

Who is on my rock?:
The ecological and evolutionary dynamics
of aquatic insects crossing lotic-lentic
boundaries in the
Lakes Basin, Sierra Nevada, California

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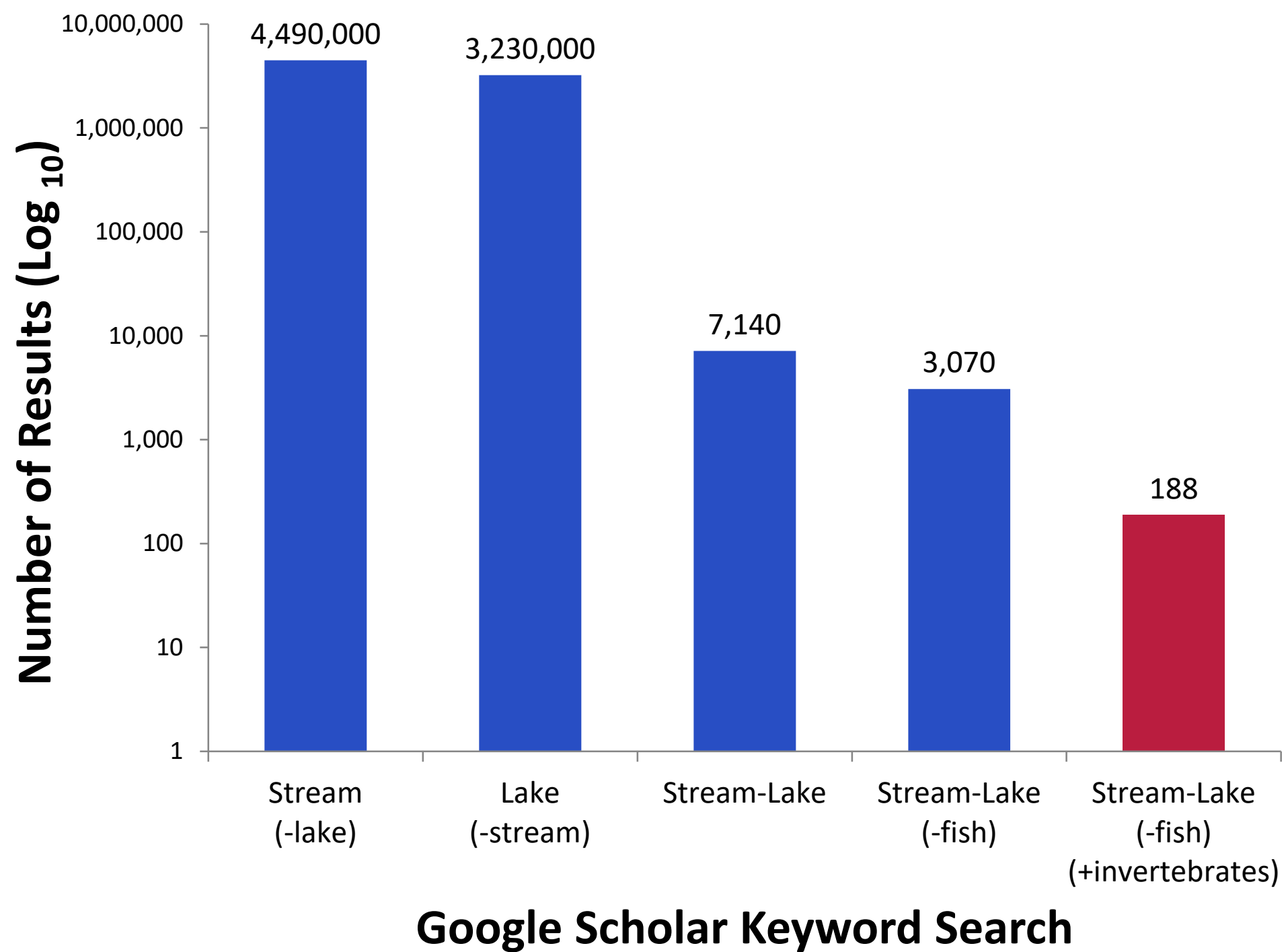
Matthew R. Cover (*CSU Stanislaus*)



#LakesBasinCA

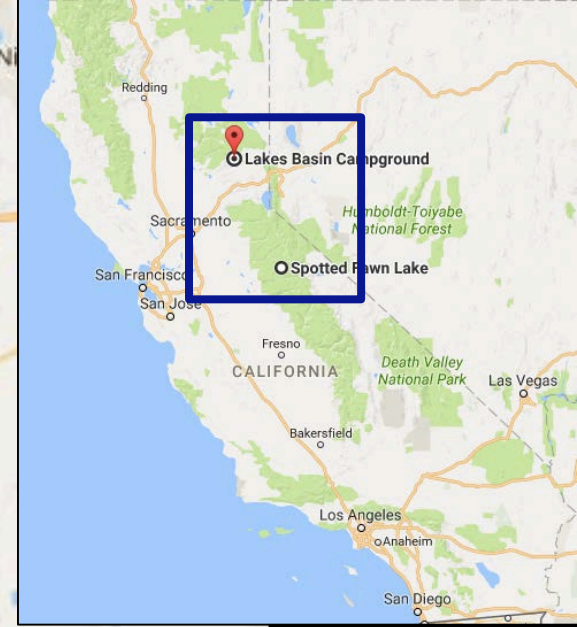
@caparisek @matthewrcover

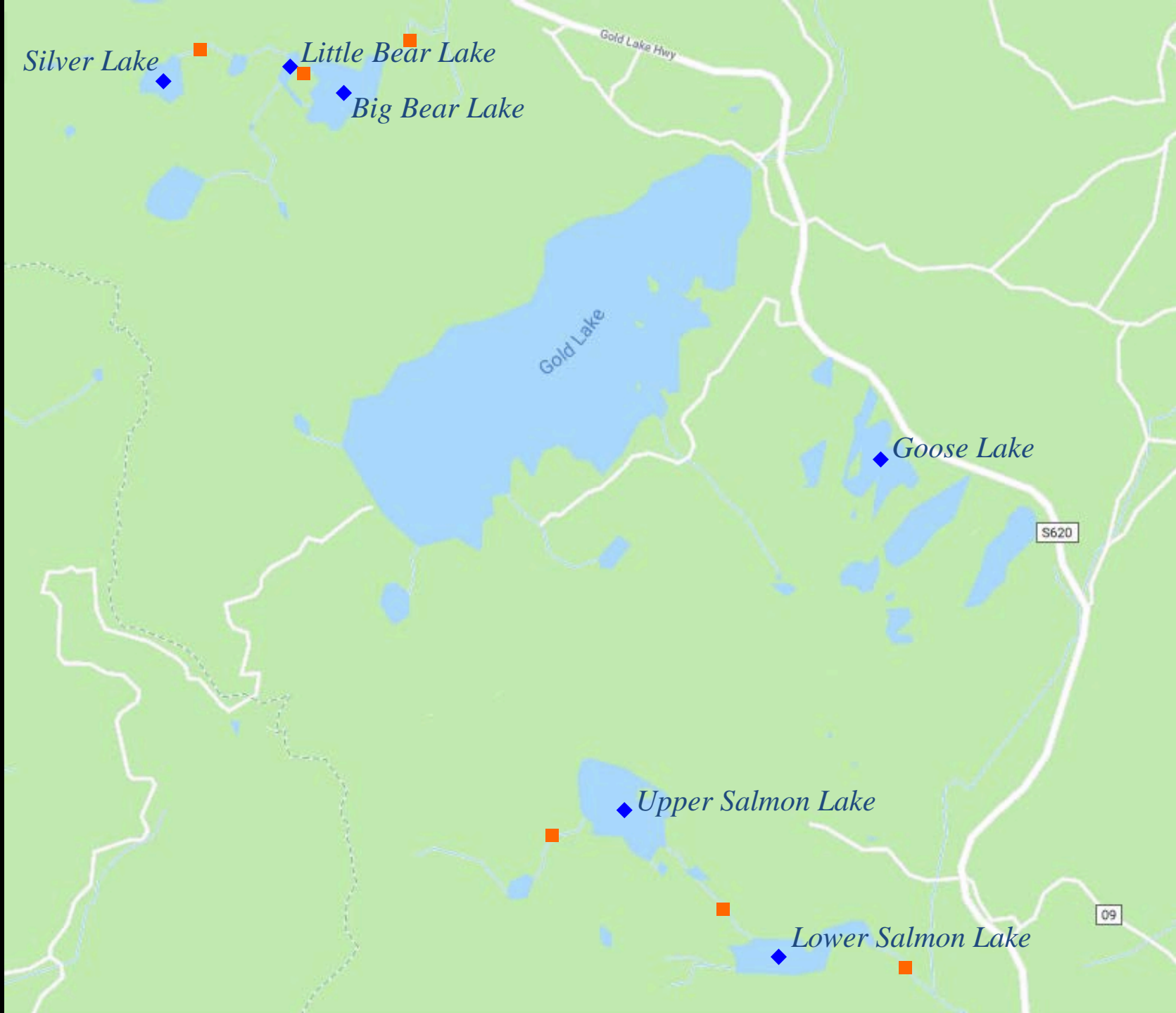




Questions

1. Do the **same species** of aquatic insects inhabit **both** streams and lakes?
2. Do the habitats cause differences in **non-heritable** characteristics?
3. Could the habitats contribute to differences in **heritable** characteristics (i.e., Eco-Evo dynamics)?





Lakes Basin

June 2017

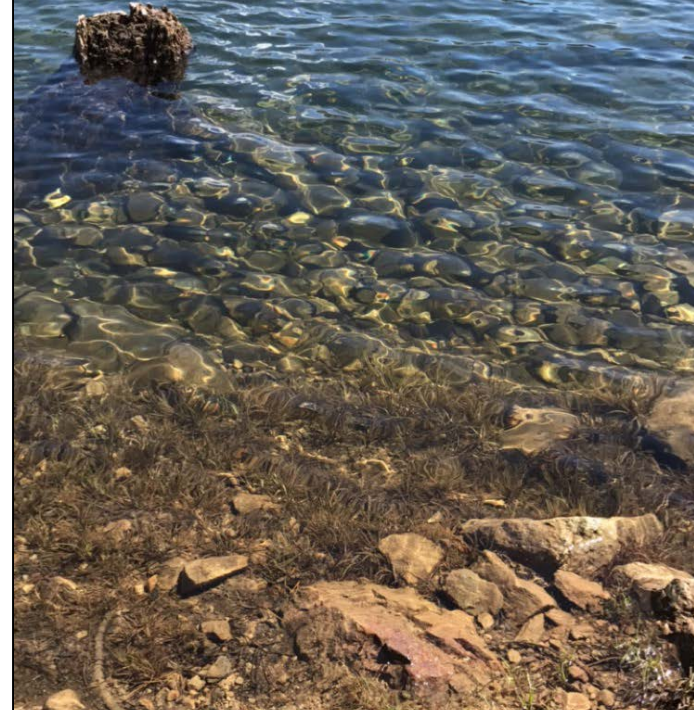


July 2017



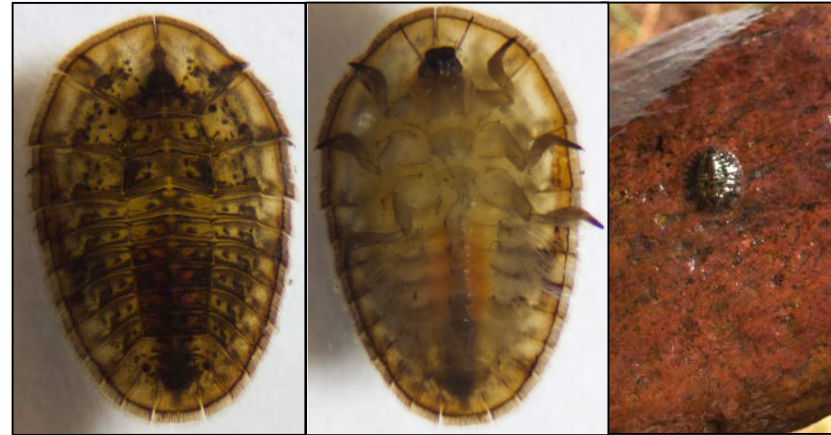
Methods

- Benthic invertebrate sampling
- DNA barcoding (mtDNA COI gene)
- Body & case morphology
- Stable isotope dietary analysis



Lotic-lentic aquatic insects

- *Eubrianax edwardsii*
 - 5 of 6 Lakes Basin lakes
 - 1 of 6 Lakes Basin **streams**



- *Heteroplectron californicum*
 - 5 of 6 Lakes Basin lakes
 - 2 of 6 Lakes Basin **streams**



- *Limnephilus externus*
 - 5 of 6 Lakes Basin **lakes**
 - 4 of 6 Lakes Basin streams



Question 2 & 3

- **Are there ecological differences in aquatic insects living in streams & lakes?**
 - Abundance
 - Life cycle phenology
 - **Morphology**
 - **Phoretic associations**
 - Diet (via stable isotope analysis)
 - Genetics (mt COI gene)



Body Morphology – *Lake vs. Stream*

- *L. externus*
 - Thicker abdominal gills in lakes (**78%**) vs streams (**29%**)
- *E. edwardsii*
 - Differences in shape & gills
 - No significant difference in oval vs teardrop body shapes (**p=0.548**)



Case Morphology – *L. externus*

- Case length for 5th instar larvae was greater in lakes than streams from the Lakes Basin (July 2017, **p=0.0001**)



Associations with *L. externus*

- **Case associations**

- ~45% from lake & stream have Chironomid midges
- Adult oribatid water mites (*feed on detritus & algae*) **Phoretic?**

- **Abdominal associations**

- Larval hygrobatoïd water mites (*pre-parasitic attendance*) **Parasitic?**
 - Lake: **33%** had mites
 - Stream: **0%** had mites



Conclusions

- The same species of aquatic insect can be present in both lake & stream habitats
- Differences in lake vs stream aquatic insects:
 - Distribution, morphology, phoretic association, diet
- How common is this lotic-lentic phenomenon?
- Early stream drying → Lake serves as refugia?



Acknowledgements

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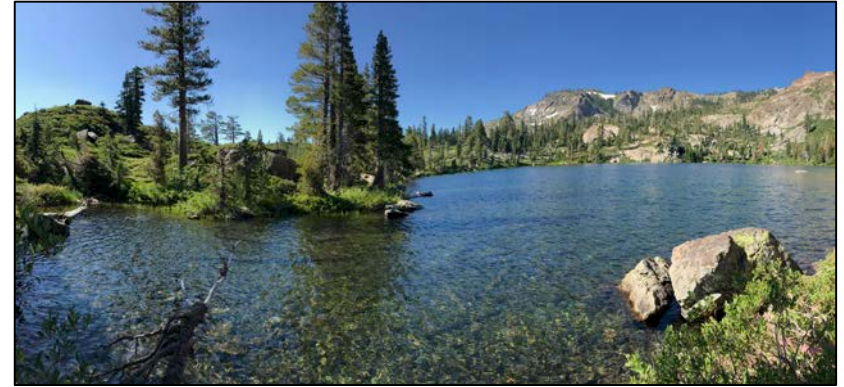
CalSFS

Biological Research Committee

California State University, Stanislaus

SNARL

UC Natural Reserve System



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DNA barcoding (mt COI)

geneious

R10

Next Tip

You can sort documents by the icon column to group them by type.

Building caches...

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Geneious 10.2.3

Back Forward BLAST Workflows Align/Assemble Tree Primers Cloning Back Up Support Help

Sources

- Local (0)
- awesome class (8)
- CCDB-31765_CAP_MS thesis (6)
 - EE (93, 1 unread)
 - HC (25)
 - LE (41)
- Sample Documents (623)
- Deleted Items (0)
- Shared Databases
- Operations
- NCBI
- UniProt

1 of 17 selected

Name	Description
Colorado: Gunnison Co.: Rocky Mountain Biological Lab	LE1Wissinger BLAST matches7LUS-L020,99%
Canada: Nev	. 07EVCAD-0632
Canada: Ma	BLAST matches7LSL-L042,99%
Canada: Ma	-PROBE-3065 BLAST matches7STT-L034,99%
Canada: Ma	1 BLAST matches7LUS-L020,99%
Canada: Alb	BLAST matches7LUS-L020,99%
CA: North Si	matches7LSL-L042,100%
CA: Mono Co	OLD

Tree

Geneious Tree Builder Consensus Tree Builder MrBayes

Exclude masked sites: ?

Genetic Distance Model: Jukes-Cantor

Tree build Method: UPGMA

Outgroup: No Outgroup

Pairwise distances will be obtained from the multiple sequence alignment. This may reduce accuracy slightly but will produce results faster.

Consensus Tree Options

Resample tree

Resampling Method: Bootstrap

Random Seed: 785,415

Number of replicates: 100

Create Consensus Tree

Sort Topologies

Support Threshold %: 50

Topology Threshold %: 0

Save raw trees

Cancel OK

Consensus Identity

1. Big Bear outlet str
2. Big Bear outlet str
3. Big Bear Lake.7LB
4. Big Bear Lake.7LB
5. Lower Salmon out
6. Lower Salmon out
7. Lower Salmon out
8. Upper Salmon inle
9. Upper Salmon inle
10. Upper Salmon La
11. Upper Salmon La
12. Upper Salmon La
13. Goose Lake.7LG
14. Goose Lake.7LG
15. Tamarack Lake.7
16. Tamarack Lake.7
17. Tamarack Lake.7
18. Tamarack outlet
19. Tamarack outlet
20. Tamarack outlet
21. Little Bear Lake.7
22. Little Bear Lake.7
23. Silver Lake.7LSL
24. Silver Lake.7LSL
25. Silver Lake.7LSL-L043.SS...
26. Lower Salmon Lake.7LLS...
27. Haven Lake.6LHA-L045.S...
28. Haven Lake.6LHA-L046.S...
29. Long Lake.8LLO-L047.SS...
30. Canada: Alberta, Wat...
31. Canada: Manitoba, C...

Display

Consensus

Threshold: 0% - Majority

Ignore Gaps

If no coverage call ?

Highlighting

All Disagree... to Consensus

Go: in any sequence

Use dots

Nucleotides

Complement

Translation on All Sequences

Translation Options

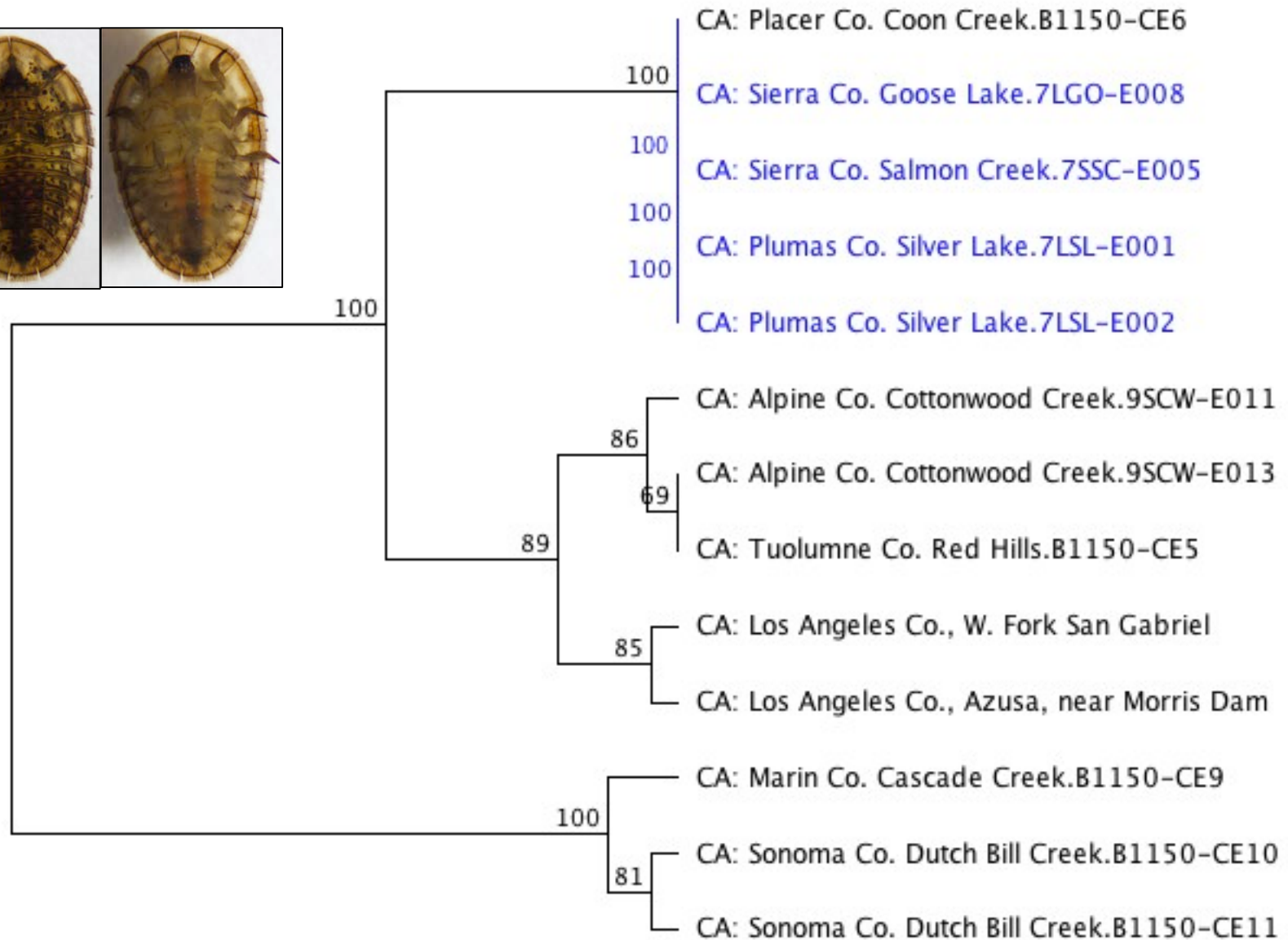
Frame: Frame 1

Genetic Code: Standard

Using 169 / 3068 MB memory

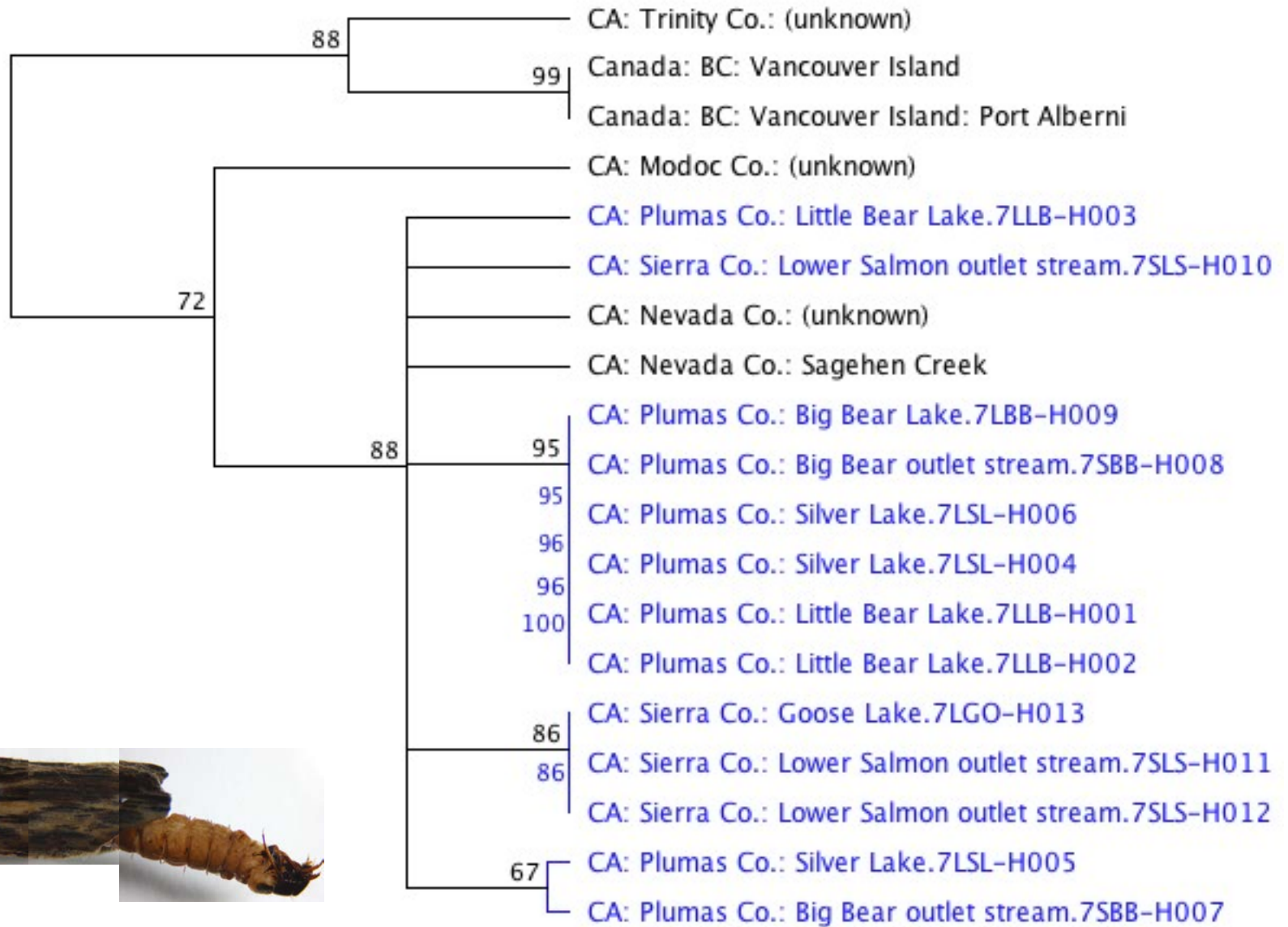
Alt click on a sequence position or annotation, or select a region to zoom in. Alt-shift click to zoom out.

Evolutionary dynamics – *E. edwardsii*



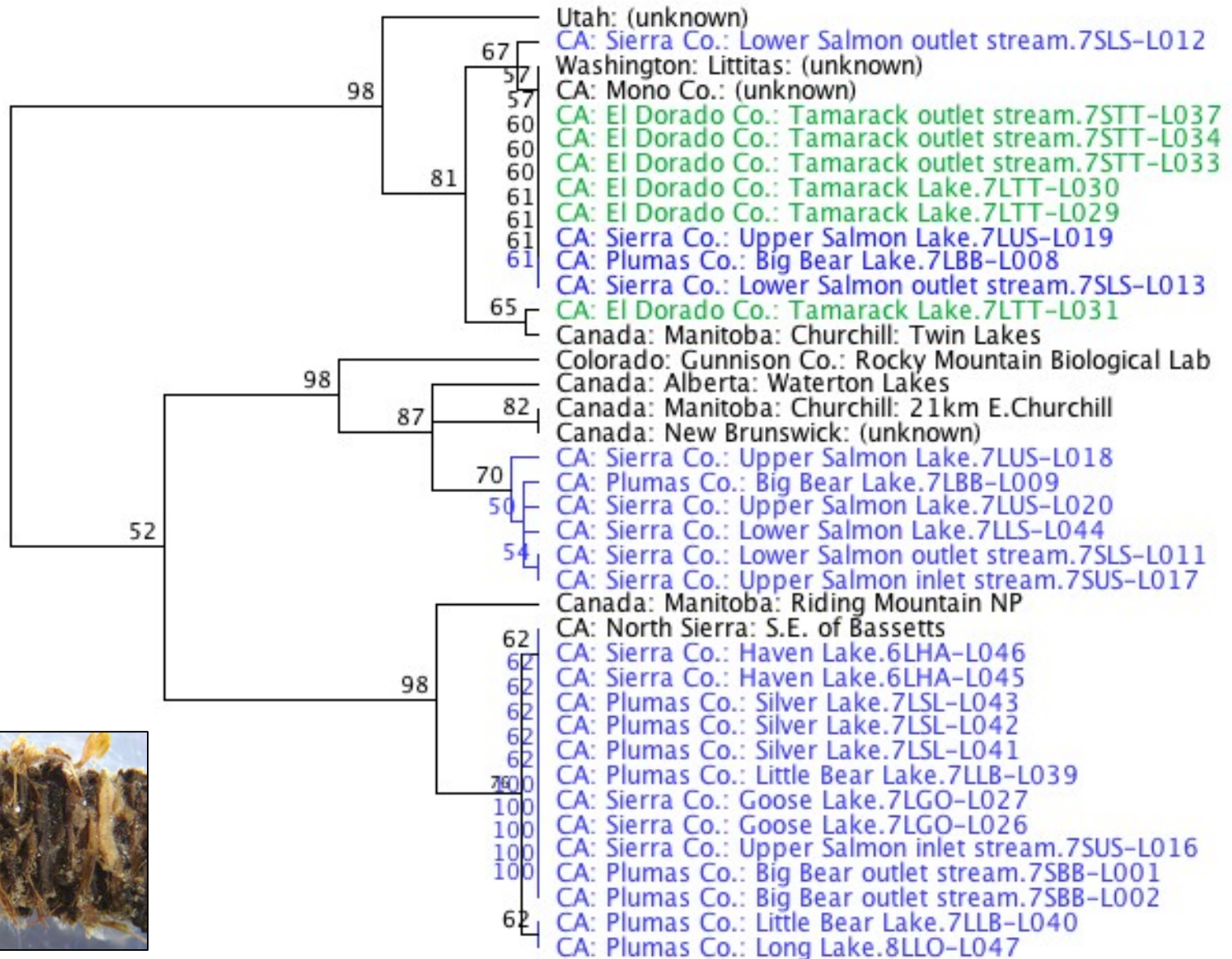
0.008

Evolutionary dynamics – *H. californicum*



0.004

Evolutionary dynamics – *L. externus*



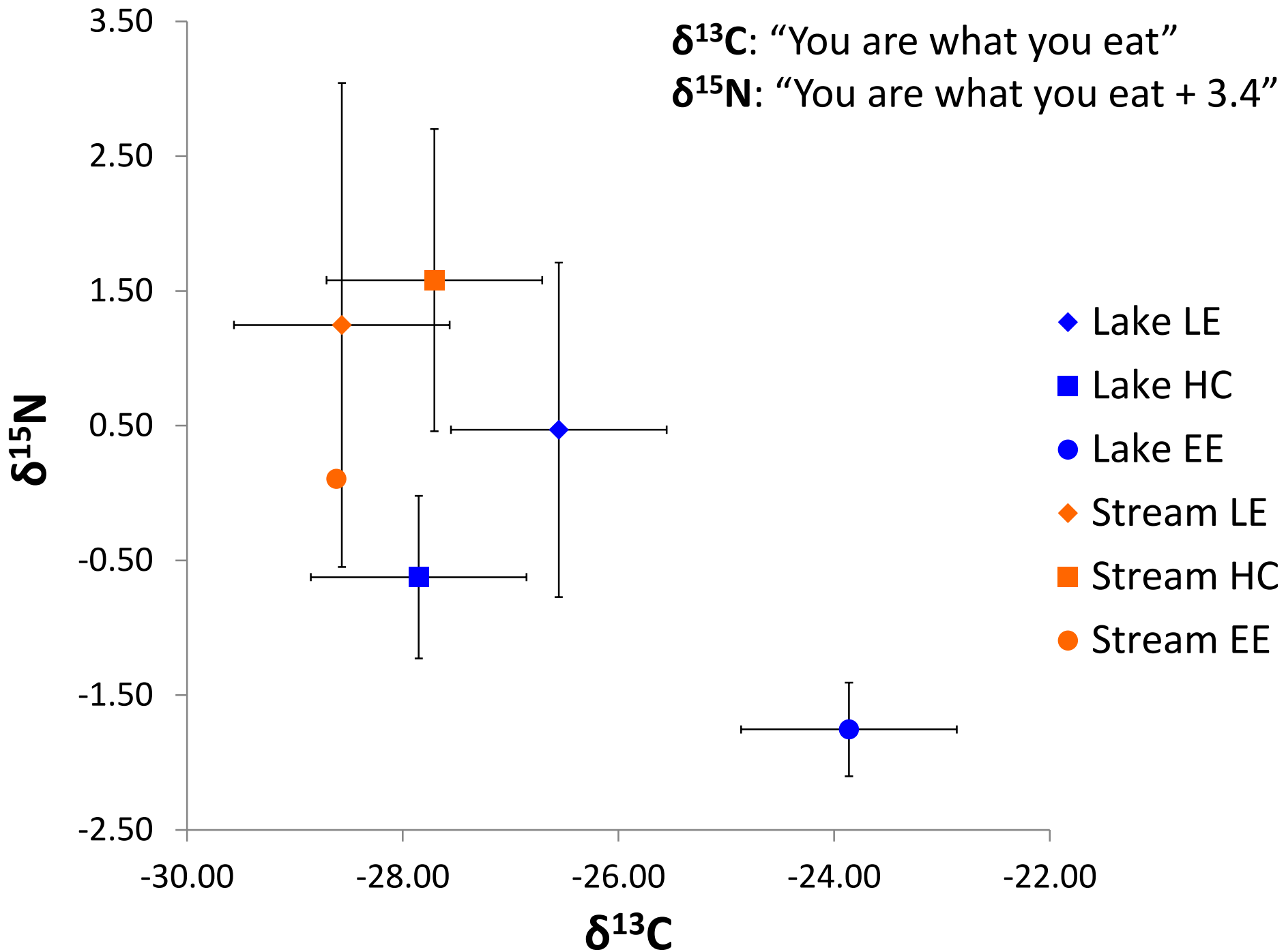
0.004

Conclusions: mtDNA

- High intraspecies variation but not between lakes and streams
 - **Low geographical structure (LE)**
 - Widespread gene flow
 - Large variation in morphology and phenology
 - Cryptic biodiversity
 - **High geographical structure (HC & EE)**
 - Genetic isolation; dispersal limited
 - No lentic vs lotic genetic structure

$\delta^{13}\text{C}$: "You are what you eat"

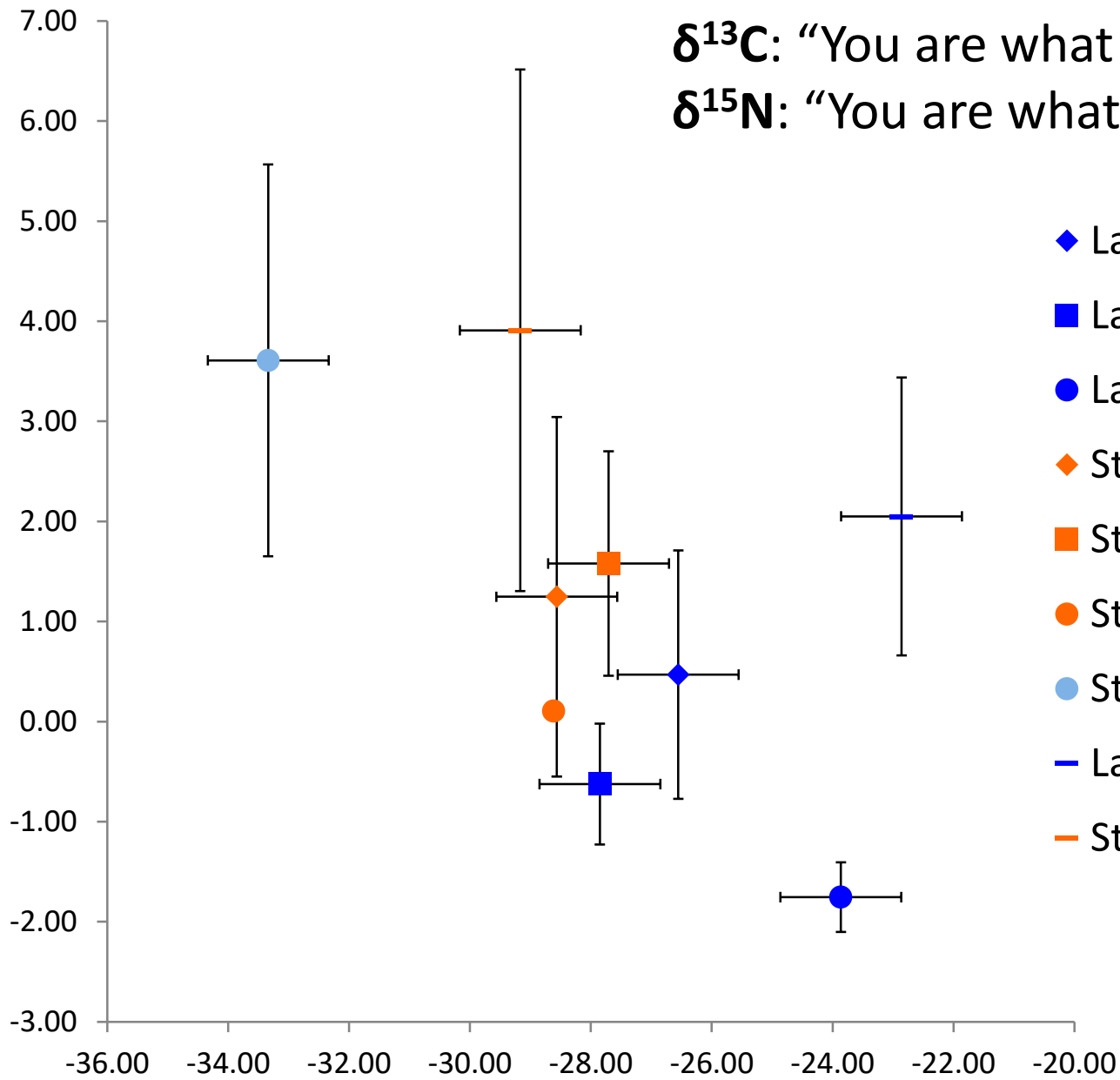
$\delta^{15}\text{N}$: "You are what you eat + 3.4"



$\delta^{13}\text{C}$: "You are what you eat"

$\delta^{15}\text{N}$: "You are what you eat + 3.4"

$\delta^{15}\text{N}$



$\delta^{13}\text{C}$

Conclusions: diet

- Diet (lake vs stream)
 - Nutritional resources different between habitat types & across landscape
 - Feeding ecology & nutritional resource isotope values flexible (e.g., diatoms, algae)
 - Greater stream leaf-litter inputs ($\delta^{13}\text{C}$ & $\delta^{15}\text{N}$ varies)
 - - $\delta^{15}\text{N}$ found in phosphorus-stressed ecosystems (diluted P?)