The range-wide, eDNA-based inventory of bull trout: early results and an ongoing invitation

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Collaborators

Bureau of Land Management
Bureau of Reclamation
Chehalis Tribe
Clark Fork Coalition
Coeur d'Alene Tribes
Great Northern LCC
Idaho Conservation League
Idaho Department of Environmental Quality
Idaho Department of Fish and Game
Idaho Power Company
Kalispel Tribes
Lewis River Bull Trout Recovery Team
Montana Department of Natural Resources Conservation
Montana Fish, Wildlife & Parks
Mount Rainier National Park
National Fish and Wildlife Foundation
The Nature Conservancy
Nez Perce Tribes
North Cascades National Park
Oregon Department of Fish and Wildlife
Trout Unlimited
University of Washington
U.S. Fish and Wildlife Service
National Forests:
Beaverhead-Deer Lodge, Boise, Colville, Deschutes, Flathead, Gifford Pinchot, Helena, Idaho Panhandle, Lolo, Mount Baker-Snoqualmie, Nez Perce-Clearwater, Payette, Salmon-Challis, Sawtooth, Umatilla, Wallowa-Whitman, Wenatchee
Regions 1, 4, and 6
Washington Department of Fish and Wildlife
Whitefish Institute
Wild Fish Conservancy
Yakama Nation

Sponsors

Great Northern LANDSCAPE CONSERVATION COOPERATIVE

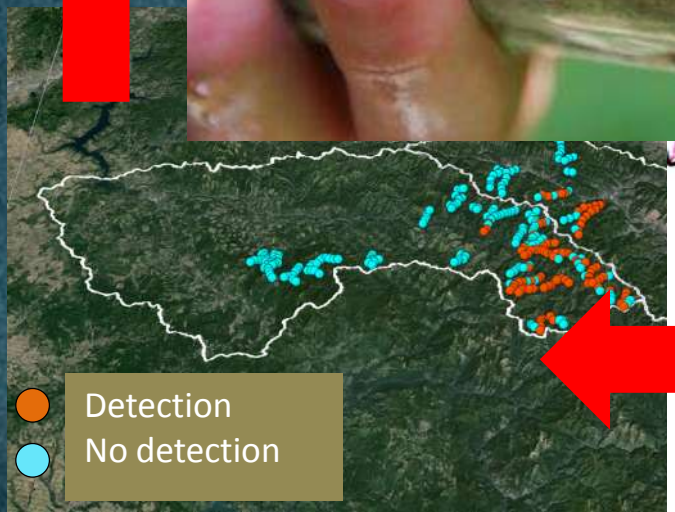
USDA U.S. FOREST SERVICE Region 1

Institutional Support

USDA Forest Service National Genomics Center for Wildlife and Fish Conservation

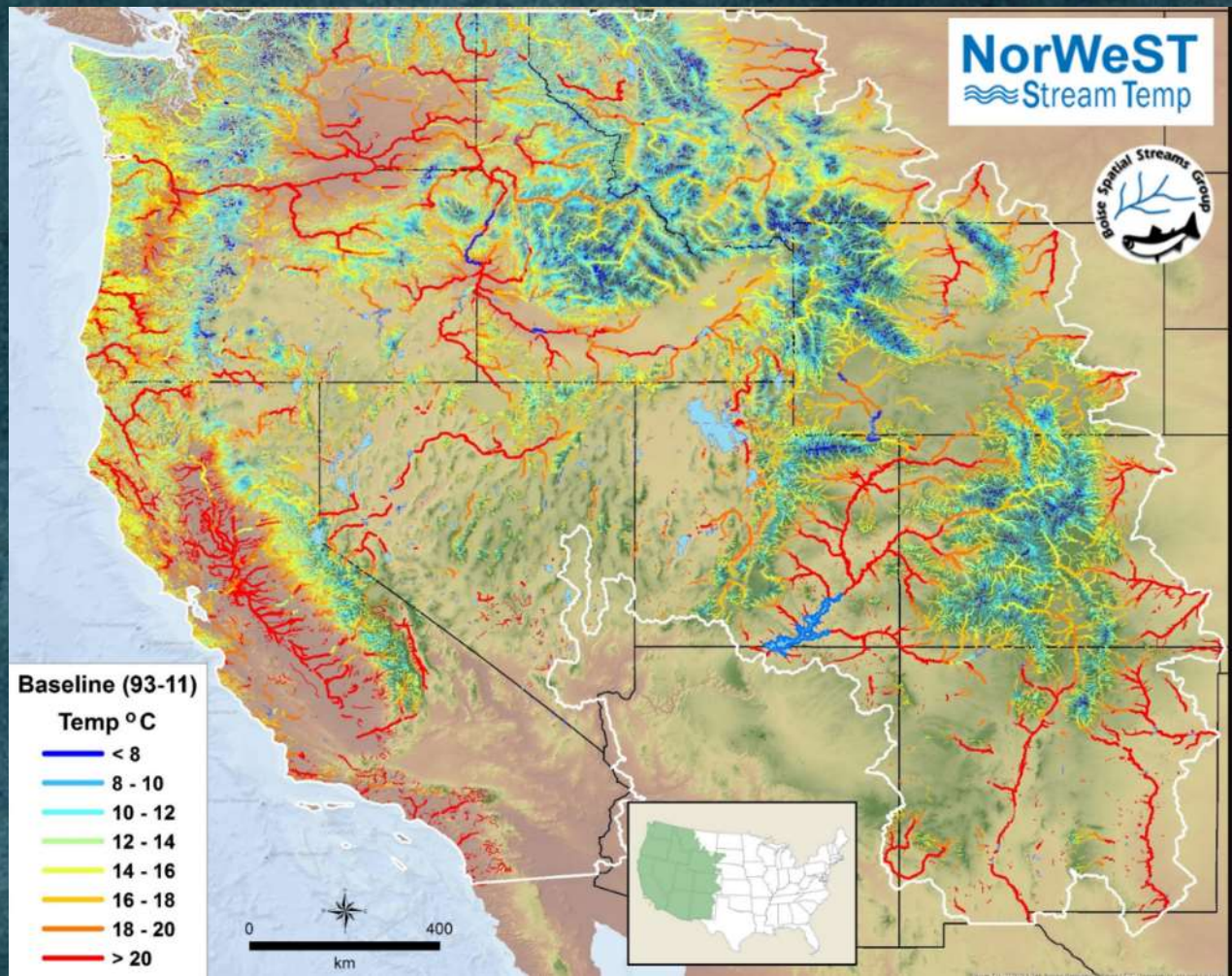
Outline

- Focal species/life stage
  - Juvenile bull trout
- Habitat uncertainty
  - SDM
  - Explicit predictions of occupancy
- eDNA sampling
  - What is it
  - Why use it
- Bull trout + eDNA
  - Deciding where to sample
  - Early results
- Closing the circle
  - Better decisions
  - Other species
- You



Why choose juvenile bull trout?

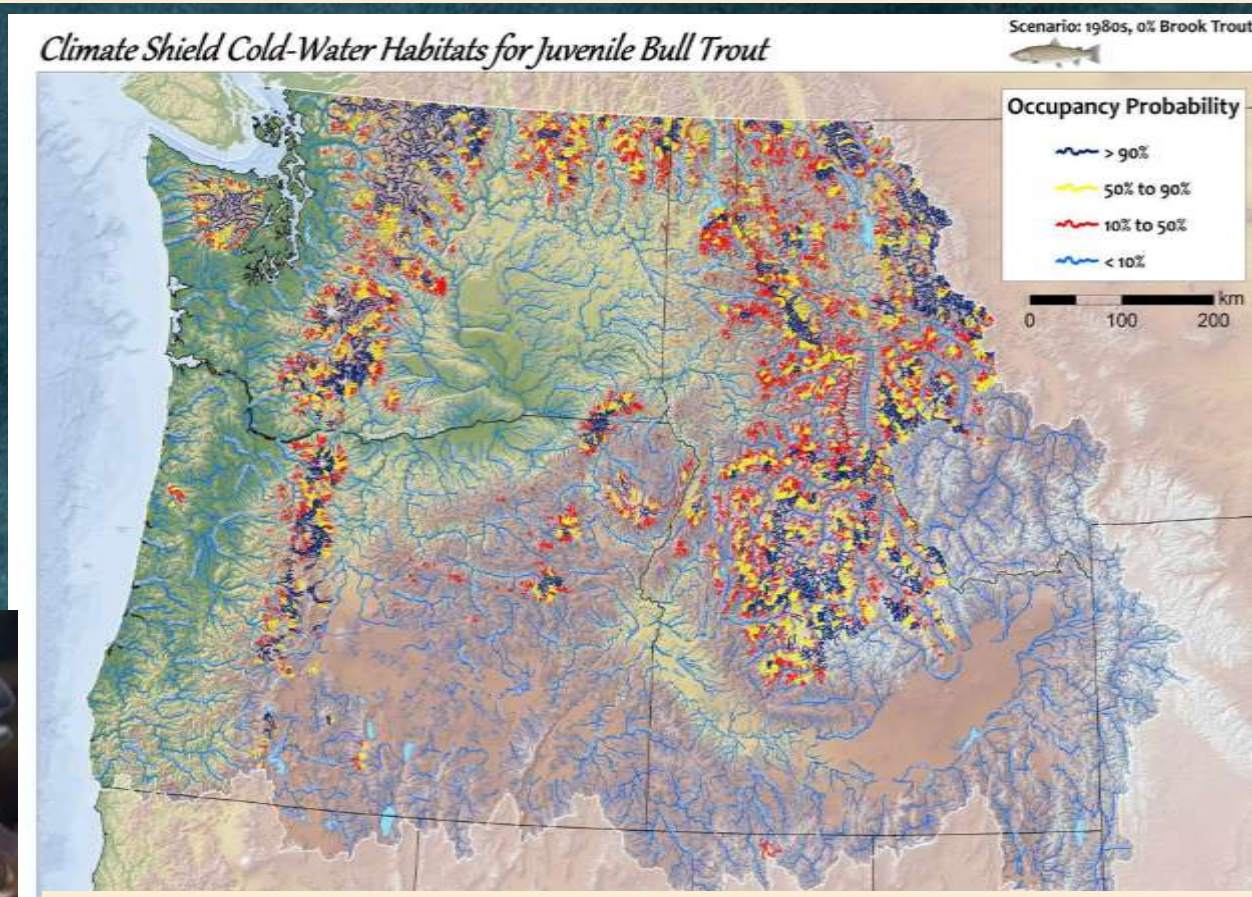
- ESA-listed as threatened
- Presence dictates land & water management & planning
- Widespread in PNW
- Often rare
- Difficult to detect
- Juveniles constrained by water temperature, vulnerable to nonnative spp.
- = candidate for occupancy modeling to identify suitable habitat



Identifying climate refugia for native trout – the Climate Shield

- Climate to cold-water habitat
- Predictions
  - Accurate & sufficient
  - Address invasive species
  - Empirical
  - Precise
  - Range-wide
- Projections
  - Address climate change
- **Validation**

https://www.fs.fed.us/rm/boise/AWAE/projects/ClimateShield.html
or Google “cold-water climate shield”



~3700 potentially occupied cold-water habitats: which ones are?

Conventional sampling issues

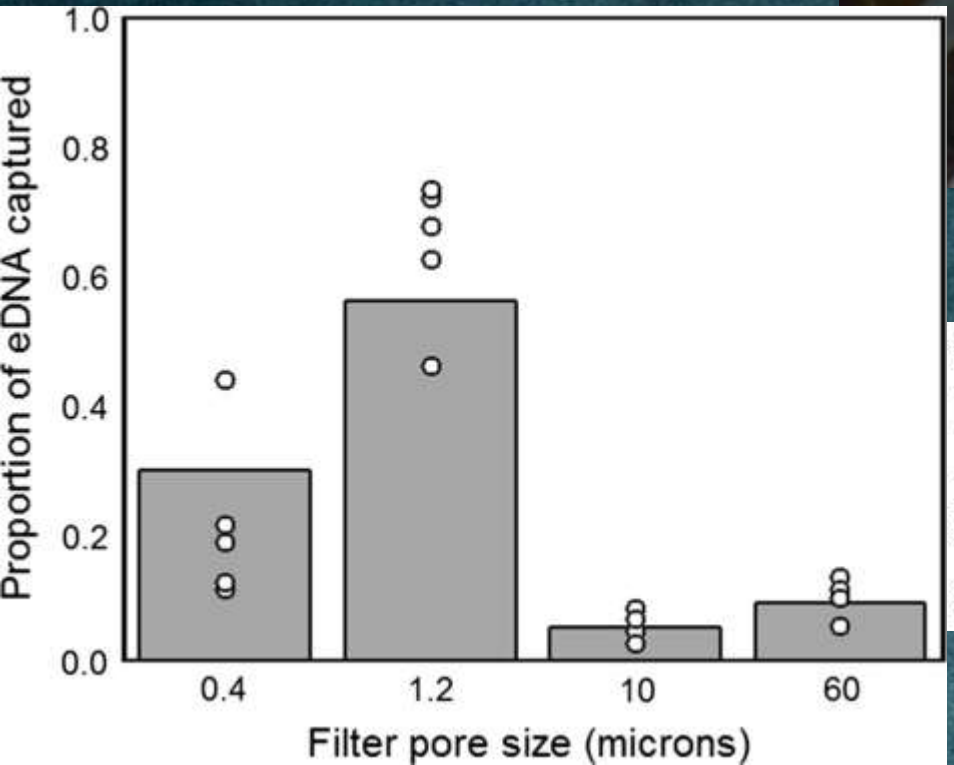
- Harmful
- Expensive & time-consuming
- Ineffective
  - Rare native species
  - Invasion fronts & removal survivors

- Is there an alternative?

What is eDNA sampling?

- Environmental = “free”
- Mitochondrial (usually)
  - Durable
  - Abundant
- Nuclear options
  - Dolly Varden & coastal bull trout

*could be RNA



Conservation Genet Resour
DOI 10.1007/s12686-015-0465-y

TECHNICAL NOTE

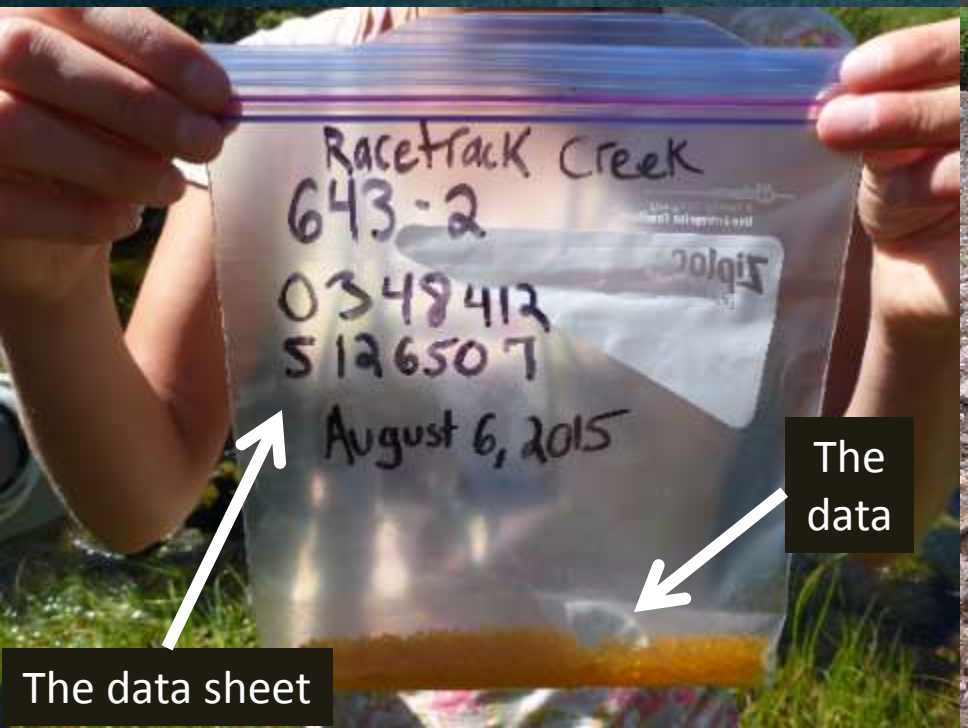
Environmental DNA particle size distribution from Brook Trout (*Salvelinus fontinalis*)

Taylor M. Wilcox[1,2] · Kevin S. McKelvey[2] · Michael K. Young[2] · Winsor H. Lowe[1] · Michael K. Schwartz[2]

Why use eDNA sampling: efficiency

- Fast
- Portable
- Stable
- Cost: pennies on the dollar, minutes on the hour

- <u>Rapid, broad-scale surveys are feasible</u>

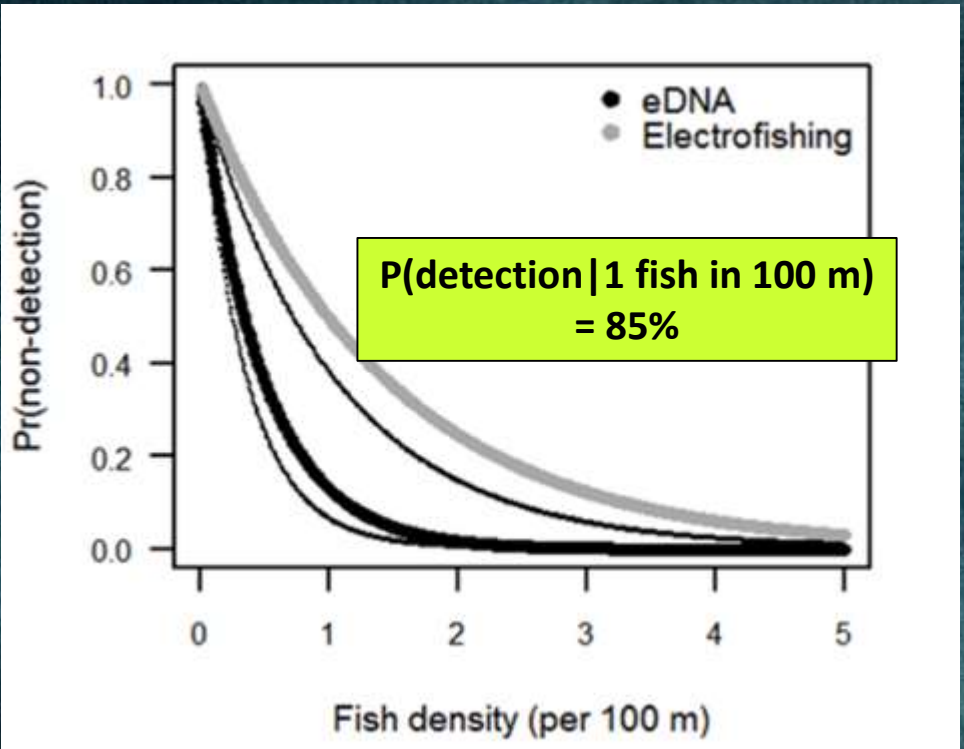


Why use eDNA sampling: accuracy

- Reliably* species-specific
- Sensitivity: high & quantified
  - Release rate: ~500 copies/sec
  - Detection threshold: 1 copy
- Very good at detecting rare species

- <u>Occupancy estimates are robust</u>

DNA Source	DNA Concentration Copies / ul	N	Proportion Successful
Brook Trout	315.5	40	1
	62.5	40	1
	12.5	40	1
	2.5	40	1
	0.5	40	0.825



OPEN ACCESS Freely available online PLOS ONE

Robust Detection of Rare Species Using Environmental DNA: The Importance of Primer Specificity

Taylor M. Wilcox[1]*, Kevin S. McKelvey[1], Michael K. Young[1], Stephen F. Jane[2], Winsor H. Lowe[3], Andrew R. Whiteley[2], Michael K. Schwartz[1]

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

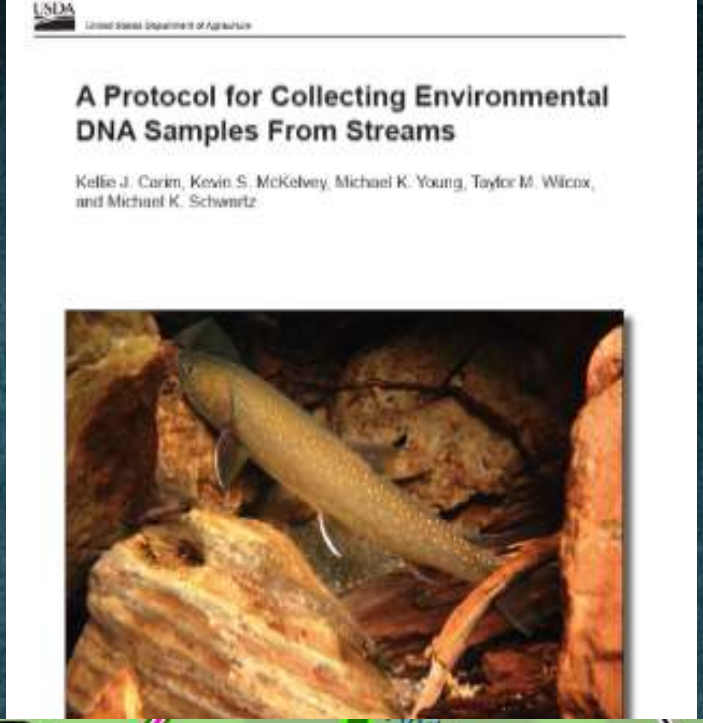
Understanding environmental DNA detection probabilities: A case study using a stream-dwelling char *Salvelinus fontinalis*

Taylor M. Wilcox[a,b,*], Kevin S. McKelvey[a], Michael K. Young[a], Adam J. Sepulveda[c], Bradley B. Shepard[d,1], Stephen F. Jane[e], Andrew R. Whiteley[e], Winsor H. Lowe[b], Michael K. Schwartz[a]

Why use eDNA sampling: revolutionary

- Apply a consistent approach
- Craft a sampling design
- Engage the stakeholder community

- Defensible, precise, broad-scale occupancy estimates for priority species in real time for reasonable cost

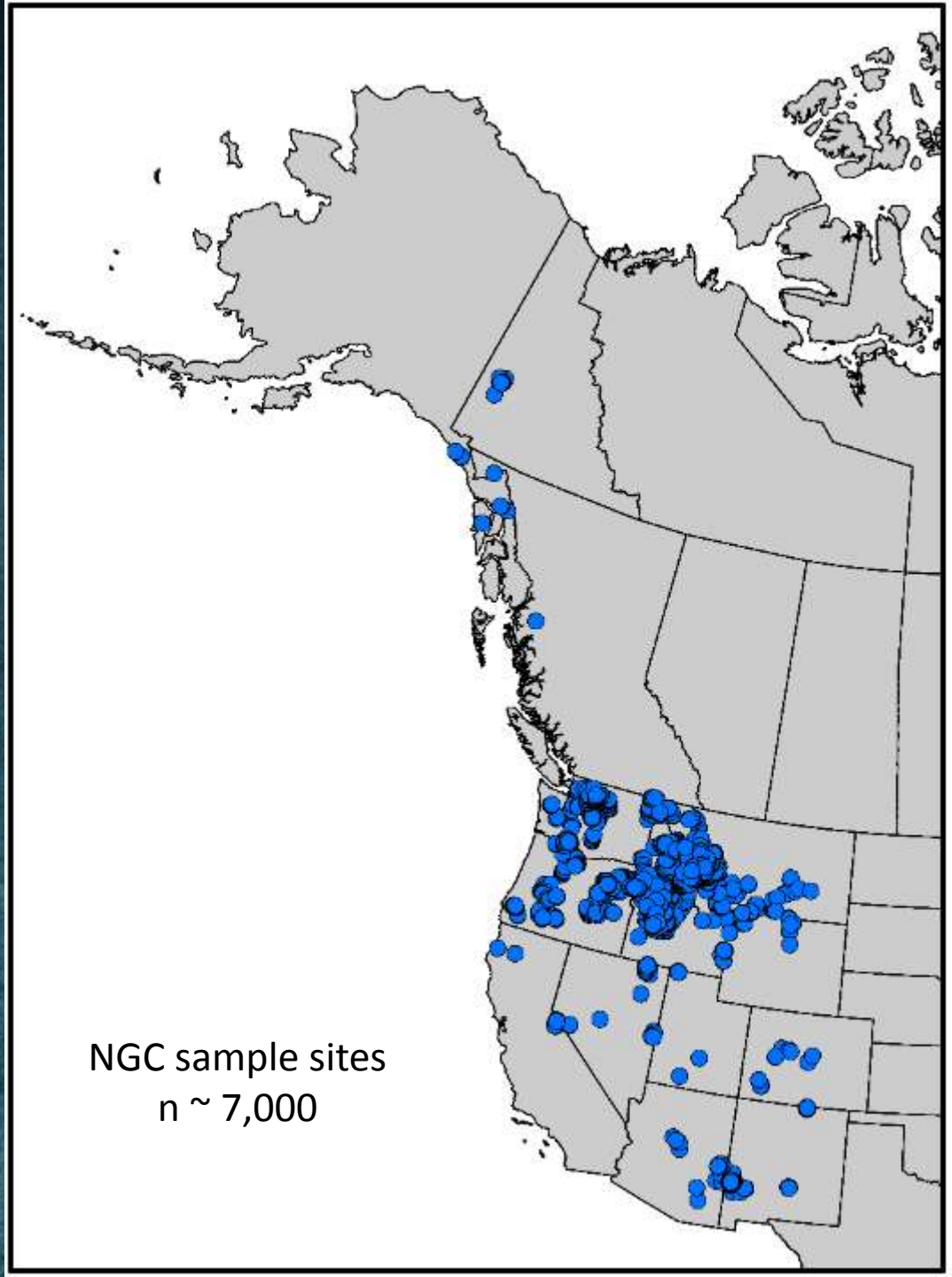

USDA

A Protocol for Collecting Environmental DNA Samples From Streams

Kellie J. Carim, Kevin S. McKelvey, Michael K. Young, Taylor M. Wilcox, and Michael K. Schwartz

Why eDNA: many applications

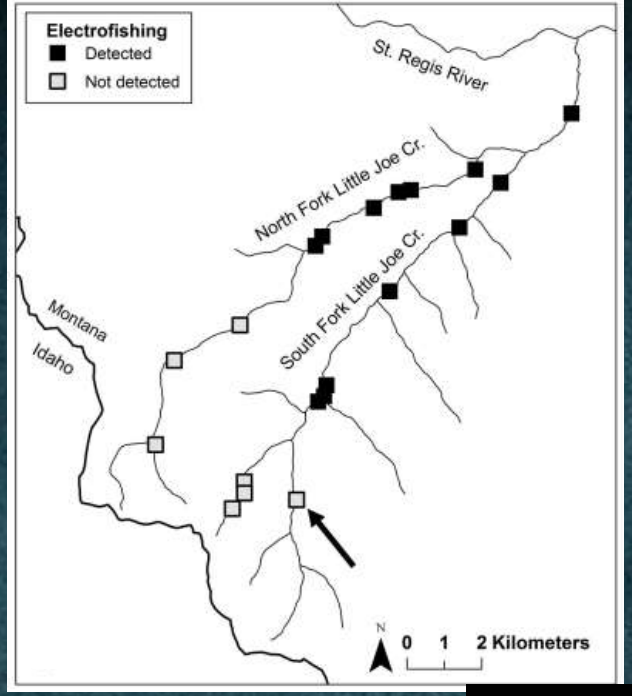
- Trout: rainbow, westslope cutthroat, Yellowstone cutthroat, brown
- Charr: bull, brook, Dolly Varden, lake, Arctic
- Salmon: Chinook, chum, coho, pink, sockeye
- Arctic grayling
- Any salmonid
- Pacific & brook lamprey
- Game fish/invaders: northern pike, sauger, walleye, smallmouth bass
- Non-game fish: sculpin (several), northern leatherside chub, loach minnow, spikedace
- Amphibians: Rocky Mountain tailed frog, western toad
- Mussels: western pearlshell, California floater
- Invertebrates: opossum shrimp
- North American river otter
- Harlequin duck
- Yuma clapper rail
- Your species here...

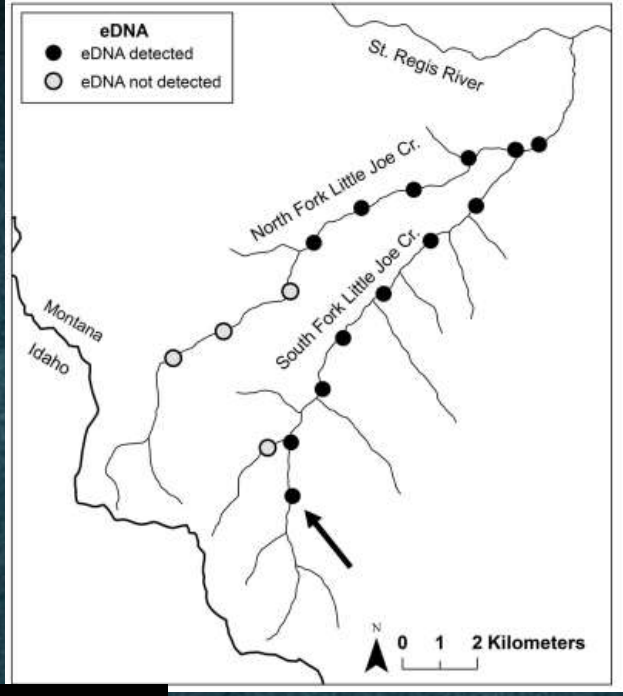


Using eDNA sampling to detect bull trout

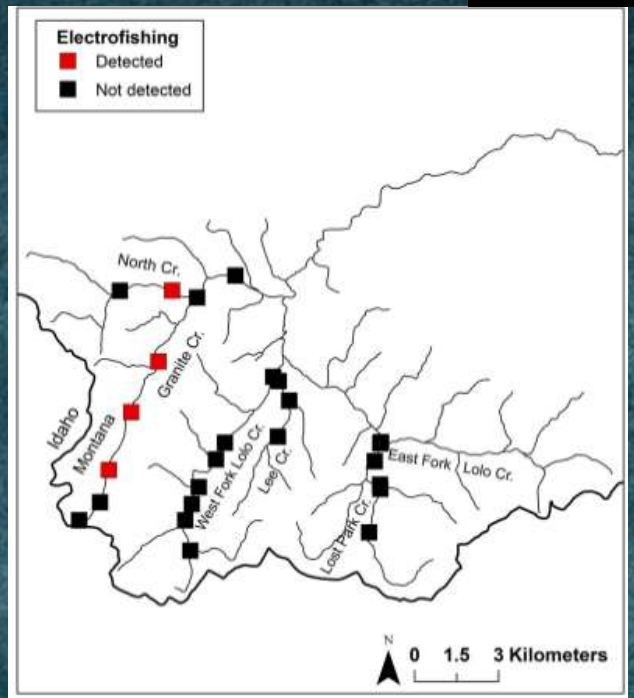
- ESA listed as threatened
- Dictates land & water management & planning
- Widespread - rare
- Difficult to detect
- Juveniles constrained by environment/community
- = ideal candidate for eDNA sampling

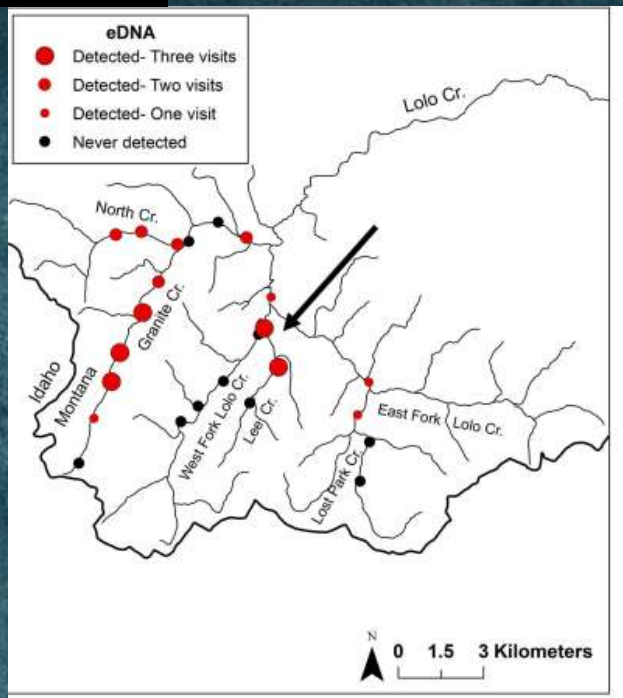
- Test: Montana 2014
- Confirmed known habitats
- Discovered new ones





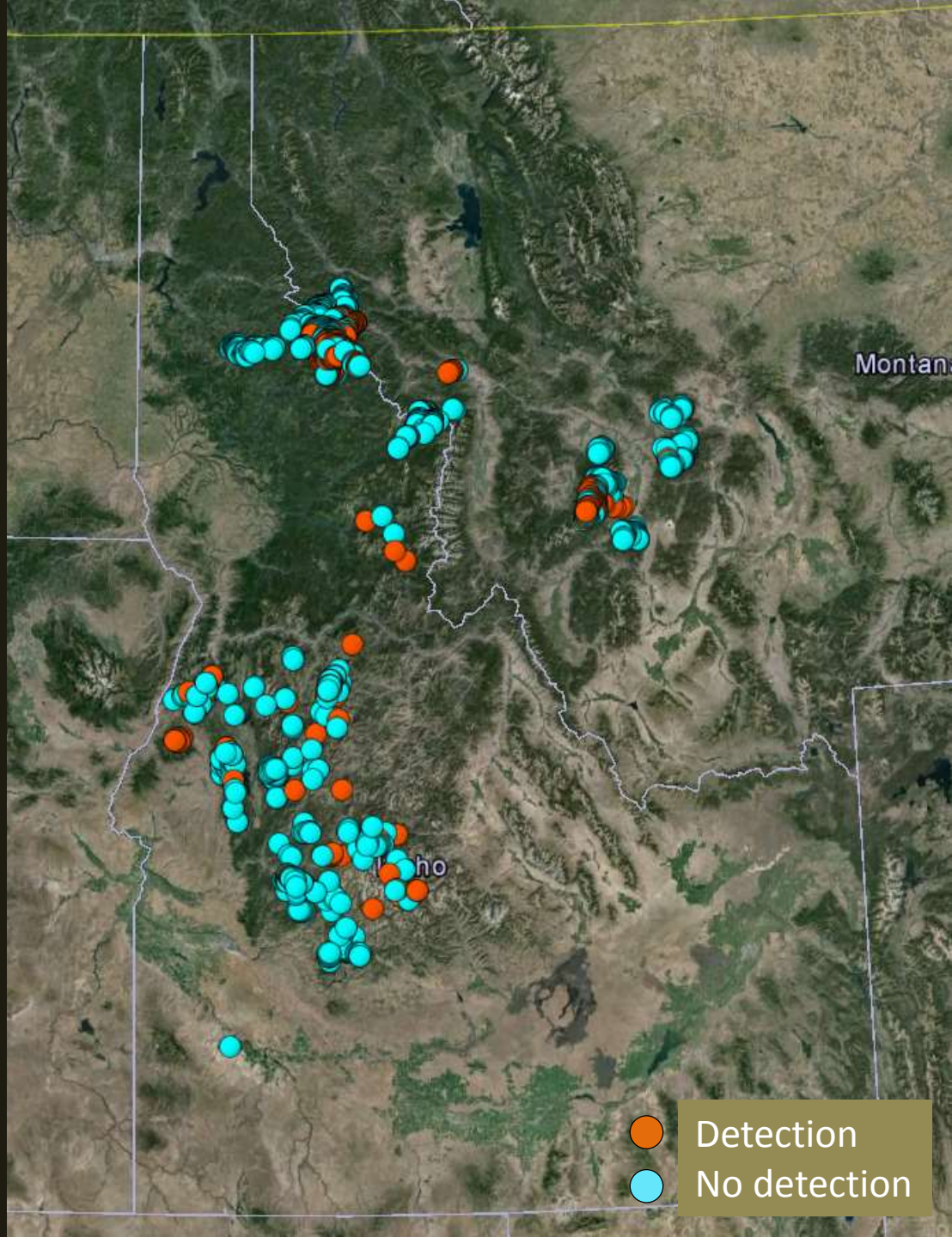
McKelvey et al. 2016

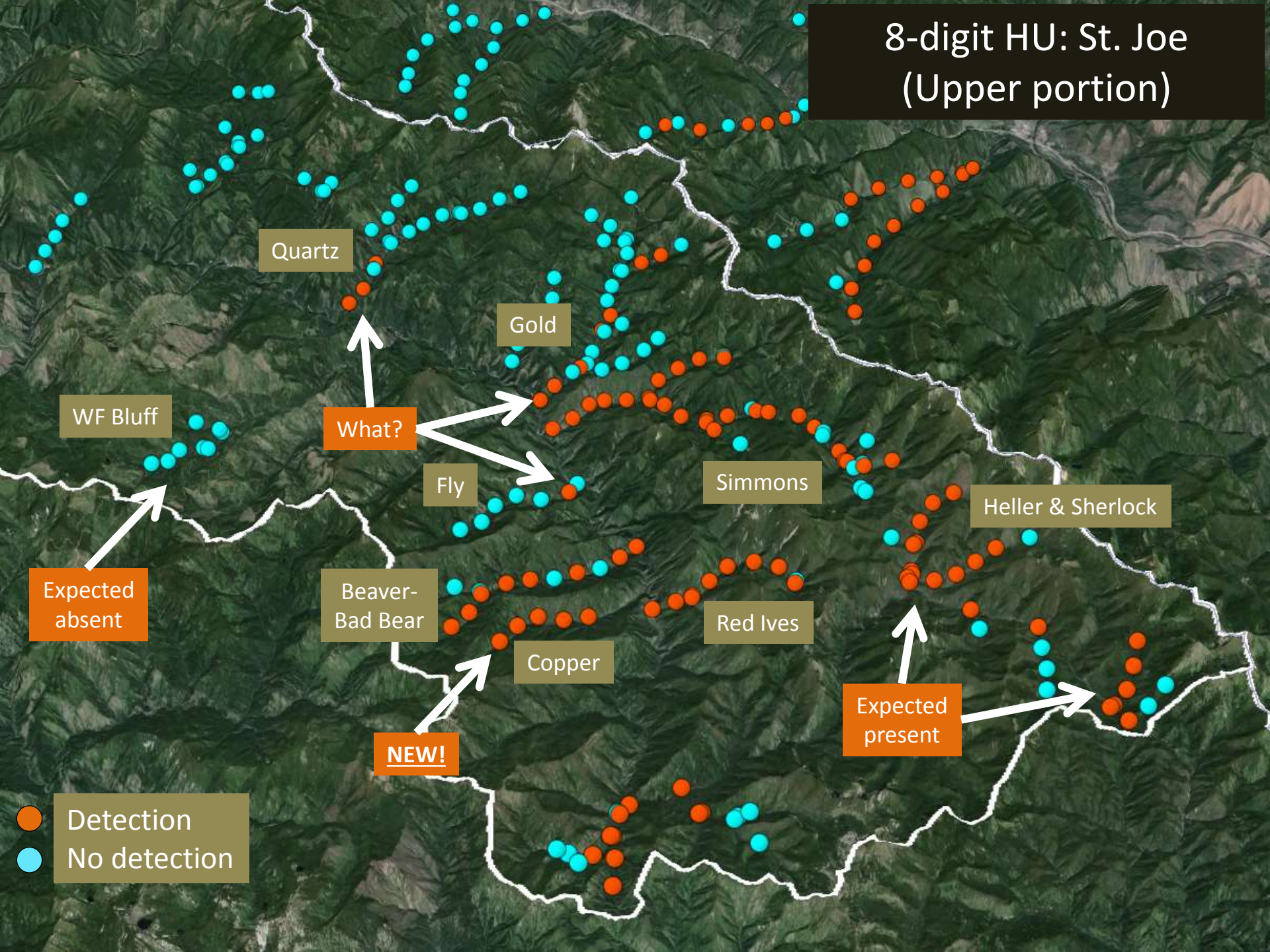


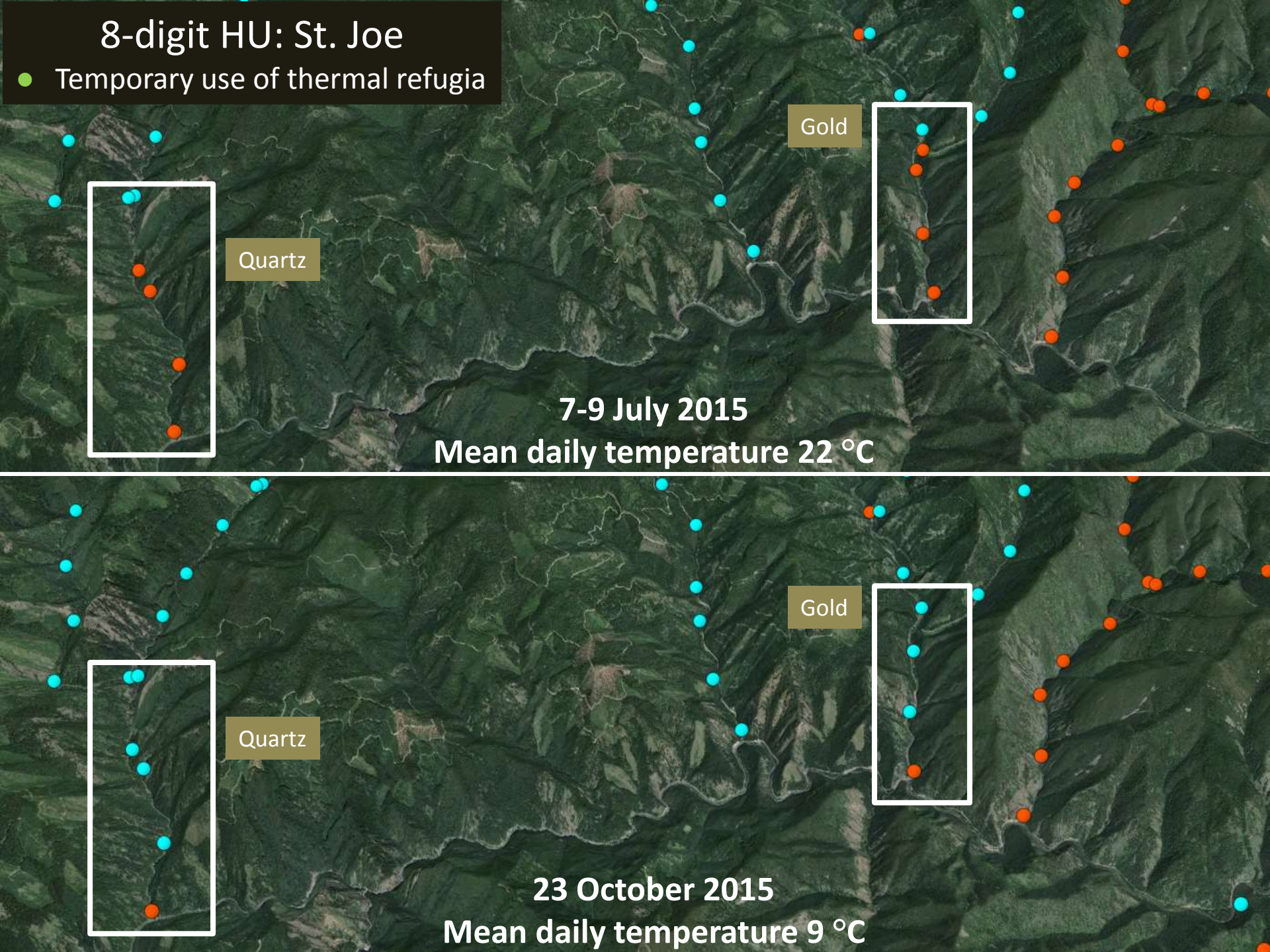


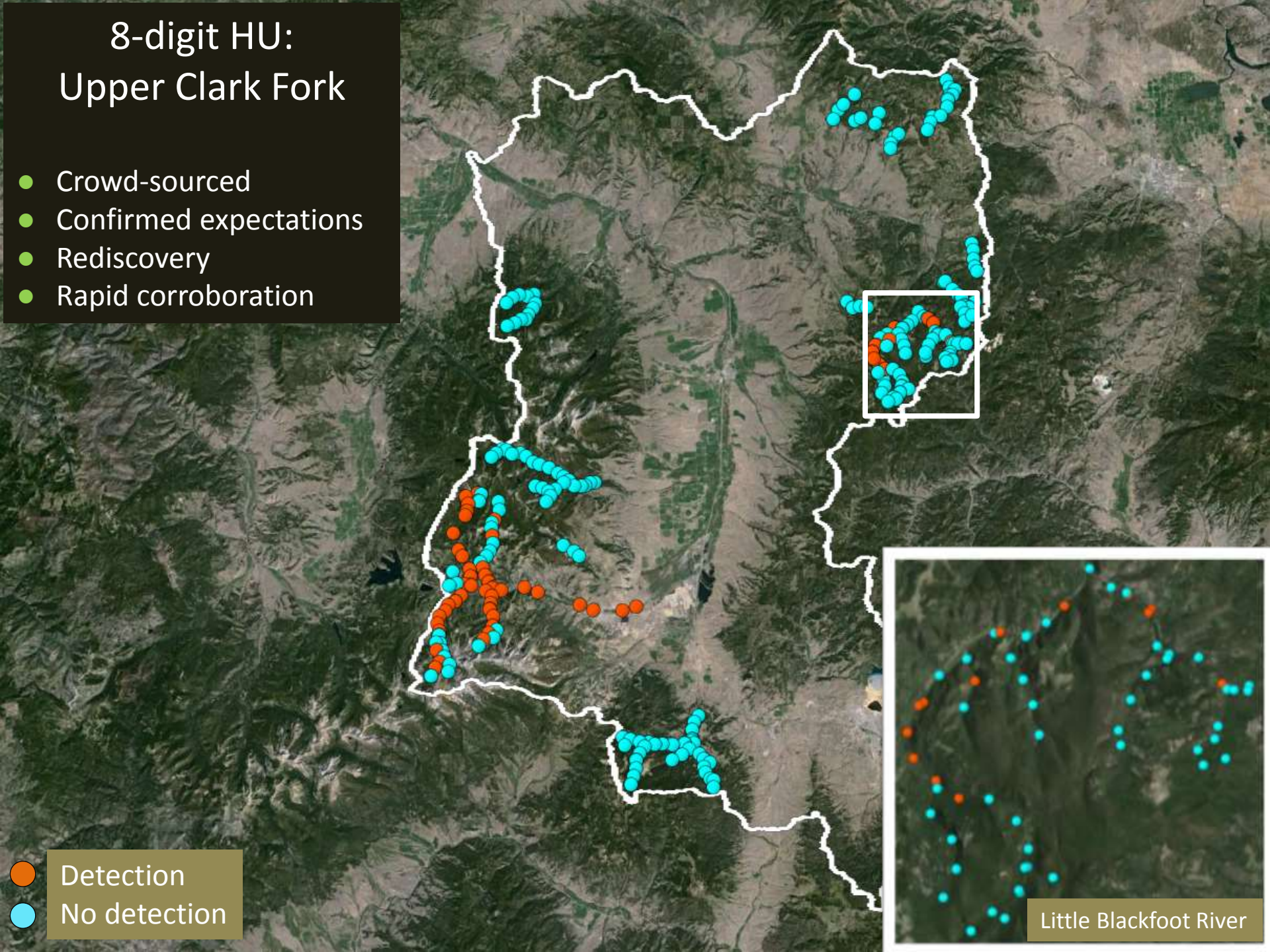
Update: the rangewide bull trout eDNA project

- Target: natal bull trout habitats
  - Cold-water habitats that are part of the Climate Shield
  - USFWS-designated critical habitat for bull trout spawning & rearing
  - Habitats about which recent occupancy is unknown
- Grain: sites at 1-km intervals
- Scope: all 8-digit U.S. HUs
- Timing
  - 2015: 500+ samples
  - 2016: 3,000+ samples
  - 2018: the rest of the range
- Cost
  - N. ID/W. MT: FREE!
  - S. ID/E. OR/WA: ½ price

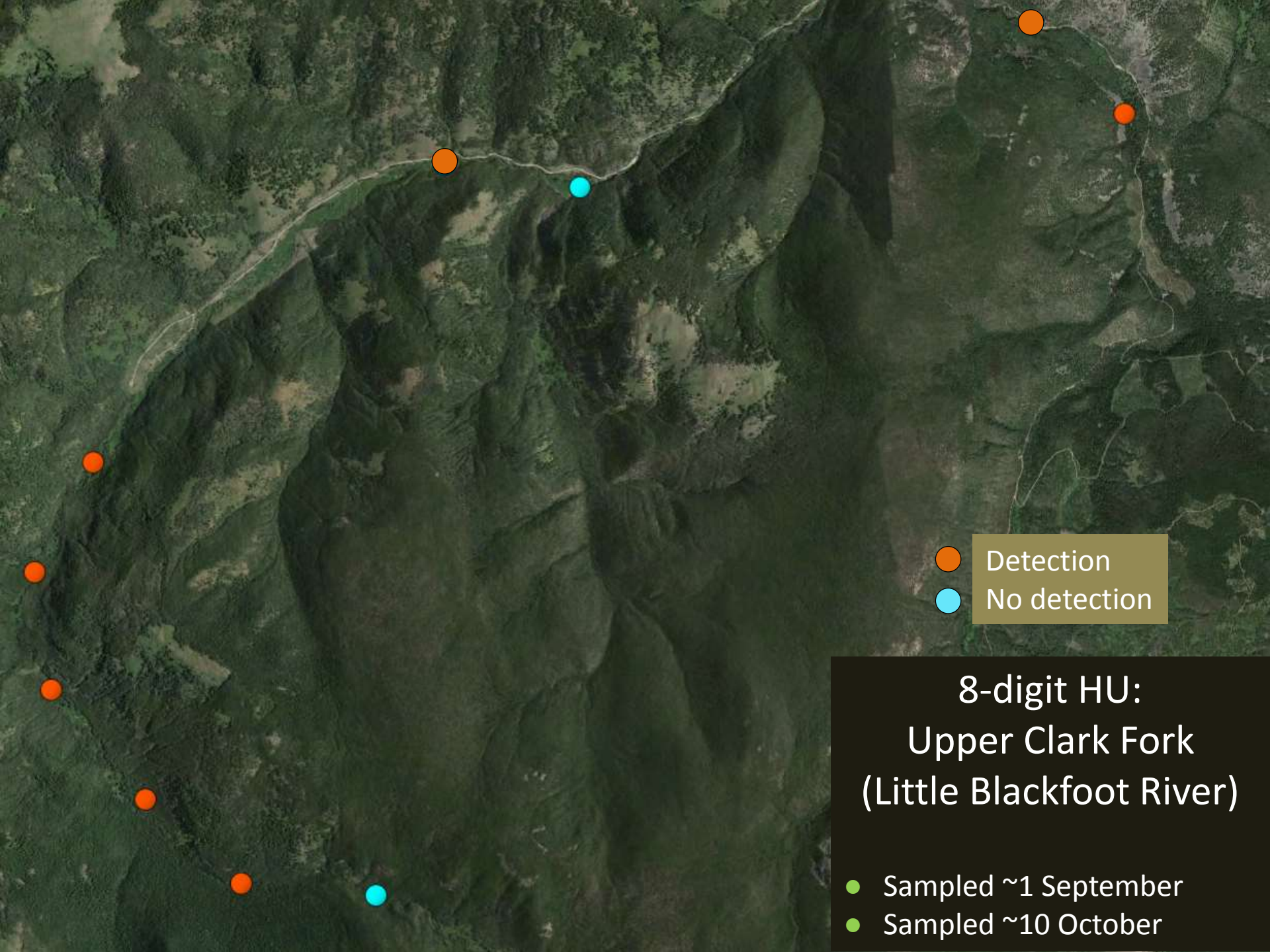



8-digit HU: St. Joe
(Upper portion)
Quartz
Gold
WF Bluff
What?
Fly
Simmons
Heller & Sherlock
Expected
absent
Beaver-
Bad Bear
Red Ives
Copper
Expected
present
NEW!
Detection
No detection


8-digit HU: St. Joe
Temporary use of thermal refugia
Gold
Quartz
7-9 July 2015
Mean daily temperature 22 °C
Gold
Quartz
23 October 2015
Mean daily temperature 9 °C


8-digit HU:
Upper Clark Fork
Crowd-sourced
Confirmed expectations
Rediscovery
Rapid corroboration
Detection
No detection
Little Blackfoot River


Detection
No detection
8-digit HU:
Upper Clark Fork
(Little Blackfoot River)
Sampled ~1 September


Detection
No detection
8-digit HU:
Upper Clark Fork
(Little Blackfoot River)
Sampled ~1 September
Sampled ~10 October

The Rangewide Bull Trout eDNA Project: want to help?

- Visit our website: www.fs.fed.us/rm/boise/AWAE/projects/BullTrout_eDNA.html

or Google "rangewide bull trout eDNA project"

- Contact us to get your library card
- Follow the simple instructions

Website: Get a bull trout hunting map

Participating in the Bull Trout eDNA Survey

Ou… ra… hab… hel… We… pro… rather, if you can sample one or more cold-water habitats in their entirety, then we welcome your participation.

To make that possible, we will provide you with all you need to conduct eDNA field sampling for juvenile bull trout. That includes:

1) A protocol that explains how to collect eDNA samples.

2) Additional guidelines specific to the bull trout eDNA survey project.

3) A map and spreadsheet of eDNA points to guide your sampling.

4) The loan of a pump set with a battery & charger. We operate a "tool library" i.e., you can reserve a pump set for use during a particular time. The number of pump sets is limited and demand is high, so it's important to reserve one. It's also critical to return it when you are done to permit others to start their sampling. If you want to buy your own pump set – which gives you more flexibility with respect to when you sample – we can give you the specifications.

5) Field kits for the collection and storage of eDNA samples. To ensure consistency in sampling and guarantee sterility of the supplies, we prefer to provide the field kits to you.

Once sampling is complete, return the pump set, field kits, and collected samples. In a few weeks, we'll share with you whether and where bull trout were present. And at the end of each year, we'll post an interactive map of the results of sampling across the range of bull trout on our results page.

Bull trout eDNA Sample Sites

…to guide your eDNA surveys for …stats anywhere throughout their …ams (>3,000) were identified using the …surveys in 312 streams (Isaak et al. …and rearing are also shown on the …to be sampled, so please review the field sampling instructions ("Participating in the Bull Trout eDNA Survey, important caveats"). To get started, print or plot the map of showing the 8-digit HUC to be sampled and identify which potential bull trout streams are of interest (and can be sampled in their entirety). Files may be periodically updated, so confirm that you have the most current versions before starting field work. Next, download the Excel file with the eDNA sample site coordinates (note that a GPS unit will be required for accurate field navigation).

Bull Trout eDNA Sample Sites

Scenario: 1980s, 0% Brook Trout

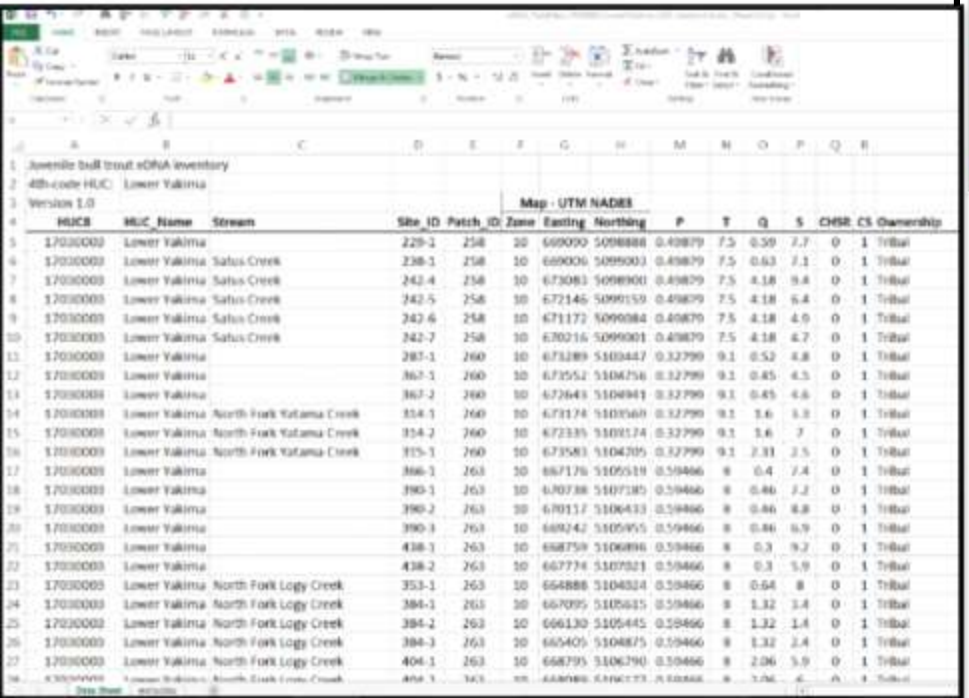
NHD Unit: 17080002 (Lewis)

Legend

- eDNA Sample Site (N=355)
  Note: The 355 sites on this map occur on streams having <10% slope and a probability of bull trout occurrence >25%.
- Intermittent Flowlines
- Slope > 10%
- Probability of Occupancy (%)
  - 10 - 25
  - 25 - 50
  - 50 - 75
  - 75 - 90
  - 90 - 100
- Bull Trout Critical Habitat
- Waterfalls

Land Ownership

No Data	NPS
BLM	Other Federal
BOR	Tribal
USFWS	State/City
USFS - Nonwilderness	TNC
USFS - Wilderness	Private
COE	Other/Unknown

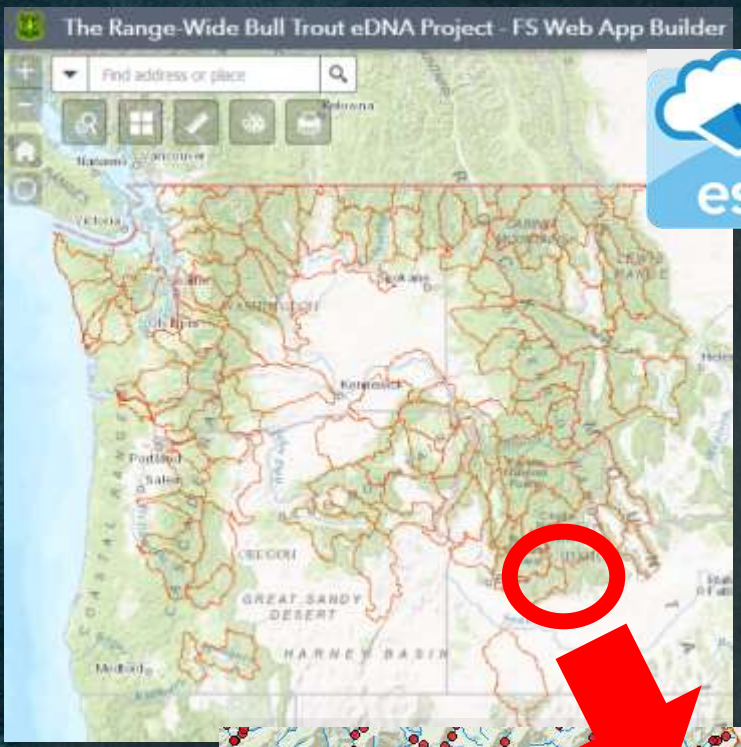


Juvenile bull trout eDNA inventory
4th-code HUC: Lower Yakima
Version 1.0

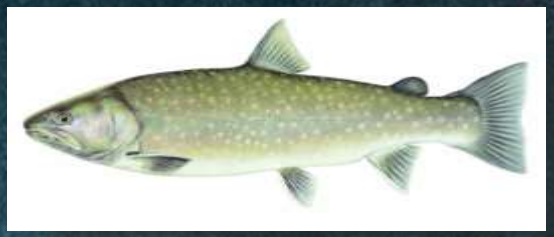
	HUC8	HUC_Name	Stream	Site_ID	Patch_ID	Map - UTM NAD83 Zone	Easting	Northing	P	T	Q	S	CHSR	CS	Ownership
5	17030003	Lower Yakima		229-1	258	10	669090	5098888	0.49879	7.5	0.59	7.7	0	1	Tribal
6	17030003	Lower Yakima	Satus Creek	238-1	258	10	669006	5099003	0.49879	7.5	0.63	7.1	0	1	Tribal
7	17030003	Lower Yakima	Satus Creek	242-4	258	10	673083	5098900	0.49879	7.5	4.18	9.4	0	1	Tribal
8	17030003	Lower Yakima	Satus Creek	242-5	258	10	672146	5099159	0.49879	7.5	4.18	6.4	0	1	Tribal
9	17030003	Lower Yakima	Satus Creek	242-6	258	10	671172	5099084	0.49879	7.5	4.18	4.9	0	1	Tribal
10	17030003	Lower Yakima	Satus Creek	242-7	258	10	670216	5099001	0.49879	7.5	4.18	4.7	0	1	Tribal
11	17030003	Lower Yakima		287-1	260	10	673289	5103447	0.32799	9.1	0.52	4.8	0	1	Tribal
12	17030003	Lower Yakima		367-1	260	10	673552	5104756	0.32799	9.1	0.45	4.5	0	1	Tribal
13	17030003	Lower Yakima		367-2	260	10	672643	5104941	0.32799	9.1	0.45	4.6	0	1	Tribal
14	17030003	Lower Yakima	North Fork Yakama Creek	314-1	260	10	673174	5103569	0.32799	9.1	3.6	5.3	0	1	Tribal
15	17030003	Lower Yakima	North Fork Yakama Creek	314-2	260	10	672335	5103174	0.32799	9.1	3.6	7	0	1	Tribal
16	17030003	Lower Yakima	North Fork Yakama Creek	315-1	260	10	673583	5104705	0.32799	9.1	2.31	2.5	0	1	Tribal
17	17030003	Lower Yakima		366-1	263	10	667176	5105519	0.59466	8	0.4	7.4	0	1	Tribal
18	17030003	Lower Yakima		390-1	263	10	670738	5107185	0.59466	8	0.46	7.2	0	1	Tribal
19	17030003	Lower Yakima		390-2	263	10	670117	5106433	0.59466	8	0.46	8.8	0	1	Tribal
20	17030003	Lower Yakima		390-3	263	10	669242	5105955	0.59466	8	0.46	6.9	0	1	Tribal
21	17030003	Lower Yakima		438-1	263	10	668759	5106896	0.59466	8	0.3	9.2	0	1	Tribal
22	17030003	Lower Yakima		438-2	263	10	667774	5107021	0.59466	8	0.3	5.9	0	1	Tribal
23	17030003	Lower Yakima	North Fork Logy Creek	353-1	263	10	664888	5104324	0.59466	8	0.64	8	0	1	Tribal
24	17030003	Lower Yakima	North Fork Logy Creek	384-1	263	10	667095	5105615	0.59466	8	1.32	3.4	0	1	Tribal
25	17030003	Lower Yakima	North Fork Logy Creek	384-2	263	10	666130	5105445	0.59466	8	1.32	3.4	0	1	Tribal
26	17030003	Lower Yakima	North Fork Logy Creek	384-3	263	10	665405	5104875	0.59466	8	1.32	2.4	0	1	Tribal
27	17030003	Lower Yakima	North Fork Logy Creek	404-1	263	10	668795	5106790	0.59466	8	2.06	5.9	0	1	Tribal

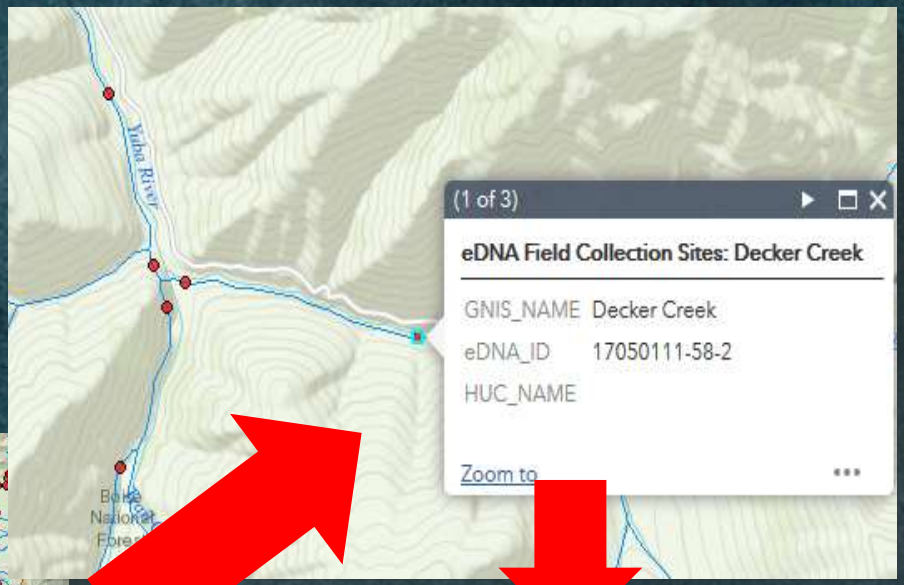
Go sample & mail everything back

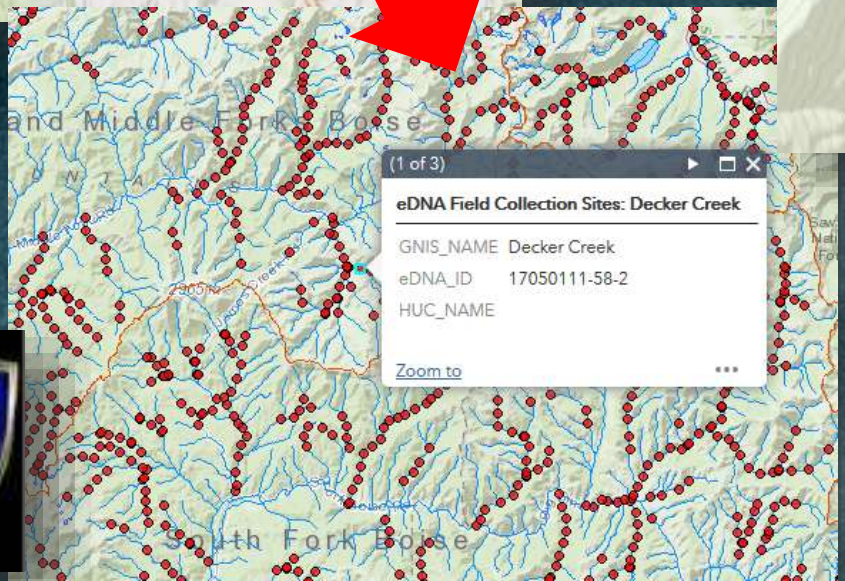
Dynamic Web Data Portal: eDNAtlas



ArcGIS Online







Climate Shield

Query & download by site, stream, HUC, or occupancy: live this week!

eDNArchive

- 1 eDNA sample = many species
- Permanent archives of biodiversity
- ~10% of samples run for other spp.













Other options

- eDNA assay development
  - $5K/taxon
  - 2–3 months*
- Sample analysis
  - $75, 1st species
  - $25, all other species
  - 56-hour turnaround
  - All gear provided*
- Beyond presence
  - Abundance
  - Co-occupancy
  - Multi-species assessments
- Questions?