The rapid, range-wide inventory of bull trout: a crowd-sourced, eDNA-based approach with application to many aquatic species

Michael Young, Dan Isaak, Kevin McKelvey, Michael Schwartz, Kellie Carim, Wade Fredenberg, Taylor Wilcox, Matt Groce, Dave Nagel, Dona Horan, Sherry Wollrab

Bureau of Reclamation
Clark Fork Coalition
Clearwater Resource Council
Coeur d'Alene Tribes
Idaho Department of Fish and Game
Idaho Power Company
Montana Department of Natural Resources Conservation
Montana Fish, Wildlife & Parks
National Fish and Wildlife Foundation
The Nature Conservancy
Nez Perce Tribes
Oregon Department of Fish and Wildlife
Trout Unlimited

U.S. Fish and Wildlife Service
USFS Beaverhead-Deer Lodge NF
USFS Boise NF
USFS Helena NF
USFS Idaho Panhandle NF
USFS Lolo NF
USFS Regions 1, 4, and 6
USFS Sawtooth NF
Washington Department of Fish and Wildlife
Yakama Nation

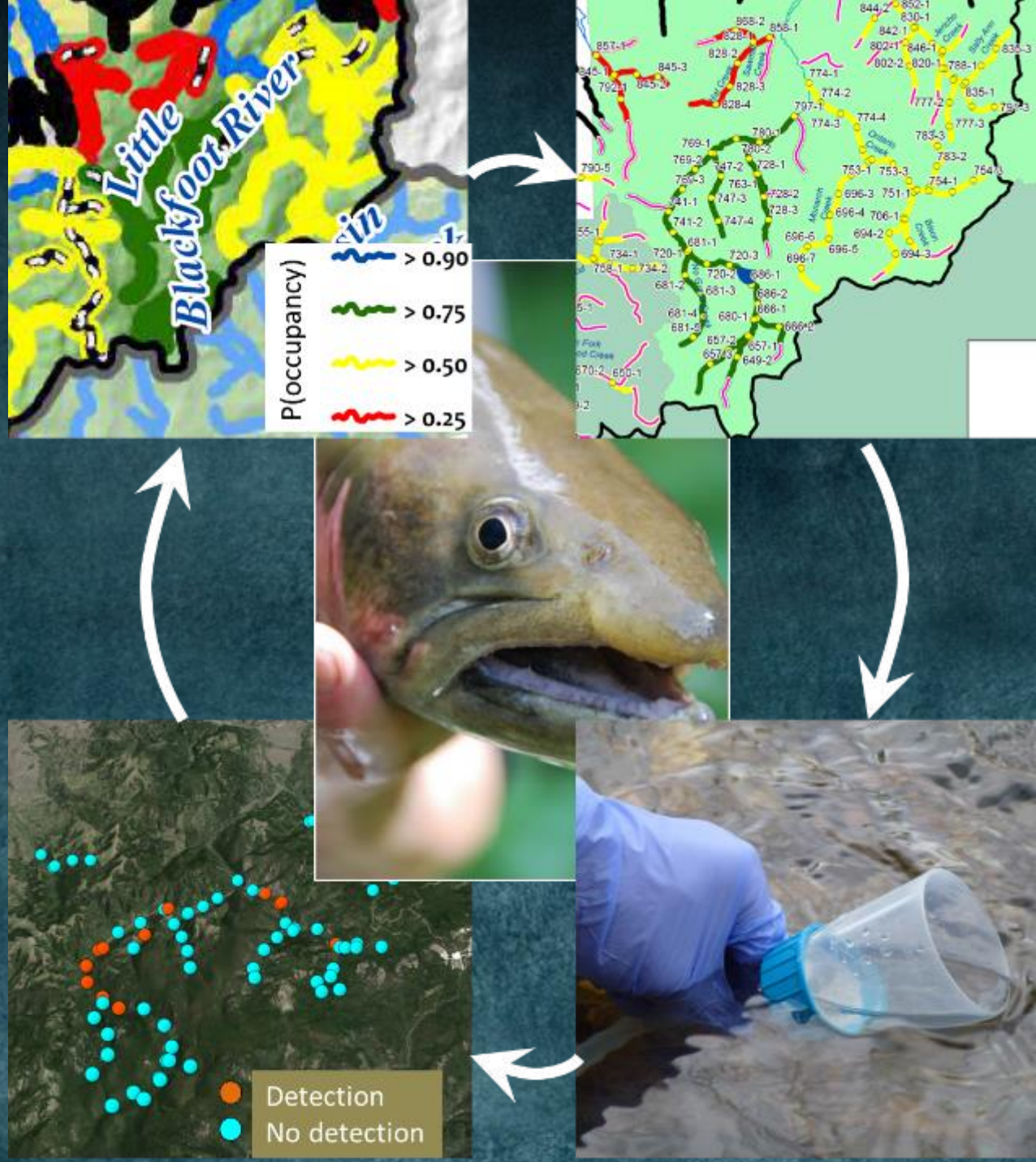
Great Northern LANDSCAPE CONSERVATION COOPERATIVE

Region 1

USDA Forest Service
National Genomics Center for Wildlife and Fish Conservation

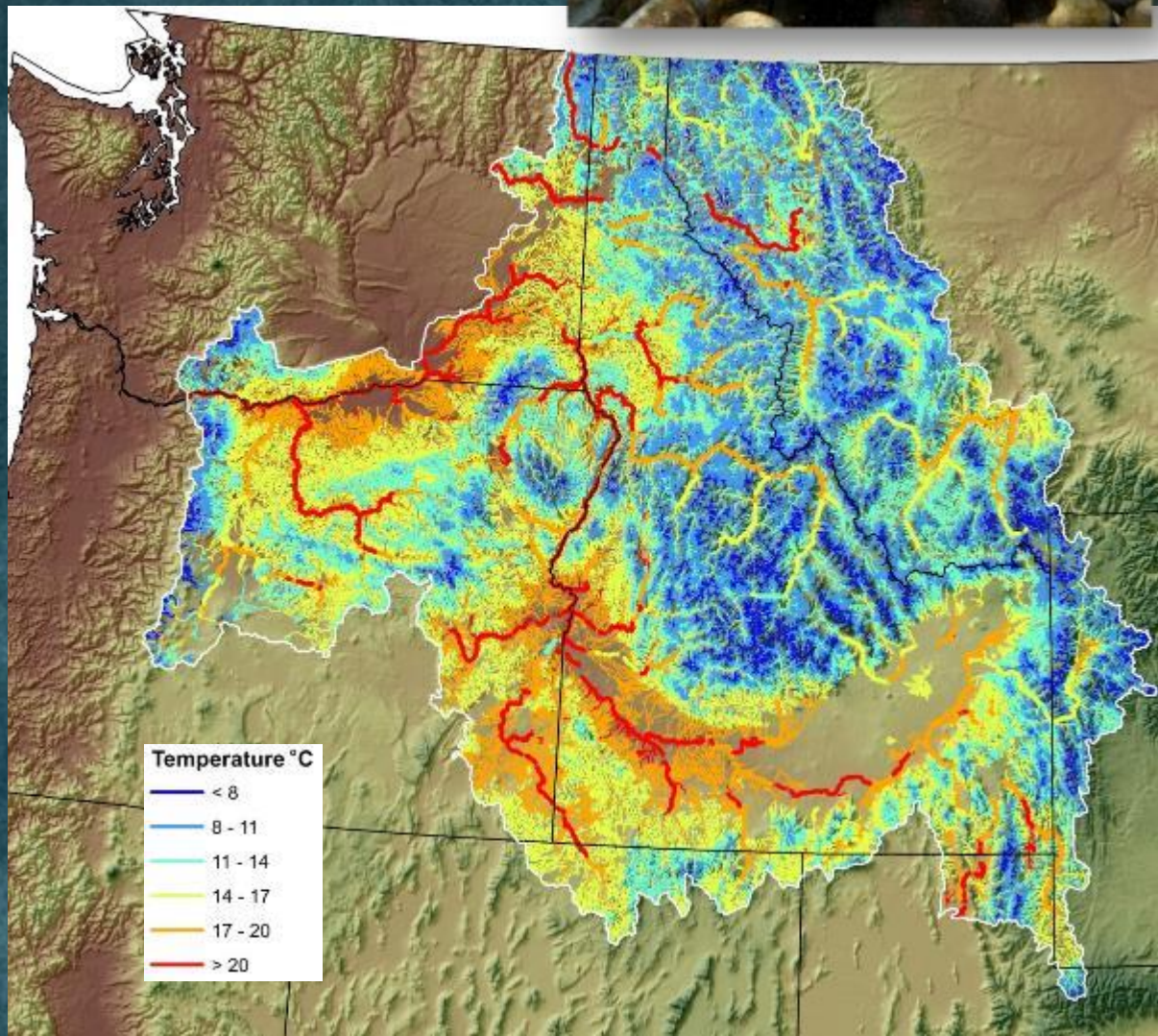
Outline

- Bull trout
  - Uncertainty
  - Predictions
  - Validation
- eDNA sampling
  - What is it
  - Why use it
- **bull trout + eDNA**
  - Basin surveys
  - Spatial, probabilistic template
  - Early results
  - You



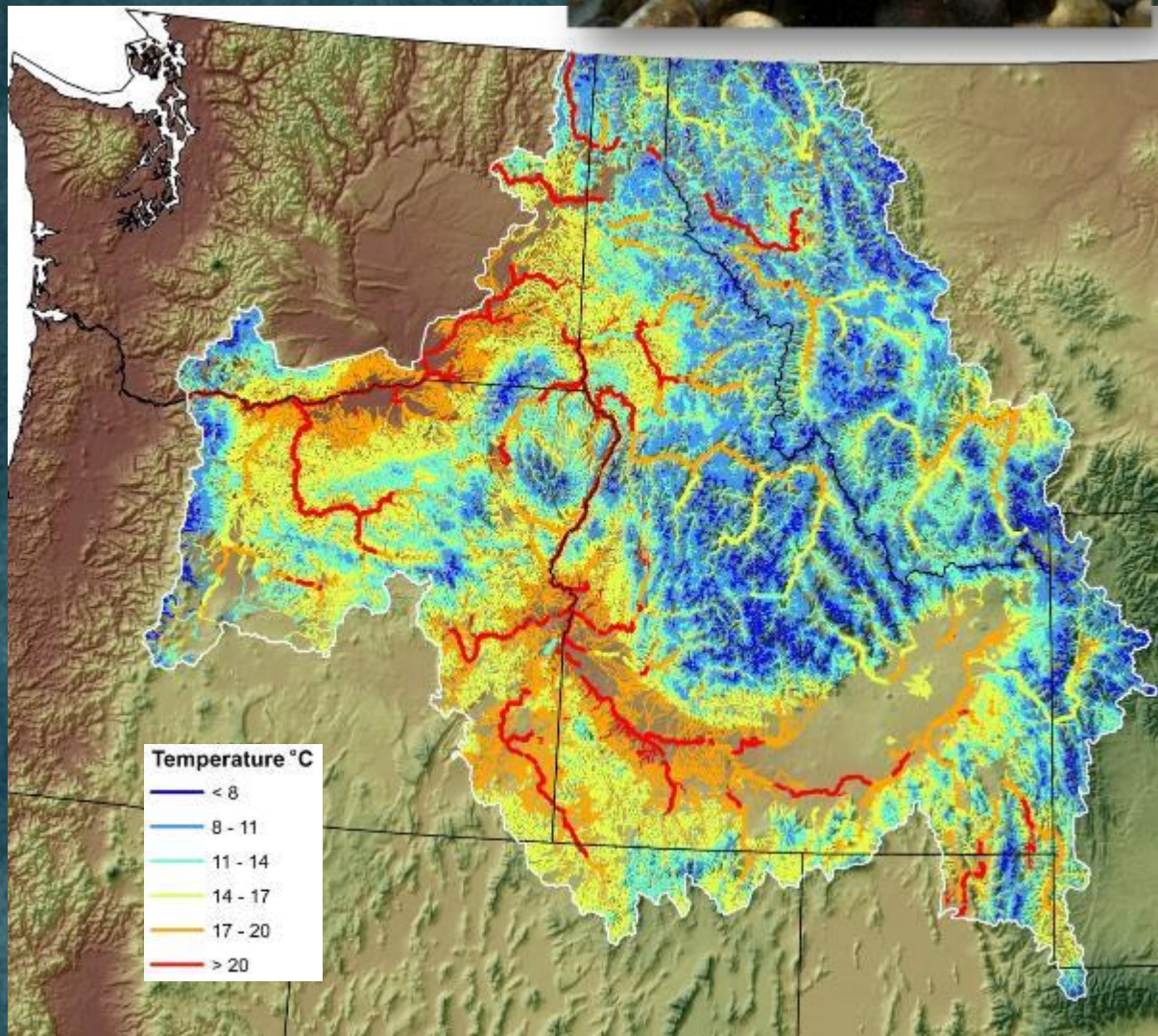
Bull trout issues

- Federally listed as threatened
- Presence dictates land management & planning
- Widespread in PNW
- Often rare
- Difficult to detect
- = worthwhile candidate for occupancy modeling to predict habitat

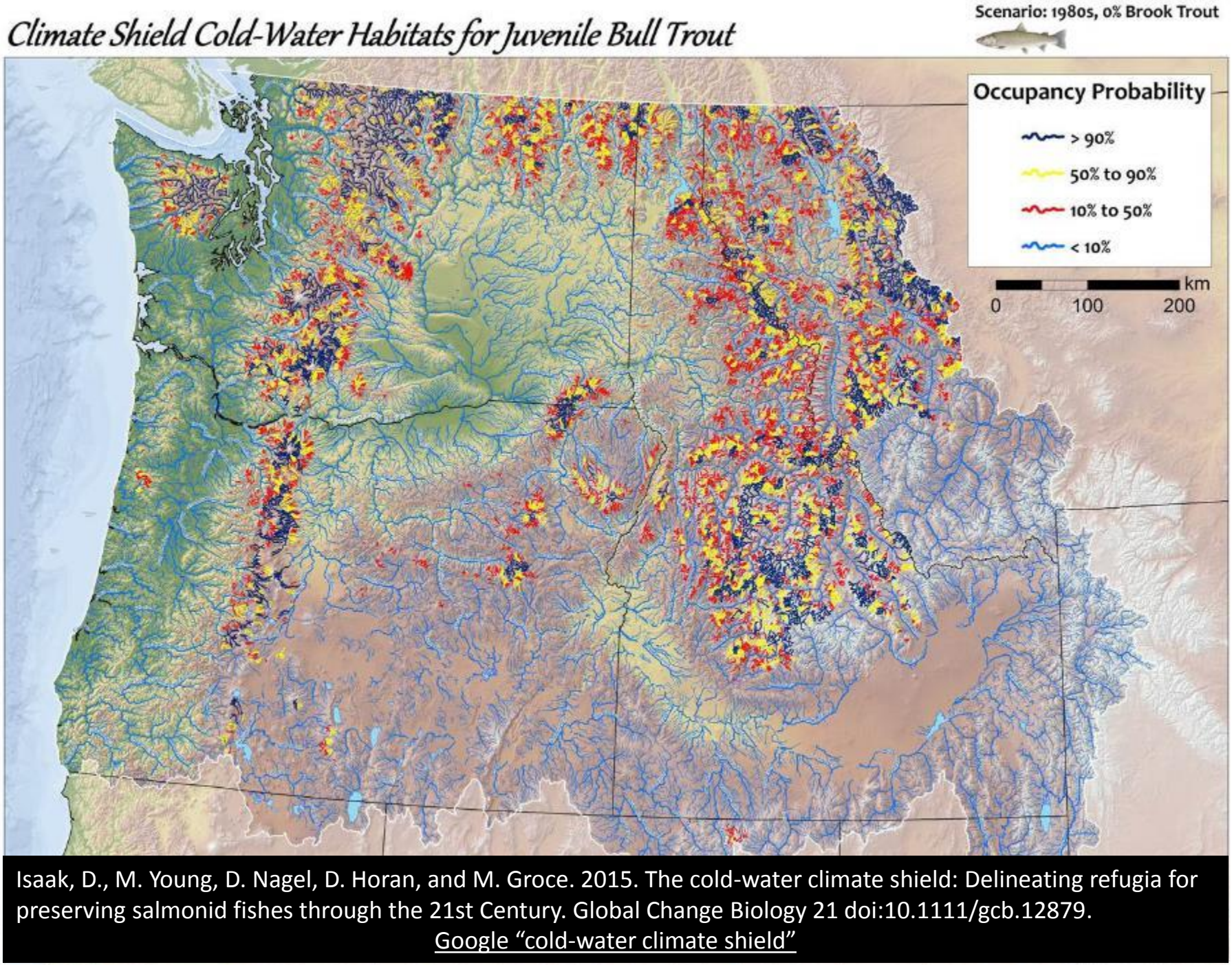


Identifying climate refugia for native trout – the Climate Shield

- Climate to cold-water habitat
- Occupancy models
  - Accurate & sufficient
  - Address invasive species
  - Empirical
  - Broad-based
- Predictions and projections
  - Address climate change
  - Spatially precise
  - Applicable range-wide

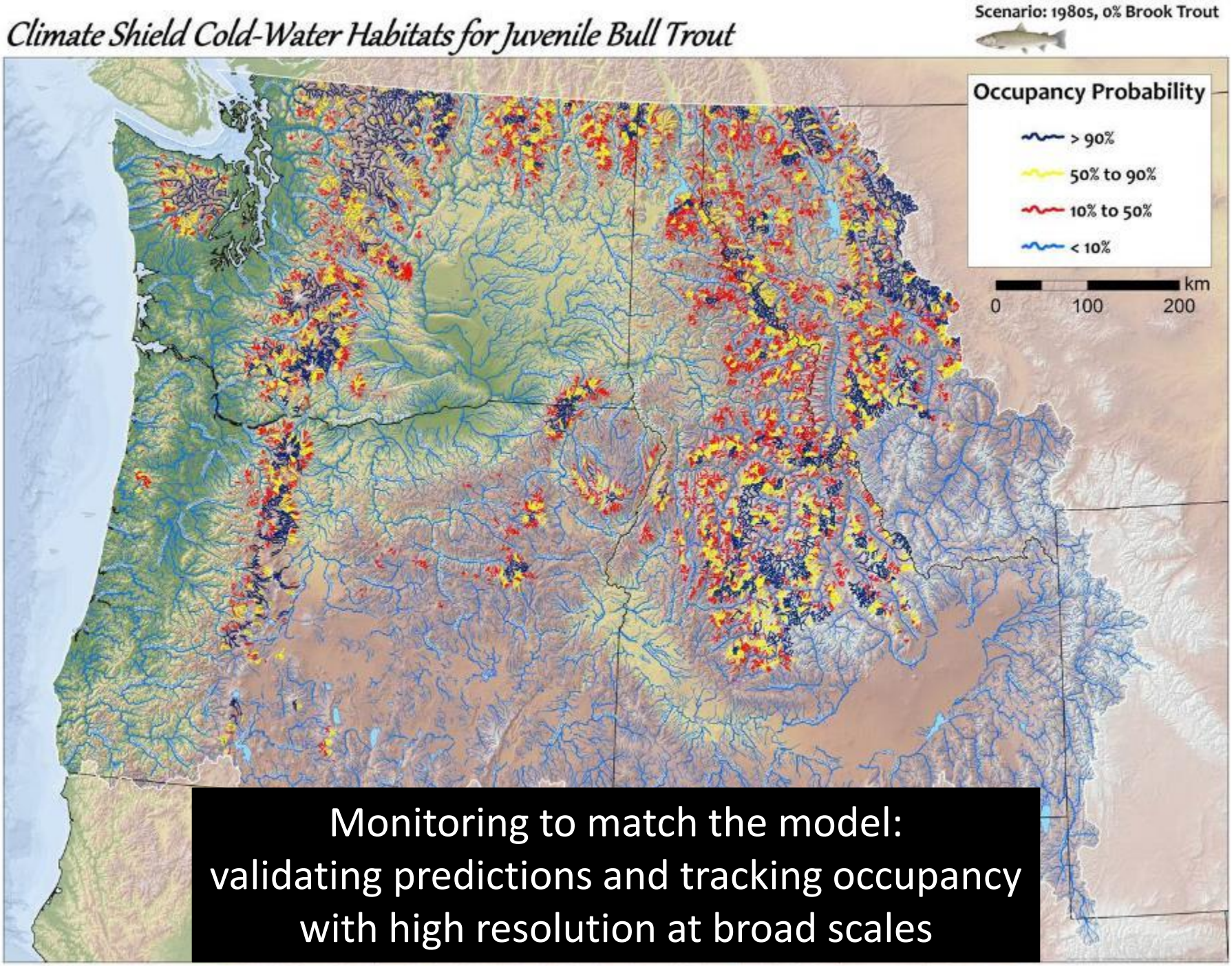


Climate Shield Cold-Water Habitats for Juvenile Bull Trout



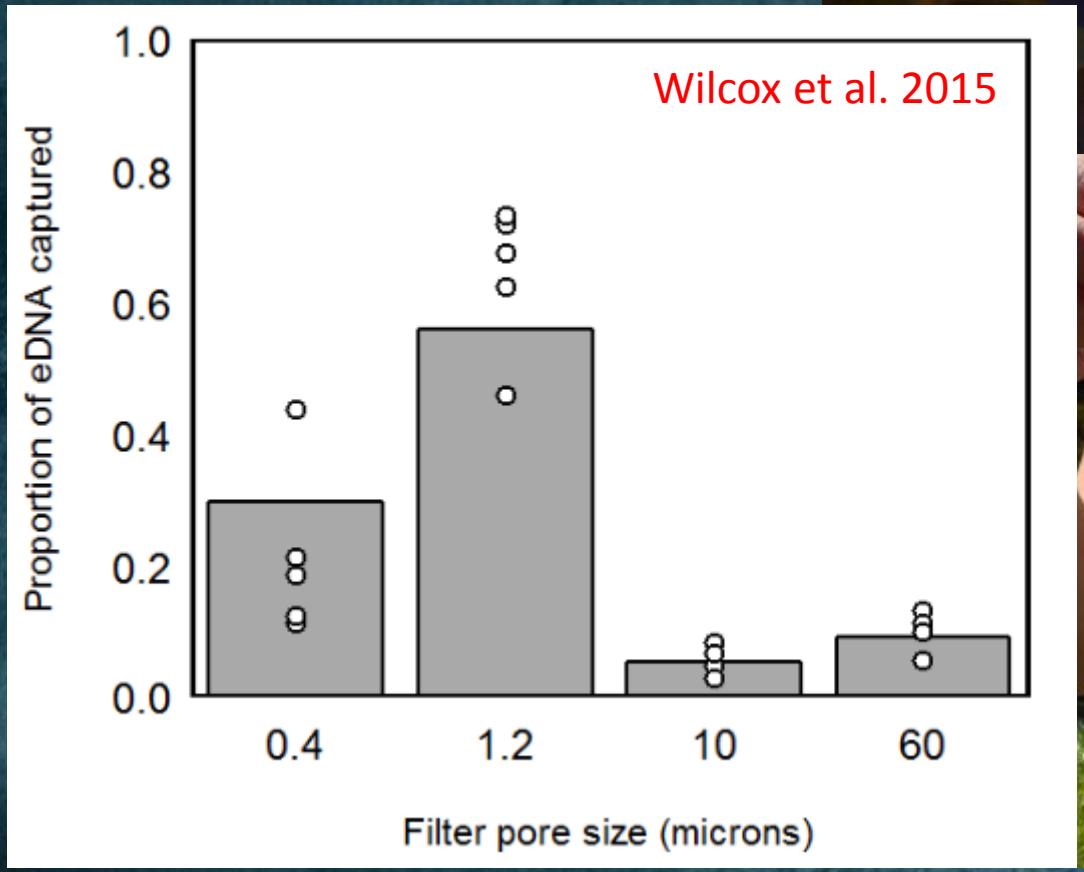
Isaak, D., M. Young, D. Nagel, D. Horan, and M. Groce. 2015. The cold-water climate shield: Delineating refugia for preserving salmonid fishes through the 21st Century. Global Change Biology 21 doi:10.1111/gcb.12879.

Google “cold-water climate shield”


Climate Shield Cold-Water Habitats for Juvenile Bull Trout
Scenario: 1980s, 0% Brook Trout
Occupancy Probability
> 90%
50% to 90%
10% to 50%
< 10%
km
0
100
200
Monitoring to match the model:
validating predictions and tracking occupancy
with high resolution at broad scales

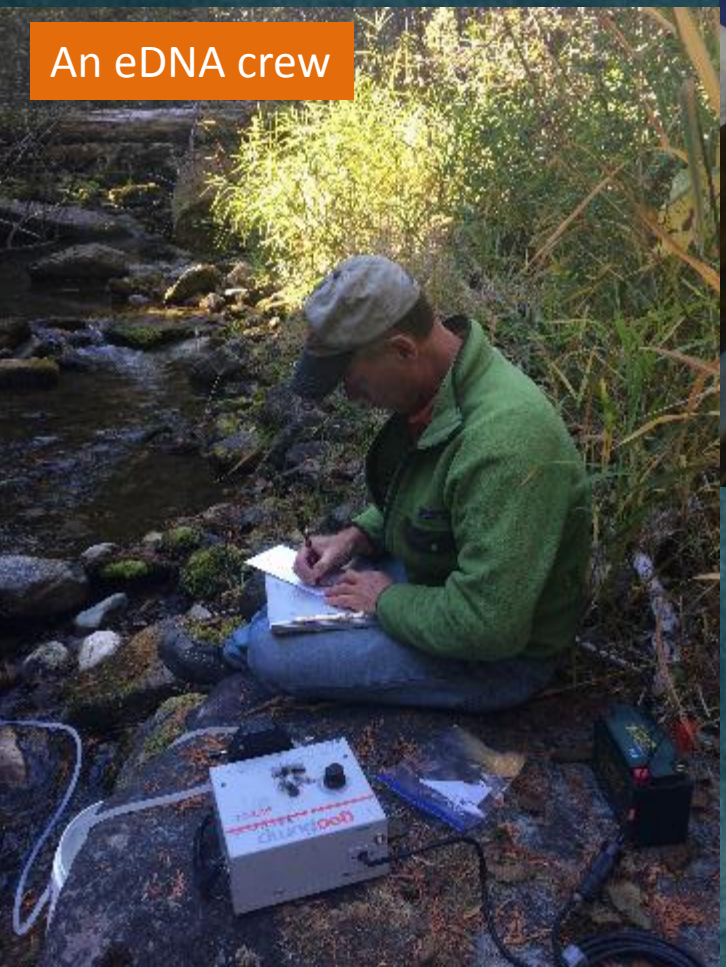
What is eDNA?

- Environmental = “free”
- Mitochondrial
- Presence
  - time-dependent
  - environment-dependent
  - ecologically dependent



Why sample eDNA?

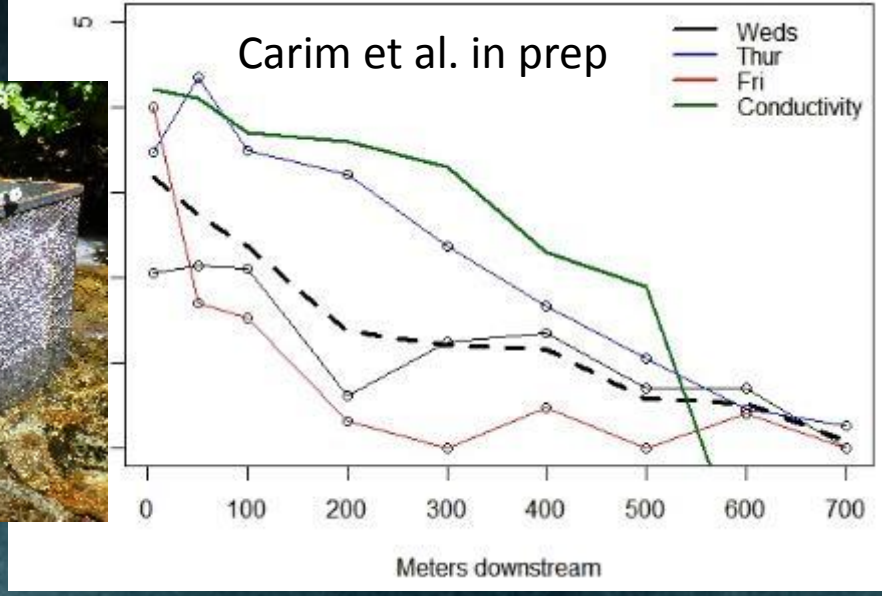
- Simple
- Fast
- Portable
- Durable
- Cost: pennies on the dollar, minutes on the hour

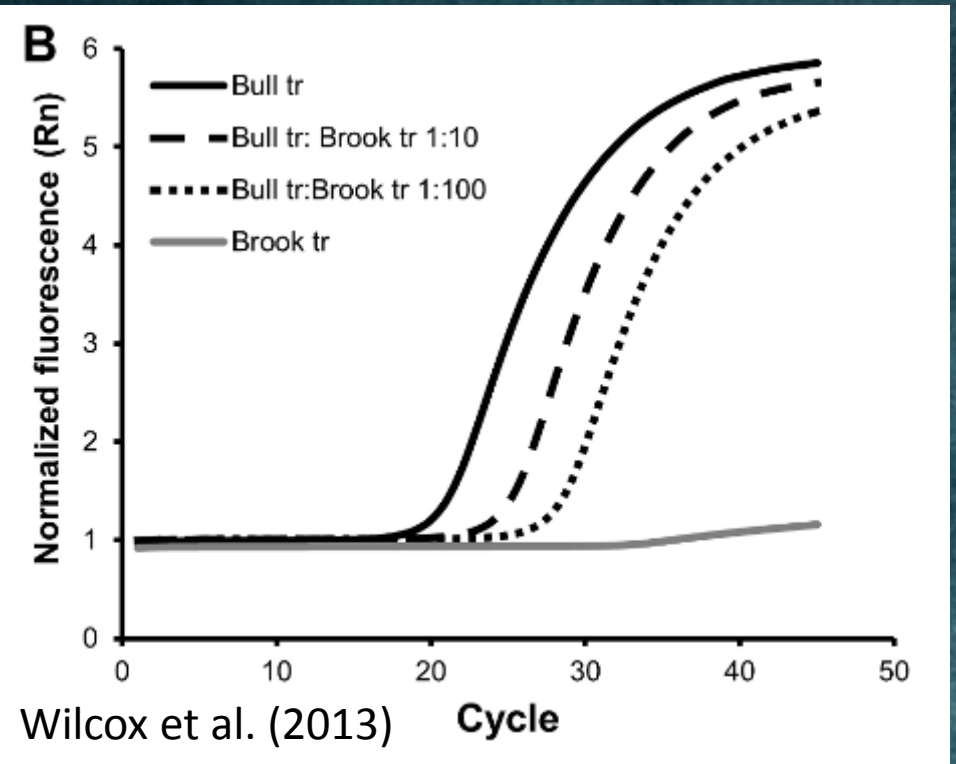


An eDNA crew

Is eDNA sampling sensitive?

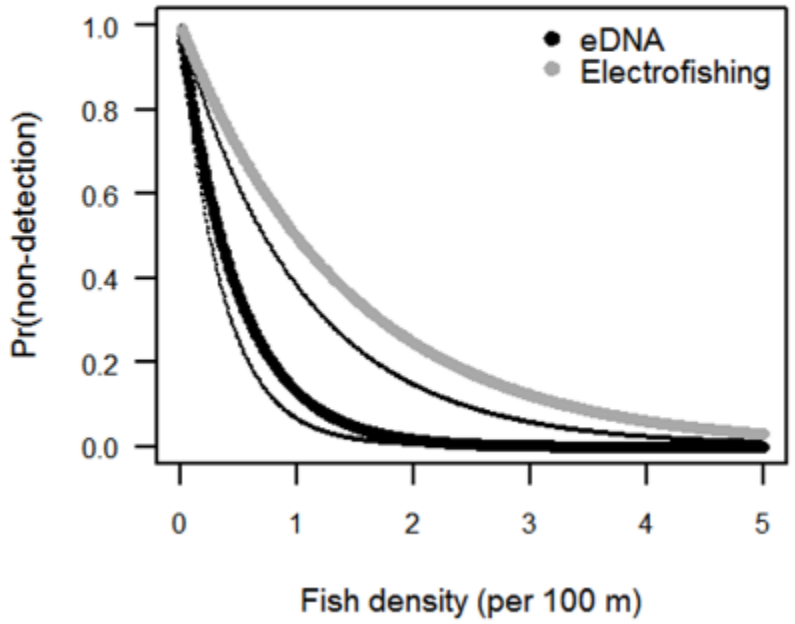
- Multiple tests, similar answers
  - Caged fish (Jane et al. 2014)
  - Field v. electrofishing
- Species-specific
- Upshot: excellent tool for detecting rare & remote species





Wilcox et al. (2013)

Wilcox et al. (in review)



The NGCWFC: fomenting the eDNA revolution

- Pioneering this approach for species detection since 2011
- Outreach
  - Hands-on training
  - Online protocol
  - Equipment “library”
- Assay design
- Samples: ~4000 analyses & growing

Administration & infrastructure

X. COMMENCEMENT/EXPIRATION DATE:

This MOU is executed as of the date of the last sig
2019, at which time it will expire, unless extende
and dated by all properly authorized, signatory

DAN ASHE, Director
U.S. Fish and Wildlife Service

THOMAS L. TIDWELL
U.S. Forest Service

FS Agreement No
FWS Agreement No 15-IA-1113400-154
DTS 058945

MEMORANDUM OF UNDERSTANDING
Between
U.S. FISH AND WILDLIFE SERVICE
And
USDA, FOREST SERVICE

The U.S. Fish and Wildlife Service (USFWS) and the U.S. Forest Service share a common interest in conservation genetics as applied to resource management issues. Each agency, operating under its own authority, has specific responsibilities related to stewardship of the Nation's natural resources. This agreement sets forth a framework for reciprocal cooperation that will assist each agency in meeting its responsibilities related to monitoring and maintaining viable wildlife and fish populations and their habitats. Implementation of this agreement is intended to maintain and enhance agency effectiveness while avoiding duplication of efforts to provide critical conservation genetics and genomics information to the participating agencies. Through this MOU we will have an avenue to gain synergy in an effort to conduct state-of-the-art genomics research, share expertise, and build partnerships under the umbrella of the National Genomics Center for Wildlife and Fish Conservation, housed at the U.S. Forest Service Rocky Mountain Research Station's facility in Missoula, Montana.

I. AUTHORITIES

Authority for the USFWS to participate in this MOU is provided for in the Fish and Wildlife Act of 1956 (16 USC 742, et seq.), the Fish and Wildlife Coordination Act (16 USC 661, et seq.), the Endangered Species Act of 1973 as amended (16 USC 1531 et seq.), and the Migratory Bird Treaty Act (16 USC 703, et seq.).

The mission of the U.S. Forest Service is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of the present and future generations. This is further complimented by the mission of the U.S. Forest Service, Research & Development to cultivate and deliver scientific knowledge and innovative technology to improve the health and use of the Nation's forests and rangelands, both public and private.

II. STATEMENT OF MUTUAL BENEFIT AND IN

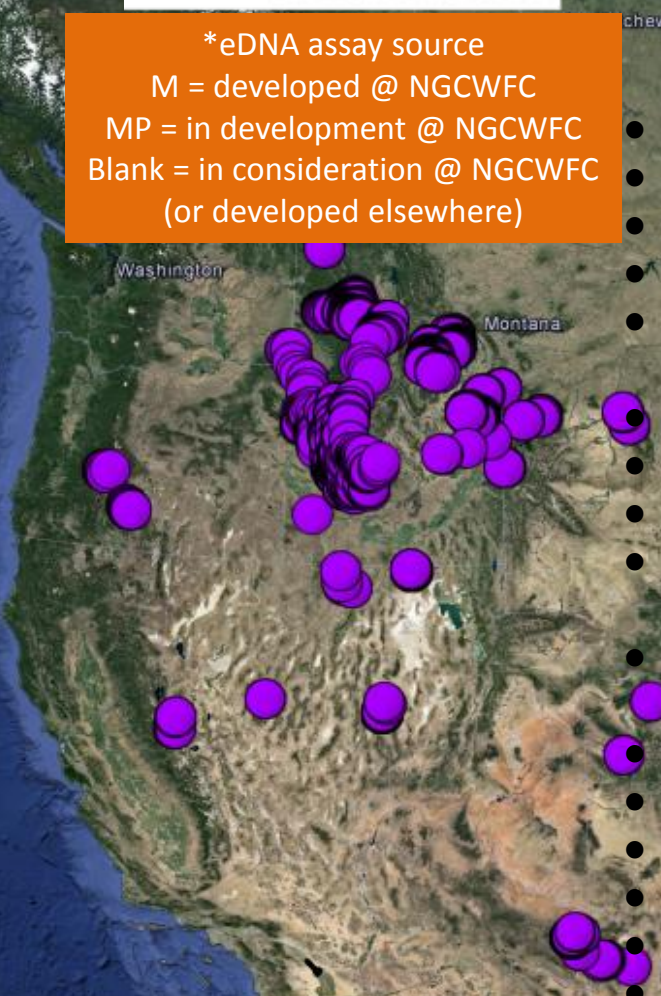
The U.S. Forest Service and U
art conservation
their

eDNA assays & analyses

- Bull trout[M]
- Brook trout[M]
- Rainbow trout[M]
- Westslope cutthroat trout[M]
- Yellowstone cutthroat trout[M]
- Brown trout[MP]
- Lake trout
- Dolly Varden
- Arctic charr
- Salmon: Chinook, chum[MP], coho[MP], pink, sockeye[MP]
- Arctic grayling[MP]
- Pacific & brook lamprey[MP]
- Northern pike[MP]
- Sculpin (several)
- Leatherside dace[MP]
- Loach minnow[MP]
- Spikedace[MP]
- Siberian sturgeon
- Rocky Mountain tailed frog
- Opossum shrimp[M]
- Capniid stoneflies
- Western pearlshell mussel[MP]
- Crayfish (several)
- River otter[M]
- Any fish[MP]
- ...and many others

USDA Forest Service
National Genomics
Center for Wildlife
and Fish Conservation

*eDNA assay source
M = developed @ NGCWFC
MP = in development @ NGCWFC
Blank = in consideration @ NGCWFC
(or developed elsewhere)

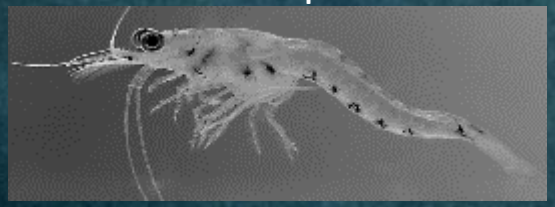


Partners

- Nez Perce, Shoshone-Bannock, Kalispel, and Snoqualmie Tribes
- USFS Regions 1, 2, 3, 4, 10
- National Forests: Idaho Panhandle, Lolo, Helena, Beaverhead-Deer Lodge, Grand Mesa-Uncompahgre-Gunnison, Boise, Payette, Salmon-Challis, Sawtooth, Willamette
- Yellowstone National Park
- U.S. Fish and Wildlife Service
- U.S. Geological Survey
- Arizona Game and Fish Department
- California Department of Fish and Wildlife
- Idaho Department of Fish and Game
- Montana Fish, Wildlife and Parks
- Nevada Department of Wildlife
- New Mexico Department of Game and Fish
- Oregon Department of Fish and Wildlife
- Utah Division of Wildlife Resources
- Clark Fork Coalition
- Trout Unlimited
- Wild Fish Conservancy
- Wildlife Conservation Society
- Hart Crowser Consultants

Applications:
Detecting invasive species

- Have non-native species arrived?
- Have they been eradicated?
- Does the non-native species barrier work?
- How long does eDNA persist?
- Where should one sample in the water?

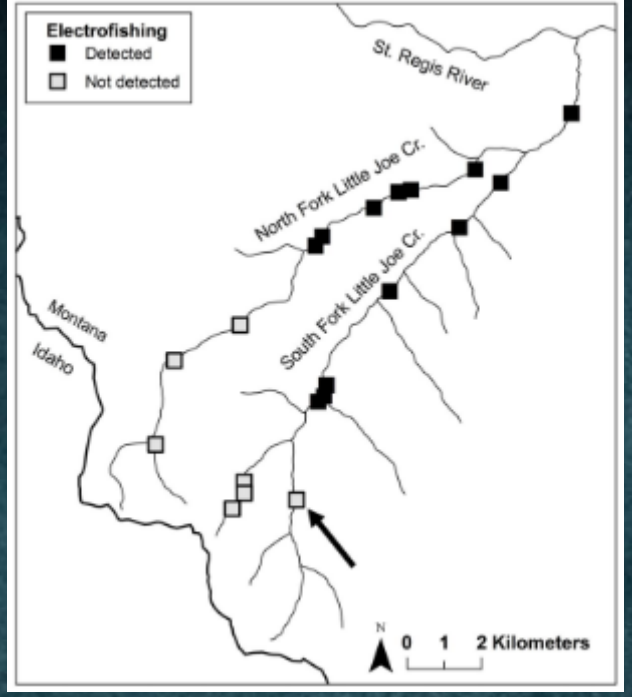


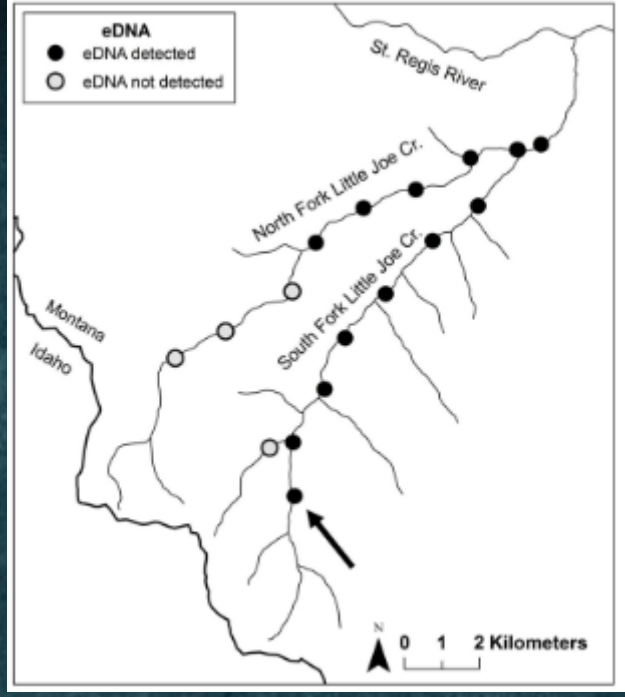
Utah DWR 2014:
chemical treatment
to remove brook trout

Using eDNA sampling to detect bull trout

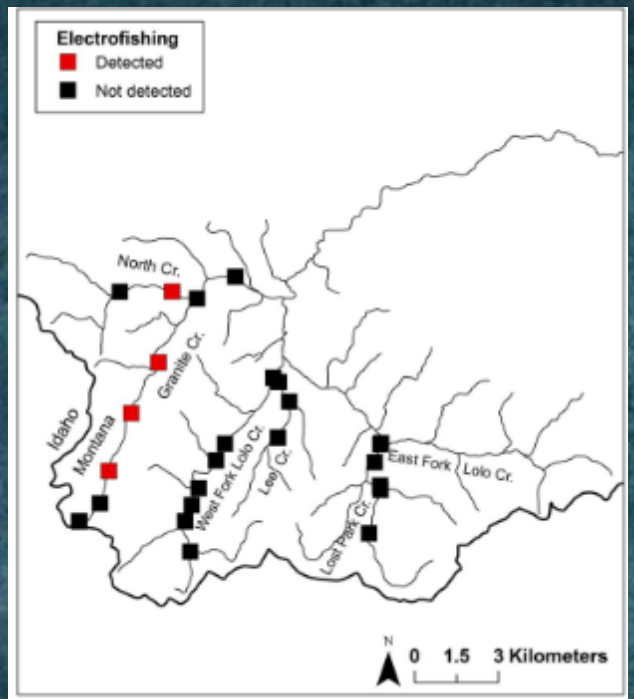
- Federally listed as threatened
- Dictates land management & planning
- Widespread in PNW
- Often rare
- Difficult to detect
- = ideal candidate for eDNA sampling

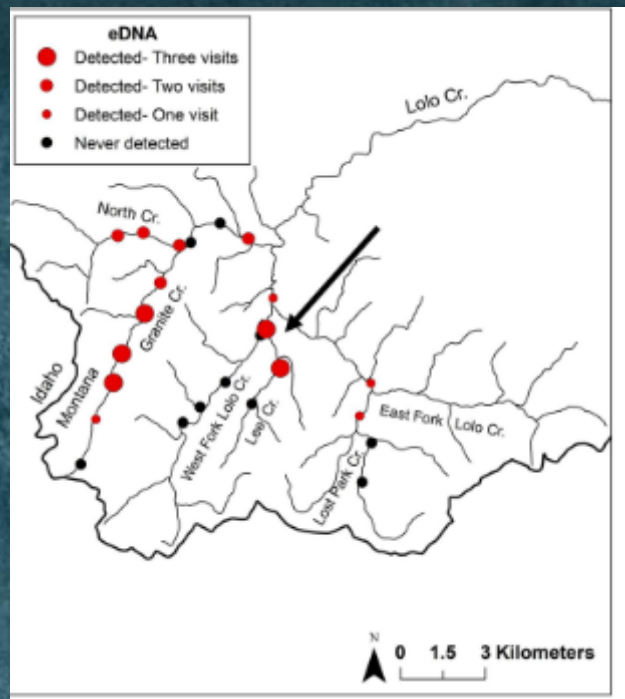
- Test: Montana 2014
- Confirmed known habitats
- Discovered new ones





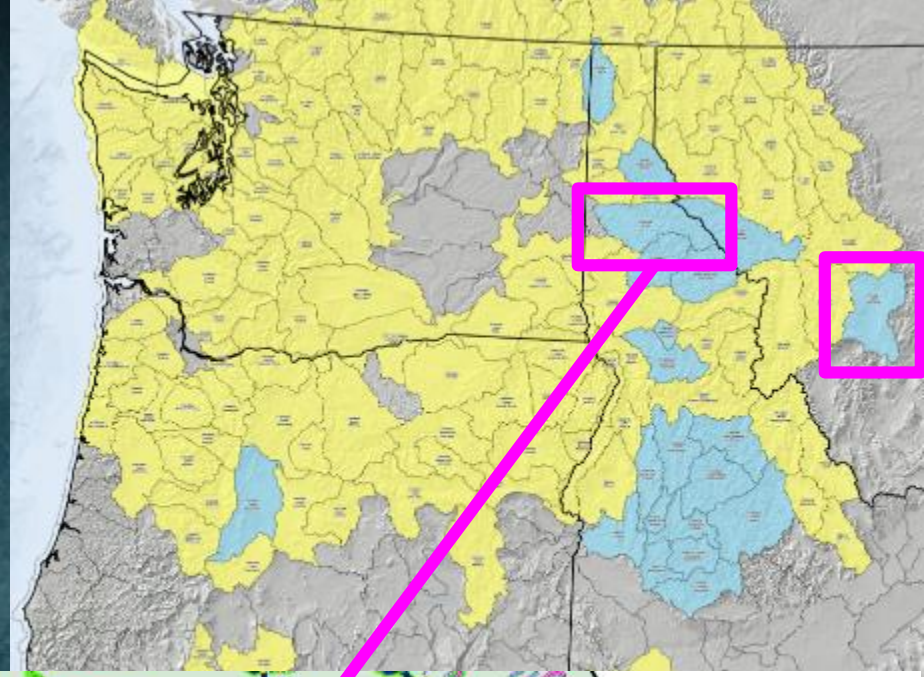
McKelvey et al. In press

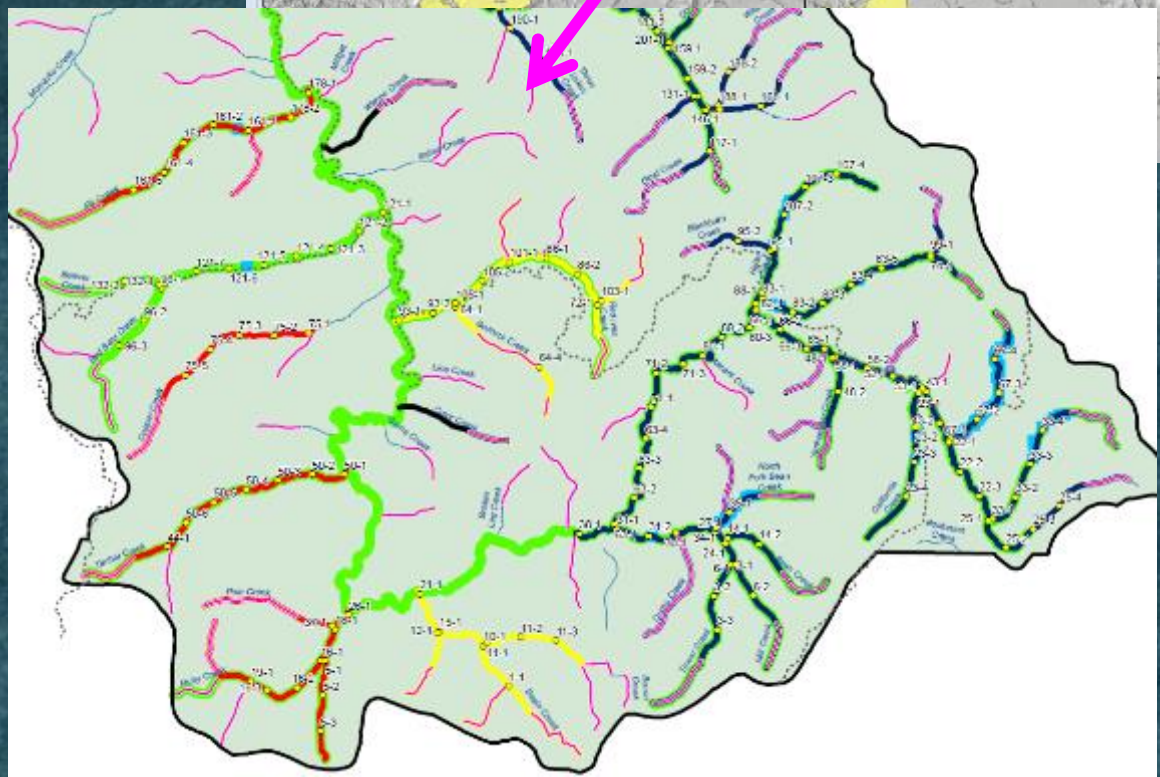




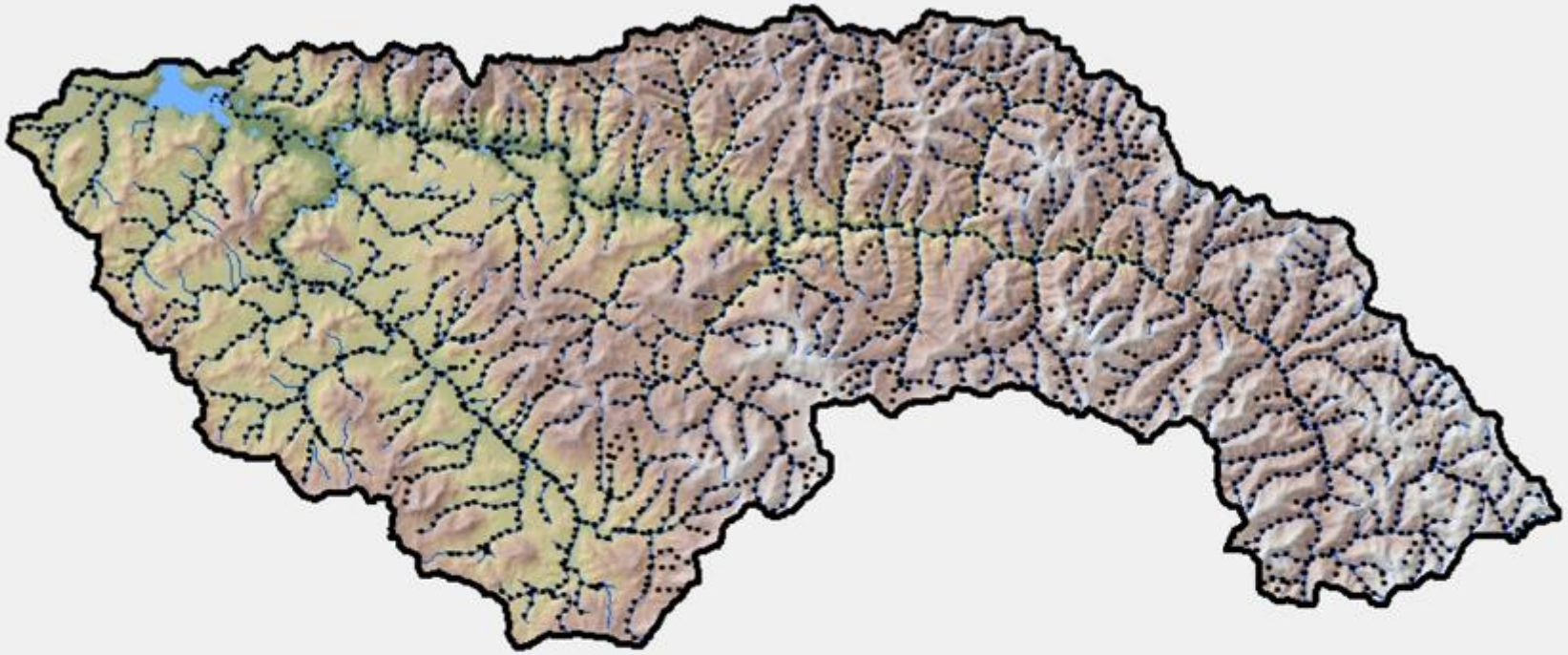
Scaling up: the range-wide eDNA-based inventory of juvenile bull trout habitat

- Scope
  - All 4th-code U.S. basins in the historical range (pending full funding)
- Sampling template
  - 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
- Timing
  - 2015: two 4th-code watersheds
  - 2018: the rest of the range





St. Joe River, Idaho



A naive sampling template

- Thousands of sites
- Expensive
- Time-consuming

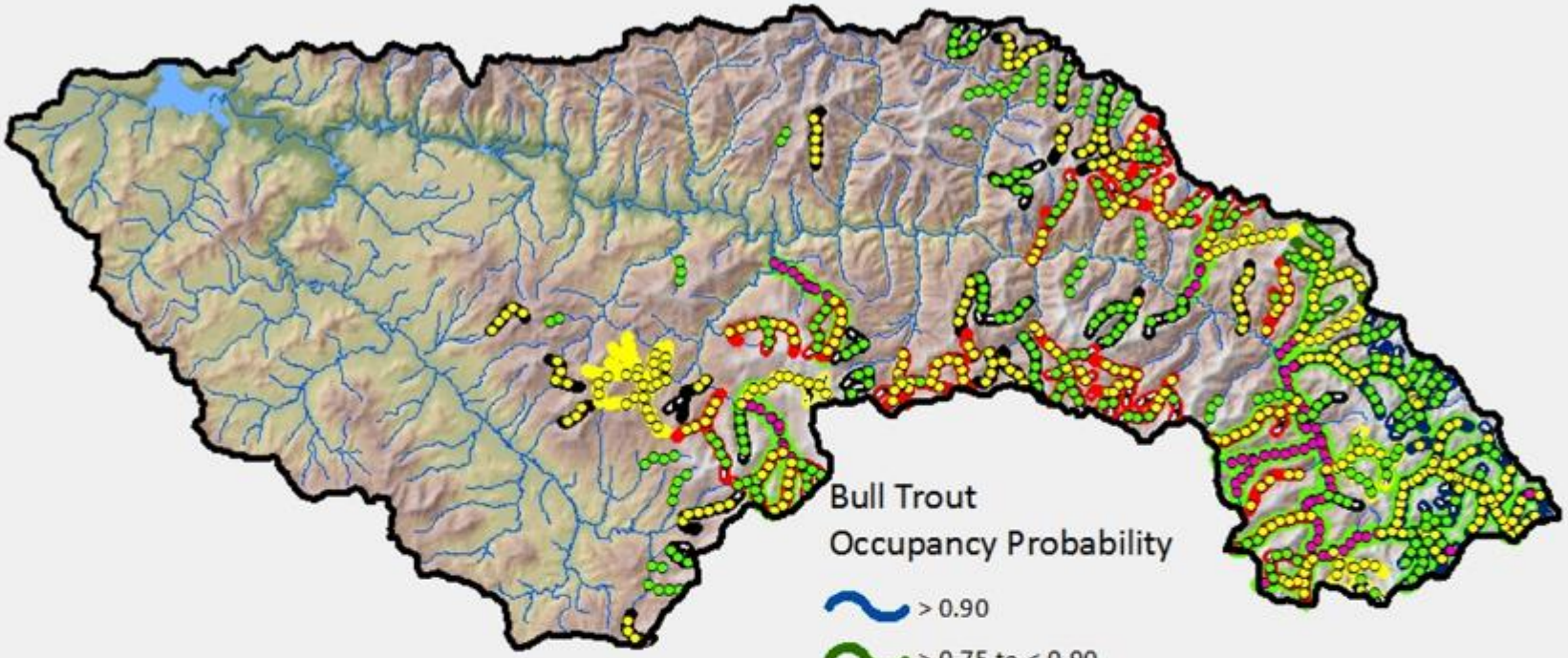
1-km sample site

Lakes

0 15 30 MI

0 25 50 KM

St. Joe River, Idaho

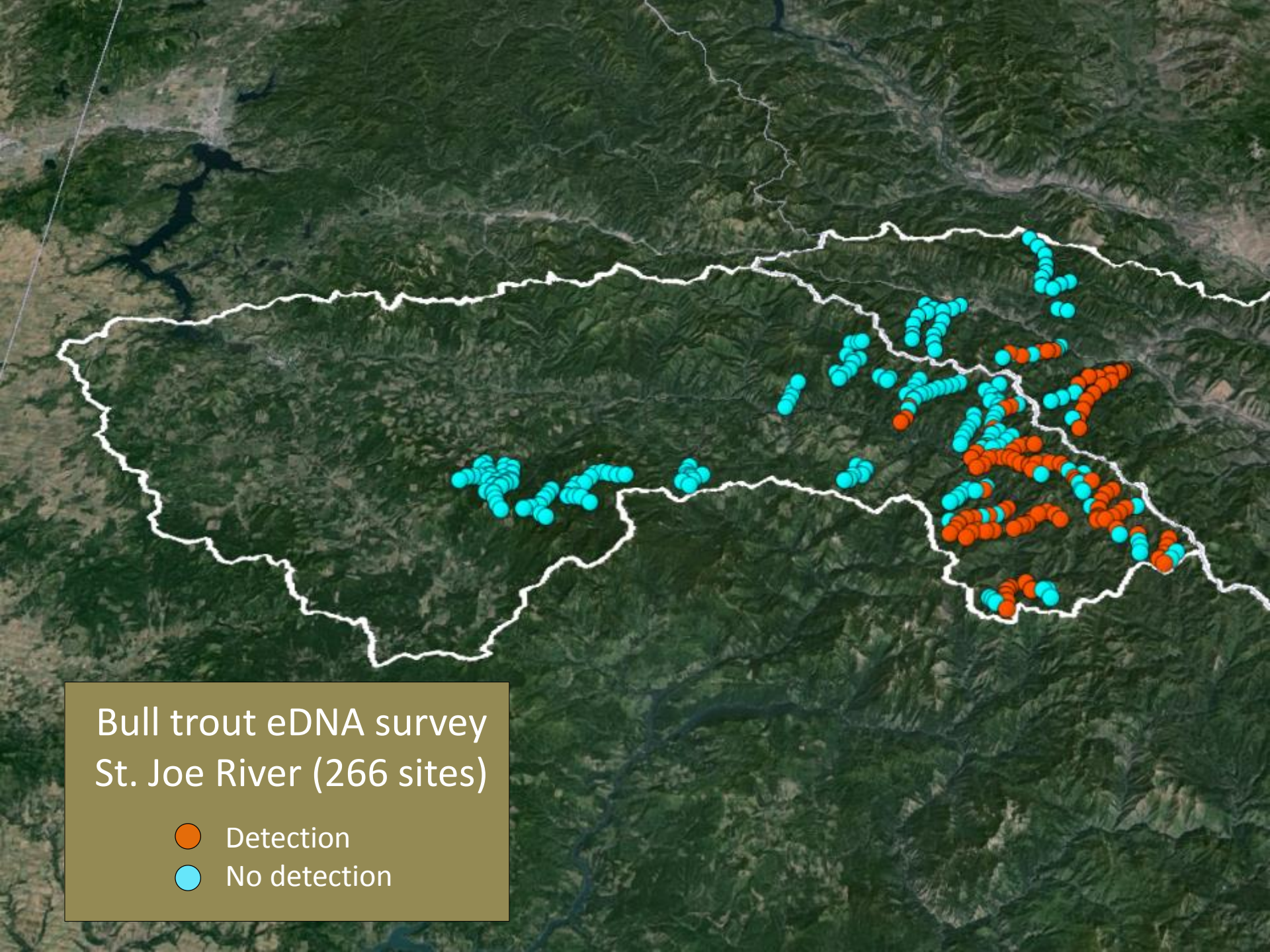


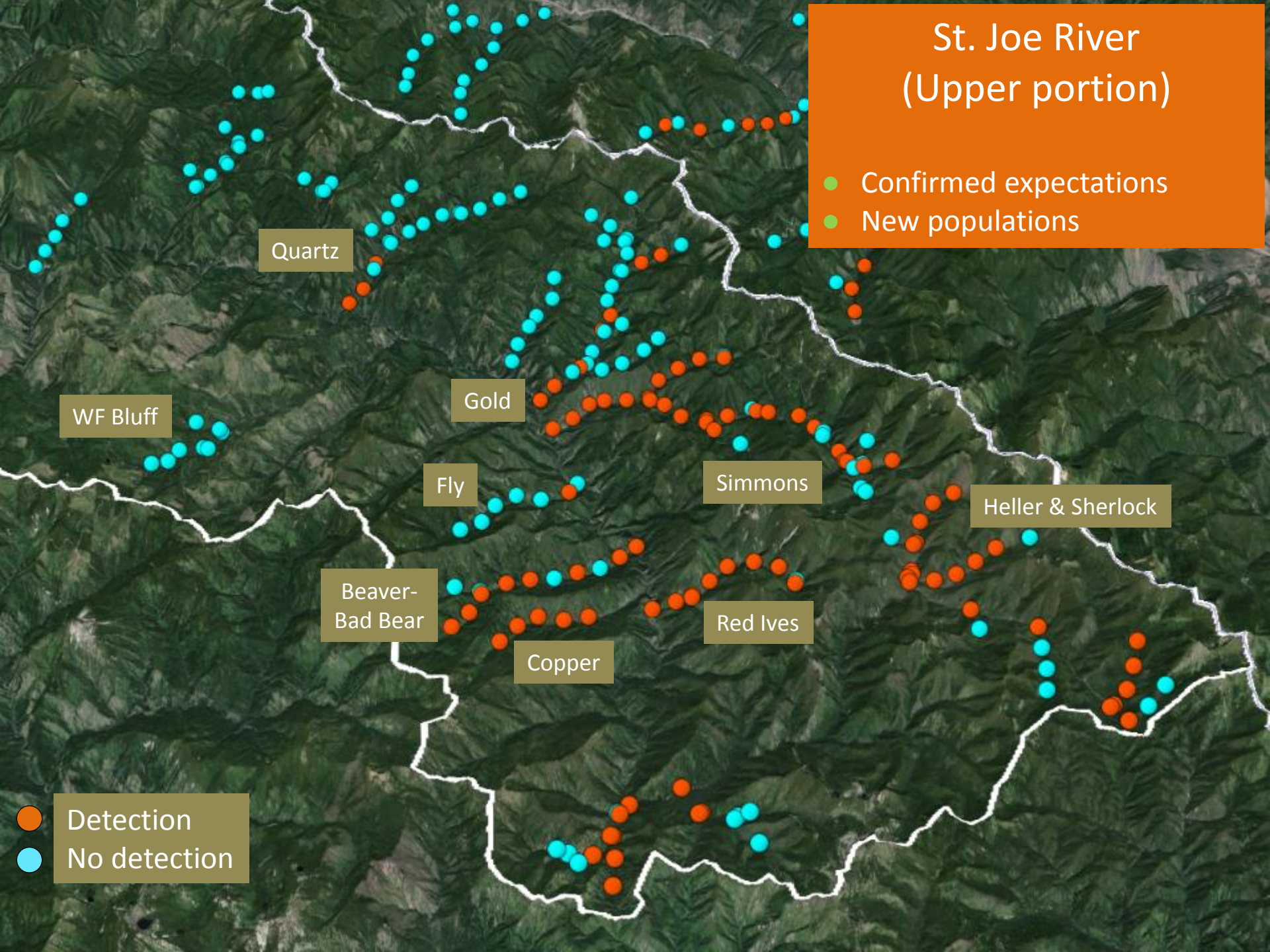
An informed sampling template

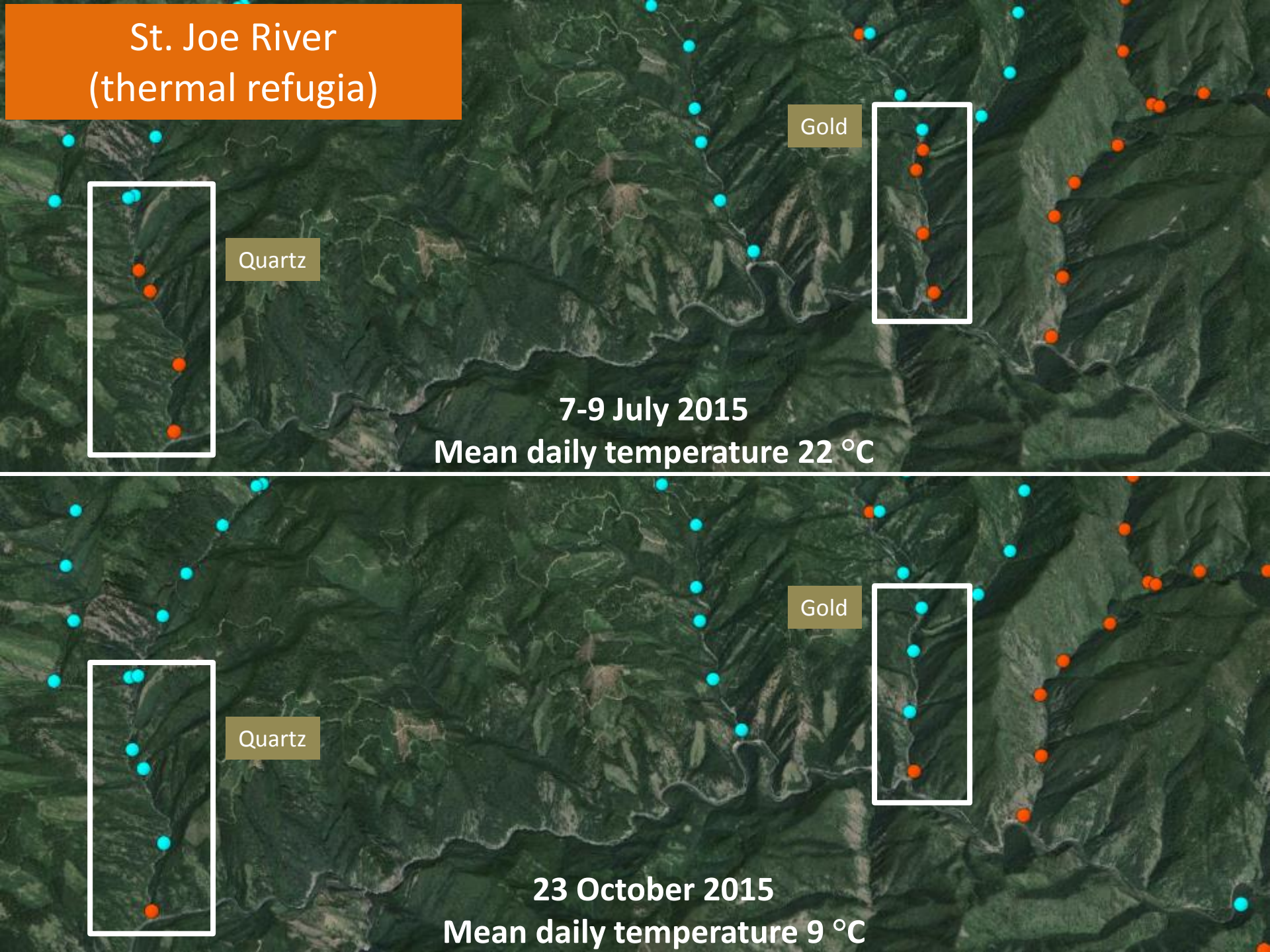
- Hundreds of sites
- Strategic
- Feasible

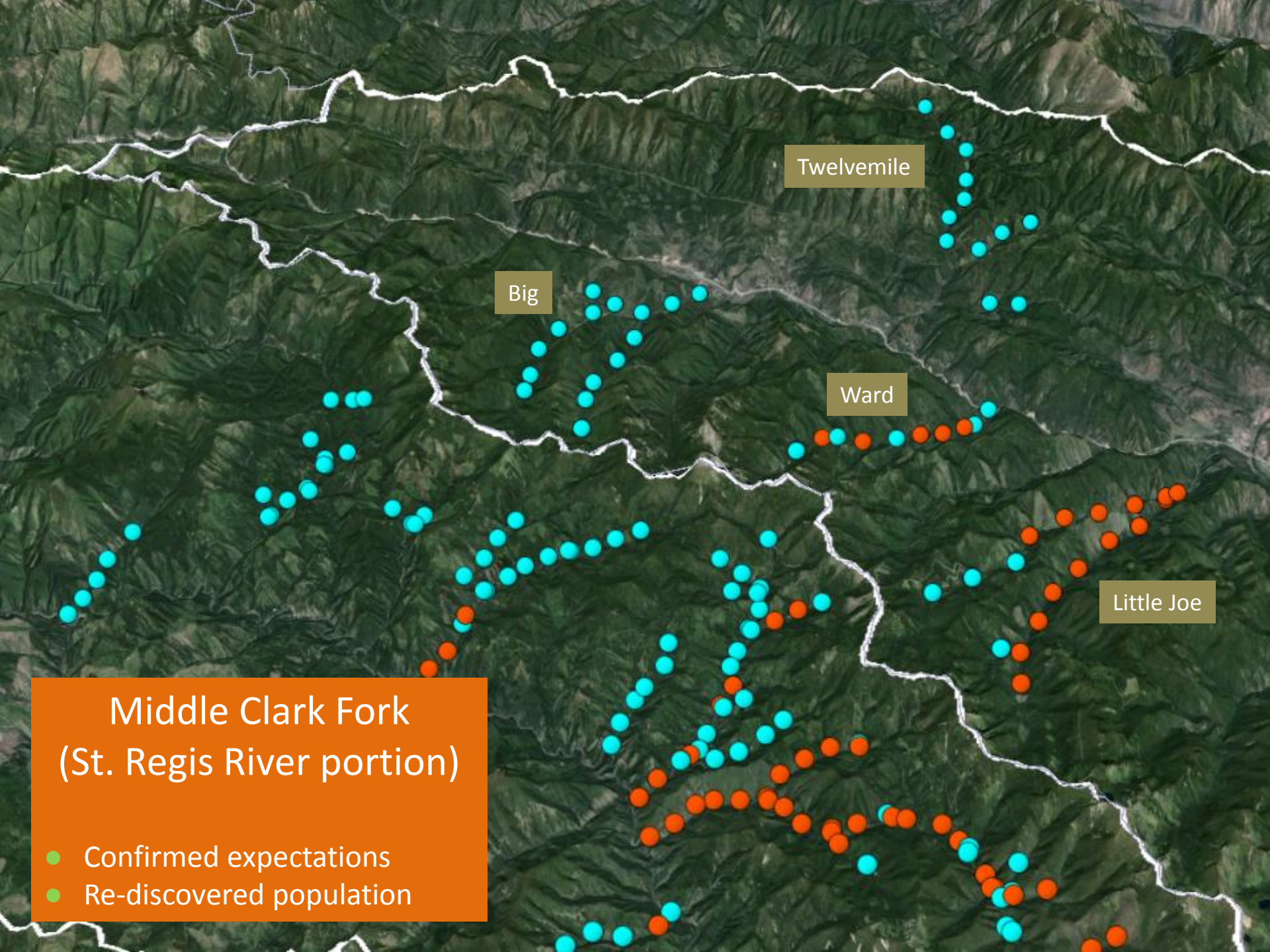
0 15 30 MI

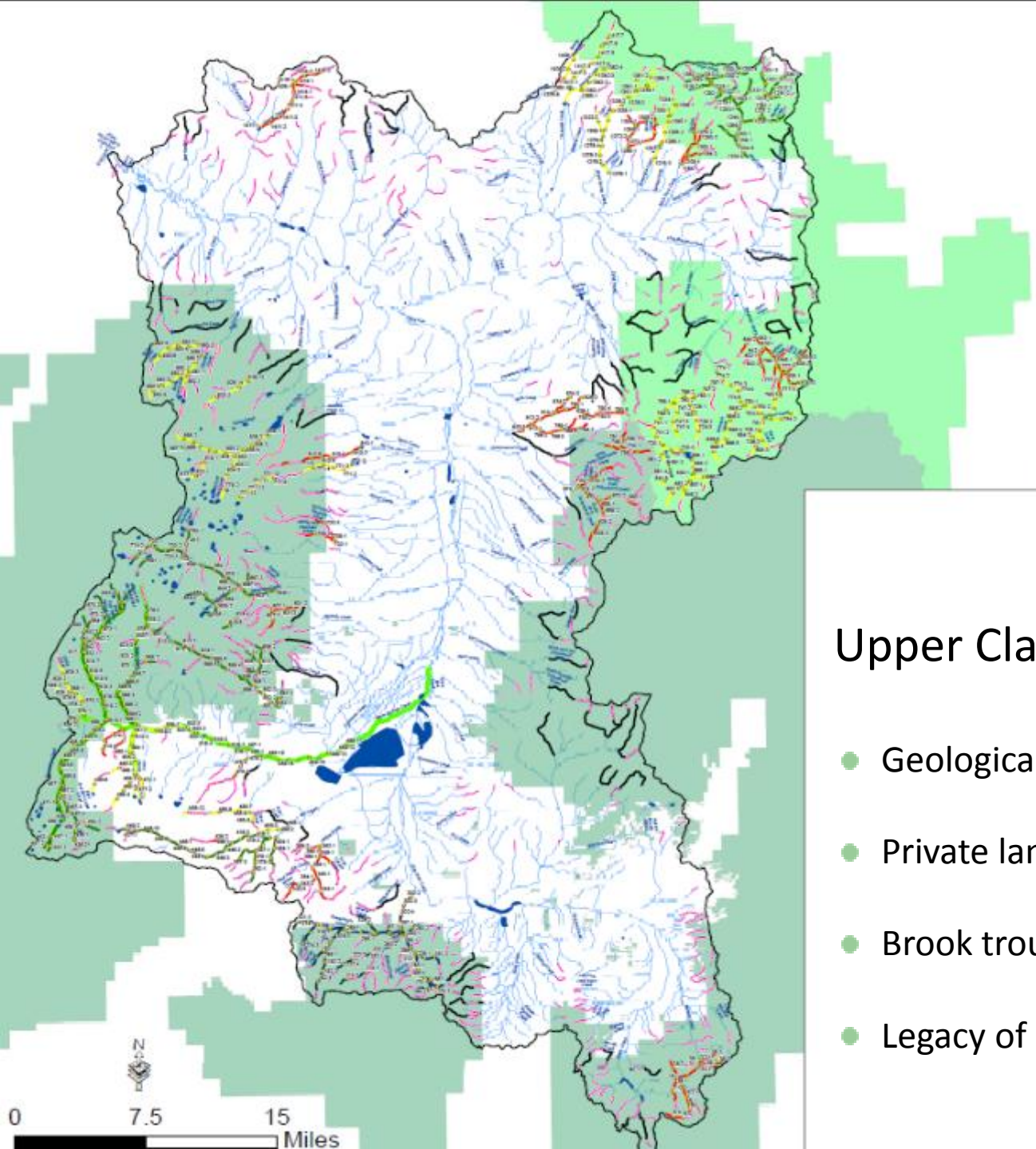
0 25 50 KM


Bull trout eDNA survey
St. Joe River (266 sites)
Detection
No detection


St. Joe River
(Upper portion)
Confirmed expectations
New populations
Quartz
WF Bluff
Gold
Fly
Simmons
Heller & Sherlock
Beaver-
Bad Bear
Red Ives
Copper
Detection
No detection


St. Joe River
(thermal refugia)
Gold
Quartz
7-9 July 2015
Mean daily temperature 22 °C
Gold
Quartz
23 October 2015
Mean daily temperature 9 °C


Twelvemile
Big
Ward
Little Joe
Middle Clark Fork
(St. Regis River portion)
Confirmed expectations
Re-discovered population



Notes

Upper Clark Fork

- Geological fish barriers common
- Private lands dominate
- Brook trout abundant & widespread
- Legacy of mining

Bull trout eDNA survey
Upper Clark Fork River (264 sites)

Detection
No detection

Montana Fish, Wildlife & Parks

Home | Hunting | Fishing | Recreation | Fish & Wildlife | Education | Enforcement | Regions | Doing Business | News | MyFWP

You are here: Home » Fishing » MFISH

MFISH - Search
Montana Fisheries Information System

You searched for:
Both Lakes and Streams in
17010201 - Upper Clark Fork with
Bull Trout

Display Criteria selected:
/ Fish Distribution, / Population Surveys, / Genetic Samples, / Fish Stocking, / Habitat Measurements, / Bull Trout Core/Nodal Areas, / Angling Days Per Year, / Stream Rating, / FWP Dewatered Concern Areas, / FWP Instream Flow Protection/Qualification, / FWP Water Leases/Conversions, / Protected Areas, / Special Fishing Regulations, / Stream Restoration Projects, / FWP Management, / Fish Logs, / References

Download Data | Launch Map | * maps may take up to a minute to load

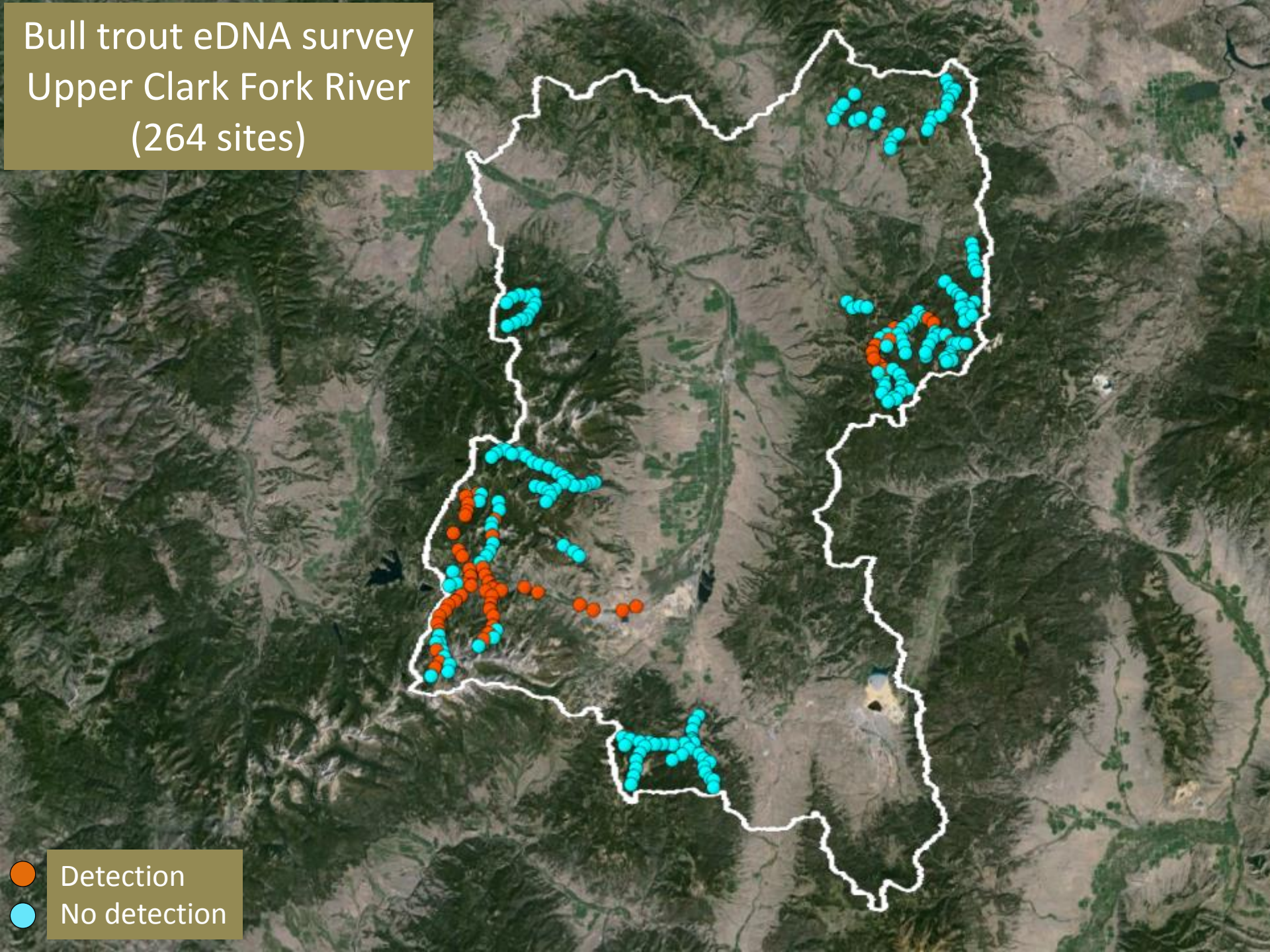
8 items found. Click a waterbody name to view the report.

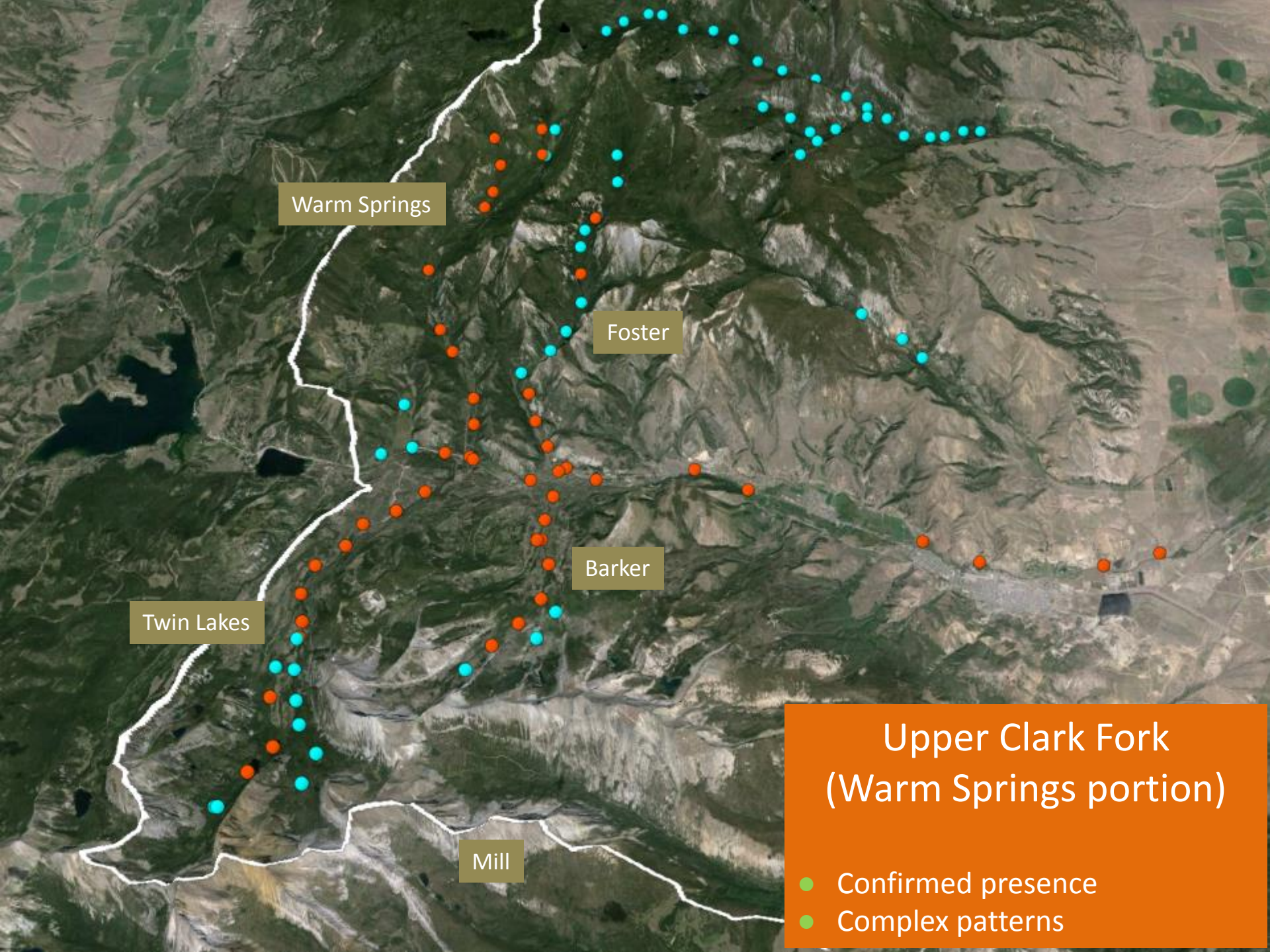
Search Results per page: 10

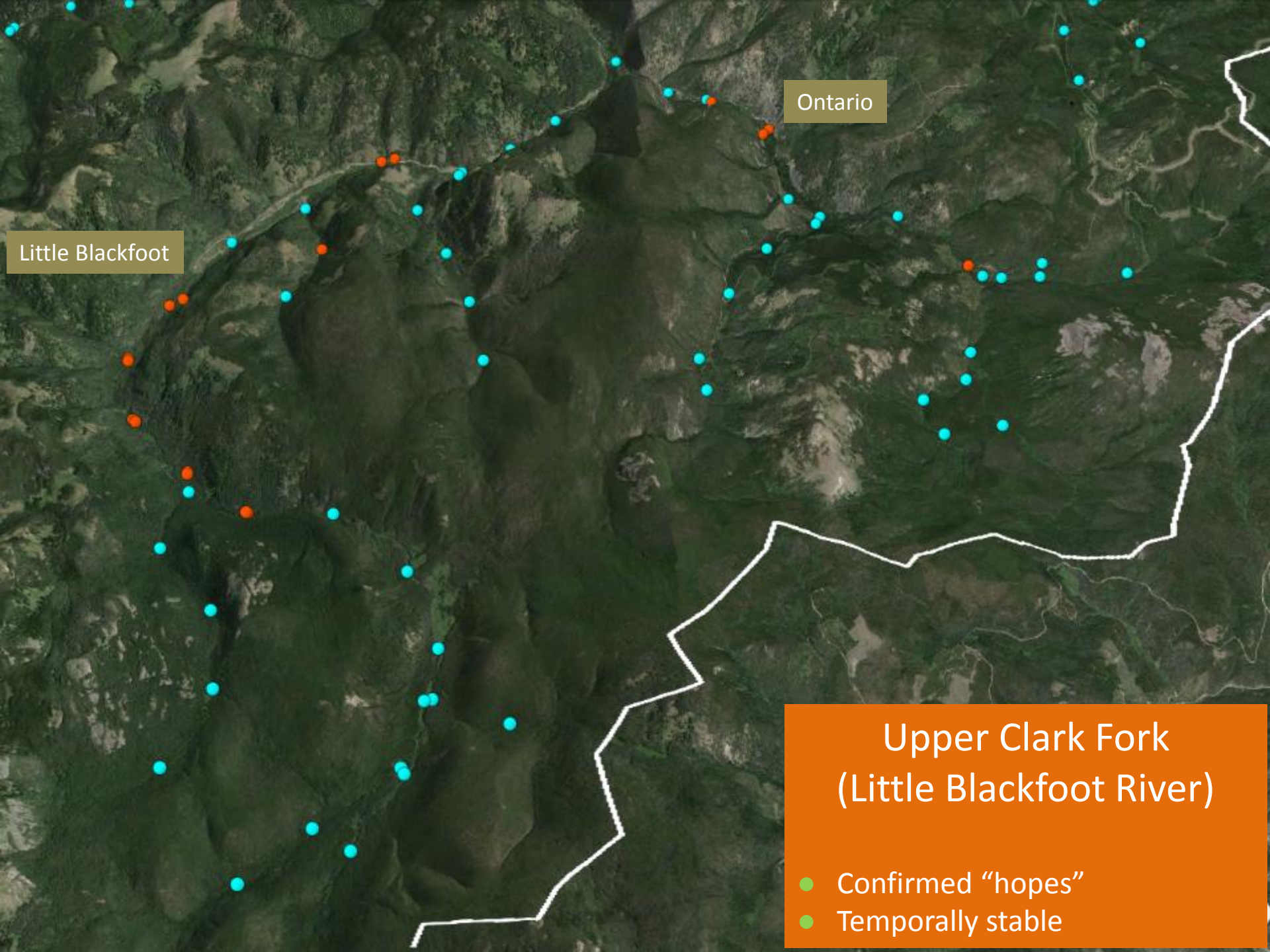
Waterbody	Tributary To	Begin	End	Miles	Total Stream Miles	Counties
Barker Creek	Warm Springs Creek	0	5	5	5	Deer Lodge
Clark Fork River	No Downlink	274.1	294.6	20.5	340	Deer Lodge; Granite; Mineral; Missoula; Powell; Sanders
Foster Creek	Warm Springs Creek	0	9.9	9.9	9.9	Deer Lodge; Granite
Silver Lake	SILVER L CANAL	-	-	-	-	Deer Lodge
Storm Lake Creek	Warm Springs Creek	0	10.9	10.9	12.3	Deer Lodge
Twin Lakes Creek	Warm Springs Creek	0	10	10	10	Deer Lodge
Warm Springs Creek	Clark Fork River	0	32.6	32.6	33.9	Deer Lodge; Granite
West Fork Warm Springs Creek	Warm Springs Creek	0	2	2	2.1	Granite

1

Page 1 of 1


Bull trout eDNA survey
Upper Clark Fork River
(264 sites)
Detection
No detection


Warm Springs
Foster
Barker
Twin Lakes
Mill
Upper Clark Fork
(Warm Springs portion)
Confirmed presence
Complex patterns

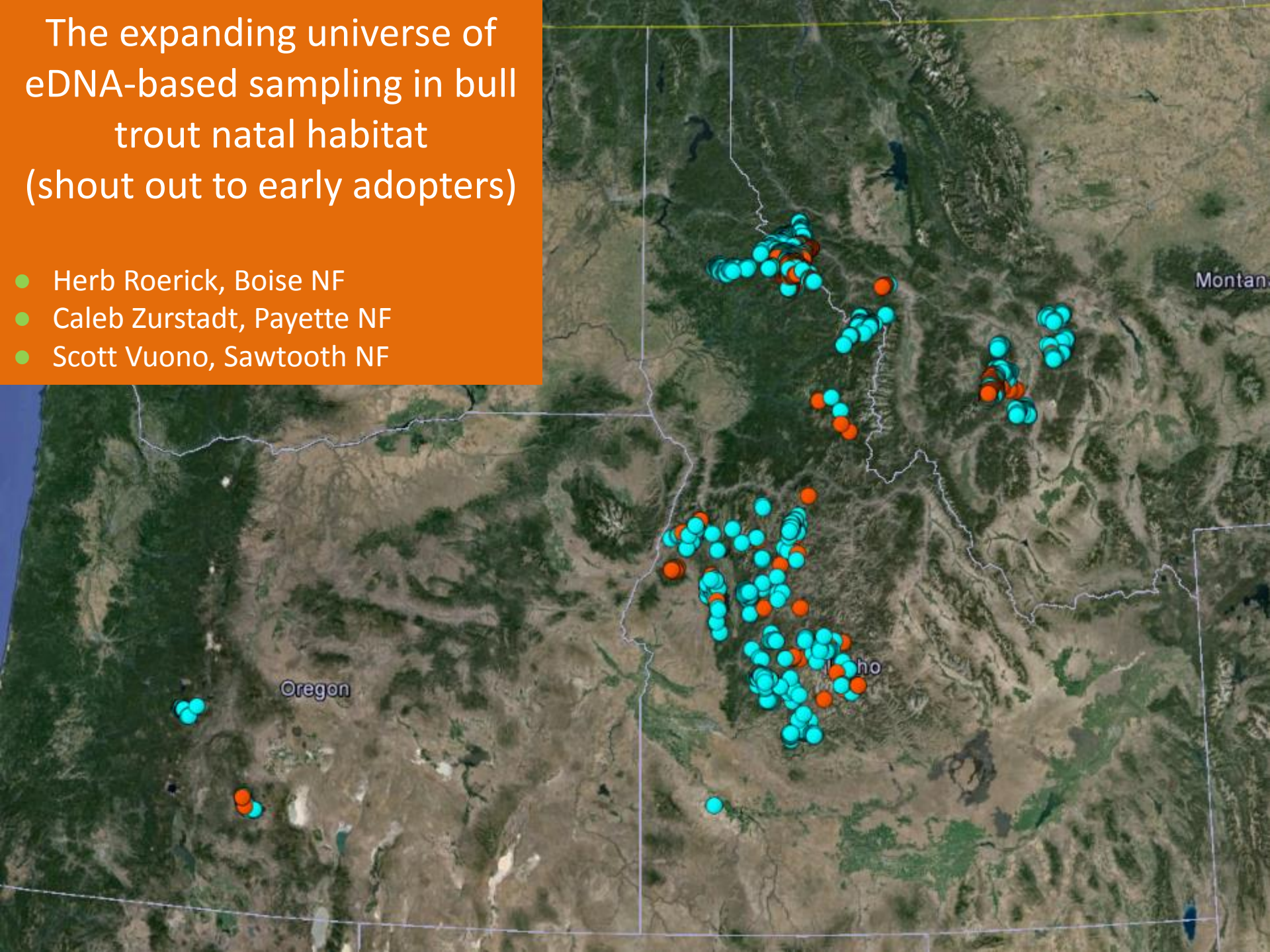


Upper Clark Fork (Little Blackfoot River)

- Confirmed “hopes”
- Temporally stable

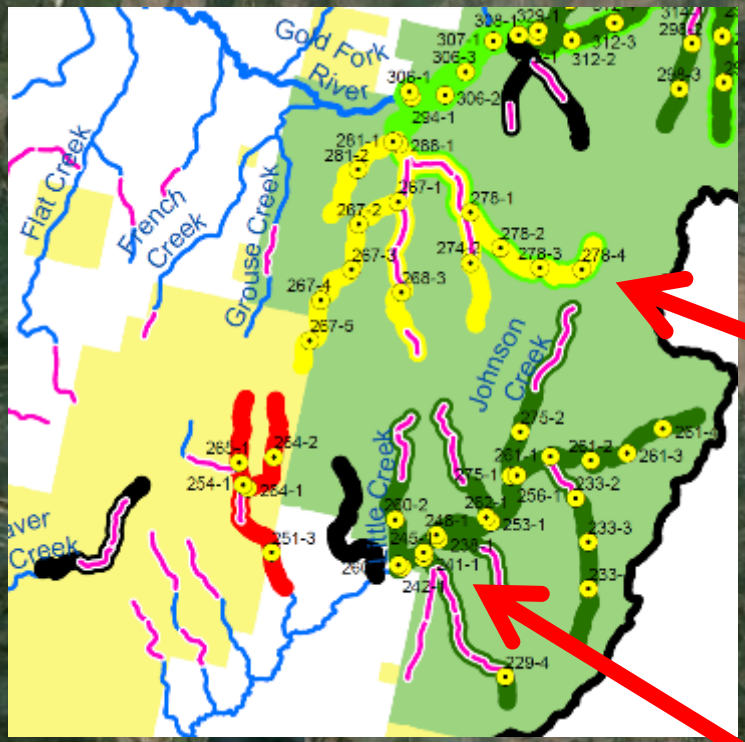
The expanding universe of eDNA-based sampling in bull trout natal habitat (shout out to early adopters)

- Herb Roerick, Boise NF
- Caleb Zurstadt, Payette NF
- Scott Vuono, Sawtooth NF



North Fork Payette
(SF Gold Fork River, Big Creek)

- No detections (despite CH designation)



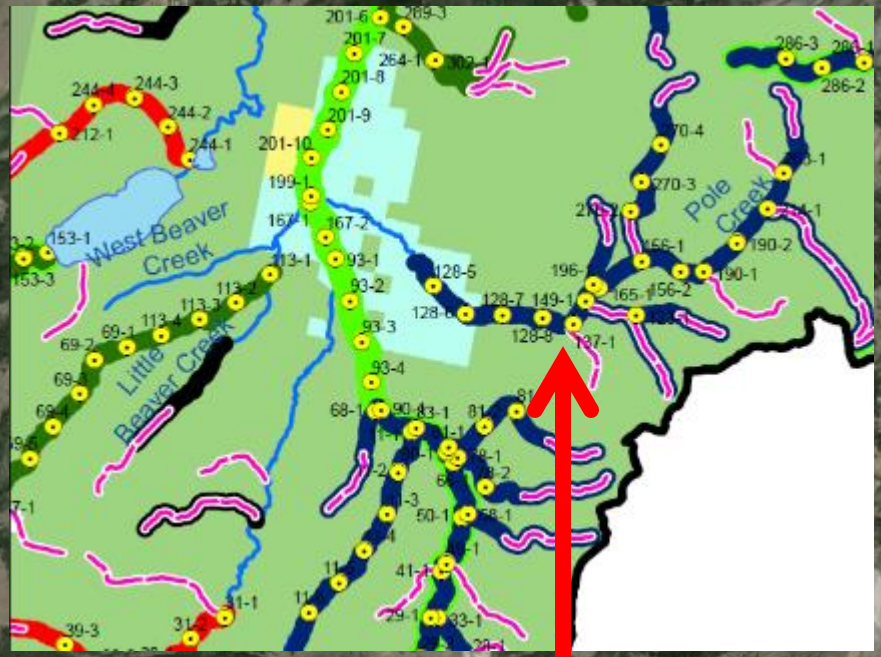
SF Gold Fork River

Big Creek

Imagery Date: 6/25/2015 11 T 5969

Upper Salmon (Pole Creek)

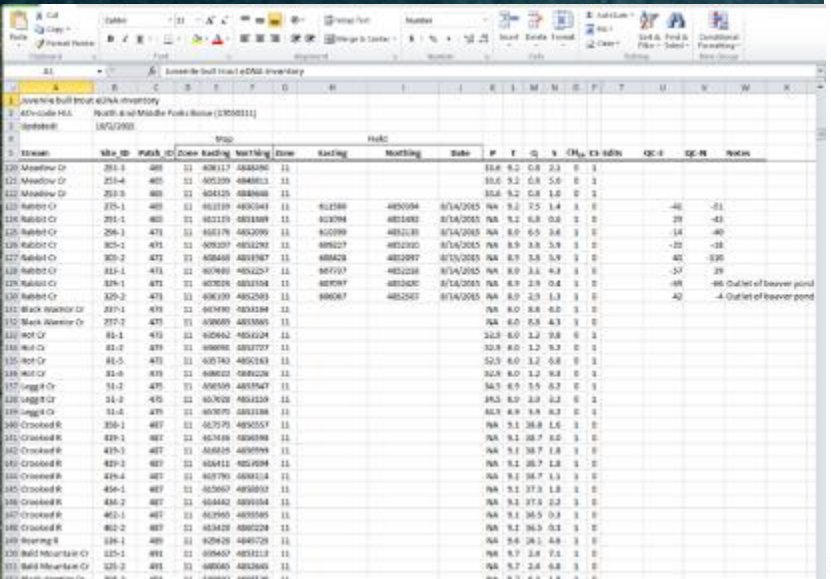
- All sites with detections



Want to get involved?

The range-wide inventory of bull trout natal habitats: how to participate

- Contact us
- Reserve a pump set & filter kits
- eDNA point map & file
- Sample entire patches!
- Funding



Bull Trout eDNA Sample Sites

Scenario: 1980s, 0% Brook Trout

NHD Unit: 17050111 (North & Middle Forks Boise)

Legend

- eDNA Sample Site (N=460
  Note: The 460 sites on this map occur on streams having <10% slope and a probability of bull trout occurrence >25%.

Probability of Occupancy (%)

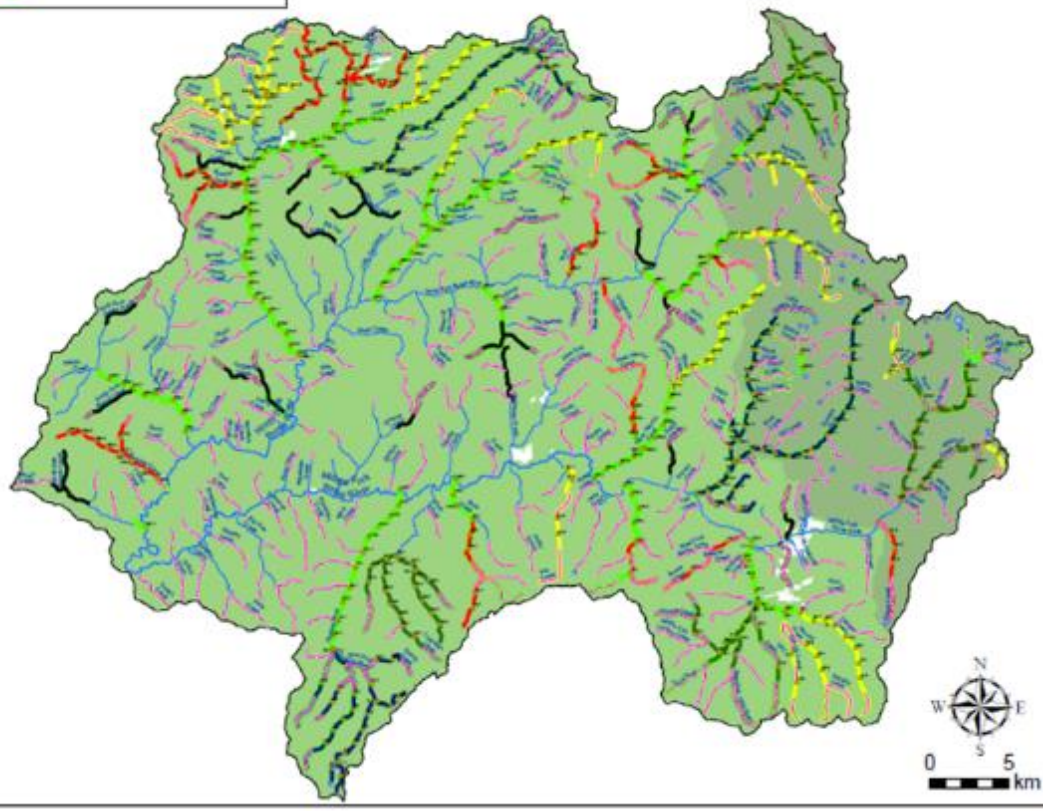
- 10 - 25
- 25 - 50
- 50 - 75
- 75 - 90
- 90 - 100

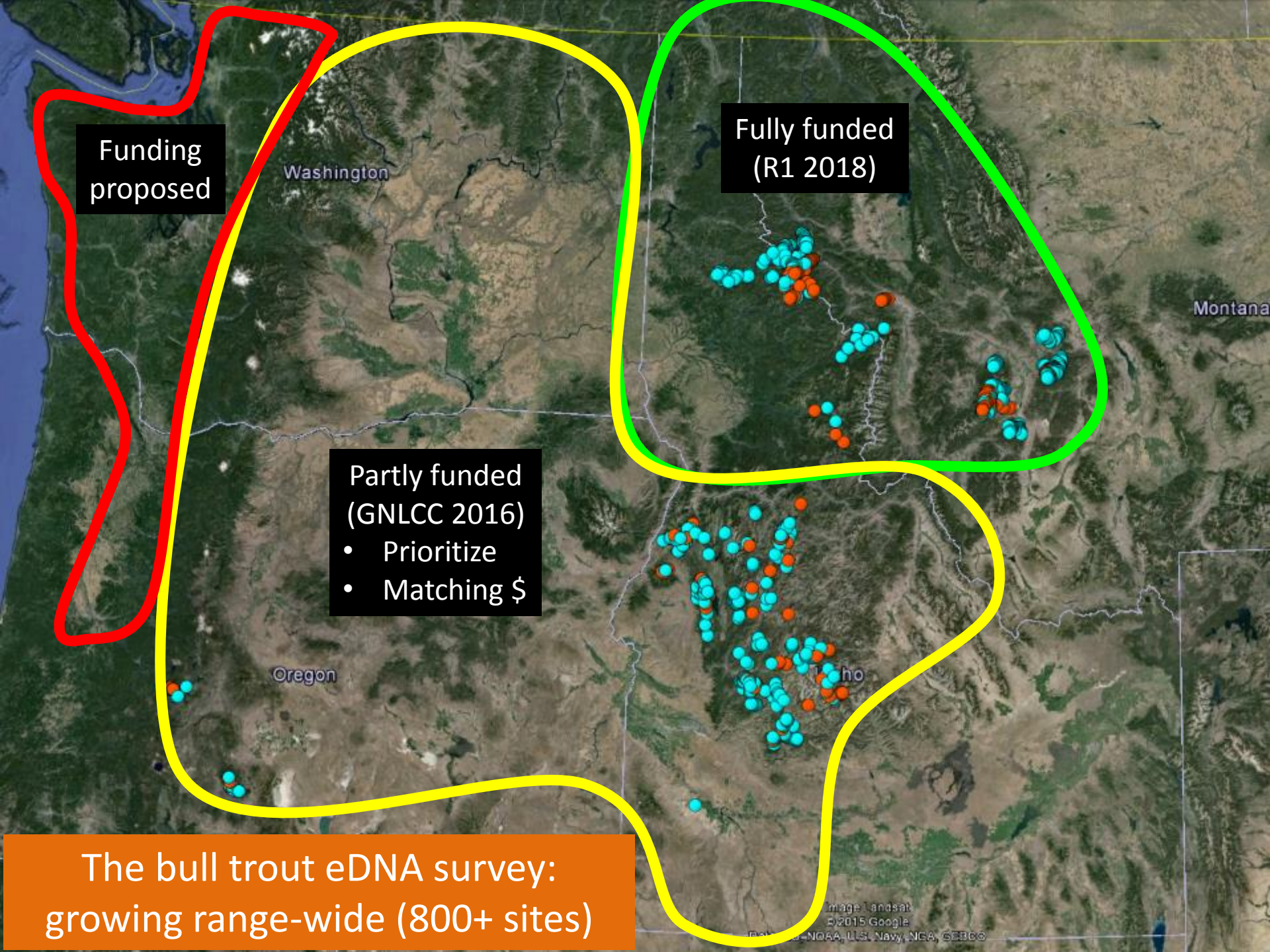
Slope > 10%

Bull Trout Critical Habitat

Land Ownership

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

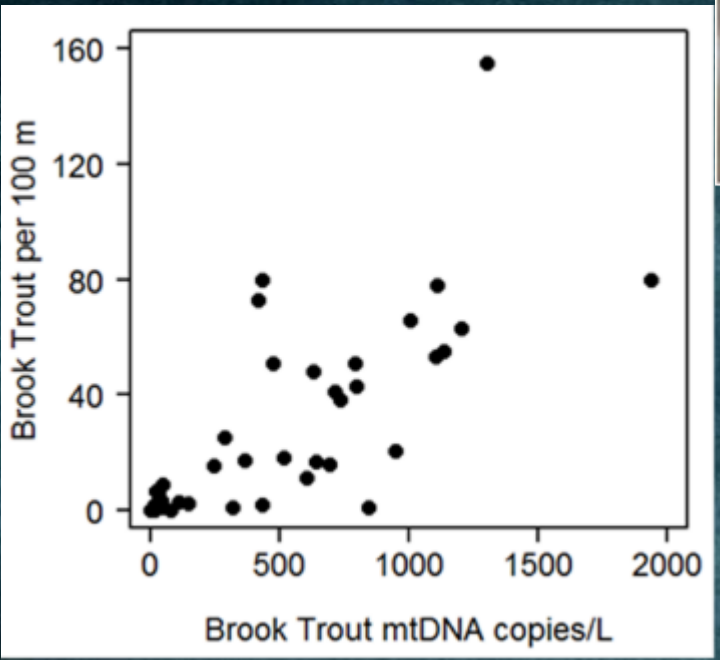




The bull trout eDNA survey: growing range-wide (800+ sites)

Other options

- eDNA assay development
  - $5K/taxon
  - 2–3 months*
- Sample analysis
  - $70, 1st species
  - $25, all other species
  - 56-hour turnaround
  - All gear provided
- Coming soon(?)
  - Abundance
  - Hybridization (sort of)
  - Multi-species assessments



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- Visit our websites
  - NGCWFC
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