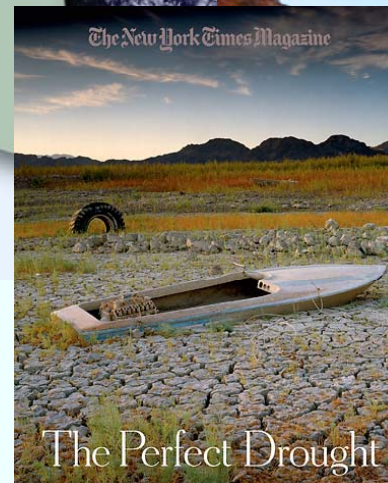
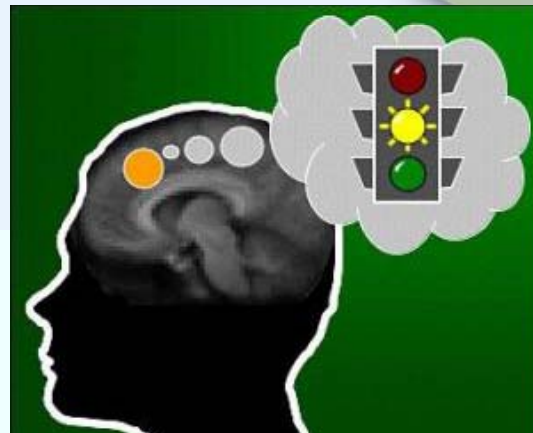
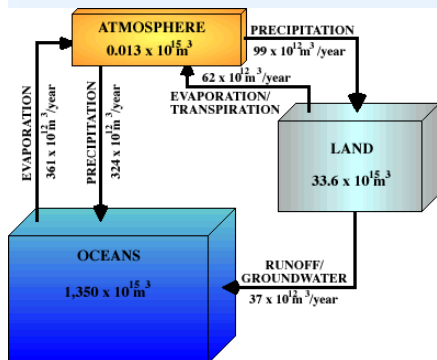


# Drought, early warning and climate services

Roger S. Pulwarty PhD

J. Verdin, R. Olsen, C. Hennig, V. Deheza,  
N. Doesken, M. Hayes, M. Hiza Redsteer, C. McNutt,  
M. Brewer and the NIDIS Implementation Team

Chief, Climate and Societal Impacts Division and  
Director, National Integrated Drought Information  
System (NIDIS)  
NOAA





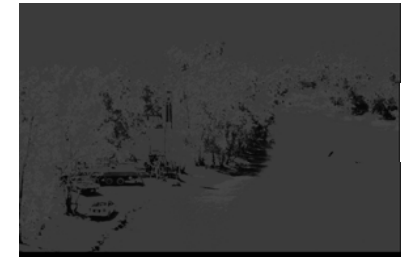
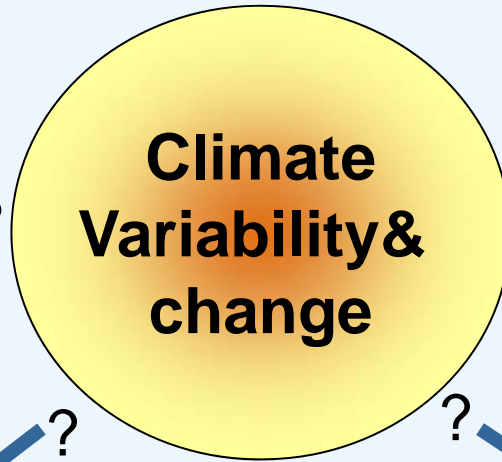
# Impacts of a Changing climate



Higher evaporation.  
More farm dams as  
surface water  
availability reduces?



Greater irrigation  
efficiency as  
surface water  
availability reduces?



Increased demand  
for groundwater as  
surface water  
availability reduces?



Increased evapo-  
transpiration due  
to higher temps?



Higher frequency  
and intensity of  
wildfires due to  
higher temps and  
droughts?



**“If we are not careful we will end up where we are going”**



Central Arizona project

Late-1980's



Development in Central

Arizona 20 years later





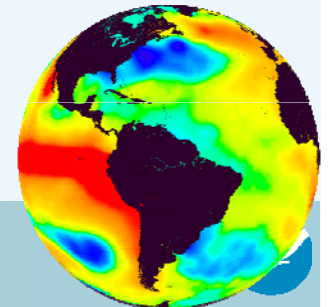
# Climate drivers of drought-a continuum

1. año-

DAYS SEASON

YEARS YEARS

YEARS YEARS

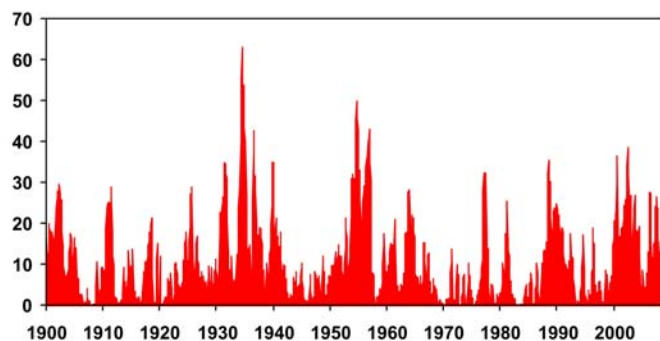




# Drought: Diverse temporal and spatial scales

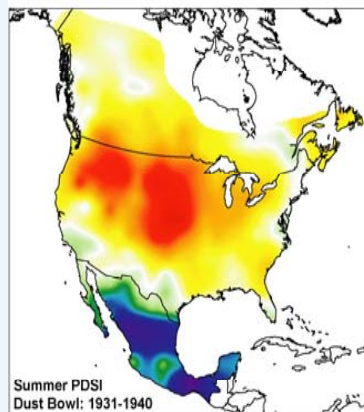
## Percent Area of the United States in Severe and Extreme Drought

January 1895–July 2008

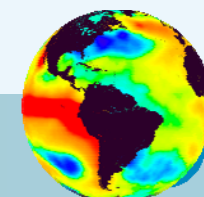
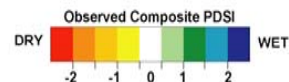
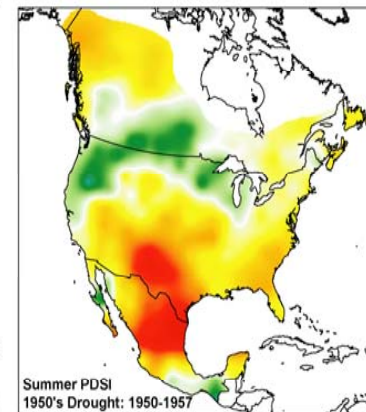


Based on data from the National Climatic Data Center/NOAA

Dust Bowl Drought (1931-1940)



1950's Drought (1950-1957)

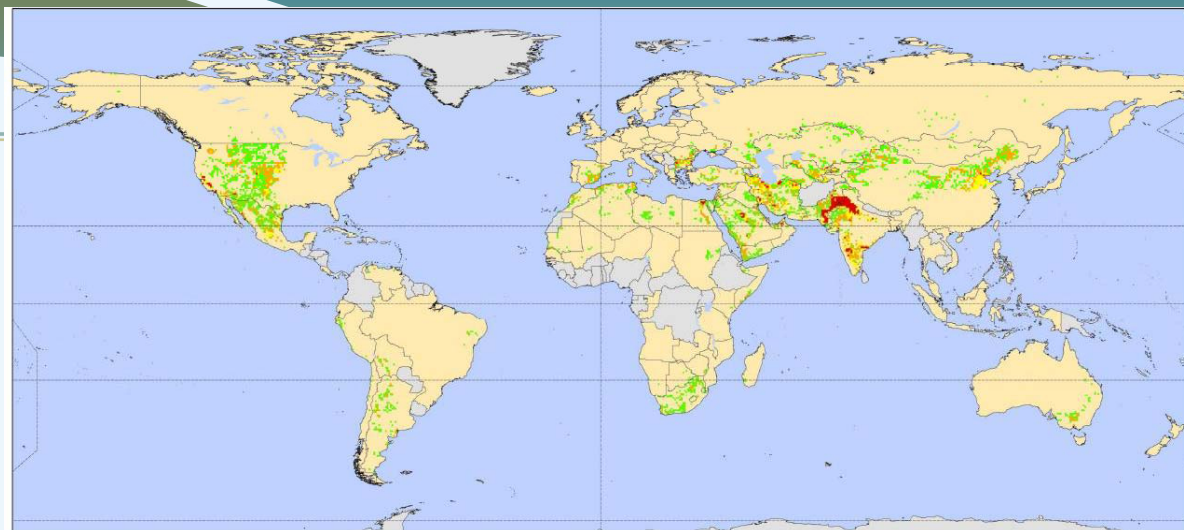




## Groundwater depletion trends

(groundwater 30% of available freshwater on the planet)

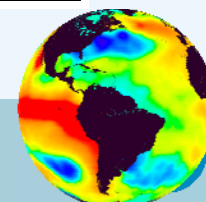
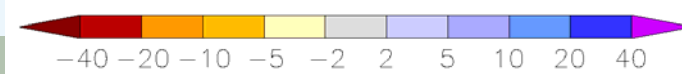
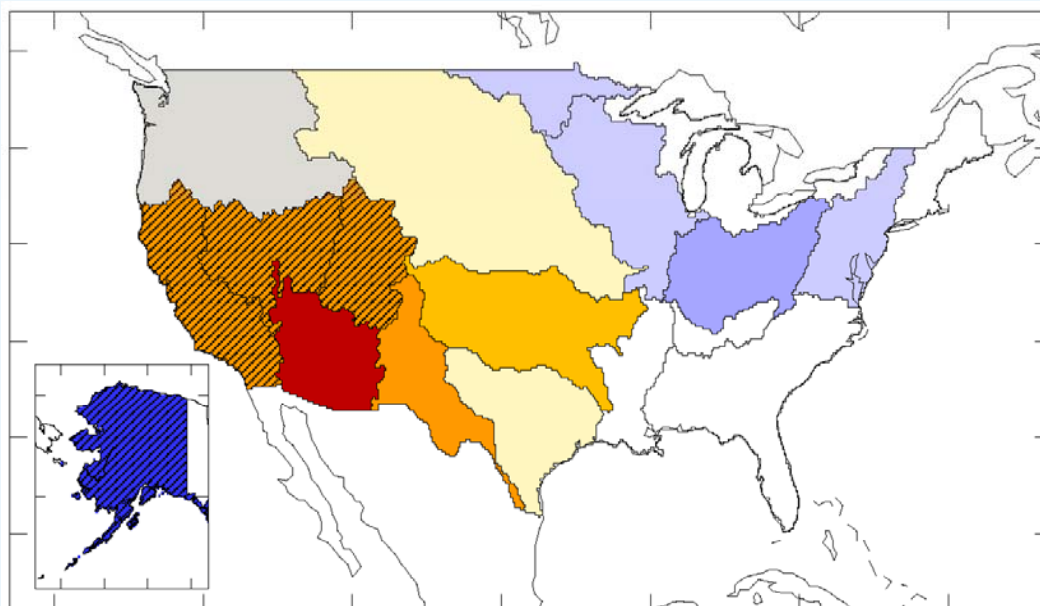
1000 = one cubic kilometer of depletion per year



(C) 

No Data	0 - 2	2 - 20	20 - 100	100 - 300	300 - 1000	1000 - 1500
---------	-------	--------	----------	-----------	------------	-------------

**The future (2041-2060): where do the models agree?**

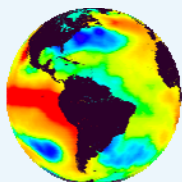


# What would “adaptation” address?

The threat already posed to society from today’s climate variations

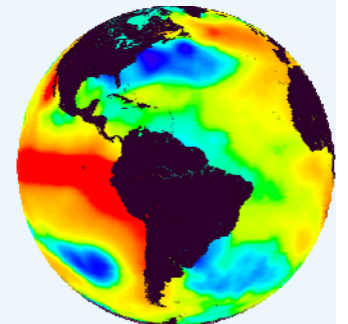
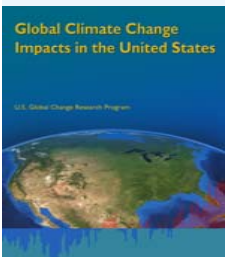
Climate-sensitive development paths that might put greater population, ecosystem services, and economies at risk

The potentially high-impact but still critically uncertain additional risks presented by climate change



# How do we “usually” adapt?

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





# Event to event.....issue attention cycle

Focusing event(s)  
and cumulative  
Impacts

Response

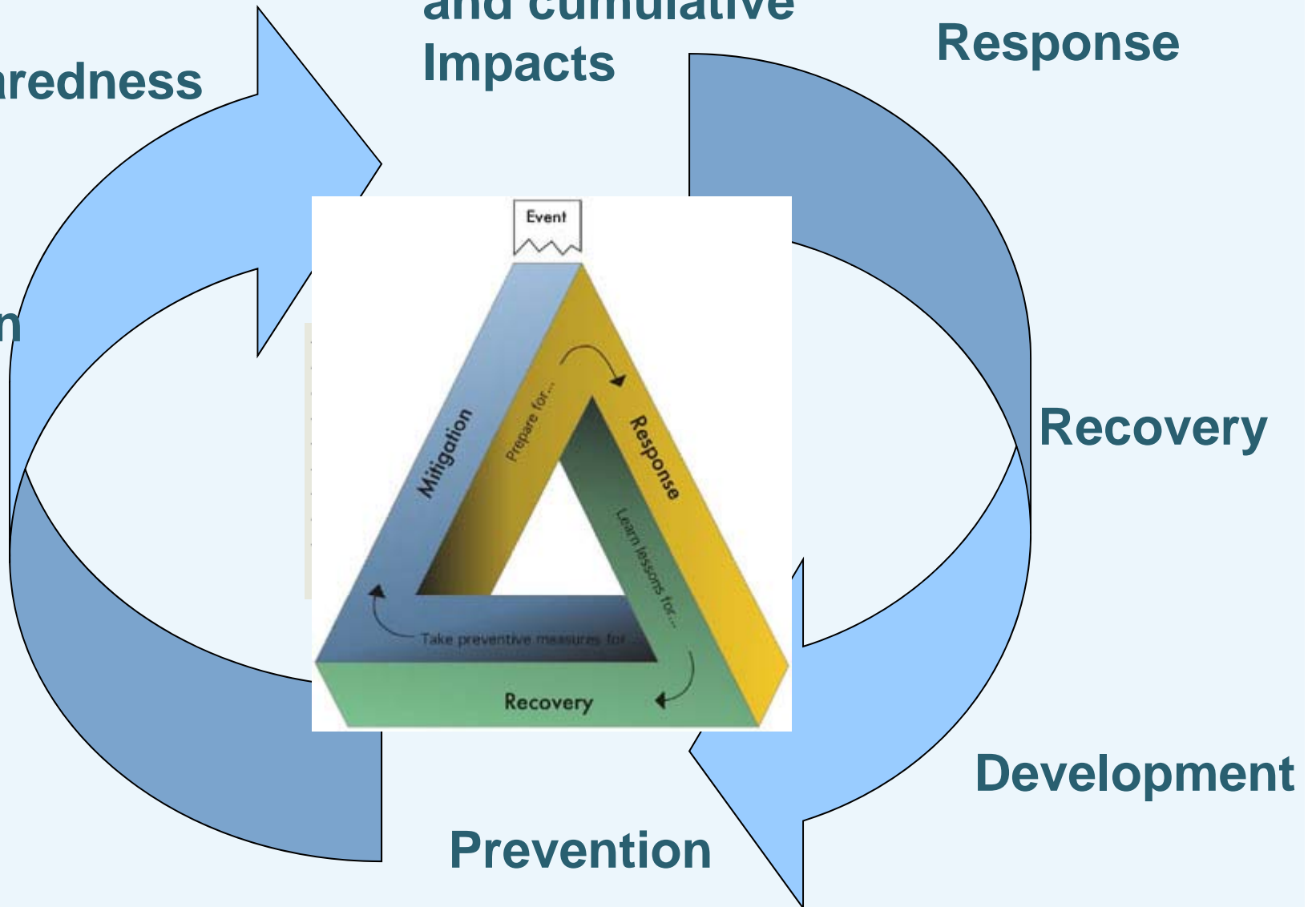
Preparedness

Mitigation

Recovery

Development

Prevention





Focus on the critical problems: not just asking but answering the right question



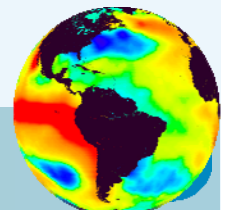
**“ALSO, THE BRIDGE IS OUT AHEAD”**



# Adaptation: Crisis, learning and redesign

## What has led to “action”?

1. Focusing events-extremes, legal decisions etc.
2. Leadership at different levels and the public are engaged:
3. Supported framework for collaboration between research and management-integrated, scenarios, scenarios/gaming, communication, embedding information into practice, evaluation
4. Existing social basis or even pressure for collaboration





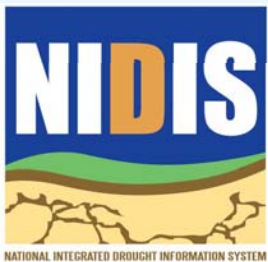
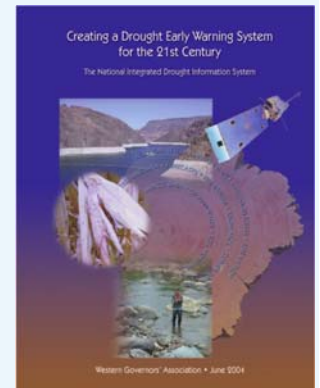
# Are droughts different from other hazards?

## 2000-2004 drought in the Colorado Basin

**“No systematic collection and analysis of social, environmental, and economic data focused on the impacts of drought within the United States exists today” Western Governors Association 2004**

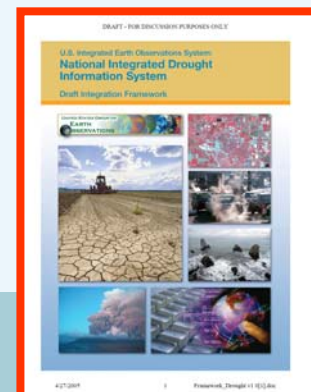
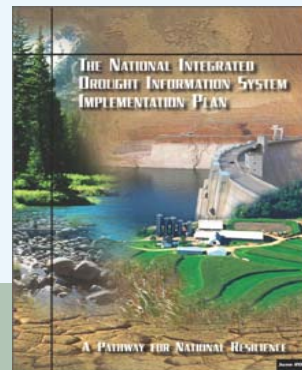
## The NIDIS Act of 2006 (Public Law 109-430)

**“Enable the Nation to move from a reactive to a more proactive approach to managing drought risks and impacts”**



30  
DAYS

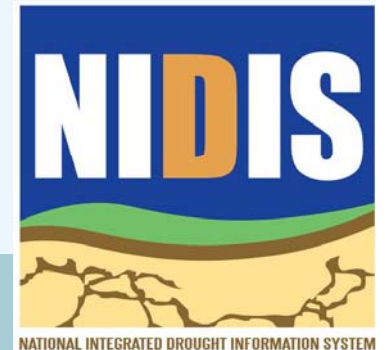
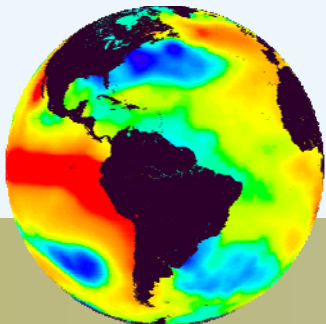
([www.drought.gov](http://www.drought.gov))





# 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



# Drought and Water Resources: Federal Partnerships (States, Tribes, Urban, other)



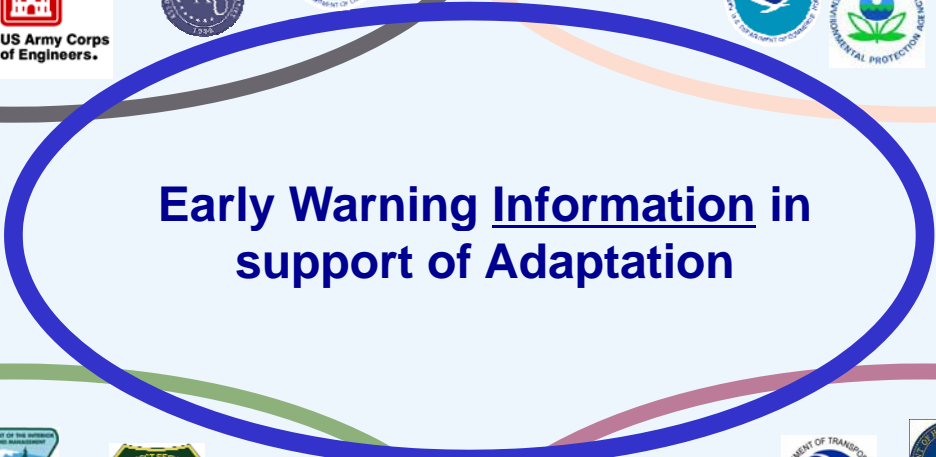
**Monitoring & Forecasting**

This block contains logos for the Forest Service (US), NASA, NSF, Environmental Protection Agency (EPA), and Natural Resources Conservation Service (NRCS).



**Drought and Flood Impacts Assessments and Scenarios**

This block contains logos for NASA, AAU, NSF, Forest Service (US), USGS, NOAA, EPA, and the Department of the Interior.



**Early Warning Information in support of Adaptation**

This central block is a blue oval containing the text "Early Warning Information in support of Adaptation".



**Communication and Outreach**

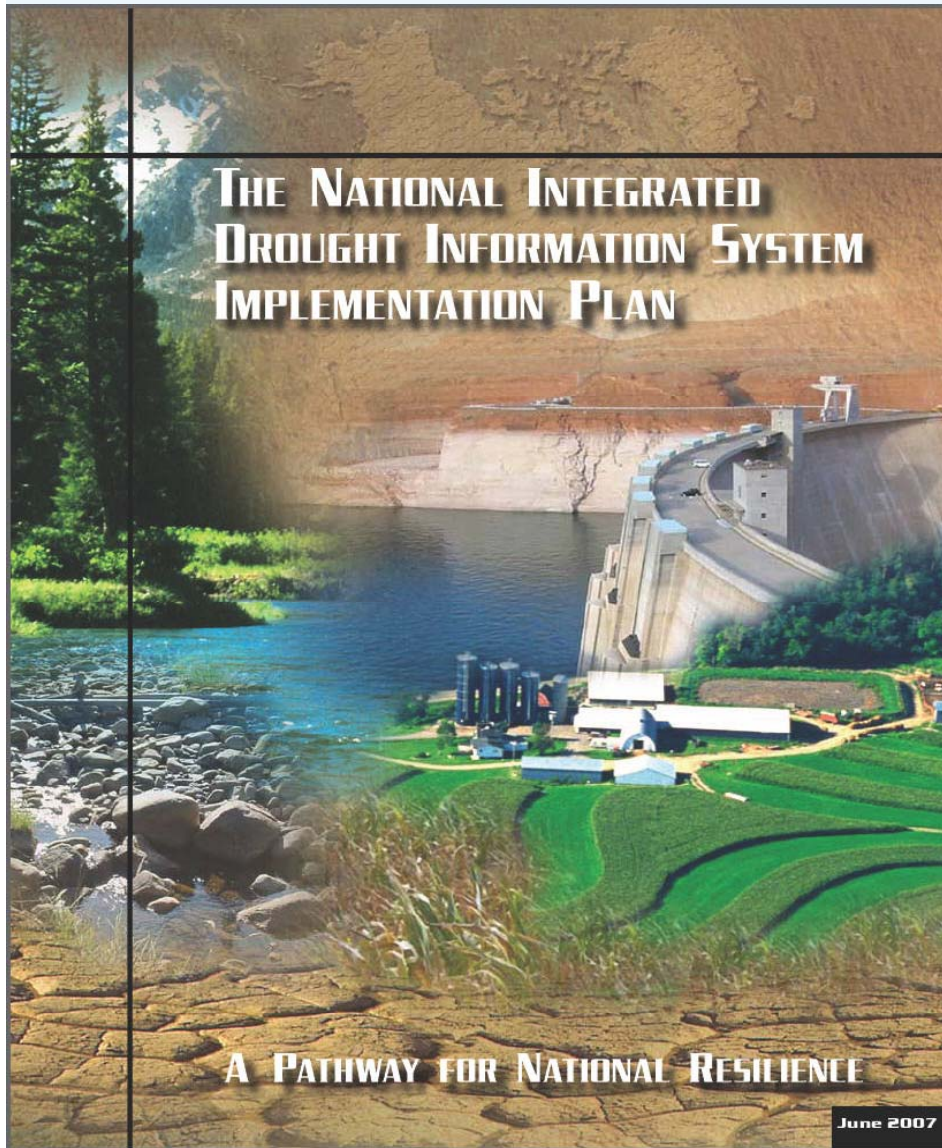
This block contains logos for EPA, Forest Service (US), AAU, U.S. Department of the Interior (Bureau of Reclamation), NOAA, National Park Service, and US Army Corps of Engineers.



**Engaging Preparedness & Adaptation**

This block contains logos for the National Governors' Association, Department of Transportation, FEMA, USDA, CDC, Department of Homeland Security, EPA, AAU, and the Department of the Interior.

# NIDIS Components



- 1. NIDIS Office**
- 2. U.S. Drought Portal**
- 3. Climate Test Beds/Drought**  
Integrating data and forecasts
- 4. Coping with Drought-Grants-**  
Impacts assessment and decision support research
- 5. Regional Drought Early Warning**  
Information Systems  
Design, Prototyping, Implementation



**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**

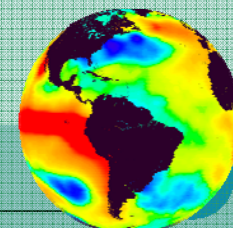
**Interdisciplinary  
Research and  
Applications**

**U.S.  
Drought Portal**

**WATERSHED/URBAN/LOCAL**

**Regional Drought Early Warning Systems**

Information clearinghouse, prototypes, and Implementation





# **National Level: NIDIS Knowledge Assessments (selected);**

**What do we know? What do we need to know?**

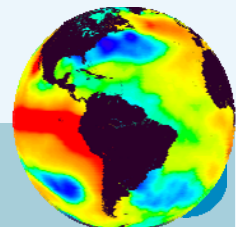
- **Remote Sensing Contributions to Drought Monitoring, February, 2008, Boulder-** NOAA, USGS, NASA, USDA, universities, state climatologists, state-local drought officials
- **National Status of Drought Early Warning Systems, June 2008, Kansas City-**NOAA, USGS, USAID, USDA, USACE, NASA, tribes, universities, state government, water managers
- **Drought, Climate change and Early Warning on Western Tribal Lands June 2009-** Columbia, Colorado, Rio Grande, Missouri Basin tribes
  - 2010-11 Four Corners region
- **WGA/WSWC Workshops on developing constituencies for NIDIS (April 2010, September 2010-Washington DC, 2011)**
- **Engaging Communities in Preparedness June 2011 Chicago**



# Impacts Assessment and Decision Support Research

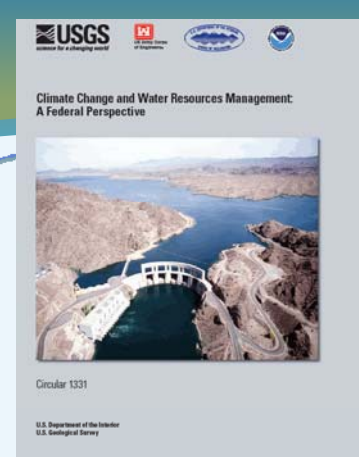
- Adaptation Policies For Urban Water Resource Management-Short-Term Drought Responses And Long-Term Planning
- Socioeconomic Assessments to Build Community Resilience in Mitigating Drought
- Climate Information System to Enhance Drought Preparedness by Underserved Farmers
- *∞ Reconciling projections of Colorado River streamflow under changing climate conditions*
- Ensemble Hydrologic Forecasts using dynamic estimates of evapotranspiration

Drought Index Evaluation and Implementation in a Geospatial Framework Linked to Hydrologic Data Web Services

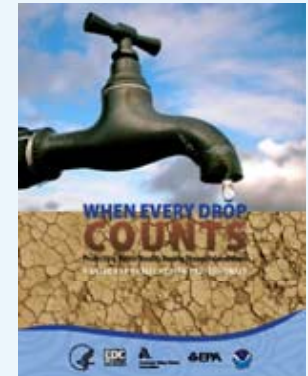




# USGS 1331- Climate Change and Water Resources Management: A Federal Perspective 2009



# 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 (GAR 2011)





National Integrated Drought Information System

# U.S. Drought Portal

www.drought.gov

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Search:

- HOME
- WHAT IS NIDIS?
- CURRENT DROUGHT
- FORECASTING
- IMPACTS
- PLANNING

## Recovery

### Area Drought Information

Select State...

Select Region...

### Maps & Tools

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

### Events & Announcements

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

### Drought In The News

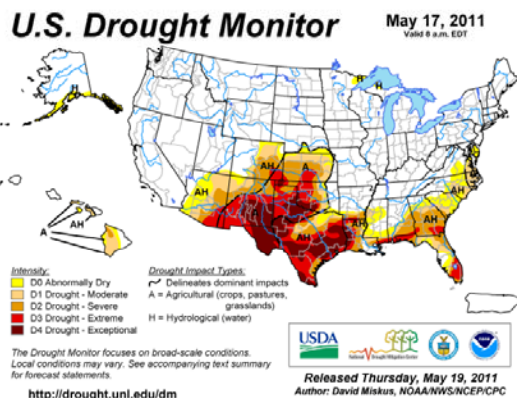
- Corps to officially remove water usage from Lanier manual - usc.com
- Parched English fields reveal ancient sites
- Klamath Basin water worries extend to wells
- 2 dozen Ky. counties declared drought areas - Kentucky.com
- Drought-hit Calif.-Ore. border getting fed help - fresnobee.com
- Trouble In 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 Journal Globe, Journal, NJC
- West Hawaii Today - Dry In Hawaii

### Featured Products

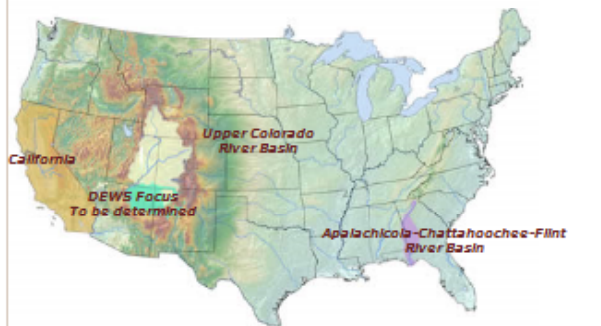
[Where are Drought Conditions Now?](#)

[How is the Drought Affecting Me?](#)

[Will the Drought Continue?](#)



### Regional Drought Early Warning Systems



(Click on an area to view the Drought Early Warning System)

### 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](#)

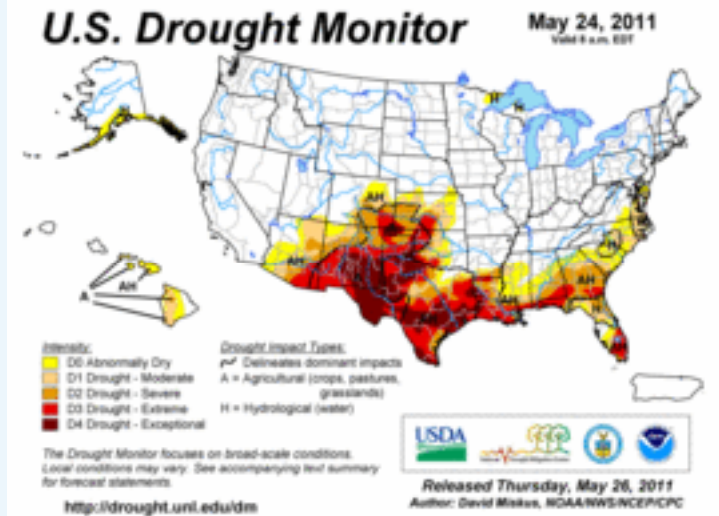
### Drought Monitor Time Series

**Key Clearinghouse Functions:**  
Credible, Accessible, Timely Information on

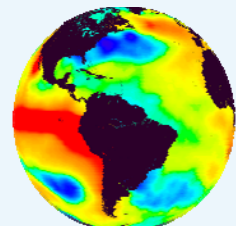
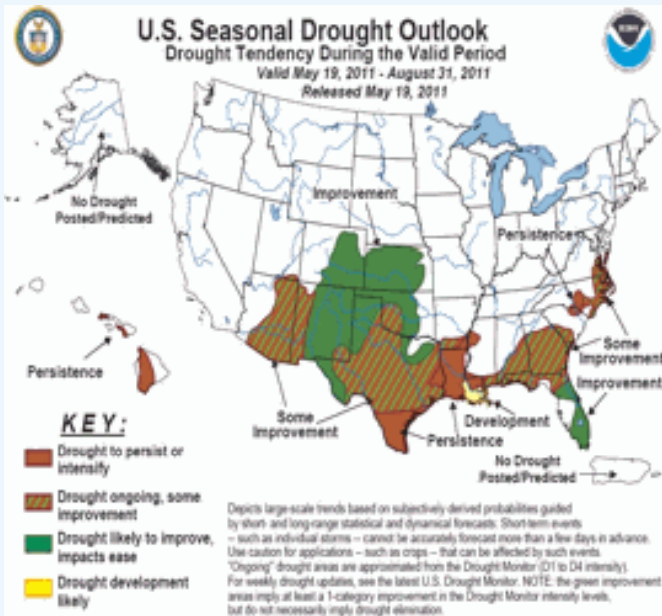
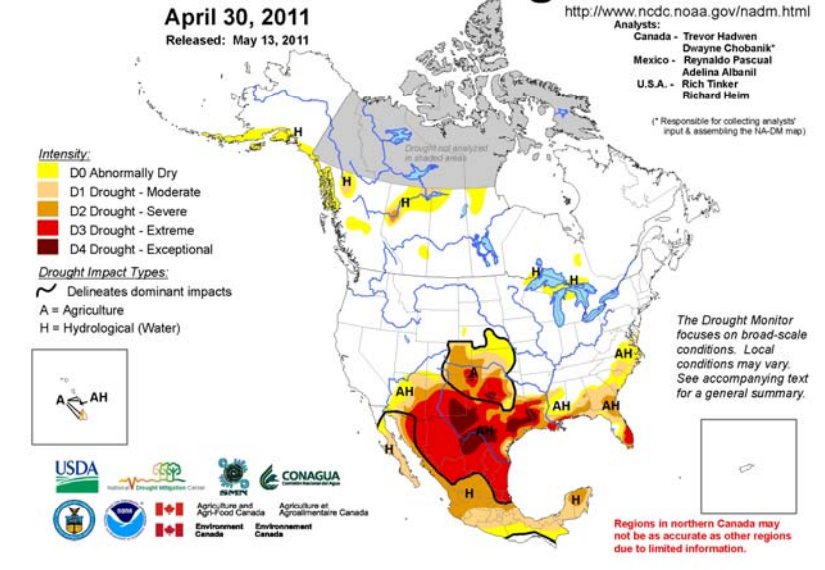
- Where are drought conditions now?
- Does this event look like other events?
- How is the drought affecting me?
- Will the drought continue?
- Where can I go for help?

May 24, 2011

# U.S. Drought Monitor



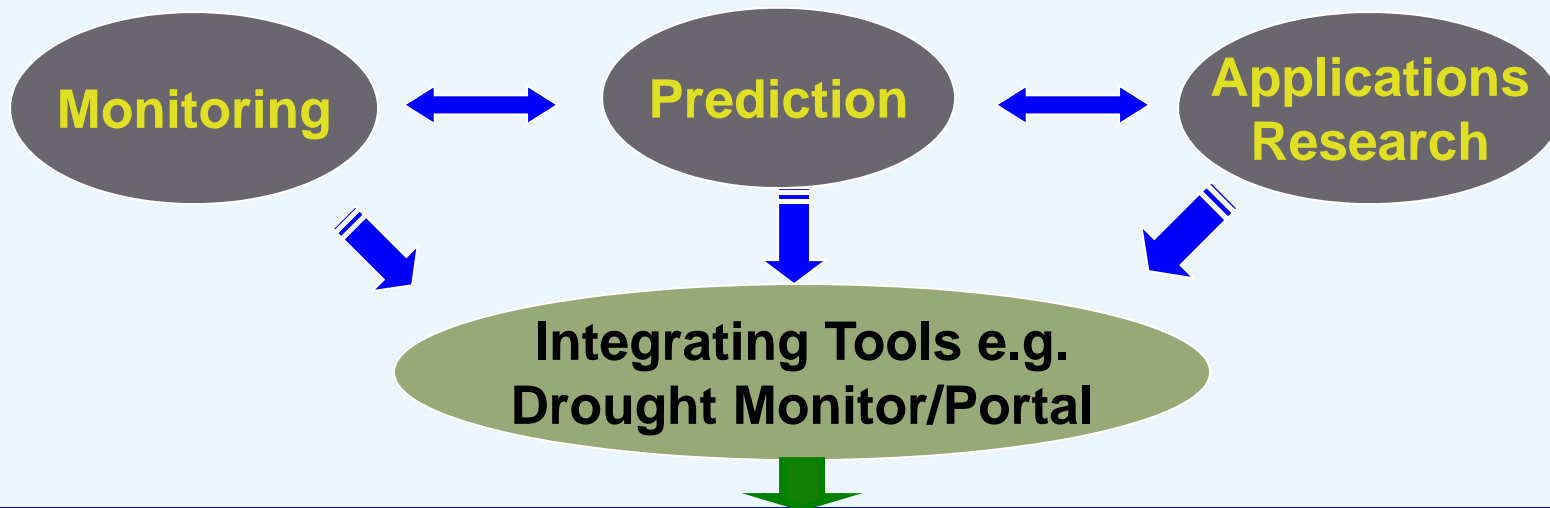
# North American Drought Monitor





## NIDIS REGIONAL INFORMATION MANAGEMENT MODEL

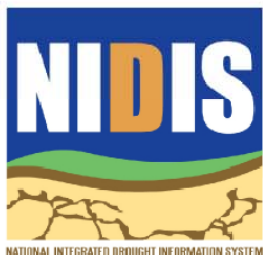
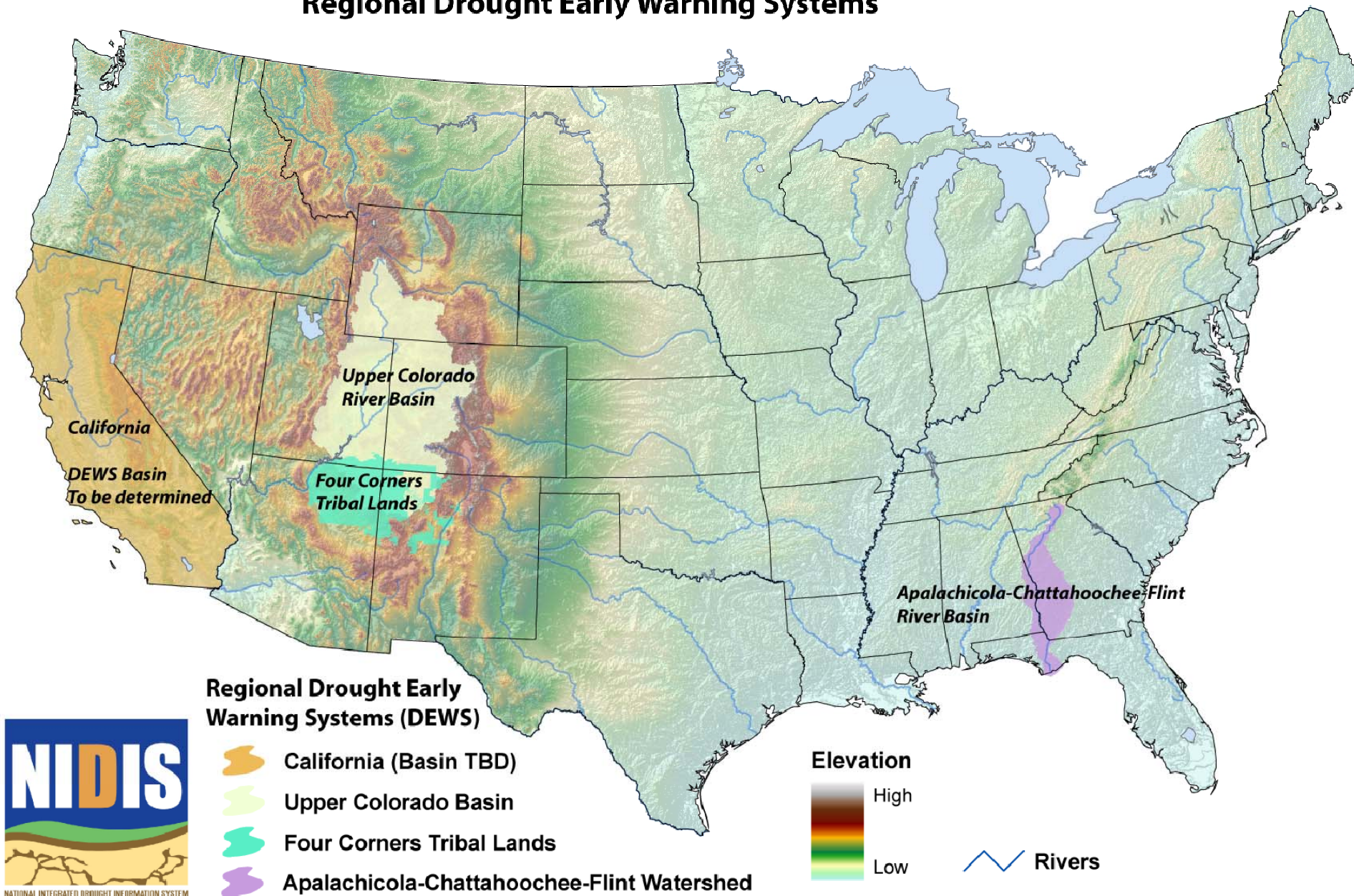
Coordinate existing federal, state, and local drought-related data and decision support activities (e.g., within watersheds and states)



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



# National Integrated Drought Information System (NIDIS) Regional Drought Early Warning Systems



Map courtesy of the USGS/Michael Budde



# Regional DEWS Implementation: Upper Colorado River Basin

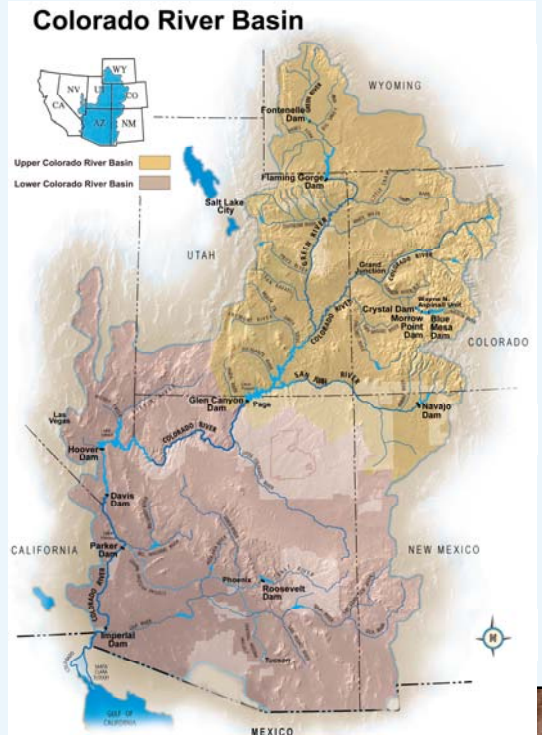
## Categories of drought information users & analysis

### Upper Basin down to Lake Mead

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

### Sub-basin

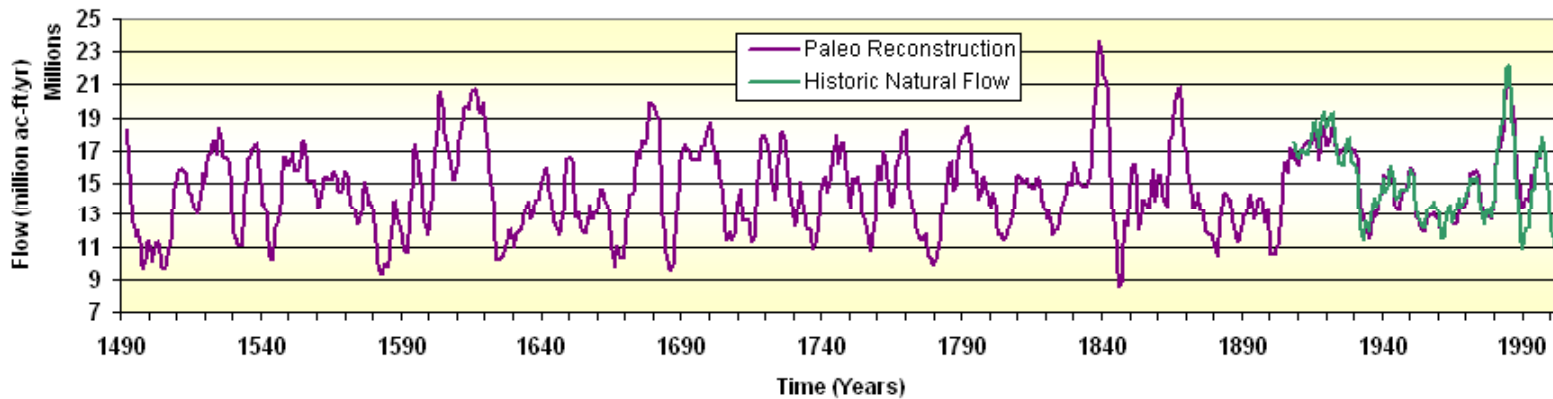
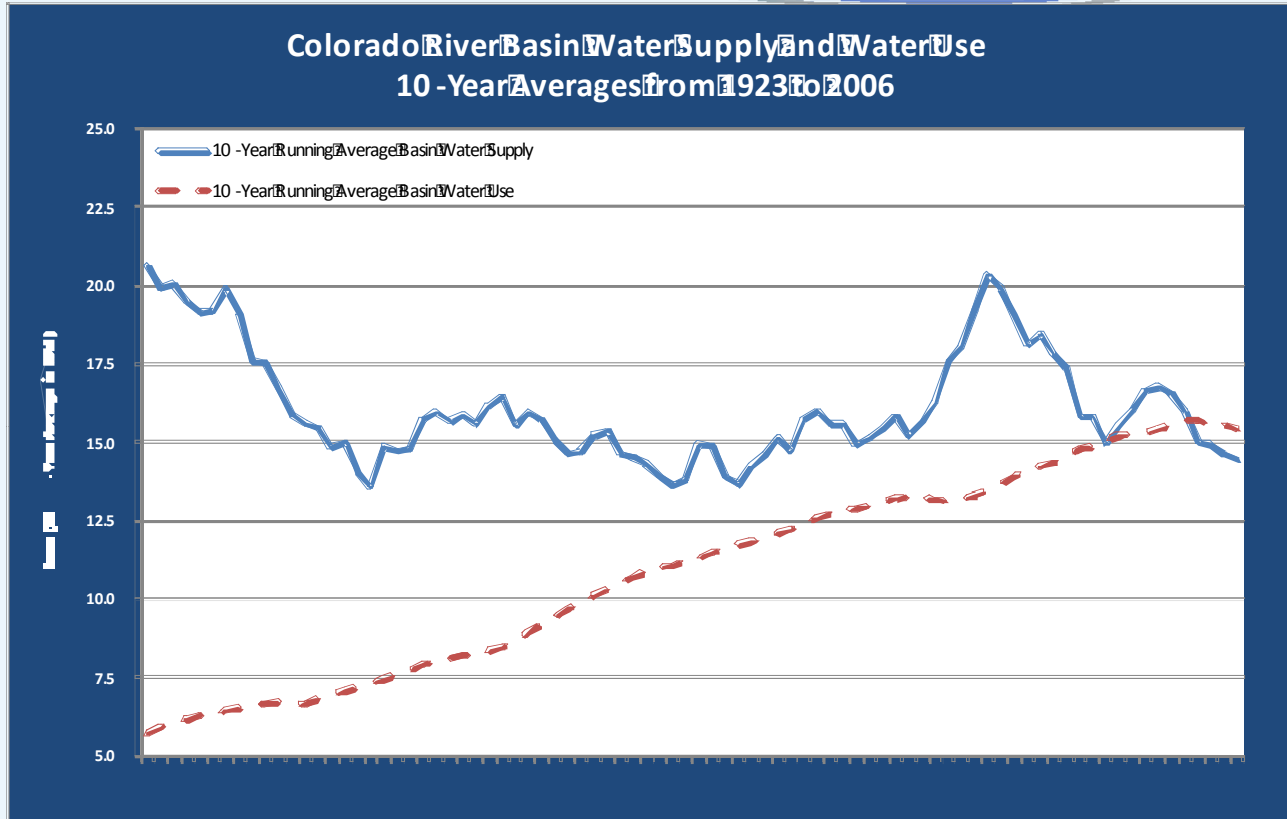
- Inter- and Intra-basin transfers; Front range urban-agriculture-Changing water demand during drought
- Ecosystem health/services including recreation and tourism impacts







# Colorado River Water Supply & Use





# US Drought Portal – Regional DEWS



National Integrated Drought Information System

Regional Drought Early Warning System

Upper Colorado River Basin

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### Area Drought Info

Select State within the DEWS

...

Select Other Regional DEWS

...

### Related Information

- [NIDIS Weekly Drought Webinars](#)
- [Tribal Resources](#)
- [Ongoing Research & Development](#)

### Upcoming Meetings

[To Be Determined](#)

**When:** TBD

**Where:** TBD

### Past Meetings

[Expand All / Collapse All](#)

[UCRB Pilot Planning meeting for Federal Partners](#)

[UCRB Scoping Workshop](#)

[UCRB Monitoring Gaps Workshop](#)

[UCRB Partners Update Meeting](#)

### Featured Products

[Current Conditions](#)

[Impacts](#)

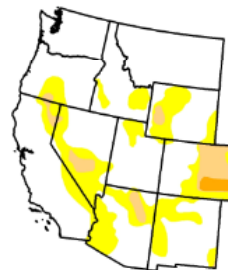
[Forecast](#)

## U.S. Drought Monitor West

November 30, 2010

Valid 7 a.m. EST

	Drought Conditions (Percent Area)					
	None	D0-D1	D1-D2	D2-D3	D3-D4	D4+
Current	70.8	27.2	0.0	0.0	0.0	0.0
Last Week (11/23/2010)	71.9	28.1	0.0	0.0	0.0	0.0
3 Months Ago (9/30/2010)	73.5	26.5	0.0	0.0	0.0	0.0
Start of Calendar Year (1/1/2010)	40.1	59.9	0.0	0.0	0.0	0.0
Start of Water Year (11/1/2009)	62.5	37.5	0.0	0.0	0.0	0.0
One Year Ago (11/30/2009)	46.8	53.2	0.0	0.0	0.0	0.0



**Intensity:**

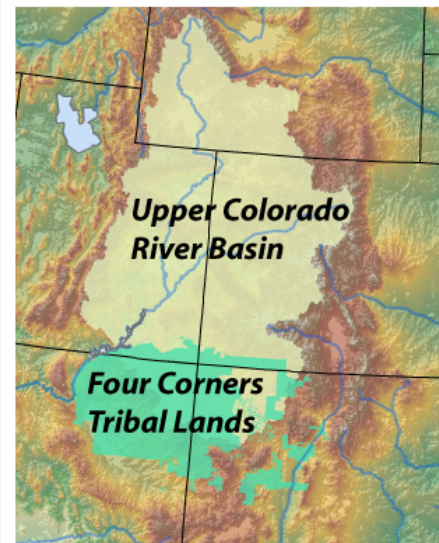
- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

<http://drought.unl.edu/dm>

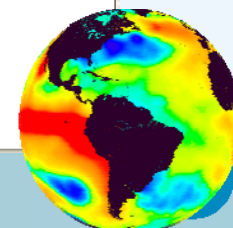
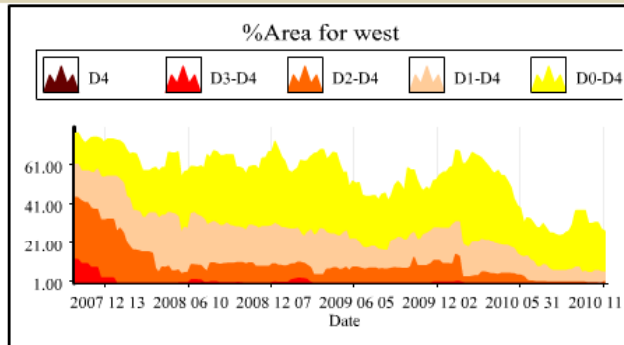
Released Thursday, December 2, 2010  
 Author: R. Tinker, CPC/NOAA

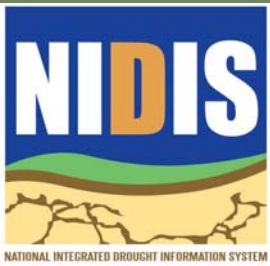
### Upper Colorado River Basin



### Drought in the News

### Drought Monitor Time Series - West





NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

**NIDIS  
Implementation  
Team: Over 50  
Federal, state, tribal  
and private sector  
representatives  
nationally**

**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  
NCAR

**U.S.  
Drought Portal**

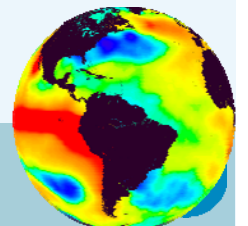
NCDC  
NDMC-NOAA, USGS, USDA,  
USBoR

**Public Awareness  
And Education**

State Climatologists  
NWS-CSD  
USDA

**Engaging  
Preparedness  
Communities**

NDMC  
State Offices, RISAs  
US BoR, USACE





## Spatial Resolution/ Time Horizon

## Operational Activity

## Decisions

Basin-wide over decades

Long-term  
Planning

Operating Criteria  
and Guidelines

Basin-wide over 1-2 years

Mid-term  
Operations

Annual Operating Plan

Sub-basin over 4-6 weeks

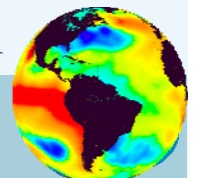
Short-term  
Scheduling

Water and Power  
Schedules

Single project over 1-7 days

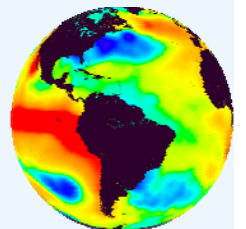
Real-time  
Control

Unit Commitment  
Economic Dispatch  
Automatic Generation  
and Control



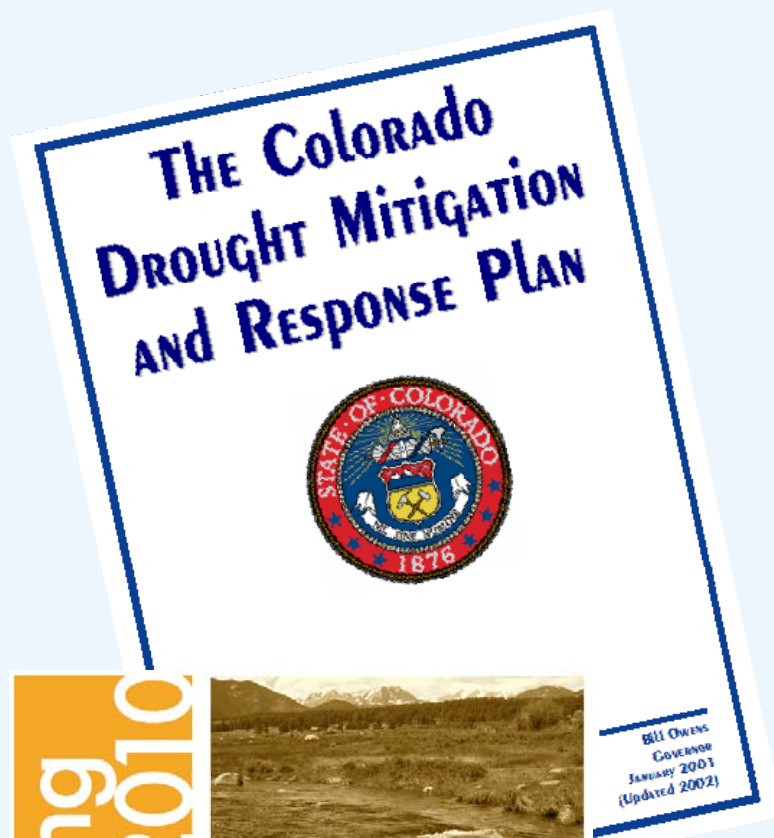
## NIDIS Products and Services in the Colorado Basin to date

- New watershed-based drought indicators and triggers used in the Upper Basin
- Improved linkages between climate and streamflow modeling during drought
- Spatial analysis of water demand during drought
- Low flow impacts database for 164 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

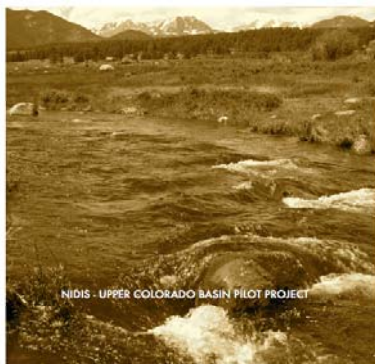




# Upper Colorado Basin Drought Outlooks



Spring  
2010

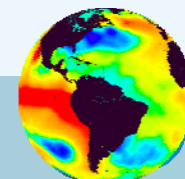


Weekly Climate, Water & Drought Assessment

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

## NIDIS role

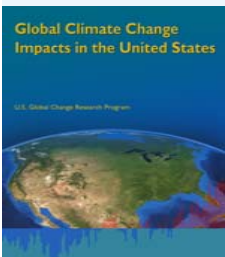
- Development of indices that incorporate current surface water conditions and a forecast component
- Assessment of trigger points and responses
- Weekly Early Warning Webinars  
• (coordinated with River Forecast Center briefings)





# Colorado River Interim Guidelines - Time to think-A Robust Solution?

- Operations specified through the full range of operation for Lake Powell and Lake Mead
- Encourage efficient and flexible water use and management in the Lower Basin through the Intentionally Created Surplus (ICS) mechanism
- Strategy for shortages in the Lower Basin<sup>2</sup>, including a provision for additional shortages if warranted
- In place for an interim period (through 2026) to gain operational experience
- Basin States agree to consult before resorting to litigation



1. Issued in Record of Decision, dated December 13, 2007; available at <http://www.usbr.gov/lc/region/programs/strategies.html>
2. Mexico water deliveries are not directly effected by these guidelines (US/Dol Bureau of Reclamation)



# Prototype Implementation Upper Colorado River Basin

## Year 2 Actions

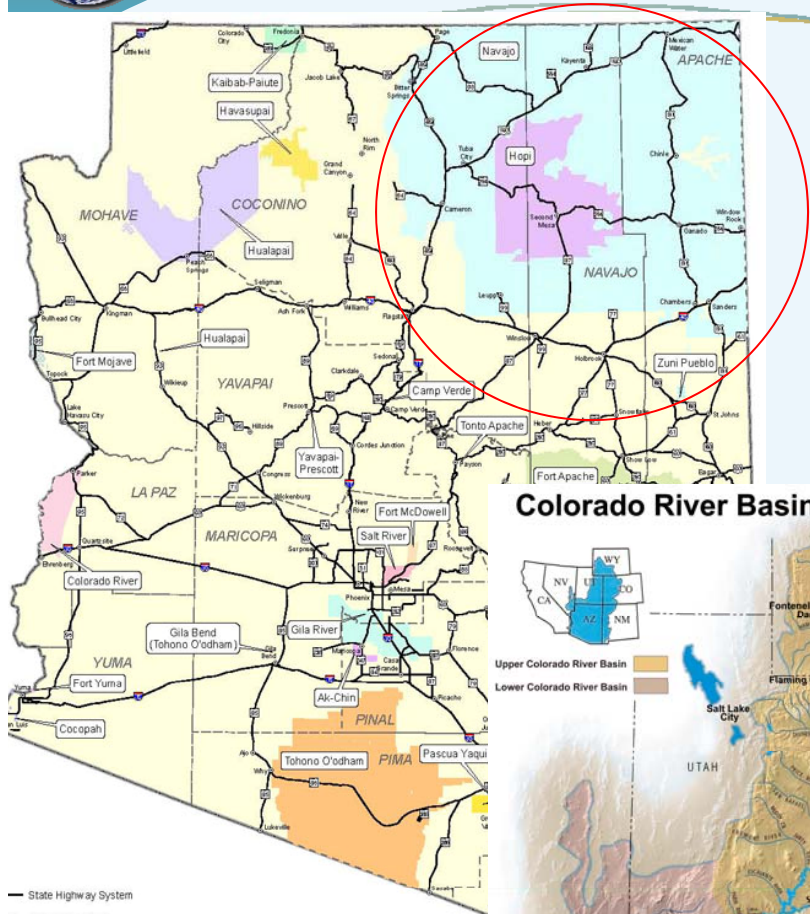
Prototyping/gaming: Given better data and information coordination, would responses have been improved for past events? Assess:

1. Value of improved information using past conditions
2. Responses for projections/ scenarios (seasons, decadal, change)
3. Develop EWS Fora
4. Feedback on priorities (e.g. data gaps) to Executive Council

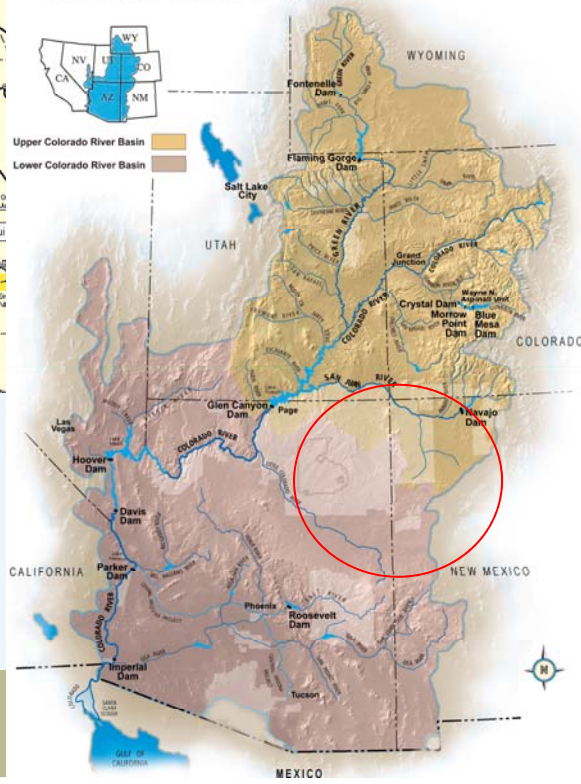




# Native Nations in SW are major land managers



Colorado River Basin



- 6 million acres/ 242kha of land
- held in trust by the US for American Indian tribes and Alaska Natives
- Reservations and tribal lands are >25% of land in AZ
- Confronting same climate trends, need same info, but context is different
  - cultural ties to landscape
  - federal trust relationship
  - widely variable capacity

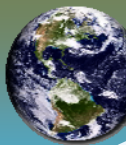


# *Kayenta, AZ* 2004



Margaret Hiza  
Redsteer USGS





## LOCAL NEWS

Comments 2 | Recommend 0

# Multiple crashes due to wind and dust along I-40

[More Phoenix Local News](#)

09:21 PM Mountain Standard Time on Thursday, March 26, 2009

azfamily.com

WINSLOW – A dust storm shut down Interstate 40 in the High Country for several hours.

It was closed in both directions east of Flagstaff near Winslow. Department of Public Safety officials say wind gusts up to 58 miles-per-hour have hit the area, blowing dust and causing multiple car crashes. The freeway was reopened at about 7:30 p.m.



Wind and dust conditions closed I-40

azfamily.com

PHOTOS: Mojos

DPS says if you see a dust storm approaching,

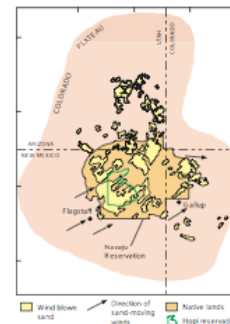


# Landscape changes



## Assessment of sand dunes and the affects of climatic variation on dune mobility in Navajo land

Work by the U.S. Geological Survey includes mapping sand dune deposits that cover one-third of the Navajo Nation, and classifying them according to stability based on the degree and type of vegetation. Sand dune deposits are being examined as indicators of climate change, and the potential of sand dune mobility is being assessed by combining mapping with data gathered on rainfall, temperature, wind speed, dust and sand migration. The final product of the dune-related work will be a map of sand dunes in GIS format, classified into groups based on the degree of vegetation and mobility. This map will provide valuable information to the Navajo Nation, and will be combined with climate information, so that it may be used to predict the potential for sand dune mobilization. Evaluating the present mobility of sand dunes is important for determining potential impacts of climatic variation on grazing and farming resources, native plants, air quality, damage to infrastructure, and health-related impacts from dust storms. (See USGS website <http://geochange.er.usgs.gov/sw/impacts/geology/sand/>)



Sand dunes are sensitive indicators of climate change, including precipitation, soil moisture balance, and wind circulation patterns. They become active during periods of drought, or increased temperature and evaporation, when the plants that are growing on them and holding them in place, die off. The degree of dune mobility can be predicted based on the ratio of precipitation to evapotranspiration.

If we calculate the dune mobility index values for wind speed, precipitation, and potential evapotranspiration (moisture loss) for the Colorado Plateau at present (using average values for 1961-1990), we can see in the graphs below that dunes fall into the category of being partly active, but largely stable, which is what we observe there today (pink dots). If we recalculate the dune mobility index values using data from the 1899-1904 drought, the values are shifted into the category of

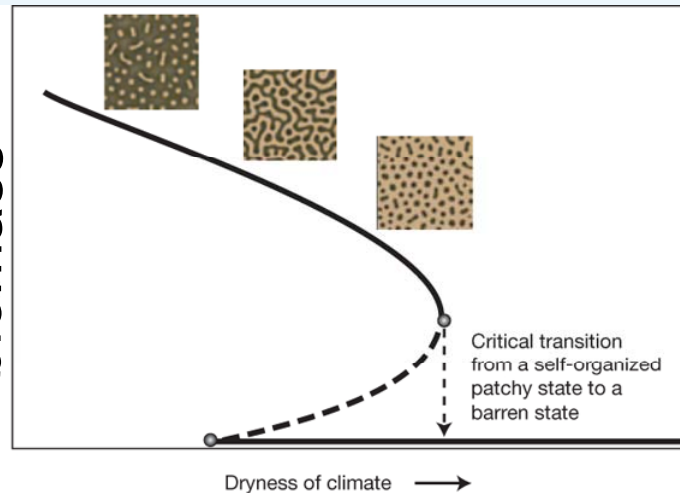


For more information contact Margaret Raza at U.S. Geological Survey, 2255 N. Getchell Road, Flagstaff, AZ 86001, mraza@usgs.gov



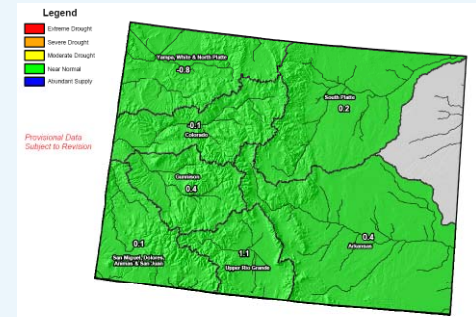
# Landscape changes- Drought Early Warning on Tribal Lands in the Four-Corners Region

Mean vegetation  
biomass



Dryness of climate

(Nature, 2009)



## LOCAL NEWS

Comments 2 | Recommend 0

**Multiple crashes due to wind and dust along I-40**

[More Phoenix Local News](#)

09:21 PM Mountain Standard Time on Thursday, March 26, 2009

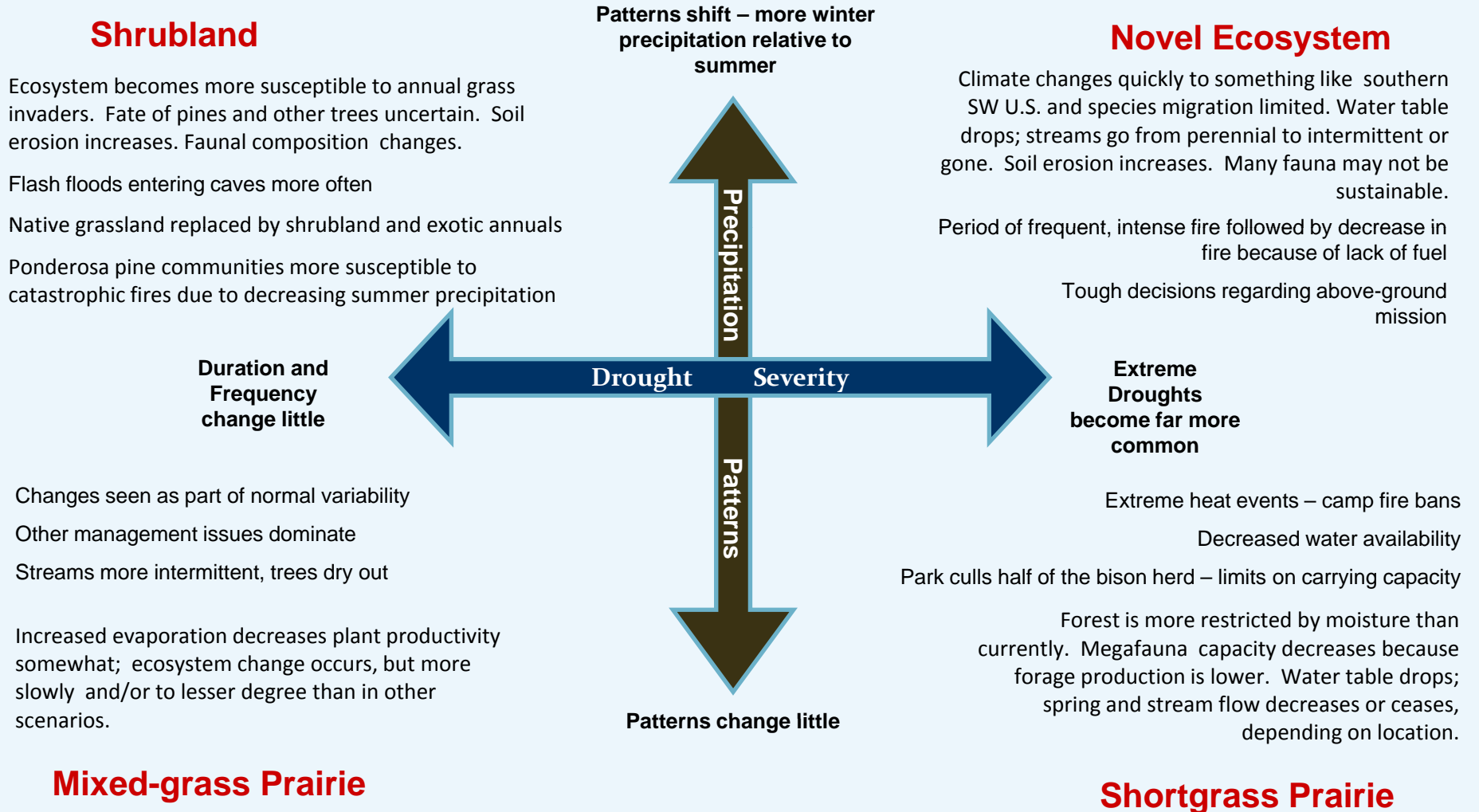
azfamily.com

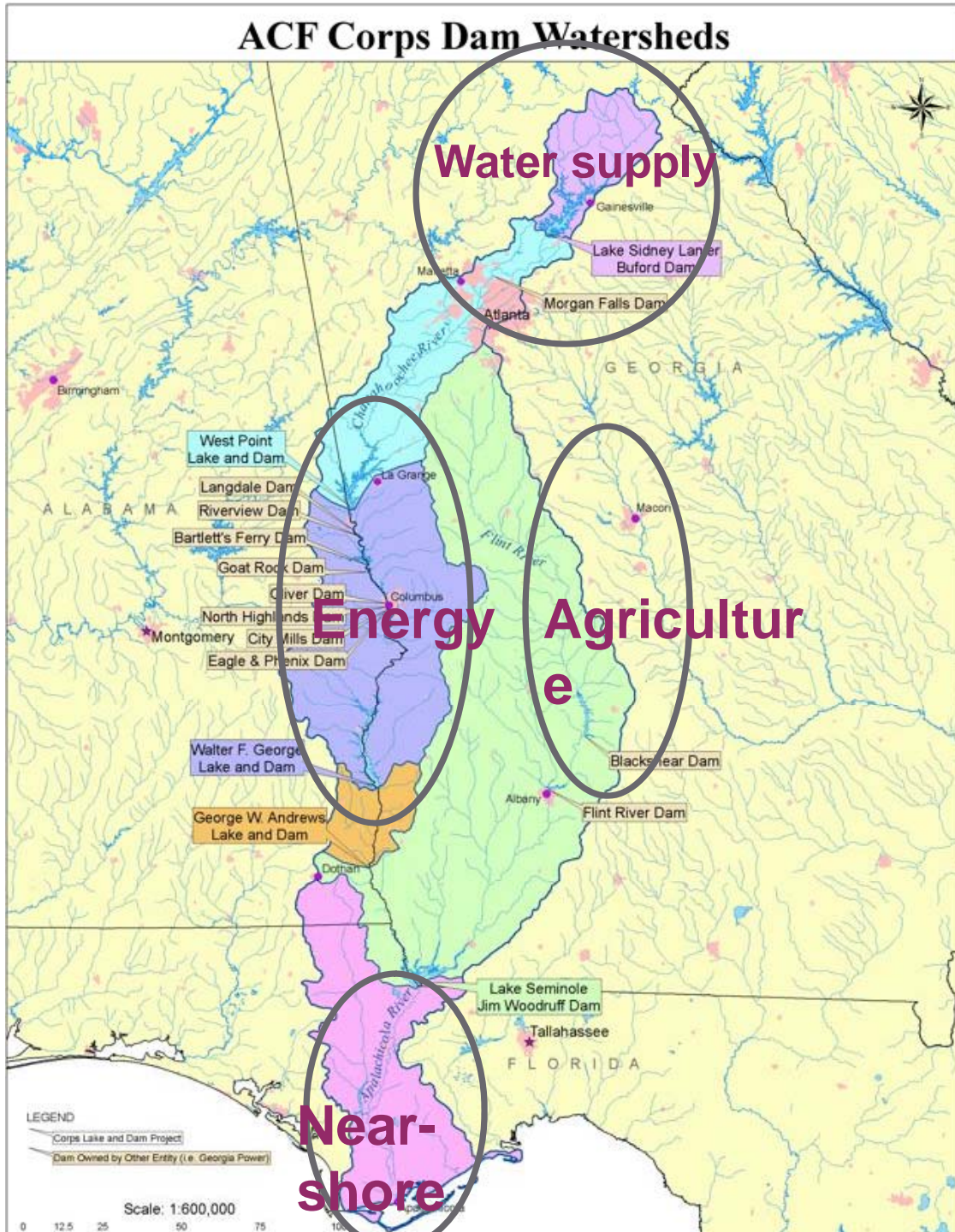
WINDY CLIM - A dust storm



# Co-produced Scenarios: Navajo Lands

Through conversations before and during workshops, the team identified the most important and most uncertain climate drivers that will affect conditions over the next 40 years. These were combined in the following matrix. (Also note that temperature increase was a 'given' so it applies in all scenarios)





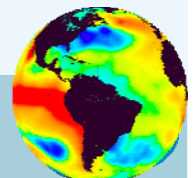
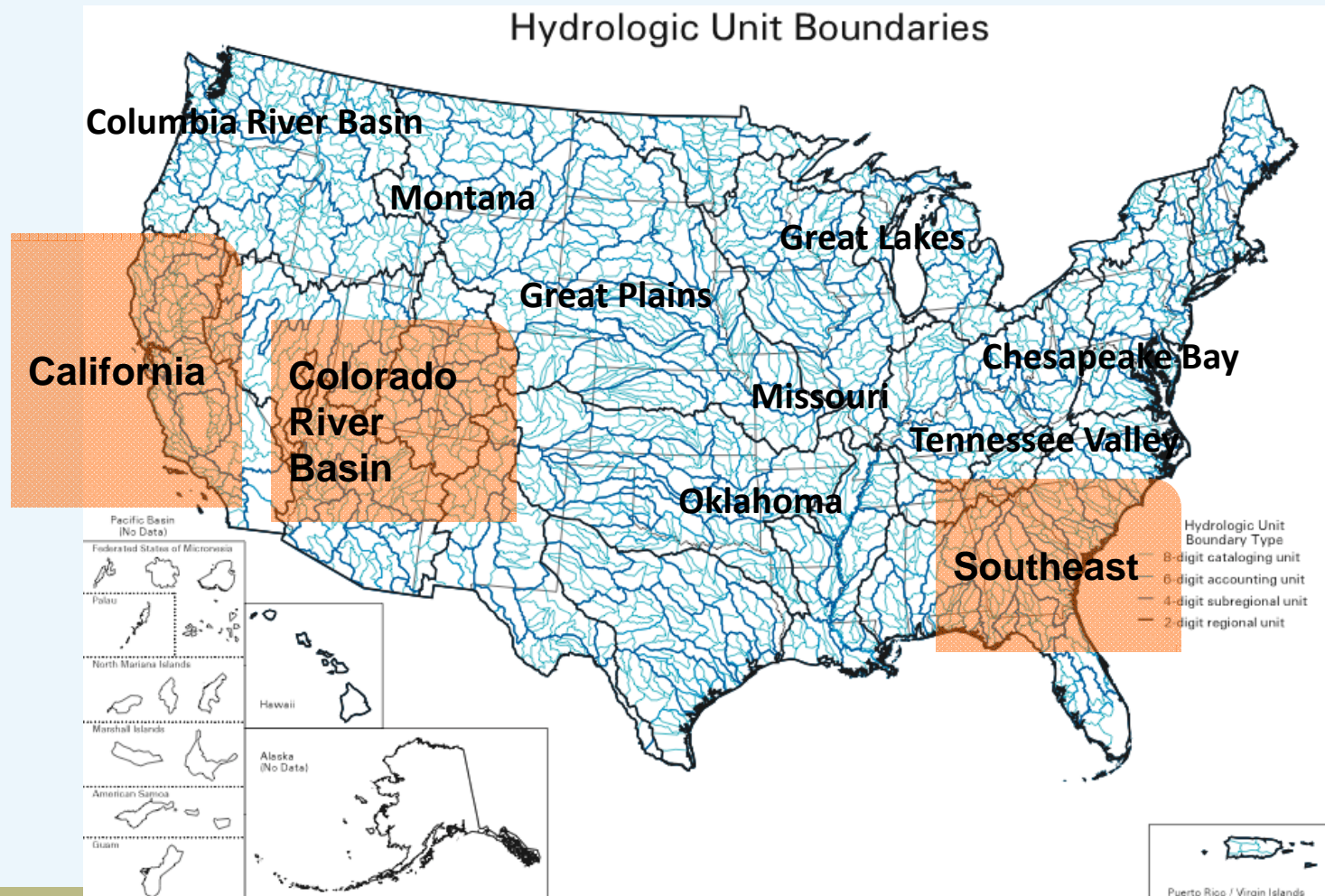
Apalachicola-  
Chattahoochee-Flint  
Basin



# Regional Drought Early Warning Systems

Highlighted-first round prototypes;

Non-highlighted-second round Regional DEWS



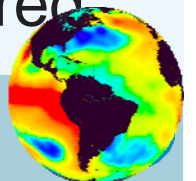


## The development phase or regional drought early warning information systems:

Information-integration, diffusion, use, evaluation

- Allows for existing barriers to cross-agency collaboration to be addressed
- Innovations and new information to be introduced and tested, and
- The benefits of participation in design, implementation and maintenance to be clarified

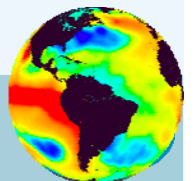
Mature prototypes becomes the regional system.  
Lessons become more likely to be successfully transferred within or to other as yet underserved regions.



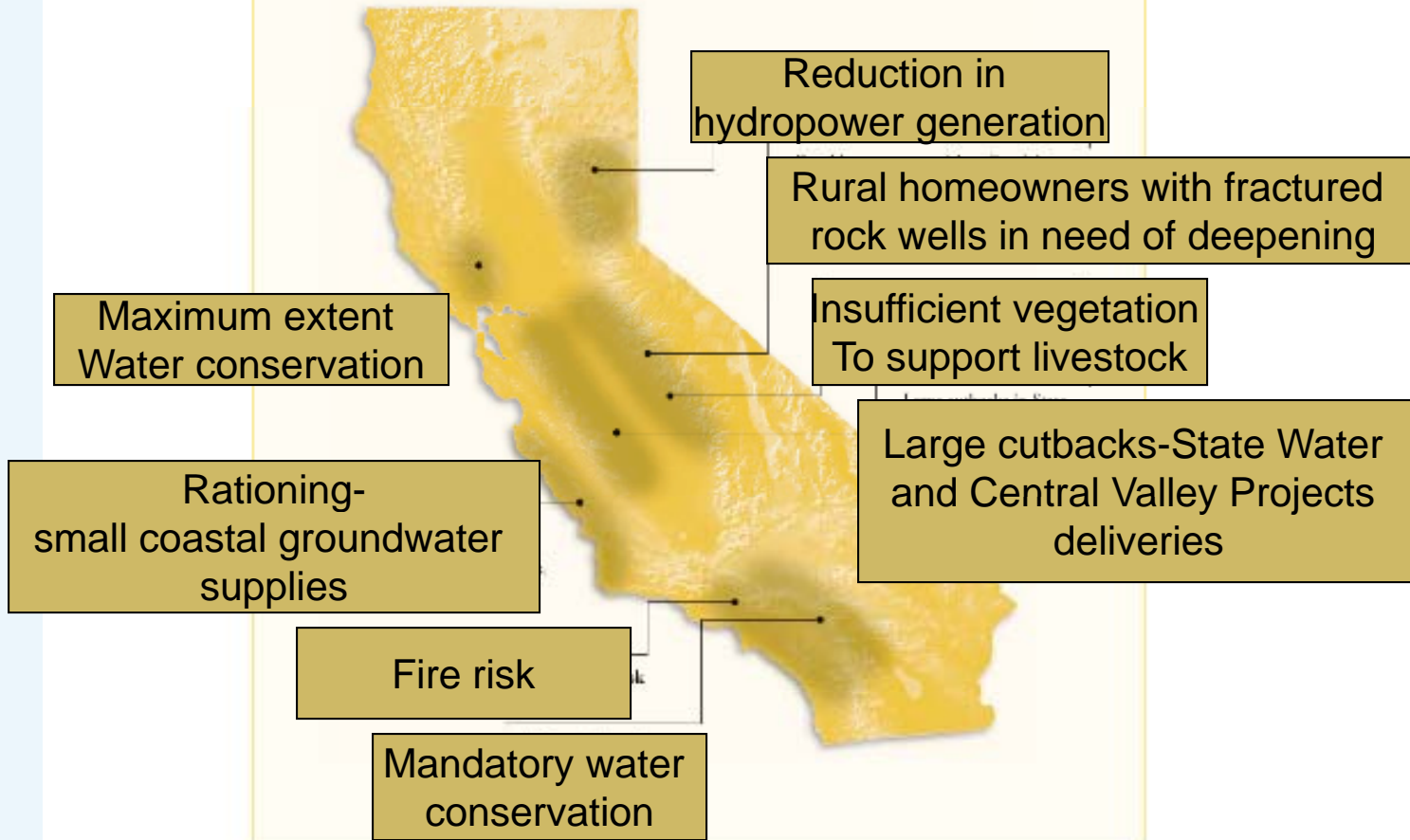




- Identifying appropriate partners, stakeholder representatives
- Setting goals/priorities, and involving partners in problem definition
- Using professionals from relevant agencies etc. to build common ground
- Producing collectively authored gaps assessments
- and agreement on the way forward
- Building longer term collaborative partnerships
- Tradeoffs-Decision quality vs decision acceptability

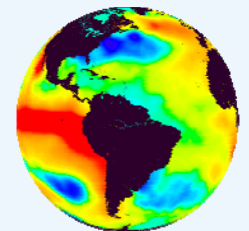
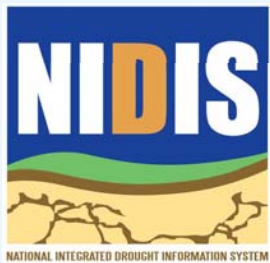


# California- Recent drought impacts



*“We would cite the National Integrated Drought Information System (NIDIS) as one example of how federal agencies can work together and with states .....NIDIS is not perfect yet– but it demonstrates key elements of how....to deliver actionable information to end users and decisionmakers”*

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

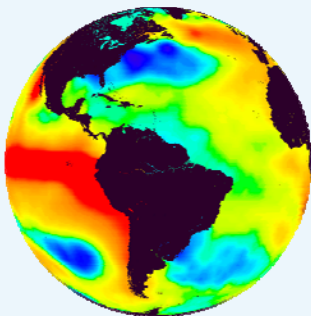


# NIDIS as prototype: Informing climate services development



**“If we don’t get NIDIS right, we can’t get a national climate service right”**

Kelly Redmond, Western Regional Climate Center



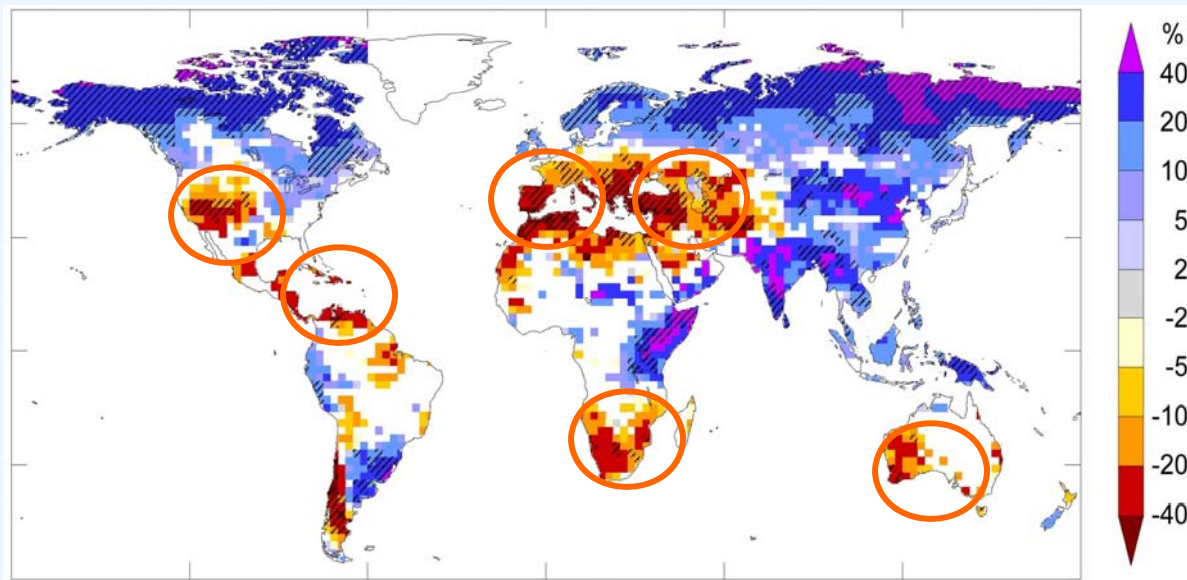
6<sup>th</sup> Drought Monitor Forum  
Austin, Tx Oct. 7-8, 2009



# Need for exchange of experience and learning among different basins

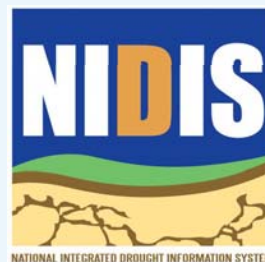
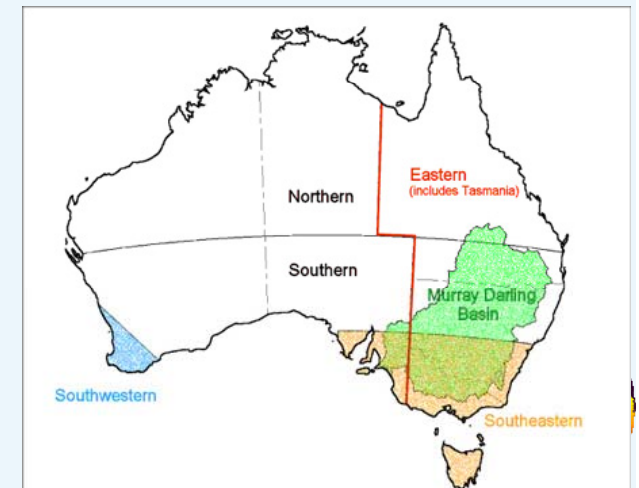
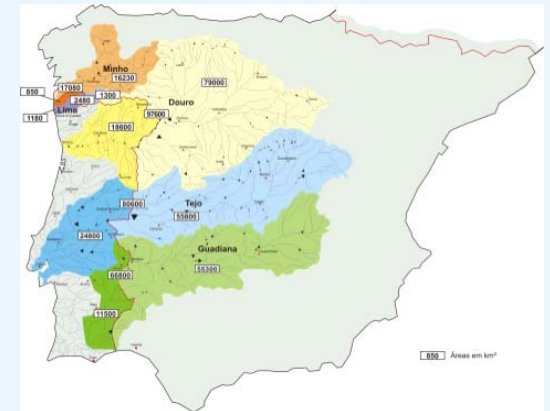
*How is awareness of slow onset problems in the context of seasonal to decadal-scale variability and longer-term change developed ?*

*How are adjustments and adaptations being designed, implemented, and evaluated ?*

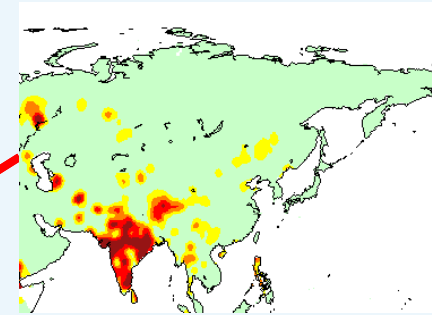
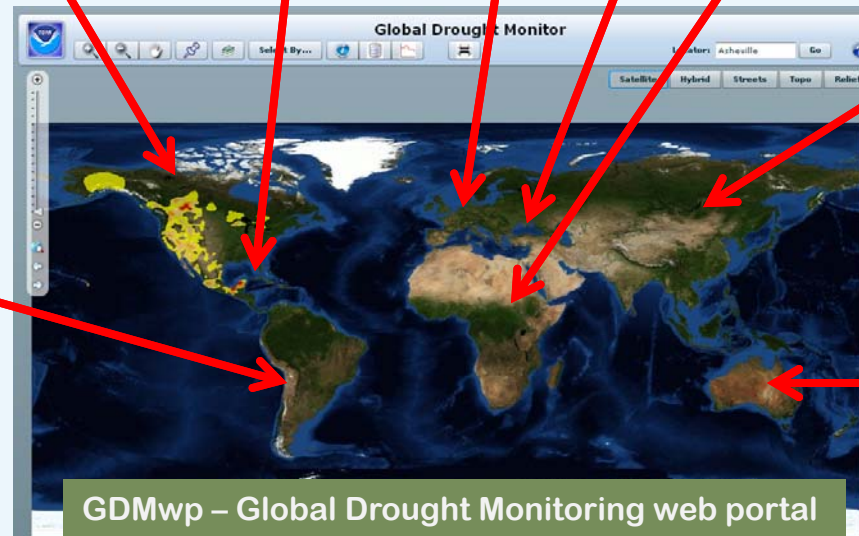
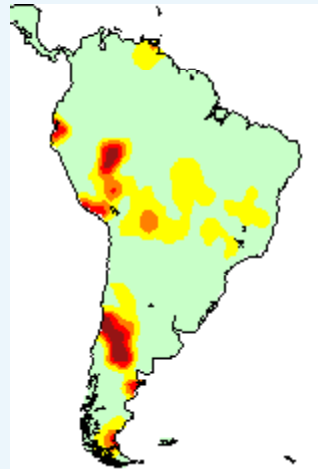
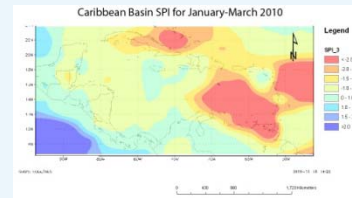
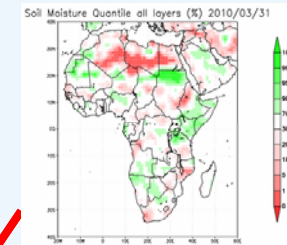
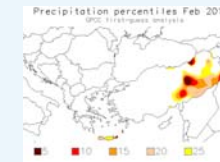
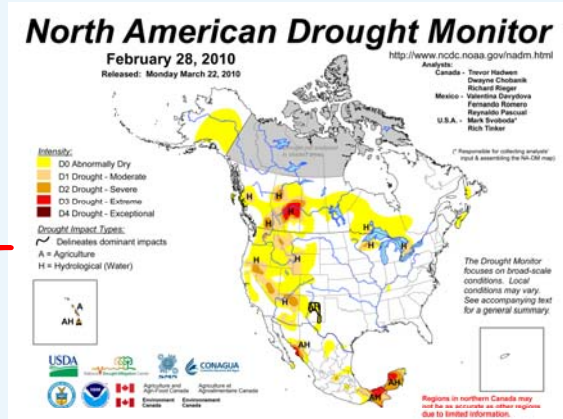
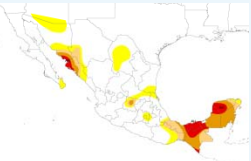
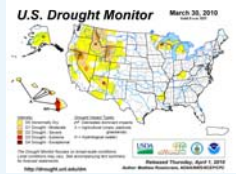
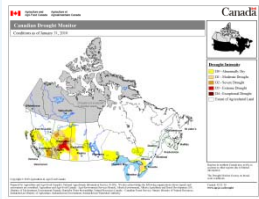


# NIDIS-Transferability

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

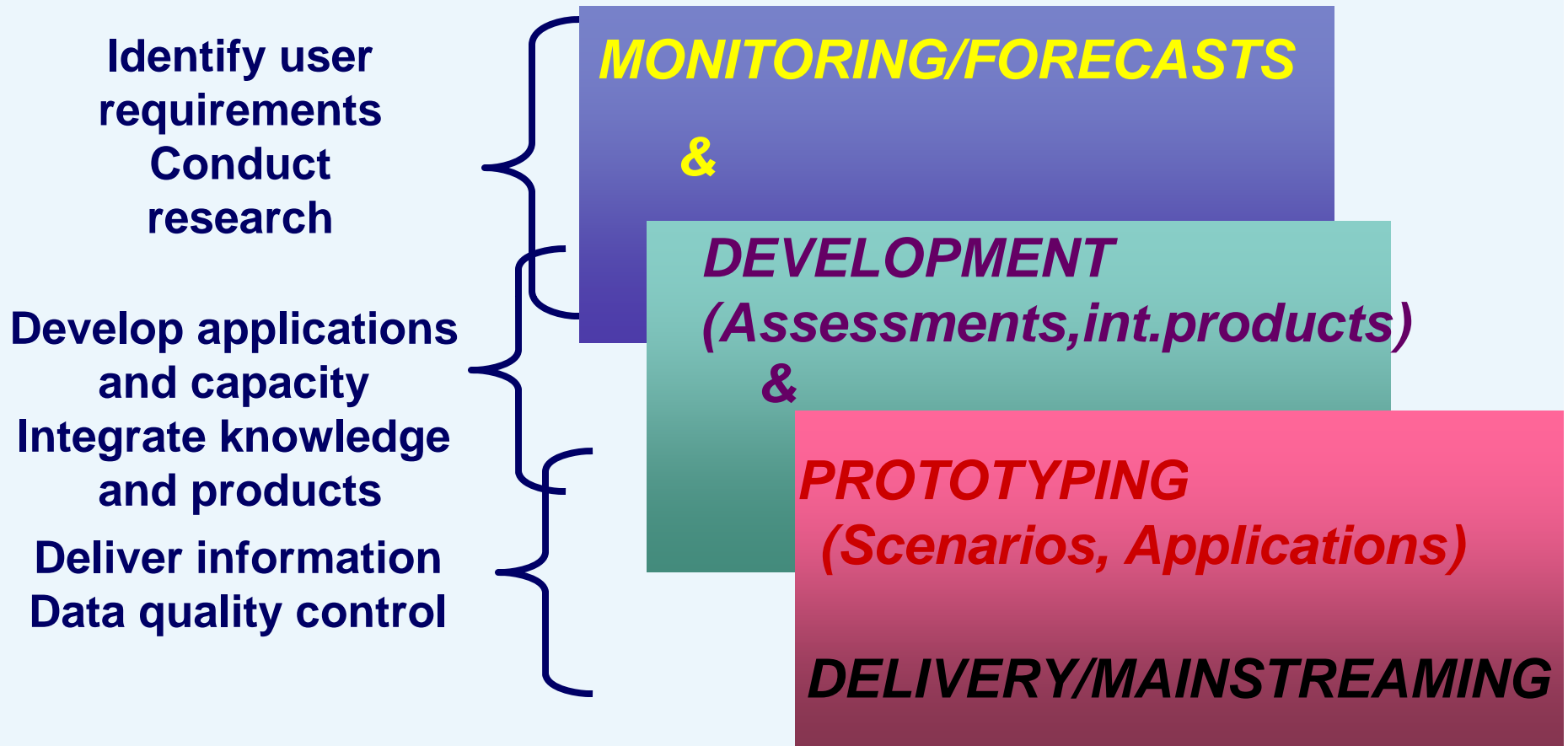


# Global Drought Monitoring Conceptual Framework



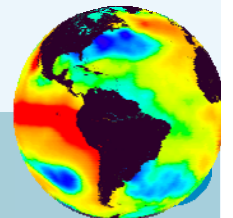


# The "Services" Challenge



Relative status of information

STATIC.....EMERGENT/DYNAMIC







# Watershed transitions



Transitions from applications to adaptation:  
Social-structural and spatial-temporal, resource management

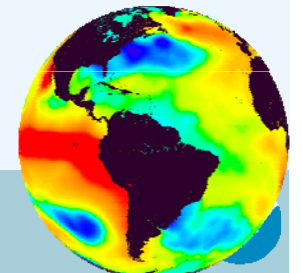
Limits of co-production

Social-ecological

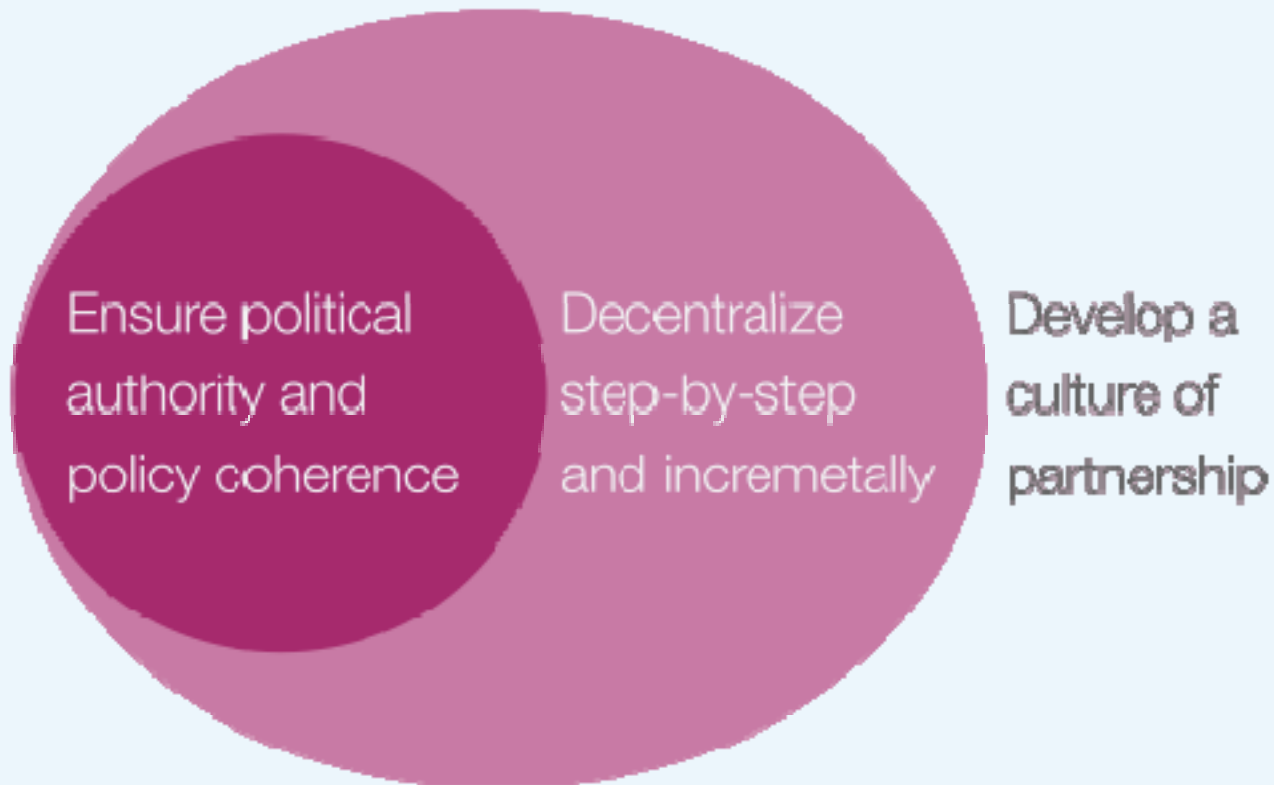
Path dependence

Organizational boundaries

Joint monitoring and joint fact-finding

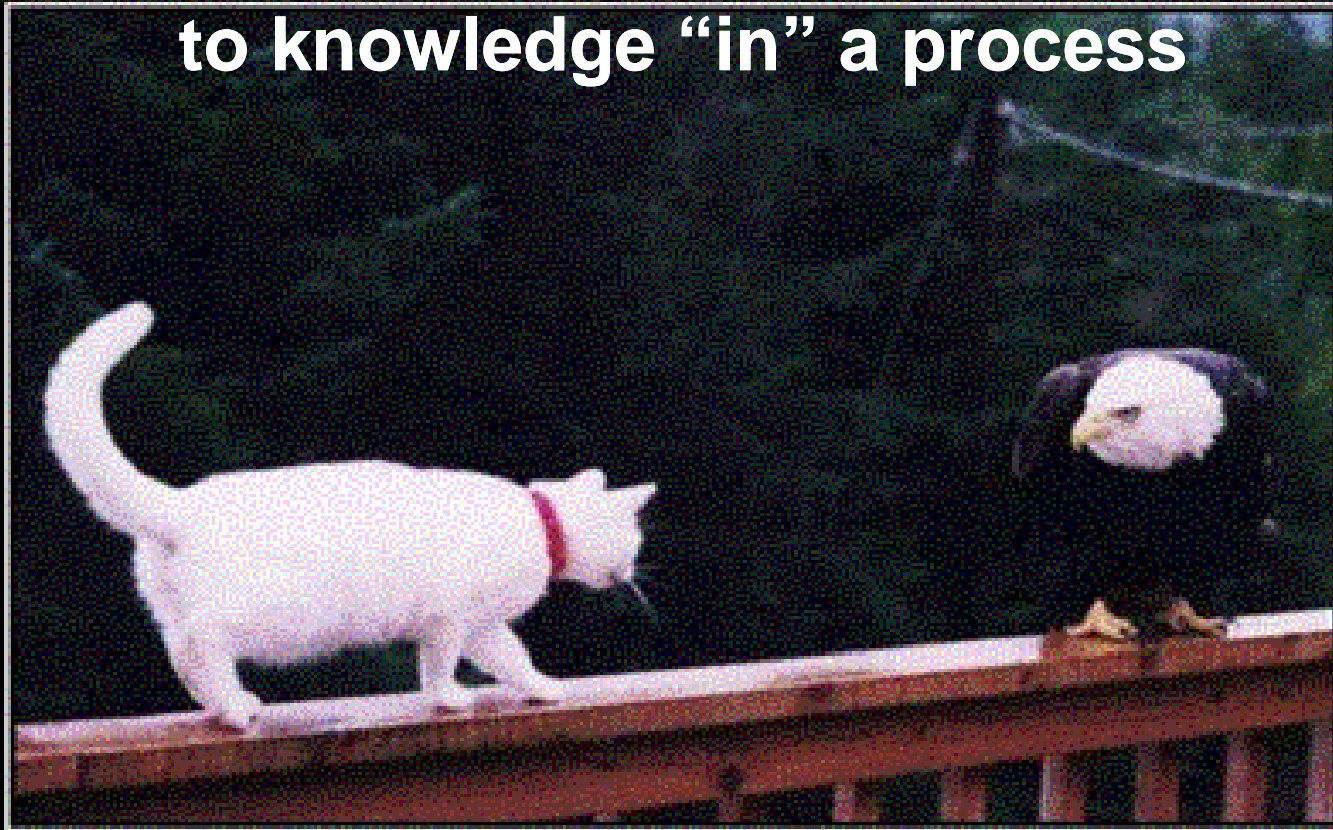


# Risk governance





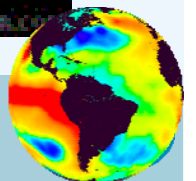
Knowledge "of" a process is not equal  
to knowledge "in" a process



**OVERCONFIDENCE**

This is going to end in disaster, and you have no one to blame but yourself.

DRYDESPACE.COM



# Challenges

- Develop strategic responses to crises: foreseeable, impending, actual; and
- Provide implementable options to critical actors for decision-making

A systemic view would involve assessing:

- Impediments to the flow of knowledge among existing network components
- Policies and practices that can give rise to failures of the component parts working as a system
- Opportunities for and constraints to learning and institutional innovation

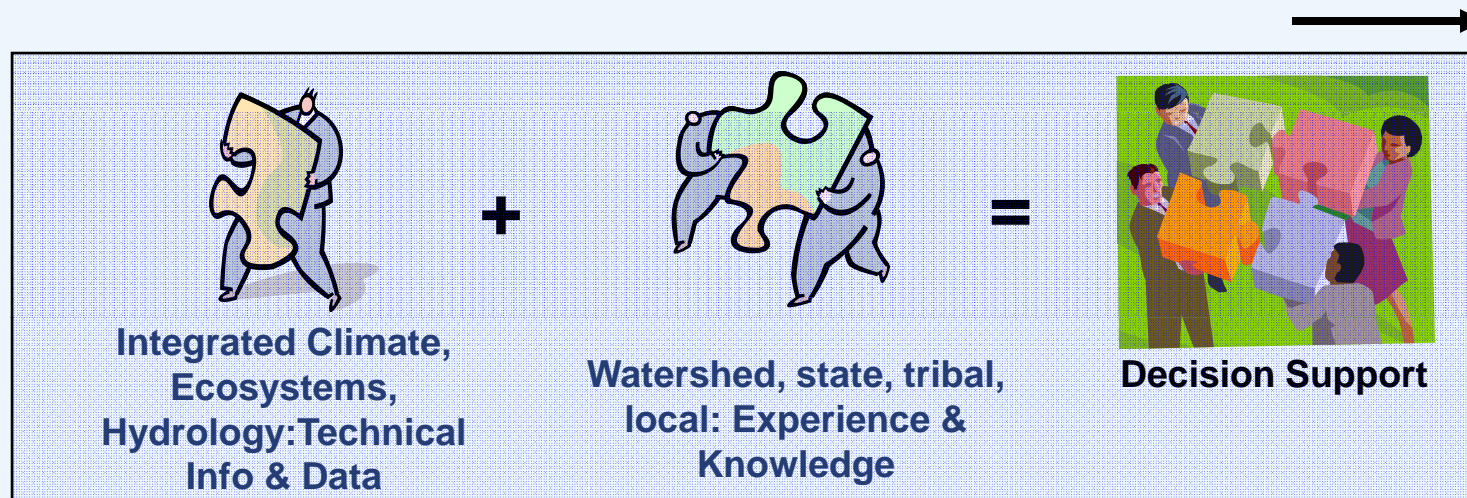


Visit the Global Assessment Report 2011 online:  
[www.preventionweb.net/gar](http://www.preventionweb.net/gar)



# Moving beyond impacts reports- Engaging communities, resources managers in a changing climate

(Federal data, NDMC, RISAs, RCCs, State Climatologists..... **NIDIS**)

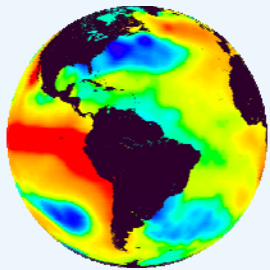


**Climate information:  
Needs, usability, evaluation**  
Entry points for proactive  
Planning-triggers and indicators



**Enabling adaptation:**  
Best available drought risk  
& water supply information  
Input to drought planning,  
preparedness and adaptation

THANK YOU!

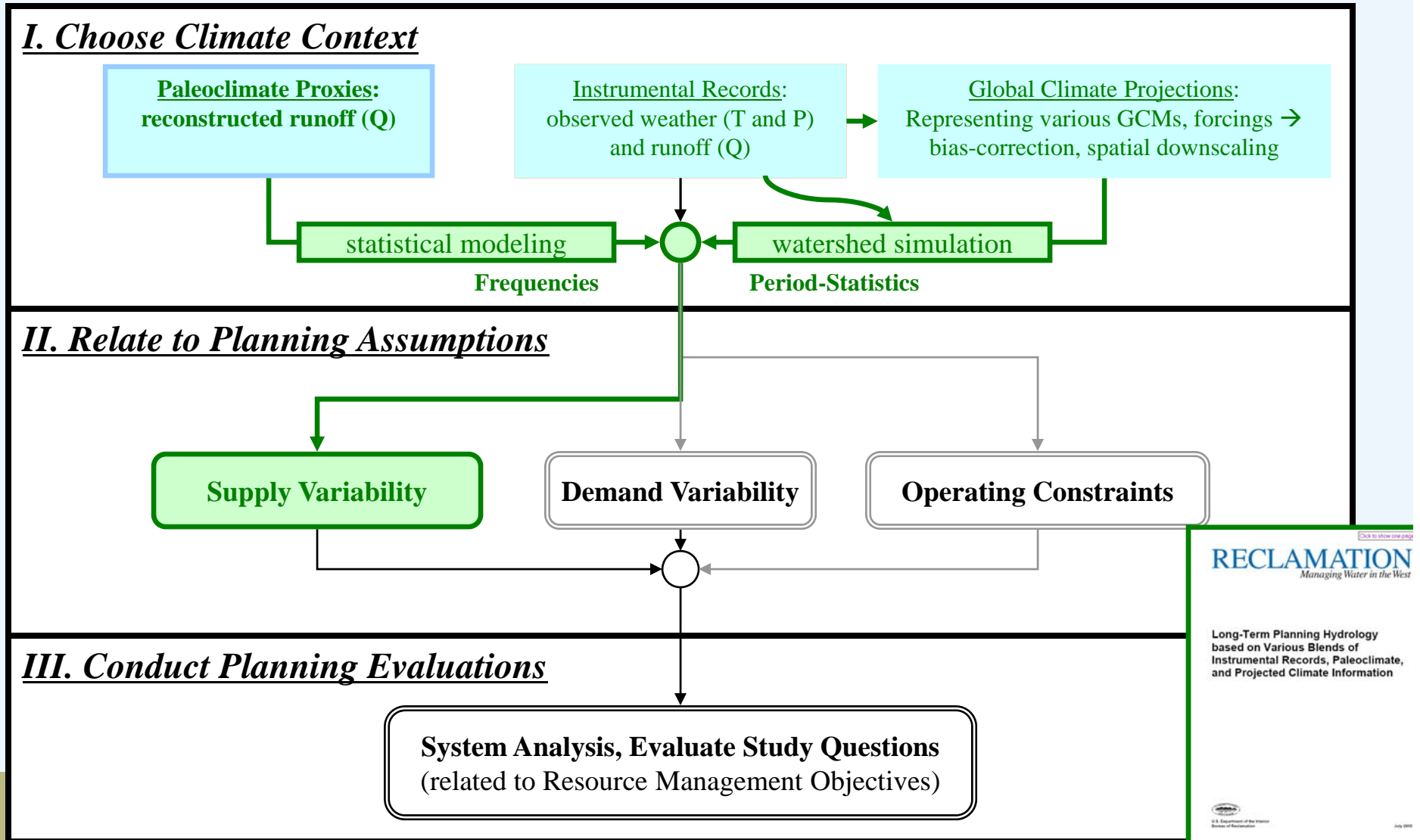


**BACKUP SLIDES**





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





# Challenges in a changing climate

## Assessing progress for each element of planning and implementation

### (i) Capacity and coordination

Priorities for early adaptation action, including land use planning, building design, emergency planning, local infrastructure provision and green space management

### (ii) Decision-making

- Monitoring decision-making is not straightforward
- Wide range of organisations that are relevant to adaptation,
- Sources of evidence here will include: Analysing how climate change is considered in decisions on regionally significant infrastructure projects, in local planning policies and in local development decisions.

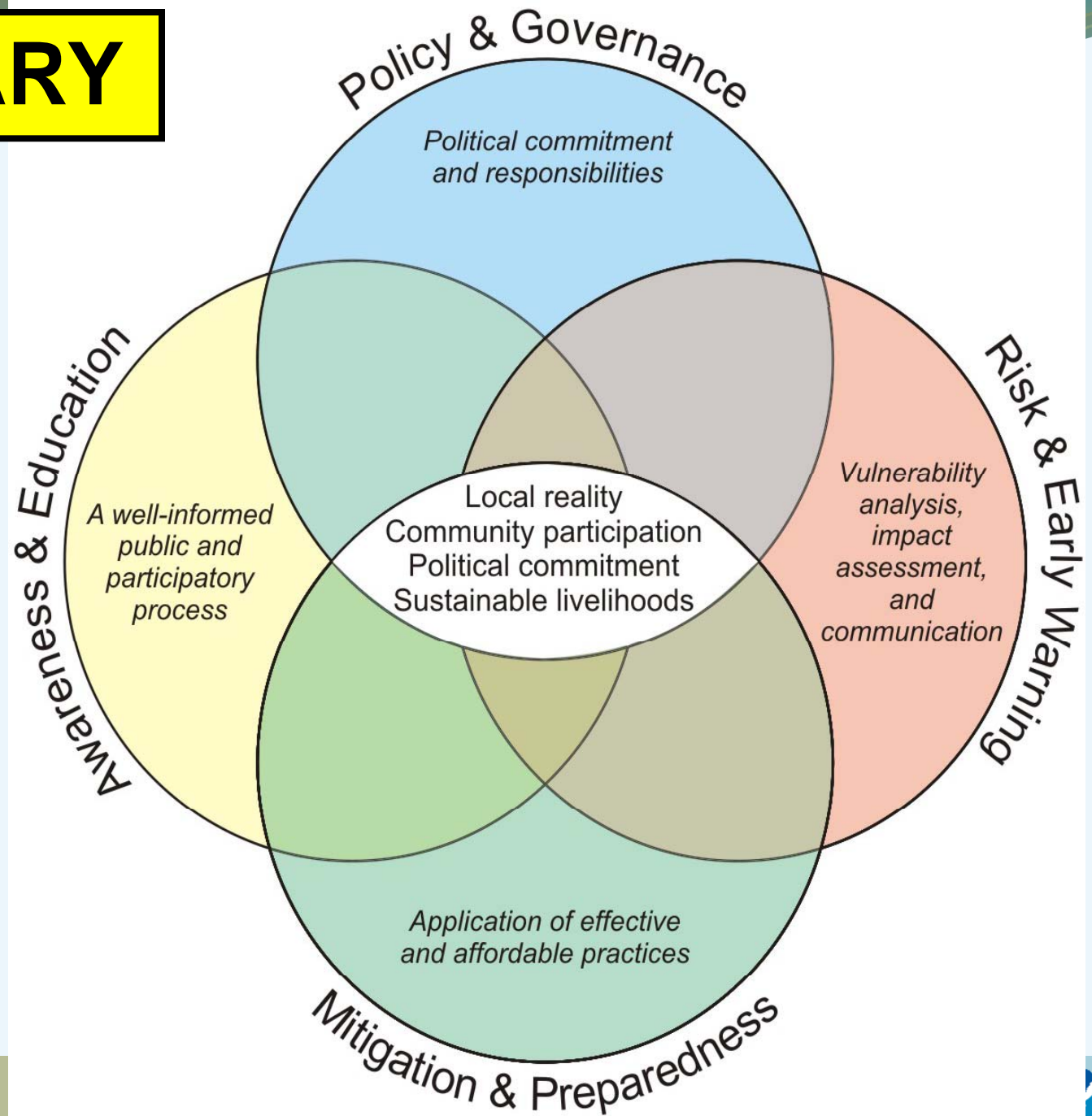
### (iii) Timeliness of action

- depends on regional/local circumstances-surprises
- cost-effectiveness of adaptation measures
- implementation monitoring and evaluation



# SUMMARY

## Principal Elements of Drought Risk Reduction Framework



# Risk Profiles

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

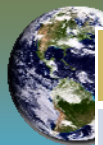


Drought and Water Resources Services

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

NOAA Produces:	With Our Partners:	Used By:
<b>Monitoring and Forecasting</b>		
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



**Type I: Those that are well-known cases from the past where a threshold was reached and the management challenges are explicit.** What lessons are available to learn that are already well documented?

**Type II: Those that are emerging now and often feature aspects of accelerating change** or where the accumulation of small change appears to lead to some large change in management or policy response

**Type III: Those that present very large scale, system-wide challenges.** Type 3 cases are examples where we know the system well enough, or the science well enough, to think that we really ought to be concerned, that there is an important tipping point/or threshold out there

# **Drought Preparedness for Tribes in the Four Corners Region Workshop**

April 8-9, 2010, Flagstaff, Arizona

Tribal perspectives on critical issues

Local Knowledge & Drought: How do we incorporate local knowledge?

What are current vulnerabilities and impacts tied to drought and climate change?

Critical drought-related information needs on tribal lands in Four Corners region

Improved monitoring emerged as the highest priority near-term need





## Revisiting past events with key basin and local decisions

Weekly drought situation assessments-  
webinars presented by key resource reps.  
(coordinated by State Clim. and RFC)

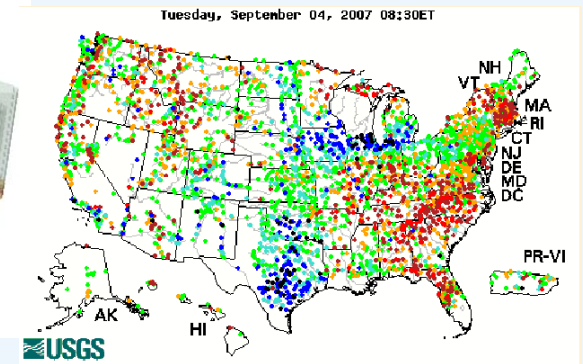
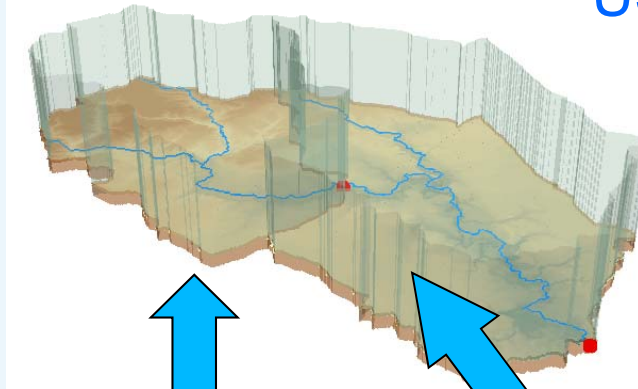
Information inputs into existing drought and  
water resources preparedness and adaptation  
plans

- Gaming scenarios on sensitivity, projections,  
potential surprises-short-term adjustments-long  
term risks
- Modifications of existing plans-prioritized actions

# Connecting geospatial and temporal water resources data

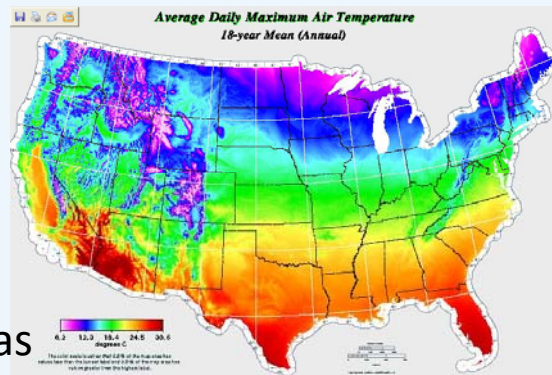
Digital Watershed

USGS NWIS Streamflow

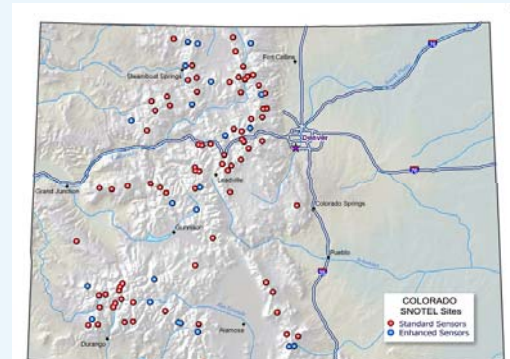


NHDPlus

NOAA NCDC  
and ASOS

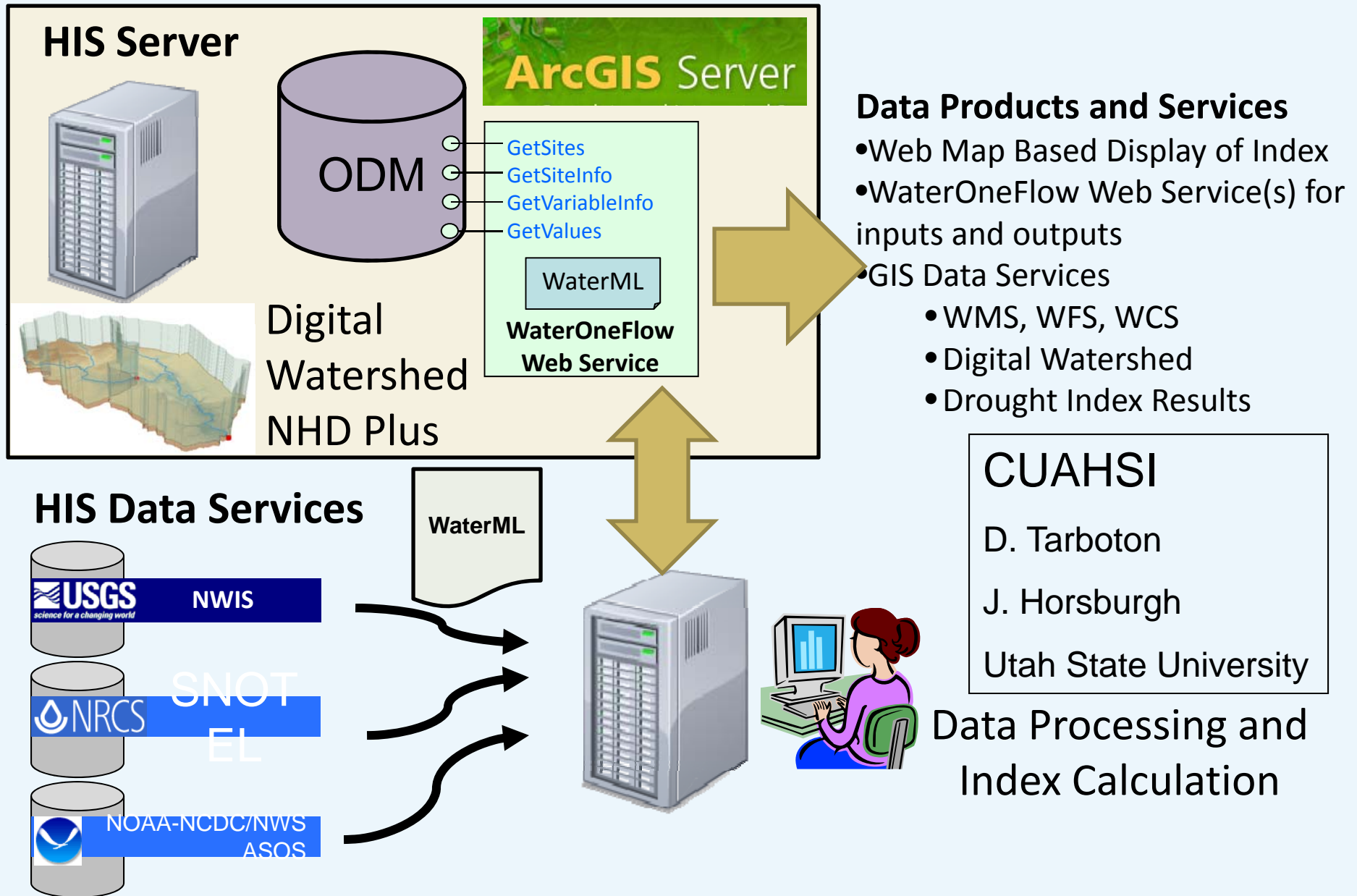


NRCS  
Snotel



David Maidment, U Texas

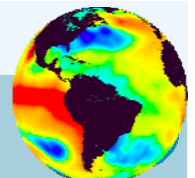
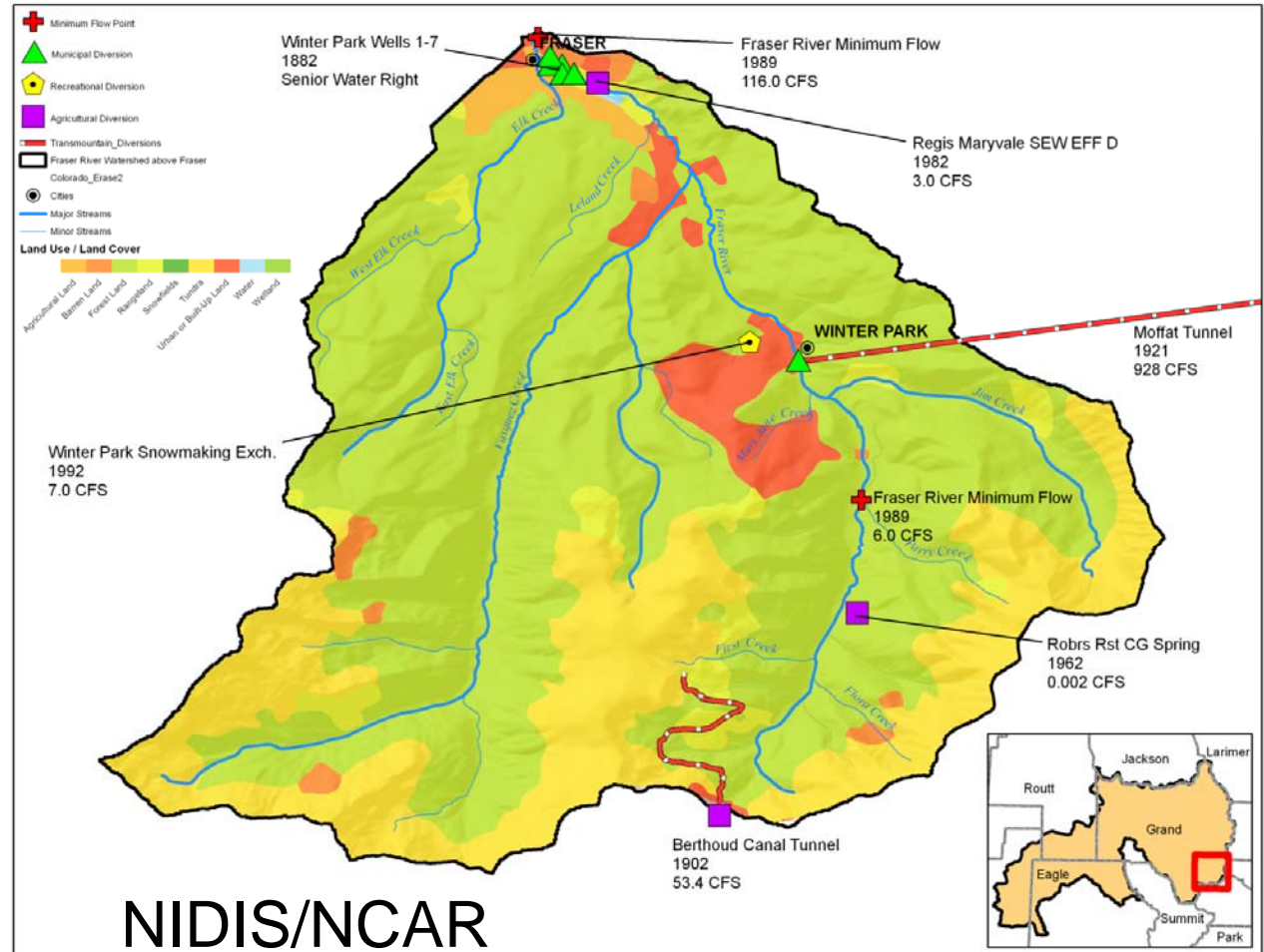
# CUAHSI HIS Custom Drought Index Server





# Upper CO Basin Water Demand Spatial Analysis

Drought vulnerability GIS database that represents relationships among water users and their respective sources of water supply





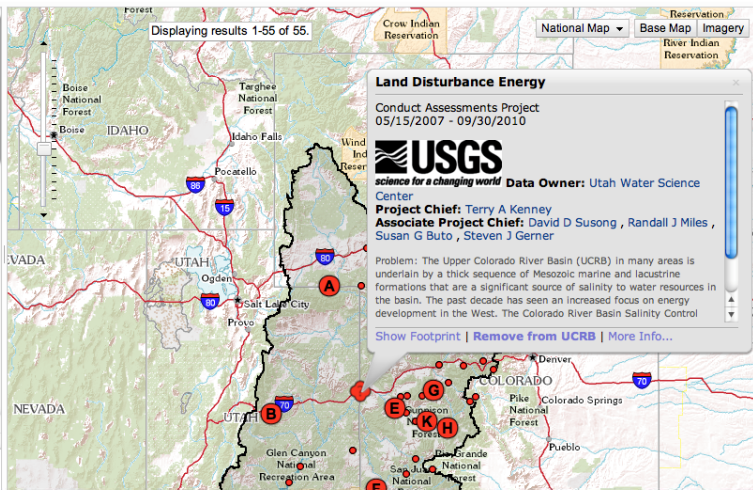
# Data Mining for Water Availability, Ecosystem Change, and Services

USGS ScienceBase-Catalog: Search | Virtual Catalogs | Admin bristol@usgs.gov | Help | myUSGS | Logou

## Projects

Filter: Item Type is BASIS+ Project (remove)

- A** [Salt Loading Manila Green River - Project](#)  
Removes from UCRB - [More Info](#)  
Project  
Numerous international, federal and state laws and agreements govern the distribution of water in the...
- B** [Muddy Creek Salinity Investigations - Project](#)  
Removes from UCRB - [More Info](#)  
Project  
Levels of dissolved solids (salts) in the Colorado River and its tributaries have increased over time as...
- C** [Land Disturbance Energy - Project](#)  
Removes from UCRB - [More Info](#)  
Project  
Problem: The Upper Colorado River Basin (UCRB) in many areas is underlain by a thick sequence of...
- D** [Upper Colorado River Basin Irrigated Lands Mapping - Project](#)  
Removes from UCRB - [More Info](#)  
Project  
Irrigation in arid environments can alter the natural rate at which salts are dissolved and



## Portal development sponsored by USGS Climate Effects Network and NIDIS

## Publications

Authors	Title	Year	Published In
Albert, Steve	Collared peccary range expansion in northwestern N...	2004	The Southwest...
Alfaro, Eric J.	Prediction of summer maximum and minimum te...	2006	Journal of Climate
Allen, J R L	Fining-upwards cycles in alluvial successions	1964	Geological Journal
Allen, Julia A.	Non-native plant invasions of United States National Parks	2008	Biological Invasions
Allred, TM; Sc...	Channel narrowing by vertical accretion along the Green Ri...	1999	Geological Society of ...
AMMERMAN, ...	Biochemical genetics of endangered Colorado squa...	1989	Transactions of the Ame...
Amundsen, M.	Uncle Sam and the yellowcake towns: The effects of feder...		
Andelt, Willia...	Long-Term Trends in Mule Deer Pregnancy and Fetal R...	2004	Journal of Wildlife Ma...
Andelt, Willia...	Occupancy of Random Plots by White-Tailed and Gunnis...	2009	Journal of Wildlife Ma...
Andersen, Do...	Characterizing flow regimes for floodplain forest conserva...	2005	Canadian Journal of F...
Andersen, Do...	Dams, floodplain land use, and riparian forest conserva...	2007	Environmenta Management
Andersen, Do...	Movement Patterns of Riparian Small Mammals dur...	2000	Journal of Mammalogy
Anderson, Da...	Factors Influencing Development of Cryptogami...	1982	Journal of Range Man...
Anderson, R S	Middle- and late-Wisconsinan	2000	Palaeogeograph...

## People

**Beth Middleton, Ph.D.**  
Research Ecologist, National Wetlands Research Center, USGS Lafayette, Louisiana, United States

**Publications**

- Book (1)  
Beth A Middleton (1999) *Wetland restoration, flood pulsing and disturbance dynamics*. In Wiley, New York. [books.google.com/books?id=Zv\\_ajg7dtM8...](https://books.google.com/books?id=Zv_ajg7dtM8...)
- Journal Article (3)  
Middleton Beth A (2009) *Regeneration of coastal marsh vegetation impacted by Hurricanes Katrina and Rita*. 54-60. In *Wetlands*. [www.dioneone.org/doi/pdf/10.1672/08-18.1](http://www.dioneone.org/doi/pdf/10.1672/08-18.1)
- All Publications  
[http://profile.usgs.gov/professional/...](http://profile.usgs.gov/professional/)

**Publication Statistics**  
Graphed by cumulative total  
All Time | Past Year | Past Month | Past Week  
Page views (1) | Downloads (0) | Readers (0)

**2 Contacts**  
Joseph Stachelek | John David

**Public Collections**  
Beth's Public Collections  
No public collections created yet.  
Read [how to create your own public collections](#).

**Awards and Grants**  
No awards or grants added yet.



# 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

**1. Historical Database Development**

**Satellite Data**

**Climate Data**

**Biophysical Data**

**Data Input Variables**

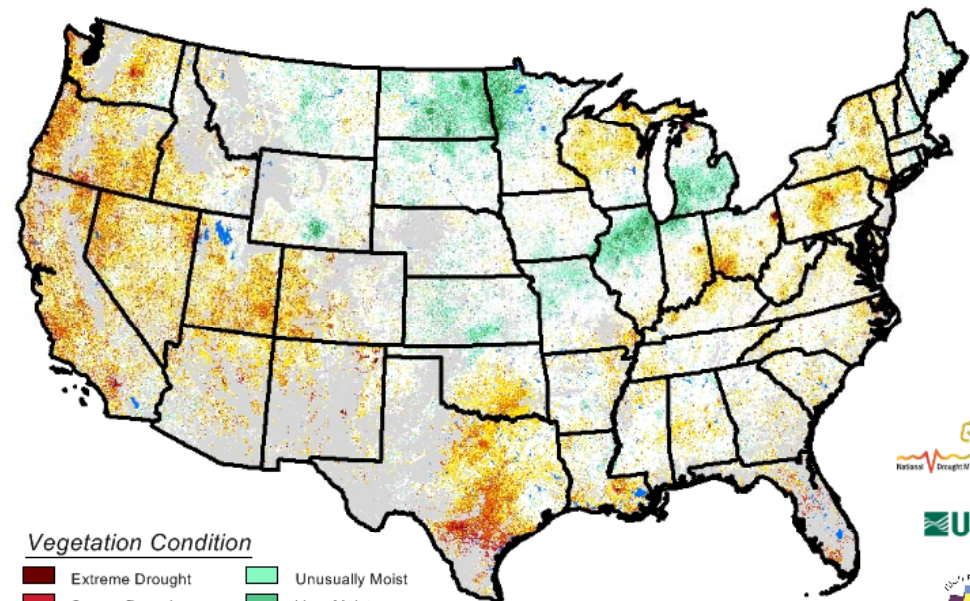
- 1) Percent Annual Seasonal Greenness (PASG)
- 2) Start of Season Anomaly (SOSA)
- 1) Palmer Drought Severity Index (PDSI)
- 2) Standardized Precip. Index (SPI)
- 1) land use/ cover type
- 2) soil available water capacity (STATSGO)
- 3) ecoregion type
- 4) irrigation status
- 5) elevation

(Source: Wardlow, 2008)

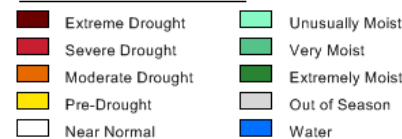
[http://drought.unl.edu/vegdiri/VegDRI\\_Main.htm](http://drought.unl.edu/vegdiri/VegDRI_Main.htm)

Vegetation Drought Response Index  
Complete

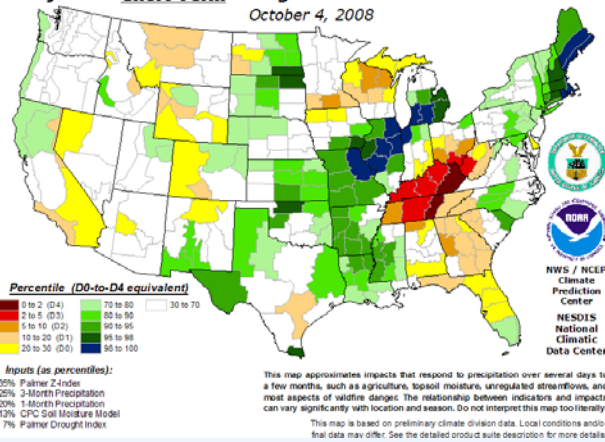
May 4, 2009



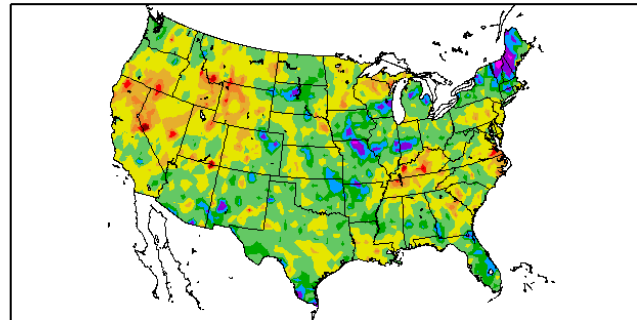
Vegetation Condition



**Objective Short-Term Drought Indicator Blend Percentiles**  
October 4, 2008



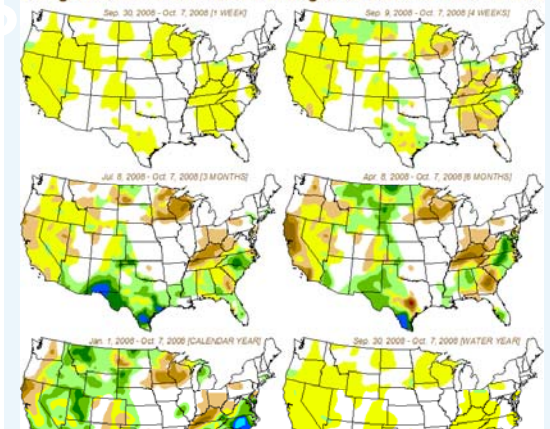
**3-Month SPI**  
6/1/2008 - 8/31/2008



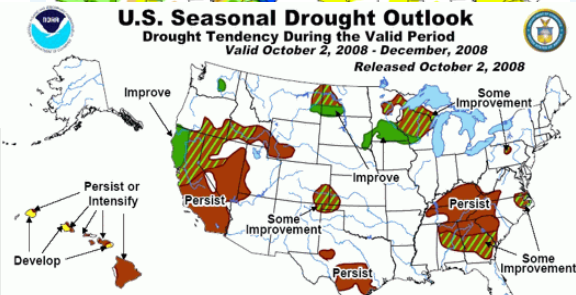
Generated 9/2/2008 at HPRCC using provisional data.

National Drought Mitigation Center

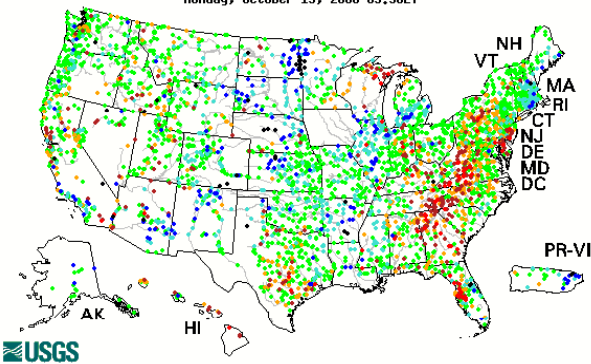
**Drought Monitor Classification Changes for Selected Time Periods**



**U.S. Seasonal Drought Outlook**  
Drought Tendency During the Valid Period  
Valid October 2, 2008 - December, 2008  
Released October 2, 2008

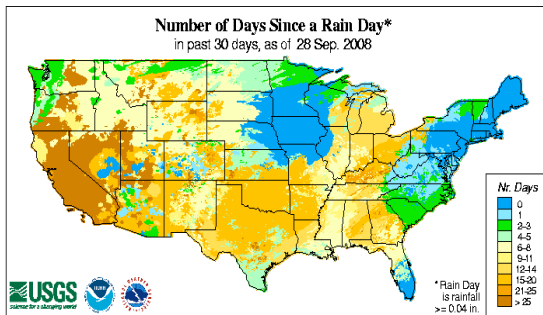


Monday, October 13, 2008 03:30ET



USGS

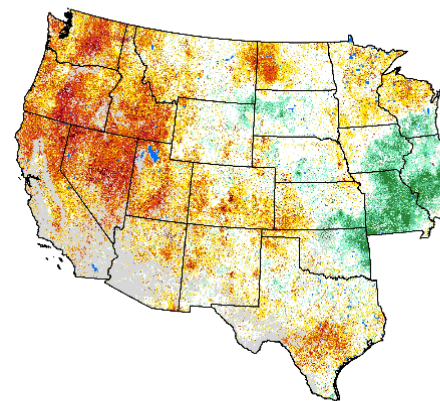
**Number of Days Since a Rain Day\***  
in past 30 days, as of 28 Sep. 2008



USGS  
National Drought Mitigation Center

**Vegetation Drought Response Index**  
Complete

September 22, 2008



**Vegetation Condition**

- Extreme Drought
- Severe Drought
- Moderate Drought
- Pre-Drought
- Near Normal
- Unusually Moist
- Very Moist
- Extremely Moist
- Out of Season
- Water

USGS

National Drought Mitigation Center  
RMA

... with more tools on the way!

**Drought Impact Reporter**

National Drought Mitigation Center  
View Drought Impacts | Add A Drought Impact | Time-Lapse Animation | About | Help | User Login

**Map Options**  
Impact Categories:

- Agriculture
- Water/Energy
- Environment
- Fire
- Social
- Other

Source: All Sources  
Time Period: Last Month  
Submit

Show Drought Monitor Layers

**Legend**

- No reported impacts
- 1 - 13 reported impacts
- 14 - 26 reported impacts
- 27 - 38 reported impacts
- 39 - 51 reported impacts
- 52 - 64 reported impacts

Instructions: Click on a state to see the reported drought impacts that affect that state.



# Drought information and Resource Management: optimizing risk reduction

## Hydropower Decision Calendars

## Municipal & Industrial Decision Calendars

## Aquatic Ecosystems Decision Calendars

## Outdoor Recreation Decision Calendars

## Agriculture Production Decision Calendars

## Reservoir Management Decision Calendar

Water Year Planning → Next Water Year Planning

Provide for late Summer/early Fall irrigation while maintaining target flows

Next water year runoff unknown, reserve water until February snowpack data

Winter season precipitation forecast for Fall release decisions

Winter releases based on Jan/Feb snowpack data

Winter/Spring forecast for Winter release decisions

Peak Flow Augmentation --- fill curve

Summer season forecast for Peak Augmentation planning

Week 2 forecasts for Peak Augmentation

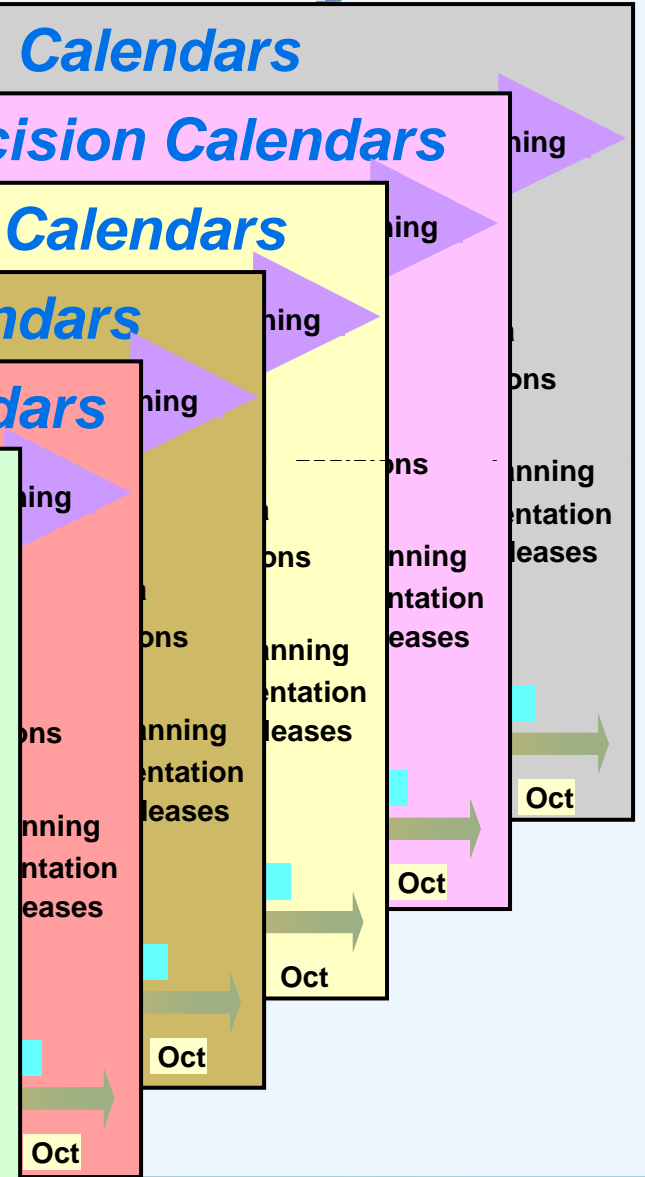
Peak Flow Augmentation releases

Plan releases for Summer irrigation & hydropower

Week 2 forecasts for Summer irrigation & hydropower release decisions

Provide for Summer irrigation & hydropower needs while maintaining target flows

Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun July Aug Sep Oct



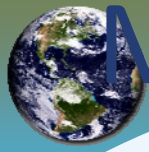


## Regional Drought Early Warning System Upper Colorado River Basin

Given better data and information coordination, would responses have been improved for past events?

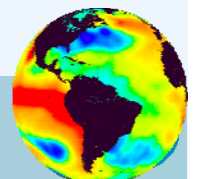
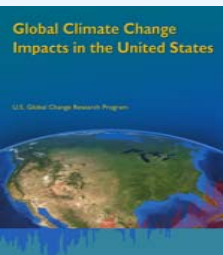
Assess:

1. Value of improved information using past conditions
2. Responses for projections/ scenarios(decadal, climate change)
3. Feedback on priorities (e.g. data gaps) to Interagency Executive Council



# Managing in a changing climate: Adaptation needs

- (1) Understand adaptation as being driven by crises, learning and redesign- Role of “surprises” in shaping responses
- **Human action in response to projections is reflexive**
  - **Key drivers, such as technological innovation and change, are unpredictable with great accuracy on scales that matter for regional and local decisions-both pressures and solutions**
  - **The system may change faster than the models can be recalibrated, particularly during turbulent periods of transition-Projections may be most unreliable in precisely the situations where they are most desired**
  - **Inactions, actions and consequences**





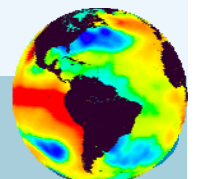
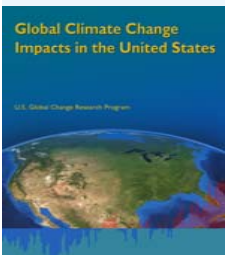
# Adaptation needs-

(2) Early warning systems for critical thresholds across climate time and space scales: Extremes in the context of change

(3) Derive risk profiles and a portfolio of measures for each location/unit of analysis, identifying the broader economic, social and environmental benefits of each measure along with its cost

Methodological developments:

- Cost-effectiveness-costs of action and of inaction
- Technological Efficiency: Drivers of adoption
- Renewables: Viability and offsets
- Evaluation: Infrastructure vs emergent events





Science for adaptation-

## Sustain a collaborative framework between research and management -

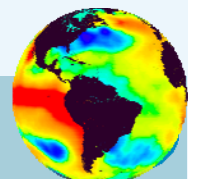
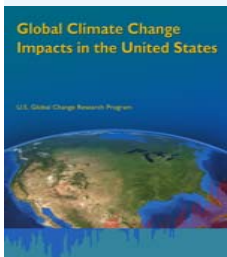
Engage both leadership and the public

Scenario planning to address problem-definition and characterize multiple uncertainties

Prioritize and select climate adaptation and resilience measures and revise periodically

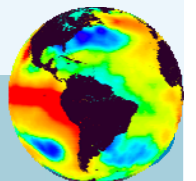
(extremes, variability and change) and development

- Assumptions-e.g. climate knowledge, forecasts of socio-economic trends and drivers of growth
- Effectiveness- Short-term adjustments/coping that constrain or enable longer-term risks
- Benefits-adaptation in support of development goals
- Limits-to adaptation e.g. ocean acidification





**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**





# 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

