Roger S. Pulwarty
Director, National Integrated Drought Information System, and
Senior Advisor for Climate (Acting)
NOAA/OAR
AND a lot of other people
Drought indices

- Rainfall
- Rainfall plus potential evaporation
- Rainfall plus evaporation
- Land surface models: Soil moisture
- Land surface plus hydrology: Streamflow
(I) Provide effective drought early warning systems:
(a) collect and integrate key indicators of drought severity and impacts; and (b) produce timely information that reflect local, regional, and State differences;

(II) Coordinate and integrate as practicable, Federal research in support of a drought early warning system

(III) Build upon existing forecasting and assessment programs and partnerships

And do this in 6 years with no dedicated funds in the first two years……..good one : )
Support cross-regional efforts to assess user needs, test drought-focused decision support tools.

Identify socio-economic effects of drought, data and info needs of resource managers and policy/decision makers.

Evaluate and transition drought information products to emergency response AND Drought Preparedness and risk management planning.
Table 1. NIDIS Implementation Milestones (FY 2007-2012, by year)\textsuperscript{19}

<table>
<thead>
<tr>
<th>Activity</th>
<th>Milestone</th>
<th>07</th>
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<tbody>
<tr>
<td>1 Initial portal operational capability at drought.gov</td>
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<td>1 Advanced portal mapping capability with GIS tools</td>
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<td>1 Populate drought.gov website (portal, plans, reports, agency links)</td>
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<td>1 Operational portal communities and collaborations</td>
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<td>1 Enhance data management and distribution</td>
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<td>1 Portal extension to hemispheric and global domains</td>
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<td>2 Drought forecast regionalization studies</td>
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<td>2 Enhance soil moisture and temperature measurements</td>
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<td>2 Forecast verification and calibration to measurements</td>
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<td>3 Coordinate with CPO Program Managers/Agencies on interdisciplinary research goals</td>
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<td>3 Inventory drought-related service (federal/state/private)</td>
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<td>3 Assess national status of drought early warning</td>
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<tr>
<td>3 Inventory drought-related research (federal/state/private)</td>
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<td>3 Coordinate drought preparedness plans</td>
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<td>3 Planning for adaptation</td>
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<td>3 Institutionalize “Drought Coordinator” network</td>
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<td>3 Enhanced regional impacts research</td>
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<td>3 Implement adaptive management strategies</td>
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<td>4 Pilot study scoping and selection</td>
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<td>4 NPIT workshops: Define criteria and assess partner interest and capacity for pilots</td>
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<td>4 First Workshop: Assessment of Drought Early Warning System in the United States</td>
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<td>4 Pilot study implementation</td>
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<td>4 Initial early warning prototypes</td>
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<td>4 Pilot study assessment and follow-on work</td>
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<td>5 Establish NIDIS Program Office, governance structure, and final Program Implementation Team</td>
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<td>5 Establish regional sub-team leads within NPIT</td>
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<td>5 Establish initial agency/state rotational assignment to NIDIS Program</td>
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<td>5 Establish NIDIS Interdisciplinary Research Coordination Board</td>
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<td>5 Extend NIDIS to National Governors’ Association and Inter-basin Watershed Commission</td>
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<td>5 Operational workshops to assess national drought monitoring and forecasting gaps</td>
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PL109-430

Reauth Hearing

\$\$
How did we get here? Status and antecedent conditions

Why has it been dry/drier than normal? Is this drought like others?

What are the impacts and where did they occur?

What information is being provided and by whom?

How bad might it get and how long will it last?

How are we planning for this year and for longer-term risks and opportunities?
Pathways to Drought Monitoring and Predictability

Key Phenomena, variables:
- SST anomalies
- Global-Scale Atmospheric Changes
- Regional Forcing and land feedbacks
- Local Impacts, Info needs

ENSO, PDO, AMO, warm pool variability, Global Warming, etc

Planetary waves, hydrological cycle, monsoons, Hadley Cell, Walker Circulation

Precipitation, soil moisture, snow, low level jets, dust, vegetation, land/atmosphere contrasts, changes in weather

Soil moisture, stream flow, precipitation, ground water, lakes, reservoirs
Principal Monthly/Seasonal Drought Outlook Inputs

CPC Seasonal Outlook

NMME

Palmer 4-mo Probabilities

Medium-Range Fcst

2-Wk Soil Moisture

Constructed Analogue Soil Model

Logged Averaged Soil Moisture Outlook for End of AUG2005 units: anomaly (mm), SM data ending at 20050608

U.S. Seasonal Drought Outlook
Drought Tendency During the Valid Period
Valid for January 01 - April 30, 2010
Released January 15, 2010

KEY:
- Drought persist or intensifies
- Drought remote but improves
- Drought removal likely
- Drought development likely

Author: David Skole, Climate Prediction Center, NOAA
http://www.noaa.gov/npcc/perspectavgs/persavgs.html

The U.S. Seasonal Drought Outlook is based on predictions of seasonal precipitation and temperature. The outlook is prepared by the Climate Prediction Center (CPC) of the National Oceanic and Atmospheric Administration (NOAA). The outlook provides a probabilistic assessment of the likelihood of experiencing a range of drought conditions over the upcoming season. The outlook is updated monthly and is based on a combination of statistical and dynamical models. The outlook provides a probabilistic assessment of the likelihood of experiencing a range of drought conditions over the upcoming season. The outlook is updated monthly and is based on a combination of statistical and dynamical models.
Managing Drought in the Southern Plains

You are invited to join us in a webinar (with limited seating) series to discuss drought conditions, impacts, and resources available to help manage drought in the Southern Plains. Webinars will be held on the 2nd Thursday of each month at 11 AM Central Time. A shortened briefing will also be offered on the 4th Thursday. The content is geared toward a general audience—anyone who has responsibility to manage or assist others in managing drought and its related impacts.

If you would like to join in these webinars, you need to register via the SCSEP website: https://www.noaaclimatemap.org or e-mail scsep@noaa.gov. For each webinar, you will receive a link with the link to access the webinar. Each webinar will last 60 minutes.

Each webinar will include an overview of the current drought assessment and outlook, summary of impacts across the region, and a Q&A session. You will have the opportunity to engage others through following webinars.

The webinar series is sponsored by a partnership of the National Drought Mitigation Center (NDMC), National Integrated Drought Information System (NIDIS), National Oceanic and Atmospheric Administration (NOAA), National Drought Mitigation Center, Southern Climate Impacts Planning Program, Climate Assessment for the Southwest, and the region's State Climatologist.

Information from the webinars will be posted on a website. Follow through http://ccc.atmos.colostate.edu/drought_webinar_registration.php for more information and to register for each webinar. There will be a summary produced and posted for each webinar. These summaries will be distributed to affected organizations or groups that are involved in managing or monitoring drought and its related impacts.

The 2012 Drought in Colorado, Utah and Wyoming

A Drought Webinar Series: National Drought Information System (NIDIS)

Drought Conditions as of early July

Water Year Precipitation through June

Spring and Early Summer Temperatures

Weekly Climate, Water & Drought Assessment

http://ccc.atmos.colostate.edu/drought_webinar_registration.php
Managing Drought Risk on the Ranch

Drought is a normal part of climate...it will happen again. Fortunately, there are things you can do before, during, and after drought to reduce your risk. Ranchers are increasingly implementing new ways to better prepare for and respond to drought.

The information, strategies and resources on this site are designed to provide livestock producers in the Great Plains region with information on how to incorporate management strategies to reduce the threat drought poses to livestock and farm operations.

Workshops and Webinars

Managing Drought Risk on the Ranch
Professional Development Webinar Series

10 am Central Time
January - May, 2013
Last Wednesday of each month

Each session will include a briefing on current drought status, followed by a session on a topic of topic of interest related to drought planning.

January 30: Managing Drought Risk on the Ranch: The Planning Process
Jerry Wolensky, Range and Forage Specialist at the West Central Research and Extension Center, and Lynn Myers, Tippecanoe County Extension Director.

February 27: Avoiding Analysis Paralysis: Monitoring and Setting Critical Dates for Decisions Making During Drought
Drayne Rice, Range and Land Management

NDMC
USDA-RMA
USDA-SARE
Cooperative Extension
NIDIS

Managing Drought Risk on the Ranch
A Planning Guide for Great Plains Ranchers

University of Nebraska - Lincoln
National Drought Mitigation Center
Available Online at: www.drought.unl.edu/ranchplan
“Hydro-Illogical” Cycle

RAIN

Apathy

MORE DROUGHT

Panic

Concern

DROUGHT
NIDIS Drought Early Warning Pilot in the Apalachicola, Chattahoochee, and Flint River Basin: Evaluation of Activities and Outcomes

Quarterly Climate Impacts and Outlook

Regional Outlook for Jan-Feb-Mar 2015

Western Region Partners
Western Regional Climate Center
Department of Interior, USGS

An Interpretation of the Origins of the 2012 Central Great Plains Drought

Assessment Report

Causes and Predictability of the 2011-14 California Drought

From Too Much to Too Little:
How the central U.S. drought of 2012 evolved out of one of the most devastating floods on record in 2011
Goals

“To understand the extent of 2012 drought impacts and response in 2012, and help provide new information and coordination for improving the nations’ drought readiness for 2013 and in the future”

• Increase public awareness of this year’s drought and potential impacts for next year
• Technical assistance
• Ensure sustained support for monitoring streamgages and other data
• Outreach with impacted communities
• Conservation plans

Sponsors-multiple (Keynotes-Sec Vilsack; Gov. Brownback) MoU

Drought and U.S. Preparedness in 2013 and Beyond
USDA / NOAA Memorandum of Understanding

First signed in 1983;
Renewed December 2012;
Allows for development of cross-agency Subsidiary Agreements.

Subsidiary Agreement: Cooperation on Drought

"establish a framework by which agencies within the Departments of Commerce and Agriculture can work together towards improving their capabilities to monitor and plan for drought, and support risk management strategies, with particular emphasis placed on serving the interests of the agricultural and forestry communities."
Developing a Coordinated National Soil Moisture Network

National Workshop Organized by NIDIS
• Kansas City, Missouri - November 13-14, 2013
• Over sixty experts from across the country
• Federal, State, and University representatives

Recommendations
• Form an Expert Working Group to articulate a Plan of Action
• Develop a sub-national pilot system
• Develop a nationwide “best available” product by blending data from disparate sources
Pilot System Components

- CRN web service - NCDC ArcServer
- SCAN web service - AWDB SOAP
- OK Mesonet web service
- West TX Mesonet web service
- NLDAS web service
- USGS Geo Data Portal
"Comparing readiness for drought before 2002 with now....... “
Are we better off?

• The number of communities, and institutions with improved capacity to inform climate risk management: ….functioning regional information coordinators

• The number of staff in or working with institutions trained to develop and communicate local climate information and help reduce impacts

• The number of applied research projects that conduct and update climate drivers, impacts and risk assessments in at-risk regions

• The percentage of the regional population covered by adequate climate risk and early warning information systems
“Today, I signed the National Integrated Drought Information System Reauthorization Act into law……to help communities better prepare for droughts…, and prevent the worst impacts on families and businesses”

March 6, 2014. President Obama

“develop and expand the Regional Drought Early Warning Information Systems”

Public Law 113–86
113th Congress

An Act

To reauthorize the National Integrated Drought Information System.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the “National Integrated Drought Information System Reauthorization Act of 2014”.

“(6) continue ongoing research and monitoring activities related to drought, including research activities relating to length, severity, and impacts of drought and the role of extreme weather events and climate variability in drought.”; and

“(C) an identification of research, monitoring, and forecasting needs to enhance the predictive capability of drought early warnings that include—

“(i) the length and severity of droughts;
“(ii) the contribution of weather events to reducing the severity or ending drought conditions; and
“(iii) regionally specific drought impacts.
(5) build upon existing forecasting and assessment programs and partnerships—

- including through the designation of one or more cooperative institutes to assist with NIDIS functions
State drought plans
Evolving drought.gov
(The NIDIS U.S. Drought Portal)

Where is the drought this week?

The major weather system that affected much of the nation’s midsection last week left abundant precipitation this week from the mid-Atlantic up into New England. Hurricane Ana lost strength as it approached Hawaii and Tropical Storm Ana passed south of the Hawaiian Island dumping up to 10 inches of rain in its path.

As of October 21, 2014, drought (D1-D4) is impacting:

- **24.90%** of the area of U.S. and 29.80% of the lower 48 states.
- **74.2 million** people in the U.S. and 74.1 million people in the lower 48 states.

Landing Page:

- Side-by-side monitoring & prediction maps with updated weekly summary below
- News Features

Featured News 3
Hicato nonemperorum quasvitis exercitio di officiam, ex euerlanes res doluuent portus, omnis nonseri inihci ut aliquia sitae modis endam, volenest Learn More

Featured News 2
Hicato nonemperorum quasvitis exercitio di officiam, ex euerlanes res doluuent portus, omnis nonseri inihci ut aliquia sitae modis endam, volenest Learn More

Featured News 1
Hicato nonemperorum quasvitis exercitio di officiam, ex euerlanes res doluuent portus, omnis nonseri inihci ut aliquia sitae modis endam, volenest Learn More
Improved regional maps and information while retaining the same great content.

Tools to make it easier to move from regional to applicable state information.
Intuitive organization:

- Current Drought
- Drought Forecasts
- Drought Impacts

Maintain / expand access to tools:

- Drought ACIS
- Map Viewer
- Time series and pie charts
- Drought Risk Atlas
- Soil moisture viewer
- Drought management database
Forecasting Tools Development-NIDIS CTB

- Updated Optimal Climate Normals (Temperature & Precipitation Trends)
- Improved Understanding of Drought and Ocean Conditions
- ENSO Plume Model Forecasts
- Improved Understanding of Drought and Land Conditions
- Reliability Conditioned on Decadal Variability
- National MultiModel Ensemble (NMME)
- Land-Data Assimilation System (LDAS)
- NOAA Drought Outlook
- Experimental Climate Divisions and Regional Drought Forecasts

Heat Waves
Storm Track Variations
Madden-Julian Oscillation

30 1

El Niño-Southern Oscillation + ?????

Decadal Variability
Solar Variability
Deep Ocean Circulation
Greenhouse Gases

3 10

30 100

SHORT-TERM
INTERANNUAL
DECADE-TO-CENTURY
Develop Models for Regional Science and Applications

- Improvements in coupled ocean and atmosphere models to simulate regional change and variability
- Increased complexity needed to simulate climate change associated with aerosols and clouds
- Increased resolution and improved physics to simulate extreme events and regional climate
- Investments in model development and analysis (computational and human requirements)
- Modelers and observational and process scientists working more closely together; “Climate Process Teams”
- Need to facilitate access to models and provide capacity for scientists outside modeling centers to conduct experiments
- Strengthen collaborations, including with information users
A complete explanation of these droughts must invoke not just the ocean forcing but also the particular sequence of internal atmospheric variability - weather - during the event.

Even a perfect SST prediction would “likely” capture much less than half the total variance in annual precipitation over North America.
Evaporative Demand Drought Index (EDDI) shows strong early warning potential.

Due to land-atmosphere feedbacks, evaporative demand ($E_0$) reflects surface moisture conditions, often before ET does,
  - responds positively to both flash droughts and sustained droughts.

Math 7

$$ ELDI_j = \frac{\sum_{t=i}^{j} (ET_{0t} - \bar{ET}_{0t})}{\sigma_{ET_{0t}}} $$

2-week EDDI

Due to land-atmosphere feedbacks, evaporative demand ($E_0$) reflects surface moisture conditions, often before ET does,
  - responds positively to both flash droughts and sustained droughts.

USDM

Note little drought in western US

Drought similar to EDDI; D3 deep much of region; drought in MO, AR, OK, 5 months after EDDI
**Status and Next Steps**

- *EDDI* furnished weekly in 2014 experimentally to:
  - USFS Rocky Mountain Research Station,
    - improving CONUSwide wildland fire forecasts (# large fires, suppression $)
  - Colorado State climatologist (Nolan Doesken),
    - Upper Colorado Basin Regional Drought Early Warning System (UCB-RDEWS).

- Two *EDDI*-defining papers to be submitted, March:
  1. physical basis of *EDDI*;
  2. applications and assessment of *EDDI*.

- Chapman Conference on California Drought, April.

- Engagement of USDM authors, through 2015.

- Attribution of flash drought dynamics.

- Linkages with short-term and seasonal forecasting of $ET_0$. 
• Could “the” drought have been anticipated?
• Is the California drought a symptom of long-term climate change?

Drought Task Force
The California Drought of 2014: Record Hot, Record Dry

CA Winter (DJF) Daily Max Temperature

Statewide 3-yr Precip Accumulation

Precipitation (inches)

Year 1 Year 2 Year 3

1981-1984
1974-1977
2011-2014

Average
California Water Action Plan

Manage and prepare for dry periods-
Streamline water transfers
Expand storage
NIDIS Drought-related Activities in California: A Few Examples

• Predicting Drought Amelioration: How Much Precipitation is Needed to End a Drought (NCDC/CPC/IRI/NIDIS)


• Partnerships and research relevant to the California State Water Action Plan (RISA/California Nevada Applications Project/NIDIS/NWS)

• Within-season monitoring of Fallow Lands (NIDIS/NASA, California DWR, others): Timely knowledge of the amount and spatial distribution of fallowing and irrigation

• California Services Assessment – across NOAA lines, assessing NOAA’s response and drought service capabilities in California to inform future actions (NCDC lead, NIDIS supported)
Atmospheric Rivers (ARs)

- Drought breaks in the western U.S. are often tied to ARs.
- ARs are narrow corridors of enhanced winds and transport of water vapor at the boundary of a low pressure system.
- ~40-70% of the drought breaks in the west coast since 1950 are due to ARs.
- Large & slow moving ARs can cause flooding.

Tuesday 12/09/14

Wednesday

Thursday

CFSR – G

Huntington 2014

February 8th, 2014
Lovelock, Nevada – Humboldt River Basin
- No groundwater pumping for irrigation (too salty)
- Very little storage upstream
- Extremely sensitive to persistent hydrologic drought

-Growing Season Crop Water Use (30m Pixels) – Computed using Google Earth Engine
-Google hosts the entire 40yr+ Landsat archive and provides parallel cloud computing
If it’s so easy why is it so hard?

Meet “The Borg”

Dreadnaught-class Starship
Are Transitions to Semi-Permanent Drought Imminent?

American hydroclimate (Hoerling et al. 2010; Seager and Vecchi 2010). This drying over recent decades is consistent with the warm state of the North Atlantic Ocean (which developed after the late 1990s) and the overall cool state of the tropical Pacific since the 1997/98 El Niño (e.g., Schubert et al. 2009; Kushnir et al. 2010).

d. Climate change forcing of U.S. droughts during 1979–2012 Next we pose the question of how large the human-influence on U.S. drought may have been, when referenced to a longer period of the climate record. The diagnosis involves intercomparison of the two parallel 10-member ensembles of ECHAM5 experiments. Shown in Fig. 14 is the difference between their annual mean climatological precipitation (top), soil moisture (middle), and surface air temperature (bottom). Further, the LTC bars of Fig. 12 are the result of averaging the mean changes in soil moisture, shown in Fig. 14 (middle panel), over each of the respective drought regions. The cause for the differences in Fig. 12 is entirely due to the model's sensitivity to the change in global sea surface temperatures.

**Fig. 14.** Simulated long-term change in annual mean (top) climatological precipitation, (middle) soil moisture, and (bottom) surface temperature: computed from the difference between fully forced ECHAM5 simulations for 1979–2012 and the ECHAM5-PI runs in which trace gas forcings are set to climatological 1880 conditions and the 1880–2012 linear trend in SSTs is removed from the monthly SST variability.
NIDIS complements the National Drought Resilience Partnership goals

**National Integrated Drought Information System:**
Public Law 113-86; reauthorized in 2014
- integrates information on key indicators of drought and drought impacts
- Provides usable, reliable, and timely forecasts of drought drought and impacts
- Improve national coordination of soil moisture monitoring

Information sharing and collaboration across all levels of government to promote drought preparedness & planning
Table 1. Short-, medium-, and long-term NIDIS Pilot activities contributing to national drought preparedness and early warning

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<th>Short – Term 1-3yrs</th>
<th>Medium – Term 3-5 yrs</th>
<th>Long – Term &gt;5 yrs</th>
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<tr>
<td>Establish a limited number of NIDIS Pilot projects to explore and demonstrate drought risk reduction strategies using drought monitoring and prediction information in partnership with users and federal, state, regional, and local agencies.</td>
<td>Evaluate effectiveness of Early Warning System Pilot projects; and initiate second series of regional NIDIS Pilot projects using lessons and technologies from the first series of Pilots in conjunction with already existing activities.</td>
<td>Transferability: Complete staging and diffusion of regional Pilot projects to achieve national coverage.</td>
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<td>Initiate NIDIS Pilot identified activities needed to improve regional to local capabilities to educate and communicate drought information and awareness.</td>
<td>Develop an understanding of factors contributing to droughts for improving the usefulness of prediction products and for improving drought preparedness.</td>
<td>Use integrated interagency drought information network for education and delivery of products and services at regional to local level.</td>
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<td>Initiate NIDIS Pilot defined activities to develop drought impacts assessment methodology and reporting requirements.</td>
<td>Begin process for transferring NIDIS Pilot lessons to non-Pilot projects at state and county levels to assess regional and local drought impacts.</td>
<td>Continued drought information system refinements such as inputs into watershed, state, and local drought plans and operations.</td>
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(NIDIS, 2007)
1. Integrated Monitoring and Forecasting

Drought Research Task Force: predictions and links between climate forecasts and stream flow projections for particular basins—drivers of drought frequency, onset, duration, and intensity. National Drought Monitor and Outlooks

2. Interdisciplinary Needs Assess., Research, Applications

“Coping with Drought” Research: assess impacts of drought, assess previous coping strategies and practices, develop decision support tools for regional, state, and local use. Consistent framework for developing triggers for actions.
3. National & Regional Drought Portals

Drought Portal: (e.g. www.drought.gov) Drought-related information-credible and accessible-where to go for help

4. Public Awareness and Education

Assessment and scientifically-based outlooks of existing and potential drought conditions and impacts-
Developed with partners:
webinars and one on one, direct workshops

5. Engaging Preparedness Communities

User guidance, cross-agency coordination and decision support tools to support drought planning and risk reduction-Conducted in partnership-test triggering criteria
• Reconstitute the NIDIS Working Groups and Program Implementation Team

• Continue advances in prediction esp. on drought persistence and amelioration (role of ARs etc)

• Establish a new cooperative institute focused on impacts assessment and drought planning under NIDIS

• Complete RDEWS and expand/transfer lessons/methods to new areas

• Strengthen cross-agency (Fed-state-tribal) monitoring capabilities incl sfc-groundwater demand and input to drought.gov

• National and international partnerships
Memorandum of Understanding

Western Governors’ Association (WGA) and National Oceanic and Atmospheric Administration (NOAA)

JUNE 2014

Collaboration on Drought, Flooding, and Wildfire Preparedness:
Sharing Information and Building Resilience in Planning for Extreme Events

June 9, 2014
Colorado Springs, Colorado

Western Governors’ Drought Forum

The 2015 Chairman’s initiative of Gov. Brian Sandoval of Nevada is designed to foster a regional dialogue in which states and industry can share case studies and best practices on drought policy, preparedness and management. In addition to meetings that will focus on specific sectors, the Western Governors’ Drought Forum will create an online resource library that will feature a growing collection of drought resources.
Thank you!

CURRENT RESERVOIR CONDITIONS

ENDI AT MIDNIGHT - JANUARY 5, 2015

LEGEND

Capacity (TAF)
% of Capacity
% of Historical Average
Historical Average

Trinity Lake
34% | 50%

Shasta Reservoir
42% | 66%

Lake Oroville
39% | 62%

Folsom Lake
45% | 91%

New Melones
23% | 40%

Don Pedro Reservoir
39% | 59%

Exchequer Reservoir
7% | 16%

San Luis Reservoir
43% | 62%

Millerton Lake
35% | 64%

Pyramid Lake
94% | 105%

Castaic Lake
36% | 45%

Pine Flat Reservoir
13% | 31%

...AND THAT IS WHY WE LIFT ON THREE...

COMMUNICATION

Coordination
Weather-climate continuum and adaptation deficits

Atmosphere region
Ocean skin global
Atmospheric chemistry
upper full Land
Ice sheets

Fronts, convective systems
Cyclones
Blocking
MJO
NAO
ENSO
QBO
PDO
AMO

1 DAY
1 WEEK
1 MONTH
1 SEASON
1 YEAR
1 DECADE
100 YEARS