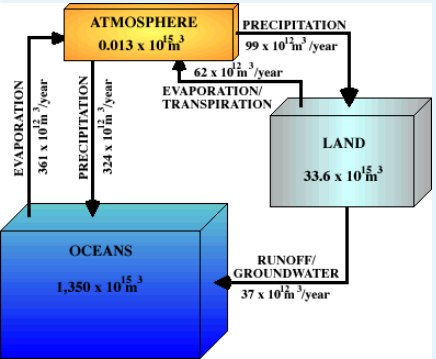
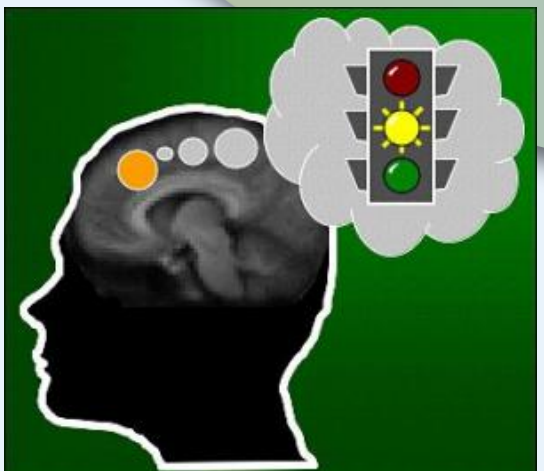
The National Integrated Drought Information System

Roger S. Pulwarty
Climate and Societal Interactions Division
NOAA CPO and ESRL

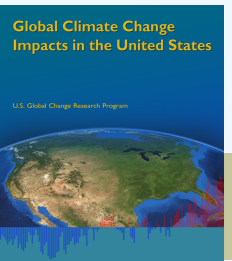
And the NIDIS Players

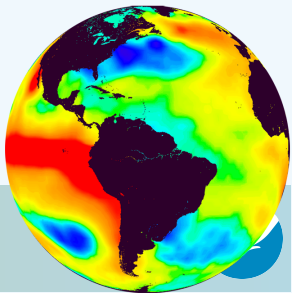




How do we “usually” adapt?

- Infrastructure/assets
- Technological process optimization
- Institutional and behavioral changes or reinforcement
- Crisis, learning and redesign





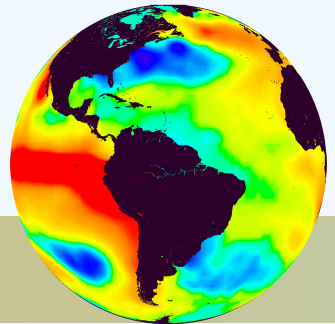
Three tasks under the NIDIS Act Public Law 109-430, 2006

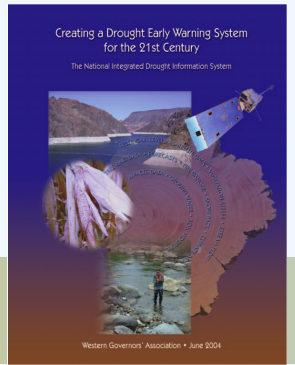
(I) Provide an effective drought early warning system:

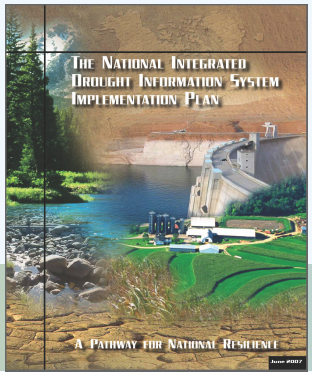
(a) collect and integrate key indicators of drought severity and impacts; and
(b) produce timely information that reflect local, regional, and State differences;

(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

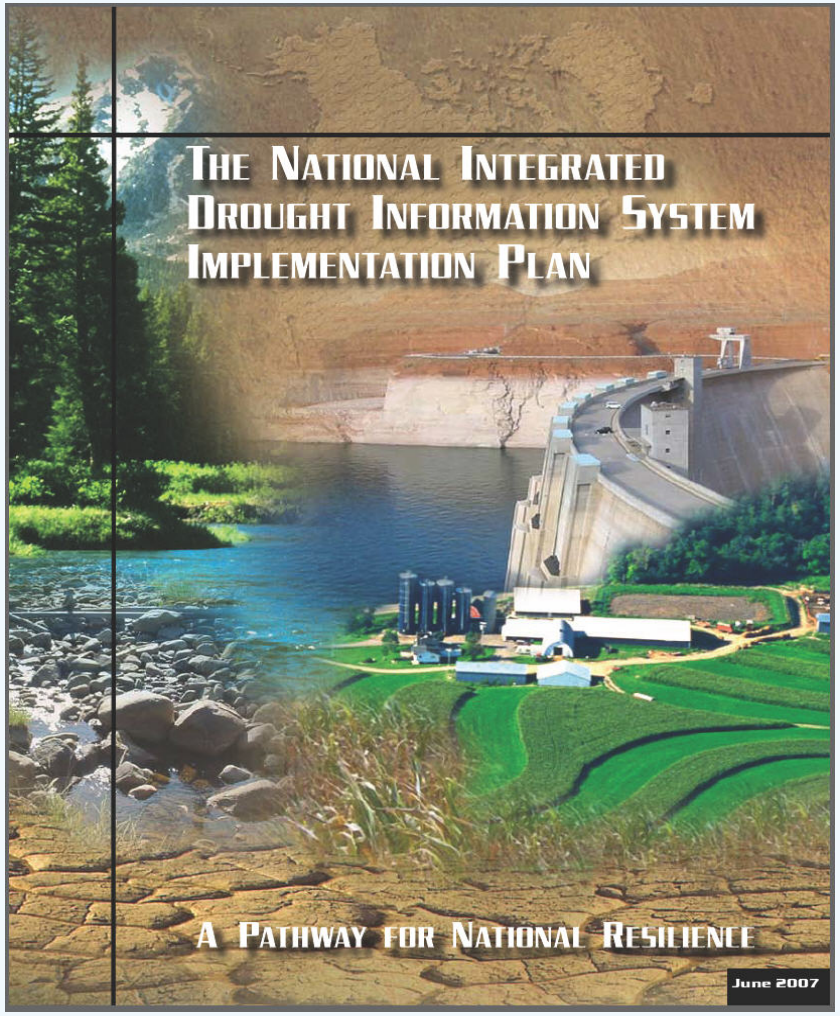






NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

NIDIS Components



1. NIDIS Office

2. Coping with Drought-Grants-
   Impacts assessment and decision support research
3. Climate Forecast Test Beds/ Drought
   Integrating monitoring and forecasts
4. U.S. Drought Portal

5. Regional Drought Early Warning Information Systems

NIDIS Governance: Executive Council

NATIONAL

NIDIS Program Office → **NIDIS Implementation Team:**

NIDIS Technical Working Groups

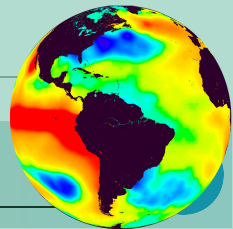
REGIONAL

- **Public Awareness And Education**
- **Engaging Preparedness Communities**
- **Integrated Monitoring and Forecasting**
- **Interdisciplinary Research and Applications**
- **U.S. Drought Portal**

WATERSHED/URBAN/LOCAL

Regional Drought Early Warning Systems

Information clearinghouse,prototypes, and Implementation



National Integrated Drought Information System

U.S. Drought Portal

www.drought.gov

Contact Us | Log In | Text-Only

Search:

HOME | WHAT IS NIDIS? | CURRENT DROUGHT | FORECASTING | IMPACTS | PLANNING | EDUCATION | RESEARCH | RECOVERY | REPORTS

Area Drought Information

Select State... Go

Select Region... Go

Maps & Tools

- Map Viewer - updated!
- GIS Resources
- Geodata Portal
- Drought Monitor Graphics
- CRN Soil Data - new!

Events & Announcements

- AMS Hydrology Abstracts due soon
- NADM Workshop - April 20-23, 2010
- Scoping workshop ACF Basin - Lake Blackshear, GA - Updated!
- Map Viewer now includes US Drought Outlook - New!
- Drought Monitor Forum - Austin 2009
- Drought Index Evaluation Workshop - Boulder, CO - August 2009
- ESA Millenium Conf - November 2009

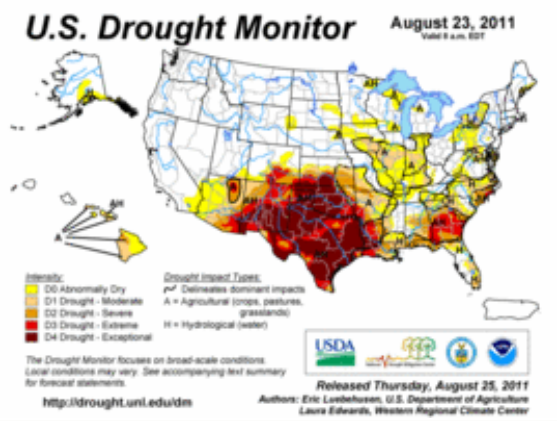
View Archive | Portal Release Notes

Drought In The News

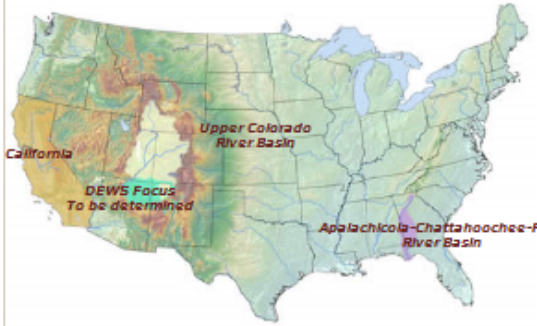
- Corps to officially remove water usage from Lanier manual | ajc.com
- Parched English fields reveal ancient sites
- Klamath Basin water worries extend to wells
- 2 dozen Ky. counties declared drought areas - Kentucky.com
- Drought-hit Calif.-Ore. border getting feds help - fresnobee.com
- Trouble In Paradise: Hawaii Waits For Drought Relief : NPR
- Rain helps pastures, but too late for corn | Richmond Times-Dispatch
- Impact of drought felt by farmers - The Joplin Globe, Joplin, MO
- West Hawaii Today - Dry in Hawaii

Featured Products

Where are Drought Conditions Now? | How is the Drought Affecting Me? | Will the Drought Continue?



Regional Drought Early Warning Systems



(Click on an area to view the Drought Ea

NIDIS Feature

In the Western United States

Using Technology To Save Water

view article

Drought Information Statements

Click on a highlighted area to view the current NWS Drought Information Statement or Click Here to select from a list

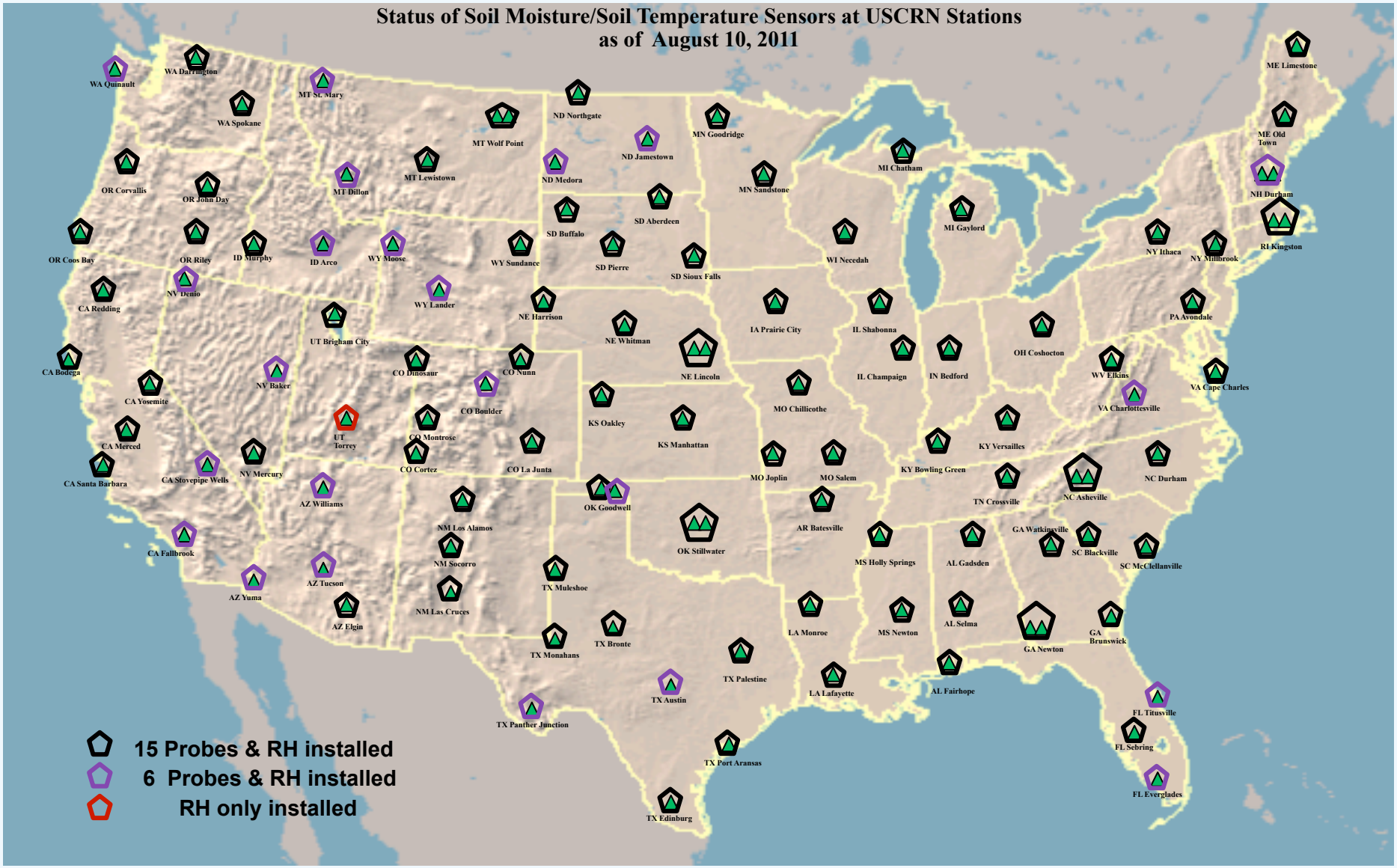
View larger map

Drought Monitor Time Series

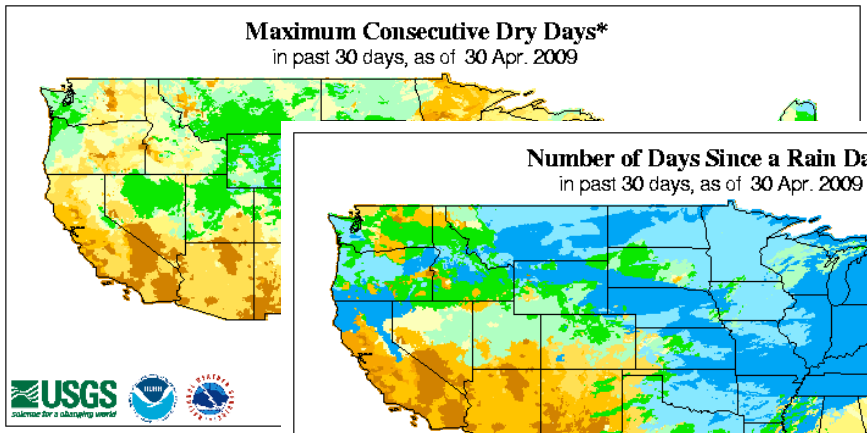
Key Clearinghouse Functions:

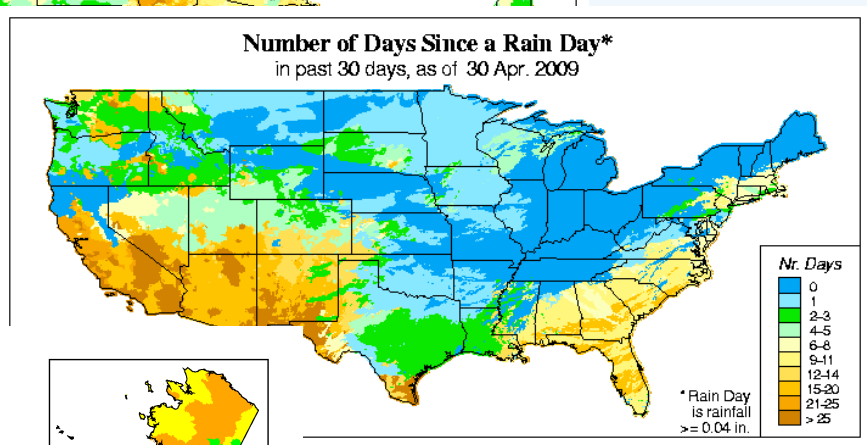
Credible, Accessible, Timely Information on

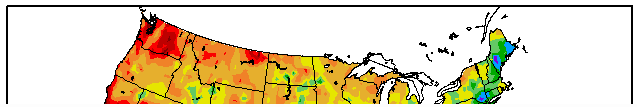
Where are drought conditions now?
Does this event look like other events?
How is the drought affecting me?
Will the drought continue?
Where can I go for help?

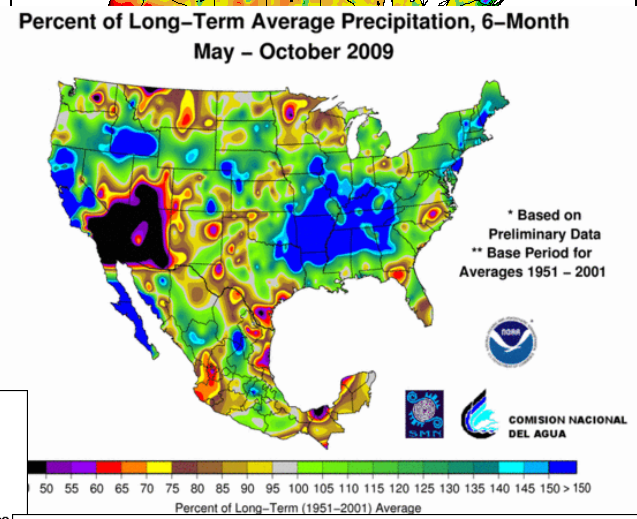

Status of Soil Moisture/Soil Temperature Sensors at USCRN Stations
as of August 10, 2011
WA Quinault
WA Darrington
WA Spokane
MT St. Mary
MT Wolf Point
ND Northgate
MN Goodridge
ND Jamestown
ME Limestone
ME Old Town
NH Durham
RI Kingston
OR Corvallis
OR John Day
MT Lewistown
MT Dillon
ND Medora
MN Sandstone
MI Chatham
OR Coos Bay
OR Riley
ID Murphy
ID Arco
WY Moose
WY Sundance
SD Buffalo
SD Aberdeen
SD Pierre
SD Sioux Falls
WI Necedah
MI Gaylord
NY Ithaca
NY Millbrook
CA Redding
NV Denio
WY Lander
NE Harrison
NE Whitman
IA Prairie City
IL Shabonna
PA Avondale
UT Brigham City
CA Bodega
CA Yosemite
NV Baker
CO Dinosaur
CO Nunn
NE Lincoln
OH Coshocton
IL Champaign
IN Bedford
WV Elkins
VA Cape Charles
CO Boulder
VA Charlottesville
CA Merced
UT Torrey
CO Montrose
KS Oakley
KS Manhattan
MO Chillicothe
KY Versailles
CA Santa Barbara
CA Stovepipe Wells
NV Mercury
CO Cortez
CO La Junta
MO Joplin
MO Salem
KY Bowling Green
NC Durham
TN Crossville
NC Asheville
AZ Williams
OK Goodwell
NM Los Alamos
AR Batesville
CA Fallbrook
NM Socorro
OK Stillwater
GA Watkinsville
SC Blackville
SC McClellanville
MS Holly Springs
AL Gadsden
AZ Tucson
AZ Yuma
TX Muleshoe
NM Las Cruces
AZ Elgin
LA Monroe
MS Newton
AL Selma
GA Newton
GA Brunswick
TX Monahans
TX Bronte
TX Palestine
LA Lafayette
AL Fairhope
TX Austin
FL Titusville
TX Panther Junction
FL Sebring
TX Port Aransas
FL Everglades
TX Edinburg
15 Probes & RH installed
6 Probes & RH installed
RH only installed

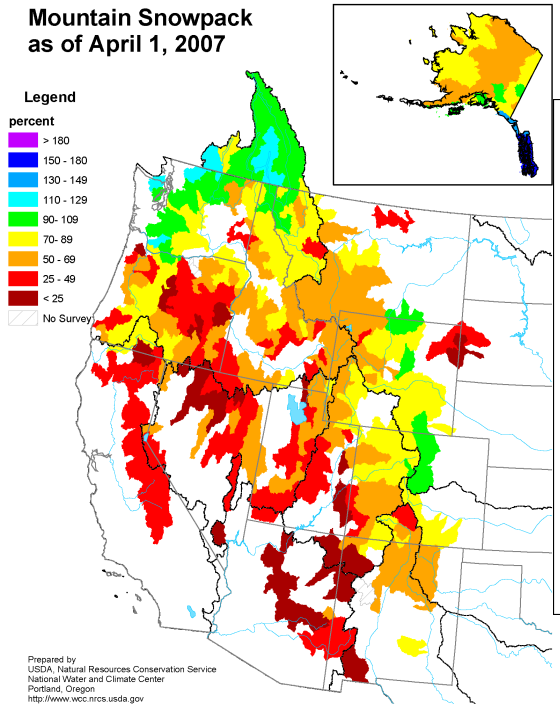
(Basic Indicators Are Still Widely Used Today)

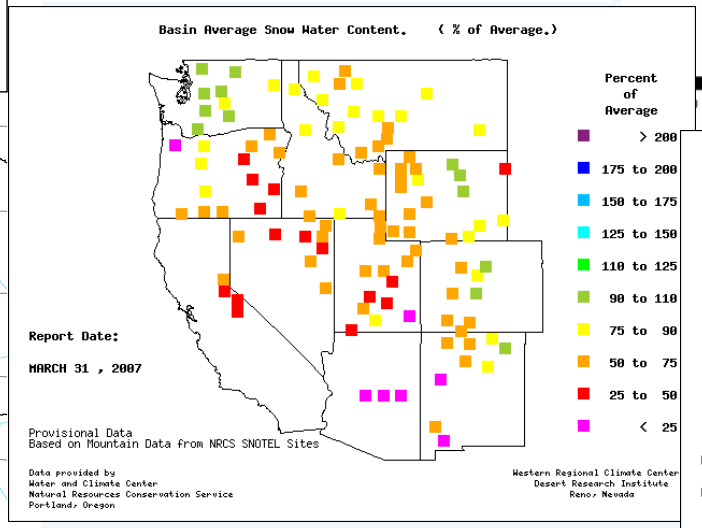


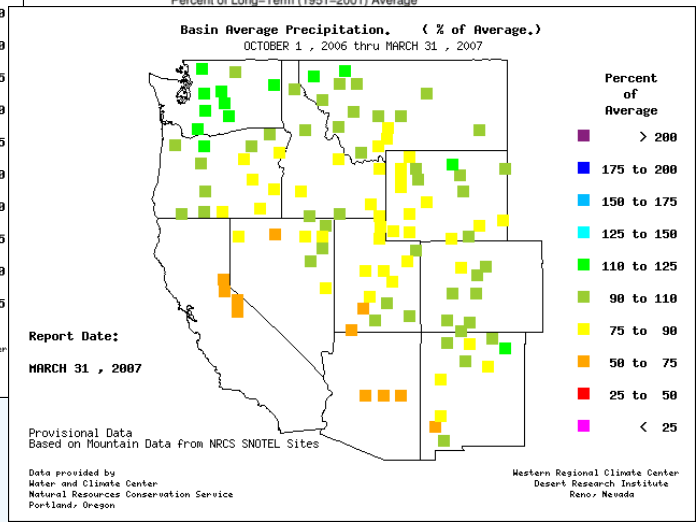












Arizona-CLIMAS
Colorado-WWA
CA&NV-CNAP
Washington-CiG
Oregon-OCS
OK-SCIPP

RISA

Support cross-RISA efforts to explore testing drought-focused tools + one new drought-focused RISA (Southern G.Plains)

Coping with Drought Research

SARP

TRACS

Socio-economic effects of drought. Data and info needs of resource managers and decision makers

Transition drought information products to operational delivery

Reconciling Projections of Future Colorado River Streamflow

NOAA, University of Arizona (CLIMAS), Reclamation, USGS, University of Colorado (WWA)

esp.cr.usgs.gov

Evaluation of Fire Forecast Products to Enhance U.S. Drought Preparedness and Response

(Univ. of AZ, CLIMAS); (DRI,WRCC, CAP); (Neptune and Company, Inc., (Univ. of AK, ACCAP)

FWS.gov

S

- Develop drought decision support portal for the Republican River Basin (NE)

A

- Identify water transfer arrangements to facilitate use of climate information in planning (AZ)

R

- Develop hydroclimatic reconstructions for water resources management (WA)

P

- Develop climate training workshops targeting Extension Agents/Farm Bureaus (OK)

Paleoclimatic Information for Drought Planning and Decision Making

(University of Arizona, University of Colorado)

http:/www.ncdc.noaa.gov/paleo

T

R

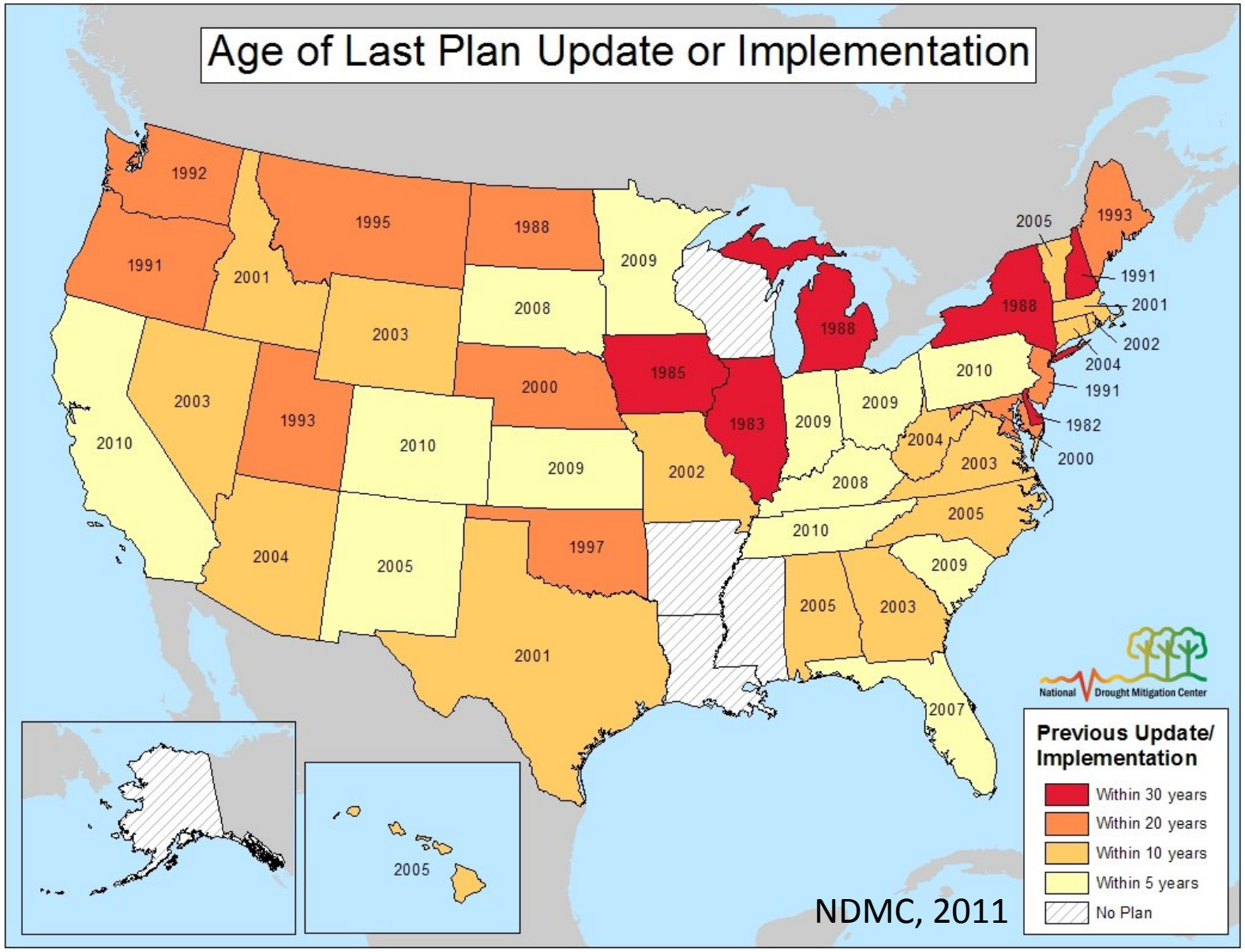
A

C

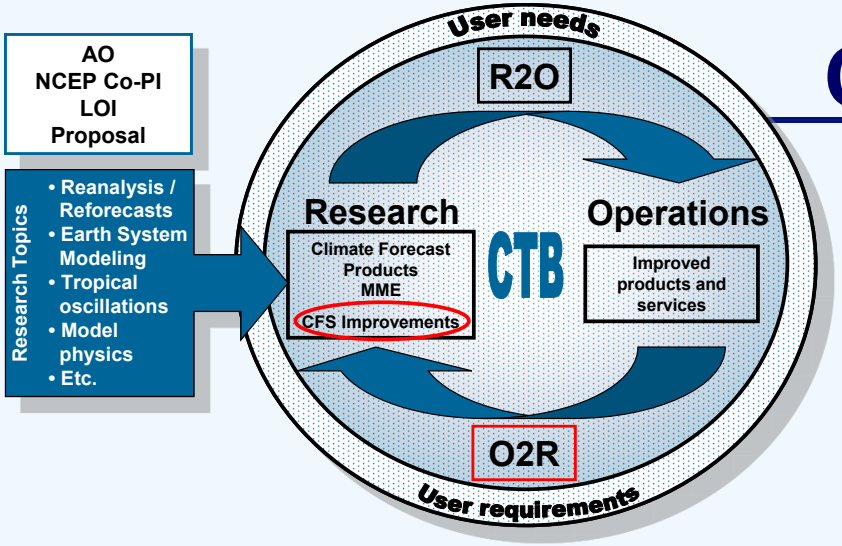
S

- Operationalize the SECC AgroClimate Tool for extension services for drought management (FL)
- Enhance decision-makers' monitoring tools by transitioning a new drought index (AZ)
- Link NOAA climate forecasts to dynamic vegetation models to produce seasonal predictions for fire management (NV)

Status of Drought Plans



Climate Test Bed



Mission

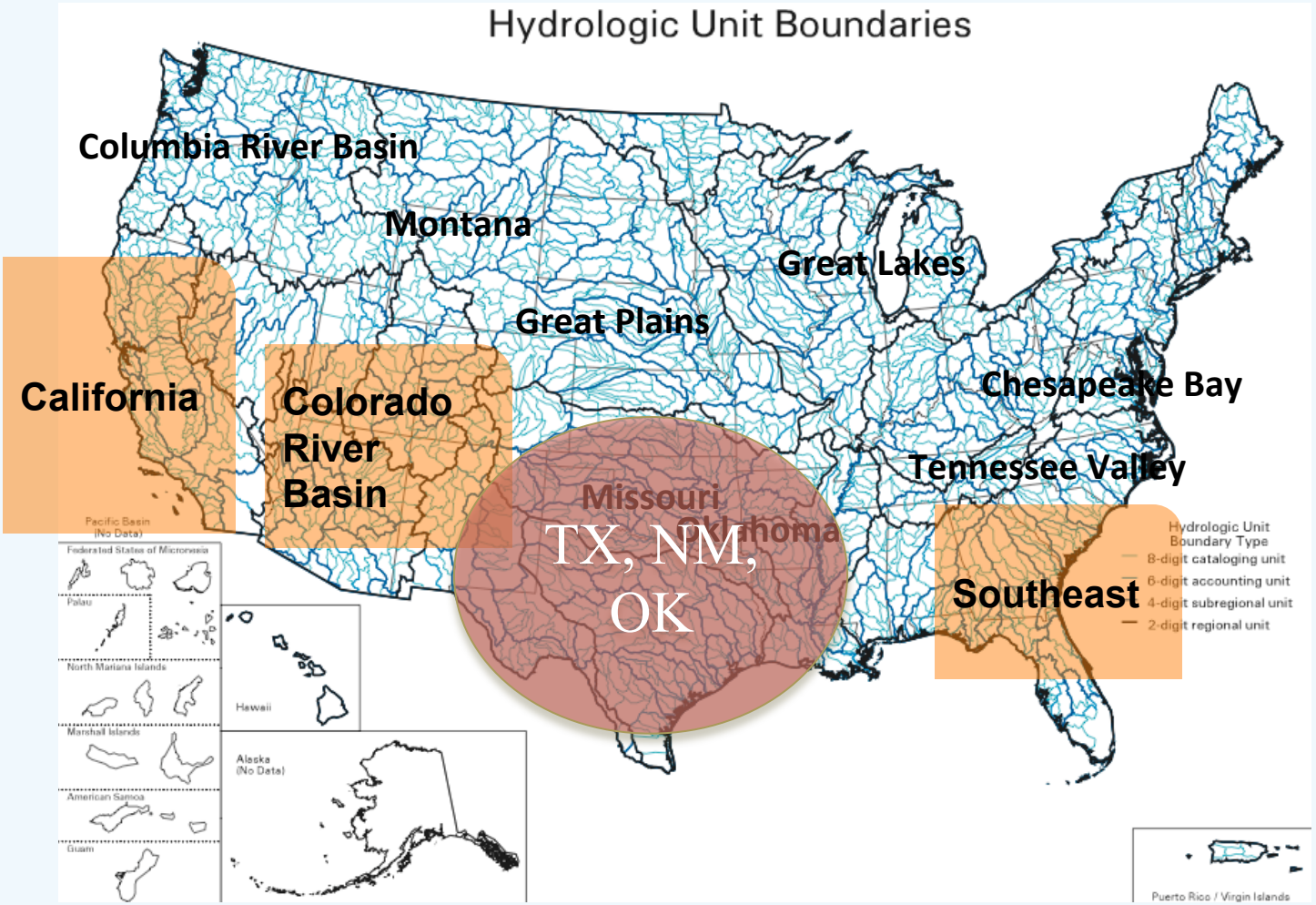
To accelerate the transition of scientific advances from the climate research community to improved NOAA climate forecast products and services.

- Joint NCEP-CPO facility @ NCEP
- CTB Science Advisor Board (SAB)
- Established in 2005
- Serves as conduit between the operational, academic and research communities

- CTB embraces *the R2O and O2R paradigms*
- CTB emphasizes three science activities
  - *CFS improvements*
  - *Multi-model ensembles*
  - *Climate forecast products*
- Bi-weekly CTB management meeting
- CTB Monthly Seminar Series
- 2011 CTB PIs Meeting and SAB meeting on Oct.6, 2011

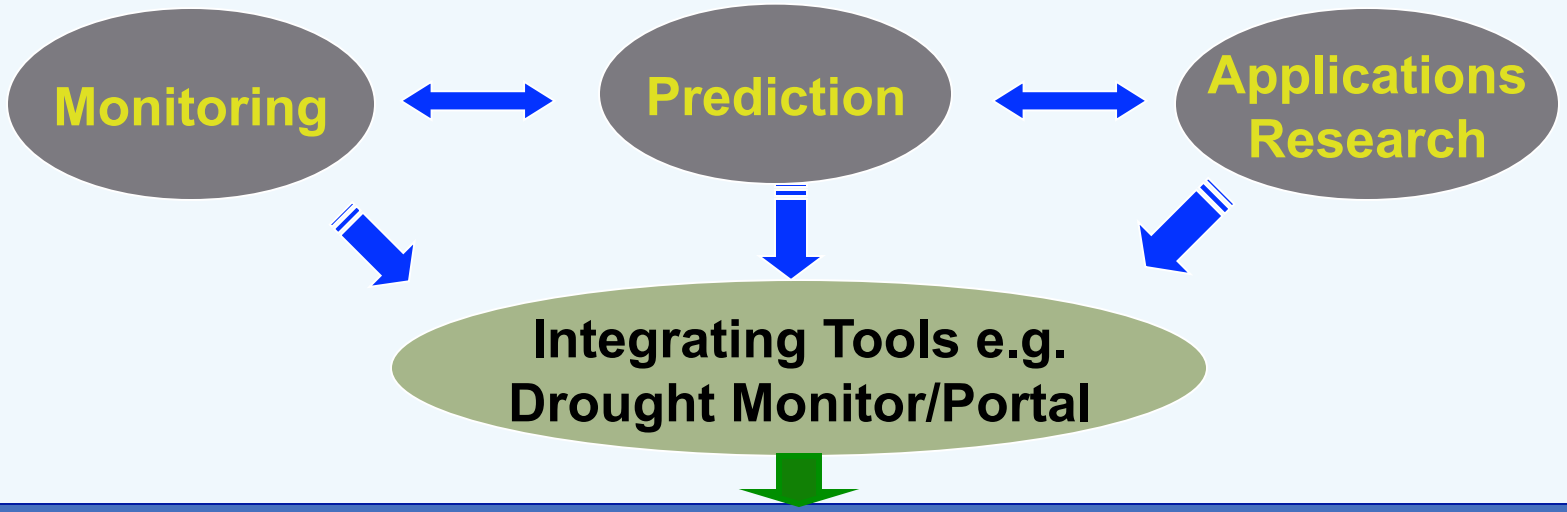
Regional Drought Early Warning Systems

Highlighted-first round prototypes;
Non-highlighted-second round Regional DEWS



NIDIS REGIONAL INFORMATION MANAGEMENT MODEL

Coordinate existing federal, state, and local drought-related data and decision support activities (e.g., within watersheds and states)



Identifying and transferring indicators, decision support tools and innovative strategies for drought risk assessment, communication and preparedness

Regional DEWS Implementation: Upper Colorado River Basin

Categories of drought information users & analysis

Upper Basin down to Lake Mead

•Coordinated reservoir operations: Low flow shortage triggering criteria (Powell/Mead)

Sub-basin

•Inter- and Intra-basin transfers; Front range urban-agriculture-Changing water demand during drought

•Ecosystem health/services including recreation and tourism impacts

NIDIS
NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

Network of Over 50- Federal, state, tribal and private sector partners

Integrated Monitoring and Forecasting

NRCS, USGS
River Forecast Center, BoR
Climate *Prediction* Center
USDA

Interdisciplinary Needs Assess., Research, Applications

Regional Integrated Sciences and Assessments
Regional Climate Centers
NWF,CWCB, NCAR

U.S. Drought Portal

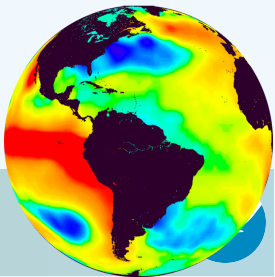
NCDC
NDMC-NOAA,USGS, USDA, USBoR

Public Awareness And Education

State Climatologists
NWS-CSD
USDA,CWCB

Engaging Preparedness Communities

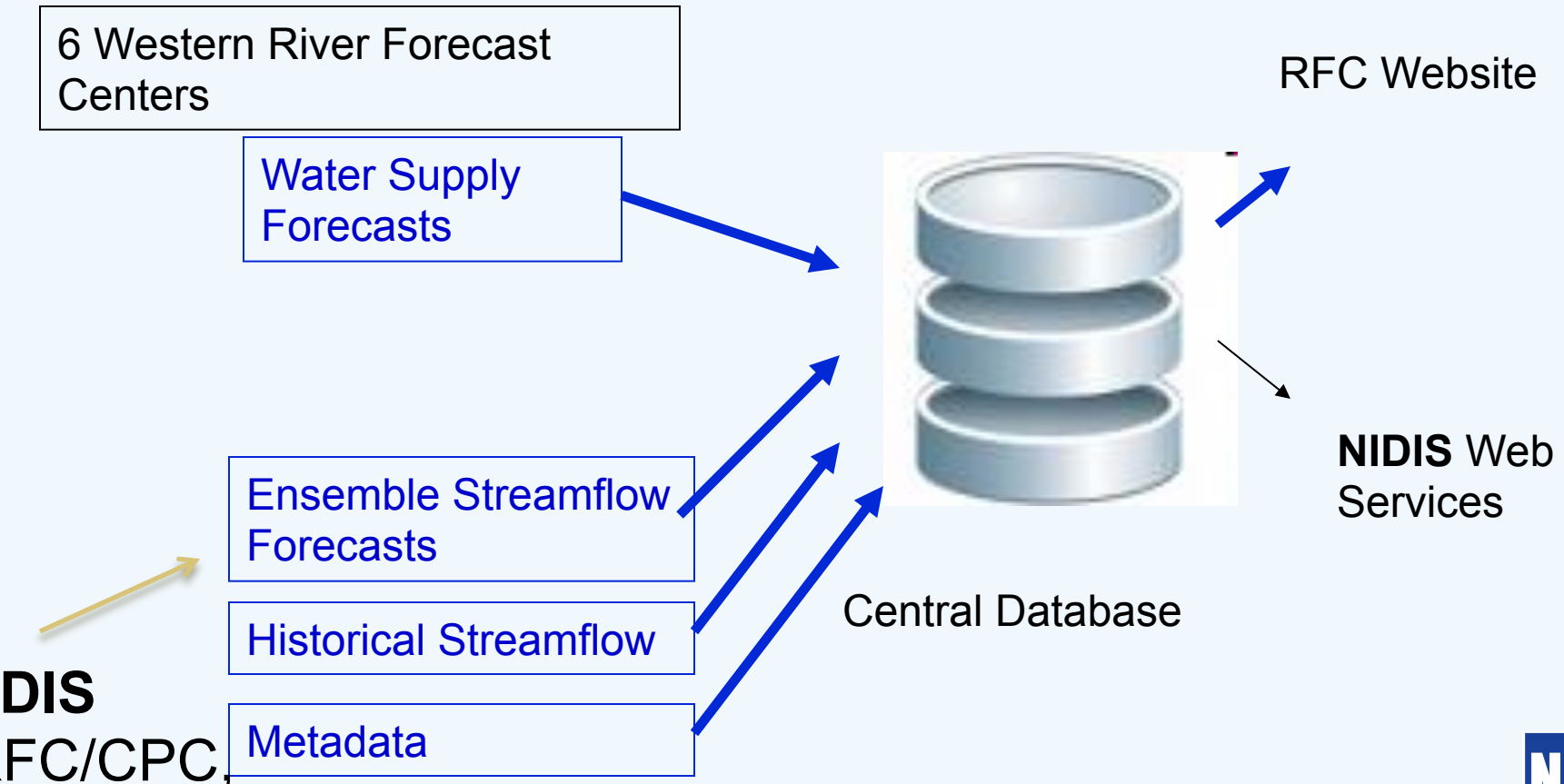
NDMC
State Offices, RISAs
US BoR, USACE, 4Corner Tribes



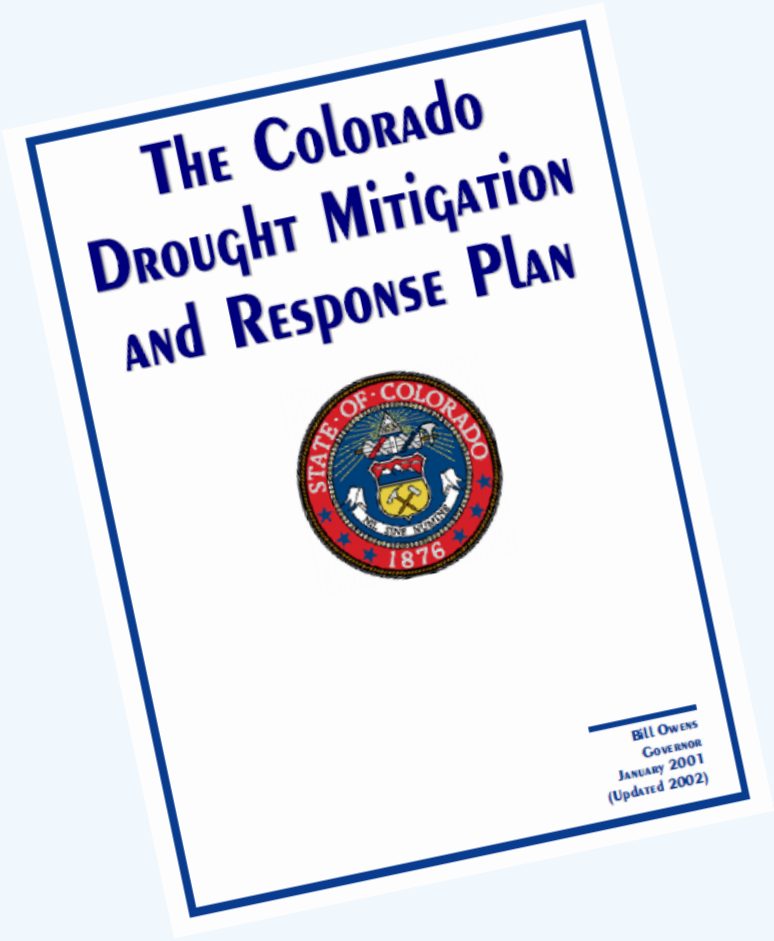
NIDIS Products and Services in the Colorado Basin to date

- Assessment of watershed-based drought indicators and management triggers in the Upper Basin-linkages
- **Improved linkages between climate and streamflow modeling during drought-Ensemble ET estimates**
- **Spatial analysis of water demand during drought**
- Low flow impacts database for 164 NWS forecast points
- UCRB Community Colorado Basin-specific Drought Portal
- **Weekly Drought and Water Outlook webinars/early warning discussions with resource managers in the UCRB**
- **Engaging underserved communities**

Current Web-based Information



Upper Colorado Basin Regional Drought Outlooks



Revision of the CO Plan to meet drought requirements of the State Natural Hazard Mitigation Plan, as well as FEMA

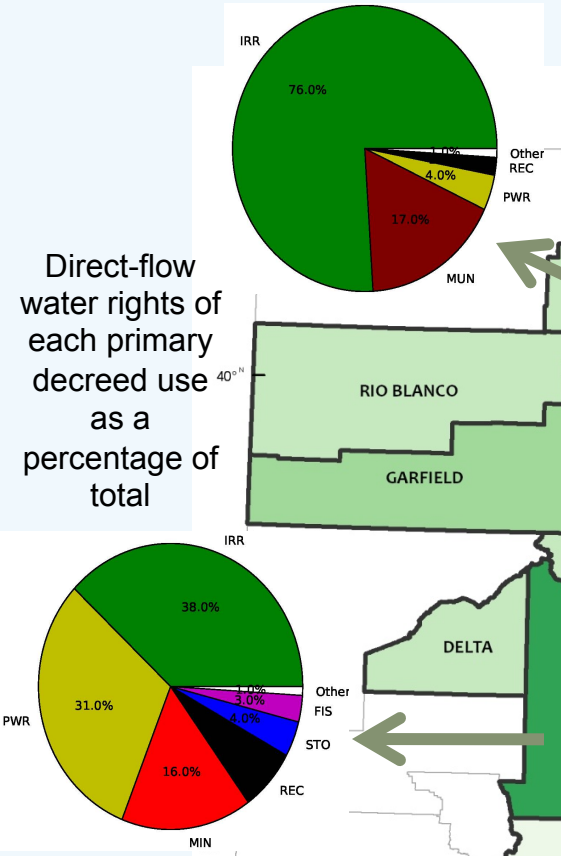
NIDIS role

- **Development of indices that incorporate current surface water conditions and a forecast component. Revise SWSI USGS**
- **Assessment of trigger points and responses**

- **Weekly Early Warning Webinars**
  - **(coordinated with River Forecast Center briefings)-120 call in from Water Districts, Tourism and Recreation, Agriculture**

Demand-Counties with peak demand in June

Direct-flow water rights of each primary decreed use as a percentage of total



EXPLANATION

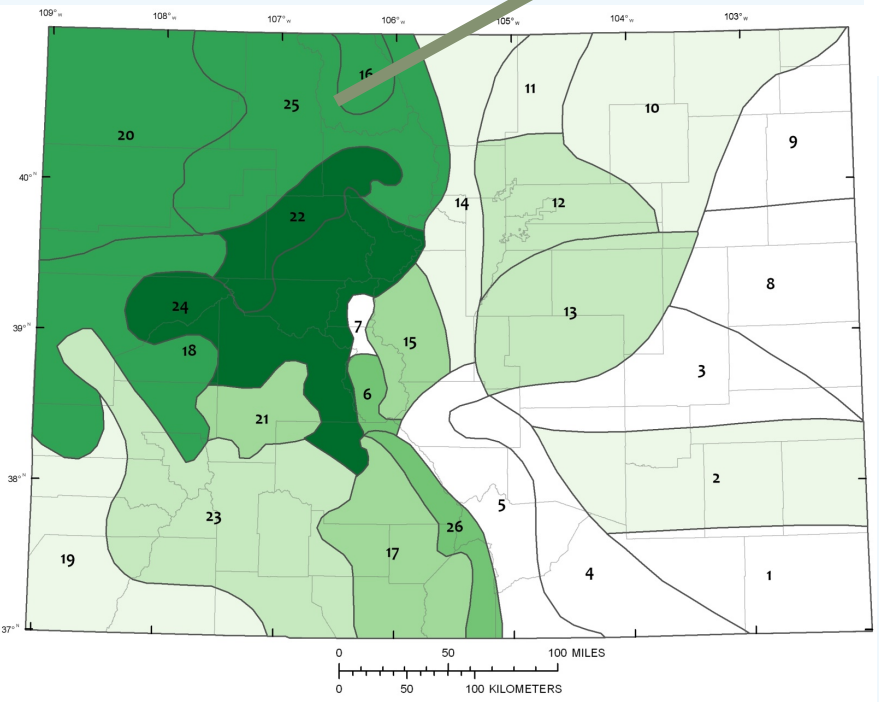
Historical Average June Peak Diversions (in acre-feet

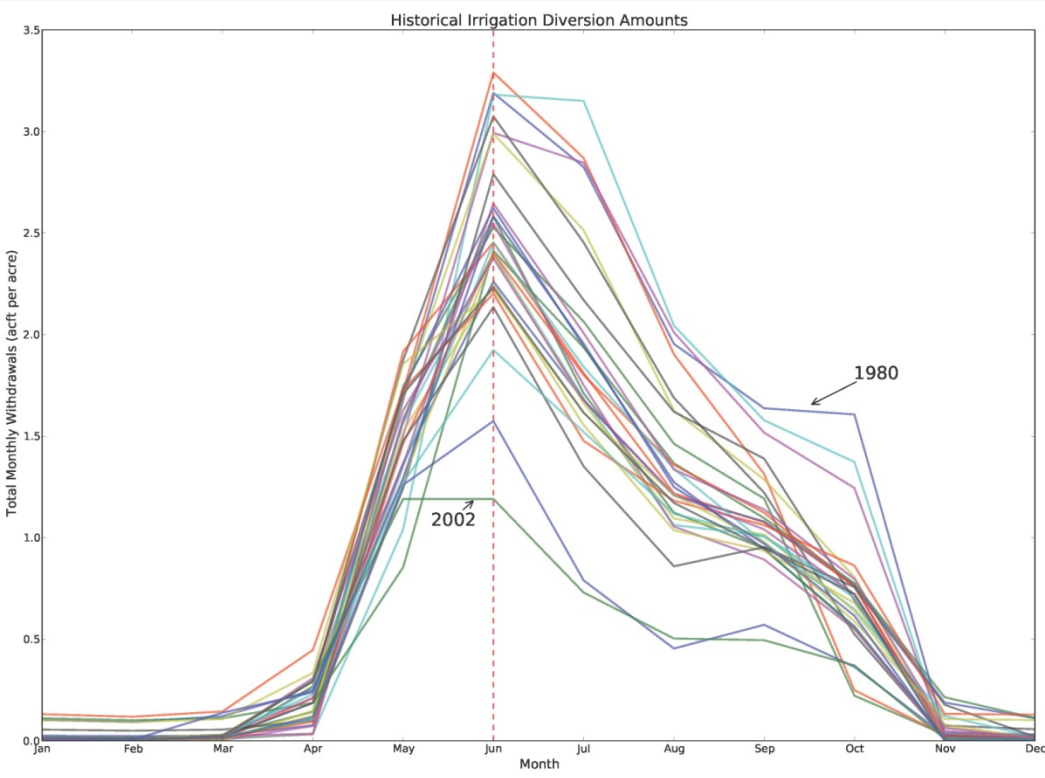
- 0 - 50,000
- 50,001 - 75,000
- 75,001 - 100,000
- 100,001 - 200,000
- 200,001 - 250,000
- 250,001 - 300,000
- Counties w/ June peak diversions

Source: CWCB / CDWR HydroBase

Wilhelmi,2011 NCAR, NOAA

Irrigated Agriculture: average (1980-2008) irrigation diversions for June (peak demand) by climate zone





EXPLANATION

June Agricultural Diversions

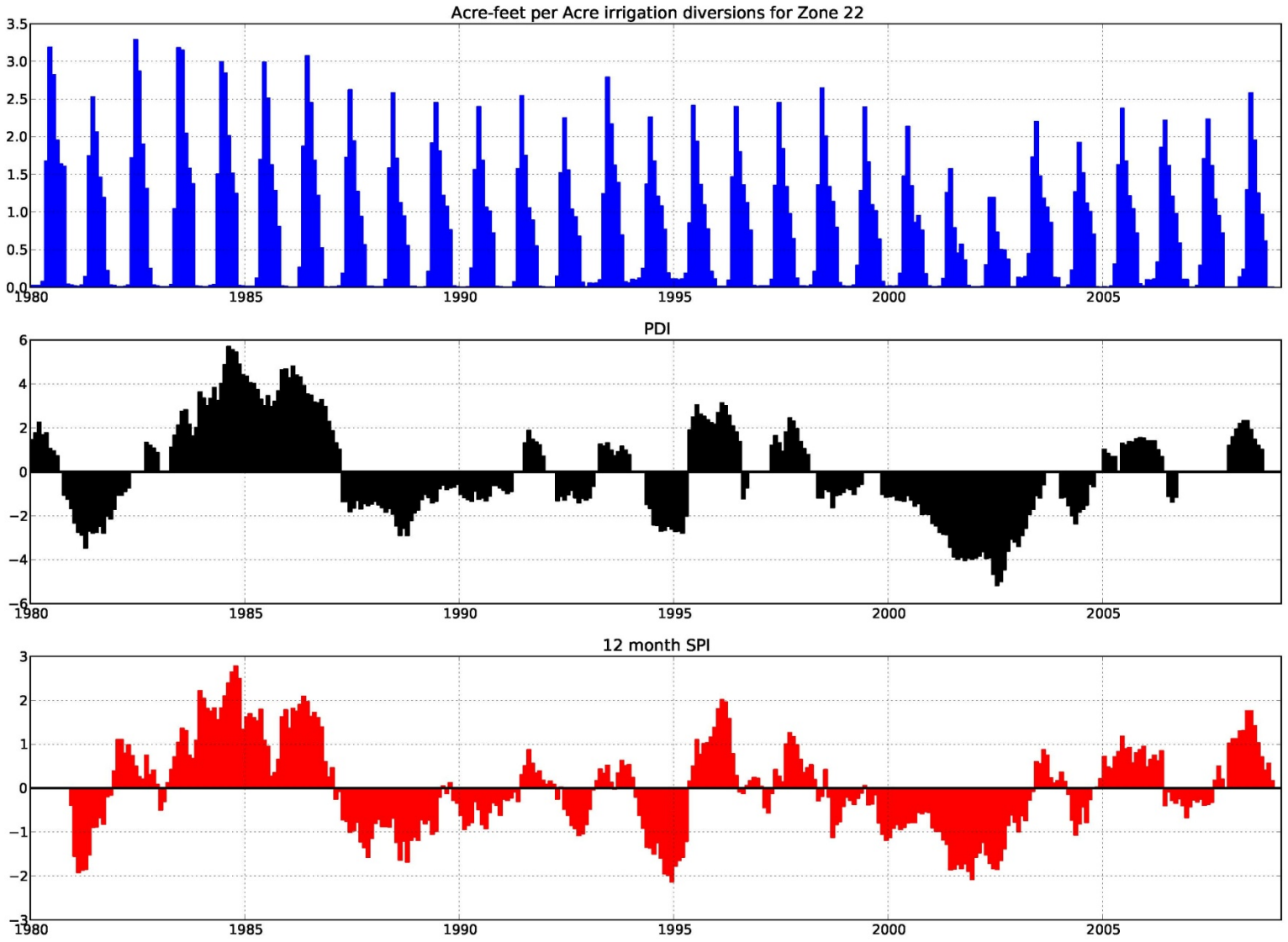
(acre-feet per acre)

	0.00
	0.01 - 0.65
	0.66 - 0.98
	0.99 - 1.27
	1.28 - 1.52
	1.53 - 2.09
	2.10 - 2.48

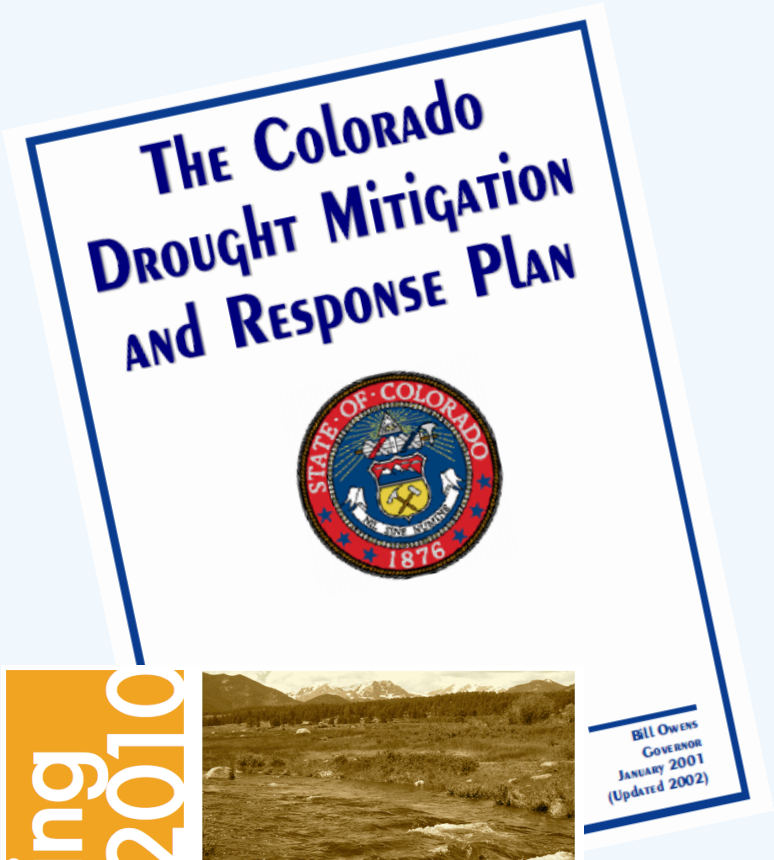
Source: CWCB / CDWR HydroBase

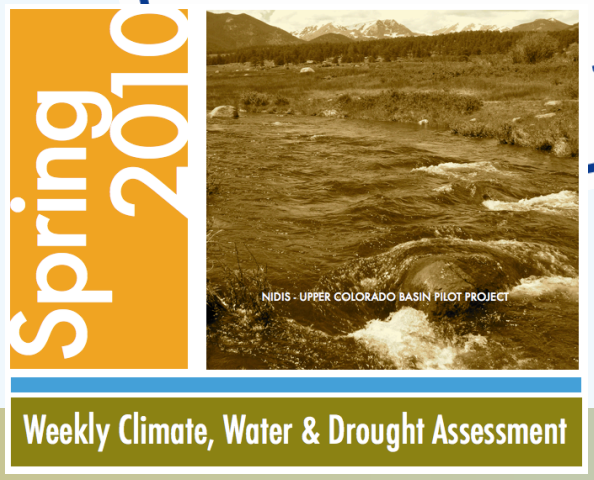
NIDIS
NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

Drought Indices in relation to impacts



Upper Colorado Basin Drought Outlooks



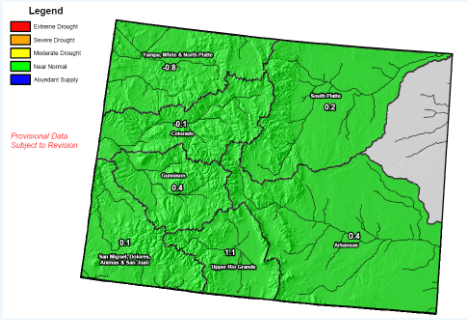


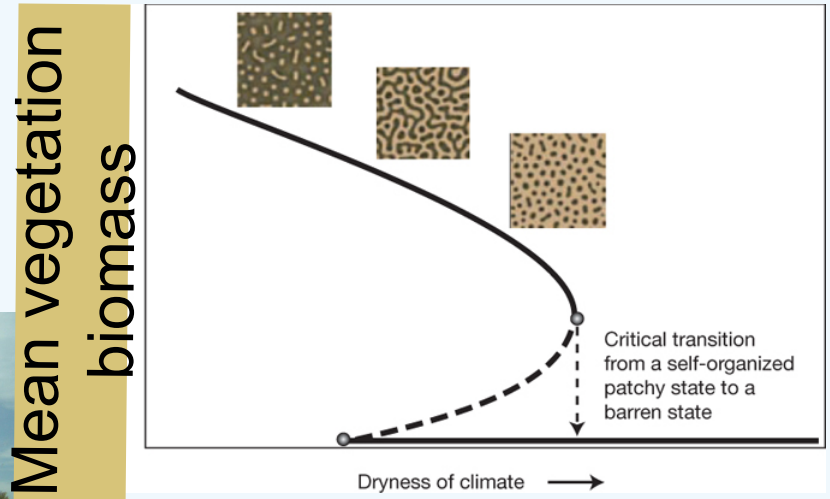
Revision of the Plans to meet drought requirements of the State Natural Hazard Mitigation Plan, as well as FEMA and EMAP

NIDIS role

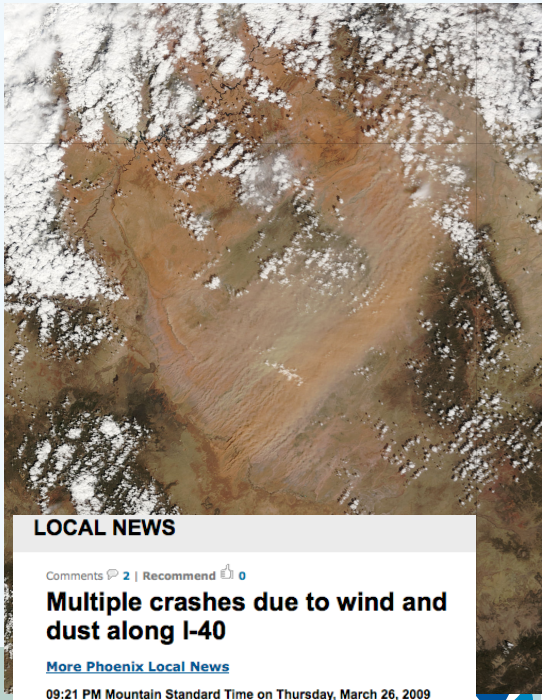
- Development of indices that incorporate current surface water conditions and a forecast component
- Assessment of trigger points and responses
- Weekly Early Warning Webinars
- (coordinated with River Forecast Center briefings)

Landscape changes- Tribal Lands in the Four-Corners Region





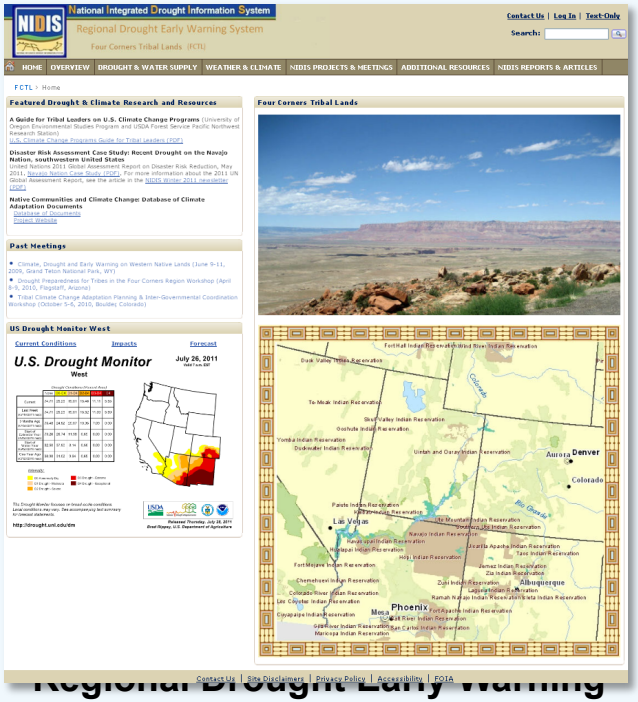
Dryness of climate



(Nature, 2009)

Nested Scenarios

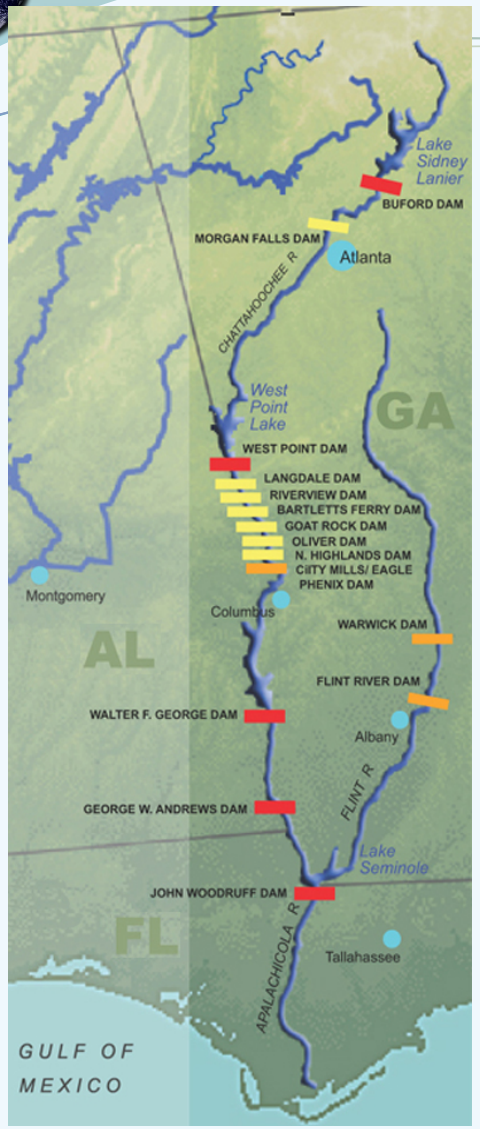
U.S. Drought Portal
www.drought.gov



- **Regional Drought Early Warning Information System pages**
  - Upcoming meetings
  - Webinar announcements
  - Past meeting notes
  - Links to weather and climate information
  - News stories from the region

- **Four Corners Forecast and Impacts page**
  - Climate adaptation resources
  - Past meeting notes
  - Links to weather and climate information
  - Additional resources

- **Drought Preparedness on Tribal Lands in the Four Corners Region (August 2011)**
  - http://www.drought.gov/portal/server.pt/community/four_corners_tribal_lands/300



Upper Chattahoochee

Middle Chattahoochee & Flint

Apalachicola River & Bay

NIDIS California Pilot Drought Early Warning Information System Pilot Studies

North Bay Counties and Russian River Valley

an early warning information system to support adaptation through the integration of observations, models, downscaled climate information, spatially distributed drought indices, predictions and projections of future drought conditions: *establish an organizing committee representing the full spectrum of interests in the region to implement a scoping workshop*

Klamath River Basin-wide Hydroclimate Information System

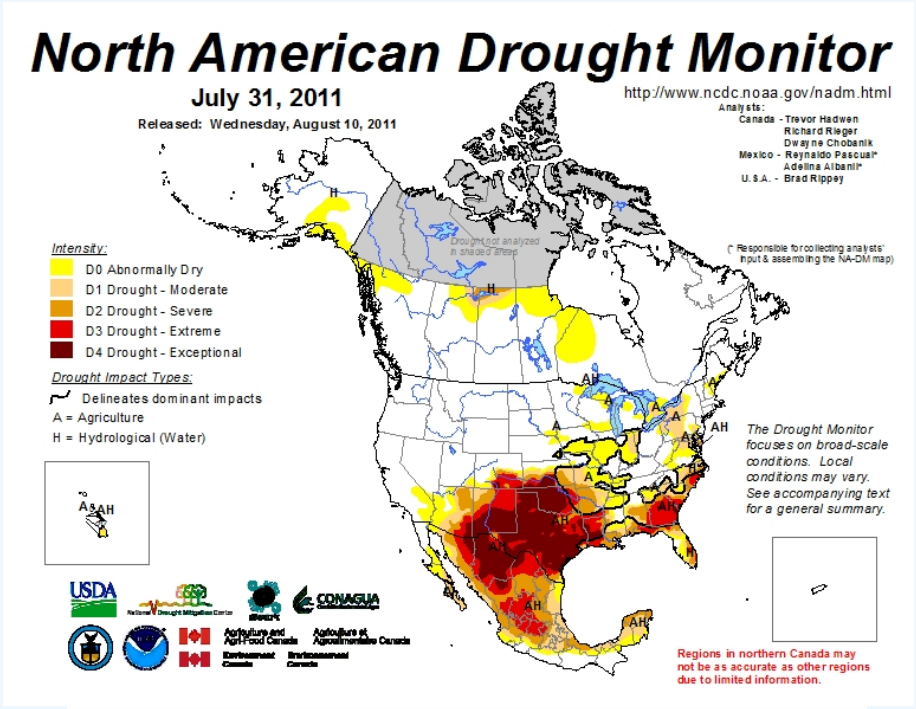
consolidated access to centralized source for water supply information and hydroclimate data as decision support resource to inform responses by the California, Oregon, tribes, and others to drought impacts: *assemble a prototype integrated information system that provides access to the RFC and other hydroclimate datasets*

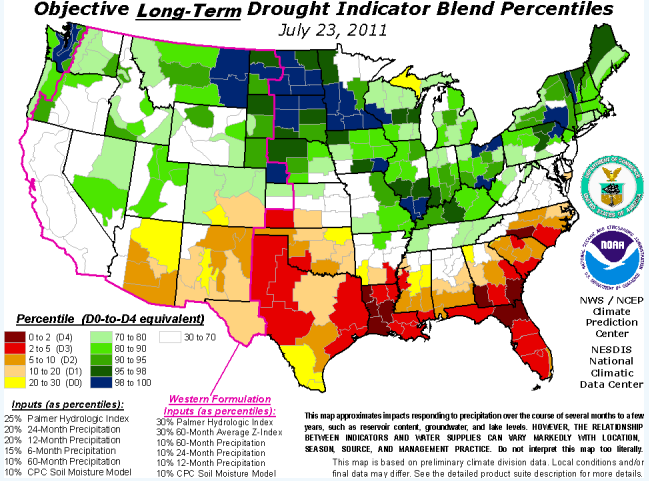
Central Valley Fallowed Land Monitoring Service

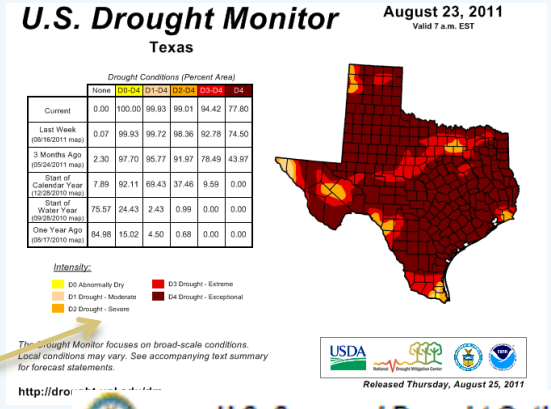
remote sensing monitoring capability to identify the extent of changes in fallowed acreage due to water shortage during drought from automated processing of Landsat digital satellite imager: *hold initial workshop of the partner organizations to develop a work plan that spells out near term and long term roles/responsibilities*

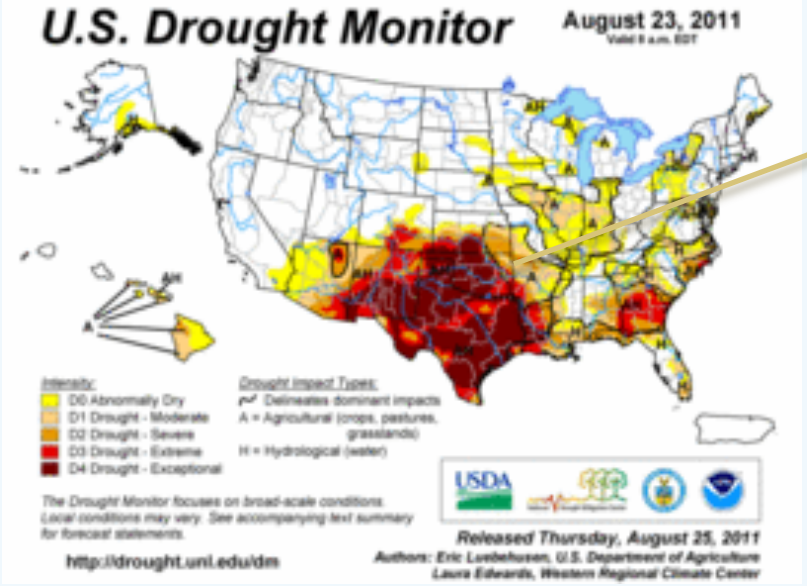
Southern California – Urban

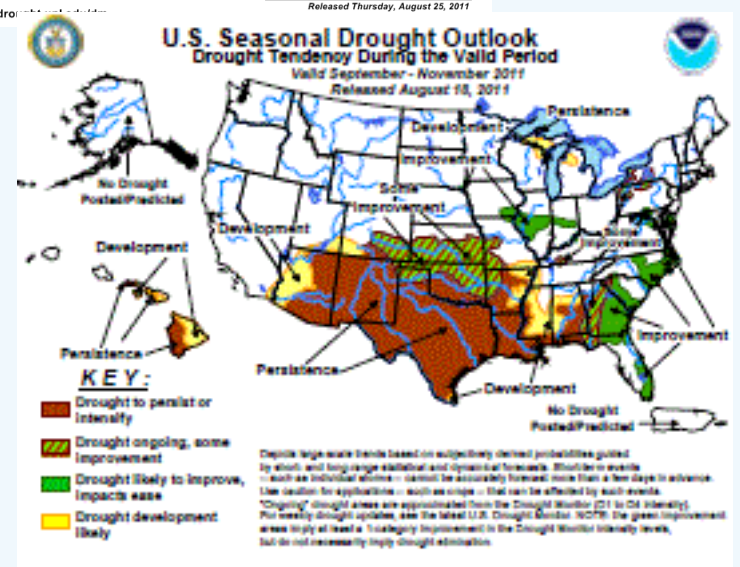
investigate drought issues in major metropolitan areas where water supplies are primarily imported, and water demands are heavily residential with a mixture of other users: *establishing a program committee implement the proposed scoping workshop*


North American Drought Monitor
July 31, 2011
Released: Wednesday, August 10, 2011
http://www.ncdc.noaa.gov/nadm.html
Analysts:
Canada - Trevor Hadwen
Richard Rieger
Dwayne Chobanik
Mexico - Reynaldo Pascual*
Adelina Albanil*
U.S.A. - Brad Rippey
(* Responsible for collecting analysts' input & assembling the NA-DM map)
Drought not analyzed in shaded areas
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
A = Agriculture
H = Hydrological (Water)
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text for a general summary.
Regions in northern Canada may not be as accurate as other regions due to limited information.


Objective Long-Term Drought Indicator Blend Percentiles
July 23, 2011
Percentile (D0-to-D4 equivalent)
0 to 2 (D4)
2 to 5 (D3)
5 to 10 (D2)
10 to 20 (D1)
20 to 30 (D0)
30 to 70
70 to 80
80 to 90
90 to 95
95 to 98
98 to 100
Inputs (as percentiles):
25% Palmer Hydrologic Index
20% 24-Month Precipitation
20% 12-Month Precipitation
15% 6-Month Precipitation
10% 60-Month Precipitation
10% CPC Soil Moisture Model
Western Formulation Inputs (as percentiles):
30% Palmer Hydrologic Index
30% 60-Month Average Z-Index
10% 60-Month Precipitation
10% 24-Month Precipitation
10% 12-Month Precipitation
10% CPC Soil Moisture Model
This map approximates impacts responding to precipitation over the course of several months to a few years, such as reservoir content, groundwater, and lake levels. HOWEVER, THE RELATIONSHIP BETWEEN INDICATORS AND WATER SUPPLIES CAN VARY MARKEDLY WITH LOCATION, SEASON, SOURCE, AND MANAGEMENT PRACTICE. Do not interpret this map too literally.
This map is based on preliminary climate division data. Local conditions and/or final data may differ. See the detailed product suite description for more details.
NWS / NCEP Climate Prediction Center
NESDIS National Climatic Data Center


U.S. Drought Monitor
August 23, 2011
Valid 7 a.m. EST
Texas
Drought Conditions (Percent Area)
None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4
Current 0.00 100.00 99.93 99.01 94.42 77.80
Last Week (08/16/2011 map) 0.07 99.93 99.72 98.36 92.78 74.50
3 Months Ago (05/24/2011 map) 2.30 97.70 95.77 91.97 78.49 43.97
Start of Calendar Year (12/28/2010 map) 7.89 92.11 69.43 37.46 9.59 0.00
Start of Water Year (09/28/2010 map) 75.57 24.43 2.43 0.99 0.00 0.00
One Year Ago (08/17/2010 map) 84.98 15.02 4.50 0.68 0.00 0.00
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.
Released Thursday, August 25, 2011


U.S. Drought Monitor
August 23, 2011
Valid 8 a.m. EDT
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
A = Agricultural (crops, pastures, grasslands)
H = Hydrological (water)
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.
http://drought.unl.edu/dm
Released Thursday, August 25, 2011
Authors: Eric Luebehusen, U.S. Department of Agriculture
Laura Edwards, Western Regional Climate Center


U.S. Seasonal Drought Outlook
Drought Tendency During the Valid Period
Valid September - November 2011
Released August 18, 2011
No Drought Posted/Predicted
Development
Persistence
Improvement
Some Improvement
KEY:
Drought to persist or intensify
Drought ongoing, some improvement
Drought likely to improve, impacts ease
Drought development likely

7 July 2011 Austin Texas
NIDIS and Lower Colorado River Authority

- The current drought is consistent with the historical impact of La Niña (hence the skillful seasonal fcsts since October 2010). *Will La Niña return later in 2011/12?*

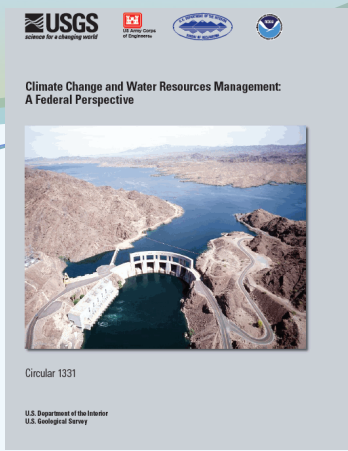
- The drought's record intensity not due La Niña alone (the record proportions of this drought could not have been anticipated). Conditions continue even with La Niña decreasing

- Over 40 institutions (Water, agriculture, tourism and recreation, wildfire)
- Ongoing warning, outlooks, and data access improvements (NIDIS, LCRA, NWS, USACE, DoI)

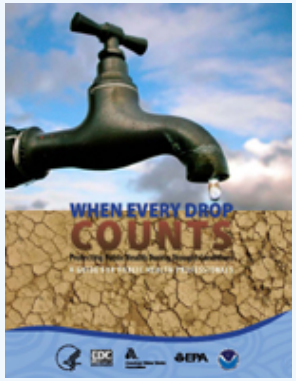
Prototyping regional climate early warning information systems-the NIDIS model

- Identifying appropriate partners, stakeholder representatives
- Setting goals/priorities, and involving partners in problem definition
- Using professionals from relevant agencies (Fed, state etc.) to build common ground
- Producing collectively authored information gaps assessments and agreement on the way forward
- Building longer term collaborative partnerships

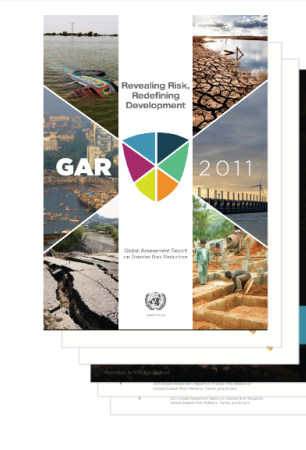
USGS 1331- Climate Change and Water Resources Management: A Federal Perspective 2009



Centers for Disease Control When Every Drop Counts: Protecting Public Health During Drought Conditions—A Guide for Public Health Professionals 2010

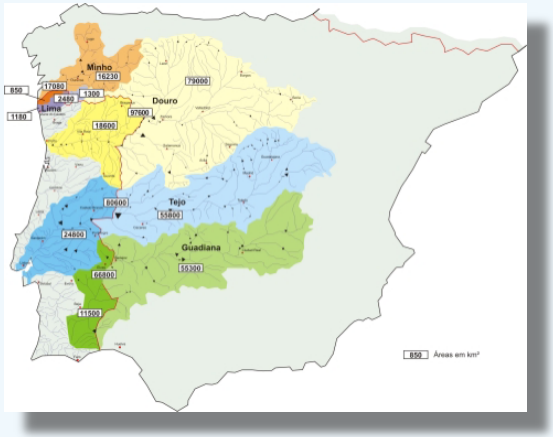


United Nations Global Assessment Report on Disaster Risk Reduction (2011)-Drought chapter

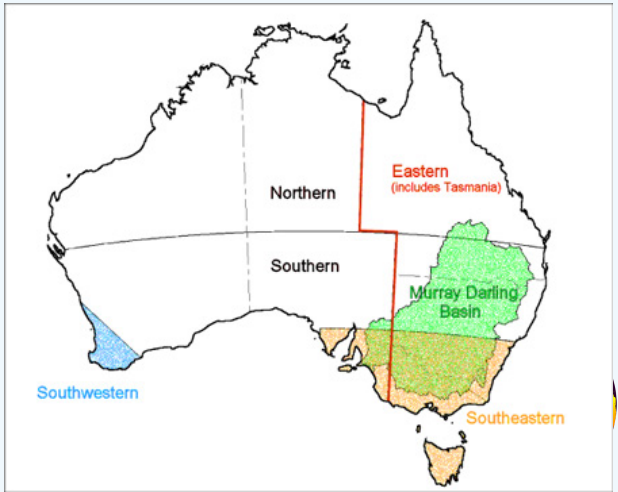


NIDIS-Transferability

- FEWSNet
- GEO Water Resources



- Mediterranean/Iberian Peninsula
- Australia (MDB/Colorado)
- India NIDIS
- Caribbean Basin
- US-Canada PNW
- GIDIS-



NIDIS
NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

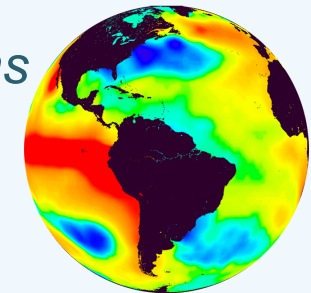
"We would cite the National Integrated Drought Information System (NIDIS) as one example of how federal agencies can work together and with states ……it demonstrates key elements of how….to deliver actionable information to end users and decisionmakers"

WGA letter to CEQ-Response to CEQ Adaptation Interim Report May 21, 2010

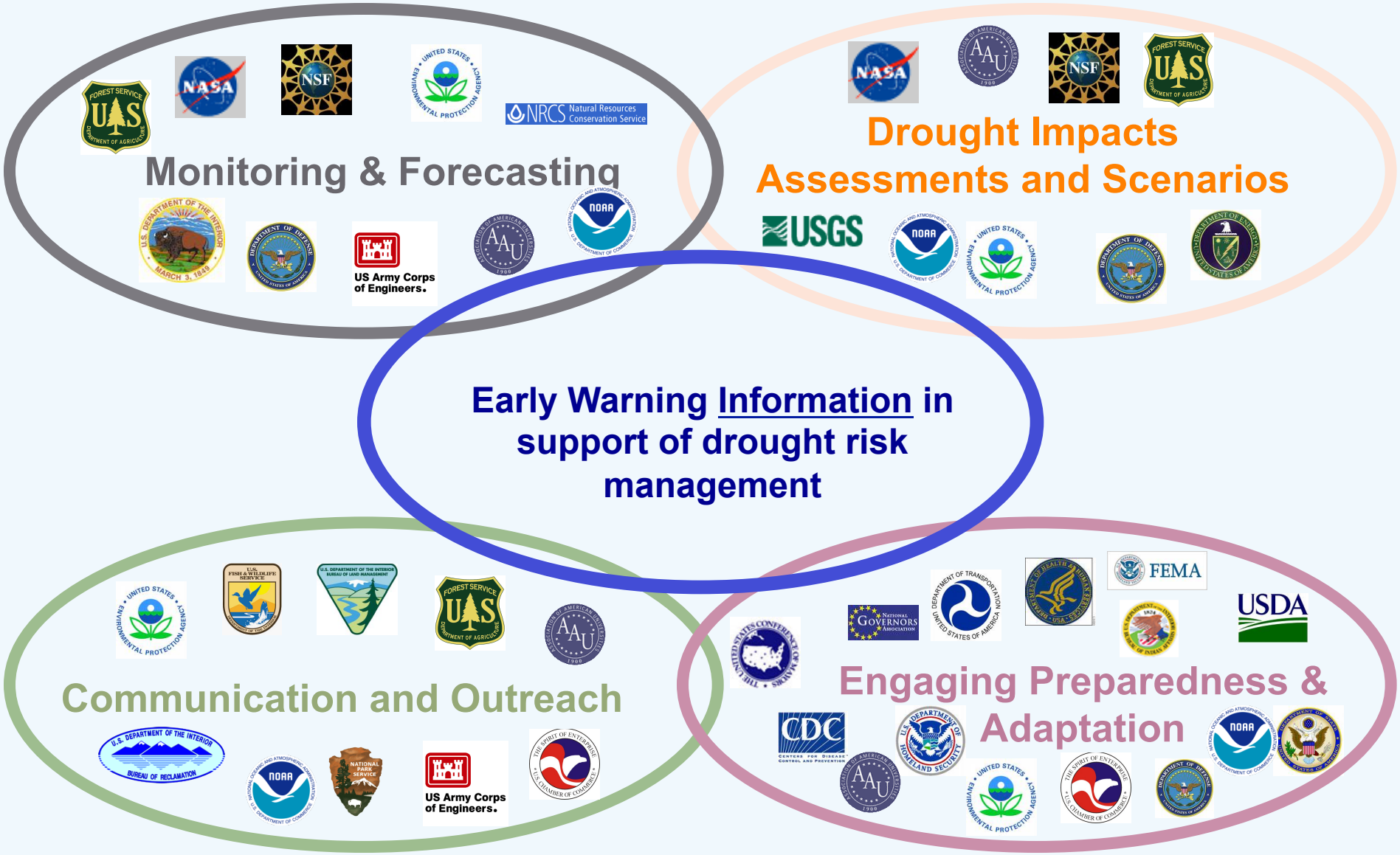
NIDIS is an important example of what a climate service should do (T. Busalacchi, NOAA Climate Working Group Chair, Sept., 2010)

NIDIS is an excellent organizational model for developing and coordinating ongoing climate assessments K. Jacobs OSTP NCA November, 2010

NIDIS offers a valuable model for interagency early warning systems design …Subcommittee on Disaster Reduction (June 2, 2011)



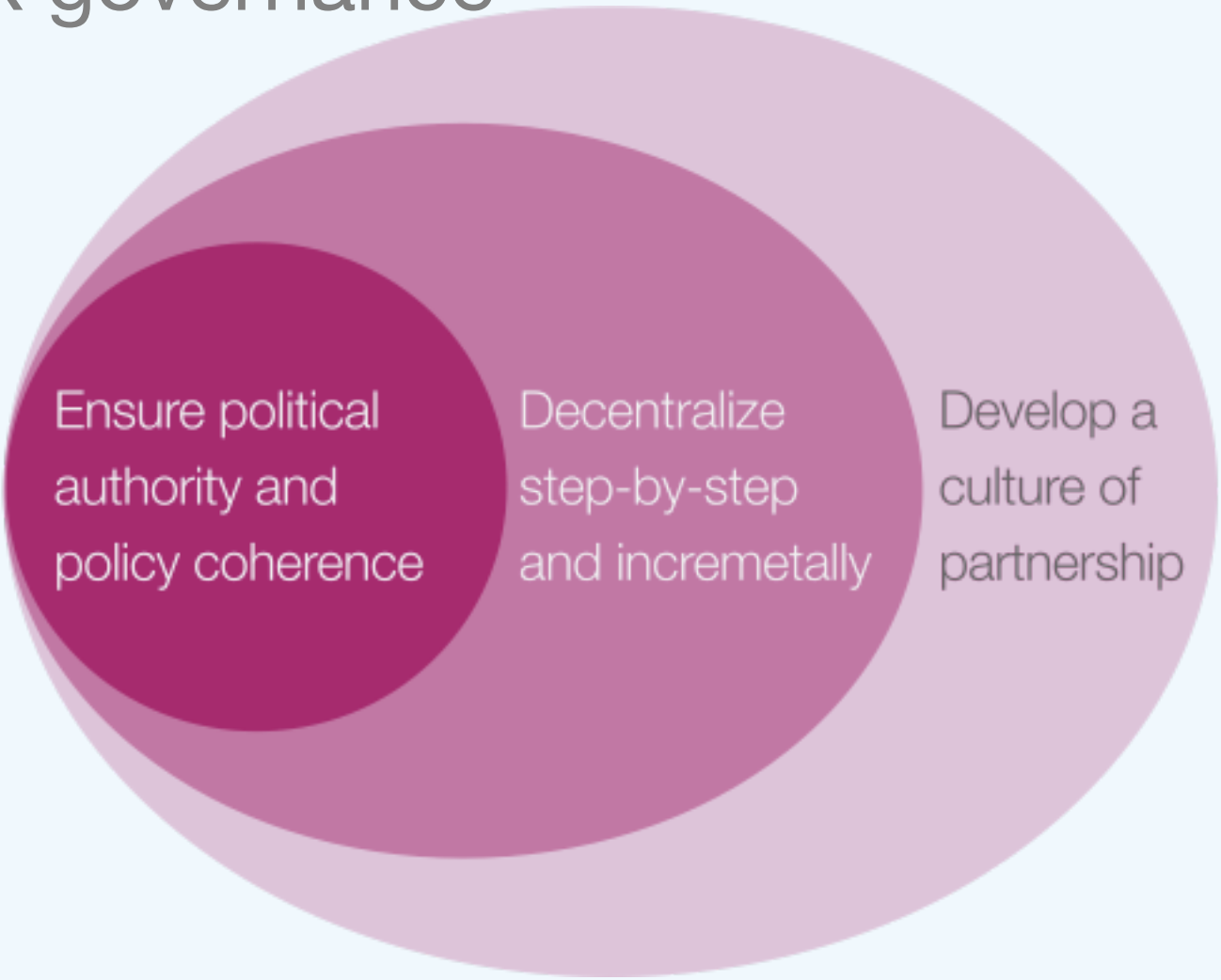
Regional Drought Information System:
(Federal, States, Tribes, Urban, other)



Categorization and Selected Driving Forces for Storyline Development

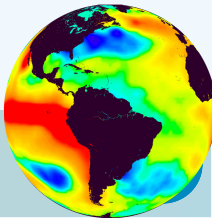
General Driving Force Category	Key CRBS Driving Forces Identified in Survey
Natural Systems (Hydroclimate)	☒ Changes in streamflow variability and trends ☒ Changes in climate variability and trends (e.g. temperature, precipitation, etc.)
Demographics & Land Use	☒ Changes in population and distribution ☒ Changes in agricultural land use (e.g. irrigated agricultural areas, crop mixes, etc.)
Technology & Economics	☒ Changes in agricultural water use efficiency ☒ Changes in municipal and industrial water use efficiency ☒ Changes in water needs for energy generation (e.g. solar, oil shale, thermal, nuclear, etc.)
Social & Governance	☒ Changes in institutional and regulatory conditions (e.g. laws, regulations, etc.) ☒ Changes in flow-dependent ecosystem needs for ESA-listed species ☒ Changes in other flow-dependent ecosystem needs ☒ Changes in social values affecting water use ☒ Changes in water availability due to tribal water use and settlement of tribal water rights claims

Risk governance



"Closing" water systems, climate and scarcity

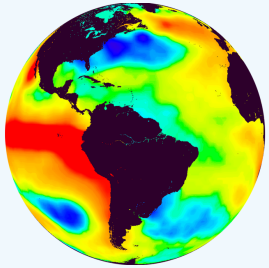
- As yet-Little comprehensive understanding of the long-term and widespread consequences of past adaptations
- Complications of changes in the spatial and temporal distribution of rainfall, soil moisture, runoff, frequency and magnitudes of droughts and floods are gradually being included in response planning-resolution?
- Systems design, operational inflexibility, and legal and institutional constraints still reduce the adaptability of water systems to respond to severe drought and climatic changes
- Compounded by lack of agreement on event definitions, such as what constitutes an "extraordinary" (i.e., severe and persistent) drought in different place
  - Equitable and reasonable use of water involves definitions of broad concepts such as "no harm," and "optimal utilization"



Definition of the core set of data, information and information technologies needed to maintain the minimum acceptable level of stewardship in the management of water resources and water infrastructure

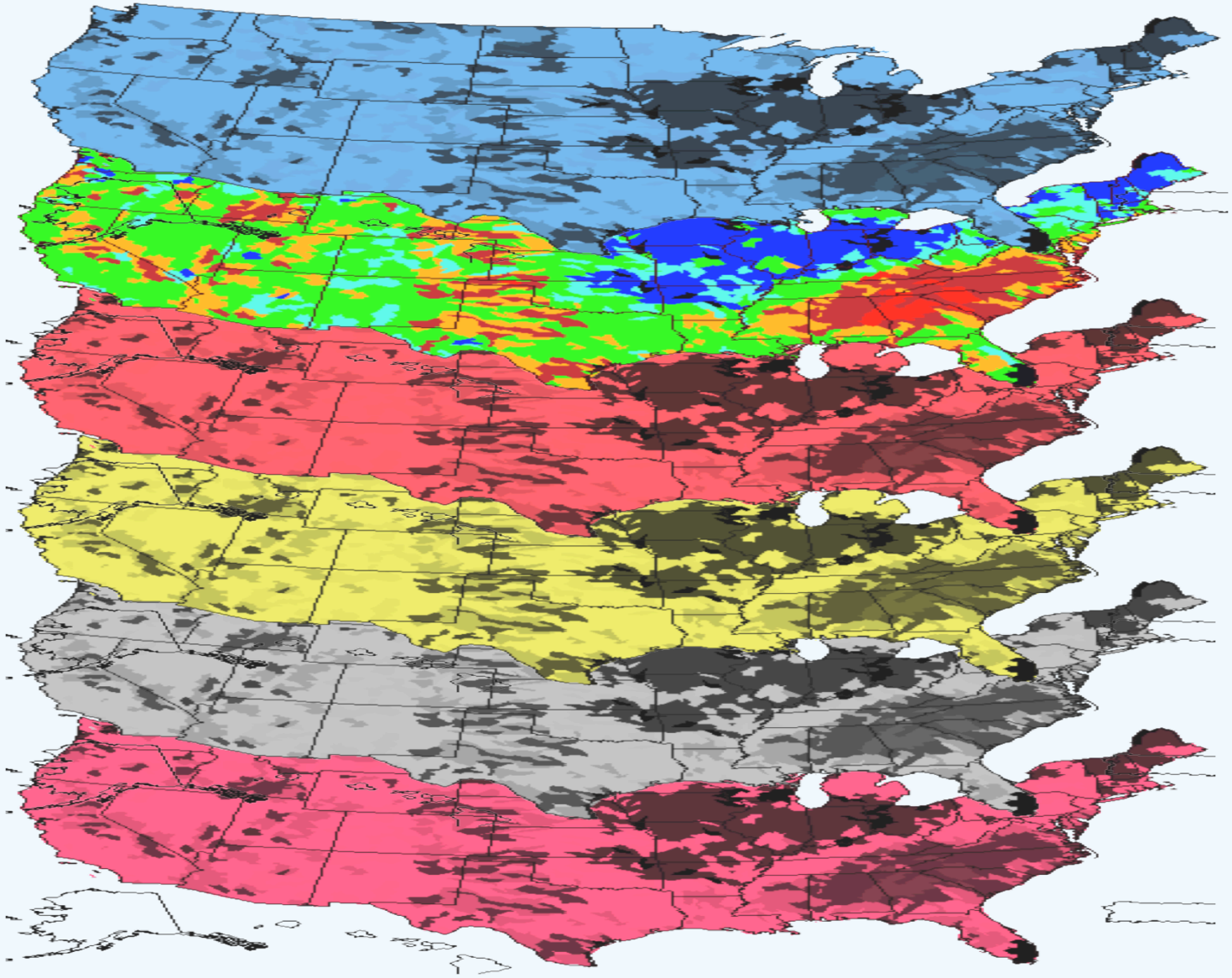
- Resolution-units of analysis
- Prototypes
- National Water Census-all accounting components

THANK YOU!



BACKUP SLIDES

National Water Census-all accounting components



Precipitation

Runoff

Baseflow

ET

Recharge

Surface Storage

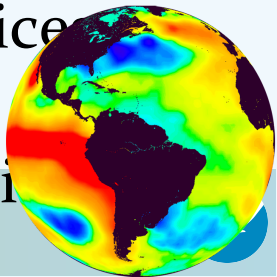
Watersheds in a changing change

- Historical context – water resource development-navigation, irrigation, hydropower
- The current threats - climate change, drought, water scarcity and declining water quality, multiple demands

Scientific challenges in facilitating adaptation in water scarce basins

Pressure for better information to support water planning and need to operate under changing extremes and rapid transitions

- Early warning information systems
- Reference data architecture for water accounting
- Managing for resilience – benefits of ecosystem service as buffers, but with triage
- Providing flexibility in adjustment –flow of informati among participants



CO Basin EWS

Existing mandates, decision cycles, and organizational capacities to guide implementation of the pilot-workshops, interviews, reports

- Colorado Division of Water Resources (CDWR)
- Colorado State Climatologist
- Colorado River Water Conservation District (CRWCD)
- Colorado Water Conservation Board (CWCB)
- CU – Western Water Assessment, CIRES, and CADSWES
- Denver Water Board
- Northern Colorado Water Conservancy District (NCWCD)
- Wyoming State Engineer
- Wyoming State Climatologist
- Utah State Climatologist
- Western Regional Climate Center
- National Center for Atmospheric Research (NCAR)
- National Drought Mitigation Center (NDMC)
- USDA: Natural Resources Conservation Service
- USFS: Region 2
- USBR: Eastern Colorado Area Office, Great Plains Region, Office of Policy and Programs, Research and Development
- USGS: Colorado Water Science Center, Central Region, Grand Canyon Monitoring and Research Center
- NOAA: Earth System Research Laboratory, National Centers for Environmental Prediction, National Climatic Data Center, National Weather Service

ACF Basin Stakeholders

ACF Stakeholders, Inc.
Alabama Department of Environmental Management
Alabama Office of Water Resources
Apalachicola National Estuarine Research Reserve
Apalachicola Riverkeeper
Auburn University
Centers for Disease Control and Prevention/National Center for Environmental Health
City of Apalachicola, FL
City of Clarkesville, GA
Environmental Protection Agency
Flint River Water Policy Center
Florida Department of Agriculture and Consumer Services
Florida Department of Environmental Protection
Florida Fish and Wildlife Conservation Commission
Florida Sea Grant Extension/Franklin County
Florida State University
Georgia Environmental Protection Division
Georgia Tribe of Eastern Cherokee
Golder Associates
Gwinnett County, GA
Habersham County (GA) Water Authority
Joseph W. Jones Ecological Research Center
LaGrange, GA
MeadWestvaco Corporation
Middle Chattahoochee Water Coalition
Muscogee Nation of Florida
National Drought Mitigation Center, University of Nebraska
NOAA/Climate Prediction Center
NOAA/Climate Program Office
NOAA/Coastal Service Center
NOAA/Earth System Research Lab
NOAA/National Climatic Data Center
NOAA/NIDIS Program Office
NOAA/NWS/Service Hydrologist
NOAA/NWS/Southeast River Forecast Center
NOAA/NWS/Southern Region Climate Services
NOAA/NWS/WFO/Birmingham
NOAA/NWS/WFO Peachtree City, GA
NOAA/NWS/WFO Tallahassee
NOAA/Restoration Center
Northwest Florida Water Management District
Southeast Indigenous Peoples' Center
Southern Nuclear
University of Florida
University of Georgia, Athens
University of North Carolina
Upper Chattahoochee Riverkeeper
US Army Corps of Engineers - Mobile District
US Fish and Wildlife Service
USGS/Alabama Water Science Center
USGS/Georgia Water Science Center
USGS/Florida Water Science Center
West Point Lake Coalition

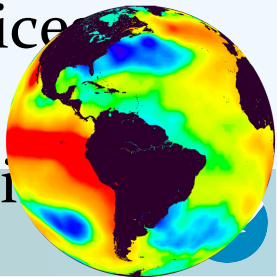
Watersheds and streams of thought

- Historical context – water resource development-navigation, irrigation, hydropower
- The current threats - climate change, drought, water scarcity and declining water quality, multiple demands

Scientific challenges in facilitating adaptation in water scarce basins

Pressure for better information to support water planning and need to operate under changing extremes and rapid transitions

- Early warning information systems
- Reference data architecture for water accounting
- Managing for resilience – benefits of ecosystem service as buffers, but with triage
- Providing flexibility in adjustment –flow of informati among participants



Western Governors Association-NOAA Memorandum, of Understanding 30 July, 2011

Two key issues:

1) extreme events affecting water quality and quantity; and

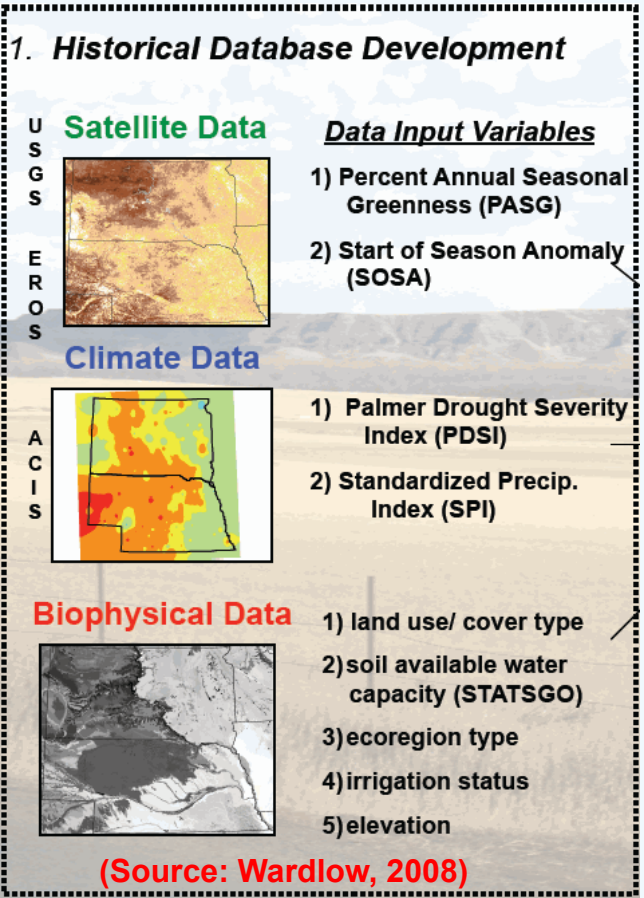
2) improving management of coastal and marine resources

Improving the use of climate information within these sectors is a particularly high priority for NOAA

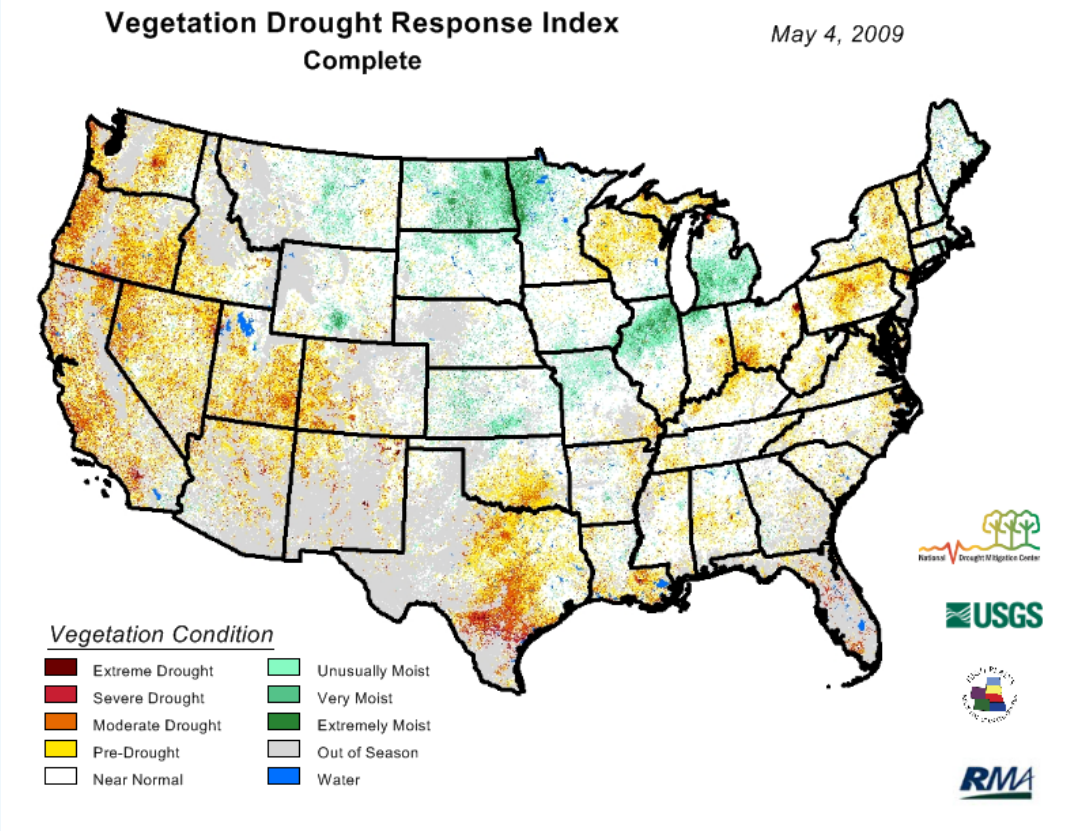
MoU widely acknowledged by Governors at WGA (July 2011) as having resulted from NIDIS related partnerships

Vegetation Drought Response Index (VegDRI)

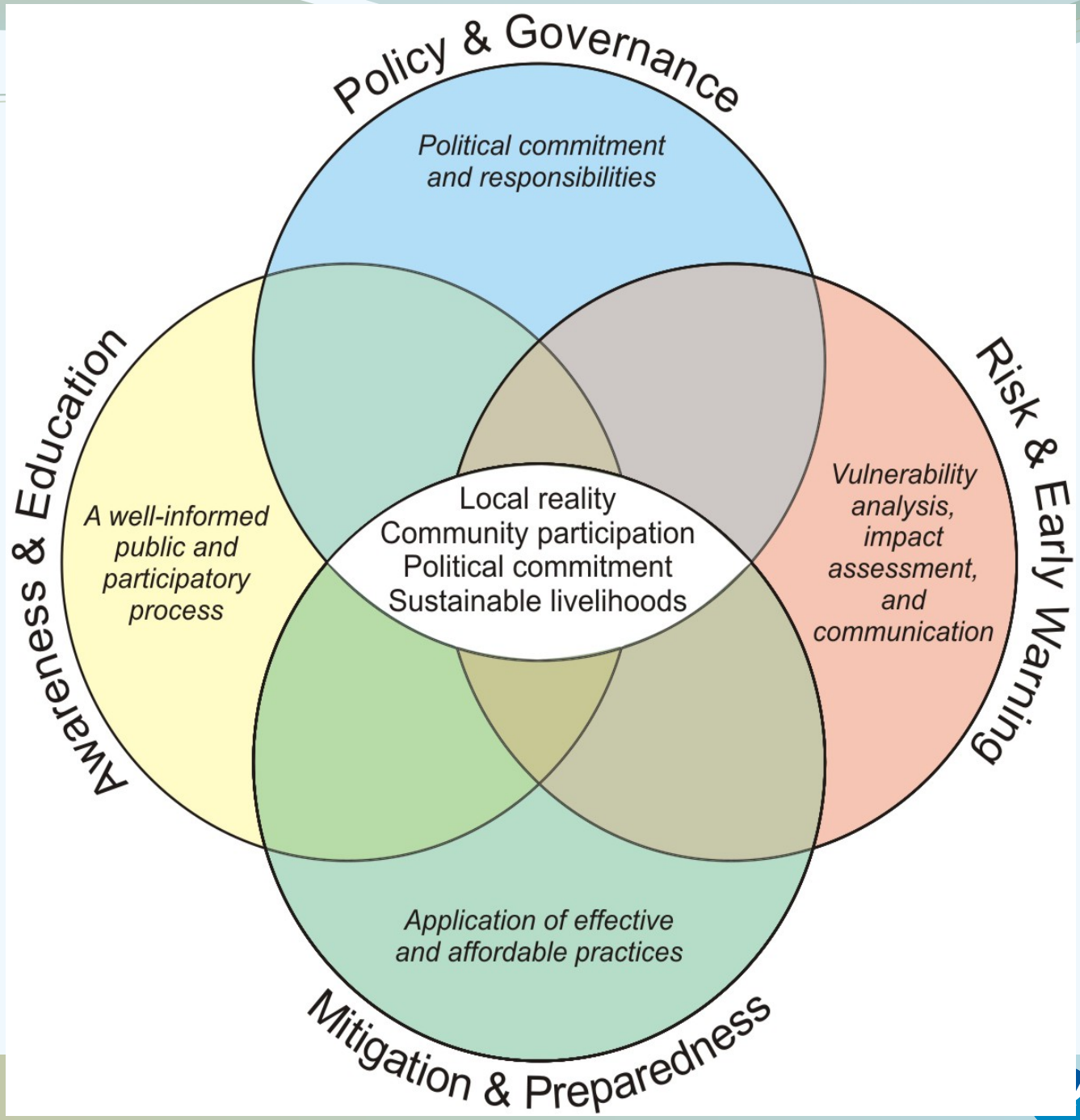
- ✓ Hybrid Drought Index that Integrates:
  - Satellite-based observations of vegetation conditions
  - Climate-based drought index data
  - Biophysical characteristics of the environment



http://drought.unl.edu/vegdri/VegDRI_Main.htm



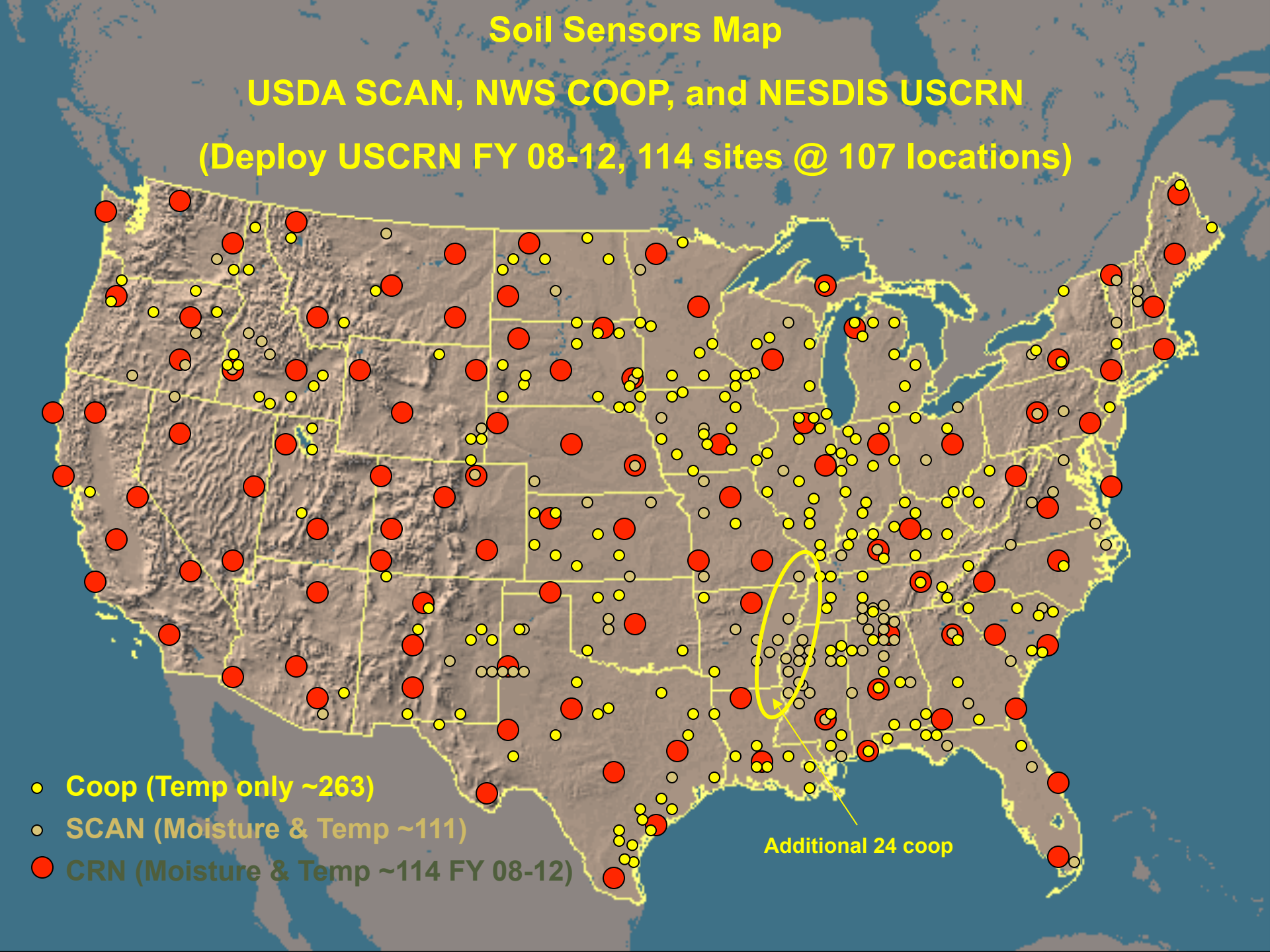
Principal Elements of Drought Risk Reduction Framework



Soil Sensors Map

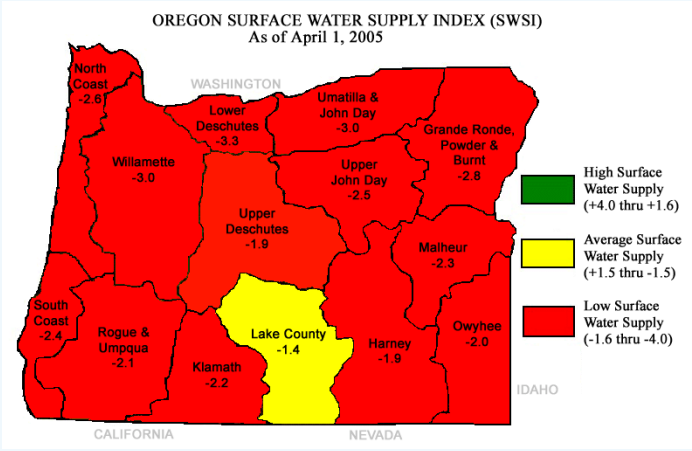
USDA SCAN, NWS COOP, and NESDIS USCRN

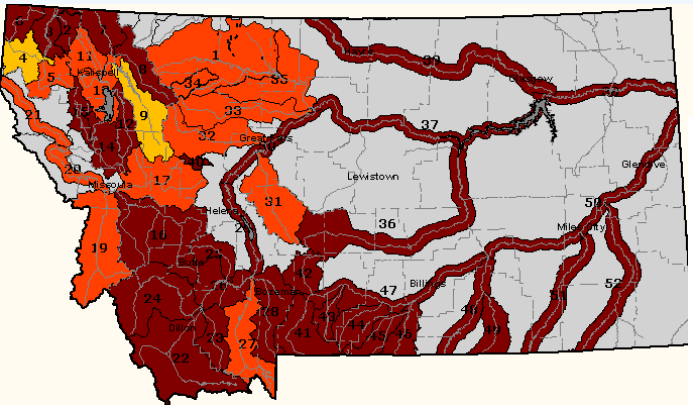
(Deploy USCRN FY 08-12, 114 sites @ 107 locations)



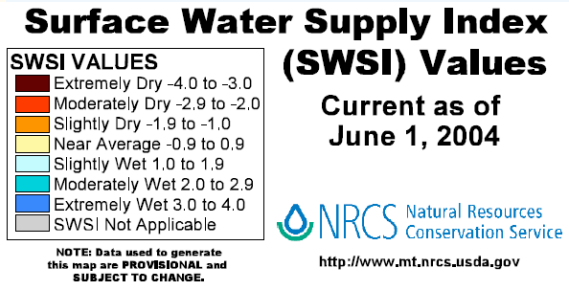
Surface Water Supply Index (SWSI)

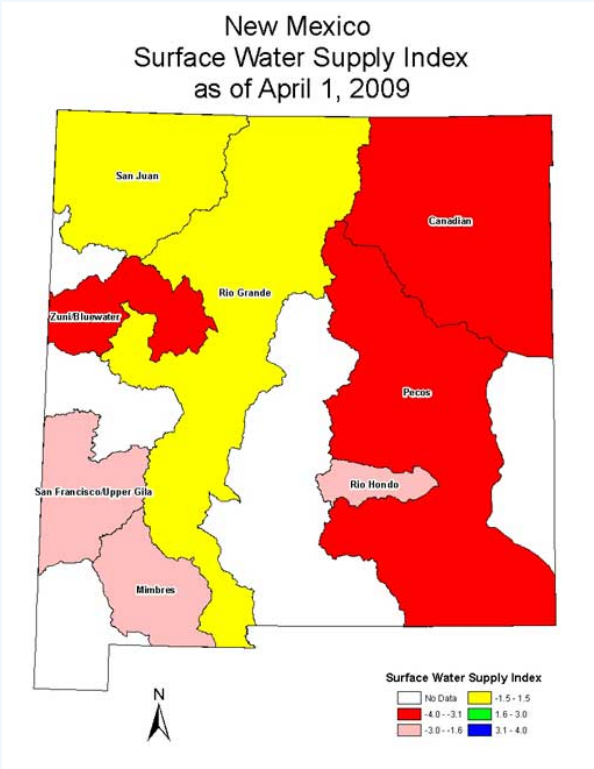
- ✓ Developed in 1981 for Colorado (adopted by other Western States)
- ✓ Integrates Snowpack, Reservoir Storage, Streamflow, & Precipitation at High Elevation
- ✓ Standardized Units
- ✓ Plotted by River Basin





http://www.wcc.nrcs.usda.gov/wsf/swsi.html



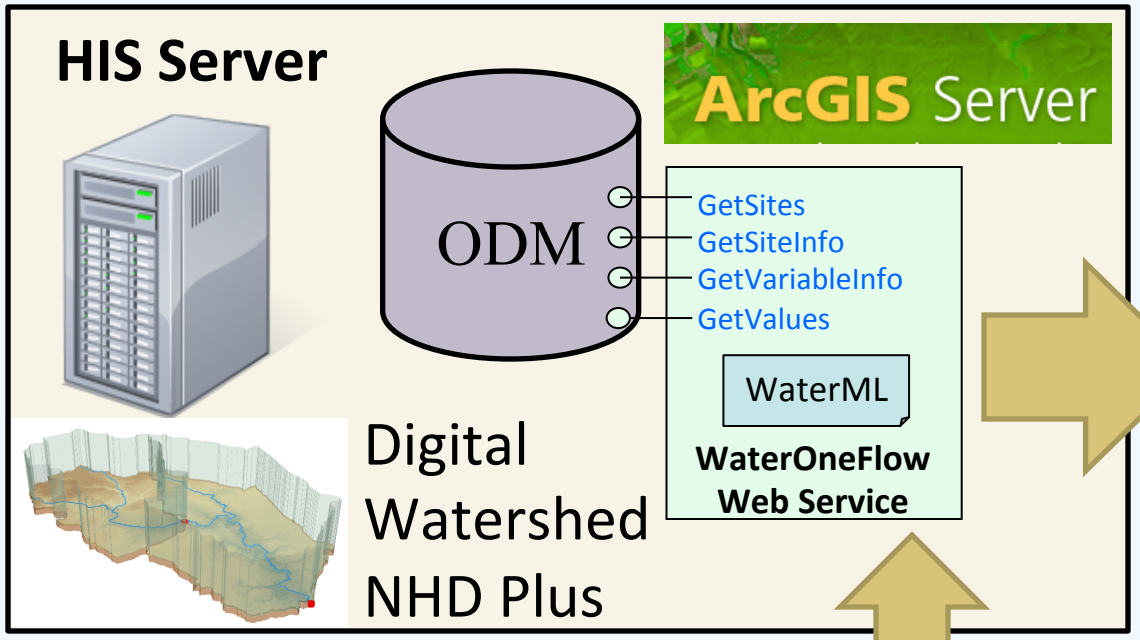


Mission: Implement a dynamic, accessible, authoritative drought information system

NOAA Produces:	With Our Partners:	Used By:
Monitoring and Forecasting		
U.S. Drought Monitor	USDA, National Drought Mitigation Center	USDA, state and local governments
U.S. Soil Moisture Monitoring	DOE, USDA (NRCS)	USDA, agricultural producers
Normalized Difference Vegetation Index	USGS, NASA	USAID (FEWS NET)
Crop Moisture Index	USDA	USDA, agricultural producers
Ensemble Water Supply Forecasts	USDA	USBR, USACE, state water management agencies, local district water managers
Soil Moisture Anomaly Forecast	USDA (NRCS)	USDA, agricultural producers

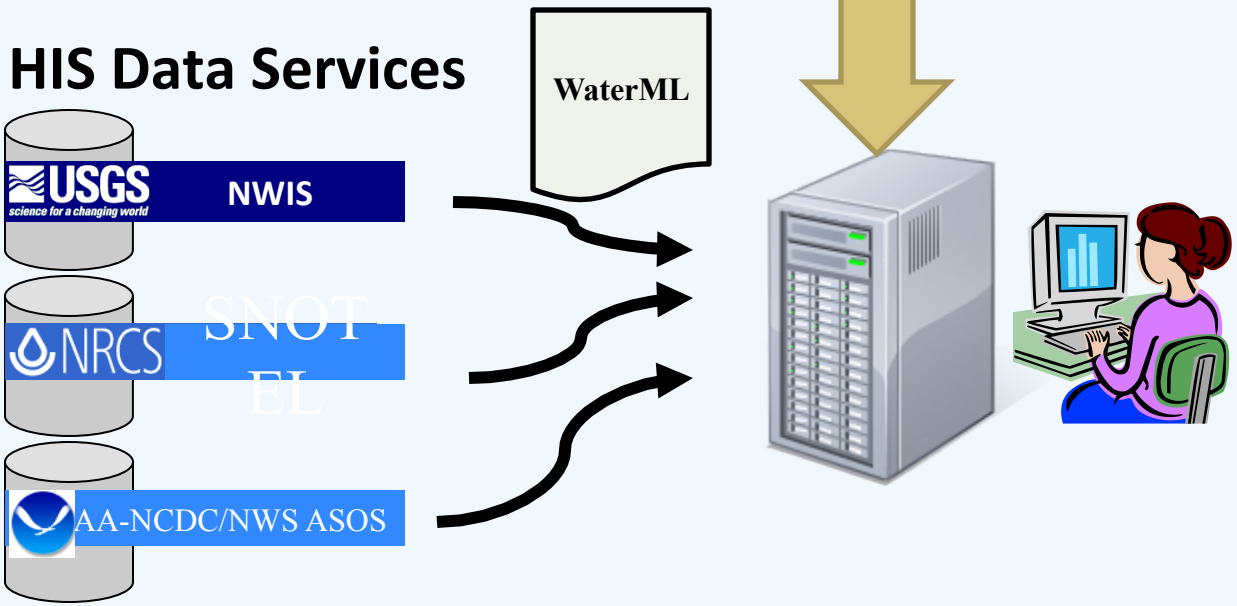
NOAA Produces	With Our Partners:	Used By:
Products Informing Risk Assessment and Management		
Reconciling projections of future Colorado River stream flow in a changing climate	USBR, USGS, University of Washington, University of Colorado, University of Arizona, University of California-San Diego	USBR, state and local water providers, reservoir managers, Water Conservancy Districts
USGS Circular 1331: Climate Change and Water Resources Management: A Federal Perspective	USGS, USBR, USACE	USBR, USACE, Water Utilities
Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation	Colorado Water Conservation Board, University of Colorado, Western Water Assessment RISA	Colorado water planners, State Climatologists
Managing Threatened and Endangered Salmon in Low Water Conditions	USBR, CA Department of Fish and Game, CA Department of Water Resources, University of California Davis, Humboldt State University	NMFS, CA Department of Fish and Game, CA Department of Water Resources, Pacific Fisheries Management Council
Assessing Drought Indicators and Triggers	USGS, USDA (NRCS), Colorado Water Conservation Board, Colorado State University, Utah State University, University of Wyoming	USGS, USDA, USBR, water planners/providers, reservoir managers, State Climatologists

CUAHSI HIS Custom Drought Index Server



Data Products and Services

- Web Map Based Display of Index
- WaterOneFlow Web Service(s) for inputs and outputs
- GIS Data Services
  - WMS, WFS, WCS
  - Digital Watershed
  - Drought Index Results



Data Processing and Index Calculation

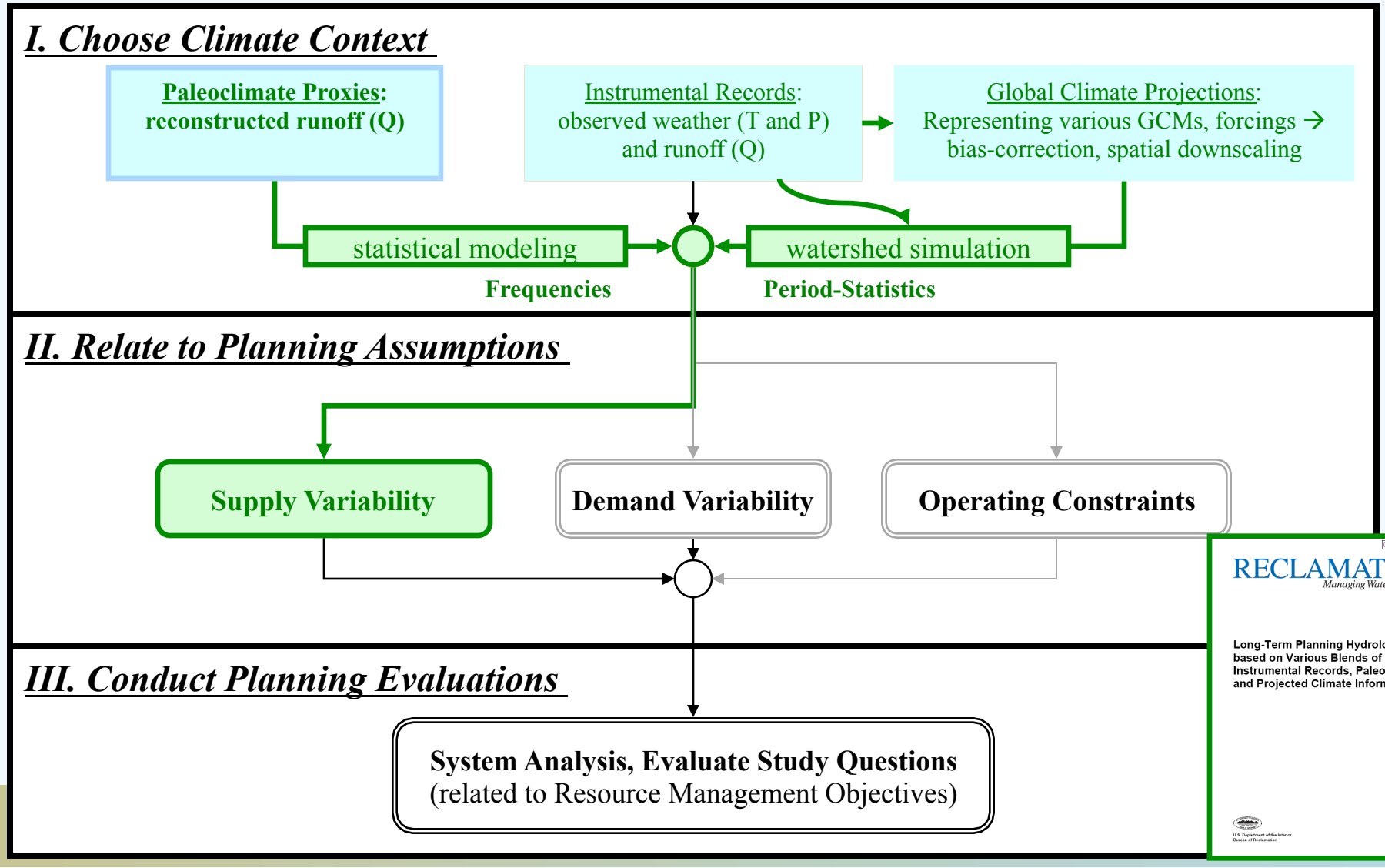
CUAHSI

D. Tarboton

J. Horsburgh

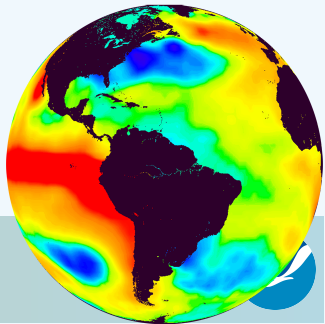
Utah State University

Supply Variability: Blend paleo, instrumental and projected climate (Reclamation-Brekke and Prairie 2009)



What does effective adaptation require?

- Knowledge of risks and opportunities
- Monitoring and early warning information services
- Response capability
  - Reliability- reducing frequency of failure
  - Robustness-maintain economic performance and environmental goals under a range of uncertain conditions
  - Resiliency-rapid rate of recovery from events (droughts, floods)
  - Vulnerability-reduced severity of the consequences of failure
  - Reduced Brittleness-inability to accommodate threshold changes (system already managed to maximum efficiency)

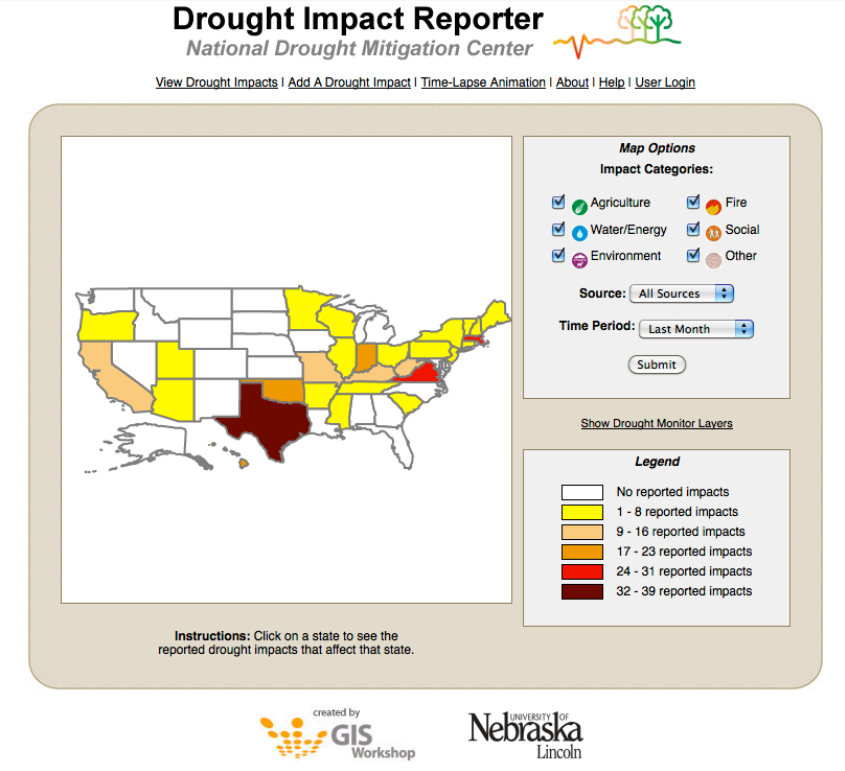


Risk Profiles

Vulnerable Sector/ activity/ group	Magnitude	Rates of Change	Persistence and reversibility	Likelihood and confidence	Distribution	Potential for Adaptation
Economic sectors (Water, Ag, Tourism etc.) Communities at risk Bounded ecosystems such as coastal, mountain are already stressed	Situation of existing Levels of vulnerability for different magnitudes of change, especially thresholds, relative to temperature, precipitation or the other critical parameters that create the vulnerability	Critical rates/steeper response curves that affect vulnerability	Likelihood that the vulnerable sector will be affected by an irreversible impact and whether it is likely to persist.	Overall confidence and likelihood, but state confidence also with any specific figures or points.	Distribution of impacts – both physically and socially within countries (not in a simple developed/developing dichotomy).	Capacity for adaptation. Is adaptive capacity sufficient to delay or prevent adverse impacts and at what cost.

Leggett and Pulwarty 2007

Drought Ready Communities (Nebraska)



http://droughtreporter.unl.edu/

- Drought Impacts Reporter
- Republican River Basin Water and Drought Portal
- Developing Drought Ready Communities-NE, OK