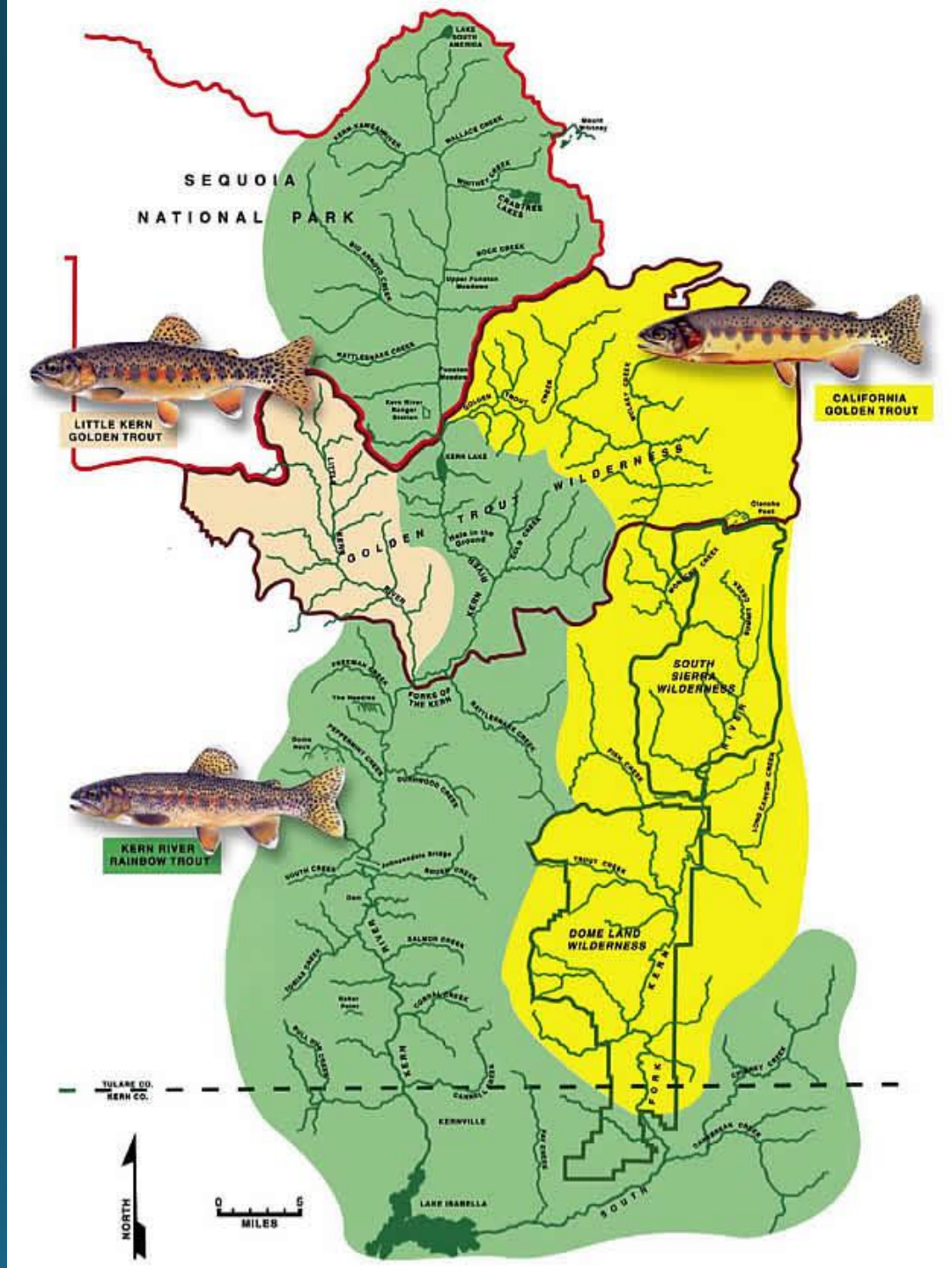
A Brief History of the Sierra Nevada - Origin of the Golden Trout

Origins of the Golden Trout

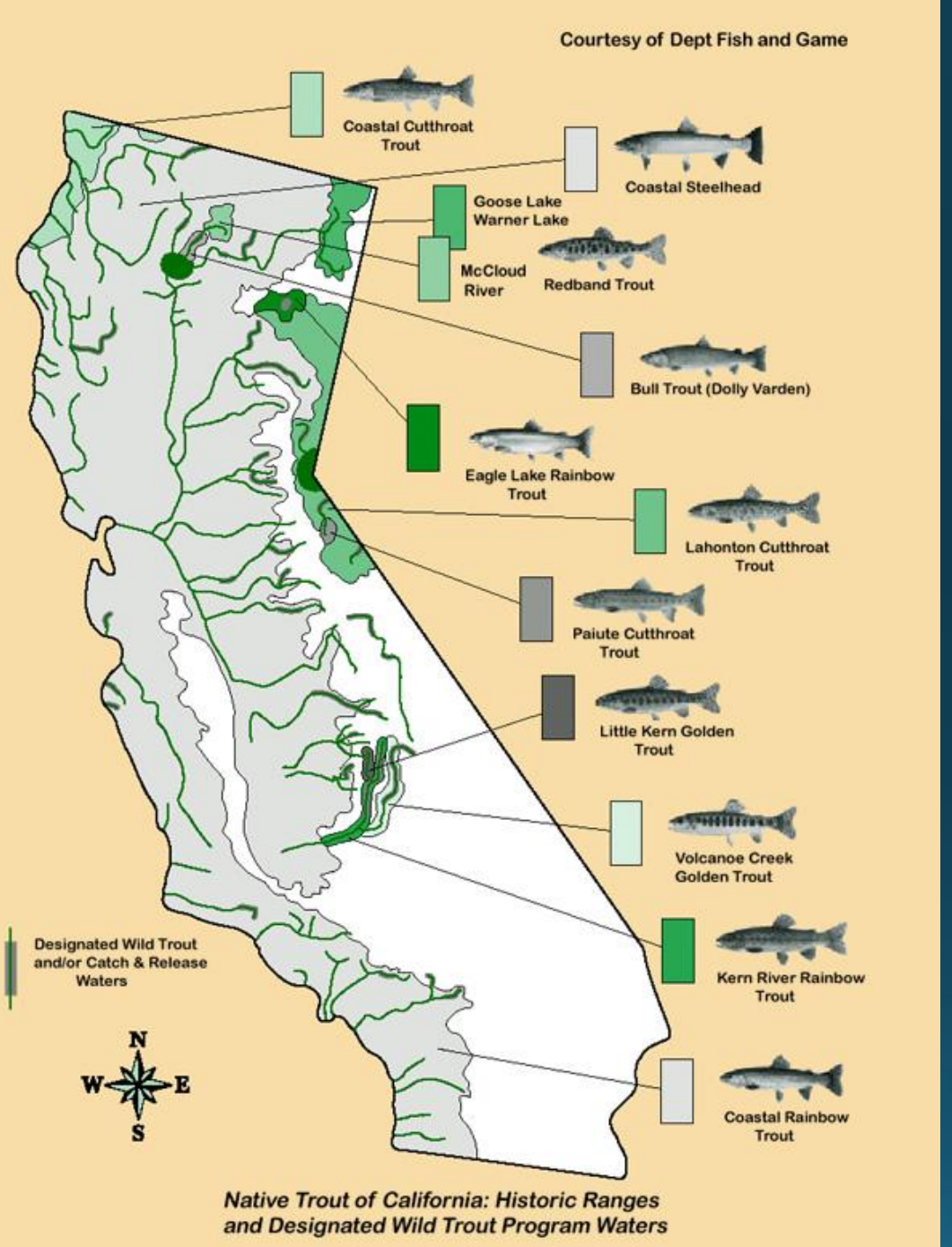
- Formation of the Sierra Nevada
- Glacial Activity
- Creation of the Kern Canyon Fault
- Incursions of Coastal Rainbows
- Development of a species over 70,000 years


SEQUOIA
NATIONAL PARK
LITTLE KERN
GOLDEN TROUT
CALIFORNIA
GOLDEN TROUT
KERN RIVER
RAINBOW TROUT
GOLDEN TROUT WILDERNESS
SOUTH SIERRA WILDERNESS
DOME LAND WILDERNESS
KERN LAKE
FORKS OF THE KERN
KERNVILLE
LAKE ISABELLA
TULARE CO.
KERN CO.
NORTH
0
5
MILES

Native Trout of California, historic ranges

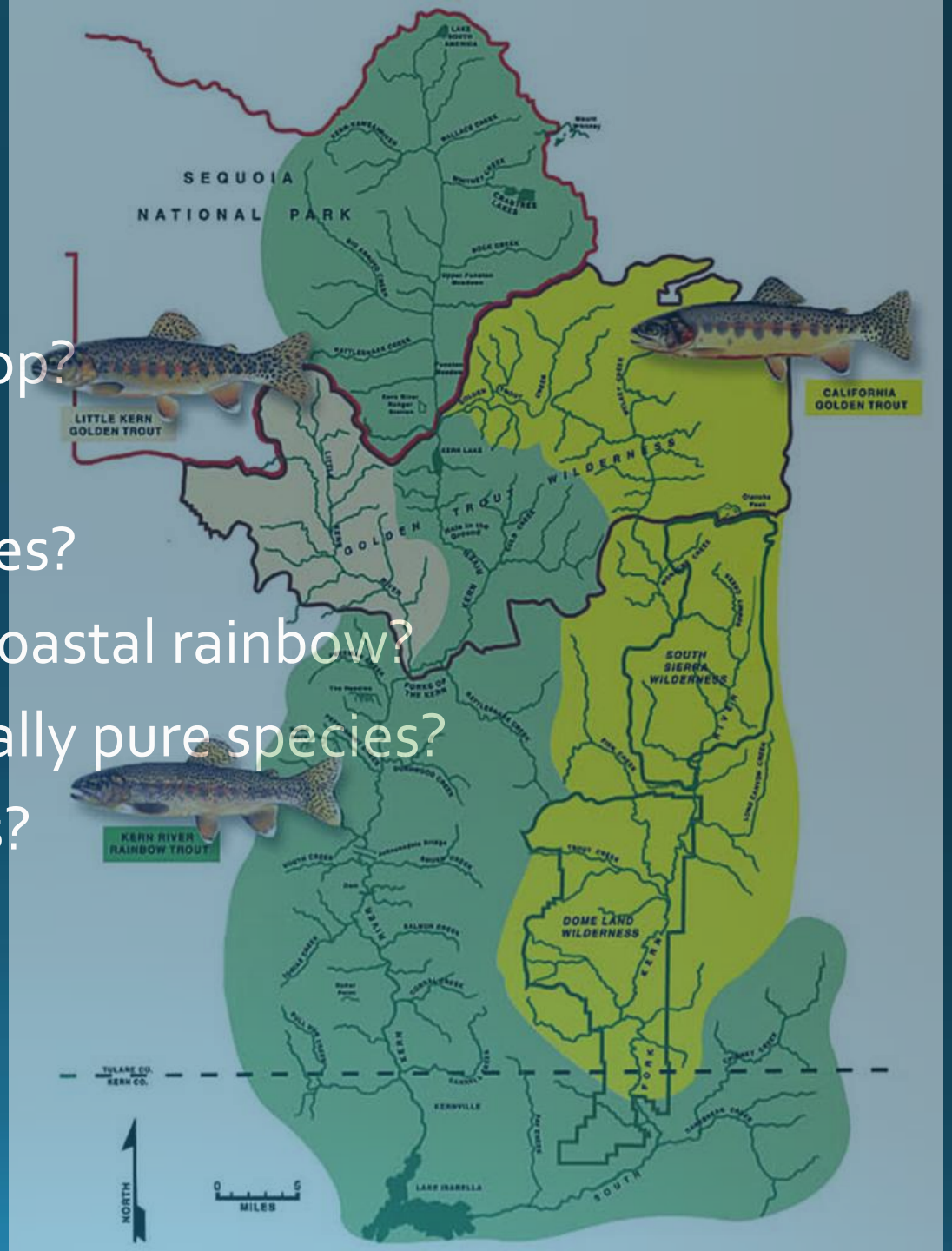
30 species of introduced non-native fish include:

- Brown Trout (1872)
- Brook Trout (1872)
- Lake Trout (1889)
- Kokanee Salmon (1941)
- Common Carp
- Black Bullhead
- Threadfin Shad
- Sacramento Perch
- Small & Largemouth Bass



Golden Trout Complex

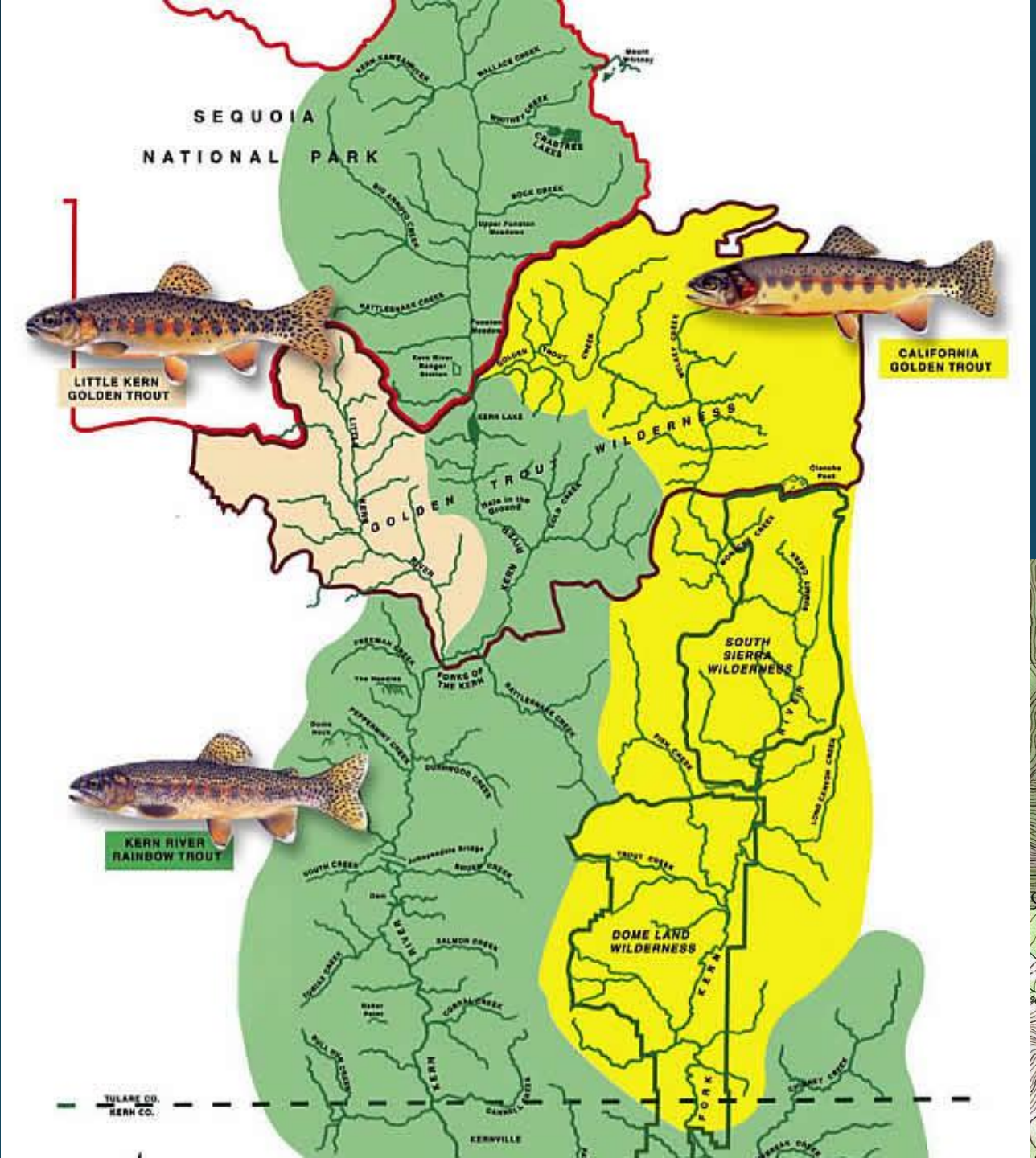
- How did the Golden Trout complex develop?
- Why are these trout unique?
- How long did it take to develop this species?
- Are they truly a separate species from a coastal rainbow?
- Will they continue to remain as a genetically pure species?
- Why do they have such bright colorations?
- Can they continue to survive?
- Can we really “protect” them?

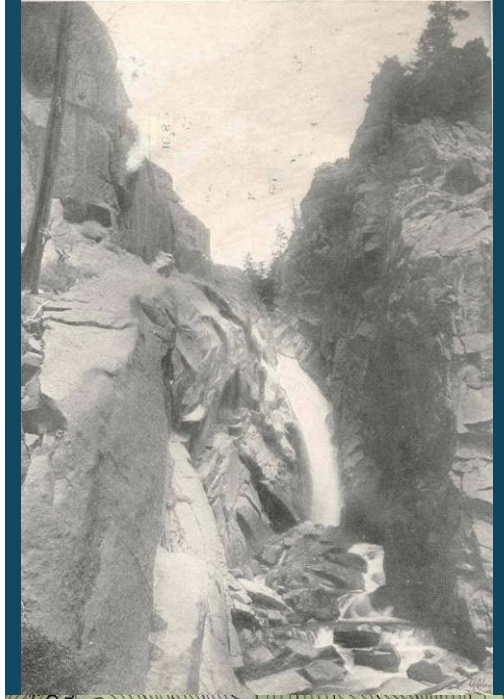


Ancestral Coastal Rainbows

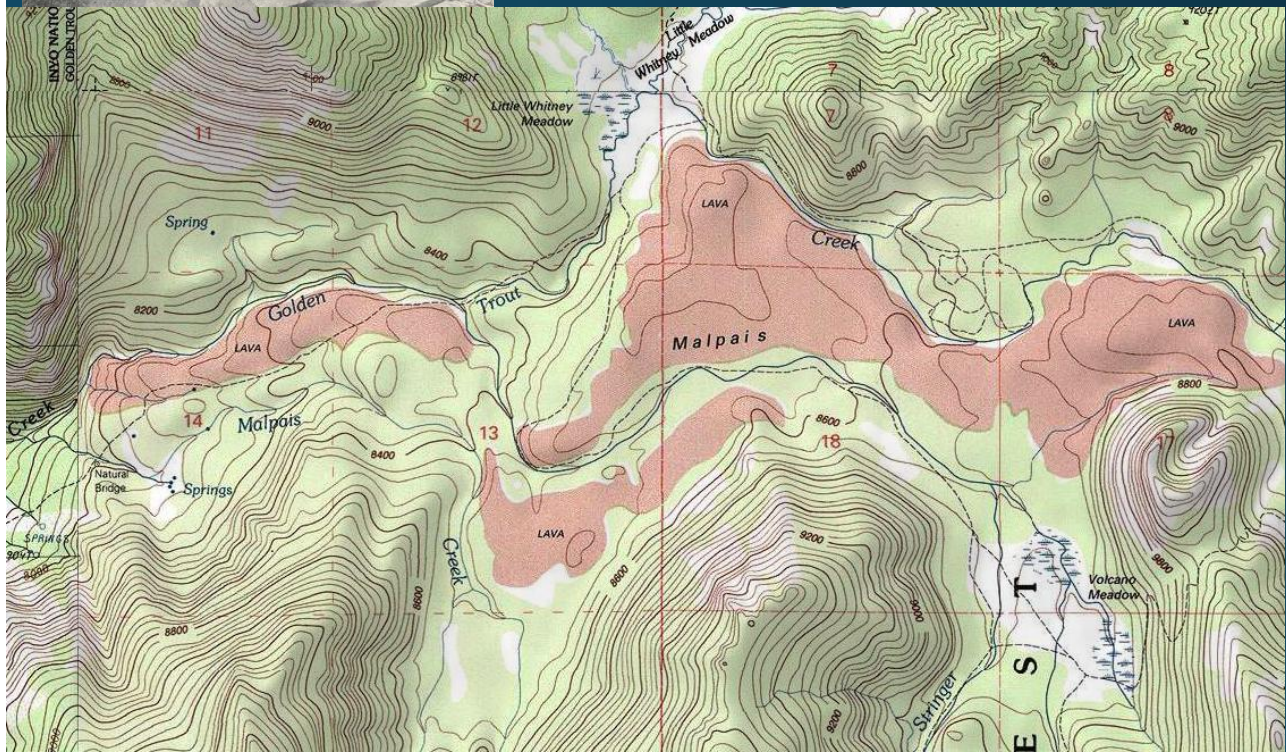
Sheepheaven Redband

- From the Mount Shasta Region.
- Genetically the closest to the Little Kern Golden.
- Same number of scales, vertebrae, and pyloric caeca (intestinal filaments).
- Both, the Shasta region and Kern basin were spared from intense glacial activity.





Oncorhynchus mykiss aguabonita
Named by David Starr Jordan in 1892 for Goldens caught at Agua-Bonita Falls on Volcano Creek near the mouth of Golden Trout Creek. Dr. Starr was the first President of Stanford University.



Volcano Golden Trout

- Distant relatives of Coastal Rainbows. Spared the last Glacial activity of the last 10,000 years. Adapted to its habitat within the South Fork Kern River drainage.
- Pure strains almost eliminated due to non-native introductions and genetic hybridization with rainbows. Last pure strain found in the headwaters of Golden Trout Creek.

Little Kern Golden

- Related to Sheepheaven Redbands, last pure strains (3000 fish, 1970) found on tributaries: Soda Spring Creek, Deadman Creek, Fish Creek, and Coyote Creek.
- Reestablished on the Little Kern within 60% of it's original range.

Kern River Rainbow

•Generally resembles coastal rainbow trout, but with brighter colors, a slight tinge of gold, and sometimes orange on the belly.
•Coloration in some areas may be influenced by natural intermixing and hybridization with the other two golden trout subspecies.
•Fine, peppery spots are profuse over most of the body and on the fins.
•On many larger fish, there is a broad rosy-red band along the sides.

Formation of the Sierra

- Plate Tectonics
- Geology
- Volcanic Activity
- Glaciation
- Climate Change
- Flora Diversity
- Human Impacts

130 Million Years Ago

50 Million Years Ago

5-10 Million Years Ago

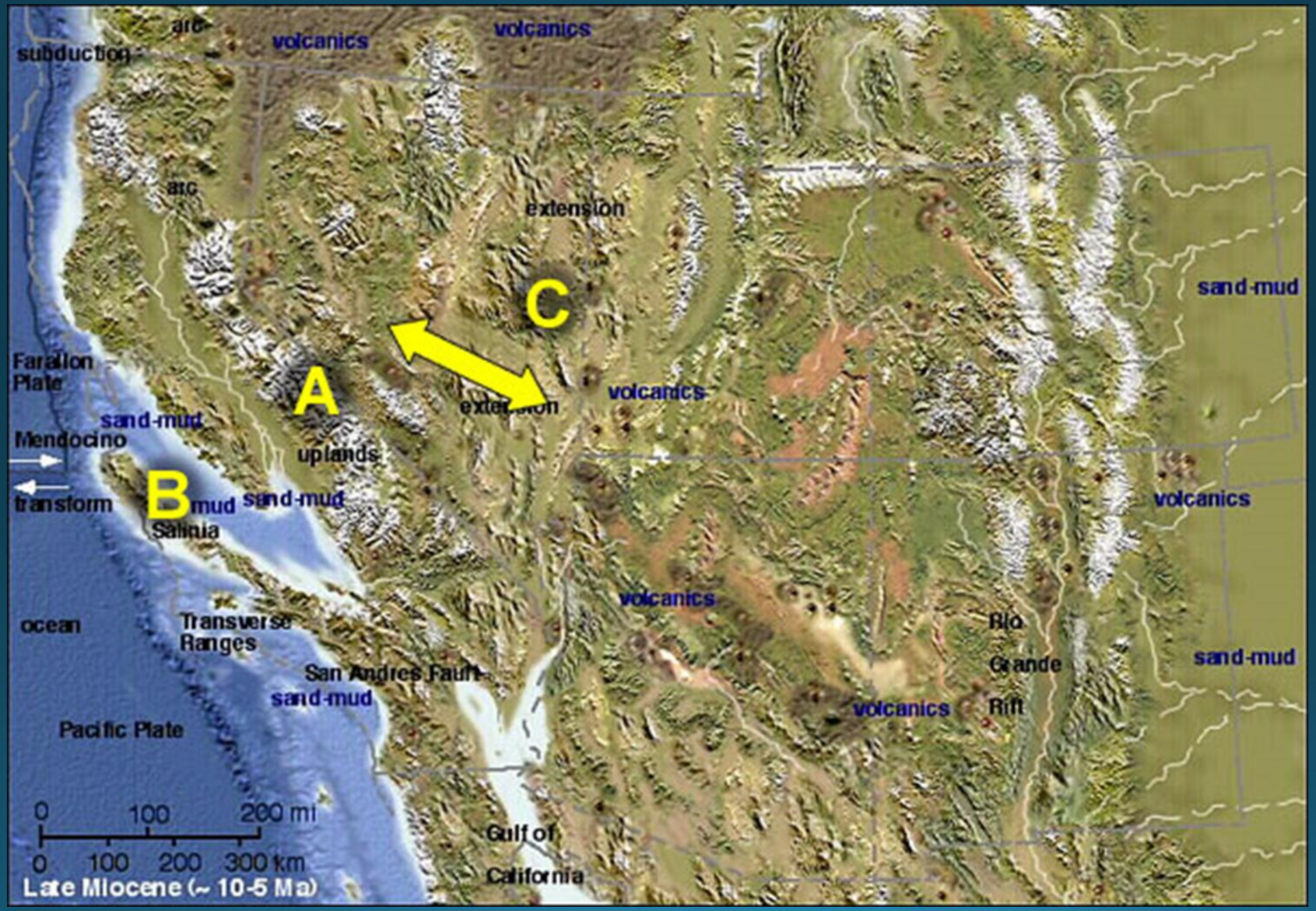
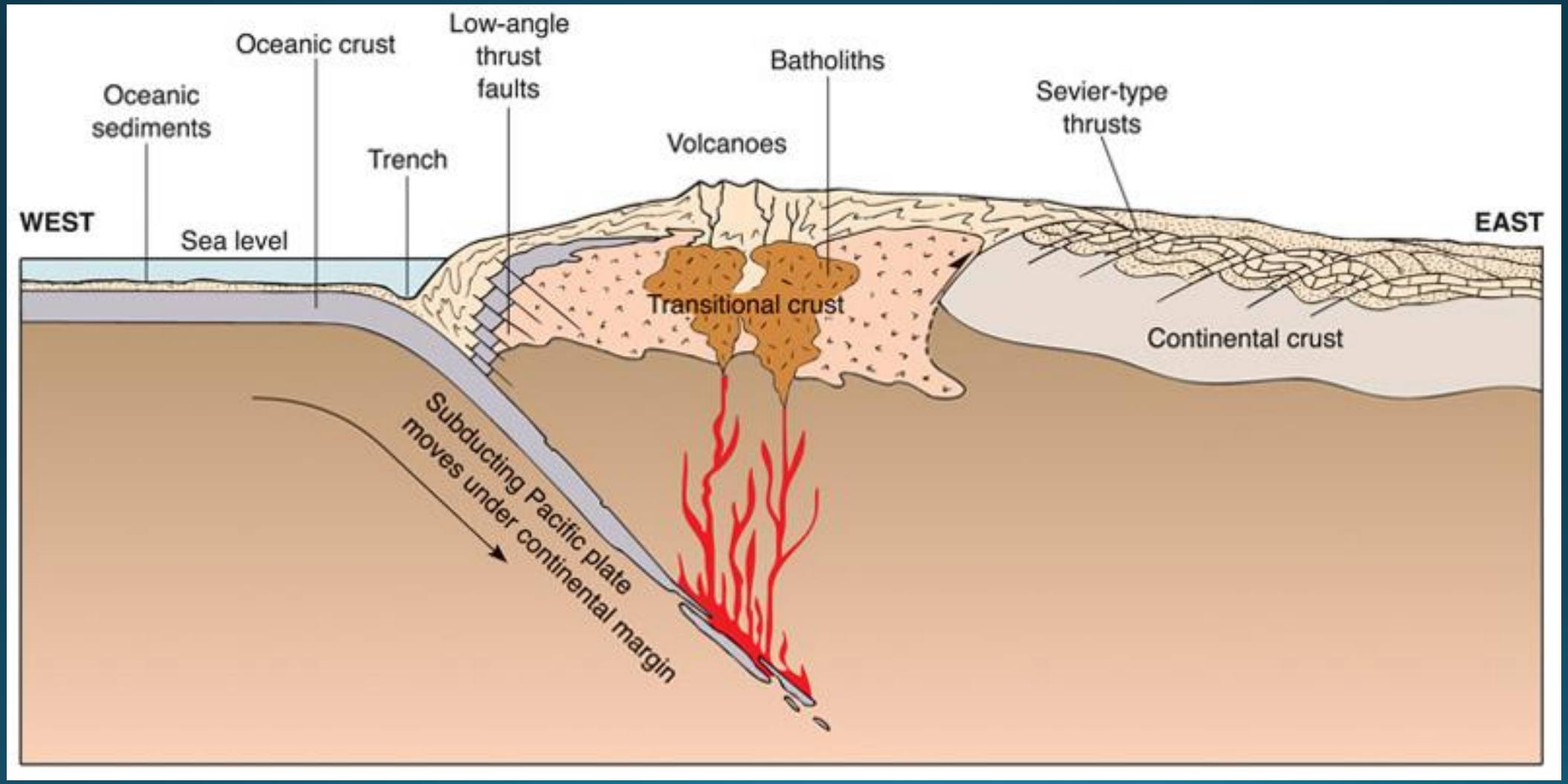
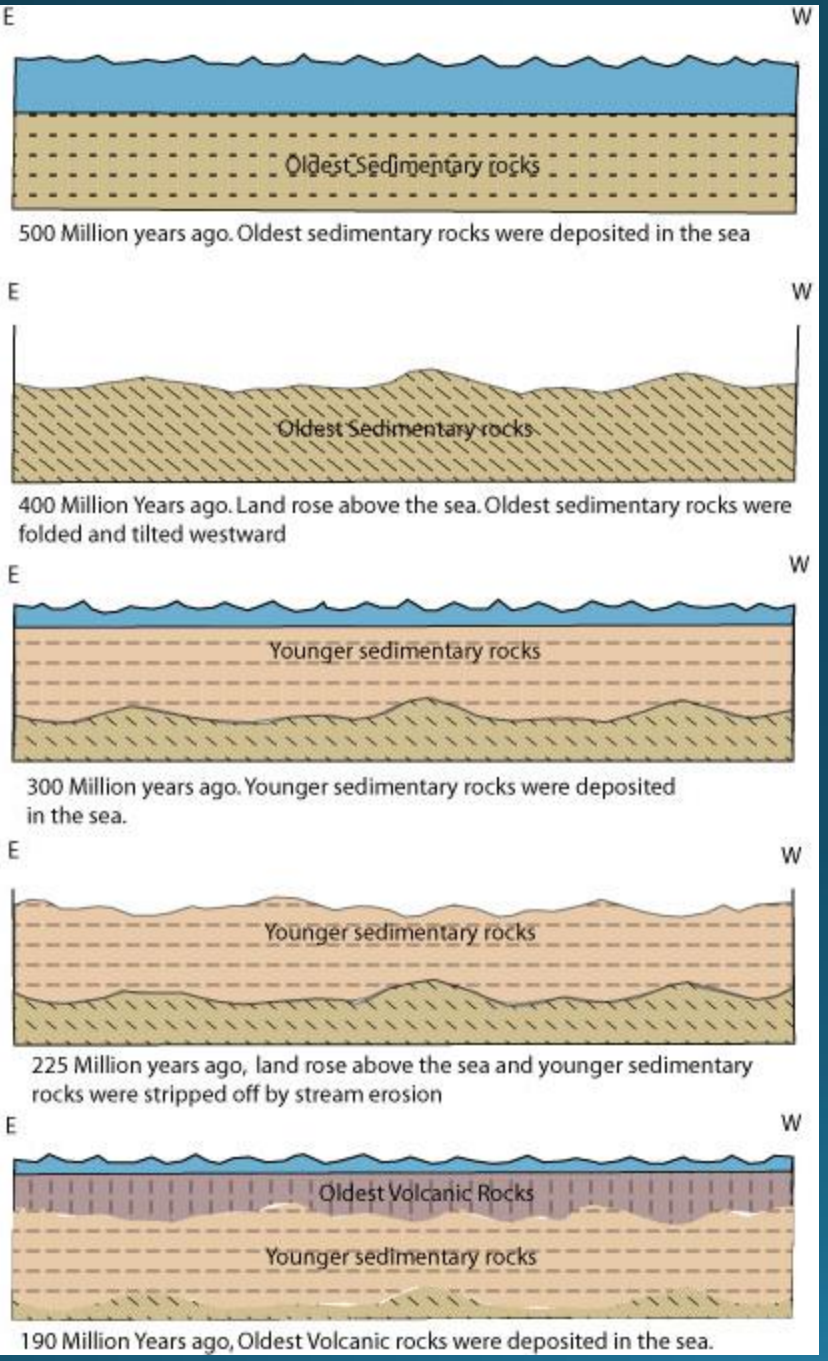
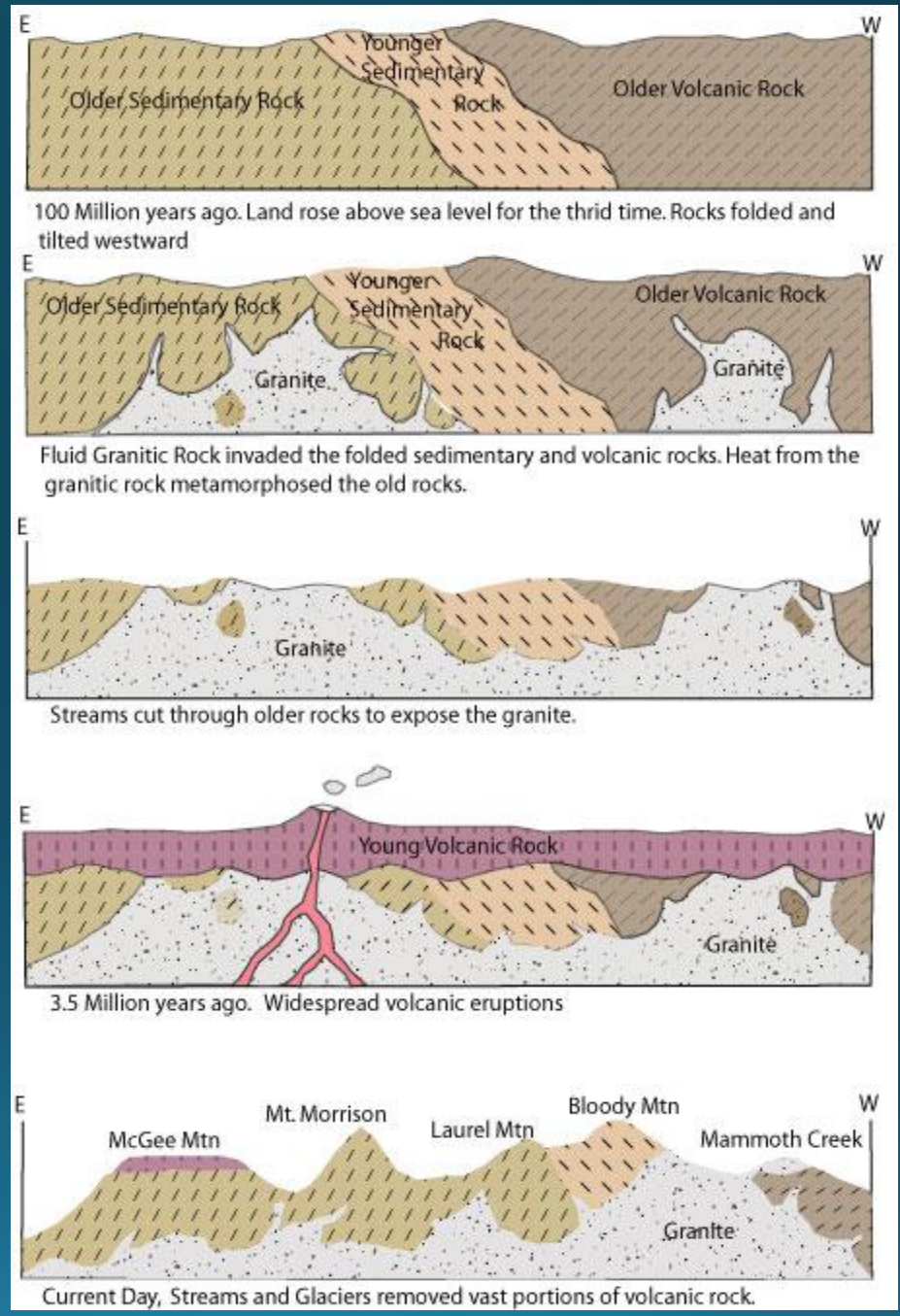


Plate Tectonics

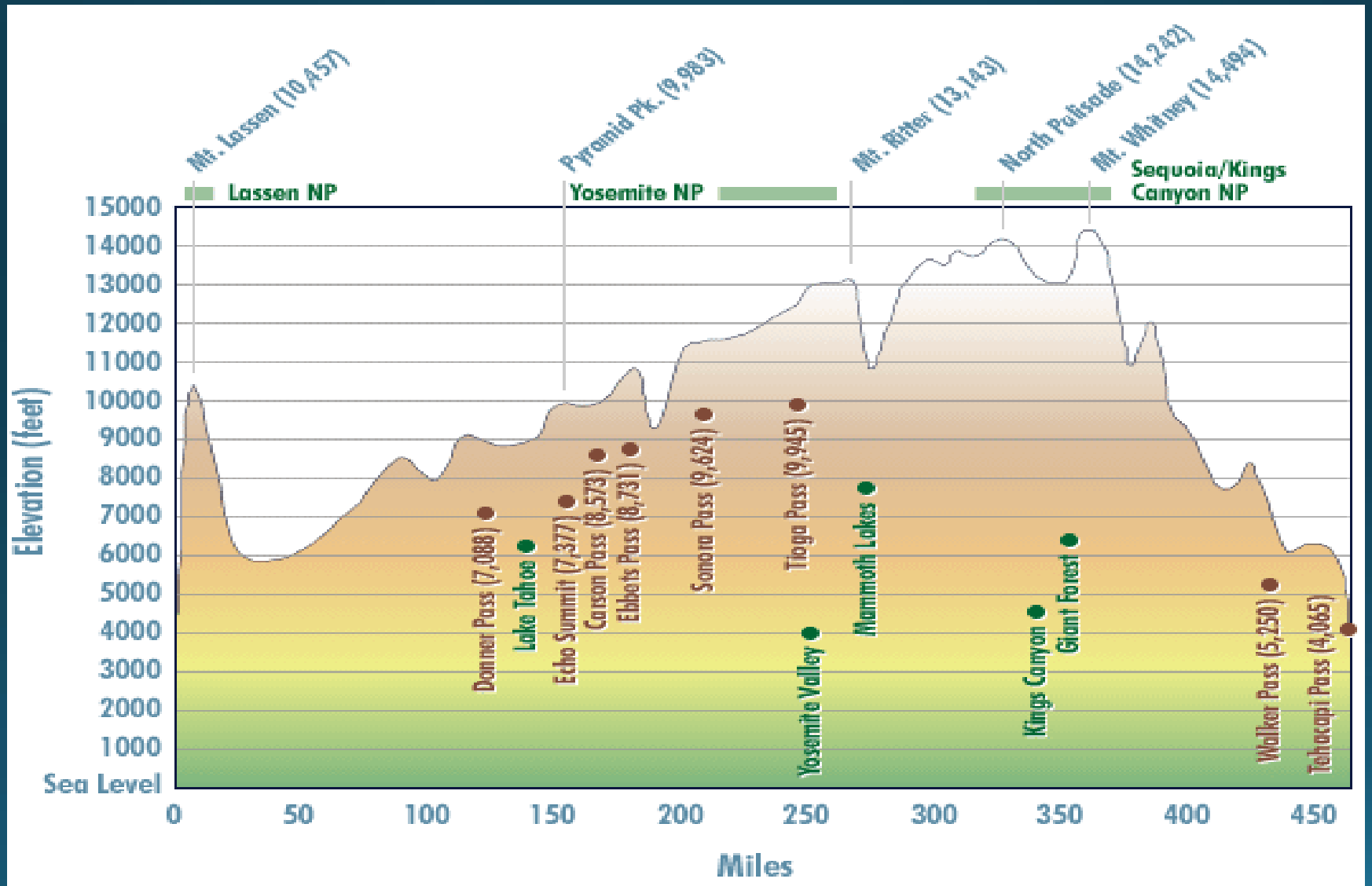



E
W
Oldest Sedimentary rocks
500 Million years ago. Oldest sedimentary rocks were deposited in the sea
E
W
Oldest Sedimentary rocks
400 Million Years ago. Land rose above the sea. Oldest sedimentary rocks were folded and tilted westward
E
W
Younger sedimentary rocks
300 Million years ago. Younger sedimentary rocks were deposited in the sea.
E
W
Younger sedimentary rocks
225 Million years ago, land rose above the sea and younger sedimentary rocks were stripped off by stream erosion
E
W
Oldest Volcanic Rocks
Younger sedimentary rocks
190 Million Years ago, Oldest Volcanic rocks were deposited in the sea.


E
W
Younger Sedimentary Rock
Older Sedimentary Rock
Older Volcanic Rock
100 Million years ago. Land rose above sea level for the thrid time. Rocks folded and tilted westward
E
W
Older Sedimentary Rock
Younger Sedimentary Rock
Older Volcanic Rock
Granite
Granite
Fluid Granitic Rock invaded the folded sedimentary and volcanic rocks. Heat from the granitic rock metamorphosed the old rocks.
E
W
Granite
Streams cut through older rocks to expose the granite.
E
W
Young Volcanic Rock
Granite
3.5 Million years ago. Widespread volcanic eruptions
E
W
McGee Mtn
Mt. Morrison
Laurel Mtn
Bloody Mtn
Mammoth Creek
Granite
Current Day, Streams and Glaciers removed vast portions of volcanic rock.

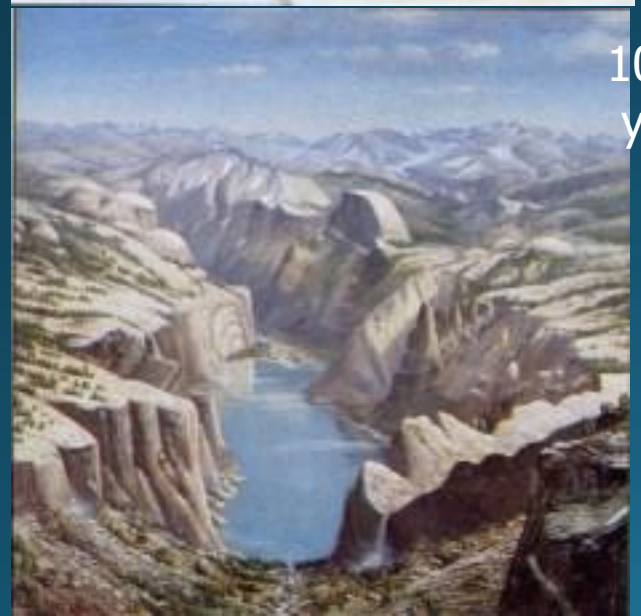
Earliest Rocks of the Sierra

Sierra Nevada Crest Profile

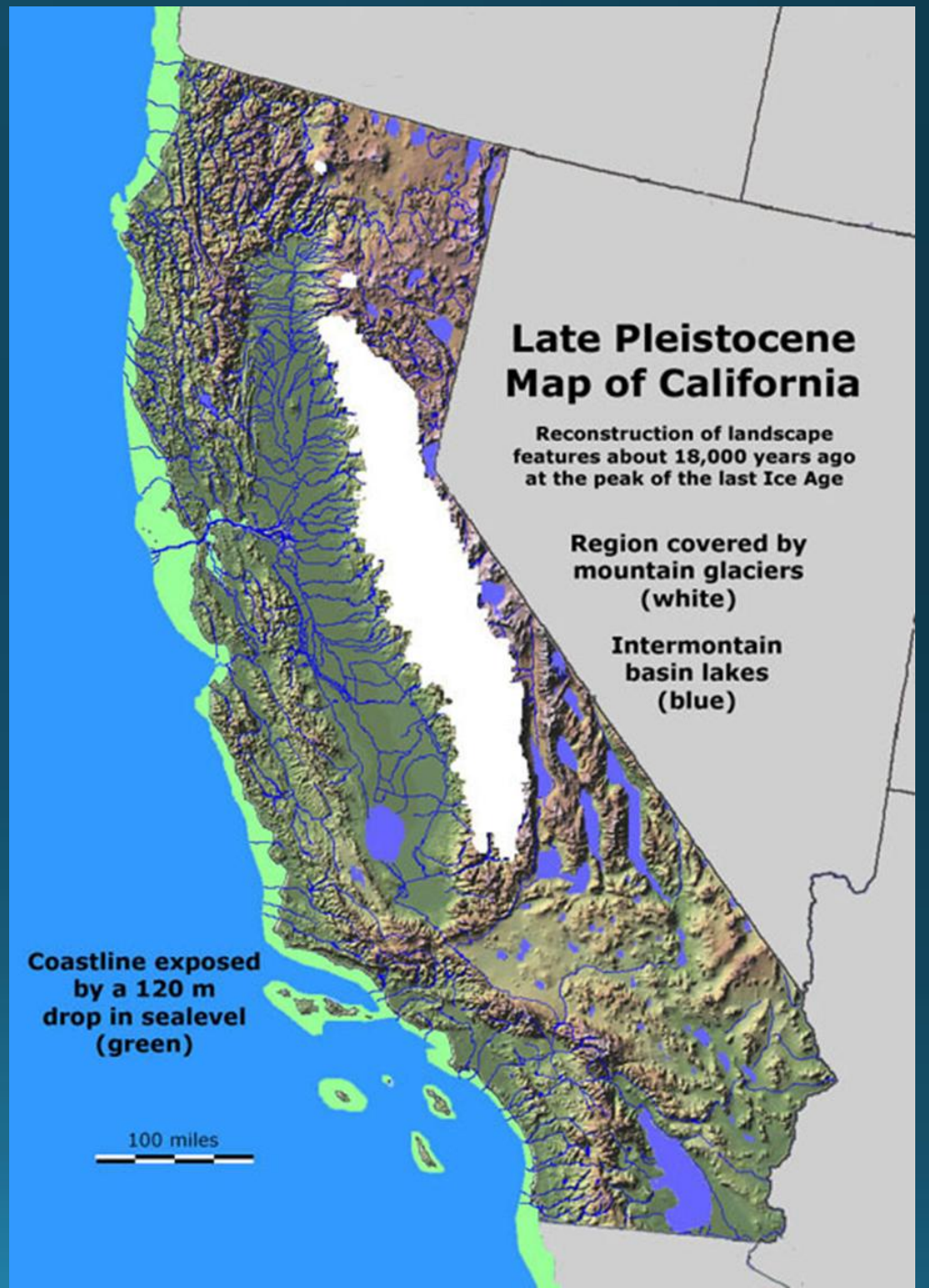


Glaciation

1 Milliion Years ago.

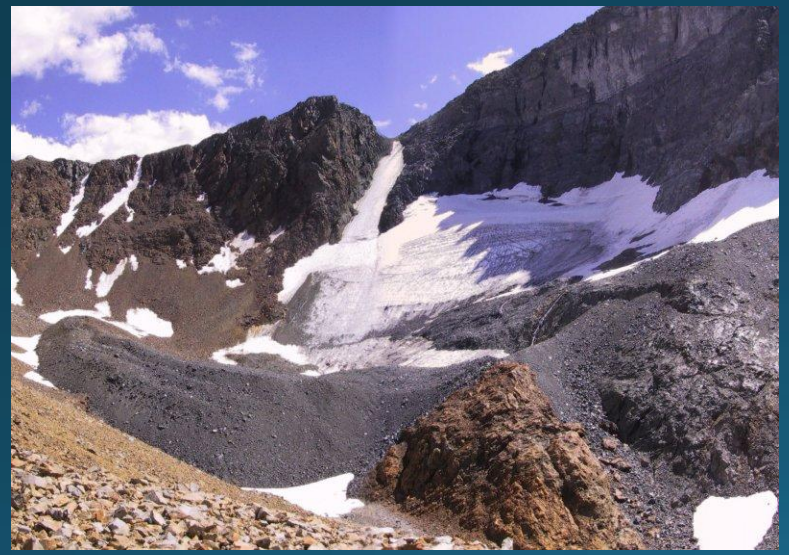


10,000 years ago



Little Ice Age Glaciers

Palisade Glaciers



Dana Glacier

McCLure Glacier

Little Ice Age from 700 to 150 years ago. Reached maximum size in 1750 and started to retreat in 1930. About 100 glaciers were identified.

Granite Batholith

Kern Canyon Fault

- A 93-mile fault created with during the early Cretaceous period , 100 million years ago by the subduction of the Farallon plate and the North American Continental plate.
- Created an entry into the high elevations of the Sierra for the Coastal Rainbows and Redbands.

Kern River
165 miles long, carved into a bowl shape valley by Glacial runoff

North/South direction

Starts at the lake basin below Forester Pass near Mt Whitney

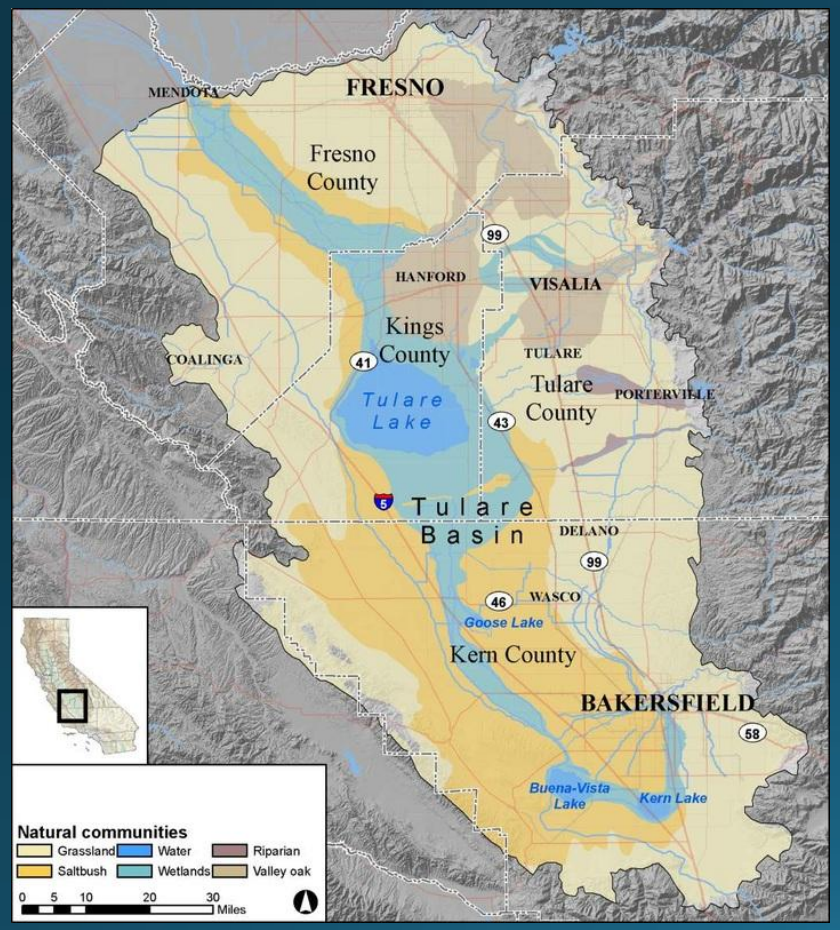
Flows into Bakersfield and ends at Buena Vista Lake

Glacial Runoff

- Allowed Coastal Rainbows and Redbands to reach the higher elevations of the Sierra within the Shasta and Kern Basin regions.

- As the runoff subsided, these fish were able to form distinct populations without further ingress of Coastal Rainbows or Redbands.

Tulare Basin connected the San Joaquin to the Kern River.



- How did the California Golden Trout get to Golden Trout Creek from the South Fork of the Kern? They are not within the same watershed!
- Why didn't the Kern River Rainbows get into Golden Trout Creek?

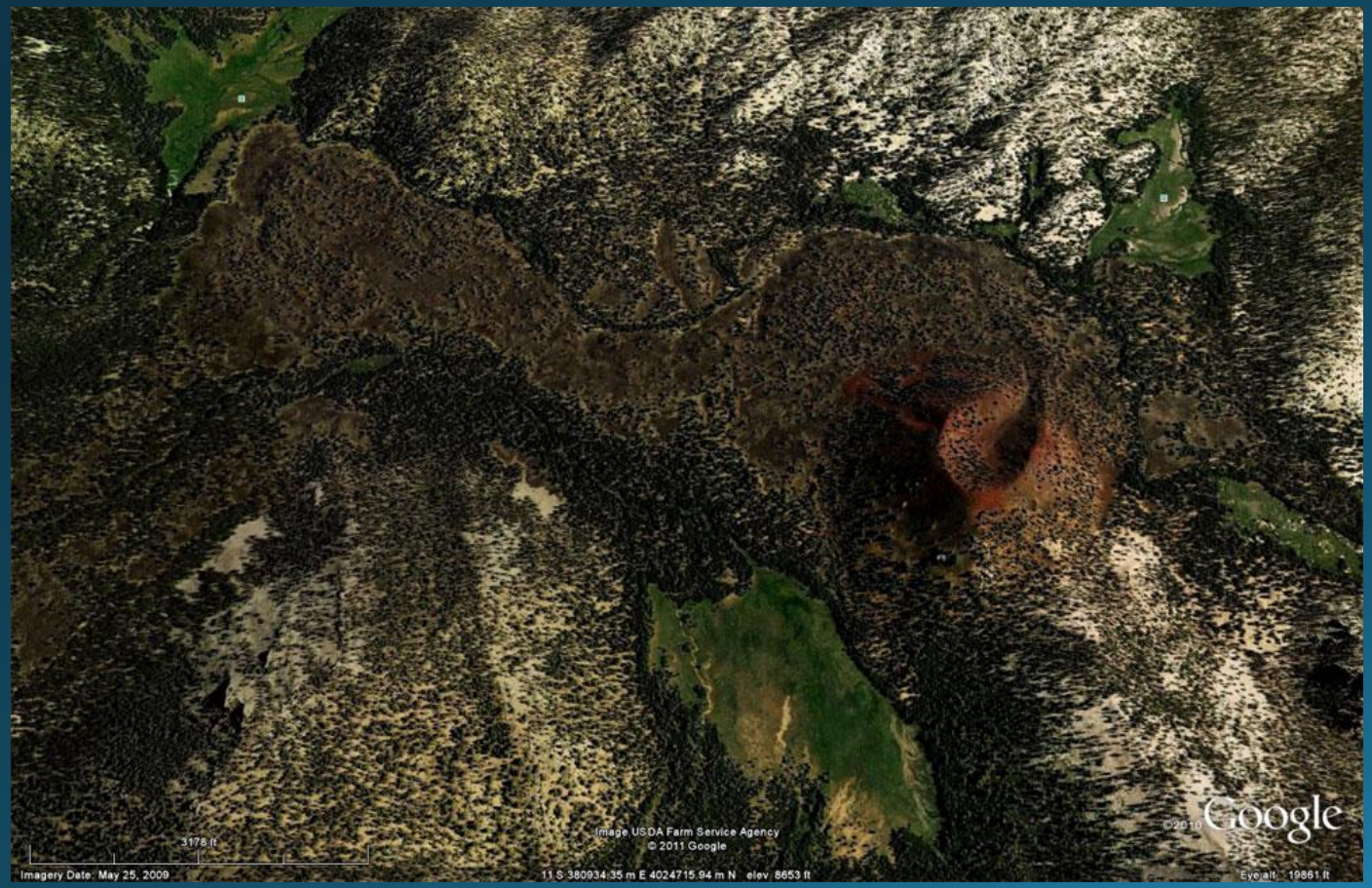
Volcanic Activity

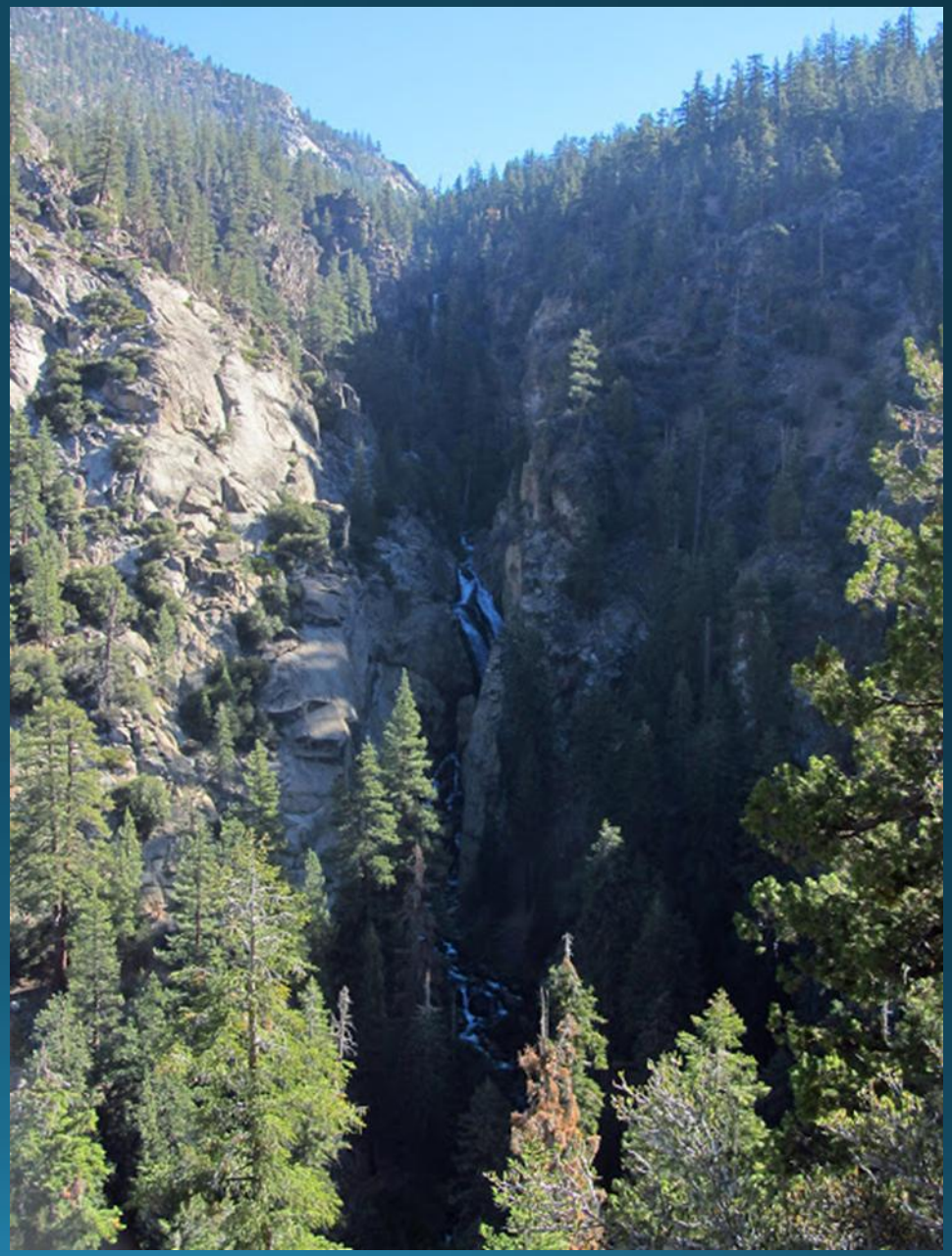
South Fork, Red Hill, Groundhog Cinder Cone

•Golden Trout Creek – Volcanic field of Cinder cones and lava flows. Most recent eruption (Groundhog cone) occurred 5,000 years ago.

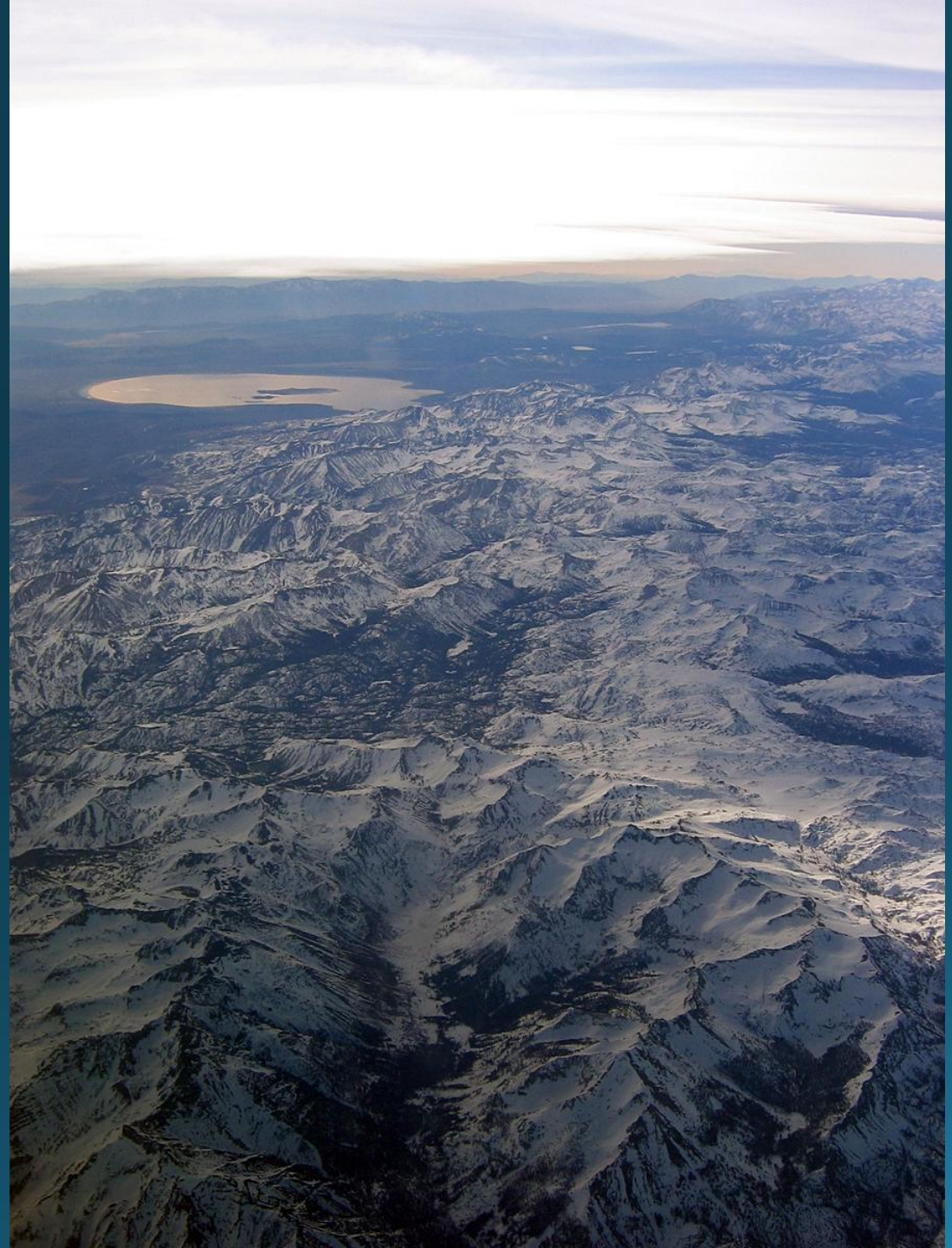
• Started 30 million years ago with faulting events. 5 million years increased activity with uplift. 3 million years activity brought gold and silver to surface.

- Lava flow over Golden Trout Creek blocked the creek from connecting to the South Fork Kern. It was forced to connect with the Main Kern about 10,000 years ago.
- Volcano Falls is a natural barrier keeping the Golden Trout separate from the Kern River Rainbows.





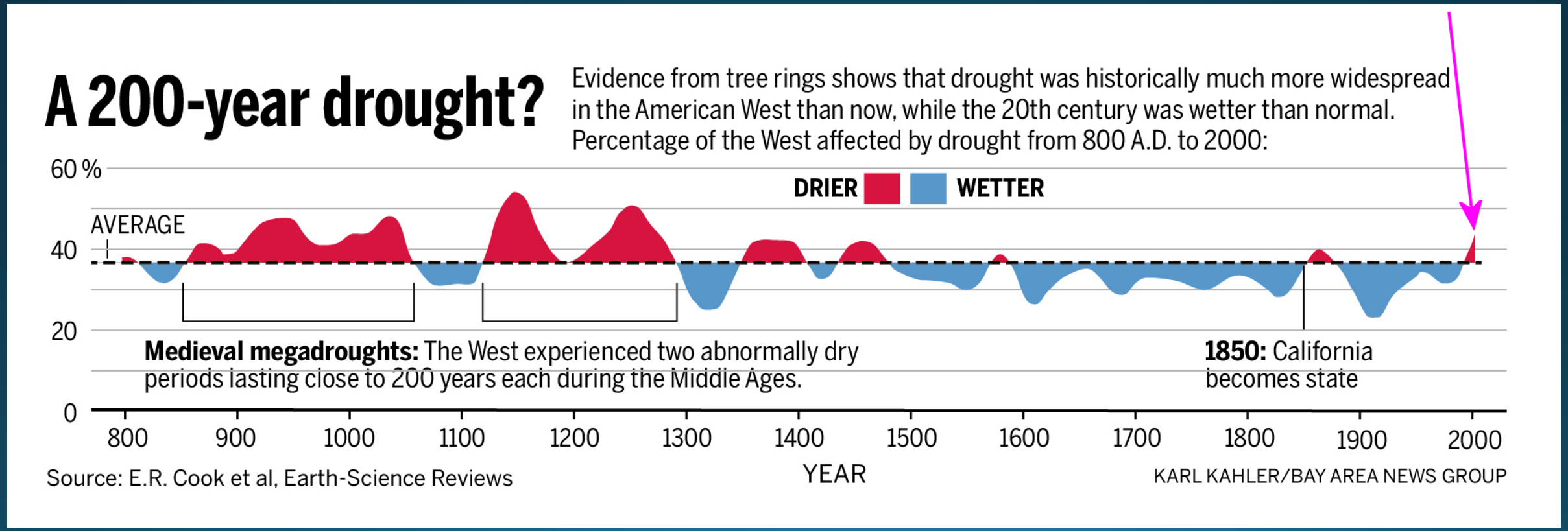
- Above Volcano Falls is a natural lava bridge spanning Golden Trout Creek.



Changing Climate

- Last 10,000 years, wet winters and dry summers
- Two droughts over the last 1200 years, each lasting 100-200 years.
- Little Ice Age occurred from 1650 to 1850 bringing the Sierran Glaciers to the same positions as the last major Ice Age 10,000 years ago.
- The last 150 years has been warm and wet. The wettest 50 year period of the Sierra has occurred during this time over the last 1000 years.

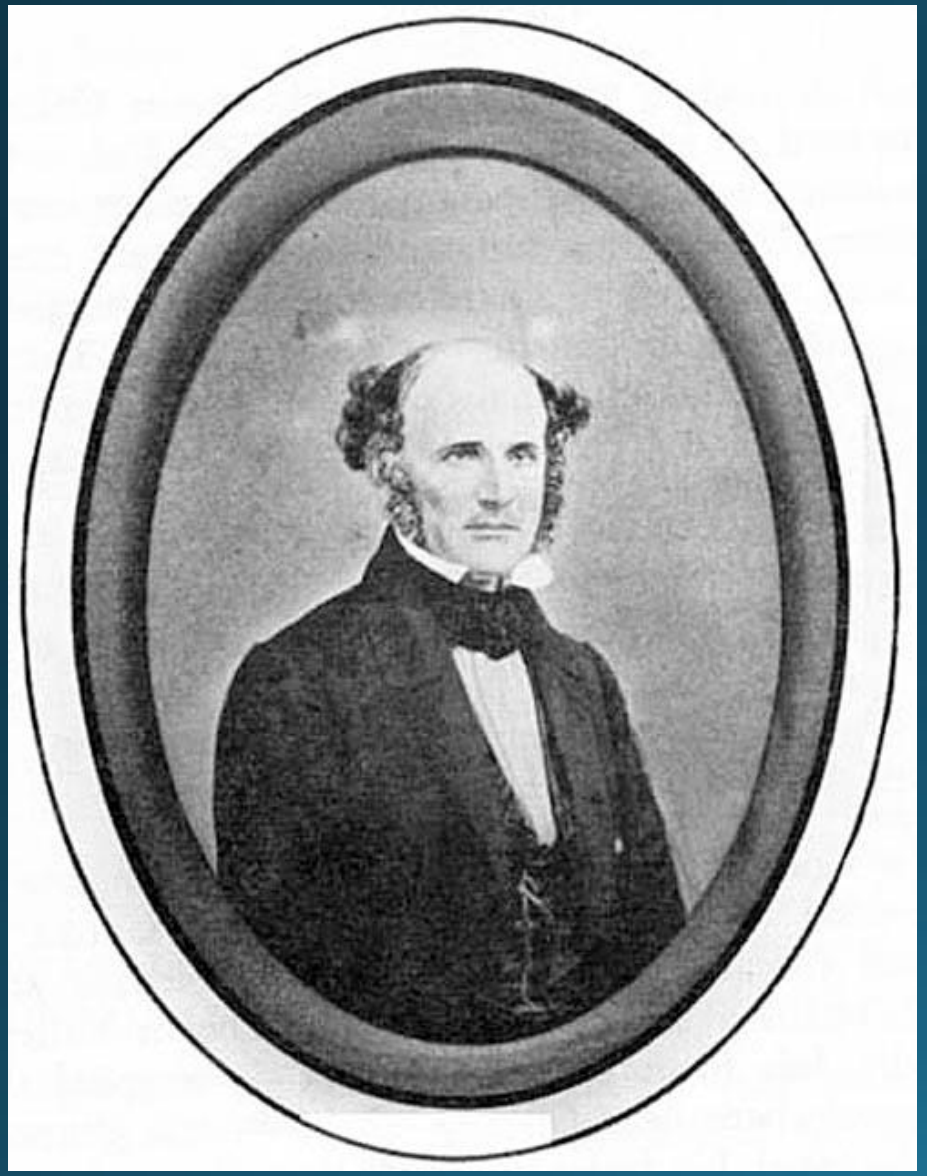
Two 200-year droughts may have wiped out the Mayan Civilization. Wettest period for the Sierra Nevada has been the 50-year period from 1900 to 1950. The period in which we based many of our water provision figures.



Human Impacts on the Golden Trout

- Fish Introductions
- Habitat Management
- Invasive species
- Agriculture
- Climate Change
- Grazing
- Logging
- Mining
- Housing
- Water Development
- Recreation

Colonel Sherman Stevens



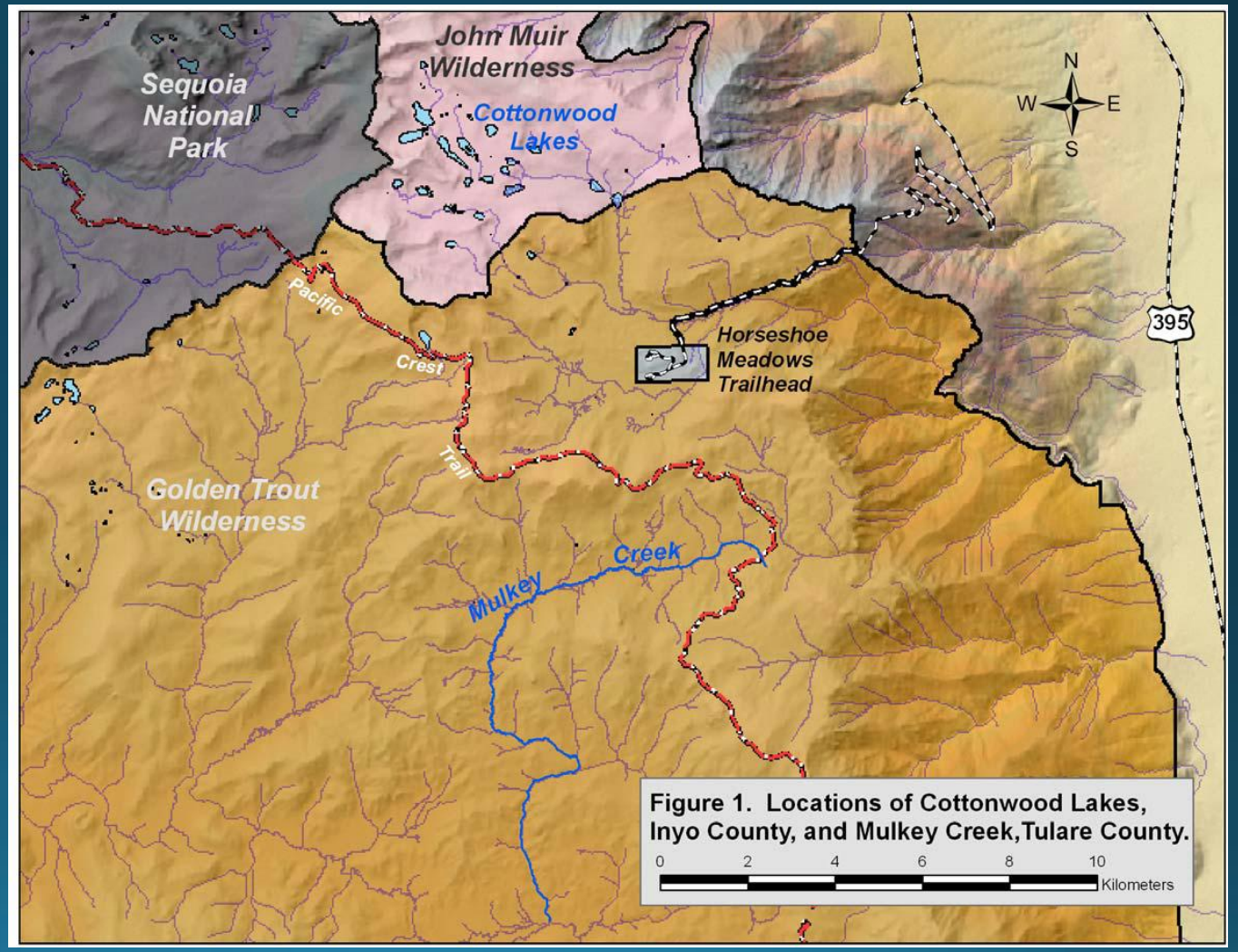
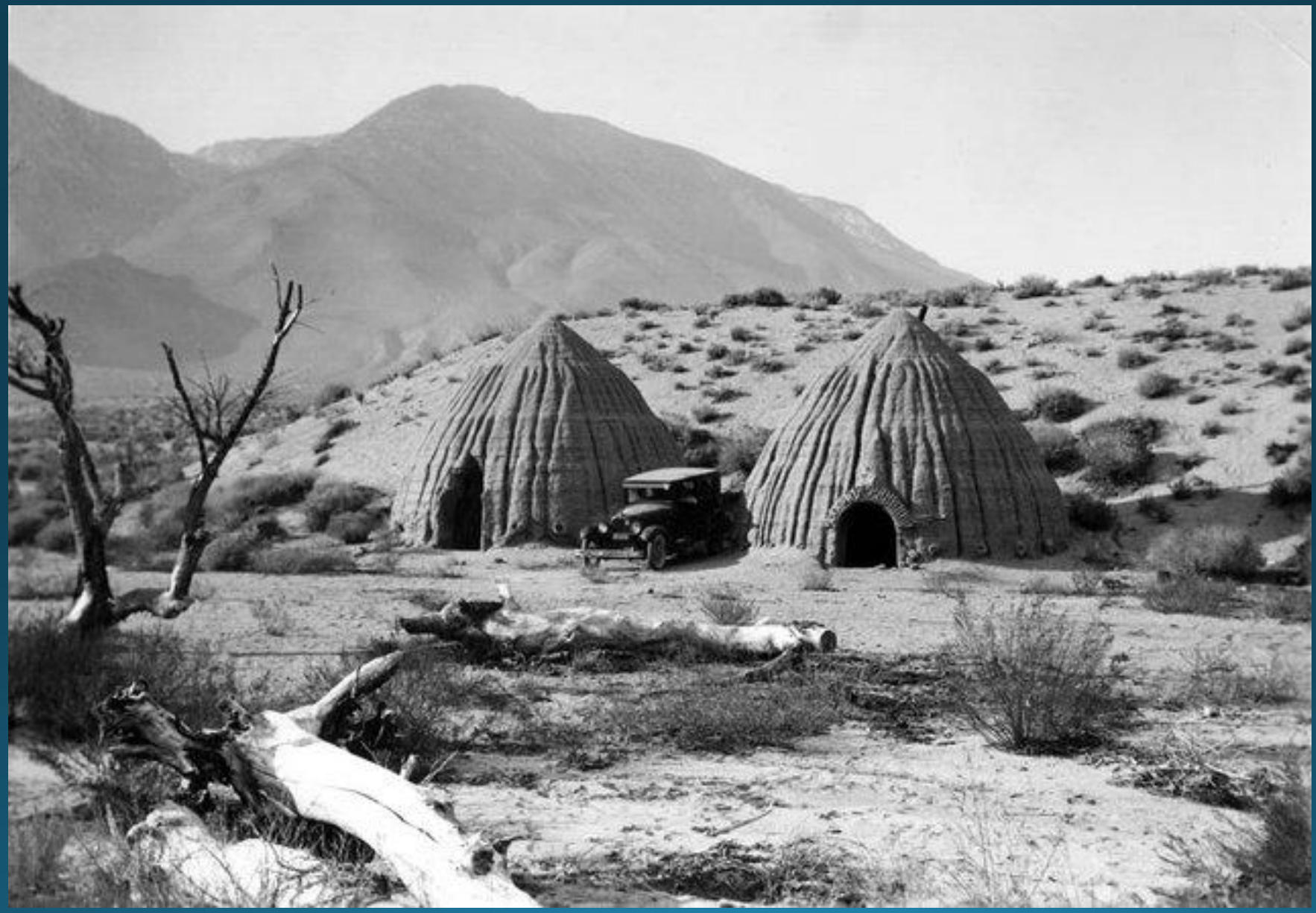


Figure 1. Locations of Cottonwood Lakes, Inyo County, and Mulkey Creek,Tulare County.

Cottonwood Sawmill

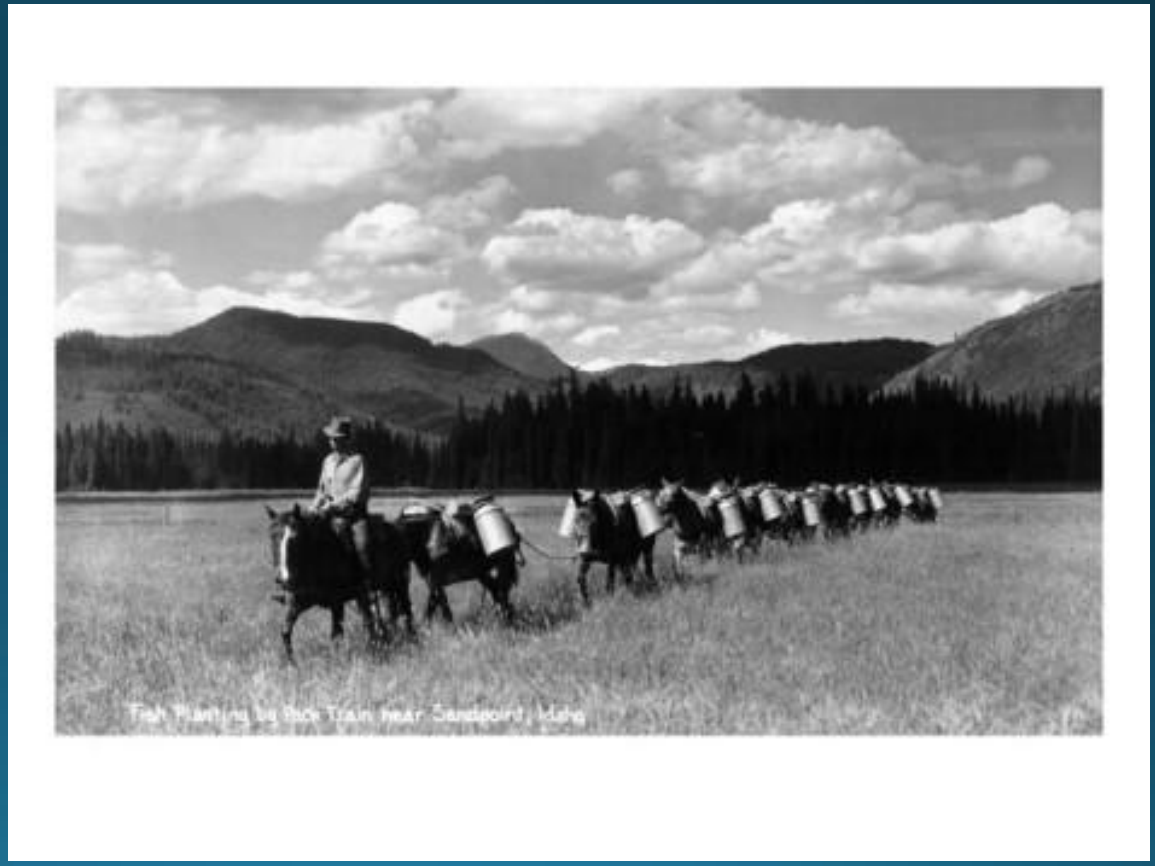
Charcoal Kilns



E.H. Edwards - 1885 Lone Pine Fire Brigade

Collecting Golden Trout Eggs

Spawning Station established in 1917 at Cottonwood Lakes. Eggs sent to Mt Whitney hatchery. Eggs sent to National fish hatchery in Bozeman, MT 1928 to 1938



Mt. Whitney Hatchery. Built in 1917.

Fish Introductions

- CDFG has ten hatcheries producing 13 million "catchable" trout, 1.2 million "subcatchable", and 12.3 million "fingerlings".
- 35 Non-native fish have become established.
- Fish planting ended in Kings, Yosemite, and Sequoia National Parks in 1980. 40% of the lakes are fishless once again.

Aerial Fish Planting

1945 to 2002

1981 King Air owned by CDFW


Jun 26, 2010 3:51:45 pm
Owens Point
"Thacher Point"
Wonoga Peak
Cottonwood Creek
"Flat Top"
Golden Trout Camp
Little Cottonwood Creek
Wonoga/Owens Trailhead
South Fork
"Edge of the World P
Cottonwood Lakes Trailhead (old)
P11218
Cottonwood Lakes Trailhead (new)
P10641
Mulkey Pass Trailhead
Cottonwood Pass
Cottonwood/Trail Pass Trailhead
Horseshoe Meadow
P10605
Round Valley
Mulkey Pass
Poison Meadow
Trail Pass
Trail Peak
P10097
Image © 2010 DigitalGlobe
Image USDA Farm Service Agency
©2010 Google
36°27'32.27" N 118°10'19.19" W elev 9954 ft
Eye alt 22676 ft

Genetic variation was identified in Cottonwood Lakes during the early 1960's

Contamination of Cottonwood Lakes may go back to the 1930's

Cottonwood Lakes closed to all fishing from 1966 to 1998.

Eggs continued to be collected at Cottonwood Lakes until 1998

Fishing Cottonwood Lakes opened in 1998

Six Numbered Lakes
Lakes #1-4
Opens Sept 1st to Nov 30th
Artificial lures required.
#1,2,3, and 4 . 2 trout, 14 inch minimum

Lake #5
Open year round, 2 trout
All Lakes contain Goldens except #6.

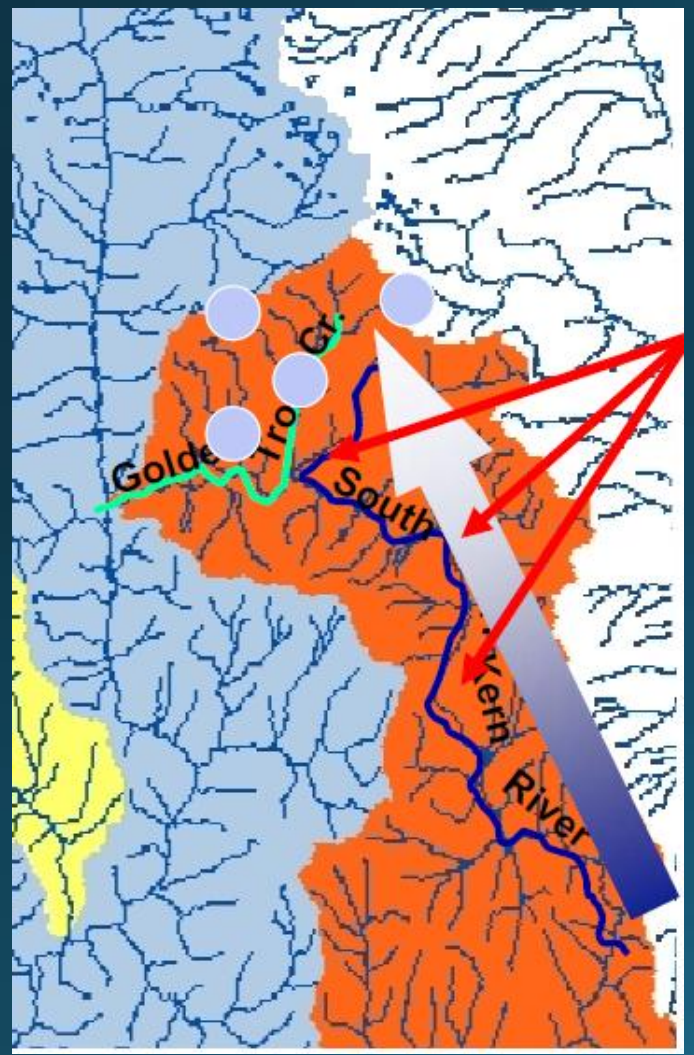
Cottonwood Lake #1 with Cirque Peak in background, 7 acres, 11,000 feet elevation, 4.3 miles from trailhead

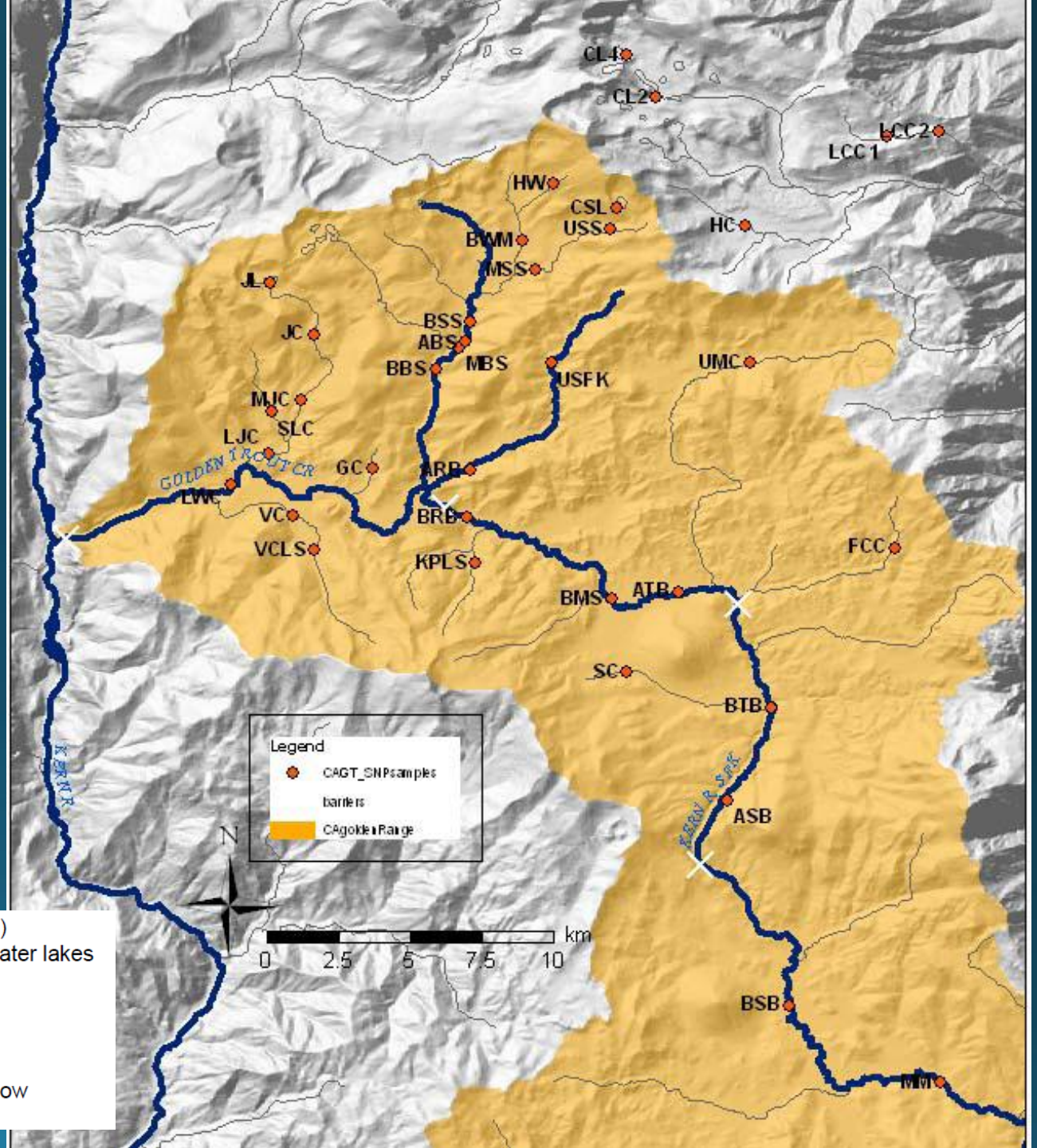
CAGT Genetic Analysis -2004

A pure strain Volcano Golden

Testing at UC Davis

Sampling throughout the Golden Trout historical range in 2004

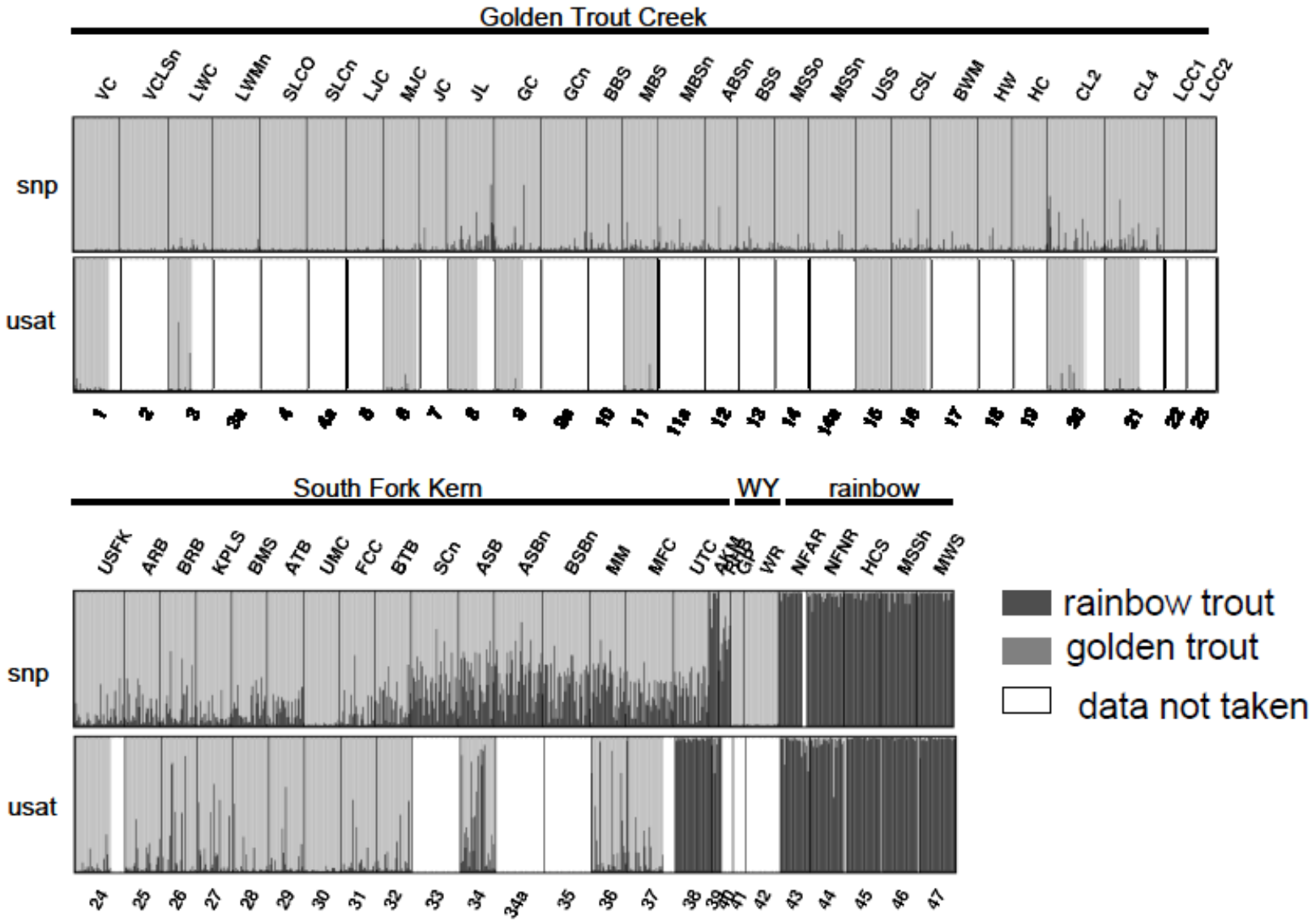




- Cordes et al. 2006 (TAFS 135:110-128)
  - hybridization localized in GTC headwater lakes
- Cordes et al., *in review*
  - introgression gradient in SFK

pure golden — rainbow

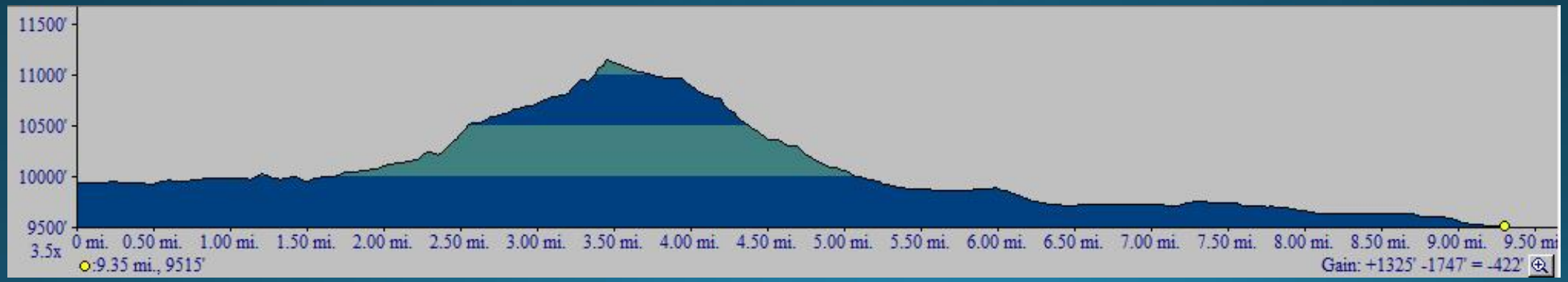
Progression of hybridization. Only pure strain of Golden Trout found in Volcano Creek.



Samples ordered from headwater to mouth for each major drainage for Golden Trout Creek and South Fork Kern River; Wyoming samples from Wind River, WY

Stephens, M.R. 2007. "Systematics, genetics, cultural history and conservation of golden trout." Dissertation, University of California, Davis.

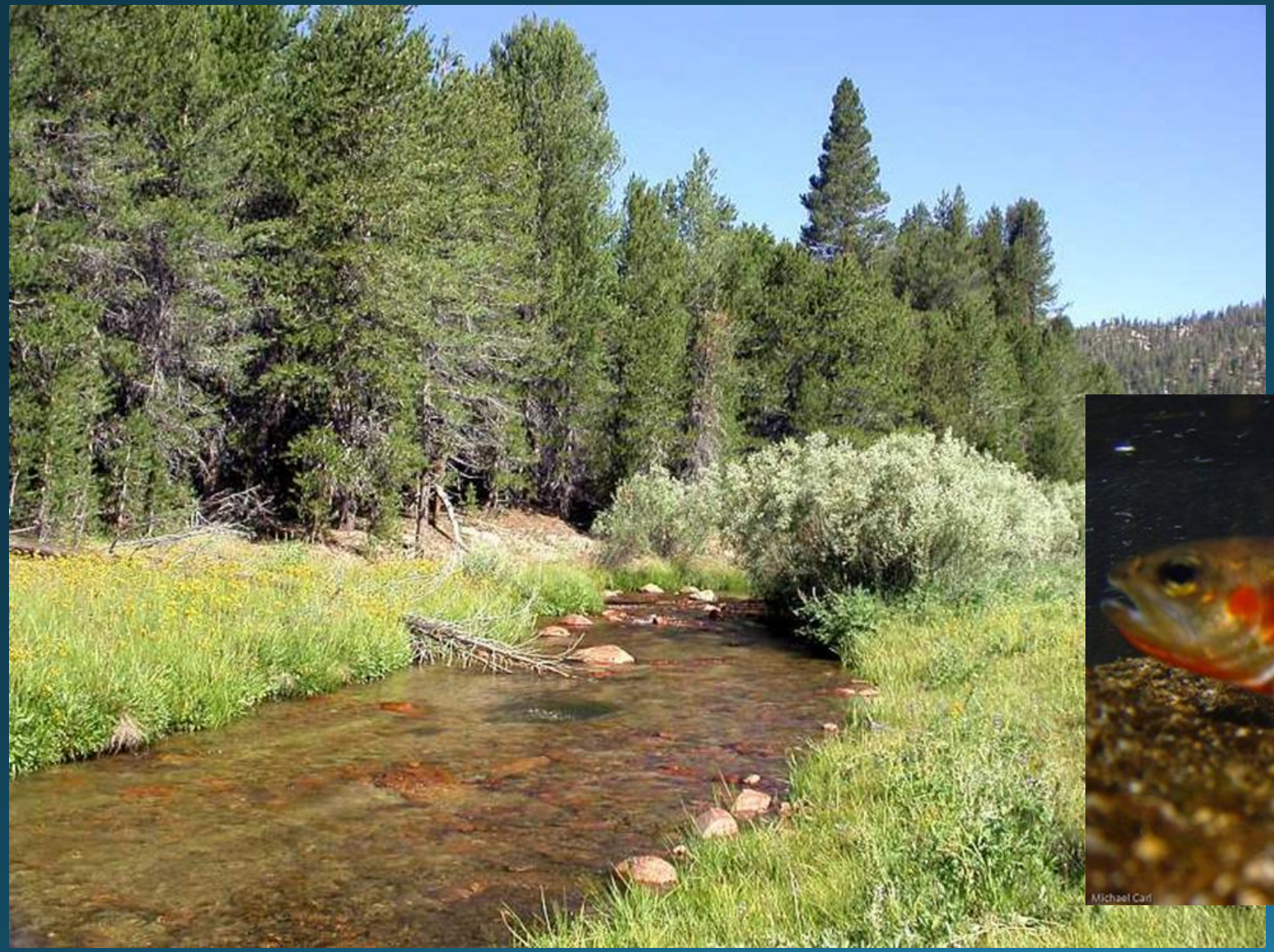
Golden Trout Creek



Gillnetting Chicken Springs and Rocky Basin Lakes

- Removal of Hybridized Goldens from the headwater lakes, Chicken Springs and Rocky Basin Lakes (2001-2003)

Golden Trout Creek



Golden Trout Creek

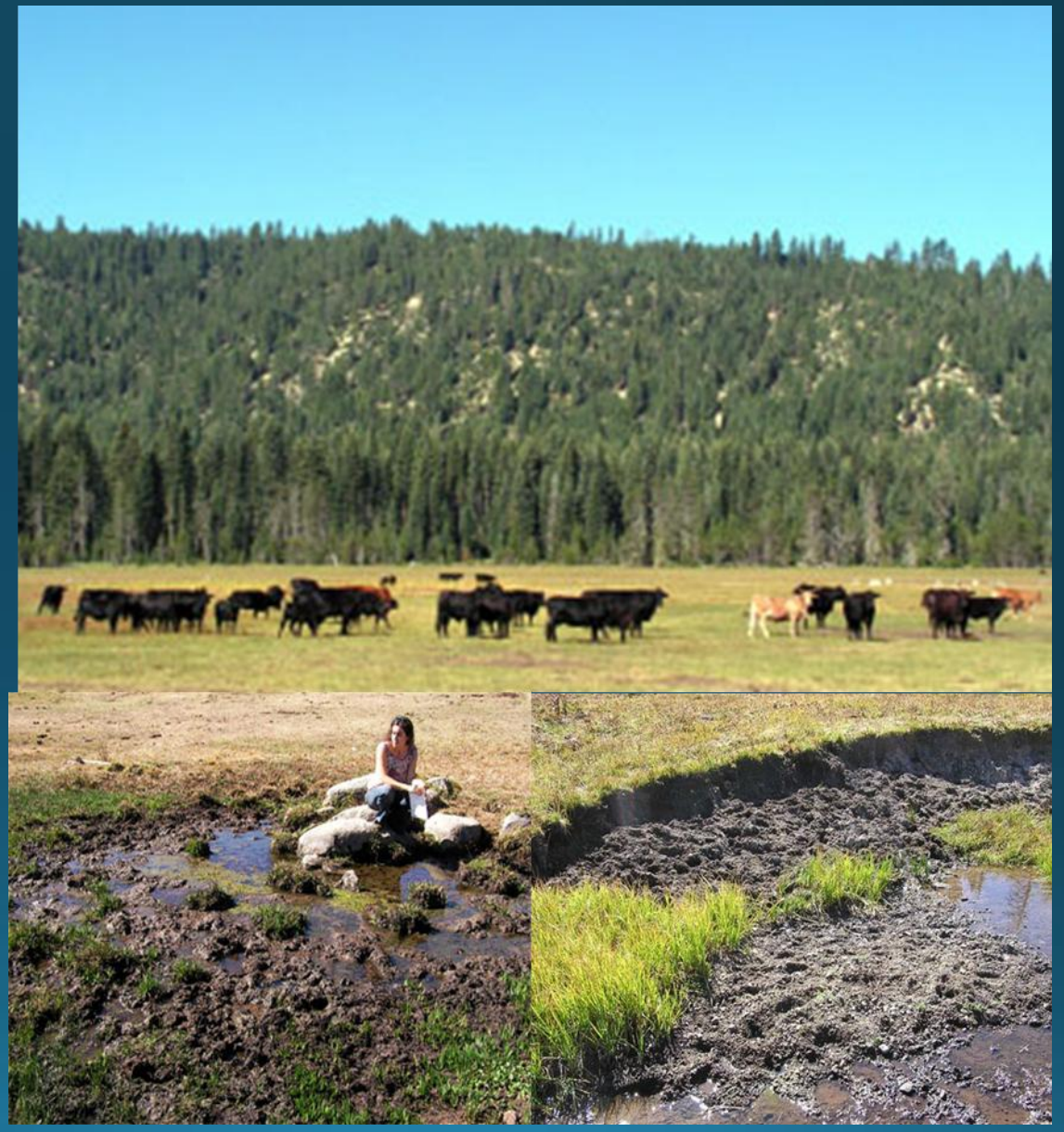
Hybrids and Competition

South Fork Kern – Monache Meadows

South Fork Kern

Cattle Grazing within the SF Kern watershed

- 7 active grazing allotments with portions of their allotments within the Golden Trout Wilderness ranging from 18,000 acres to 54,000 acres.



Period of Rest – 2001 to 2011

Rested Stream Reach Templeton Meadow

Grazed Stream Reach Mulkey Meadow

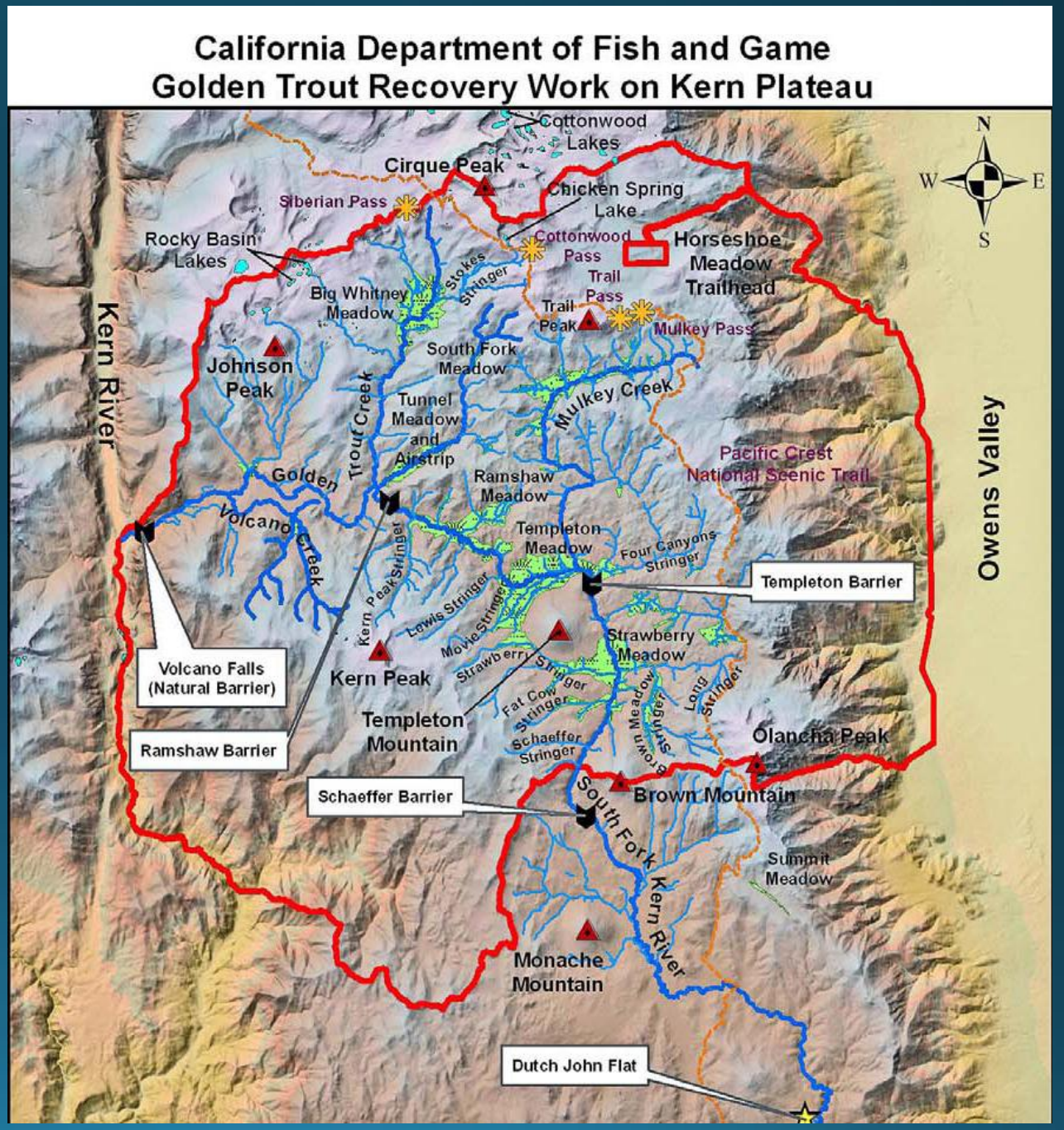
USING BANK TRAMPLING EROSION TO AS A MEASURE OF GRAZING INTENSITY, HOW DOES THIS AFFECT DIVERSITY OF AQUATIC LIFE?

- AS GRAZING INTENSITY INCREASES THE BEST ATTAINABLE CONDITIONS FOR DIVERSITY DECLINE
- SOME STREAMS MAY BE IS SUCH A DEGRADED STATE THAT RECOVERY IS NOT POSSIBLE WITHOUT ACTIVE ENGINEERING TO IMPROVE CHANNEL STRUCTURE AND REMOVE SEDIMENTS

Building Barriers on the SF Kern

- Ramshaw Barrier – 1970
- Templeton Barrier – 1975
- Schaeffer Barrier – 1983 (Rebuilt 2003)

Brown Trout up to 5 lbs found in Tunnel Meadows (1969) eating most of the Goldens.



Schaeffer Barrier in Monache Meadows

12 - Schaeffer Barrier showing gabion basket construction completed 1983. September 1983. Photo courtesy of INF.

Rebuilt in 2003, following collapse in 1997

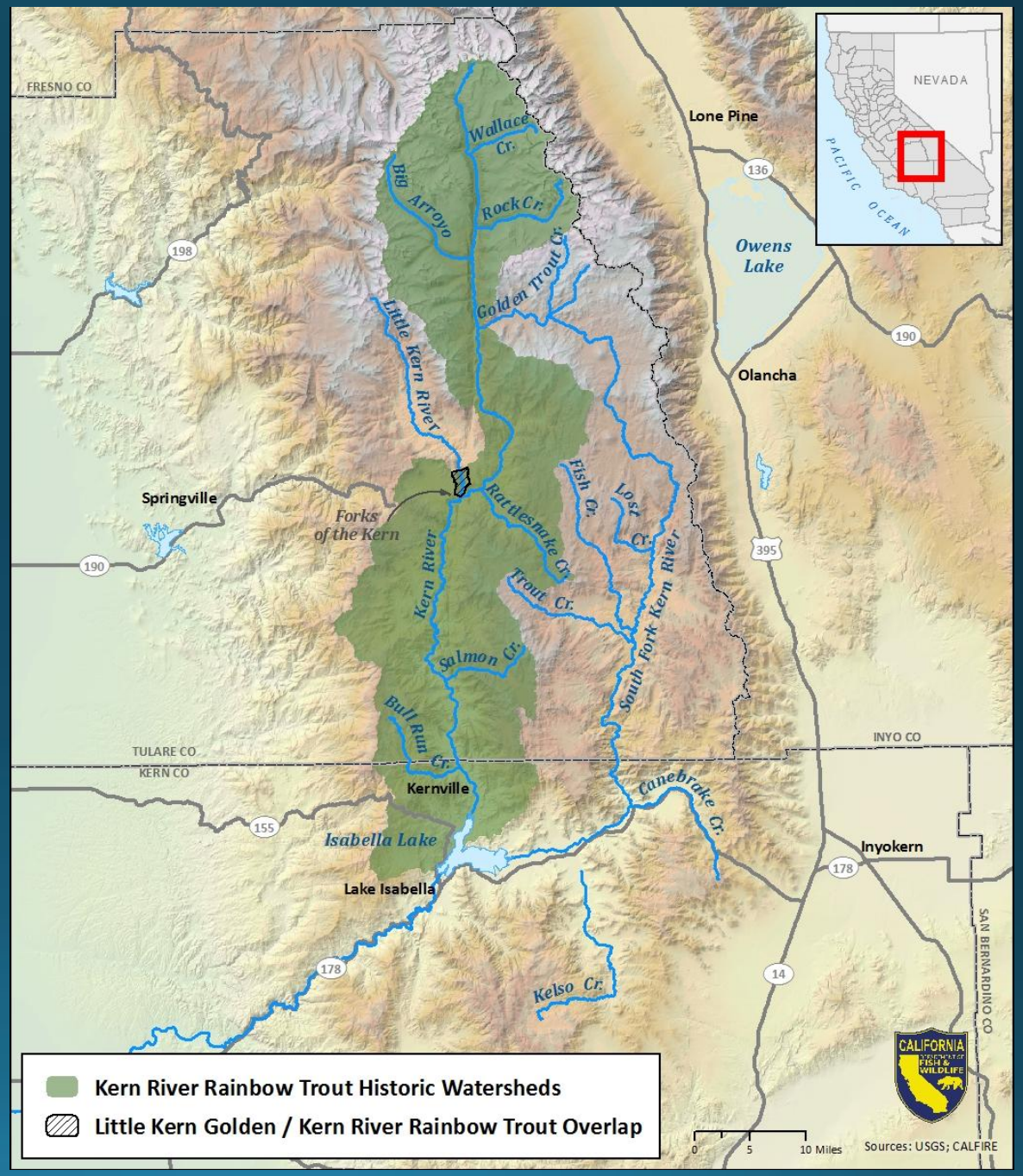
Templeton Barrier
In Templeton Meadows
1975

Chemical treatments to remove invasive fish above the barriers.

- 10 treatments from 1969 to 2000 in the SF Kern
- Currently, No known invasive fish above Schaeffer Barrier

SF Kern Golden

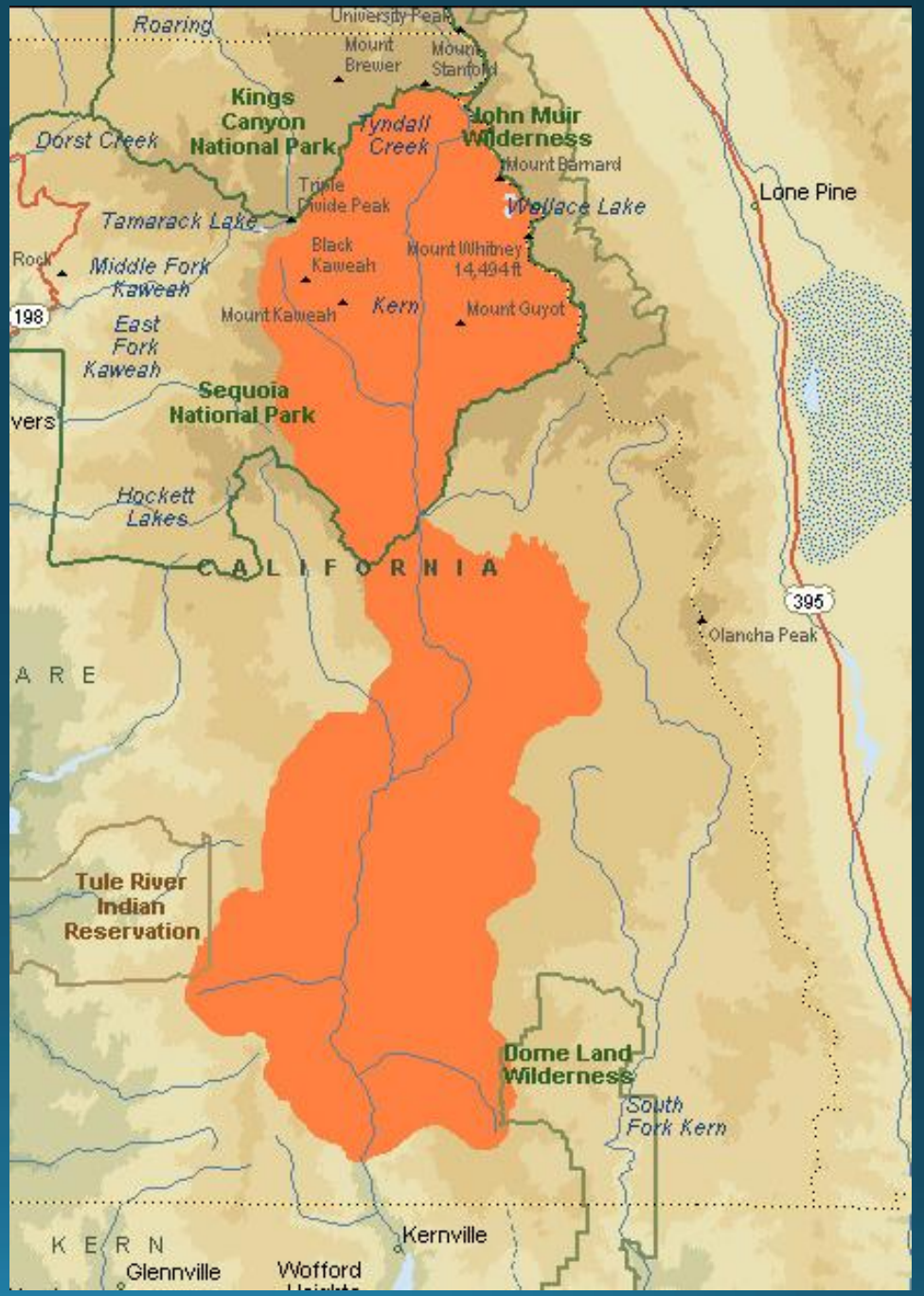
Upper Kern River



Current range of KRR

Southern Boundary for KRR considered "Pure Strain" is Durrwood Camp about 8 miles upstream of Johnsondale Bridge.

CDFW recently conducted surveys throughout the watershed in search of "pure" Kern River rainbow trout. Genetic studies found a population in a headwater lake of Big Arroyo. Steps are being taken to capture a portion of this population and rear them in a hatchery.



Kern River Hatchery

- 1981 to 1997. Set up to propagate Little Kern Goldens. Contamination shut the program down.
- Now intending to propagate Kern River Rainbows. Located pure strains in headwaters of Big Arroyo.

Collecting Brood stock – Kern River Rainbows

Today, remnant populations live in the Kern River above Durrwood Creek, in Upper Ninemile, Rattlesnake and Osa Creeks, and possibly in upper Peppermint Creek.

Brood stock are being maintained at the Kern River Hatchery.

Upper Kern River

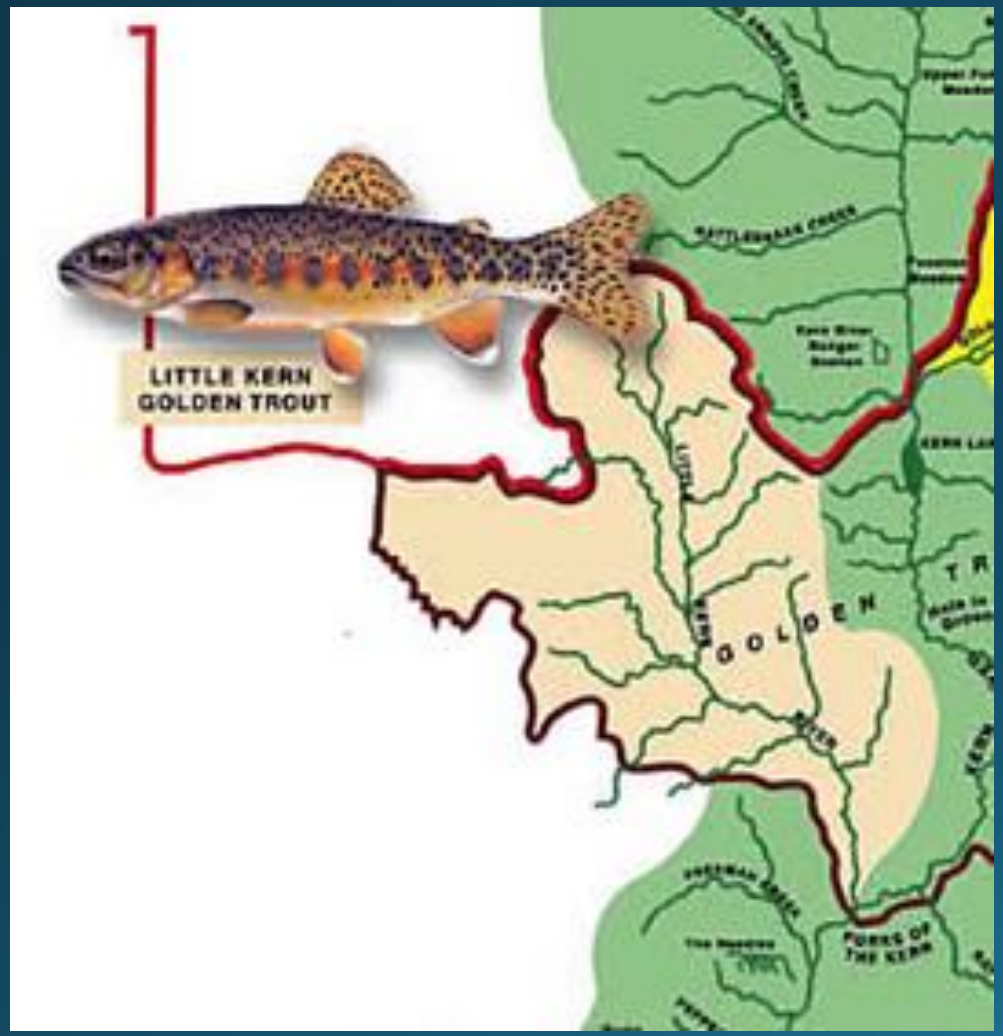
Brown Trout intrusions

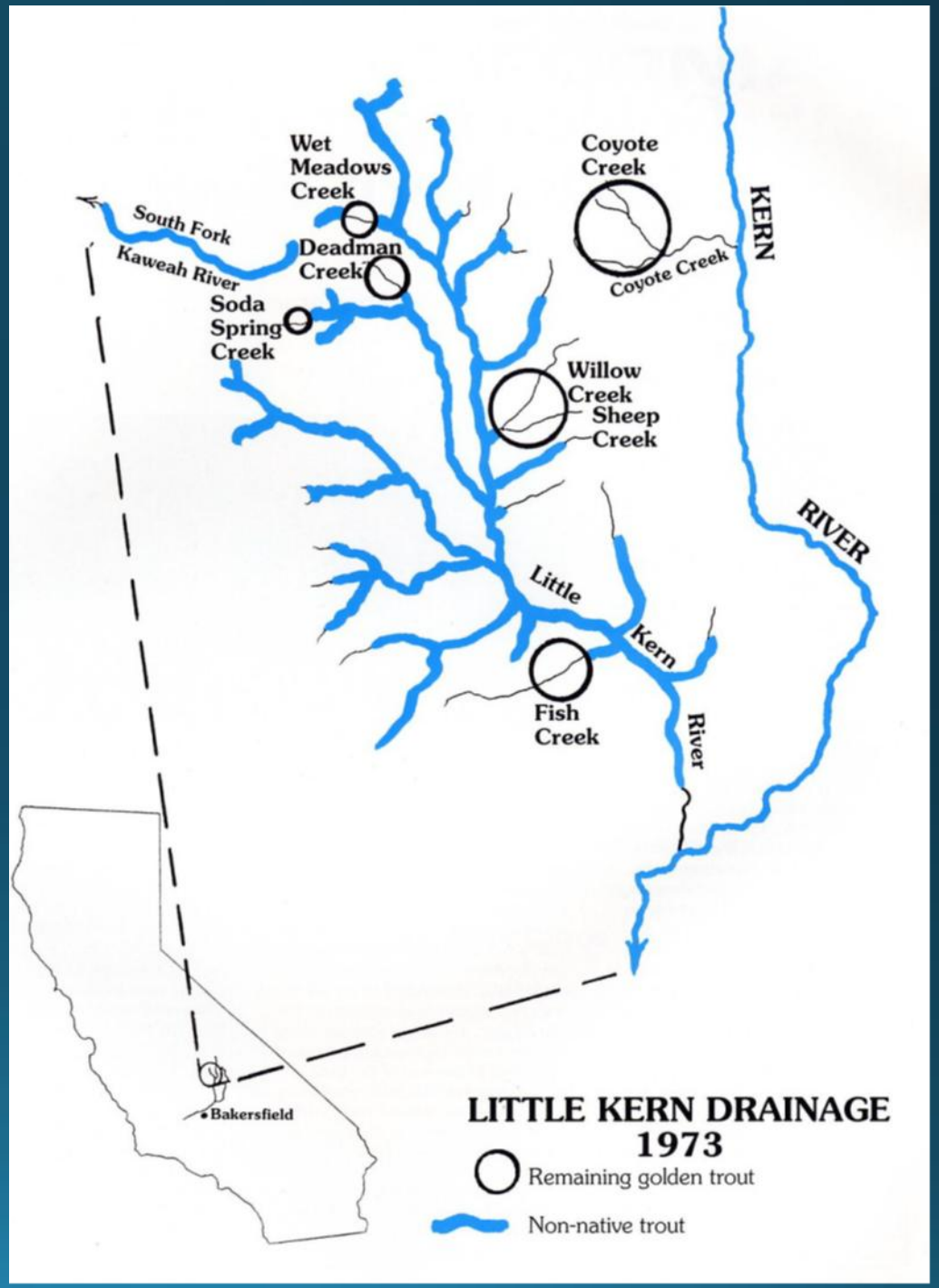
Kern River - Hole in the Ground

Hole in the Ground
Kern River

Little Kern Golden

Historical Native Range





Little Kern Rainbows

Rainbows were introduced in 1930-1941 in Little Kern River ,Alpine Creek, Clicks Creek, Mountaineer Creek, Peck's Canyon , and Shotgun Creek .

Browns were introduced to Clicks Creek in 1935 and Brookies to many Little Kern Drainage waters in 1930-1941.

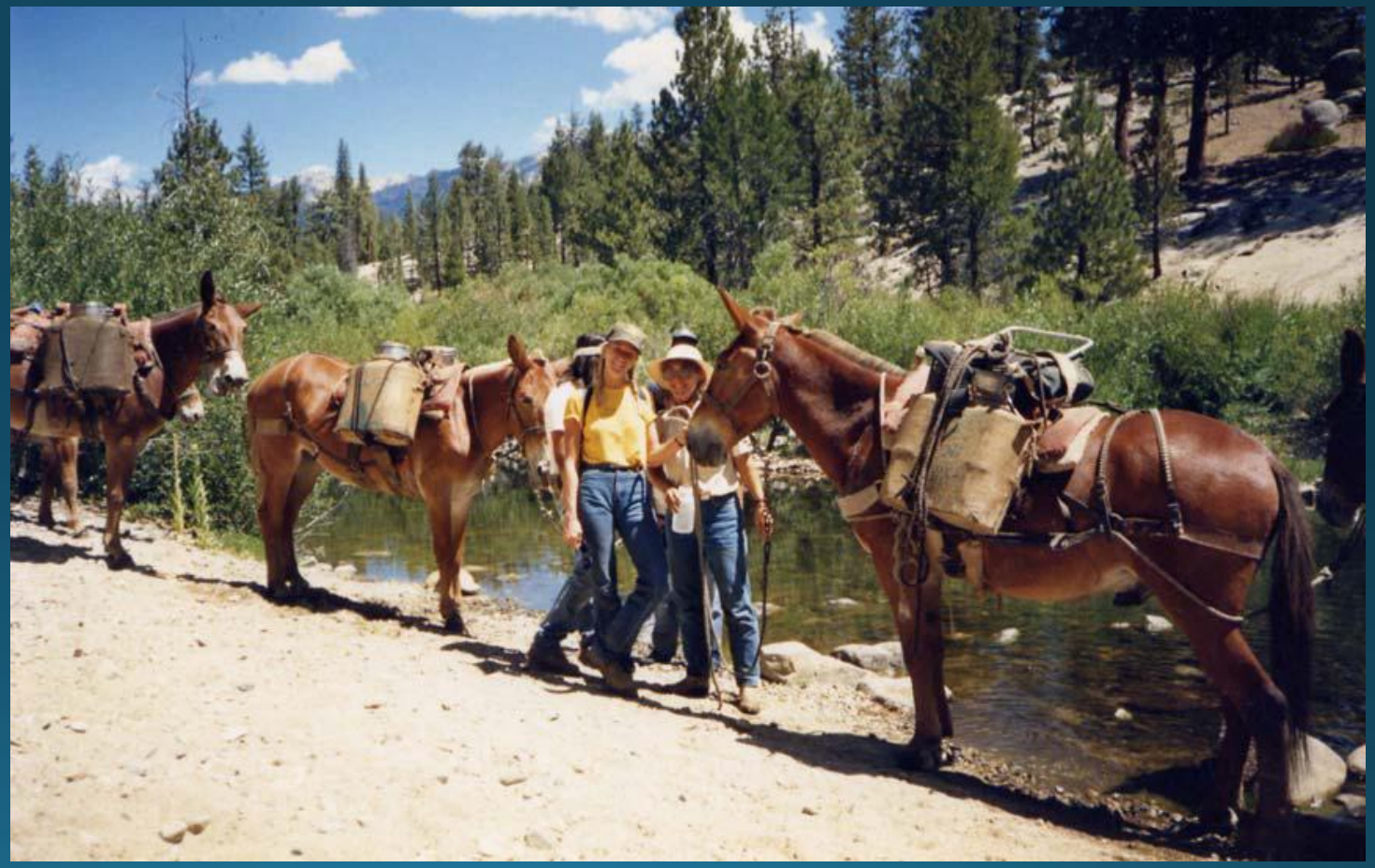
In 1973, Early genetic studies, using allozymes, identified only six remaining pure populations of Little Kern Golden Trout.

Five of these occurred in the endemic habitat occupying only 10% of 100 stream miles in the basin having a total of less than 5,000 pure LKR trout.

One was identified outside the native habitat.

Chemical Treatment and Restocking

Over 100 chemical treatments of Rotenone and 27 barriers were constructed.
80,000 hatchery raised LKR were transplanted into the chemically treated sections.
By late 1990's , 70% of the LKR habitat was restored to pure strains.

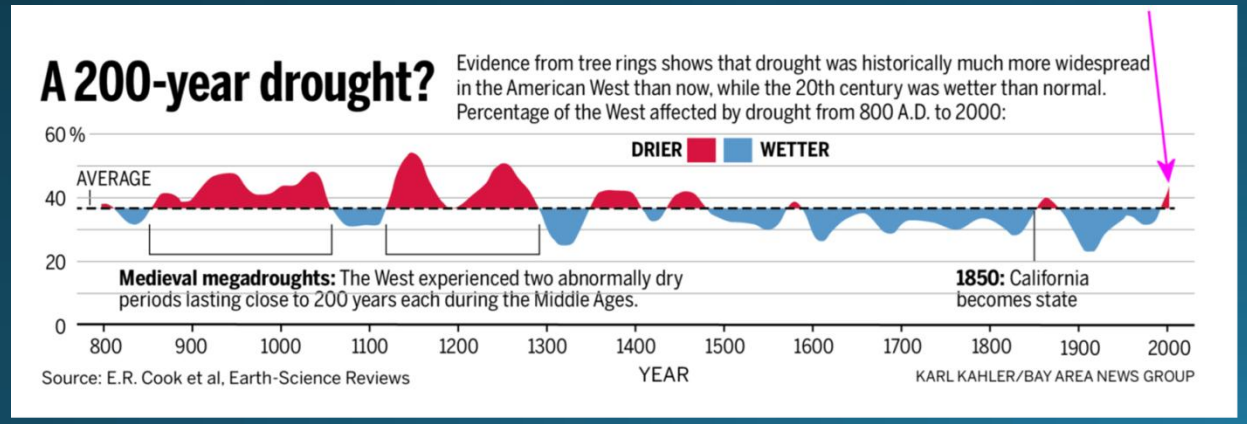


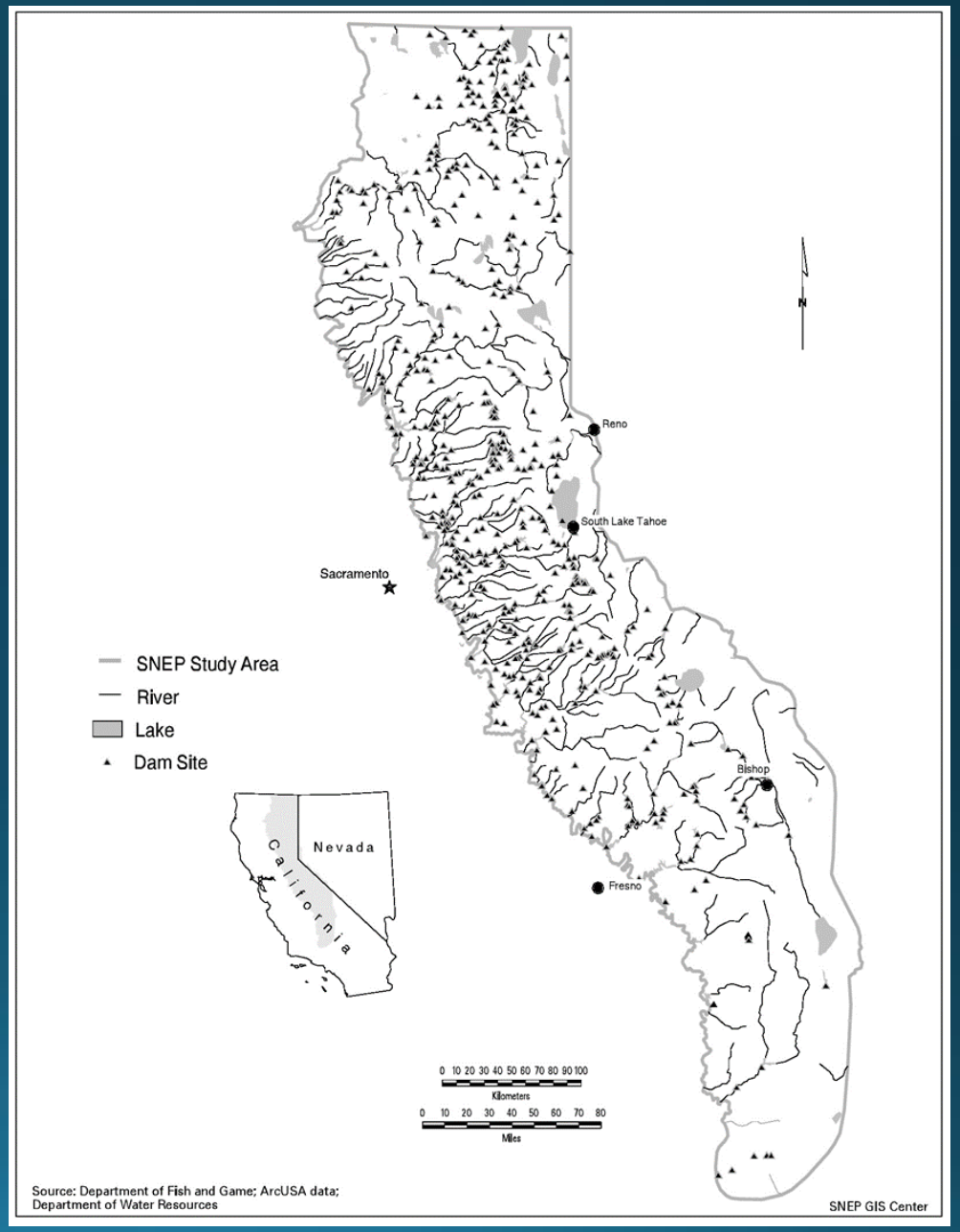
Additional Impacts to Golden Trout

- Precipitation changes
- Water Temperature increases
- Change in Forest cover
- Grazing

Precipitation and Water Management

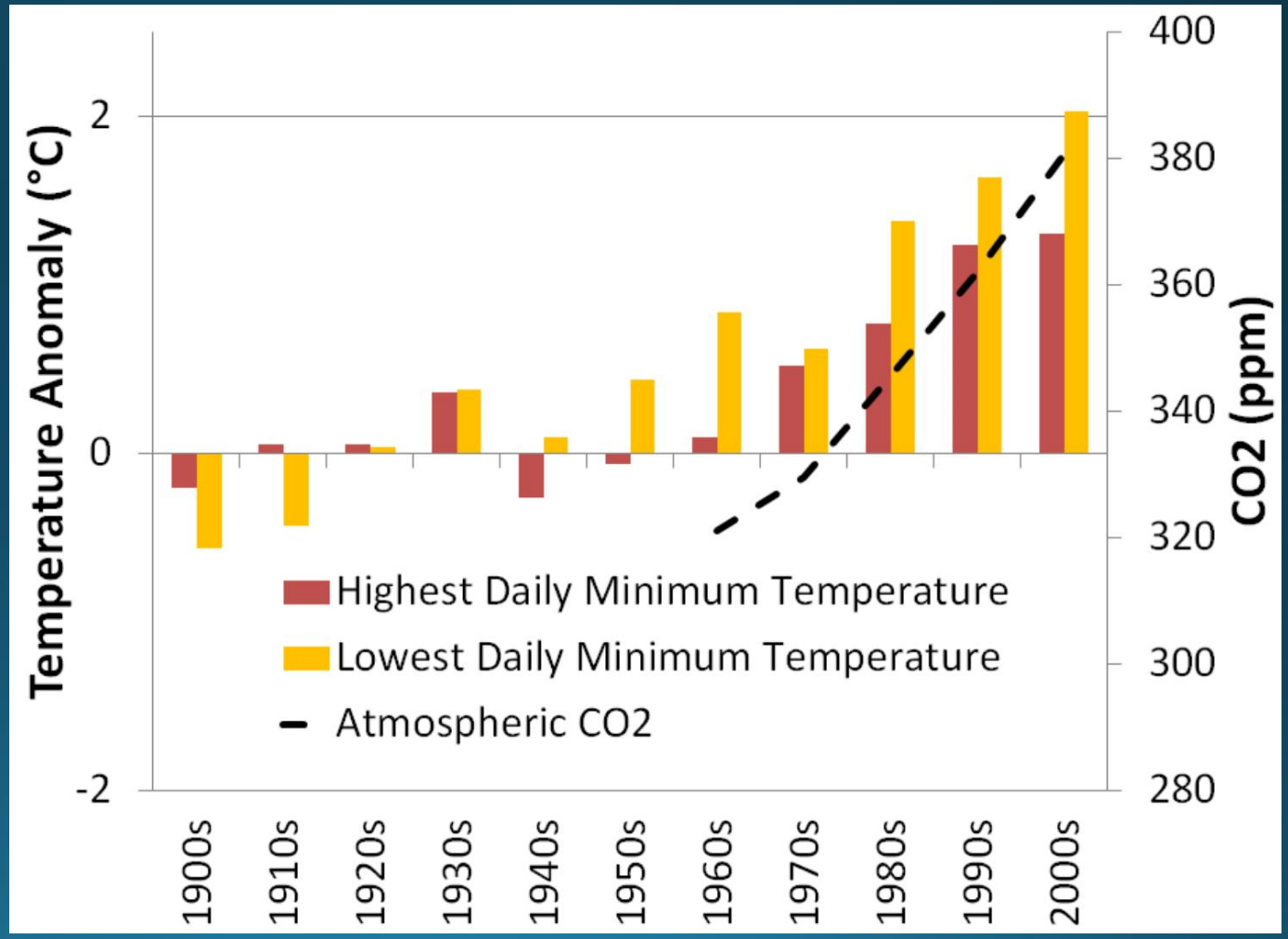
Will there be enough water for the fish?



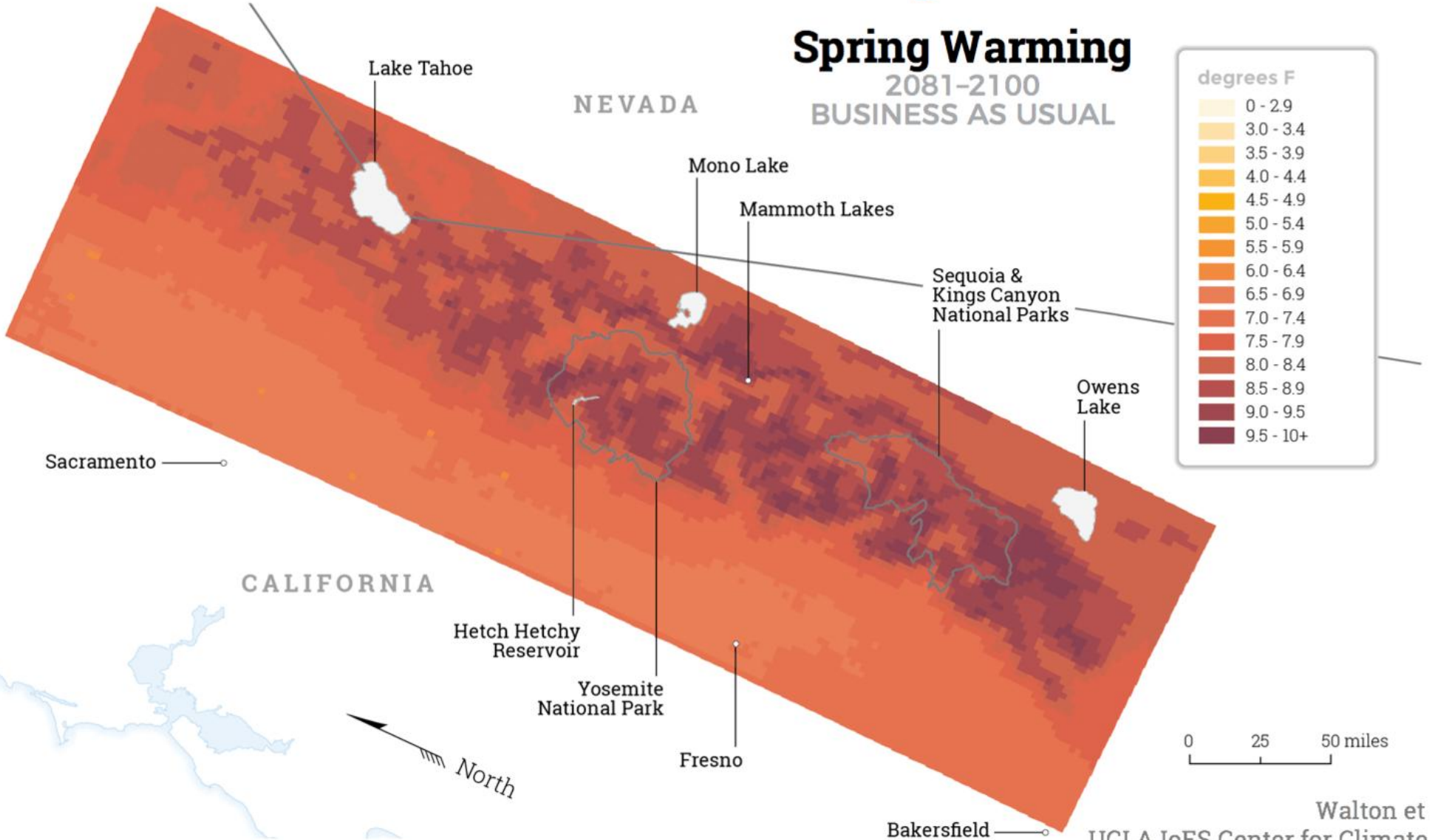


Temperature increase with higher Atmospheric CO_2

TU anticipates a 50% reduction in native cutthroats in the next 70 years due to higher water temps.



Future Warming



Walton et al., 2017:
UCLA IoES Center for Climate Science

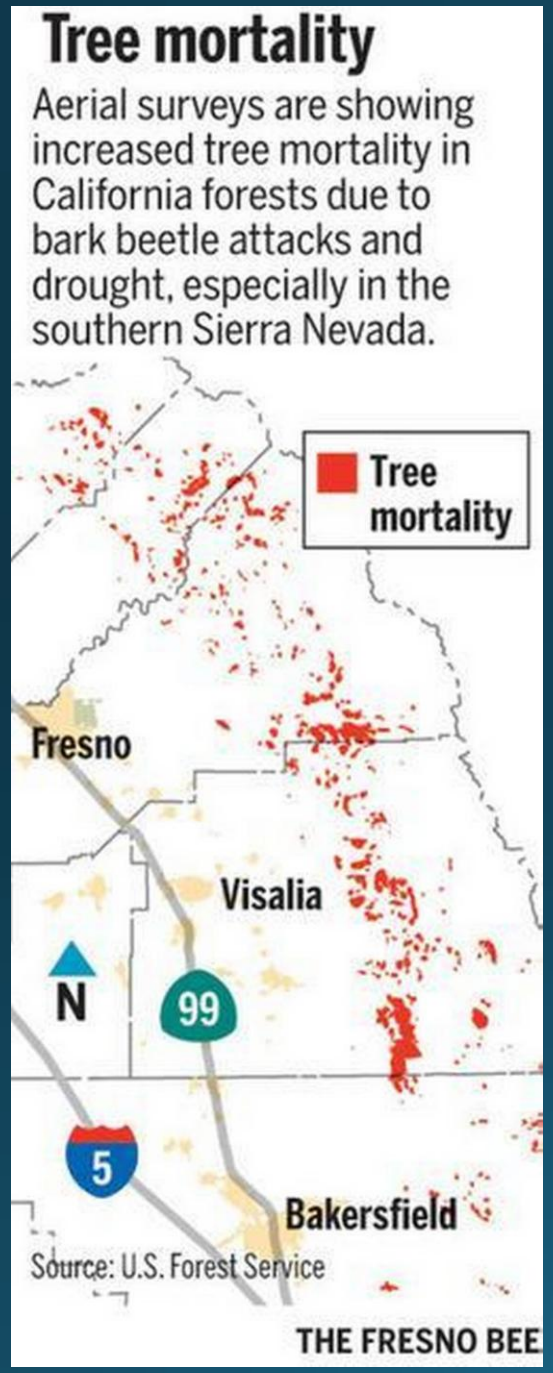
Our forests hold 70% of all carbon emissions

No longer a Carbon Sink .
Forests are becoming a source of carbon to the atmosphere due to warm soil temperatures allowing increased bacterial breakdown of the forest litter.

Fires in 2016 lost 10 years of carbon savings

Bark Beetle Mortality

Timberline will rise about 1000 feet with many conifers lost below 3500 feet elevation.



Future of the Golden Trout

- Protect the genetic Integrity of the Species. Pure strains of Volcano Golden are limited to about 9 miles of stream, presently.
- Get the CO_2 levels back to historical levels, bringing down temperatures.
- Eliminate Grazing within the Golden Trout habitat.
- Maintain the historical range of the Goldens by excluding invasive species.
- Adapt water management policies to ensure adequate water for native fish.
- Use Forest Management tools to create healthy forests and assist in the survival of the Golden Trout.

The End