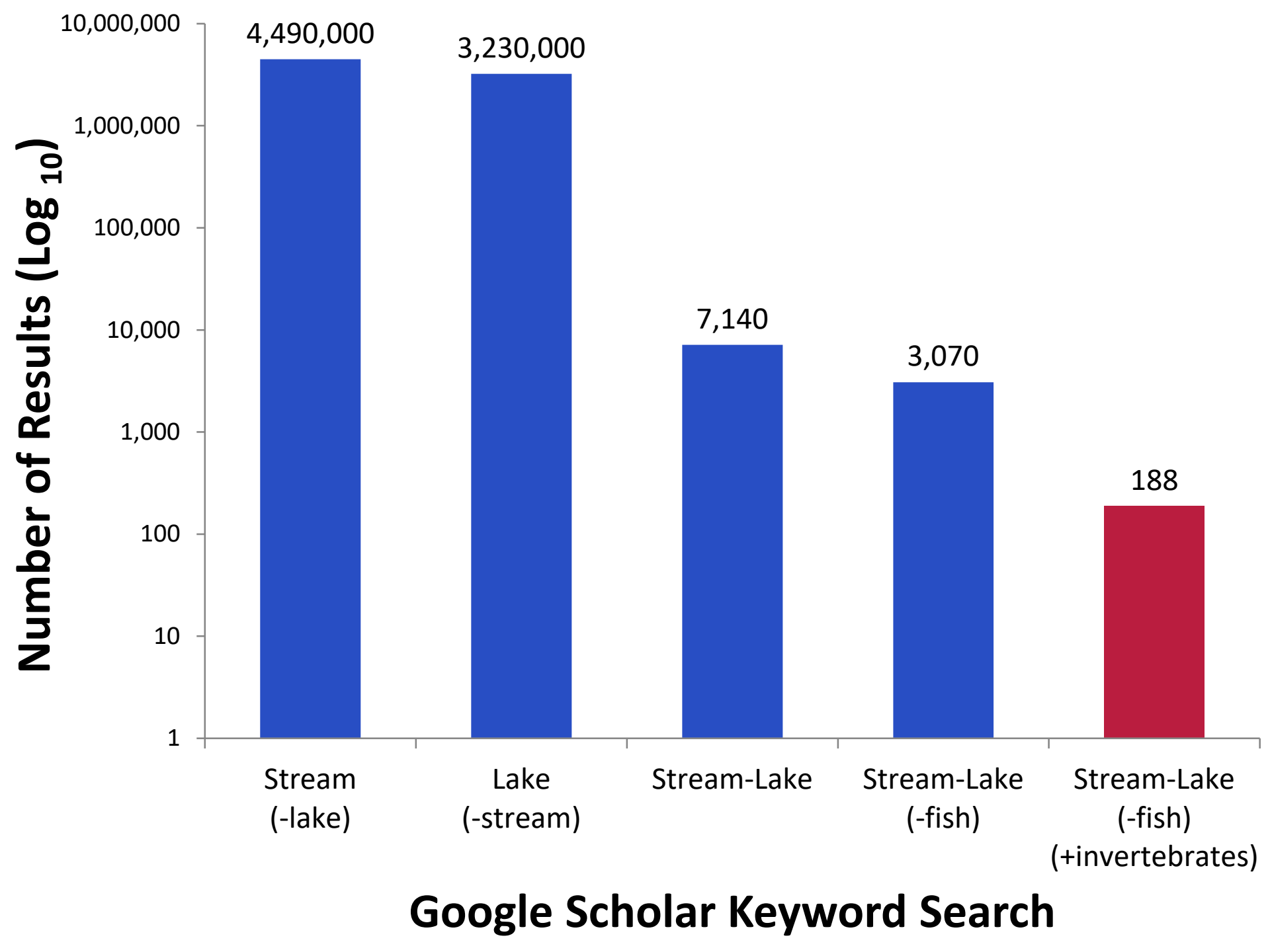
Who is on my rock?: The ecological and evolutionary dynamics of aquatic insects crossing lotic-lentic boundaries in the Lakes Basin, Sierra Nevada, California

Christine A. Parisek *(UC Davis)*
Michael P. Marchetti *(St. Mary's College of CA)*
Matthew R. Cover *(CSU Stanislaus)*

#LakesBasinCA

@caparisek @matthewrcover

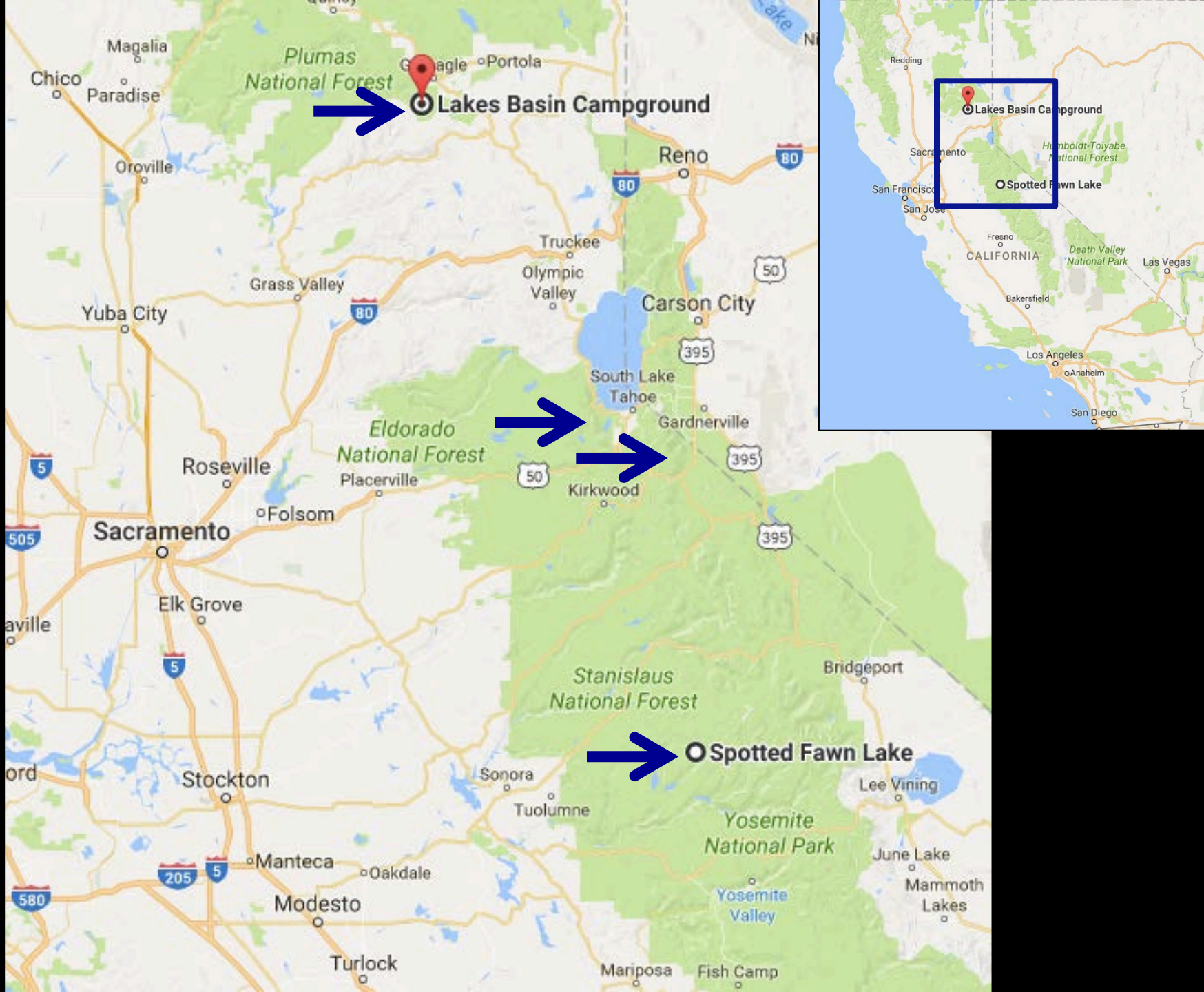

10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Number of Results (Log 10)
4,490,000
3,230,000
7,140
3,070
188
Stream (-lake)
Lake (-stream)
Stream-Lake
Stream-Lake (-fish)
Stream-Lake (-fish) (+invertebrates)
Google Scholar Keyword Search

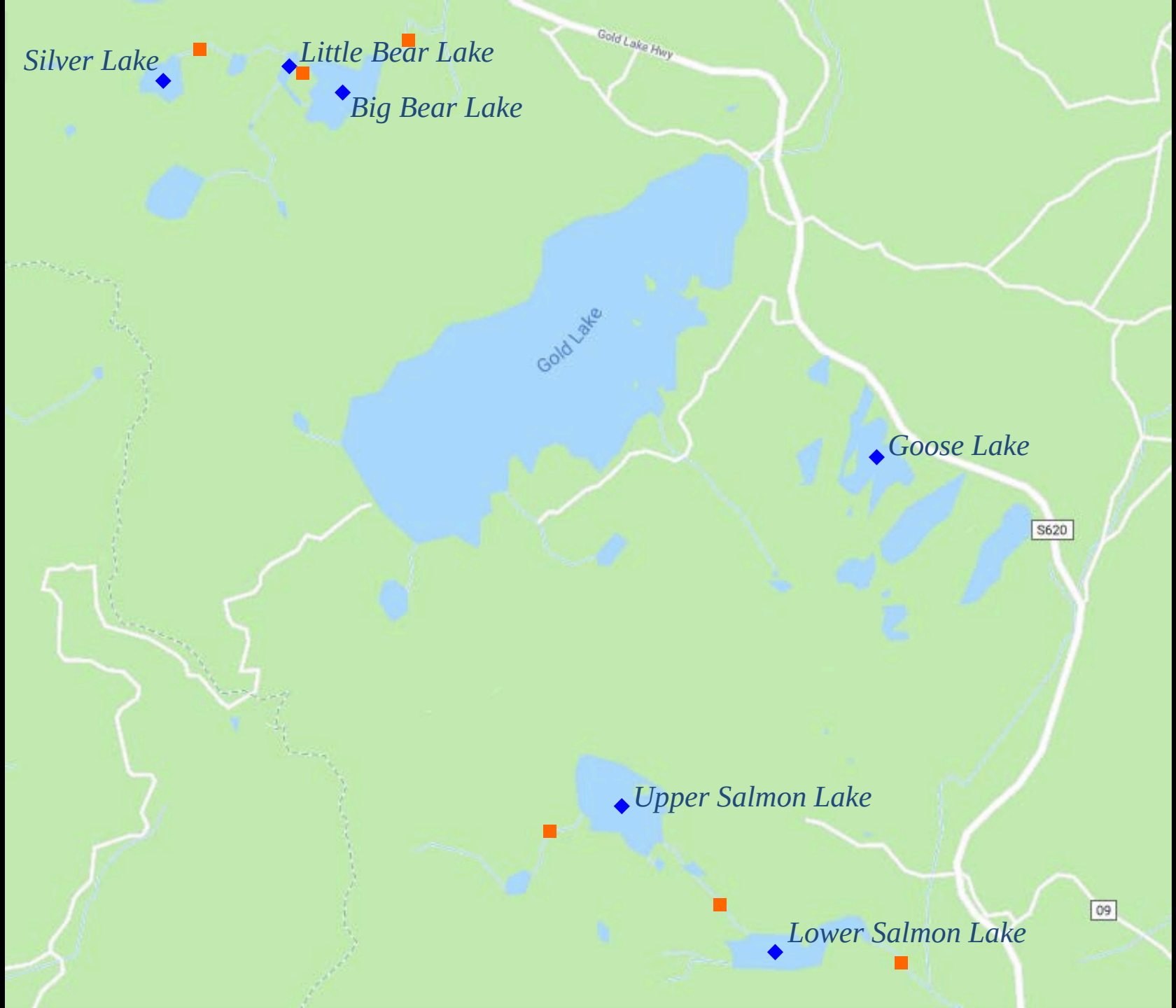
Questions

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 Campground
Spotted Fawn Lake
Plumas National Forest
Eldorado National Forest
Stanislaus National Forest
Yosemite National Park
Magalia
Chico
Paradise
Portola
Oroville
Reno
Truckee
Olympic Valley
Grass Valley
Yuba City
Carson City
South Lake Tahoe
Gardnerville
Kirkwood
Roseville
Placerville
Folsom
Sacramento
Elk Grove
Stockton
Manteca
Oakdale
Modesto
Turlock
Sonora
Tuolumne
Bridgeport
Lee Vining
June Lake
Mammoth Lakes
Yosemite Valley
Mariposa
Fish Camp
Redding
San Francisco
San Jose
Fresno
CALIFORNIA
Death Valley National Park
Las Vegas
Bakersfield
Los Angeles
Anaheim
San Diego


Silver Lake
Little Bear Lake
Big Bear Lake
Gold Lake Hwy
Gold Lake
Goose Lake
S620
Upper Salmon Lake
Lower Salmon Lake
09

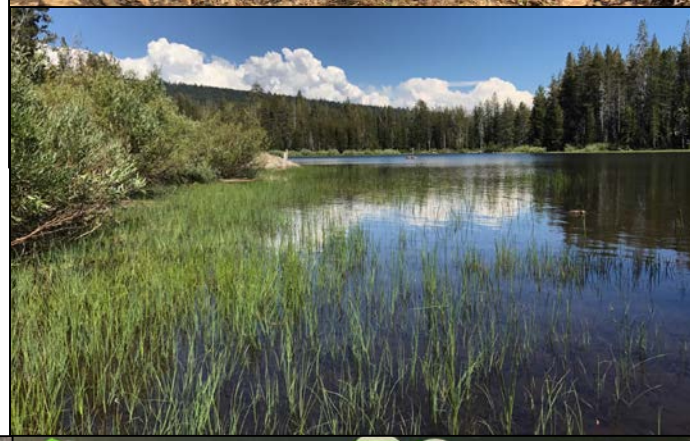
Lakes Basin

June 2017

July 2017

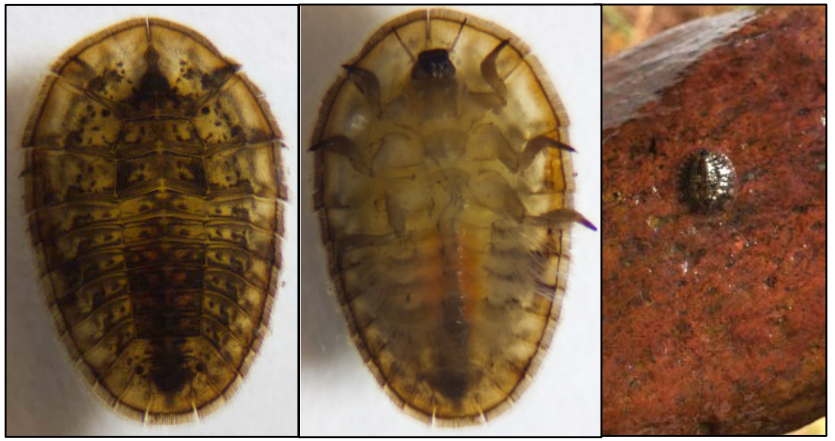
Methods

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



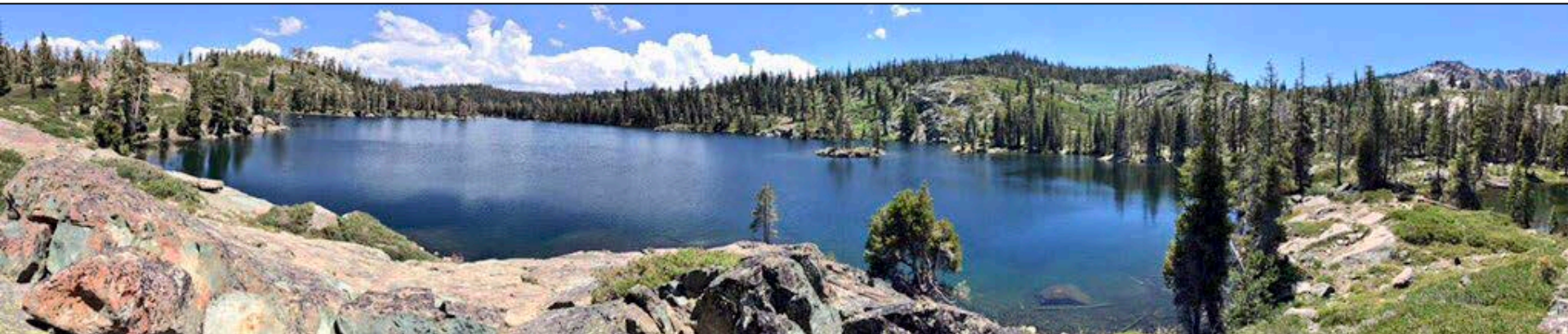
Lotic-lentic aquatic insects

- *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 hygrobatoid 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

Matthew Cover
California State University, Stanislaus

Michael Marchetti
Saint Mary's College of California

Roland Knapp & Dave Herbst
Sierra Nevada Aquatic Research Lab (SNARL)

Heather Proctor
University of Alberta, Canada

#LakesBasinCA

Christine Parisek
caparisek@ucdavis.edu
@caparisek

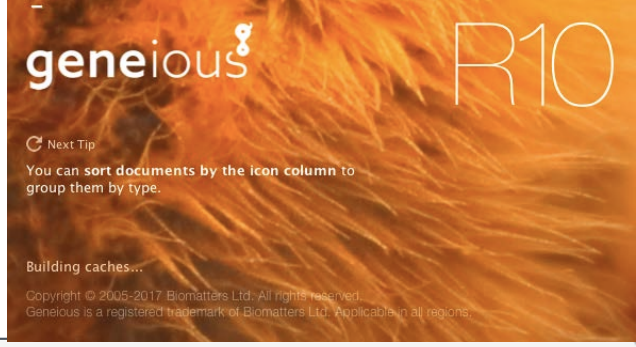
Matt Cover
mcover@csustan.edu
@matthewrcover

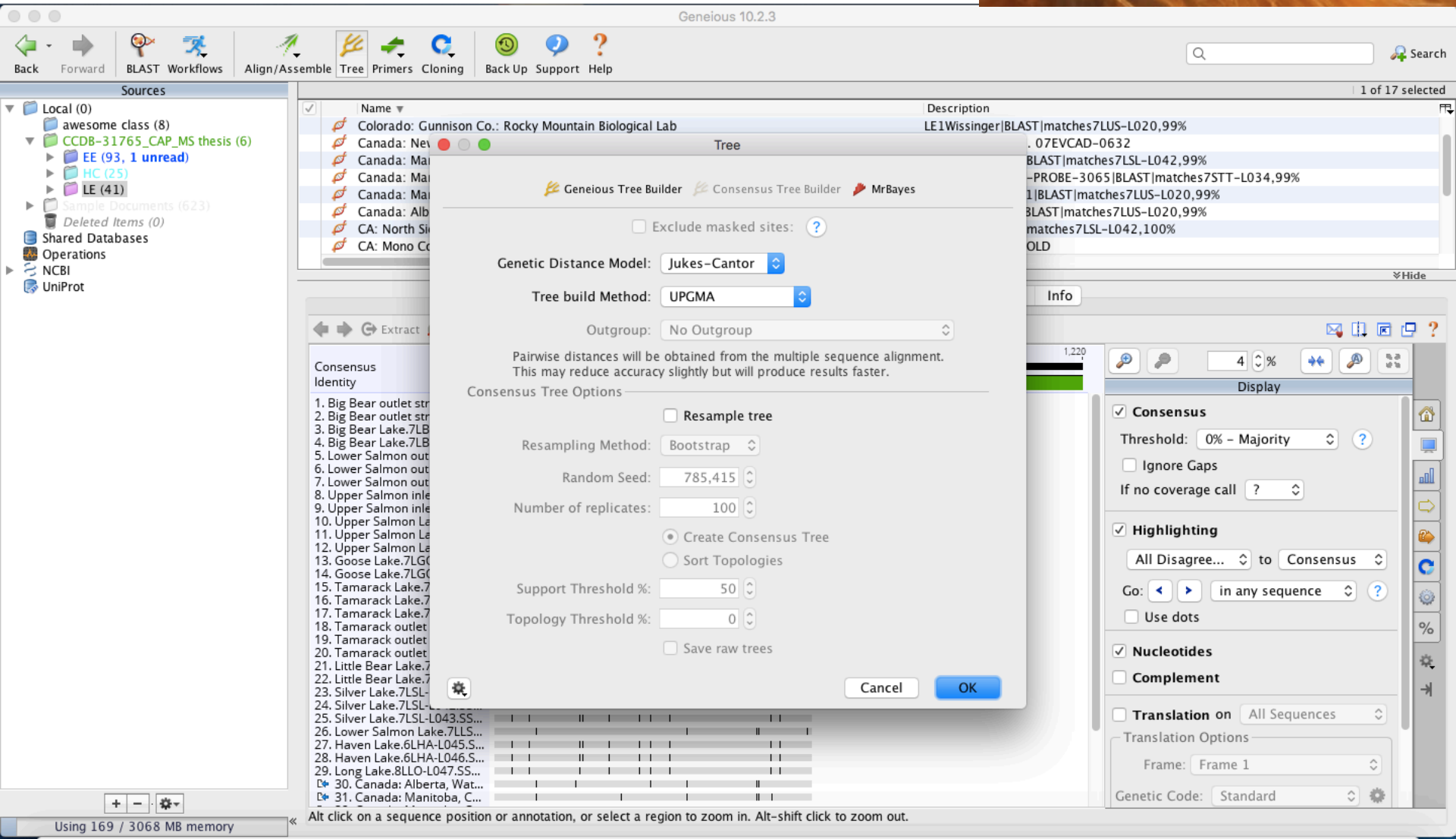
CalSFS

Biological Research Committee
California State University, Stanislaus

SNARL
UC Natural Reserve System

DNA barcoding (mt COI)

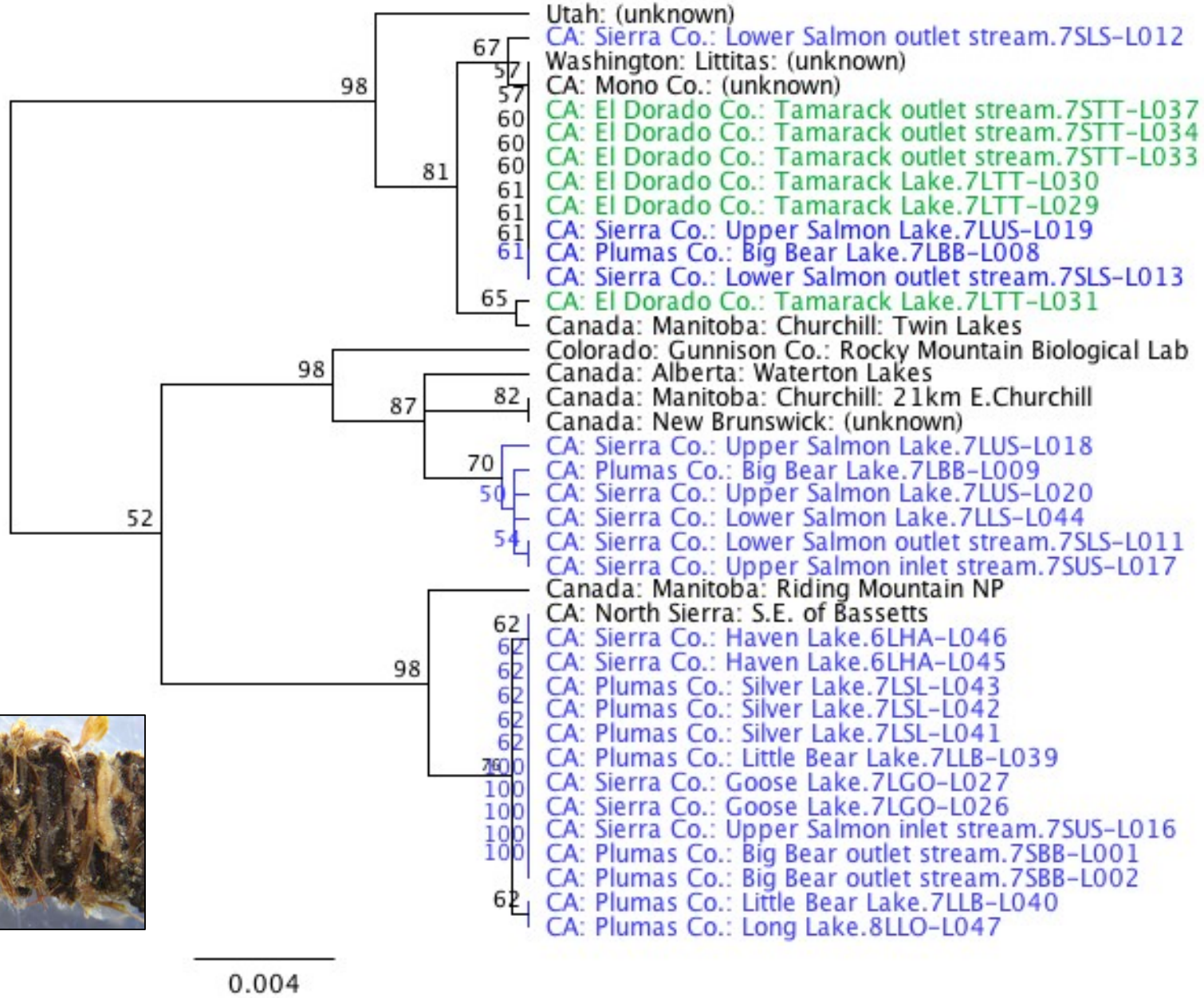




Evolutionary dynamics – *E. edwardsii*

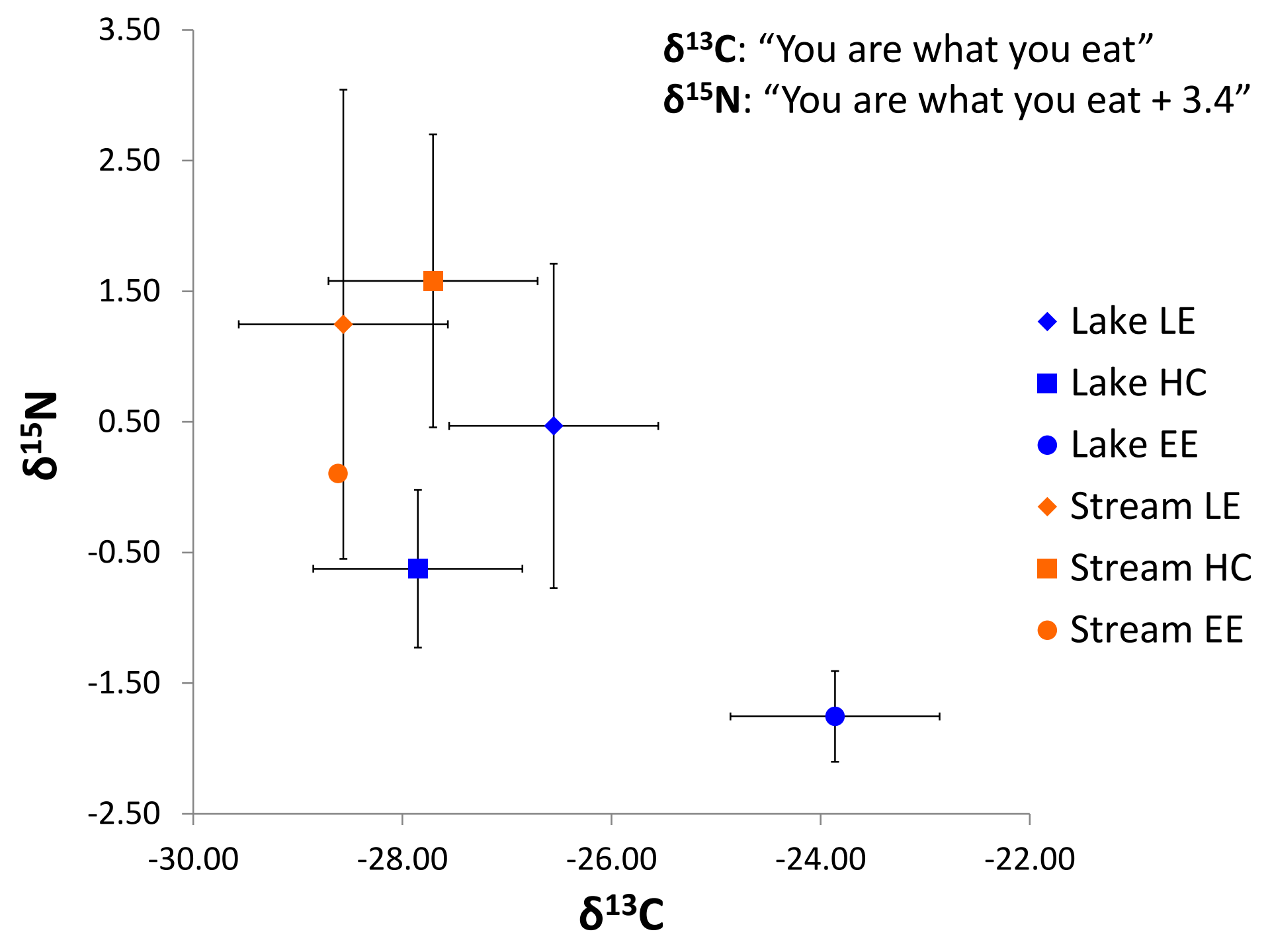
Evolutionary dynamics – *H. californicum*

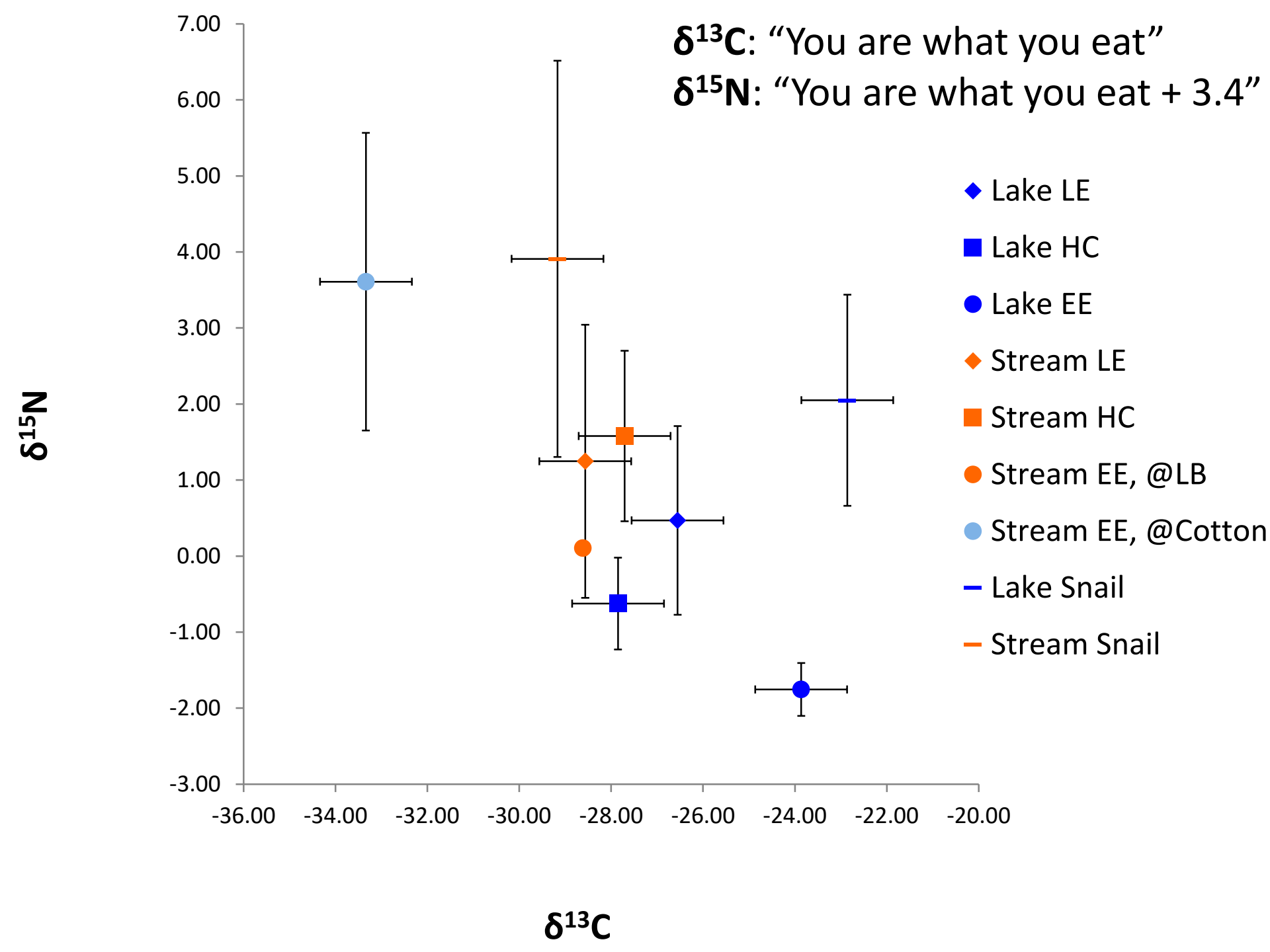
Evolutionary dynamics – *L. externus*



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


δ13C: “You are what you eat”
δ15N: “You are what you eat + 3.4”
3.50
2.50
1.50
0.50
-0.50
-1.50
-2.50
δ15N
-30.00
-28.00
-26.00
-24.00
-22.00
δ13C
Lake LE
Lake HC
Lake EE
Stream LE
Stream HC
Stream EE


δ13C: “You are what you eat”
δ15N: “You are what you eat + 3.4”
Lake LE
Lake HC
Lake EE
Stream LE
Stream HC
Stream EE, @LB
Stream EE, @Cotton
Lake Snail
Stream Snail
δ15N
δ13C
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-36.00
-34.00
-32.00
-30.00
-28.00
-26.00
-24.00
-22.00
-20.00

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 ($\delta^{13}C$ & $\delta^{15}N$ varies)
  - - $\delta^{15}N$ found in phosphorus-stressed ecosystems (diluted P?)