Range-wide Genetics of the Foothill Yellow-Legged Frog (*Rana boylii*)

Ryan Peek *(May 31, 2018)*

UC DAVIS
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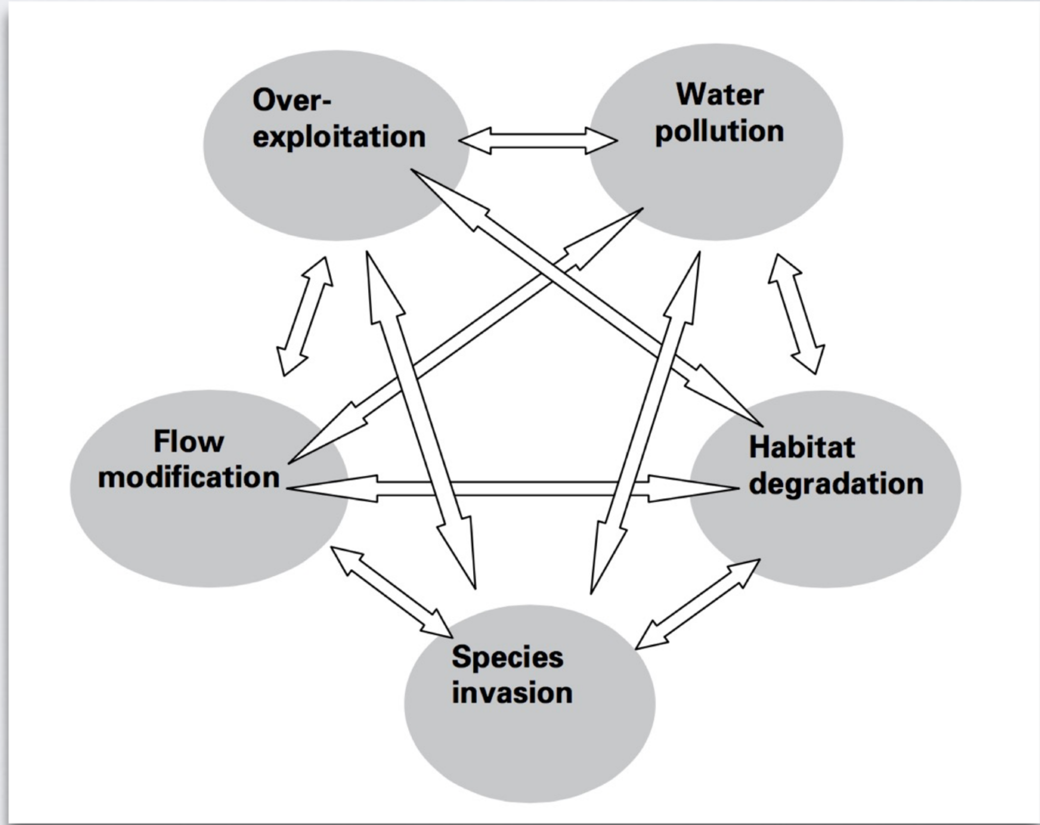
OVERVIEW

- Imperiled Freshwaters & Amphibian Declines
- *Rana boylii:* Range & Current Status
- Genetics Overview
- FYLF Rangewide Genetics: What we know

IMPERILED FRESHWATERS

- Half the world's population lives within 20 km of a permanent river *(Small and Cohen 1999)*

- Projected mean extinction rates in freshwater organisms 5x greater than terrestrial *(Ricciardi and Rasmussen 1999)*



Dudgeon et al. 2006

AMPHIBIAN DECLINES

- Uniquely link aquatic and terrestrial ecosystems
- Have persisted through the last 4 mass extinctions
- Amphibian taxon are at greatest risk of extinction *(Stuart et al. 2004)*

RANA BOYLII

- First described by Baird 1854, Zweifel 1955
- Zweifel described as distinct species (looked at 565 adults and many juveniles)
  - Max body size measured by was 73 mm (SVL)
  - Adults >=40 mm

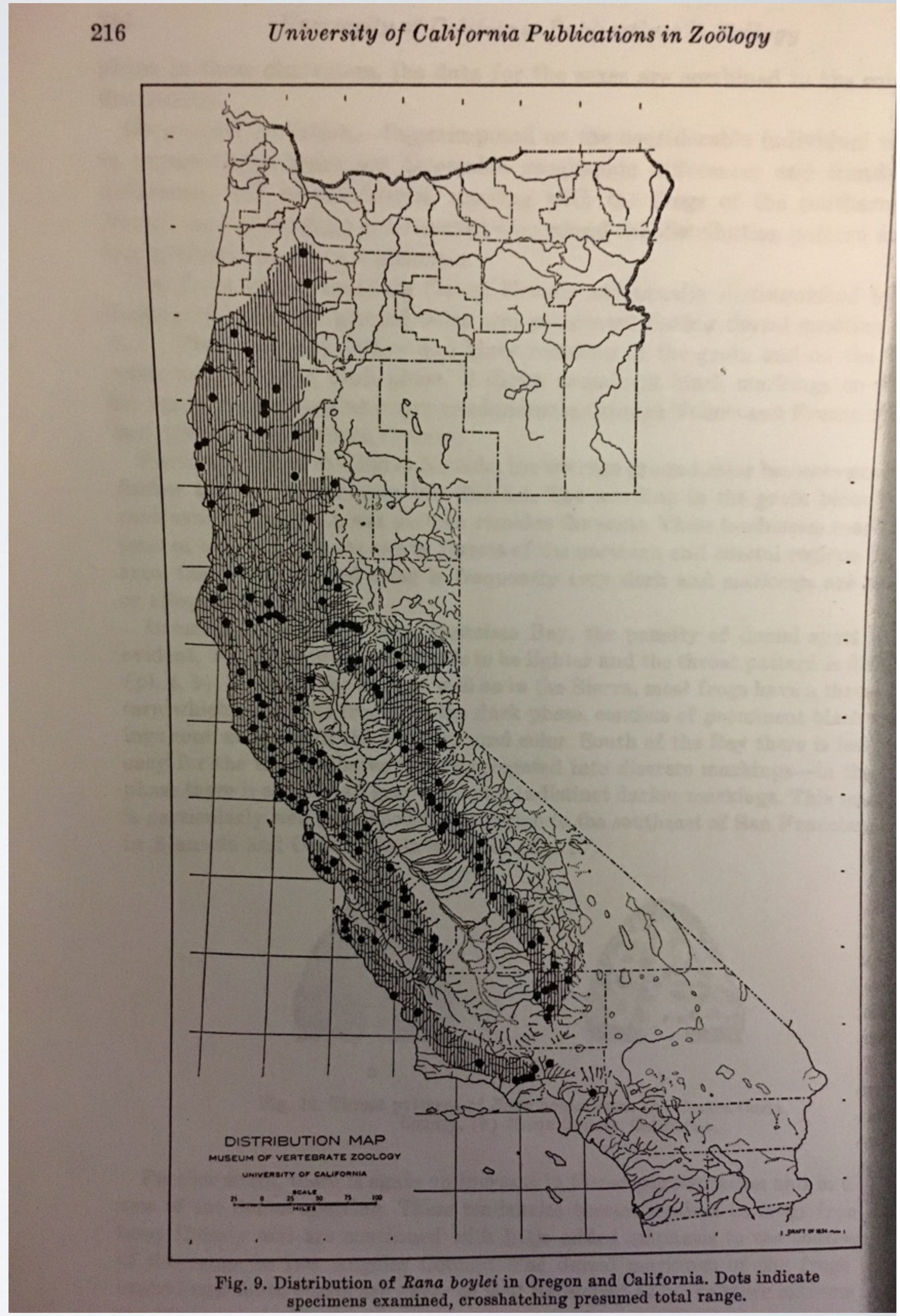
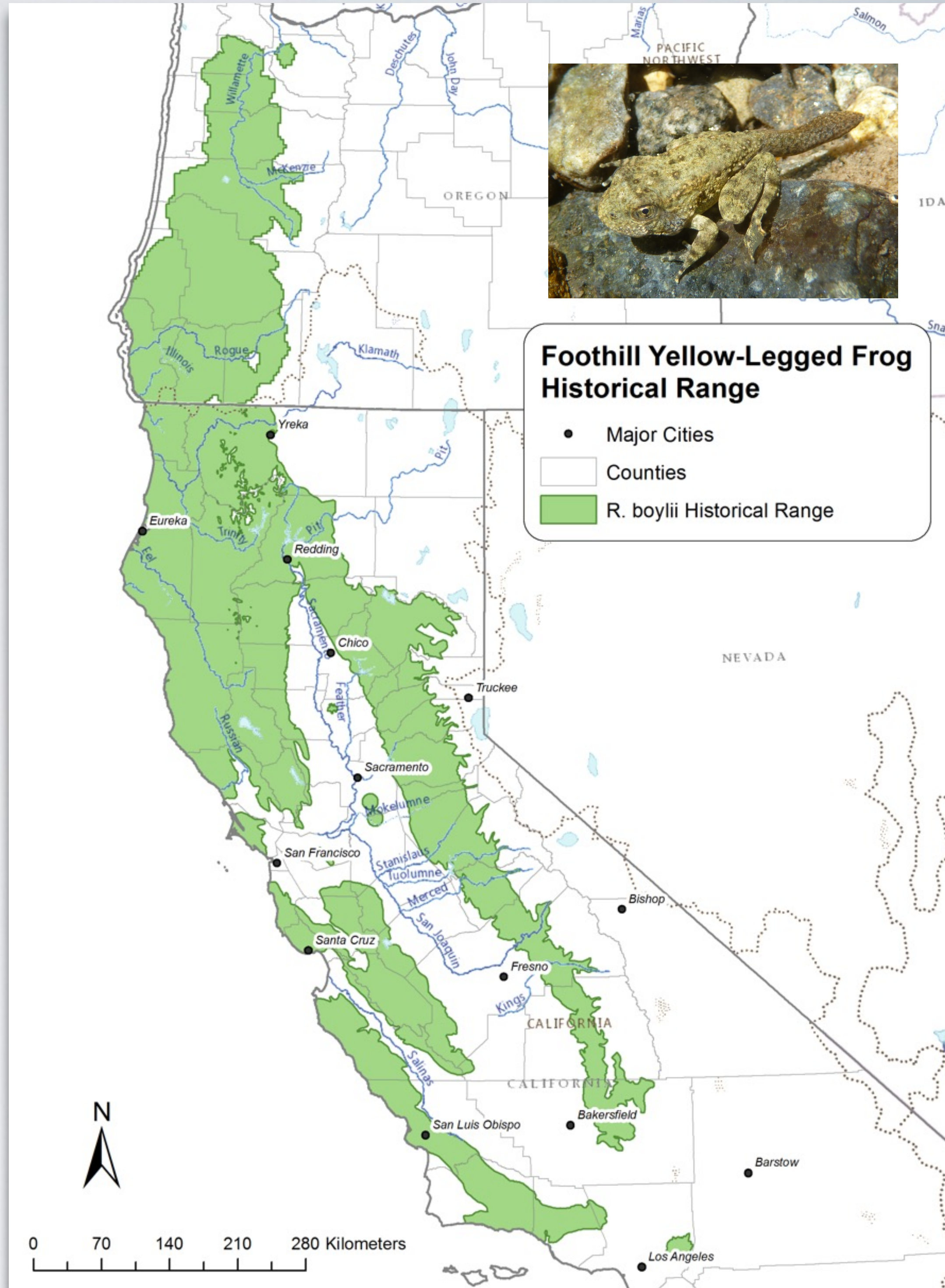


Fig. 9. Distribution of *Rana boylei* in Oregon and California. Dots indicate specimens examined, crosshatching presumed total range.

Rana boylii

(Foothill yellow-legged Frog)

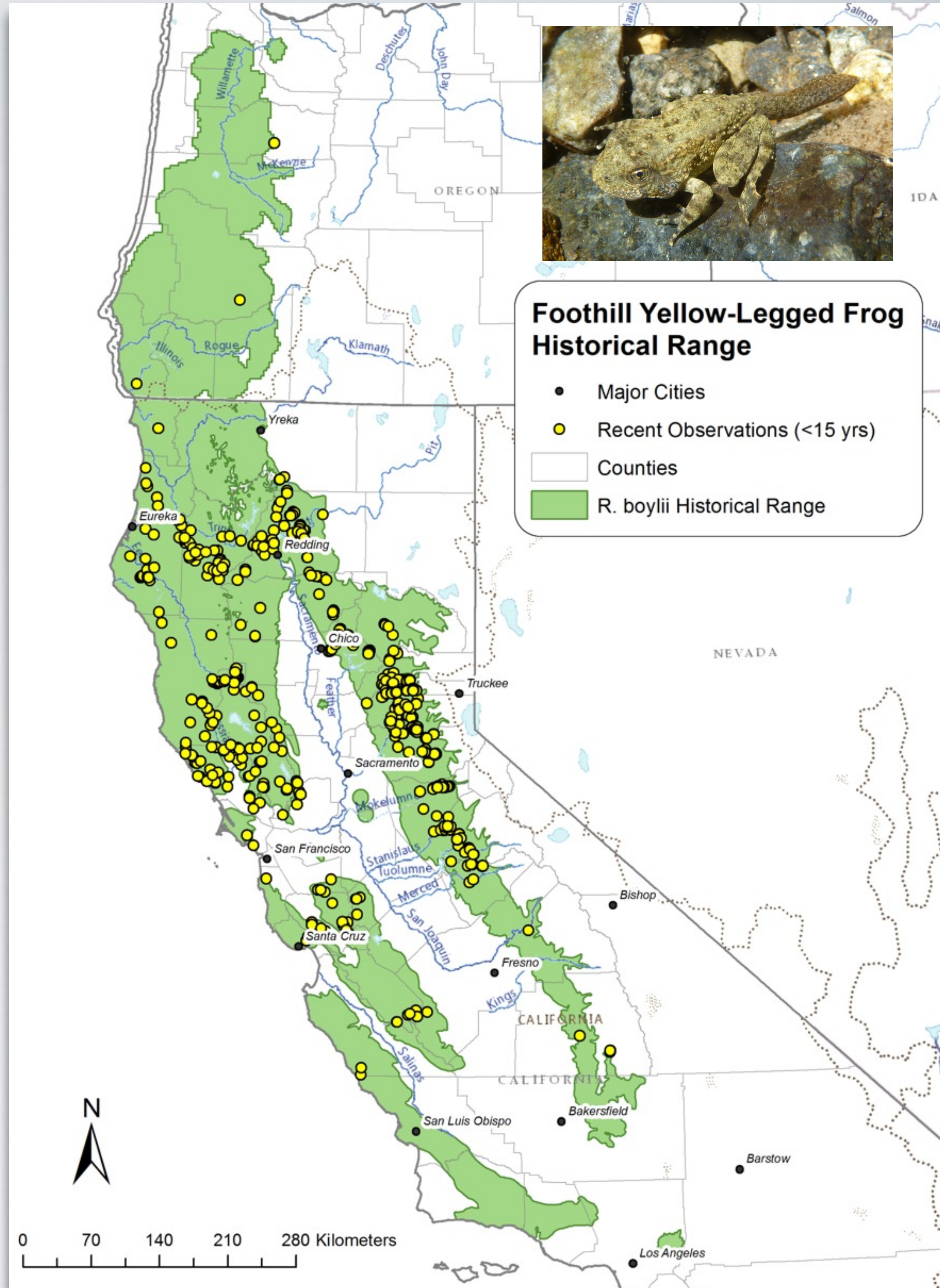
- Extant in CA and OR for ~5-8 million years *(Macey et al. 2001)*
- Obligate river breeding frog, uses wide range of habitat



Rana boylii

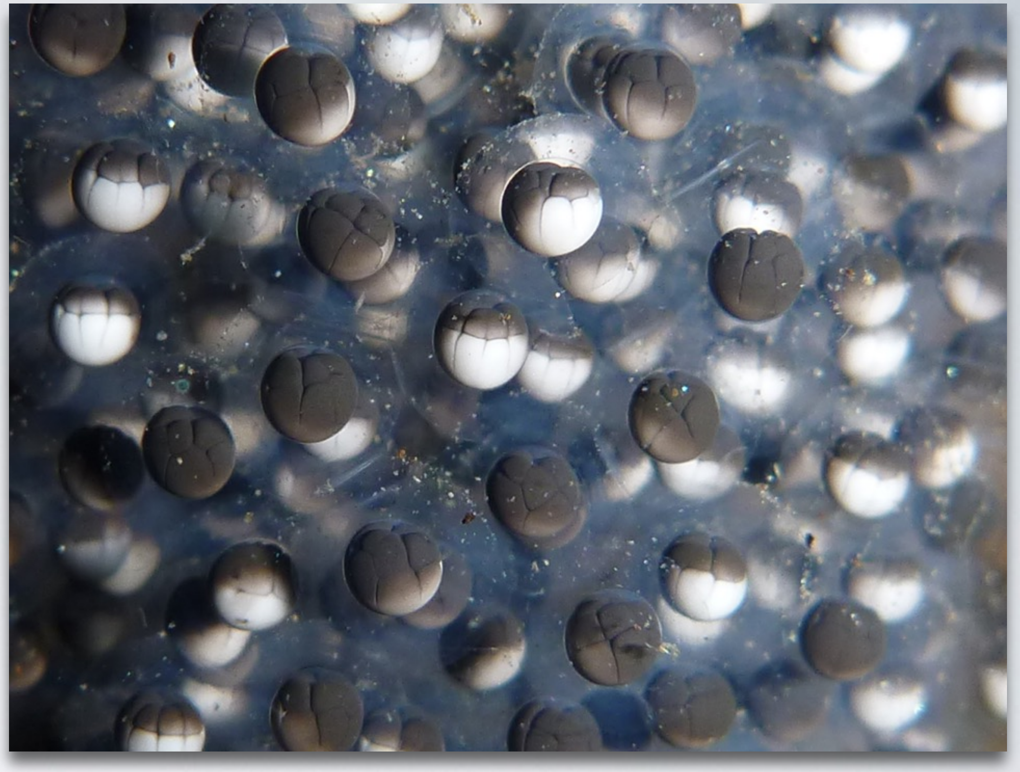
(Foothill yellow-legged Frog)

- Extant in CA and OR for ~5-8 million years *(Macey et al. 2001)*
- Obligate river breeding frog, uses wide range of habitat
- Has disappeared from over 50% of historical range *(Davidson et al. 2002)*



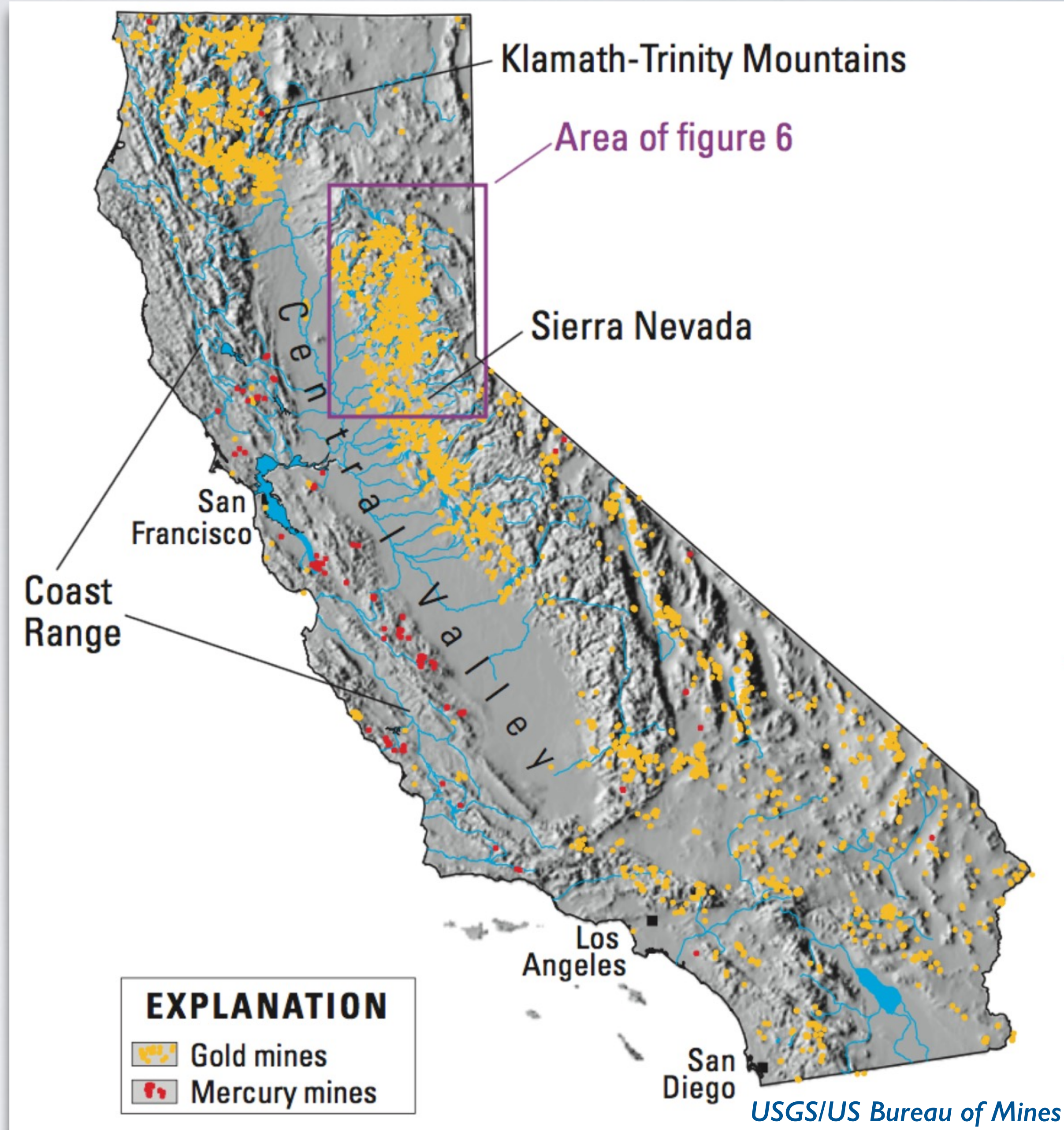
Rana boylii:
Hydrology & Breeding

- Strongly linked with temporal and regional hydrology
- Oviposition is strongly tied to local cues of receding flow rate and increasing water temperature



SIERRA NEVADA GOLD

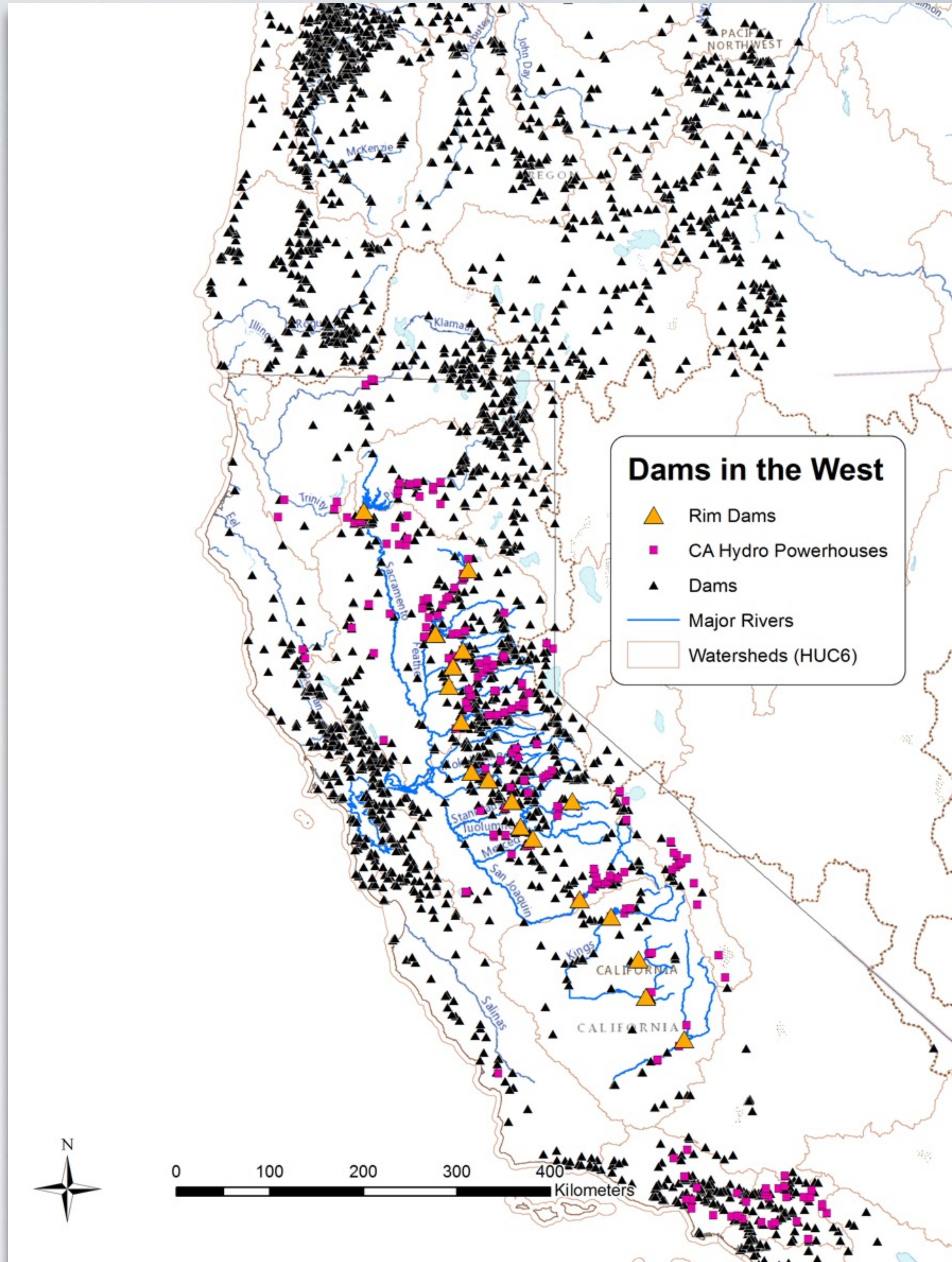
- Permanently changed the geomorphology/ecology of CA watersheds
- Estimated 8x more material excavated from Yuba/Bear/American than during construction of Panama Canal



USGS/US Bureau of Mines

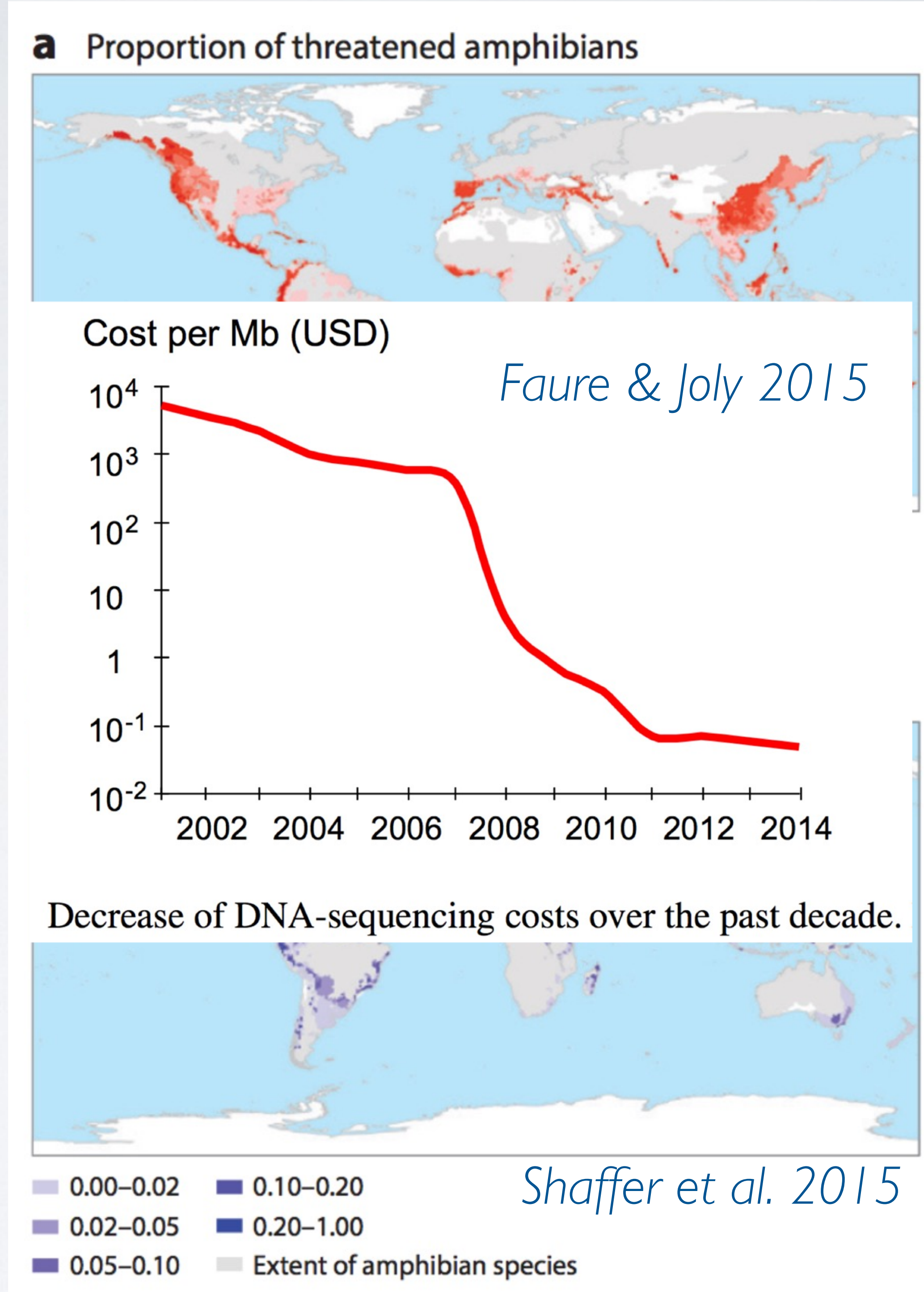
DAMMED

- Over 1,400 large dams *(NID 2007)*
- CA has more hydropower dams than any other state *(Hall 2006)*
- Residential energy demands expected to increase by 24% by 2035 *(US EIA 2010)*



Genetics as a Tool for Conservation

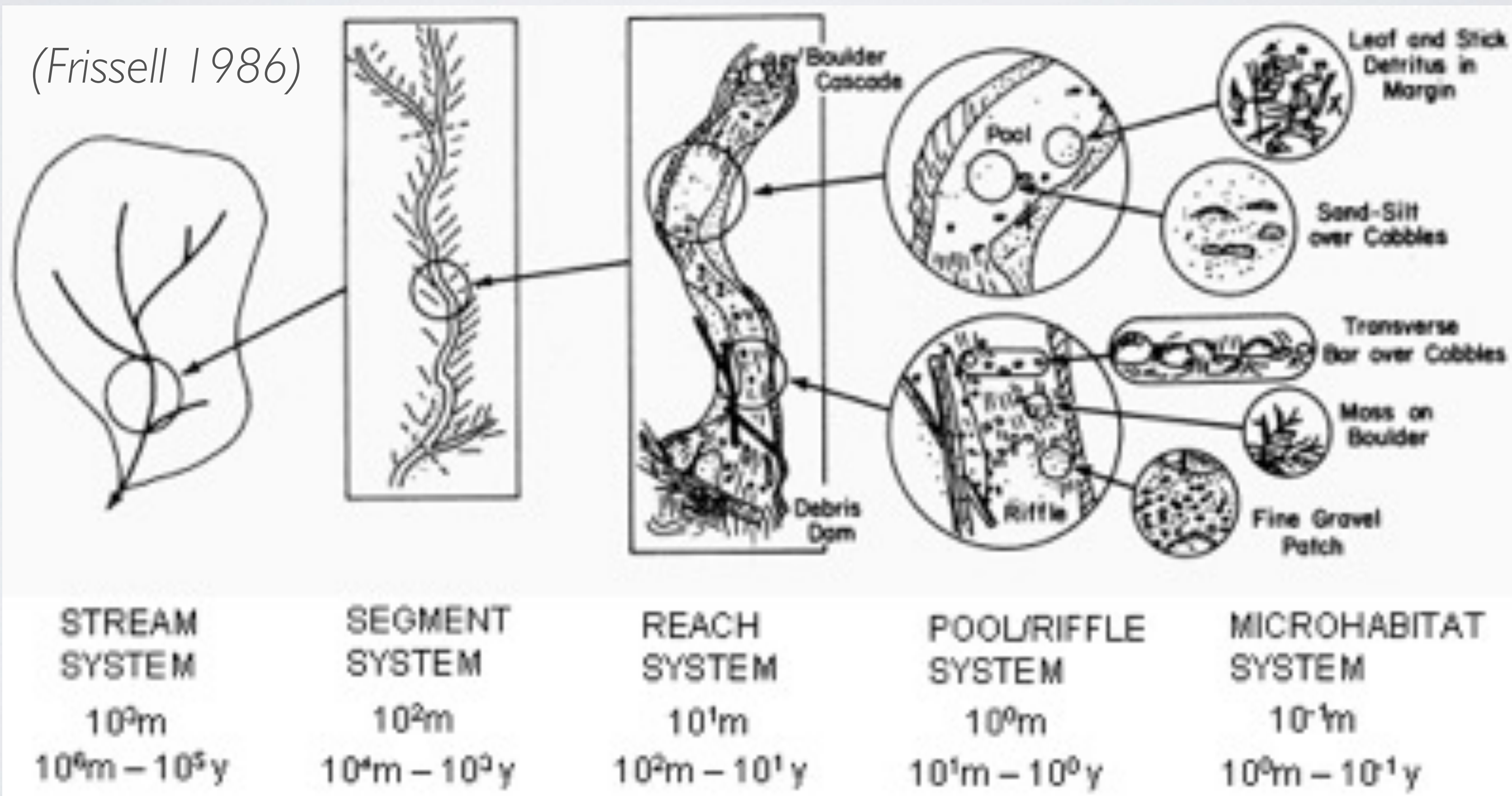
- Many species lack data & are highly cryptic and inaccessible
- New tools to obtain data (**M**assive**P**arallel**S**eqencing & eDNA)



TIMESCALES: GENETICS VS. RIVERSCAPES

- Genetic marker timescale can match riverscape scale
- Geomorphic "segment" scale is best match biologically and genetically

(Frissell 1986)



millennia → decades → months

1. PHYLOGENY

- Macey et al 2001: Used 2013 bp segment of mtDNA
- Looked at relationship of FYLF with 5 other Ranids
- Total informative sites: 401, 642 variable sites

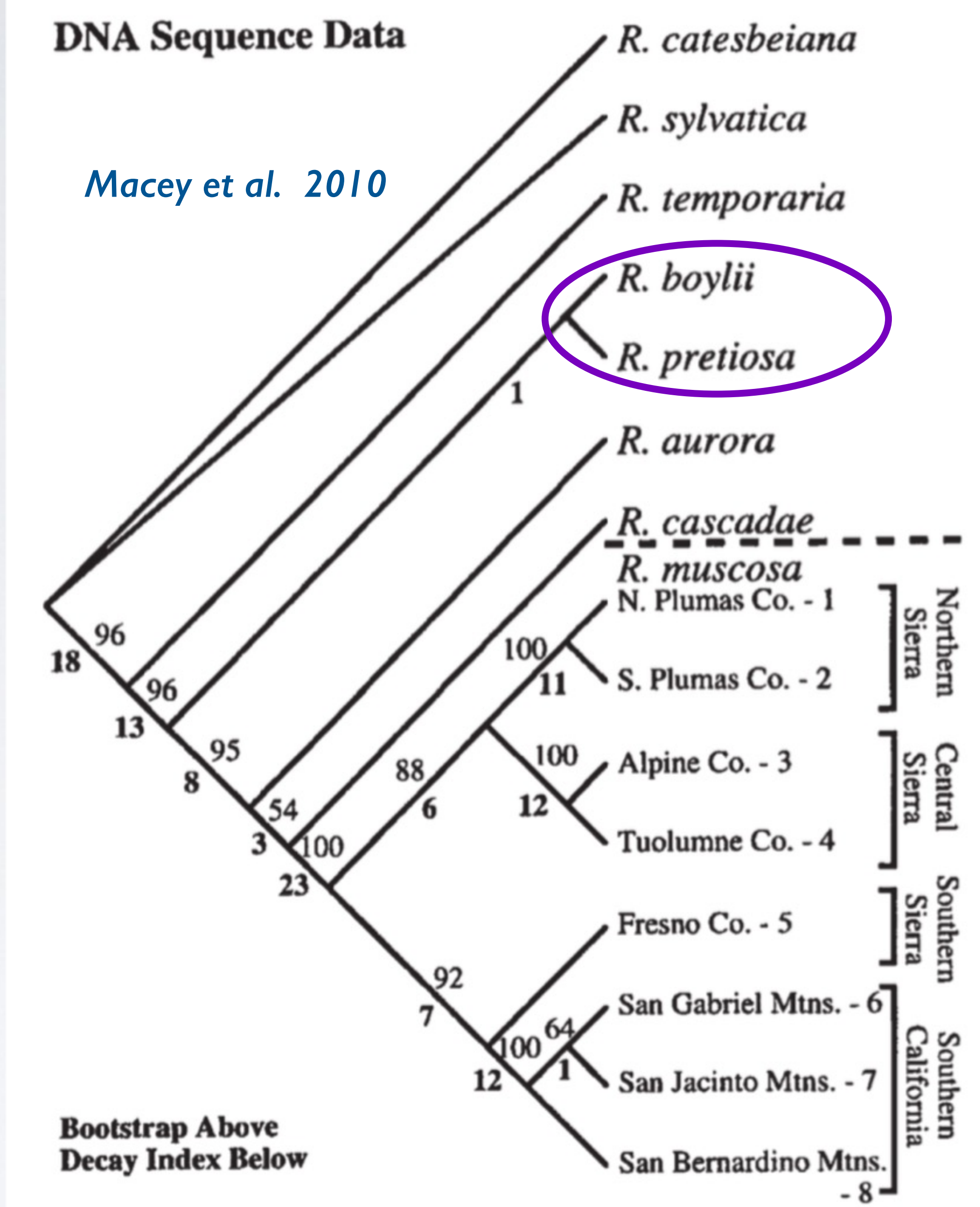
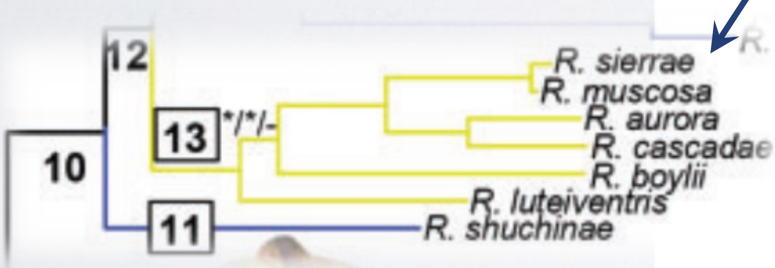


Figure 1. Single most parsimonious tree produced from analysis of the 2013 aligned (401 phylogenetically informative) positions. The tree has a length of 1240 steps. Bootstrap values are presented above branches and decay indices below branches. Note that the yellow-legged frogs, *R. boylii* and *R. muscosa*, do not form a monophyletic group.

1. PHYLOGENY

- Yuan et al 2016: 6 nuclear DNA, 3 mtDNA loci
- Similar pattern with FYLF at root



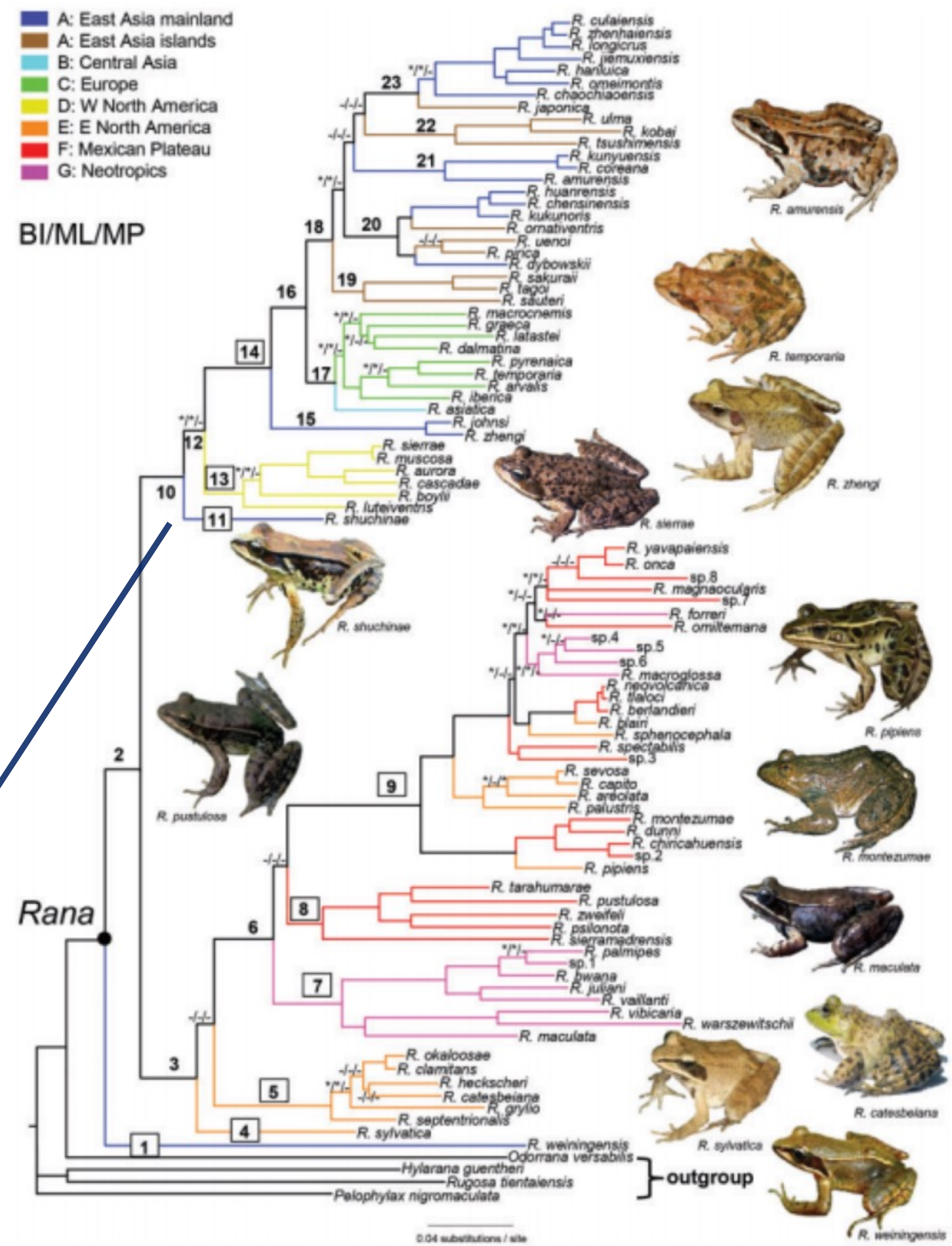
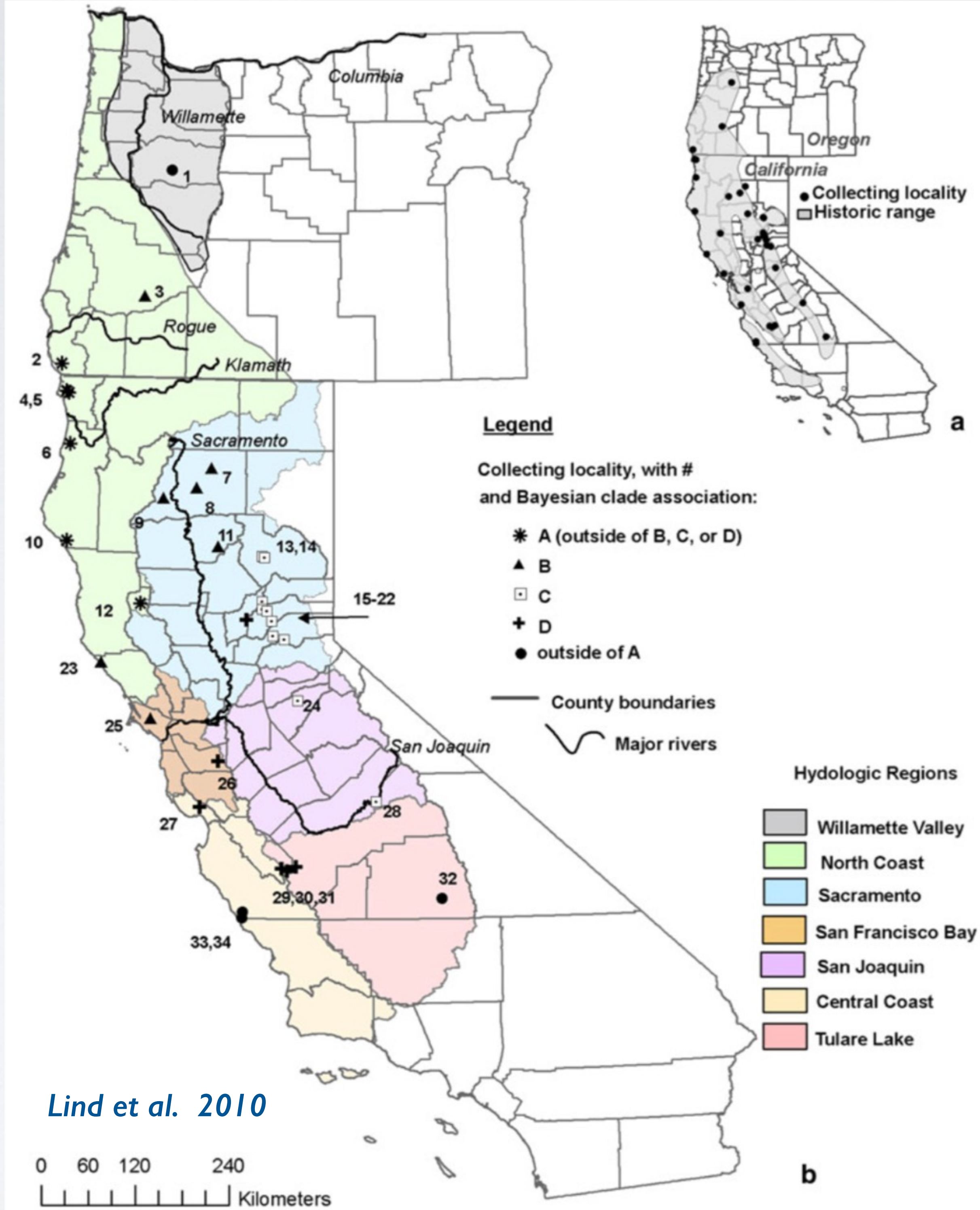


FIGURE 1. The BI tree derived from the combination of six nuDNA and three mtDNA loci. Branches without support symbols were strongly supported in all three phylogenetic analyses (BI, ML, and MP); we treated bootstrap proportions ≥70% and BPPs ≥95% as significantly supported (*). Bootstrap proportions <70% and BPPs <95% were considered weakly supported (–). Support values are shown only for branches that were weakly supported in at least one of the three analyses, in which case support values are shown in order for BI, ML, and MP analyses. Colors of branches indicate the geographic distribution of extant taxa. Numbers on branches correspond to clades discussed in this study. Numbers with a black box correspond to the nine subgenera (plus *Rana sylvatica*) referred to in Supplementary Table S2, available on Dryad. Photographs depict the morphological variation of *Rana* across clades 1, 4, 5, 7, 8, 9, 11, 13, 15, 17, and 18. Frog illustrations are used with permission from David Hillis, Hui Zhao, Todd Pierson, Andreas Noellert, and Richard Sage.

II. RANGE-WIDE GENETICS

- Previous work identified structure among major watersheds *(Lind et al. 2010)*
- Largely the basis for current status…
- Little/no information on genetic health of populations within/among watersheds



Lind et al. 2010

II. RANGE-WIDE GENETICS UPDATED

- More robust data (more loci)
- Shaffer Lab (*Melstad et al. 2018 in press*)
  - Largely supporting original Lind et al. analysis
- Peek et al (*in prep*)
  - Finer resolution
  - Feather Watershed is Unique

Population Genomics of the Foothill Yellow-Legged Frog (*Rana boylii*) and RADseq Parameter Choice for Large-Genome Organisms

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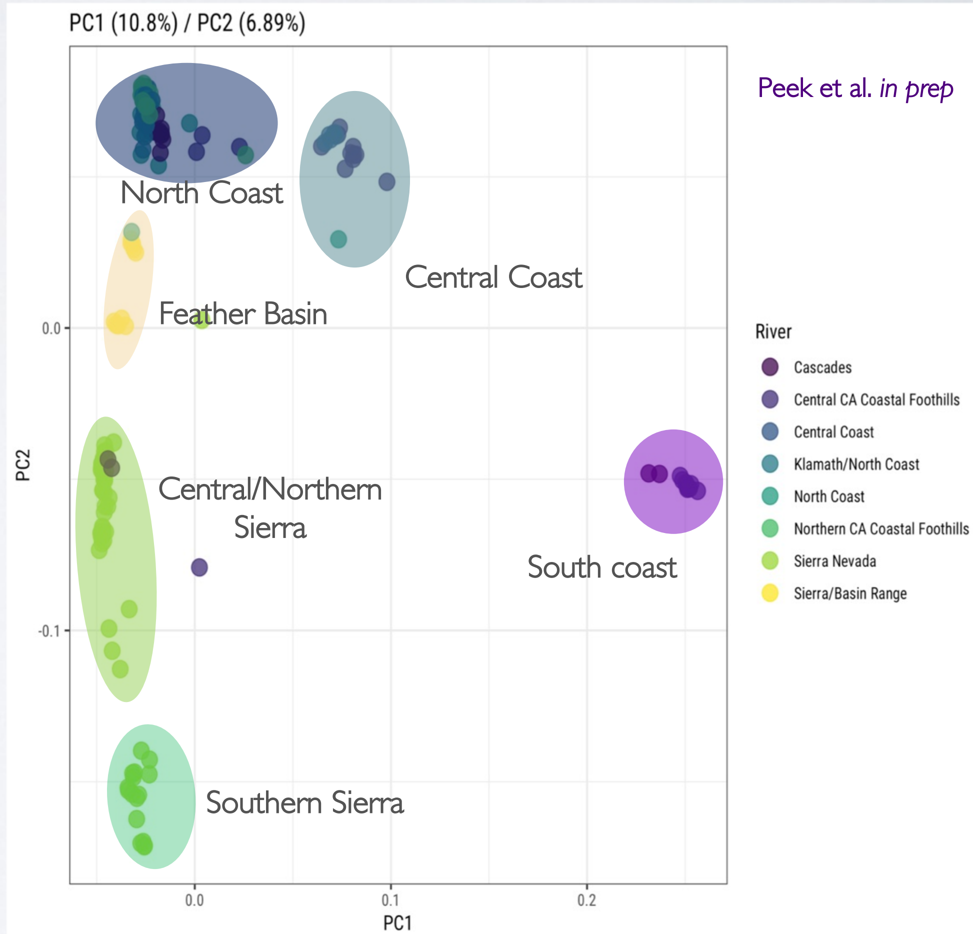
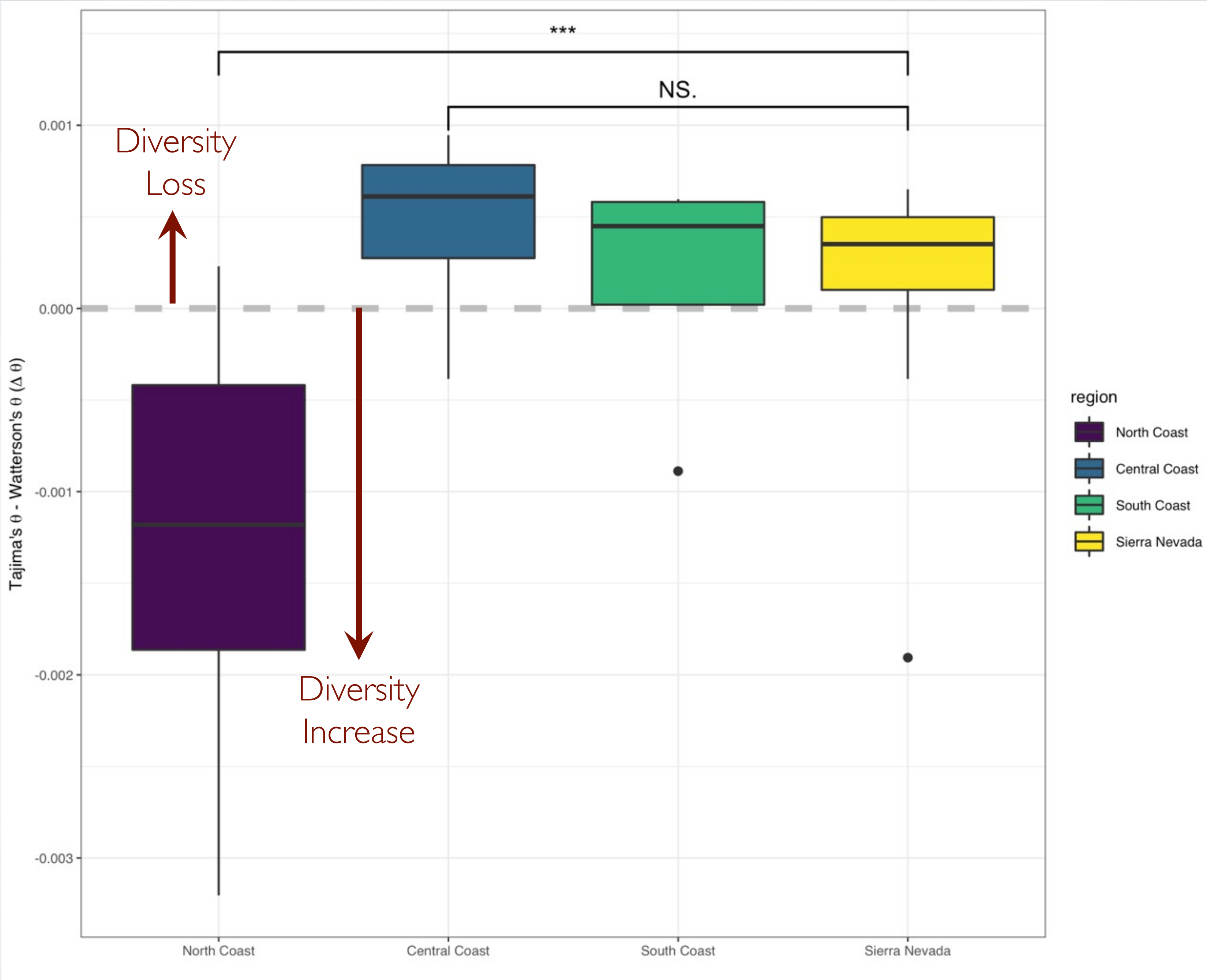
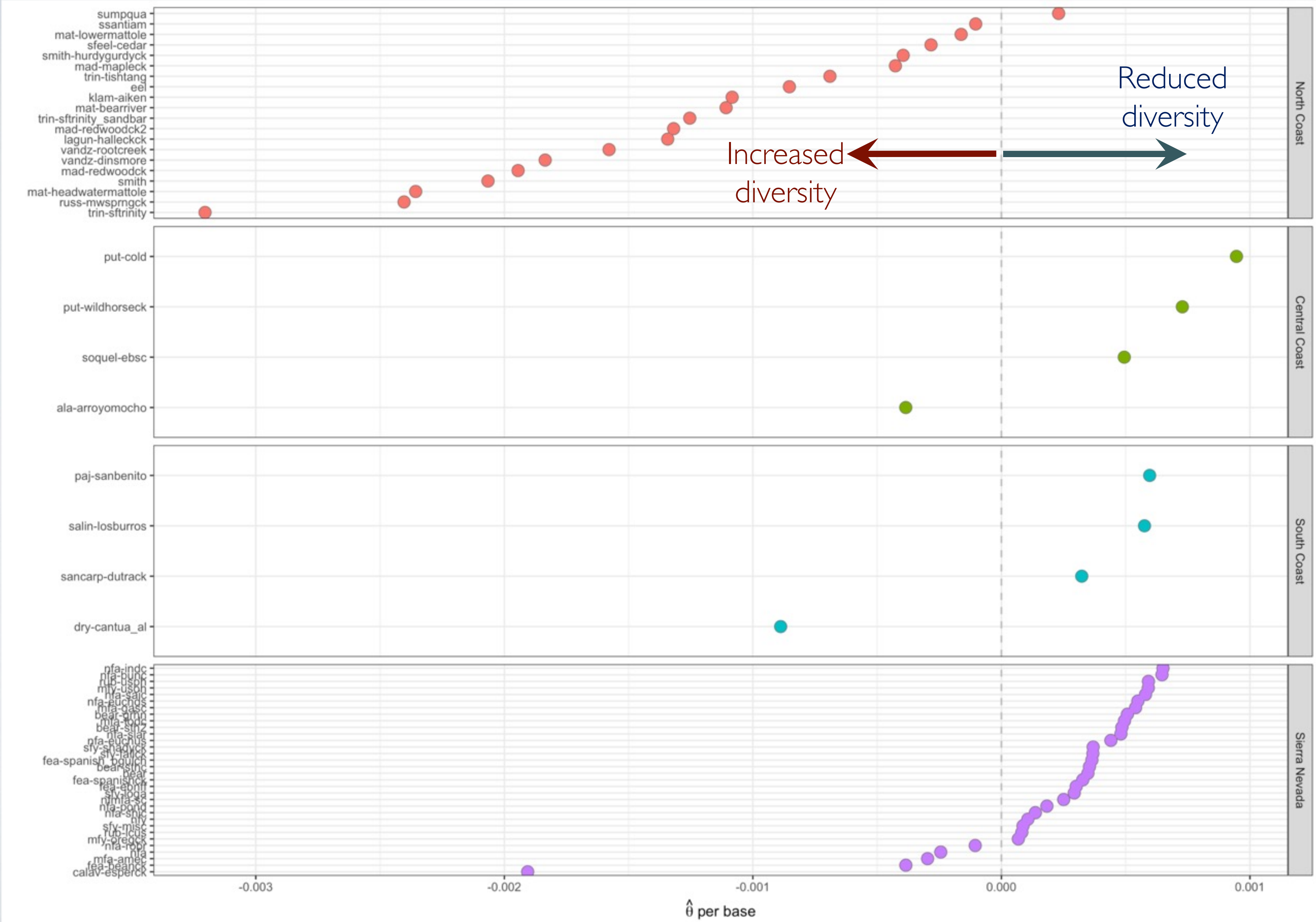


III. GENETIC DIVERSITY: ECOREGIONS



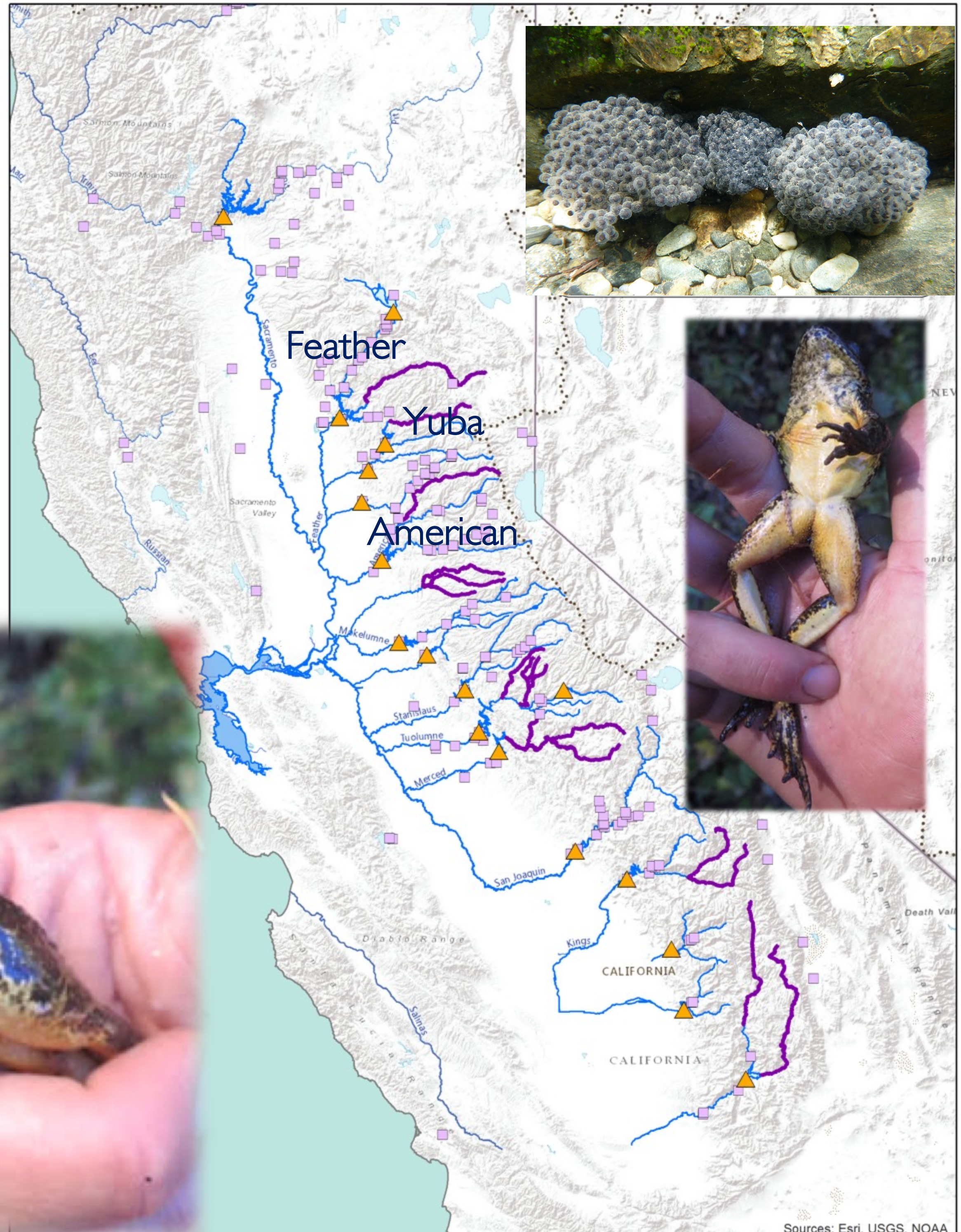
III. GENETIC DIVERSITY: POPULATIONS



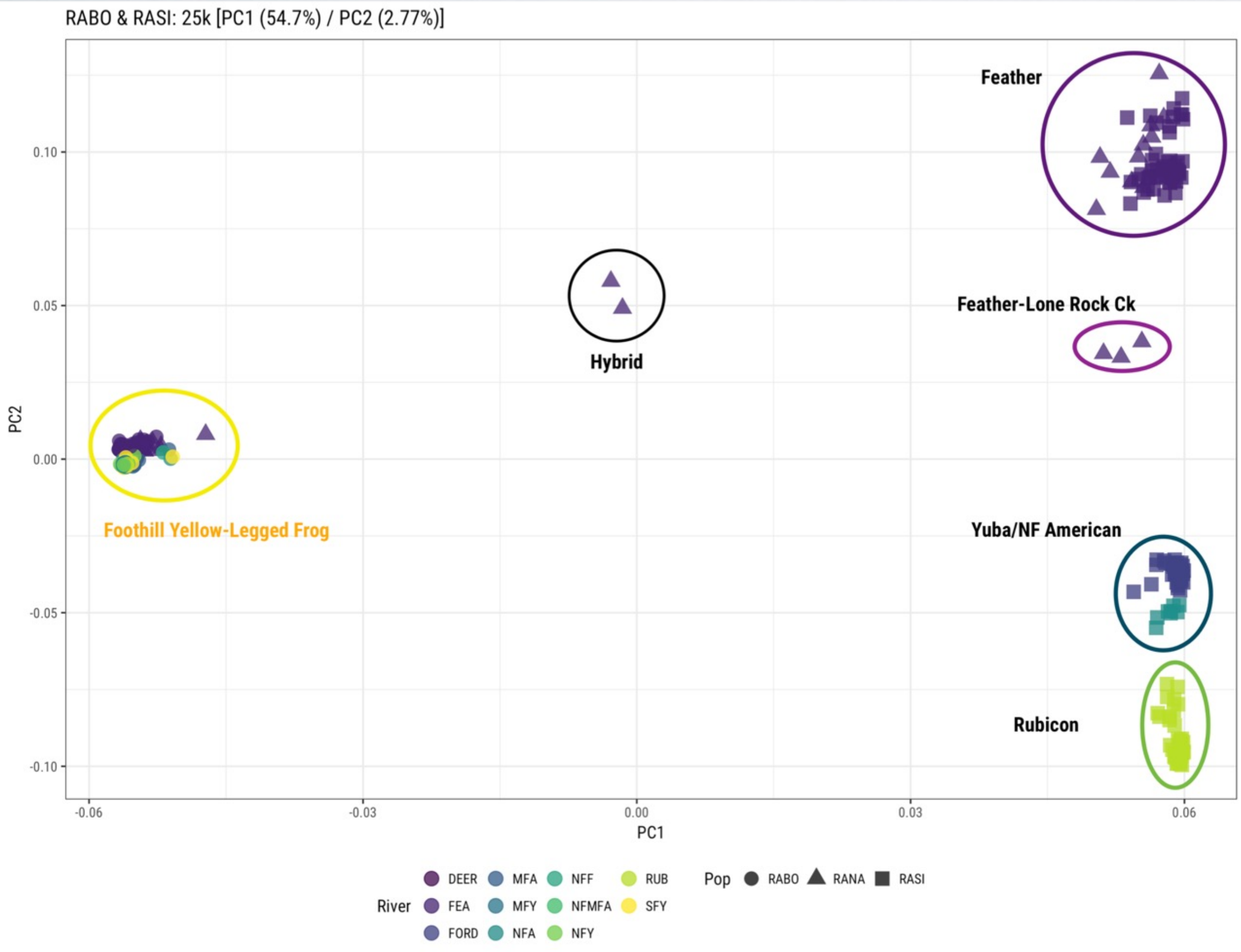
FYLF GENETIC DIVERSITY SUMMARY

- North Coast appears to have robust populations and highest diversity
- Sierra Nevada is least diverse and populations appear most at risk
- South/Central coast exhibit similar pattern to Sierras

IV. HYBRIDIZATION IN SIERRA NEVADA BETWEEN FYLF AND SYLF



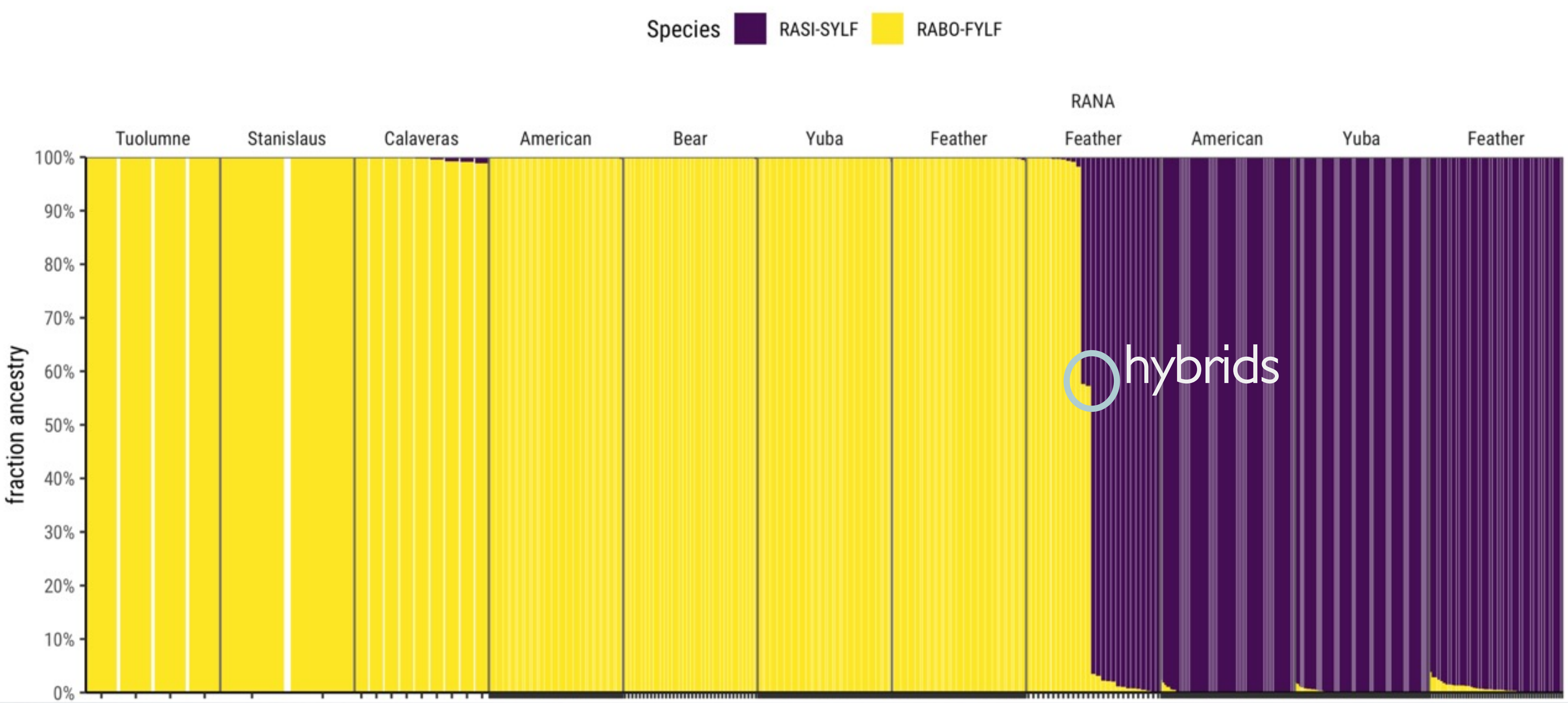
HYBRIDIZATION: FYLF & SYLF



- Rare hybridization detected between FYLF and SYLF in Bean Creek
- Only 2 of 200+ frogs were hybrids
- Appear to be F1 hybrids

HYBRIDIZATION: FYLF & SYLF

- Current modeling shows higher migration rates in Feather vs. other watersheds, rare event but more common in Feather



SUMMARY: CONFLUENCE OF CONSERVATION

- Important to assess adaptive capacity via genetic variation
- Inform future conservation, flow management, Forest plans
- Going to require managing regionally/locally to implement functionality for species persistence

Thanks

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  - *Caren Goldberg, Mallory Bedwell,*
  - *Brad Shaffer*

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