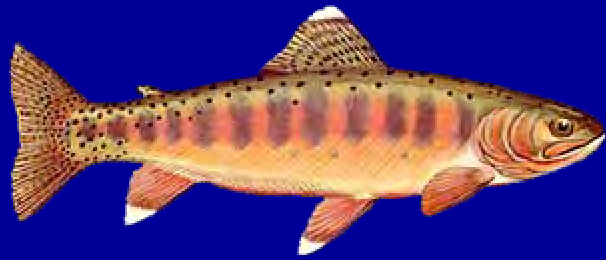
Will California golden trout and their habitat be will resilient to climate change?

Kathleen R. Matthews

US Forest Service Research

Sierra Nevada Research Center

Outline



- Golden trout background
- How climate change may impact CGT and their habitat
- What can be done?

California Golden Trout

- California's state fish; one of few native fish in the High Sierra >8000 ft
- Native to South Fork Kern River and Golden Trout Creek; not native to any lakes
- Most of its native range now within Golden Trout Wilderness
- Threatened by degraded habitat and introduced brown and rainbow trout
- Petitioned for federal ESA listing

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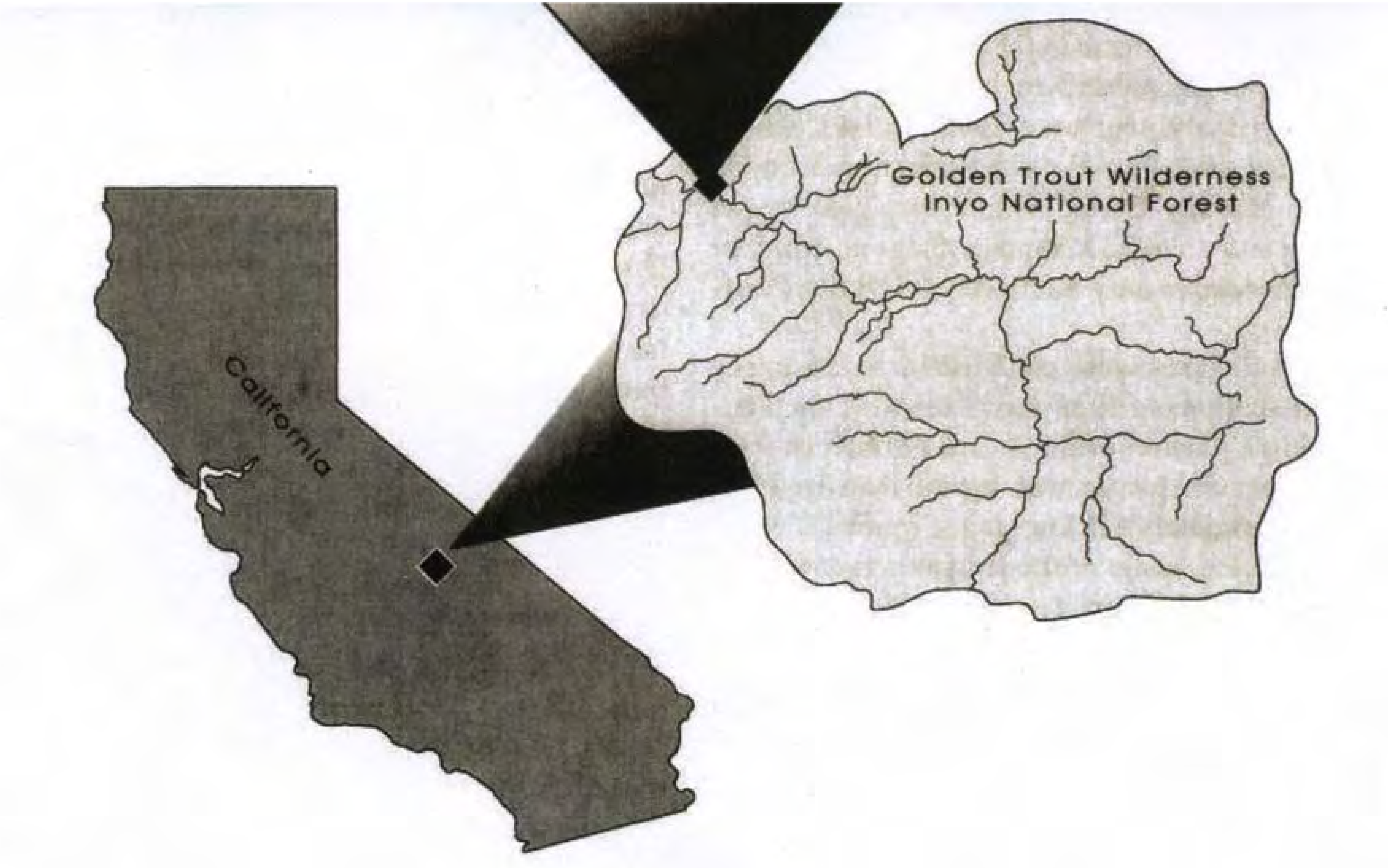
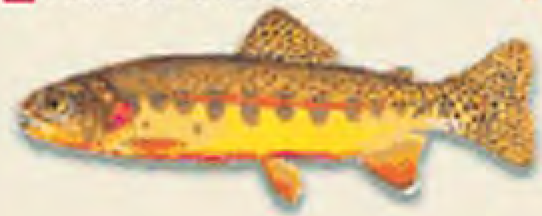
Golden Trout Wilderness



Golden Trout native habitat

The Kern River drainage is home to two different kinds of golden trout. Each evolved independently after migrational barriers contained the trout to different parts of the drainage.

California Golden Trout



Little Kern Golden Trout

Source: California Department of Fish & Game

Golden Trout Wilderness encompasses most of the subalpine meadows of the Kern Plateau

Golden trout, Kern Plateau and GTW history

- Native American Use for >8000 years
- Sheep and cattle grazing starting in the 1860s
- Sheep removed in 1900
- Golden trout described by David Starr Jordan in 1893
- Resorts and airfield for fly-in fishing trips 1950-1978
- Calif Fish and Game removes non-native trout and reestablishes golden trout
- Golden Trout Wilderness established 1978—allowed grazing to continue
- Cattle exclosures built starting in the 1980s

Cattle grazing in the GTW

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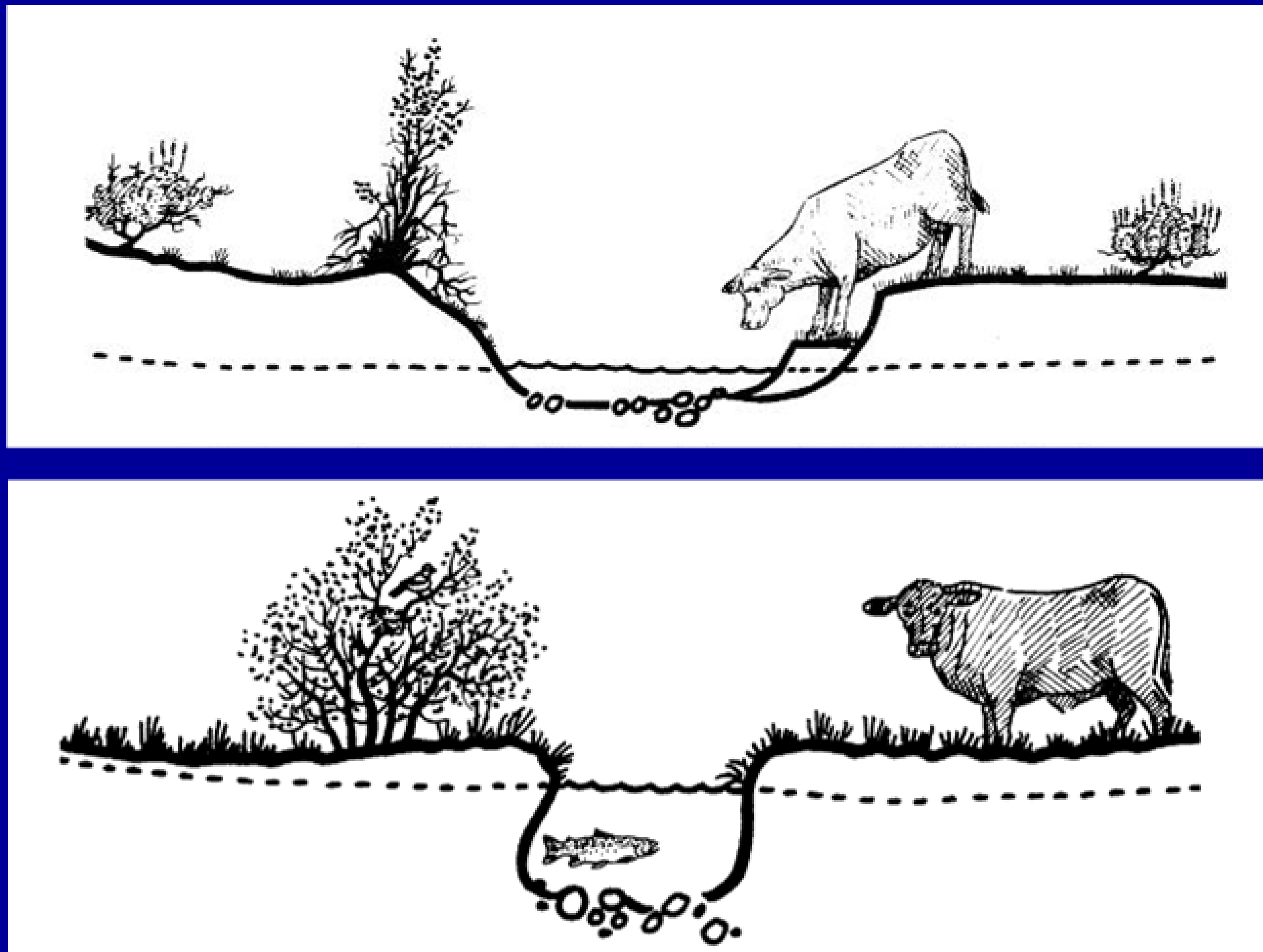
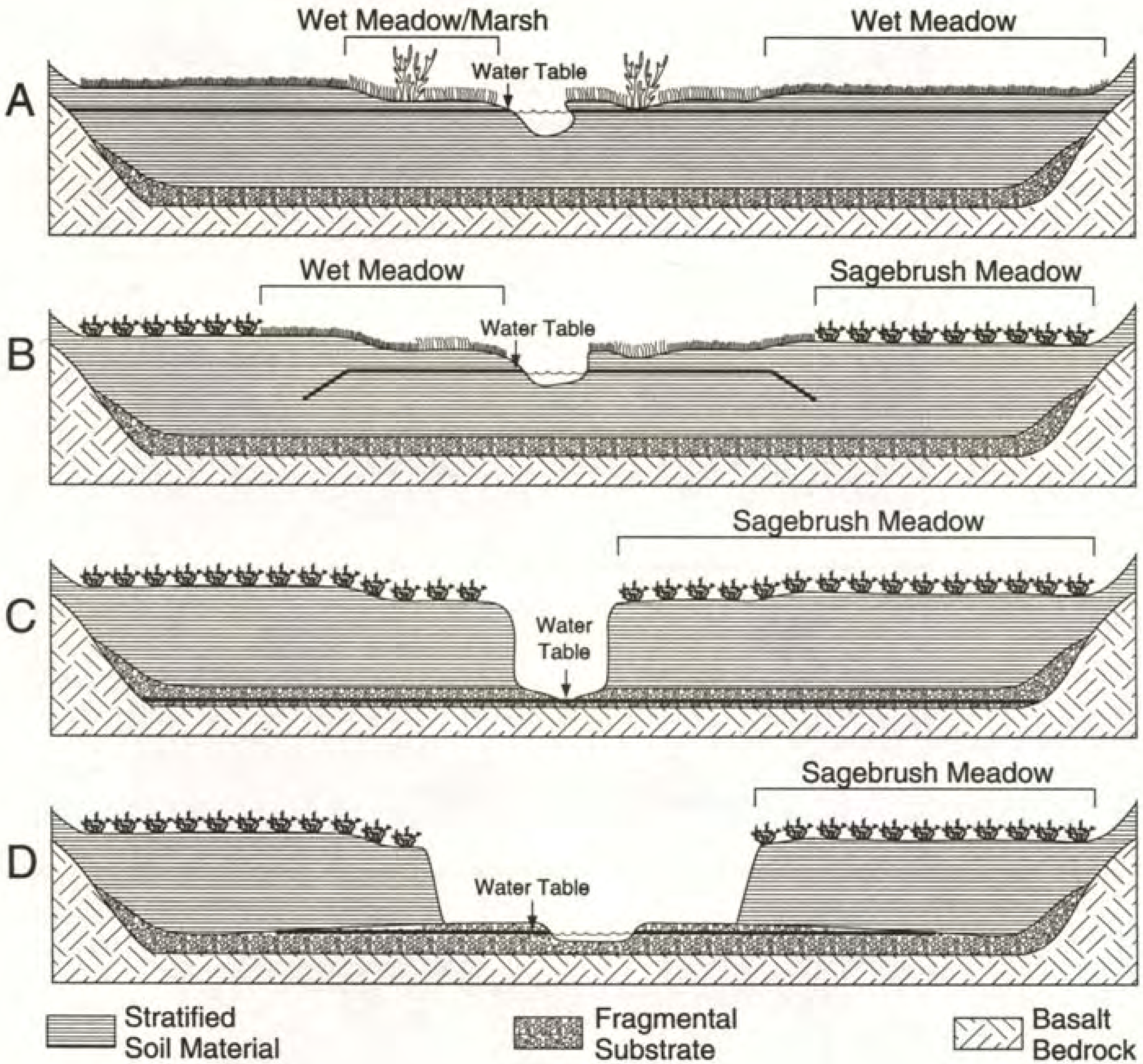
What do cattle do?



From Cleary and Webster 1990



Source: BLM 1993g

A major shift in streamside vegetation over the past 150 years—

Wet meadow species has declined while sagebrush is now moving closer to the stream.

Wood 1975.

Micheli & Kirchner 2002

Ecological Applications, 8(4), 1998, pp. 1104–1117

EFFECTS OF STREAM CHANNEL MORPHOLOGY ON GOLDEN TROUT SPAWNING HABITAT AND RECRUITMENT

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Abstract. Populations of stream-dwelling salmonids (e.g., salmon and trout) are generally believed to be regulated by strong density-dependent mortality acting on the age-0 life stage, which produces a dome-shaped stock-recruitment curve. Although this paradigm is based largely on data from anadromous species, it has been widely applied to stream-resident salmonids despite the fact that the processes limiting or regulating stream-resident populations remain poorly understood. The purpose of the present study was to determine whether stream channel morphology affects the availability of spawning habitat for California golden trout, and whether spawning habitat availability influences the production of age-0 trout and recruitment into the adult population.

Wide stream reaches contained significantly more spawning habitat and a higher density of nests and age-0 trout than did narrow reaches. In contrast to the idea that salmonid populations are regulated by density-dependent mortality of age-0 fish, we found that the mortality of age-0 trout was largely density independent. In addition, over most of the range of observed fish densities, the density of a particular cohort was positively correlated between years for age-0, age-1, and age-2 trout. Therefore, our golden trout study population was limited by spawning habitat, with spawning habitat availability influencing the production of age-0 trout as well as recruitment into the adult population.

Grazing by cattle has widened the study streams, and our current findings help to explain why stream sections subject to grazing had more spawning habitat and higher golden trout densities than ungrazed sections. Individual growth rates of golden trout are apparently negatively density dependent, and these grazing-related increases in trout density have

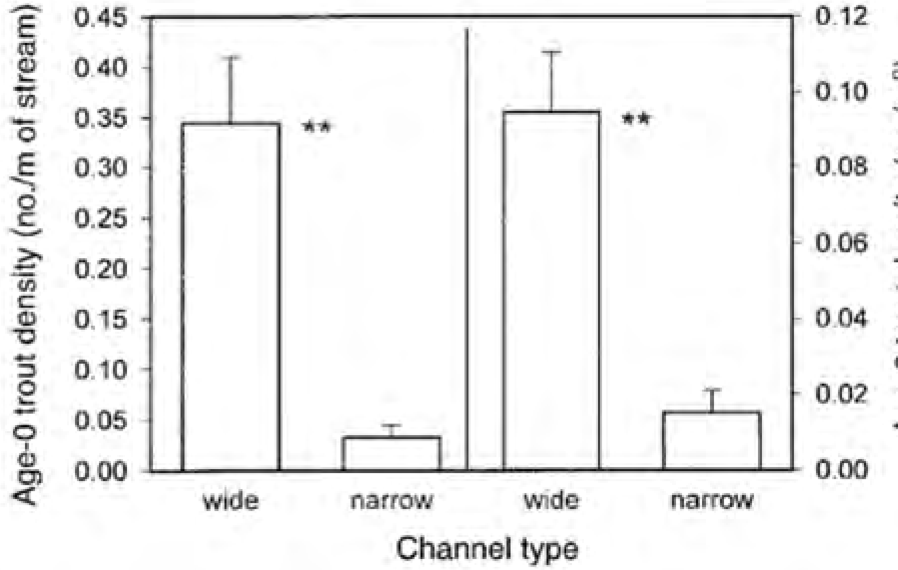
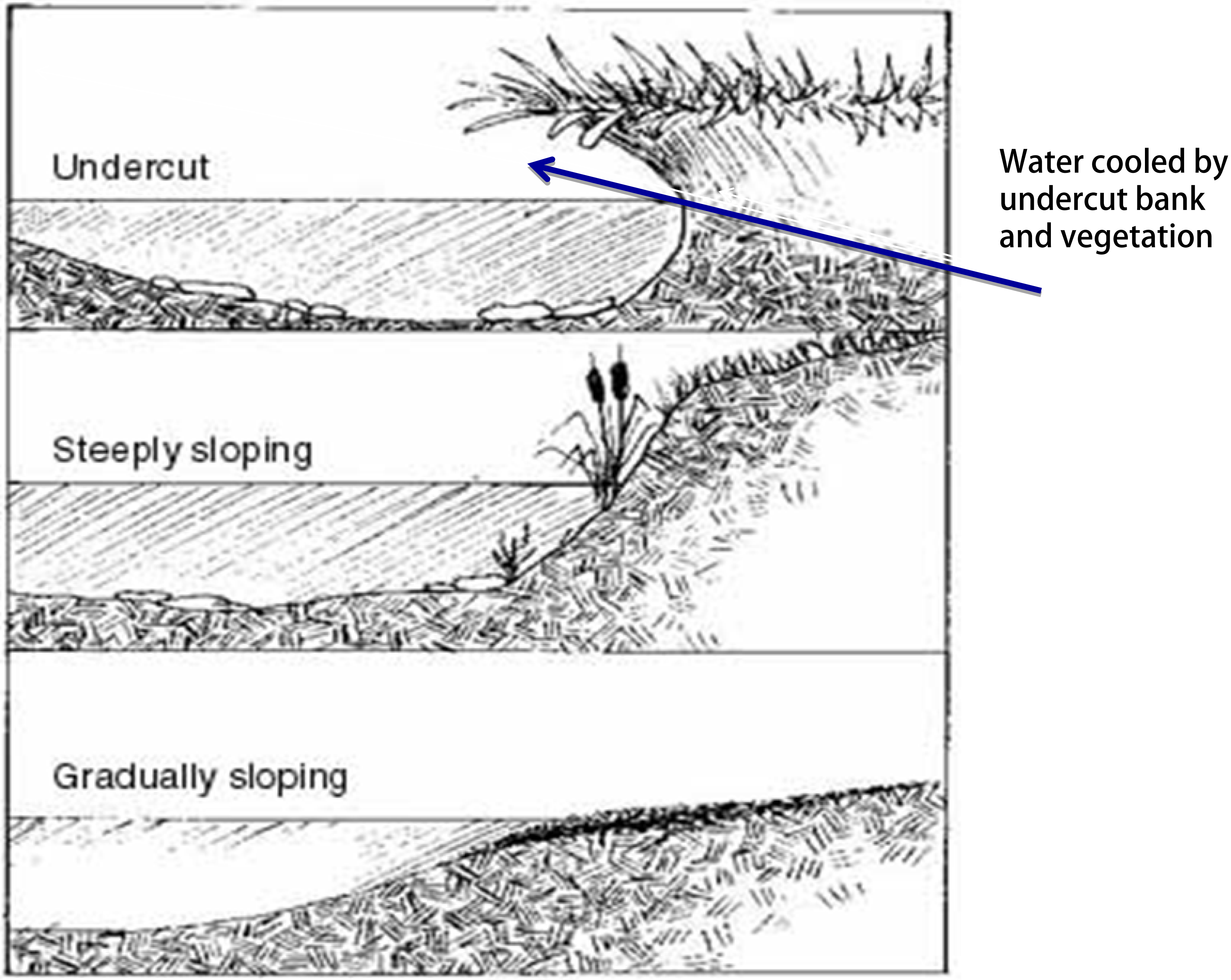
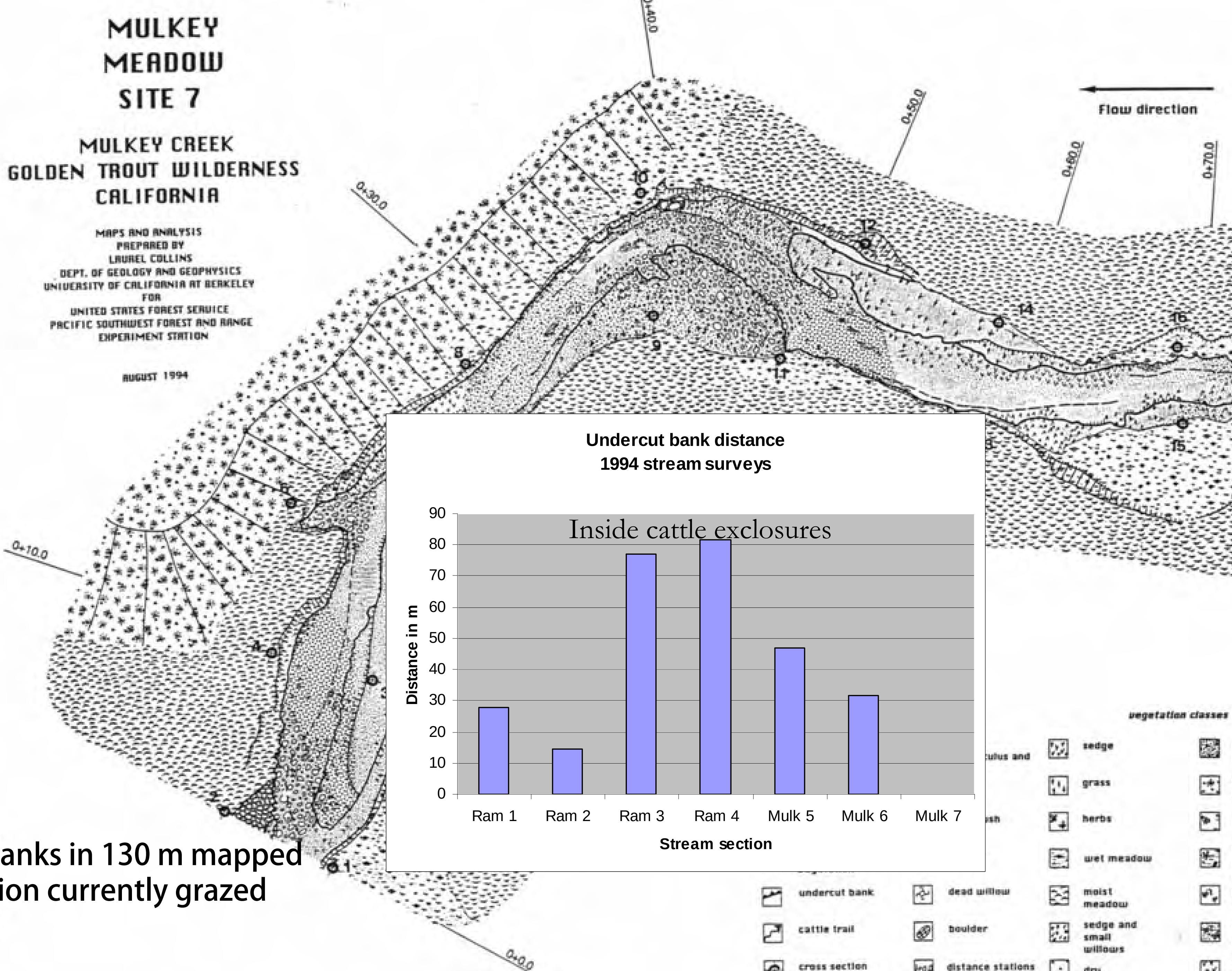


FIG. 8. Comparison of the density of age-0 golden trout (number/m of stream, number/m^2) for wide vs. narrow reaches in Mulkey Creek. Bars represent means, and error bars show 1 SE. Wide reaches contained significantly higher age-0 trout densities than did narrow reaches (**: $P < 0.005$).

Golden trout population parameters

- Over 4000 fish/km; ~ 3 fish/m^2
- Highest recorded salmonid densities & biomass
- Growth rates are density dependent & population dominated by small fish (<100 mm), few fish >200 mm


Undercut
Steeply sloping
Gradually sloping
Water cooled by undercut bank and vegetation



No undercut banks in 130 m mapped stream section currently grazed

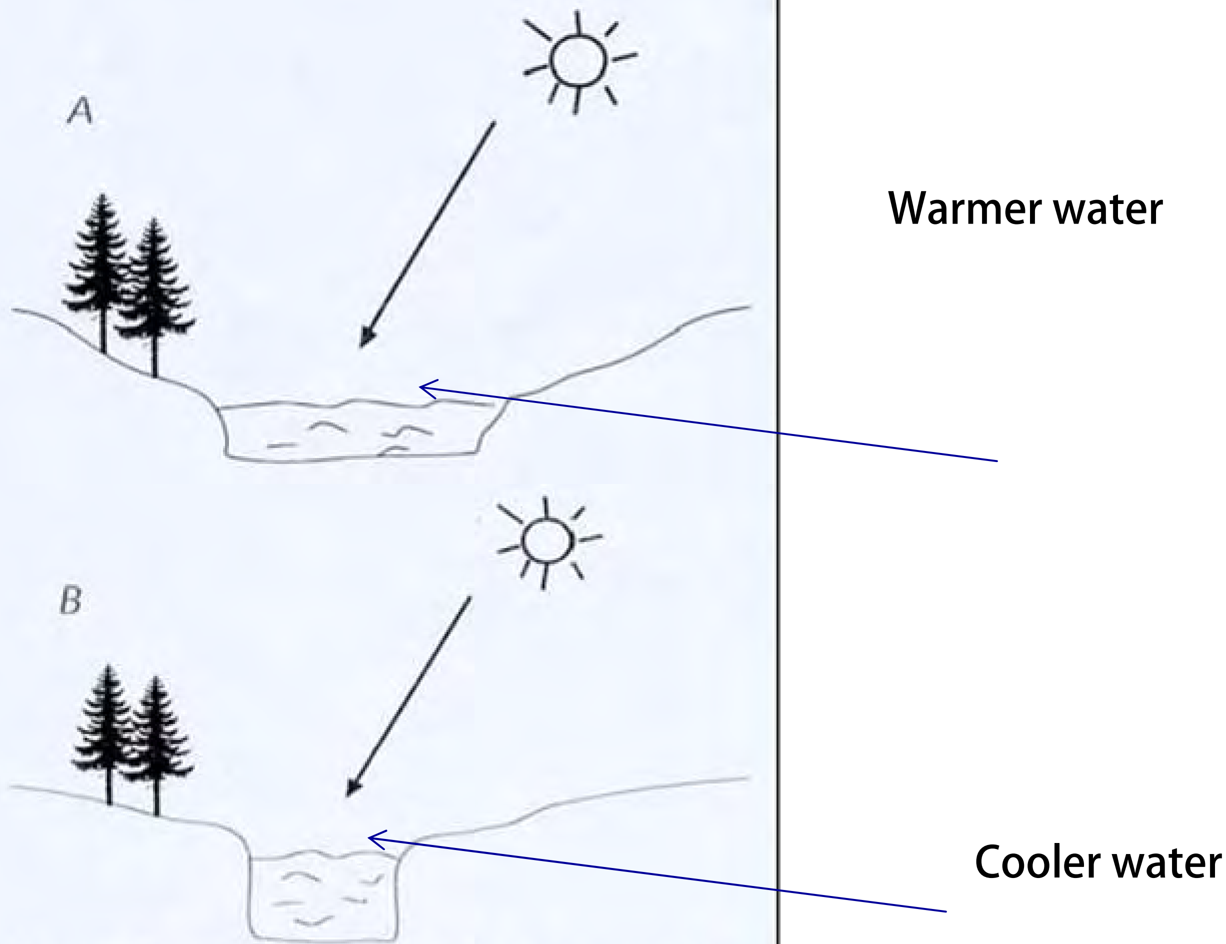


Figure 3.—Stream A and B both carry the same volume of water. Stream A has twice as much surface area to receive solar radiation as does stream B. Thus, the water temperature in stream A will rise nearly twice as fast as that in stream B.

Cattle grazing in Golden Trout Wilderness meadow streams results in:

- Collapsed streambanks and reduced streamside vegetation
- Shallower, wider stream sections—vulnerable to warmer water temperature
- Increased sediment
- Reduced habitat for adult fish—overhanging banks, deep pools

Cattle grazing in the GTW

- Our 1992-1994 research determined that:
  - Current levels of grazing are preventing recovery of degraded habitat
  - Overgrazed streams have reduced availability of preferred habitats (undercut and vegetated banks) for adult golden trout
  - Overgrazed streams actually increase spawning habitat and spawning success, resulting in extremely high fish densities
  - Inyo National Forest has been resting 2 meadows-Ramshaw & Templeton

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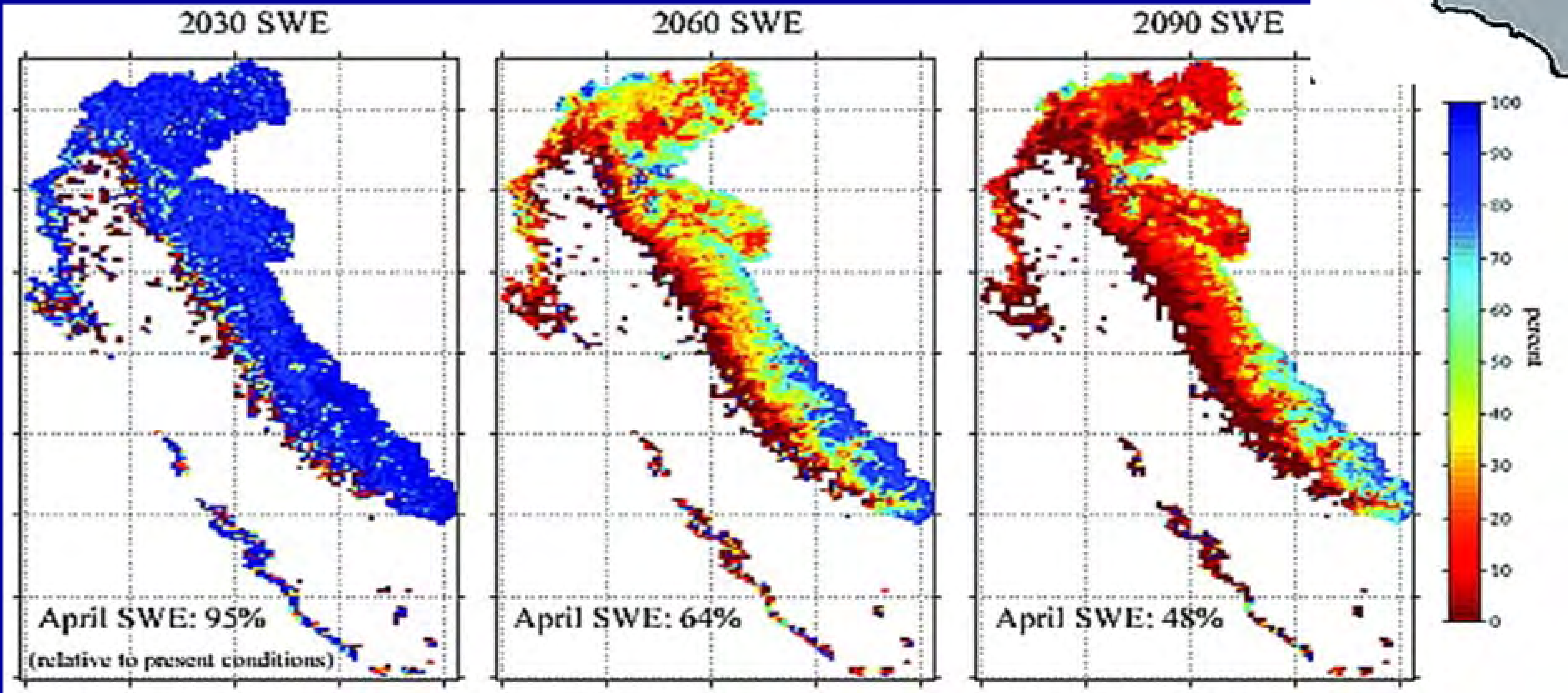
Climate change: reduced snowpack in Sierra Nevada?

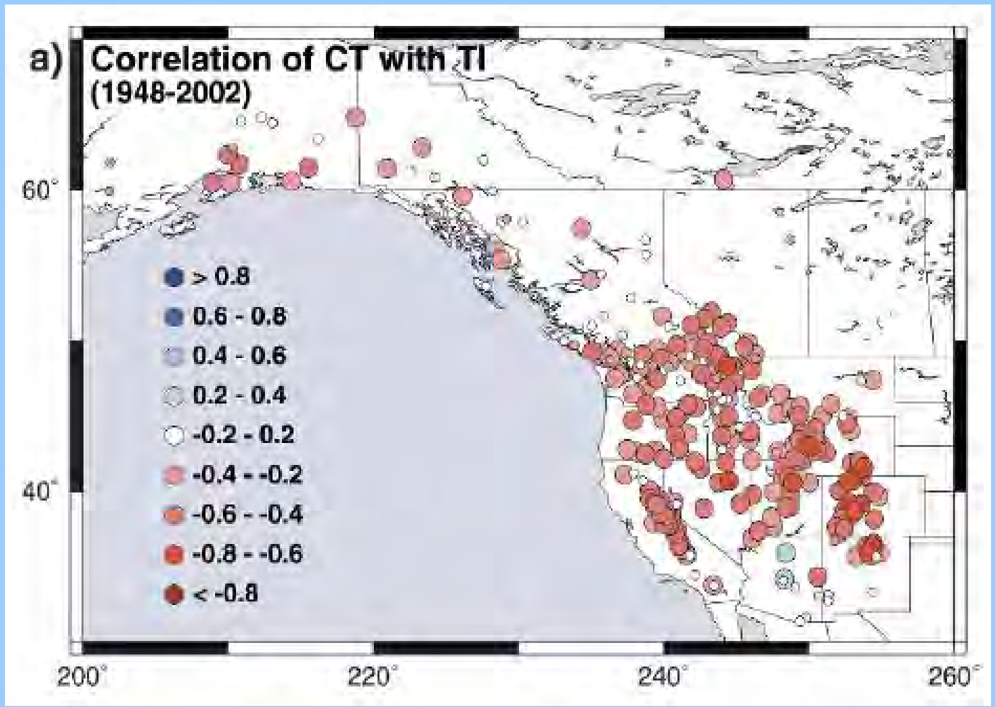


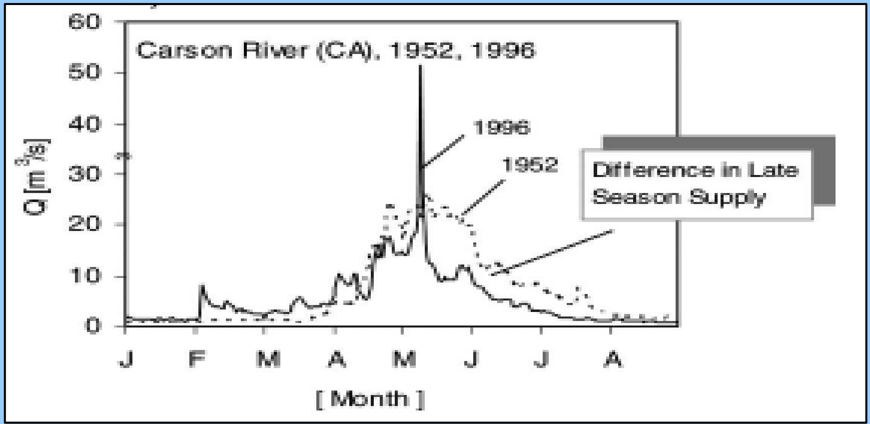
From: **Knowles, N.,** and **D. R. Cayan**, Potential effects of global warming on the Sacramento/San Joaquin watershed and the San Francisco estuary, Geophys. Res. Lett., 29(18), 1891, 2002.

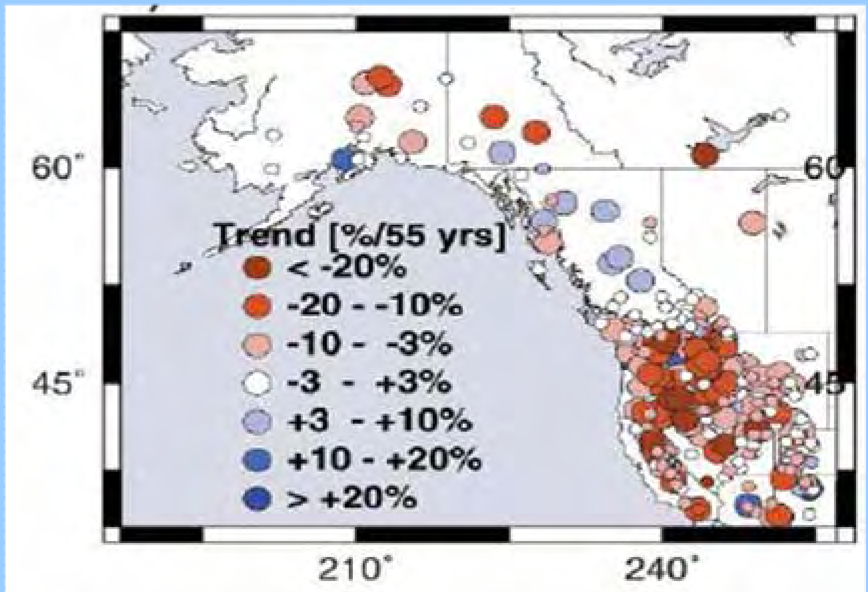
Evidence for regional changes that have already occurred:

Earlier run-off & decreased fraction as snowmelt (more rain than snow)

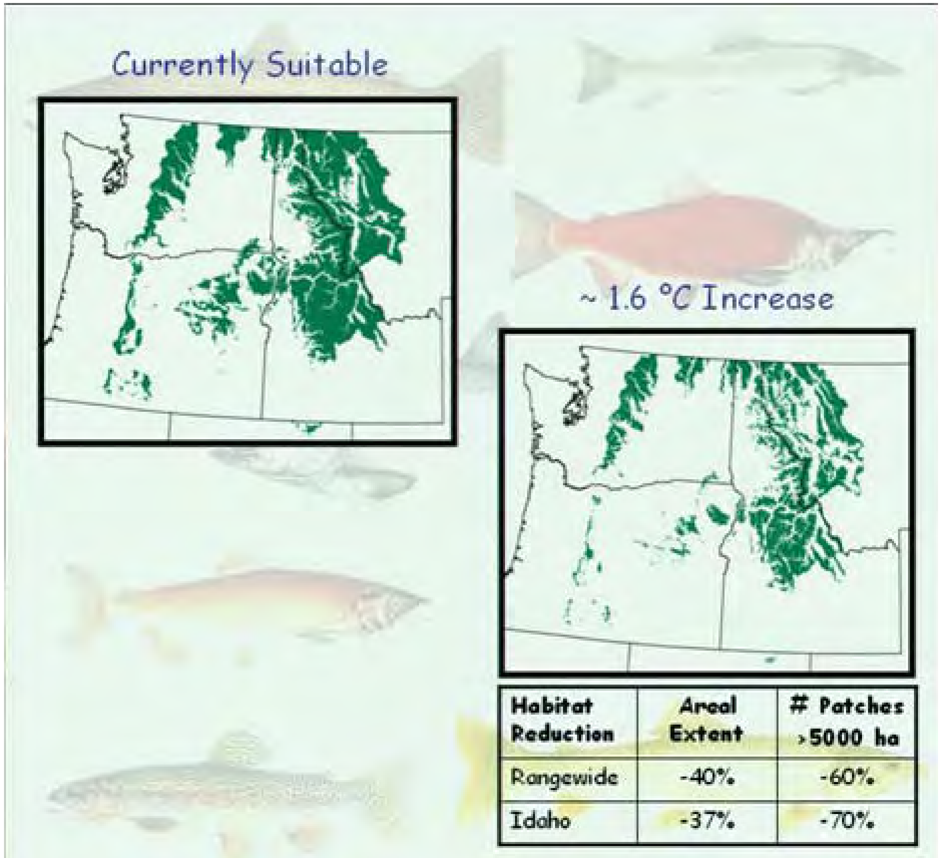
Warming trends in climate correlate with earlier flows

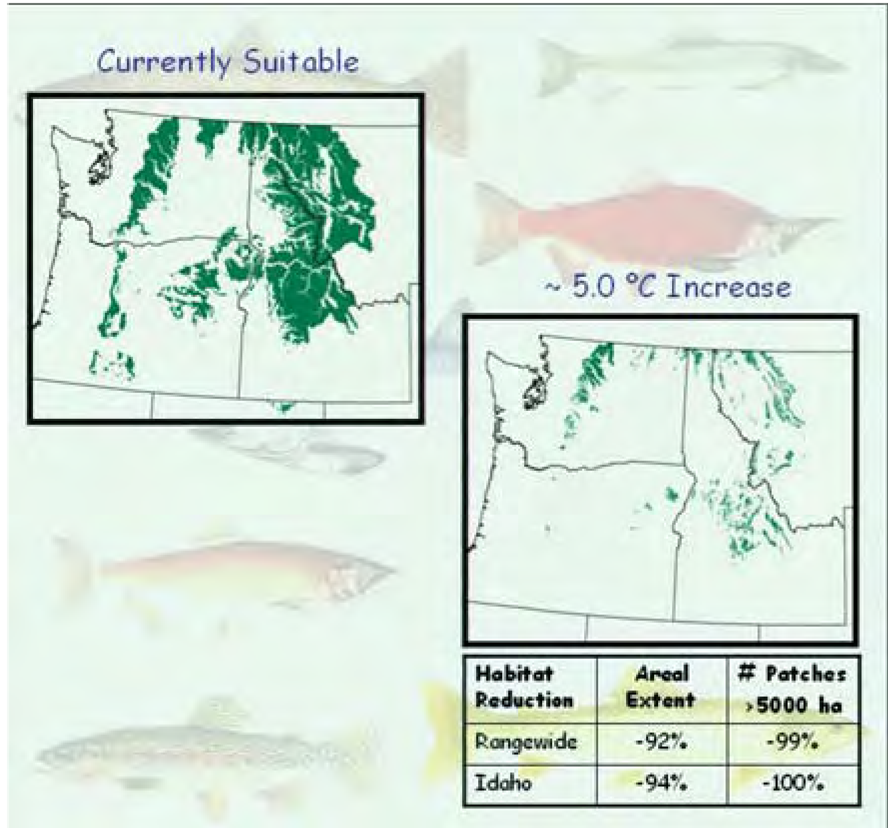






From Stewart, Cayan, Dettinger J.Climate 2004

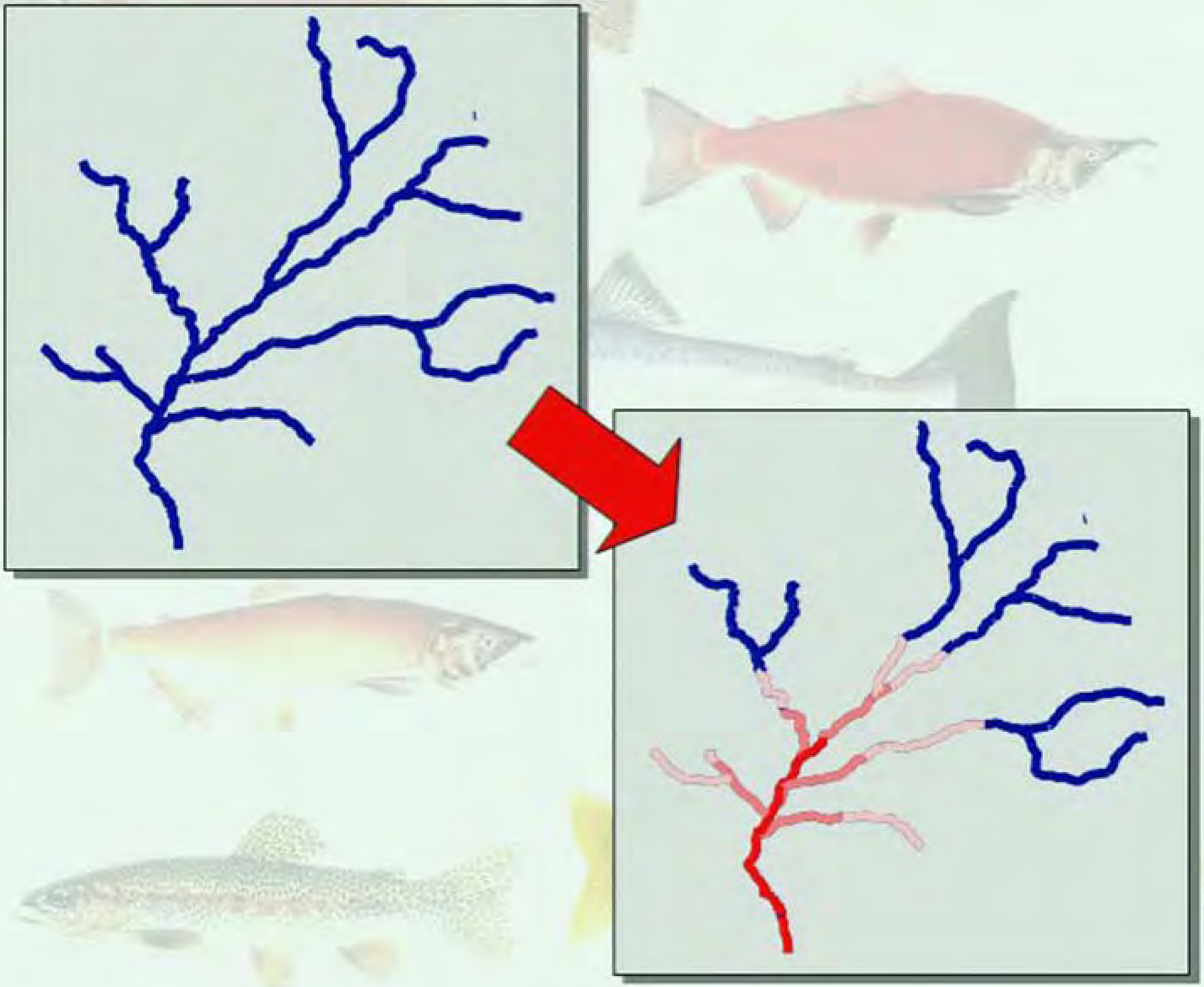




Predicted changes to Bull trout habitat in the Columbia Basin

Rieman et al. 2007

Thermal Regimes



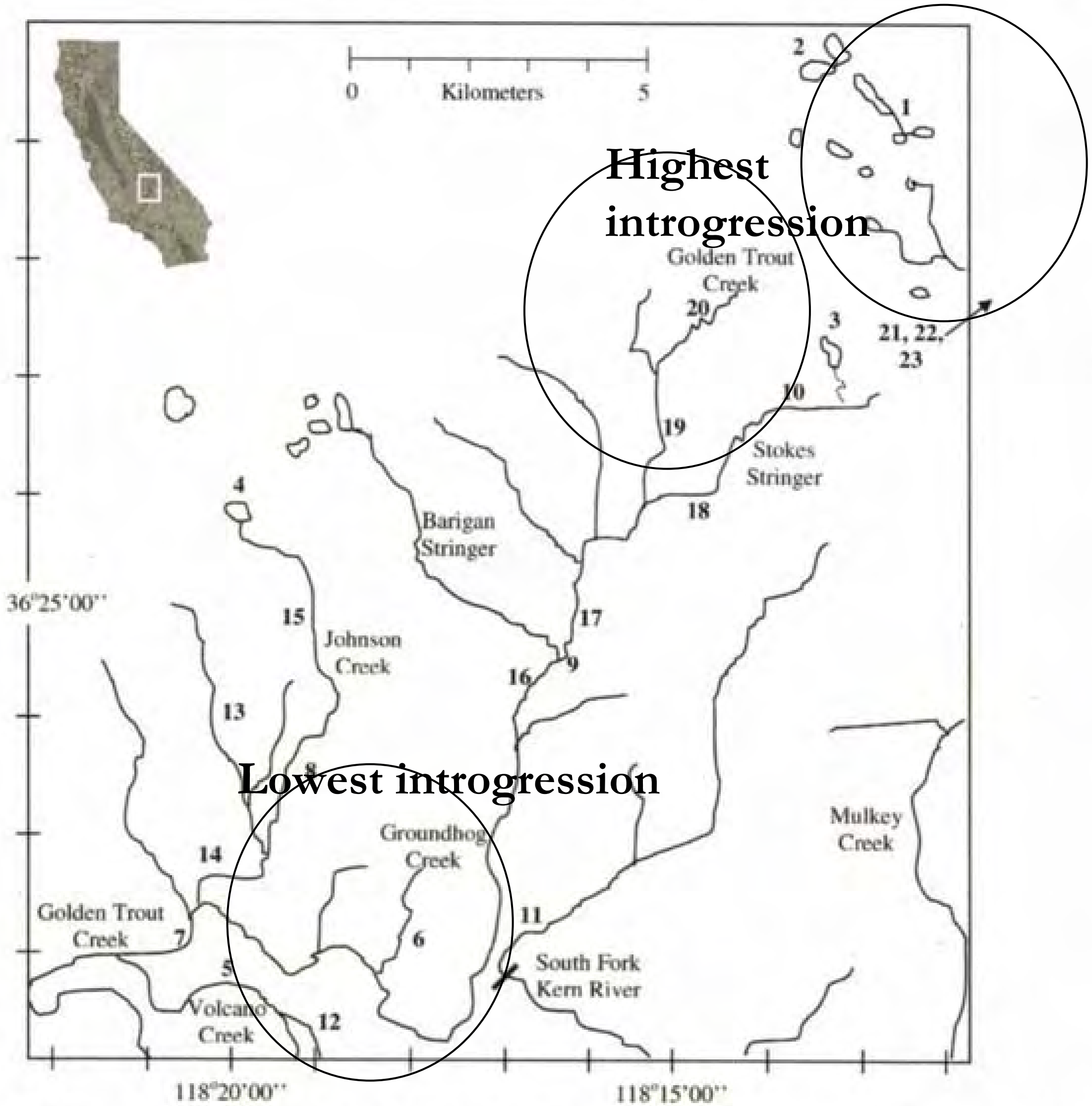


FIGURE 1.—Location of sample sites used to examine introgressive hybridization in native populations of California golden trout. Numbers correspond to the location numbers given in Table 1. Sample sites 21, 22, and 23 are part of the Cottonwood Creek system that drains from the Cottonwood Lakes (not pictured).

Cordes et al 2006 TAFS: "Indications of introgression were found in all but one of the sampled Golden Trout Creek drainage locations, the lowest average levels (0–8%) occurring in the lower reaches of Golden Trout Creek. The highest levels (12–17%) were in the Cottonwood Lakes populations that have been used as California golden trout broodstock by the DFG."

Climate change: some factors that may influence golden trout and their habitat

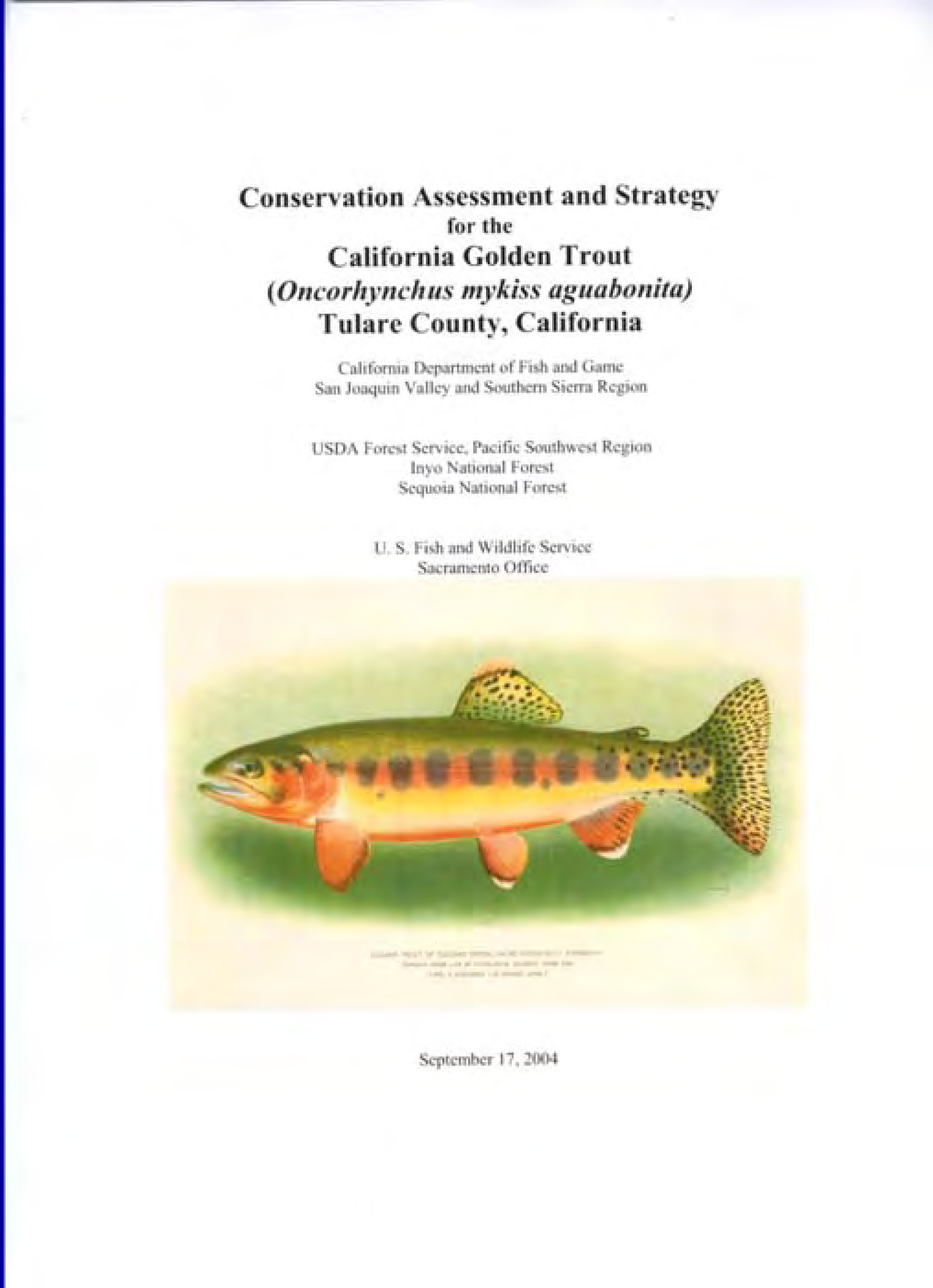
- Decreased snowpack—may be more dramatic at lower elevation (<9000 ft)
- Earlier snowmelt some year-round mountain streams going dry by summer
- More sediment scouring from increased precipitation
- Increased water and air temperatures

What do we know about climate change impacts on trout?

- No major assessment of predicted changes on trout in California
- Most work describes physical changes to snowpack or flow
- We need to begin understanding how these physical changes will affect species
- We need risk assessments of how different predicted changes may affect native and non-native species

What do we know about golden trout and their habitat?

- CGT preferentially select and use habitat features (undercut banks, vegetated areas, deeper pools) typically impacted by cattle (Matthews NAJFM) 1996
- Current levels of grazing do not allow for recovery of important habitat features (Knapp & Matthews 1995, current R5 monitoring)>> Need for restoration
- Summer water temperatures in Mulkey & Monache Meadows already reaching 24-25°C (Matthews 1995, C. McGuire CDF&G)—this is the upper limit of temperature tolerance for trout


Conservation Assessment and Strategy
for the
California Golden Trout
(Oncorhynchus mykiss aguabonita)
Tulare County, California

California Department of Fish and Game
San Joaquin Valley and Southern Sierra Region

USDA Forest Service, Pacific Southwest Region
Inyo National Forest
Sequoia National Forest

U. S. Fish and Wildlife Service
Sacramento Office

September 17, 2004

Preliminary data from temperature monitoring locations on the SFKR shows that summer water temperatures can reach **25°C.—upper limit for trout**

No mention of climate change as a stressor


What can we do about climate change?
Millar—5 R strategy
Reduce
Resist
Resilience
Respond
tRiage
Golden Trout strategy: ensure this important ecosystem is resilient to the further stress of climate change

Interaction between climate change and current threats may lead to stressful/lethal water temperatures

•From grazing:

- Widened shallow streams
- Loss of undercut banks
- Reduced streamside vegetation

• CGT habitat already stressed and may not have resiliency to adapt to climate warming

- Currently not resilient to increased water temps from climate change
- Unless overgrazed areas are restored, climate change could lead to harmful/lethal water temperature

Recovering Stream Habitat in the Golden Trout Wilderness—Ramshaw Meadows currently rested to grazing

Streamside vegetation, depth, and undercut banks keep CGT habitat more resilient to climate warming

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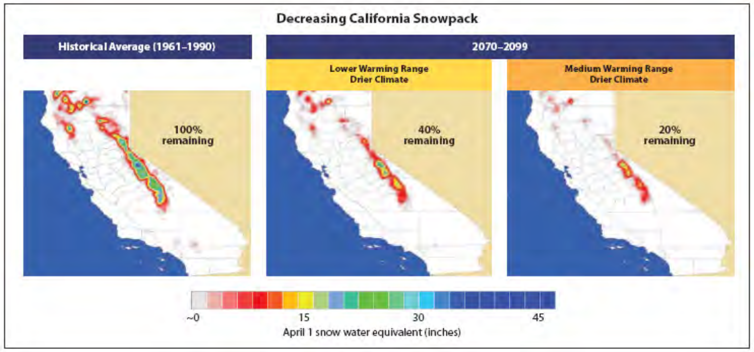
Water temperature varies throughout stream

- Shaded undercut bank, 1 m deep
- Coolest temperatures found here

- Open to solar radiation, .2 m deep
- Highest temperatures found here

GTW temperature vulnerability assessment

- In 2008, deployed 25 temperature probes in vulnerable and recovering stream sections
- In 2009-2010, hope to deploy about 100 more



Climate warming

Loss of genetic diversity


[Article]

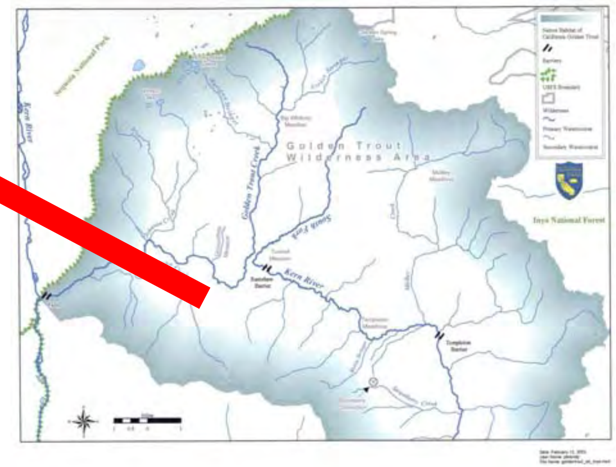
Identifying Introgressive Hybridization in Native Populations of California Golden Trout Based on Molecular Markers

Jan F. Cordes, Molly R. Stephens, Marc A. Blumberg, and Bernie May

Degraded habitat

Non-native trout

Can Golden Trout handle another stressor?



Limited distribution

California Golden Trout Research Needs

- Determine extent & duration of stressful temperatures
- Compile water temperature database
- Create scenarios with 1-5°C temperature increases
- Focus on management actions that increase resiliency—restoration & grazing practices

California Golden Trout Resilience Strategy

- Assess what proportion of habitat is resilient & what proportion is vulnerable to increased water temperature
- Determine necessary steps to ensure majority of habitat is resilient—adequate vegetation, bank stability, etc.
- Look to innovative ways to keep cows away from the stream
- Important trout deserves active restoration and conservation
- Create golden trout "refuges/preserves" to provide more protection

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