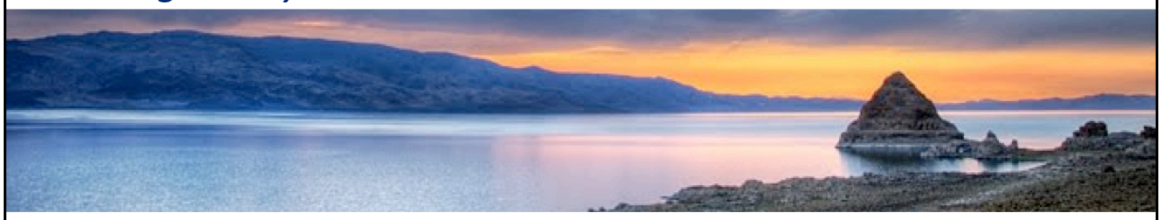
# Climate Change Vulnerability of Native Americans in the Southwest: *A Case Study of Tribal Climate Adaptation Among the Pyramid Lake Paiute Tribe*



**Dr. Karletta Chief and Mr. Schuyler Chew**
**University of Arizona**

NCCWSC Climate Change Science and Management Webinar Series
Tuesday, October 14, 2014

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# Outline

1. Project Overview
2. Socio-economic Vulnerability
3. Participatory Workshop
4. Cui-ui & LCT video
5. Hydrologic Model
6. Adaptation Recommendations

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# 1. Project Overview

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# Interdisciplinary Partnership

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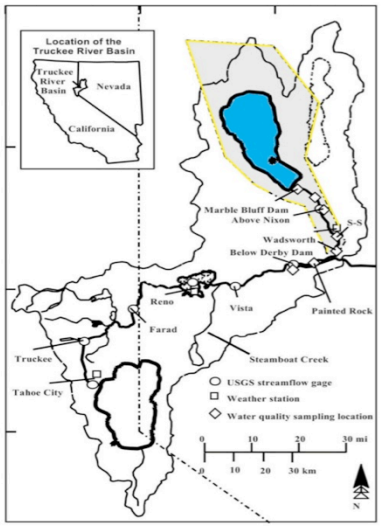
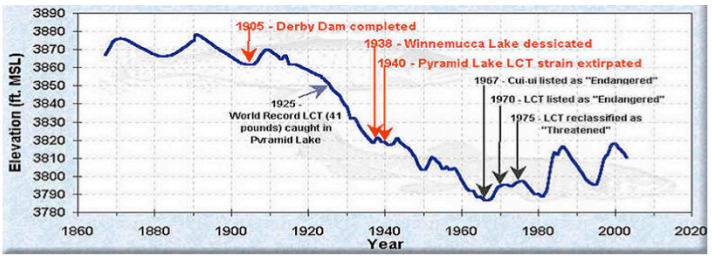
- **Dr. Karletta Chief**, Hydrologist, U of A
- **Dr. Aleix Serrat-Capdevila**, Hydrologist, U of A
- **Schuyler Chew**, Research Analyst, U of A
- **Dr. William J. Smith Jr.**, Env Geographer, UNLV
- **Dr. David E. Busch**, Ecologist, USGS
- **Kameron Morgan**, Water Quality Specialist, Pyramid Lake Paiute Tribe

# Pyramid Lake Paiute Tribe




Truckee River Basin (Warwick et al., 1999)

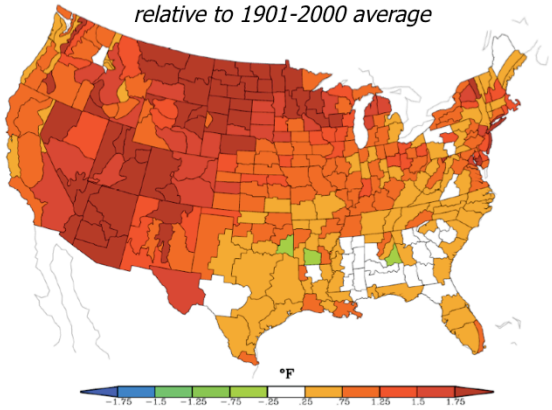




# Rapid Warming Trend

- Parts of the West have already warmed more than 2 °F compared to average 20th century temperatures
- The Southwest is among the most rapidly warming regions in the world

*2000 to 2007 temperature relative to 1901-2000 average*




*map from M. Hoerling, NOAA; Slide courtesy of J. Overpeck*

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# Project Goals

- Determine the potential of the Pyramid Lake Paiute Tribe to adapt to climate change by understanding vulnerabilities, thresholds, and resiliencies of the systems
- Propose collaborative tribal water management and adaptive strategies for the Pyramid Lake Paiute Tribe

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# Project Goals

- Produce a framework for a decision support system model of a coupled climate-biophysical-social system
- Explore the potential for effective partnerships and collaborations between tribes and scientists

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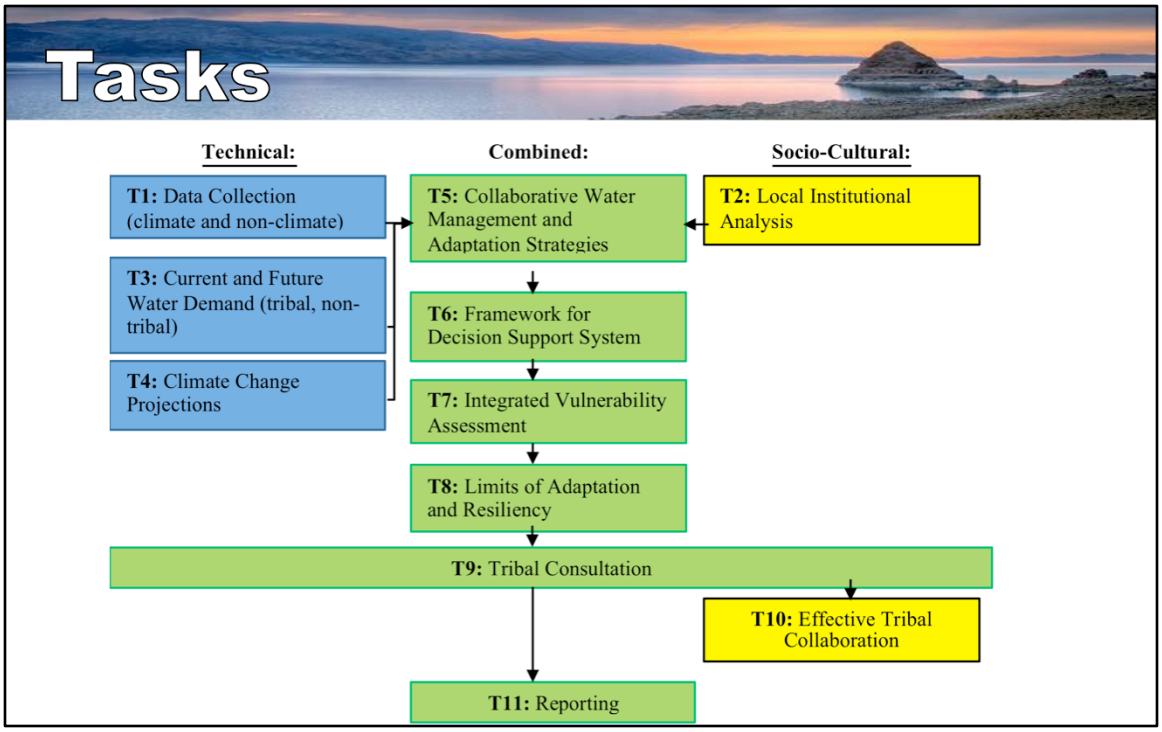
Tasks
Technical:
Combined:
Socio-Cultural:
T1: Data Collection (climate and non-climate)
T3: Current and Future Water Demand (tribal, non-tribal)
T4: Climate Change Projections
T5: Collaborative Water Management and Adaptation Strategies
T2: Local Institutional Analysis
T6: Framework for Decision Support System
T7: Integrated Vulnerability Assessment
T8: Limits of Adaptation and Resiliency
T9: Tribal Consultation
T10: Effective Tribal Collaboration
T11: Reporting


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# Socio-economic Vulnerability

## Internal Factors

- Education and employment
- **Climate Change perceptions**
- Institutional capacity
- Technology
- Physical Capacity
- Economic resources and financial capital
- **Social capital**
- **Natural capital**

## External Factors

- Federal support and entitlement
- **Power relation and legal stressor**
- Job opportunity and migration

Climatic Change
DOI 10.1007/s10584-013-0737-0

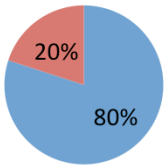
**Climate change in arid lands and Native American socioeconomic vulnerability: The case of the Pyramid Lake Paiute Tribe**

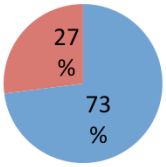
Mahesh R. Gautam · Karletta Chief · William J. Smith Jr.

# PLPT Climate Change Perspectives

## Surveys with tribal members indicated

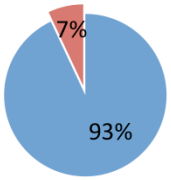
**80% were aware of climate change and observed changes in their environment**




**73% believed climate change is happening and humans play a role in climate change**

**93% expressed their priority for climate change action at the national level (Gautam et al. 2013)**

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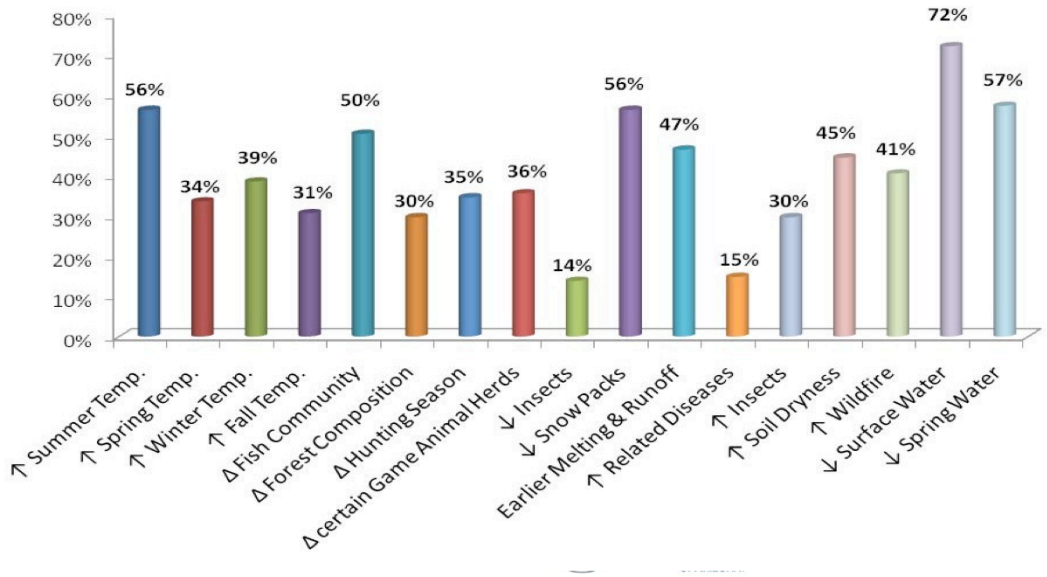
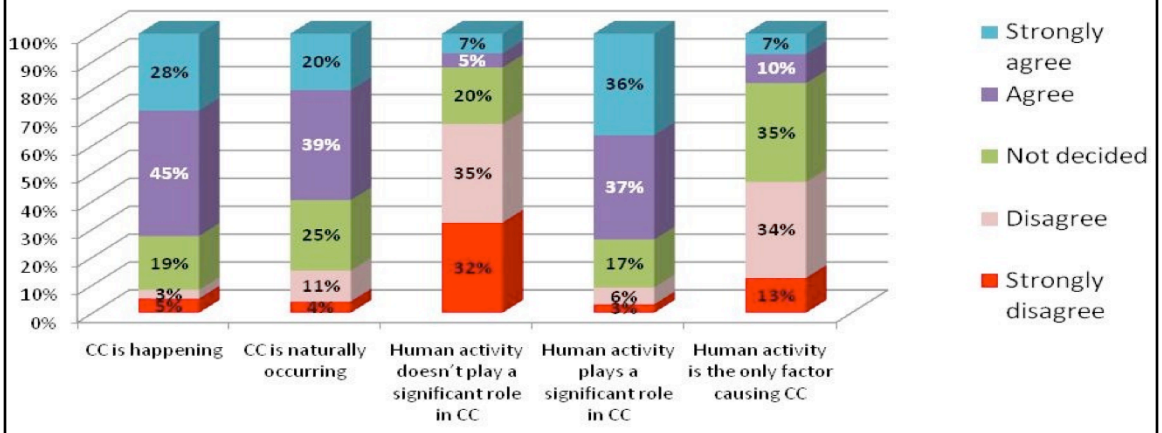
# Observed Environmental Changes



# Climate Change Beliefs

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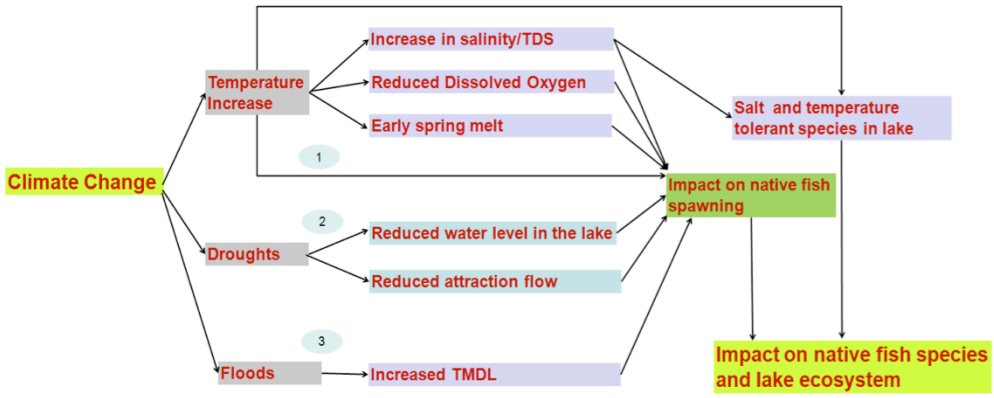
# Scientific Cognitive Map




**Expert Cognitive map based on literature review**

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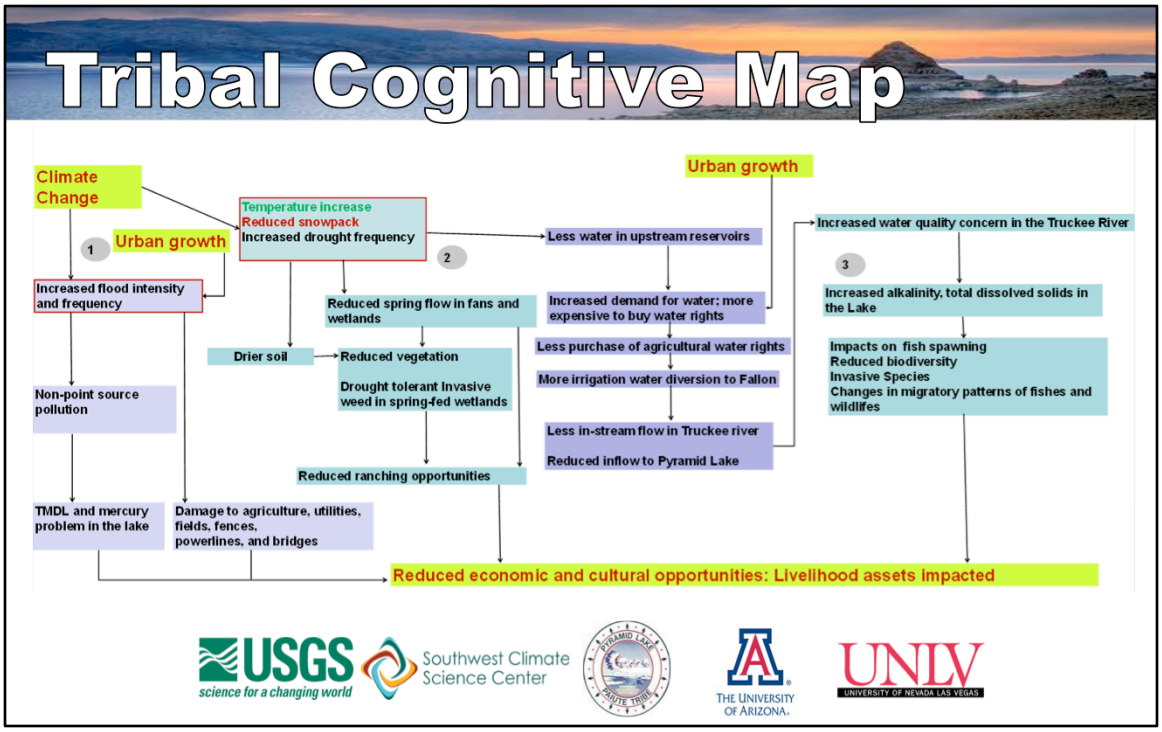
Tribal Cognitive Map
Climate Change
Urban growth
1
Urban growth
Temperature increase
Reduced snowpack
Increased drought frequency
2
Less water in upstream reservoirs
Increased water quality concern in the Truckee River
3
Increased flood intensity and frequency
Reduced spring flow in fans and wetlands
Increased demand for water; more expensive to buy water rights
Increased alkalinity, total dissolved solids in the Lake
Drier soil
Reduced vegetation
Drought tolerant Invasive weed in spring-fed wetlands
Less purchase of agricultural water rights
More irrigation water diversion to Fallon
Impacts on fish spawning
Reduced biodiversity
Invasive Species
Changes in migratory patterns of fishes and wildlifes
Non-point source pollution
Less in-stream flow in Truckee river
Reduced inflow to Pyramid Lake
Reduced ranching opportunities
TMDL and mercury problem in the lake
Damage to agriculture, utilities, fields, fences, powerlines, and bridges
Reduced economic and cultural opportunities: Livelihood assets impacted
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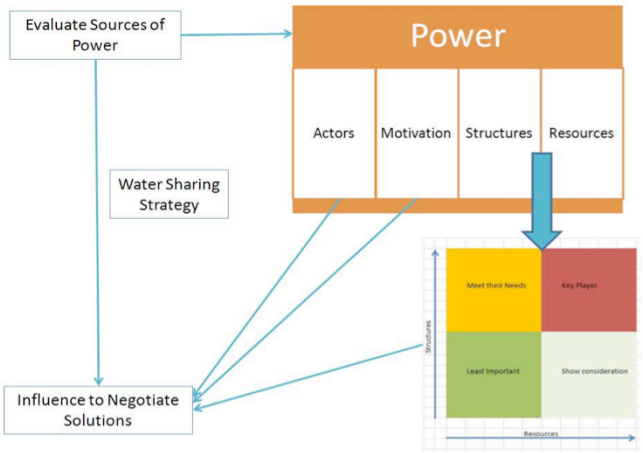
# Power Analysis Framework




PLPT position of power increased over the 20th century as a result of partnerships and federal intervention on behalf of the tribe

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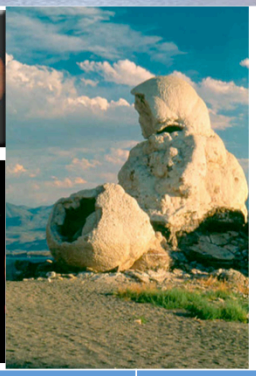
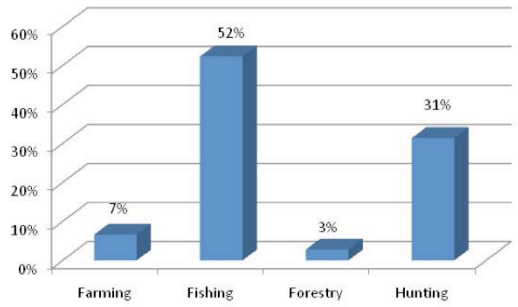
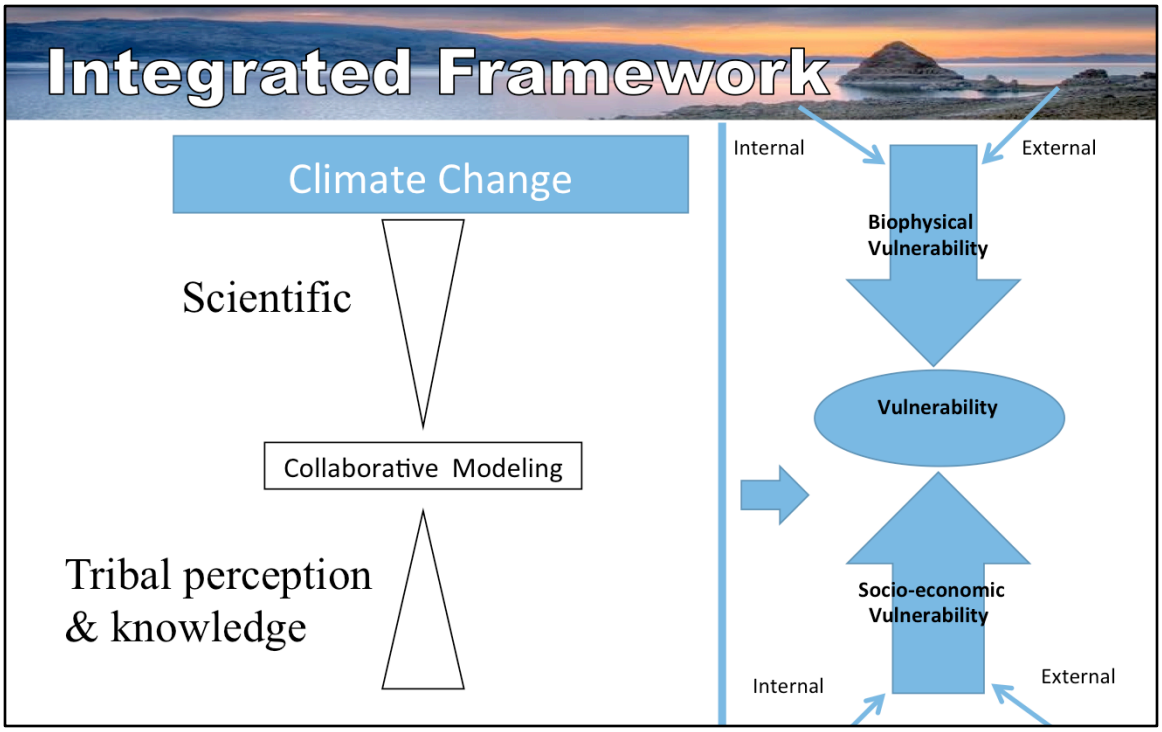
# Socio-economic Vulnerability

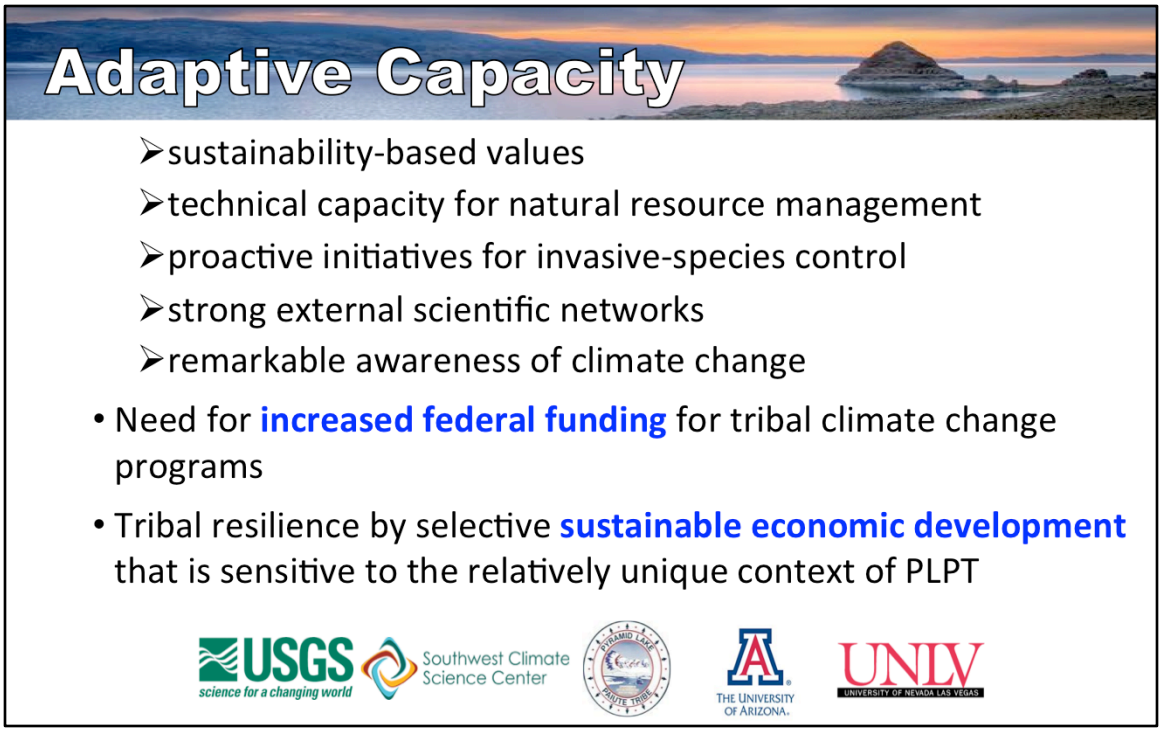



| Characteristic | Value |
|---|---|
| Population | 2,253 |
| Housing Units | 687 |
| Total Area [acres] | 475,000 |
| Population Density [people/mi$^2$] | 3 |

PLPT's vulnerability to climate change is tied to a **cultural and economic dependence on Pyramid Lake**
**External socio-economic factors** influence adaptive capacity and amplify potential impacts
The sustenance of Pyramid Lake ecosystem is extremely important for **economic, spiritual, and cultural** reasons and this is reflected in the fact that cui-ui, the lake, and people are considered the three central components of tribal identity.
**Climatic and non-climatic impacts threaten** the endangered cui-ui fish by decreasing water quantity and quality.




An **integrated analysis** that **merges biophysical and socioeconomic vulnerabilities** using model driven (top–down) and local perception-knowledge driven (bottom–up) is needed to precisely quantify these impacts and uncertainties.




- Despite limited economic opportunities and dwindling federal support, PLPT's adaptive capacity is strengthened by **sustainability-based values**, **technical capacity** for natural resource management, **proactive initiatives** for invasive-species control, strong **external scientific networks**, and a remarkable **awareness of climate change**.
- Like many tribes, PLPT would benefit from **increased federal funding** for tribal climate change programs, and its resilience would be enhanced by selective **sustainable economic development** that is sensitive to the relatively unique context of PLPT.

# 3. Participatory Workshop

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# Workshops and Presentations

| Project Kickoff Meeting | National Congress of American Indians | Climate Change Planning Workshop | Nevada Water Resources Association | Great Basin Consortium | Scenario Discussion |
|---|---|---|---|---|---|
| Nov. 2012 | June 2013 | Sept. 2013 | Nov. 2013 | Dec. 2013 | Aug. 2014 |

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# Climate Change Workshop

Two-day Workshop with tribal members on September 25-26, 2013 at the Nixon Gym:

- 20 participants asked to consider:
- Environmental, water & ecological challenges facing Pyramid Lake
- Management alternatives and solutions to these challenges

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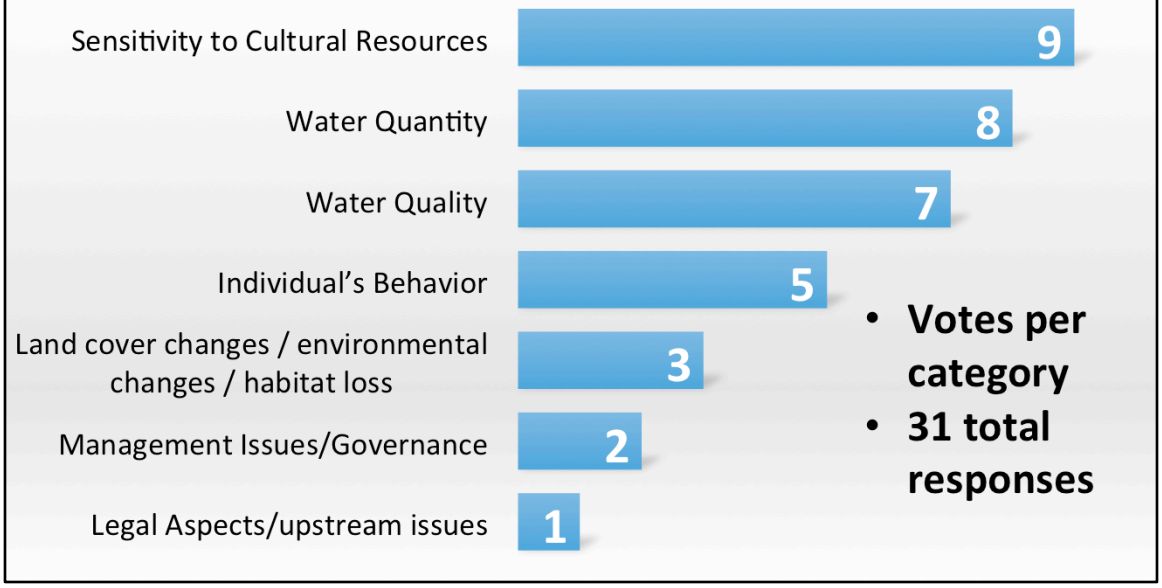
# Categories of challenges




- **Votes per category**
- **31 total responses**

# Ecological indicators

**Water Quantity**

- Lake level
- Snow pack
- Spring flow rate & duration
- Water table height
- Upstream reservoir storage

**Water Quality**

- Water temperature
- Dissolved oxygen
- Concentration of calcium carbonate
- Total dissolved solids
- Nutrients
- Cyanotoxins (blue/ green algae)

**Land cover, environmental changes / habitat loss**

- Bird count / wildlife census
- Botanical census
- Annual migration count of Cui-ui
- Benthic surveys
- CREEL - count of fishing (Stations)
- Particulate matter / aerosols

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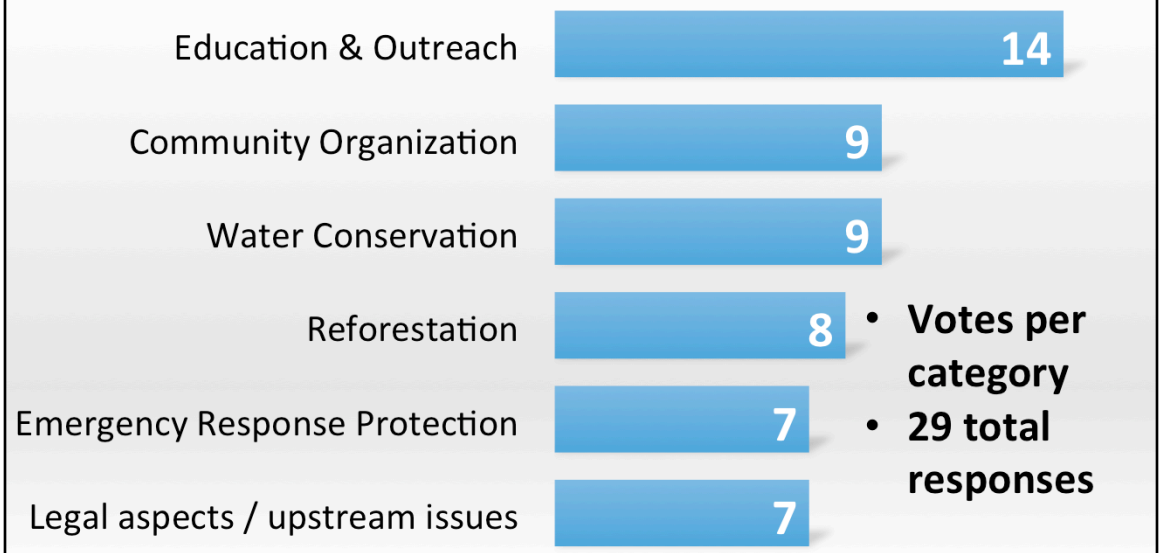
# Management Alternatives & Solutions




- **Votes per category**
- **29 total responses**

# Interesting observations

- Many problems identified were non-environmental; tied to management, governance, and social issues
- Educational outreach and cultural sensitivity were mentioned both as a challenge and a solution
- Participants cited a need for better outreach to and collaboration with upstream river users and managers

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# Leading the way for Tribes

- Pyramid Lake Paiute Tribe is one of many tribes in the Great Basin that are leading the charge on climate change adaptation planning

Visit to Pyramid Lake during the Great Basin Tribal Climate Adaptation Planning course co-hosted by ITEP, DRI, and PLPT

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# Main lessons from course

- Developing an effective adaptation plan requires buy-in and support from tribal government and community
- Essential to get tribal council/leadership to pass a tribal resolution which supports the development of adaptation plan
- Tribe needs to decide what is important/relevant by consulting with the community

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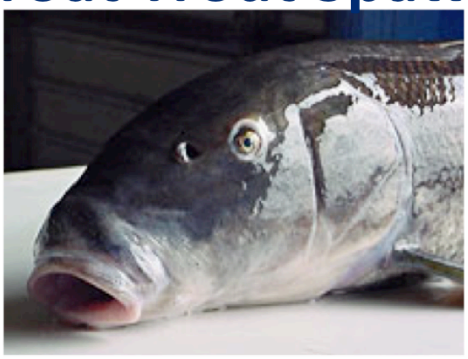
# 4. Video on Cui-ui and Lahontan Cutthroat Trout Spawning



https://www.youtube.com/watch?v=1sBAYBMeRFs

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# Cui-ui & Lahontan Cutthroat

- Cui-ui, *Chasmistes cujus*
- Long lived fish, up to 40 years
- Caught at the surface only during the spawning season
- Does not need to spawn annually
- More resilient than LCT

- Lahontan cutthroat trout, *Oncorhynchus clarki henshawi*
- Only lives 6-8 years
- Sensitive to temperature (44-59°F)
- Needs to spawn annually – virtually impossible in Truckee River

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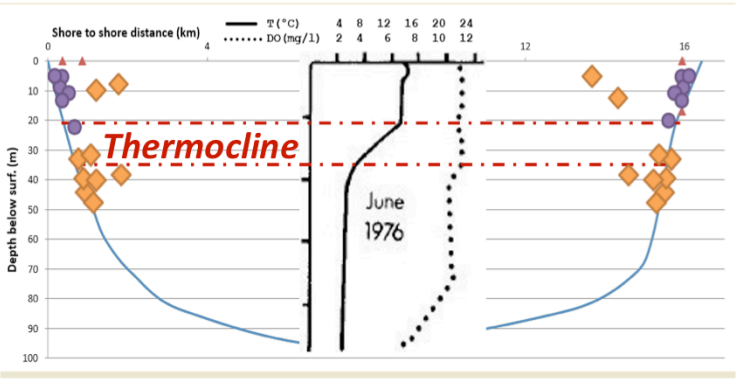
# LCT depth constraints

- LCT sensitive to temperature and prefer depths beneath the thermocline (area where temperature changes most rapidly with depth)

Cui-ui

LCT

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# Cui-ui migration

- Cui-ui migrate to the south end of Pyramid Lake every spring and await "environmental cues" before migrating to spawn

- **Temperature**
- **Water quantity**
- **Water quality**
- **And other environmental factors**

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# Cui-ui spawning

- Cui-ui require specific depths, temperature, stream velocity to spawn, and need to bury their eggs beneath the gravel
  - Head of gravel bars, where flow is rapid and substrate relatively free of silt
  - TDS 600 mg/L required for eggs to “water harden”
  - Eggs buried to depth of 10 cm

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# Adaptation Considerations

| Ecological Requirements | Potential Impacts | Adaptation Considerations |
|---|---|---|
| ▪ LCT require specific temperature and depth ranges for their habitat | ▪ Could warmer temps and lower lake levels push LCT out of their current habitat into deeper regions? | ▪ How viable are hatchery operations if lake cannot support LCT habitat? Is it possible to boost operations to keep up with changes? |
| ▪ Cui-ui depend on environmental cues to begin migratory spawning | ▪ Could consecutive low-flow years or earlier snowmelt interfere with "cues" and inhibit cui-ui spawning? | ▪ Are the Marble Bluff Dam operations compatible with changes in flow patterns? |
| ▪ Cui-ui eggs require various conditions for incubation, e.g., TDS < 600 mg/L | ▪ Could changes in Truckee River water quality impair the survival of cui-ui eggs? | ▪ Should water quality standards be reevaluated to account for these changes? |

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# 5. Hydrologic Model

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# Lake Water Balance Model

- Mass-balance model of Pyramid Lake volume:
  - Storage: water present in the lake
  - INPUTS: Truckee River stream flows and precipitation over the lake
  - OUTPUTS: Exiting the lake through evapotranspiration.
- Two models were developed
  - Monthly time step
  - Annual time step

$$V_t = V_{t-1} + (Q_{t-1} \times T) + (A_{t-1} \times P_{t-1} \times T) - (A_{t-1} \times E_{t-1} \times T)$$

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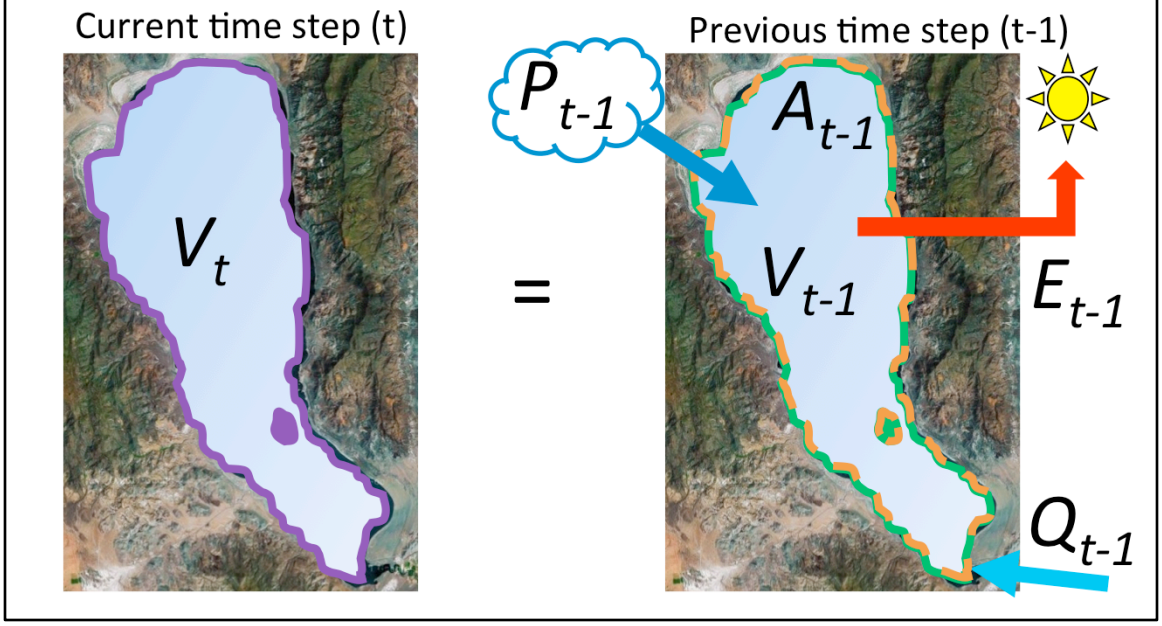
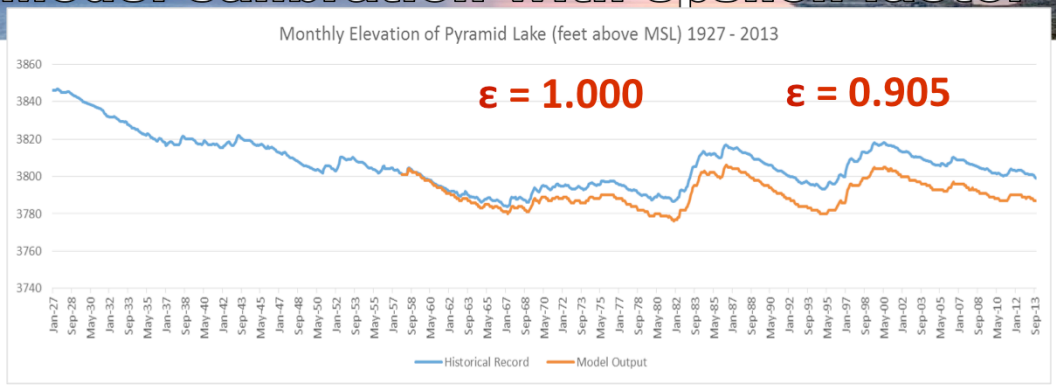
$$V_t = V_{t-1} + (Q_{t-1} \times T) + (A_{t-1} \times P_{t-1} \times T) - (A_{t-1} \times E_{t-1} \times T)$$




Vt is Lake volume at current time step (m3)
Vt-1 is Lake volume at previous time step (m3) from bathymetry
Qt-1 is Truckee River flow IN at previous time step (m3/time) Nixon, NV
T is time step (1 month or 1 year)
At-1 is Lake surface area at previous time step (m2) from bathymetry
Pt-1 is rate of precipitation IN at previous time step (m/time) Nixon, NV
Et-1 is rate of evapotranspiration OUT at previous time step (m/time) Blanney - Criddle Formula, mean daily temperature for Nixon, NV

# Model calibration with epsilon factor




- A correction factor epsilon ($0 < \varepsilon \leq 1$) was included with evapotranspiration $E_t$ to account for missing inputs (e.g., local stream flows, surface runoff, etc.)

$$V_t = V_{t-1} + (Q_{t-1} \times T) + (A_{t-1} \times P_{t-1} \times T) - (A_{t-1} \times E_{t-1} \times \varepsilon \times T)$$

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# Lake Elevation Climate Scenarios

- A range of future climate scenarios (until December 2100) were developed to simulate the impacts of changes in:
  - Truckee River flow
  - Mean temperature
  - Precipitation
- These are hypothetical scenarios which use modified historical records of river flow. (changed by a %)
- Scenarios will become more robust with input from regional downscaled climate models.

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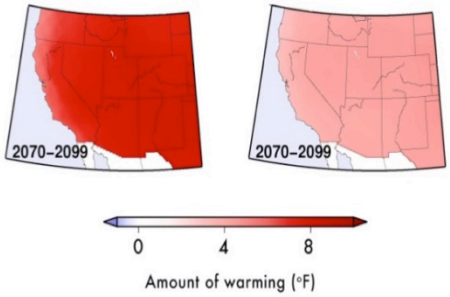
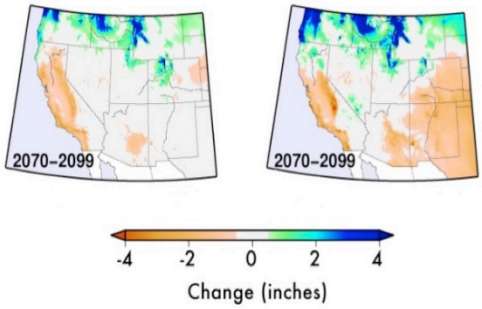
# Climate Projections for US Southwest

**Temperature change (°F) by year 2100**




Temp. increase up to 3 to 9°F

**Precipitation change (in.) by year 2100**




2 in. decrease to 2 in. increase

swcarr.arizona.edu

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# Lake Elevation Climate Scenarios

| Scenario | Change in River flow ΔQ | Change in Temperature Δθ | Change in Precipitation ΔP |
|---|---|---|---|
| 1) No change | 0 | 0 | 0 |
| 2) Truckee River flow | 5% dec., 5% inc. & no change | 0 | 0 |
| 3) Temperature | 0 | 2°F dec., 2°F inc. & no change | 0 |
| 4) Precipitation | 0 | 0 | 1" dec., 1" inc. & no change |
| 5) Extreme Cases | Worst: 5% dec. Best: 5% inc. | Worst: 2°F inc. Best: 2°F dec. | Worst: 1" dec. Best: 1" inc. |

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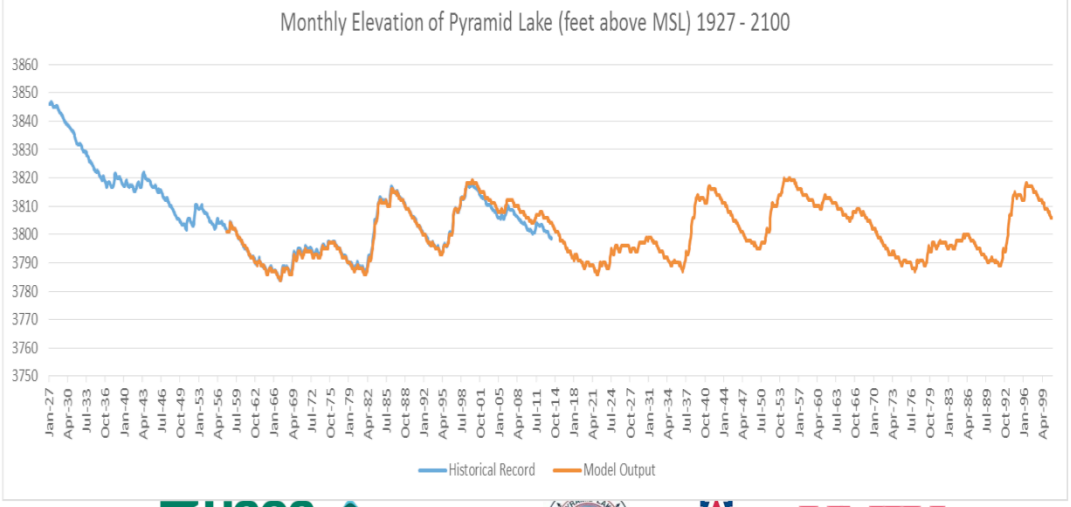
# Scenario 1: No Changes

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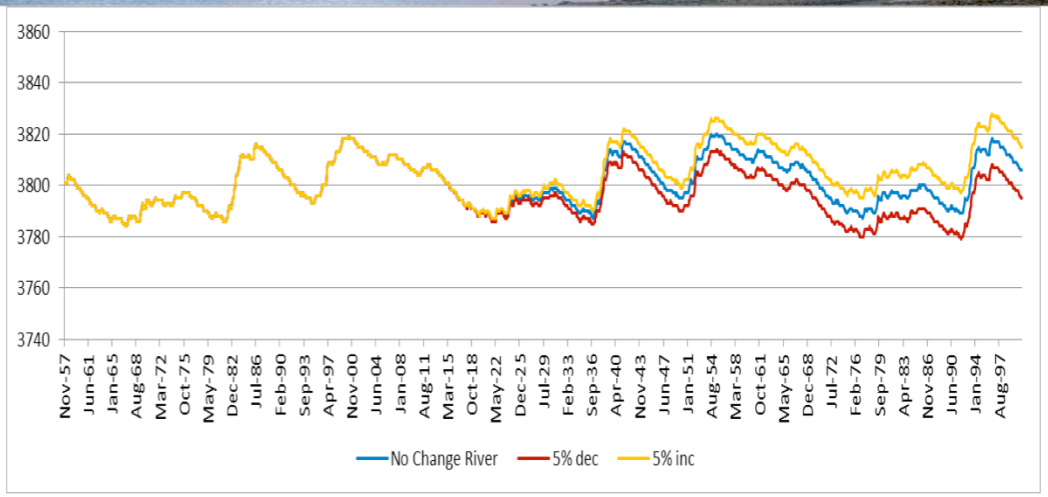
# Scenario 2: Truckee River Flow

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# Scenario 3: Temperature


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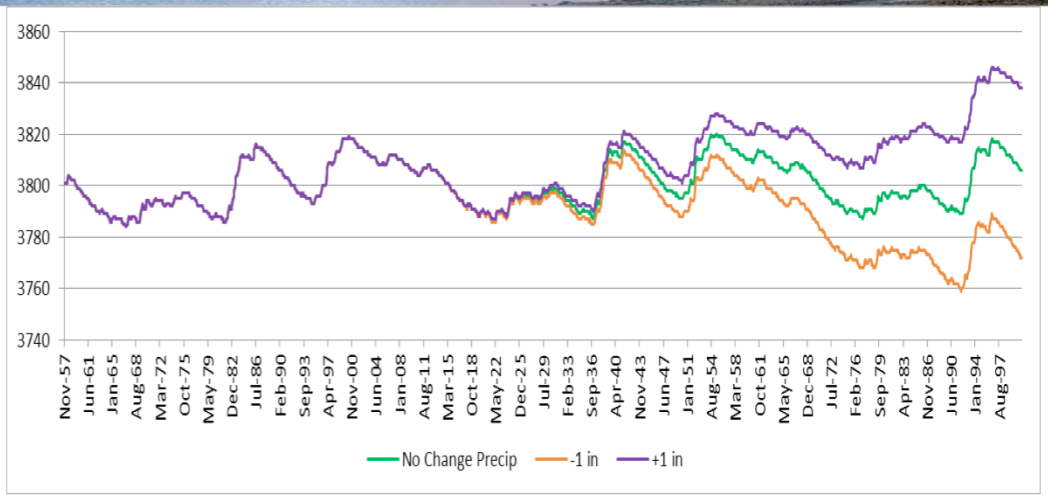
# Scenario 4: Precipitation

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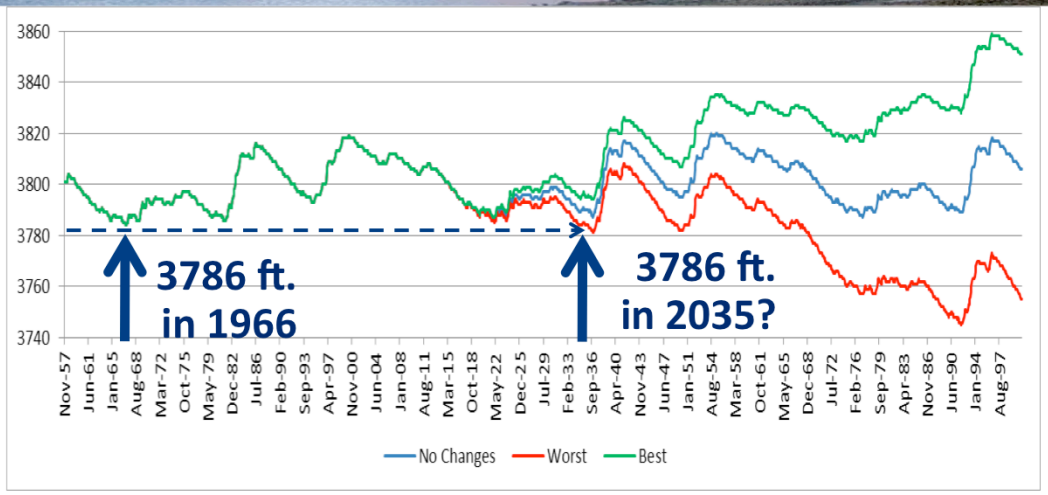
# Scenario 5: Extreme Cases

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# 6. Adaptation Recommendations

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# Adaptation Recommendations

1. Manage Stampede Reservoir releases at convenient times for cui-ui spawning
2. Increase irrigation efficiency which will reduce water demand and follow soil conservation practices which will improve water quality.
3. Revisit Operations of Marble Bluff Dam to adapt to changes the hydrologic regime of the river
4. Revisit hatchery operations to adapt to changes in fish populations.

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# Adaptation Recommendations

5. Maintain and enhance efforts to restore the natural riparian habitat of the Truckee River
6. Adapted urban planning and residential outdoor landscaping to promote water harvesting of storm runoff, reduce erosion, enhance water quality, water for community gardens.
7. Integrated comprehensive Emergency Response Plan (for mitigation of chemical pollution and sediment pollution upstream)

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# Adaptation Recommendations

8. Monitoring environmental indicators is important.
9. Outreach: Engage schools and the community. Teach the value of environmental and cultural resources, and the opportunities to face today's challenges, as well as the role of the youth.
10. Establish tribal led reservation-wide initiatives to increase education of global change and protecting the environment. Involve high schools and senior centers.

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Thank you!
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