Drought, Thresholds and Early Warnings

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Are the assumptions about planning borne out by what we know from the climate record and for projected conditions?

Many potential futures
Observed Global Changes—What is in the data

- **Specific Humidity**
  - 3 Datasets

- **Air Temperature Near Surface (Troposphere)**
  - 7 Datasets

- **Glaciers (Glacier Mass Balance)**
  - 4 Datasets

- **Temperature Over Oceans**
  - 5 Datasets

- **Snow Cover (March-April, Northern Hemisphere)**
  - 2 Datasets

- **Sea-Surface Temperature**
  - 7 Datasets

- **Sea Level**
  - 7 Datasets

- **Sea-ice**
  - 3 Datasets

- **Ocean Heat Content**
  - 7 Datasets

- **Land Surface Air Temperature Over Land**
  - 5 Datasets
Climatic drivers of drought—a continuum

Droughts span an enormous range of time scales
Droughts are caused by a number of complex variables—land surface feedbacks

Heat Waves
Floods
Storm Track Variations
Madden-Julian Oscillation

El Niño-Southern Oscillation

Decadal Variability
Solar Variability
Deep Ocean Circulation
Greenhouse Gases

30 DAYS
1 SEASON
3 YEARS
10 YEARS
30 YEARS
100 YEARS

SHORT-TERM
INTERANNUAL
DECADE-TO-CENTURY
Interannual (precipitation)

Decadal Trend (20th Century)
The Colorado River Basin: Two perspectives on the same drought(s)

- Operation governed by the “Law of the River” including:
  - Colorado River Compact (1922)
  - Boulder Canyon Project Act (1928)
  - U.S.-Mexico Water Treaty (1944)
  - Colorado River Storage Project (1956)
  - Colorado River Basin Project Act (1968)

- “Closed” water system
- Very variable hydrology
- Large amount of storage capacity
Colorado Drought:

- Maximum snowpack on 2002 at 56% of average. Complete meltout 48 days earlier than average.

- Precipitation deficits have persisted throughout most of the decade (some good years such as 2011).
Colorado River Water Supply & Use

10-Year Averages from 1923 to 2006

Streamflow

Demand

750-2005

Some droughts in the past have been more severe and longer-lasting than any in the last century.
I. The Colorado Basin—An innovation in “adaptation” interim through 2026

Spatial Resolution/Time Horizon

- International-Regional over Decades
- Region-wide over 1-2 years
- Sub-basin over 4-6 weeks
- Single project over 1-7 days

Operational Activity

- Long-term Planning
- Mid-term Operations
- Short-term Scheduling
- Real-time Control

Decisions

- Operating Criteria and Guidelines
- Annual Operating Plan
- Water and Power Schedules
- Automatic Generation and Control
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

Relating Drought Indices to management
Irrigation diversions

Water diversions

Acf diversions per acre

PDSI

SPI 12mth

2012 UR Forum Mapping Global Risk
Another Perspective: Drought and Climate Change on the Diné/Navajo and Hopi Nations and the Four Corners Region

Native Nations in Southwest US are major land managers

Regional Characteristics

Reservation history and local land tenure

Drought and climate change: Thresholds

2012 UR Forum Mapping Global Risk
Navajo/Dine and Hopi (rain-fed) Homelands

North American Drought Monitor
August 31, 2011
http://www.ncdc.noaa.gov/nadm.html

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

Drought Impact Types:
- A = Agricultural
- H = Hydrological (Water)

The Drought Monitor focuses on broad scale conditions. Local conditions may vary. See accompanying text for a personal summary.

North American Drought Monitor
November 2012

Regions in northern Canada may not be as accurate as other regions due to limited information.

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<th>Year</th>
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Changing Streamflow

Photographs of the stream flow in Wheatfields Creek upstream of Wheatfields Lake in April 2005 (left) and April 2006 (right).

In this region, changes in average annual temperature 1\textdegree{} C increase $\Rightarrow$ 50mm precipitation lost to evapotranspiration (ET)

Slide courtesy of Jolene Tallsalt Robertson, Navajo Nation Dept of Water Resources
Sand Dune Mobility = $W/(P/PE)$

**Stable Sand Dunes**

$= P/PE > 0.31$

**Partly Active Dunes**

**Fully Active Dunes**

$= P/PE < 0.125$
Landscape changes-
Native American Lands in the Four-Corners Region-
Early-warning signals for critical transitions

Dust from NE Arizona
Traditional Knowledge and Perspectives:

• Increases our ability to understand changing environmental conditions
• Refines timing of events
• Fills monitoring gaps
• Procedural equity
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)

**Scenarios: Diné/Navajo Lands**

**Shrubland**
- Ecosystem becomes more susceptible to annual grass invaders. Fate of pines and other trees uncertain. Soil erosion increases. Faunal composition changes.
- Flash floods entering caves more often
- Native grassland replaced by shrubland and exotic annuals
- Ponderosa pine communities more susceptible to catastrophic fires due to decreasing summer precipitation

**Novel Ecosystem**
- Climate changes quickly to something like southern SW U.S. and species migration limited. Water table drops; streams go from perennial to intermittent or gone. Soil erosion increases. Many fauna may not be sustainable.
- Period of frequent, intense fire followed by decrease in fire because of lack of fuel
- Tough decisions regarding above-ground mission

**Mixed-grass Prairie**
- Extreme heat events – camp fire bans
- Decreased water availability
- Grazing herd – limits on carrying capacity
- Forest is more restricted by moisture than currently. Megafauna capacity decreases because forage production is lower. Water table drops; spring and stream flow decreases or ceases, depending on location.

**Shortgrass Prairie**
- Extreme Droughts become far more common
- Changes seen as part of normal variability
- Other management issues dominate
- Streams more intermittent, trees dry out
- Increased evaporation decreases plant productivity somewhat; ecosystem change occurs, but more slowly and/or to lesser degree than in other scenarios.
So what is needed?

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More Native researchers (cultural, social, physical, natural) to work for their communities
Drought remains a hidden risk

Most estimates of disaster losses exclude indirect losses – livelihoods, informal economies, intangible losses including ecosystem services, quality of life and cultural impacts.

In some areas drying due to climate change will be overlain on the periodic droughts those areas have always experienced!

Short-term actions do not always provide long term risk reduction - can reduce or increase longer-term risks.

For exposed and vulnerable communities, even non-extreme weather and climate events can have extreme impacts.
Thresholds: Variability and Change

**Type I:** Those that are well-known cases from the past where a threshold was reached and the management challenges are explicit

**Type II:** Those that are emerging now and often feature aspects of accelerating change

**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 ought to be concerned
Other examples of nonlinear change

- Fisheries collapse
- Eutrophication and hypoxia
- Disease emergence
- Invasive Species and species losses
- Vegetation die-back
- others
Assessing Drought Early Warning Systems – WMO, NIDIS, UNISDR

Monitoring & Forecasting

Drought and Flood Impacts Assessments and Scenarios

Communication and Awareness

Drought Early Warning Information Systems

Engaging Preparedness
Extremes in the context of variability and change:

- Pressure for better information to support planning under changing extremes-rates and transitions

- **Is a threshold an emergent property** of some underlying set of attributes of a system? (models not calibrated for rapid transitions)

How does new information relate to what is already known?
- how often should criteria for “robustness” be reconsidered?

- Many public sector applications require a more systematic connection between early warning scenarios and recommended decisions than do private sector applications

- More challenging is understanding the socialization of lessons learned by particular individuals and organizations through their own, direct trial and error experiences
OVERCONFIDENCE
This is going to end in disaster, and you have no one to blame but yourself.
THANK YOU!
Backup slides
Climate risk management: governance

** Accountability** - CRM needs to be located in a ministry or department, preferably with planning oversight and some fiscal responsibility to provide political authority and policy coherence across sectors. **Emergency management organizations can rarely play that role.**

**Efficiency** - only occurs when CRM is carried out in partnership with at-risk households and communities and organizations that represent them. Benefits are cost-effectiveness, sustainability, citizenship and social cohesion.
• Much more work is needed to show the value of existing observations to improve impacts assessments and warnings

• Reference water data accounting/architecture

• Better understand whether and how best to use probabilistic information with scenarios-reliable set of statistical procedures to test whether an increase in autocorrelation is significant (response curve trigger- cross-correlation among units before a critical threshold

• Rates and transitions-Are critical climate (extremes+ variability+change) impacts occurring/predicted in 1, 5-20 yrs?

• Prototyping/policy gaming: Given better data and information coordination, would responses have been improved for past events?
Why is “communication” not enough?

Broad societal processes that create dynamic pressures and unsafe conditions are not easy to change, yet are fundamental to human vulnerability

• The “push” supply of new information by would-be providers of information/technology, and the “pull” demand for new information from would-be learners is never linear

• Social process(es) of risk communication are more than “one-way” AND even more than “two-way”

• More challenging is an understanding the socialization of lessons learned by particular individuals and organizations through their own, direct trial and error experiences
Mexico - Water availability projection to 2030

At the national level, a 10% reduction in annual water availability was projected under climate change scenarios for 2030.

“Business as usual”