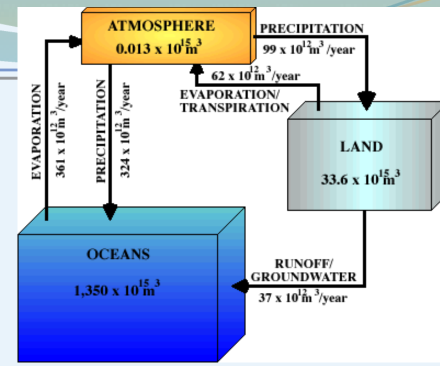
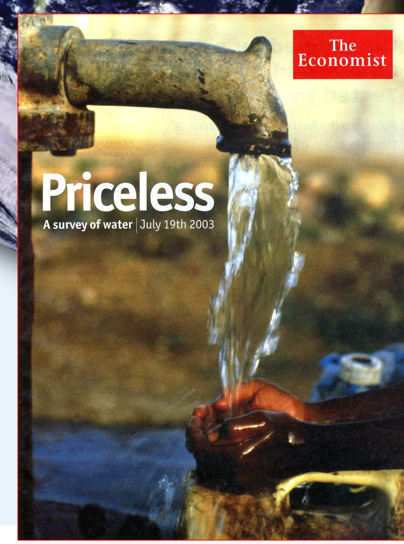
Attribution

or Retribution ?



Roger Pulwarty and Robin Webb
NOAA

Earth System Research Laboratory



30 DAYS | 1-4 SEASONS | >1 YEAR | 10 YEARS | 30 YEARS | 100 YEARS

SHORT-TERM-Seasonal

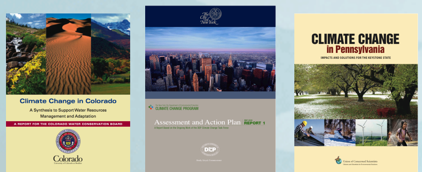
DECADE-TO-CENTURY

An informed society responding to climate and its impacts

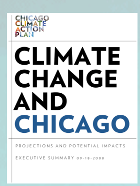
Are present drought conditions harbingers of future states?

Regional Climate Assessments: Uncertainty Language

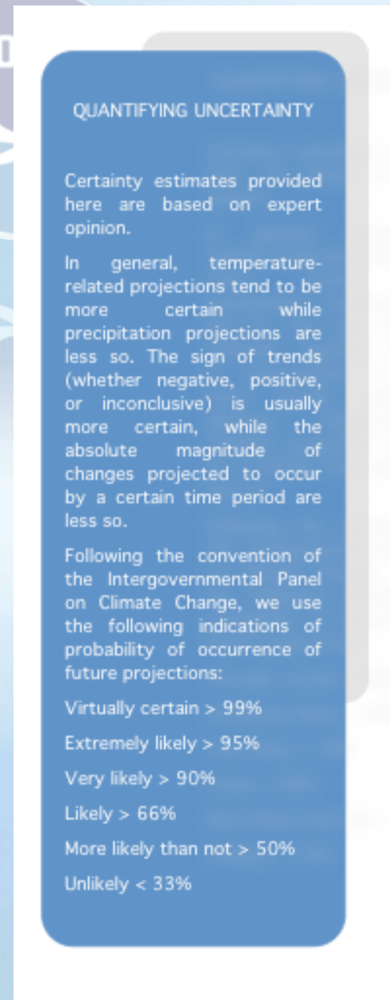
Quotes & explains IPCC likelihood statements



Uses and explains IPCC terminology but scientists make own judgments



No uncertainty or limited technical framework



QUANTIFYING UNCERTAINTY

Certainty estimates provided here are based on expert opinion.

In general, temperature-related projections tend to be more certain while precipitation projections are less so. The sign of trends (whether negative, positive, or inconclusive) is usually more certain, while the absolute magnitude of changes projected to occur by a certain time period are less so.

Following the convention of the Intergovernmental Panel on Climate Change, we use the following indications of probability of occurrence of future projections:

Virtually certain > 99%

Extremely likely > 95%

Very likely > 90%

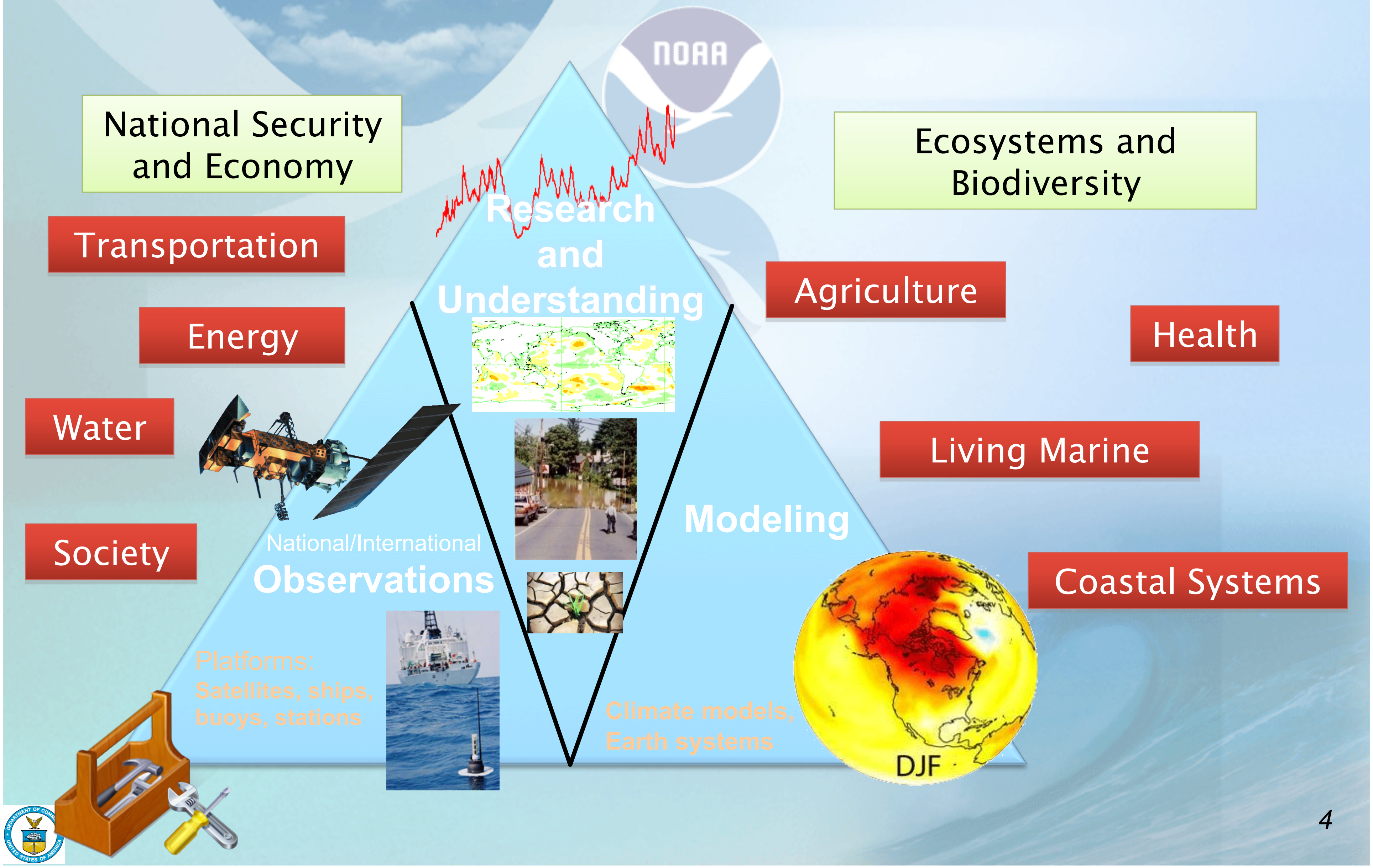
Likely > 66%

More likely than not > 50%

Unlikely < 33%

"It is **extremely likely (>95%)** that global temperatures and temperatures over Chicago are expected to warm further over coming decades...."

A Changing Climate For Risk Management



What does "adaptation" address?

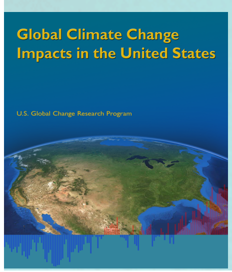
The threat already posed to society from today's climate variations

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 adapt?

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



Practical implications

- Need mechanisms for anticipatory coordination within development plans
- Develop climate risk management triggers (thresholds) for early warning of potential conflicts among water users
- Develop and employ water efficient technologies
- Engage communities and states in "mainstreaming" climate information into practice through participatory mechanisms (including co-development of scenarios)
- **What adaptation interventions have been put into place and how do we know they're working?**
- **Ok and: higher resolution, timing and World peace**

Attribution statements on the ongoing drought in Southwest USA

Possible poleward expansion of the subtropical region of descent of the Hadley Circulation is an outcome that is favored by models in response to a warming climate. Transfer the dry conditions of northern Mexico to the U.S. Southwest and southern Great Plains; may already be happening-Additional observations and modeling improvements will be required to assess the likelihood of its occurrence with greater confidence (CCSP SAP 1.3 page 90, Seager et al 2007; IPCC, 2007)

Semi-arid regions of the Southwest are projected to dry further, and model results suggest that the transition may already be underway. (CCSP SAP 3.4 page 69)

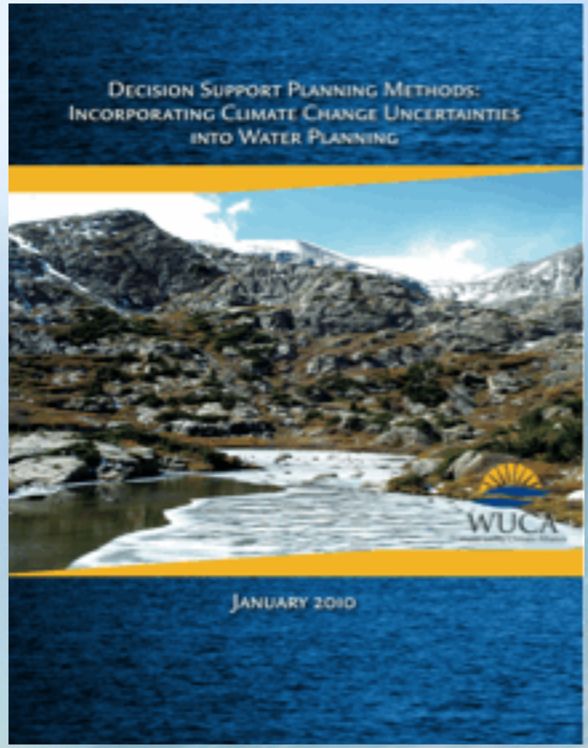
The most recent of the historical droughts, which began in 1998 and persists at the time of writing, has yet to etch itself into the pages of American history, but it has already created a tense situation in the West as to what it portends. Is it like the 1930s and 1950s droughts and, therefore, likely to end relatively soon? Or is it the emergence of the anthropogenic drying that climate models project will impact this? (CCSP SAP 3.4 page 80)

“Human-induced climate change appears to be well underway in the Southwest. Recent warming is among the most rapid in the nation, significantly more than the global average in some areas. This is driving declines in spring snowpack and Colorado River flow” (USGSAP page 128, 2009)

In the past decade, many locations, notably in the headwaters region of the Colorado River, have been more than 1°C warmer than the 20thcentury average. This warming has been the primary driver in reducing late-season snowpack and the annual flow of the Colorado River. (Overpeck and Udall, Science, July 2010)

Decision Support Planning Methods: Climate Change Uncertainties and Water Planning

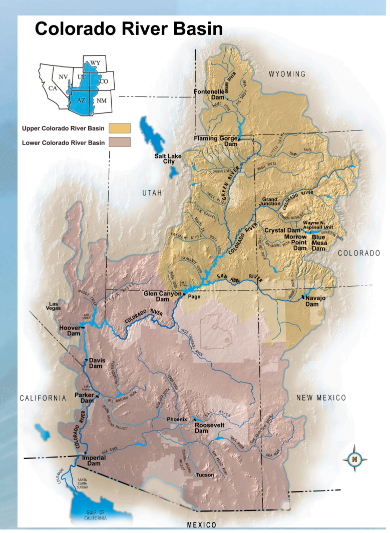
1. Classic decision analysis,
2. Traditional scenario planning,
3. Robust decision making,
4. Real options, and
5. Portfolio planning

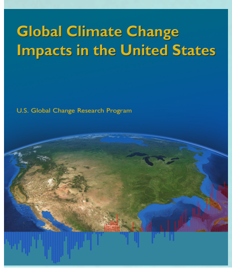


Evaluation

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[2], including a provision for additional shortages if warranted
- <u>In place for an interim period (through 2026) to gain valuable operational experience</u>
- <u>Basin States agree to consult before resorting to litigation</u>



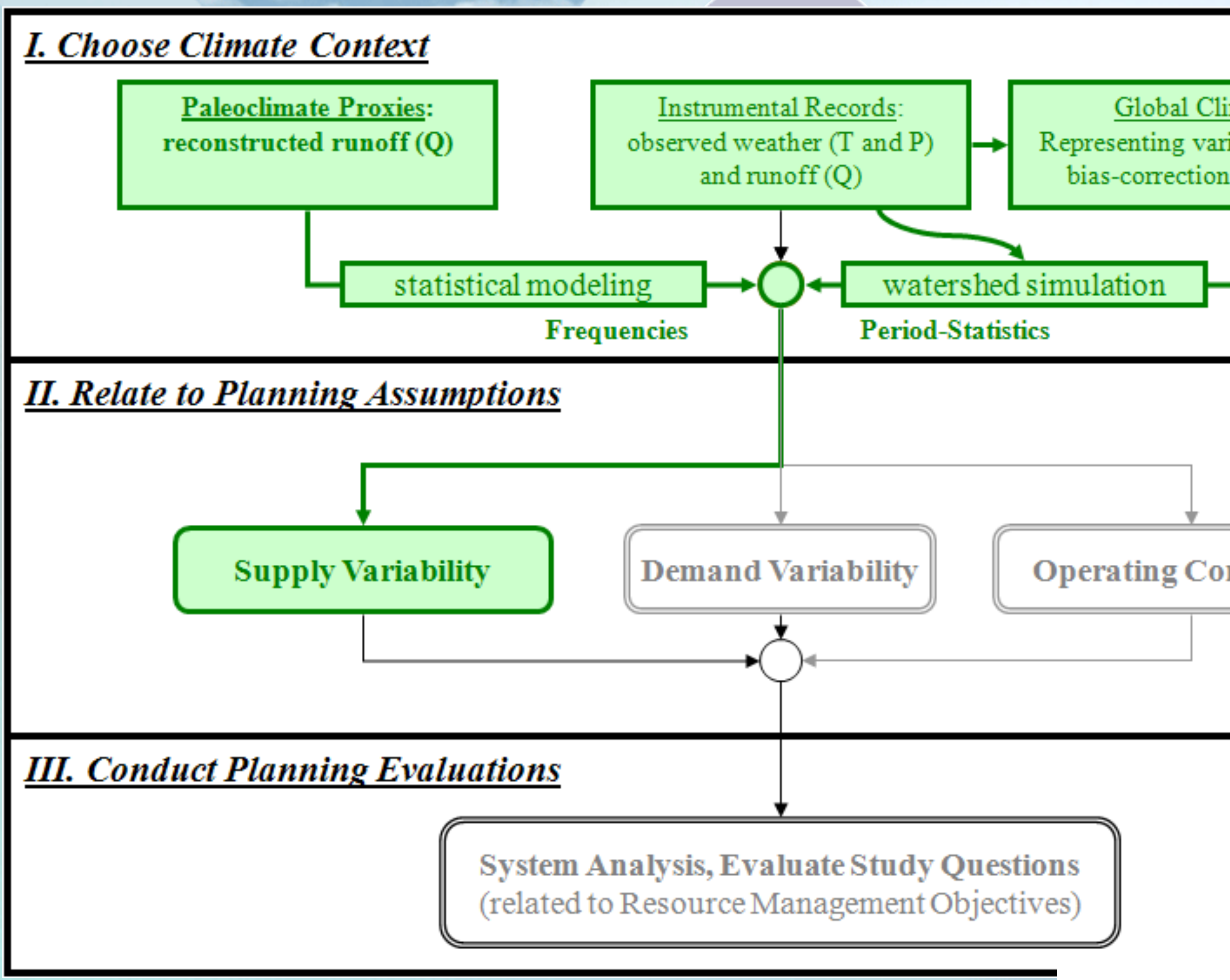


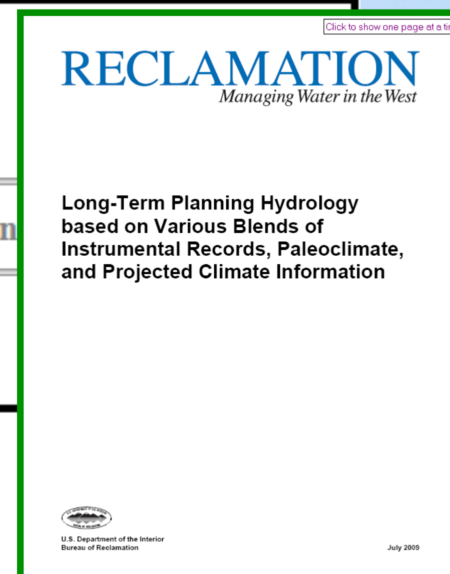
1. Issued in Record of Decision, dated December 13, 2007; available at http://www.usbr.gov/lc/region/programs/strategies.html
2. Mexico water deliveries are not directly effected by these guidelines

(US/DoI Bureau of Reclamation)

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
		Unit Commitment Economic Dispatch
Single project over 1-7 days	Real-time Control	Automatic Generation and Control

... LC/UC 2007 approach has since been extended to blend paleo-spell and projected climate/hydrology (Reclamation 2009)




RECLAMATION
Managing Water in the West

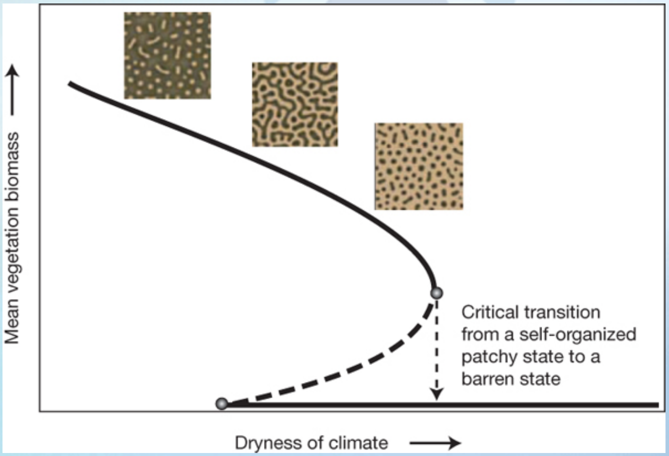
Long-Term Planning Hydrology based on Various Blends of Instrumental Records, Paleoclimate, and Projected Climate Information

U.S. Department of the Interior
Bureau of Reclamation

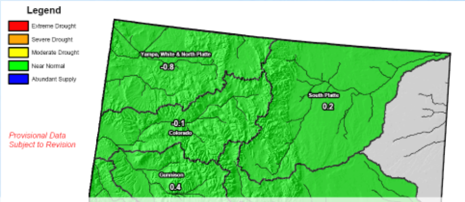
July 2009

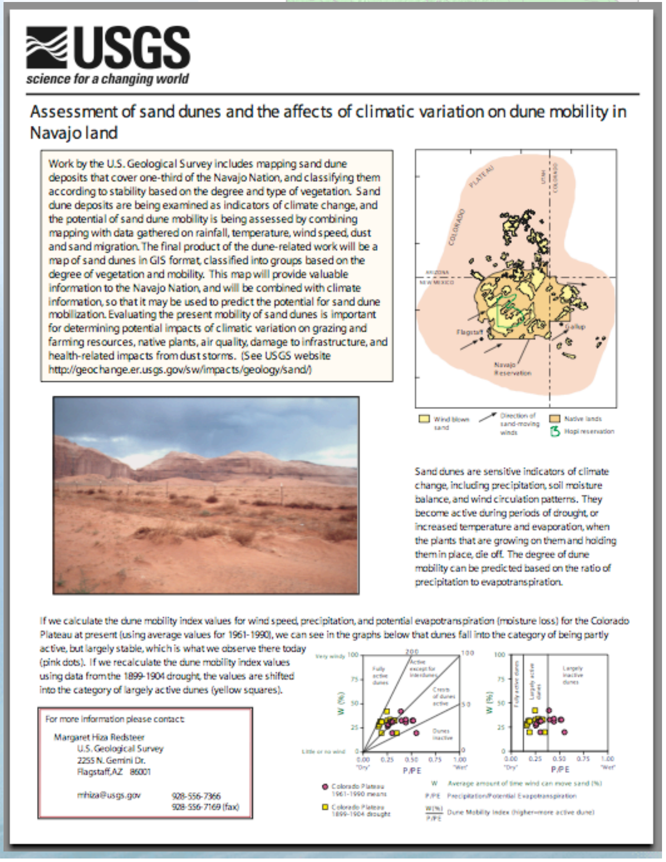
Info: Levi Brekke (lbrekke@usbr.gov),
Jim Prarie (jprairie@usbr.gov)

Drought on Native American Lands-Landscape changes in the Four-Corners Region



(Nature, 2009)





USGS
science for a changing world

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/)

Wind blown sand
Direction of sand-moving winds
Native lands
Hopi reservation

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 largely active dunes (yellow squares).

For more information please contact:

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Flagstaff, AZ 86001

mhiza@usgs.gov 928-556-7366
928-556-7169 (fax)

Colorado Plateau 1961-1990 means
Colorado Plateau 1899-1904 drought
W Average amount of time wind can move sand (%)
P/PE Precipitation/Potential Evapotranspiration
W(%) / P/PE Dune Mobility Index (higher=more active dune)

Nested Scenarios: Left High and Dry? (NPS)

High-Level Scenario	Local Scenario
Livelihood loss, Upheaval, Migration…	Desert shrublands

"Left High and Dry" is a world in which societal concerns around climate change rise, yet there is little real leadership shown to address challenges at a global or national level. At the same time, SW experiences more extreme droughts, with associated consequences for fire danger, vegetation and mega-fauna.

- **Perennial streams transition and dry up**
- **Water table dropping and spring discharge leads to possible long term water partitioning**
- **Fire intensity and severity increase and frequency of erosion, invasives, closures and fire restrictions increases as well**
- **Higher temperatures lead to increasing needs for emergency response for heat exhaustion and other heath related issues for visitors**
- **Vegetation biomass and forage availability for wildlife decreases**
- **Increase in disease within wildlife communities**
- **Increase in social trails and trail management issues**
- **As forest disease increases because of warmer winters and drought the fire risk increases as well**
- **Exposure of archaeological and paleological resources to climate change impacts**

UNFCCC-The effect of a range of scientific, methodological and policy-related choices on the attribution, but *not* the full range of all uncertainties.

Policy choices analysed here:
–Indicator
–Timeframes
–Emission scenarios
–Mixture of Greenhouse gases

Two main factors influence results:

•Whether a source emitted ‘early’ versus ‘late’

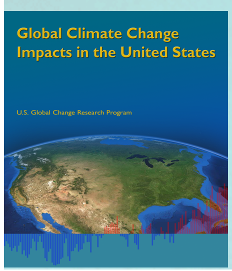
•The share of emissions of short-lived / long-lived gases

•What is “dangerous” climate change?

Current work suggests, that the impact of policy choices, such as time horizon of emissions, climate change indicator and greenhouse-gas mix and relative contributions is larger than the impact of scientific uncertainties on absolute changes in temperature

Prioritize and select climate mitigation and adaptation/ 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



Are the present drought conditions harbingers of future states?

Economic diversification within sectors to reduce dependence on climate-sensitive resources, particularly for regions that rely on narrow ranges of climate-sensitive economic conditions

The recent drought, forced by reduced precipitation and with reduced evaporation, has no signature of model-projected anthropogenic climate change (Southeast US: Seager, 2007)

The Basins and climate change

- Historical context – water resource and policy development
- The current threats - climate change, water scarcity and poor water quality

The policy and science challenges to facilitating adaptation in water scarce basins

- Managing for resilience – adaptive management, triage, environmental rights and environmental managers
- Providing flexibility in adjustment – water trade and carry-over
- Facilitating structural change in irrigation dependent regions - Thinking transformation not marginal change

Designing a Climate Early Warning Information Systems

- What exists?
  - Monitoring, forecasting, projections
  - Drought/flood-sensitive planning indicators and management triggers
  - Paleo-record
  - **A plethora of “statements” about future conditions and conditioning factors**

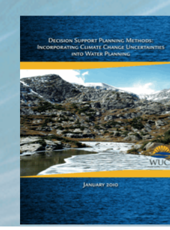
- **How does present anticipatory coordination and information flow take place?**
  - What partnerships, decision support tools and actions are needed (to improve information development, coordination and flow for preparedness and risk reduction)?

Uncertainty is critical but so is…….

Decision Support Planning Methods: Incorporating Climate Change Uncertainties into Water Planning

Portfolio planning

- used in the financial world to select a portfolio containing a mix of assets or strategies that minimize exposure due to future scenarios
- uncertainty is handled through the use of probabilities and Monte Carlo simulations
- exposure to uncertainty is minimized through hedging
- used extensively in the electric utility area

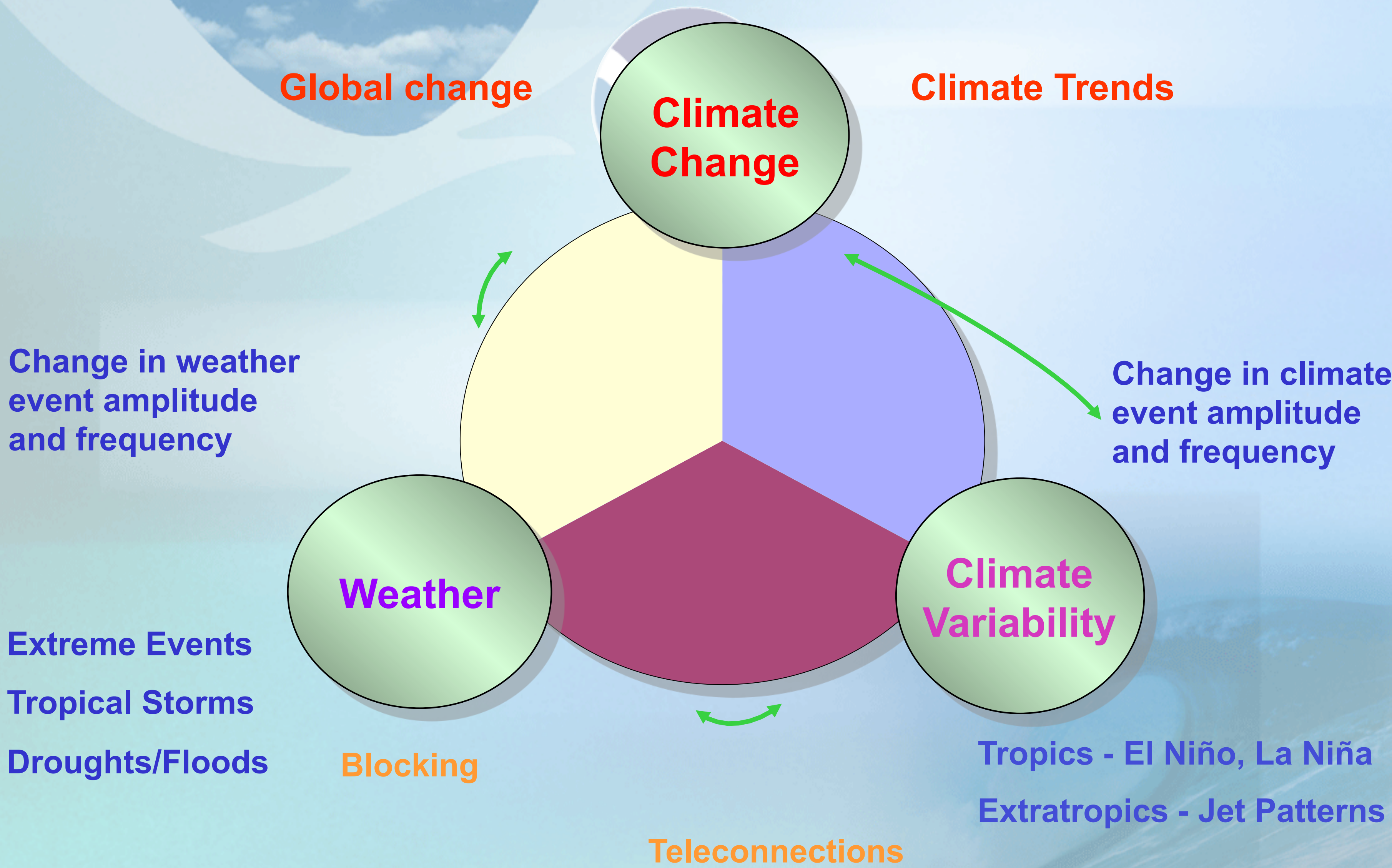


Focus on the critical problem asking AND answering the right questio

- Acknowledge uncertainties in science, but manage the risks
- Focus on improving decisions

"ALSO, THE BRIDGE IS OUT AHEAD"

Extremes – Climate Linkage



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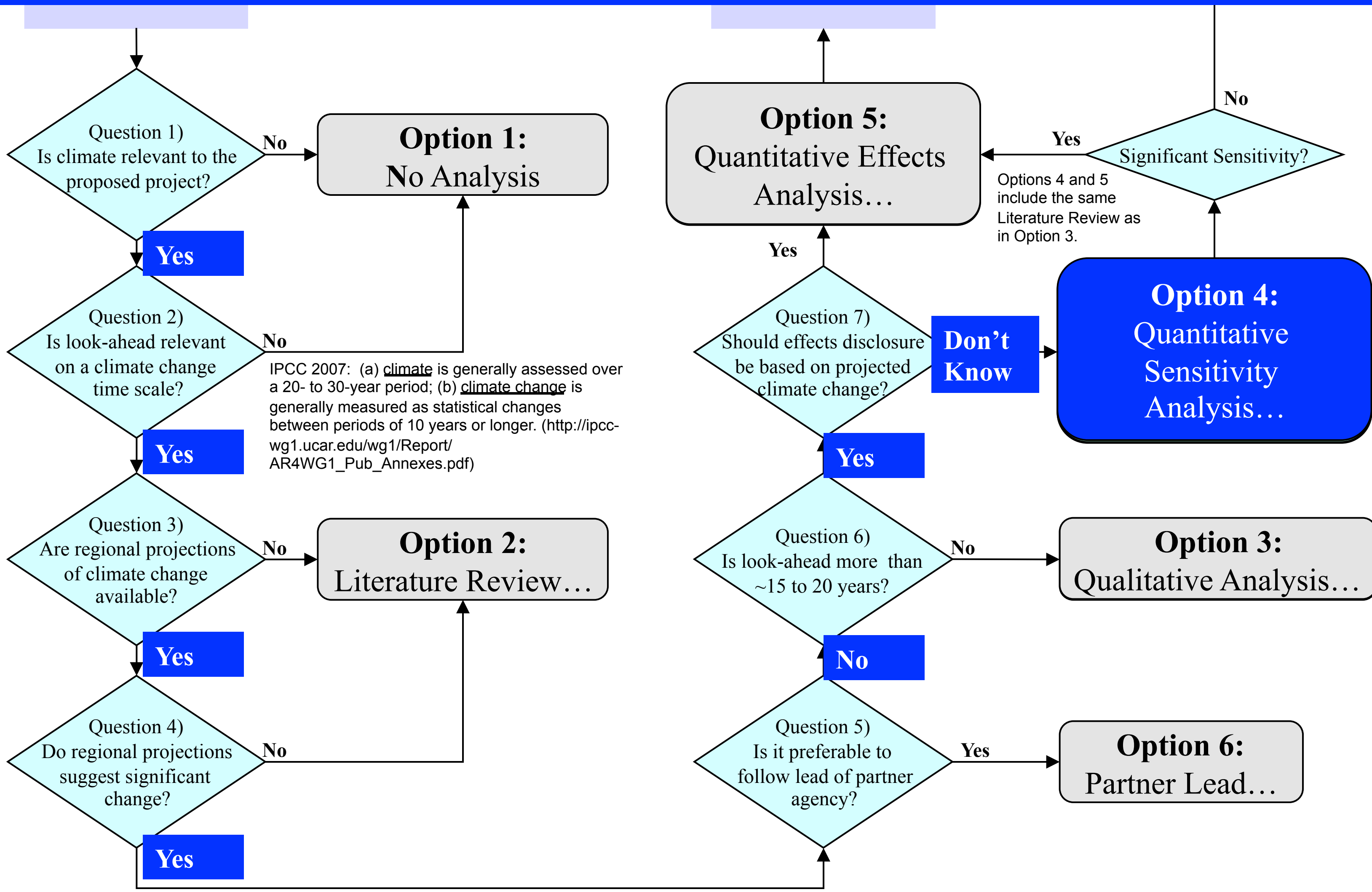
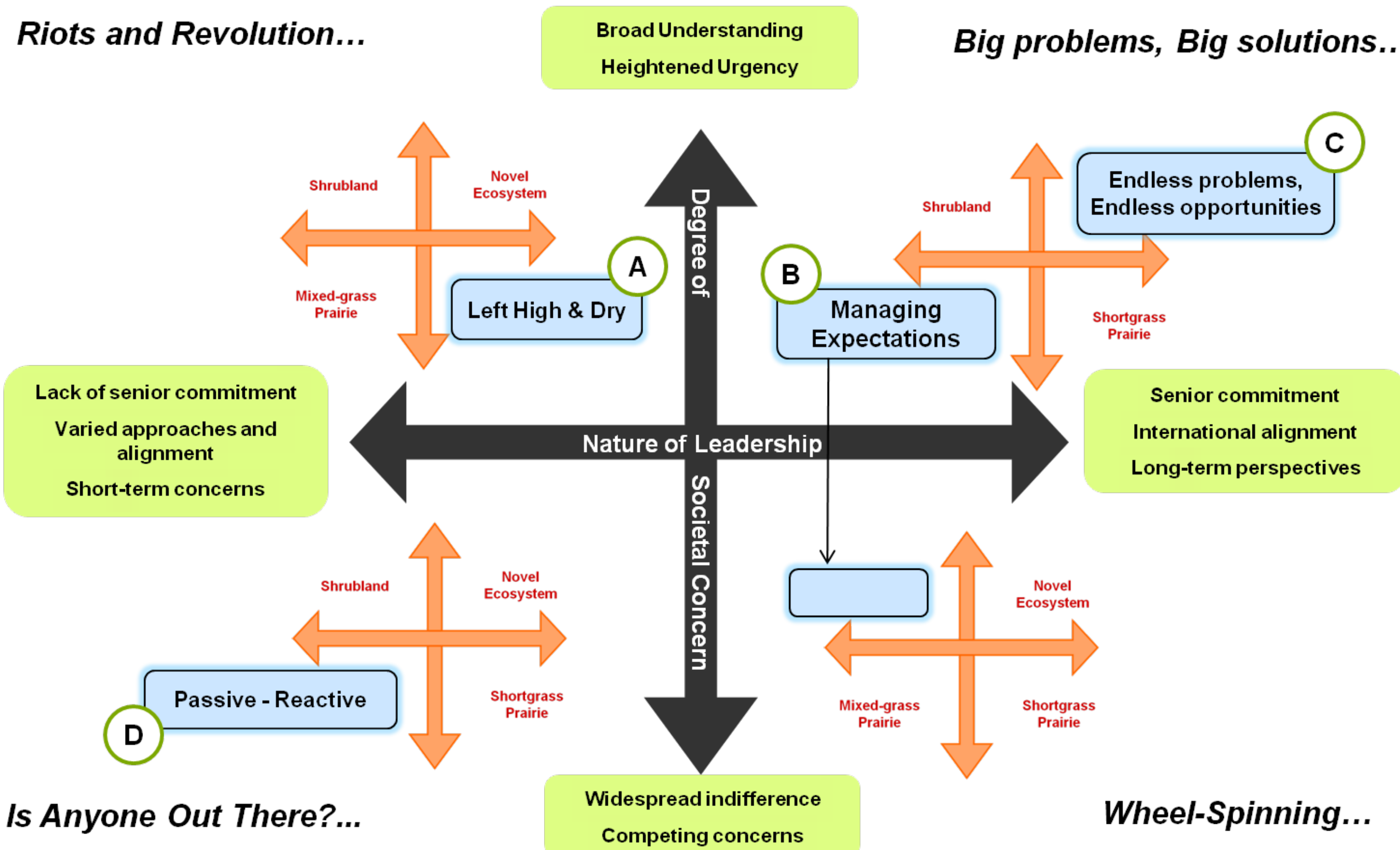
Case Study: ESA Consultation in CA's Central Valley, sensitivity to climate (CVP OCAP 2008)

http://www.usbr.gov/mp/cvo/OCAP/sep08_docs/Appendix_R.pdf



Nested Scenarios



Welling, NPS and others