Climate Change and the Upper Rio Grande Watershed: Assessing Impacts and Developing Insights for Strategic Adaptations

Brian H. Hurd

Dept of Agricultural Economics & Agricultural Business
New Mexico State University

NM STATE

“Far West Texas
Climate Change Conference”

El Paso, Texas
June 17, 2008

Overview

- Some Results From the Upper Rio Grande
  - Approach and Conceptual Framework
  - Climate and Population Change Scenarios
  - Changes in Streamflow
  - Economic Consequences
- Thoughts on Adaptation and Going Forward
  - Adaptation: how, what, where, and when
  - Taking action and coping with uncertainty
  - Tactics and strategies

Climatic Shifts in Hydrograph

<u>Model assumptions</u>

temperature ↑ 4°C

diurnal temp. range ↓ 1.4°C

Precipitation ↑ 10%

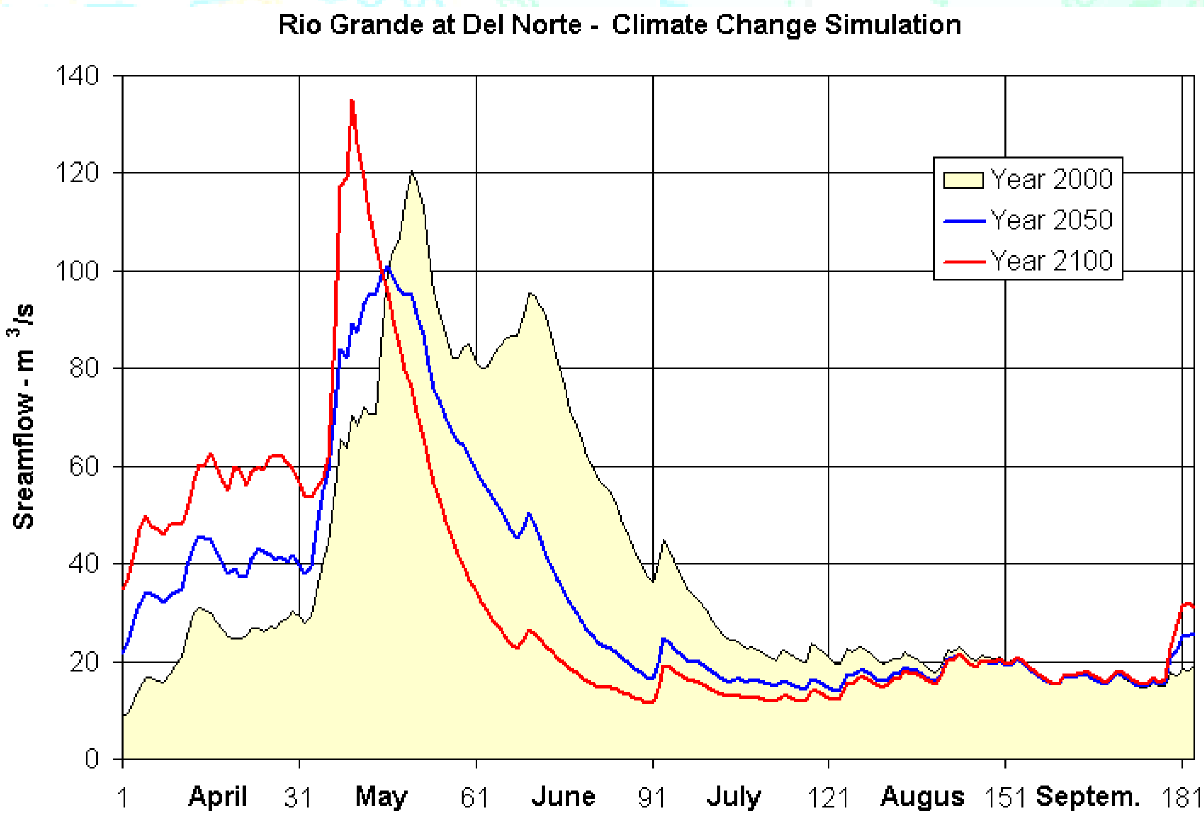
<u>Results</u>

Earlier snowmelt

Higher peak streamflow

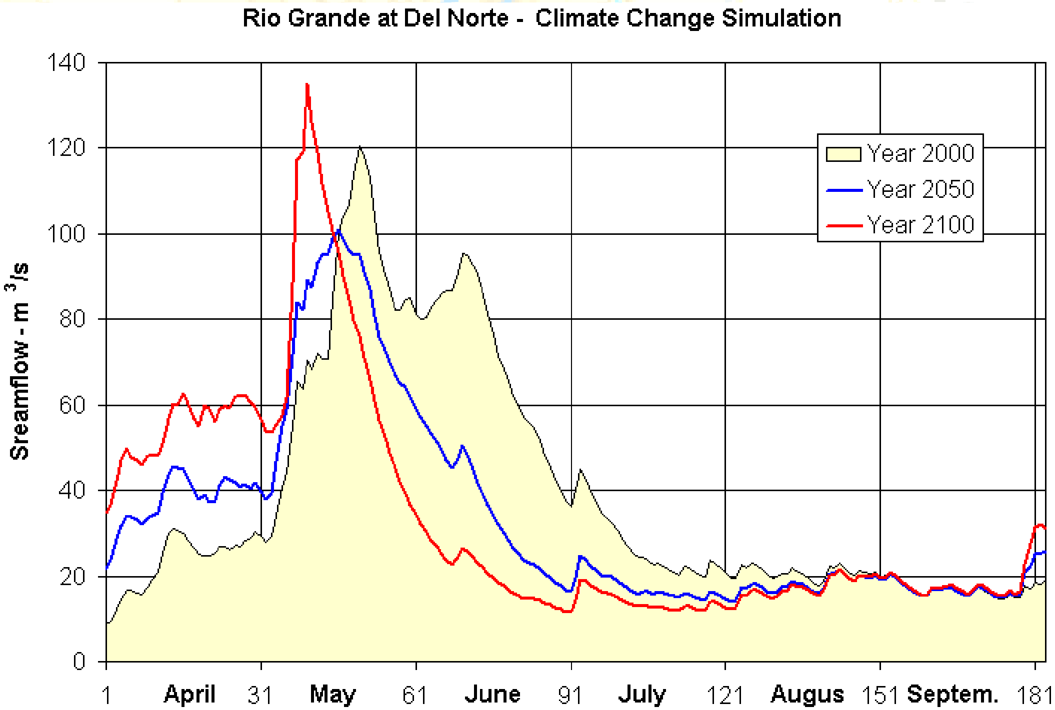
Lower summer streamflow

<u>Implications for Water Users?</u>



Days – April 1 to September 30

Implications?



What does it mean for …

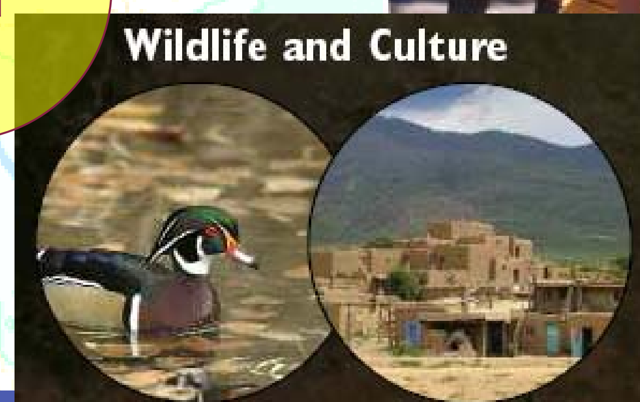
- Water storage and distribution systems?
- Urban and rural water users?
- Water quality?
- Hydropower?
- Recreational and cultural functions?
- Riparian ecosystems and migratory patterns?

What are the Risks?

The health of New Mexico's rural economy, blend of cultures, and unique ecosystems is tightly hinged to water.

With no water to spare, the Rio Grande is a highly vulnerable watershed where virtually all surface waters are consumed by people, plants, and evaporation.

Projections of less water and more people heighten the need for more finely tuned systems of water use and management.



Climate Change and It's Implications for New Mexico's Water Resources and Economic Opportunities

Hurd, B.H. and J. Coonrod. 2007.

Objective: To use data and information specific to the Rio Grande's upper watershed to evaluate and assess a range of plausible impacts of climate change on regional water users by integrating:

Climatology
Hydrology
Economics

Acknowledgements:

Research support from the National Commission on Energy Policy and William and Flora Hewlett Foundation.

RioGEM model developers Drs. Jim Booker of Siena College and Frank Ward of New Mexico State University.

Anne Watkins (New Mexico Office of the State Engineer) and Dr. Dave Gutzler (University of New Mexico).

New Mexico State Univ. Agricultural Experiment Station.

Approach

- **Characterize Plausible Future Conditions**
  - **Climate Change**
    - Identify and apply representative climate change scenarios
      - (‘dry’, ‘middle’, ‘wet’ in 2 time periods, ‘2030s’ and ‘2080s’).
  - **Population Growth**
    - Develop a baseline demographic change scenario that estimates changes in population, incomes and urban water demand.

- **Simulate Hydrologic and Economic Processes**
  - **Streamflow Change**
    - A simplified lumped water balance model (WATBAL) is used to project changes in streamflows, irrigation requirements, and evaporation losses.
  - **Water Use and Economic Impacts**
    - A hydro-economic water management model of the Upper Rio Grande watershed (RioGEM) optimizes the economic value of water use across the entire watershed.

Conceptual Framework

Climate Change
(GCMs)
Changes in Temperature
and Precipitation

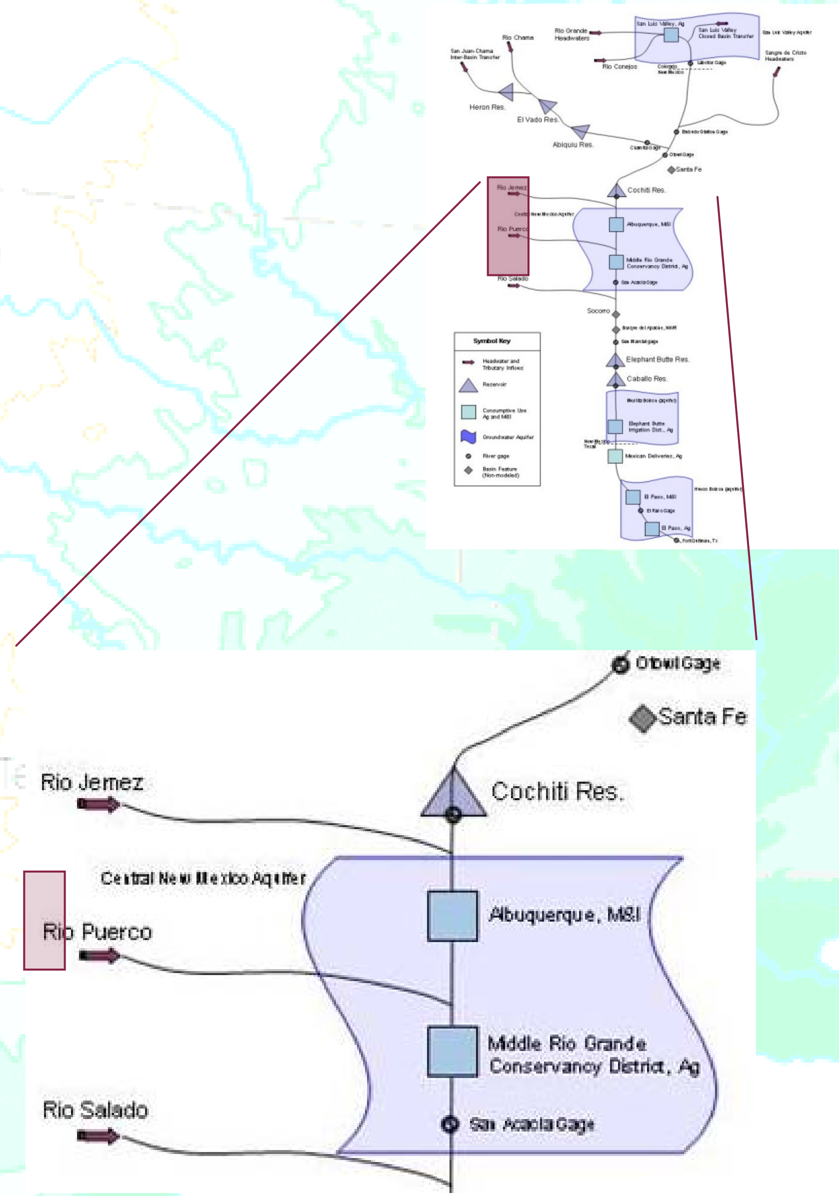
Streamflow
(WATBAL)
Changes in Streamflows, Evaporation,
and Irrigation Requirements

Demographic Change
Changes in Population
and Income

Hydro-Economy
(RioGEM)
Changes in the Value of Water, Water Use,
Reservoir and Aquifer Storage,
and Economic Welfare

Key Features of RioGem Hydro-Economic Model

- Monthly Time-step
- Water Supply
  - Streamflow, Reservoirs and Aquifers
- Water Users
  - Consumptive users
    - Agriculture, Cities (M&I)
  - Reservoir recreation
  - Ecosystem maintenance flows (50+ cfs at San Acacia)
- Sensitivity to Climate
  - Streamflow timing and rates
  - Reservoir evaporation
  - Irrigation requirements



Assumptions and Limitations

Climatic change can profoundly affect New Mexico's character and economy in ways difficult to measure. In this study:

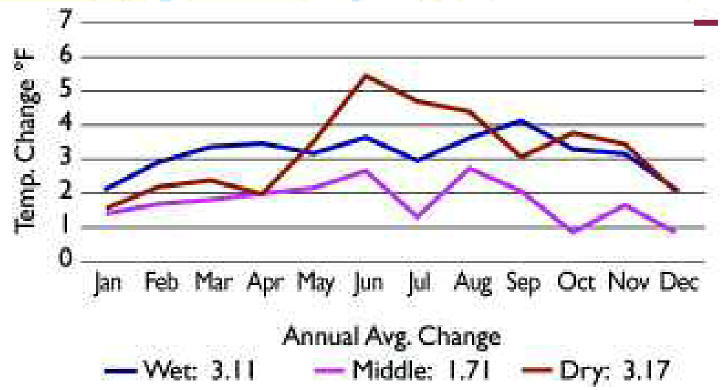
- **Monetary values and efficient water markets are assumed**
- **Future runoff and streamflow conditions are perfectly anticipated**
- **Some important economic, social and environmental values are not included**
  - Lost value associated with open space, wildlife, recreation, tourism, and scenic beauty
  - Damages from Summer Floods and Storms
  - Degraded rangeland affecting livestock and wildlife
  - Diminished water quality

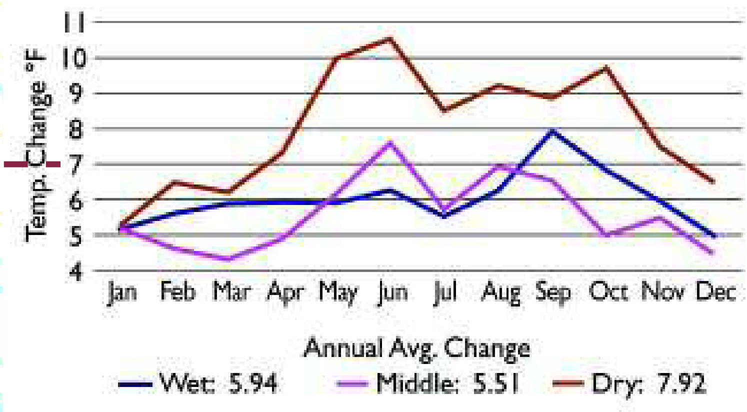
Analysis more than likely understates the value of impacts on the well being of New Mexico's communities and environments.

Climate Change Scenarios

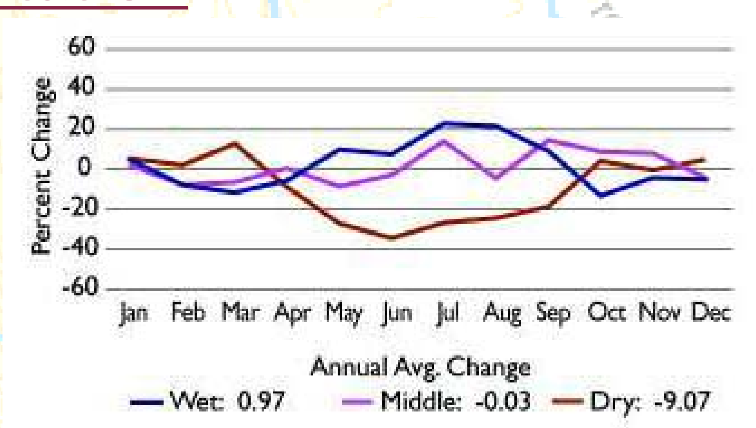
2030s | **2080s**

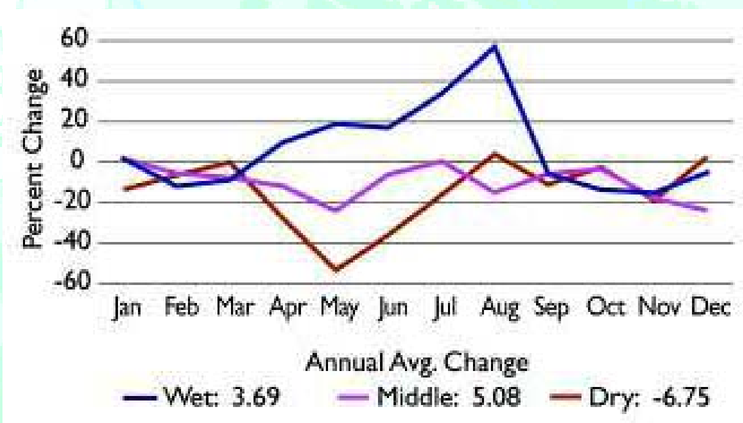
Temperature





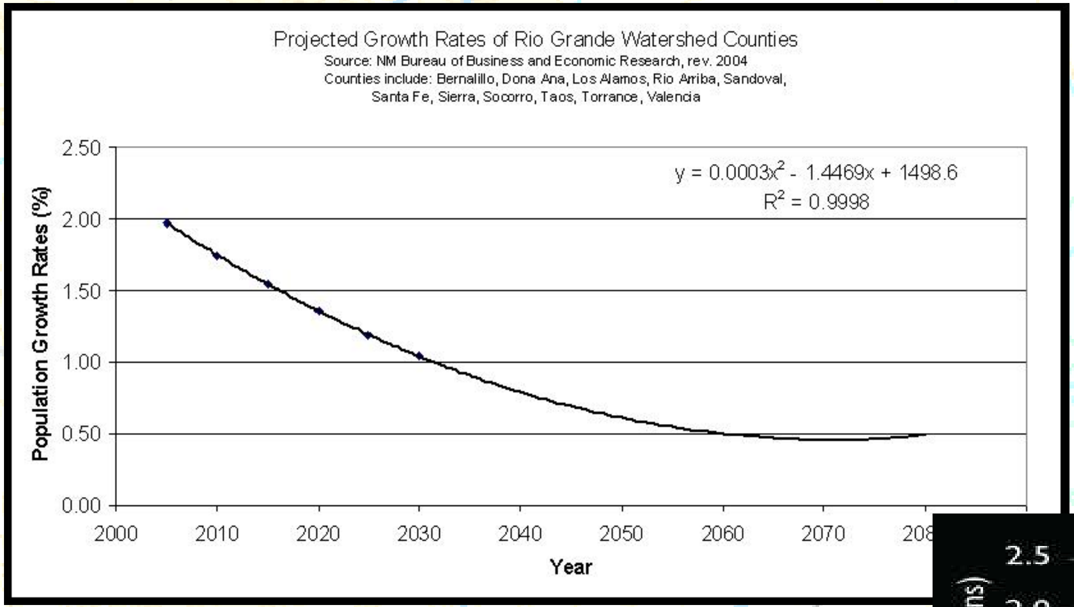
Precipitation





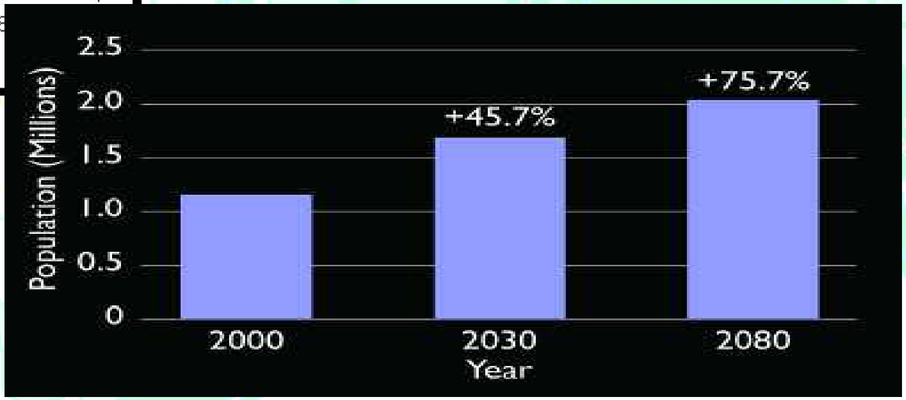
Population Growth Scenarios

(New Mexico Counties along the Rio Grande)



Annual Growth Rate Projected to Decline

Total Population Expected to Grow Significantly



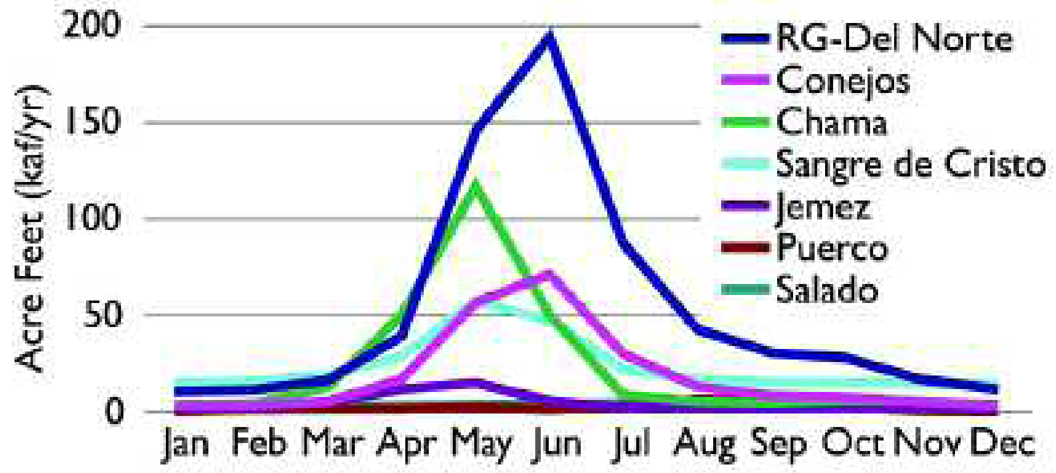
Source: Based on estimates from the New Mexico Bureau of Business and Economic Research (NMBBER), 2004

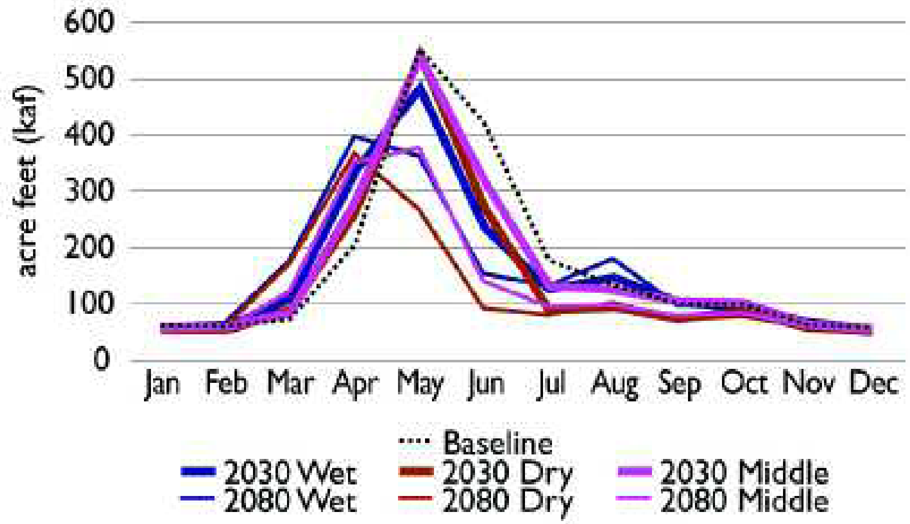
Present and Future Streamflow Hydrographs

Present:

Hydrographs of Major Rio Grande Tributaries

(1971-2000)



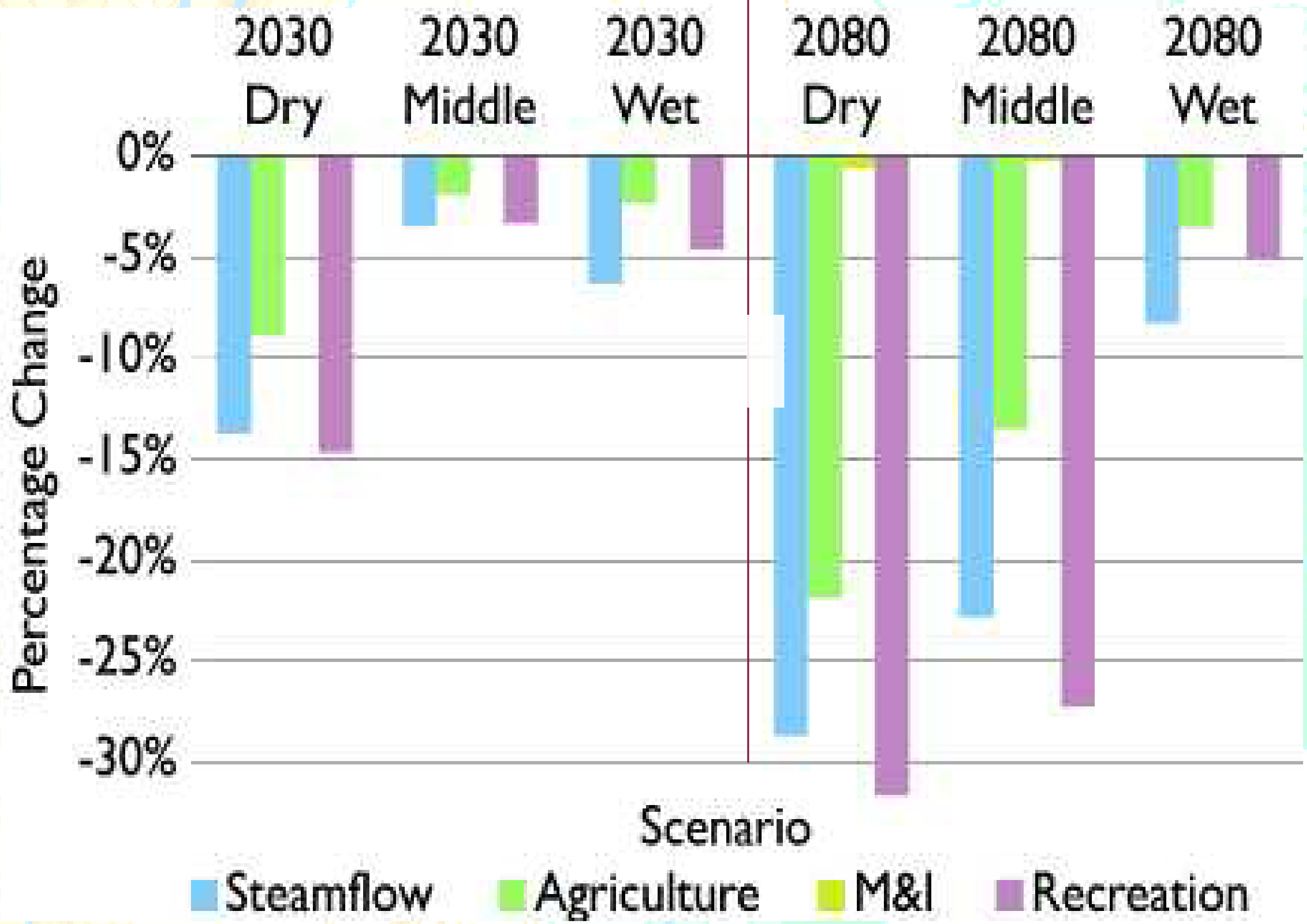


Future:

Hydrographic Shifts under Climate Change

(aggregate Rio Grande Streamflow)

Projected Changes in Streamflow and Economic Output



Key Findings

Water Supply Changes

1. Earlier snowmelt and peak runoff, greater evaporation losses.
2. Runoff is reduced by as much as 1/3 under drier scenarios. Even under ‘wetter’ scenarios total runoff falls due to higher evaporation rates.

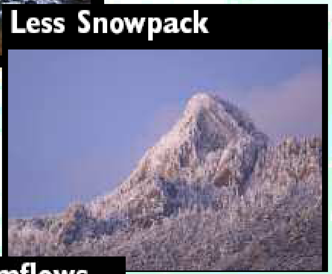
Water Demand Changes

3. Rising populations and lower water supplies will raise pressure to tighten and fine tune water management systems. Systems with limited storage capacities are most vulnerable.
4. Projected economic losses range from $13 million to $115 million by 2030, and from $21 million to over $300 million by 2080.

Rural and Environmental Stress

5. Traditional agricultural systems and rural communities are most at risk, and may need transitional assistance.
6. Losses to New Mexico’s residents, tourists, and wildlife could go well beyond such market-derived figures, including losses to the environment, water quality, and quality of life.


Earlier Snowmelt


Less Snowpack


Reduced Streamflows


Droughts


Floods

Questions and Challenges

Where Will Our Food Be Grown?

- Growing competition for agricultural resources from energy
- Rising immigration and labor costs
- Lower standards and regulations in other countries
- Increasing globalization

Does Imported Food have “Hidden Costs”?

- Transportation intensive with a heavy environmental footprint
- Uncertain health and food safety controls
- Reduced freshness, healthfulness
- Loss of domestic/local agricultural capability and infrastructure

Can Farms and Cities Better Help Each Other?

- Local sourcing enhances food security and reduces ‘hidden costs’ –
  -- may be even more valuable in the future?
- Locally produced foods are gaining in consumer and community preferences
- New Mexico is fortunate to have significant agricultural capabilities
- Opportunities exist for enhanced agro-urban cooperation
- Need to conserve agricultural capability and provide transitional assistance

Going Forward

Goal: <u>Smarter Decisions & Wiser Choices</u>

1. Quality Data and Information is Key
   - Strengthen adaptive management capability
   - Monitor and measure
   - Reduce uncertainty

2. Climate Aware Strategies
   - Mitigate (reduce) GHG emissions
   - Build adaptive capacity
     - e.g., policy, planning, partnerships

3. Shared Responsibility, Shared Burden
   - Cities → reduce outdoor water use, xeriscape
   - Farms → timing, technology, best management practices

Context for Adaptive Action

- Climatic change can cause significant harm to societies and ecosystems

- Reducing GHG emissions (aka mitigation) will likely reduce both the **degree** and **likelihood** of adverse conditions

- Longevity and inertia of atmospheric GHG forcing means some degree of climate change is **unavoidable**

- Therefore, adaptation is not a question of ‘if’ but rather of

How? What? Where? and When?

Terms and Definitions

Adaptation is a deliberate change in system design, function or behavior in response to or anticipation of changing conditions or events.

Reactive (autonomous) adaptation

A disturbance occurs and systems absorb impacts and attempt restoration to pre-disturbed conditions

Proactive (anticipatory) adaptation

The nature and timing of a disturbance is anticipated and systems reorganized to improve capacity to avert damages and leverage any resulting opportunities

"… organizations increasingly face adaptive challenges requiring them to **abandon the familiar and routine**. Instead, they need to develop the capacity to harness knowledge and creativity to fashion unique responses, stimulate organizational learning and sometimes **embrace transformational change**."

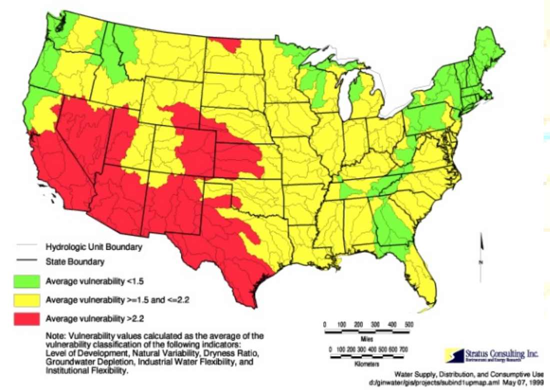
Carl Sussman, "*Building Adaptive Capacity: The Quest for Improved Organizational Performance*"

How? – Building Adaptive Capacity

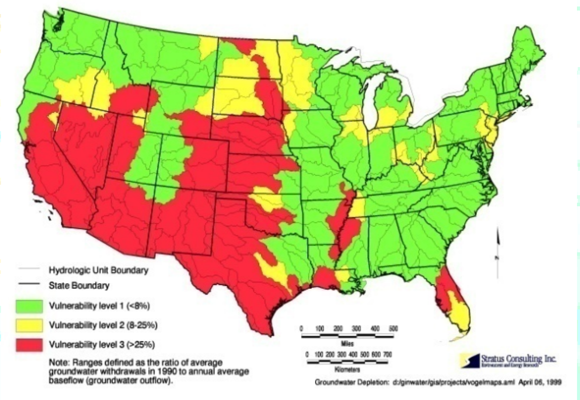
Adaptive Capacity is the ability of systems, organizations and individuals to:

- Adjust to realized and potential changes and disturbance events
- Take advantage of existing and emerging opportunities
- Successfully cope with adverse consequences, mitigate damages, and/or recover from system failures

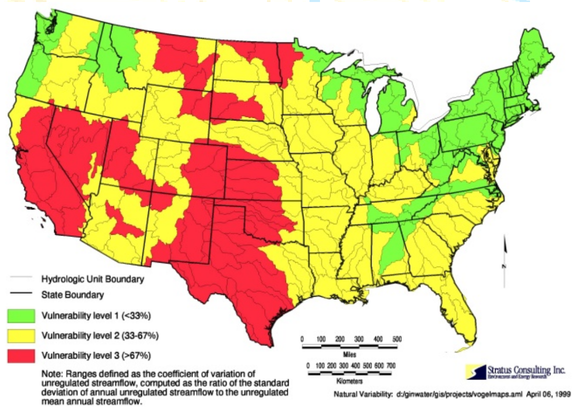
What? And Where? Identifying Vulnerable Systems: Water Resources Across the United States



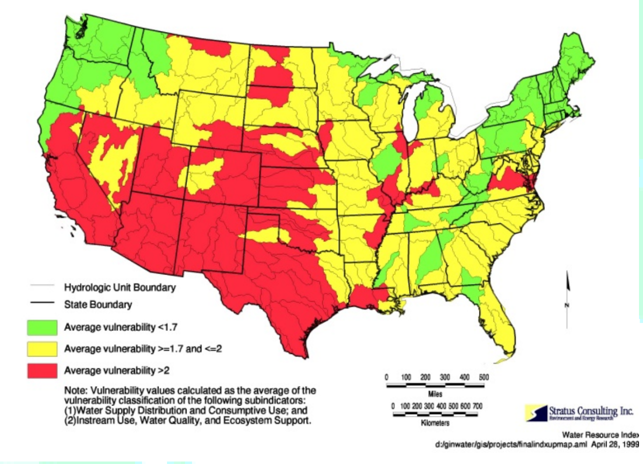
Rates of consumptive water use relative to surface supply



Extraction Rate of Groundwater Resources



Natural climatic variability



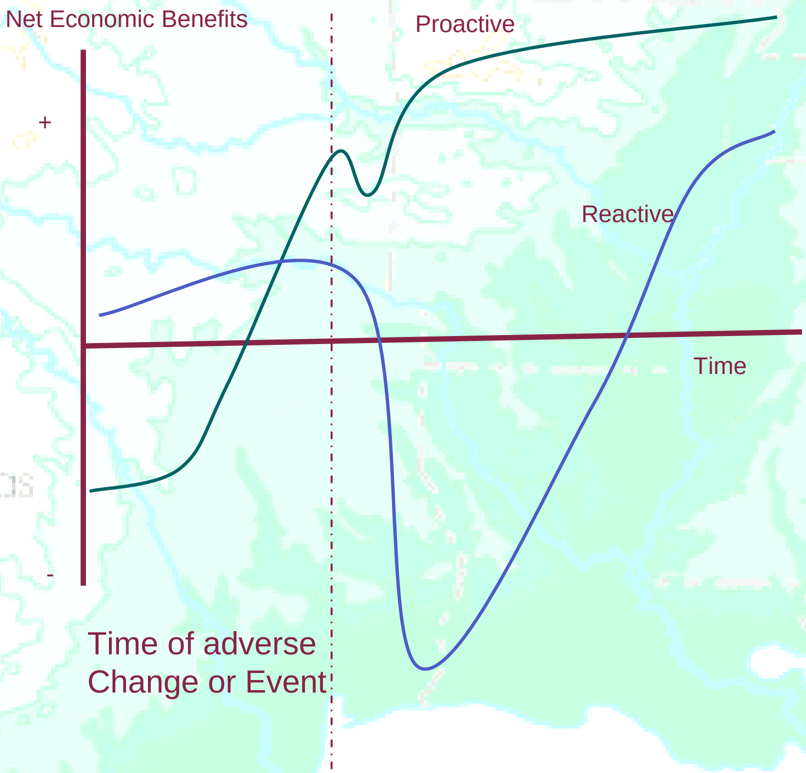
Overall Index

Source: Hurd, B.H., N. Leary, R. Jones, and J.B. Smith. 1999. "Relative Regional Vulnerability of Water Resources to Climate Change." *Journal of the American Water Resources Association*, December, 35(6): 1399-1410.

When? Timing Adaptations: the Relative Cost and Success of Reactive versus Proactive Adaptation

- Benefits of delayed action
  - Increased accuracy based on evolving knowledge and information
  - Postponed expenditures and possibly better technologies and lower unit costs

- Risks of delayed action
  - Less successful adaptation
    - More welfare losses and service disruptions
    - Greater likelihood of irreversible losses
  - Reduced adjustment time



Win-Win Strategies and Other Low Hanging Fruit

- **Improve science and information development, integration, and dissemination**
  - Integration of climatology, hydro sciences, and resource management
  - Strengthen institutional capacity, cooperation & collaboration
    - Establish strategic partnerships between State-Univ.- Nat. Labs. – Local Gov't

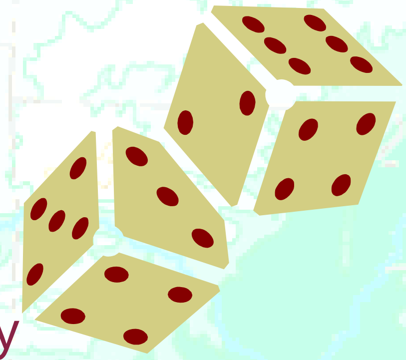
- **Develop appropriate risk management institutions and policies**
  - Climate-risk sensitive policies and regulations
    - Appropriate insurance and disaster recovery incentives
    - Greater 'risk sharing' rather than 'blanket protection' from climate risks
  - Enhance stakeholder awareness and decision-making participation

- **Increase the use of resource markets and incentive-based policy designs**
  - Compensate for the value of 'saved' water
  - Increase voluntary and cooperative solutions to improve water use efficiency and compliance, conversely limit use of regulatory 'stick approaches'

- **Add flexibility and safety to infrastructure design and assessment**
  - Greater flexibility in design
  - Wider safety margins and tolerances
  - Enhance water supply opportunities – e.g., desalination, aquifer mgt.

- **Consider climatic factors in land use planning and building codes**
  - Risk appropriate zoning
  - Conservative building code enforcement
  - Increase public awareness of risks and responsibilities e.g., flood plains and levee tolerances

Coping With the Uncertainties of Climate Change



- Changing climates are like a game of chance where the deck is stacked and dice loaded
  - It is difficult and uncertain to assess changes in climatic probabilities
  - We can hope that they are gradual and incremental
- Decision heuristics or ‘rules of thumb’ may be necessary
  - Revise risk beliefs accordingly – using subjective or expert opinion as necessary
  - Play as if you knew how the odds were changing as though you were counting cards or playing with loaded dice
- Small changes in risk beliefs MAY only require small changes in strategies/actions
- However, anticipatory structural changes may be the ‘best’ overall strategy, enhancing system
  - Reliability, flexibility, failure tolerance

Closing Thoughts

- Adaptation <u>complements</u> mitigation in a comprehensive and coordinated climate strategy

- Enhancing adaptive capacity reduces vulnerability, increases success likelihood, and may have non-climate benefits

- Look for 'no-regret' and 'win-win' opportunities to:
  - Strengthen capability and expertise in climate science, hydrology, and resource management
  - Foster partnerships and strategic alliances to harness capacities across organizations and institutions e.g., State-Labs-Univ-local gov't-NGOs
  - Invest in education and economic development, the keys to unlocking the engine of adaptive capacity

More information can be found at:
http://agecon.nmsu.edu/bhurd