DRY TIMES

NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM NEWSLETTER

APRIL 2014 // WWW.DROUGHT.GOV // VOLUME 4 ISSUE 1

Dessiccated cotton after a dust storm near Ropesville, Texas, March 2014. TIM BENSON PHOTO

The 3.5-year-long Texas drought has been especially severe in parts of North Texas and the Panhandle. Since the end of October 2010, the Lubbock area has received approximately 30 inches of precipitation. Normal precipitation over the same period would be 60-65 inches. The resulting lack of vegetation, particularly on idle farmland, has led to conditions on the ground similar to those during the 1930s Dust Bowl. No immediate relief is in sight, but NOAA has issued an El Niño watch, and if an El Niño does develop, the odds will improve for precipitation late next year.

JOHN W. NIELSEN-GAMMON, TEXAS STATE CLIMATOLOGIST

Reauthorized through 2018, NIDIS seeks to build upon its first seven years of developing foundations for a nationwide drought early warning system

NIDIS enters a second generation

BY
NIDIS STAFF

ABOUT THE NIDIS ACT OF 2014 (H.R. 2431)

Cosponsors:
Rep. Ben Luján (D-N.M.)
Rep. Lamar Smith (R-Texas)

Timeline:
2013
Introduced: June 19
Referred to Committee: June 19
Reported by Committee: Dec. 5

2014
Passed House: Feb. 10
Passed Senate: Feb. 25
Signed by the President: March 6

Read the text of the bill:
http://www.gpo.gov/fdsys/pkg/BILLS-113hr2431enr/pdf/BILLS-113hr2431enr.pdf

LEARN MORE ABOUT NIDIS
Visit http://drought.gov/drought/content/what-nidis for information on NIDIS history and implementation, participating agencies, and. supporting documents

Since 2006, NIDIS has promoted collaboration among government agencies, researchers, regional groups and individuals regarding information about drought, and worked to provide the nation with a drought early warning system. On March 6, 2014, President Obama signed into law bipartisan legislation reauthorizing NIDIS through 2018.

The reauthorization spells out the following goals for NIDIS:

- To provide an effective drought early warning system consisting of forecasts, and assessments on both national and regional levels
- To build upon existing forecasting and assessment programs and partnerships through designation of one or more cooperative institutes to assist with NIDIS functions
- To continue ongoing research and monitoring activities related to drought and the role of extreme weather events and climate variability in drought.

Furthermore, NIDIS continues to pursue its goals of leadership and networking for drought monitoring, forecasting and planning; developing interactive systems to support these goals; and providing educational resources about drought.

Background

NIDIS grew out of a number of activities. The National Drought Policy Act of 1998 gave rise to a National Drought Policy Commission which ensured collaboration among government agencies on drought-related issues. The commission's report, *Preparing for Drought in the 21st Century,* laid the groundwork for drought early warning in the U.S. through a series of recommendations to Congress.

Following the commission's recommendations, NIDIS was envisioned in a 2004 report from the Western Governors' Association. The NIDIS implementation team conducted workshops and meetings with federal, state and local agencies, academic researchers, and other stakeholders.

A national conference was sponsored by the Geological Society of America (GSA) and twenty other scientific and technical organizations in Longmont, Colo., in September 2006. The conference organizers presented their recommendations to the U.S. Congress in July 2007, along with a fact sheet and report.

President Obama's statement

March 6, 2014

Today, I signed the National Integrated Drought Information System Reauthorization Act into law. This bipartisan legislation ensures that the federal government can continue to provide timely, effective drought warning forecasts and vital support to communities that are vulnerable to drought. States, cities, towns, farmers, and businesses rely on tools and data from the National Integrated Drought Information System to make informed decisions about water use, crop planting, wildfire response, and other critical areas.

As climate change increases the intensity of weather-related disasters such as droughts, wildfires, storms and floods, providing access to updated drought-related science and tools is growing even more important.

Currently, a number of Western states are facing drought conditions, including a severe drought in California, and my Administration is pursuing every measure to provide relief and support in partnership with States. To complement the National Integrated Drought Information System, as part of my Climate Action Plan, federal agencies have also formed a National Drought Resilience Partnership to help communities better prepare for droughts in the long term, and prevent the worst impacts on families and businesses.

I commend Congress for passing this bipartisan bill to continue to build our national resilience to drought and help communities, farmers, businesses and individuals better prepare and recover when disaster strikes.

About the cover image: Amateur photographer Tim Benson has lived his life on the South Plains, and is currently residing in Ropesville, Texas, a small farming community. His work documents drought's effects on the rural areas of the Texas Panhandle. You can reach him at timsplumbingco@earthlink.net.

The Obama Administration announced in 2013 an interagency National Drought Resilience Partnershipto help communities better prepare for drought and reduce the impact of drought events on livelihoods and the economy

Agencies join forces over drought

LEARN MORE ABOUT THE NDRP

For a fact sheet about the partnership, FAQs, the National Drought Forum report and more links and downloads, visit drought.gov/drought/content/ndrp .

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The consensus of the most-up-to-date, peer-reviewed science is that global climate change will increase the length and severity of droughts in many regions of the U.S. in the future. Decreases in rainfall and snowpack in the West are reducing the health and productivity of forests and agricultural systems. Damages from the 2012 drought totaled approximately $30 billion, and the severe drought currently affecting California and other areas of the Southwest is impacting critical economic sectors, such as agriculture, ranching, and water resource management.

People and property have always been vulnerable to extreme events, but recent trends are making many of those vulnerabilities worse. There is a significant opportunity for greater federal, state, tribal, and local coordination to address drought vulnerabilities and enhance community preparedness for future drought events.

Launched in November 2013, the National Drought Resilience Partnership (NDRP) is dedicated to helping communities better prepare for future droughts and reducing the impact of drought events on livelihoods and the economy. NDRP is comprised of U.S. Department of Agriculture (USDA), National Oceanic and Atmospheric Administration (NOAA), Department of the Interior, the Assistant Secretary of the Army for Civil Works, Federal Emergency Management Agency, Environmental Protection Agency, and the U.S. Department of Energy. The NDRP complements the work of the National Integrated Drought Information System (NIDIS), as President Obama indicated with the NIDIS reauthorization earlier this year (see the president's statement on page 2.)

NDRP's goal is to ease access to federal drought resources by linking information such as monitoring, forecasts, outlooks, and early warnings with longer-term resilience strategies in critical sectors≠≠.

In 2014, the NDRP will develop an interactive clearing house to ease access to federal assistance, host regional drought outlook forums to hear directly from communities, enhance monitoring and forecasting through a coordinated soil moisture network, and undertake a pilot project in the West to create a local-scale drought resilience plan.

NDRP is engaged in active dialogue with States to partner on tools and actions to enhance community drought planning and water resources management. Themes include:

- Decision-relevant information and tools
- Sustainable infrastructure (for consideration: water conservation & efficiencies, water storage, water re-use and other technologies, watershed management, including the integration of green and gray infrastructure)
- Resilient landscapes and ecosystems policy
- Drivers: Incentives, regulatory flexibility, planning and communications

The federal family's strong response to drought is an ongoing effort, encompassing all sectors of the federal government's reach and authorities. We invite partnership with state, tribal, local and private partners to develop longer-term strategies and policies that enhance community preparedness and reduce risks associated with drought.

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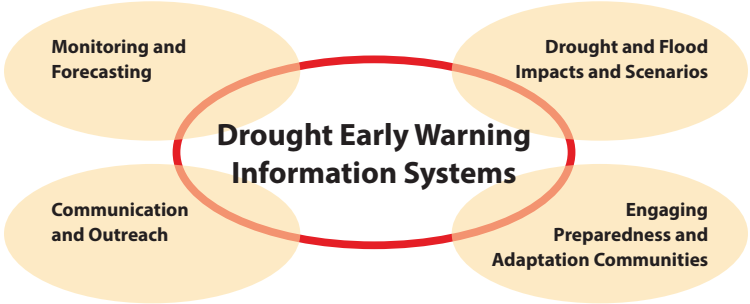

ON THE HILL

Dr. Roger Pulwarty explains the science of drought to two Senate panels and urges federal agencies to cooperate on sharing information to boost resilience

Director speaks out in Washington, D.C.

BY
LISA DARBY AND
ROGER PULWARTY
NOAA/NIDIS

SENATE COMMITTEE HEARINGS ON VIDEO

Feb. 14, 2013
Drought, Fire and Freeze: The Economics of Disasters for America's Agricultural Producers

Go to http://www.ag.senate.gov/hearings/drought-fire-and-freeze

April 25, 2013
Exploring the Effects of Drought on Energy and Water Management

Go to http://www.energy.senate.gov/public/index.cfm/2013/4/full-committee-hearing

RECENT BRIEFINGS IN 2014

■ Deputy NOAA Administrator Mark Schaefer provided information on the California drought conditions to House and Senate staff in February.

■ Dr. Pulwarty provided a briefing on national drought conditions and responses, sponsored by Reps. Napolitano (Calif.) and Kirkpatrick (Ariz.) in March.

NIDIS Director Dr. Roger Pulwarty testified before two Senate committee hearings in 2013, and joined the Western Governors at the White House in 2014 for a briefing on the drought in the West.

In 2013, Dr. Pulwarty testified on two Senate panels: first, the Committee on Agriculture, Nutrition and Forestry for the "Drought, Fire and Freeze: The Economics of Disasters for America's Agricultural Producers;" then, the Committee on Energy and Natural Resources for the hearing, "Exploring the Effects of Drought on Energy and Water Management."

For both, Dr. Pulwarty talked about the drought of 2012 (read an interpretation of this event by NOAA's Drought Task Force on page 18), including antecedent conditions, associated weather conditions, and the evolution of the drought.

Dr. Pulwarty underscored goals for achieving a comprehensive vision of a truly "national integrated drought information system:"

■ Improving the understanding and predictability of droughts across a variety of timescales, including the role of precipitation 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 national and regional drought information by using successful approaches (information development, products, capacity, and coordination) to develop early warning systems in more areas;

■ Improving coordination among institutions that provide 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.

For the second committee, Dr. Pulwarty outlined drought impacts on the energy sector, including:

■ The 2007-09 drought in the Southeast threatened cooling water supplies of more than 24 of the nation's 104 nuclear power reactors.

■ During that time, power plants from Atlanta, Ga., to Raleigh, N.C., cut back their water use, resulting in N.C. customers facing blackouts. In addition, Duke Energy was working hard to keep the water intake system for its McGuire nuclear plant underwater as water levels dropped.

Dr. Pulwarty shows the U.S. Drought Monitor map to the Senate Committe on Natural Resources in April 2013. He stressed the need for coordination among federal agencies in using climate and weather data to inform decisions about drought.

■ Also in 2007, the Browns Ferry, Ala., nuclear plant had to drastically reduce its output to avoid exceeding the temperature limit on discharge water to the Tennessee River.

■ A severe drought in Texas in 2011 affected many power plants' cooling water reservoirs, while associated heat increased peak electricity (air conditioning) demands.

His testimony included actions that could improve the energy sector's resilience to drought:

■ Greater understanding of which energy plants and sources are susceptible to water shortages in drought-sensitive locations. For instance, the impact of increased biofuel production on water resources depends on where the feedstock is grown and whether irrigation is required. Collaborative activities among NOAA and other agencies could include evaluating the likelihood and consequences of the shortages, and options for prevention and mitigation in the short and long term.

■ Improved understanding of links between climate and hydrological processes, including aquifer recharge rates and groundwater movement. Such data and research are necessary for Congress and other federal

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agencies to develop effective policies.

■ Improved coordination among federal agencies and other stakeholders, especially regarding climate and weather information at the energy-water interface.

In February, 2014, the White House hosted a Western Governor Association (WGA) briefing on the ongoing drought across the West. Presentations on conditions, impacts, and actions were provided by the NOAA Administrator Kathy Sullivan, Secretary of Interior Sally Jewell, Secretary of the Department of Agriculture Thomas Vilsack, and the President's Science Advisor John Holdren. Attendees included eight Western governors including the WGA Chair Colorado Gov. John Hickenlooper, Deputy Secretary of Interior Michael Connor, USDA Undersecretary for Natural Resources and Environment Robert Bonnie, Council on Environmental Quality Chair Michael Boots along with Dr. Pulwarty.

The governors spoke about increasing concerns over wildfires in the West. Sec. Vilsack's comments, in particular, centered on USDA-DOI efforts to structure wildfire risk and fiscal investments.

President Obama wanted to ensure that the agencies were meeting the needs of California during the ongoing drought. He focused as well on lessons from there which could in turn inform long-term risk reduction across the nation, and ways in which federal agencies and the states could strengthen their partnerships.

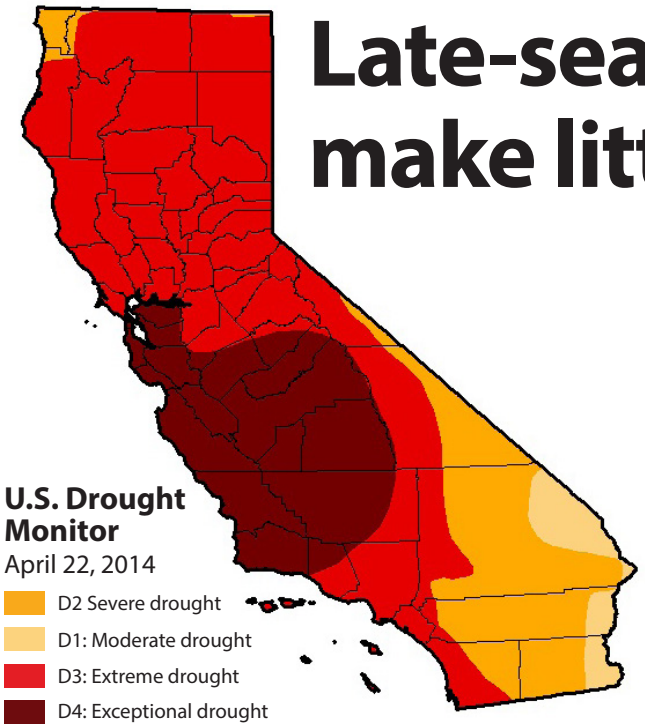
A selection of NIDIS-supported projects launched in 2013

Principal investigator	Affiliation	Title of project	Summary of project goals
Puneet Srivastav, Kathleen Miller, Mark Masters Contact: srivapu@auburn.edu	Auburn University, NCAR, Albany State University	Managing Drought in the Apalachicola-Chattahoochee-Flint (ACF) River Basin through the Development of Improved Drought Indicators and Policy Alternatives	The goals of the proposed project are to (a) define groundwater levels as a.drought indicator in support of NIDIS DEWS and (b) develop effective drought management policies for the ACF River Basin to help resolve tri-state (AL-GA-FL) water conflicts.
Linda Prokopy lprokopy@purdue.edu	Purdue University	Evaluating the Impact of Extreme Drought on Farm Advisors Perception of Climate Risks in the U.S. Corn Belt	This study has four objectives: 1) Ascertain how the 2012 drought changed advisors' perceptions of risk associated with climate change; 2) Determine how the 2012 drought changed advisors' beliefs about the existence and/or causes of climate change; 3) Identify how the 2012 drought changed advisors' willingness to respond to climate change; and 4) Characterize the readiness of different types of agricultural advisors to use climate information.
Ruth Langridge rlangrid@ucsc.edu	Univ. of California-Santa Cruz	Increasing Drought Resilience Under Climate Change: Assessing Costs and Benefits, Developing Tools and Analyzing Motivations to Develop Local Groundwater Drought Reserves	Research will consist of three components: >> Identification of factors that motivate agencies with long-term groundwater overdraft and significant conflicts over water to reduce drought vulnerability through improved groundwater management and the development of a drought reserve; >> Analysis of the impacts of establishing and sustaining a local drought reserve versus a no-reserve option, and an outline of an integrated modeling approach to calculate financial costs and benefits; >> Development of web-based tools to assist local agencies and communities in calculating metrics to determine sustainable groundwater thresholds for a groundwater reserve.
Jason Otkin, Jeffrey Basara, Mark Svoboda Contact: jason.otkin@ssec.wisc.edu	Univ. of Wisc.-Mad. (CIMSS), University of Oklahoma, and Univ. of Nebraska-Lincoln	Facilitating Adaptive Management Under Conditions of Rapid Drought Onset Using the GOES-based Evaporative Stress Index	This investigation will develop and evaluate an innovative drought early warning toolkit based on satellite-derived maps of evapotranspiration (ET) that will be used to support decision-making and risk characterization for the agricultural and natural resources communities. Recent examples of rapid drought development across the central U.S. have clearly demonstrated the need for a reliable drought early warning system (DEWS) that would be capable of providing stakeholders additional time to prepare for worsening drought conditions.
Maureen Hodgins mhodgins@waterrf.org	Water Research Foundation	Drought Management under a Changing Climate: Using Cost-Benefit Analyses to Assist Drinking Water Utilities	This project will help water utilities identify and prioritize drought mitigation alternatives based on a cost-benefit analytical approach. The project white papers and final report will help water customers, boards of governance, and other stakeholders better understand the total possible costs of drought and improve acceptance of drought planning and mitigation measures to minimize these costs.
David Watkins and Paul Block dwatkins@mtu.edu	Michigan Tech, University of Wisconsin	Integrated Seasonal Drought Forecast-Adaptive Management System for the Lower Colorado River Basin in Texas	This CSI-SARP: Coping with Drought project will develop an integrated seasonal drought forecast-adaptive management system to mitigate drought impacts for the Lower Colorado River in Central Texas. To address rapidly growing demands and risks associated with drought, hydroclimatic (precipitation, streamflow) forecasts with seasonal lead times are proposed to provide advance information toward improved allocation decisions. Historically, such forecasts have not been objectively integrated into decision making; however, the LCRA is considering approaches to formally include the use of seasonal forecasts in their next Water Management Plan, making this project timely.
Kris Wernstedt krisw@vt.edu	Virginia Tech	Seasonal Climate Signals: Developing a Community of Practice in Emergency Management of Droughts and Floods	The objectives of our proposed project are to 1) model and assess the utility of seasonal climate forecasts for emergency planning and management of drought- and flood-related hazards in U.S. metropolitan areas; 2) evaluate different attributes of seasonal forecasts for communicating information relevant for emergency planning and management of drought- and flood-related hazards; 3) develop a network of practitioners supporting the use of climate information in drought and flood planning and management; and 4) furnish a written and web-based guidebook for emergency managers for use of seasonal climate forecasts of droughts and floods.

CALIFORNIA

Below-normal precipitation, above-normal temperatures loom for California

Late-season rains, snow make little dent on drought



U.S. Drought Monitor
April 22, 2014

- D2 Severe drought
- D1: Moderate drought
- D3: Extreme drought
- D4: Exceptional drought

After experiencing the second driest January on record statewide, California in February saw slightly above-normal precipitation when averaged statewide. March brought near-normal precipitation averaged over the state, and April through the 24th has been drier than normal in most places.

Despite late winter and early spring precipitation, a large precipitation deficit remains and drought conditions have expanded in California. On the first of the year only 28% of the state was categorized as "extreme to exceptional drought" (D3-D4) by the U.S. Drought Monitor. That area has expanded to 77% of the state in the April 22 Drought Monitor release.

Statewide average precipitation over the first three months of 2014 totaled 7.7 inches. Though this is still far below the 1895-2014 average of 11 inches for this period, it is within one standard deviation of the mean and an improvement over the record low 3.1 inches recorded in January-March 2013.

From the start of water year 2014 (October 1, 2013) through the end of March, California statewide average precipitation totaled 9.38 inches. This is the third driest October-March period statewide, behind October-March ending in 1977 (6.73 inches) and October-March ending in 1924 (8.76 inches).

The past 33-month period (since July 2011) is still driest on record for California statewide at 43.5 inches. The average 1898-2014 for this 33-month period is 63.8 inches of precipitation.

California's snowpack is in very poor condition, at only 15% of average for late April statewide. Reservoir storage has improved somewhat over the last few months due to heavy precipitation events as well as early season snow melt, though California's five largest reservoirs are at less than 70% of their historical average.

What's ahead: Change in conditions unlikely

Drought is expected to persist and intensify throughout California over the next three months.

Beyond a storm predicted for April 25-27, below-normal precipitation and above normal temperatures are anticipated. Over the next three months, there are equal chances of above normal, normal, or below normal precipitation for California, tending towards below normal in the far northern portion of the state. There is potential for a more active than normal monsoon season, which may bring precipitation to the southeastern portion of California. Unfortunately, this does not have much potential to improve the state's water resources.

Above normal temperatures are likely for the spring and summer months across California.

February forum attracts a crowd

More than 200 people from government agencies, industries, water agencies, agriculture, non-governmental organizations, scientists, tribes, and other stakeholders from across California, attended "The California Drought Outlook Forum: What's Ahead and What We Can Do" in Sacramento in February. In addition, about 100 individuals participated via webinar and conference call.

The meeting was organized by NIDIS, NOAA and California partners.

Agenda items included information and discussion on current drought conditions and outlooks for the upcoming months; potential impacts and possible responses; early warning information needs and resources; assistance programs; and ways to improve preparedness, readiness, and resilience. For instance, NOAA-supported NIDIS pilot activities in California in the Southern California, Russian River, Central Valley, and Klamath regions, are developing targeted science products and resources to inform drought early warning, impact assessment, and preparedness actions.

To see a complete agenda, the 2-page outlook document from the meeting and slides of the presentations, go to http://drought.gov/drought/news/california-drought-outlook-forum-what%E2%80%99s-ahead-and-what-we-can-do

NEXT FORUM SET FOR MAY 15-16

What: "Making Decisions in Dry Times: Science and Strategies for Dealing with Drought"

Where: DoubleTree by Hilton Hotel, 2001 Point West Way, Sacramento

The 1-1/2 day forum will provide information on drought conditions, forecasts, and other science; discuss information uses and needs for decision-making; and offer ways to improve long term preparedness and resilience.

For registration information and an agenda, visit http://www.joss.ucar.edu/meetings/california-drought-forum-making-decisions-in-dry-times

A research team reviews the aftermath of drought and subsequent oyster fishery collapse and makes recommendations for its restoration

Oysters on the edge

BY
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Executive Summary

This report summarizes efforts conducted through the University of Florida Oyster Recovery Team, in collaboration with various stakeholders, to describe conditions in Apalachicola Bay prior to and after a historic collapse of the oyster fishery. It characterizes conditions in the bay, reviews possible causes for the fishery collapse, and outlines a plan for future monitoring, research and fishery management.

Conclusions in this report are based on analyses of data collected in historical monitoring programs conducted by the Florida Fish and Wildlife Conservation Commission, Florida Department of Agriculture and Consumer Services, Apalachicola National Estuarine Research Reserve (Florida Department of Environmental Protection) and Northwest Florida Water Management District, as well as field, experimental, and community data collected by the authors, who are reporting in their capacity as members of the University of Florida Oyster Recovery Team.

Findings

■ Apalachicola River discharge levels are strongly influenced by rainfall over the Apalachicola-Chattahoochee-Flint River Basin. The lower part of this basin was frequently classified by the National Integrated Drought Information System (NIDIS) as in an 'exceptional drought' during the last three years.

■ Water quality data indicate that 2012 was a year of high salinity at all monitoring stations in the bay, likely caused by low river flows and limited local rainfall in most months.

■ A large decline in oyster landings was reported after August 2012 in the bay, and the number of reported oyster harvesting trips also dropped off each month during the second half of that year.

■ The 2012 decline in oyster landings and recruitment of juvenile oysters is unprecedented during the period of data analyzed and has likely involved recruitment failure or high mortality of small oysters.

■ Fisheries independent monitoring data, collected by state agencies, indicate a general downward trend in abundance of legal-sized (3 inch or larger) oysters in the bay in recent years and a large decline in sub-legal (smaller than 3 inches) oysters present in 2012.

■ Because of the low abundance of sub-legal oysters in 2012 there is a high likelihood that legal-sized oysters will be in low abundance in 2013 and likely in 2014 as well.

■ The current size limit of 3 inches appears to be effective at reducing the risk of "growth overfishing" where yield (pounds of meat harvested) is reduced because oysters are harvested at too small a size. However, it is essential that this size limit be accepted by the community, adopted by the industry, and enforced by regulatory agencies and the county judicial system.

Substantial future harvesting of sub-legal oysters could have negative effects not only on oyster populations but also a serious impact on the national reputation of Apalachicola oysters as a high-quality seafood product.

■ Oysters, white shrimp, brown shrimp, blue crab and multiple finfish species have been analyzed for the presence of oil residue. All samples were either below the limits of detection or below quantifiable limits. Thus, based on analyses conducted so far, there is no evidence of chemical contamination from the Deepwater Horizon oil spill in the seafood sampled from Apalachicola Bay.

■ A large percentage of oysters in the bay have some degree of shell parasitism by clams, polychaete worms, sponges or other organisms. This parasitism negatively affects the integrity and aesthetics of the oyster shell, the overall growth and productivity of the oysters, and the economic value of product bound for the half-shell market. There are no historic data to compare degree of shell parasitism observed in 2012-2013.

Recommendations

Monitoring

■ There is a need to continue the monitoring of oysters in Apalachicola Bay, both in terms of tracking landings reported by oystermen, and in the sampling done by state agencies. The fisheries independent monitoring program needs to be expanded in its spatial extent to include all of the bay where oyster bars occur, including areas that are closed to fishing, because these may represent important sources of oyster spat.

■ Oysters should be included on the list of invertebrate species routinely assessed by Fish and Wildlife Research Institute (FWRI) stock assessment staff. These assessments can identify persistent uncertainties in oyster ecology or population status and help guide research such as the relationship

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APALACHICOLA - CHATTAHOOCHEE - FLINT

The bay is a national treasure, and its demise would sever critical links among our modern society, nature and our heritage.

THE AUTHORS

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between Apalachicola River flows and juvenile oyster survival rate or culling mortality.

Management and Restoration

■ Acceptance by the community and industry, and enforcement and adjudication of rules regarding size limits, spatial restrictions, and weekly and seasonal closures is essential for these measures to be effective in sustaining the oyster population.

■ Throughout our work on this project there were persistent reports of high levels of unreported harvest and illegal harvest from closed areas. While tangible evidence of illegal activity is not available, it is clear from our simulation models that lack of compliance with current regulations could greatly reduce the likelihood of Apalachicola Bay oyster populations returning to historic population levels, regardless of management action taken.

■ Oyster leases should be explored as a possible alternative to open-access fisheries. The concept of TURF (Territorial User Rights Fisheries) as a lease arrangement could be appealing to oyster fishermen and help promote restoration actions such as re-shelling because the fishermen would benefit directly from the restoration activities they were engaged in by having a "share" of the restored area (the lease) to manage and harvest from.

■ The total current area of oyster bar in Apalachicola Bay that is not open to fishing is unknown, and the degree to which this area is the source of the oyster spat for the entire bay also is unknown. If this area is small or declining, then large-scale oyster relay from these closed areas to areas open to fishing may reduce the total spat available throughout Apalachicola Bay, increasing the risk of "recruitment overfishing" where harvests of adults could influence availability of future spat.

■ Therefore, the practice of 'relaying' should be carefully evaluated in regard to its short-term benefits versus potential longer-term negative impacts to the fishery—in other words, whether or not it is depleting a substantive portion of the source population of oyster spat.

■ Management actions such as shell planting could expedite the recovery of Apalachicola Bay oyster resources. However, a new modeling tool called ECOSPACE, brought forward by the UF Oyster Recovery Team, suggests that shell planting needs to be conducted at a considerably greater scale than current levels to be effective—approximately 200 acres per year for a 5-year period. A very important uncertainty is whether shell planting should concentrate large amounts of shell in small areas to create thick layers of shell or whether shell should be spread over larger areas but not in as thick a shell layer. Restoration should be done in a manner that provides information on efficacy and cost-effectiveness of different shelling strategies, including evaluating different densities of shelling and different kinds of shell material.

■ A participatory decision-making process, involving SMARRT (the Seafood Management Assistance Resource and Recovery Team), relevant state agencies and experts from the state university system is needed to support long-term management of the oyster fishery in a more robust manner. The ECOSPACE model could further support members of SMARRT and management agencies to screen different policy or restoration alternatives.

Research

■ Research is needed to identify an optimal approach for monitoring long-term settlement, juvenile and adult survival, productivity, health, mortality, oyster diseases, and product quality of oysters. Subsequently this information could be used to inform changes in the oyster monitoring program.

■ Research is needed to quantify how oyster population dynamics, product quality and the fishery are affected by interactions between river flow, nutrients, salinity, harvesting intensity and

continued on facing page

BELOW: Oyster shells
APALACHICOLA BAY OYSTER SITUATION REPORT

continued from previous page

restoration methods.

■ There is a need to assess the harvesting practices of the oystermen and how they respond to changes in oyster abundance.

■ The ECOSPACE model has additional functionality to identify effects of varying flow regimes and to screen flow alternatives, relative to Apalachicola Bay oyster population dynamics and harvest potential when the model is linked with the Apalachicola Basin River Model currently being used by the Apalachicola-Chattahoochee-Flint River Stakeholders Group.

Outreach and Education

■ A community-based outreach and education program is needed to foster actions consistent with supporting a sustainable bay ecosystem and economy.

■ Involvement of oyster harvesters and processers in research and restoration projects can aid in educating the entire community about bay stewardship.

The Future

The situation in Apalachicola Bay, as outlined in the pages of this report, highlights a series of interwoven ecologic, fisheries, and community concerns. The bay is a national treasure, and its demise would sever critical links among our modern society, nature and our heritage. Work to date is a starting point toward understanding the processes underlying the current crisis, and includes steps that can and should be taken in initial efforts to restore the bay.

However, if we are truly committed to bringing the bay back to a point even close to its former productivity, a great deal of work is still required. These studies and analyses were conducted on a shoestring budget with internal funds from UF/IFAS, and limited support from Florida Sea Grant and from the National Institute of Environmental Health Sciences.

If we are truly committed to the restoration of the bay, we can't stop here. There is a critical need for follow-up work, bringing together state and federal agencies, academic researchers, and the community, to look out over a 5-, 10-, and 20-year time scale, to conduct interventions, do the necessary research, and monitor outcomes. This will require a strong leadership structure and it will cost money.

The question remains as to whether we, as a society, are willing to make this investment of time, and money, to preserve this priceless natural resource for our lifetime, and the lifetimes of our children.

DROUGHT WEBINARS

Current webinar listings are at http://www.drought.gov/drought/content/regional-programs/regional-drought-webinars

Managing Drought in the Southern Plains

The Southern Climate Impacts Planning Program SCIPP holds bi-weekly discussions of drought and its impacts on the 2nd and 4th Thursdays of each month at 11:00 a.m. Central Time. States covered include Oklahoma, Texas, Louisiana, Arkansas, Tennessee, and Mississippi. To join in, please register at http://www.southernclimate.org/ You can view past webinars on YouTube at https://www.youtube.com/user/SCIPP01

Upper Colorado River Basin Webinar

The Colorado Climate Center conducts weekly 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

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

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

Currently the webinars occur monthly, and will increase in frequency if drought conditions warrant. Webinar partners include the USACE, NWS and USGS. To receive webinar announcements, send a request to lisa.darby@noaa.gov to get on the email list. To view previous webinar summaries, visit http://www.drought.gov/drought/regional-programs/acfrb/acfrb-home and scroll down to click on ACFRB Announcements in the righthand column.

Midwest and Great Plains Drought Update

The National Oceanic and Atmospheric Administration (NOAA), the American Association for State Climatologists (AASC) and the High Plains Regional Climate Center (HPRCC) have responded to drought across the Midwest and Great Plains by organizing, creating and presenting webinars since July 3rd of 2012. These webinars are held monthly but can be more frequent when conditions warrant.

The webinars consist of a regional climate summary, impacts due to drought and climate outlooks.

The webinars are held on the third Thursday of every month at 1pm CT. A link to the webinar registration page, along with recordings and powerpoints from previous webinars, can be found at this web site: http://mrcc.isws.illinois.edu/webinars.htm.

COASTAL CAROLINAS

Traditional indices for upland drought -- rainfall, soil moisture, groundwater levels, snowpack -- don't do enough to tell the story for the coast

Seeking salinity's role in drought

BY PAUL CONRADS
US Geological Survey (USGS), South Carolina Water Science Center

The location of the freshwater-saltwater interface in surface water bodies along the coast is an important factor in the ecological and socio-economic dynamics. Salinity is a critical coastal response variable that integrates hydrological and coastal dynamics including streamflow, precipitation, sea level, tidal cycles, winds, and tropical storms. The position of the interface determines the freshwater and saltwater aquatic communities and the freshwater availability for municipal and industrial water intakes. Freshwater tidal marshes support a larger biodiversity as compared to brackish and saltwater tidal marshes.

There are many definitions of drought and most describe it as a decline in precipitation having negative impacts on water supply and agriculture. Four general types of drought are recognized: hydrological, agricultural, meteorological, and socioeconomic. Drought indices have been developed incorporating data such as rainfall, streamflow, soil moisture, groundwater levels, and snow pack.

These drought indices were developed for upland areas and may not be appropriate indices for characterizing coastal drought. Because of the uniqueness of drought impacts on coastal ecosystems, there is a need to develop a coastal drought index. With the availability of many real-time and historical salinity datasets, there is an opportunity to leverage these datasets for the development of a coastal drought index using salinity data.

The ultimate goal for this drought early warning pilot project is for the USGS to complete a comprehensive site-selection process of identifying historical and current salinity time-series data and ecological data near coastal resources of concern for the Atlantic coast from Altamaha Sound in Georgia to the Outer Banks of North Carolina. Ideally, a generalized methodology for determining a salinity drought index would use datasets that

continued on facing page

Project has potential for expansion along the coast

BY DAN TUFFORD
CISA

The NOAA Climate Program Office is supporting ecosystem work that is complementary to the USGS real-time salinity drought index outlined above.

Prior research shows that changes in the pattern of longitudinal salinity dynamics can have negative impacts on coastal ecological resources (Gilbert et al. 2012*).

The goal of this project is to work with land managers in coastal estuaries and The Nature Conservancy to understand and characterize ecological drought in ecosystems they manage, and develop ecological interpretations of the salinity indices that the USGS develops. The USGS and NIDIS look at the index development as a prototype effort that, if productive, could be expanded elsewhere along the US coast.

First, a needs assessment with coastal resource managers will cover all or most of the coastal ecological resources that are potentially impacted by drought and to develop a strong understanding of site-specific issues and concerns. Particular focus will be on drought early warning and monitoring through the use of existing or new indicators or indices.

Also identification of additional data and research needed to effectively understand and monitor drought in coastal ecosystems.

Second, researchers on this project will collaborate with the USGS on the development of a drought-sensitive salinity index at specific locations along the North and South Carolina coast. Index values will be linked to ecological impacts or outcomes at nearby managed lands.

When development of the ecological interpretation is complete, project researchers will work with resource managers at specific locations to test the indices in the context of potential future climate. The specific objective will be to evaluate the indices as prediction tools for adaptation planning for future drought. Developing tools for adaptation planning will be a three-step process comprising:

- Stakeholder-driven (mainly wildlife refuge and National Estuarine Research Reserve resource managers) scenario development
- Simulation modeling using integrated hydrologic and salinity models, the newly developed salinity index, and the stakeholder-driven input (above)
- Communicating the results to the refuge managers in a format that encourages exploration of long-term strategies for conservation and management.

** Gilbert, S., K. Lackstrom, and D. Tufford, 2012: The Impact of Drought on Coastal Ecosystems in the Carolinas: State of Knowledge Report. Columbia, SC, University of South Carolina: 67 pp.* (http://www.cisa.sc.edu/resourcesReports.html)

represent a range of coastal rivers --unregulated tidal rivers draining one physiographic province, unregulated tidal rivers draining two or more physiographic provinces, regulated tidal rivers draining one physiographic province, regulated tidal rivers draining two or more physiographic provinces, and tidal sloughs.

However, in these times of limited funding, the USGS will begin the project with the alternative approach of developing site-specific salinity indices for a limited number of selected sites. Rather than undertake a large regional data assessment and site selection, data from a few selected sites with long-term datasets (greater than 15 years of continuous 15-minute salinity data) from the Savannah, Charleston, and/or Myrtle Beach areas will be used to develop site-specific, not generalized, salinity drought indices.

The approach of proceeding directly to the analysis of salinity time-series data for a limited number of sites also leverages work to be conducted by researchers from the University of South Carolina-CISA and East Carolina University on effects of drought in southeastern coastal ecosystems.

The general approach for developing the site-specific salinity drought indices involves four tasks:

- Obtain three to five long-term salinity datasets in the vicinity of the Savannah National Wildlife Refuge and the Waccamaw National Wildlife Refuge;
- Analyze salinity time-series data for selected sites by using various statistical and numerical techniques;
- Characterize the site-specific salinity drought indices using similar categories as the Drought Monitor of D0, D1, D2, D3, and D4 (droughtmonitor.unl.edu), and
- Document the development of the site-specific salinity drought index in a USGS Report.

The challenge for the salinity data analysis is to characterize the salinity dynamics in response to drought and not the occasional intrusion event. Determining the best analytical approach will be a discovery process of applying various statistical and numerical techniques to evaluate which ones are most appropriate to developing salinity drought indices. The final approach will probably be a combination of various techniques that discriminate chronic changes in salinity behavior.

WHAT IS CISA?

Based at the University of South Carolina, the Carolinas Integrated Sciences and Assessments group works with a variety of stakeholders across North and South Carolina to incorporate climate information into water and coastal management and related decision-making processes. The program is supported by NOAA's Regional Integrated Sciences and Assessments (RISA) program. Learn more at http://www.cisa.sc.edu/

Citizens contribute input for better study of impacts

BY AMANDA BRENNAN, KIRSTIN DOW, BENJAMIN HAYWOOD, KIRSTEN LACKSTROM AND DAN TUFFORD
Carolinas Integrated Sciences and Assessments (CISA)

HOW TO GET INVOLVED

Please contact Amanda Brennan (abrennan@sc.edu) if you would like copies of the drought impacts reporting materials or have recommendations for groups who may be interested in participating in the project.

The documentation of drought impacts helps decision-makers and scientists to more clearly understand how droughts impact society. Sectors such as agriculture have experience in documenting the impacts, through the U.S. Department of Agriculture Farm Service Agency personnel who regularly work with farmers.

In contrast, people who use coastal resources to make a living (e.g., fishermen), manage coastal lands, or recreate along the coast may not know about the benefits of drought impact reporting, or know what one's options are for reporting. As such, our knowledge of drought impacts in coastal ecosystems is not as robust as our knowledge of drought impacts from other sectors.

To address this issue, CISA has begun introducing drought impact reporting to stakeholders in coastal areas. A first step was the development of informational materials to support reporting through the Community Collaborative, Rain, Hail & Snow Network (CoCoRaHS) (http://www.cocorahs.org/). These materials have been shared through the network of regional CoCoRaHS coordinators in North and South Carolina. CISA is also working to recruit groups in coastal areas to participate in drought impacts reporting using CoCoRaHS.

Queen Quet of the Gullah/Geechee Nation and the Gullah/Geechee Sustainability Think Tank are partnering with CISA to establish a network of CoCoRaHS-drought impact observers in their communities. CISA is also coordinating with the Low Country Institute to recruit Master Naturalists to participate in this citizen effort.

In conjunction with this work, CISA team members have conducted interviews in Beaufort County (SC) with individuals involved in commercial and recreational fishing, land and resource management, outdoor recreation, and non-profit conservation. The goal of these interviews is to improve understanding of drought impacts on those sectors and needs for information. CISA will develop a summary report and peer-reviewed journal articles from the information shared during these interviews.

In order to enhance drought impact reporting beyond the scope of the NIDIS pilot, CISA helped to organize an intra-Regional Integrated Sciences and Assessments (RISA) working group meeting on drought impacts monitoring and reporting in 2013.

A CoCoRaHS rain gauge allows citizens to observe and record precipitation data.
HENRY REGES PHOTO

CALIFORNIA

Monitoring the extent of bare agricultural lands can assist California to decide water project allocations and operations of a state drought water bank

Following fallowed land

BY
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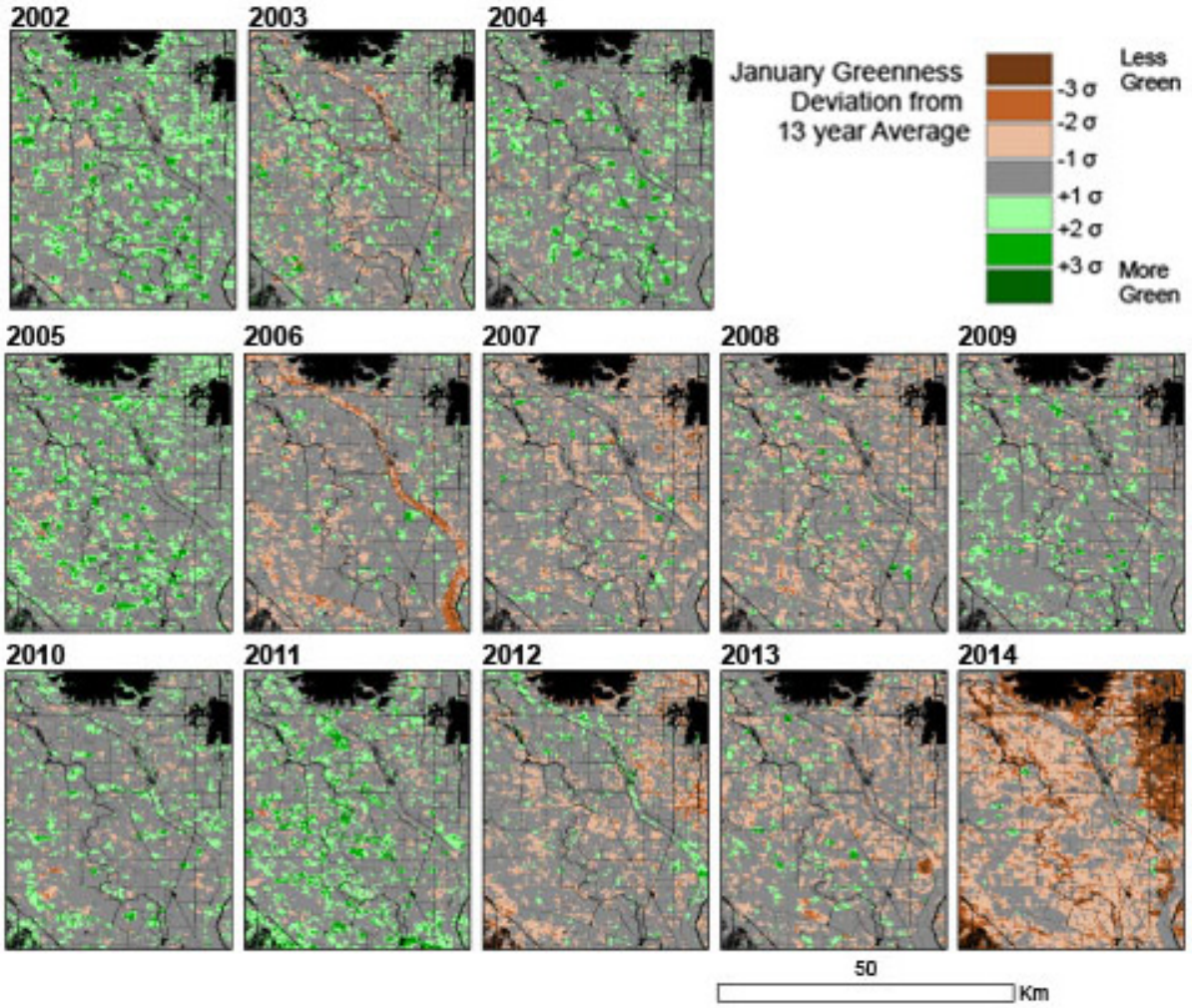
RICK MUELLER AND AUDRA ZAKZESKI
USDA/NASS

FORREST MELTON, LEE JOHNSON, AND CAROLYN ROSEVELT
NASA/CSUMB

JEANINE JONES, KENT FRAME AND JEAN WOODS
CDWR



The image depicts cropland greenness in January, year to year: Comparing current month to Mean (μ) and Standard Deviation (σ) for that month in the 13-year record of MODIS data from 2002 to 2013

A shortage of water for irrigation and crop production is a principal impact of drought in the Central Valley of California, prompting action by state, federal, and local governments to mitigate adverse effects. The extent of fallowed land is a key measure of drought impact that can inform decisions to take mitigating action.

In spite of its importance, there is no comprehensive, objective and systematic within-season measurement of this variable to support decision-making. To help meet the need for better, more timely information on fallowed land extent, a study was conducted to test the feasibility of using satellite imagery to rapidly map fallowed area to support within-season decision making. The study was conducted by a team of researchers from NASA Ames Research Center/California State University Monterey Bay (NASA/CSUMB), USDA National Agricultural Statistics Service (USDA/NASS), USGS, and the California Department of Water Resources (CDWR). Funding support was provided by the NASA Applied Sciences Program, NIDIS/NOAA, and the USGS WaterSMART Program.

The results clearly pointed the way to the establishment of an ongoing fallowed land monitoring service, and funding has been authorized to proceed with its establishment over the next three years. Due to the ongoing drought in California, the work plan is being accelerated to provide within-season fallowed acreage figures on a quasi-operational basis beginning in mid-April 2014, and monthly thereafter through November.

The California Department of Water Resources (CDWR) determines the technical basis for decisions that are critical to agriculture in the Central Valley

continued on next page

during periods of water shortage due to drought. Such decisions include water project allocations, state emergency proclamations or executive orders by the governor, and determinations to operate a state drought water bank.

The impact of water shortage for irrigation and crop production is experienced most directly and immediately as an increase in the extent of fallowed land, which in turn serves as a proxy for socio-economic impacts. Drought causes land to be taken out of production, decreasing farm income and sales of inputs, and increasing unemployment among on-farm workers and related businesses.

Timely and accurate knowledge of the extent of fallowing can provide insight into the severity of drought impacts, and provide the basis for sound decisions for response. Similarly, counties can use land fallowing information to support requests for USDA drought disaster designations or emergency proclamations pursuant to the California Emergency Services Act. Local water agencies can use information about expected fallowing to guide decisions about buying water on the spot market. Such designations trigger eligibility for a number of programs, including low-interest loan and debt set-aside programs.

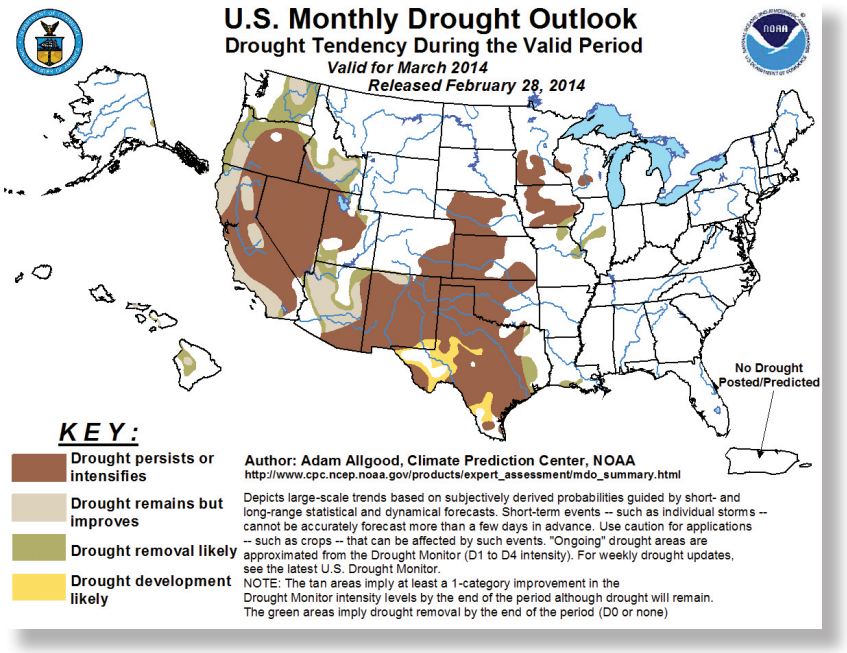
To meet its needs, CDWR called for provision of monthly county-level fallowed extent acreage estimates, available within two weeks of the end of the month, and accurate to within +/- 25% of the true value. The feasibility project demonstrated the ability to advance by 6 months estimates of potential fallowed acreage from USDA/NASS, with delivery of the initial fallowed area datasets in early July of the current year, as opposed to early January of the following year.

Furthermore, since USDA/NASS fallowed acreages are only available since 2007, it was shown that historical context can be extended backward through 2001 by applying an automated cropland classification algorithm to monthly vegetation index imagery from the NASA MODIS instrument.

Finally, the project team demonstrated an ability to provide early season estimates of potentially fallow acreage as early as mid-April of the current year, and to provide monthly updates from April through November. This acceleration in the delivery of information by nine months, with historical context, provides early season estimates in time for CDWR to adjust plans for facilitating water transfers, and for CDWR and USDA to anticipate potential disaster assistance requests.

Drought mitigation actions can be better targeted and implemented earlier, heading off more serious impacts associated with a delayed response. In view of the positive results obtained in the feasibility study, NASA has awarded the investigators three more years of funding. This support will make it possible for USDA/NASS, NASA/CSUMB, and USGS to stand up a robust and enduring set of procedures, and transfer them to CDWR to operate as an ongoing fallowed land monitoring service.

Timely predictions help farmers, ranchers make short-term decisions for growing season



NOAA updates outlook every month, every season

BY
MAUREEN O'LEARY
NOAA

WHERE TO FIND THE MAPS

Weekly Monitor
The U.S. Drought Monitor is updated weekly and posted on Thursday mornings at droughtmonitor.unl.edu.

Monthly Outlook
The U.S. Monthly Drought Outlook is posted on the last day of each month at http://www.cpc.ncep.noaa.gov/products/expert_assessment/monthly_drought.html.

Seasonal Outlook
The U.S. Seasonal Drought Outlook is released on the third Thursday of each month at http://www.cpc.ncep.noaa.gov/products/expert_assessment/season_drought.gif

Last summer NOAA added a new monthly product to its toolkit that gives farmers and ranchers more timely and accurate drought predictions.

NOAA's Monthly Drought Outlook reflects rapidly evolving drought conditions which has helped communities around the nation become more resilient to and prepared for drought.

Improvements in weather and climate model forecasts and associated post-processing, as reflected in extended range forecasts (e.g., 6-10 day, 8-14 day, and monthly forecasts) are what made this monthly product possible.

Monthly and seasonal drought outlooks issued by NOAA's Climate Prediction Center complement the U.S. Drought Monitor, the weekly drought condition update (http://droughtmonitor.unl.edu/).

The monthly drought outlook is part of the suite of climate services NOAA provides to support informed decision-making and build a weather-ready, climate-smart nation.

RESEARCH

Dataset of reference evapotranspiration (ET_0) shows promise as a stand-alone indicator of rapidly developing agricultural drought

Measuring the atmosphere's thirst

BY MICHAEL HOBBINS
NOAA/NIDIS

FOR MORE INFORMATION
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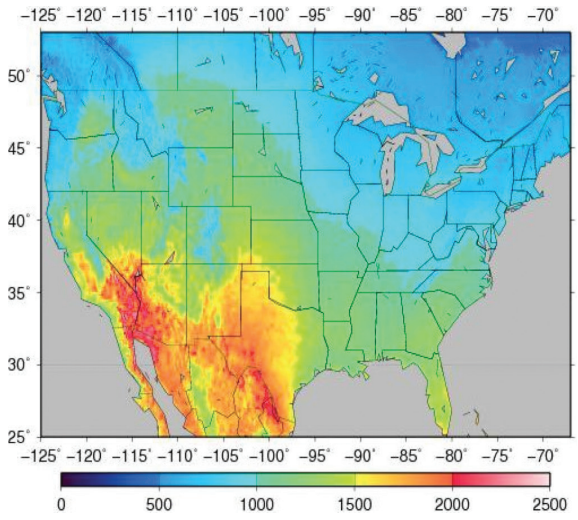
In an ongoing two-year project, NIDIS is collaborating with NOAA's Office of Hydrologic Development (OHD) to generate NOAA's first operational, long-term reanalysis of reference evapotranspiration (ET_0). This new dataset represents a new direction within the NOAA's operational mission and will not only fulfill missions for both funding partners but is also generating multiple spin-off uses in the greater operational and scientific communities in agriculture and hydrology, and beyond.



NOAA's mean annual ET_0 depth (in mm), as estimated by the ASCE Standardized Reference Evapotranspiration Equation and forced by NLDAS drivers for 1981-2010.

What is ET_0? What can it do for you?

Specifically, ET_0 synthesizes (or measures, in the case of weighing lysimeters) the evapotranspiration that would occur under prevailing conditions from a very specific reference crop surface that is presumed to mimic a well-watered, actively growing crop of green grass or alfalfa that completely shades the ground.

More simply, it provides a measure of the evaporative demand of the atmosphere, or its "thirst" for water from the surface.

The concept of evaporative demand, most commonly under the name "potential evaporation," has been used for many years in the agricultural community to schedule irrigation, and in hydrology to estimate the actual evapotranspiration rate in land surface models. More recently, climatologists have used evaporative demand as a measure to indicate changes and trends across the land surface/atmosphere interface to address such issues as whether a region is becoming more or less arid, and why.

Traditionally, evaporative demand has been observed at evaporation pans, but the trend over the past few decades has been towards a synthetic measure that includes all appropriate meteorological and radiative drivers — wind speed, humidity, temperature, sunshine, and longwave radiation.

This move to ET_0's fully descriptive physical synthesis has been hastened since the publication of the United Nations Food and Agricultural Organization report #56 (better known as "FAO-56"; http://www.fao.org/docrep/x0490e/x0490e00.htm) and the standardization effort led by the American Society of Civil Engineers (ASCE). Prof. Richard Allen of the University of Idaho, one of the world's leading authorities on ET_0, spearheaded both efforts.

What are NOAA's specific uses for the new ET_0 product?

The new 35-year, daily ET_0 reanalysis under development will be used by NIDIS in support of the USGS's National Water Census. In combination with remotely sensed thermal imagery from USGS Earth Resources Observation and Science Center, it will provide one of the key variables in the ongoing operational estimation of actual evapotranspiration across the conterminous US — a national first.

OHD would like to include it as a part of a collaborative and integrative framework for providing the nation with a seamless suite of water resources information across all operationally useful time and space scales. The goal is eventually to transition its generation to the National Water Center, currently nearing completion in Tuscaloosa, Alabama.

The NOAA ET_0 reanalysis is based on spatially distributed drivers from the North American Land Data Assimilation System (NLDAS) run by NOAA's Environmental Modeling Center. These drivers represent hourly meteorological and radiative conditions at the earth's surface across CONUS from January 1, 1979, to within five days of the present at a spatial resolution of 0.125 degrees (roughly 12 km across CONUS). In our reanalysis, ET_0 is expressed as a daily water depth.

Project status

The ET_0 reanalysis is being rolled out in a multi-generational manner. The first generation estimates daily ET_0 across CONUS from January 1, 1979 to the

present, in a strict interpretation of the concept. This ET_0 generation has been verified against observations from nearly 1000 agro-meteorological stations in long-standing networks such as AgriMet in the Pacific Northwest, CIMIS in California, and the Oklahoma Mesonet. These data are available online from the USGS Geo Data Portal (contact Mike Hobbins for details).

Research directions

Future generations of NOAA's ET_0 product will be bias-corrected against the station observations; and address some of the fundamental assumptions inherent in the traditional parameterization of ET_0 — specifically that there is often a significant difference between the actual land surface conditions and those assumed by the ET_0 concept (i.e., that it is wet) — and adjusts the meteorological and radiological input variables to the ET_0 parameterization.

This latter advance will be especially important away from irrigated land (which tends to match the reference surface) in areas such as rangeland. This exciting development in ET_0 estimation — given the rather frightening sobriquet "ambient conditioning" — is currently under development by Prof. Allen, with whom we are collaborating.

Who else is using NOAA's ET_0, and for what?

We are working hard to keep up with the many demands for the dataset from early adopters from across the agricultural and hydrological gamut.

Beyond the central purpose — supporting the goals of NIDIS and OHD — the most significant current spin-off of the project has been within NOAA as a support for the effort to forecast ET0 (known as "FRET"), currently rolling out at NWS Weather Forecast Offices across the western US. The ET0 reanalysis acts as a climatology against which FRET's 1- and 7-day ET_0 forecasts are compared in order to yield a forecast depth anomaly — or difference between the forecast ET_0 depth and the long-term mean depth for the same period.

Such anomalies are perhaps more useful measures than just a forecast depth to those such as irrigating farmers, who may be unfamiliar with the mechanics of ET_0 but who still need to know whether or not the atmosphere will be drier or more thirsty than normal in the coming days.

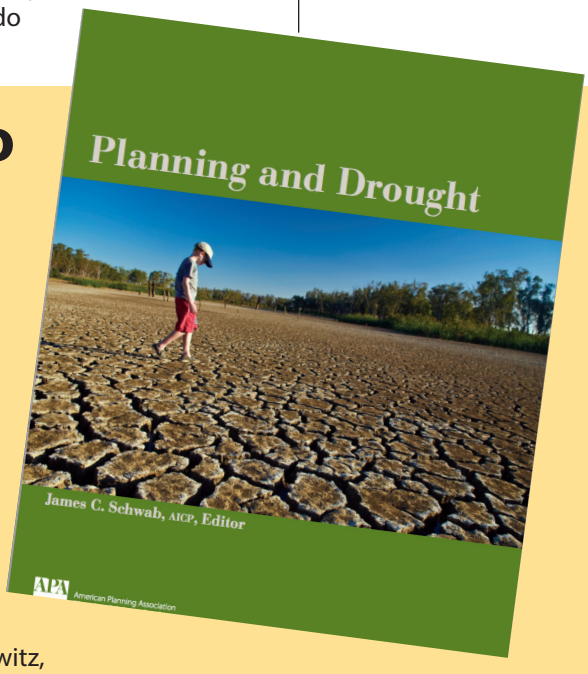
Promise as a drought early warning

A second use hews more closely to NIDIS's mission. Preliminary work indicates that ET_0 itself may act as a useful indicator of developing drought.

As the land surface dries, ET_0 picks up on its feedbacks with the atmosphere and, as a result, increases beyond its long-term mean. This response has led to the use of ET_0 in a new drought indicator, called the "Evaporative Demand Drought Index" or "EDDI," whose signal has been shown to precede measures observed in remote sensing of, say, NDVI or crop stress.

EDDI is still under test by a team from NIDIS, NCAR, and the Desert Research Institute, but we believe it holds great promise as a stand-alone indicator of fast-developing agricultural drought. The index is already in use by the US Forest Service's Rocky Mountain Research Station as a predictor of wildland fire suppression costs, and will support the Colorado

New publication outlines steps to take in planning for drought



The new publication "Planning and Drought" offers a comprehensive guide for citizens, planners and communities to explore what drought is, how to track it, its impacts, and how planners and communities can prepare to mitigate its effects. The book includes eight case studies illustrating the range of drought's consequences and how different organizations prepared for and responded to them.

NIDIS and the National Drought Mitigation Center joined the American Planning Association to create the new guidebook, published in January 2014.

Find a free download at http://drought.gov/media/pgfiles/PAS574.pdf or purchase a hard copy for $60 at http://www.planning.org/store/product/?ProductCode=BOOK_P574.

The report was edited by James C. Schwab, AICP, Manager of APA's Hazards Planning Research Center, which led the project to produce the report, with contributions from Jeff Brislawn, Marilyn Hall of AICP, Cody Knutson, Marsha Prillwitz, Kelly Redmond, James C. Schwab and Mark Svoboda.

The Hazards Planning Research Center is part of APA's National Centers for Planning, which include the Green Communities and Planning and Community Health Research Centers.

MISSOURI RIVER BASIN

To kick off NIDIS newest drought early warning system, decision-makers, tribes, regulators, researchers and others from the Rockies, Plains and Midwest states met in February to explore common issues and needs

Agencies, communities come together over 'a basin of extremes'

BY
DOUG KLUCK
CHAD MCNUTT
MARK SVOBODA
KELLY SMITH
KATHLEEN BOGAN
NOAA/NIDIS

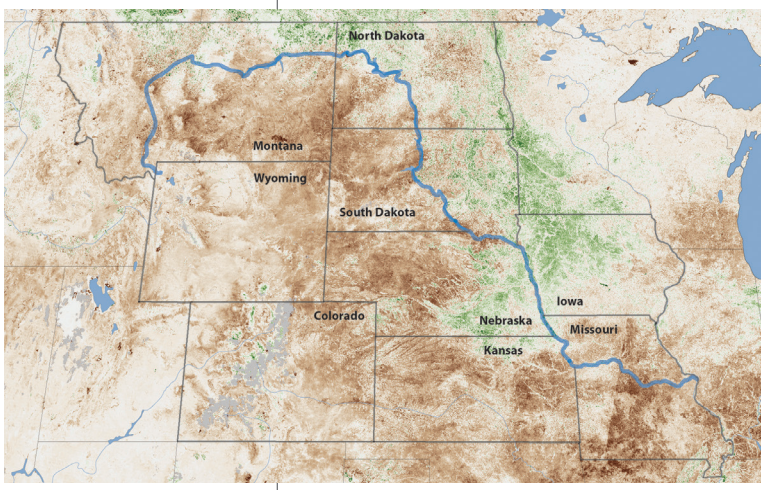
People from more than 70 federal, state, tribal, academic, regional and national institutions met in Nebraska City, Nebraska, in February 2014 to discuss the current state of drought awareness, planning and capacity across the Missouri River Basin.

The meeting was the first of a multi-year engagement process in the basin to better understand existing resources, vulnerabilities, impacts and priorities. The goal is to create a Drought Early Warning System (DEWS).

Regional DEWS (RDEWS), developed by the National Integrated Drought Information System (NIDIS), explore and demonstrate a variety of early warning and drought risk reduction strategies.

They incorporate drought monitoring and prediction information in partnership with federal, state, tribal and local agencies, organizations and other users. Located throughout the contiguous U.S., RDEWS help regions plan for and establish best practices in drought-stressed times, and transfer this information to under-served regions of the country.

Key sponsors of the Nebraska meeting were NIDIS, which is part of the the National Oceanic and Atmospheric Administration (NOAA), National Drought Mitigation Center (NDMC), Western Governors Association (WGA), U.S. Department of Agriculture (USDA), North Central Climate Science Center (NCCSC) and South Dakota State University.



ABOVE LEFT
Brown areas on the map show below average plant growth in June and July of 2012.
NASA GRAPHIC

ABOVE RIGHT
North Dakota Air National Guards place sandbags alongside a home by the Missouri River in Bismarck, N.D., during the flood of 2011.
DEPT. OF DEFENSE PHOTO

Vast, productive basin is vulnerable to drought and flood

The Missouri River Basin is known for intense weather and extreme climate variability, such as the stark differences between record high flows and flooding in 2011, followed by record low flows and drought in 2012.

Drought is a normal part of climate throughout the Basin, causing devastating impacts during the 1930s Dust Bowl, the 1950s, 1988-89, 2000-2006, and 2012-13.

While the effects of flooding tend to be concentrated along waterways, the effects of drought spread across the landscape. Drought has direct impacts on agriculture, water supply, water quality, wildlife habitat, wildfire, landscapes, and air quality. It has physical, economic and social effects on the well-being of people, families and communities. Widespread drought disrupts farming and livestock production, which can, in combination with market processes, increase food prices.

Many aspects of human activity affect vulnerability to flood and drought, including land and water use patterns, population shifts and agricultural practices. Warming climate adds urgency to the need to address drought in the basin, because heat contributes to drought. More frequent extreme weather such as the heavy precipitation that led to flooding in 2011 also threatens the region's productivity.

Stakeholders at the meeting requested:

- Networks for regional drought monitoring and planning.
- Better understanding of drought as a hazard, societal vulnerability, and coping strategies.
- Education and outreach to citizens, agencies and organizations in the basin.

Gaps that came up included the need to:

- Create or revisit state drought plans.
- Develop early warning information and delivery systems based on the historical pattern of floods followed by droughts, such as the 2011 flood and 2012 drought.
- Communicate information about drought severity and impacts to states, tribes, and various sectors to increase awareness of the hazard.
- Communicate about related water use issues.
- Consolidate tools and information about drought.
- Capitalize on the strong, pre-existing foundation of connectedness in the basin while developing NIDIS as a key coordinator of drought information.
- Improve vulnerability analysis.
- Identify trigger or tipping points.
- Improve monitoring of soil moisture, stream flow and snow pack.
- Research and communicate ground water vulnerability.
- Offer education and outreach through trusted entities.

Next steps

NIDIS and its partners are in the process of identifying activities for building and enhancing a drought early warning information system in the Missouri River Basin. Next steps will include:

- Improving understanding of impacts and vulnerability to drought.
- Partnering with states and tribes to create new or improved drought plans.
- Continuing to support and assess ways to enhance the Midwest and Great Plains Drought and Flood Update Webinar series.
- Assessing approaches for improved forecasts and long-term monitoring.
- Initiating a series of regional or sub-basin meetings to understand impacts and ways to inform drought risk management.

FOR MORE INFORMATION
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Chad McNutt (chad.mcnutt@noaa.gov)
Mark Svoboda (msvoboda2@unl.edu)

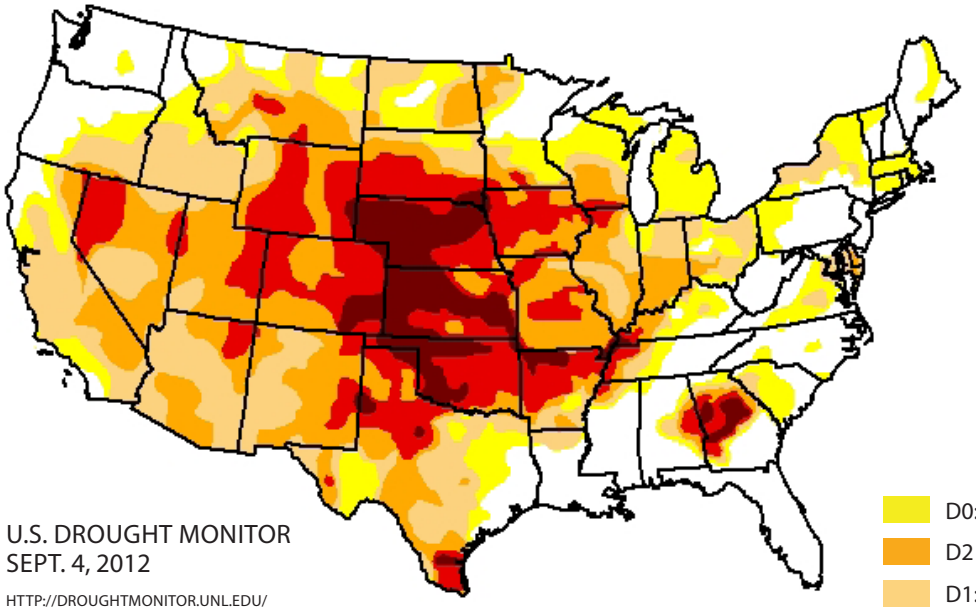
Participants at the workshop

American Planning Association
Army Corps - Missouri River Water Management
Bureau of Indian Affairs
Bureau of Land Management
Bureau of Reclamation
Center for Research on the Changing Earth System
Colorado Climate Center, Colorado State University
Colorado Water Conservation Board
East Dakota Water Development District
Eastern Tallgrass Prairie & Big Rivers LCC
Environmental Protection Agency, Region 7
Federal Emergency Management Agency
High Plains Regional Climate Center
InterTribal Buffalo Council
Intertribal Council On Utility Policy (COUP)
Iowa Dept. of Agriculture & Land Stewardship
Kansas State University
Kansas Water Office
Local public
Mid-America Regional Council
Missouri Department of Natural Resources
Missouri River Association of States and Tribes
Montana Department of Natural Resources and Conservation
National Drought Mitigation Center
National Integrated Drought Information System (NIDIS)
National Oceanic and Atmospheric Administration
National Park Service
Natural Resources Conservation Service - National Soil Survey Center
National Weather Service
Nebraska Department of Agriculture
Nebraska Department of Health & Human Services
North Central Climate Science Center, Colorado State University
North Dakota State Water Commission
Northern Arapaho Tribe
Omaha World-Herald
Santee Sioux Nation of Nebraska
South Dakota School of Mines and Technology
South Dakota State University Extension
South Dakota State University/South Dakota State Climate Office
U.S. Department of Agriculture - Agricultural Research Service
U.S. Geological Survey - Earth Resources Observation and Science Center
U.S. Geological Survey - Nebraska Water Science Center
U.S. Geological Survey - North Central Climate Science Center
U.S. Geological Survey - South Dakota Water Science Center
University of Colorado, Boulder
University of Nebraska Medical Center
University of Nebraska Public Policy Center
Western Governors' Association
Wyoming State Engineer's Office

NOAA's Drought Task Force Narrative Team interprets the 2012 Central Great Plains Drought, when conditions ranging from 'abnormally dry' to 'severe drought' affected more than three quarters of the Lower 48

Exploring the 2012 drought: Timing, causes, impacts, extent

How do 2012 rainfall and high temperatures compare to years past?

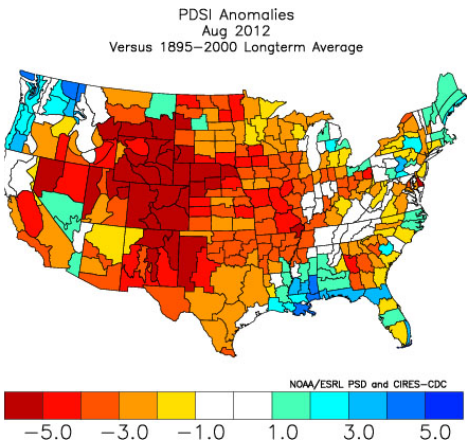


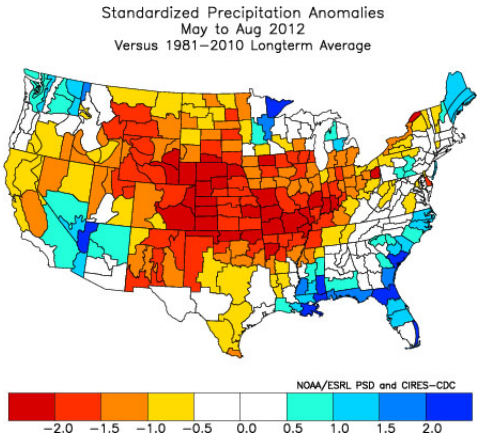
U.S. DROUGHT MONITOR
SEPT. 4, 2012

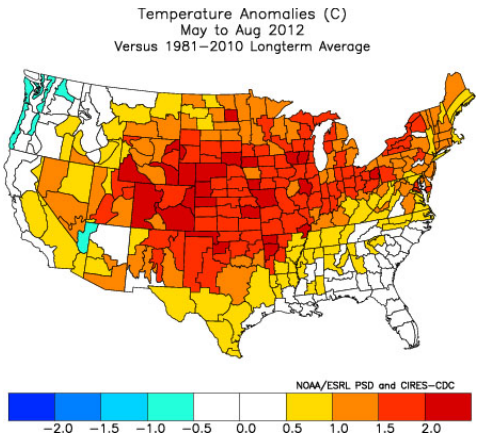
HTTP://DROUGHTMONITOR.UNL.EDU/

Precipitation deficits for the period May through August 2012 were the most severe since official measurements began in 1895, eclipsing the driest summers of 1934 and 1936 that occurred during the height of the Dust Bowl. This prolonged period of precipitation deficits, along with above normal temperatures, resulted in the largest area of the contiguous United States in drought since the U.S. Drought Monitor began in January 2000. By early September, over three-quarters of the contiguous U.S. was experiencing at least abnormally dry conditions with nearly half of the region (the Central Plains in particular) experiencing unprecedented severe drought.

- D0: Abnormally dry
- D1: Moderate drought
- D2 Severe drought
- D3: Extreme drought
- D4: Exceptional drought







For a longer-term perspective, the Palmer Drought Severity Index (PDSI) for August 2012 is compared to a long-term PDSI average spanning from 1895 to 2000 (map on the left, above) and identifies the core region of the drought to be the central Plains region, with the most extreme moisture deficits occurring over the western Plains (consistent with the Drought Monitor map).

A central U.S. epicenter for the drought is also affirmed by the May-August standardized rainfall deficits (middle map) with -2 standardized departures from the 1981 to 2010 long-term average being widespread from Colorado to Missouri. Much of the dry region also experienced hot temperatures (map on the right).

The combination of low rainfall and high temperatures is typically seen during summertime droughts over the central U.S.

What caused the 2012 Central Great Plains Drought?

The central Great Plains drought during May-August of 2012 resulted mostly from natural variations in weather.

■ Moist Gulf of Mexico air failed to stream northward in late spring as cyclone and frontal activity were shunted unusually northward.

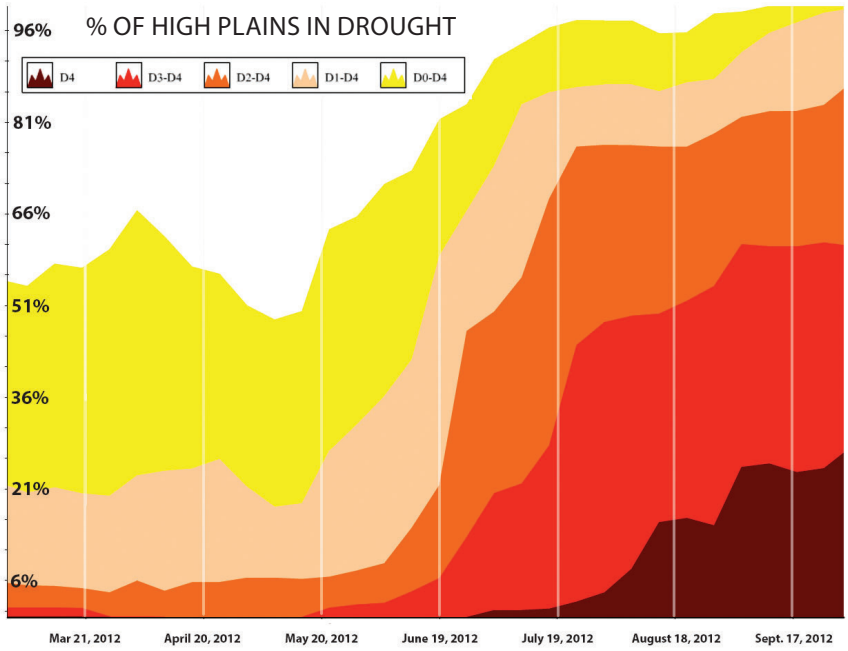
■ Summertime thunderstorms were infrequent and when they did occur produced little rainfall.

■ Neither ocean states nor human-induced climate change, factors that can provide long-lead predictability, appeared to play significant roles in causing severe rainfall deficits over the major corn producing regions of central Great Plains.

BELOW: THIS FIGURE WAS CREATED USING THE DROUGHT MONITOR GRAPHIC TOOL AT HTTP://WWW.DROUGHT.GOV/DROUGHT/CONTENT/TOOLS/DROUGHT-MONITOR-GRAPHICS

Timing of the 2012 Central Great Plains Drought: Was it a "flash drought?"

The 2012 Central Great Plains drought developed suddenly, and did not appear to be just a progression or a continuation of the prior year's record drought event that occurred over the southern Great Plains, but appeared to be a discrete extreme event that developed over the Central U.S. The figure to the left shows the rapid expansion of abnormally dry to exceptional drought conditions during June 2012 for the High Plains (Wyoming, Colorado, Kansas, Nebraska, South Dakota and North Dakota), an example of a flash drought. The x-axis extends from Mar 1, 2012 through Sep 30, 2012.



Impacts of the Drought

Along with the rapid development of the drought, impacts emerged quite swiftly. Loss estimates by the end of July 2012, before drought severity peaked, were $12B. It remains to be seen if the economic effects of the 2012 drought will approach prior events, including the 1988 drought that inflicted $78 billion in losses and the 1980 event that caused $56 billion in losses (adjusted for inflation to 2012 dollars). Broad sectors were affected, and continue to be affected, by the 2012 drought. Notable for the swiftness of impacts was the reduction in crop yields caused by lack of timely rains. Also, curtailment of commerce on major river systems occurred owing to reduced water flow. It is expected that water supply reductions in the semi-arid western portions of the drought where reservoir storage was depleted by lack of rains will also have long-term impacts, as will livestock health and its long-term effect on herd stocks. Preliminary USDA estimates of farm and food impacts of the 2012 drought indicate corn yield (per acre of planted crop) was about 123 bushels. This is 26% below the 166 bushel yield expectation that the USDA had at the commencement of the growing season.

Was the extent and severity of this drought predicted?

Official seasonal forecasts issued in April 2012 did not anticipate this widespread severe drought. Above normal temperatures were, however, anticipated in climate models, though not the extreme heat wave that occurred and which was driven primarily by the absence of rain.

FOR MORE INFORMATION

Read the full report:

http://www.drought.gov/media/pgfiles/2012-Drought-Interpretation-final.web-041013_V4.0.pdf

Selected Recent Drought Publications:

Hunt, E., M. Svoboda, B. Wardlow, K. Hubbard, M. Hayes, T. Arkebauer. 2014. Monitoring the effects of rapid onset of drought on non-irrigated maize with agronomic data and climate-based drought indices. Agricultural and Forest Meteorology, 191, 1-11, [10.1016/j.agrformet.2014.02.001].

Otkin, J. A., M. C. Anderson, C. Hain, I. Mladenova, J. Basara, and M. Svoboda, 2013. Examining flash drought development using the thermal infrared based Evaporative Stress Index. J. Hydrometeor 14, 1057-1074

Pozzi, W et al 2013: Towards Global Drought Early Warning Capability: Expanding international cooperation for the development of a framework for global drought monitoring and forecasting Bulletin of the American Meteorological Society 94, 776-785

Pulwarty R. and Verdin, J. 2013: Crafting integrated drought early warning systems: The case of drought. In Birkmann, J (ed) Measuring Vulnerability to Natural Hazards. United Nations University Press ISBN-13: 978-92-808-1202-2 pp. 124-147

Schwab, J., 2013; Planning and Drought. Published by American Planning Association APA Planning Advisory Service ISBN: 978-1-611901-21-4 144 pp.

Hoerling, M., J. Eischeid, A. Kumar, R. Leung, A. Mariotti, K. Mo, S. Schubert, R. Seager, 2014: Causes and Predictability of the 2012 Great Plains Drought. Bull. Amer. Meteor. Soc., 95, 269–282.

Xia, Y., Ek, M. B., Peters-Lidard, C. D., Mocko, D., Svoboda, M., Sheffield, J., Wood, E. F., 2014. Application of USDM Statistics in NLDAS-2: Optimal Blended NLDAS Drought Index Over the Continental United States. Journal of Geophysical Research, 119, doi:10.1002/2013JD020994

Wilhite, D. M. Sivakumar, R. Pulwarty, 2014: Managing drought risk in a changing climate: The role of National Drought Policy. Weather and Climate Extremes (Special Issue) http://www.sciencedirect.com/science/article/pii/S2212094714000164

Instrumental readings alone don't tell the whole story of drought on Hopi lands. Existing resource management and technical staff can use local observations to plan for mitigation tailored to a region's specific needs

How to help a community develop a drought impacts reporting system

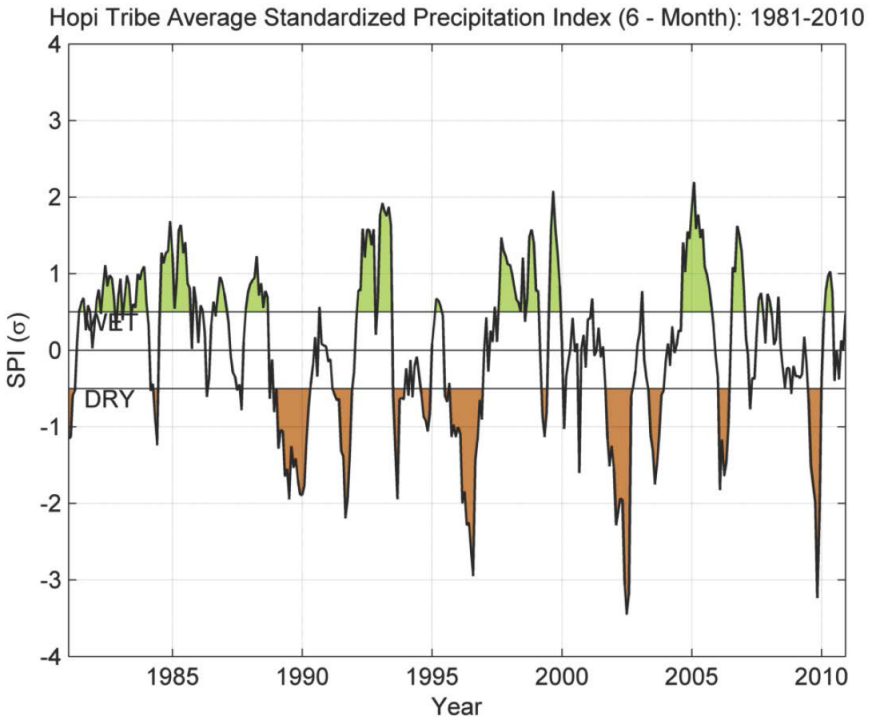
BY
ALISON M. MEADOW
Southwest Climate Science Center
DANIEL B. FERGUSON AND MICHAEL CRIMMINS
Climate Assessment for the Southwest (CLIMAS)

This article first appeared in the Western Rural Development Center's magazine *Rural Connections i*n 2013.

Drought is, of course, a shortage of precipitation, but shortage for whom and by how much? Arguably, those who experience its impacts best define drought.

Monitoring for drought, one might then assume, would rely heavily on observations of the impacts of drought. In fact, standard drought monitoring relies primarily on measurements of precipitation and streamflow to determine drought status in a particular region. Most experts in drought monitoring, planning, and response recognize the need for a greater focus on monitoring drought impacts, but such information remains a relatively small portion of drought status assessments due to the complex nature of the impacts and the difficulty in ascribing a particular impact directly to drought – particularly if the observer is not specifically trained in resource management or monitoring.

Our recent work with the Hopi Tribe's Department of Natural Resources (HDNR) has helped convince us that, depending on the circumstances of a particular community, impact observations can be at least as important as hydroclimatic data in determining drought status and selecting appropriate responses.



ABOVE: Drought index for Hopi Tribe showing increasing frequency of deep drought episodes over the past thirty years (brown areas indicate short-term drought conditions). This figure was created using average monthly precipitation data extracted from PRISM climate database; http://www.prism.oregonstate.edu/).

'We're not going anywhere so we have to take care of what we have'

The Hopi people have lived in the Four Corners region of the Southwest for at least 1000 years, with some notable periods of absence during previous severe droughts.

The region has been experiencing frequent deep drought events over the past several decades with interludes of average or even wet conditions. This pattern of climate variability has produced acute short-term impacts (e.g., poor forage for livestock) and longer-term impacts to water resources (e.g., drying of near-surface springs) across the region. Persistent drought conditions harm Hopi livelihoods by diminishing crop production from traditional farming, impairing culturally significant wild plants, and stressing livestock, which can drive ranchers to reduce herd size.

Tribal resource managers offer this message: the region is their home, they have neither intention or ability to move away, and they must, therefore, make the best possible management decisions to maintain the land and Hopi livelihoods. As one manager told us, "We're not going anywhere, so we need to take care of what we have."

Over the last three years we have been working with the HDNR to develop a drought status-monitoring program based largely on environmental indicators relevant to the region. In this case, impacts monitoring is a better choice than hydroclimatic data because it allows the community to work around the limited availability of long-term and readily available climate data in the region, characterize drought status according to local needs and for local decisions, and create a program that fits the current technological and resource capacities of the community.

The following summarizes our process and some of the lessons we learned. We present it here in hopes of inspiring others to consider the role of locally relevant and consistently collected impacts data in drought monitoring and status assessment.

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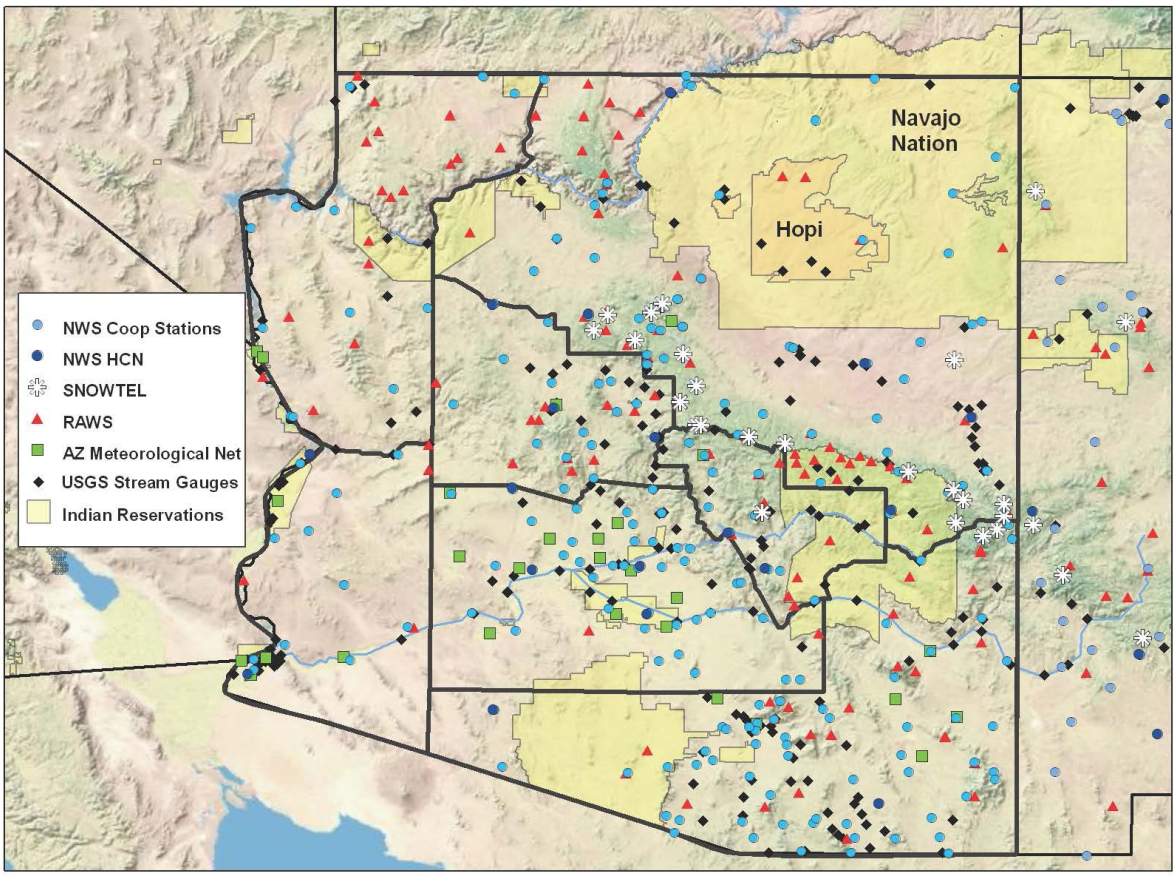


This map of weather and streamflow instruments across Arizona highlights the relative dearth of instrumental data available for tribal lands (indicated by yellow shading). Map by Zack Guido, Climate Assessment for the Southwest, University of Arizona.

Particular challenges on tribal land

As a complex natural hazard, drought affects different people and communities in vastly different ways that are not always captured by hydroclimatic data. Sparse rains may lead to immediate drought impacts in one community without water storage capacity and have little or no impact on another community with ample water storage.

Many Hopi people are dryland farmers and ranchers who rely on seasonal rains to support their crops and livestock. Here, the timing and form of precipitation matters as much as the amount. A heavy rain that simply runs off parched soils is of little value to ecosystems desperate for soil moisture, while a gentler storm may allow moisture to sink into the soil for greater benefit.

The sensitivity of the Hopi people to drought conditions has been especially acute in recent years. In 2009, the HDNR approached researchers at The University of Arizona with a problem. Tribal resource managers knew that drought conditions were severe, yet did not see their perception of conditions reflected in national drought monitoring products. Because drought monitoring is primarily focused on instrumental data, the fundamental problem for places like the Four Corners is a lack of reliable, long-term weather stations to generate that data. The lack of data in turn hindered the HDNR's ability to declare and retract drought warnings, take appropriate mitigation steps, or engage in public education about drought status and opportunities for drought aid.

While the lack of formal precipitation and temperature monitoring on reservation lands is a problem, this is a longer-term issue of funding for basic monitoring without an immediate solution. In partnership with the HDNR we have devised what we hope will provide a more immediate solution: utilize the existing resource management and technical staff within HDNR to develop a stream of monitoring information based on impact observations. By developing a local drought impacts monitoring program, the HDNR can tailor drought indicators to their own decision needs as well as their existing capacity for data management.

Steps in the project process

■ Identify community's needs

Together with the HDNR, we first assessed their observations, concerns, wishes, and capacity related to drought monitoring. Using a focus group of resource managers, we examined a seasonal calendar and identified the times during the year when precipitation is most important to Hopi livelihood. Managers also discussed whether they had perceived any changes in precipitation patterns in recent memory. Other topics included pressing concerns about the potential for loss of traditional farming methods and crops; the requirement to reduce herd sizes distressing households with little other income; and the loss of culturally important plants that suffer under drought conditions.

■ Identify community goals

Our next step was to determine the purpose of

continued on next page

PROJECT SUPPORTERS

>> NOAA Sectoral Applications Research Program
>> University of Arizona

FIRST QUARTERLY DROUGHT STATUS REPORT DEBUTS

The Hopi Department of Natural Resources and a team from the University of Arizona's Climate Assessment for the Southwest program worked together to produce the first Hopi Quarterly Drought Status report in April 2014.

The report is the first product resulting from the work described in the accompanying article.

a Hopi drought monitoring system. Currently Hopi drought monitoring is used internally to guide tribal planning and mitigation activities such as providing financial support for ranchers who need to haul water for their livestock, to determine whether livestock reductions are necessary, and to inform the general public and elected officials about the state of the community's land and resources.

■ **Identify key impacts for that community**

To guide the development of a monitoring program, we attempted to determine impacts that were most detrimental to the community. The concerns about drought consistently raised by HDNR staff included poor forage for livestock, insufficient water for livestock (in springs or impoundments), and not enough precipitation (or at the wrong time) for the dryland agriculture.

■ **Identify community assets**

An important consideration in designing a monitoring program was that it fit the capabilities and resources available in HDNR. As with many resource agencies at all levels of government, the HDNR is financially strapped and lacks the technology to manage a data-intensive program. The HDNR is fortunate, though, to have technicians who are intimately familiar with the landscape and are regularly surveying the land as part of the tribe's resource management and grants reporting responsibilities. Because these technicians were out on the land, collecting ecological status information regularly, and were familiar with the landscape, we determined that implementing a drought impact monitoring program would essentially mean just tweaking the system already in place to incorporate a focus on drought impacts.

■ **Identify gaps in best practices.**

Our next step was to engage with the resource technicians and their managers to determine what kind of monitoring they were doing already, how they were recording the information, and how that information was managed and used within HDNR.

Through this process we learned that different parts of HDNR were charged with monitoring different resources, collected data in different ways, and had differing levels of expertise. By examining the data collection forms for each branch of DNR, interviewing technicians from each branch, and going out in the field with technicians, we were able to compile a list of resources that are regularly monitored, those that are not, and how that data is used. For example, springs are checked and flow-rates measured monthly, but water levels in earthen dams, which provide water for livestock, were not systematically assessed on the same schedule.

Based on these insights, we are currently in the process of developing a short drought monitoring protocol for HDNR resource technicians. Not all technicians will answer every question (for example, water resources technicians are not expected to contribute rangeland status observations), but the format is the same for all technicians, meaning that the data can be assimilated in one main database by the HDNR. Our recommended drought impacts monitoring protocol for Hopi DNR will draw on their concerns, is based on existing monitoring practices, and fits the resources available within the HDNR.

■ **Consider data management issues**

A key lesson for our team was the need to carefully assess the data management and technological capacities of our partners. In the case of HDNR, both are limited due to funding and the relative isolation of the community (which limits internet bandwidth and cellular connections).

While there are many technological tools that could be applied to monitoring drought conditions in an area with few weather stations—such as remote sensing technology—those were not an effective solution because they could not be easily integrated into existing technological or data management frameworks. By keeping the impacts monitoring list as short as possible (and to still remain useful for decision makers), we hope to allow the HDNR to quickly integrate this data into their management structures.

■ **Provide training to reporters**

In addition to the drought impacts monitoring protocols, we are developing a training module for the technicians who will be collecting the data. Although most are familiar with other ecological monitoring practices, our assessments demonstrated the need to provide some additional background on the importance of consistency in monitoring for drought.

We will use a scenario-based approach to training in which the technicians are presented with a range of realistic situations so that we can all come to better understand how drought impacts data could be used to support resource management decisions.

We will test the use of these protocols by accompanying resources technicians to the field to see how they work on-the-ground. We will also work with the data managers to see how information coming from the technicians is being uploaded to the drought database as well as what kinds of reports can and are generated based on the impacts data.

Once the monitoring protocols have been implemented in the Hopi DNR, we will periodically return to evaluate how well they are being followed, whether more protocols have been added to the program, and how drought impacts data are being used in decision making.

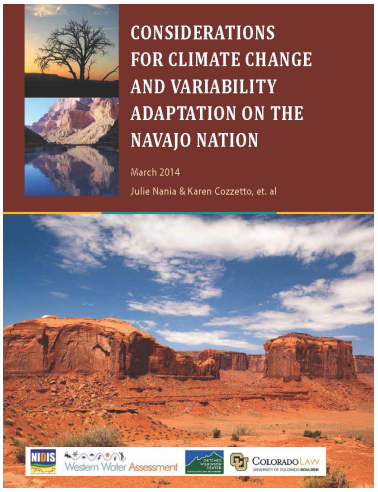
This collaborative project has provided us with ample opportunities to explore the importance and practicality of monitoring drought through systematic collection of impacts data. We are at a relatively early stage in this experiment. We hope the new monitoring protocols will prove useful to and useable by the Hopi Department of Natural Resources and will strengthen their drought planning and response program. We also hope this work will provide lessons for other communities struggling to better characterize and track drought in their region.

As the Navajo Nation anticipate a hotter, drier future, report offers tools and insights for adaptation, and hope for resilience

Four Corners face changing climate

In the U.S. Southwest, 2001-2010 was warmer than any decade in the 20th century. Heat waves are happening more often, cold waves less. On the Navajo Nation, drought conditions have dominated since 1994, punctuated by brief episodes of wetness, yet there have been even worse droughts in the Southwest in the last 2,000 years.

In the middle of this region are the Navajo Nation reservations lands, 27,000 square miles (the size of West Virginia) of arid to semi-arid land that's home to more than 170,000 people.



A new report led by the University of Colorado Boulder, "Considerations for Climate Change and Variability Adaptation on the Navajo Nation," synthesizes state-of-the-science information on the region's climate, water cycle, and ecology. And it goes much further, discussing social, legal, economic, infrastructural, and other factors that affect people's vulnerabilities to climate impacts as well as their adaptive capacity, outlining one approach for how the region's residents might plan for ongoing environmental change.

"It's not only that the Navajo Nation is facing serious climate challenges," said report lead author Julie Nania, Esq., with the Getches-Wilkinson Center for Natural Resources, Energy and the Environment at the University of Colorado Boulder. "It's also that in some cases, they may be vulnerable to climate-related impacts, for example, because many people run livestock," she said.

"On the other hand, they may be particularly well-poised to take leadership on adaptation planning, because they have the sovereign authority to address some of these issues very effectively."

During the past decade, intertribal organizations around the United States have started to recognize climate change and variability as significant factors that can affect tribal resources, livelihoods and cultures. The National Tribal Air Association calls climate change "perhaps the most pressing environmental issue of our time."

The new report--more than 200 pages long--highlights likely and actual environmental changes occurring in the Southwest and Four Corners region. Among them:

■ Average annual temperatures in the U.S. Southwest increased by about 1.6 degrees Fahrenheit between 1901 and 2010.

■ There were more heat waves in the 2001-2010 decade than there were in 20th century decades, on average.

■ Snowmelt and snowmelt-fed streamflow peaks occurred earlier in many areas.

■ On the Navajo Reservation, many streams that once flowed yearlong flow only intermittently now; and others once intermittent have dried entirely.

■ The growing season is longer by 17 days, compared with the 20th Century

■ Climate projections suggest that annual average temperatures in the Southwest will increase by between 2 and 9 degrees Fahrenheit by the end of the 21st Century.

■ Moving sand dunes on the Navajo Reservation, which have buried homes, cropland and ranchlands since the 1950s, may become more widespread in the future.

The report also presents an example of an adaptation planning and implementation process, applicable to any group facing disruption. It outlines many of the challenges that Navajo communities may face, considers the strengths and capacities that the Nation may already have in place to institute adaptation efforts, and suggests potential adaptation strategies.

Nania said she and her co-authors hope Navajo Nation natural resource planners -- some of whom worked closely with the authors of the new report -- will find the information a helpful guide for the adaptive planning process.

One example in the report features the golden eagle, which is protected on Navajo Reservation lands. The bird's numbers are declining on the Colorado Plateau, likely due due in part to climate shifts and non-climatic factors. The report outlines a process that resource managers and the broader community could use to come up with effective ways to address the eagles' decline.

"We hope resource managers and communities will take this report and adapt it to suit their own needs," said Dr. Karen Cozzetto, co-lead author on the report and a researcher with NOAA's Cooperative Institute for Research in Environmental Sciences at CU-Boulder. "They have the expertise and the knowledge to carry forward this kind of adaptation planning."

WHERE TO FIND THE REPORT

Go to http://drought.gov/drought/news/new-report-documents-changes-navajo-nation-lands-offers-hope-resilience or contact the authors at Julie.Nania@colorado.edu or Karen.Cozzetto@colorado.edu

PROJECT SUPPORTERS

National Integrated Drought Information System (NIDIS)

Western Water Assessment

The Getches-Wilkinson Center for Natural Resources, Energy and the Environment at the University of Colorado Law School

Renewable and Sustainable Energy Institute

AUTHORS

Primary authors of the report include CU-Boulder's Julie Nania, Getches-Wilkinson Center for Natural Resources, Energy and the Environment, and Karen Cozzetto, Western Water Assessment. Contributing authors include Nicole Gillette, Ann Mariah Tapp, Sabre Duren, Michael Eitner and Beth Baldwin. Although this report is not a product of the Navajo Nation, the knowledge shared by tribal resource managers and other professionals across the Southwest have been incorporated throughout this report.

Interactive tool lets users compare drought statistics, severity on a local scale

How bad is it really? Drought Atlas taps past data to help assess risks

BY THE NATIONAL DROUGHT MITIGATION CENTER

TRY OUT THE ATLAS
http://droughtatlas.unl.edu/

Every time a drought occurs, people ask, "How does this drought compare……" to the last drought event, the drought of record for an area or a significant or historical drought that left an impression on the public even outside of the area impacted. This comparative information, up to this point, has not been readily available at individual stations, and more often than not has only been available for climate divisions.

The National Drought Mitigation Center on March 21 unveiled a new online Drought Risk Atlas that provides analysis of data on drought frequency and severity for thousands of spots across the country.

"The Drought Risk Atlas contains more than 3,000 of the best climate record stations in the U.S. and houses more than 1 billion records of index calculations alone," said Mark Svoboda, climatologist and leader of the NDMC's Monitoring program area. The stations chosen for the atlas go back at least 40 years with nearly continuous data, and some go back more than 100 years.

"Whenever there is a drought, people want to know how it compares with past droughts," he said. "Until now, that information hasn't been readily available for a given climate station. We heard from stakeholders about the questions they needed answered." Stakeholders include agricultural producers, agency personnel, and planners.

Users can find the closest climate station and see how often drought has affected an area, how bad it has been and how long it lasted, Svoboda said. They can look at drought through the lens of several different indices, including the U.S. Drought Monitor, the Standardized Precipitation Index (with and without evapotranspiration), the Palmer Drought Index, deciles, and more. They can choose to look at records for a cluster of stations near each other that exhibit similar historic patterns.

The project was funded under a grant from the Sectoral Applications Research Program (SARP) of NOAA's Climate Program Office. Contributors include the National Drought Mitigation Center, High Plains Regional Climate Center, Applied Climate Information System, NIDIS, the U.S. Department of Agriculture and the USDA Risk Management Agency.

NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

Created through bipartisan efforts in Congress in 2006, 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 educational resources, interactive systems and tools to promote drought awareness and response