What can we do so that Sierra yellow-legged frogs are more resilient to climate change?

Kathleen R. Matthews & Igor Lacan

US Forest Service Research
Sierra Nevada Research Center

Rana sierrae (muscosa) in the Sierra Nevada

- Endemic to high elevation (found up to 3600 m) Sierra Nevada water bodies
- Native to fishless aquatic habitats
- Have declined throughout most of its range
- Warranted for federal listing
- Recent research documents fish stocking as one major factor in their decline

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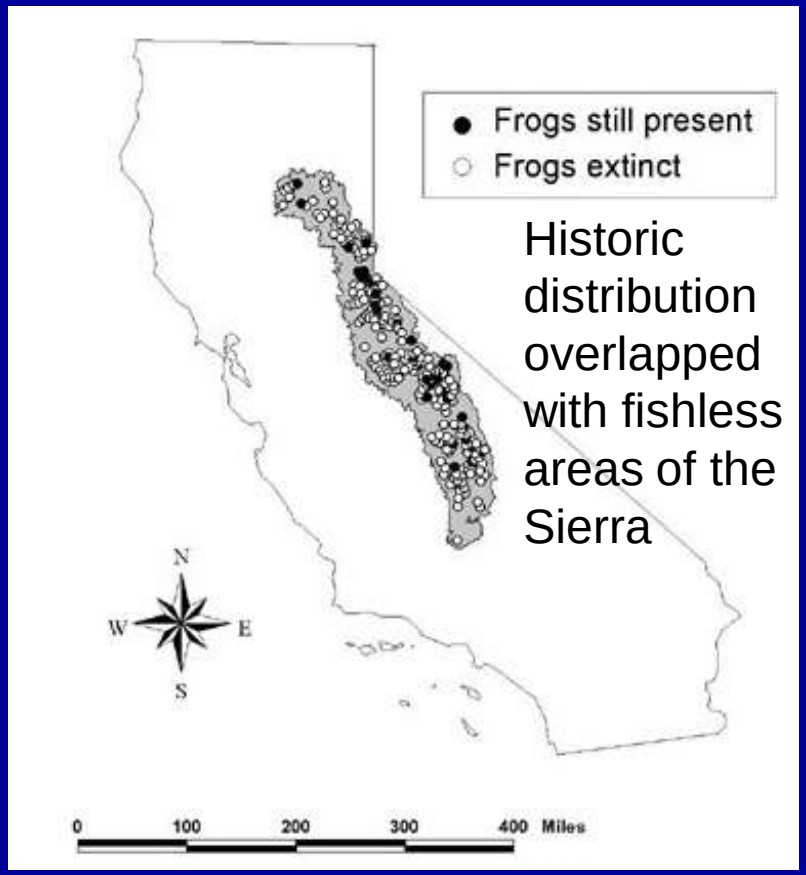
Current distribution



Adapted from Jennings and Hayes 1994

- Grinnell & Storer (1924) called it the most common vertebrate in the Sierra Nevada
- Many agencies--Sequoia-Kings Canyon and Yosemite National Parks, Forest Service, and Cal Fish & Game have begun restoration projects including fish removals

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Animal Life in the Yosemite - 1924

"It is a commonly repeated observation that frogs, in tadpole form at least, do not occur in lakes which are stocked with trout…but the *advent of fish in a lake sooner or later nearly or quite eliminates the frogs*…In such alpine lakes as are suited to occupancy by frogs (through the absence of fish) both adults and tadpoles are usually present"

From *Animal Life in the Yosemite* - an early work on the wildlife of the Sierras - by Grinnell and Storer, 1924

Trout in Sierra Nevada Lakes

- Most lakes were naturally fishless—exception Lahontan cutthroat trout
- As a result of stocking, >80% of lakes larger than 1 hectare now have exotic trout
- National Park Service terminated fish stocking in California parks
- Current controversy--Cal Fish & Game fish stocking lawsuit

Sierra Nevada Research Center

Tom Stienstra - Outdoors

"Trout War" continues over fish planting

Tom Stienstra

Thursday, December 11, 2008

Lake managers fired a blast of their own this week in California's "Trout War," the fight over planting rainbow trout in lakes and streams to provide fishing - and whether or not those plants harm anything.

IMAGES

View Larger Image

TOM STIENSTRA

Four lake managers said they will defy the threat of a lawsuit from an environmental group, the Center for Biological Diversity, and announced they will keep planting trout at their respective lakes.

The four are the concessionaires at San Pablo and Lafayette reservoirs in the East Bay hills, and at Lake Amador and Collins Lake in the foothills east of the Sacramento Valley. The Department of Fish and Game was forced to halt trout stocks abruptly two weeks ago at all four of these lakes as part of a legal settlement to stop plants at 175 lakes and

Trout Plant Ban Will Have Wide Ranging Impact

By Dan Bacher

Lake Natoma, situated on the American River east of Sacramento, is one of the best habitats in California for producing huge rainbow trout. Frank Palmer of Orangevale set the California state inland lake record for rainbow trout on October 2, 2005 when he pulled a 27 lb. fish from the lake. His monster eclipsed the previous record of 23 pounds set on January 17, 2000 by 7-year-old Jeremy Brucklacher of North Highlands, also at Natoma.

The lake is a "big trout factory", due to its relatively stable water temperature, high abundance of pond smelt and other forage, and relatively light fishing pressure. Fish planted in the lake by the DFG as 10 to 14 inch catchables hold over and grow rapidly, up to 3 pounds per year.

Lake Natoma is on a hit list of about 175 California waters, including some of the Sierra Nevadas most productive trout fisheries, that will be not planted by the Department of Fish and Game until an environmental impact report (EIR) is finished by the agency, under a court order by Sacramento Superior Court Judge Patrick Marlette.

The ruling is result of a lawsuit filed in 2006 against the DFG by the Pacific Rivers Council and the Center for Biological Diversity, represented by students from the Stanford Law Clinic. The EIR process is now scheduled to be completed in January 2010.

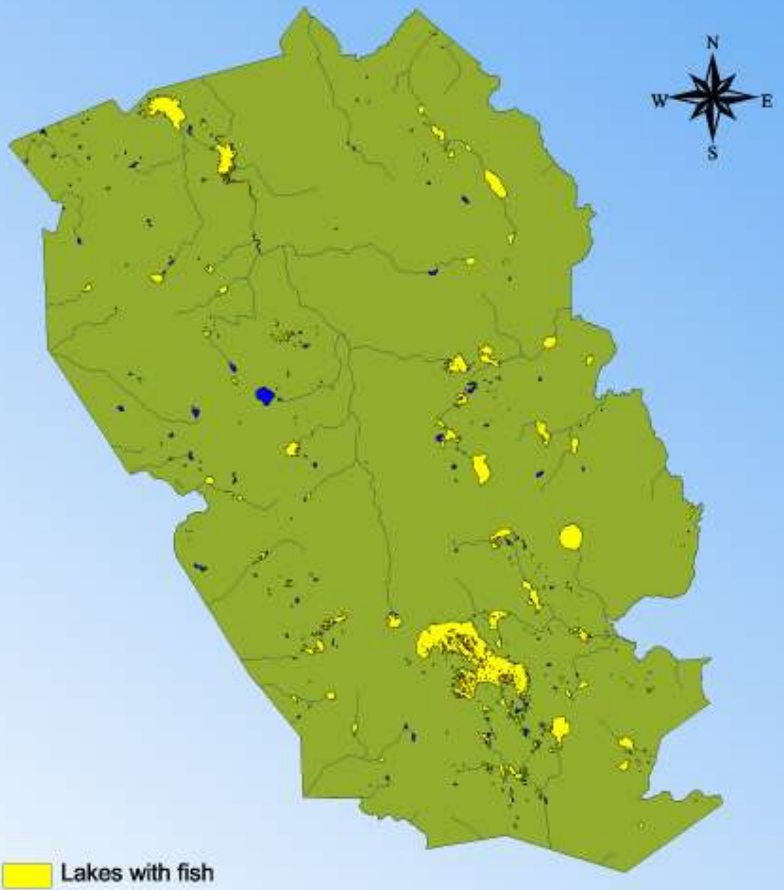
Although the list of lakes chosen for a suspension of plants has puzzled many anglers, the DFG and groups said the decision has been made under a set of parameters that they DFG and groups came to agreement on.

We didn't actually pick these lakes, said Jordan Traverso, DFG spokesperson. Rather the DFG and

U.S. Forest Service Pacific Southwest Research Station

Desolation Wilderness

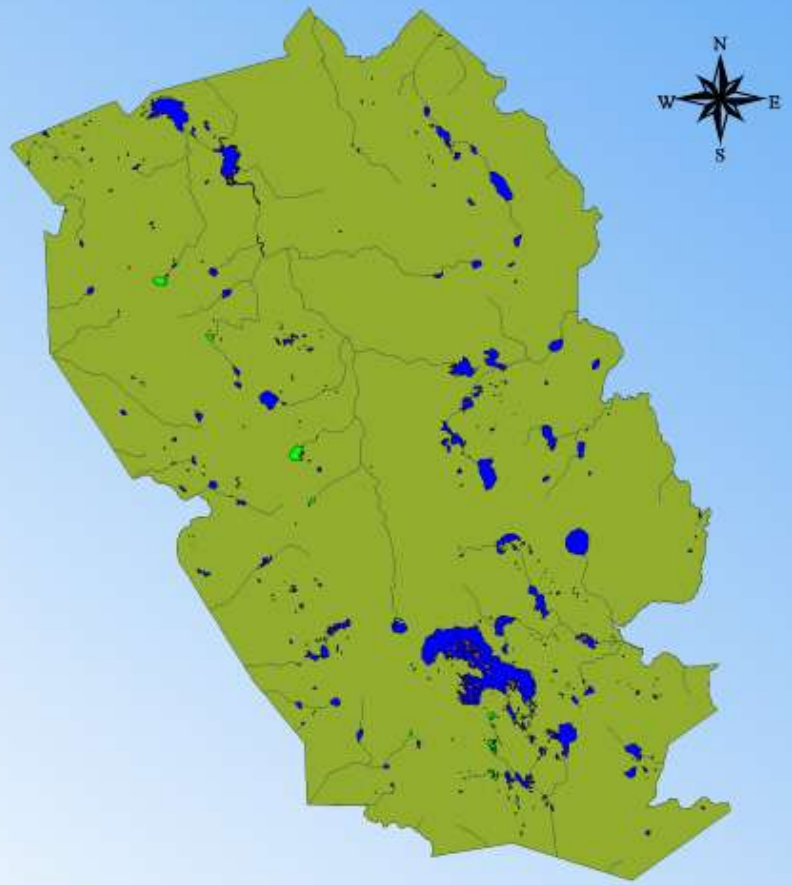
Distribution of Introduced Trout in the Desolation Wilderness



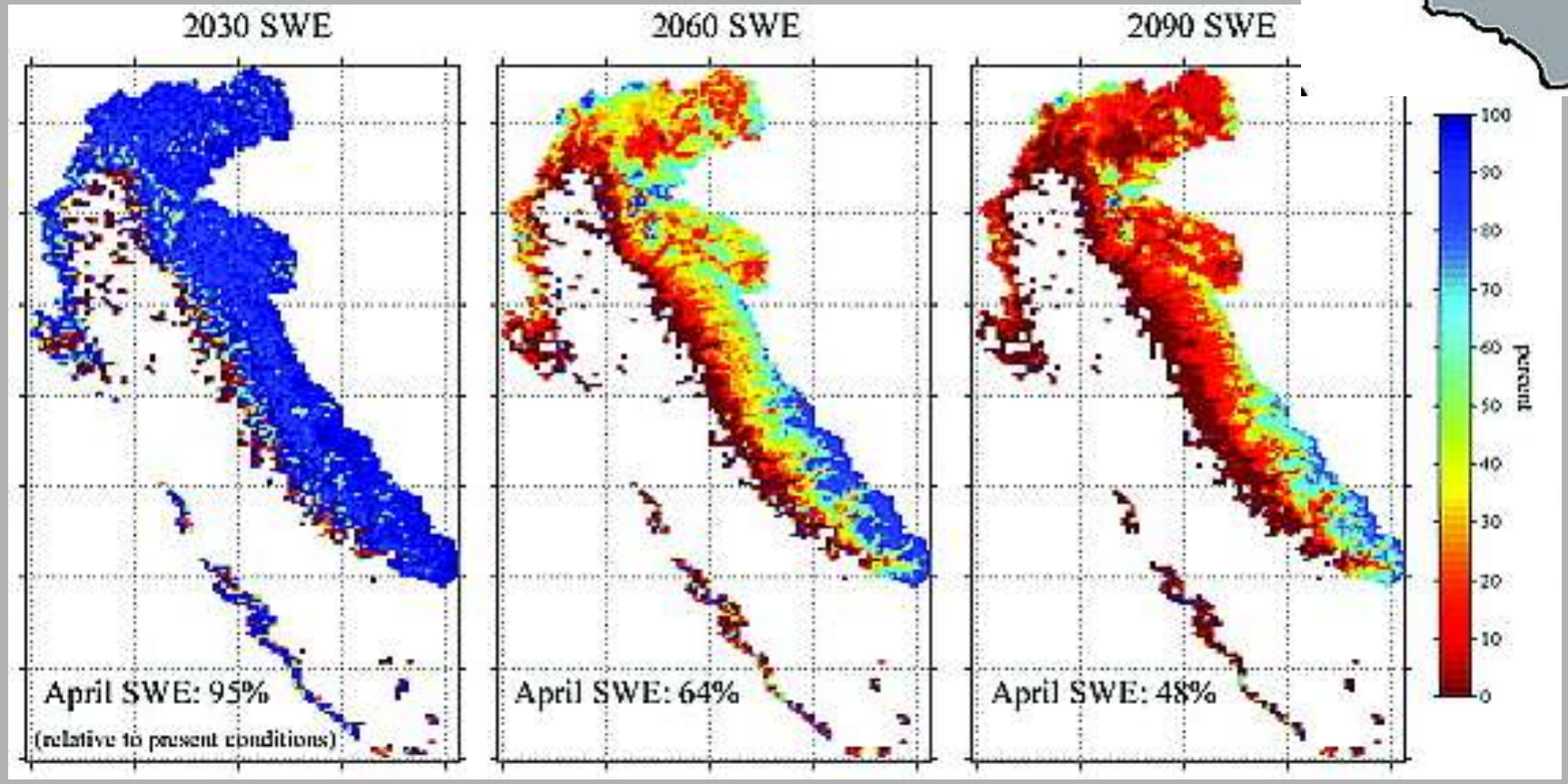
U.S. Forest Service Pacific Southwest Research Station

Desolation Wilderness

Distribution of Mountain Yellow-legged Frogs in the Desolation Wilderness



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.

What can we do about climate change? Millar—5 R strategy

Reduce

Resist

Resilience

Respond

tRiage

Sierra Nevada yellow-legged frog & high mountain lakes: ensure this important ecosystem is resilient to climate change

Are Sierra yellow-legged frogs currently resilient to climate warming?

- Population declines
- Reduced distribution
- Chytrid fungus
- Widespread trout introductions

How might climate change impact frogs?

- Less snowpack & water availability
- Higher summer temperatures
- More vulnerable to disease
- Interact with other stressors—climate change & introduced trout?

The Ecosystem: High Sierra Lakes

- >10,000 lakes & ponds above 2500 m, most in Wilderness
- Small (<10 ha), shallow (<10 m), and clear (oligotrophic)
- Summer water may persist or not dependent on snowpack
- Most (99%) historically fishless
  - Invertebrates, frogs, snakes
  - Most lakes > 1 ha stocked with non-native trout

METHODS

Study site: Dusy Basin, Kings Canyon NP

- Location:

  37°5’40” N, 118°33’45” W

  Elevation: 3470 m

- Surveyed frogs, mapped lakes using GPS

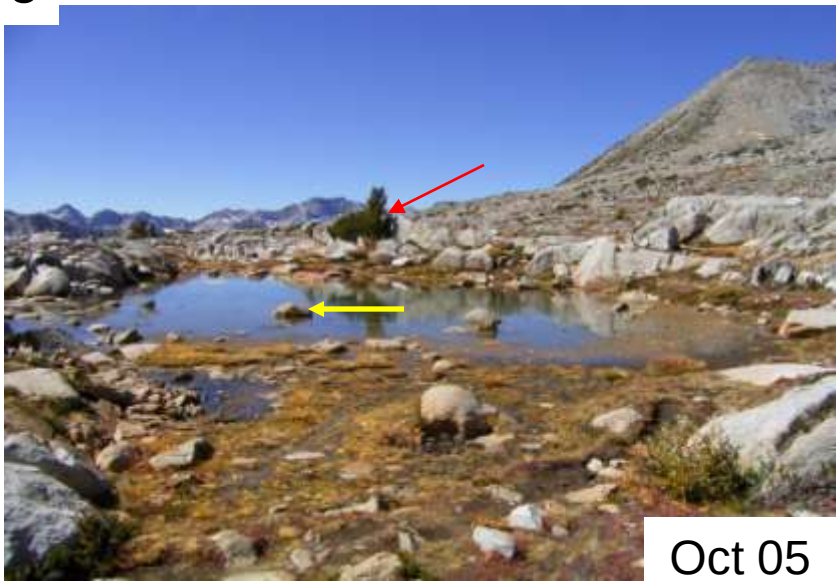
Snowpack and lake levels vary year to year

July 98

Lake 5

July 03

Sept 02



Oct 05

Does snowpack and lake level affect recruitment?

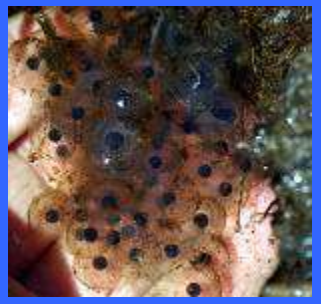
Rana sierrae life cycle

Froglet/Tailed Frog

Subadult/
Recent
Metamorph

Adult

Legged Tadpoles



Eggs

Tadpoles

Tadpole phase lasts 3-4 years and requires perennial water

Herpetological Conservation and Biology 3(2):211-223.
Submitted: 1 December 2007; Accepted: 26 July 2008.

INTERACTION OF AN INTRODUCED PREDATOR WITH FUTURE EFFECTS OF CLIMATE CHANGE IN THE RECRUITMENT DYNAMICS OF THE IMPERILED SIERRA NEVADA YELLOW-LEGGED FROG (*RANA SIERRAE*)

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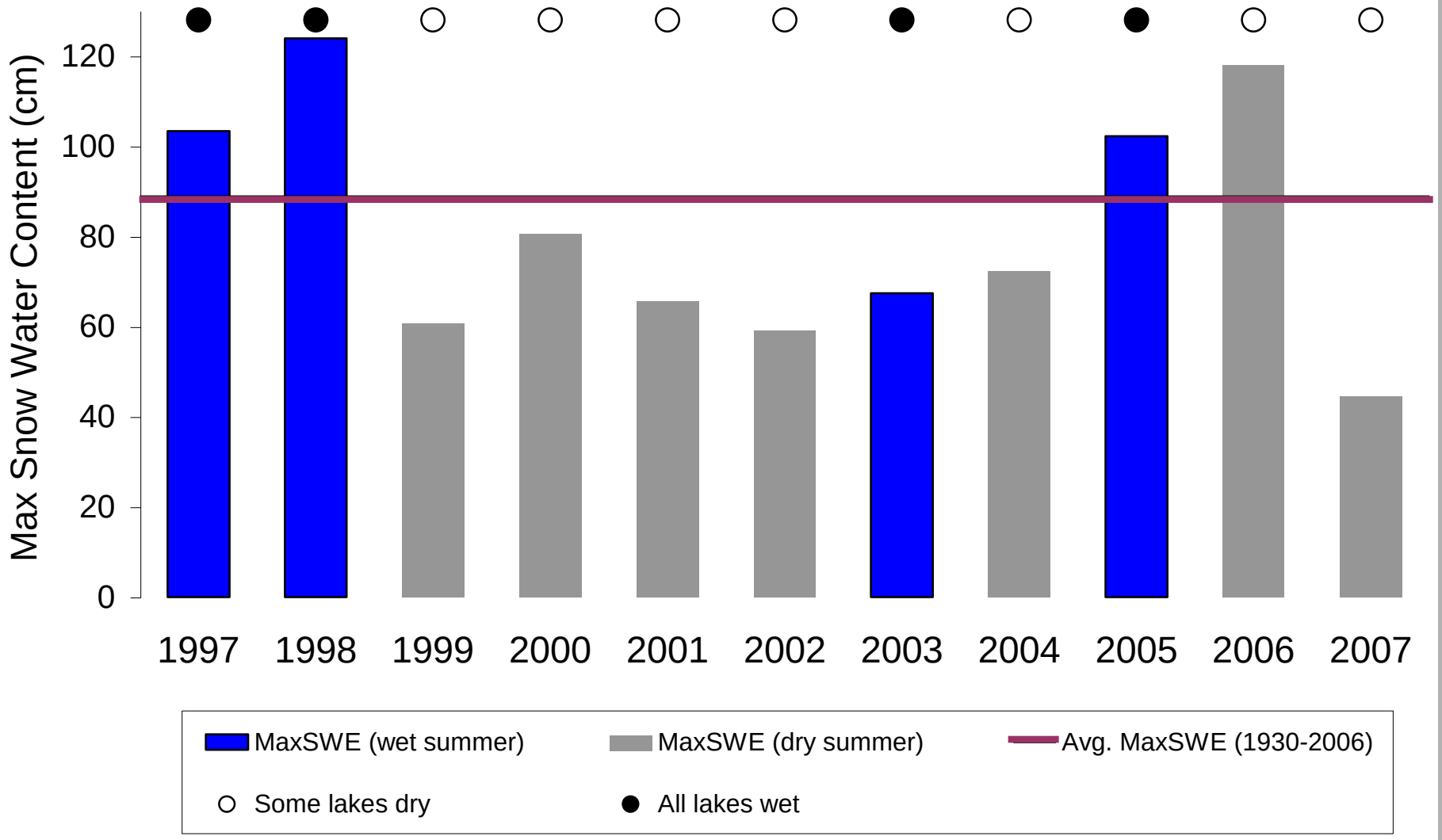
Abstract.—**Between-year variation in snowpack (from 20 to 200% of average) and summer rainfall cause large fluctuations in volume of small lakes in the higher elevation (> 3000 m) Sierra Nevada, which are important habitat for the imperiled Sierra Nevada Yellow-legged Frog, *Rana sierrae*. Climate change (global warming) is predicted to increase these fluctuations, potentially leading to more frequent summer lake drying of shallow, fishless ponds where most *R. sierrae* breeding and larval development (requiring ≥ 3 years) occurs today. This study explored the interaction between water availability and the abundance and recruitment of *R. sierrae* in Dusy Basin, Kings Canyon National Park, California, USA. We mapped the Dusy Basin lakes with GPS, calculated water volumes in a low-snowpack and a high-snowpack year (2002, 2003), and counted *R. sierrae*. The lakes that dried up in 2002 were repopulated by adults in 2003, without any recruitment of metamorphosed frogs from previous year's tadpoles. The lakes that retained water, even with notable volume decreases (-60%), showed tadpole-to-subadult recruitment in the following year (2003). Similar results are obtained using data for years 1997-2006: significantly greater abundance of metamorphs in permanently wet lakes than in lakes that had dried even once during the 10 years. Similarly, those lakes that had retained water during any two preceding years had significantly more metamorphs than lakes that had dried up during that period. Our results suggest that any increase in drying of small ponds will severely reduce frog recruitment. Combined with the invasive fish that prevent frog breeding in larger lakes, lake drying may cause extinction of local frog populations.**

Key Words.—climate change; global warming; habitat; precipitation, *Rana muscosa*; *Rana sierrae*, Sierra Nevada; water

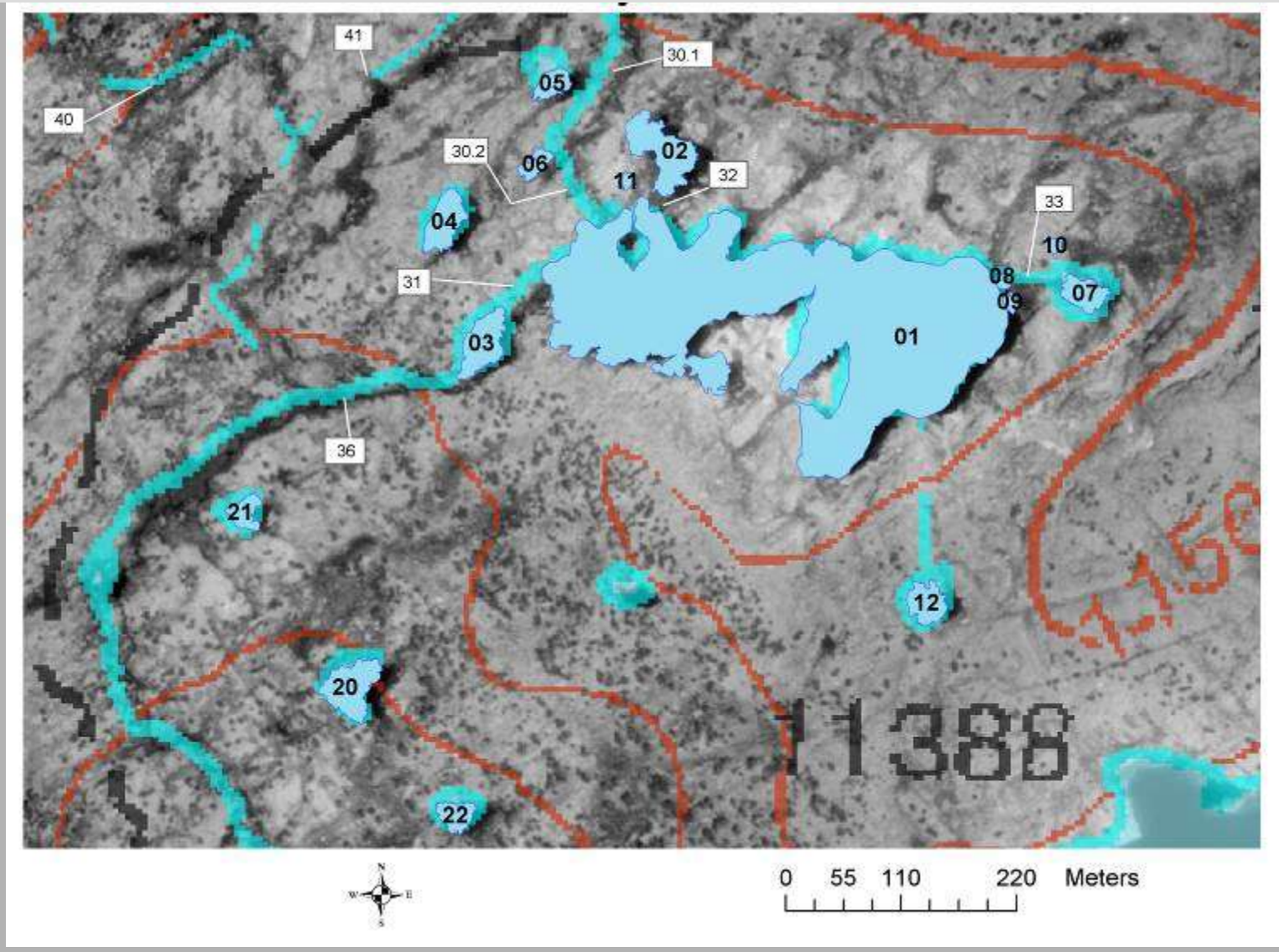
INTRODUCTION

Variability in Snowpack

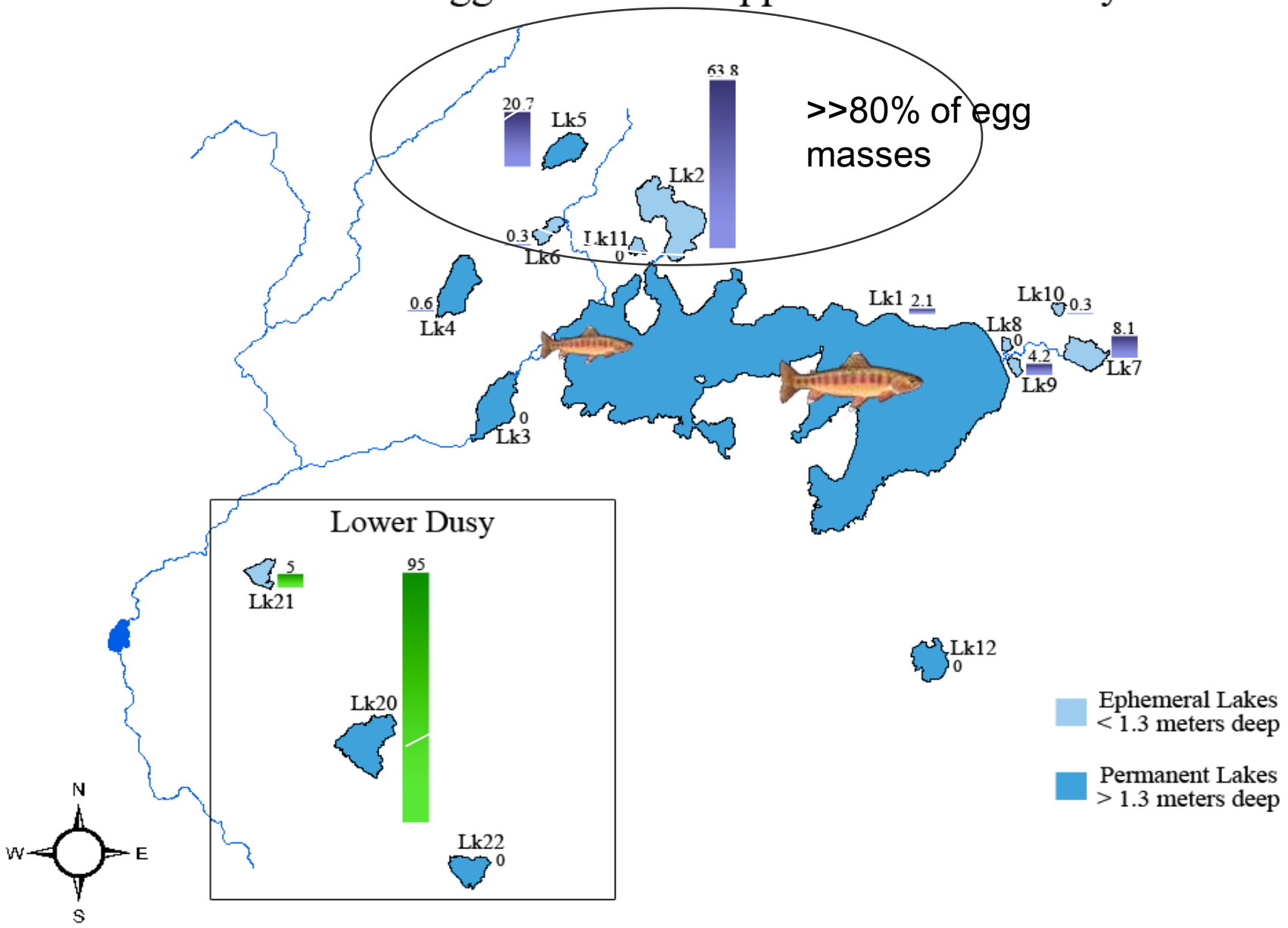


METHODS

Dusy Basin – small, high-elevation lakes



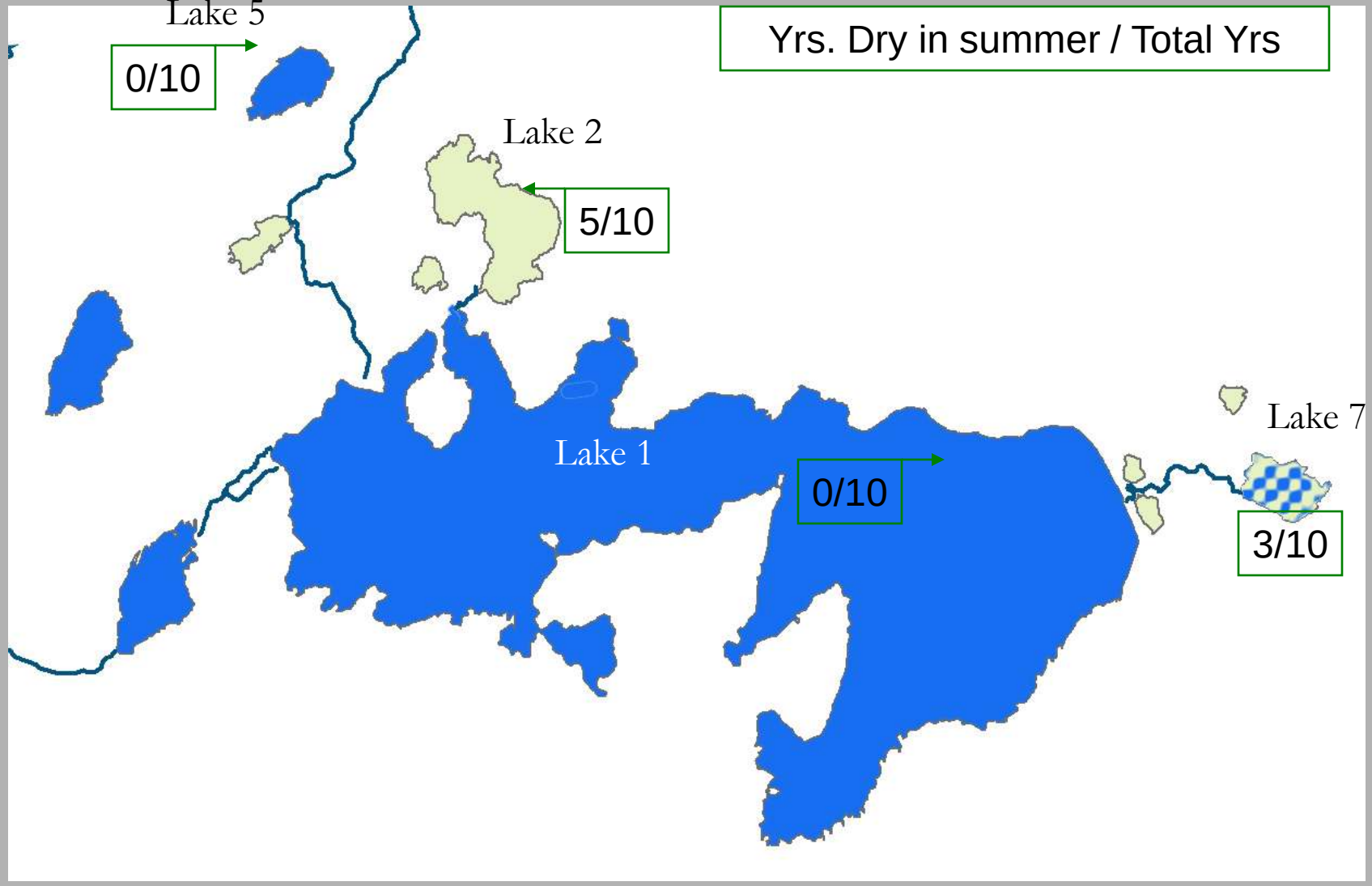
Percent of Total Egg Masses for Upper and Lower Dusy Basin




September 15, 2008 Main breeding lake dry
Lake perimeter July 2008

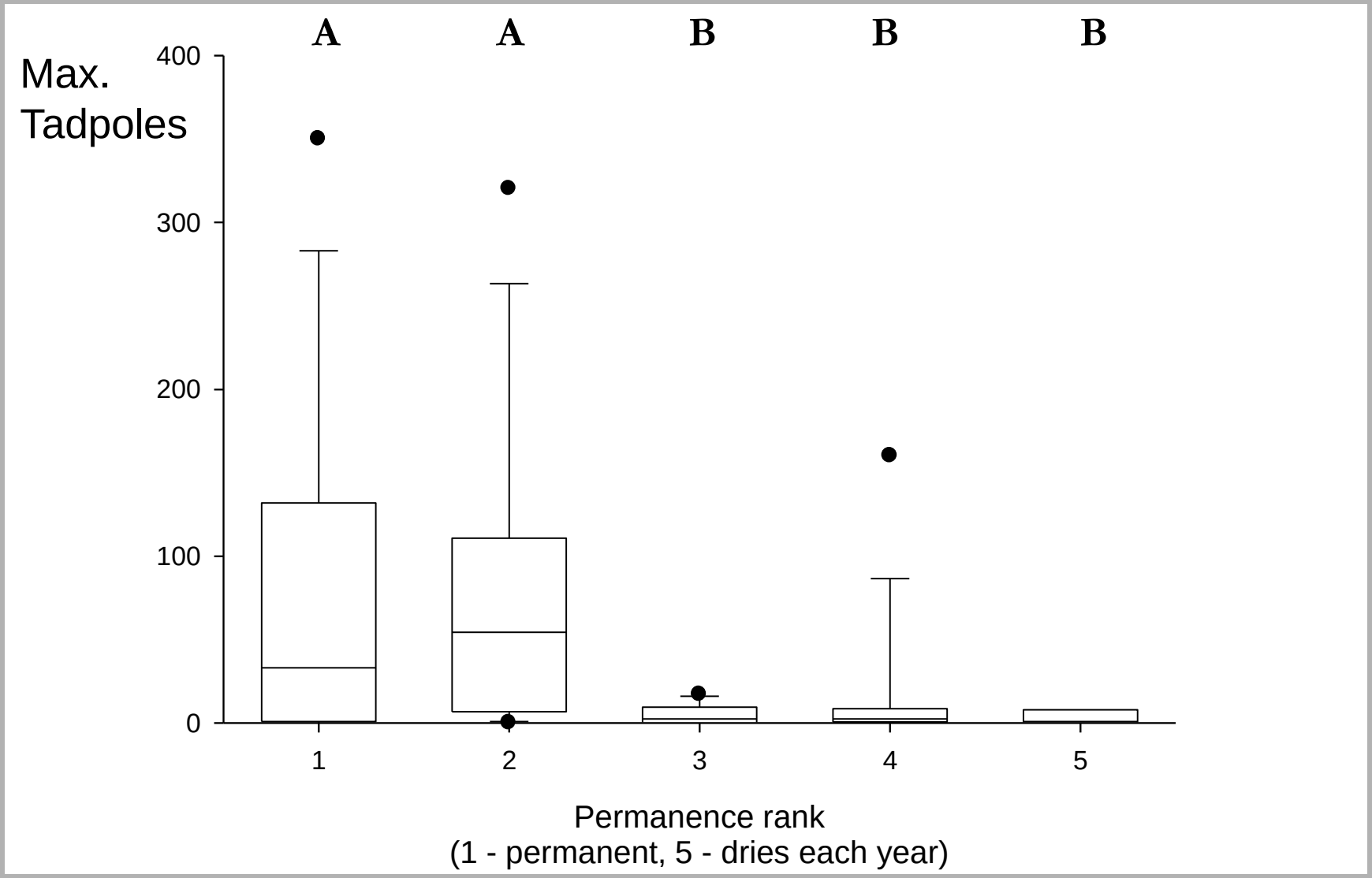
RESULTS

Some lakes dry up in summer



RESULTS

Lake permanence vs. tadpole counts



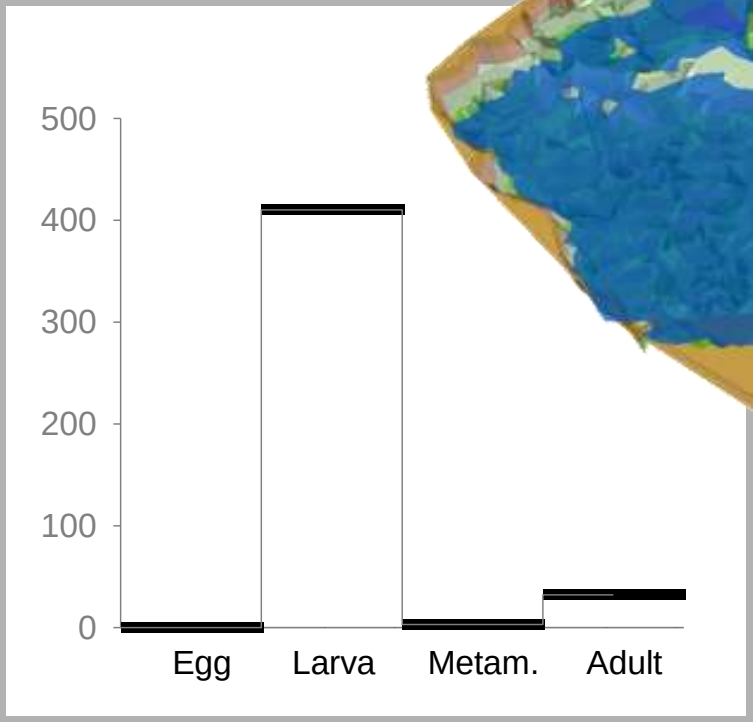
RESULTS

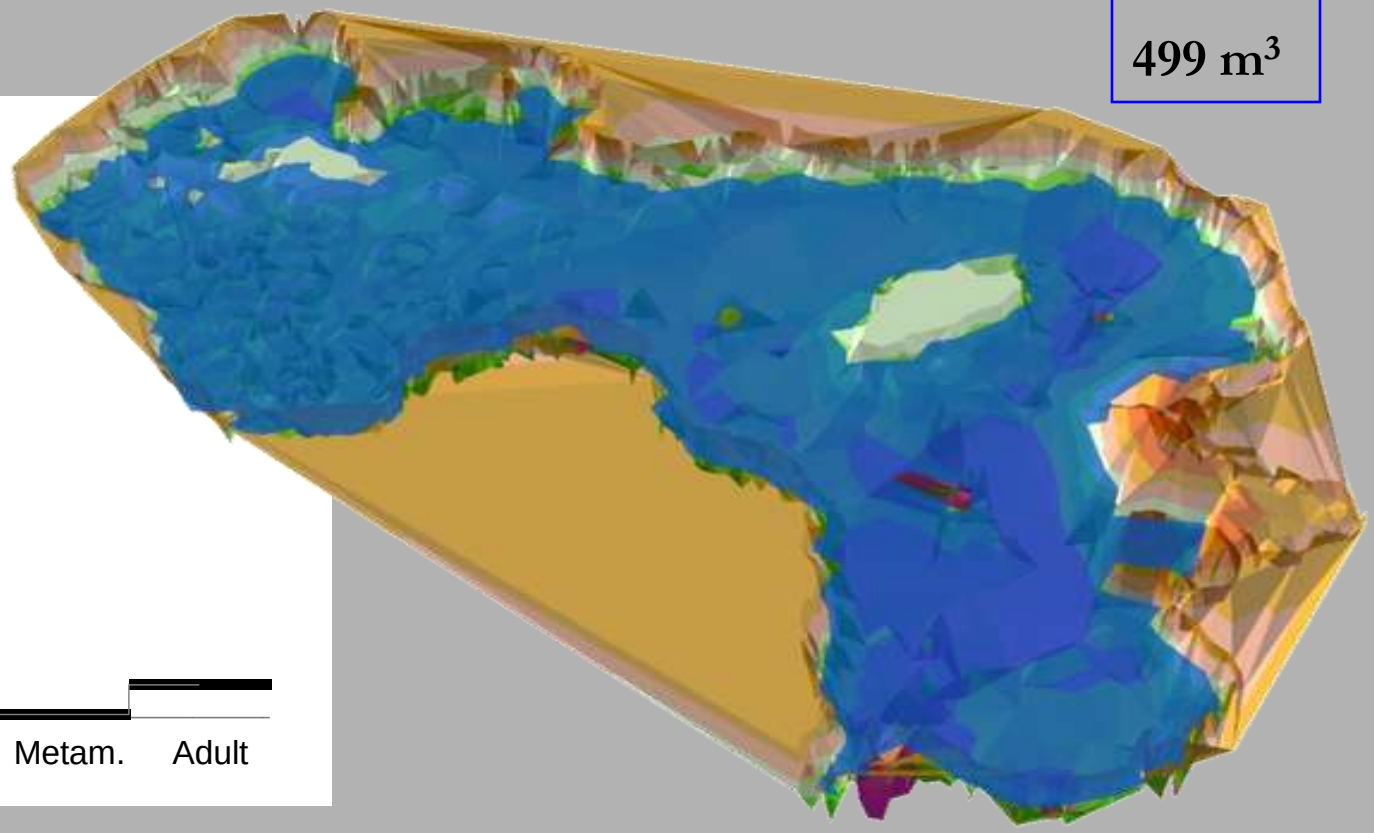
Lake 2

28 July 2002

Water Volume

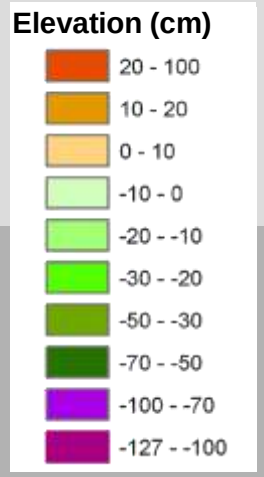
499 m^3





RESULTS

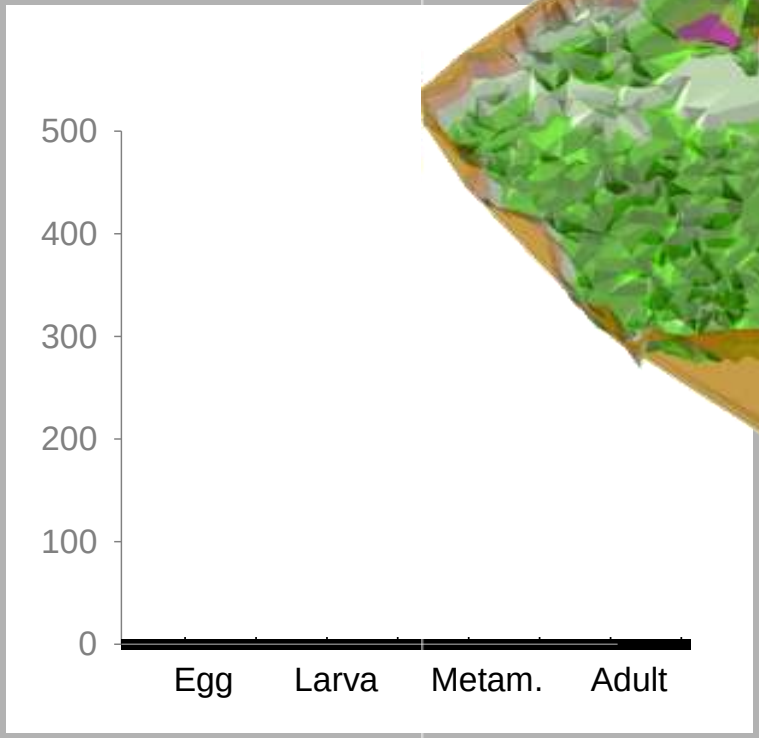
Lake 2

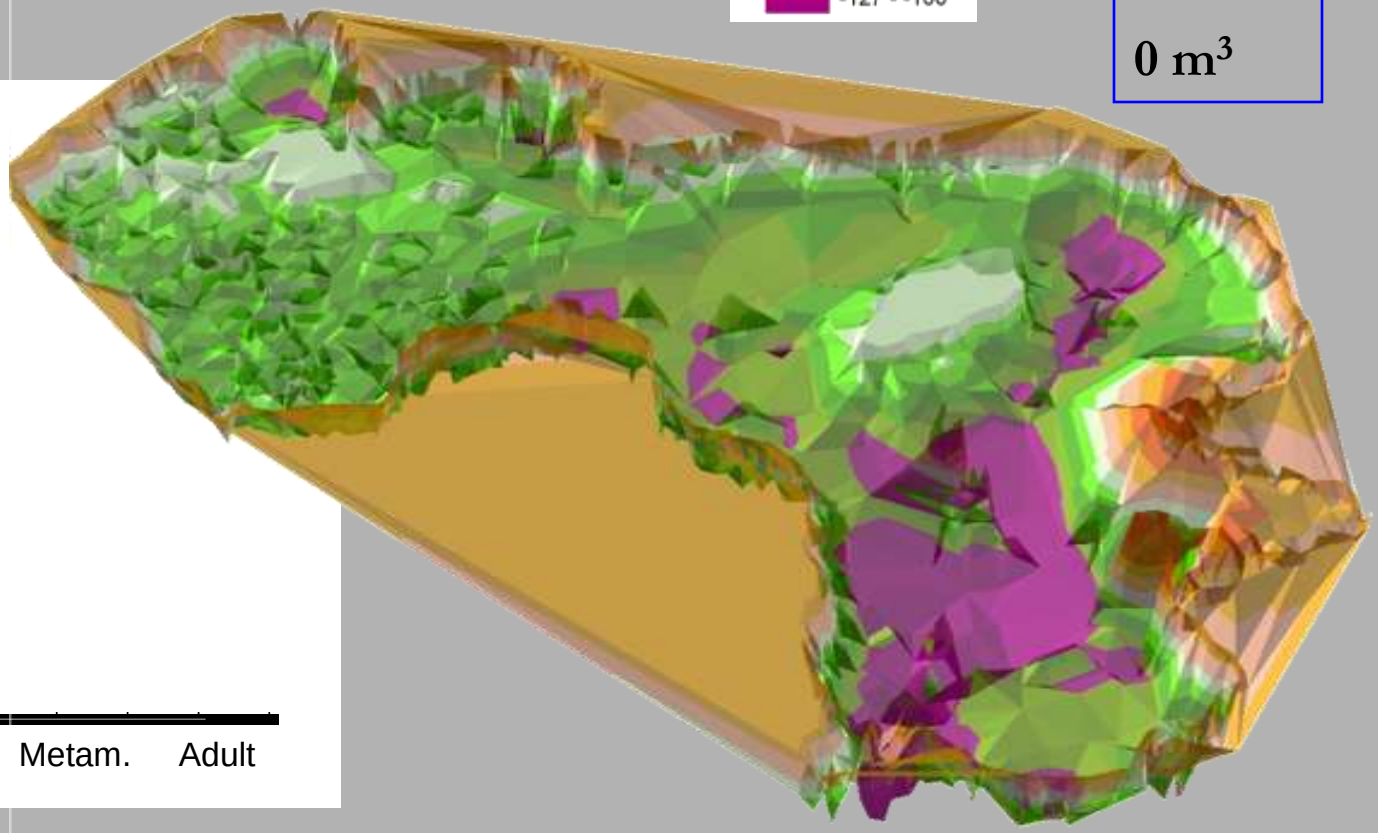


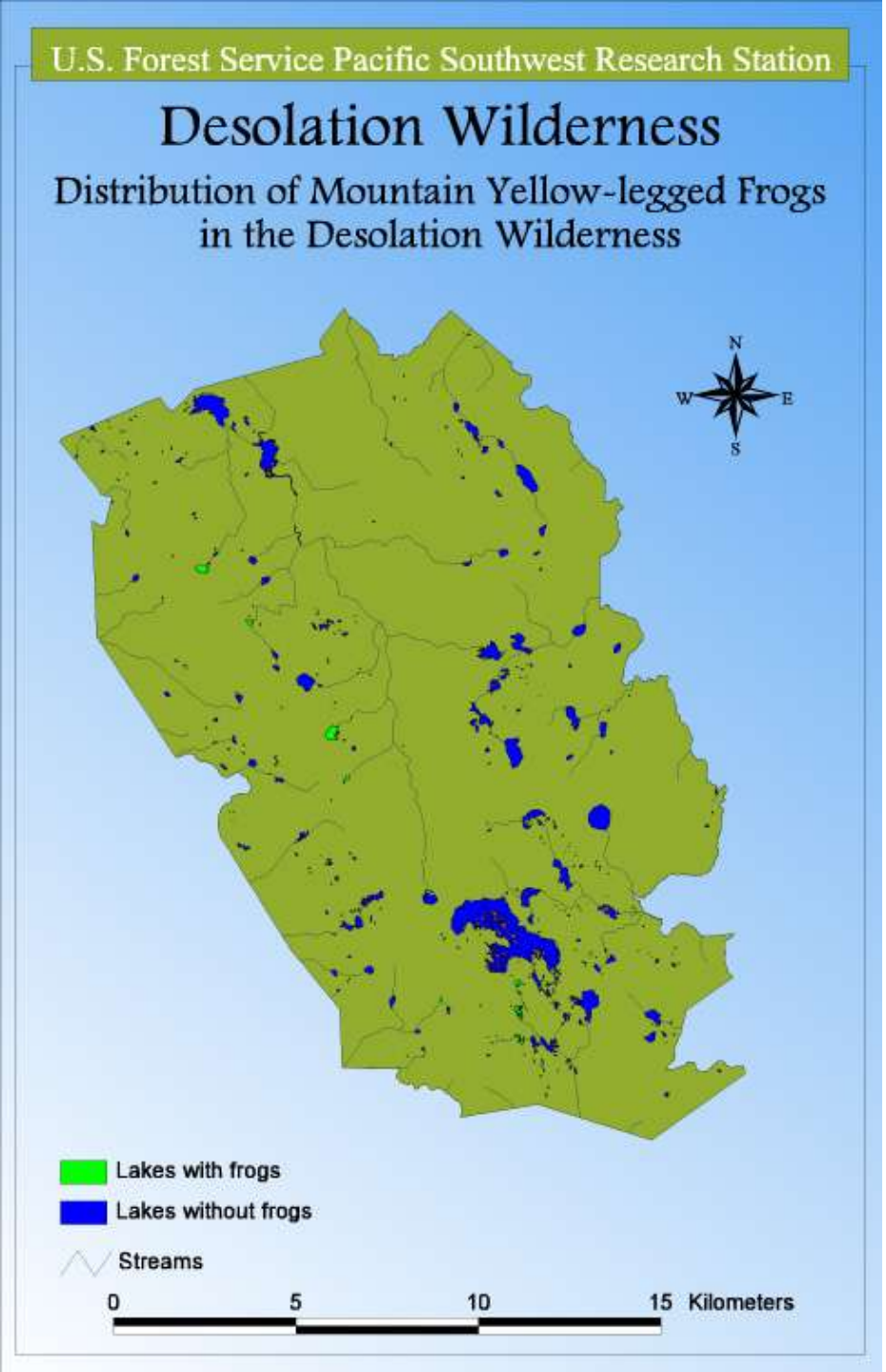
1 September 2002

Water Volume

0 m^3







The temporary “trout stocking ban” does not allow stocking trout in lakes with Sierra yellow-legged frogs.

In many basins this stocking ban would only apply to smaller lakes (where the frogs are found) and the larger lakes that frogs may need in low water years would continue to be stocked.

DISCUSSION

Interaction of climate change + trout = ?

Effects of Climate Change

- Loss of high-snowpack yrs (highest egg production)
- Increased summer drying of breeding lakes

→ **Reduced breeding success**

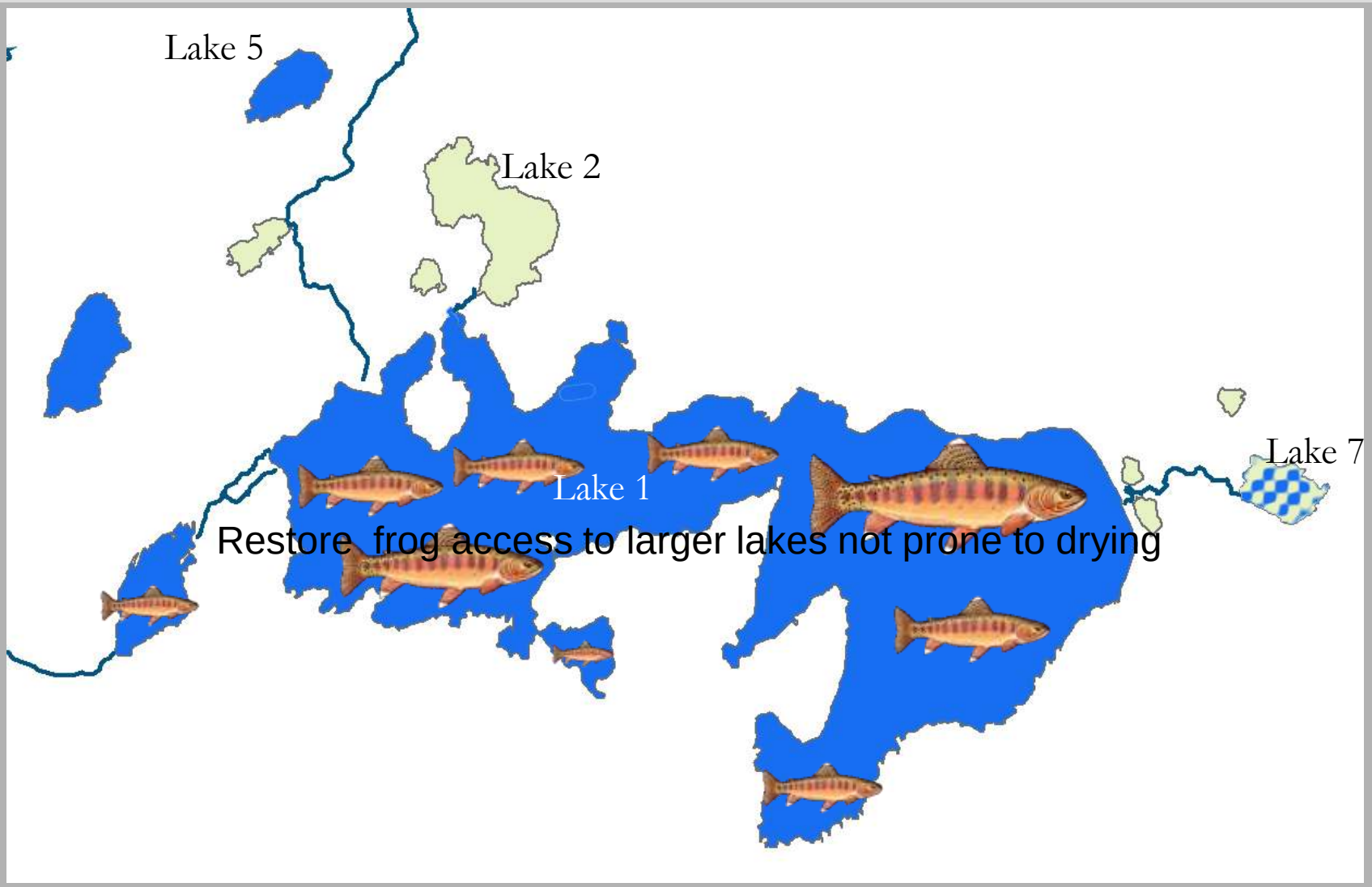
Effects of Fish predator- trout

- Breeding restricted to small, shallow lakes

→ **Limited breeding sites**

DISCUSSION

Larger lakes are no longer breeding habitats



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BIOLOGICAL CONSERVATION

Removal of nonnative fish results in population expansion of a declining amphibian (mountain yellow-legged frog, *Rana muscosa*)

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ABSTRACT

The mountain yellow-legged frog (*Rana muscosa*) was once a common inhabitant of the Sierra Nevada (California, USA), but has declined precipitously during the past century due in part to the introduction of nonnative fish into naturally fishless habitats. The objectives of the current study were to describe (1) the effect of fish removal from three lakes (located in two watersheds) on the small, remnant *R. muscosa* populations inhabiting those lakes, and (2) the initial development of metapopulation structure in each watershed as *R. muscosa* from expanding populations in fish-removal lakes dispersed to adjacent habitats. At all three fish-removal lakes, *R. muscosa* population densities increased significantly fol-

What can we do so that frogs are more resilient to climate change?

- We can't stop climate warming but we can make species more resilient to predicted changes
- Reduce impacts of one current stressor—fish stocking
- Prepare Sierra-wide restoration strategies
- Balance the needs of imperiled native species with recreational fishing
- Measures must be taken to ensure the survival of these important frogs

Sierra Nevada Research Center