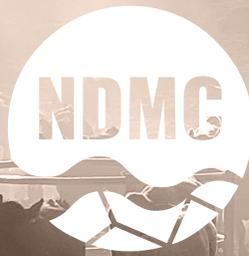




BUILDING RESILIENCE



NATIONAL DROUGHT
MITIGATION CENTER
UNIVERSITY OF NEBRASKA

Annual Report • 2019

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National Drought Mitigation Center

2019 Annual Report
Building Resilience
Lincoln, Nebraska

Editorial Coordination

Cory Matteson

Editorial Content

Kelly Helm Smith, Deb Wood
and Cory Matteson

Design and Layout

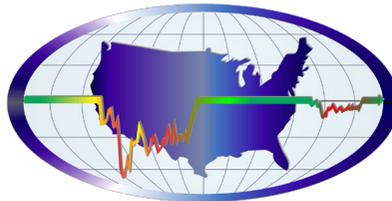
Brendon Orr

Images

National Drought Mitigation Center,
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This publication also is available
in electronic PDF format
from the center’s website:
drought.unl.edu



| 1995

National Drought Mitigation Center



| 2007

National Drought Mitigation Center



| 2017

National Drought Mitigation Center

FROM THE DIRECTOR



In 1995, the National Drought Mitigation Center debuted with six staff members, including me, and within a year we'd produced the world's first on-line "drought clearinghouse" along with a monthly suite of Standardized Precipitation Index maps — our first foray into the world of operational drought-monitoring product development.

A quarter of a century later — more on that shortly — and look how far we've come. The SPI is but one of scores of resources that U.S. Drought Monitor authors utilize in drafting the weekly map that informs the nation of up-to-date drought conditions. More specifically, as of 2019, the USDM, which the NDMC has housed for its 20-year history, provides weekly drought conditions about the U.S. *and* all of its territories. (Welcome aboard, U.S. Virgin Islands and U.S.-affiliated Pacific Islands!)

That continued refinement, evolution and expansion of the USDM is emblematic of how the NDMC staff treats the products, knowledge and research we share with people who want to better understand and prepare for drought in all its forms— we build on it. And that is why the theme of this year's annual report is "Building Resilience."

You can read about how the USDM (page 14) evolved from a map that we original authors had to draw by hand to a GIS-created process incorporating dozens of data sources, a network of nearly 500 on-the-ground observers and the analysis of expert authors. And on page 6, you can learn about an effort that the NDMC undertook to create state-level drought impact tables. I often say that "impacts are the face of drought!" Indeed, they show us where we are vulnerable to the effects of drought and as such they are the critical link that ties together drought early warning/monitoring and policies and planning. A severe drought looks different in Connecticut than it does in California. We wanted to provide key context that helps a state's residents (or others looking from afar) know what to expect when drought hits, and our team combed through thousands of drought impact reports to provide concise lists anyone can use. This year, we also revamped and updated our collection of state drought and emergency plans (page 16) and created a board game (page 7).

Product development, implementation and improvement is one of many ways we strive to build resourcefulness against drought. Leading discussions with international drought experts, as we did during the 2019 Water for Food Global Conference at the University of Nebraska (page 4), traveling across the globe to address drought at its doorsteps (page 10) and inviting leaders to come work with us in Lincoln (page 11) has been our calling card for, let's see, 25 years.

That's right. The National Drought Mitigation Center turns 25 in 2020! You'll find an announcement about an event to celebrate the 25th birthday on the back inside cover of this Annual Report. We look forward to celebrating the work our dedicated team has done for the past 25 years, and look to build on it — this year and well beyond. □

Mark Svoboda, Ph.D., Director



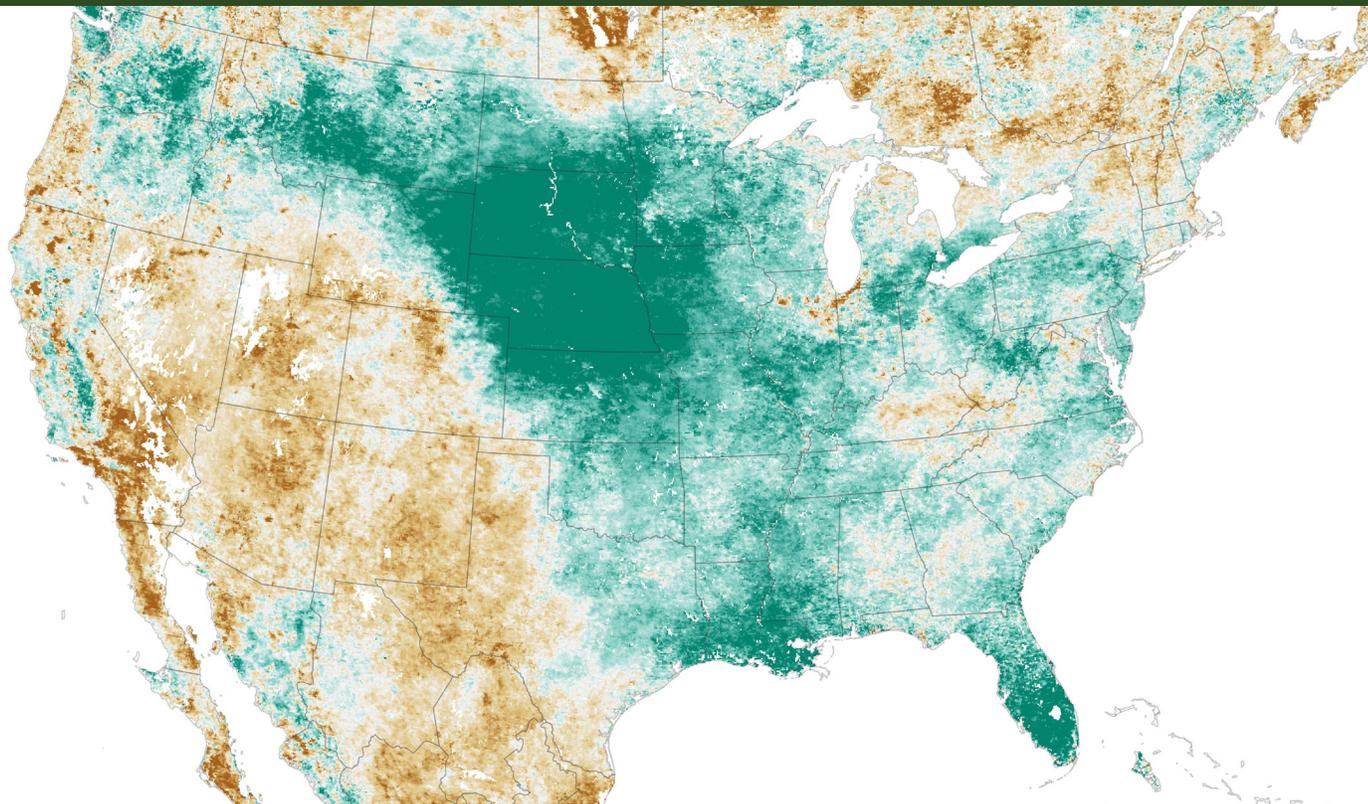
First coined at NDMC, ‘flash drought’ gains national attention

From late August through early October, drought engulfed much of the Southeast U.S. in a way that many don't expect drought to behave — suddenly. Only 7% of Georgia began September in drought. By the end of the month, drought covered 62% of the state. Kentucky went from 0% to 91% over the same month. Drought in the Southeast region spiked from covering about 6% of the region to 44% in less than a month. While many droughts embody the frequent description of the natural disaster as a creeping phenomenon, taking months or years to develop, the Southeast drought grew widespread and severe in a matter of weeks. It was a classic flash drought.

A flash drought, as defined by the American Meteorological Society, “is an unusually rapid onset drought event characterized by a multi-week period of accelerated intensification that culminates in impacts to one or more sectors” such as agricultural or hydrological impacts. National Drought Mitigation Center director Mark Svoboda is credited with coining the term in the early 2000s, and this past year, he and other NDMC staff helped to explain the nature of the Southeastern flash drought to reporters from The New York Times, E&E News and The Associated Press.

Svoboda initially came up with the term to help convey to a USA Today reporter that a drought in the

The NASA Earth Observatory images show the rapid onset of the 2019 Southeast and Mid-Atlantic U.S. flash drought by measuring evaporative stress, with brown indicating drought conditions. The first map shows conditions between July 16 and Aug. 13, and the second map shows the period between Sept. 10 and Oct. 8, the peak of the drought. NASA Earth Observatory images by Lauren Dauphin using [ESI data](#) provided by [Christopher Hain](#).



Southern Plains in the early 2000s was developing with rapid intensity.

“This was a late summer onset drought,” he said. “They were having hot, windy, dry conditions. Grass fires were a big issue. Concern about planting of winter wheat was an issue. Late effects on soybeans was an issue.”

Svoboda said he wanted to convey to readers that drought doesn’t always take years to develop, especially when it impacts crops at a critical time in their development cycle. As with the development of the U.S. Drought Monitor, which categorized drought by levels in ways that were similar to tornadoes and hurricanes, Svoboda turned to familiar terminology regarding another type of natural disaster, the flash flood.

“I wanted to find a term that would resonate for this quicker developing drought, and flash drought just popped in my head,” he said. “And that took off like wildfire.”

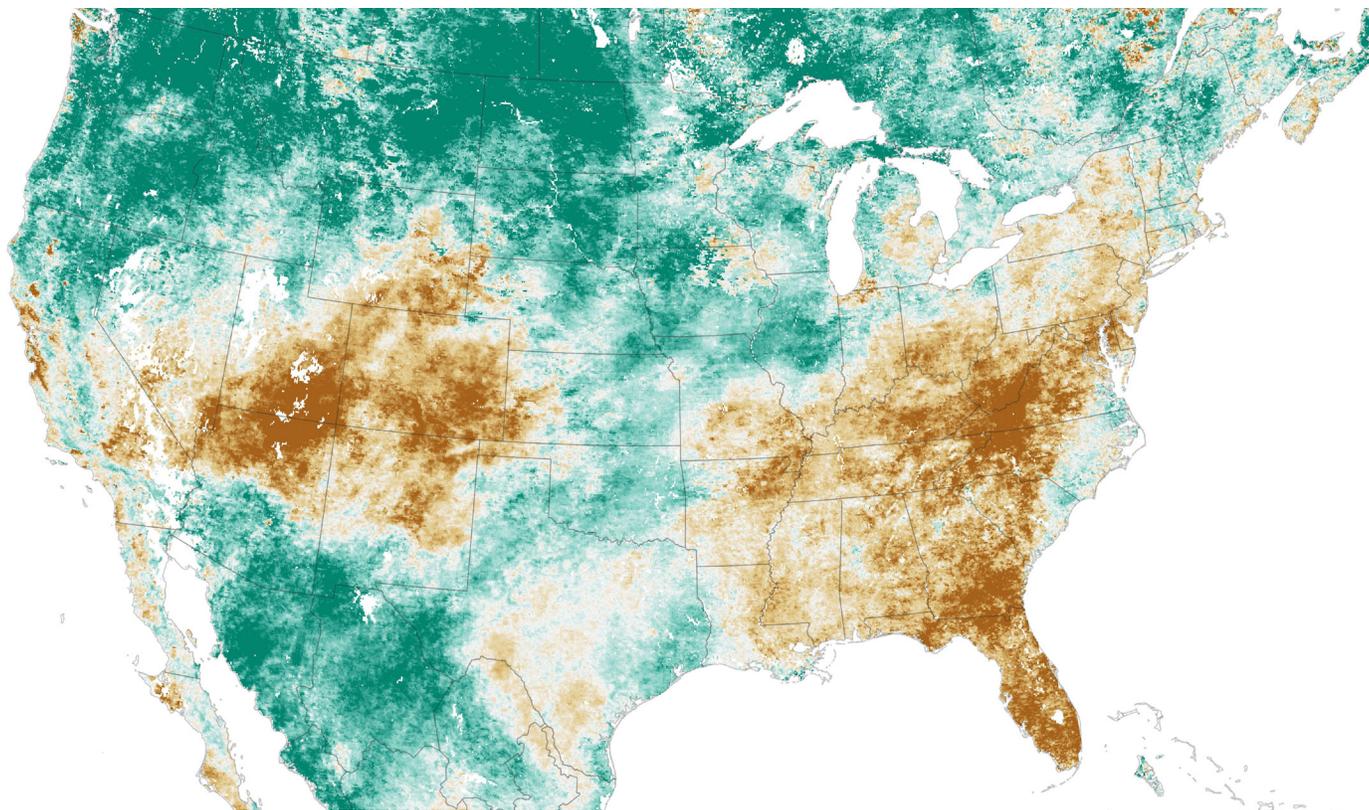
Flash drought gained national attention during 2011 and 2012, “when the media and scientific community began to extensively use the term when referring to the devastating droughts that affected parts of the central United States each of those years,” Jason Otkin, associate scientist, Cooperative Institute for Meteorological Satellite Studies at the University of Wisconsin-Madison, wrote in a 2017 paper that argued that flash drought should be defined by its rapid intensity.

Svoboda, a co-author of the paper, said that developments in satellite technology are helping experts more quickly assess conditions like the ones that led to the 2019 Southeast flash drought. Svoboda, a former USDM author, said that human nature can lead experts to take conservative approaches to declaring both the start and end of a drought.

“We have to trust this new breed of indicators that are looking at stress that we can’t even see with the human eye,” Svoboda said. “These are looking at indicators of plants that are seen by a sensor that the human eye doesn’t denote until it’s yellow and wilting. The satellite can see that stress in the plant before it shows visible signs to the human eye. It takes a change in mindset to evaluate, trust and integrate these new tools into the Drought Monitor process in order to be using the state of the science and being responsive to these rapid onset flash droughts.”

The USDM’s combination of data, expertise and network of hundreds of on-the-ground observers throughout the U.S. and its territories is set up to respond to drought that develops at any speed, he said.

On the web: Read a study about the challenges imposed by flash droughts in the U.S. at journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-17-0149.1 □



Drought experts converge at Water for Food Conference

At the 2019 Water for Food Global Conference at the University of Nebraska, a group of drought experts from Nebraska and well beyond gathered to discuss what's next in their respective views when it comes to drought mitigation, and what's at stake if the topic is ignored.

"Floods kill people, but droughts destroy civilizations," said Jesse Bell, Claire M. Hubbard professor of Health and Environment at the University of Nebraska Medical Center in Omaha.

The panel, "Drought Early Warning and Risk Management: Provision of Tools and Services for Informed Decision and Policy Making," was held April 30. Director Mark Svoboda organized the panel centered on projects and collaborations the NDMC is involved in both here and abroad. His presentation centered on developing drought-monitoring tools for the U.S. and around the world. Svoboda said the drought center is always open to working with groups that want to better prepare people and places for coming droughts: "We welcome partnerships in helping us do just that."

In not only Africa, but around the world and at home, the NDMC partners with an array of agencies already, and that was reflected in the panel of drought experts who spoke at the Water for Food Global Conference. Eduardo Martins, president of FUNCEME, the Meteorology and Water Resource Center of Ceará State (in northeastern Brazil), Rachael McDonnell, principal researcher with the International Water Management Institute, Ravinder Kaur, principal scientist with the Indian Agricultural Research Institute, and Bell have each worked with the NDMC on significant projects.

Bell said that, while U.S. citizens don't typically consider drought to be a human health threat, droughts likely have killed more people internationally than any other type of climate or weather-related disaster due to famine and malnutrition.

He has joined NDMC staff at prior workshops to discuss his research on the effects of drought on public

"Floods kill people, but droughts destroy civilizations."

– Jesse Bell, Claire M. Hubbard professor of Health and Environment at the University of Nebraska Medical Center in Omaha

health. He said during his presentation that there is no code for "drought" when a patient is admitted to a hospital, so his research on the subject identifies events that are synonymous with drought — heat waves, reduced water quality and access, food security, dust storm and wildfires among them — to help quantify drought's impact on public health.

Bell said that efforts to make public health officials better aware of drought's potential impacts on people have improved in recent years, citing the Center for Disease Control's [resource guide](#) on preparing for the health effects of drought, which featured contributions from Bell and NDMC staff.

McDonnell discussed how utilizing drought monitoring and early warning, impact assessment and mitigation, preparedness and response have shaped policies that are being built in four Middle East and North Africa countries through a USAID-funded project in which the IWMI and NDMC participate.

"We are finding that drought is very different in those countries, and it's political," McDonnell said. "One of the big challenges is all of those countries, all four countries, have received a lot of refugees. For example, the population in Lebanon was 4 million; now it's 6 million."

McDonnell said that drought monitoring maps have been tailored to each of the four countries — Jordan, Lebanon, Tunisia and Morocco — and stakeholders have been asked to review maps made with 2014 data and compare the data-driven findings with their personal experiences with drought over that period.



NDMC director Mark Svoboda (right) responds to an audience member's question during a panel session at the 2019 Water for Food Global Conference at the University of Nebraska. Others from left are Jesse Bell, UNMC professor, Ravinder Kaur, Indian Agricultural Research Institute principal scientist, Rachael McDonnell, International Water Management Institute principal researcher, and Eduardo Martins, FUNCEME president.

During Kaur's presentation, she said that a composite drought index developed with NDMC staff for India's two most drought-prone states, Karnataka and Maharashtra, improved ability to pinpoint different levels of drought. She said that comparing the CDI system's drought declarations with crop yield deviation data showed stronger correlations than the existing system.

Martins said nine northern states in Brazil currently utilize a drought monitor, and Minas Gerais and Espirito Santo to the south would soon employ a monitor as well, thanks to collaboration with NDMC staff that began in

March of 2014. By June of 2014, the Brazilian team was able to generate a drought monitor map of their own.

"People have to be empowered and feel that they are part of the process, that they have some ownership of that too," Martins said.

To view videos from the 2019 Water for Food Global Conference, visit the [conference website](#) or the Water for Food YouTube page. □

U.S. Drought Monitor now offers tables showing drought impacts at state level

Drought looks different across the country's nearly 3.8 million-square mile span, which the National Drought Mitigation Center captures with a new set of U.S. Drought Monitor tables that reflect drought impacts at state levels. The project, led by former NDMC research assistant Mary Noel, provides localized drought impact tables for all 50 states and Puerto Rico and is now available to the public on the [USDM website](#).

"It really supports all the pillars of drought planning," said Noel. "It connects the impacts and assessments to monitoring pillars. It connects impacts to mitigation. If you don't know what's actually occurring in that state, then how do you know what to plan for and how to help out?"

The tables offer information that includes the often-considered agricultural impacts of drought, while also listing key impacts outside of that realm. In severe drought (D2), house foundations in Alabama may crack, Connecticut golf courses may begin to conserve water and dust storms may sweep across New Mexico. In extreme drought (D3), the health of Nevada's wild horse population is likely to deteriorate, leading officials to round up and relocate them to less impacted areas.

"They're all unique, which is a great outcome," Noel said of the tables. "We really wanted these tables to bring awareness to these underrepresented sectors that are affected by drought. The goal is twofold. One goal is for the users of the U.S. Drought Monitor to understand what this level of severity actually means for their area. The other is for the USDM authors, to help them better understand what category of drought they should label a place. So it's both the users and the authors who can utilize these tables."

To create the state impact tables, Noel focused on one drought event in each state, gathering information from entries in the Drought Impact Reporter, a database created in 2005 to collect on-the-ground reports about emerging droughts. DIR impacts reported during the onset of the selected drought events were downloaded, coded and cross-referenced with the USDM's drought severity levels at the time the impacts were reported.



Former National Drought Mitigation Center research assistant Mary Noel presented on the creation of state impact tables for the U.S. Drought Monitor at the USDM Forum in Bowling Green, Kentucky.

Beginning the sizable undertaking alphabetically, Alabama was the project's pilot state.

Noel then fact-checked the tables with stakeholders in Alabama to confirm that the impacts found during data collection were accurate. She said the state impact tables were built with the expectation that they will be updated and evolve.

"I'm really excited that this project was actually implemented," she said. "People want to use it, and it can be used, which I think is the whole purpose of science." □

NDMC's scenario game, Ready for Drought, shows value of collaboration

Ready for Drought, a role-playing game created by the National Drought Mitigation Center, is an activity that has players work in teams of six to address the strain drought puts upon a community from the perspectives of private citizens, local decision makers, responders, business and industry, and communities. In the process it details the scope of drought, and the resources that can reduce its effects. The game was modeled after the suite of Extreme Event games created by LabX and presented by the National Academy of Sciences, said Ready for Drought's lead creator, NDMC graduate assistant Markéta Podebradská.

"They have three different extreme events: hurricane, flooding, earthquakes," Podebradská said. "We really liked the format of their game and wanted to do something similar, adapted to drought."

Podebradská was taking a class in which she was assigned to develop a classroom activity and, after consulting with NDMC climatologist Deborah Bathke, went to work on Ready for Drought, and became part of NDMC's scenario-building team.

Podebradská observed a drought tournament hosted by the North Platte Natural Resources District in Scottsbluff. There, Bathke and other NDMC staff refereed and moderated the game, which had been tailored to the participants and the area. It involved the effect of drought on North Platte River Basin, the Sandhills and the city.

"We were there to help facilitate," Podebradská said. "They put a lot of energy and money into developing these scenarios of drought and what it would look like when there was a drought in that area of certain severity and what would it mean to hydrology or to the streams there. They had these very specific scenarios."

Ready for Drought provides a general scenario for the Missouri River Basin that can be played in about 90 minutes. The game was initially tested during a class taught by Podebradská's advisor, former NDMC director and current University of Nebraska-Lincoln School of Natural Resources climatologist Michael Hayes.

"The goal was to create a simple, low-cost game, where the full package can be downloaded online,"



National Drought Mitigation Center graduate assistant Markéta Poděbradská leads a trial run of NDMC's Ready for Drought game. Shawna Richter-Ryerson

Podebradská said. "Anybody who wants to either have an icebreaker for a drought meeting or have an educational game for university or high school settings can download it and have something in their hands that they can do on their own."

Support to create the game was provided by the National Integrated Drought Information System.

Download the game rules and setup material at: drought.unl.edu/Education/DroughtGame.aspx. □

2019 BY THE NUMBERS



15
PROJECTS

15
VISITING DELEGATIONS
FROM **9** COUNTRIES

63
EVENTS
IN **11** COUNTRIES



72
TOTAL PUBLICATIONS

26
OTHER REPORTS

31
REFEREED ARTICLES



1
BOOK & BOOK CHAPTER



United States Drought Monitor (USDM) cited by: The Washington Post, Forbes, The Associated Press, The New York Times, Los Angeles Times, The Weather Channel, AccuWeather

2,088

NDMC MEDIA MENTIONS*

8,798

USDM MEDIA MENTIONS*



**Media statistics from Meltwater*

2019

BY THE NUMBERS



MONETARY IMPACT

\$7.16

BILLION

Total Livestock Forage Disaster Program payments triggered by the USDM through June 2019

\$4.5

MILLION

Total active grants in 2019

\$109.4

MILLION

Ad Value Equivalence of USDM mentions in the media*

\$22.2

MILLION

Ad Value Equivalence of drought center mentions in the media*

\$12.7

MILLION

Ad Value Equivalence of USDM + University of Nebraska

**AVE calculations according to Meltwater*



WEB STATISTICS



5.4M

PAGEVIEWS

of all NDMC websites (includes 4.8 million USDM views)



1.5M

USERS

of all NDMC websites (includes 1.2 million USDM users)



47.5%

MOBILE + TABLET TRAFFIC

on the U.S. Drought Monitor



137.2K

FILE DOWNLOADS

across all websites

OUR PEOPLE

22

FACULTY & STAFF



5

GRADUATE STUDENTS



@DROUGHTCENTER



7,126

FOLLOWERS



734
SINCE 2018



2,262

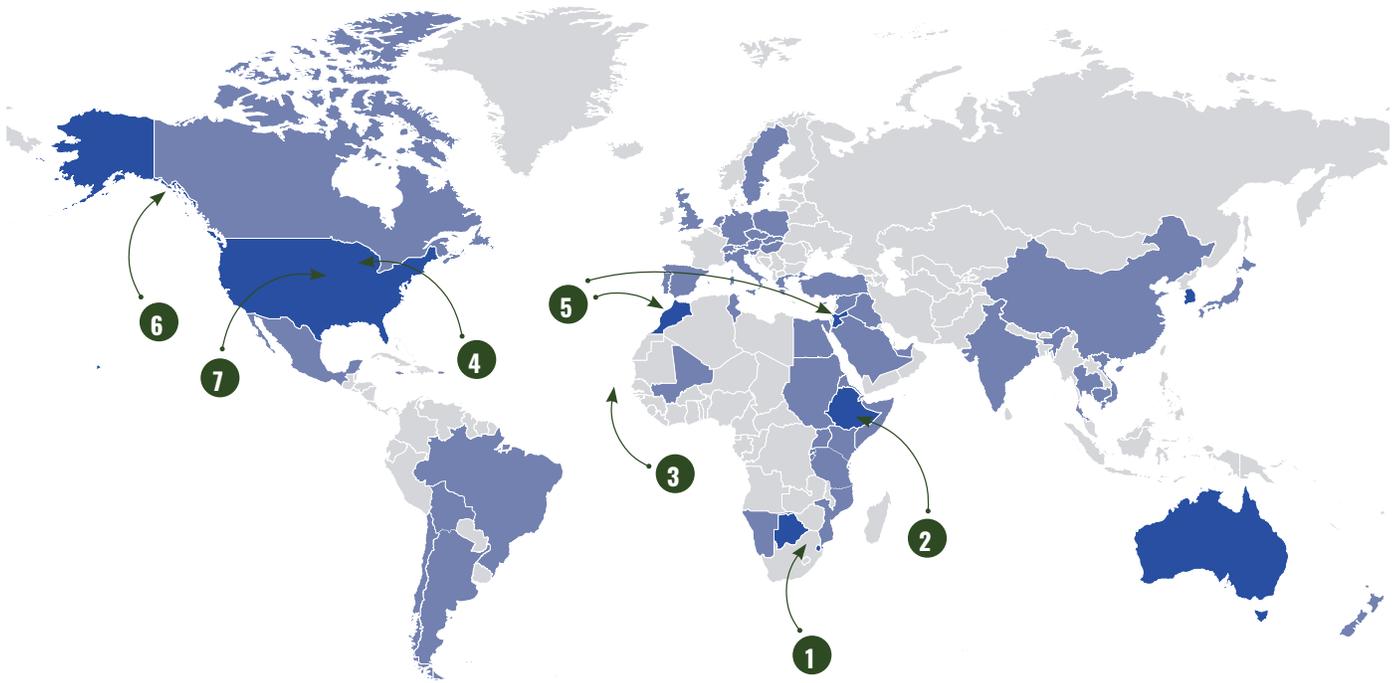
FOLLOWERS



394
SINCE 2018

Where we work

A key component of the National Drought Mitigation Center's mission is to collaborate with local, tribal, national and international organizations. In 2019, NDMC faculty and staff traveled across the globe to present, listen and collaborate. Here are some of the events they attended. **Dark blue** indicates countries where we worked in 2019, and the **lighter blue** indicates countries where we have worked in the past. **Green circles** highlight our top international projects for the year; descriptions are below.



1 Botswana and Eswatini Workshop

Location: Botswana and Eswatini

In January, National Drought Mitigation Center director Mark Svoboda traveled to southern Africa to meet with meteorological, natural resource emergency management and planning experts from Botswana and Eswatini thanks to a partnership with the World Bank. For more information, read about the experts' 2019 visit to Lincoln on page 11.

2 The first-ever African Initiative for Planetary and Space Science workshop

Location: Addis Ababa, Ethiopia

In February, NDMC climatologist and remote sensing expert Tsegaye Tadesse participated in the first AFIPS workshop, where researchers and leaders gathered to discuss the cultural, economic and societal impacts of space science development in Ethiopia and other African nations.

3 The Food and Agriculture Organization of the United Nations' Global Framework on Water Scarcity (WASAG) Conference

Location: Praia, Cape Verde

In March, Svoboda was invited to deliver a keynote speech and serve as the co-chair of the drought working group at the WASAG conference, where the theme was "Leaving No One Behind." The goal was to identify practical, innovative and collaborative solutions to address water scarcity in agriculture in a changing climate.

4 Wisconsin Specialty Crop Growers meeting

Location: Hancock, Wisconsin

In March, NDMC's Tonya Haigh and Tonya Bernadt spoke to producers about a project intended to improve drought early warning information and provide a seasonal outlook for specialty crop growers.

5 Middle East and North Africa (MENA) drought management meeting

Location: Amman, Jordan; Rabat, Morocco

In May, former NDMC director Michael Hayes and planning coordinator Cody Knutson traveled to Jordan, where they and International Water Management Institute staff organized a workshop funded by USAID. Svoboda also travelled to Morocco, and joined Knutson, Hayes and NDMC outreach coordinator Deborah Bathke in Jordan in October for a MENA project workshop.

6 USDA Drought Workshop

Location: Juneau, Alaska

In May, Bathke facilitated a drought workshop in Juneau as part of the center's work with the U.S. Department of Agriculture. The event was designed to prepare stakeholders to transition from a snow to rain-dominant system.

7 Santee Tribal Workshop

Location: Niobrara, Nebraska

In November, Knutson and Hayes facilitated the Lower Missouri River Tribes Adaptation Planning Workshop hosted by the Santee Nation.

Experts from Africa, Australia, Asia among those to visit NDMC in 2019

The National Drought Mitigation Center staff travels all over the world to provide support and knowledge to drought planners, and it also opens its doors to visitors from across the globe. The NDMC office, located at the University of Nebraska's School of Natural Resources, welcomed leaders, policymakers and academics from nine countries.

Two delegations from South Korea, representing the Ministry of Interior Safety, Ministry of Environment, Korea Meteorological Administration, K-Water, Korea Rural Community Corporation, Rural Research Institute and Hankyong National University, made trips to Lincoln in October and November.

“We have an incredibly large climate variability. When it’s dry, it’s really dry. When it’s wet, you just get flooded out. People in Australia need to be prepared to deal with extremes and they need notice of when those extremes are going to happen.”

– Laura Guillory, programmer, University of Southern Queensland Centre for Applied Sciences

In the summer, Laura Guillory, a programmer with the University of Southern Queensland’s Centre for Applied Climate Sciences, worked with NDMC geospatial analyst John Swigart on building a composite drought index (CDI), similar to the U.S. Drought Monitor, for Australia. A CDI incorporates multiple data sets, including weather, soil moisture, evapotranspiration, crop conditions and others, to examine current drought conditions. At the time of her visit, Australia was experiencing the hottest drought in its history.

“We have an incredibly large climate variability,” Guillory said. “When it’s dry, it’s really dry. When it’s wet, you just get flooded out. People in Australia need to be prepared to deal with extremes and they need notice of when those extremes are going to happen.”

In the months that followed her visit, wildfires raged across the country, drawing international attention to the crisis.



Members of a Korean government delegation shake hands with NDMC director Mark Svoboda after signing a memorandum of understanding.

In June, representatives from Botswana and Eswatini came to NDMC to participate in a two-day workshop facilitated by the World Bank that served as the first steps in building drought preparedness strategies there. A highlight from the trip – NDMC staff, led by director Mark Svoboda, worked around the clock to build CDI prototypes for the two countries.

Reuben Maboko, chief water engineer of Botswana’s Ministry of Land Management, Water and Sanitation Services, who presented on Botswana’s drought conditions on the first day of the workshop, said that the trip to Nebraska helped prepare the teams for their respective next steps.

“It was really nice to see the maps,” he said. “The most interesting thing was to see how what we have already correlates very well with the (prototype) maps, which was really good to see. And it got us really motivated to see that this is something that can be done.” □

NDMC 2019 Publication Highlights

SURVEY OF RANGELAND MANAGERS EXAMINES LAG IN RESPONSE TO 2016 DROUGHT

Haigh, Tonya R., Otkin, Jason A., Mucia, Anthony, Hayes, Michael J. and Burbach, Mark E. Drought early warning and the timing of range managers' drought response. *Advances in Meteorology* (2019).

When rangeland managers see signs of drought, they may need to take action. During a significant flash drought that began in the early spring of 2016 and took hold in parts of the Northern Plains, 87% of managers who responded to a survey created by Tonya Haigh at the National Drought Mitigation Center said that they bought extra hay, grazed pastures earlier, or destocked herds.

But many of those surveyed did not begin taking action until the fall of 2016, even though drought monitoring and early warning tools such as the U.S. Drought Monitor and products from the National Weather Service and U.S. Department of Agriculture were registering drought months earlier.

Haigh, a research specialist with NDMC, wrote that this offers an opportunity to understand proactive decision-making and improve outcomes for rangeland managers.

"It's important to understand the decisions rangeland managers make during drought in order to provide drought early warning information that is relevant and actionable to them," Haigh said.

The study utilized information from a survey of agricultural producers in Nebraska, Wyoming, South Dakota and Montana who were affected by the flash drought that began to develop in late March of 2016.

On the web at www.hindawi.com/journals/amete/2019/9461513/abs/#supplementary-material-1.

A 2016 flash drought hit areas of Nebraska, Wyoming, Montana and South Dakota (pictured) hard. National Drought Mitigation Center research specialist Tonya Haigh surveyed rangeland managers about their responses to the drought and the findings were recently published. Joe and Cindy Painter of South Dakota shared this photo of conditions at their ranch.

EXAMINING HOW DROUGHT IMPACTS STATE RECREATIONAL AREAS

Jedd, Theresa M., Bhattacharya, Devarati, Pesek, Cara and Hayes, Michael J. Drought impacts and management in prairie and Sandhill state parks (2019). *Journal of Outdoor Recreation and Tourism*, (2019).

Interviews with Nebraska state recreation area managers show how drought affects outdoor recreation and how resources like the U.S. Drought Monitor could be incorporated into a park management plan, according to the research paper published last June.

Jedd, an environmental policy specialist formerly with the National Drought Mitigation Center, stated that Nebraska park managers are concerned with the possibility of experiencing dry years.

"Just like agricultural producers adjust their operations during droughts, managers mobilize park resources," Jedd said. "A lot of this is behind the scenes, but data from our sample shows that the top management at state parks worry about drought for many reasons, from making sure that campers in tents have shade structures to prevent heat injuries to preventing long-term ecological damage."

On the web at www.sciencedirect.com/science/article/pii/S2213078019300131#!. □



Our team

LEADERSHIP

- Dr. Mark Svoboda**
Director
- Dr. Kelly Helm Smith**
Assistant director & communication coordinator
- Dr. Deborah Bathke**
Education coordinator
- Brian Fuchs**
Monitoring coordinator
- Dr. Cody L. Knutson**
Planning coordinator
- Dr. Tsegaye Tadesse**
Geospatial coordinator

STAFF

- Tonya Bernadt**
Education and outreach specialist
- Ann Fiedler**
Administrative assistant
- Denise Gutzmer**
Drought impact specialist
- Dr. Tonya Haigh**
Project manager rural sociologist
- Dr. Theresa Jedd**
Post-doctoral researcher
- Dr. Tingting Liu**
Drought policy & impact analyst
- Cory Matteson**
Communications specialist
- Mary Noel**
Research assistant
- Jeff Nothwehr**
GIS and web specialist
- Brendon Orr**
Web graphics designer
- Chris Poulsen**
GIS manager
- Dr. Renata Rimsaite**
Water markets analyst
- Curtis Riganti**
Climatologist
- Claire Shield**
Climatologist
- John Swigart**
Geospatial analyst
- Deborah Wood**
Publication specialist
- Nicole Wall**
Outreach and research specialist
- Nicky Wood**
Administrative assistant

STUDENTS

- RaeAnna Hartsgrove**
Graduate research assistant
- Jenna M^cCoy**
Undergraduate intern
- Anduaem Shiimeles Shiferaw**
Graduate research assistant
- Elliot Wickham**
Graduate research assistant
- Beichen Zhang**
Graduate research assistant

Partnerships

INTERNATIONAL

- Global Water Partnership
- International Center for Biosaline Agriculture
- International Water Management Institute
- U.S. Agency for International Development
- Korea Water Resources Corporation
- Queensland Drought Mitigation Centre: University of Southern Queensland
- United Nations
 - Convention to Combat Desertification
 - Environment Program
 - Food and Agriculture Organization
 - World Meteorological Organization
- World Bank

FEDERAL

- NASA
 - Jet Propulsion Lab
 - Goddard and Marshall Space Flight Centers
- National Science Foundation
- U.S. Department of Agriculture
 - Agricultural Research Service
 - Office of the Chief Economist
 - World Agriculture Outlook Board (USDA Chief Meteorologist)
 - Foreign Agriculture Service, Borlaug Fellowship Program
 - Climate Hubs
 - Natural Resources Conservation Service
 - Forest Service
 - Risk Management Agency
- U.S. Department of Interior

- Bureau of Indian Affairs
- U.S. Fish & Wildlife Service
- U.S. Bureau of Reclamation
- U.S. Geological Survey
 - Earth Resources Observation and Science (EROS) System
- U.S. Department of Commerce
 - National Integrated Drought Information System
 - National Centers for Environmental Information
 - National Weather Service
 - River Forecast Centers
- NOAA Office of Atmospheric Research
- NOAA Climate Program Office
 - Sectoral Applications Research Program
 - Modeling, Analysis, Predictions and Projections
 - National Water Center
- Federal Emergency Management Association
- U.S. Environmental Protection Agency
 - Office of Research and Development (ORD)
- U.S.A.C.E.

ACADEMIC

- University of Nebraska
 - Extension
 - Public Policy Center
 - Daugherty Water for Food Global Institute
 - High Plains Regional Climate Center
 - State Climate Office
 - School of Natural Resources
- Colorado State University
- Southern Climate Impacts Planning Program
- Carolinas Integrated Sciences and Assessment
- Desert Research Institute, University of Nevada, Reno

- University of Wisconsin Cooperative Institute for Meteorological Satellite Studies
- North Central Climate Collaborative (NC₃)
- University of North Dakota Extension
- Iowa State University Extension
- University of Maryland Earth System Science Interdisciplinary Center
- Oklahoma State University
- Kansas State University
- Extension Disaster Education Network
- University of Nebraska Medical Center

STATE OF NEBRASKA

- Nebraska Governor's Climate Assessment and Response Committee
 - Water Availability and Outlook Committee
- Nebraska Health & Human Services, vector-borne disease surveillance
- Nebraska Emergency Management Association

OTHER ORGANIZATIONS

- Banner Associates, Inc.
- Community Collaborative Rain, Hail & Snow Network
- Great Plains Tribal Water Alliance
- American Planning Association
- Iowa Wine Growers Association
- Iowa Hops Growers
- Wisconsin Potato and Vegetable Growers Association
- Wisconsin Cranberries Growers

U.S. Drought Monitor celebrates its 20th year

In the late 1990s, National Drought Mitigation Center founding director Don Wilhite assigned Mark Svoboda to find every drought-related index, indicator and tool that existed, and request access to the data that was used to create them. Unfortunately, Google didn't debut until after he began his search.

"There wasn't a whole lot out there, and I remember the response to my request for operational data was getting a hard copy map in the mail of the Palmer Drought Severity Index from the National Climatic Data Center," Svoboda said. "That wasn't even delivered digitally at the time."

With scarcity of information in mind, Svoboda presented on drought mapping at the 1998 American Meteorological Society annual meeting. Another presenter at the session, Douglas Le Comte of the Climate Prediction Center, was interested in combining various drought indices into one map. The two talked after the meeting about joining forces.

"That's where the idea was born to make a higher resolution map made from combining several indicators, including impacts, together that shows where drought is and how severe it is," said Svoboda, who is now the NDMC director.

Their collaboration spearheaded the creation of the U.S. Drought Monitor, which celebrated its 20th anniversary this year. Every week since the Drought Monitor was unveiled at a White House press conference on Aug. 11, 1999, the NDMC, U.S. Department of Agriculture (USDA) and the National Oceanic and Atmospheric Administration (NOAA) have teamed up to release an update of the USDM.

An extensive network from an array of agencies has contributed data and on-the-ground observations to produce more than 1,000 maps, and the USDM has grown to include all U.S. states and territories, including the additions of the U.S.-affiliated Pacific Islands and the U.S. Virgin Islands in 2019. It has triggered billions of dollars in federal aid and low interest loans. Federal, state, tribal, local and basin-level decision makers use it to detect emerging droughts.

And it all started as a map made with CorelDRAW 8.

"I think I have a curled-up map that actually shows one of the original drafts of the Drought Monitor," Le

"I think I have a curled-up map that actually shows one of the original drafts of the Drought Monitor."

– Douglas Le Comte, NOAA Climate Prediction Center

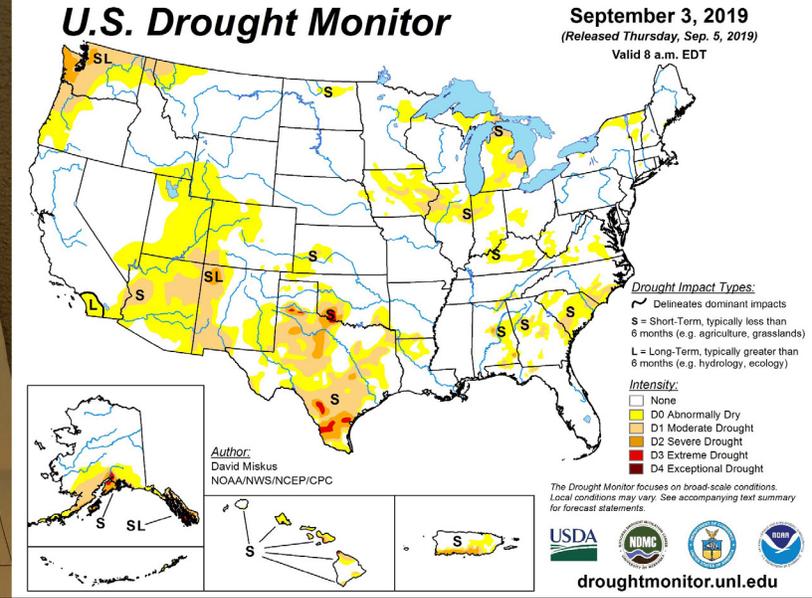
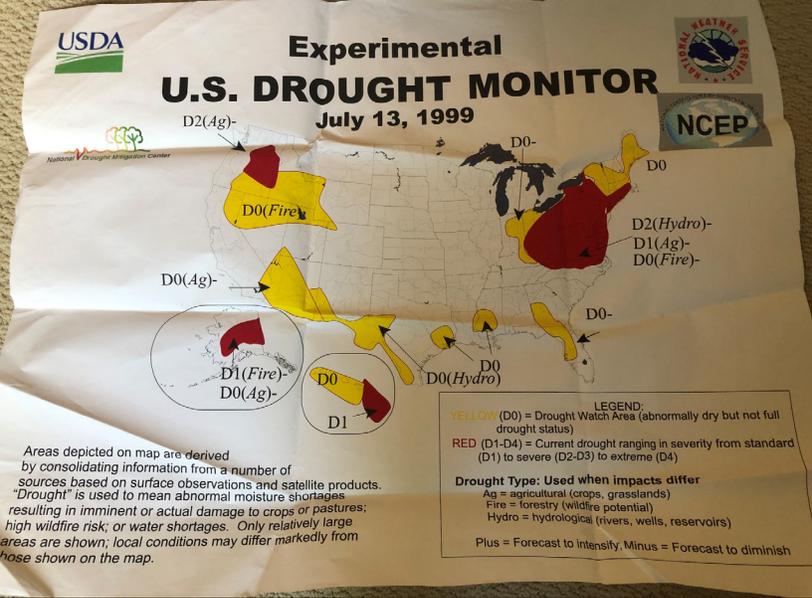
Comte, now retired from the CPC, recently said from his Arlington, Virginia, home.

Dated July 13, 1999, the prototype features some classifications familiar to those who have used the USDM over its 20-year existence. Yellow blobs indicating abnormally dry areas covered much of the Southwest and Northeast. Encircled in red were portions of the Pacific Northwest, Alaska, Hawaii, the Northeast and the Mid-Atlantic, including all of Maryland, Virginia and Washington D.C. These were the only two colors on the draft, though, with red being an all-encompassing indicator of drought. (Each level of drought now has its own designated color.) Arrows specified the class and types of drought in those locales, with one pointed directly at our nation's capital. That drought, the USDM's early authors believe, helped provide the project with a big green light.

"Serendipity is the word," Le Comte said.

Not long after creating that mid-July map, a secretarial briefing regarding the USDM was held at the White House. The USDM's proponents told officials that it could help heighten awareness of drought as an environmental hazard, provide the public and decision-makers vital information about the creeping disaster and decrease response lags to drought, like the rare one building in the Northeast in the summer of '99.

"The Palmer wasn't showing that drought evolving nearly fast enough," said Svoboda, who was a USDM author for 17 years. "Our new prototype showed potential to pick up the signal earlier given we weren't solely relying on any one drought indicator in particular. So they informed us that this new prototype drought indicator was going to go operational this summer. After production of the first operational map in early August, the very next week, the experimental label was off the map. So I think that might be the shortest experimental product in government history. That drought is really what made it



The process of creating the weekly U.S. Drought Monitor has evolved over its 20-year history, but its purpose — to show where drought is affecting people in the U.S. and its territories — remains steadfast.

all happen, in a way. So we quickly ramped up from two authors to six authors in the span of just a few months.”

The first six USDM authors were Svoboda and Michael Hayes from the NDMC, Le Comte and Rich Tinker from NOAA’s Climate Prediction Center (CPC), and Brad Rippey and David Miskus, who was on assignment from the CPC at the USDA, where he joined Rippey. Nearly 30 authors have taken two-week shifts creating the map over its 20-year history.

The map is now created with GIS software, and authors consider data from more than 50 sources, including precipitation, temperature, evapotranspiration, the Palmer Drought Severity Index, the Standardized Precipitation Index, soil moisture indicators, hydrologic data, snowpack data, satellite-based assessments of vegetation health, land-data assimilation models and many more.

The USDM has been written into the Farm Bill since 2008 as a trigger for drought relief under the Livestock Forage Disaster Program, and after widespread drought in 2012, it became a trigger for fast-track Secretarial Disaster Designations. As of 2019, the USDM had been used to distribute approximately \$7.2 billion in aid to livestock producers. The USDM helps producers receive aid faster, said Brian Fuchs, NDMC Monitoring Coordinator and USDM author since 2006.

USDM authors have come to rely on the team of local, state and regional experts on the Drought Monitor network listserv, where climatologists and evaluators

“There’s no drought that’s going to happen anymore without somebody knowing about it. And that’s a good thing.”

– Brad Rippey, NOAA Climate Prediction Center

provide updates from their locations and also respond to drafts of the map as publication dates near. They often also share news stories about experiences of drought, like a village in Alaska that ran out of stored water as the state grappled with persistent drought throughout 2019.

“I think if the Alaska drought (in 2019) had happened 20 years ago, we might have missed it,” Rippey said. “There’s no drought that’s going to happen anymore without somebody knowing about it. And that’s a good thing.”

On the web at droughtmonitor.unl.edu. □

Database includes more types of drought planning

Drought planning is going mainstream, and the National Drought Mitigation Center has expanded its online collection of state plans that address drought to include more plan types. Until now, the NDMC's online database of drought plans mainly included stand-alone drought plans. It now also includes existing water plans, hazard plans and climate plans for each state and Puerto Rico.

The updated state planning information on the NDMC website allows users to view a U.S. map that not only shows which states have drought plans — 47 and Puerto Rico — but also shows, via color-coding, how recently the plans were created or updated, and whether the plan identifies mitigation or response actions to be taken. Layers showing which states address drought in hazard, water and climate plans also show how recently the plans were created.

NDMC graduate research assistant RaeAnna Hartsgrove and former NDMC staff members Theresa Jedd and Nicole Wall analyzed nearly 150 existing state plans to see whether they included definitions of drought, outlined drought impacts, included triggers for action, focused on mitigation or response strategies, and other key factors. Hartsgrove said one main project goal was to provide state planners with a user-friendly space to search for relevant information when the time comes to create or update state plans that focus on or involve drought.

“We want states to be on top of their planning, and if we have this as a reference, it helps planners get to see which plans include these criteria,” Hartsgrove said.

Users who visit the updated state plan database first view a U.S. map displaying which states have drought plans, and how recently they were updated. On that page, a drop-down menu below the map allows users to search for climate, water and hazard plans as well. When viewing drought plans, the state of Washington, which

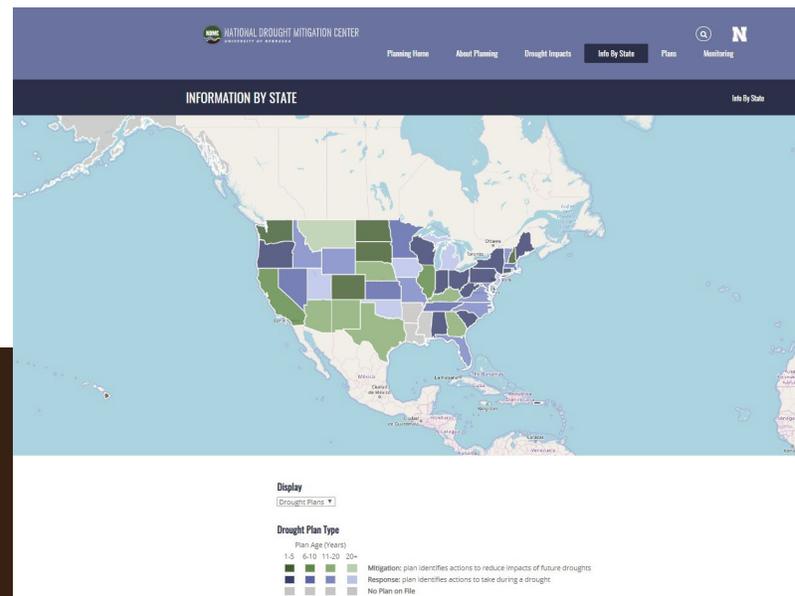
produced a drought contingency plan in 2018, is shaded in a deep olive to signify its recent release and mitigation focus. Clicking on the state takes the user to a page that not only includes a link to that plan, but also provides links to the state's water, general hazard and climate plans, relevant Washington state website links, contact information for key officials and the latest U.S. Drought Monitor map of the state.

“The database provides improved access to the content of several drought-related state plans,” said NDMC planning coordinator Cody Knutson. “It not only allows for someone to assess what type of plans are in place across the country, but it can be a great benefit to planners from states looking for guidance or examples of drought-related activities that could be included in their own plans.”

The work to collect and code plans was done through the Drought Risk Management Resource Center, funded through the National Integrated Drought Information System and the National Oceanic and Atmospheric Administration's Sectoral Applications Research Program. NDMC is located in the School of Natural Resources at the University of Nebraska-Lincoln.

The updated and expanded state plan database can be found at drought.unl.edu/droughtplanning/InfobyState.aspx. □

The National Drought Mitigation Center has expanded its online collection of state plans that address drought to include existing water plans, hazard plans and climate plans for each state and Puerto Rico.





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