Lahontan Climate Change Adaptation Planning
WORKSHOP AGENDA

January 15, 2015, South Lake Tahoe

8:30 WELCOMING & Public Forum

8:40 PRESENTATIONS

10:00 *****break*****

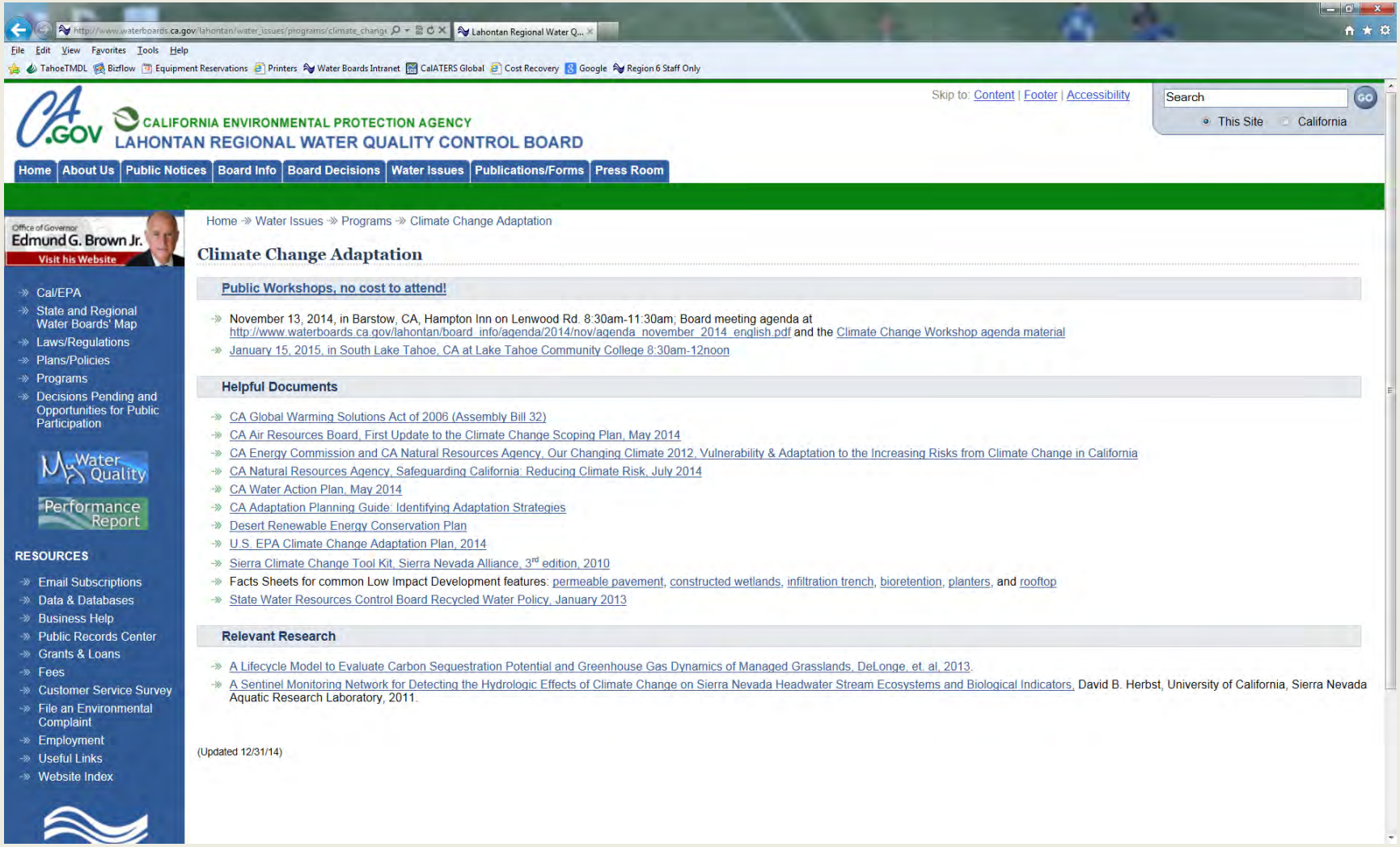
10:15 SMALL GROUP BRAINSTORM

11:30 REPORT OUT from small groups

12:00 NEXT STEPS & Closing

Lahontan Climate Change Adaptation Webpage

http://www.waterboards.ca.gov/lahontan/water_issues/programs/climate_change_adaptation/index.shtml



CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
LAHONTAN REGIONAL WATER QUALITY CONTROL BOARD

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- Laws/Regulations
- Plans/Policies
- Programs
- Decisions Pending and Opportunities for Public Participation

Water Quality Performance Report

RESOURCES

- Email Subscriptions
- Data & Databases
- Business Help
- Public Records Center
- Grants & Loans
- Fees
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Climate Change Adaptation

Public Workshops, no cost to attend!

- November 13, 2014, in Barstow, CA, Hampton Inn on Lenwood Rd. 8:30am-11:30am; Board meeting agenda at http://www.waterboards.ca.gov/lahontan/board_info/agenda/2014/nov/agenda_november_2014_english.pdf and the Climate Change Workshop agenda material
- January 15, 2015, in South Lake Tahoe, CA at Lake Tahoe Community College 8:30am-12noon

Helpful Documents

- CA Global Warming Solutions Act of 2006 (Assembly Bill 32)
- CA Air Resources Board, First Update to the Climate Change Scoping Plan, May 2014
- CA Energy Commission and CA Natural Resources Agency, Our Changing Climate 2012, Vulnerability & Adaptation to the Increasing Risks from Climate Change in California
- CA Natural Resources Agency, Safeguarding California: Reducing Climate Risk, July 2014
- CA Water Action Plan, May 2014
- CA Adaptation Planning Guide: Identifying Adaptation Strategies
- Desert Renewable Energy Conservation Plan
- U.S. EPA Climate Change Adaptation Plan, 2014
- Sierra Climate Change Tool Kit, Sierra Nevada Alliance, 3rd edition, 2010
- Facts Sheets for common Low Impact Development features: permeable pavement, constructed wetlands, infiltration trench, bioretention, planters, and rooftop
- State Water Resources Control Board Recycled Water Policy, January 2013

Relevant Research

- A Lifecycle Model to Evaluate Carbon Sequestration Potential and Greenhouse Gas Dynamics of Managed Grasslands, DeLonge, et. al, 2013.
- A Sentinel Monitoring Network for Detecting the Hydrologic Effects of Climate Change on Sierra Nevada Headwater Stream Ecosystems and Biological Indicators, David B. Herbst, University of California, Sierra Nevada Aquatic Research Laboratory, 2011.

(Updated 12/31/14)

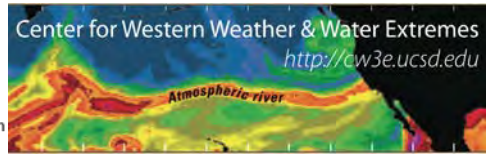
Climate Variability & Change, & California Water

Mike Dettinger, US Geological Survey,
Scripps Institution of Oceanography
w/ Dan Cayan, David Pierce, Suraj Polade, Mary Tyree & Sasha Gershunov

USGS science for a changing world

Southwest Climate Science Center

CNAP California-Nevada Climate Applications Program



KEY POINTS

- **Expect climate change; expect warming.**
- **Average precipitation may not change much, but volatile precipitation in California's past and future will combine with warming to produce wilder dry (and wet) spells.**
- **Importance of the presence or absence of very largest storms**

USGS science for a changing world

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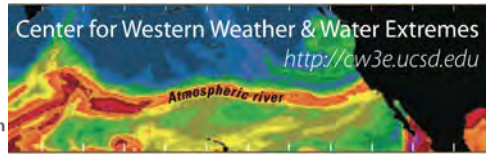
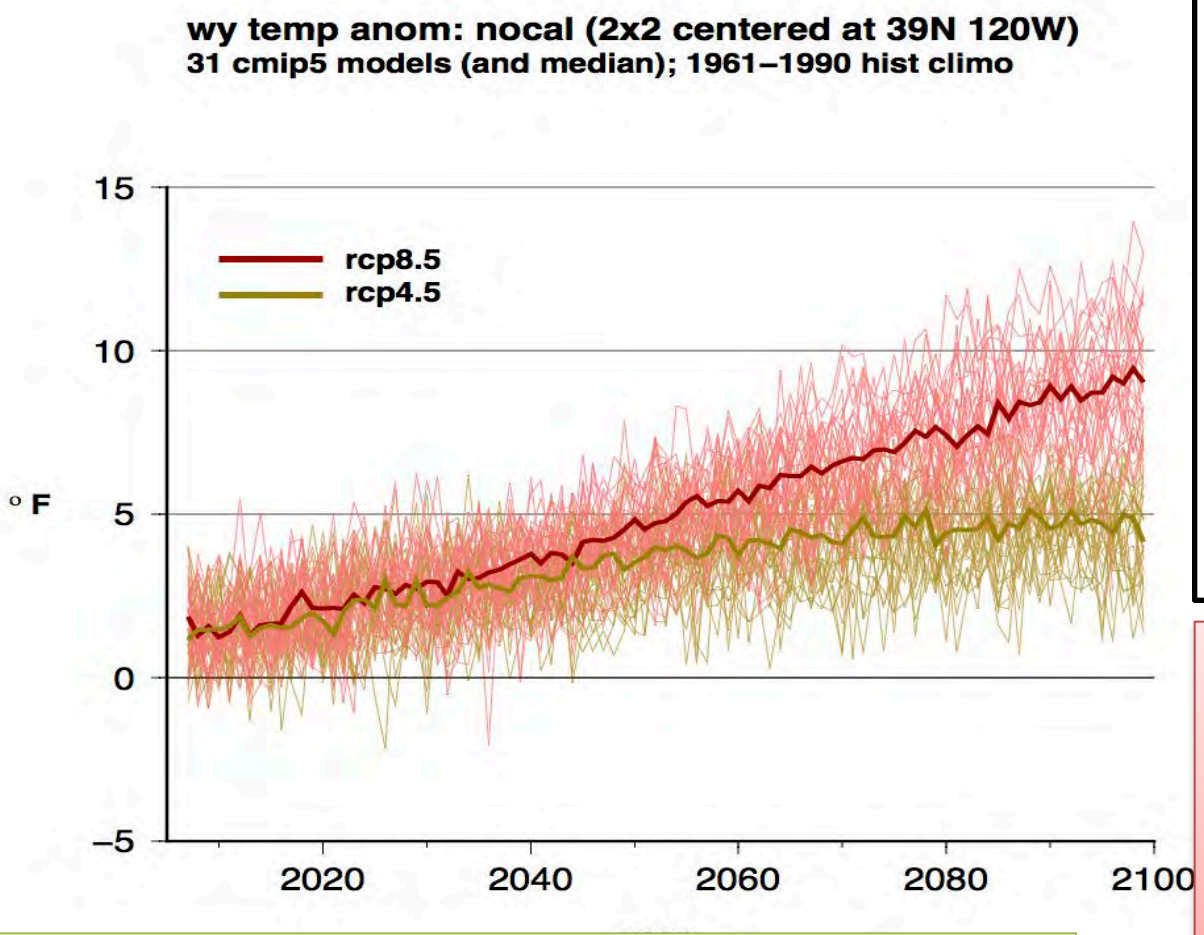
CNAP California-Nevada Climate Applications Program



PROJECTED TEMPERATURES



virtually all climate simulations project warming, but with a wide envelope of temperature change

5th IPCC GCMs project +4-6° F warming by 2060, under mid and high emissions

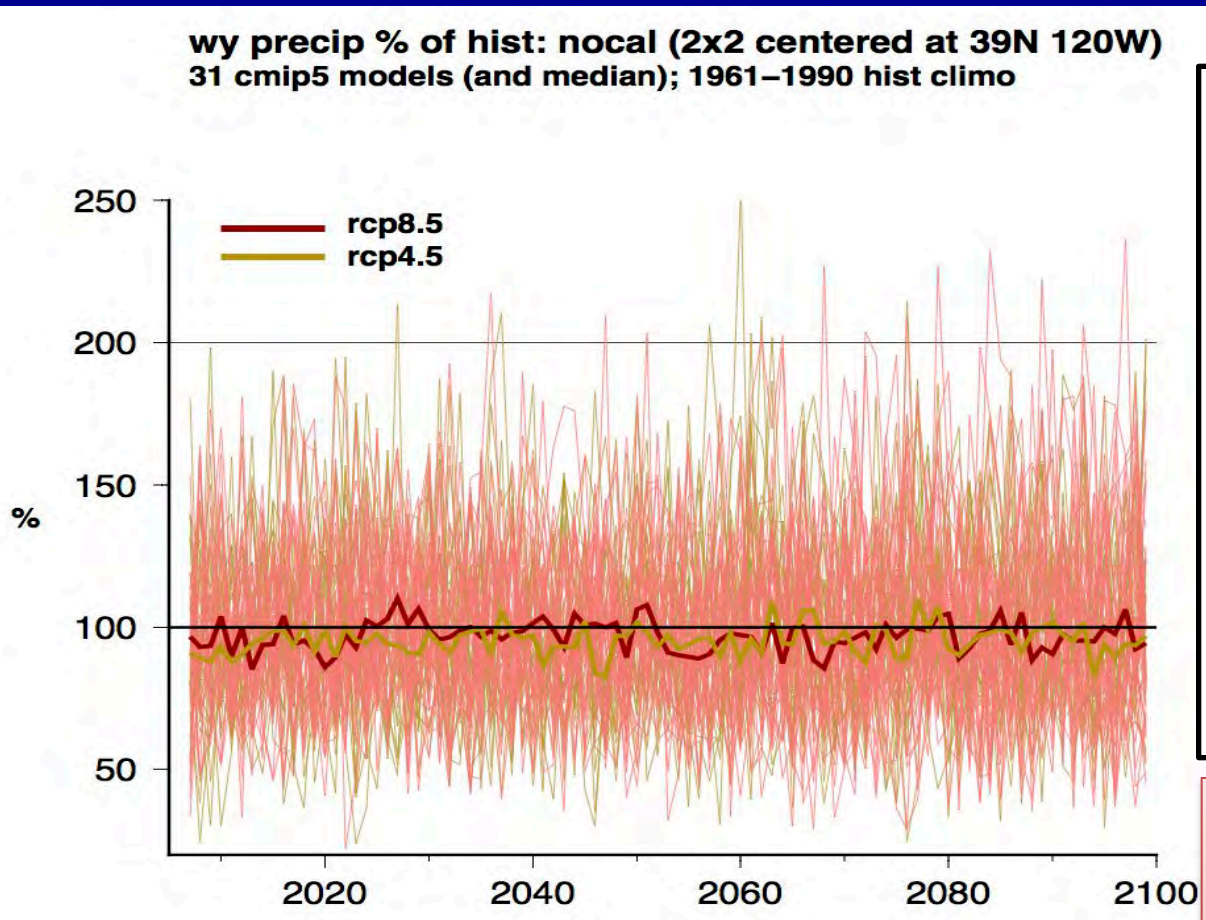
31 GCMs X 2 RCP Emissions Scenarios IPCC 5th Assessment (CMIP5) models

Some important questions:

Which emissions pathway will we take?

How will temperature change in near term?

PROJECTED PRECIPITATION CHANGES



5th IPCC GCMs project large precipitation volatility but modest avg change (maybe drier)

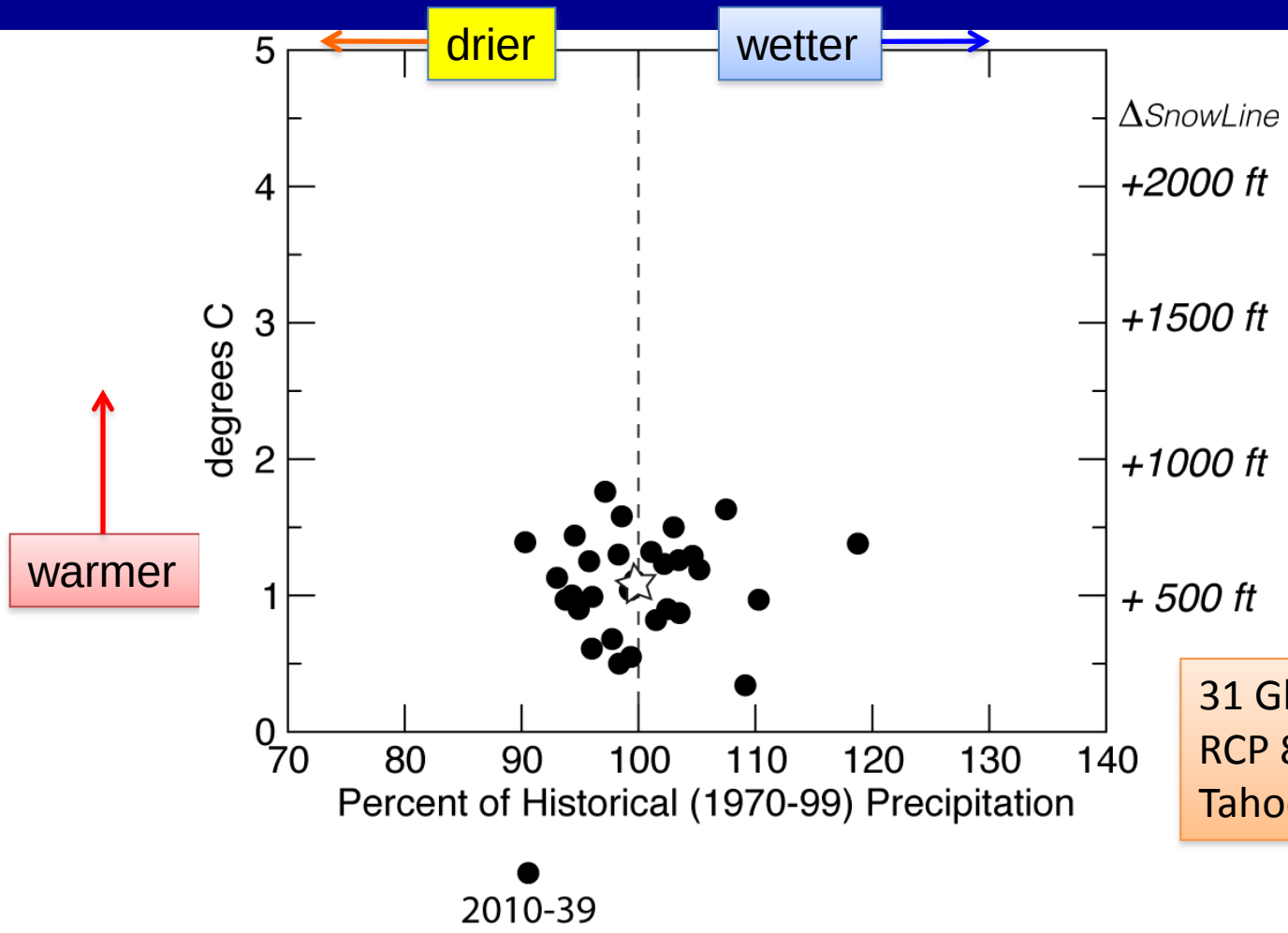
31 GCMs X 2 RCP Emissions Scenarios IPCC 5th Assessment (CMIP5) models

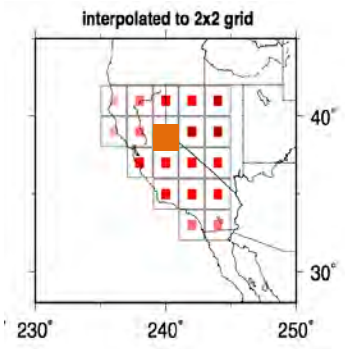
The important question:

Are there other changes lurking below weak annual-avg trends?

climate simulations disagree as to wetter vs drier overall; projected changes stay within natural range of variability

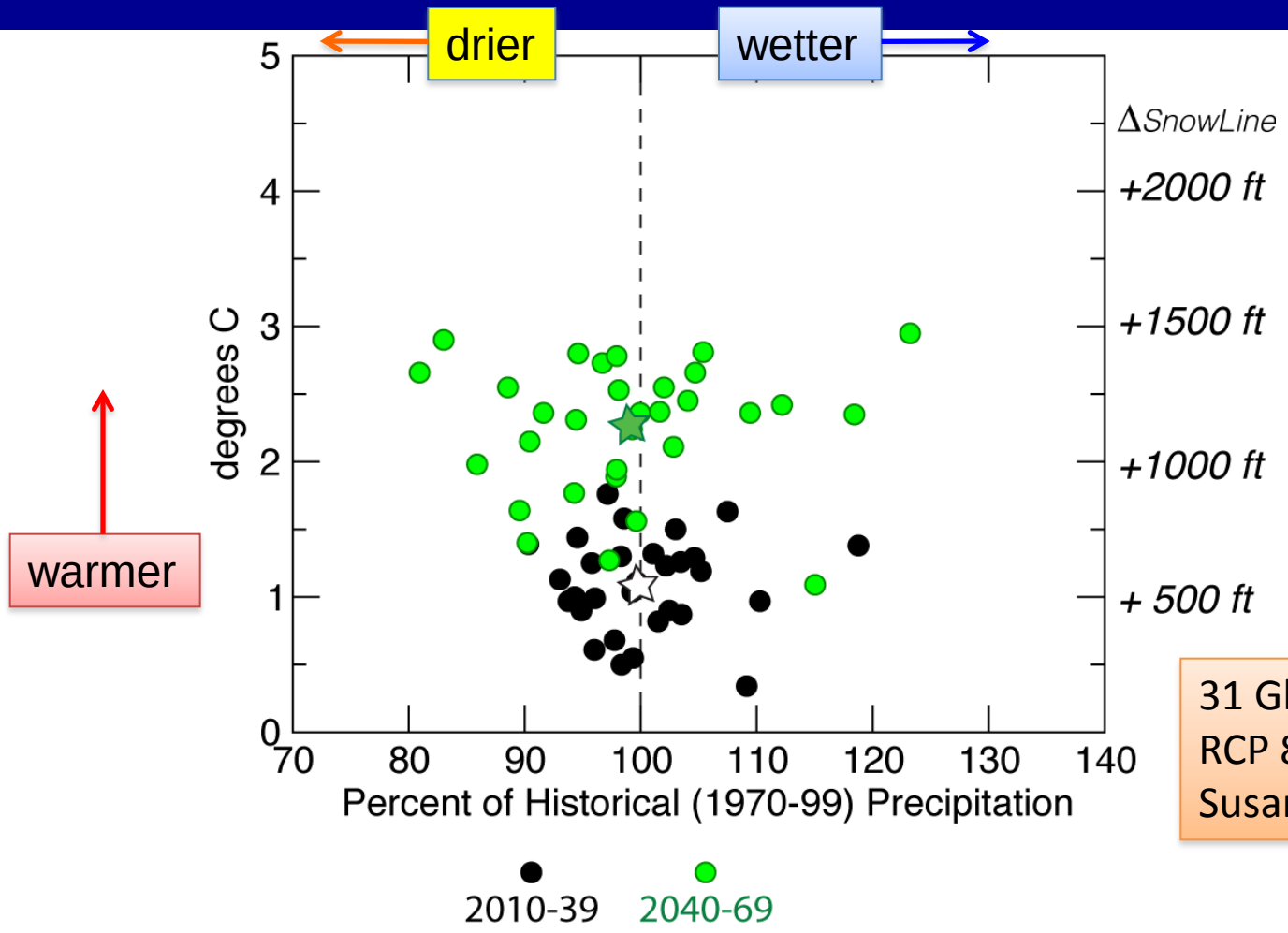
PROJECTED TEMPERATURE & PRECIPITATION CHANGES

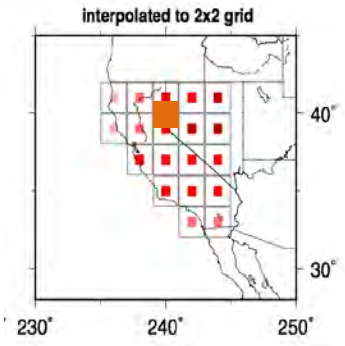




31 Global Climate Models; RCP 8.5; centered on Lake Tahoe

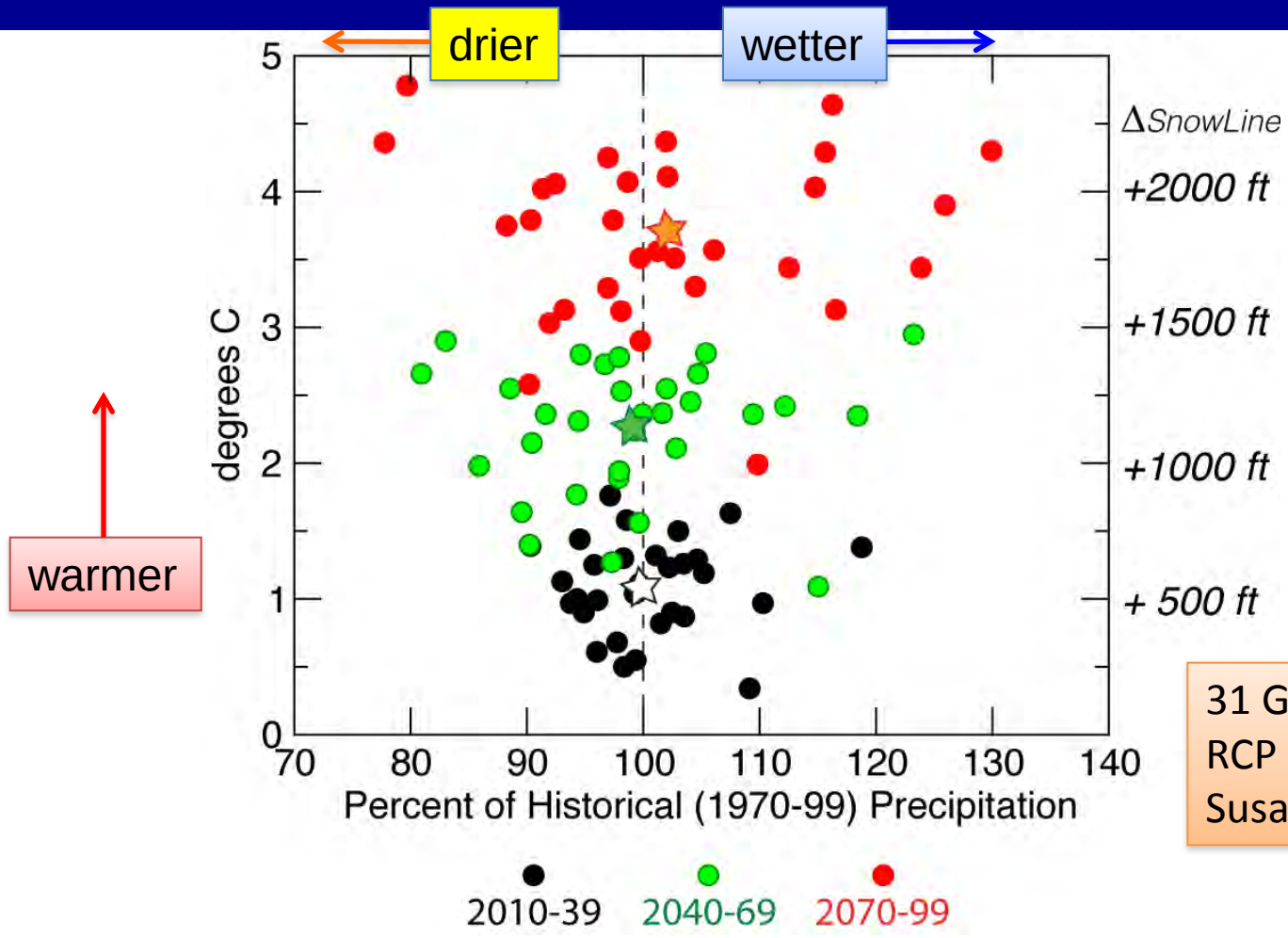
PROJECTED TEMPERATURE & PRECIPITATION CHANGES

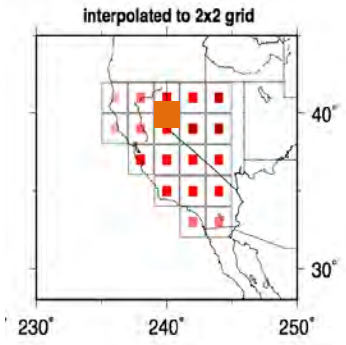




31 Global Climate Models; RCP 8.5; roughly centered on Susanville

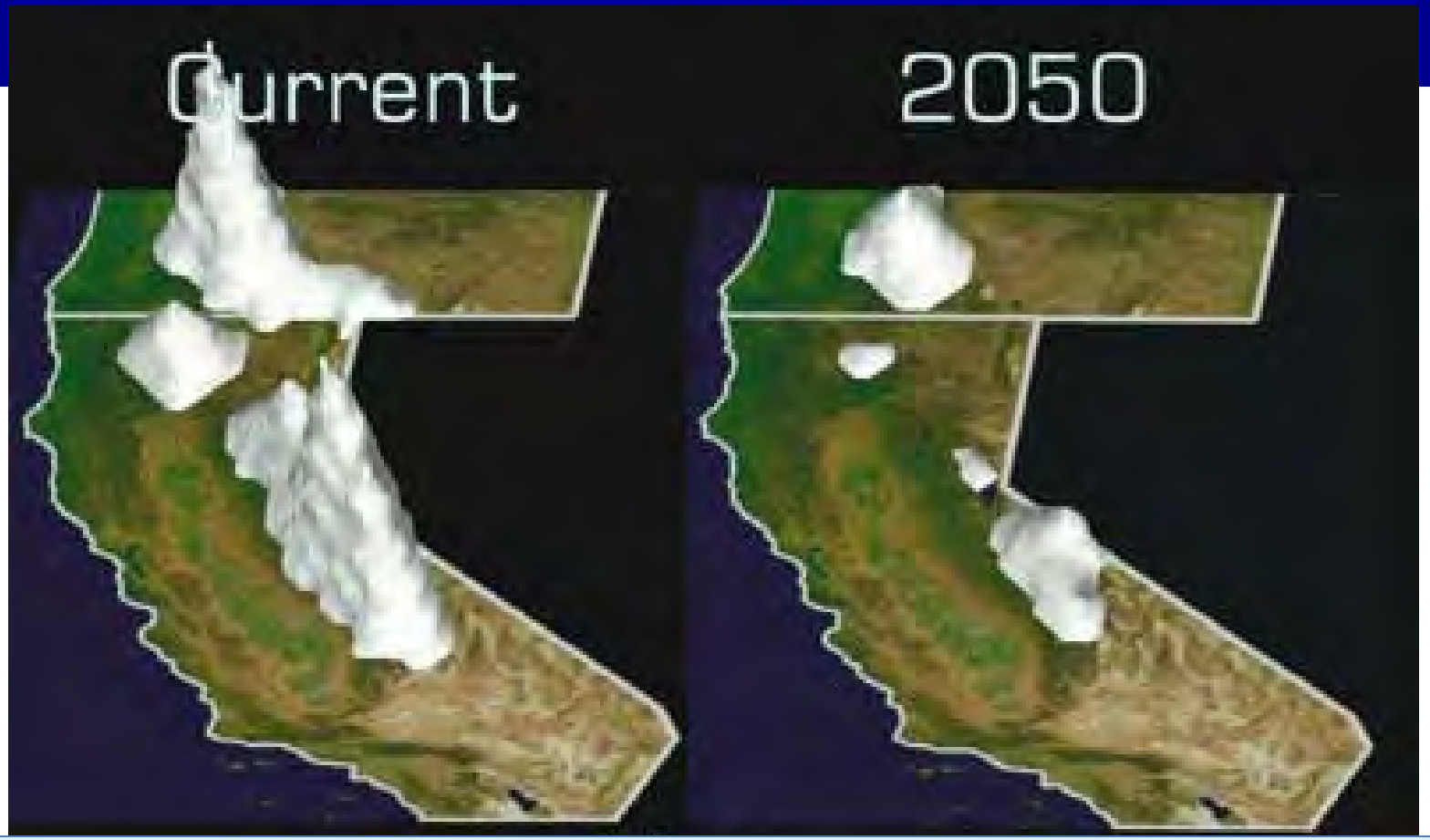
PROJECTED TEMPERATURE & PRECIPITATION CHANGES





31 Global Climate Models; RCP 8.5; roughly centered on Susanville

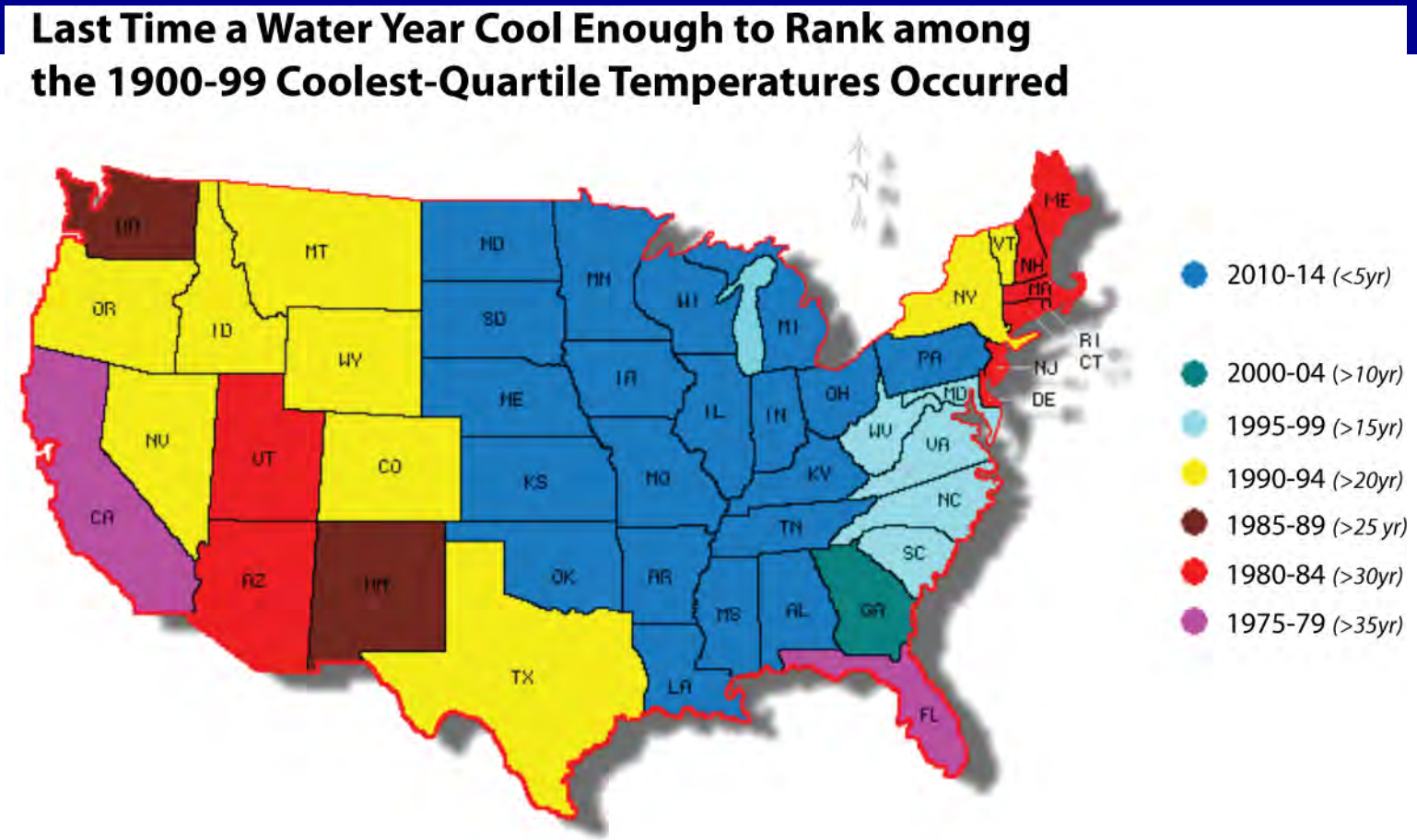
LOSS OF SPRINGTIME SNOWPACK



Under recent scenarios, Sierra Nevada loses half of its spring (April 1) snow pack due to climate warming. *This is an amount similar to the total free-board space set aside each winter for flood control in the Sierra Nevada.*

e.g., Knowles, N., and D.R. Cayan, 2002: Potential effects of global warming on the Sacramento/San Joaquin watershed and the San Francisco estuary. *Geophysical Research Letters*, **29**(18), 1891.

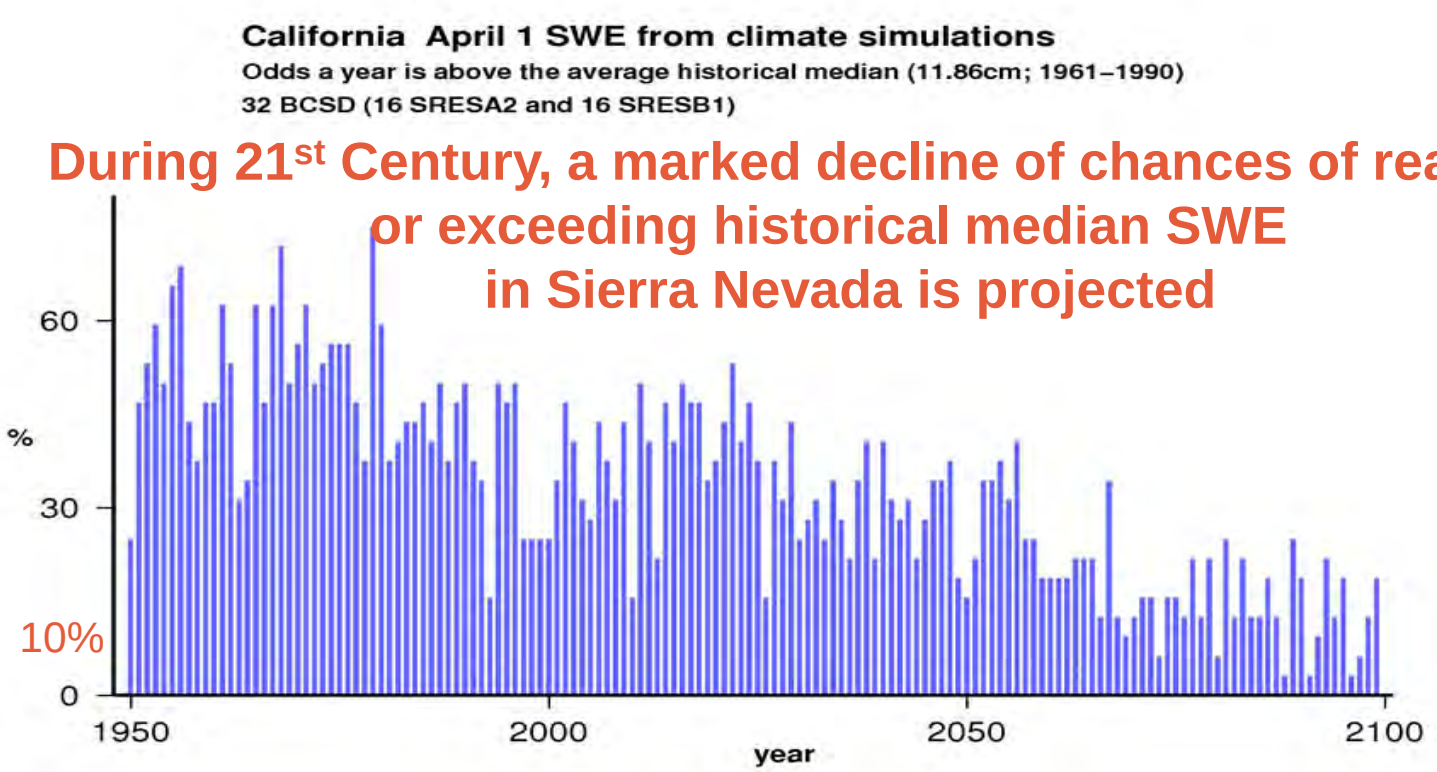
OBSERVED LOSS OF COOL YEARS

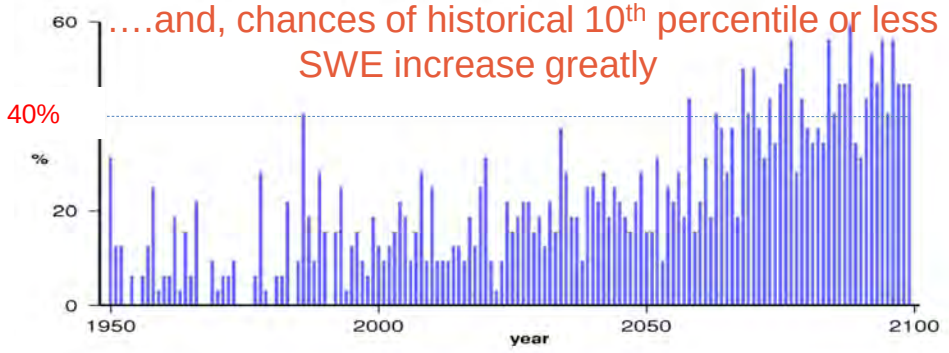


How well do you even remember what a cool year is like?

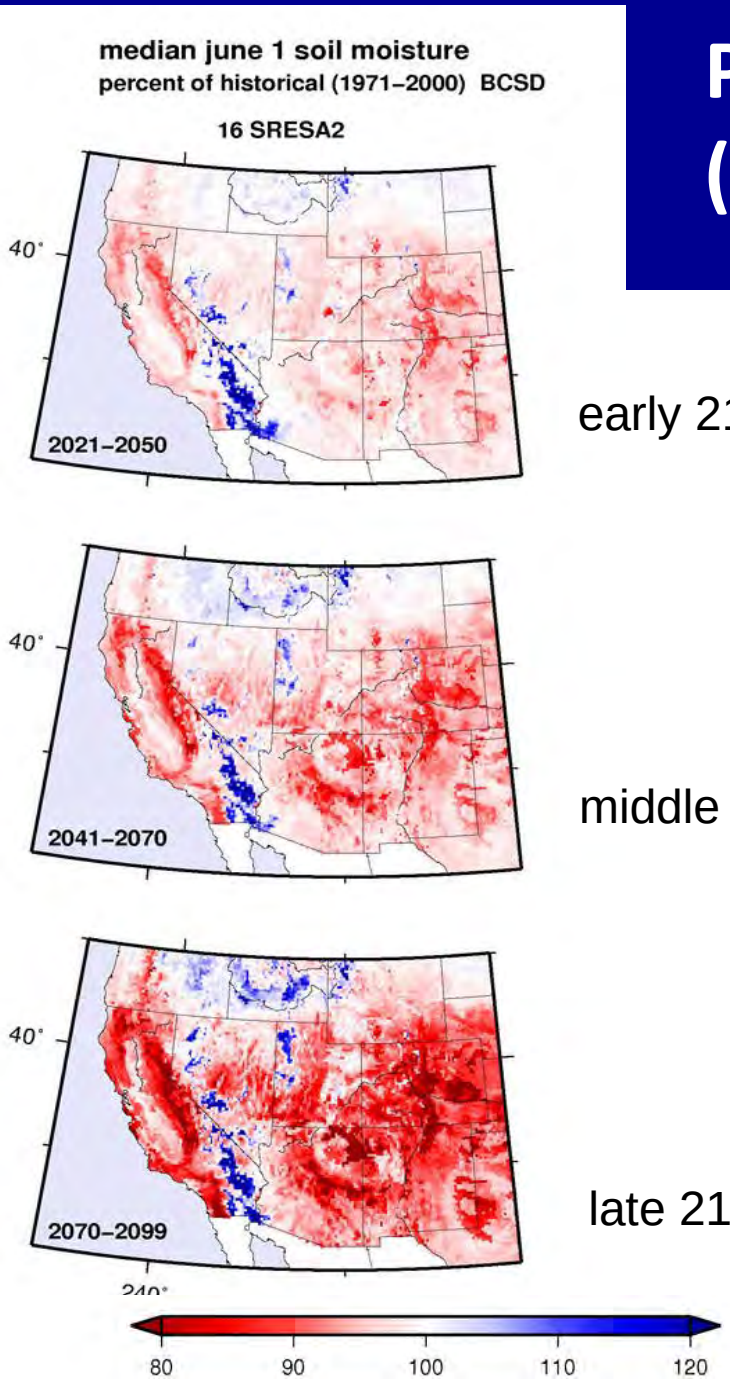
Its been more than 35 yrs since the State of California experienced a year in its historical coolest quartile!

PROJECTED SWE CHANGES





PROJECTED SOIL MOISTURE (JUNE)



early 21st

middle 21st

late 21st

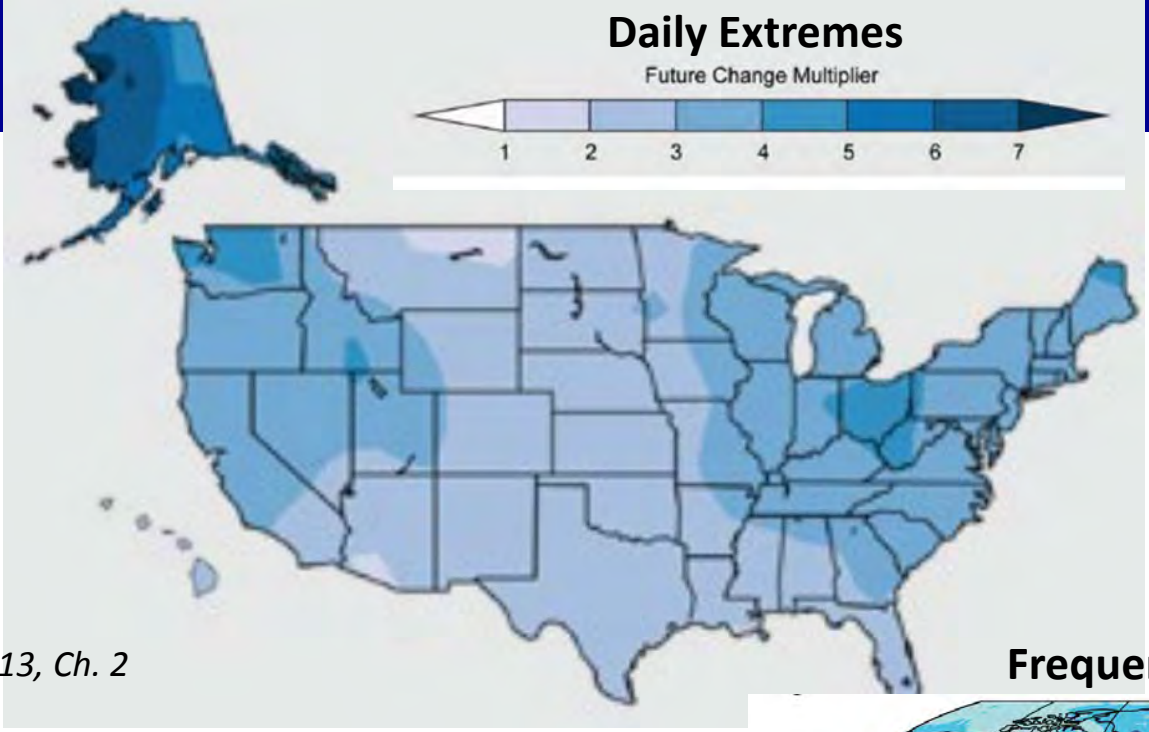
Drier Summer Landscapes

increased warming and diminished snow causes successively greater soil drying during 21st Century

(*this picture could change somewhat under more recent IPCC5 simulations*)

Cayan et al. 2013, Ch 6 Southwest Climate Assessment

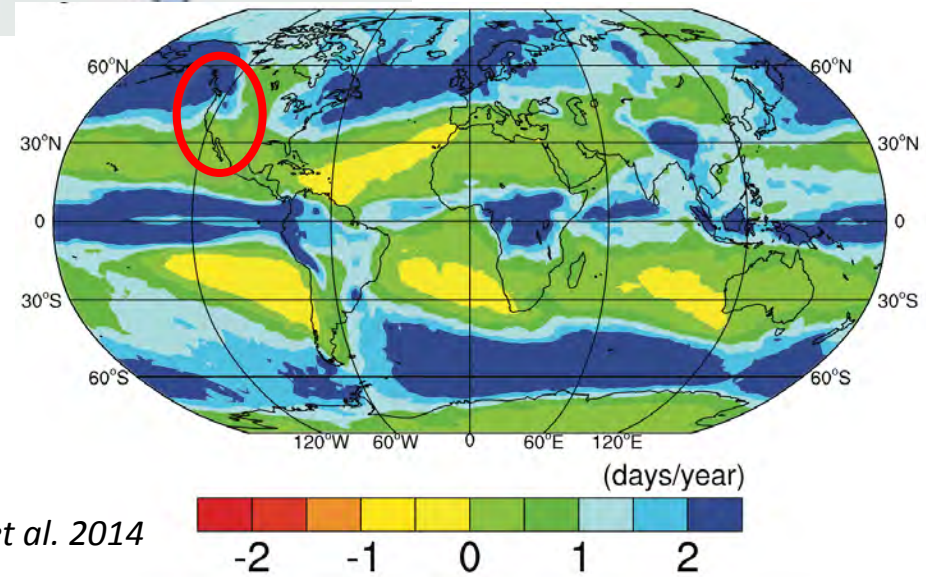
PROJECTED CHANGES IN HEAVY PRECIPITATION



NCA, 2013, Ch. 2

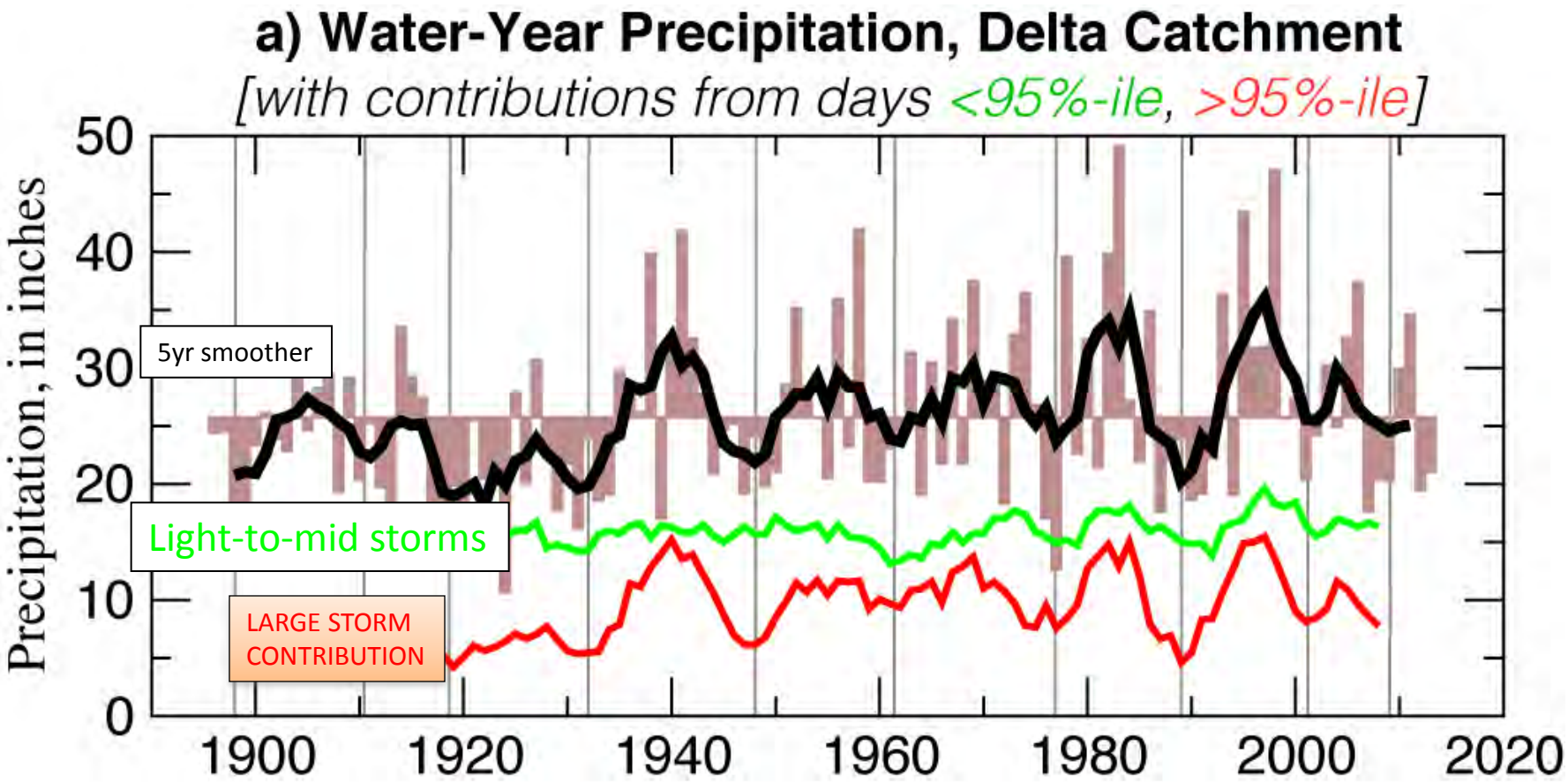
Projected changes in 99-percentile daily precipitation

Frequency (days/yr)



Polade et al. 2014

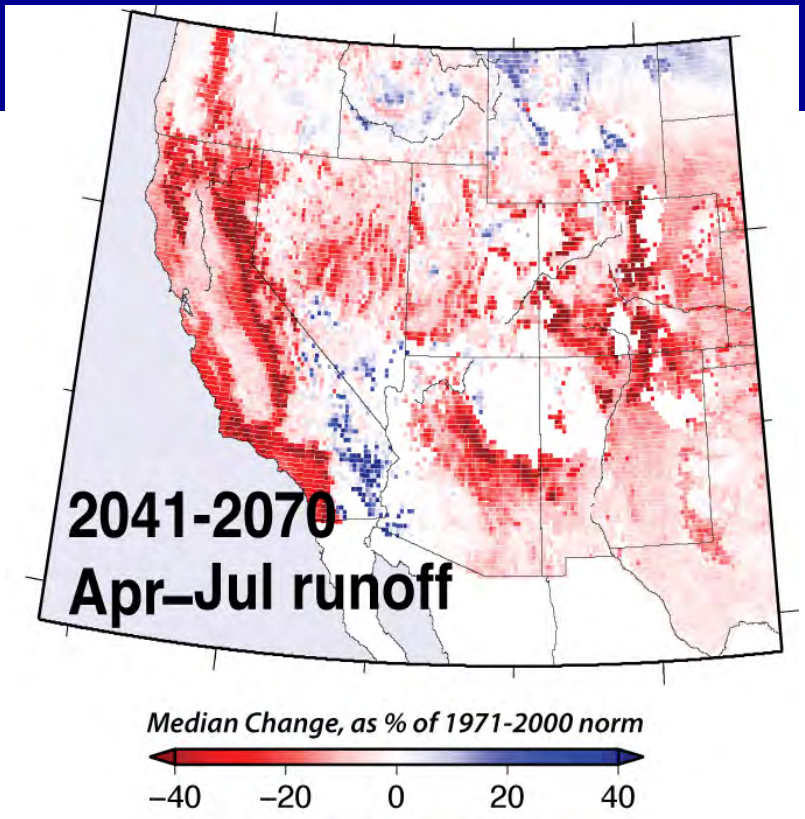
OBSERVED ROLE OF LARGEST STORMS IN CALIFORNIA DROUGHTS



Even historically, a few large storms (or their absence) account for disproportionate amount of Ca's precipitation variability

Dettinger and Cayan *2014, San Francisco Estuary and Watershed Science*

PROJECTED STREAMFLOW CHANGES

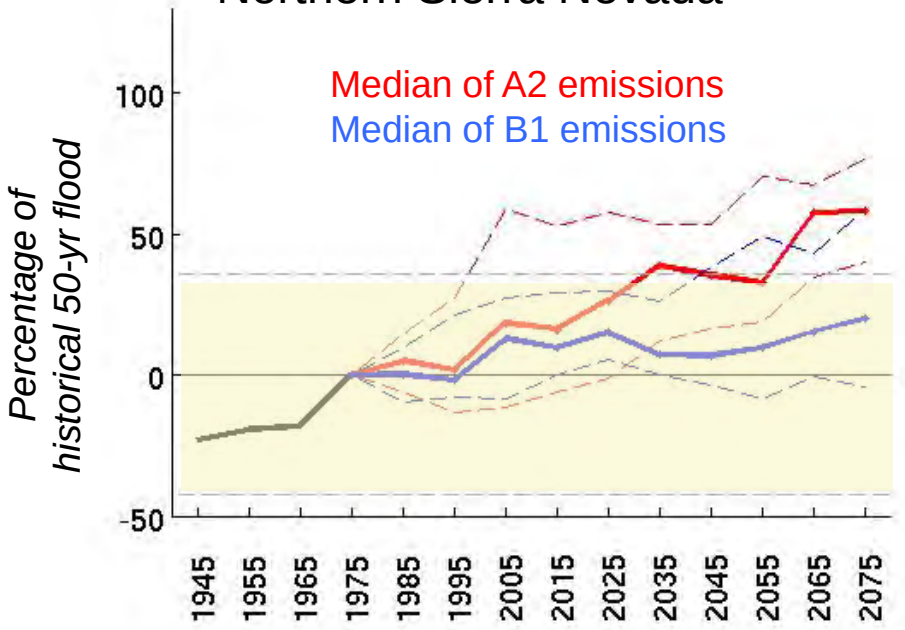


16 models, A2 emissions

Cayan et al., SWCA, 2013

Distributions of 50-yr flood changes

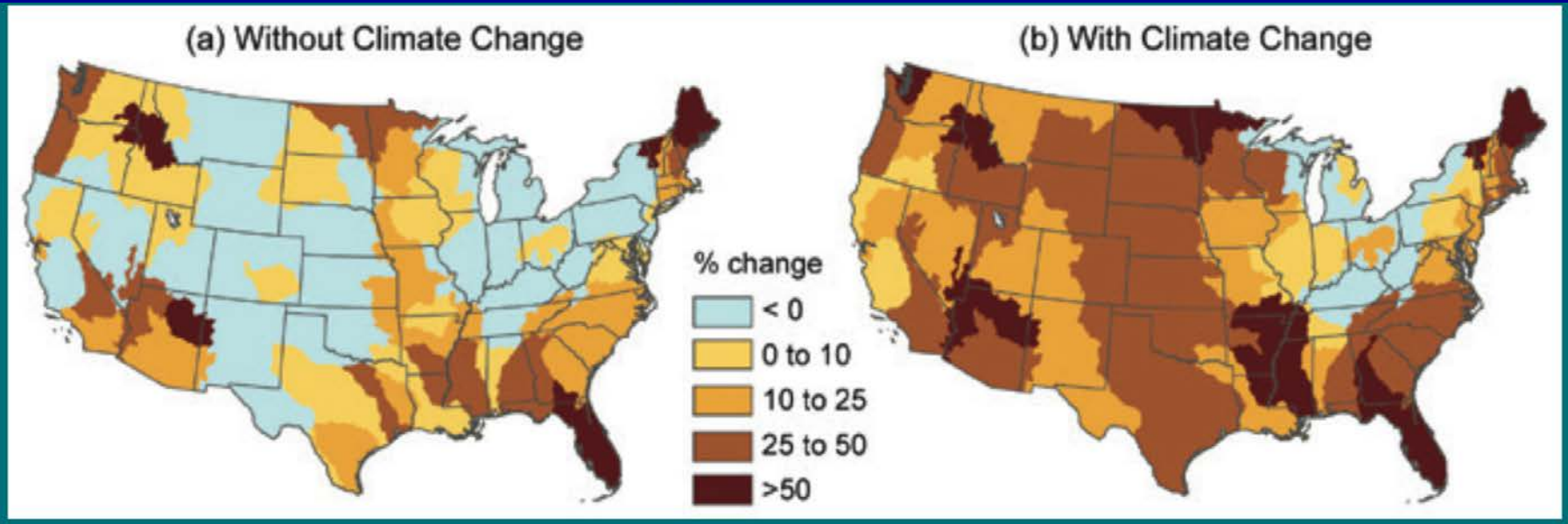
Northern Sierra Nevada



Center of sliding 50-yr window

Das et al., ClimChg, 2012; JH, 2013

PROJECTED CHANGES IN WATER WITHDRAWALS



The effects of climate change, primarily associated with increasing temperatures and potential evapotranspiration, are projected to significantly increase water demand across most of the United States. Maps show percent change from 2005 to 2060 in projected demand for water assuming (a) change in population and socioeconomic conditions consistent with the A1B emissions scenario (increasing emissions through the middle of this century, with gradual reductions thereafter), but with no change in climate, and (b) combined changes in population, socioeconomic conditions, and climate according to the A1B emissions scenario. (Figure source: Brown et al. 2013[4])

Georgakakos et al. NCA 2013

SUMMARY POINTS

- California's climate is prone to year-to-year and longer term variation in precipitation—drought is an expected part of our climate—present and future.
- Climate warming will broadly affect California hydroclimate and impact water systems across-the-board, but heterogeneously. Expected impacts of climate change: longer "warm" season, loss of spring snow pack, greater winter flood risks.
- Annual-precipitation changes remain uncertain in northern California. However, climate change is currently projected to affect precipitation intensities—fewer overall wet days but more intense heavy events.
- Implications:
  - Less snow, more rain
  - Earlier run-off from traditionally snow-fed mountain watersheds
  - Larger floods
  - Potentially, less stored water
  - Water quality implications: warmer surface water, warmer & longer dry spells

USGS science for a changing world

Southwest Climate Science Center

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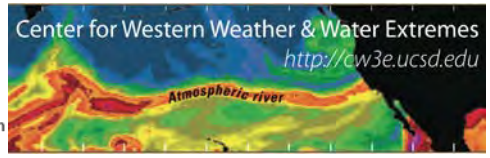


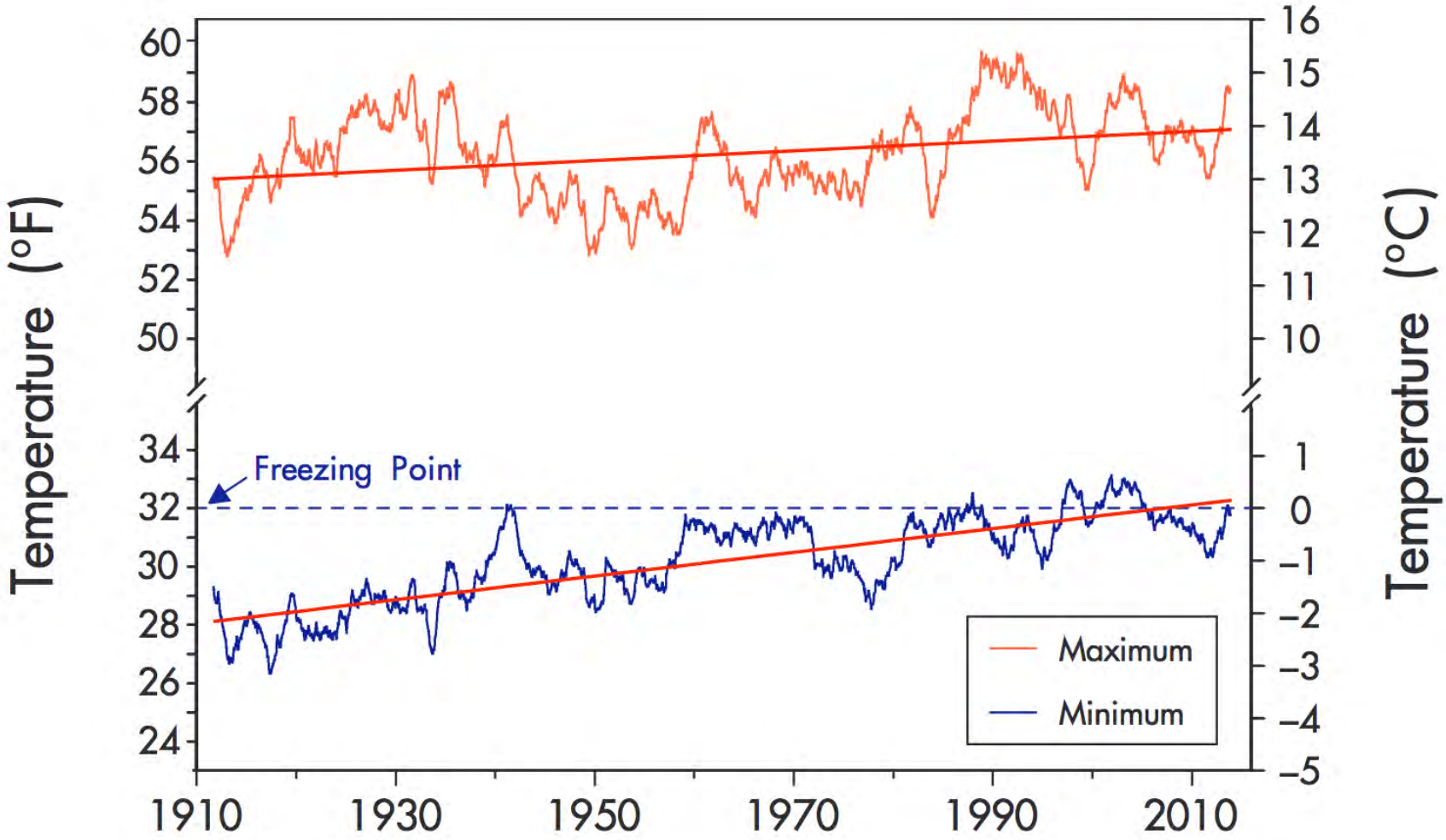
Climate Change Impacts and Responses

S. Geoffrey Schladow

Department of Civil and Environmental Engineering, UC Davis

Director UC Davis Tahoe Environmental Research Center

THE CLIMATE IS CHANGING



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HOW COULD CC IMPACT WATER QUALITY/QUANTITY?

1. MORE AND LESS WATER
2. HYDROLOGY – TIMING & PEAK OF SNOWMELT
3. WILDFIRES (IN & OUT OF BASIN)
4. A LONGER "SUMMER" FOR THE LAKE
5. LAKE DEAD ZONE
6. INTERNAL NUTRIENTS AND HEAVY METALS
7. CONTINUED CHANGE IN ALGAL COMMUNITY – FILAMENTOUS ALGAE, CYANOBACTERIA AND HABs.
8. NEARSHORE DEGRADATION
9. PATHOGENS

1. **MORE AND LESS WATER**
2. **HYDROLOGY – TIMING & PEAK OF SNOWMELT**
3. **WILDFIRES (IN & OUT OF BASIN)**
4. **A LONGER "SUMMER" FOR THE LAKE**

THERE IS NOTHING BOARDS CAN DO TO PREVENT THIS

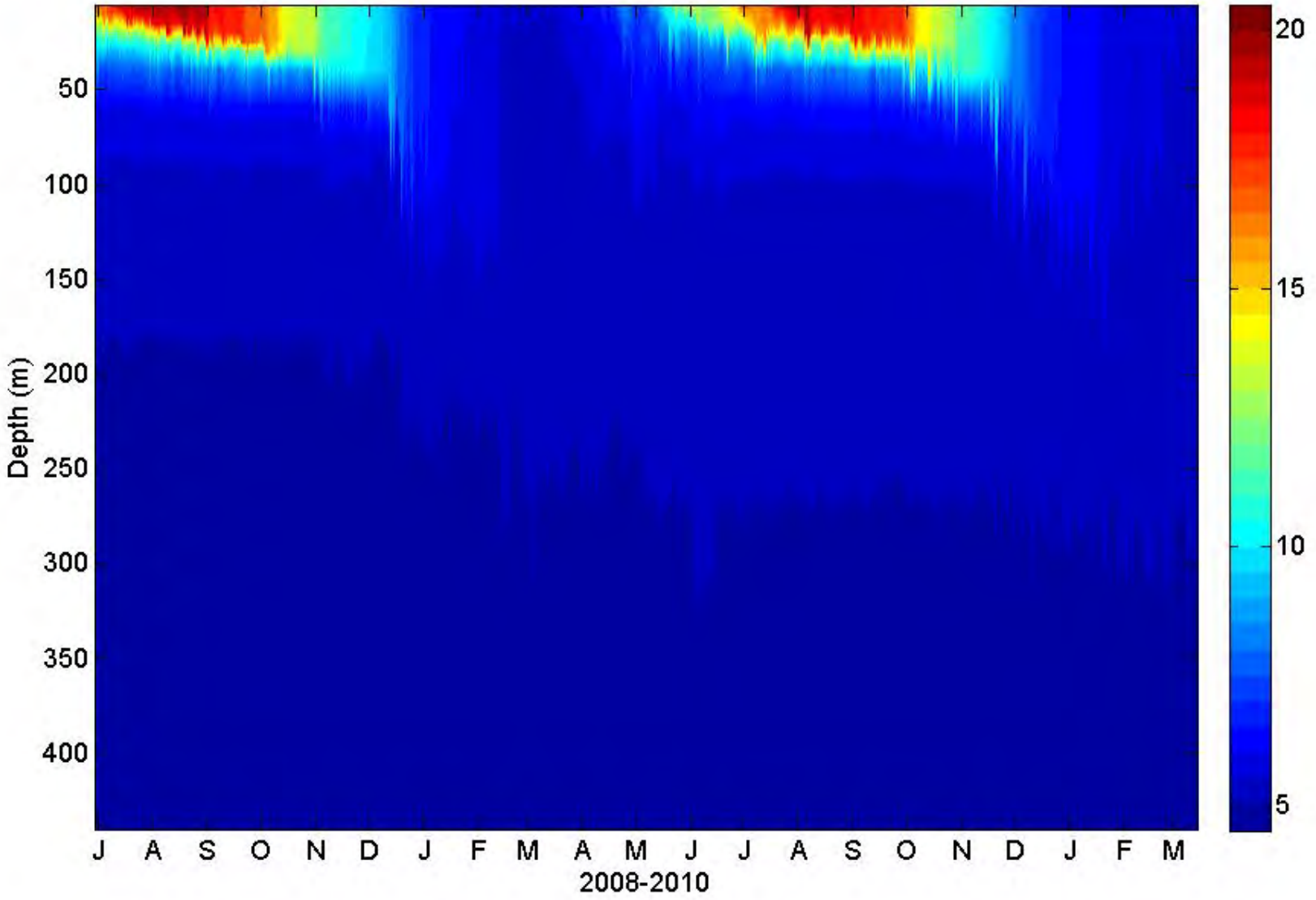
ADAPTATION COULD INCLUDE:

- DESIGN CODES/LAND USE THAT REFLECT THE NEW HYDROLOGY
- CREDITING FOR FLOODPLAIN RESTORATION
- RETHINK WATER QUALITY STANDARDS WHEN NATURE IS OUT OF ATTAINMENT
- DEVISE PARTITIONING BETWEEN "NATURAL" LOADS AND ANTHROPOGENIC LOADS

5. LAKE DEAD ZONE
6. INTERNAL NUTRIENTS AND HEAVY METALS
7. CONTINUED CHANGE IN ALGAL COMMUNITY – FILAMENTOUS ALGAE, CYANOBACTERIA AND HABs.

THESE ARE THINGS THE BOARD CAN DO SOMETHING ABOUT, IN PART THROUGH THE TMDL

Typical Thermal Stratification Pattern



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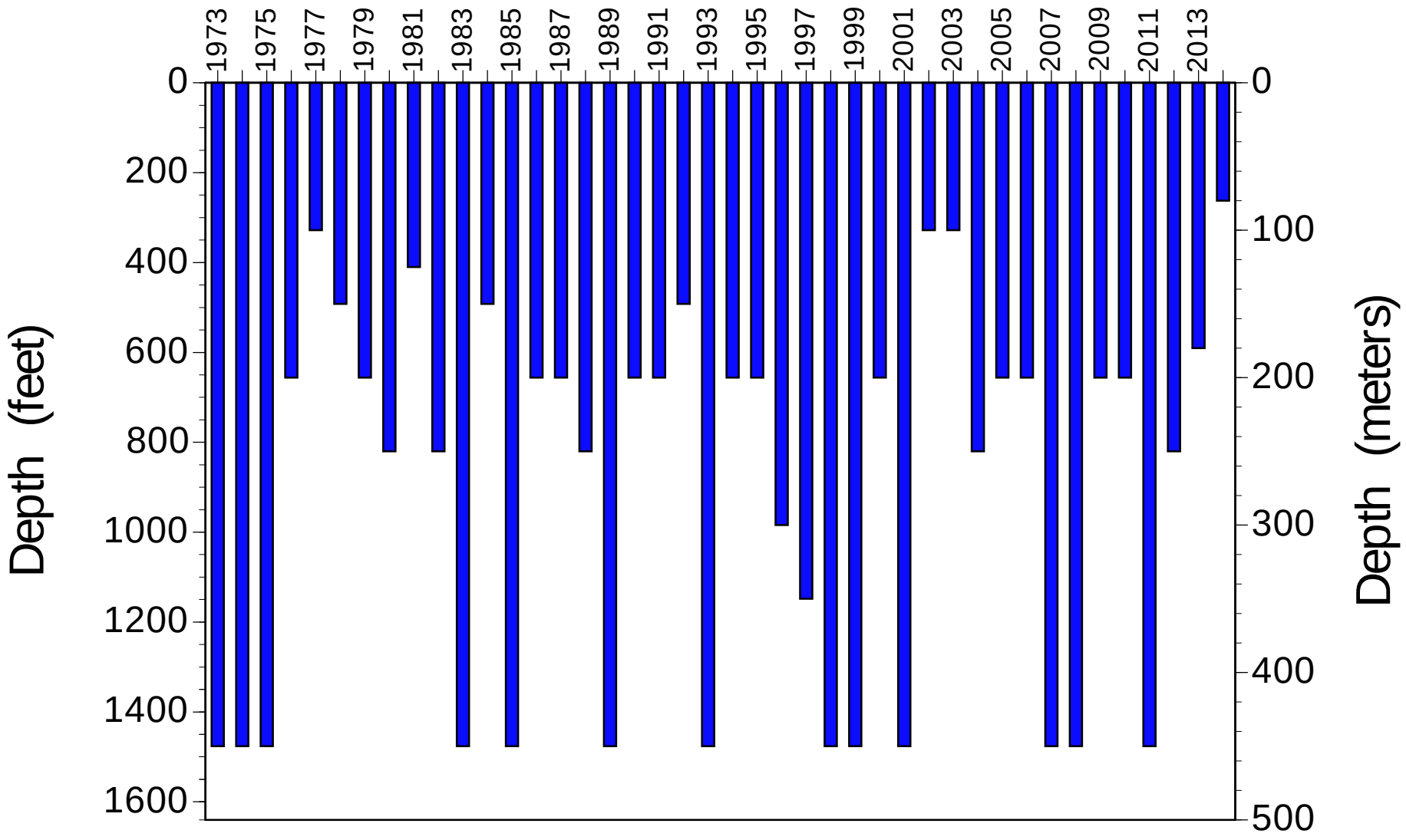
Last 41 Years – Depth of Winter Mixing



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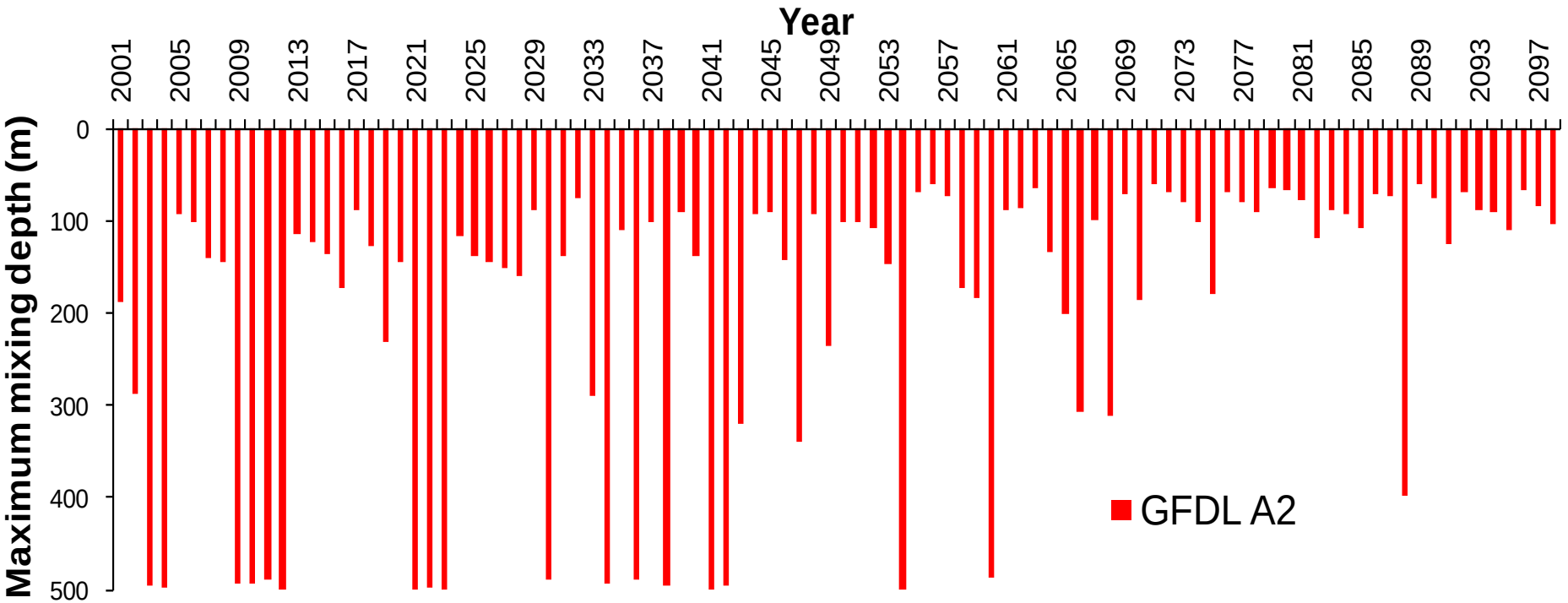
Winter Depth of Mixing in the Next 85 Years



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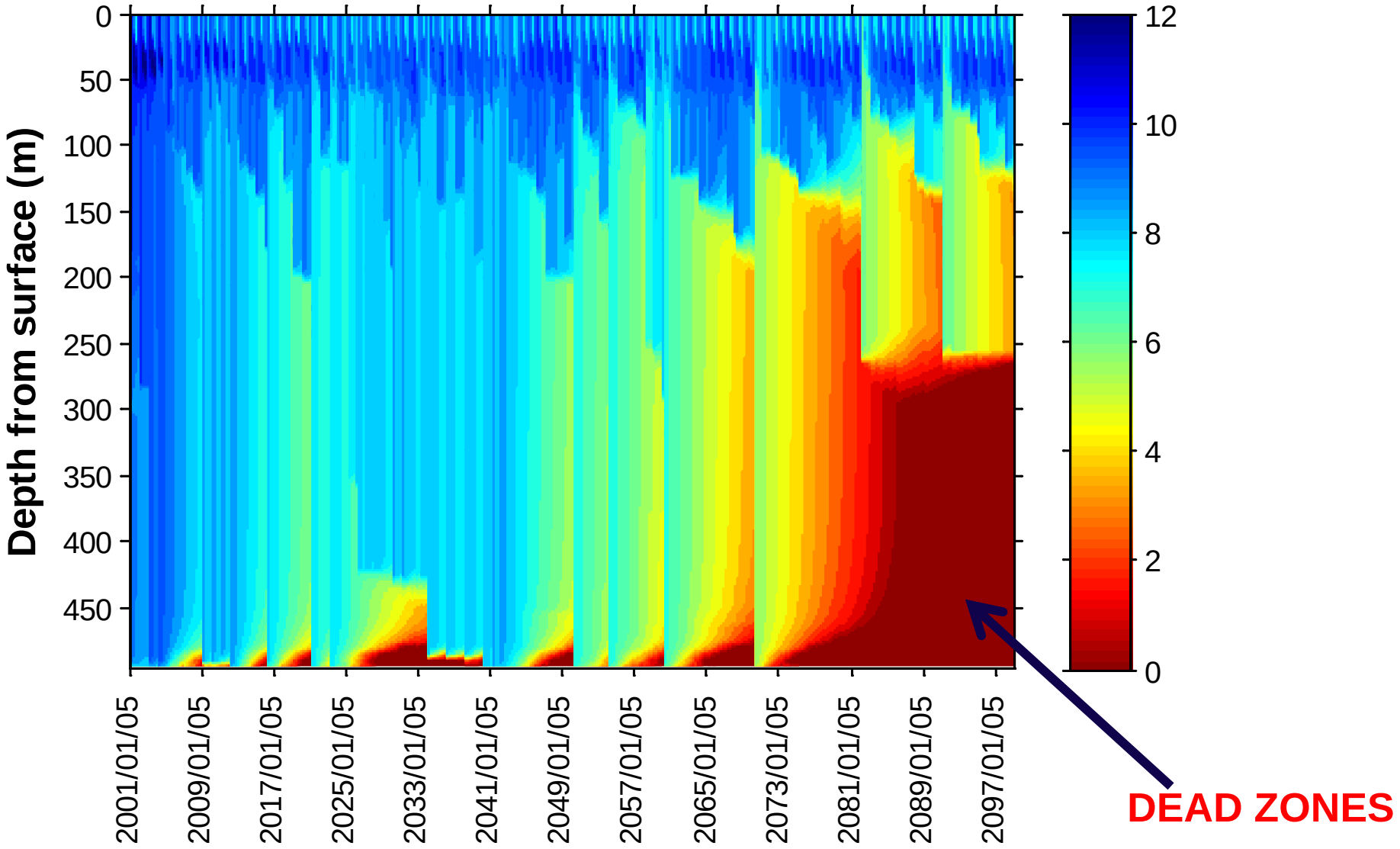
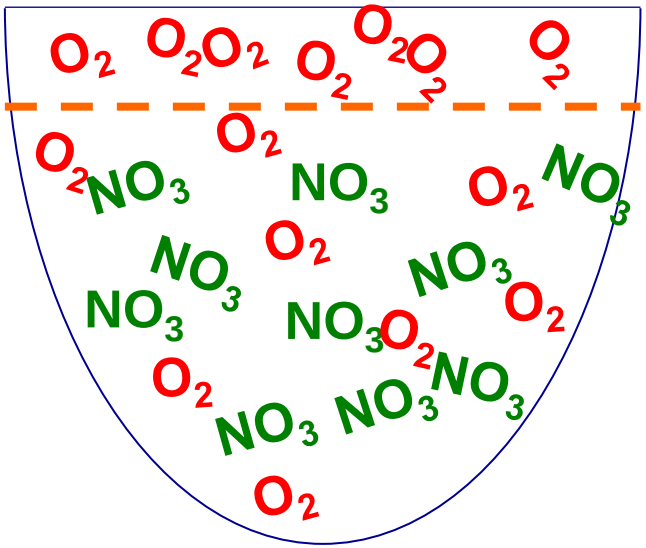
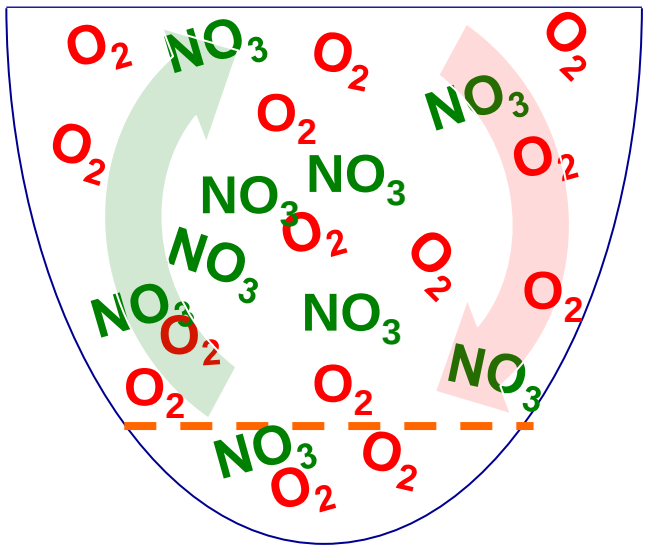
Dissolved Oxygen in the Next 85 Years



NOW

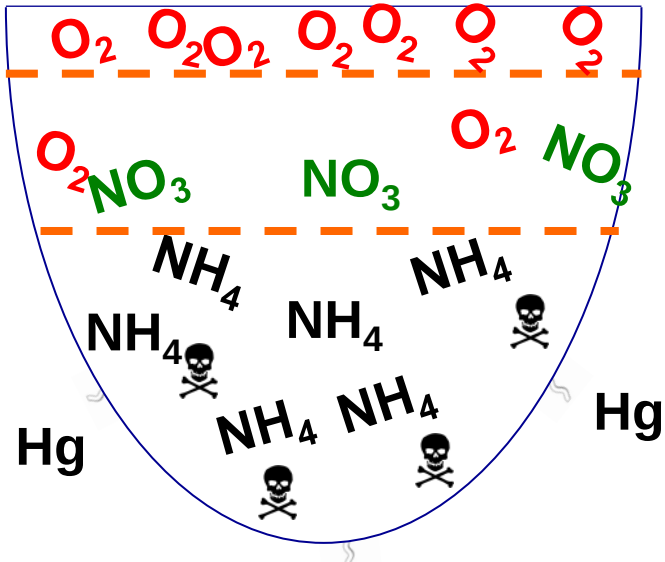


Summer

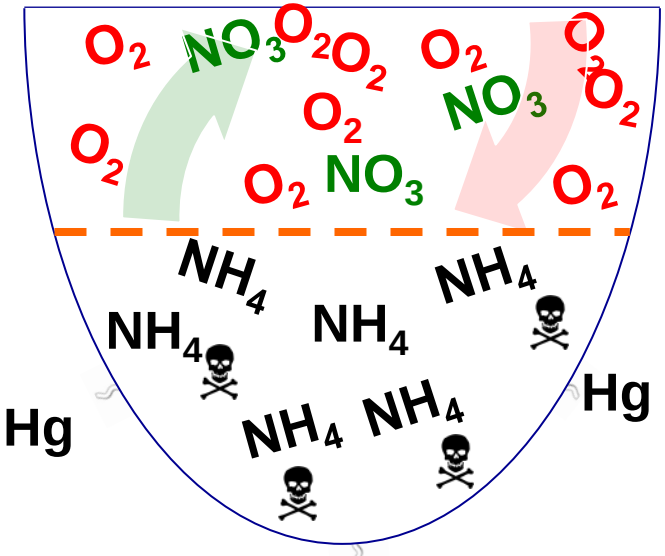


Winter

FUTURE



Summer



Winter

THESE PROCESSES APPLY TO ALL LAKES, NOT JUST TAHOE

Prolonged stratification → anoxia

- Fish kills, odors, disease
- Release of nutrients from sediment fuels excess algae
- Release of heavy metals from sediments
  - higher water treatment costs
  - ecosystem and human health concerns (e.g. Hg)

WHAT THE BOARD CAN DO

STICK WITH THE TMDL (ESPECIALLY ADAPTIVE MANAGEMENT)

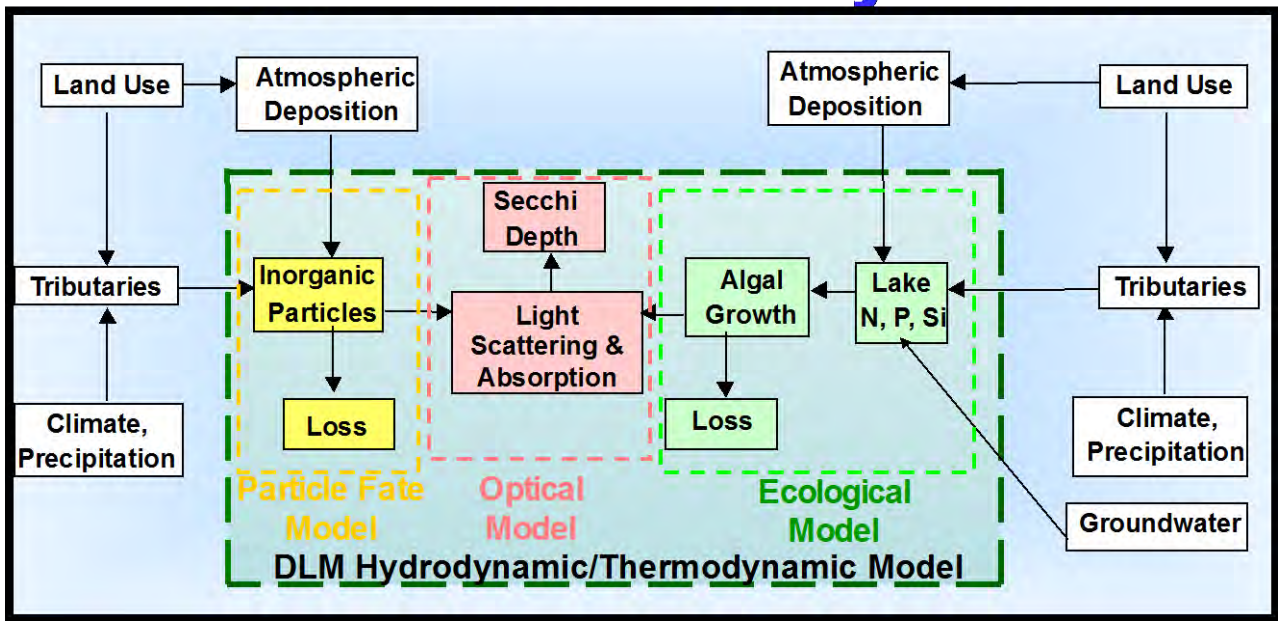
REDUCTIONS IN NUTRIENTS TO THE LAKE WILL SLOW ALGAL GROWTH AND THE RATE OF OXYGEN DECLINE

THIS WILL GIVE TAHOE (AND ANY LAKE) MORE RESILIENCE

IMPORTANT POINTS!!

- PLANNING AND ACTION CAN TAKE PLACE NOW BECAUSE THE TMDL PRODUCED A PROCESS-BASED MODEL FOR THE SYSTEM
- THIS REQUIRED ALMOST 10 YEARS OF SCIENCE
- THE CENTRAL UNDERPINNING OF THE TMDL – THE IMPACT OF FINE PARTICLES – WAS "DISCOVERED" THROUGH MODELING

Lake Tahoe Clarity Model



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8. NEARSHORE DEGRADATION

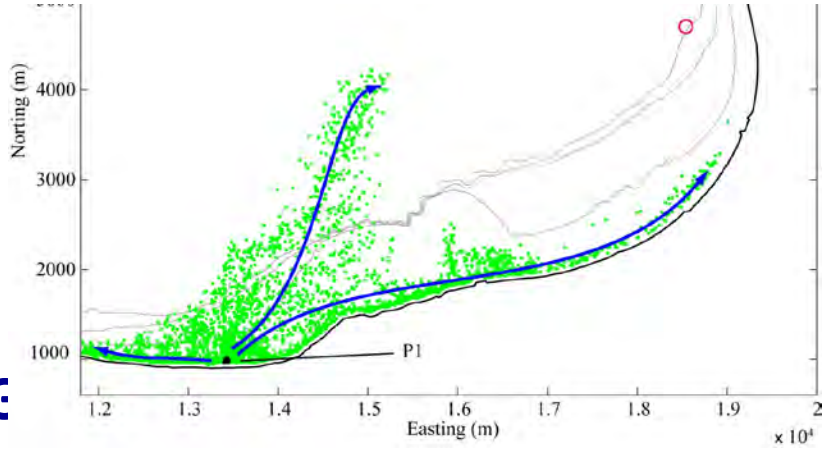
9. PATHOGENS

UNLIKE THE CENTRE OF THE LAKE, THE NEARSHORE LAGS IN ITS UNDERSTANDING

ACTIONS THAT CAN BE TAKE ARE TO UNDERTAKE A "TMDL-LIKE" PROCESS, FOCUSED ON MODELING TO HELP CONFIRM PROCESSES AND TO HELP WEIGH FUTURE OPTIONS AND PREDICT OUTCOMES

SHOULD:

1. **IDENTIFY DRIVERS**
2. **QUANTIFY SOURCES**
3. **MODEL CONTROL OPTIONS**
4. **BUILD ON EXISTING KNOWLEDG**



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THANK YOU

TSC TAHOE SCIENCE CONSORTIUM

Addressing Science Needs in the Lake Tahoe Basin

Maureen McCarthy, PhD
Executive Director, Tahoe Science Consortium

Presentation to Lahontan Water Quality Board
Climate Change Forum, 15 January 2015

TSC Climate Science Symposium: Summary of Findings

USGS science for a changing world

Pacific Southwest Research Station

UCDAVIS TAHOE ENVIRONMENTAL RESEARCH CENTER

DRI Desert Research Institute

University of Nevada, Reno

www.tahoescience.org

TSC Climate Science Symposium

- TSC Climate Science Symposium held 13 Nov 2014
- ***Purpose***: Stimulate discussion among researchers working on climate impacts and ecological resiliency in the Lake Tahoe Basin and across Sierra Nevada Ecoregion
  - Exchange findings
  - Identify research gaps
  - Develop collaborations
  - Climate change
  - Storms & floods
  - Droughts & heatwaves
  - Wildfires & air quality
- 40+ participants including researchers from universities, federal agencies (USGS, USFS, USBR, NOAA/NWS), and CA/NV agencies, TRPA

TSC TAHOE SCIENCE CONSORTIUM

Panel 1: Climate Models & Impacts: Research Challenges & Gaps

- **Linking climate/weather to watershed/forest to environment/lake quality models across scales (SNAWPS)**
- **Resolving complex topography in downscaled climate models (typically with 2-6 km resolution)**
- **Linking extreme events with paleo/historical precedence and climate models**
- **Quantifying the sources of uncertainty in climate models and observed data**
- **Characterizing the impact of warmer temperatures on lake mixing and predicting change in oligotrophic/eutrophic status**
- **Understanding impacts of vegetation change on nearshore nutrient loading**

TSC TAHOE SCIENCE CONSORTIUM

Panel 2: Storms & Floods: Research Challenges & Gaps

- **Predicting flood levels from precipitation**
- **Forecasting snow levels and flood levels**
- **Understanding relationship between snowpack and nutrient loading in streams & lakes**
- **Correlating local and downstream soil moisture content from snowpack**
- **Validating remote sensing to quantify bioecological change**
- **Communicating uncertainties in probablistic models**
- **Funding long-term meteorological and ecological monitoring**

TSC TAHOE SCIENCE CONSORTIUM

Panel 3: Droughts & Heatwaves: Research Challenges & Gaps

- **Quantifying impacts of droughts on pelagic & nearshore clarity**
- **Modeling warmer water temperatures on AIS**
- **Validating models for evapotranspiration/water budget of Tahoe**
- **Mining species and ecosystem studies to better predict effectiveness of future restoration actions**
- **Linking watershed species interactions, plasticity, and compound structure to predict future distributions**
- **Promoting open data policies and creating data portals to enhance transdisciplinary data sharing**

TSC TAHOE SCIENCE CONSORTIUM

Panel 4: Wildfires & Air Quality: Research Challenges & Gaps

- **Quantifying synergy of weather, climate, and wildfire**
- **Modeling the impact of warmer temperatures on forest health, vegetation, biodiversity, invasives**
- **Developing models of smoke dispersion (and composition) from wildfires and prescribed burns**
- **Developing better fuel management metrics to measure forest health and fire risk reduction**
- **Modeling impacts of wildfires and flooding on nutrient loading, vegetation change & ecosystem resiliency**
- **Testing & validating fire hazard maps for wildland-urban interfaces**
- **Deploying low-cost sensors for warning of extreme events**

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Next Steps

- Community data sharing (& model)
- Link climate impacts to management actions in Tahoe and Sierra Nevada
- Integrate Tahoe science into regional climate impact studies (e.g., CA 4th Climate Assessment)
- Use 2015 Tahoe Science Conference to highlight science-based management for climate adaptation & resiliency

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WATER For The SEASONS

"A Program for Sustaining Water Resources in a Changing Climate"

Maureen McCarthy, PhD
Executive Director, UNR Academy for the Environment

Presentation to Lahontan Water Quality Board
Climate Change Forum (15 January 2015)

Water for the Seasons: Building Resiliency to Climate Change in Snow-fed Arid Land River Systems

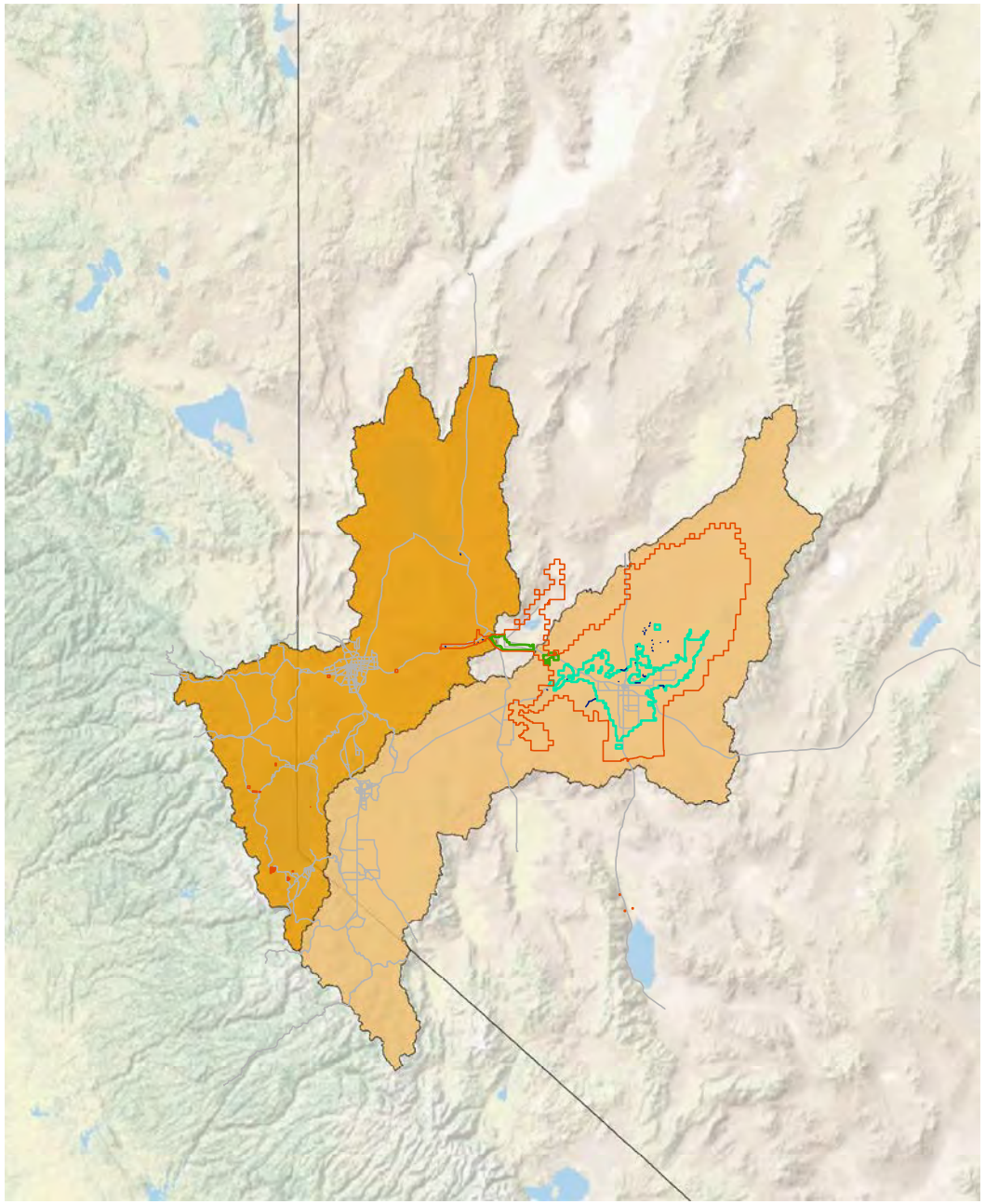
University of Nevada, Reno

USGS science for a changing world

DRI Desert Research Institute

Project Objectives

- Co-develop climate-stress scenarios with stakeholders
- Populate scenarios with scientifically-valid detail
- Understand climate- and climate-change impacts on the water systems
- Explore efficacy of alternative water policies under climate extremes



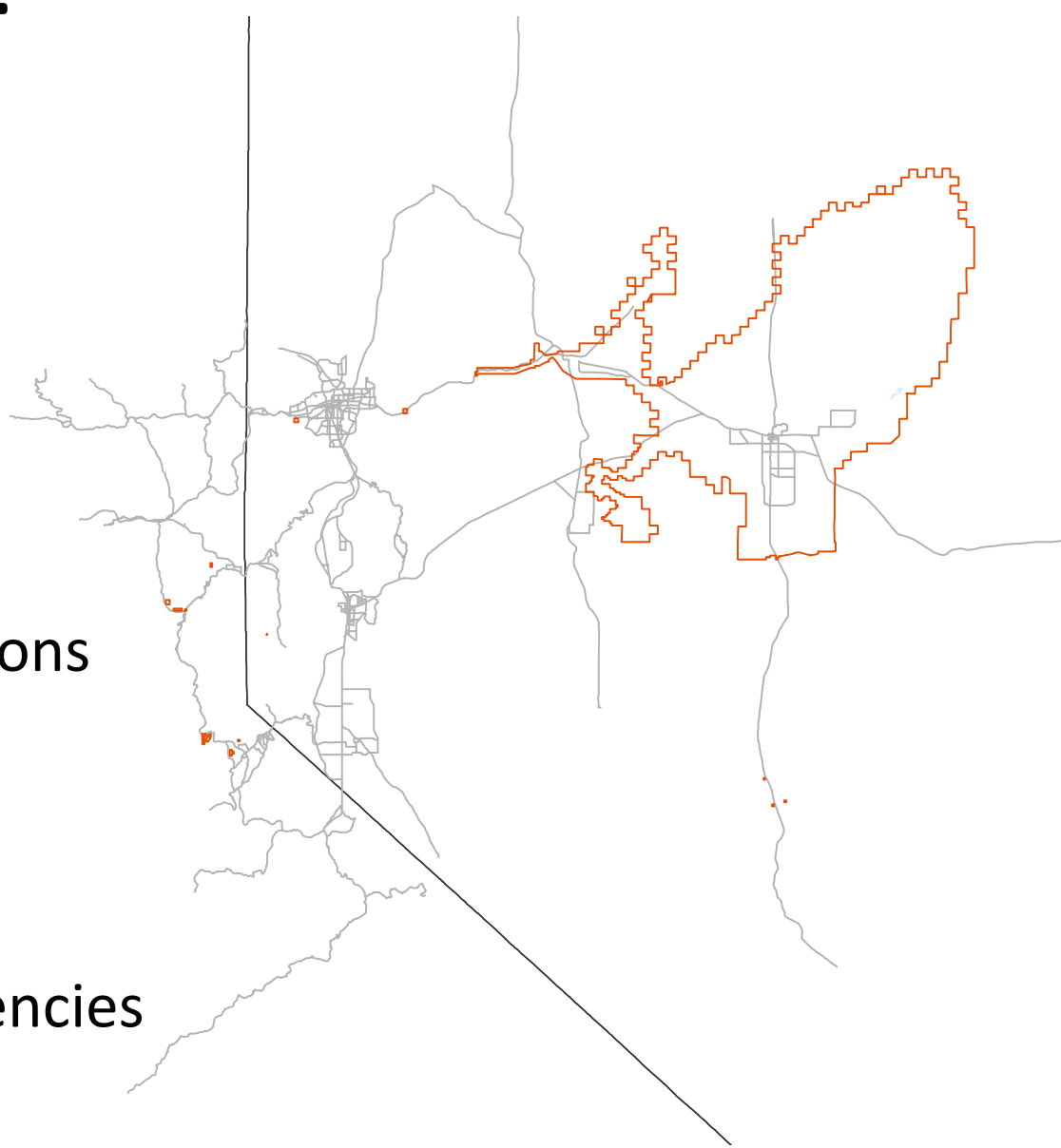
Water for the Seasons:
From Headwaters to Terminus

Lake Tahoe Sept 14

Lahontan Reservoir Oct 2014

Who's Involved?

- Agriculture Producers
- Water Managers
- Tribal Communities
- Ecosystem Managers
- Conservation Organizations
- Economic Development Organizations
- Federal, State, Local Agencies

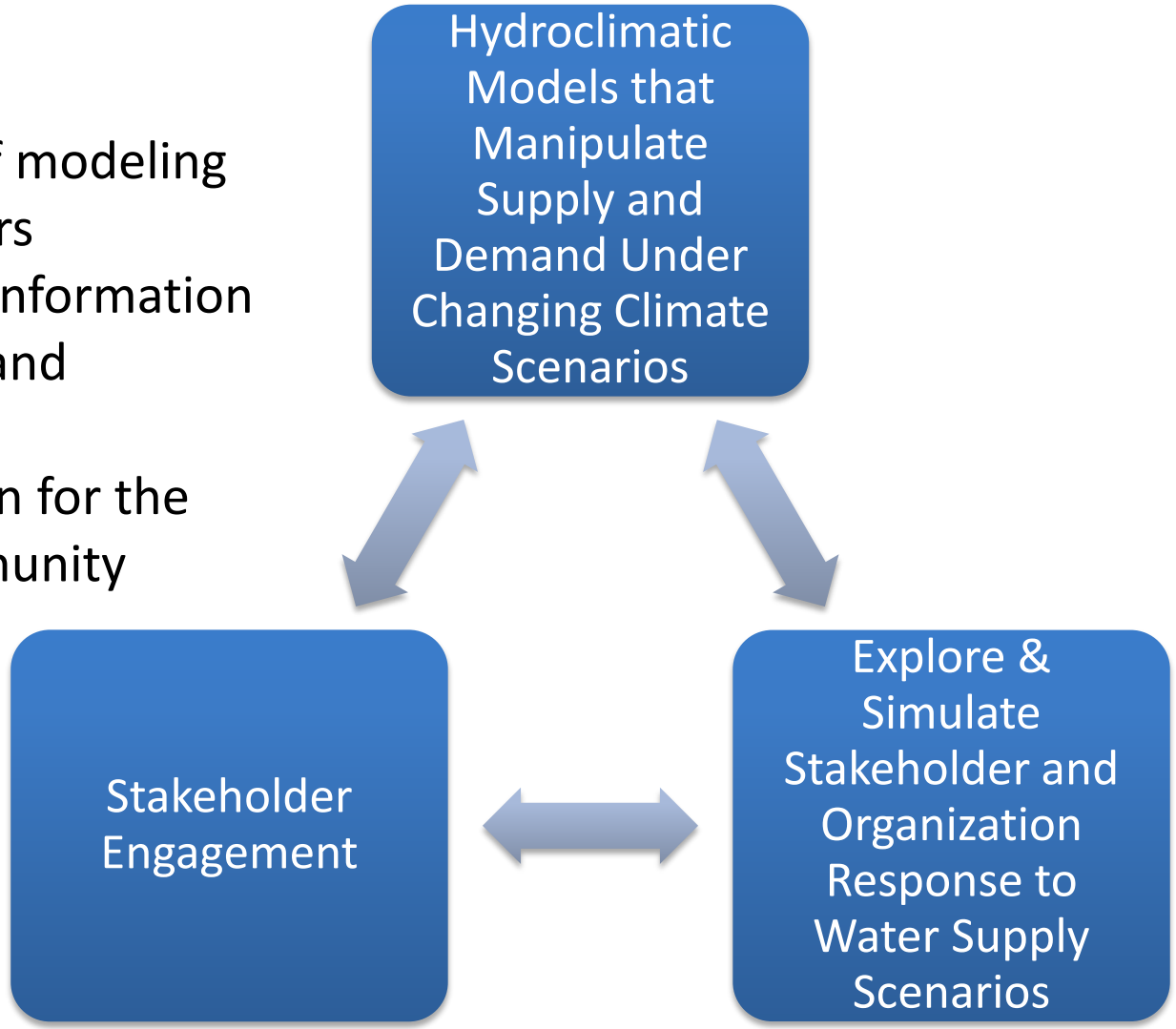


Truckee-Carson River System.

Collaborative Modeling

Directly involves stakeholders in systems modeling:

1. To improve utility of modeling outputs for end users
2. To increase flow of information between scientists and resource users
3. To provide education for the resource user community



Engaging Water Rights Holders and Water Managers to to Assess Climate Impacts and Water Sustainability

- How do changing climate conditions stress water resources on the river system? {Moderate and Worst-case}
- What information from climate and hydrologic models are most useful (actionable) to water users/managers?
- What policy instruments are perceived as most useful for adapting to or mitigating water stress – and how feasible are they for implementation?
- What management or policy actions are available and implementable to enhance water sustainability?

Actions to Enhance Lahontan's Climate Adaptation Strategies

- Focus on extreme events that may be more frequent/intense in future decades (e.g., intense droughts, atmospheric river events, heatwaves/wildfires)
- Integrate water supply/demand with water quality protection considerations
- Incorporate socioecomonic and environmental policy approaches as well as physical/natural scientific models to anticipate community and ecological resiliency
- Expand monitoring and evaluation activities to continuously assess effectiveness of water quality programs in building resiliency
- Implement adaptation strategies that allow for scientific uncertainties in climate modeling and weather forecasts and are able to adapt to improvements in both

Back Up Slides

Water Sustainability in Snow-Fed Arid Land River Systems in the Western United States

- Managing large-scale river systems
  - Increasing and diverse demands for water use
  - Urban population growth
  - Decreasing and variable water supplies

- Arid lands in the Great Basin
  - Dependency on Sierra Nevada snowpack
  - Decision-making processes under consecutive years of scarcity are not well-understood

Truckee Canal, Oct 2014.

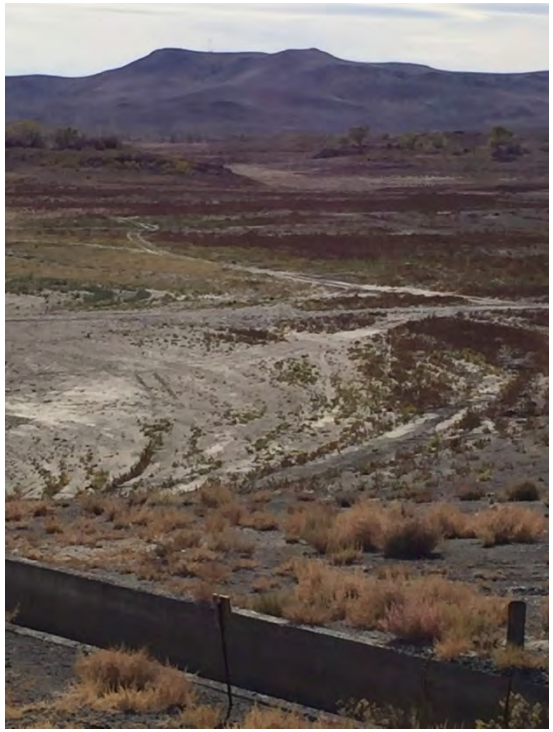
Resiliency Theory

A Climate Resilient Community:

- Understands, acknowledges, anticipates and absorbs changing climate-stress scenarios
- Capacity to adapt, respond effectively and to reorganize as necessary to maintain essential community functions and identity

Source: Walker, 2008, Resilience Practice.

Defining and Understanding the Social-Ecological System



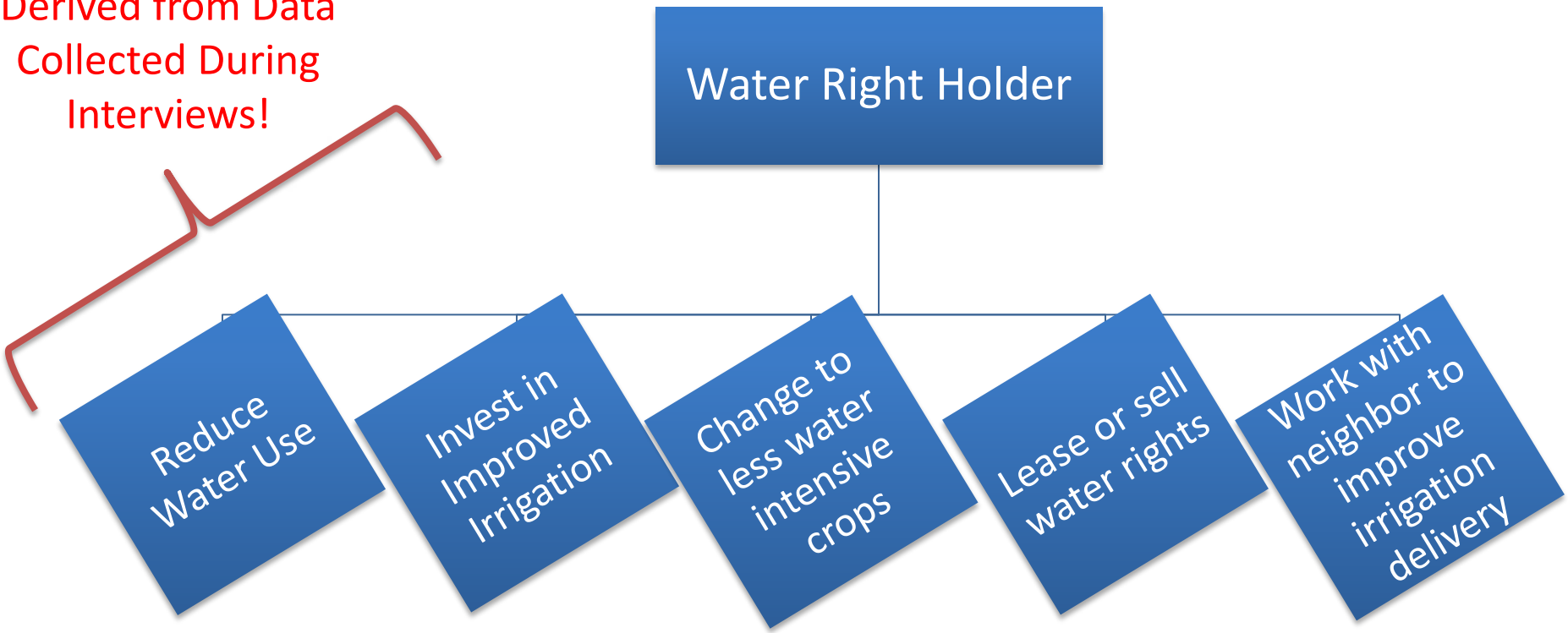
- Resilience *of* what?
- Resilience *to* what?
  - Identifying system drivers and disturbances
  - Developing a historical profile of the system
- Organizations and stakeholders involvement through collaborative modeling (aka participatory research)
- Develop the Stakeholder Advisory Group

Lahontan Reservoir, Oct 2014.

Assessing Resilience

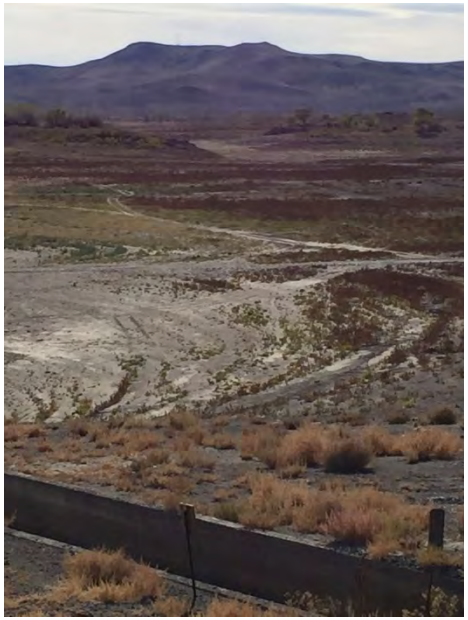
Agent Based Modeling *Scenario:* Water Supply Reduction

Decision Criteria Derived from Data Collected During Interviews!



What are the barriers and opportunities for institutional change within the policy making system itself?

Where are we now?



- Developing survey instruments
  - Organizations
  - Water Right Holders
- Climate and hydrological modelers' input
  - Questions that test model uncertainties
  - Identify system thresholds and tipping points
  - Importance of defining and understanding the system and actors in order to effectively:

Thank you!

Additional project team members:

Maureen McCarthy, Project Director; UNR Academy for the Environment

Greg Pohll, DRI

Justin Huntington, DRI

Seshadri Rajagopal, DRI

Staci Emm, UNR Cooperative Extension

Mike Dettinger, USGS

Rich Niswonger, USGS

United States Department of Agriculture
National Institute of Food and Agriculture

Integrate Climate, Hydrology and Policy

Traditionally Independent Endeavors

- **Social Science Survey Instruments**
  - Interviews
- **Climate Modeling**
  - Extreme events
- **Physical Hydrology Models**
  - Groundwater and Surface Water/Watershed Models
- **Water Operations Models**
  - Riverware

Collaborative Approach

- Assess System Resiliency
- Develop Stakeholder Advisory Group (SAG)
- Model water supply/demand outcomes
- Develop policy scenarios in response to water supply/demand outcomes
- Iterative… assess and manage resilience, engage in continuous feedback

Definitions

- Climate-stress scenarios – the cumulative impact of multi-year variability of climate conditions, potentially unprecedented in magnitude and impact, that stress the system

- Drought – insufficient water to meet needs (*Redmond, 2010)*

- Stakeholder – water right holders who have legally recognized right to withdraw a specific amount from the system *and* water users, who actively utilize water as a consumptive good or as an input in production of another good

- Organization – an entity that has managerial responsibilities on the system

- Resiliency – the ability of a system to “bounce back”

RECLAMATION

Managing Water in the West

TRUCKEE BASIN STUDY

Presentation to the Lahontan Water Board

Jan 15, 2015

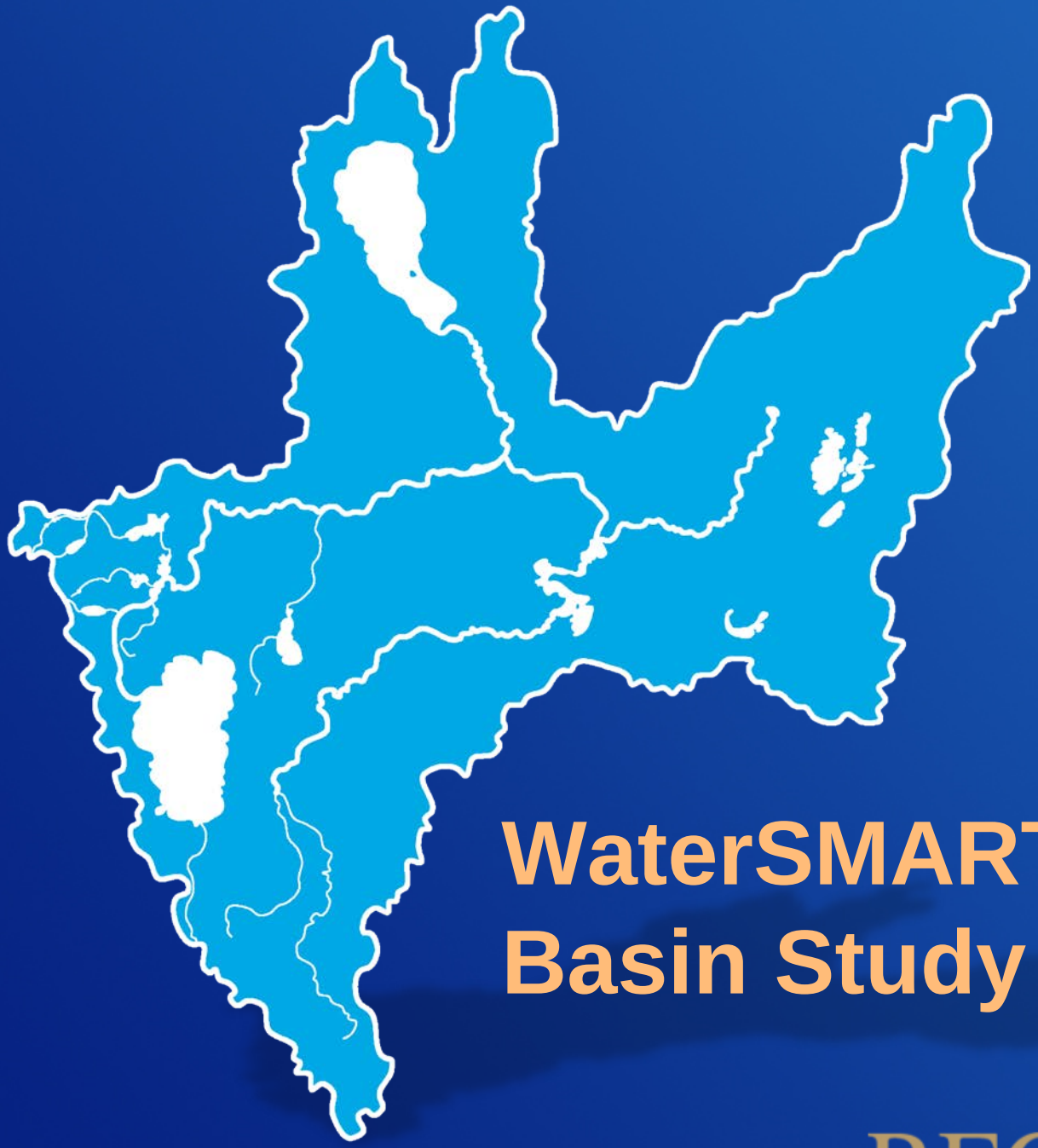
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

TMWA

PCWA
water • energy • stewardship

TRUCKEE RIVER FLOOD PROJECT

TAHOE REGIONAL PLANNING AGENCY



WaterSMART and the Basin Study Programs

RECLAMATION

WaterSMART Program

- **Implements SECURE Water Act, Public Law 111-11**

- **Established in 2010 by Secretary Salazar to…**
  - **Help water resource managers make sound decisions about water use**
  - **Develop strategies to ensure sufficient water supplies for multiple uses**
  - **Develop adaptive measures to climate change**
  - **Improve water conservation**
  - **Promote sustainability**

RECLAMATION

Truckee Basin Study Partners

RECLAMATION

Overview of Basin Study Progress

RECLAMATION

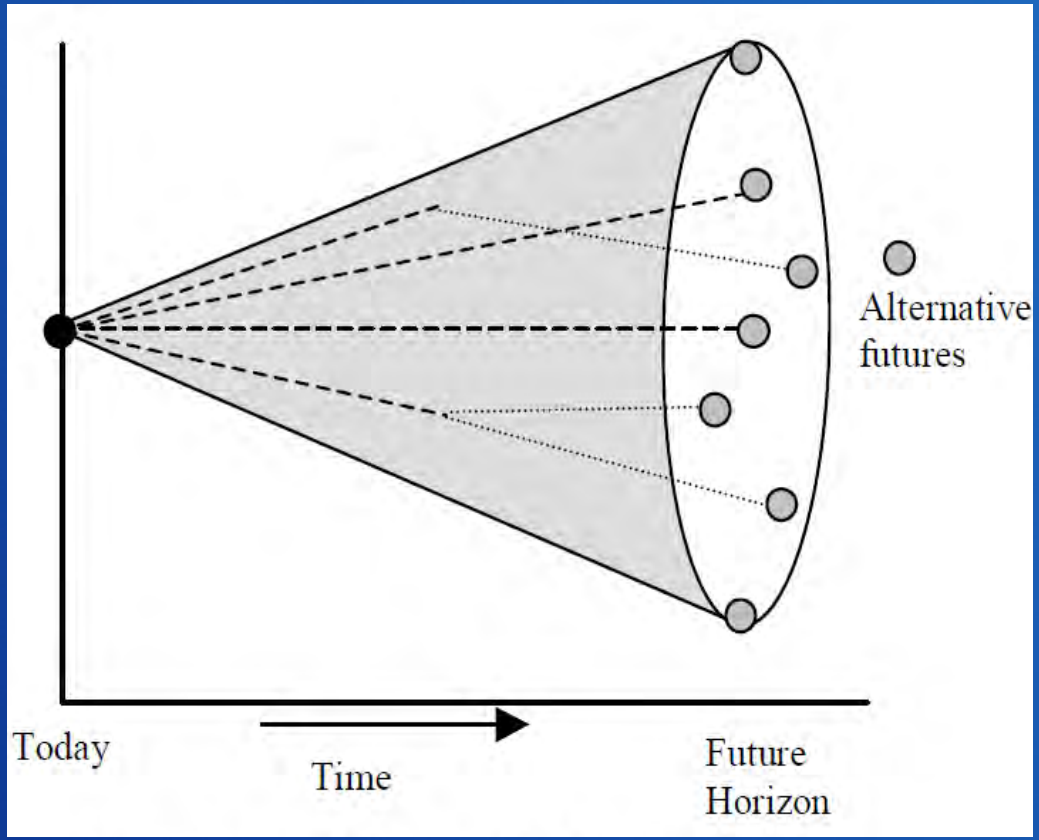
Truckee Basin Study
Milestones and Products

- Evaluation of studies, reports, and plans 2012-2013
- Development of future demand– August 2013
- Development of future supply
  - Climate Ensembles (Dec 2013)
  - Downscaling (Jan 2014)
  - Truckee Basin hydrology (Mar 2014)
  - Carson River hydrology (Jun 2014)
- Vulnerability assessment workshop – Jul 2014
- Options and Findings Meeting – November 2014
- Draft-Final Basin Study – January 2015

RECLAMATION

Scenario Development

- **Effective treatment of uncertainty is key to Basin Study**
- **Uncertainty is addressed through “scenarios”**
- **Scenarios built from Supply, Demand, and Operational components.**



Supply and Demand Assessments

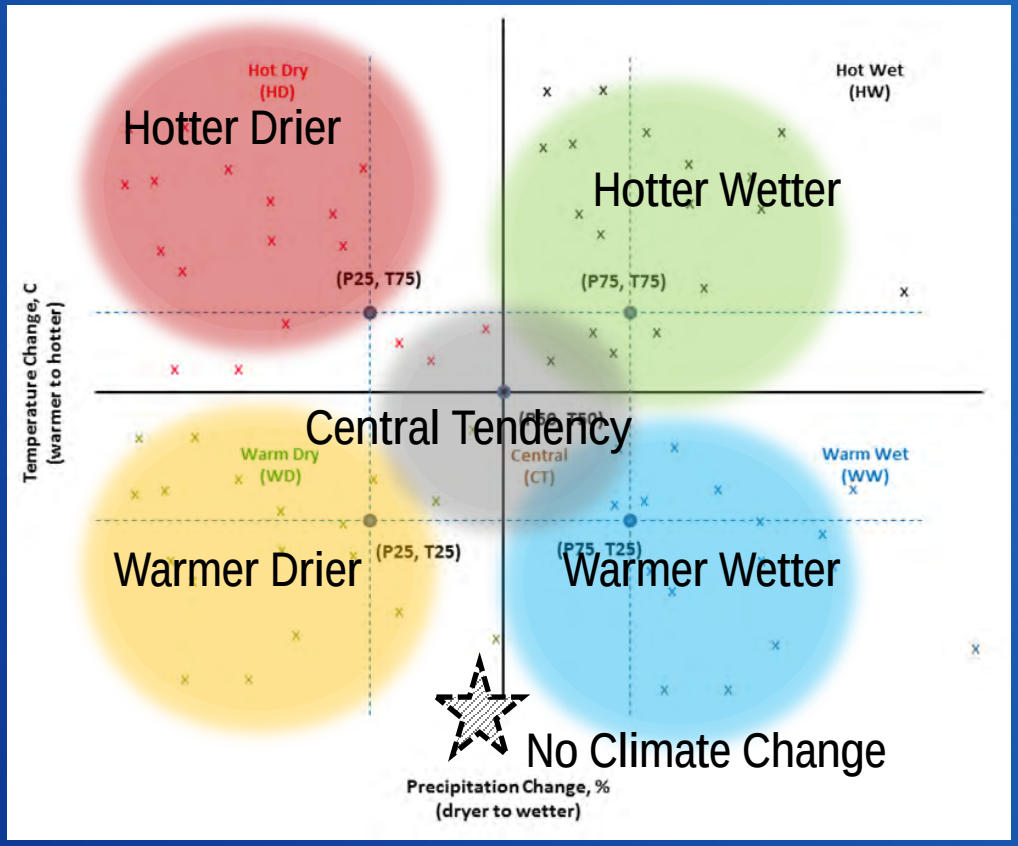
- **Supply Assessment**
  - One baseline supply condition based on hydrologic conditions absent climate change
  - Five future supply conditions based on hydrologic conditions differentiated by changes in climate

Demand Assessment

- One baseline demand condition based on 2012 water demand
- Two future demand conditions based on water use associated with different economic conditions and regional growth trajectories (Robust Economy and Existing Trends)

Future Supply Scenarios

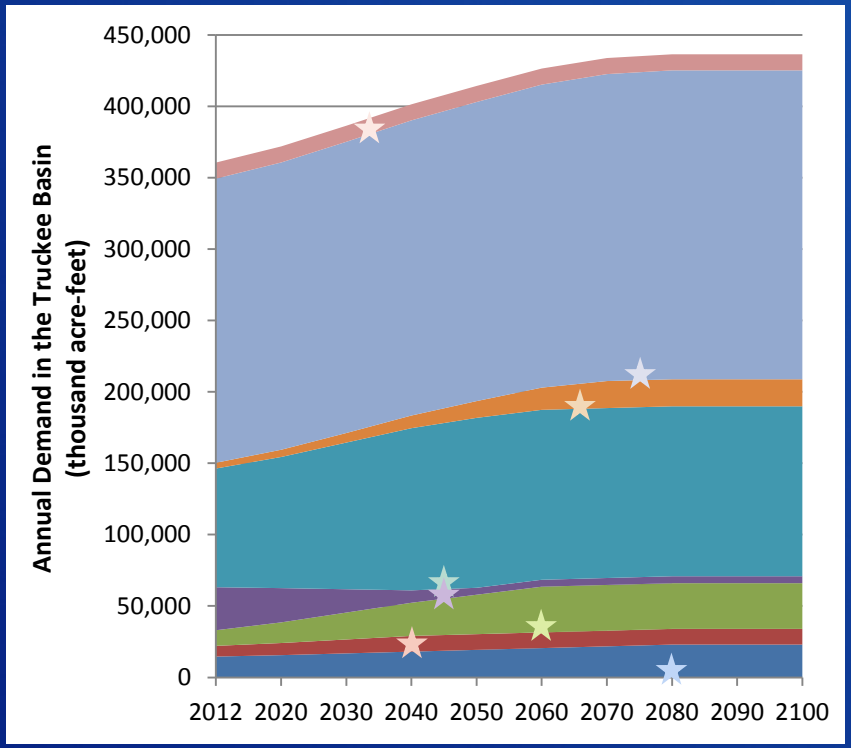
- Consider the range of potential future hydrologic conditions resulting from climate change
- Based on 100 years of projected climatic conditions in the Truckee and Carson basins



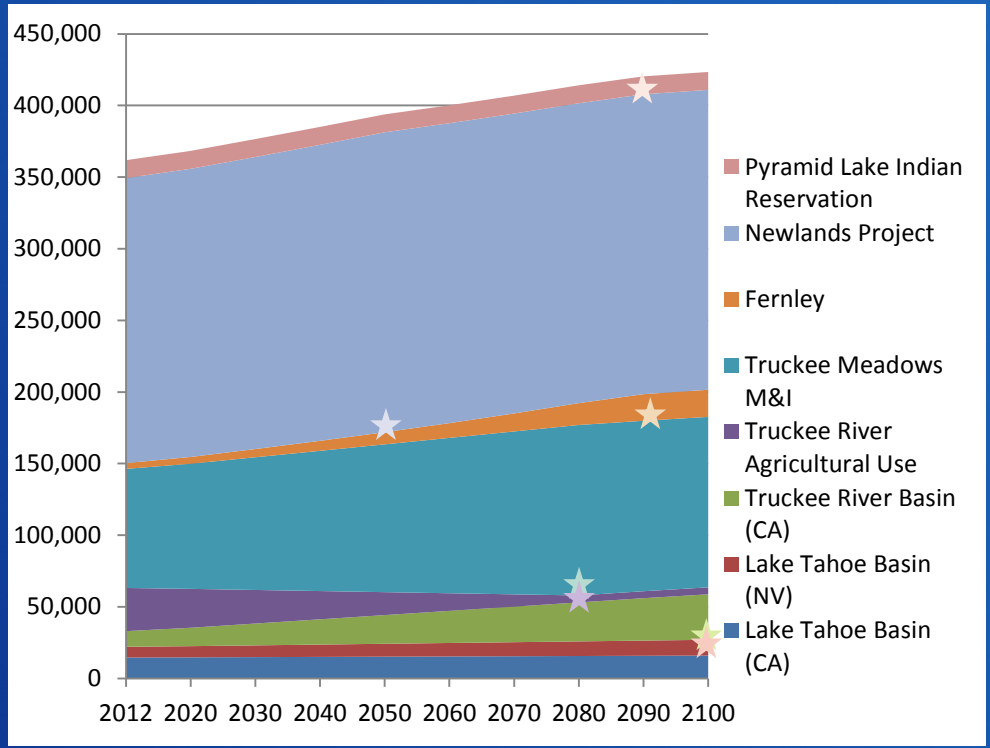
RECLAMATION

Composite Consumptive Demands

Robust Economy



Existing Trends



★ = Year in which future demand is fully reached

RECLAMATION

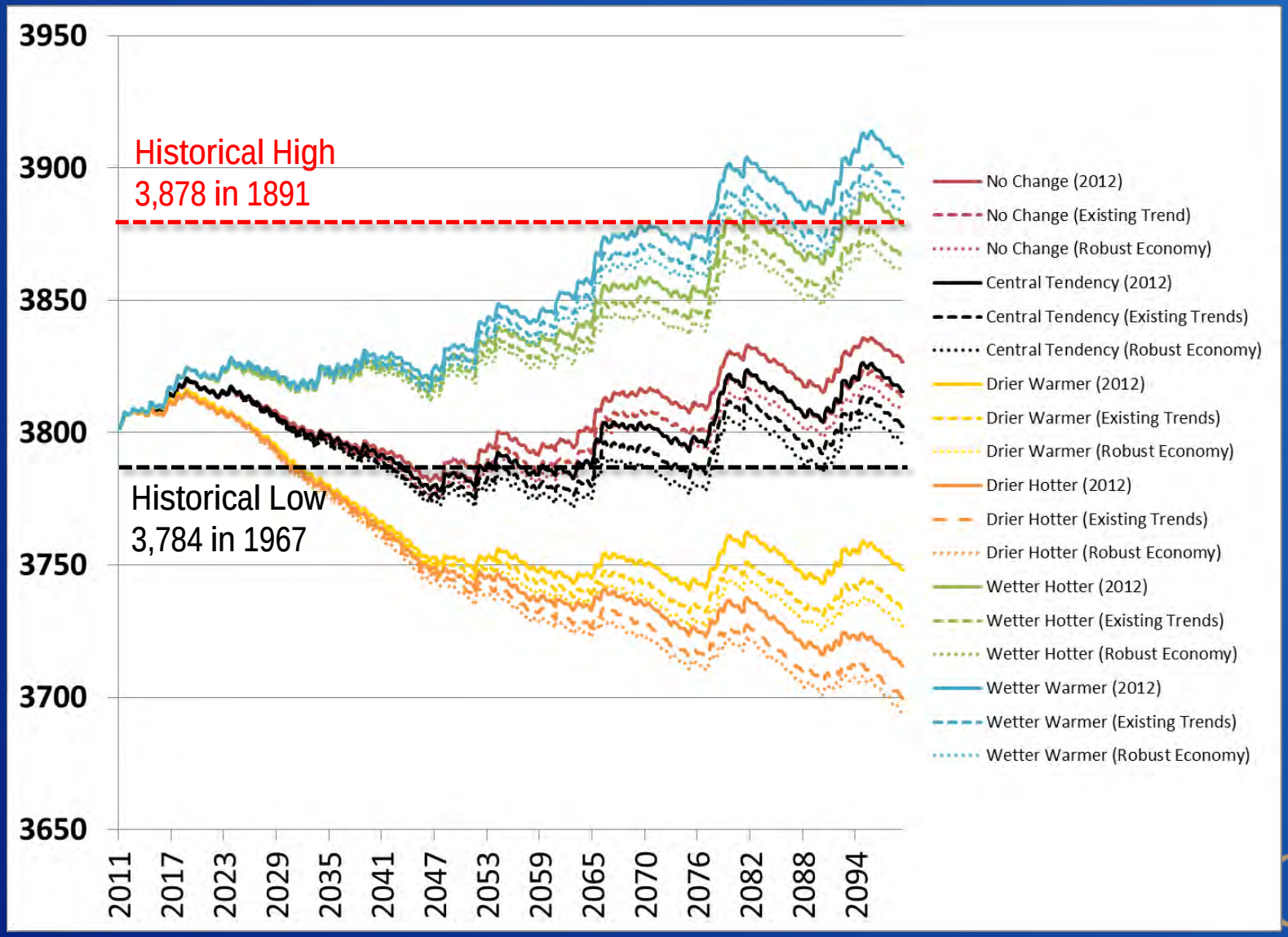
Risk and Reliability Assessment

- Identified key vulnerabilities to the range of potential future conditions.
- Described how well the current infrastructure and operations can meet the needs of each water user community under the range of potential future conditions.

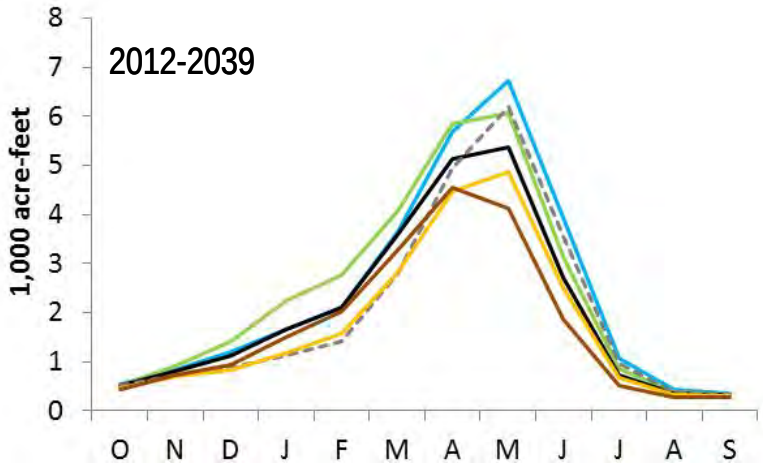
Findings about Basin-wide Vulnerabilities

- A wide range of uncertainty exists for Truckee Basin supplies, mostly due to uncertainty in future precipitation.
- Increases in temperature will shift natural runoff in important ways, and reduce water supplies.
- In comparison to the uncertainty in future supplies, the uncertainty in water demands is insignificant.
- Maintaining the historical balance between supply and demand may not be possible if the climate departs significantly from historical conditions, even with exceptional changes in human behavior.

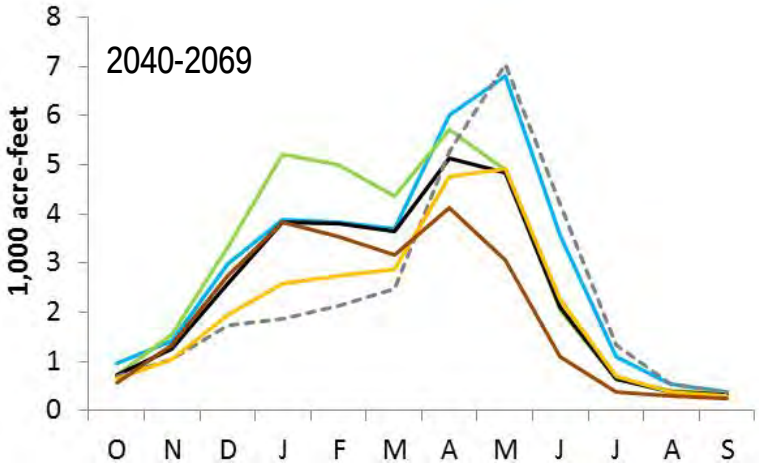
Precipitation is the Least Certain and Causes the Greatest Vulnerability

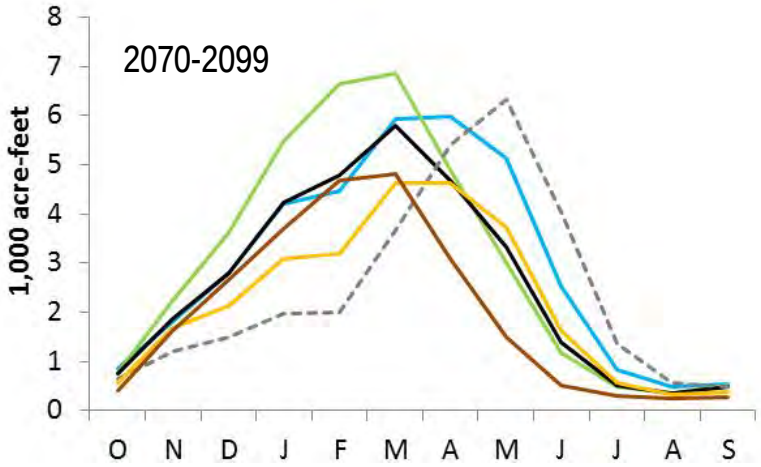


Seasonality Shifts Are Certain



warmer, wetter
no climate change
hotter, wetter
warmer, drier
central tendency
hotter, drier

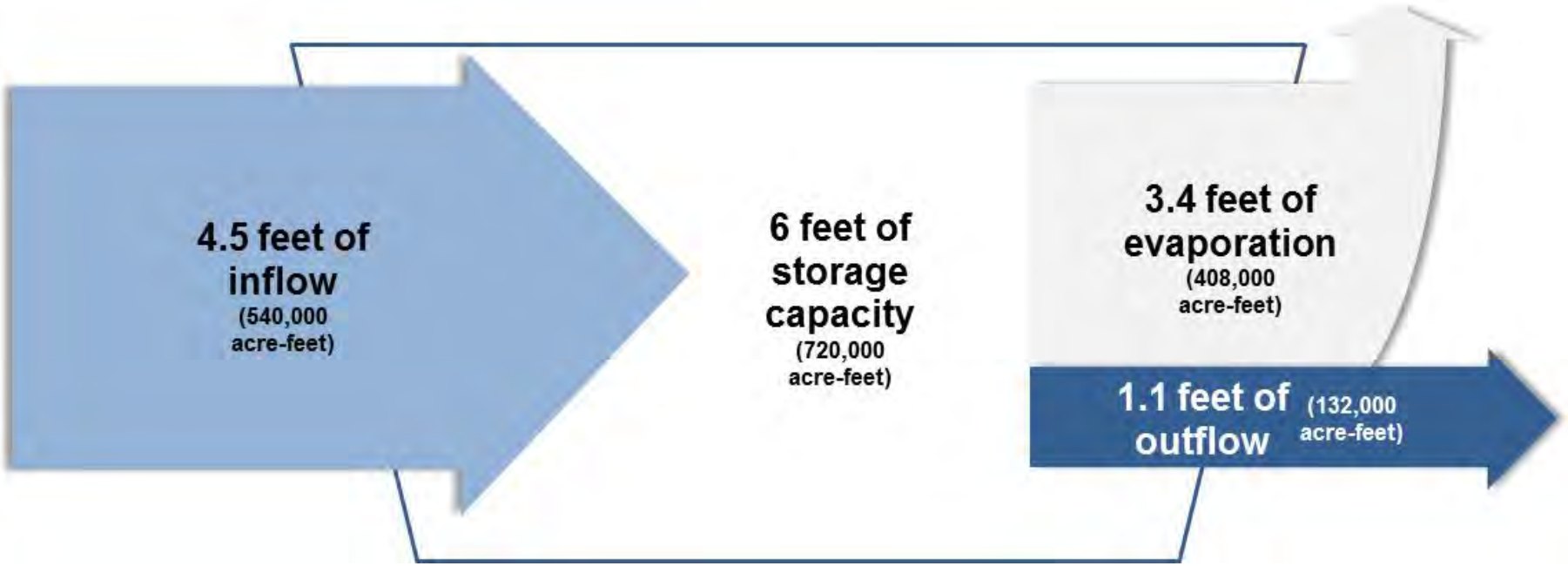




Seasonality Shifts Result in New Operational Challenges

RECLAMATION

Increases in Temperature also Reduce Supplies at Lake Tahoe



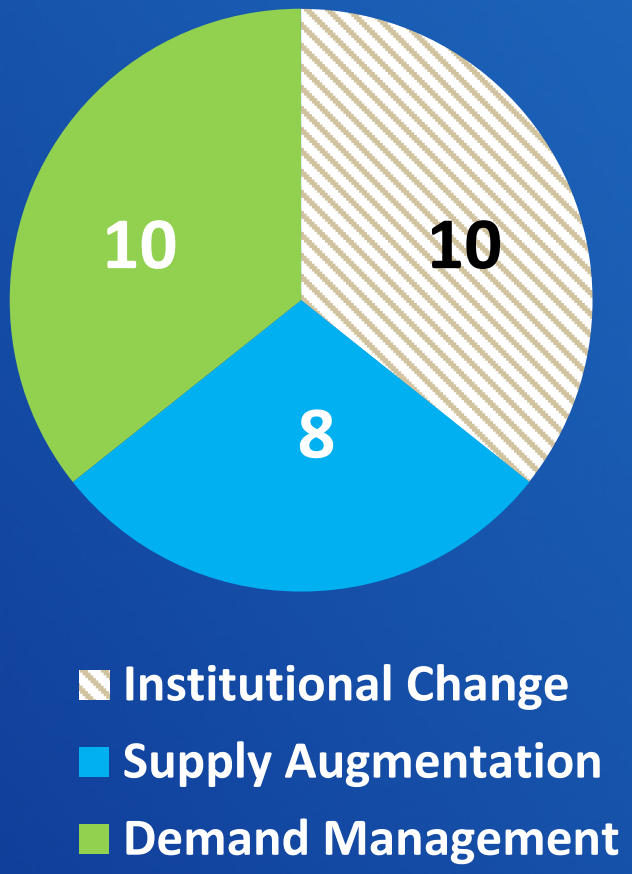
RECLAMATION

Options Identification and Evaluation

RECLAMATION

Options Suggested for the Basin Study

- **140+ individual suggestions from TAG**
- **Organized thematically by "Adaptation Strategy"**
  - **Institutional Change –** "operate what we have better"
  - **Supply Augmentation –** "obtain more water"
  - **Demand Management –** "shift or reduce demands"



RECLAMATION

Institutional Change

Adaptation Strategy	Grouping	Option
Institutional Change	Basin-wide Planning	Define regional priorities and goals for water use
		Eliminate prior appropriation
	Surface Water Reservoir Management	Allow TCID carryover storage in Truckee River reservoirs
		Change balance of credit storage available to users at Truckee River reservoirs
		Remove storage limits at Truckee River reservoirs
		Modify flood control curves to adapt to climate
		Modify OCAP criteria at Lahontan Dam to improve success of refill
	Surface Water Rights Management	Allow management of water between Pyramid Lake fisheries and Lahontan Valley wetlands
		Create open water markets
		Consolidate agricultural water rights

Supply Augmentation

Adaptation Strategy	Grouping	Option
Supply Augmentation	Alternative Sources	Interbasin Transfer of Groundwater
	Conveyance Facility Improvements	Augment Truckee Canal capacity
	Groundwater Storage	Aquifer storage and recovery
	Modifications to the Hydrologic Cycle	Forestry-based watershed management
		Weather modification
		Wetland, meadow, and stream corridor restoration
	Surface Storage	Additional Carson River storage
		Increase Truckee River reservoir storage

Demand Management

Adaptation Strategy	Grouping	Option
Demand Management	Agricultural Use	Convert to low water-use crops
		Reduce conveyance losses
		Transfer agricultural water rights to municipal and industrial uses
		Water rights retirement
		Water use efficiency improvements
	Environmental Flows	Revise flow targets to correspond with peak flows under climate change
	Municipal & Industrial Use	Increase outreach and education on conservation
		Mandate efficiency improvements
		Outdoor use efficiency improvements
	Water Quality	Water quality improvements for the lower Truckee River

Considerations for Evaluating Options

Completeness: Information needed to evaluate the option already exists. Does not require large speculation about effectiveness, future decisions, or other conditions.

Applicability to Basin-wide Vulnerabilities: Option is anticipated to address water supply for the entire Basin or to help restore supply-demand balance for water user communities.

Use of Basin Study Tools: Option can be represented using tools available to the Basin Study. Development of new models is not required to test the option.

Options Selected for Additional Evaluation

- Adapt Reservoir Flood Management Operations
- Adapt OCAP Storage Targets
- Consolidate Agricultural Rights
- Forest Management
- Truckee Canal Rehabilitation
- Additional Truckee River Basin Storage
- Raise Lahontan Dam
- Adapt Fish Flow Regimes

Lahontan Water Board
Overview of Water Board Tools

Summary of Water Board tools

Steps in adaptation strategy development

Issues to consider during Today's Breakout Session

Guiding Principles

Workshop Instructions – Dr. Amy Horne

Water Board tools

- California Water Code
- Clean Water Act

- Mission: to preserve and enhance the quality of California's water resources for the benefit of present and future generations

Water Board tools (continued)

- Basin planning
  - Identify and protect beneficial uses
  - Set narrative and numeric water quality standards
  - Describe control measures including waste discharge prohibitions
- Limited water quality monitoring

Water Board tools (continued)

- Implementation and Enforcement
  - Permits – set discharge limits and require best management practices and performance measures
  - Inspections/Self-monitoring reports
  - Cleanup requirements – spills, repairs
  - Grants and low interest loans

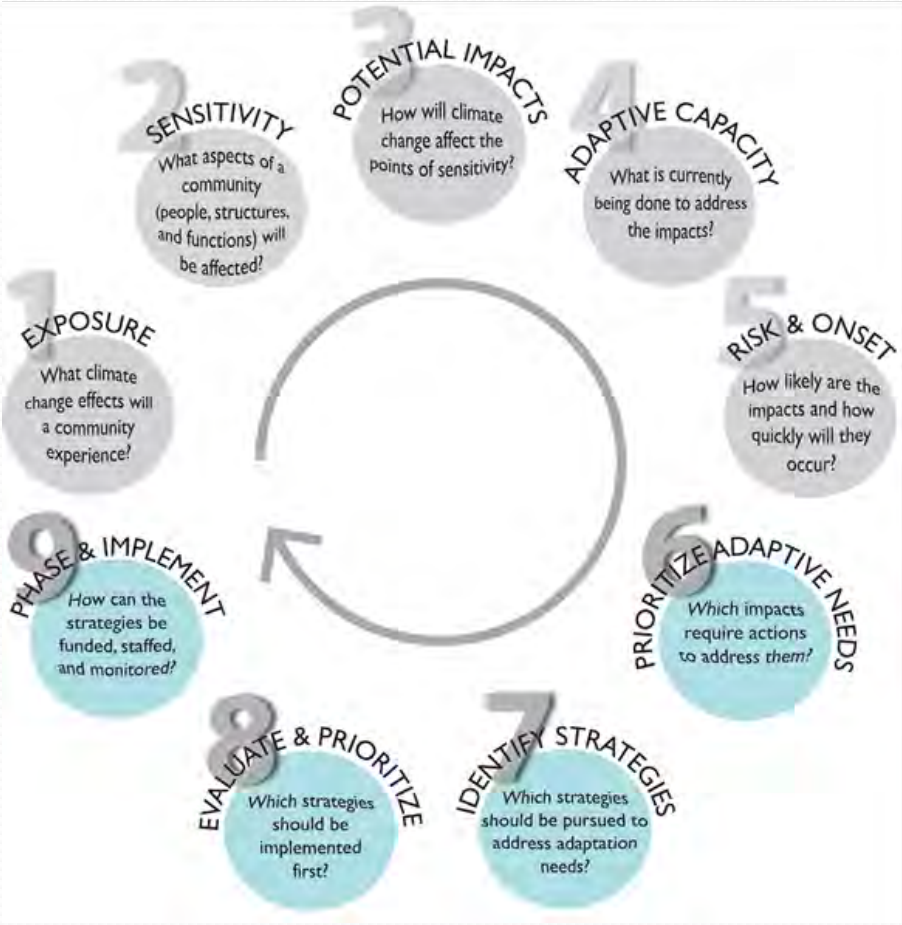
Water Board tools - Examples

- Require additional treatment to meet standards and offer low interest loans or grants
- Require infrastructure maintenance, repairs and upgrades
- No net loss of wetlands; require restoration
- Prohibitions against floodplain development in Truckee River and Lake Tahoe Basins

Water Board tools - Examples

- Facilitate vegetation management to lessen the severity of impacts from wildfires – Timber Waiver
- Require low impact development practices- increased infiltration, mimic natural hydrology
- Implement Recycled Water policy including salt and nutrient management
- Invasive species control – encourage all management measures and allow for aquatic pesticides

Nine Steps in Adaptation Strategy Development



Nine Steps in Adaptation Strategy Development

1. Exposure (identify environmental changes)
2. Sensitivity (who and what will be affected)
3. Potential Impacts (effects on points of sensitivity)
4. Adaptive Capacity (what is already being done)
5. Risk and Onset (how likely to occur and when)
6. **Prioritize Adaptive Needs (required actions)**
7. **Identify Strategies**
8. **Evaluate and Prioritize (which first?)**
9. **Phase and Implement (how to fund or resource?)**

Issue Areas to Consider in Breakout Groups

- Groundwater Reliability
- Watershed Protection
- Land Use
- Infrastructure Protection
- Monitoring

Guiding Principles for Adaptation

- Adopt integrated approaches
- Prioritize the most vulnerable
- Use best-available science
- Build strong partnerships
- Apply risk-management methods and tools
- Apply ecosystem-based approaches
- Maximize mutual benefits
- Continuously evaluate performance

Your Input is Requested!

- **In the year 2040, what policies and tools including changes to organizations and applicable law should the Lahontan Water Board have for dealing with the effects of climate change?**

- **What are the key steps the Lahontan Water Board should take to get from the current policies and practices to the desired state in 2040?**