmental Health, Centers for Disease Control and Prevention

NICOLE WALL
National Drought Mitigation Center

Drought is a complex phenomenon with numerous and far-reaching consequences. The environmental, agricultural, and economic effects of drought are well known and well understood. However, the impacts of drought on public health are less widely recognized or studied.

As drought can be a slow evolving event and many of the impacts on health can be easily overlooked, awareness and education on these issues are key to making sure drought in the United States is not the forgotten natural disaster in public health.

According the Emergency Events Database (EM-DAT), drought likely kills more people worldwide than all other severe hydrometeorological disasters, such as flooding and blizzards, and the Centre for Research on the Epidemiology of Disasters (CRED) estimates that more than one billion people were affected by drought globally between 1994 and 2013. According to NOAA's U.S. Billion-Dollar Weather and Climate Disasters, from 1980-2014, there were 22 drought events in the United States that were each responsible for economic losses of over $1 billion. Additionally, over the past 10 years, 39 states have been affected at some point by extreme or exceptional drought, and over the next century drought will likely become even more common and severe.

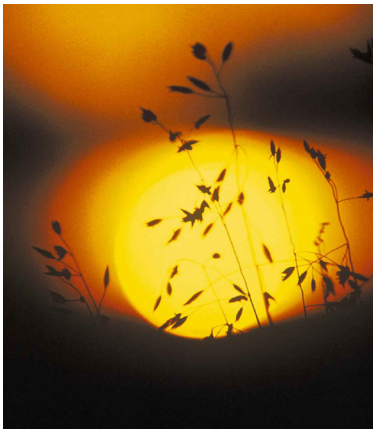
Because drought is a common phenomenon in the United States, better understanding the relationship between drought and health is important for the public health community. Health impacts of drought largely depend upon duration and frequency of the drought and the demographics, location, and vulnerabilities of affected populations. Some drought-related health effects occur suddenly, while others occur over an extended period of time.

The contribution of drought to the risks to human health in the United States can include the following:

1) Loss of money and jobs, especially for businesses that rely on water, such as farmers, landscapers, and resort operators, thus contributing to stress, anxiety, and depression;

2) Changes in the frequency and patterns of some diseases, for example, increasing mosquito populations carrying viruses (e.g., West Nile virus) due to an increase in areas of stagnant water or making it easier for some infectious diseases (e.g., valley fever) to be transmitted by creating dry and dusty soil conditions;

3) Worsening asthma and other heart and lung diseases by intensifying wildfires and decreasing air quality;



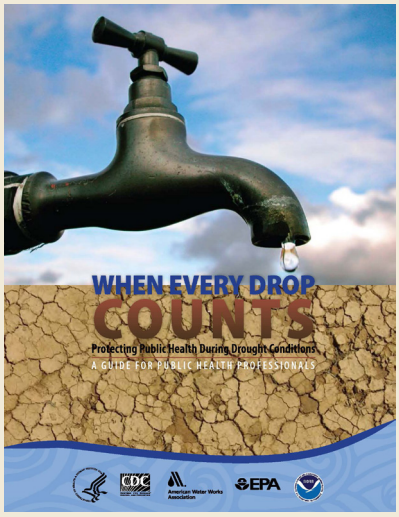
4) Greater risk of death and injury by intensifying heatwaves;

5) Decreasing water availability and quality, which affects everyone, including people who are more vulnerable and rely more heavily on water, like those who are in nursing homes and hospitals; and

6) Increases in food prices, thus contributing to multiple impacts on nutrition for vulnerable populations.

Additionally, at-risk groups based on social and demographic factors and those with preexisting health problems are more likely to be adversely affected by drought. Some examples include people with chronic medical conditions, people with low income, pregnant women, infants and children, and adults aged 65 and older. Because of the far-reaching effects of drought, at-risk groups considered during drought are more broadly defined and also include people whose water sources are highly susceptible to environmental change (e.g., agricultural businesses).

To prepare for the health effects of drought, proper planning is necessary to help protect communities. Active engagement between officials in the drought monitoring and public health communities is the first step in trying to understand issues that will impact public safety and determine best practices of sharing information to reduce the impacts of drought. Because of the importance of the impact of drought on health, the Centers for Disease Control and Prevention (CDC) has partnered with the Cooperative Institute for Climate and Satellites – NC (co-located at NOAA's National Centers for Environmental Information) and National Drought Mitigation Center (NDMC) to better understand the effect of drought on human health.



FOR MORE INFORMATION on drought and public health effects, see the following links:

CDC and the National Public Health Information Coalition (NPHIC) drought toolkit communication: http://www.cdc.gov/nceh/drought/toolkit/

Every Drop Counts: Protecting Public Health during Drought Conditions—A Guide for Public Health Professionals: http://www.cdc.gov/nceh/ehs/docs/when_every_drop_counts.pdf

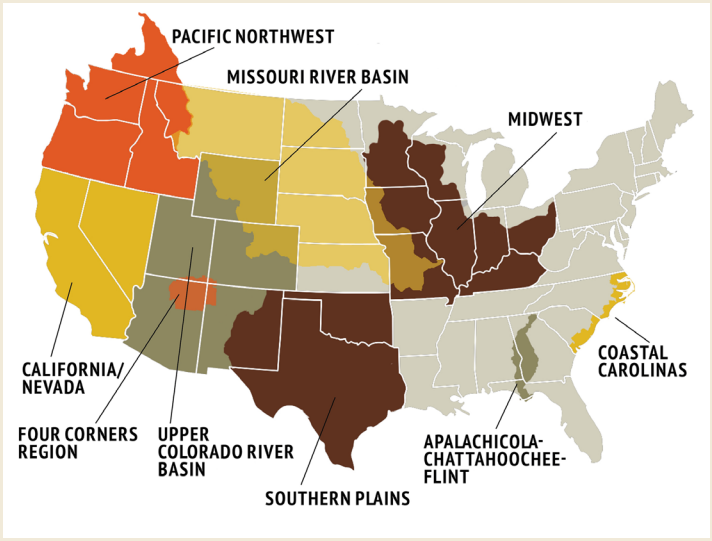
Drought-Ready Communities: A Guide to Community Drought Preparedness: http://drought.unl.edu/portals/0/docs/DRC_Guide.pdf

NDMC's Drought Impact Reporter which collects, catalogs, and displays impacts occurring in ten sectors (including society and public health): http://droughtreporter.unl.edu/map/

NDMC's Drought Management Database is a collection of mitigation strategies by different sector: http://drought.unl.edu/droughtmanagement/Home.aspx

NIDIS and its partners launch two new regional Drought Early Warning Systems in the Midwest and in the Pacific Northwest

Building regional collaborations



What is a Drought Early Warning System (DEWS)?

A DEWS utilizes new and existing partner networks to optimize the expertise of a wide range of federal, tribal, state, local and academic partners in order to make climate and drought science readily available, easily understandable and usable for decision makers; and to improve the capacity of stakeholders to better monitor, forecast, plan for and cope with the impacts of drought.

The map above show regions where NIDIS has established regional Drought Early Warning Systems. For more information about each DEWS, go to https://www.drought.gov/drought/regions.

BY KATHLEEN BOGAN, COURTNEY BLACK AND ALICIA MARRS / NIDIS

Sooner or later you will experience a drought. Even if you live in a place notorious for its precipitation, like Washington and Oregon west of the Cascades. There, in 2015, the near absence of winter snowstorms left dirt and grass on ski runs through the season. A dry summer crisped urban lawns brown.

Even where one year produces record rains, a devastating drought can descend the very next year, as happened in the Midwest from 2011 to 2012. There, Indiana, Ohio, and Kentucky all set statewide annual precipitation records in 2011. By August the following summer, parts of each of these states were experiencing extreme to exceptional drought, the most severe classifications. According to the USDA, the period from 2010-2012 was the first time since 1928-1930 that corn yield fell for three years in a row.

There's nothing to do but ride it out, right?

Not exactly. You can't stop a drought, but you can anticipate it, prepare for it and respond to it intelligently.

Those tasks—foresight, preparation and response—are at the core of NIDIS Drought Early Warning Systems (DEWS). DEWS are the regional building blocks for NIDIS's eventual goal of a nationwide Drought Early Warning System.

In February 2016, NIDIS launched two new regional DEWS in the Pacific Northwest (Oregon,

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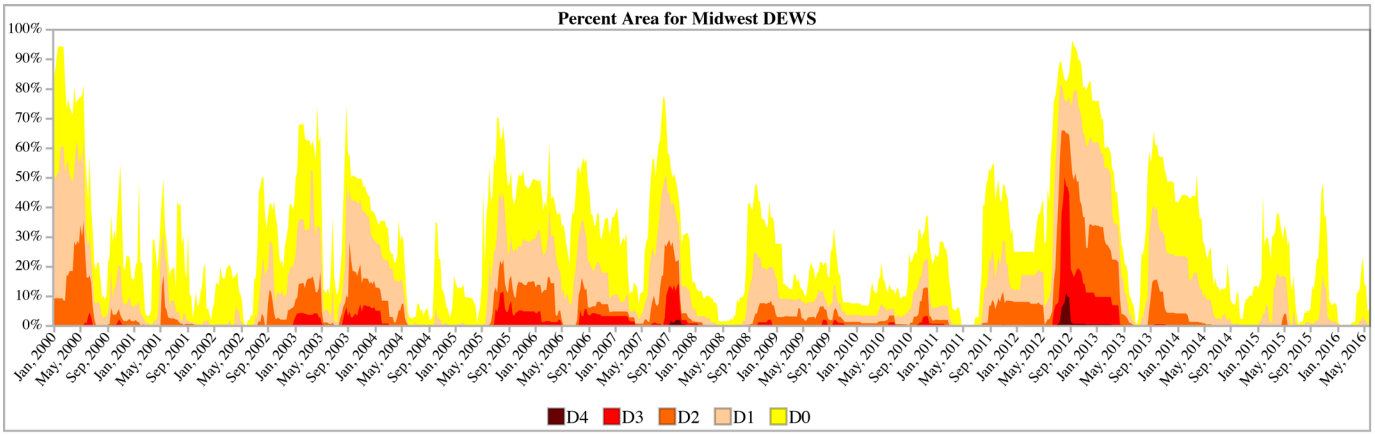

The time series above shows the ebb and flow of drought conditions in the Midwest DEWS from January 2000 through May 2016, according to the U.S. Drought Monitor. To generate a time series like this one for a specific state or region, visit https://www.drought.gov/drought/drought-monitor-graphics

Washington, Idaho, western Montana, and parts of British Columbia) and in the Midwest (the Ohio and Mississippi River Basins in Minnesota, Wisconsin, Iowa, Illinois, Missouri, Indiana, Ohio, and Kentucky.) Representatives from federal, tribal, state, local, academic, non-profit and private organizations attended the launch meetings, all with an interest in developing a proactive approach to improving drought resilience.

Other regional DEWS exist in California-Nevada; the Upper Colorado River Basin; the Missouri River Basin; the Southern Plains states of Oklahoma, New Mexico and Texas; the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama and Florida; and the Coastal Carolinas.

All the DEWS are developing strategic plans to map out goals over the next few years. Most of them share the following objectives:

- To provide a forum for a diverse group of federal, tribal, state, and local stakeholders that represent all economic sectors.
- To collaboratively strategize and develop appropriate, relevant, useful, and readily available drought, climate, weather and water-related information.
- To develop an understanding of the existing observation and monitoring networks, data,

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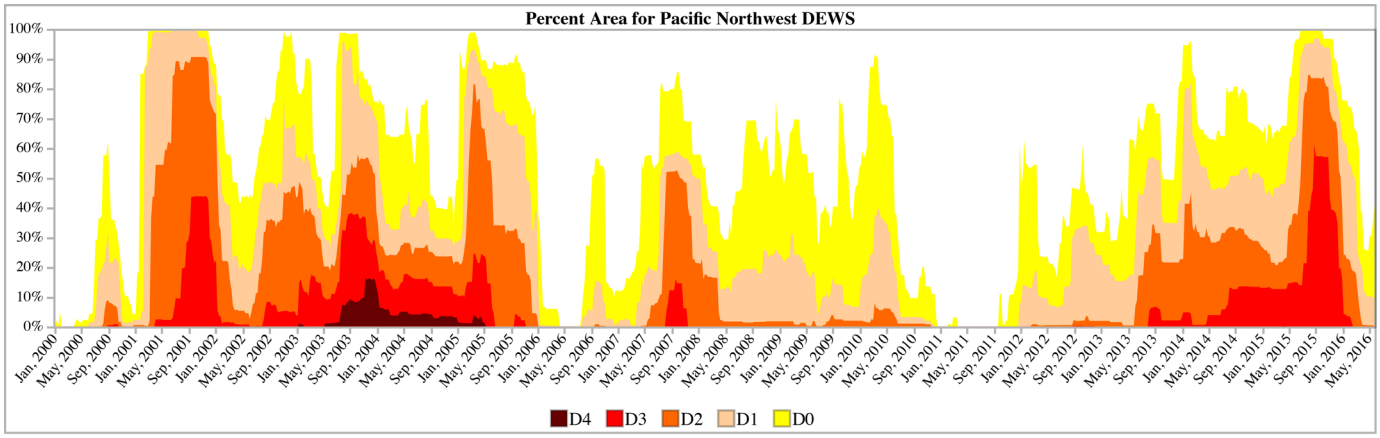
Participants in the Midwest DEWS Kickoff meeting gathered at the Embassy Suites in St. Louis, Missouri, in February 2016.



The time series above shows the ebb and flow of drought conditions in the Pacific Northwest DEWS from January 2000 through May 2016, according to the U.S. Drought Monitor. To generate a time series like this one for a specific state or region, visit https://www.drought.gov/drought/drought-monitor-graphics

tools, research, and other planning and mitigation resources available for a DEWS.

- To identify economic sector-specific and geographic needs for future monitoring, prediction, planning and information resources.

The Midwest DEWS: Challenges

Precipitation extremes in the Midwest (whether is it too wet or dry) have a major impact on the region's resources, economic sectors and residents. Over the last century, the overall precipitation trend in the Midwest has been towards wetter conditions and less-frequent droughts than the region experienced in the early 20th century. However, the Midwest has still felt adverse impacts during droughts of recent decades, particularly in 1988, 2005, and 2012. These adverse impacts include limited barge transportation on major rivers (including the Mississippi River), decreased agricultural production, challenges for municipal water supply and reduced productivity for hydropower.

An added challenge in recent years has been the tendency to transition from drought to flood and back to drought within short time spans, sometimes within a matter of months. The 2012 drought occurred a year after epic floods throughout the Midwest and Great Plains. In addition, wet springs have been more common, which also affects important Midwest sectors. For agriculture, wet springs reduce the number of workable field days, delay planting, and increase nitrogen loss. The wet springs of 2011 and 2013 were followed by dry summers, which exacerbated the challenges faced by farmers.

The frequency of extreme precipitation events and amount of precipitation in the Midwest is expected to continue to increase in the future. However, recent decades have demonstrated that droughts can and will still occur in a wetter climate. They have also demonstrated the challenges associated with a rapid change between the climatic extremes. Proper planning and preparation for both drought and high precipitation and understanding the relationship between the two events is important for developing climatic resilience in the Midwest.

The Pacific Northwest DEWS: Challenges

Despite its soggy reputation, the Pacific Northwest experienced multiple droughts in the early 21st century, in 2001, 2003 and 2005. By 2015, when almost the entire region reached historic drought conditions, the eastern portions of Oregon and Idaho had already been suffering under prolonged drought for four years. The Pacific Northwest water supply is largely

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For more information

Find out more about the Midwest DEWS: https://www.drought.gov/drought/dews/midwest/about-midwest-dews

Find out more about the Pacific Northwest DEWS: https://www.drought.gov/drought/dews/pacific-northwest/about

contingent on snowpack, which acts as a kind of reservoir for the region. As temperatures warm in spring, the snowpack melts, feeding streams, rivers, lakes, and reservoirs that are used to irrigate agricultural lands, support ecosystems, supply hydropower, and sustain drinking water supplies to cities. Snowmelt also supplements groundwater aquifers relied upon by small systems and vulnerable communities. How and when that snowpack develops and eventually melts largely dictates how and if drought may develop throughout the year.

Snowpack accumulation during the winter of 2014-15 was at a record low. This "snow drought" was exacerbated by excessively high temperatures, and by precipitation falling as rain (and running off) instead of snow. Bare ground lay exposed in some areas where multiple feet of snow pile up in average years. Then an unusually hot summer unfolded. Higher-than-average temperatures during summer 2015 were in line with what experts expect for the region by mid to late century under most climate scenarios. Those high temperatures could be seen as a preview of the future, and a wakeup call for evaluating how water is managed in the region.

The kickoff meetings

The launch meetings for the Pacific Northwest and the Midwest DEWS each opened with a closer look at the conditions and vulnerabilities in the regions. Presentations included climate information on drivers and trends, existing monitoring and observation tools and networks, forecasting and research, state drought plans and strategies, and sector-specific impacts.

Then, through small-group discussion, participants identified resource needs and targets for future actions in their regions. Major themes at both meetings included:

- Expanding collaboration and information sharing among agencies and organizations at all levels, as well as among economic sectors.
- Assessing vulnerability, impacts and adaptive capacity, and using that information to improve drought resilience planning.
- Improving existing monitoring and observation networks, and applying the data to seasonal forecasting and hydrologic processes.
- Developing public outreach and communication strategies, particularly for informing communities about the potential early onset of drought.

Teams from each DEWS are working on strategic plans to identify specific actions in support of the themes above. When complete, the plans and timelines proposed actions will be available on drought.gov.

Washington State Department of Ecology Drought Coordinator Jeff Marti shows off the tiny apple in his lunch and the Pacific Northwest DEWS Kickoff meeting. The apple's size illustrated impact of the drought that gripped the state in 2015.

DEWS Partnerships

Partners involved in the launch of the Midwest DEWS include:

- Midwestern Regional Climate Center (MRCC)
- Illinois State Water Survey
- Kentucky Climate Center
- University of Missouri Extension
- National Drought Mitigation Center (NDMC)
- Federal Emergency Management Agency (FEMA)
- NOAA
- National Weather Service (NWS)
- U.S. Army Corps of Engineers (USACE)
- United States Department of Agriculture (USDA)

Partners involved in the launch of the Pacific Northwest DEWS include:

- Climate Impacts Research Consortium (CIRC)
- Climate Impacts Group (CIG)
- Columbia River Inter-Tribal Fish Commission (CRITFC)
- Desert Research Institute (DRI)
- Idaho Department of Water Resources (IDWR)
- National Drought Mitigation Center (NDMC)
- National Oceanic & Atmospheric Administration (NOAA), including the National Integrated Drought Information System (NIDIS), National Weather Service (NWS), and the Northwest River Forecast Center (NWRFC)
- Northwest Power & Conservation Council
- Office of Washington State Climatologist (OWSC)
- Oregon Climate Change Research Institute (OCCRI)
- Oregon Climate Service (OCS)
- Oregon Water Resources Department (OWRD)
- U.S. Department of Agriculture (USDA), including the Natural Resource Conservation Service (NRCS), Northwest Climate Hub, and U.S. Forest Service (USFS)
- U.S. Department of Interior (DOI)
- Northwest Climate Science Center (NWCSC)
- U.S. Geological Survey (USGS)
- Western Regional Climate Center (WRCC)
- Washington State Department of Ecology

Researchers in the Carolinas paint a picture of drought through photos, videos, and graphics for a new website

A drought portrait

BY AASHKA PATEL
Carolinas Integrated Sciences and Assessments (CISA)
GRAPHICS BY JUNYU LU
Carolinas Integrated Sciences and Assessments (CISA)

CISA researchers are developing a visual narrative about the historical character of drought in the Carolinas with the goal of conveying it through a website designed for educational and planning purposes.

Drought is a slow moving natural hazard originating from an extended rainfall deficit ranging from seasons to years and, typically, cascading into moisture deficiencies in other parts of the hydrologic cycle (soil moisture, for example). Drought events are commonly characterized based on the intensity and duration of moisture shortage and frequency of occurrence using a range of metrics and statistics.

Impacts of drought can be far-reaching. The sensitivity of natural resources and communities to drought and the severity of resulting drought impacts vary with different drought characteristics. A localized understanding of drought is, therefore, essential for effective drought-related planning and response actions.

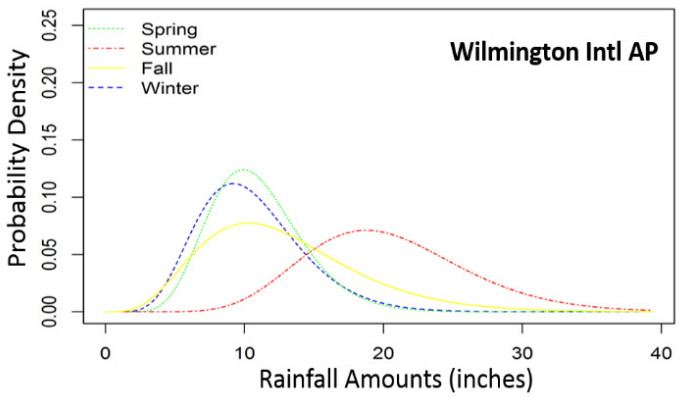
This project will analyze and map the nature of drought events recorded in the past 120 years in the Carolinas, and connect it to local drought-related impacts and experiences through photos, videos and other narrative formats.

The range of information produced will summarize the observed drought characteristics in the region as well as allow comparisons of individual drought events with average conditions, past events, and their variability across the region. The format will include location-specific graphics and maps covering the Carolinas region. For example, the first figure (below, left) shows the variation and probability of seasonal precipitation totals for a single station located in Wilmington, NC.

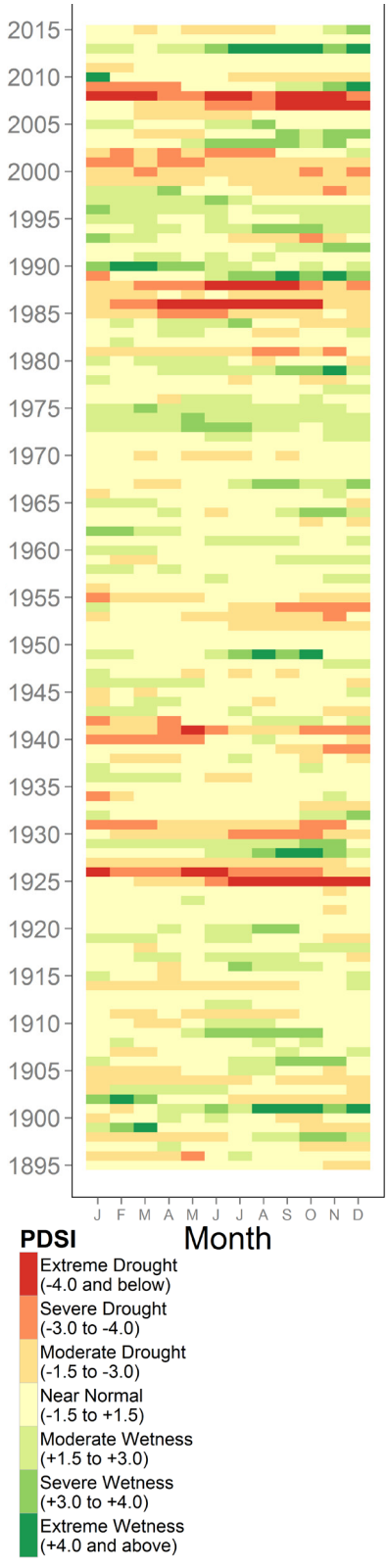
The second figure (right), shows for Climate Division 1 in NC levels of dryness based on precipitation and temperature, as measured by the Palmer Drought Severity Index (PDSI).

This type of information can be useful for local and regional resource management decisions, such as those for surface water permitting, regional water quality planning, and reservoir operations. Some of this information will also be presented in the form of case studies placing individual drought events in recent memory in the historical context.

This article originally appeared in "Carolinas Climate Connection," the newsletter of the Carolinas Integrated Sciences and Assessments, a NOAA RISA Team.
http://www.cisa.sc.edu/



Palmer Drought Severity Index, NC



New initiative to explore drought impacts on wildfire planning, behavior, and effects in the U.S. West, improve products and communication

California firefighters approach a wildfire near Sonora in August 2014. A spark from a passing vehicle ignited the blaze in the parched grassland next to Highway 49. ANDREW WILLIAMS PHOTO

Addressing the drought-wildfire nexus

BY TAMARA U. WALL AND TIMOTHY J. BROWN
Desert Research Institute
ALICIA MARRS AND KATHLEEN BOGAN
NIDIS

Images of burning forests, neighborhoods, and "smoked out" communities have pervaded the media in the United States in recent years. Drought has been a contributing factor to many of these fires.

As average temperatures have climbed over the past decades, heat has contributed to drought, and further accelerated depletion of soil and vegetative moisture.

Drought makes it that much more difficult to manage the timber and brush that feed wildfires, and can delay and hinder reforestation efforts after a fire. Mitigation and recovery techniques, when compromised, increase the potential number and intensity of wildfires and the smoke that accompanies them, threatening wildlife, property, water, and air quality.

Drought amplifies the impacts of wildfires, in both intensity and consequences. It compromises fire planning, behavior, and post-fire restoration in many ways, including:

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In October 2015, fire managers and planners from the western U.S. met to explore the relationship between drought and fire at the "Integrating Drought Science and Information into Wildfire Management Workshop" held in Boise, Idaho. This graphic synopsizes some of the major themes from the discussion.

Details of the event and the initiative growing out of it are discussed on the followng pages. For a downloadable pdf of the report containing this graphic, go to https://www.drought.gov/drought/documents/wildfire-and-drought-impacts-wildfire-planning-behavior-and-effects

- Increasing management uncertainty by altering where and how fire burns.
- Aggravating hazardous conditions for fire fighters and nearby communities during fire events.
- Escalating demand for firefighting resources and associated costs.
- Swelling the potential for large wildfires which produce considerable smoke, compromising air quality and impacting local and regional public health.
- Worsening the effectiveness of fuel management and restoration, decreasing ecological resilience. Public acceptance of smoke from fuel treatments such as prescribed fire (Rx fire) still lags.
- Weakening barriers to fire (natural and human-made) by reducing fuel greenness, snow pack and moisture, thus increasing availability to burn.
- Expanding the likelihood that vegetation types will shift post-fire, allowing opportunities for invasive species to establish.

In order to better understand the relationship between drought and wildfire in the western United States, and to meet stakeholder needs at the state and regional level, the Desert Research Institute (DRI), Western Regional Climate Center (WRCC) and NIDIS have partnered to form the NIDIS Drought and Wildfire Nexus (NDAWN).

The NDAWN initiative kicked off at a workshop in October 2015, where fire managers and planners emphasized a need for increased engagement across agencies and the public on the topic of drought and wildfire. Experts in prescribed fire, wildland fire management, climatology, smoke and air quality, fuels management, fire behavior, drought, and policy gathered in Boise, Idaho, for the "Integrating Drought Science and Information into Wildfire Management Workshop," the first explicit drought-fire focused workshop to occur in the western U.S. (see participant list in sidebar). Sponsors of the event were NIDIS, DRI, WRCC, the California Nevada Applications Program (CNAP, a NOAA Regional Integrated Science Applications team), and the National Drought Mitigation Center (NDMC).

NDAWN's goal is to identify priorities and actions to improve products and communication among the drought and fire communities. In addition to exploring drought impacts on wildfire planning, behavior and effects in the western U.S., NDAWN will examine how drought information is used and could be improved across fire management agencies. NDAWN's objective are:

1) To involve the fire community in the NIDIS regional Drought Early Warning Systems (DEWS) and other drought information networks supported by NIDIS, National Drought Mitigation Center (NDMC), the Western Governors' Association (WGA), state, and local agencies to successfully utilize drought information in fire management programs.

2) To provide a baseline of how drought information is currently used in the wildfire community, and then identify changes in use and priority issues over time.

3) To identify gaps and needs related to drought information in the wildfire community.

4) To initiate the development of a network that disseminates and utilizes drought information in fire management planning, behavior, and effects for decision makers at state and regional levels.

To achieve these objectives, NIDIS, DRI, WRCC and their partners will hold a series of workshops in the National Interagency Fire Center's (NIFC) Geographic Area Coordination Center regions. These workshops will seek to better identify and address drought impacts by looking at the roles of fuel types, topography, climatic conditions and cultural and societal settings within those regions.

For more information about NDAWN, contact Tamara Wall (tamara.wall@dri.edu) or Tim Brown (tim.brown@dri.edu) at the Desert Research Institute, or Alicia Marrs at NIDIS (Alicia.marrs@noaa.gov).

To read the full report on the "Integrating Drought Science and Information into Wildfire Management Workshop," go to https://www.drought.gov/drought/documents/wildfire-and-drought-impacts-wildfire-planning-behavior-and-effects.

Meeting participants

Agencies represented at the Integrating Drought Science and Information into Wildfire Management Workshop in Boise, Idaho, in October 2015 include:

Bureau of Indian Affairs
Bureau of Land Management/ Predictive Services
Bureau of Reclamation
California Bureau of Land Management
Desert Research Institute
Environmental Protection Agency Region 10
Idaho Department of Lands
Lamont-Doherty Earth Observatory
Montana Department of Natural Resources
National Drought Mitigation Center
National Park Service
NOAA/National Integrated Drought Information System
NOAA/National Weather Service
The Nature Conversancy
University of Oklahoma/Southern Climate Impacts Planning Program
US Fish and Wildlife Service
USDA Forest Service
Western Governors' Association

Midwinter meeting and webinar anticipate spring, summer conditions in California

Cautious message for California

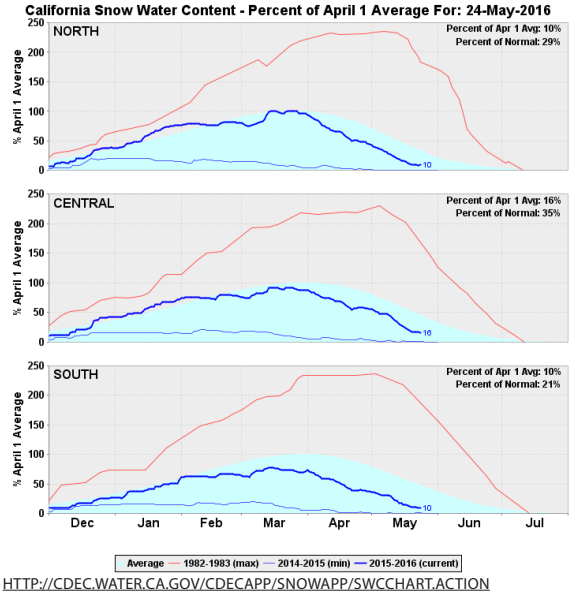
BY AMANDA SHEFFIELD
CNAP/NIDIS

In January 2016, the NIDIS California DEWS in collaboration with the California-Nevada Applications Program (CNAP), a NOAA RISA team, held two meetings to discuss "What's ahead for California in 2016?" Drought has gripped California for four years, so a major emphasis of this mid-winter meeting was to update the California NIDIS community on current conditions and water supplies at a critical junction in the water year, and to discuss what lies ahead. El Niño dominated the news this winter, and California is optimistic that because of this climate pattern the drought will in part be relieved. To assist California decision makers in the coming months, the NIDIS/CNAP group issued a cautious message about what is achievable this year and what lies ahead, based upon historical precedents and seasonal forecast indicators.

At the first meeting on January 22, 30 stakeholders and decision makers from Southern California gathered at Scripps Institution of Oceanography in La Jolla. This in-person meeting provided an opportunity to engage with the Southern California NIDIS community following the drought outlook meeting the previous July. The meeting began with a weather and climate update for California and the western U.S. by climatologist Dr. Kelly Redmond of the Western Regional Climate Center. Dr. Michael Dettinger of U.S. Geological Survey presented on current water storage in California's reservoirs and snow pack, as well as on tables of historical probabilities of the likelihood of precipitation reaching normal for the water year (the nine months following Oct. 1), given the precipitation totals at the time of the meeting.

To wrap up the morning, Dr. Julie Kalansky of Scripps led a discussion on attendees' decision calendars, linking decision tools with timelines. In the afternoon, Dr. F. Martin Ralph of the Center for Western Water Extremes (CW3E) presented on atmospheric rivers, an important component of California water resources. The last two presentations of the afternoon were focused on forecasting, including NMME precipitation forecasts by Dr. Shrad Shukla (UC Santa Barbara) and long lead ENSO forecasts by Dr. David Pierce (Scripps).

On Jan. 26, the NIDIS team held a complementary webinar with similar presentations for a statewide California audience. Drs. Redmond, Pierce, and Shukla presented on the status and prospects of the 2016 water year to more than 50 on-line participants from a variety of sectors and regions. Based on feedback, NIDIS and CNAP plan to develop a set of workshops, meetings, and webinars to consistently engage the growing California DEWS community to better plan and cope with the impacts of drought.



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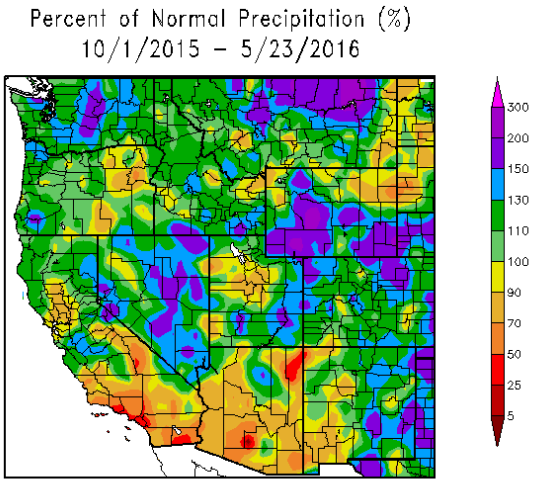
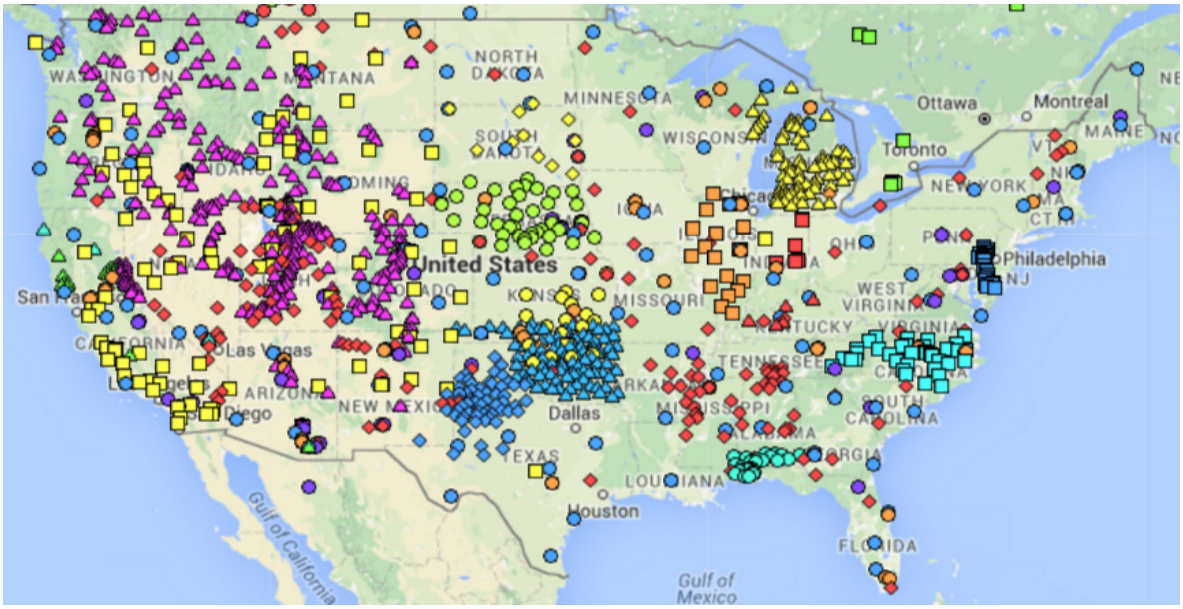


WWW.HPRCC.UNL.EDU

Please direct any questions about these events or the California DEWS to Dr. Amanda Sheffield (amsheffield@ucsd.edu). Dr. Sheffield recently joined the CNAP team to serve as the link between the NIDIS program office and the California-Nevada Drought Early Warning System.

Presentations can be found at: http://cnap.ucsd.edu/nidis_socal_20160122.html and http://cnap.ucsd.edu/nidis_webinar_20160126.html

Experts convene to outline next steps in constructing a national soil moisture monitoring network



This map shows soil moisture monitoring networks in the contiguous U.S., built from the database of networks maintained by Texas A&M University. http://soilmoisture.tamu.edu/

Piecing together a network

BY KATHLEEN BOGAN / NIDIS

How do you build a network when the pieces don't quite fit together yet?

Let's say it's a soil moisture monitoring network, you want it to be a national network, and you know that there is a lot of soil moisture monitoring going on out there.

In situ monitoring takes place nationally (for example, through NOAA's Climate Reference Network or CRN; and Soil Climate Analysis Network or SCAN, managed by the Natural Resources Conservation Service), through in-state systems (such as mesonets, which are networks of weather stations in some states, including Oklahoma and Kansas), and at smaller scales, both publicly and privately.

On the ground, monitoring devices might be a kilometer or two apart. Or they could be more isolated, without another station for miles. Some have records dating back to the early '90s. Some were up and running almost 20 years later. There are sensors at 5 cm depth, at 10 cm, at 60 cm and other depths, but not at all stations. There are different kinds of sensors from site to site, and they are placed in different kinds of soils, and you don't necessarily know which sensor is in which kind of soil. For an annotated comparison of various networks, see the chart on page 18.

Some soil moisture monitoring is performed remotely, via satellites (such as NASA's Soil Moisture Active/Passive satellite (SMAP), or the Cosmic-Ray Soil Moisture Observing System (COSMOS), operated by the University of Arizona).

Soil moisture is also modeled, including models from the North American Land Data Assimilation System (NLDAS), developed by NASA and NOAA.

Many groups use the soil moisture data. They include farmers who are planning which crops to plant in the upcoming season, or gauging how much to irrigate on a given day. Public health officials may be interested in tracking Valley Fever pathogens that thrive in dry soils, because a buildup of those pathogens can cause an outbreak. Water managers can find soil moisture data useful when deciding on optimal reservoir releases to address downstream flooding concerns, or meeting downstream water needs.

The broad uses of soil moisture data and the complexities associated with these sorts of decisions formed much of the agenda for the National Soil Moisture Monitoring Network Workshop on May

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SELECTED IN SITU SOIL MOISTURE NETWORKS IN THE U.S.

Network Name	Geographic Region	Number of Stations	Period of Record	Observing Depths (cm)
Agricultural Research Service (ARS)	Oklahoma	44	2005-present	5, 25, 45
AmeriFlux	United States	39	1997-present	Variable
Atmospheric Radiation Measurement (ARM)	Kansas, Oklahoma	17	1996-present	5, 15, 25, 35, 60, 85, 125, 175
Automated Weather Data Network (AWDN)	Nebraska	52	2006-present	10, 25, 50, 100
Climate Reference Network (CRN)	United States	114	2009-present	5, 10, 20, 50, 100
Cosmic Ray Soil moisture Observing Station (COSMOS)	United States	54	2008-present	Variable
Delaware Environmental Observing System (DEOS)	Delaware	29	2004-present	5
**Georgia Automated Environmental Monitoring Network (GAEMN)	Georgia	79	1992-present	Variable
Illinois Climate Network (ICN)	Illinois	19	1988-present	5, 10, 20, 50, 100, 150
Kansas Mesonet	Kansas	15	2008-present	5, 10, 20, 50, 100
Michigan Enviro-weather (Automated Weather Network, MAWN)	Michigan, Wisconsin	80	2000-present	5, 10
Missouri Agriculture Weather Network (MAW)	Missouri	8	2002-present	5, 10
**New Jersey Mesonet	New Jersey	10	2003-present	5
NOAA Hydrometeorological Testbed	Western U.S.	25	2004-present	Variable
North Carolina EcoNet	North Carolina	36	1999-present	20
Oklahoma Mesonet	Oklahoma	113	1998-present	5, 25, 60, 75
**Remote Automated Weather Stations (RAWS)	Western U.S.	50	1983-present	Variable
Snowpack Telemetry (SNOTEL)	Western U.S.	414	2000-present	Variable
Soil Climate Analysis Network (SCAN)	United States	203	1996-present	5, 10, 20, 50, 100
South Dakota Automated Weather Network (SDAWN)	South Dakota	11	2000-present	5, 10, 20, 50, 100
UA Fairbanks Water and Environmental Research Center (WERC)	Alaska	24	2000-present	Variable
West Texas Mesonet	Texas, New Mexico	64	2000-present	5, 20, 60, 75

DATA FROM MIKE STROBEL PRESENTATION, HTTPS://WWW.DROUGHT.GOV/DROUGHT/SITES/DROUGHT.GOV.DROUGHT/FILES/MEDIA/CALENDAR/PRE_SOILMOISTURE2016_STROBEL1.PDF

24-26 in Boulder, Colorado. Organizers and sponsors included Mike Strobel of the USDA Natural Resources Conservation Service; Jessica Lucido of the US Geological Survey, Steven Quiring of Texas A&M University, and Chad McNutt of NOAA/NIDIS.

More than 50 individuals, representing federal and state agencies, research organizations, academic institutions, citizen science groups and private enterprises, spent two days considering how to fit together the many pieces of soil moisture monitoring into a coordinated, useful network that would help boost national resilience to drought and other extreme events. By tapping into the experiences and knowledge of these experts in soil science, hydrology, remote sensing, streamflow management,

continued on next page

governmental affairs and other specialities, the organizers sought to take another step toward crafting a coordinated national soil moisture network.

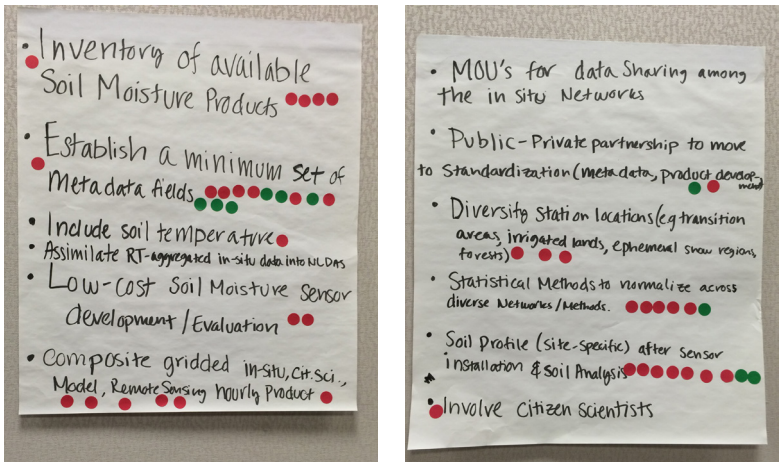
The 2016 meeting built upon previous efforts from a workshop held in Kansas City, Missouri, in November 2013. Key findings from that workshop were summarized in this way:

> *A coordinated national soil moisture system, therefore, will only be successful if it is beneficial to a broad range of end users, encourages consistent calibration/validation practices and metadata characterization, and effectively leverages the full variety of existing networks and modeling efforts.*

Participants in the May meeting in Boulder echoed this assessment. Organizer Mike Strobel outlined some of the next steps for the network, as advanced by the participants. These included:

- Determining an organizational structure and leadership/steering committee necessary to keep the efforts moving forward.
- Developing a strategic plan.
- Exploring funding mechanisms to support the development of the network.
- Defining the specifications for the network and how these would underlie guidelines for participants.
- Exploring ways to incorporate monitoring efforts already underway.
- Engaging with users in order to respond to their needs as they relate to the data.

For more information about the NSMMN, contact Mike Strobel, michael.strobel@por.usda.gov.



Meeting participants used sticky-dot "votes" to indicate their interest in establishing consistent metadata for monitoring stations, and recording a site-specific soil profile for each sensor.

Meeting participants

Representatives of the following groups attended the National Soil Moisture Monitoring Network meeting in Boulder in May 2016:

Agriculture and Agri-Food Canada
Ball Aerospace & Technologies Corp
CICS-NC/NOAA
Cooperative Institute for Research in Environmental Sciences (CIRES)
Colorado Climate Center / Colorado State University
Decagon Devices, Inc.
Environmental Modeling Center, National Centers for Environmental Prediction, NOAA
Geospatial Research Laboratory / Penn State University
Global Science & Technology
The GLOBE Program
Iowa State University
Kansas State University
Montana Climate Office
Montana State University Extension
NASA
NASA Goddard Space Flight Center
NASA Short-term Prediction Research and Transition Center (SPoRT)
National Drought Mitigation Center (NDMC)
National Center for Atmospheric Research (NCAR)
Nebraska State Climate Office
National Integrated Drought Information System (NIDIS)
National Oceanic and Atmospheric Administration (NOAA)
NOAA/ Atmospheric Turbulence and Diffusion Division (ATDD)
NOAA/Earth System Research Laboratory, Physical Sciences Division
NOAA/National Weather Service, Arkansas-Red Basin River Forecast Center
Oklahoma State University
Princeton University
Science Applications International Corporation (SAIC)
Texas A&M University
Texas Water Development Board
The Climate Corporation
U.S. Army Corps of Engineers, Missouri River Basin Water Management
U.S. Geological Survey
University Corporation for Atmospheric Research (UCAR), Joint Office for Science Support (JOSS)
University of Colorado
University of Maryland
University of Nevada, Reno
US Army Corps of Engineers, Hydrologic Engineering Center (HEC)
US Department of Agriculture (USDA)
USDA Natural Resources Conservation Service (NRCS)
USDA NRCS, Snow Survey
USDA NRCS, National Water and Climate Center
U.S. Geological Survey
Washington State University
Western States Water Council
The White House Office of Science and Technology Policy

Wind gusts reached 73 mph when dust storm rolled across the Oklahoma Panhandle on April 5, 2016. For more information about how dust in the air and other impacts of drought can affect human health, see page 6. Photo by Gary McManus, Oklahoma State Climatologist.

The National Integrated Drought Information System (NIDIS) is a nexus of drought information, policy and research. We promote collaboration among government agencies, communities and individuals at all levels to share information about drought, and provide resources for planning, forecasting, management and recovery. Together with our federal, state and local partners we pursue these goals:

- **Leadership and networking among all sectors to plan for and cope with the impacts of drought**
- **Supporting research on the science of drought, including indicators, risk assessment and resilience**
- **Creating regional early warning systems for drought management**
- **Developing resources, systems and tools to promote drought awareness and response**