

# A molecular reinterpretation of the biodiversity of *Cottus* in western North America

Michael Young, Rebecca Smith, Kristy Pilgrim, Kevin McKelvey,  
 Dan Isaak, Sharon Parkes, and Michael Schwartz  
 U.S. Forest Service, Rocky Mountain Research Station  
 National Genomics Center for Wildlife and Fish Conservation



and the SculpinQwest Collaborative



109	110	113	176	109	222	141	210	162	123	96
100 Cr Reach	(PBB)	UTME	RYAN	Zona	BCT					
145	120	170	BCT	195	BCT					
167	125	195	BCT	211	BCT					
137	121	211	BCT	191	BCT					
102	81	191	BCT	180	BCT					
164	106	180	BCT	178	BCT					
159	127	178	BCT	181	BCT					
71	116	181	BCT	142	BCT					
180	112	142	BCT	171	BCT					
116		171	BCT	147						
88		147								

# Outline

- Units of conservation
- The problem with *Cottus*
- Resolving that problem: crowds & genes
- Case studies: the species complexes



# What is biodiversity?

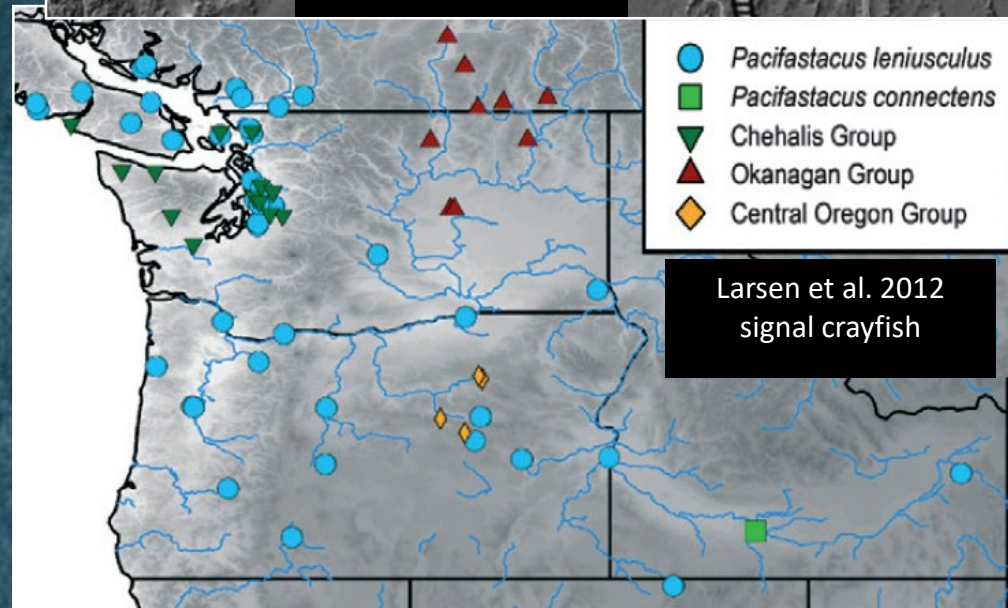
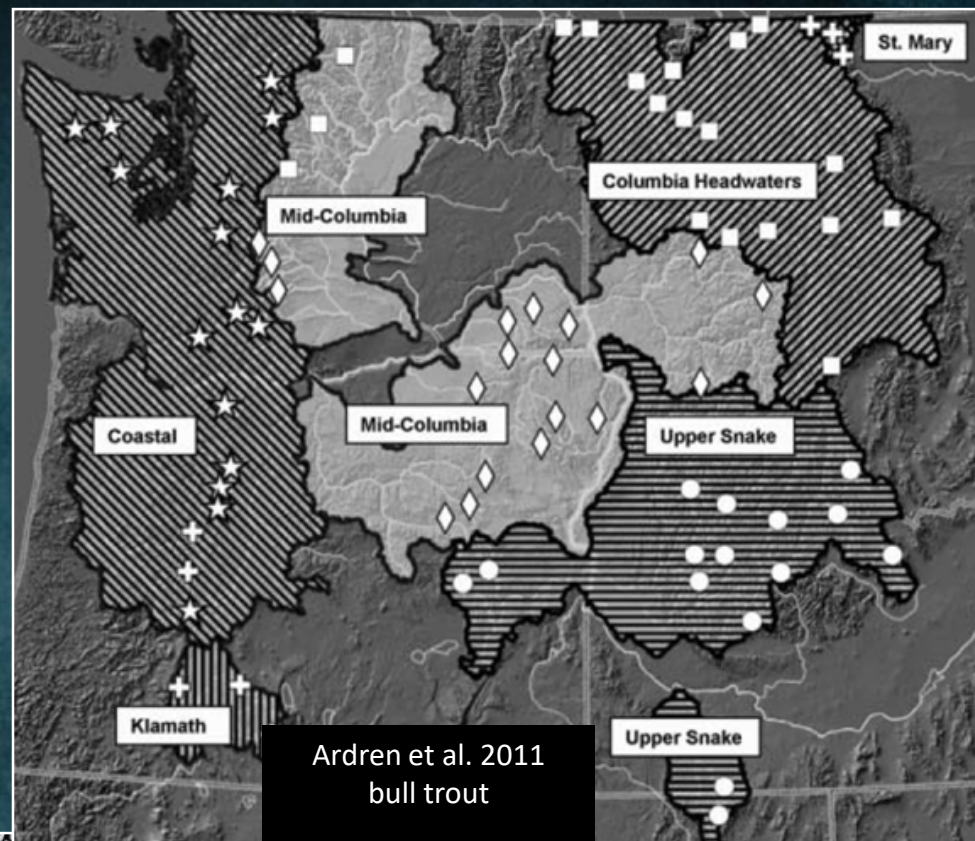
Conservation units: recognizable, substantive components of the evolutionary legacy of a taxon

- DPS
- ESU
- GMU
- Stock
- UCS
- Subspecies
- Species
- MOTU

...all are lineages

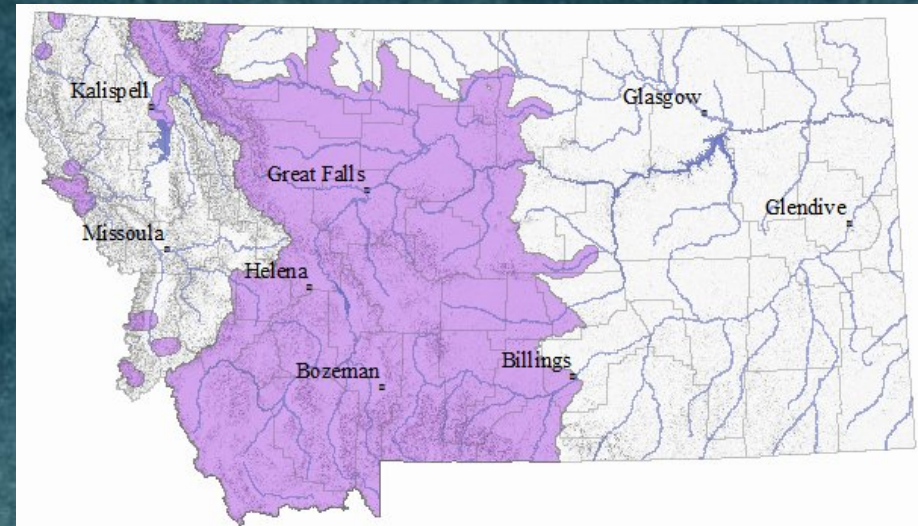
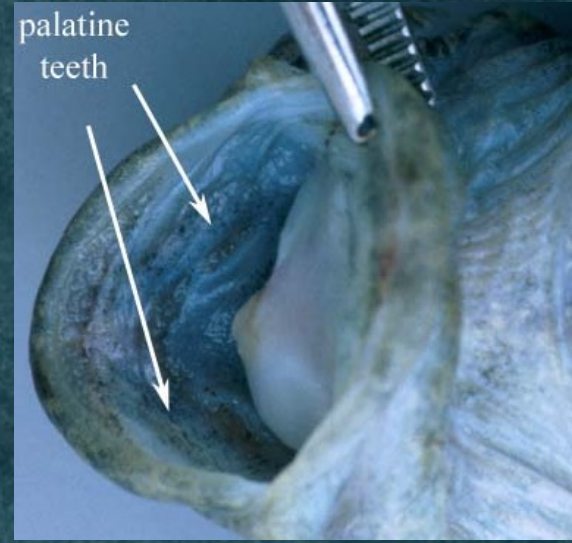
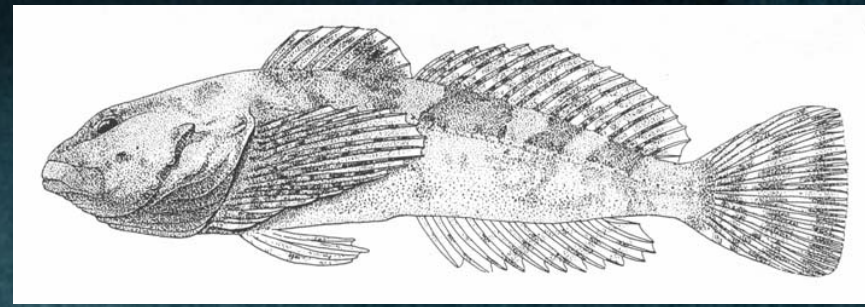
## Why is it relevant?

- ESA & SARA
- Tinkering: demographic manipulation via translocation
- Basis for understanding evolutionary histories



# The problem with *Cottus*

- Most challenging group to identify
- Morphology: difficult & “unstable”
- Hybridization ongoing & ancient
- Taxonomy unsatisfying
- Extraordinarily abundant



DNA barcoding at riverscape scales: assessing biodiversity among fishes of the genus *Cottus* (Teleostei) in northern Rocky Mountain streams

MICHAEL K. YOUNG, KEVIN S. MCKELVEY, KRISTINE L. PILGRIM and MICHAEL K. SCHWARTZ  
U.S. Forest Service, Rocky Mountain Research Station, 800 East Beckwith Avenue, Missoula, MT 59801, USA

*Cottus* uberdiversity!

- 13 distinct lineages
- Groups correspond with major watershed boundaries (mostly)
- Groups not readily assigned to known species

NUMBER 634

DECEMBER 4, 1963

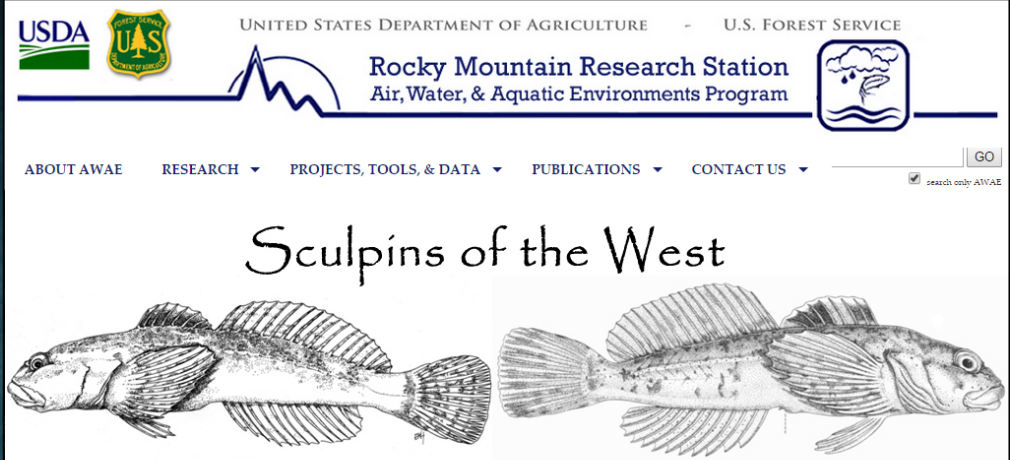
OCCASIONAL PAPERS OF THE MUSEUM OF  
ZOOLOGY  
UNIVERSITY OF MICHIGAN  
ANN ARBOR, MICHIGAN

FOUR NEW SPECIES OF FRESHWATER SCULPINS, GENUS  
*COTTUS*, FROM WESTERN NORTH AMERICA

BY REEVE M. BAILEY AND CARL E. BOND<sup>1</sup>

# SculpinQwest: the collection approach

- Sourcing the crowd: the SculpinQwest collaborative
  - 100s of biologists & citizen-scientists from every state and province in western NA
  - A simple collection protocol
  - ~8,000 specimens
- Rewarding the crowd: providing results to the stakeholders



Broad-scale genetic monitoring of aquatic species

Home > Projects > Diversity of Cottus

### Wanted: Your help to understand the diversity of *Cottus* in western North America

Sculpin DNA

Particulars | Species of Interest | Phylogeography | Publications and Posters | Briefing Papers | Contact

Fishes of the genus *Cottus* depend on the same kind that even experts are occ

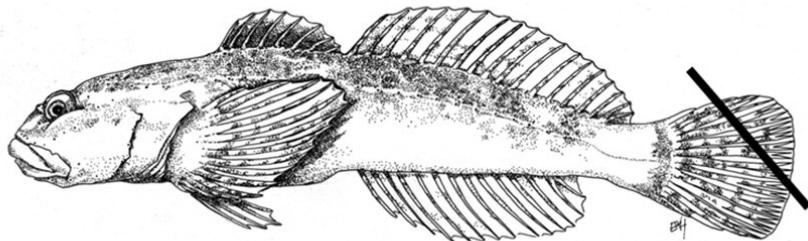
In our studies of the fre

for fish managers and ichthyologists in the West. They share streams, rivers, and lakes with trout and salmon, and Yet we don't know how many kinds of sculpins there are. The morphological differences between species are so subtle the biodiversity of sculpins in the West is underestimated and unappreciated.

ca we have encounte

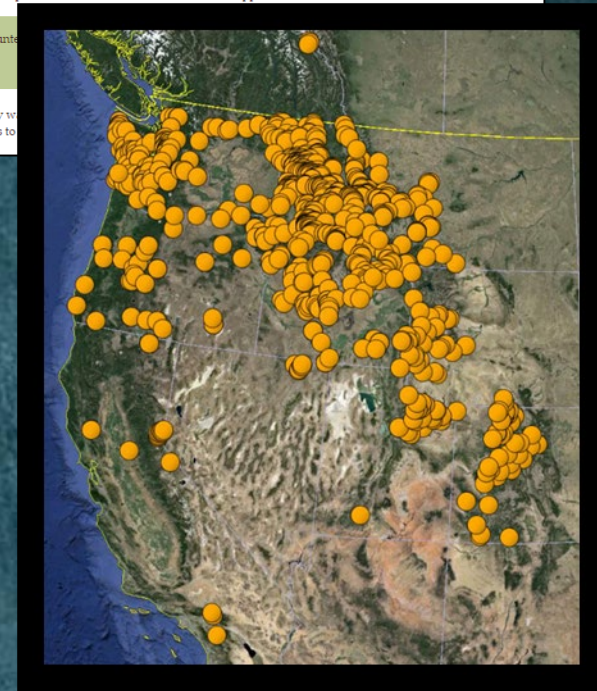
and this diversity w  
renew the efforts to

## Tissue sampling protocol for sculpins



My colleagues and I are using DNA barcoding to identify and locate potential conservation units—subspecies, ESUs, DPSs, stocks, or species new to science—of sculpins from throughout western North America. Your help is sought to obtain:

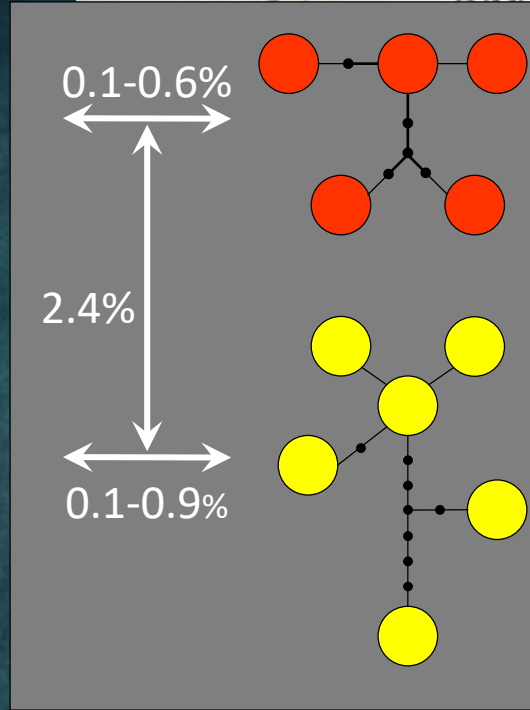
- Tissues from up to 5 individuals (or even 1–2) of all sculpin species (see page 2) from individual sites in any river basin in western North America—the Columbia, Colorado, Fraser, Yukon, or coastal river basins, and the Great Basin.



Google "Sculpin Qwest"

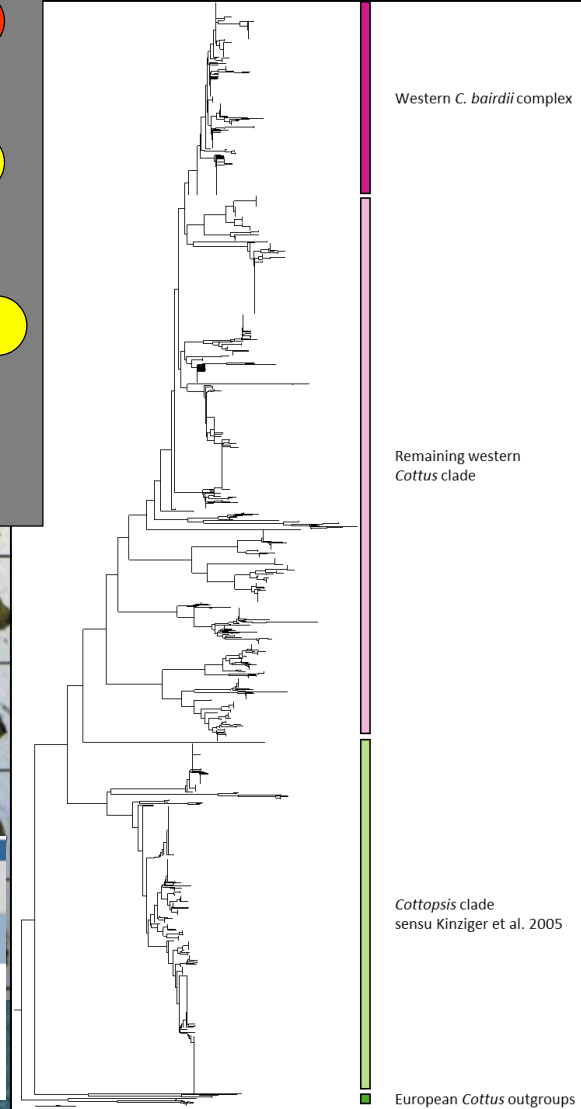
# SculpinQwest: the molecular approach

- COI (mtDNA)
  - The ~600 bp “barcode”
- cyt b (mtDNA)
  - The most commonly sequenced gene for fish
- S7 (nuDNA)
  - A non-coding intron with modest evolutionary rates
- Rhodopsin (nuDNA)
  - Highly conserved for detecting ancient divergence



Stream NORTH UTM (start): Zone 11T Easting 682787 Northing 5178213  
 Site(circle): PIBO Mid HW Other (end): Zone 11T Easting 686776 Northing 5178139  
 Width 2.9 m Date 2/25/09 Done by MZ, MY

Sp. nm	Sample	Sp. mm	Sample	Sp. mm	Sample	Sp. mm
11T	TP					



**IBOL WORKING GROUP | 1.1 VERTEBRATES**  
**Fish barcode of life (FISH-BOL)**

**progress**

specimens barcoded: 109818  
 species barcoded: 10970  
 unnamed barcode clusters found: 2367

**research** Fish DNA Barcoding

NCBI Resources How To Sign In to NCBI

Nucleotide Nucleotide Search Help

The Nucleotide database will include EST and GSS sequences in early 2019 [Read more](#)

**Nucleotide**

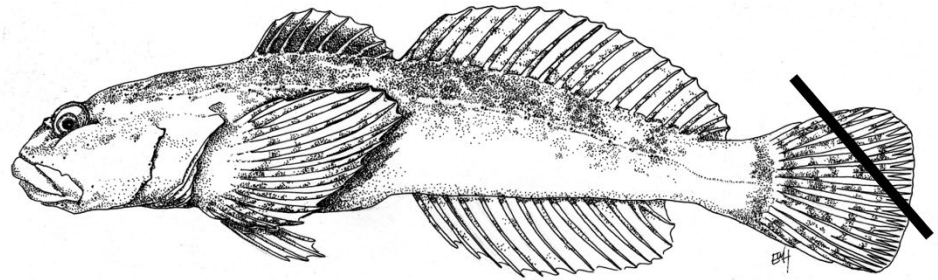
The Nucleotide database is a collection of sequences from several sources, including GenBank, RefSeq, TPA and PDB. Genome, gene and transcript sequence data provide the foundation for biomedical research and discovery.

# Lineage delineation

- Species concept: evolutionary
- Criteria: standard phylogenetic analyses
  - Distances (%)—barcode gap
  - Diagnosable—monophyletic
  - Allopatry with respect to close relatives
- Null hypothesis: existing taxonomy is correct
  - Ingroup defined by specimen nearest type location
  - Applied to each species complex
- Provisional: ~90% complete
- Four case histories

## WANTED:

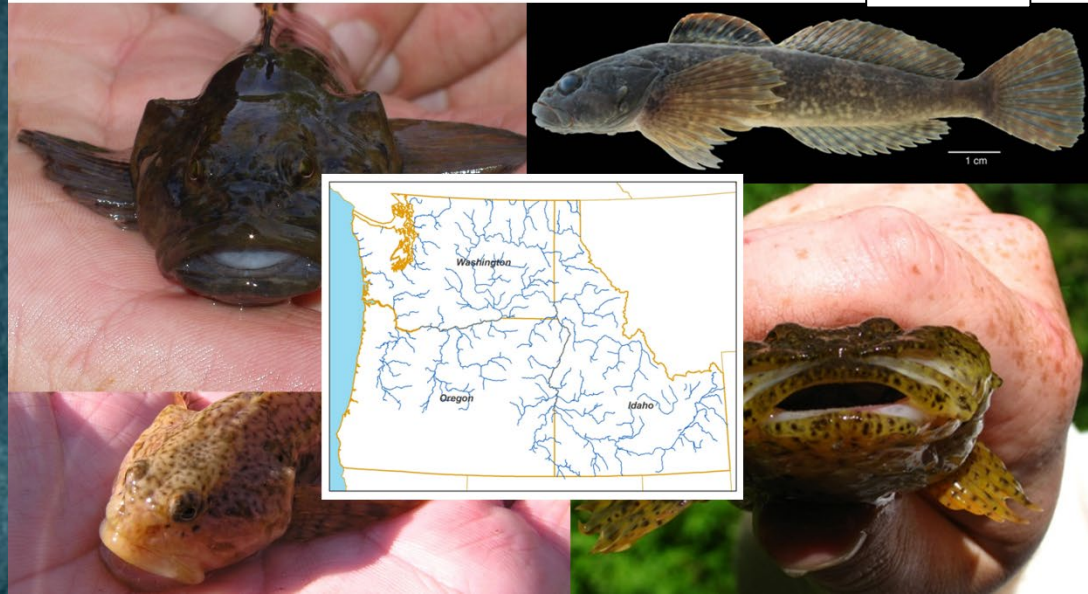
Upper caudal clips from Cottidae



As part of a one-year evaluation of the use of DNA barcodes for identifying sculpins from the Columbia River basin, I would appreciate receiving a few (2-5) fin clips from all species from as many waters as possible in Idaho, Oregon, Washington, and Wyoming.

Data wanted: fin clips (in ethyl alcohol, on chromatography paper, or in coin envelopes), GPS data, date, your name.

For more information, contact Michael Young at the Rocky Mountain Research Station in Missoula, MT ([mkyoung@fs.fed.us](mailto:mkyoung@fs.fed.us); 406 542-3254)





Torrent sculpin complex

*C. rhotheus*

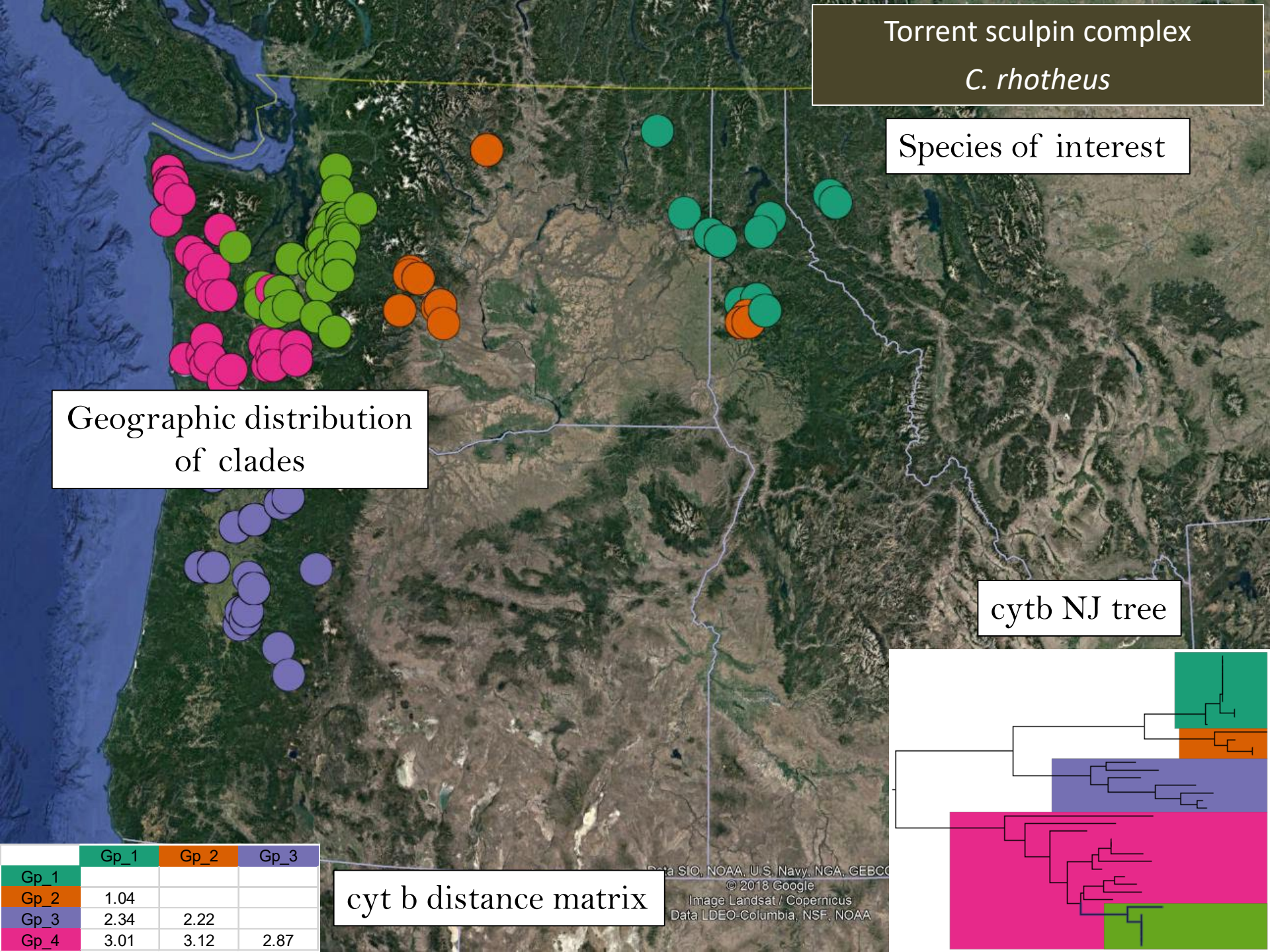
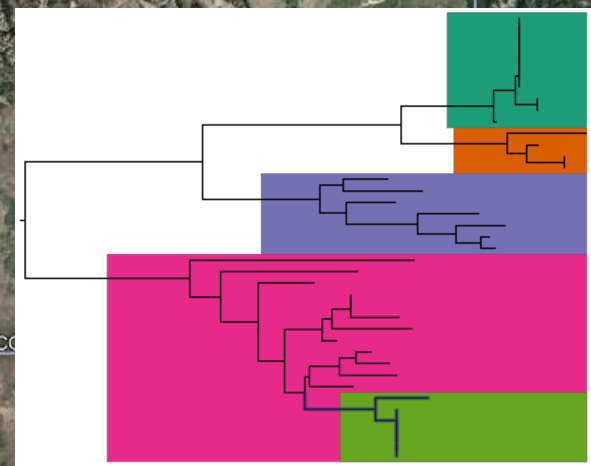
Species of interest

Geographic distribution  
of clades

cytb NJ tree

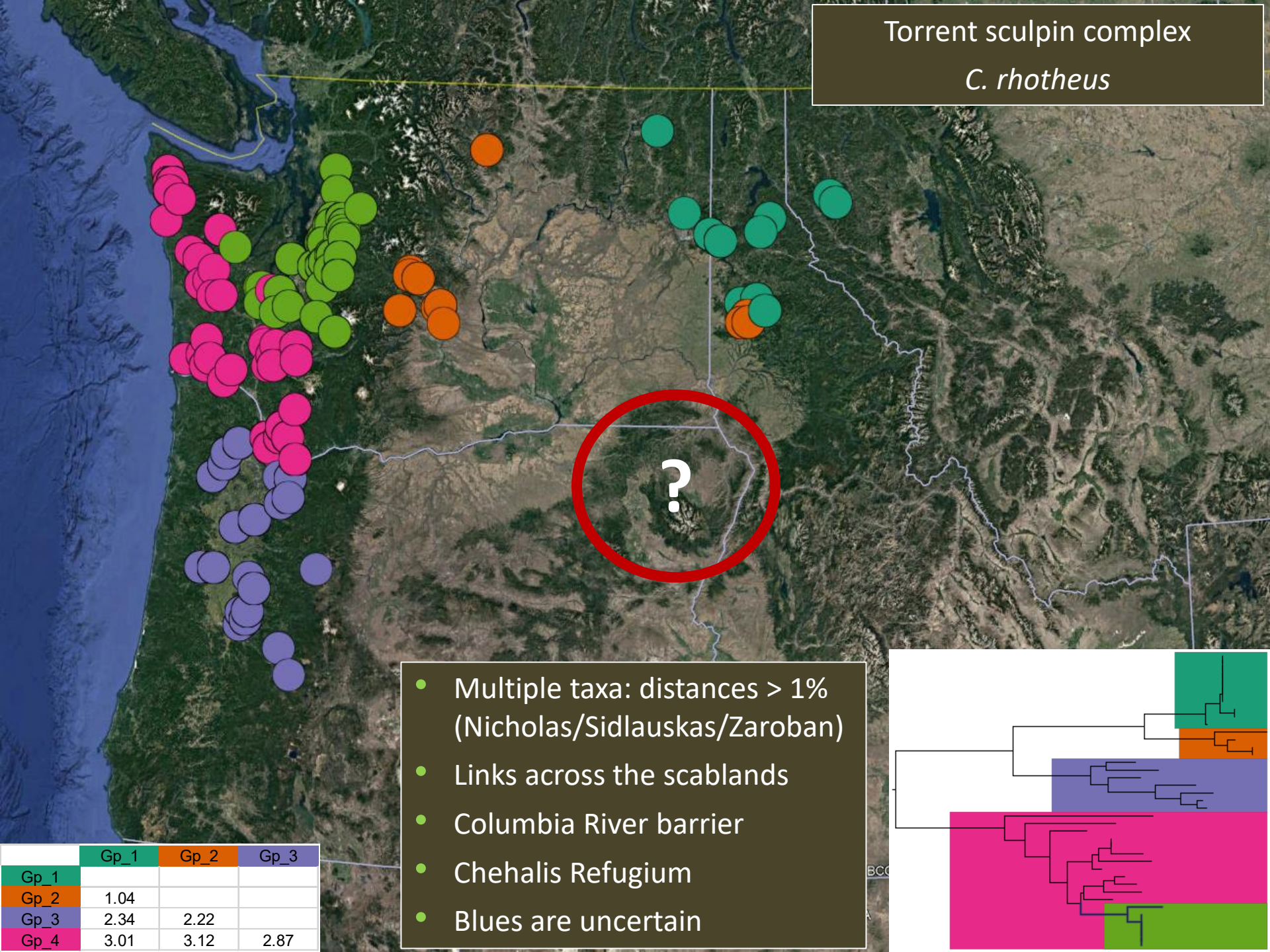
cyt b distance matrix

	Gp_1	Gp_2	Gp_3
Gp_1			
Gp_2	1.04		
Gp_3	2.34	2.22	
Gp_4	3.01	3.12	2.87



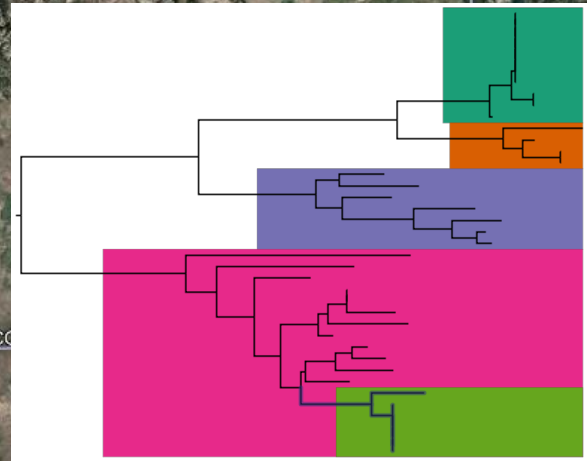
# Torrent sculpin complex

*C. rhotheus*



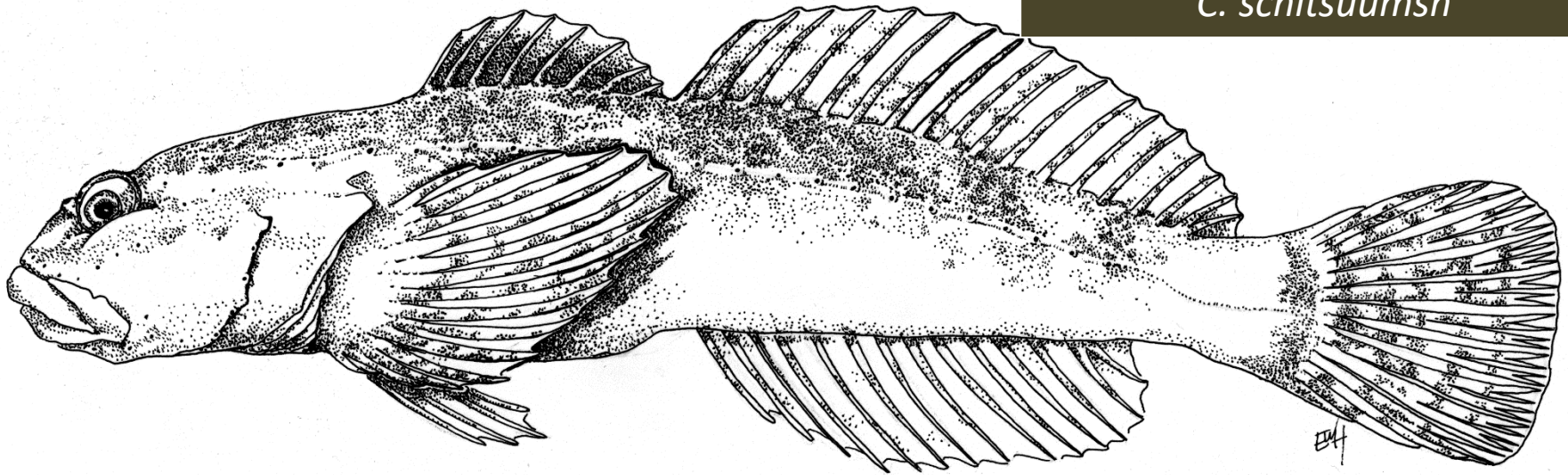
- Multiple taxa: distances > 1% (Nicholas/Sidlauskas/Zaroban)
- Links across the scablands
- Columbia River barrier
- Chehalis Refugium
- Blues are uncertain

	Gp_1	Gp_2	Gp_3
Gp_1			
Gp_2	1.04		
Gp_3	2.34	2.22	
Gp_4	3.01	3.12	2.87



Cedar sculpin

*C. schitsuumsh*



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## Article

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### ***Cottus schitsuumsh*, a new species of sculpin (Scorpaeniformes: Cottidae) in the Columbia River basin, Idaho-Montana, USA**

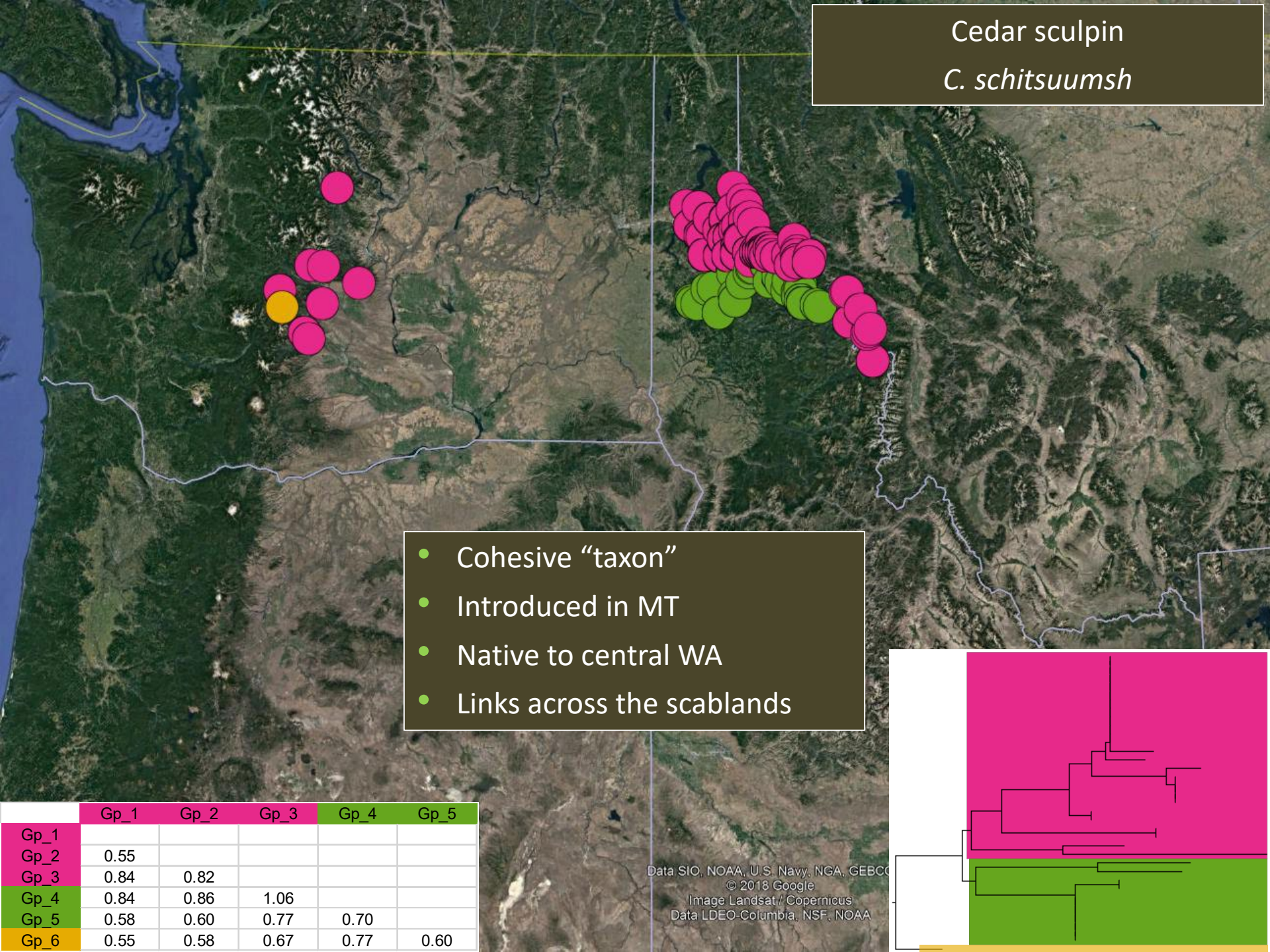
MICHAEL LEMOINE<sup>1,3</sup>, MICHAEL K. YOUNG<sup>2</sup>, KEVIN S. MCKELVEY<sup>2</sup>, LISA EBY<sup>1</sup>,  
KRISTINE L. PILGRIM<sup>2</sup> & MICHAEL K. SCHWARTZ<sup>2</sup>

<sup>1</sup>Wildlife Biology Program, University of Montana, Missoula, Montana 59812, USA

<sup>2</sup>U.S. Forest Service, Rocky Mountain Research Station, Missoula, Montana 59801, USA

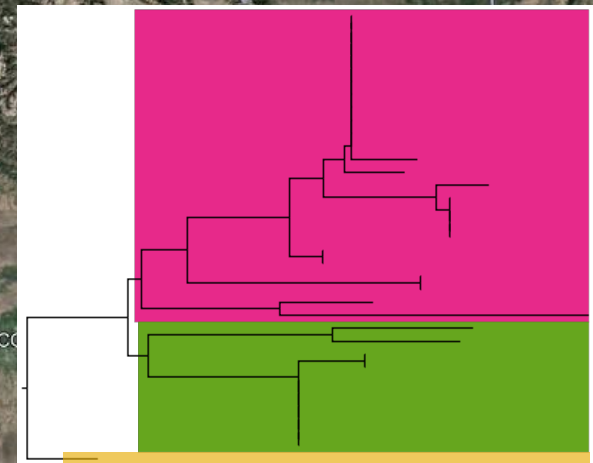
<sup>3</sup>Corresponding author. E-mail: [michaell.lemoine@umconnect.umt.edu](mailto:michaell.lemoine@umconnect.umt.edu)

Cedar sculpin  
*C. schitsuumsh*



- Cohesive “taxon”
- Introduced in MT
- Native to central WA
- Links across the scablands

	Gp_1	Gp_2	Gp_3	Gp_4	Gp_5
Gp_1					
Gp_2	0.55				
Gp_3	0.84	0.82			
Gp_4	0.84	0.86	1.06		
Gp_5	0.58	0.60	0.77	0.70	
Gp_6	0.55	0.58	0.67	0.77	0.60



Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
© 2018 Google  
Image Landsat / Copernicus  
Data LDEO-Columbia, NSF, NOAA

Shorthead sculpin complex

*C. confusus*



**J. D. McPhail**

College of Fisheries  
University of Washington  
Seattle, Washington

**Distribution of Freshwater Fishes  
in Western Washington'**

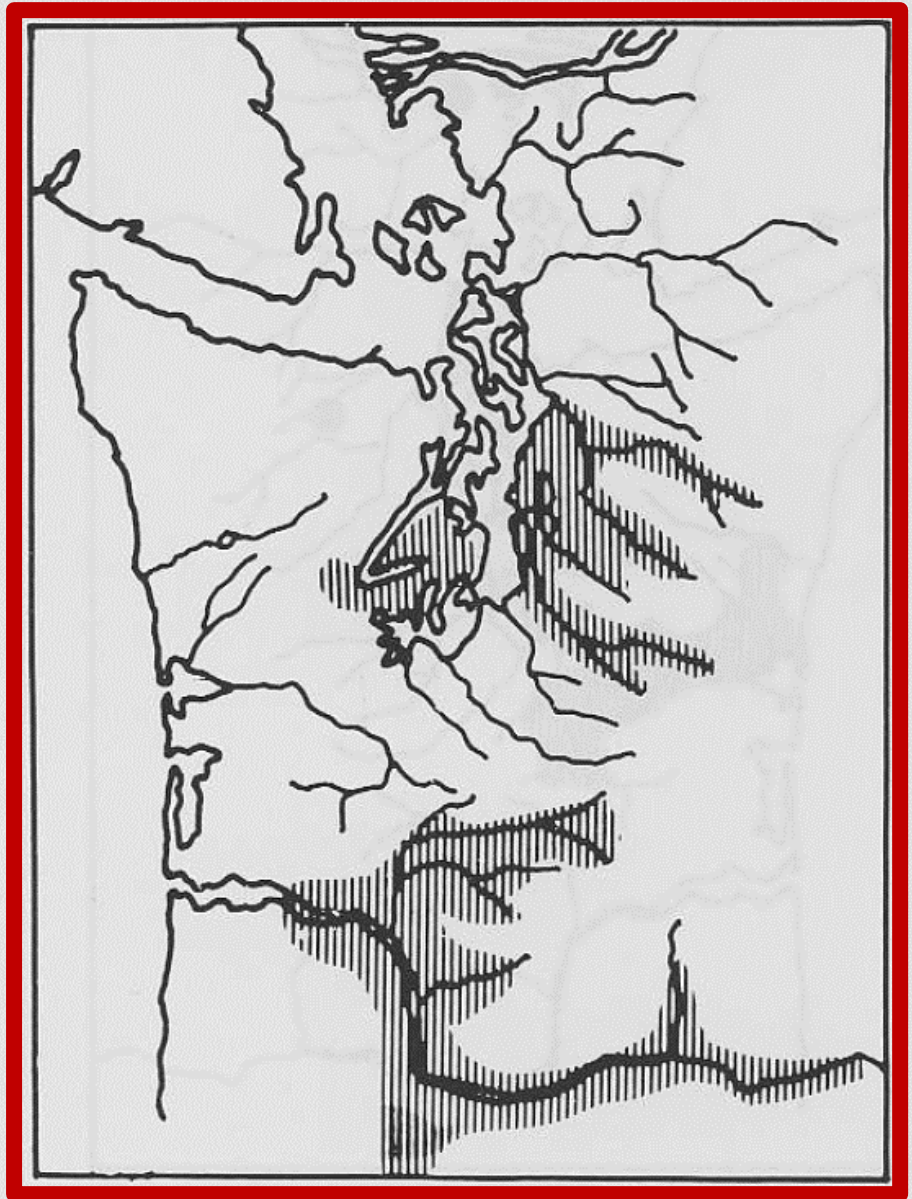
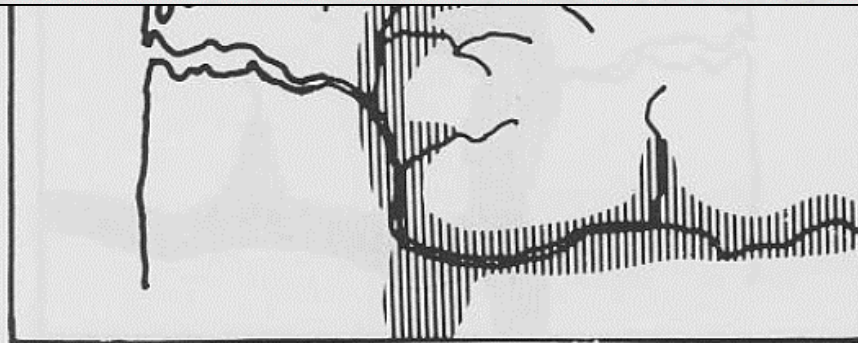
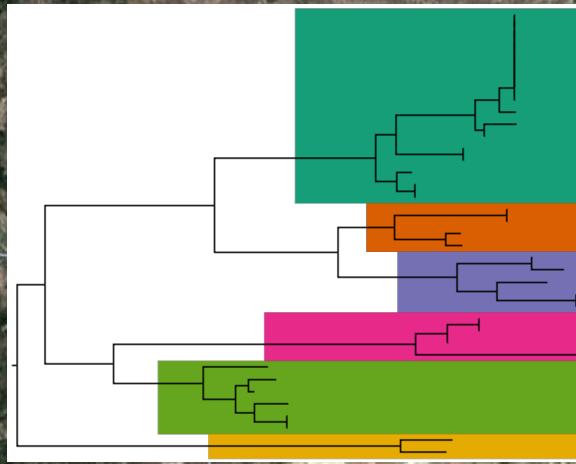
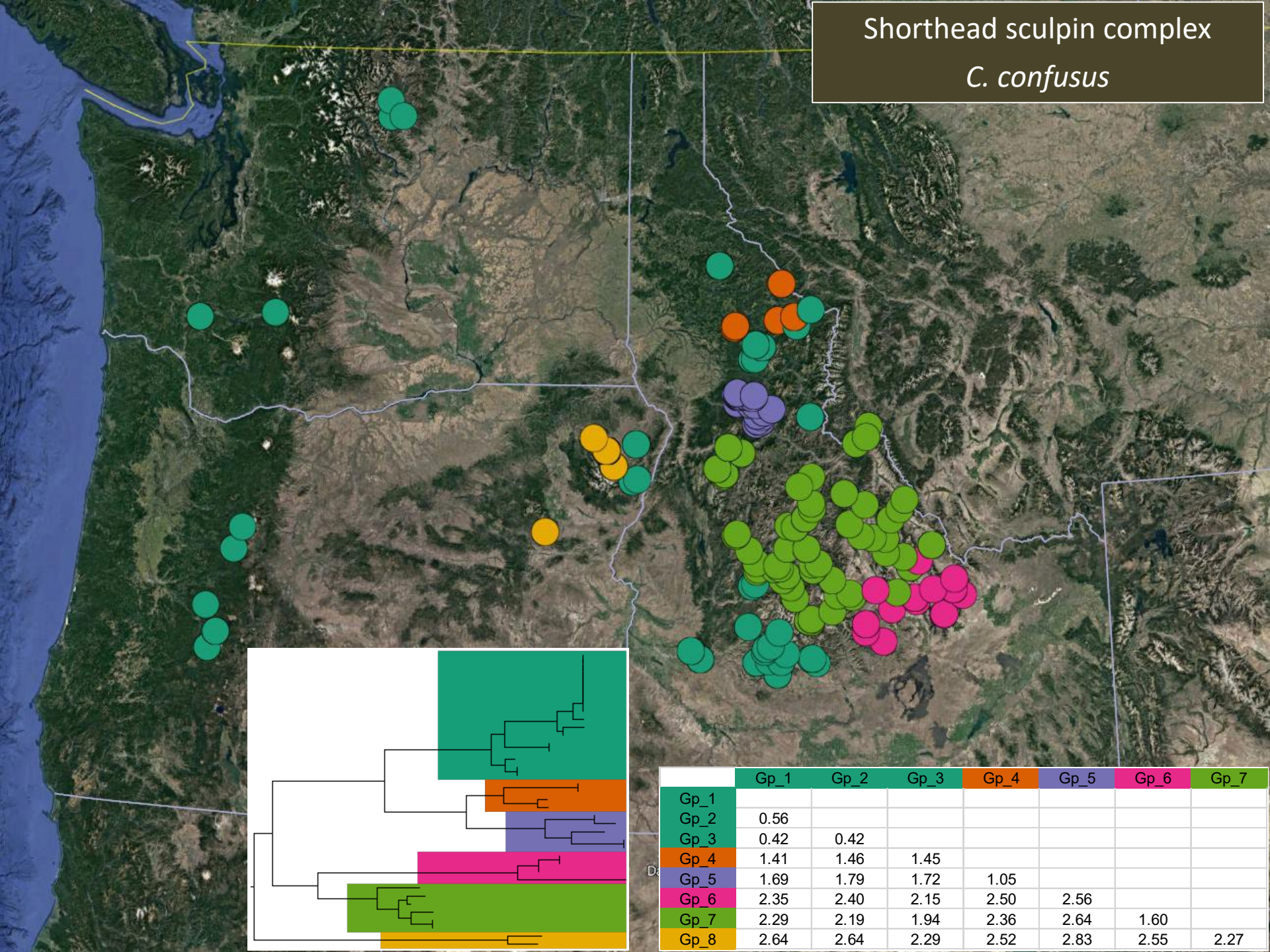


Figure 8. Left. Western Washington distribution of the leopard dace, *R. falcatus*.

Figure 9. Right. Western Washington distribution of the shorthead sculpin, *C. confusus*.

# Shorthead sculpin complex

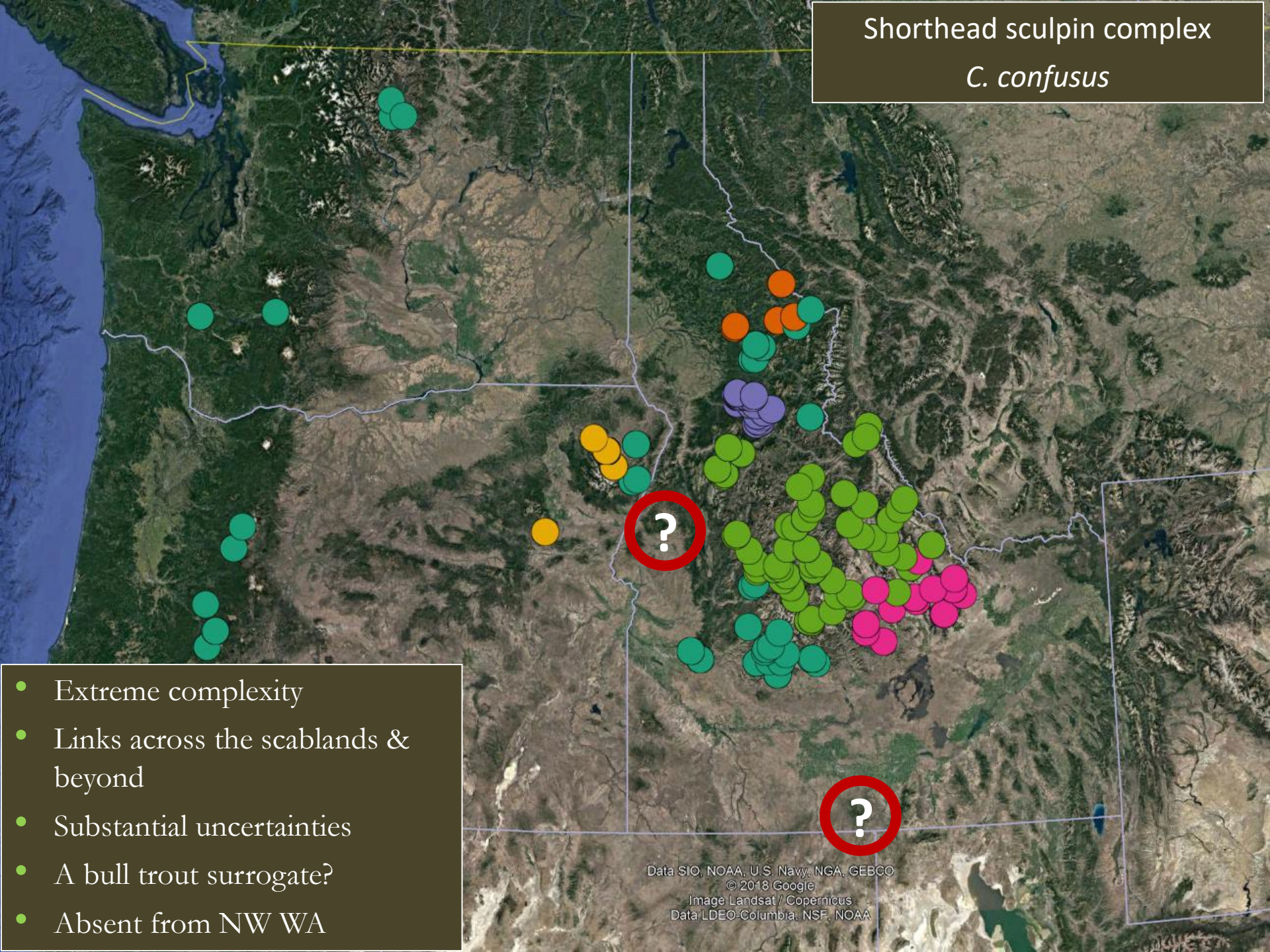
*C. confusus*



	Gp_1	Gp_2	Gp_3	Gp_4	Gp_5	Gp_6	Gp_7
Gp_1							
Gp_2	0.56						
Gp_3	0.42	0.42					
Gp_4	1.41	1.46	1.45				
Gp_5	1.69	1.79	1.72	1.05			
Gp_6	2.35	2.40	2.15	2.50	2.56		
Gp_7	2.29	2.19	1.94	2.36	2.64	1.60	
Gp_8	2.64	2.64	2.29	2.52	2.83	2.55	2.27

# Shorthead sculpin complex

*C. confusus*

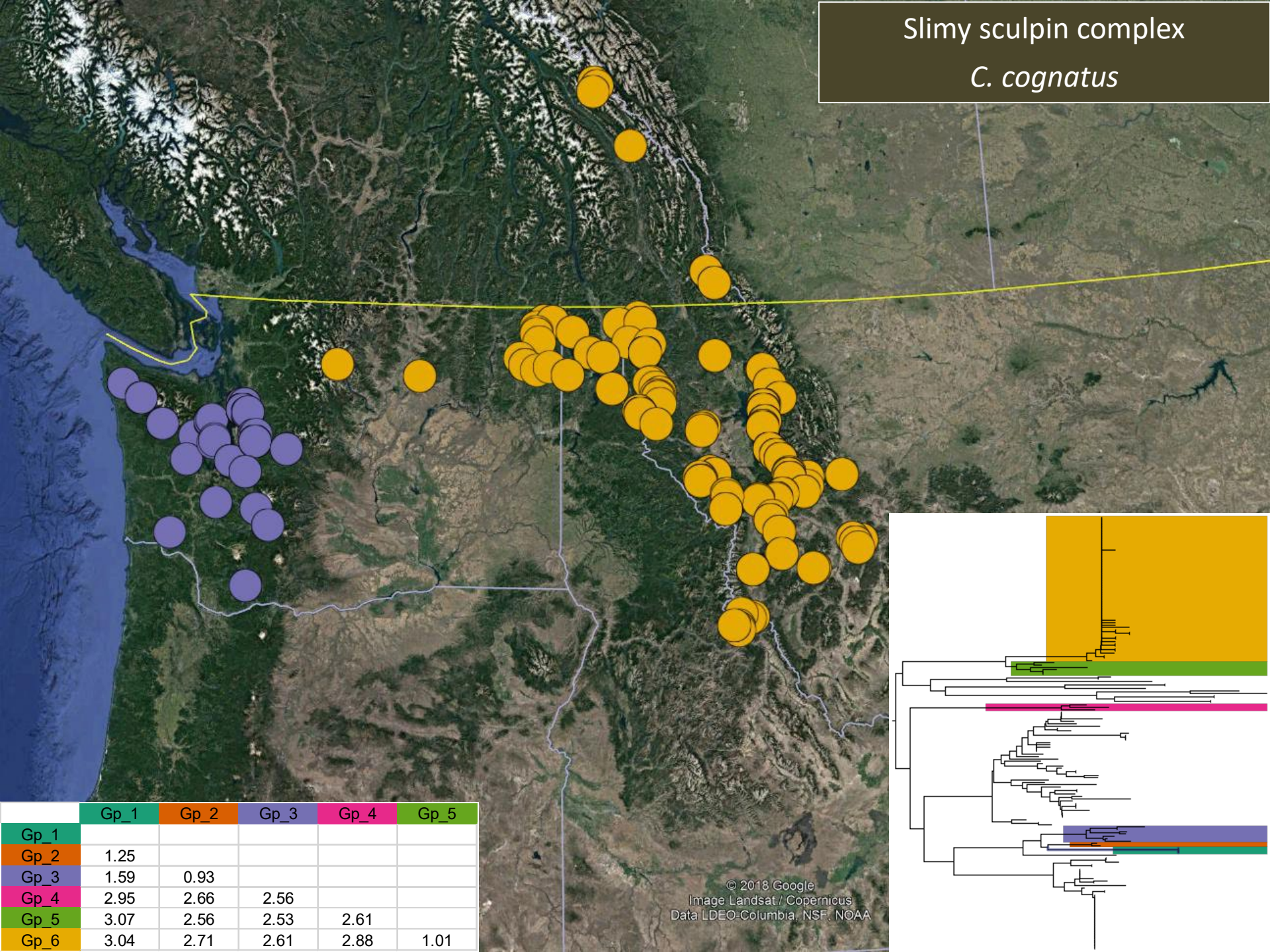


- Extreme complexity
- Links across the scablands & beyond
- Substantial uncertainties
- A bull trout surrogate?
- Absent from NW WA

Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
© 2018 Google  
Image Landsat / Copernicus  
Data LDEO-Columbia, NSF, NOAA

# Slimy sculpin complex

*C. cognatus*



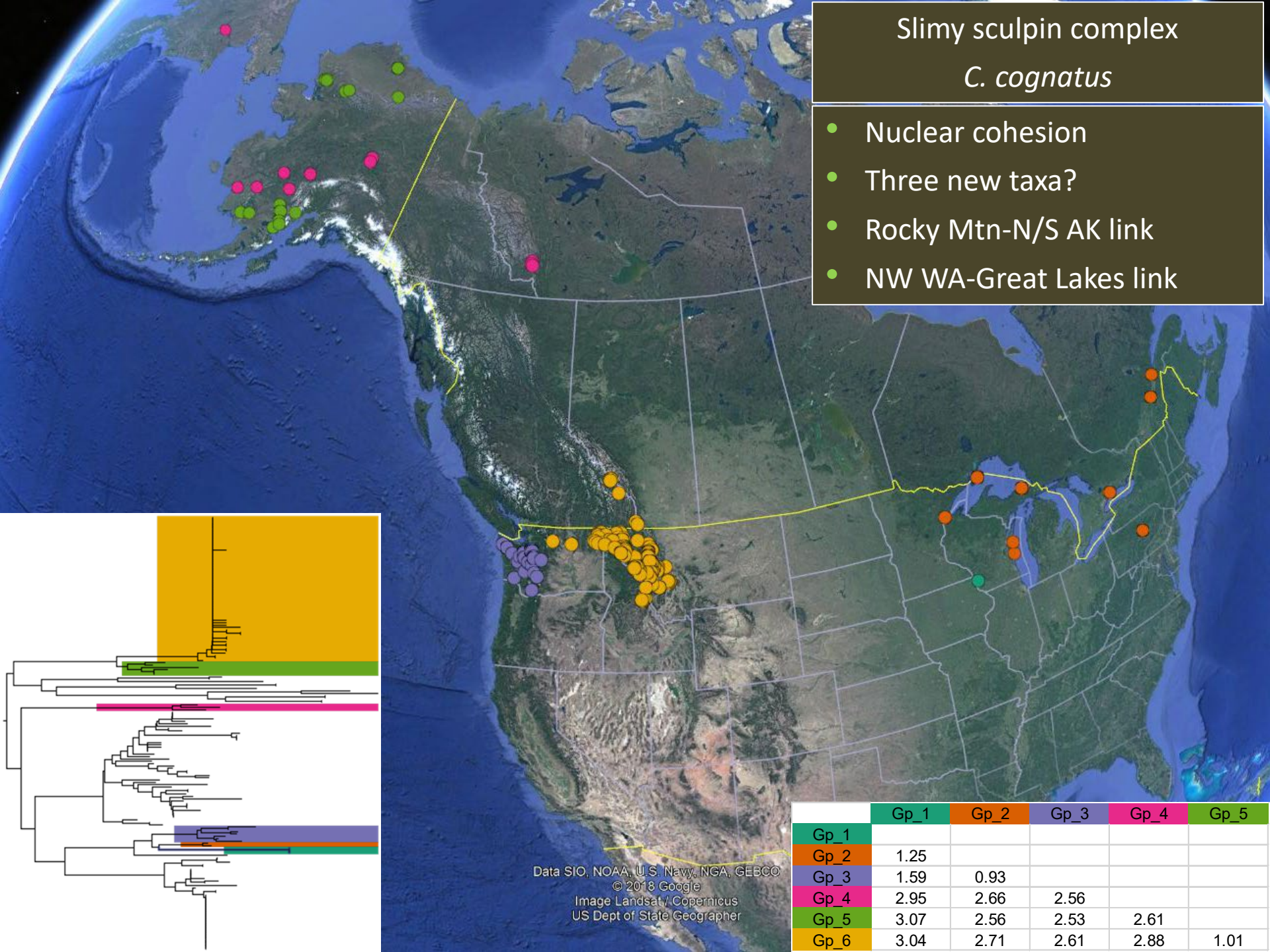
	Gp_1	Gp_2	Gp_3	Gp_4	Gp_5
Gp_1					
Gp_2	1.25				
Gp_3	1.59	0.93			
Gp_4	2.95	2.66	2.56		
Gp_5	3.07	2.56	2.53	2.61	
Gp_6	3.04	2.71	2.61	2.88	1.01



# Slimy sculpin complex

*C. cognatus*

- Nuclear cohesion
- Three new taxa?
- Rocky Mtn-N/S AK link
- NW WA-Great Lakes link



Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
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Image Landsat / Copernicus  
US Dept of State Geographer

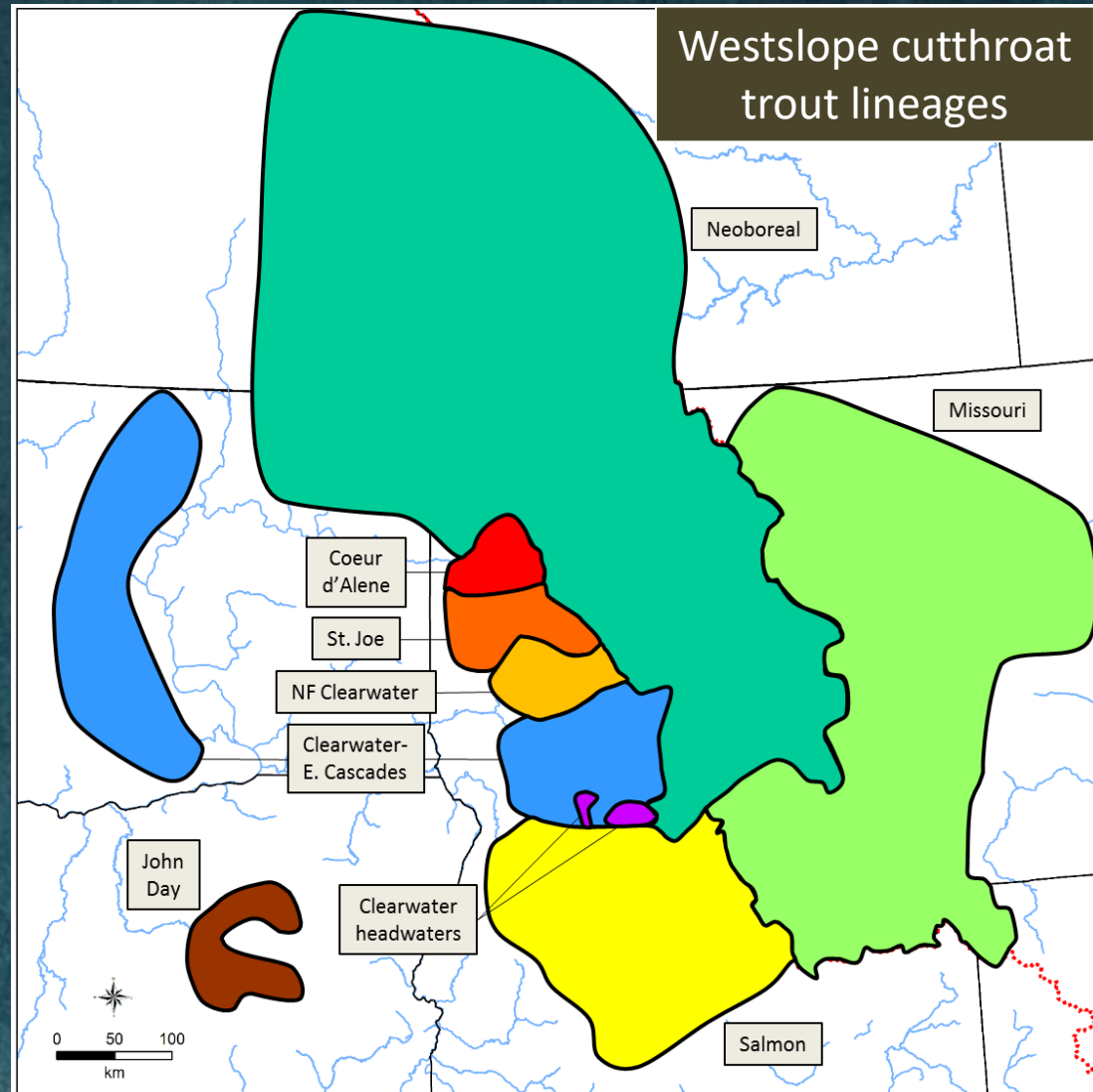
	Gp_1	Gp_2	Gp_3	Gp_4	Gp_5
Gp_1					
Gp_2	1.25				
Gp_3	1.59	0.93			
Gp_4	2.95	2.66	2.56		
Gp_5	3.07	2.56	2.53	2.61	
Gp_6	3.04	2.71	2.61	2.88	1.01

# Briefly...

- Additional results
  - *C. gulosus* is not found in WA
  - *C. beldingii* isn't either...but *C. tubulatus* is
  - *C. bendirei* is real...just not here
- Biodiversity hotspots & “gray” zones
  - The Blues
  - E. Cascades
  - Columbia Gorge tributaries (Klickitat R. downstream)
- Corroboration from comparative phylogeography



Young et al. (2018). The phylogeography of westslope cutthroat trout. Pages 261-301 in Trotter P, Bisson P, Schultz L, Roper B (editors). Cutthroat Trout: Evolutionary Biology and Taxonomy. Special Publication 36, American Fisheries Society, Bethesda, Maryland.



<https://www.fs.usda.gov/treesearch/pubs/57473>