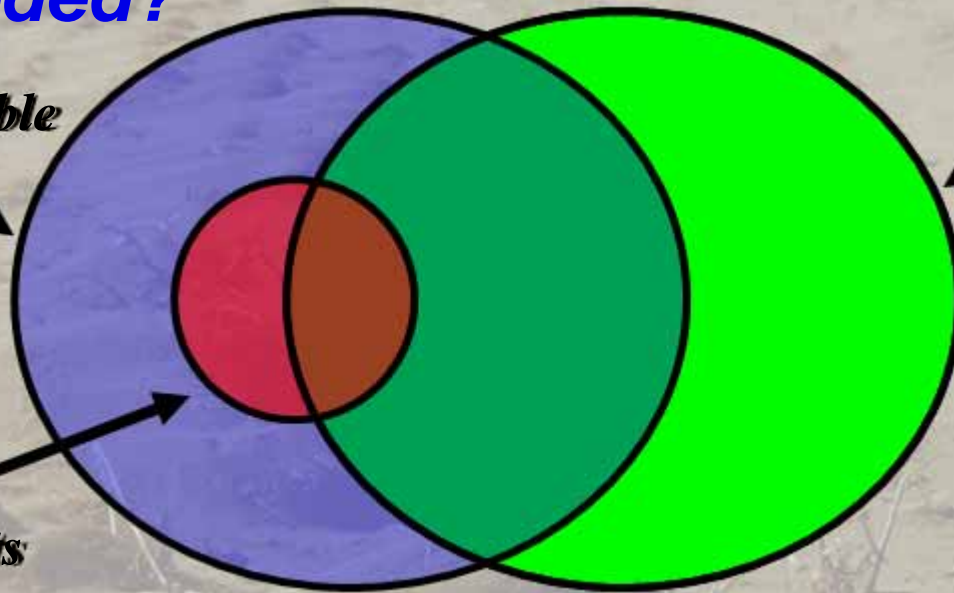


# Experiences from the water resources and agricultural sectors during drought: *What do users want? What do researchers want? What is needed?*

*What is potentially predictable/observable*

*Spectrum of User Needs*

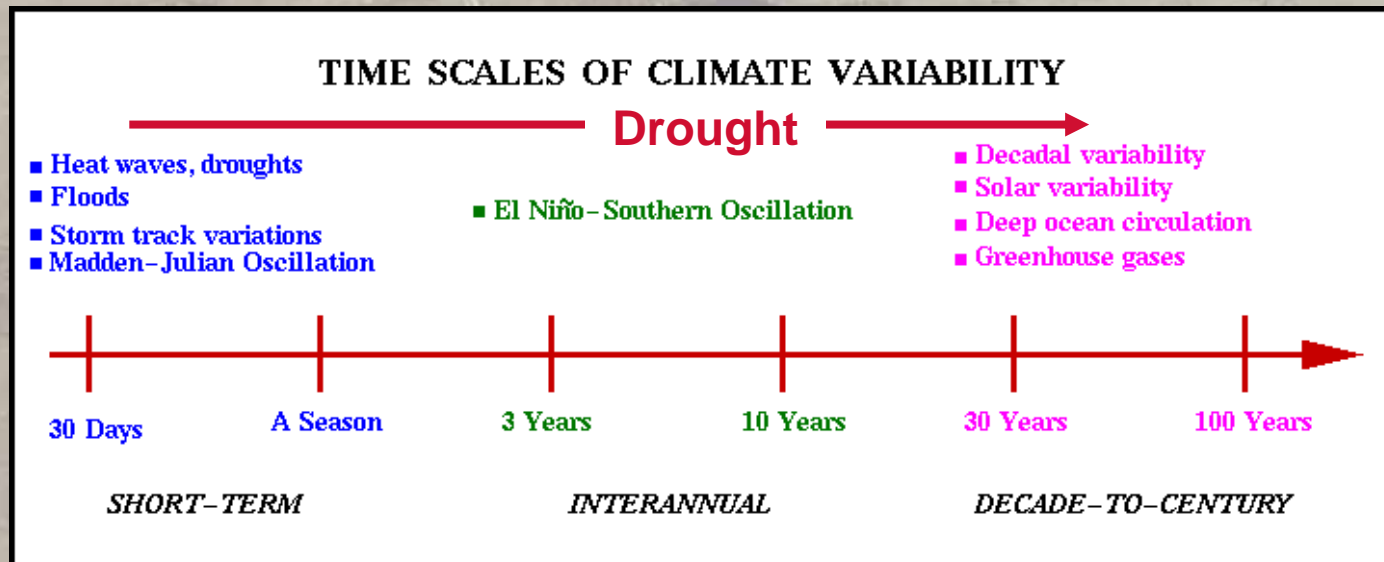
*Current Forecast/  
Monitoring Products*



**Robert. S. Webb** (NOAA OAR Earth System Research Laboratory)  
**Roger S. Pulwarty** (NOAA CIRES Climate Diagnostics Center)

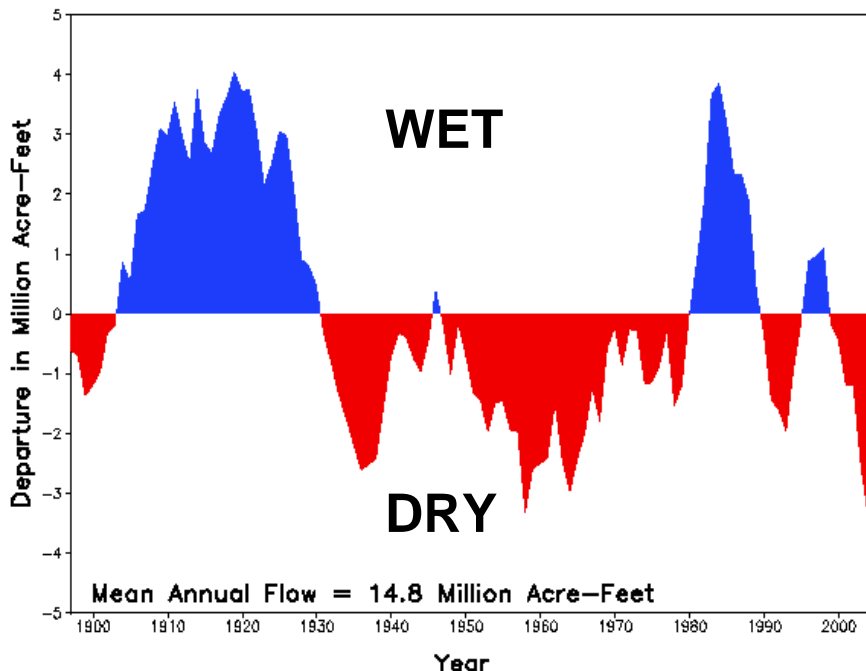
# Framing of the Questions:

- **Critical Issue Driven**
  - Reliability of water supply
  - Yield and profitability of agriculture production
- **Overarching temporal and spatial scales of climate impacting these critical issues**
- **Need to understand information needs, quality and acceptability of information, context of use, accessibility and benefit**



# 2001-2002 Drought in Colorado

Annual Colorado River flow at Lees Ferry, AZ.  
Departure from 9 Year Moving Average.



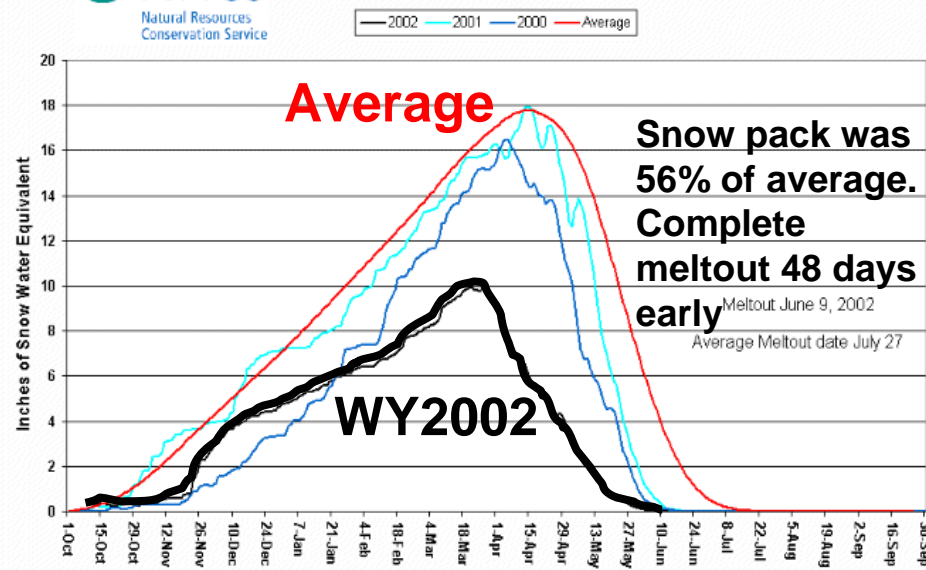
## Colorado River Flow

(Average 100 year natural flow ~14.8 maf)

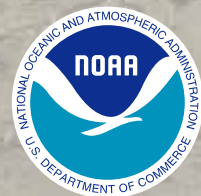
| Years            | Duration       | Average Flow   |
|------------------|----------------|----------------|
| 1931-1935        | 5 years        | 11.4 maf       |
| 1953-1956        | 4 years        | 10.2 maf       |
| 1959-1964        | 6 years        | 11.4 maf       |
| 1988-1992        | 5 years        | 10.9 maf       |
| <b>2000-2004</b> | <b>5 years</b> | <b>9.9 maf</b> |



Colorado Statewide Snowpack  
Based on provisional SNOTEL data.



- Winter wheat production fell by nearly 30 million bushels between 2001 and 2002
- Most irrigators received only 50% of their typical supply, 14% received none.

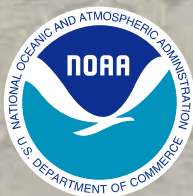




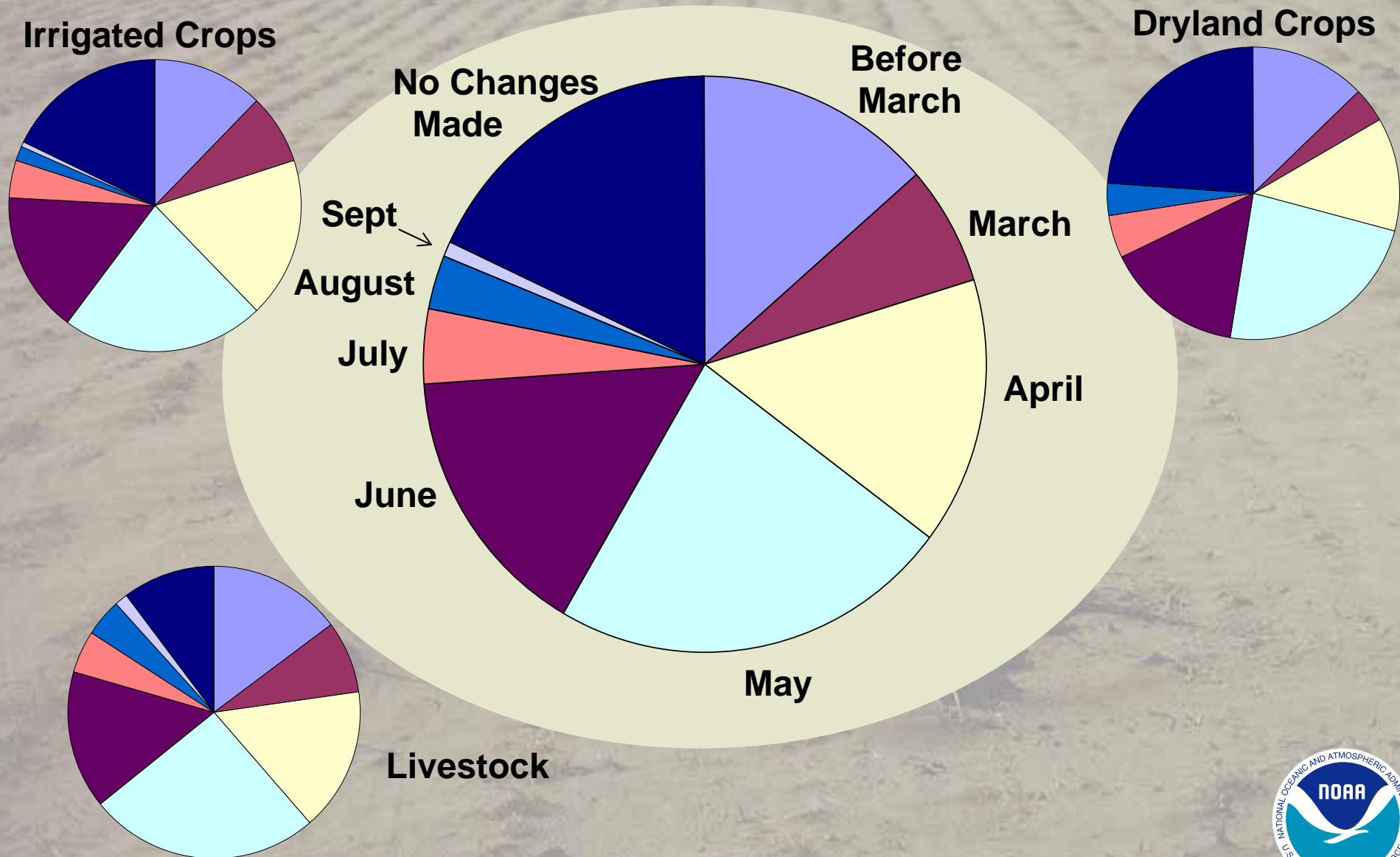
# Water Agriculture Production: Yield and profitability

(collaborative project with CSU)

- **Sector Dependent Requirements**
- **What is going on over a year**
  - What seed to buy and how much
  - When/if to plant or abandon crop
  - Irrigate or lease out water rights
  - Buy feed or cull herd
- **Information needs (monitored and/or forecasted)**
  - ✓ What types of climate monitoring and climate forecast products could help mitigate the impacts of drought on agriculture?
  - ✓ When in the agriculture management decision process is this information needed for making strategic decisions and for making tactical decisions.
  - ✓ Where and how do you get climate and weather information

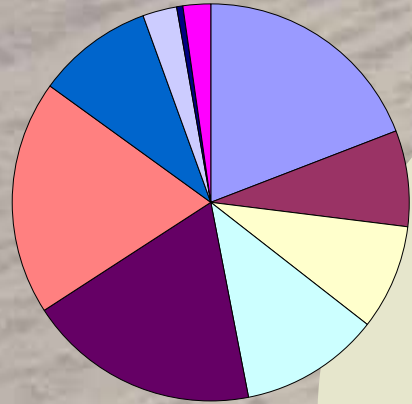


# When did you first make changes in your production practices because of the 2002 drought?

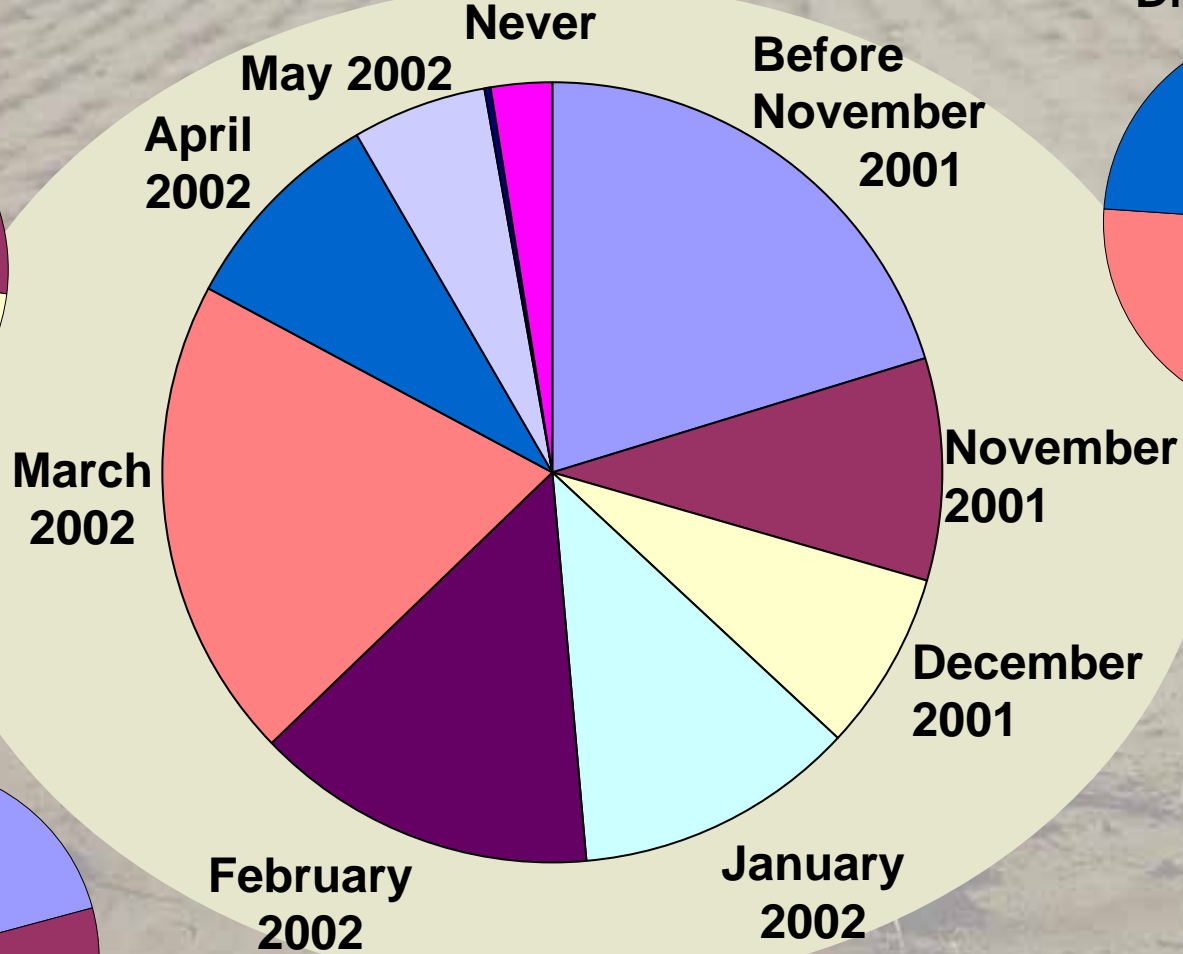
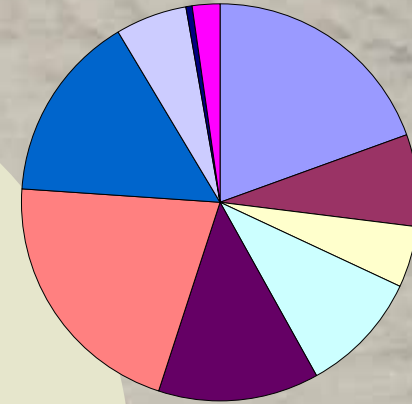


# What is the latest date an accurate drought forecast for Colorado would have been useful to you for making different production decisions than those actually made?

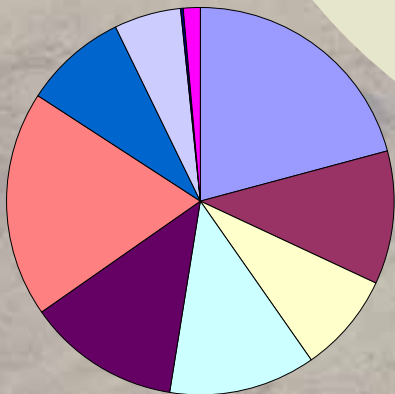
### Irrigated Crops



### Dryland Crops



### Livestock





# Water Resource Management: reliability of supply

- **Sector Dependent Requirements**
- **What is going on over a year**
  - **Seasonally dependent deliveries**
  - **Peak and minimum flow**
  - **Optimize reservoir water levels**
  - **Hydropower production**
- **Information needs (monitored and/or forecasted)**
  - ✓ Snowpack/SWE
  - ✓ Soil moisture
  - ✓ Streamflow
  - ✓ Timing of spring peak and late season low flows
  - ✓ Reservoir levels
  - ✓ Ground water
  - ✓ Surface water supply index (SWSI)
  - ✓ Temperature & Precipitation
  - ✓ Evapotranspiration, evaporative losses
  - ✓ Demand metrics, water and hydropower
  - ✓ Outlooks of these, and how precipitation and temperature outlooks relate to long term average or other thresholds

# Water 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

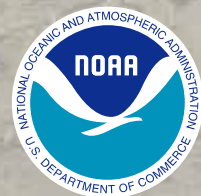
Peak Flow Augmentation releases

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



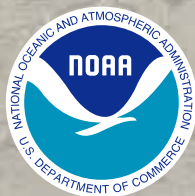


# Water Resource Management: barriers to use

| Factor                     | Water Manager's Perspective   | Researcher's Perspective  |
|----------------------------|---|---|
| Identifying critical issue |   |   |
| Time frame                 |   |   |
| Spatial resolution         |  <p>A cartoon illustration of a man in a dark suit and orange tie, holding a red watering can and watering a small potted plant. The man has a long, thin nose and a somewhat indifferent expression.</p> |  <p>A cartoon illustration of a woman in a long dress pouring water from a bucket. She is standing on a large, cylindrical object labeled 'SCIENCE'. The water is being poured into a large, dark, swirling mass on the ground.</p> |
| Goals                      |   |   |
| Basis for Decisions        |   |   |
| Expectation                |   |   |
| Product Characteristics    |   |   |
| Frame                      |   |   |
| Nature of Use              |   |   |

# Water Resource Management: communication challenge

| Factor                     | Water Manager's Perspective   | Researcher's Perspective   |
|----------------------------|---|--|
| Identifying critical issue | Based on experience   | External assessment  |
| Time frame                 | Immediate (operations)<br>Long-term (infrastructure)                                  | Scientifically defensible<br>Fundable project  |
| Spatial resolution         | Institutional boundaries or authorities   | Scientifically defensible/funding  |
| Goals                      | Optimization of multiple conditions and minimize adverse impacts                      | Enhanced understanding, prediction, explanation  |
| Basis for Decisions        | Procedure, judgment, training, Economics, Politics, risk reduction                    | Scientific methods, funding availability, disciplinary training                                      |
| Expectation                | Save money and time<br>Protect the life and property                                  | Understanding, prediction, continued improvement   |
| Product Characteristics    | Simple but accurate<br>Context is important   | Peer-review publication and recognition  |
| Frame                      | Safety and well being, Profit<br>Consistency with institutional culture, policy, etc. | Physical (atmospheric, hydrologic, etc.) conditions as drivers<br>Dependent on scientific discipline |
| Nature of Use              | Applied   | Conceptual   |

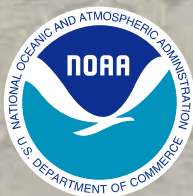




# What do users want? What do researchers want?

## What is needed?: *Conclusions and Insights*

- An outcome of the drought has been the development of regional partnerships between users of climate information and researchers.
- These partnerships make it possible to develop a mutual understanding of how problems are framed including drought information needs and usability of various climate products.
- These partnerships provide alternatives to external research-based optimization and simulations to identify opportunities to improve operational efficiency.
- Interests now extend beyond current drought conditions to assessments of recent droughts in the context of longer-term climate variability and change (e.g., how much more extreme or changes in expected occurrence interval).





# What do users want? What do researchers want?

## What is needed?: *Future Directions*

- Users and researchers need to partner in a dialog about managing risks and hedging strategies.
- How such partnerships are supported and sustained remains an open question.

### *National Integrated Drought Information System*

Stakeholder/Science identification of information needs

