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DROUGHT FORECASTING, MONITORING, AND DECISION-MAKING: A REVIEW OF THE NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

BEFORE THE
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U.S. HOUSE OF REPRESENTATIVES

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Good morning Chairman Hall and members of the Committee. My name is Roger S. Pulwarty and I am the Program Director of the National Integrated Drought Information System (NIDIS) at the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA). Thank you for your leadership in authorizing NIDIS in 2006 and for inviting me to provide the Committee with an update on the Program. It is an honor to be here today. My testimony will report on the information and data that have been made available to local, state, and regional water decision-makers, and how we can improve the information for anticipating and managing current and future drought conditions.

NIDIS is part of the suite of weather and climate products and services NOAA provides to improve management of sectors of our economy - including energy, agriculture, water, and living marine resources that are sensitive to variations and changes in long-term weather. Using observations, research and predictions, decision support tools, and sustained user interaction, NOAA provides assessments and predictions of weather and climate variability on timescales ranging from weeks to decades for a variety of phenomena, including drought. In this testimony, I will highlight the NIDIS' role in improving the Nation's capacity for understanding, predicting, and responding to drought.

Drought in the U.S.

Drought is part of the American experience. Severe, long-lasting droughts occurred in the Southwest during the 13th century, and in the central and lower Mississippi Valley in the 14th through 16th centuries. The great Civil War drought of 1861-1864 led to the first water rights agreement in the West - in the San Luis Valley in the state of Colorado where I live. In the 20th century, droughts in the 1930s (Dust Bowl era) and 1950s were particularly severe and widespread. In 1934, 65% of the contiguous United States was affected by severe to extreme drought. These extreme events, including droughts of

shorter duration but nevertheless severe, such as in 1977, have been felt throughout economies, ecosystems, and livelihoods, and certainly shaped much of the planning and practice surrounding modern water resources management and related decisions.

Since 2000, the total United States land area affected by drought of at least moderate intensity has varied from as little as 7% of the contiguous United States (August 3, 2010) to as much as 46% of the U.S. land area (September 10, 2002). The issue of drought is particularly timely. Based on weekly estimates of the areal extent of drought conditions since 2000, the average amount of land area across the United States affected by at least moderate-intensity drought annually has been 25%. According to the U.S. Drought Monitor (USDM) (created by the U.S. Department of Agriculture (USDA), U.S. Geological Survey (USGS), the National Aeronautics and Space Administration (NASA), NOAA, and the National Drought Mitigation Center at the University of Nebraska), more than half the country (56%) experienced drought conditions over the past month (June 2012) — the largest percentage since the monitor was started 12 years ago. NOAA also notes that the period from January through June of this year was the warmest first half of any year on record for the contiguous United States. The average temperature nationwide during this six month period (January-June 2012) was 52.9 degrees Fahrenheit, or 4.5 degrees above average over the instrumental record. Other records have also been set this year. For instance, on June 26, Red Willow, Nebraska set a temperature record of 115 degrees, eclipsing the 114-degree mark set in 1932. Twenty-eight states east of the Rockies set temperature records for the six-month period, putting further pressure on agricultural irrigation requirements and direct plant crop stress, on energy demands for cooling, and water storage management.

The U.S. National Integrated Drought Information System

The National Integrated Drought Information System Act of 2006 (Public Law 109-430, hereafter NIDIS Act) builds on longstanding efforts among agencies and institutions that have historically focused on drought risk assessment and response. The NIDIS Act prescribes an interagency approach, led by NOAA, to "Enable the Nation to move from a reactive to a more proactive approach to managing drought risks and impacts." The goals of NIDIS are to (a) improve public awareness of drought and attendant impacts and (b) improve the coordination and capacity of counties, states and watershed to reduce drought risks proactively

Under the Act, NIDIS is authorized to conduct three tasks to achieve these goals:

i. Provide an effective drought early warning system that: (a) collects and integrates key indicators of drought severity and impacts, and (b) produces timely information that reflects local, regional, and state differences,
ii. Coordinate and integrate as practicable, Federal research in support of a drought early warning system, and,
iii. Build upon existing forecasting and assessment programs and partnerships.

At the national level, the multi-agency NIDIS Executive Council oversees the NIDIS Program Office. The NIDIS Program Office coordinates the multi-agency and multi-state NIDIS Program Implementation Team (NPIT). The NPIT is currently composed of

representatives from federal, state and Native American tribal agencies, and academic and private entities. In accordance with the Act, NIDIS was developed, and is continually being improved by engaging those affected by drought, integration of physical/hydrological and impacts information from observing networks, development of a suite of drought decision support tools, and the interactive delivery of information at watershed, state and county levels across the United States.

To meet these goals, NOAA supports four elements at the national level under NIDIS, all of which work together. The Drought Early Warning and Information Systems (DEWS) integrate information from "Coping with Drought" Research, the Climate Test-bed, and the Drought Portal, and fills in information gaps to provide drought early warning to drought-vulnerable regions of the Nation. Below is a brief description of each element, which I will explain in more detail below:

- "Coping with Drought" Research: Provides grants to assess impacts of drought on agriculture, ecosystems, and water resources and to develop decision support tools for regional, state, and local use. Partners include the Regional Integrated Sciences and Assessments Program and the Sectoral Applications and Research Program.
- Climate Test-beds: Research to improve predictions and links between climate forecasts and stream flow projections for particular basins. In addition, the Earth System Research Laboratory's Physical Sciences Division, the Geophysical Fluid Dynamics Laboratory, and the Interagency Drought Task Force, all support NIDIS through research on drivers of drought frequency, onset, duration, and intensity.
- The U.S. Drought Portal: A one-stop-shop (www.drought.gov) for drought-related information and products provides credible and easily-accessible information to the public and private sectors on the web.
- Regional Drought Early Warning Information Systems (DEWS): The system facilitates ongoing assessment and scientifically-based outlooks of existing and potential drought conditions and impacts. These results are disseminated through webinars and workshops to resource managers. The system also develops user guidance, webinars, workshops with, and decision support tools for resource managers to support drought planning and risk reduction. These activities are conducted in partnership with other agencies, tribes and states, and the National Drought Mitigation Center (University of Nebraska).

Four elements of NIDIS

"Coping with Drought" (CWD) Research

CWD Research is a NOAA-supported, cross-agency grants initiative developed to support interdisciplinary research that advances the NIDIS objectives of developing drought early warning systems. Its main goal is to determine how climate data and information could help reduce vulnerability to drought by evaluating the impacts of, planning for, and responding to, drought that feed into early warnings.

Currently, two programs in the NOAA Climate Program Office support CWD - the Sectoral Applications Research Program (SARP) and the Regional Integrated Sciences

and Assessments (RISA). SARP projects identify socioeconomic effects of drought and data information needs of resource managers and policy/decision makers and develop new tools, methodologies and knowledge to address these needs. RISA CWD supports regionally-specific efforts to test tools and methodologies to cope with drought and funds one drought-focused RISA.

Some examples of outcomes from Coping with Drought grants and the institutions that led these studies include:

- Creating guidebooks on water resources reliability (University of Arizona (UA)), river restoration (Briggs), and community drought preparedness (National Drought Mitigation Center at the University of Nebraska);
- Linking NOAA climate forecasts to dynamic vegetation models to produce seasonal predictions for fire management (University of Nevada, Reno – Desert Research Institute – Western Regional Climate Center);
- Conducting workshops on using climate information in drought decisions (University of Nebraska, Lincoln, UA);
- Transferability of the University of South Carolina's Dynamic Drought Index Tool to other regions; and,
- Reconciling projections of future Colorado River stream flow (multiple Universities).

Climate Test-beds

NOAA formed the Climate Test-beds (CTB) to accelerate the transition of scientific advances from the climate research community into improved NOAA operational climate forecasts, products, and applications. The CTBs serve as a conduit between the operational, academic and research communities. This enhanced transfer of research to operations seeks to significantly increase the accuracy, reliability, and scope of NOAA's suite of operational climate forecast products to meet the needs of a diverse user community.

Some of the questions that are being addressed by CTBs include:

- Why was the prediction of the severity and duration of a particular drought or flood event missed in a given year?
- Does the reliability of forecasts of drought events vary over time?
- How do other drivers of climate variability, such as the Arctic Oscillation and the Atlantic Multi-decadal Oscillation, affect the forecast reliability of droughts dominated by the influence of the El Niño-Southern Oscillation (ENSO) in the western U.S.?

In addition, because high precipitation events are important for flooding and for ending droughts, CTBs also focus on the links between droughts and floods across timescales. One effort is conducted in partnership with NIDIS, the NOAA River Forecasts Centers, the Earth System Research Laboratory's Physical Sciences Division, and the Climate Prediction Center.

The U.S. Drought Portal
The U.S. Drought Portal (www.drought.gov) was released in 2007 as an information clearinghouse. It is a major component of NIDIS that directly provides current drought conditions, current drought impacts, and the projected length of drought. The U.S. Drought Portal provides routinely updated data products to help managers monitor and prepare for drought. Some examples of NOAA products now located on the Drought Portal include the USDM, Crop Moisture Index, ensemble water supply forecasts, and the location of relief sources as requested by the USDA. The USDM provides current drought conditions and can also be accessed directly online without going through the one-stop drought portal. The USDM also features new tools and resources developed specifically for NIDIS such as advanced mapping with GIS tools.

The NIDIS' U.S. Drought Portal experiences an average of 10,000 unique hits each month, but this number spikes significantly (60,000-70,000 at present) as drought severity increases in any given region. As part of the continuous improvement of products and services for the Nation, NIDIS is working to improve the usefulness at the local level of drought.gov by creating watershed level sub-portals hosted on the national website. In partnership with other agencies, tribes and states, the NIDIS teams coordinate and develop capacity to prototype, and then implement, regional drought early warning information systems using the information portals and other sources of local drought knowledge.

Regional Drought Early Warning Information Systems (DEWS)
Drought varies from region to region. As noted by the Congressional Research Service (2012) - extreme drought is different for Lubbock, in northwest Texas, a normally dry area, than it is for Athens, in north central Georgia, a normally wet area. In addition to physical variations, there are diverse stakeholder needs even within a single basin, such as water supply for the city of Atlanta in the northern part of the basin to irrigation for the agricultural sector (Flint) and power generation (Chattahoochee) in the middle part of the basin to ecosystem and fishery needs at the southern end of the basin (Apalachicola Bay).

As a result, NIDIS developed regional early warning information systems where drought had different physical drivers, timescales and impacts to develop tools, outlooks, and stakeholder engagement mechanisms appropriate for similar regions around the country. The locations for regional drought early warnings systems implementation are based on an assessment of drought sensitivity (including publicly identified information needs), drought type (snowpack or rainfall driven, short-term, multi-year), and management unit (watershed, city, county, etc.).

The early "prototype" for each potential Regional DEWS addresses existing barriers to cross-agency collaboration, innovations and new information to be introduced and tested, and clarifies the benefits of participation in design, and implementation and maintenance. To ensure information gaps are filled, NIDIS also conducts knowledge assessments to: (1) determine where major gaps in data, forecasts, communication, and information delivery exist; (2) identify innovations in drought risk assessment and management at state and local levels; and (3) engage constituents in improving the effectiveness of

NIDIS. Thus, the "early warning information system" in this organizational model does not simply involve the dissemination of a forecast. It allows for major innovations from the research community to incorporate new, locally specific information and technologies for detecting and communicating drought risks and warnings to be tested and introduced. There are a growing number of positive examples of such partnerships, and in line with its implementation plan, NIDIS is developing similar Regional DEWS in other watersheds across the country.

In this process, NIDIS has implemented Regional Drought EWS in the Upper Colorado River Basin, and are creating similar Regional Drought EWS including the U.S. Southeast (Apalachicola-Chattahoochee-Flint, Basin, the Carolinas) and the state of California. The lessons and tools from these systems are being transferred to other states and regions, e.g. the Pacific Northwest, the lower Great Plains and the Chesapeake Bay tributaries, to help create a fully "National" drought early warning presence.

With regard to evaluating the DEWSs, and for future improvements, NIDIS conducted the first ever assessment of the status of DEWS across the U.S. There is significant leveraging of existing system infrastructure, data, and products produced by operational agencies, for example, the snow-depth from Department of Agriculture, reservoir levels from the Department of the Interior and the U.S. Army Corps of Engineers. NIDIS also reports on advances in hazards research, advances in the development of early warning systems, and in new technologies and techniques that can improve the effectiveness of existing DEWSs.

Benefits of NIDIS

NIDIS is providing a dynamic and accessible drought information system that enables users to determine the potential impacts of drought, the associated risks, and the decision support tools needed to better prepare for, and mitigate the effects of drought. Specifically, NIDIS coordinates drought monitoring and forecasting systems; provides an interactive drought information clearinghouse and delivery system for products and services; and allows for mechanisms to improve and incorporate coordinated drought preparedness and planning. Four specific examples below illustrate how NIDIS develops its partnerships and directly serves communities and meets user needs.

<u>NIDIS Upper Colorado River Basin Early Warning Information System</u>

As the first system of its kind, the Colorado Basin EWS illustrates the various scales of NIDIS Early Warning Systems. In 2008, NIDIS convened a series of stakeholder workshops in the Colorado Basin for partners and end-users to determine existing capabilities, indicators and drought information needs. Resulting NIDIS Products and Services include watershed-based drought indicators and triggers used in the Upper Basin; improved linkages between climate and streamflow modeling during drought; spatial analysis of water demand during drought; low flow impacts database for 164 National Weather Service forecast points; basin-specific Drought Portal; and weekly drought and water outlook webinars/early warning discussions with local resource managers.

Each product has been well-received. For example, the webinars bring together stakeholders from federal and state agencies, water conservation districts, recreation and tourism to discuss status of the snowpack, streamflow, reservoir conditions, water demand, and short-term (e.g., 5 days), seasonal forecasts (e.g., 30 days to 90 days) and long-term variations. The groups use data and information from federal and state agencies, and universities, to develop status reports and outlooks. The sessions allowed local experts and practitioners to interact and directly update the weekly USDM map with local information on drought and soil moisture conditions. This refinement at the local level was sought by states and communities in drought-sensitive regions, such as the Western States Water Council.

According to the Colorado State Climatologist, the Upper Colorado Basin has become much more engaged in the USDM weekly update cycle because of the improved local input. He added that since the NIDIS EWS has been involved, contributions to the USDM are better coordinated and it is now a more useful product. Due to increased consistency in monitoring and communications, the weekly drought assessment webinars have also improved the level of awareness of drought conditions (both physical system and impacts). Thus, the Colorado Basin EWS actively feeds into, and improves the applicability and usefulness of, the national level Drought Monitor by enhancing information about local conditions.

A Southeastern City Benefits from NIDIS

Through the NIDIS "Coping With Drought" program, researchers worked with the Watershed Division of Auburn, AL (53,000 residents) on methods using seasonal to interannual climate forecasts to reduce the impact of drought on water supply and demand. In March 2011, the city issued a drought update in an effort to curb water demand based on this information. As a result of the city's proactive response to the impending 2011 drought, its water supply was not greatly affected. The city now uses this climate information in water management planning and demand management on an ongoing basis.

Drought-Ready Communities

The number of watershed, state and local drought and water plans using NOAA-based information has significantly increased since NIDIS was initiated. Drought preparedness advice and planning are carried out by water-dependent managers such as State Engineers, Water Availability Task Forces, farmers, agribusinesses, land managers, city councils, and others. However, the results of drought-related research, including data analyses, are not always disseminated in a timely fashion or through easily accessible or compatible modes for incorporation into risk management.

Identification and development of drought triggers and indicators requires active engagement among researchers, information brokers, and stakeholders in various sectors responsible for managing drought-related risks. Many of the lessons learned following drought events can be documented with post-drought assessments to ensure that these critical lessons are not lost. Post-drought assessments are a key step within the drought planning process, and NIDIS is learning from existing networks, such as Cooperative

Extension, and has been engaged by the American Planning Association to help address and reduce the urban impacts of drought. One key product, a Drought-Ready Communities guidebook to improve drought planning, was developed specifically in response to this need by NIDIS, the Sectoral Applications and Research Program, and the National Drought Mitigation Center.

The Southern U.S. Drought 2011-2012

As early as the summer of 2010, NOAA's Climate Prediction Center predicted that La Niña conditions would increase the potential for drought formation across the southern United States. The forecast for drought formation was verified, and the Fall 2010 drought was one of the most severe multiple-year droughts on record. It continued into the following year with the 2011 Water Year in Texas being the driest in 100 years with impacts on water resources, agriculture, energy, and tourism of more than $10 billion to date. At this time, the physical drivers of drought in the United States are increasingly understood to be linked to sea surface temperatures (SST) in the tropical Pacific Ocean coupled with local land surface feedbacks and atmospheric anomalies.

The data, tools and experience from NIDIS activities were brought to bear during the onset of drought in the Southern United States in Fall 2010. NIDIS conducted a series of drought information outlooks related to that drought, with the NOAA/NESDIS National Climatic Data Center and the NOAA/NWS Southern Region Office, in partnership with the States of Texas, Oklahoma, New Mexico, and others. The drought information outlooks are a new approach to improve communication and delivery of drought early warning information for planning and risk management. The research, impacts assessments, and coordinating mechanisms supported by NIDIS improved coordination and usability of drought information in Texas. NIDIS engaged local partners such as the regional weather and climate offices and state climatologists to lead this effort together with researchers and products from NOAA's Earth System Research Lab, the Climate Prediction Center and other Federal entities. From this research it became clear that La Niña was a critical initiator but not the main driver of ensuing drought severity and duration highlighting the need for additional research. This work has gained attention in national media, including the Wall Street Journal, on January 2, 2012, which carried one of the outlooks created by NIDIS.

NIDIS' External Support and Partnerships

NIDIS aims to provide directly accessible, timely drought information to users, and as such, has enjoyed strong user support. For example, NIDIS has been acknowledged by the Western Governors Association as providing a natural prototype for achieving effective early warning and drought information to support risk management by (1) engaging both leadership and the public at regional, state and local levels, and (2) establishing an authoritative basis for integrating monitoring and research products to support risk management.

Part of the support that NIDIS has generated, and the program's ability to meet the Nation's needs, results from the strong partnerships with other agencies, outreach organizations, and an enabling set of programs and observational capabilities, such as the

Cooperative Observer Program (COOP) Monitoring network, a decentralized citizen-based effort to provide local data; the National Resources Conservation Service SNOwpack TELemetry (SNOTEL) sites; the Water Census led by the U.S. Geological Survey (USGS) under the Department of the Interior's WATERSMART efforts; and streamflow and reservoir levels from the U.S. Army Corps of Engineers and the Bureau of Reclamation. In addition to these are the state and regional partnerships such as the Western Governors Association, the Western States Water Council, various State Water Conservation Boards; and academic institutions especially the National Drought Mitigation Center (NDMC) at the University of Nebraska, Lincoln. These essential partners work actively with NIDIS on improving operational products (i.e., U.S. Drought Monitor, Drought Impact Reporter, Vegetation Drought Response Index), applications (i.e., drought planning at all levels), and education (i.e., K-12 activities) within the drought research community, media and general public to make our Nation more resilient in the face of drought and its impacts.

Next Steps for NIDIS

Key to the future success of NIDIS is an improved understanding of the drivers of drought onset, severity and duration from seasonal to yearly to decades. Success will also be heavily dependent on a sustained national system of credible, consistent, and authoritative observations.

NIDIS will continue to improve our ability to successfully measure the program's effectiveness and achievements, including measures of:

- Number and type of projects that conduct and update risk and vulnerability assessments and assessment of user needs;
- Number of institutions with increased capacity and opportunities to inform drought risk management and reduce exposure to drought risks;
- Number of staff trained to respond to and mitigate impacts of climate related events; and,
- Increased percentages of the U.S. population covered by adequate drought risk and early warning information systems.

NIDIS has also begun developing a network of state-based drought information coordinators to ensure (a) ensure strong links among Federal, state, private and tribal information providers and users, as well as (b) develop closer cross-sectoral collaboration between meteorological and hydrological services and agencies that work in urban and rural areas, such as extension services, development projects, community-based and non-governmental organizations.

To achieve a more comprehensive vision of a truly "national integrated drought information system" requires improvements that NIDIS has already begun to address, and that your interest in the program and in supporting its reauthorization will help further. These include:

- Improving the understanding and predictability of droughts across a variety of timescales for seasonal, to interannual and decadal time scales including the role of precipitation events in reducing drought duration and intensity;

- Improving collaboration among scientists and managers to enhance the public awareness and effectiveness of observation networks, monitoring, prediction, information delivery, and applied research;
- Improving the national and regional drought information framework by transferring successful approaches (information development, products, capacity, and coordination) to areas covered by the drought portal, but not yet having active early warning systems;
- Improving coordination between institutions that provide different types of drought early warning**;**
- Developing impact indicators to form part of a comprehensive early warning system; and,
- Working with the private sector and others on guidance and standards for developing value added products to support drought plans.

Conclusion

Thank you for the opportunity to be with you today. We, at NOAA, are grateful of the Committee's continued interest in NIDIS. I look forward to working with you in helping the Nation and our communities take full advantage of NIDIS to reduce the impacts of drought and as you move forward in the reauthorization process. Thank you.