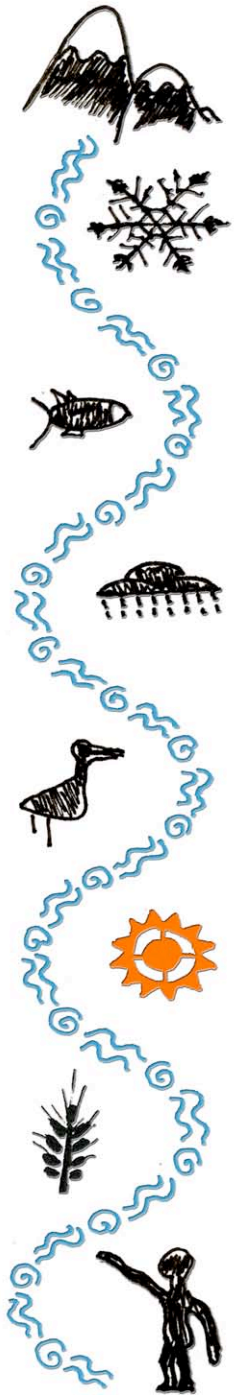
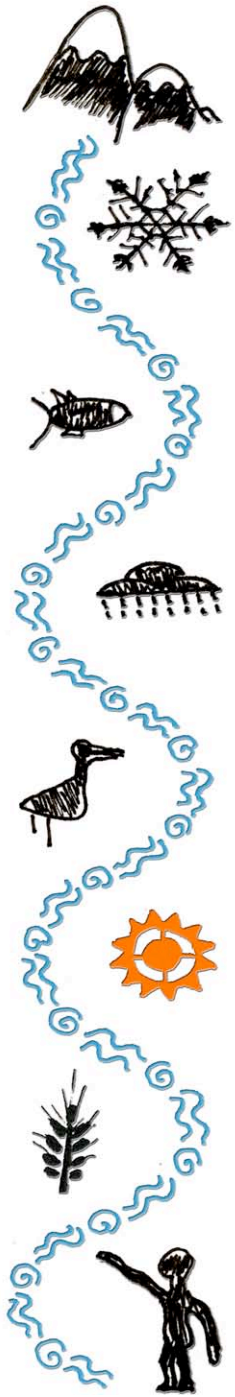


The nexus of science and resource management: Re-visiting adaptive management and decision environments

Roger S. Pulwarty

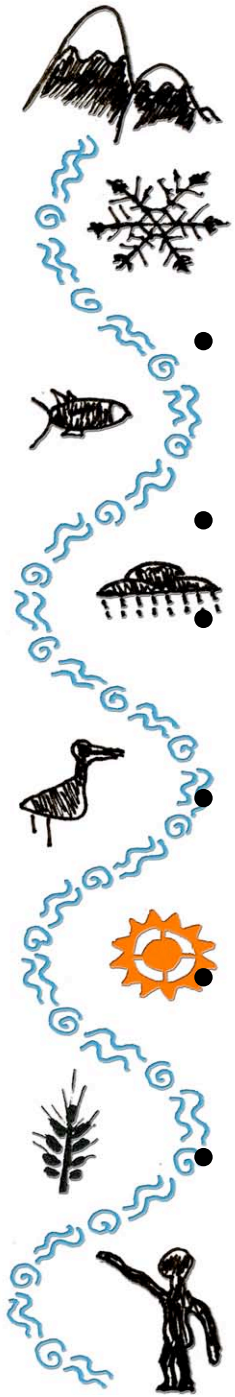
NOAA/Climate Diagnostics Center
and University of Colorado, Boulder



Adaptive management: Learning by doing

- Policies aimed at facilitating complex innovation will need to be as learning-based and as flexible as the innovation process
- Cognizant of nature's time scales

- Scales of change are not easy to separate
- Rate of innovation vs. nature of innovation

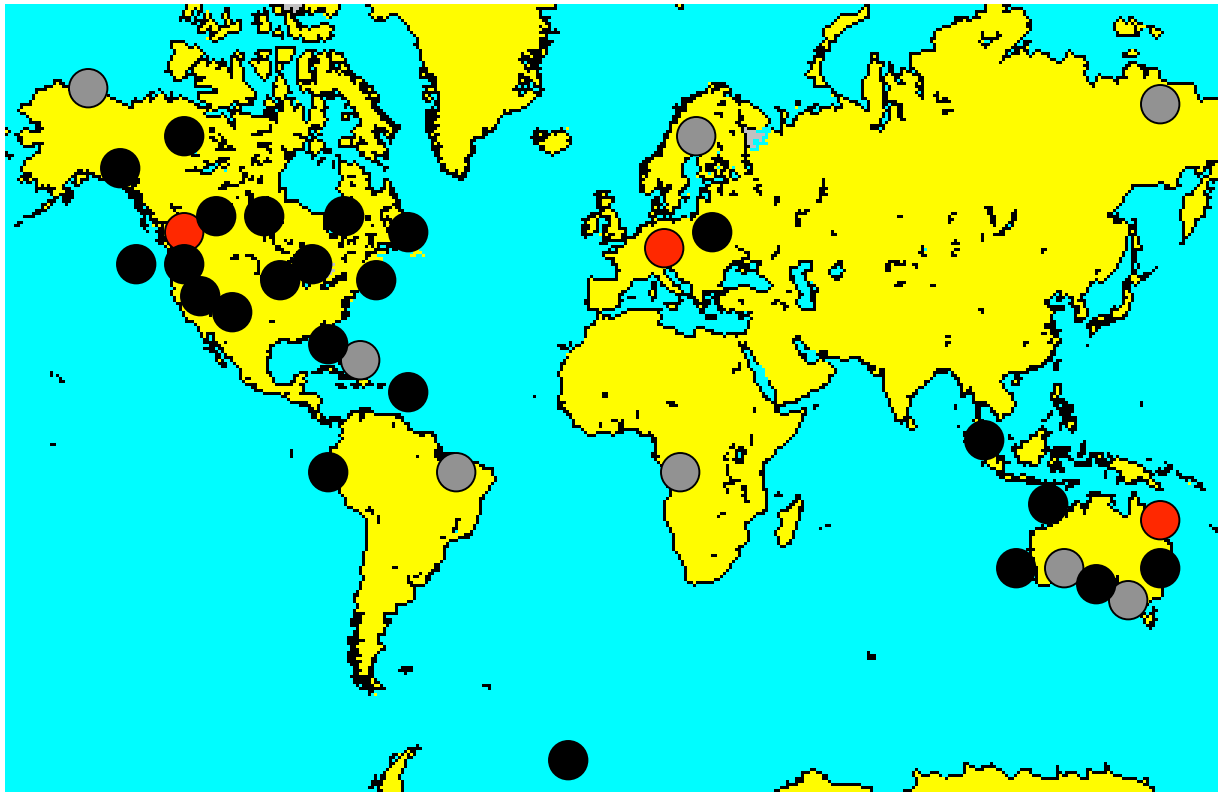


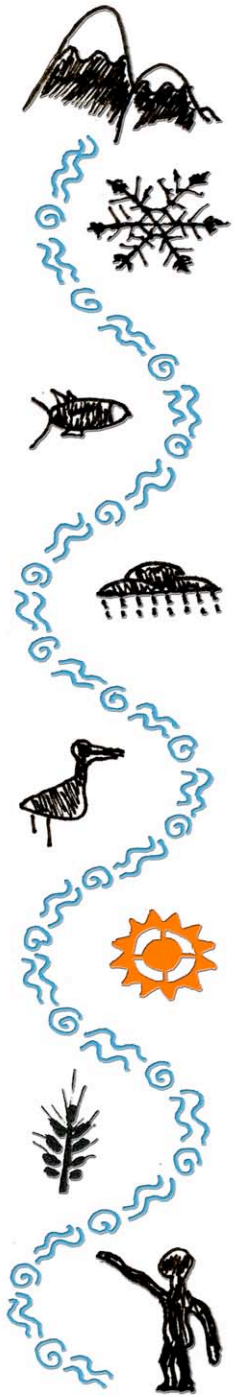
Elements of adaptive management

- Recognition of scientific and management complexity and uncertainty
- Directive and/or need for action
- Implement management actions to address resource problems as experiments
- Monitor and evaluate effects of action/experiments (what works, what does not)
- Develop integrated models for ecosystem interactions, legal and cultural requirements etc.
- Develop experiments in a participatory process involving a key parties

A pathetic track record for implementation of adaptive management:

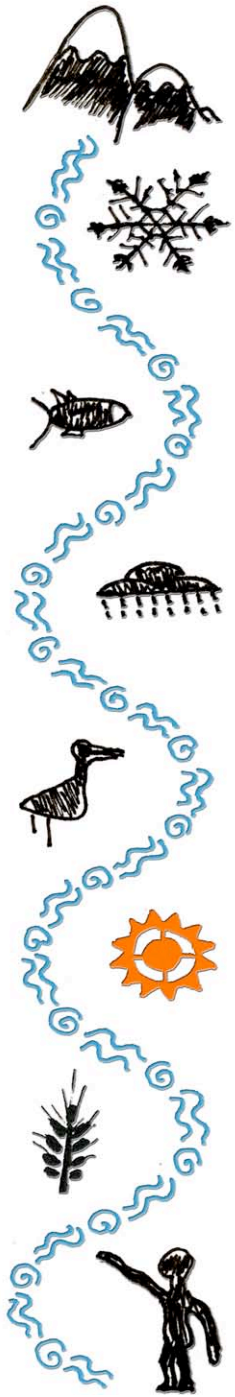
Successful ○ Modeling failure ● Implementation failure





Subset

- Colorado River Grand Canyon
- Columbia River System
- Everglades
- CALFED
- Rio Grande



Benefits of controlling seasonality hydrology

- Conveyance of flood waters
- Storage for power and irrigation
- Predictable navigation opportunity
- Enhanced recreational uses

AM Needs

- Sufficient water resources for experimentation
- Resilience identified/understood in key ecosystem components
- Flexibility among stakeholders?
- Room for political negotiations?

Everglades Scale Issues

-1/2 Wetlands Lost

-Water Allocation among land uses of agriculture, urban and conservation

Subsystem Scale Issues

-Wading Bird Foraging

-Endangered Species (Wood Stork, Panther)

-Changes due to water management

Landscape Scale Issues

Biotic changes due to:

-Nutrient Enrichment

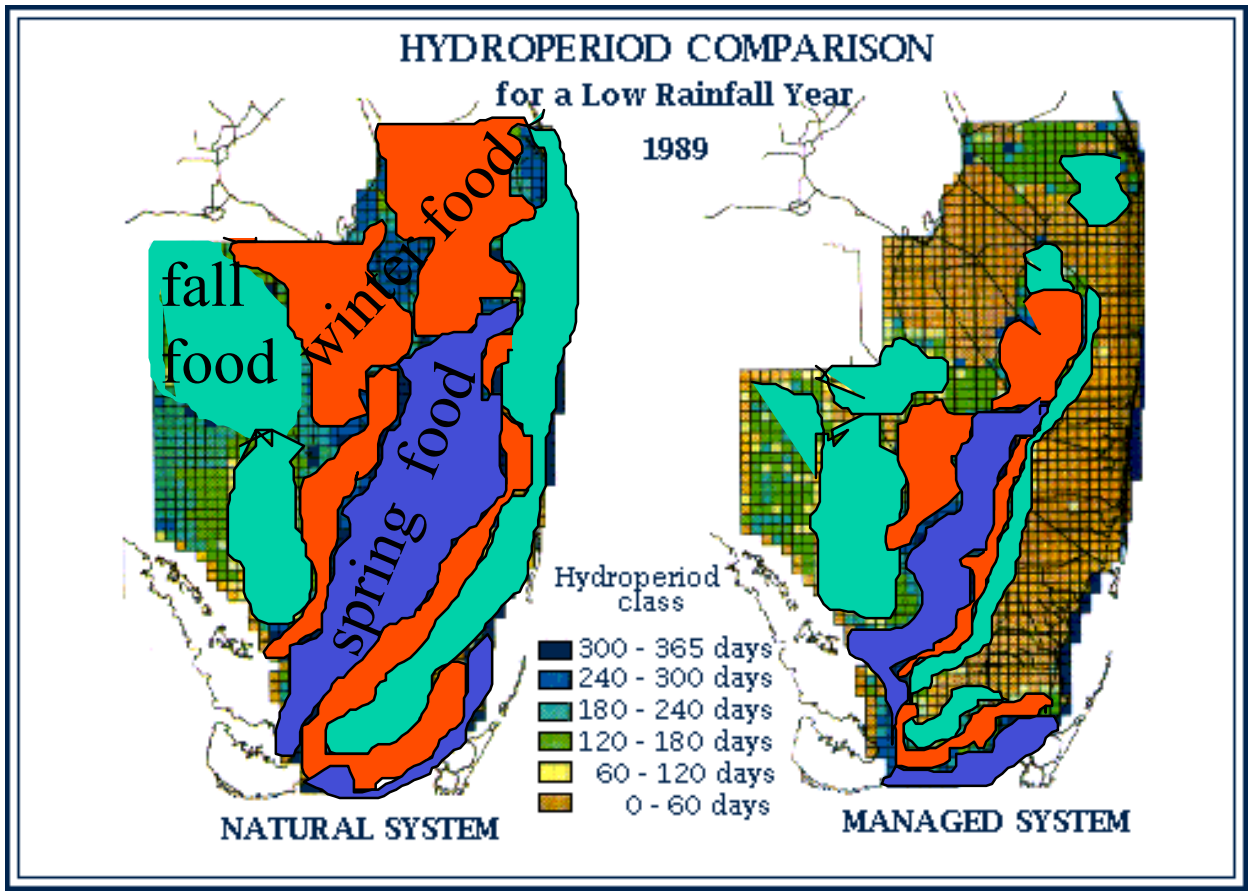
-Altered Hydrology

-Altered Disturbance Regime

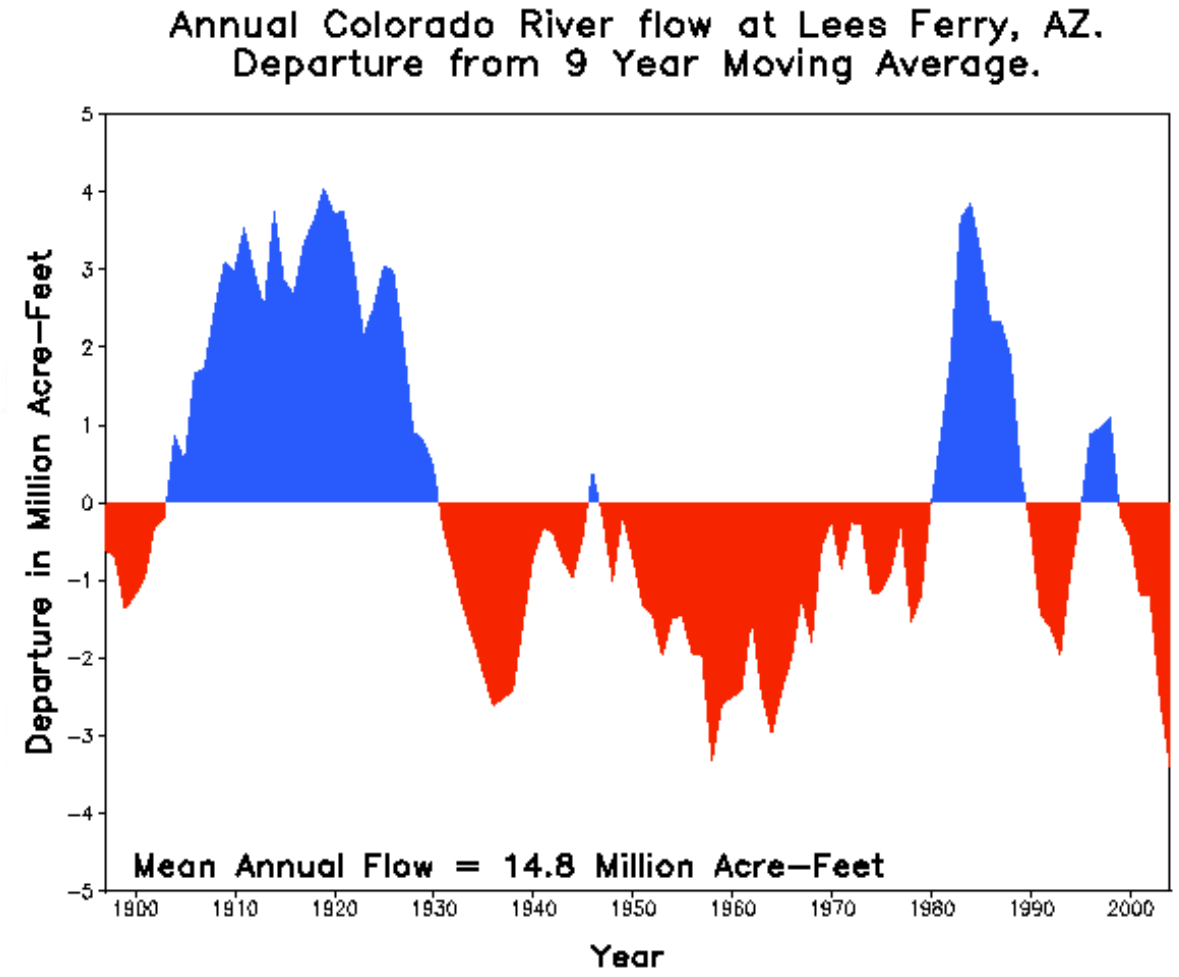
Regional scale issues

climate

The birds saw it differently: seasonal drying concentrated the goodies



Colorado River Flow Departures from Average



Climatic Influences

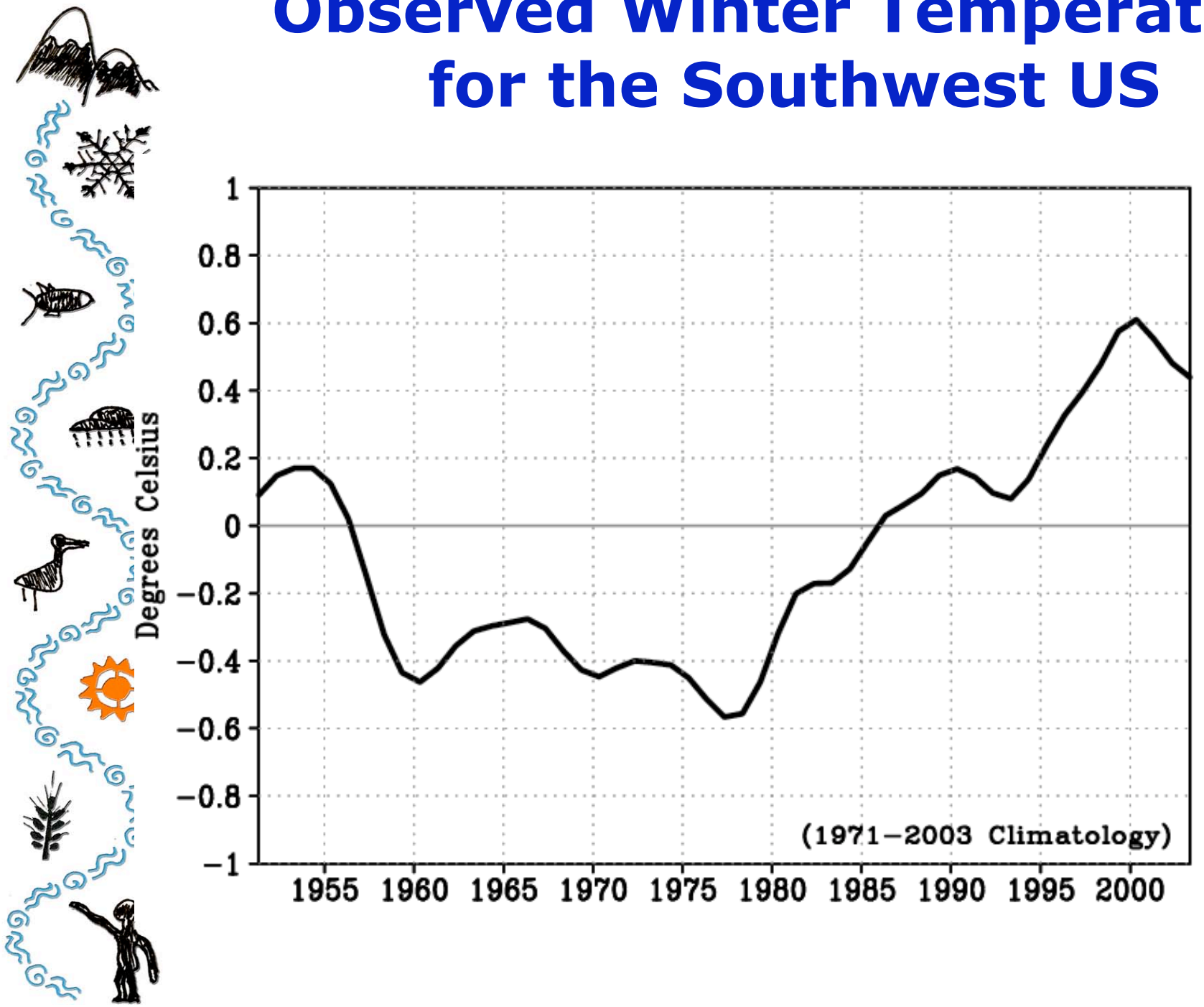
ENSO, PDO

Southwest Monsoon

Land Surface Feedbacks

Extreme Events

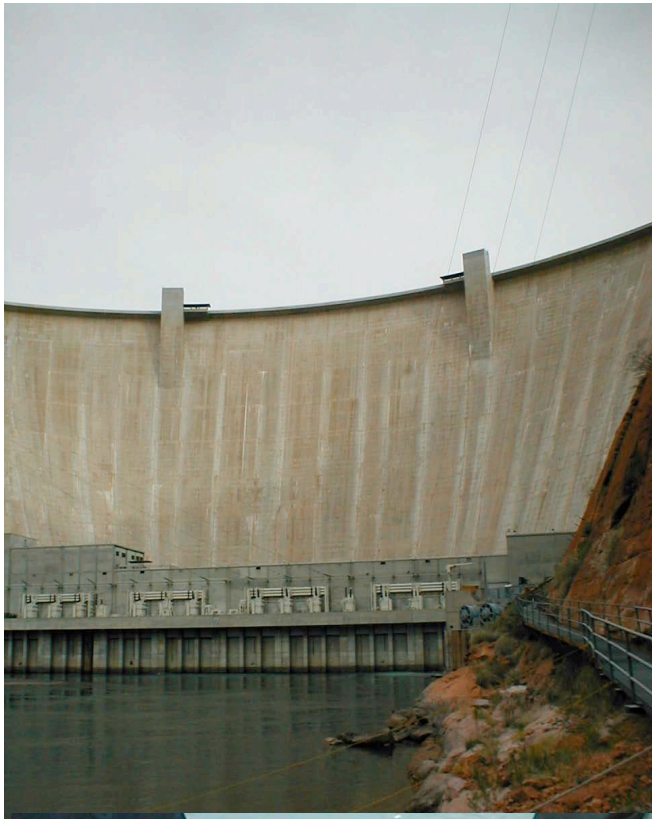
Observed Winter Temperature for the Southwest US



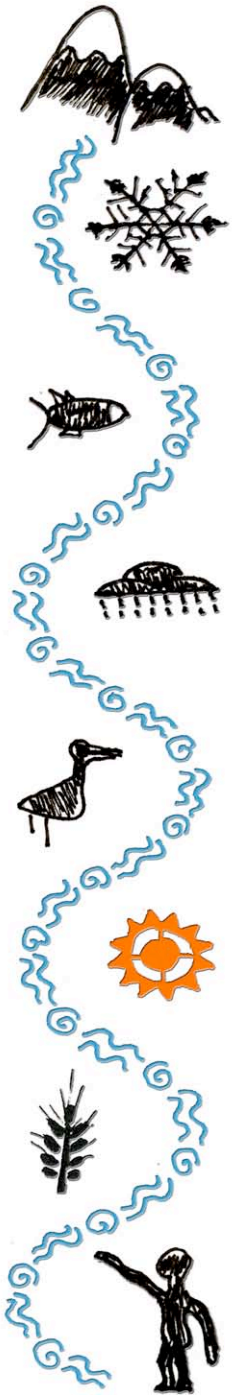
Issues in the Grand Canyon

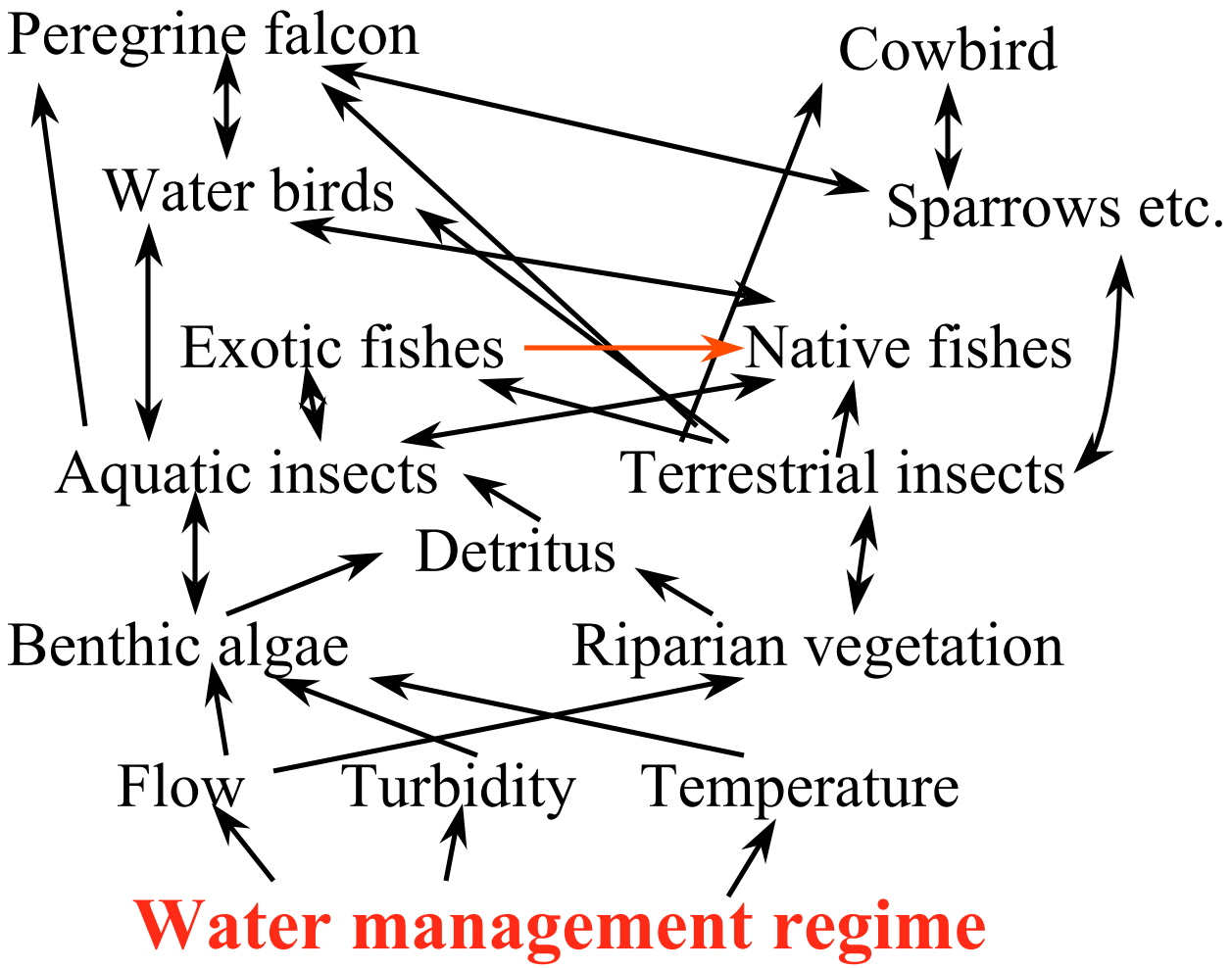
- Dam Construction
  - Loss of sediment input
  - Lower flows
  - Temperature changes
  - Trophy fishery
- Endangered species
  - Exotics

Hydropower,Recreation,
Over-allocation

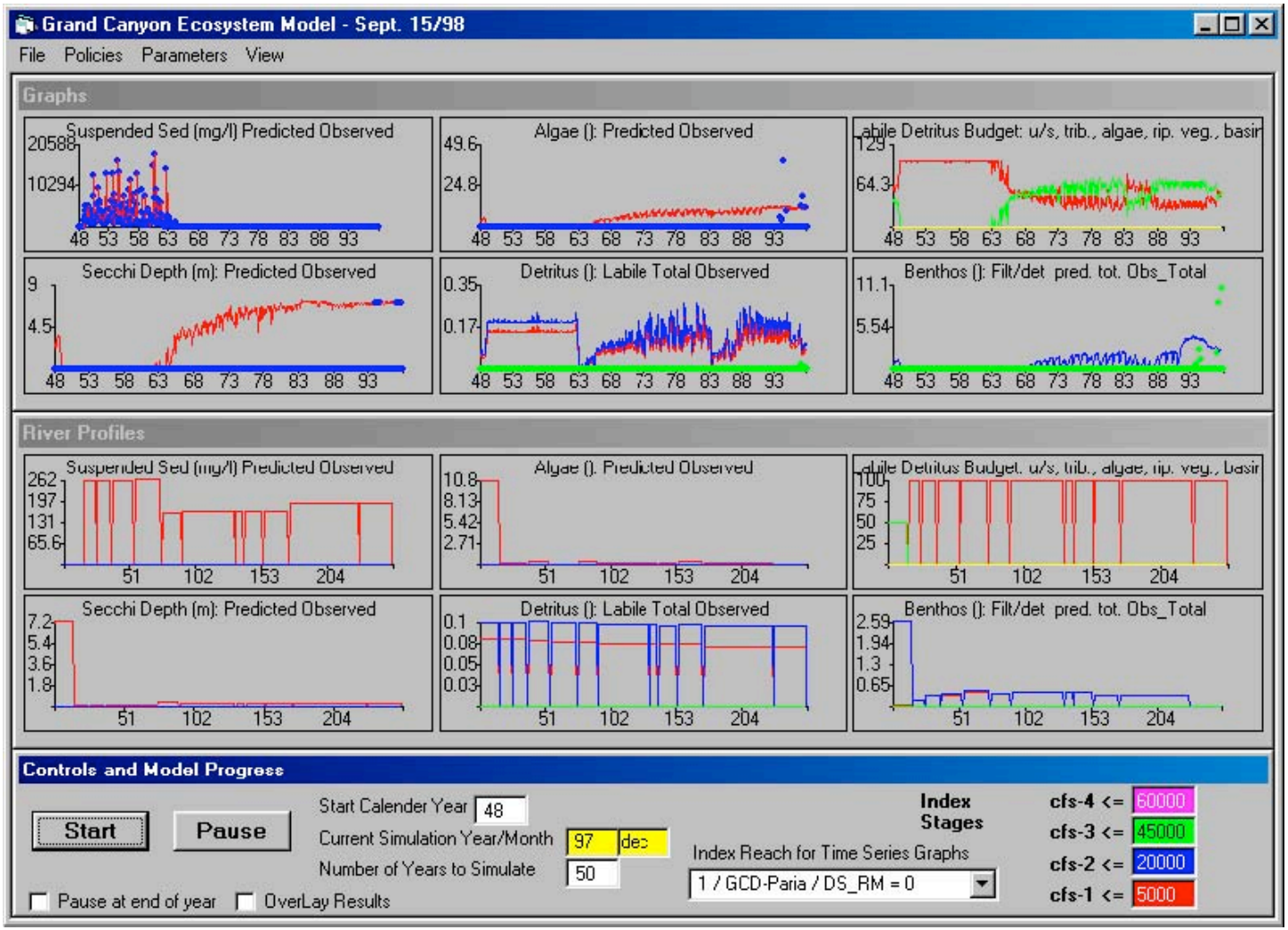


We can now build some really impressive looking models

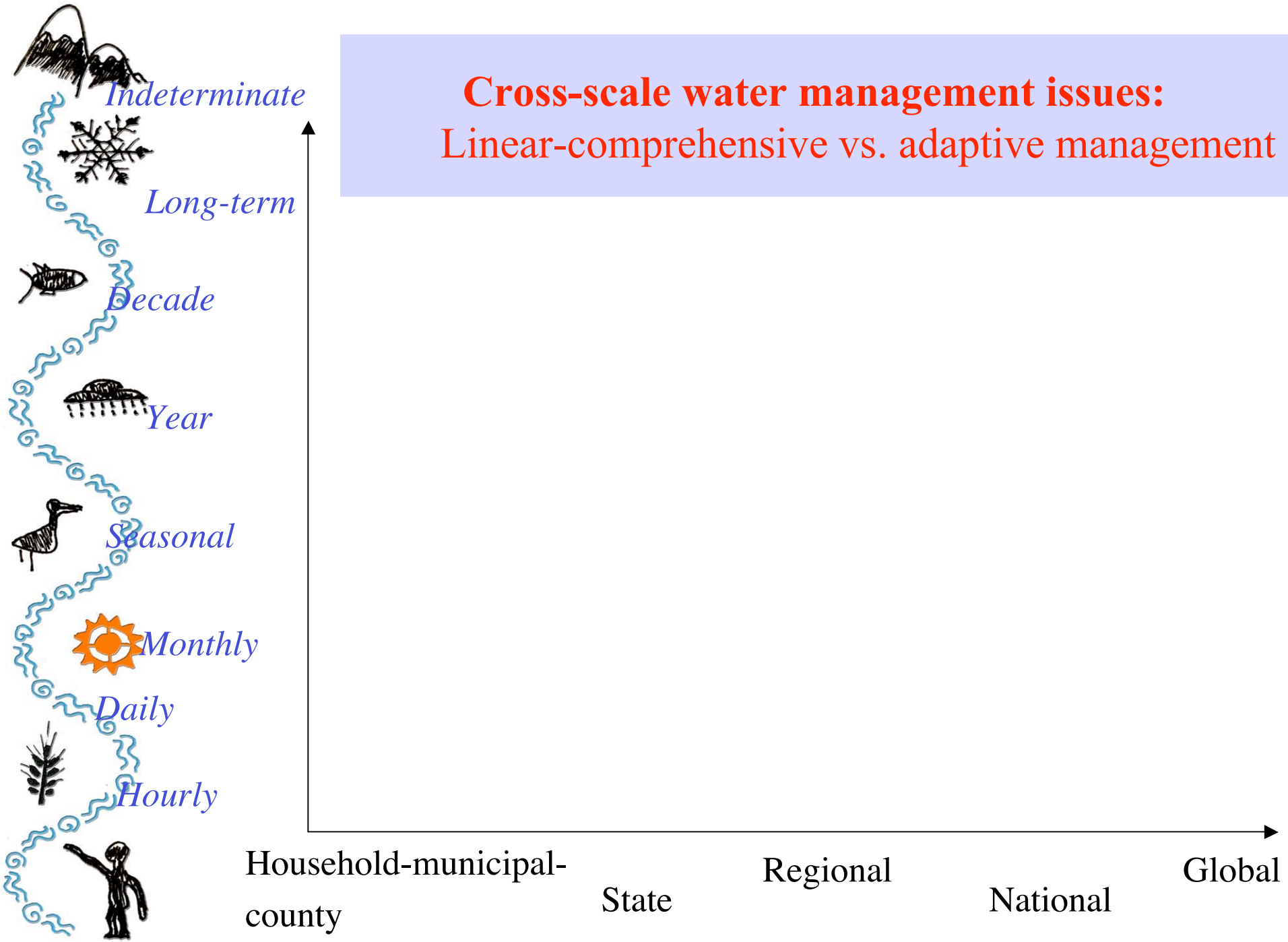


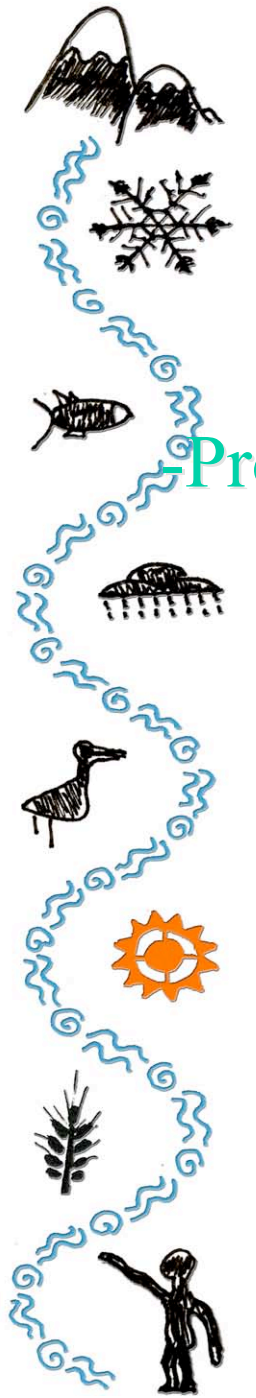


These models look right when compared to available data



Cross-scale water management issues:
Linear-comprehensive vs. adaptive management





Managing Uncertainty:

Where is the uncertainty?

-Problem Domain

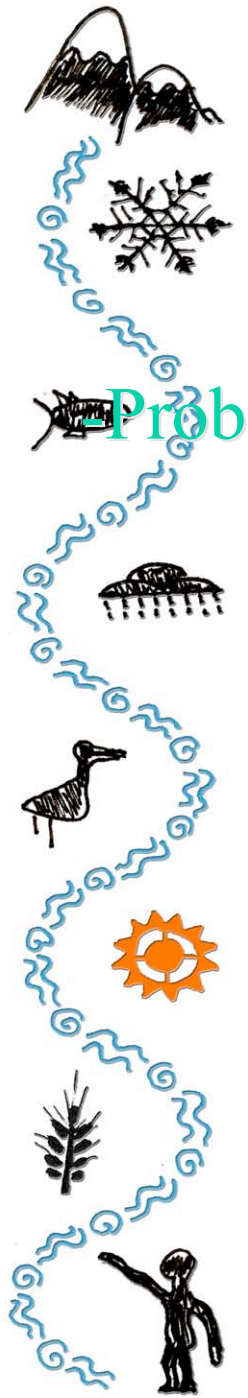
-science

-organizational

-community

-political

- adequate theory
-multiple hypotheses & congruent management actions.
-tractability (complexity)
-confronting models w/data
-independence/ rigor
-novelty



Managing Uncertainty:

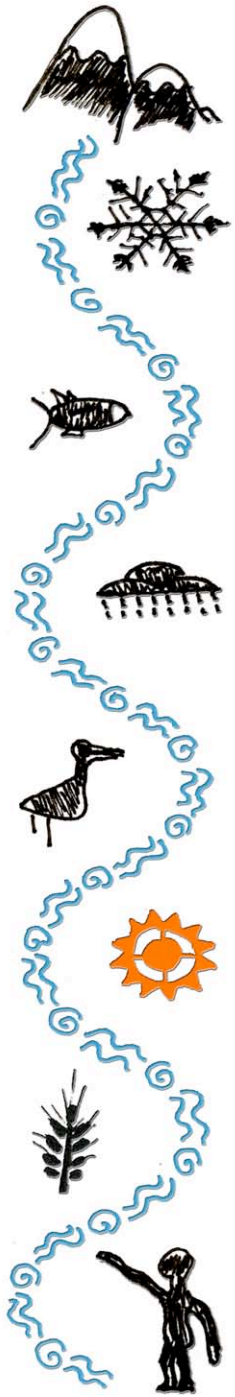
Where is it?

-Problem Domain

-science

-organizational
-community
-political

- expressions of power
- multiple equilibria
  paths not taken
- NONE are scale invariant
- stability of institutions
  novelty of approaches
- role of epistemic groups
- multiple discourses
- juggling domains

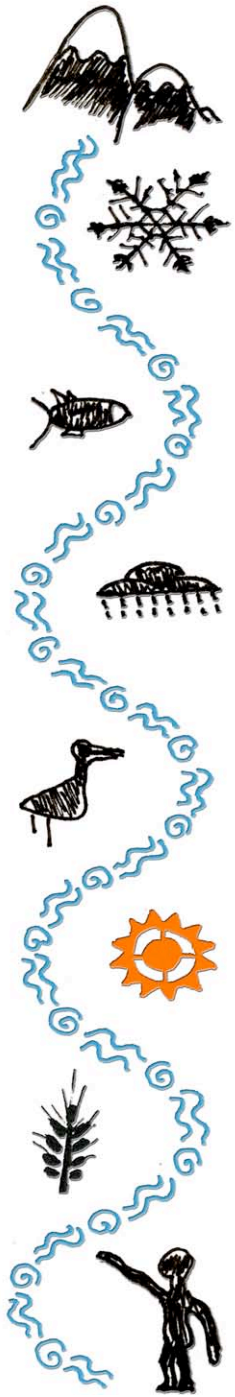


Columbia River

- Flexibility and risk management remain underlying concepts
- Broad range of potential outcomes (growth, energy demand, NOT “most likely” etc.)

- By 2000 the Columbia River Basin managers were no longer using the term

  “adaptive management”



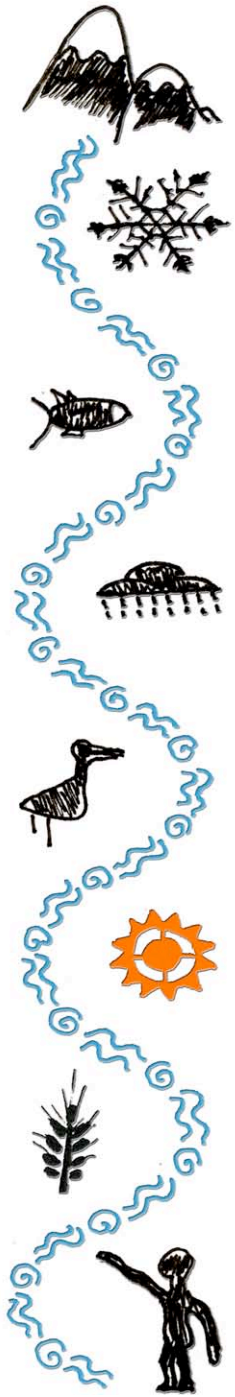
Well-defined standards or procedures for confronting uncertainty in AM are lacking

- "Acceptable risk" is poorly defined
- Experiments are visibly gambles, and public decisions are not supposed to be
- Admission of uncertainty is too often seen as weakness, therefore assume that investment in small research or engineering solutions will do the job
- No clear definition of risk management authority and responsibility

"Flexibility" can be a dodge for difficult decisions

–Usefulness of projections in AM

- Are the findings & understandings at the level to be usable?
- Early-warning:
  - Do they convey the uncertainty needed for hedging strategies?
  - Do they tell us how to hedge better against [remaining] uncertainty?



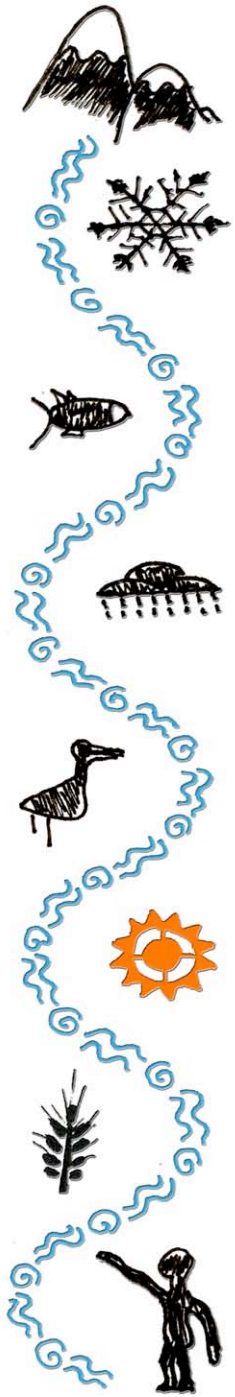
AM problems: Limited ability to experiment
"war" of competing models and projections

Actors, resistors, decision makers

- "Adaptive management" models have become mediating tools in the dialog among actors, resistors, decision-makers

  i.e. not necessarily a "consensus builder" but highlights potential tension and exposes perceptions of risk and uncertainty

e.g. water leasing vs. permanent transfers



Problem framing: water managers and researchers

- Goals
- Critical issue identification
- Time frames
- Basis for decisions
- Expectations
- Product characteristics
- Nature of “use”

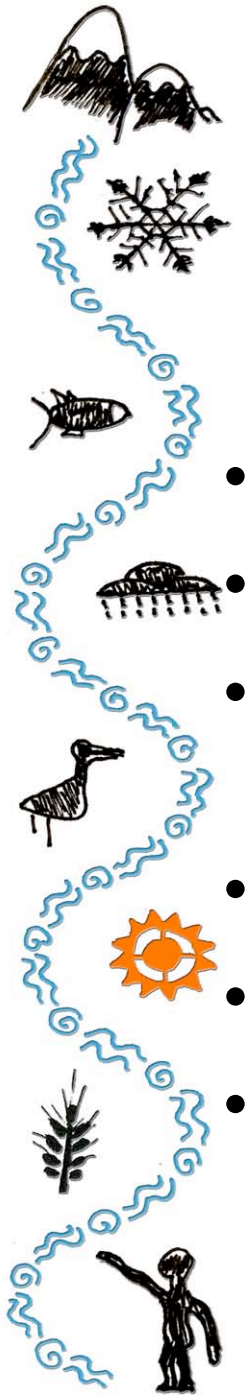
The Known, Unknown, and the Unknowable

- Most managers do not believe that climate change scenarios should elicit a change in resources planning
- E.g. most water utilities believe that they can withstand a repeat of past drought patterns given current infrastructure and water policy: criticality, capacity, credibility
- Know-how, know-what, know-where, know-when,

- KUU
- Choice/desirability of outcome is influenced by many factors beyond probabilities and payoffs

  (see also “comparative ignorance hypothesis” Fox and Tversky 1995)

- Meta-uncertainty-Researchers do not always know how unsure they are or what is needed to be known



Envisioning the future: What can these experiences provide for scenario development?

- Concrete examples and representative events
- Use easily recalled supporting evidence
- Ask people to project themselves into the situation (explain outcomes, situation etc.)
- Plausibility (also implausibility)
- Prior experience and beliefs
- Document situation in which scenarios are presented and discussed

Additional criteria for scenario "validity"

- Purpose of the scenario
- Criteria the scenario must meet to be declared acceptable for use
- The context in which the scenario is to be used

Different value frames in forecast applications: Distributional and procedural issues

Technical frame	**Application frame**	**Procedural frame**
Quality	Relevance	Access
Consistency	Compatibility	Legitimacy
Economic potential	Usefulness	Usability
Dissemination	Communication	Capacity
Efficiency	Efficiency	Equity
Expert	Consultative	Co-production

Option Space

O_0 Ignore the "Problem"

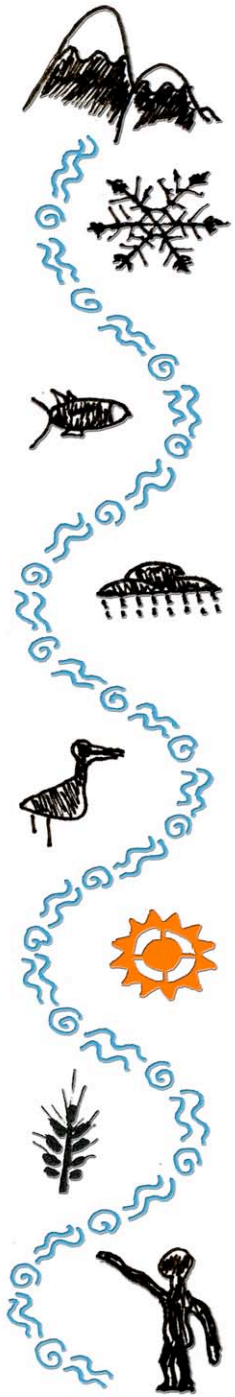
O_1 O_2 O_3 O_4 O_5
O_6 O_7

Just Plain Stupid Options

O_{12} O_{13} O_{14}
Uncertainty-Hedging Options

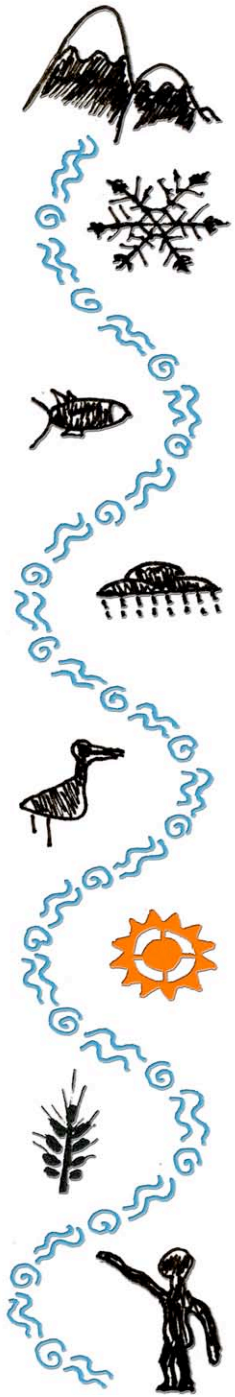
O_8 O_9 O_{10} O_{11}

Science-Confident Options



Alternatives assessments

- Fixed policy/practice
- "Trial & Error" – random choice of new practices
  - Nobody does this
- AM as implementing new, provisionally optimal practices on the basis of feedback
- AM as implementing & varying policies in order to learn –
  - Could be optimal, but not necessarily
- Adaptive governance



Opportunities for “win-win” situations and rule changes may exist. Changes are extremely difficult to implement

- Criticality
- Credibility
- Capacity
- Communication