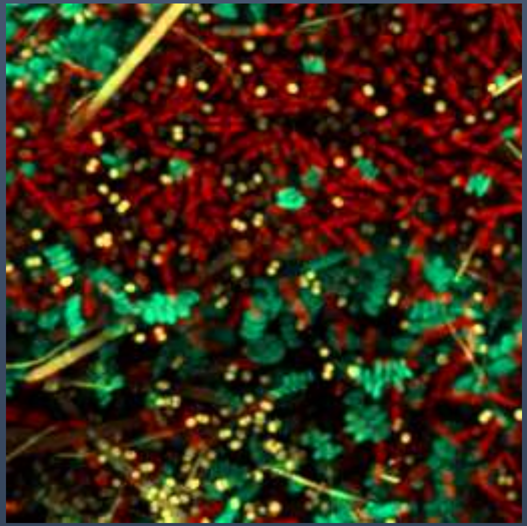
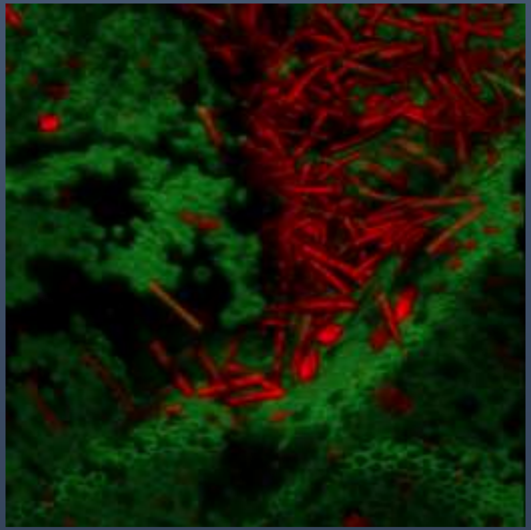
The first statewide stream macroinvertebrate bioassessment in Washington State with a relative risk and attributable risk analysis for multiple stressors

Chad Larson

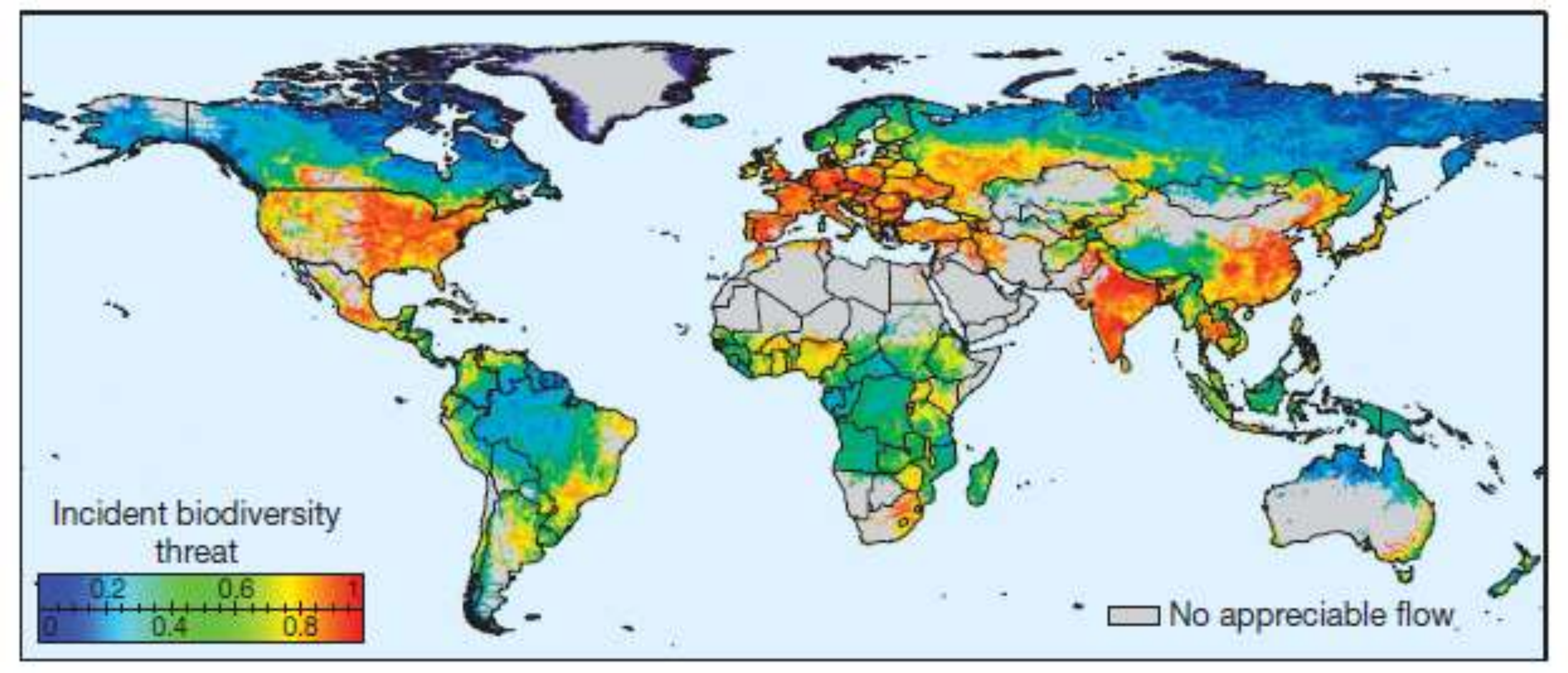
Environmental Assessment Program

Washington State Department of Ecology





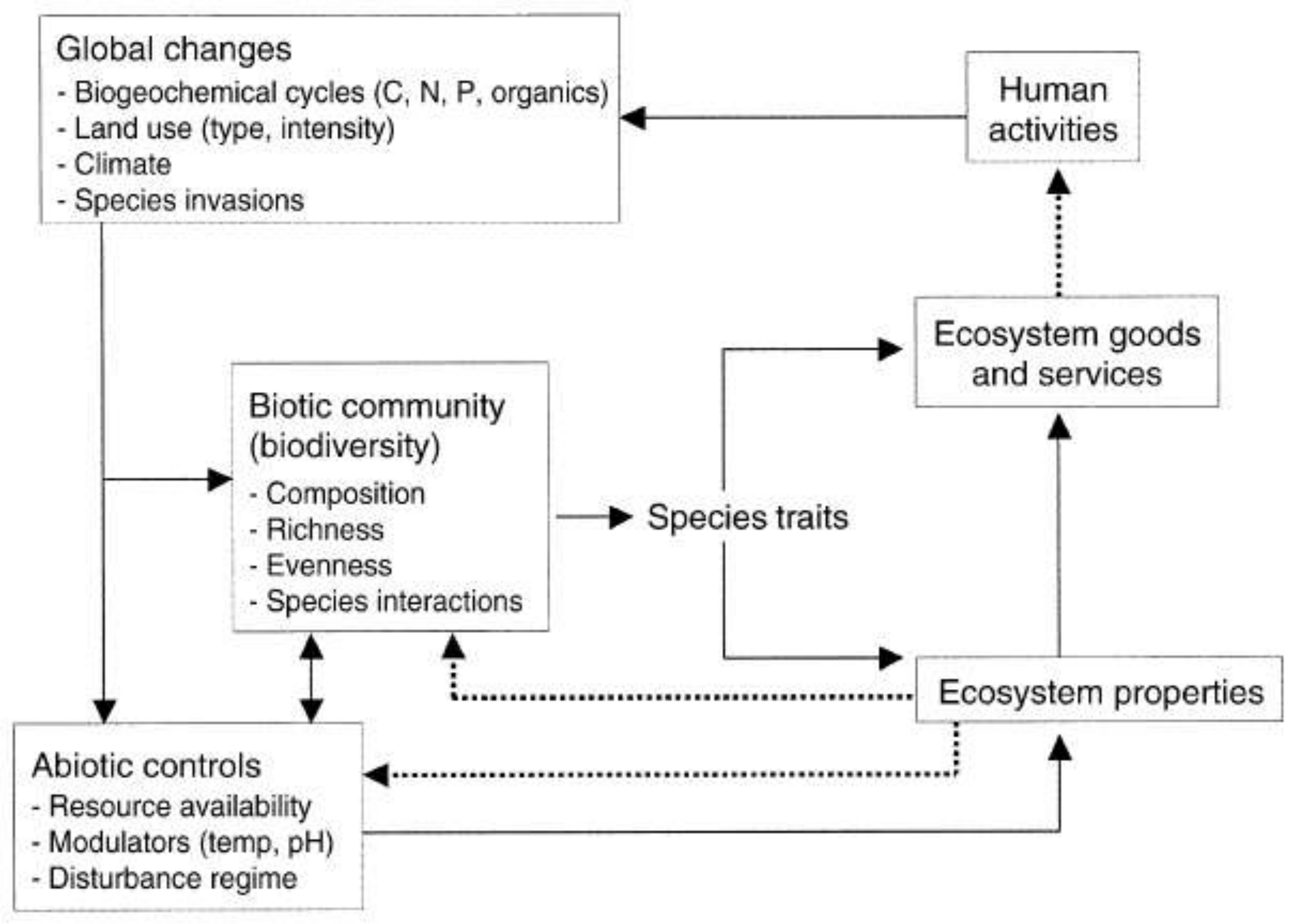
Freshwater systems under threat



Vörösmarty et al. (2010) *Nature*

Freshwater systems comprise only a fraction of the total water found on the planet, yet supply nearly two-thirds of the water used in the world

Biodiversity matters



Hooper et al. (2005) *Ecological Monographs*

Background

Clean Water Act – restore & maintain the chemical, physical and biological integrity of the nation's waters

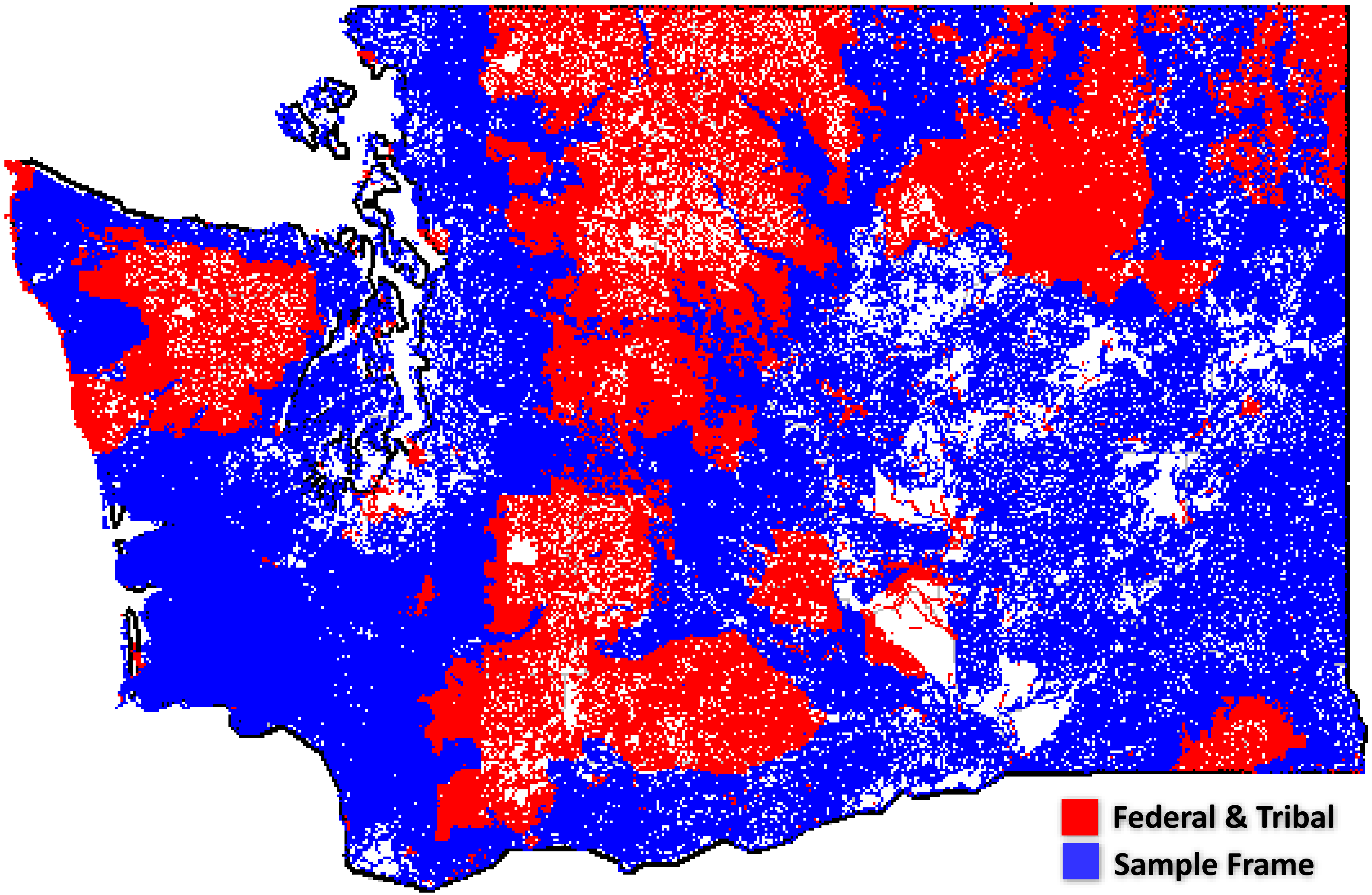
Prior to 2009, WA had no comprehensive stream biological monitoring program

Beginning in 2009, Watershed Health Monitoring Program implemented GRTS random sample survey design

50 sites in each of 7 Salmon Recovery Regions & 1 unlisted region

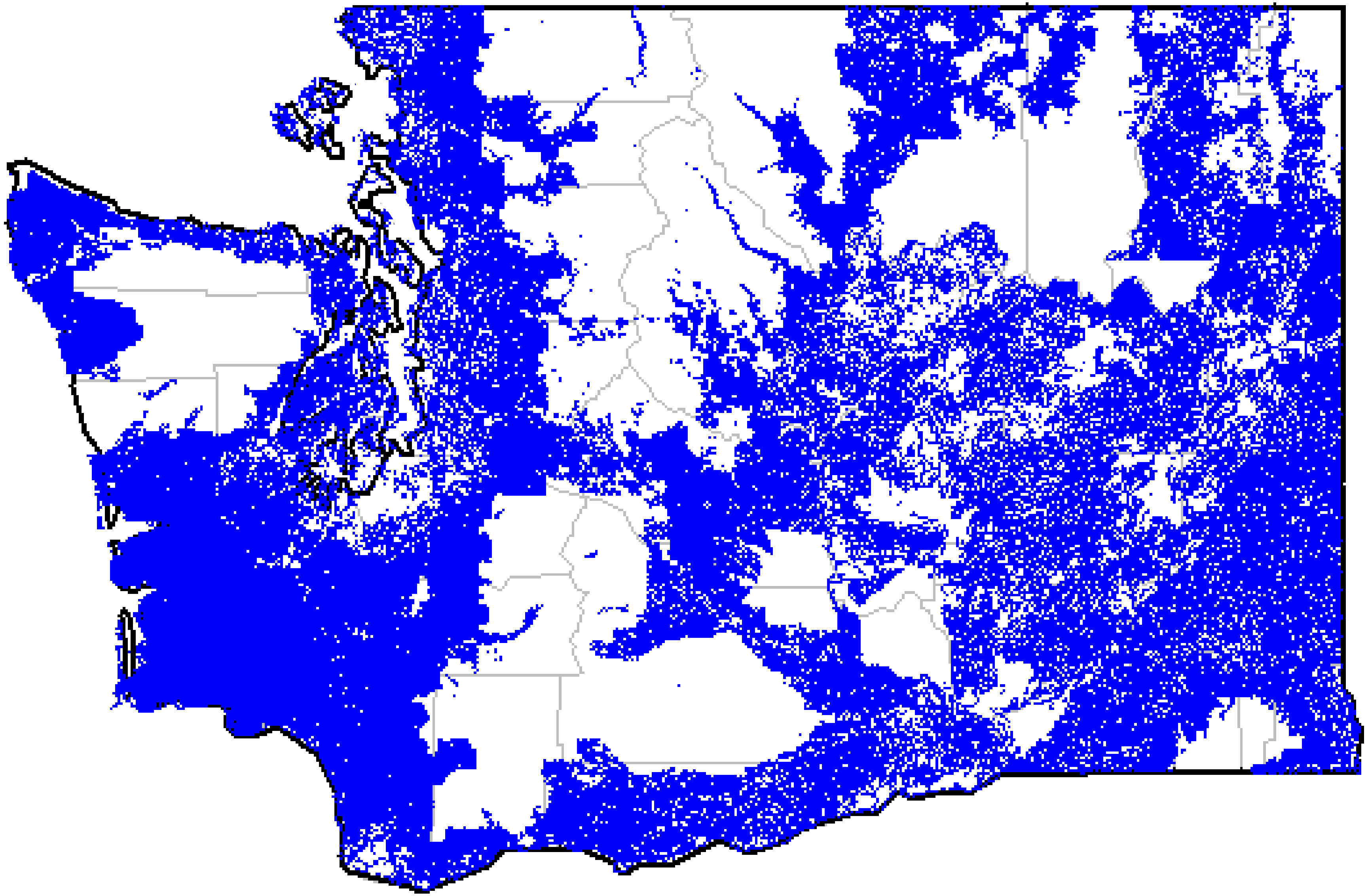
WA master sample points

387,543 points

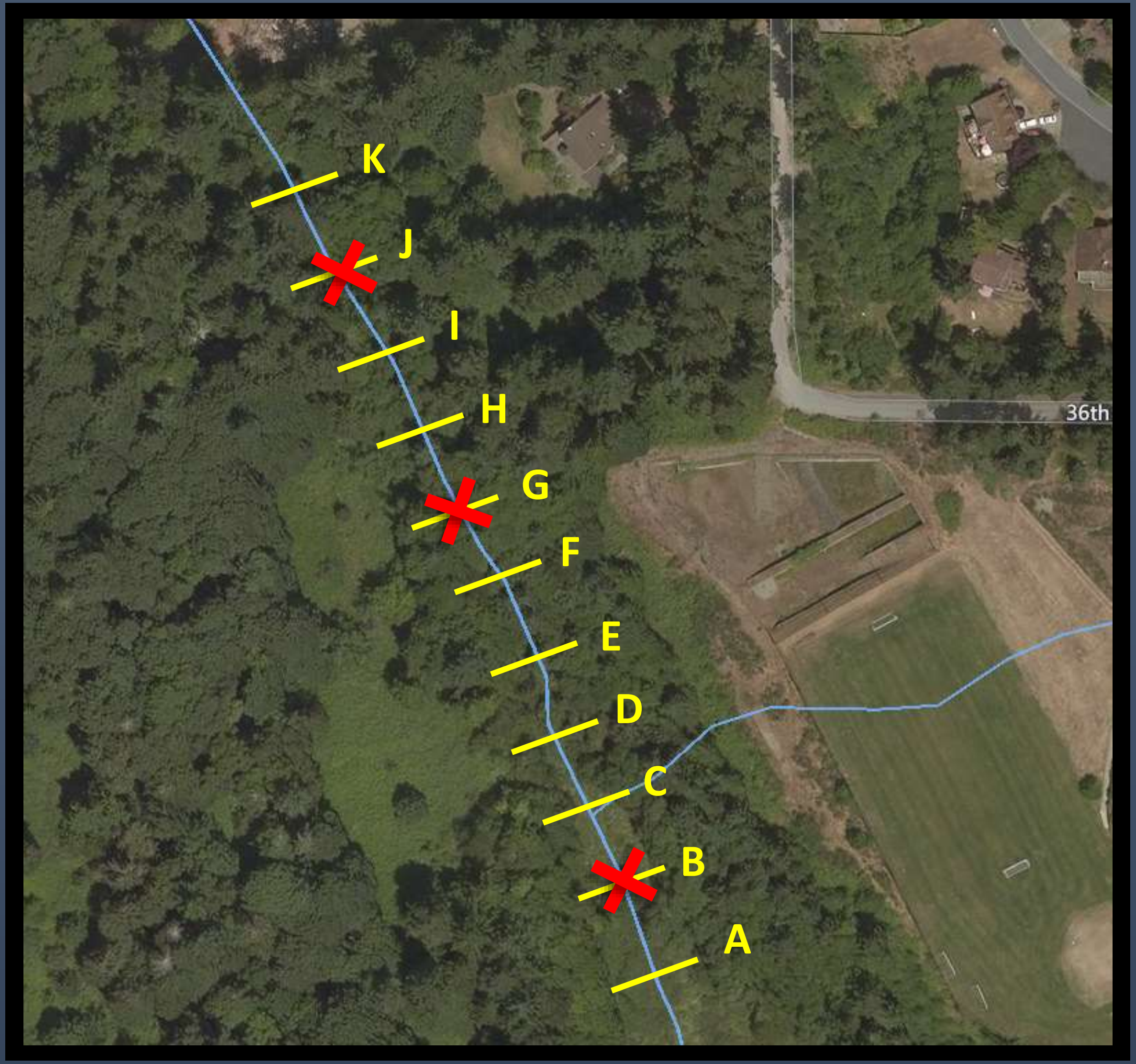


WA master sample points

248,402 points



Measuring Chemical, Physical and Biological Parameters



11 major transects evaluated for substrate, riparian habitat and fish habitat

Physical, chemical and sediment parameters evaluated

262 habitat metrics generated with the data

8 randomly selected transects are sampled for invertebrates and periphyton

Standardized Sampling Protocol:

Composite sample from 8 randomly selected transects at a stream reach (8 ft^2)

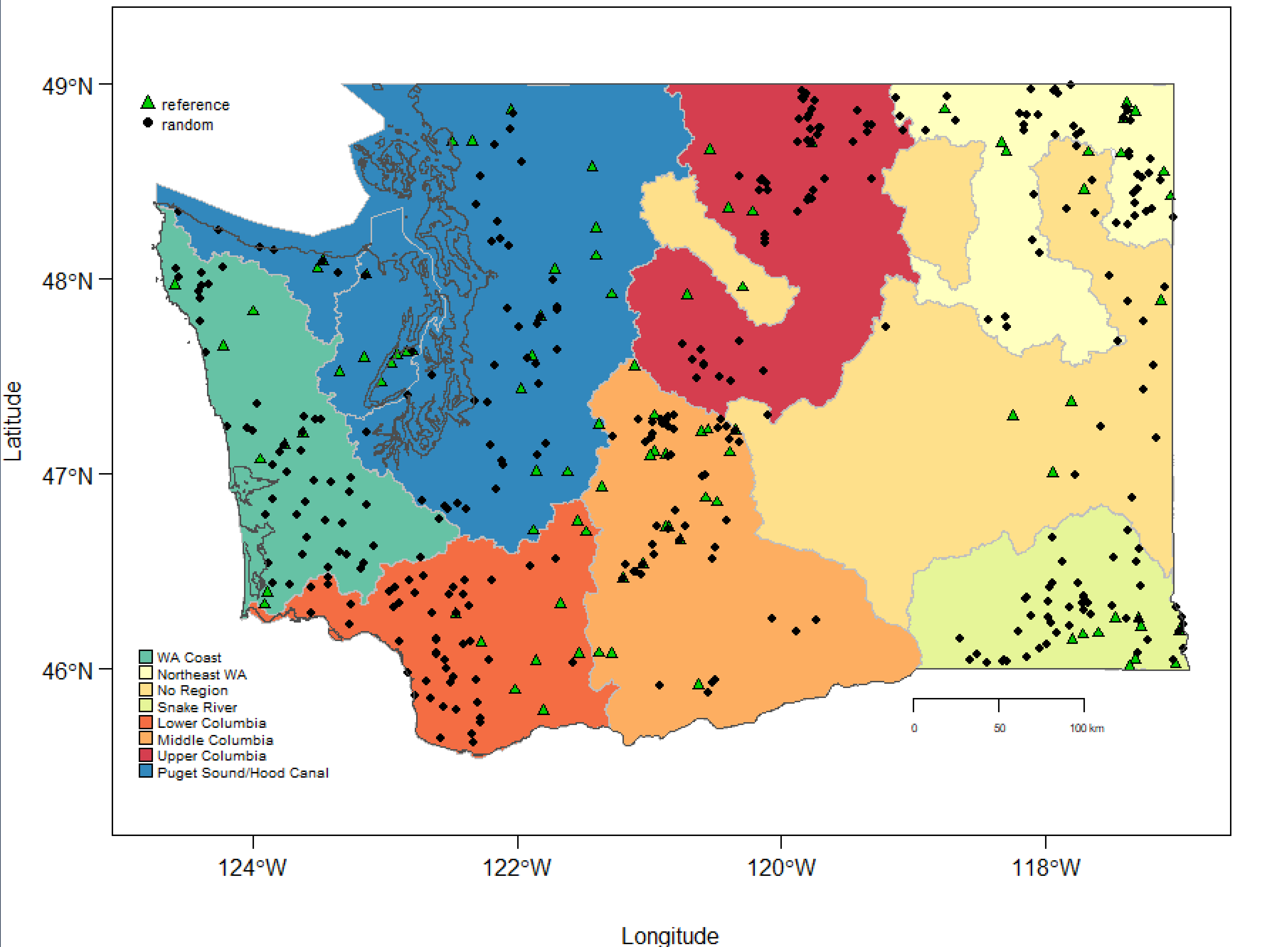
500 µm D-net kick-net sampler

30-second ‘kick’ sample at each transect

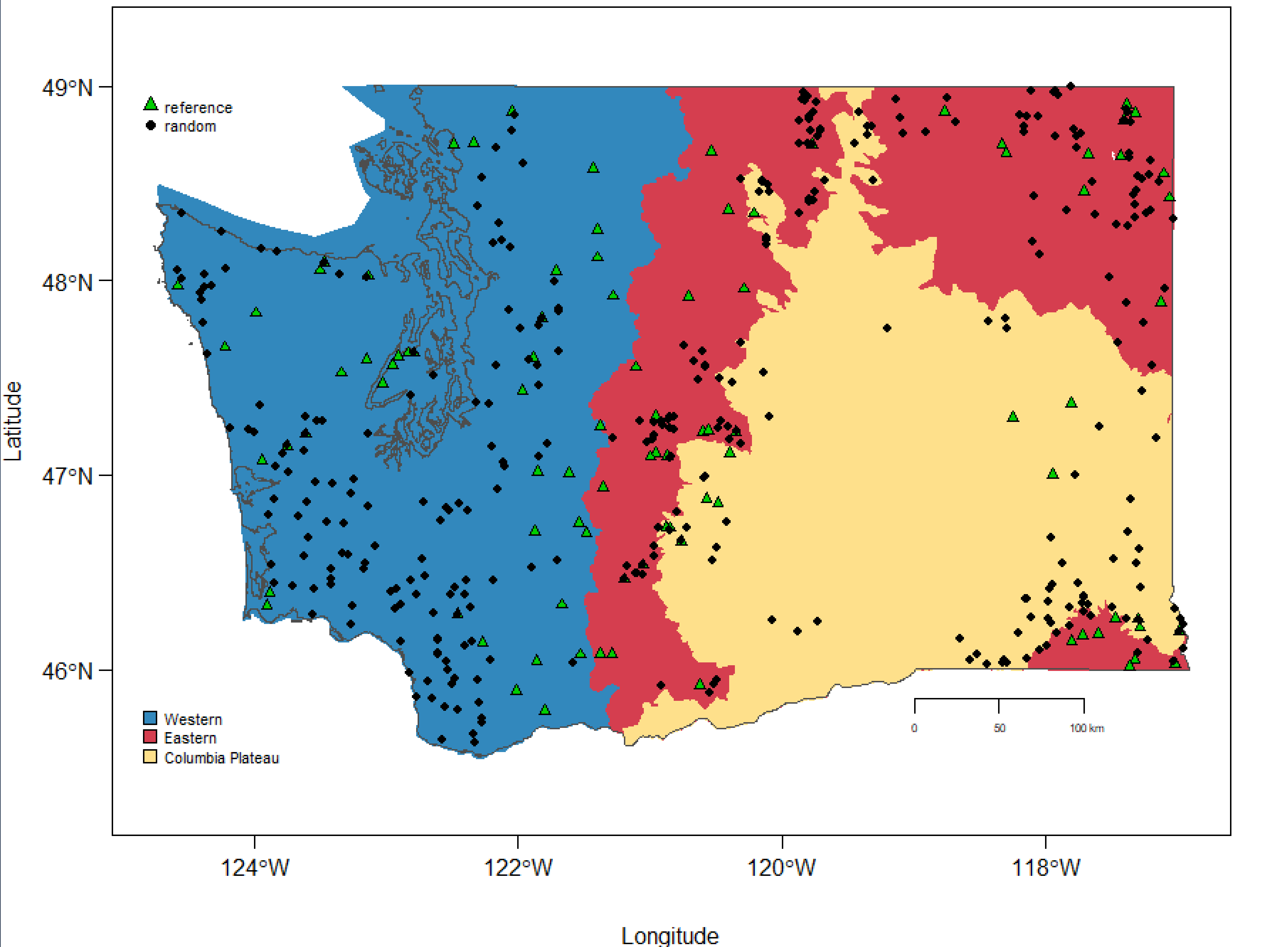
Minimum of 500 organisms subsampled and identified to ‘lowest practical level’ (i.e., typically genus & species)

10% of samples are recounted by different taxonomist and sorting efficiency, taxonomic precision, percent taxonomic disagreement, and percent difference in enumeration are calculated; all measures must be within acceptable industry criteria (e.g., Bray-Curtis index of at least 90%)

10% of sites are revisited within a given year



reference
random
WA Coast
Northeast WA
No Region
Snake River
Lower Columbia
Middle Columbia
Upper Columbia
Puget Sound/Hood Canal
0
50
100 km
49°N
48°N
47°N
46°N
124°W
122°W
120°W
118°W
Latitude
Longitude

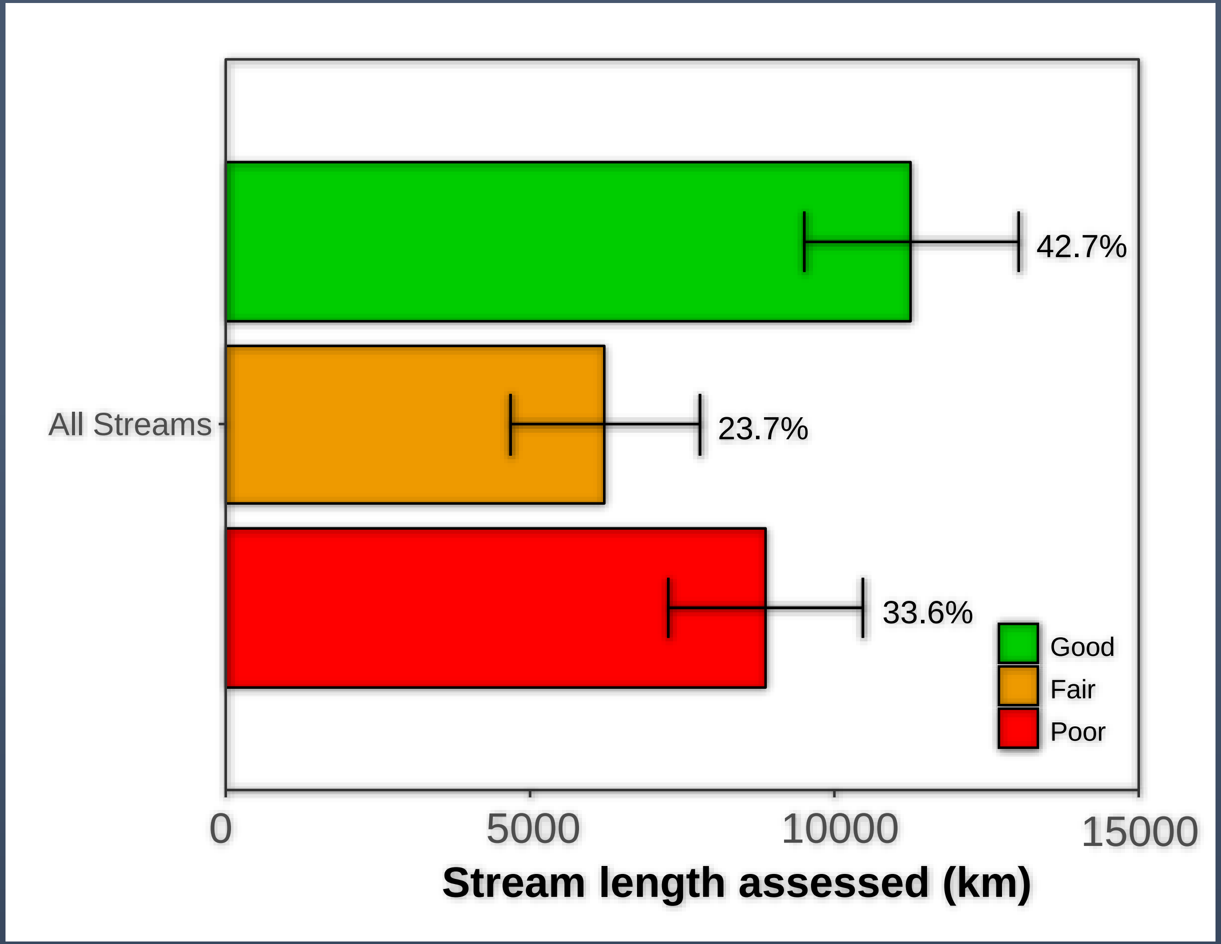

reference
random
Western
Eastern
Columbia Plateau
49°N
48°N
47°N
46°N
124°W
122°W
120°W
118°W
Latitude
Longitude
0
50
100 km

Benthic Index of Biotic Integrity (B-IBI)

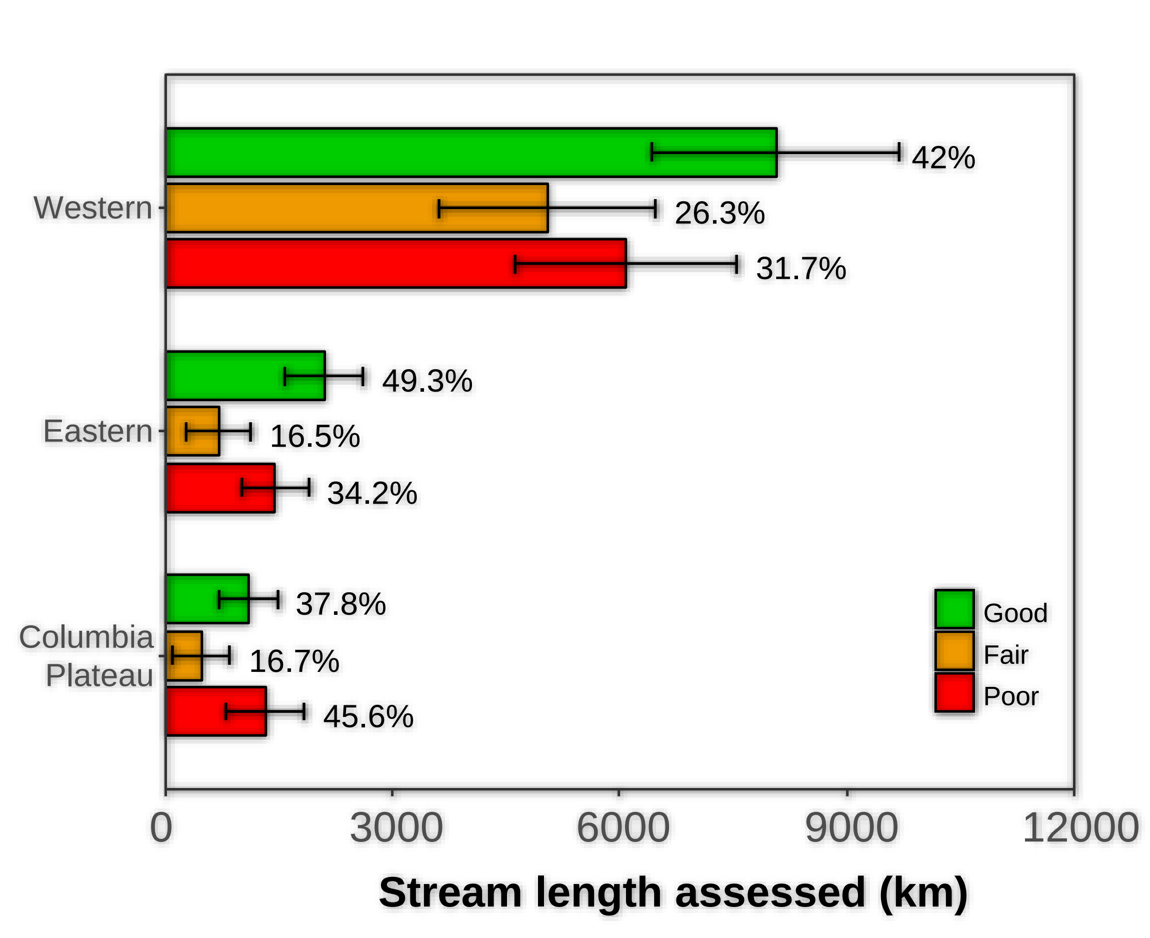
Metric	Predicted response to stress
Taxa richness	Decrease
Ephemeroptera richness	Decrease
Plecoptera richness	Decrease
Trichoptera richness	Decrease
Clinger richness	Decrease
Long-lived richness	Decrease
Intolerant richness	Decrease
Percent dominant	Increase
Predator percent	Decrease
Tolerant percent	Increase

B-IBI ranges from 0-100 with higher scores indicating greater biological health

Status

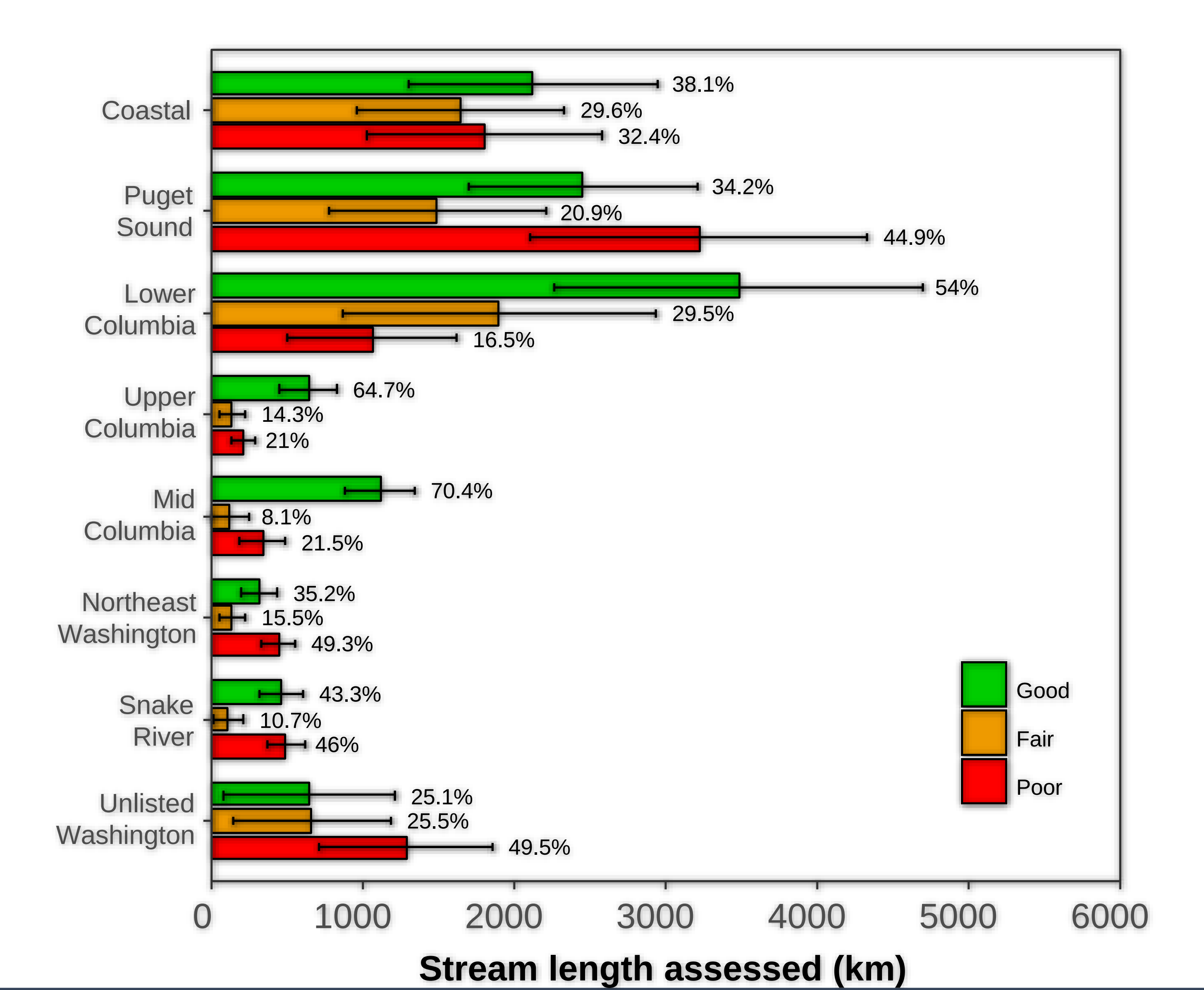


All Streams
42.7%
23.7%
33.6%
Good
Fair
Poor
0
5000
10000
15000
Stream length assessed (km)



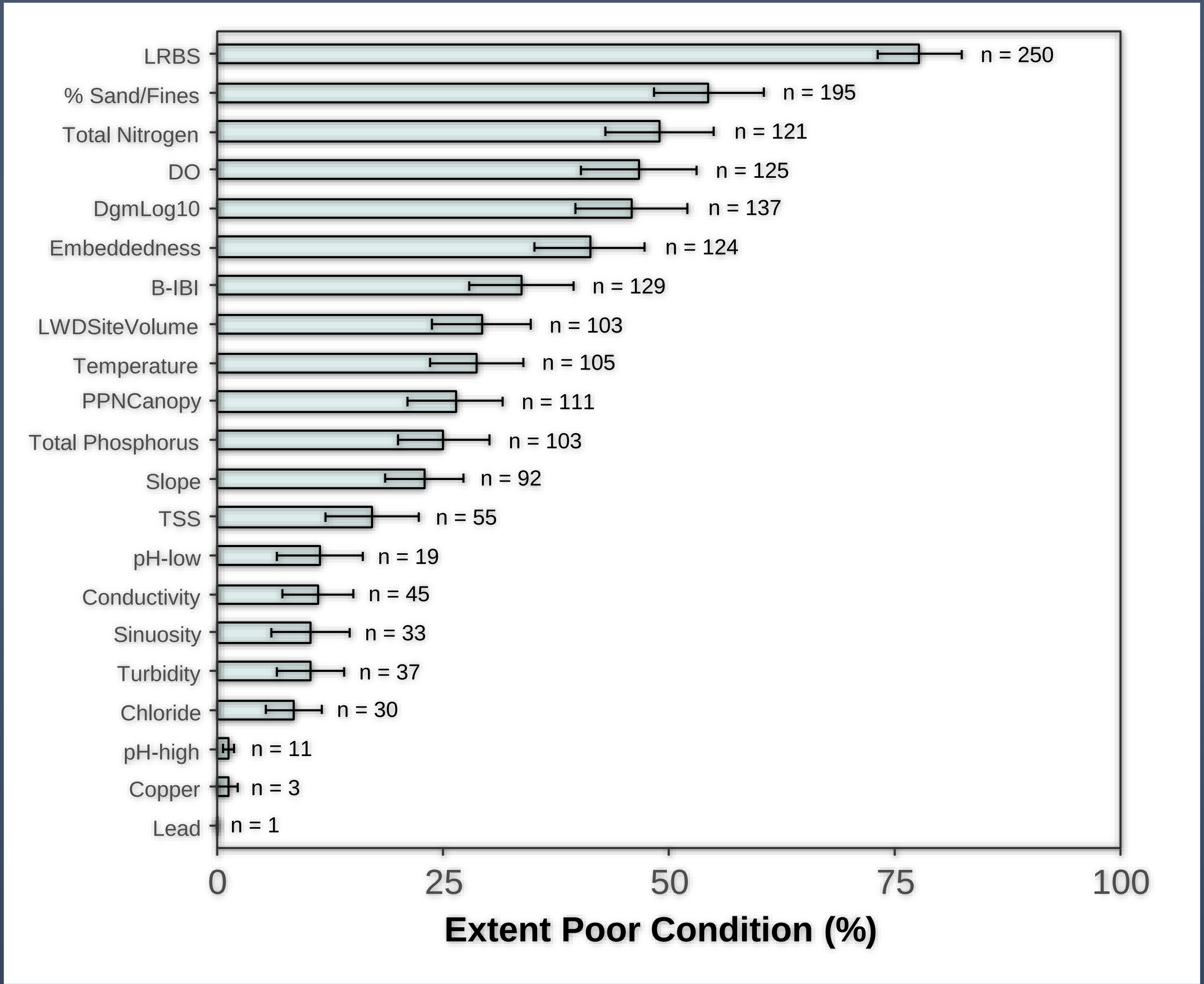
Western
42%
26.3%
31.7%
Eastern
49.3%
16.5%
34.2%
Columbia Plateau
37.8%
16.7%
45.6%
Good
Fair
Poor
0
3000
6000
9000
12000
Stream length assessed (km)

Status



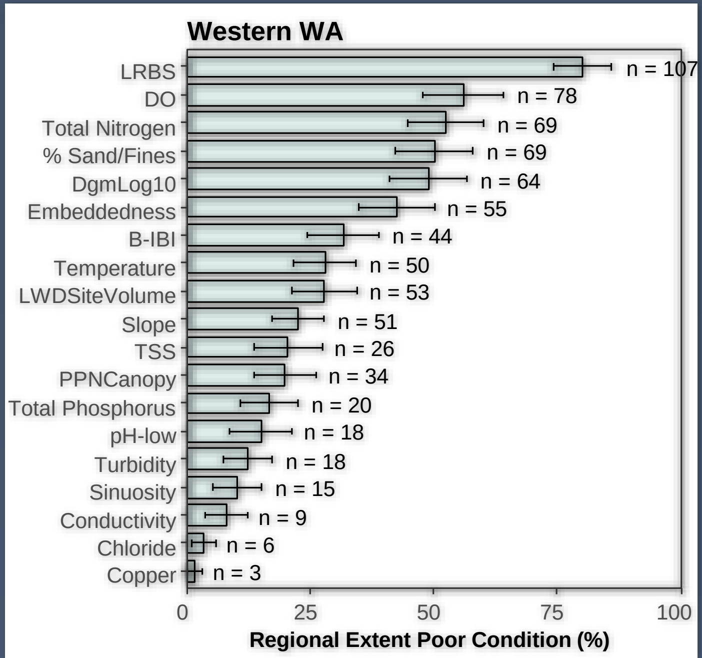
Coastal
38.1%
29.6%
32.4%
Puget Sound
34.2%
20.9%
44.9%
Lower Columbia
54%
29.5%
16.5%
Upper Columbia
64.7%
14.3%
21%
Mid Columbia
70.4%
8.1%
21.5%
Northeast Washington
35.2%
15.5%
49.3%
Snake River
43.3%
10.7%
46%
Unlisted Washington
25.1%
25.5%
49.5%
Good
Fair
Poor
0
1000
2000
3000
4000
5000
6000
Stream length assessed (km)

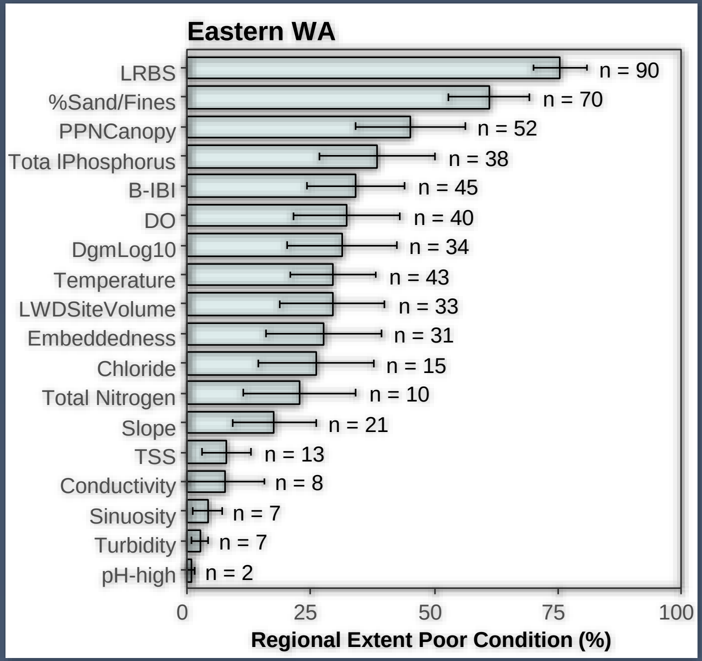
Extent

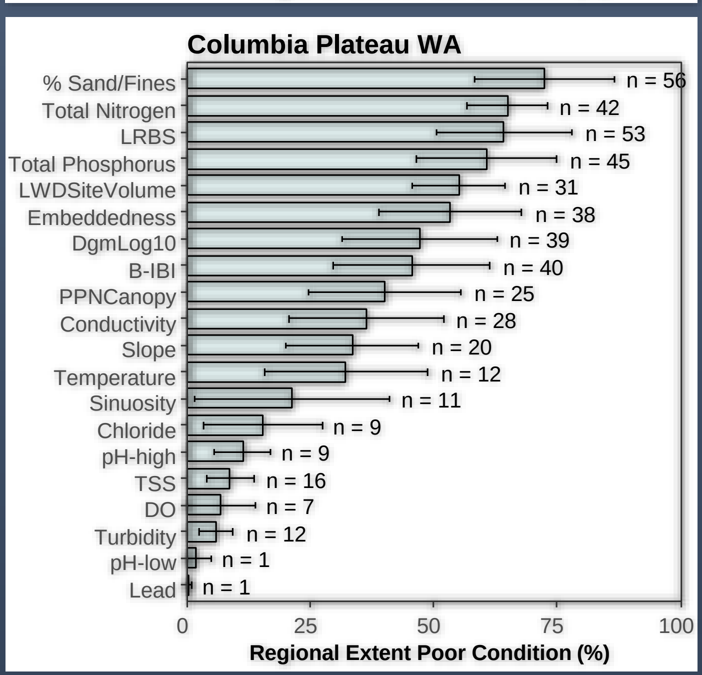


LRBS
% Sand/Fines
Total Nitrogen
DO
DgmLog10
Embeddedness
B-IBI
LWDSiteVolume
Temperature
PPNCanopy
Total Phosphorus
Slope
TSS
pH-low
Conductivity
Sinuosity
Turbidity
Chloride
pH-high
Copper
Lead
n = 250
n = 195
n = 121
n = 125
n = 137
n = 124
n = 129
n = 103
n = 105
n = 111
n = 103
n = 92
n = 55
n = 19
n = 45
n = 33
n = 37
n = 30
n = 11
n = 3
n = 1
0
25
50
75
100
Extent Poor Condition (%)

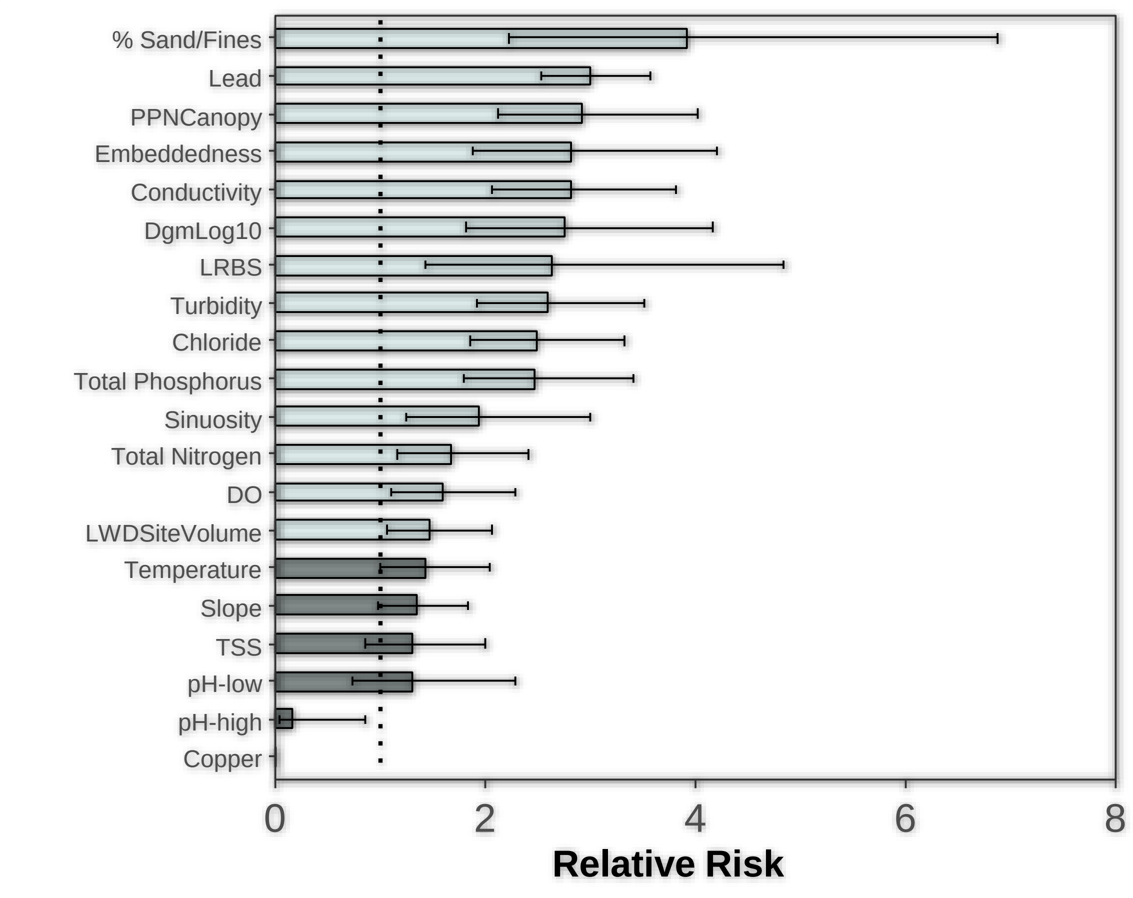
Regional Extent

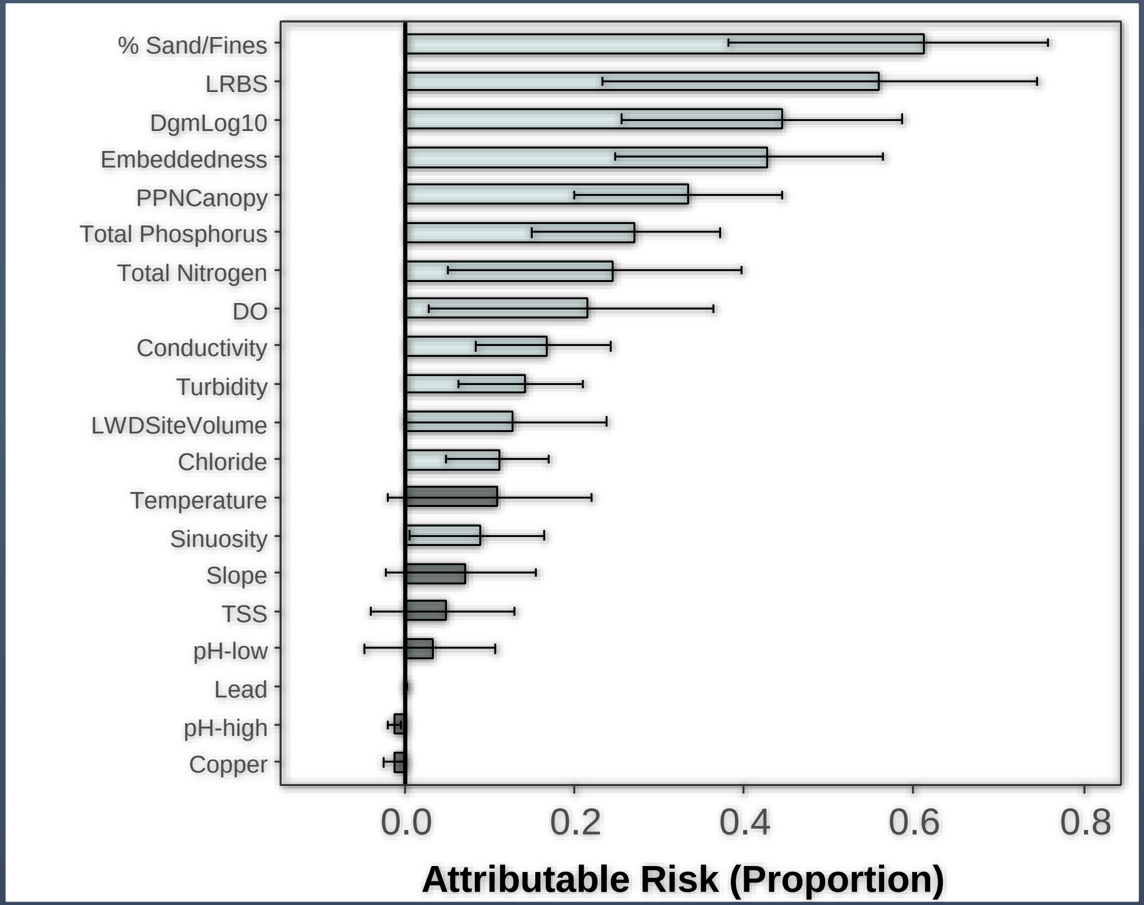


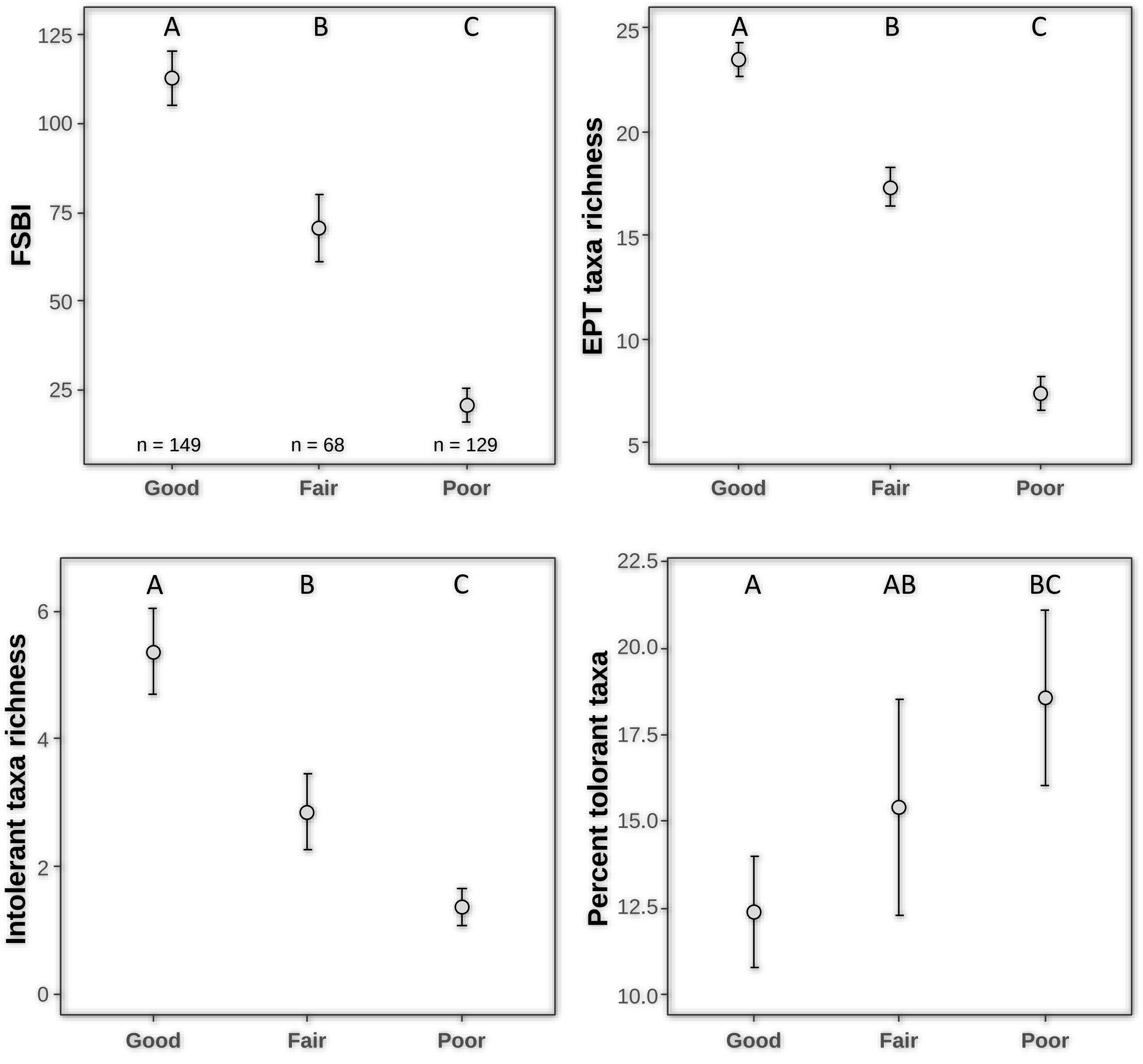




Stressor Identification

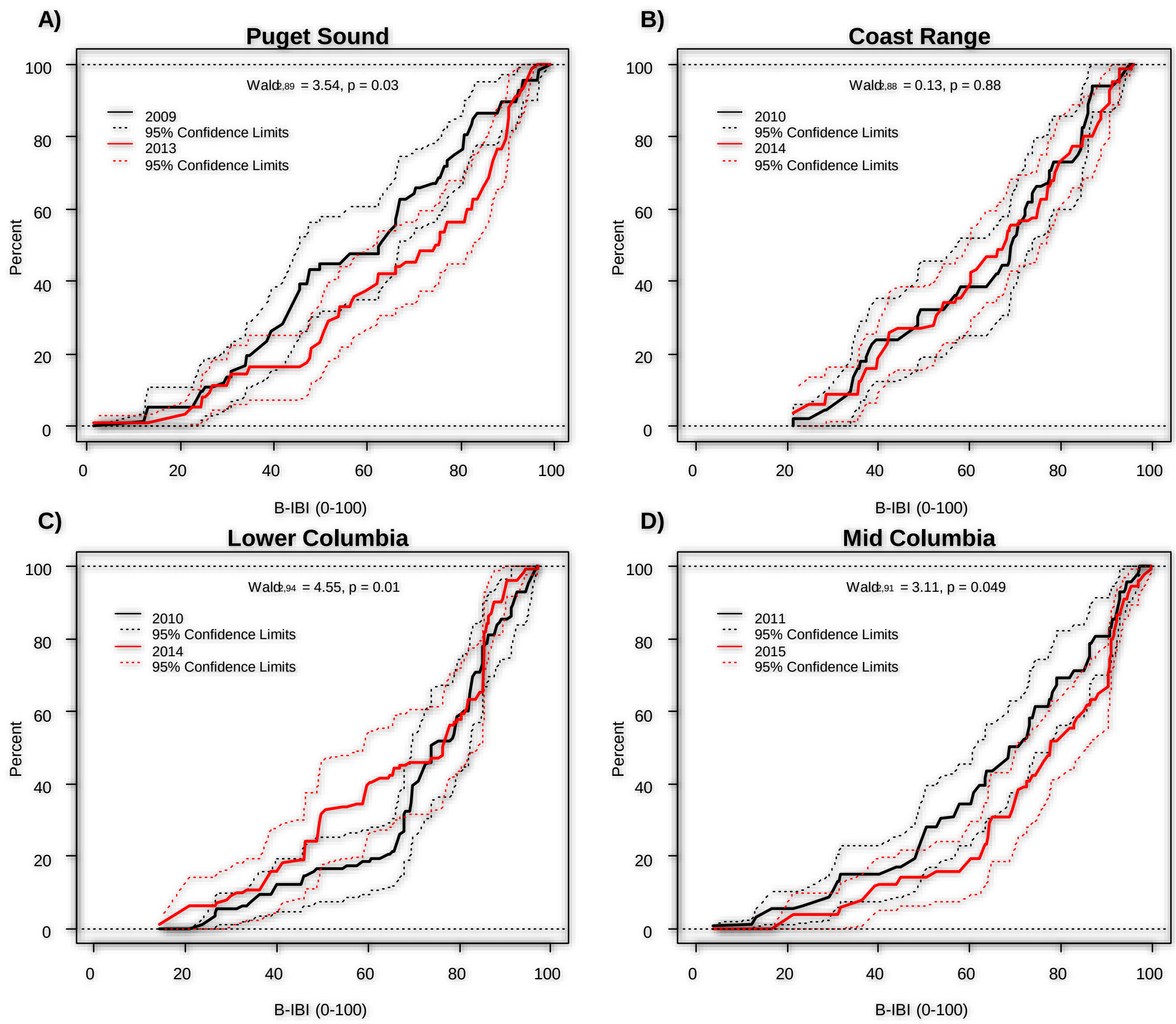






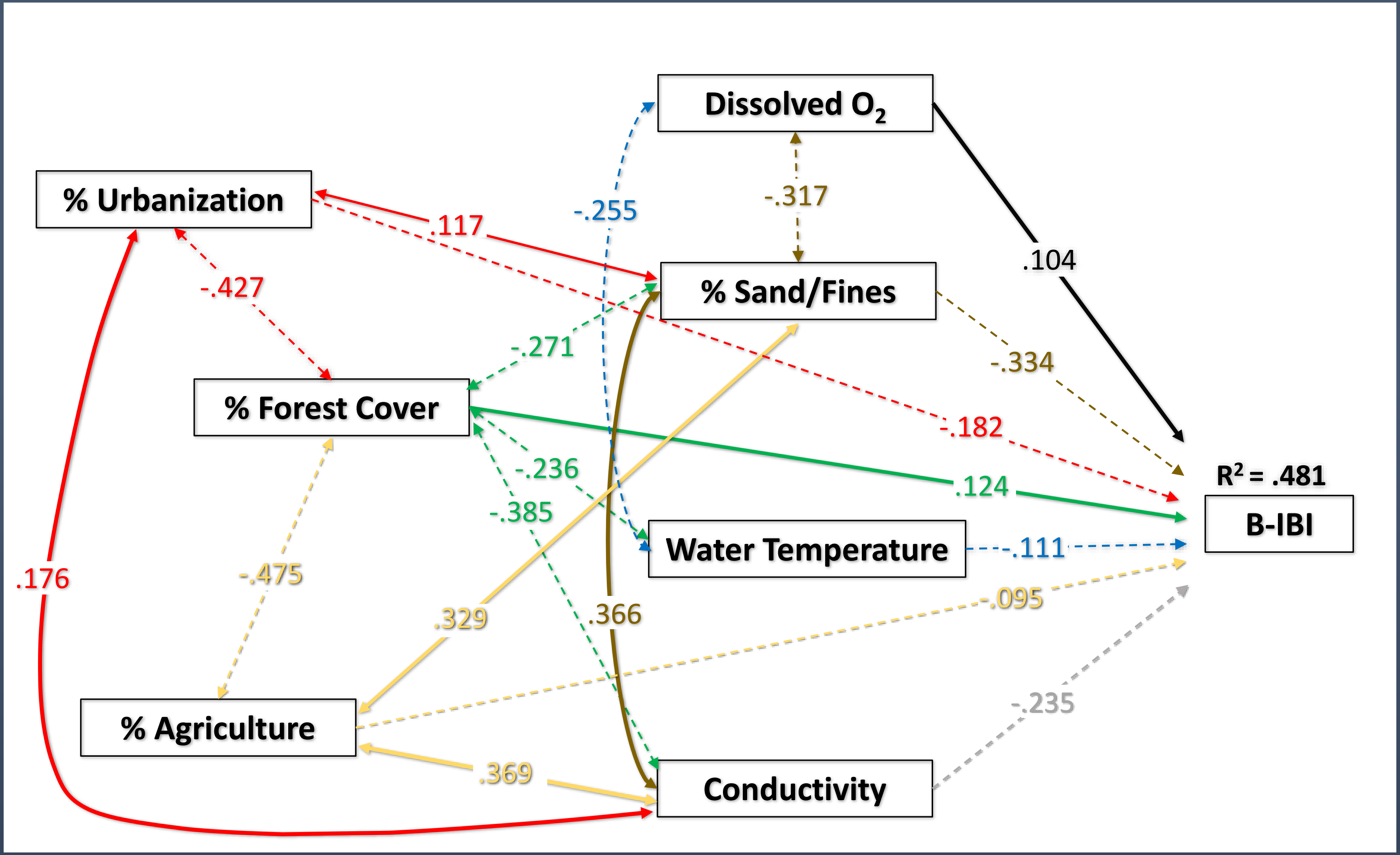
A
B
C
FSBI
125
100
75
50
25
n = 149
n = 68
n = 129
Good
Fair
Poor
EPT taxa richness
25
20
15
10
5
Intolerant taxa richness
6
4
2
0
AB
BC
Percent tolorant taxa
22.5
20.0
17.5
15.0
12.5
10.0

Trends



A)
Puget Sound
Wald$_{2,89}$ = 3.54, p = 0.03
2009
95% Confidence Limits
2013
95% Confidence Limits
Percent
B-IBI (0-100)
B)
Coast Range
Wald$_{2,88}$ = 0.13, p = 0.88
2010
95% Confidence Limits
2014
95% Confidence Limits
Percent
B-IBI (0-100)
C)
Lower Columbia
Wald$_{2,94}$ = 4.55, p = 0.01
2010
95% Confidence Limits
2014
95% Confidence Limits
Percent
B-IBI (0-100)
D)
Mid Columbia
Wald$_{2,91}$ = 3.11, p = 0.049
2011
95% Confidence Limits
2015
95% Confidence Limits
Percent
B-IBI (0-100)

Causal Analysis: Structural Equation Model

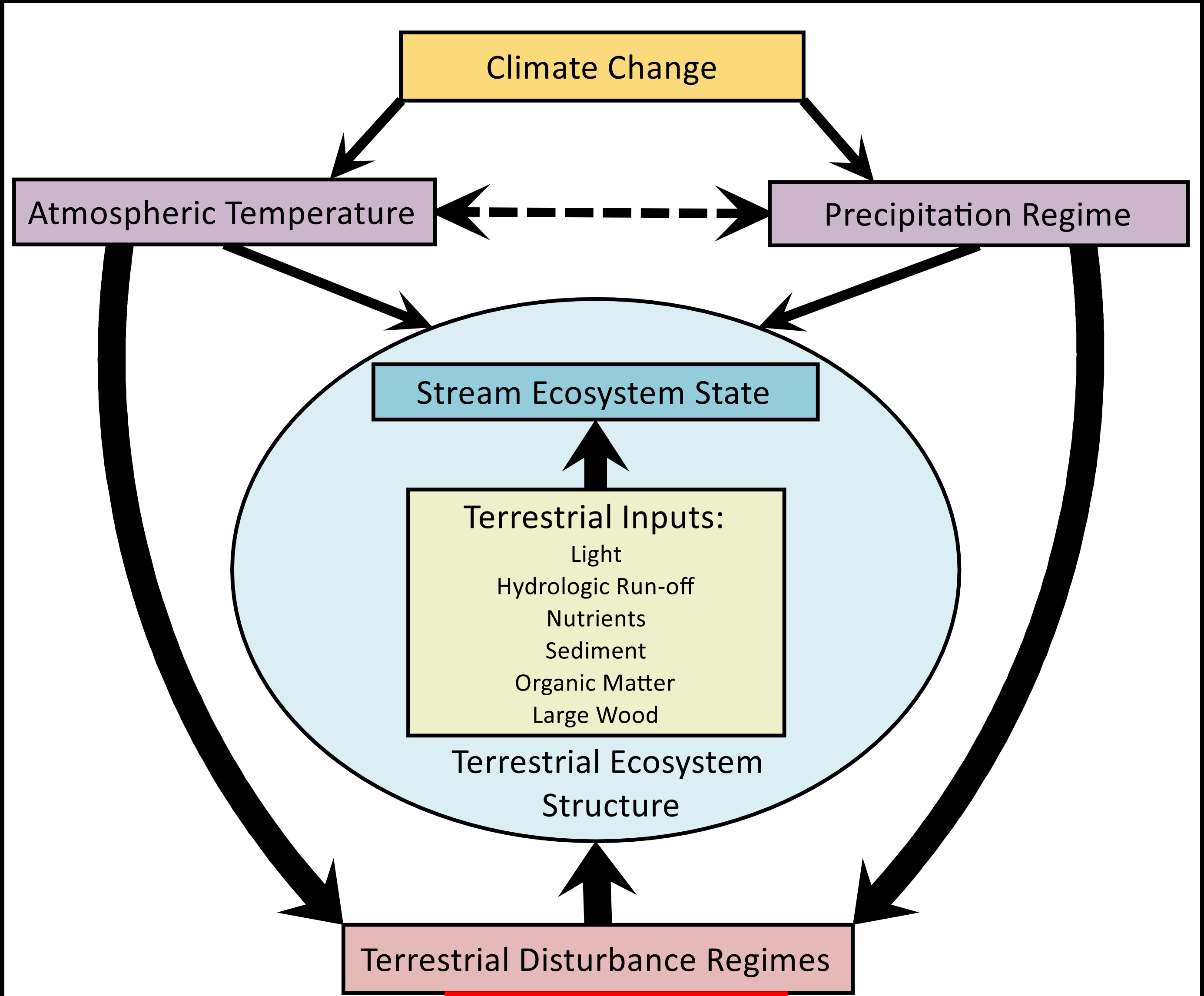


Summary:

- In general, nearly 1/3 of stream kilometers assessed in WA in poor biological condition
- Regionally, Puget Sound and far eastern WA had highest proportion of stream kilometers in poor biological condition
- Poor substrate conditions prevalent across the state
- Poor B-IBI scores 4 times more likely when associated with elevated % sand/fines
- AR suggests that nearly 60% of streams now in poor biological condition could be improved with reduction of sand/fines
- Loss of sensitive taxa with impairment

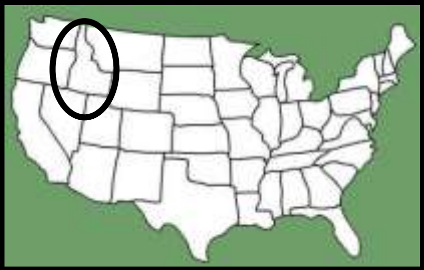
CLIMATE CHANGE, WILDFIRE AND A MESSAGE OF RESILIENCE FROM THE "RIVER OF NO RETURN"

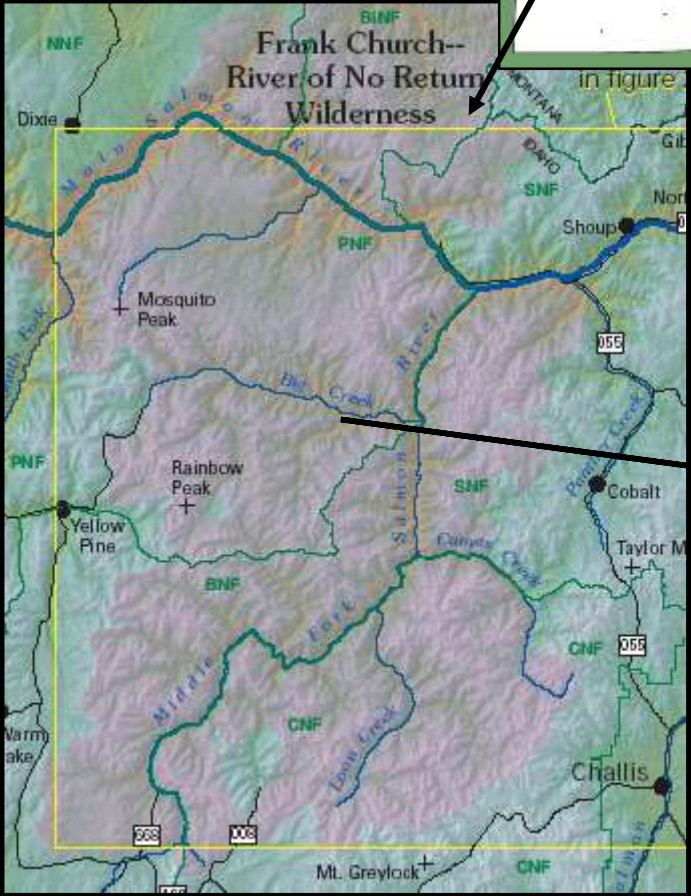
Colden Baxter
Stream Ecology Center, Department of Biological Sciences
Idaho State University

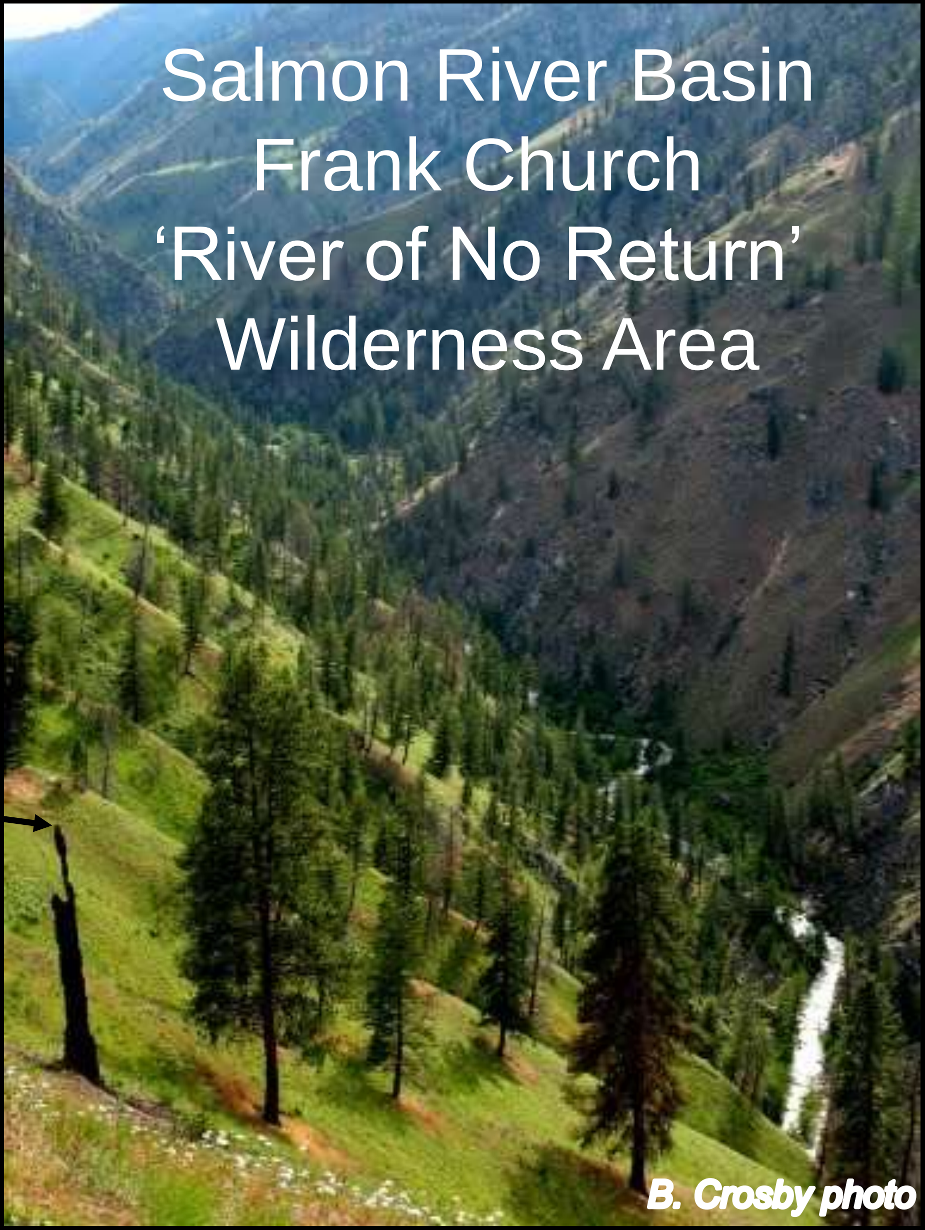


Davis, Baxter, Rosi-Marshall, Pierce, & Crosby Ecosystems 2013

Study Location





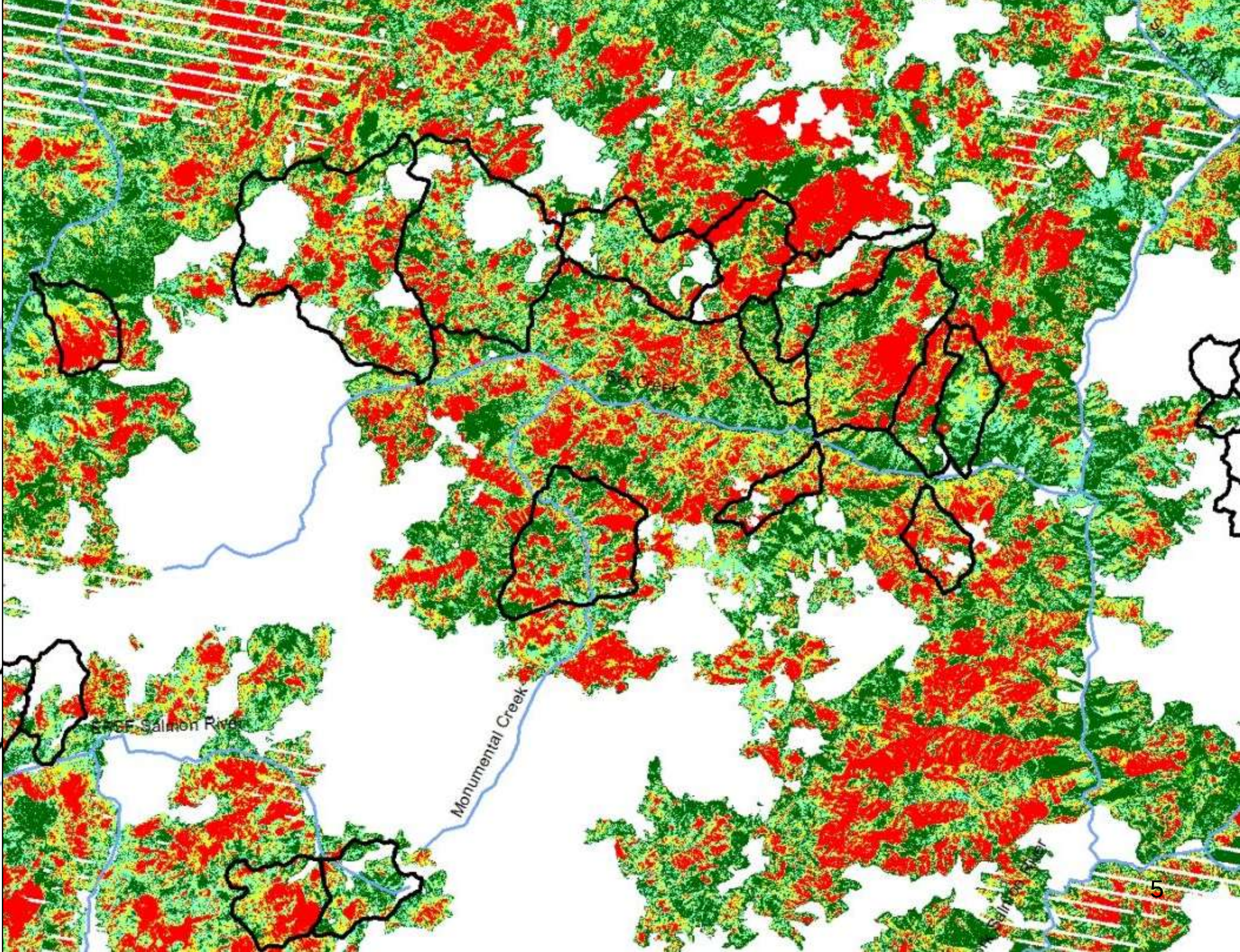


Bastion of native biodiversity, complexity and connectivity

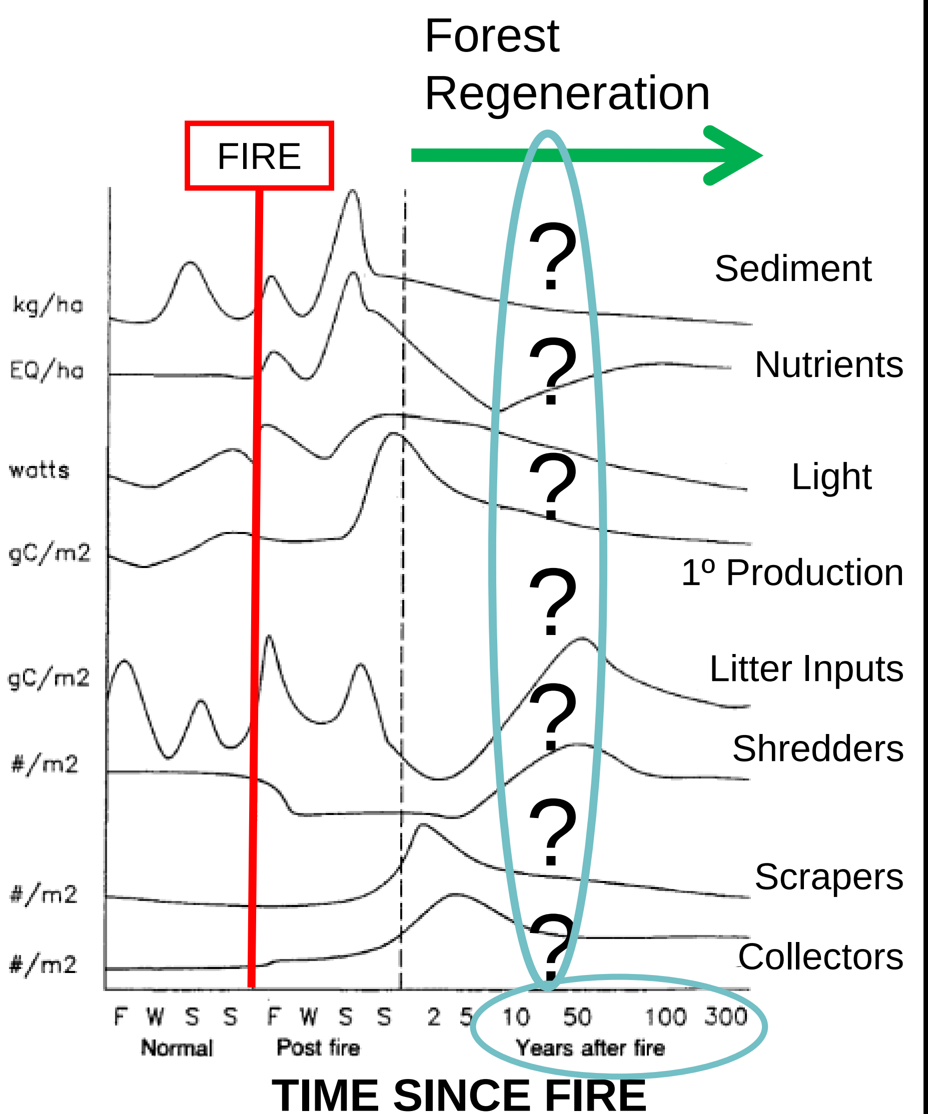
A landscape *on fire*

NASA MODIS image

August 12, 2007


EFSF Salmon River
Monumental Creek

Post-fire trajectories…changing?

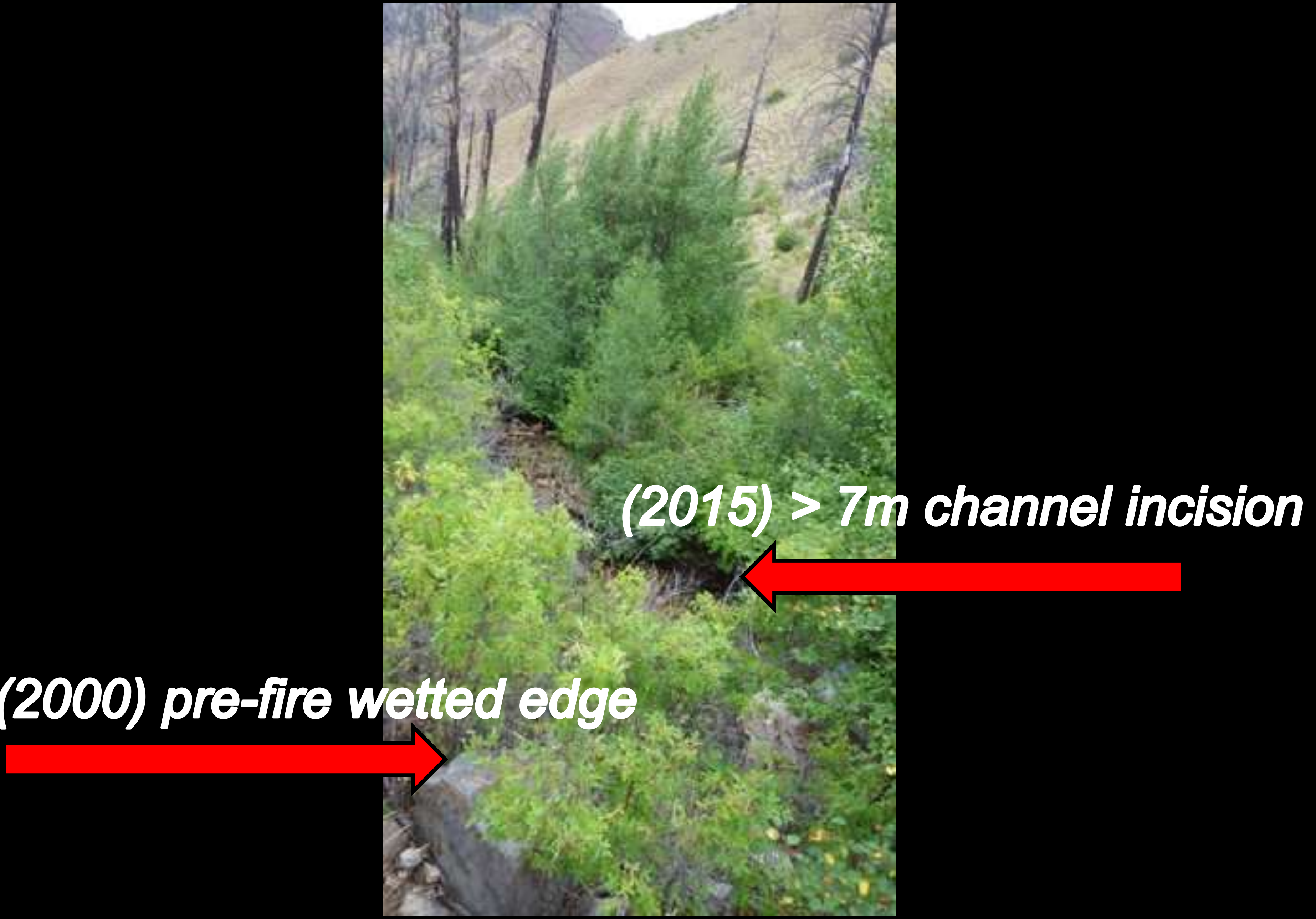


Adapted from Minshall et al. 1989

Post-fire: Limited conifer regrowth?

Mortar Creek Fire, Burned 1979, Photo 2012

Dramatic changes in physical habitat…

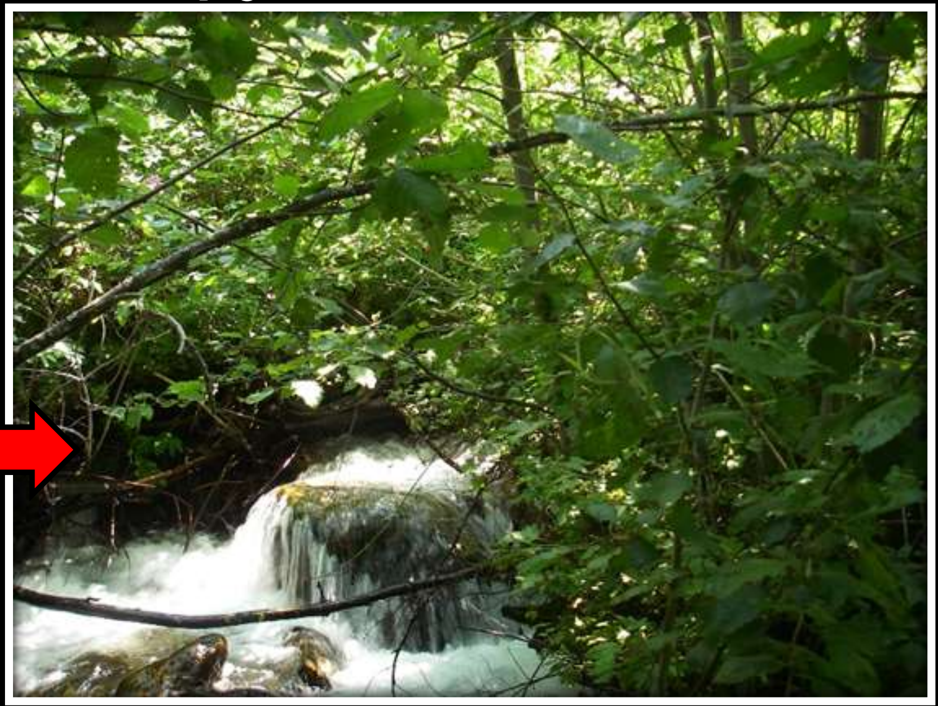


Divergent Riparian Regrowth…

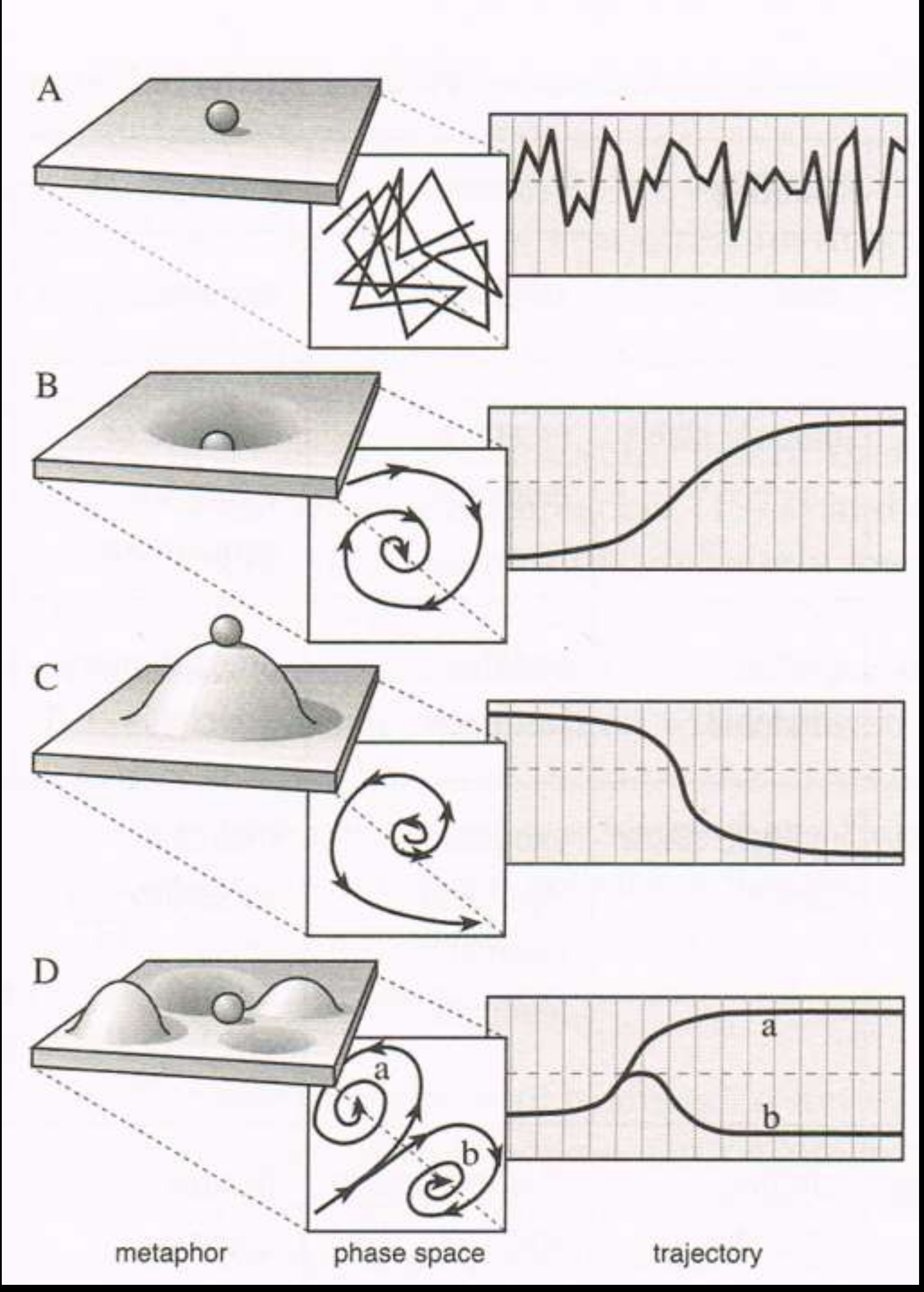
Divergent Riparian Regrowth…

Retaining relatively open canopy, or…

Rapidly regaining closed canopy



- Resistance & resilience
- Is the “mid-term” the new “long-term” state?
- Are changes reversible or no?
- We can’t tell without long term studies…

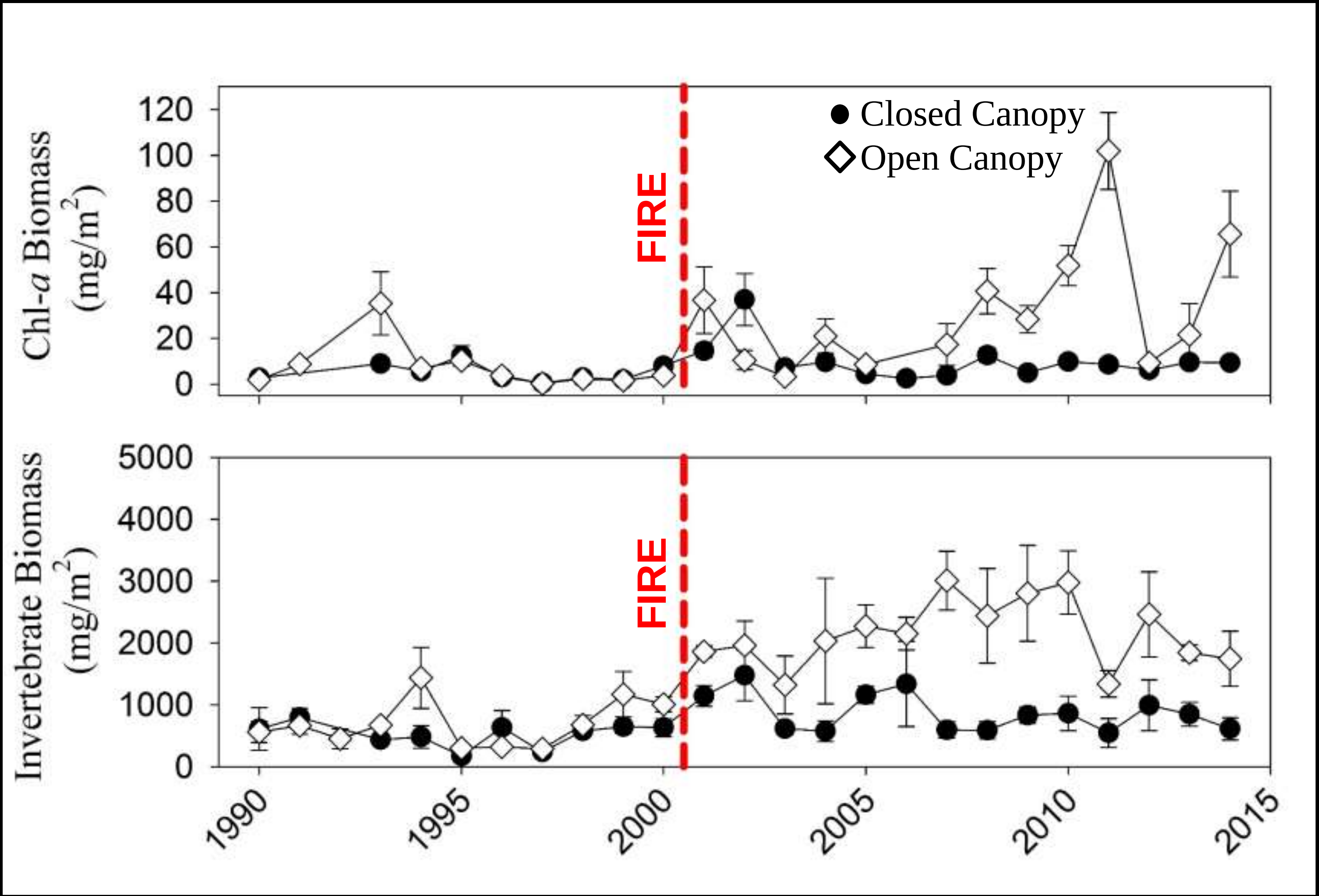


Gunderson & Holling 2001

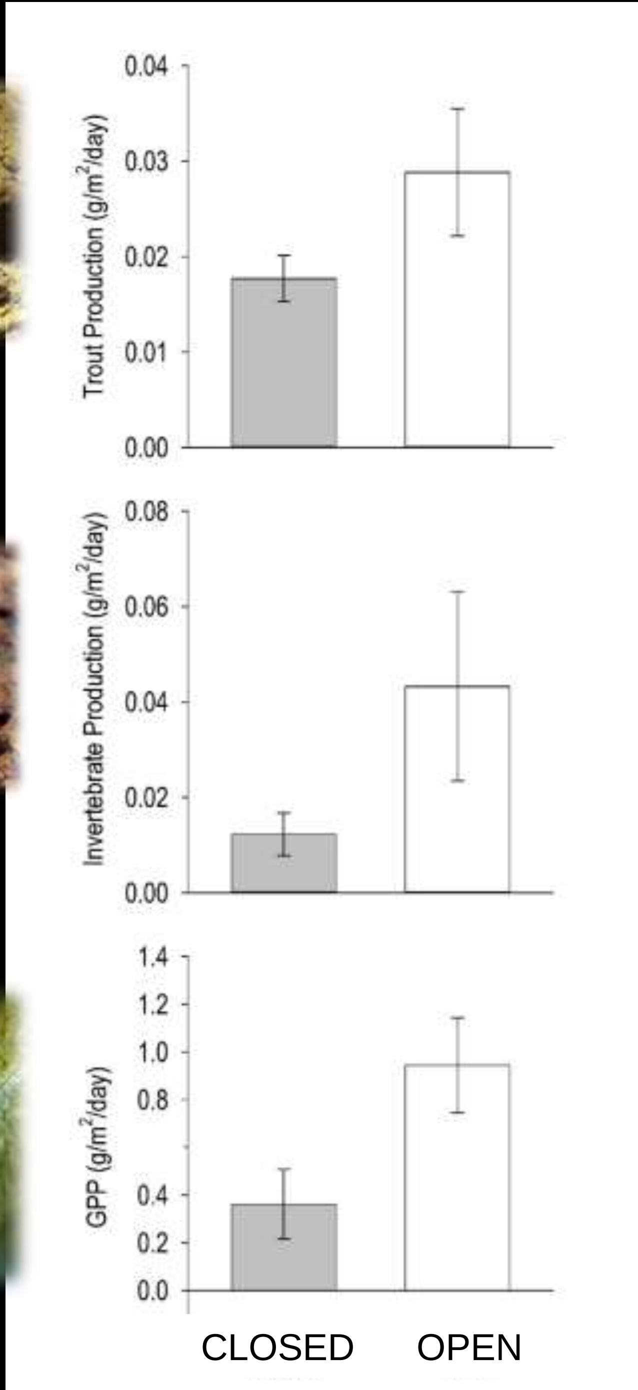
Need for decadal-scale studies…

30-yr monitoring – started by G.W. Minshall

Time series - Periphyton & Invertebrates



Davis, Baxter et al. Fresh. Biol. 2013; Rugenski & Minshall Ecosphere 2014

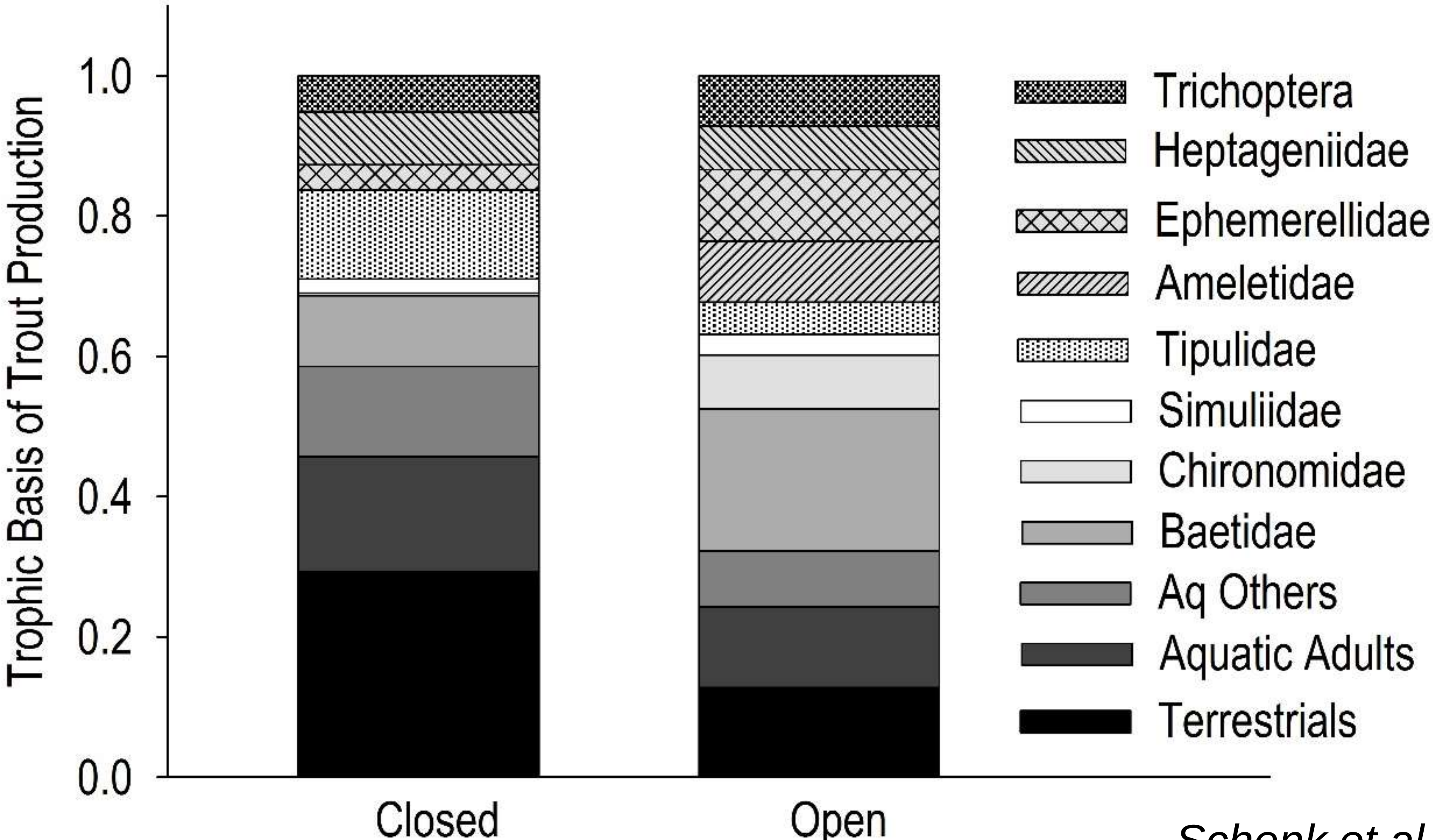


Multi-trophic level responses mediated by riparian regrowth & light

Matt Schenk, M.S. student

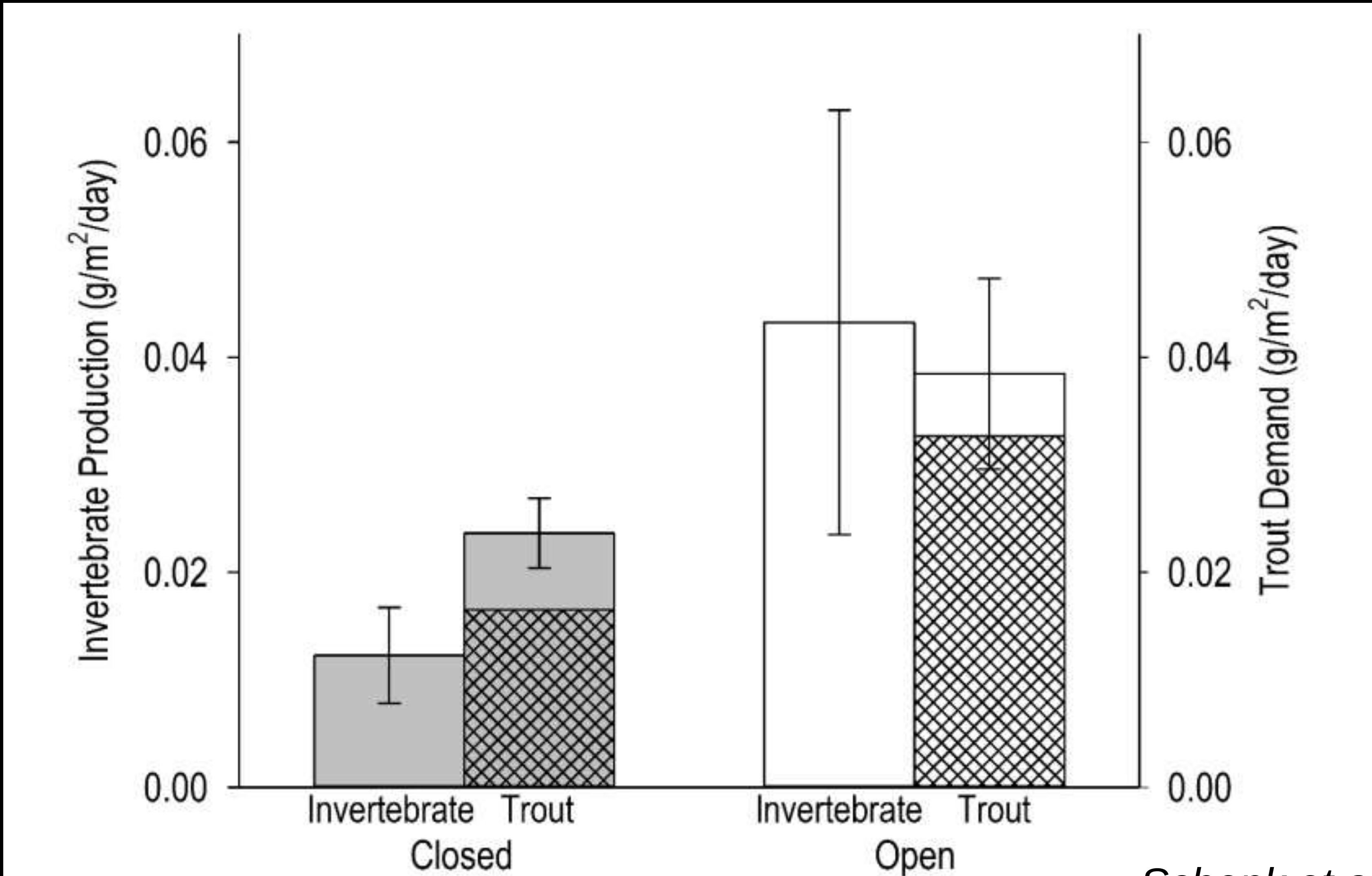
Schenk et al In prep.

2X terrestrial invert subsidy of salmonids under closed canopy



Schenk et al In prep.

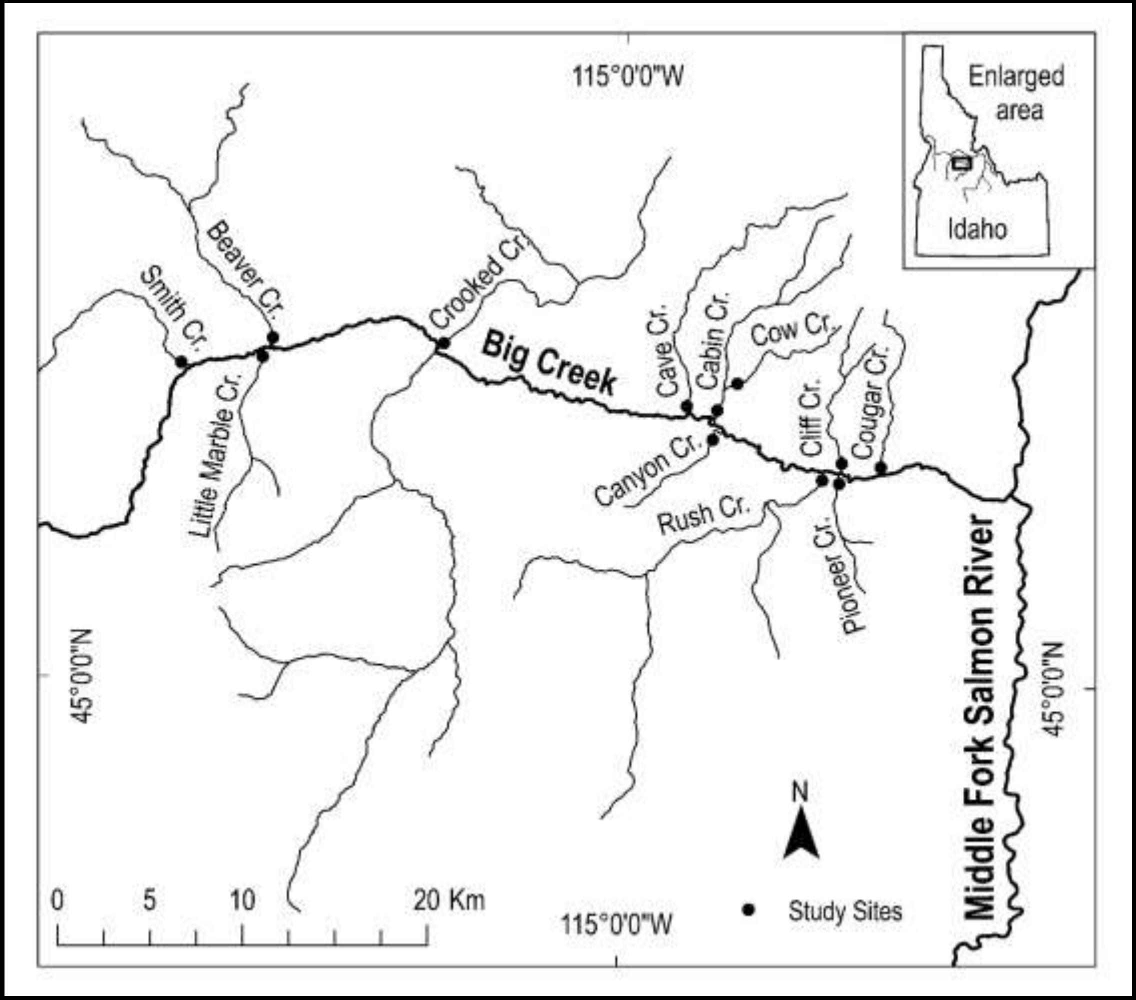
…which may mediate "top-down" control



Schenk et al

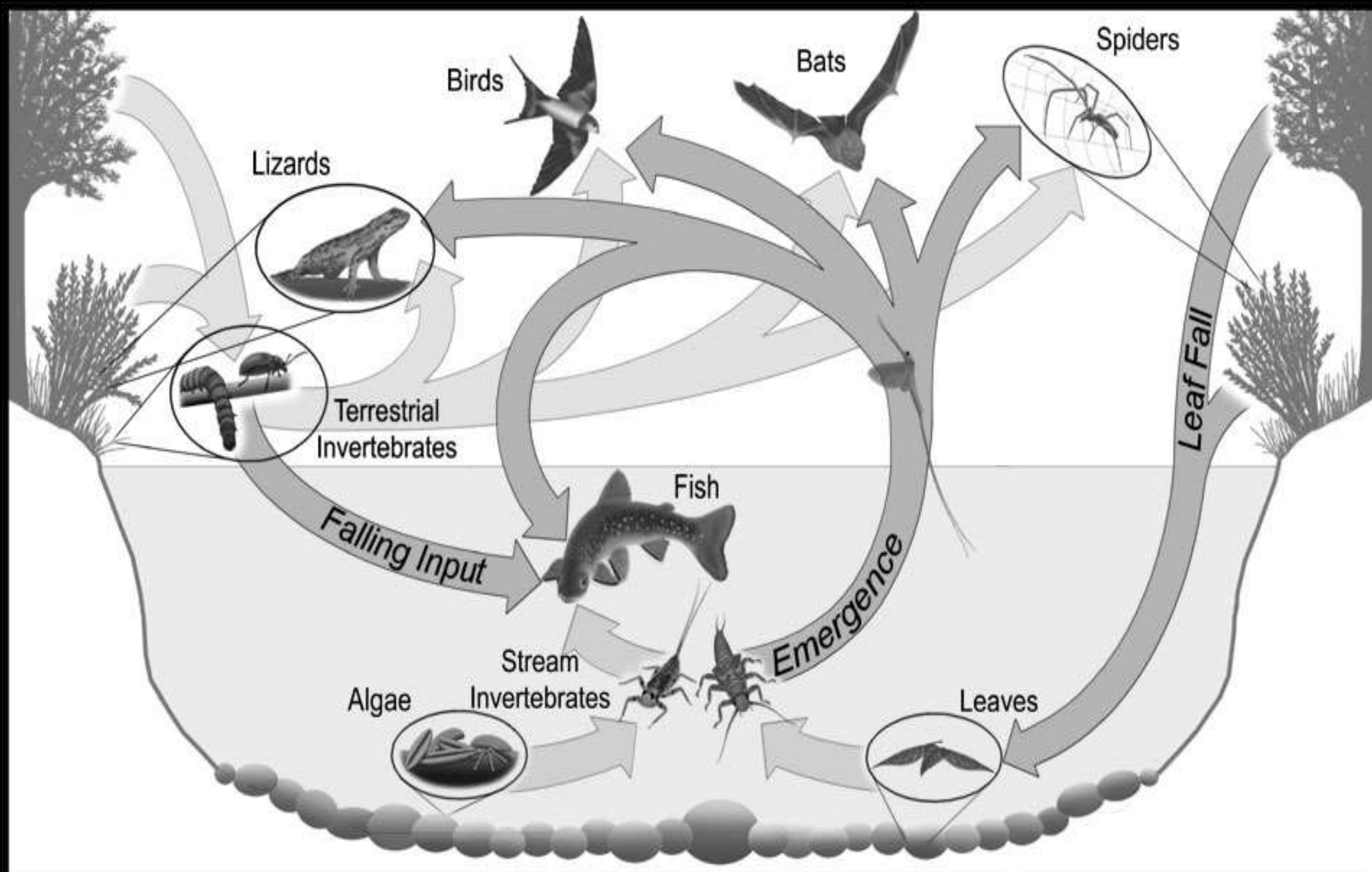
…paired stream findings corroborated by 12 stream, basin-wide comparison

Best models:
(for fish biomass)
- light
- nutrients
- invert biomass



Schenk et al In prep.

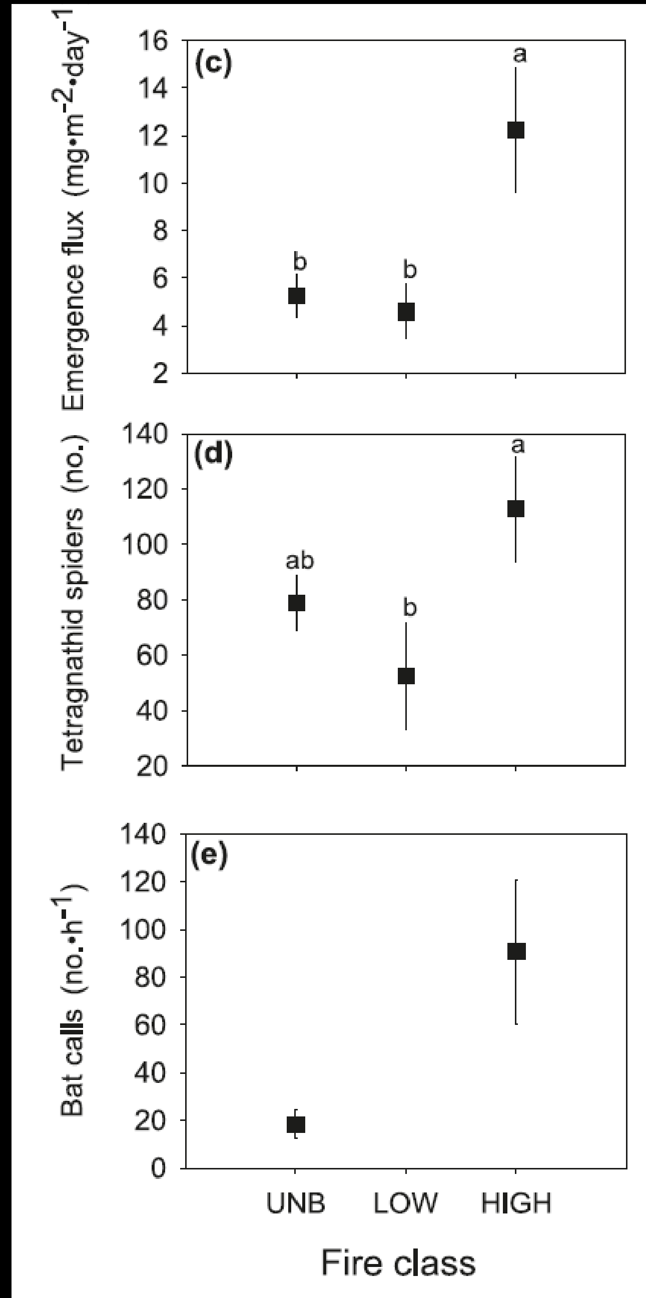
Responses "reverberate" between land and water



Baxter et al. Fresh. Biol. 2005

Malison & Baxter. 2010. Can. J. Fish. Aquat. Sci.

via emerging insects, responses extend to riparian wildlife



Malison & Baxter. 2010. Can. J. Fish. Aquat. Sci.

Bird responses

Mazeika Sullivan & Kerri Veirling

High severity burn sites…
- Greater overall abundance & richness
- Greater incidence of riparian obligates (e.g., dippers) & fly-catchers

Low severity burn and unburned sites…
- Greater incidence of generalists (e.g., crows)

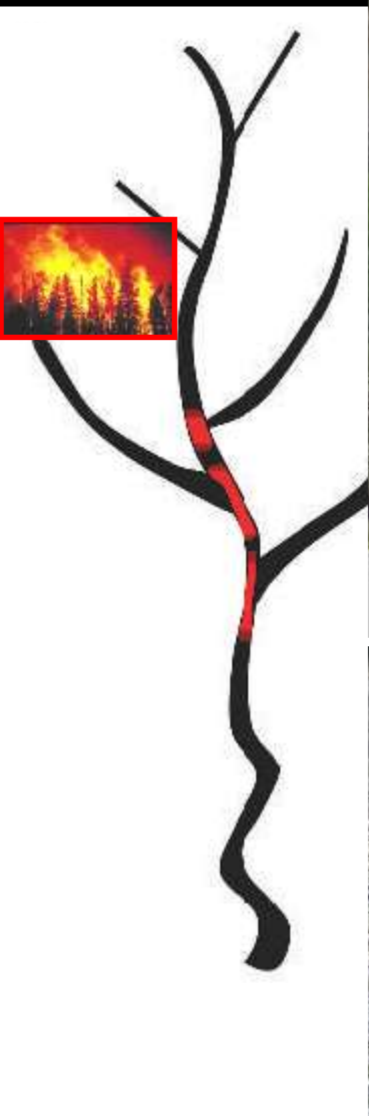
THE ECOLOGICAL IMPORTANCE OF SEVERE WILDFIRES: SOME LIKE IT HOT

RICHARD L. HUTTO[1]

Hutto, Eco Apps 2008

Jackson, Malison, Sullivan & Baxter, 2015

Network dynamics & the “fire pulse”



Benda et al. BioScience 2004, R. Thurow RMRS

Export of habitat-forming sediment and wood

Export of insects from tributaries disturbed by fire & debris flows?

Network dynamics & the “fire pulse”

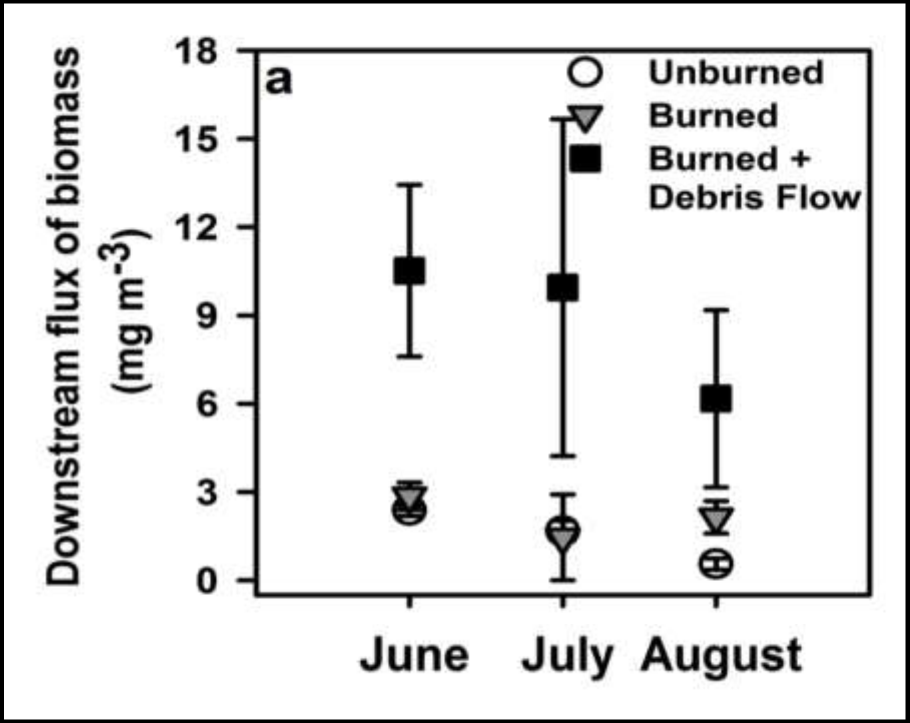
Hannah Harris, M.S. student

Burned + debris flow (*n* = 5)

Burned (*n* = 5)

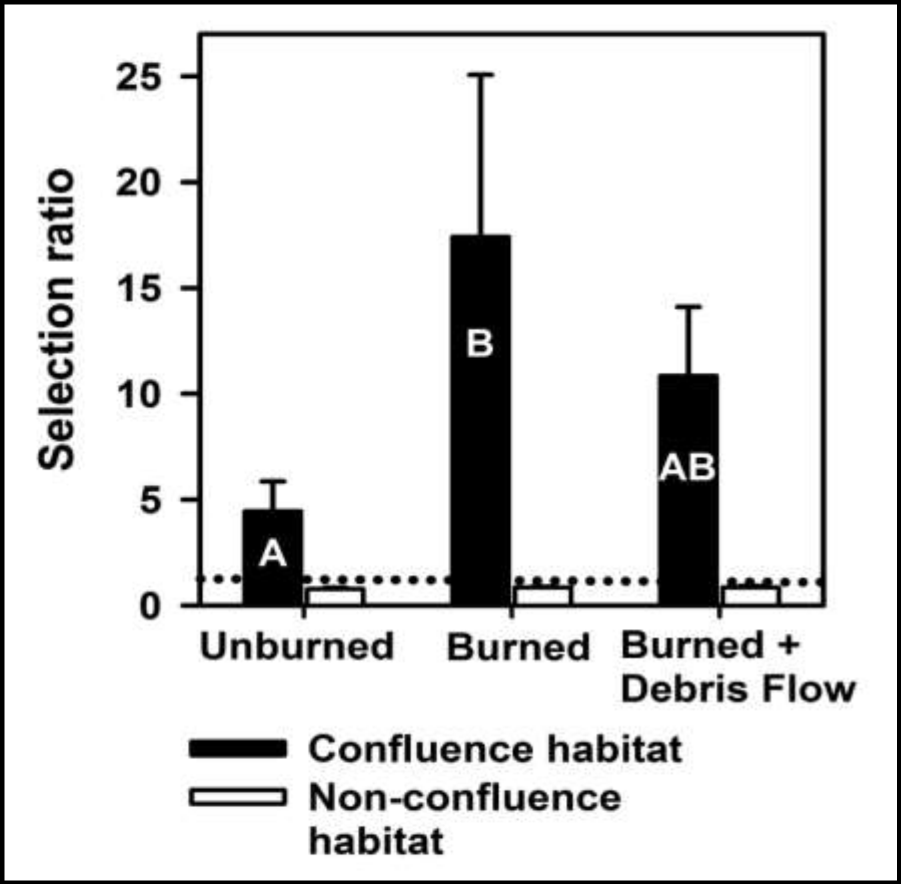
Unburned (*n* = 5)

Disturbance increases insect export from tributaries to mainstem



Harris, Baxter & Davis 2016 Freshwater Science

Fish Use of Confluences



- Confluence habitat proportionally small
- Strong selection for confluences
- Preference for confluences with *disturbed* tribs

Harris, Baxter & Davis Aquat. Sci. 2018

Other signs of resilience…

2018

2004

Riparian veg responses mediated by wolf-ungulate interactions?

Summary & Discussion

• Post- severe wildfire “pulse” of productivity may extend more than a decade

• Trajectory of riparian regrowth and light regime mediate longer term patterns in post-fire productivity

• Effects reverberate between land & water and propagate through networks (e.g., debris flows)

• Some signs point to state changes, but what most would consider “positive” rather than “doomsday”

• Overall, message of resistance and resilience in face of dramatic disturbance

• “Time will tell…”

Management Discussion

- additional lines of evidence…

- warming of central Idaho headwater streams slow; role as “climate refugia” – Isaak et al. 2016. *PNAS*

- pulses of juv anadromous salmonids from these drainages post-fire – Copeland et al. 2017, pers. comm.

- low salmon returns driven by “out of basin” impacts; notably Snake River dams – Thurow et al. 2016; pers. comm.

Slow climate velocities of mountain streams portend their role as refugia for cold-water biodiversity

Daniel J. Isaak[a,1], Michael K. Young[b], Charles H. Luce[a], Steven W. Hostetler[c], Seth J. Wenger[d], Erin E. Peterson[e], Jay M. Ver Hoef[f], Matthew C. Groce[a], Dona L. Horan[a], and David E. Nagel[a]

Management Discussion

• no need to “fortify” against natural effects of wildfire — especially in wilderness

• such actions (in name of “forest health”) may be misplaced and erroneously credited as restoration or mitigation

• could be diversions from addressing actual problems

• may even have unforeseen, undesired effects

Management Discussion

- "manage for the mess" – *J. Sedell*
- preserve dynamism, processes that create and maintain complexity in nature (habitat and organisms)
- these are keys to resilience and adaptive capacity in face of climate change

Acknowledgments

ISU Stream Ecology Center

- Dr. G. Wayne Minshall
- ***Pre-2005*** J. Barger, J. Davis, P. Dey, K. Harris, P. Hulet, J. Hopkins, A. Kleven, P. Koetsier, D. Lawrence, J. Mann, T. Mihuc, J. Minshall, M. Monaghan, J. Morris, D. Moser, C. Myler, S. Owen, A. Prussian, H. Ray, C. Relyea, S. Relyea, C. Robinson, T. Royer, J. Schomberg, E. Snyder, R. Snyder, S. Thomas, L. VanEvery, R. Vannote, J. Varricchione
- ***Post-2005*** R. Blackadar, A. Bell, J. Benjamin, J. R. Bellmore, K. Behn, J. Cornell, K. Crismon, B. Crosby, J. Davis, A. Eckersell, T. Gardner, J. Giersch, S. Godsey, H. Harris, K. Heinrich, M. Lamb, M. Lyon, R. Malison, R. Martin, S. Owen, J. Ortiz, N. Olsen, J. Paris, M. Scharer, M. Schenk, M. Ventura, I. Verkaik

Funding & Support

DeVlieg Foundation, National Science Foundation, US Forest Service, Idaho State University, James Morris Endowment, Taylor Wilderness Research Station

Submerged aquatic vegetation and its potential effect on salmonid cold-water refuges

Francine Mejia[1], Christian Torgersen[1], Eric Berntsen[2], and Joseph Maroney[2] ,

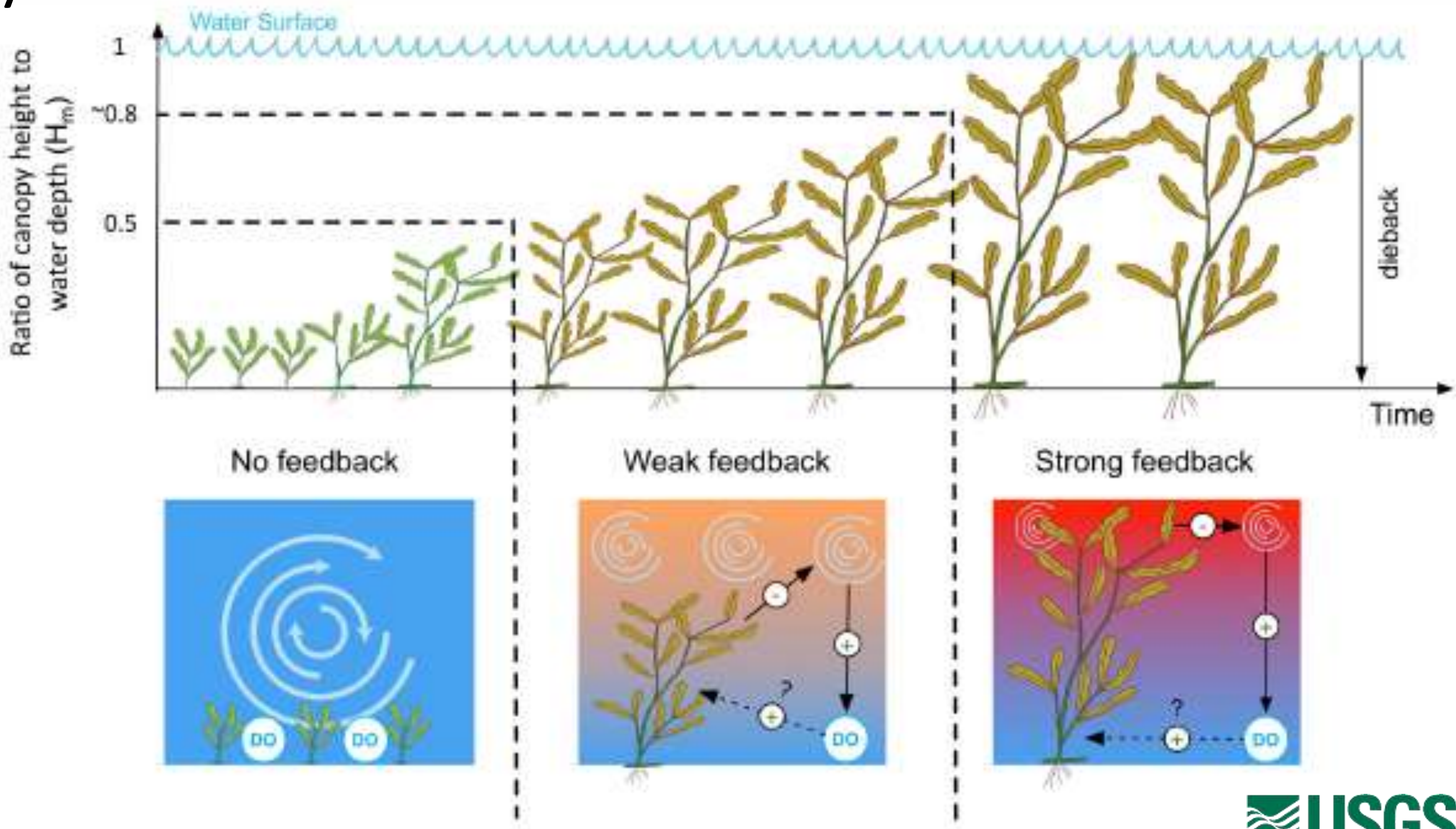
[1]USGS Forest and Rangeland Ecosystem Science Center, Cascadia Field Station, Seattle, Washington, USA
[2]Kalispel Tribe Natural Resources Department, Usk, Washington, USA

How does submerged aquatic vegetation (SAV) potentially influence fish habitat?

(Vilas et al. 2017)

SAV can influence many physicochemical aspects of the aquatic environment:

- Light penetration
- Water temperature
- Water velocity
- Fine sediments
- Phosphorus cycling
- Dissolved oxygen

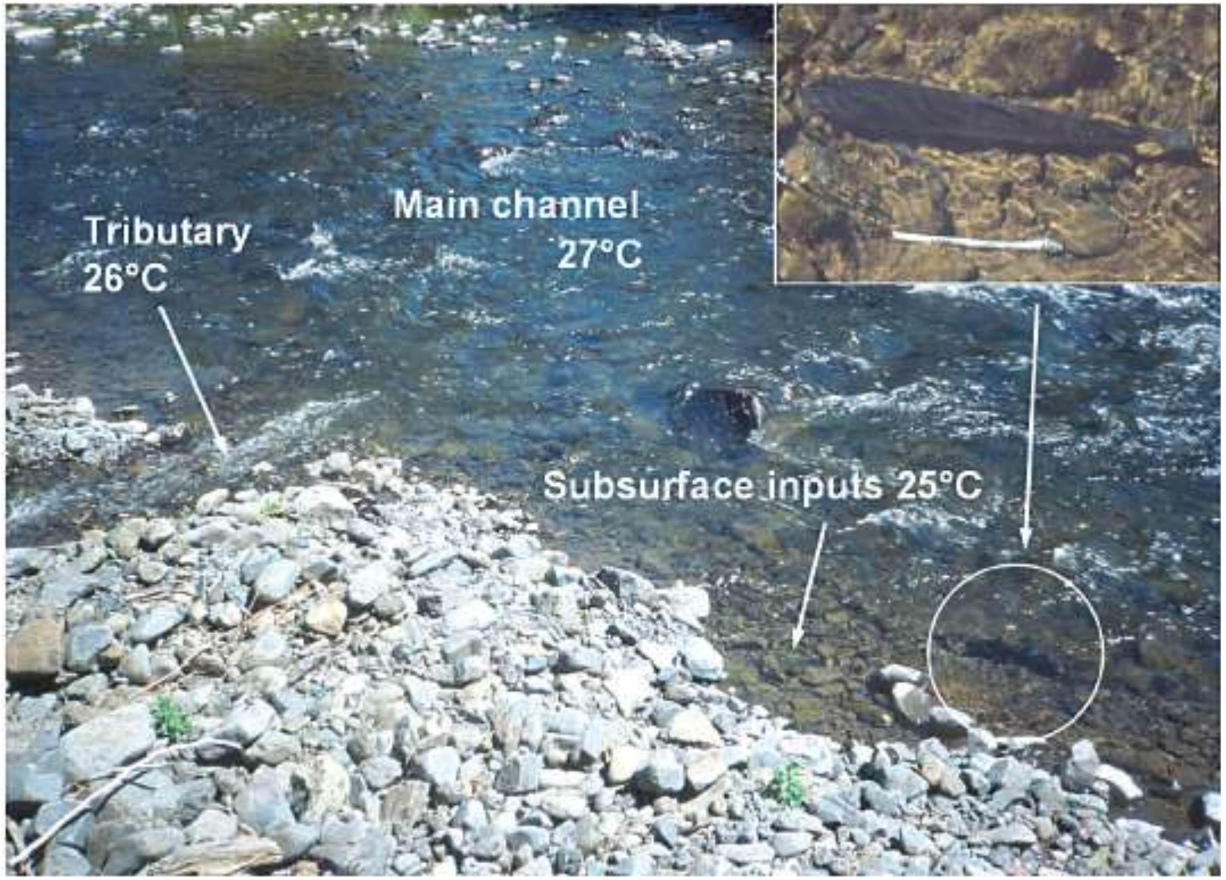


USGS
science for a changing world

What is a thermal refuge?

Areas that may be either cold or warm in relation to the surrounding water.

Cold-water refuge = a thermal refuge in the summer that is colder than the surrounding water.



Primer --Torgersen et al 2012

USGS
science for a changing world

How does submerged aquatic vegetation (SAV) potentially influence cold-water refuge?

Bull trout

Source: Raymond Ostlie

Westslope cutthroat trout

Source: Western native trout initiative

Trout needs
- High DO
- Cool temperatures
- Flowing water

SAV creates conditions with
- Lower DO
- Warm temperatures
- Slow moving water

Study Goal

Evaluate how removal of SAV influences water temperature and dissolved oxygen

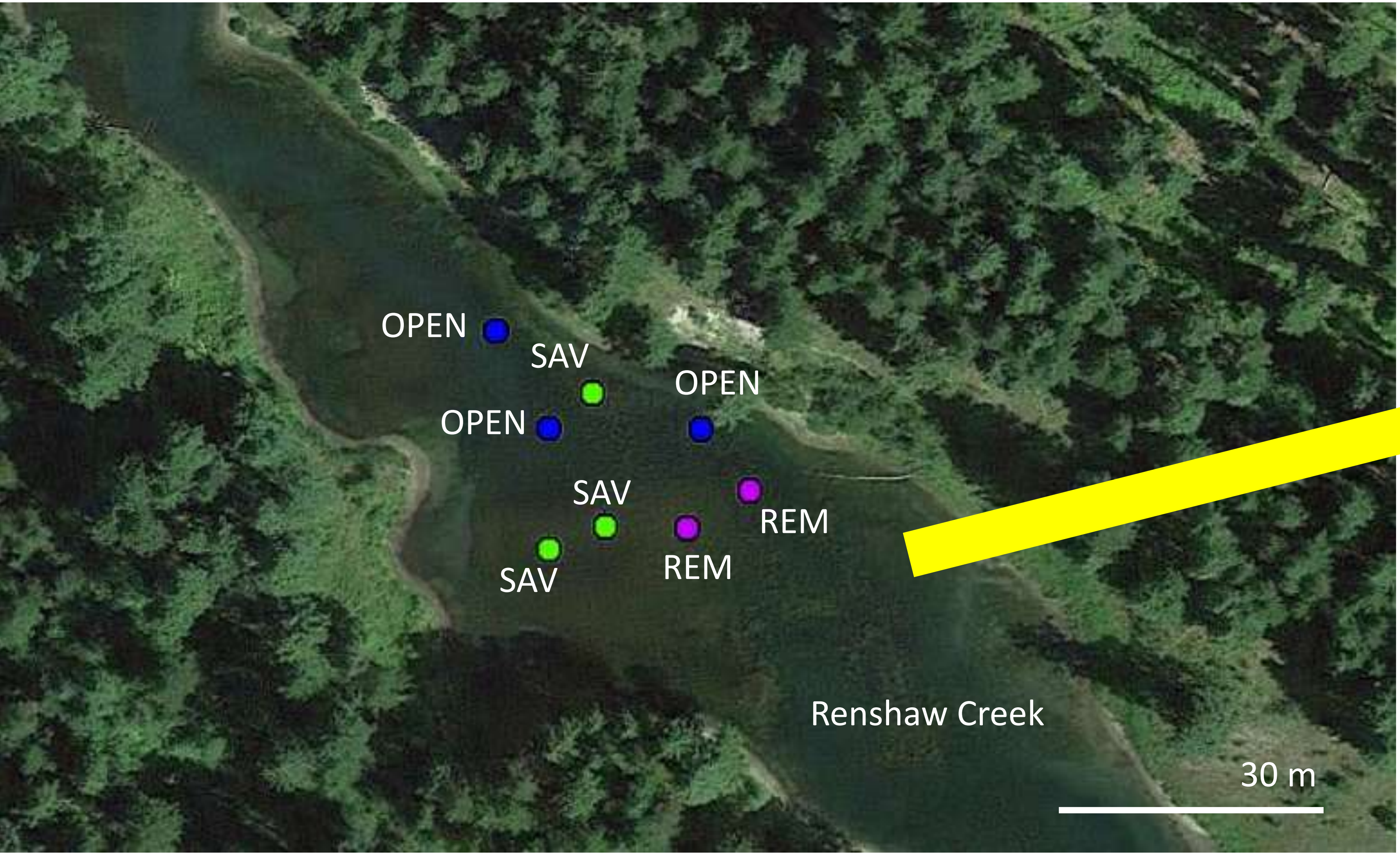
Hypotheses:

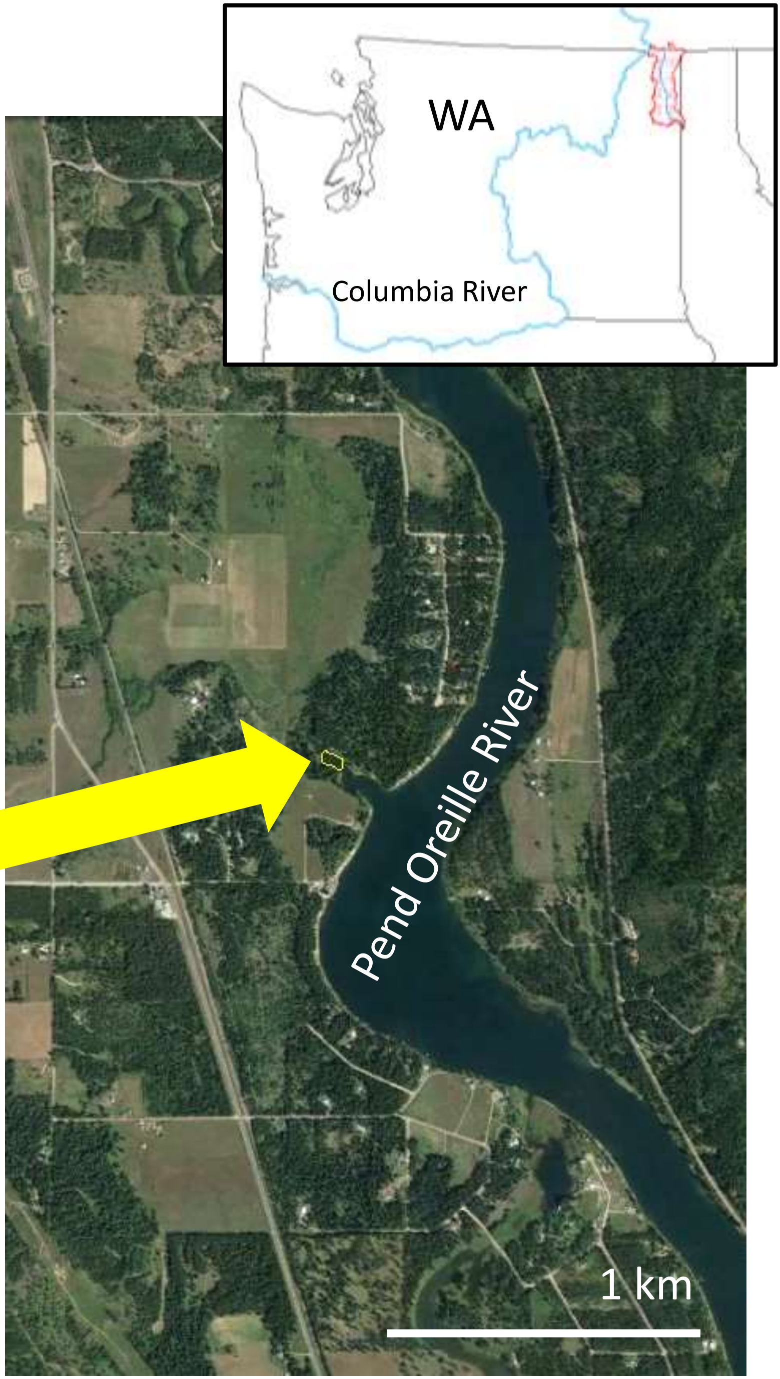
1) Dense SAV areas exhibit **stronger vertical temperature gradients** and have **lower bottom dissolved oxygen** than areas without SAV (open).

2) Areas where SAV is removed exhibit **weaker vertical temperature gradients** and **have higher bottom dissolved oxygen** (more like open areas).

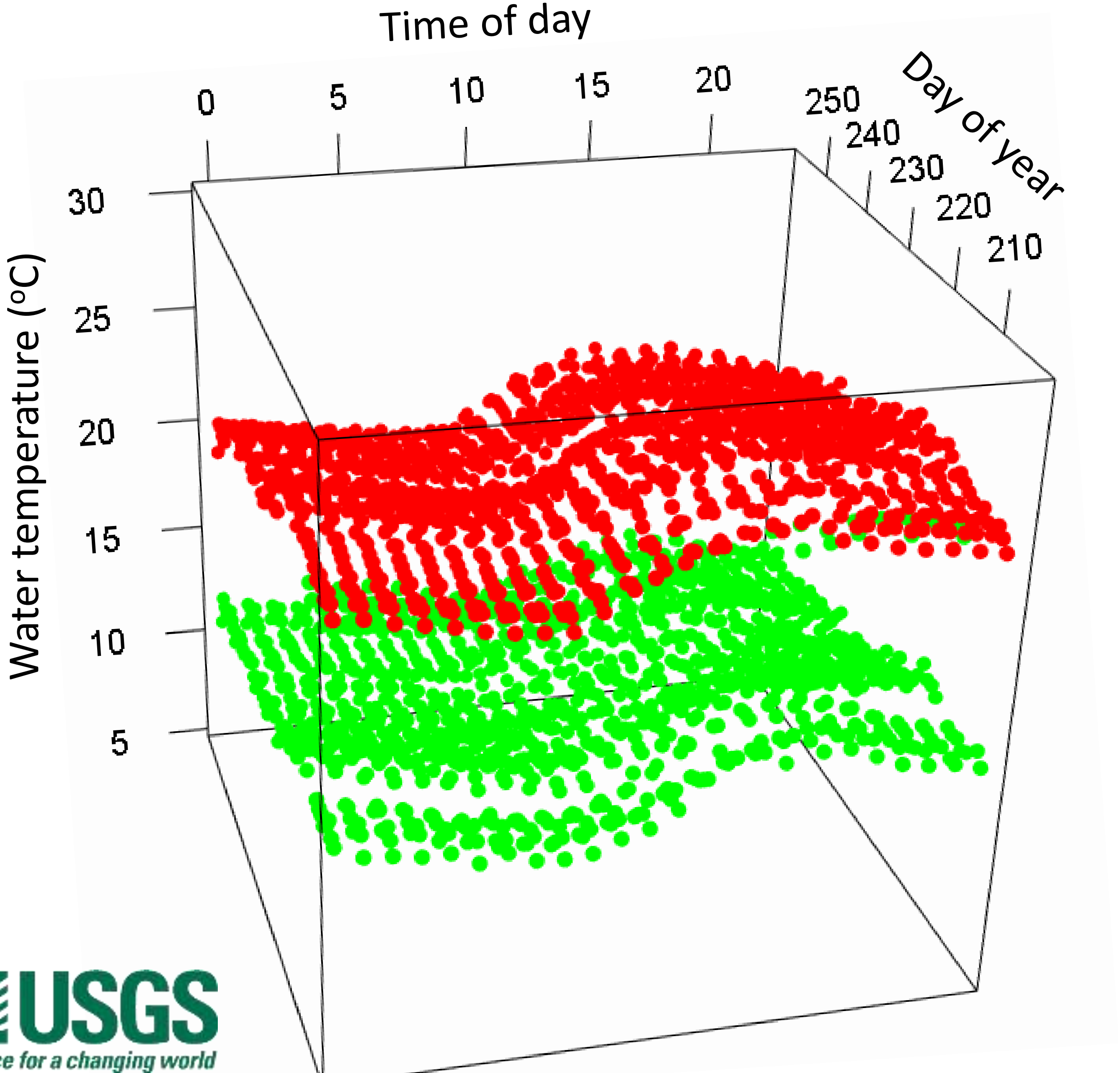
Study Area

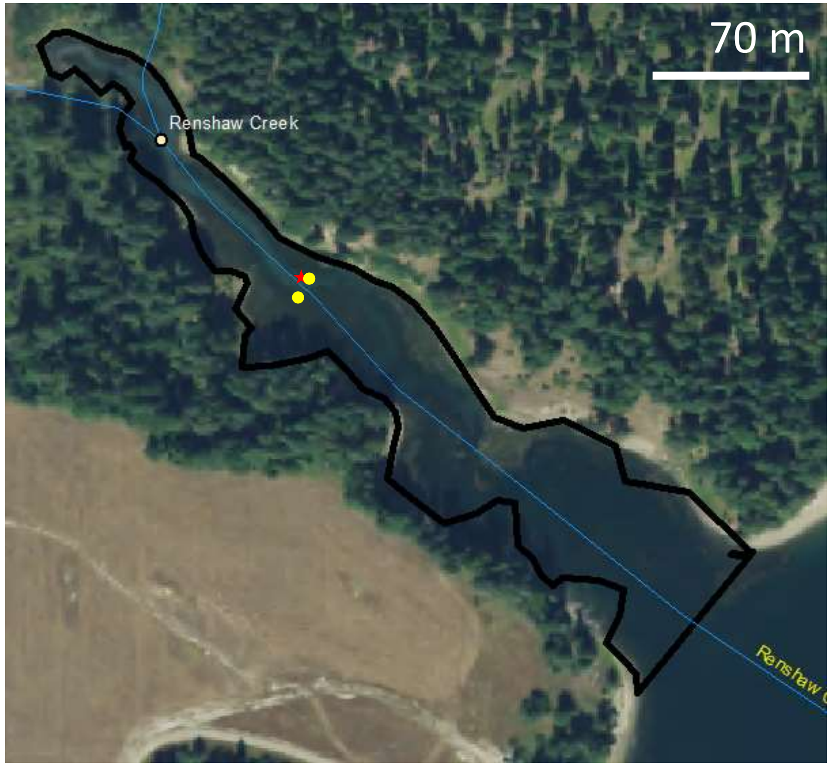
Pend Oreille River
Aug 9 – Aug 12

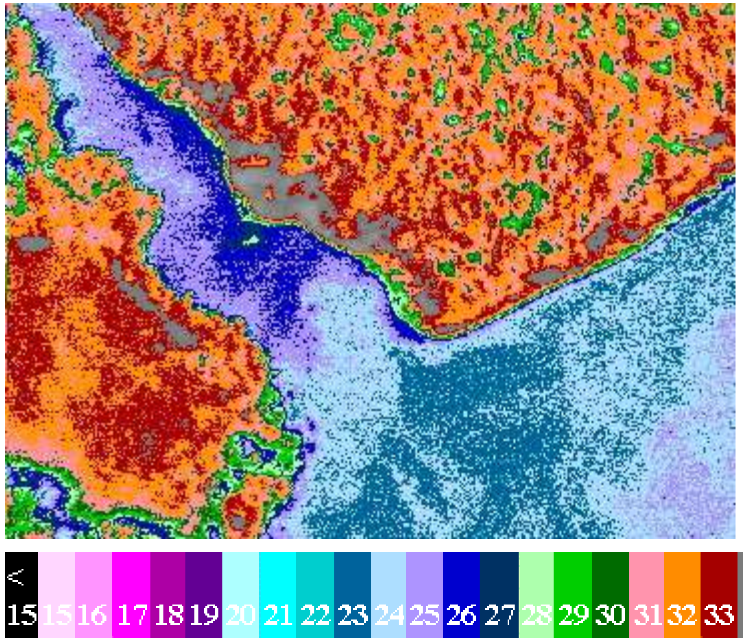




Renshaw Creek rkm 65.9 (2017)



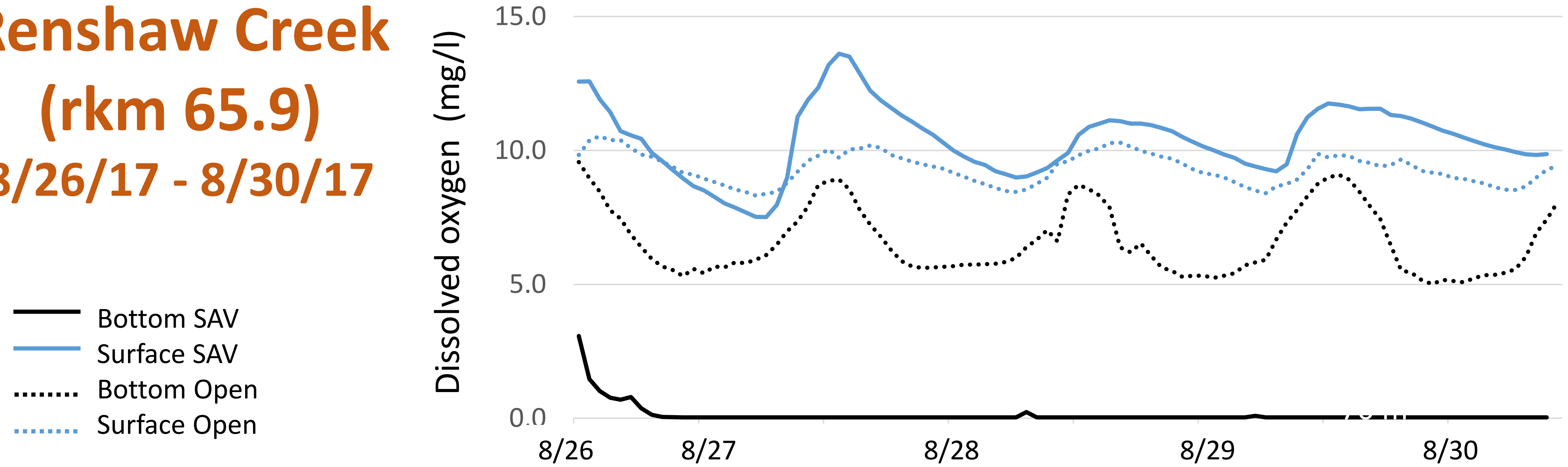


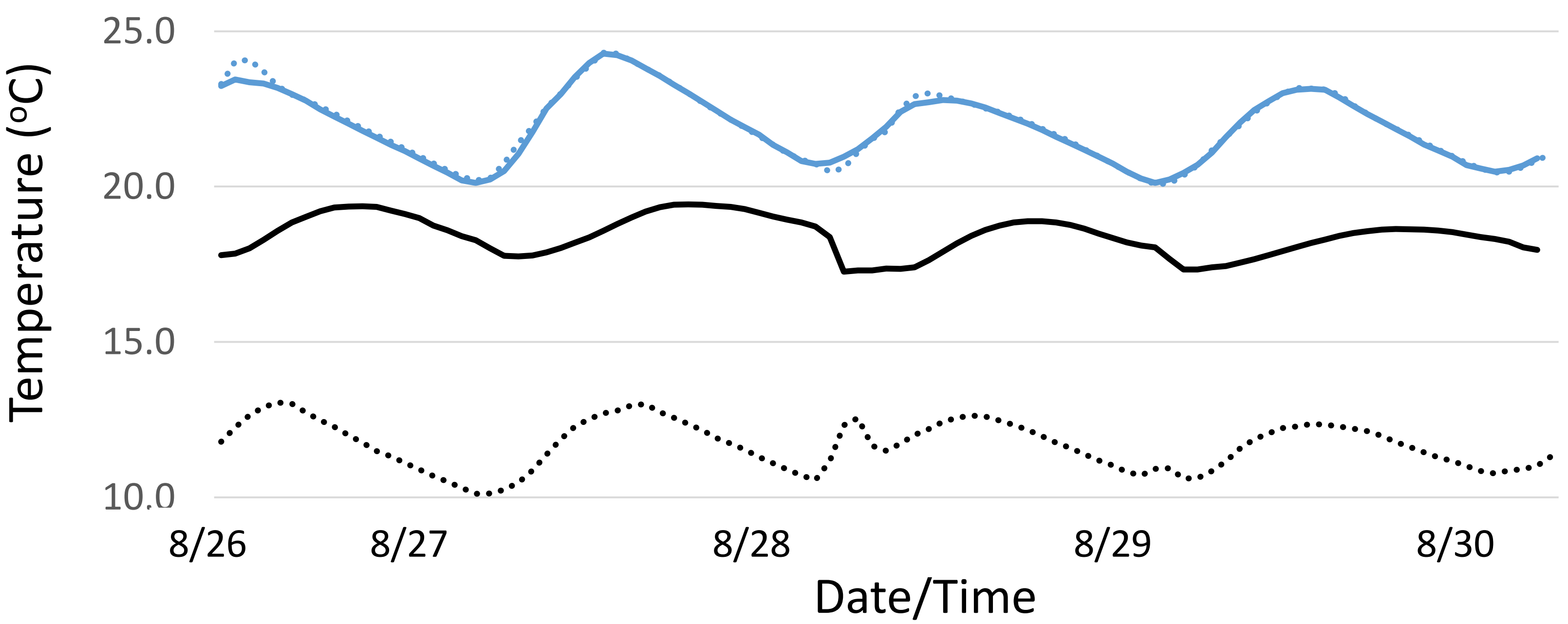


USGS
science for a changing world

Renshaw Creek (rkm 65.9)

8/26/17 - 8/30/17

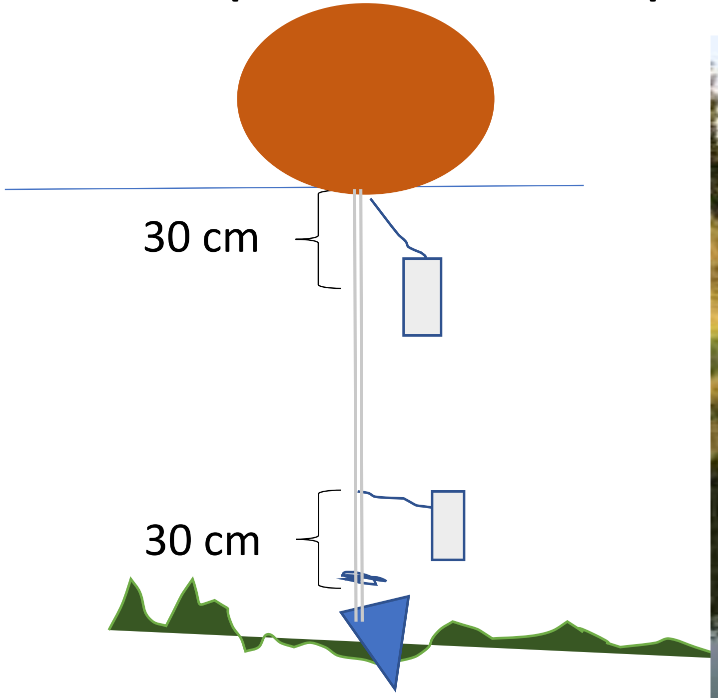




Methods

PME miniDOT logger dissolved oxygen/temperature

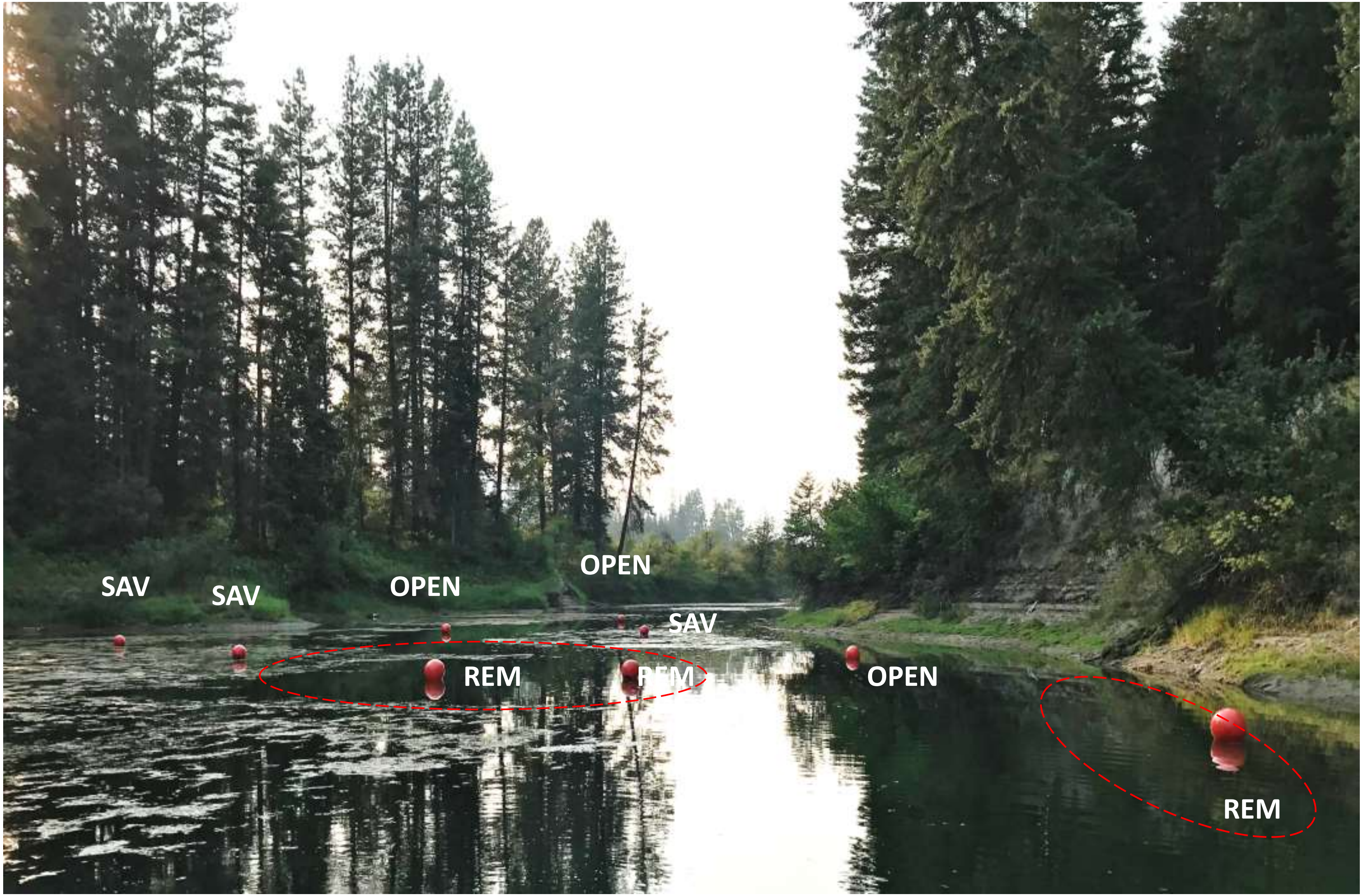
HOBO pendant® temperature/light data logger

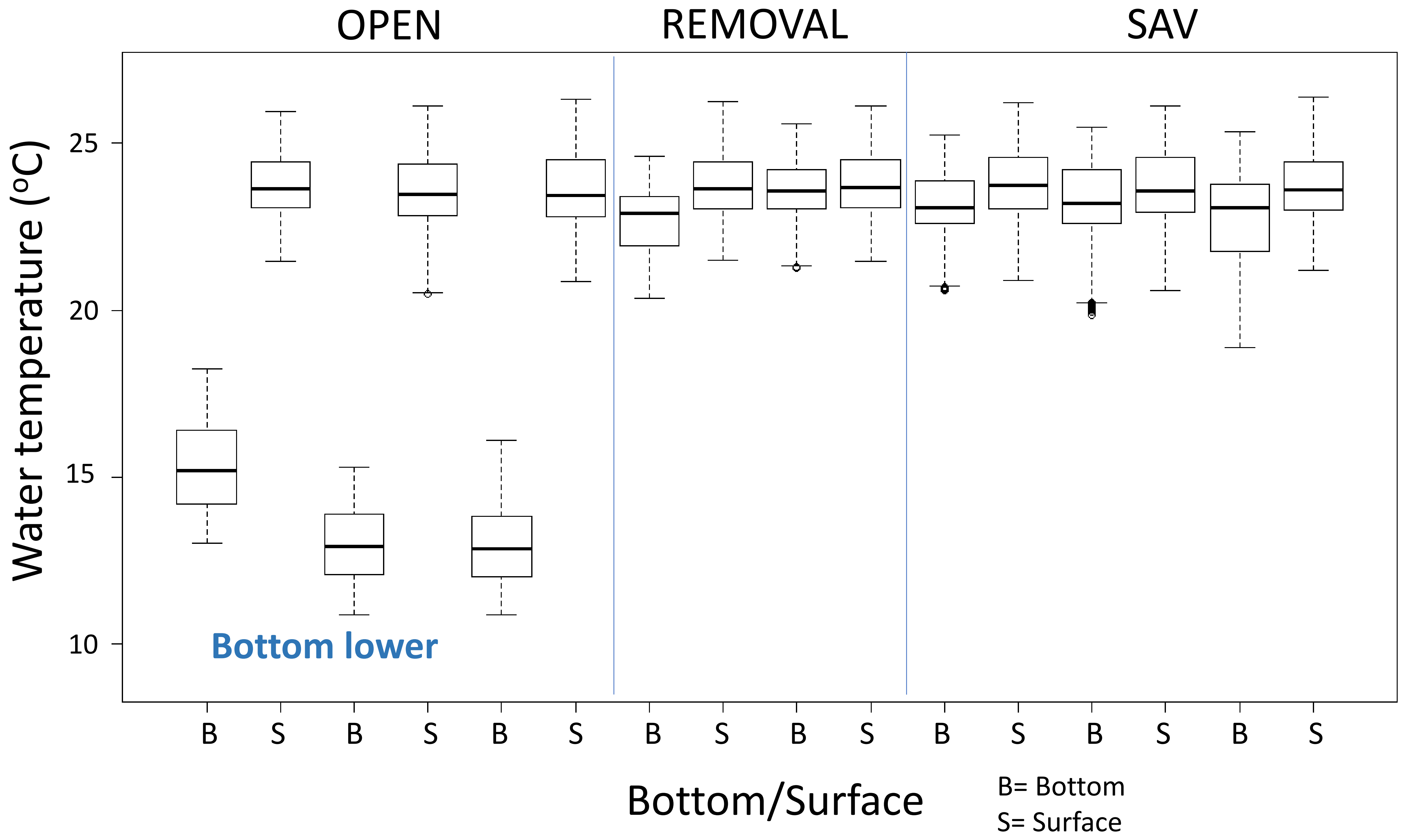


Nitrogen & Phosphorus

Water velocity using an Acoustic Doppler Current Profiler (ACDP)

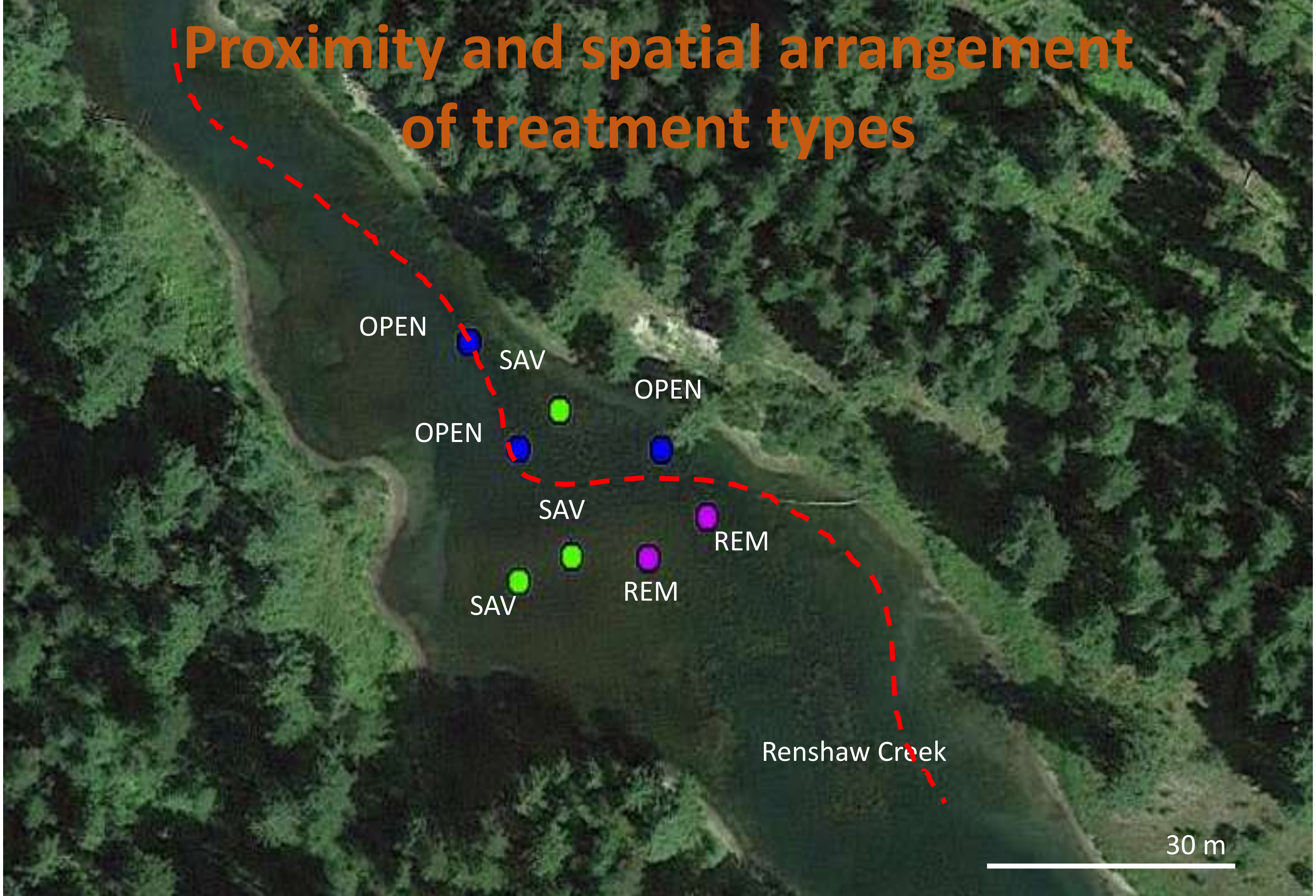
USGS
science for a changing world

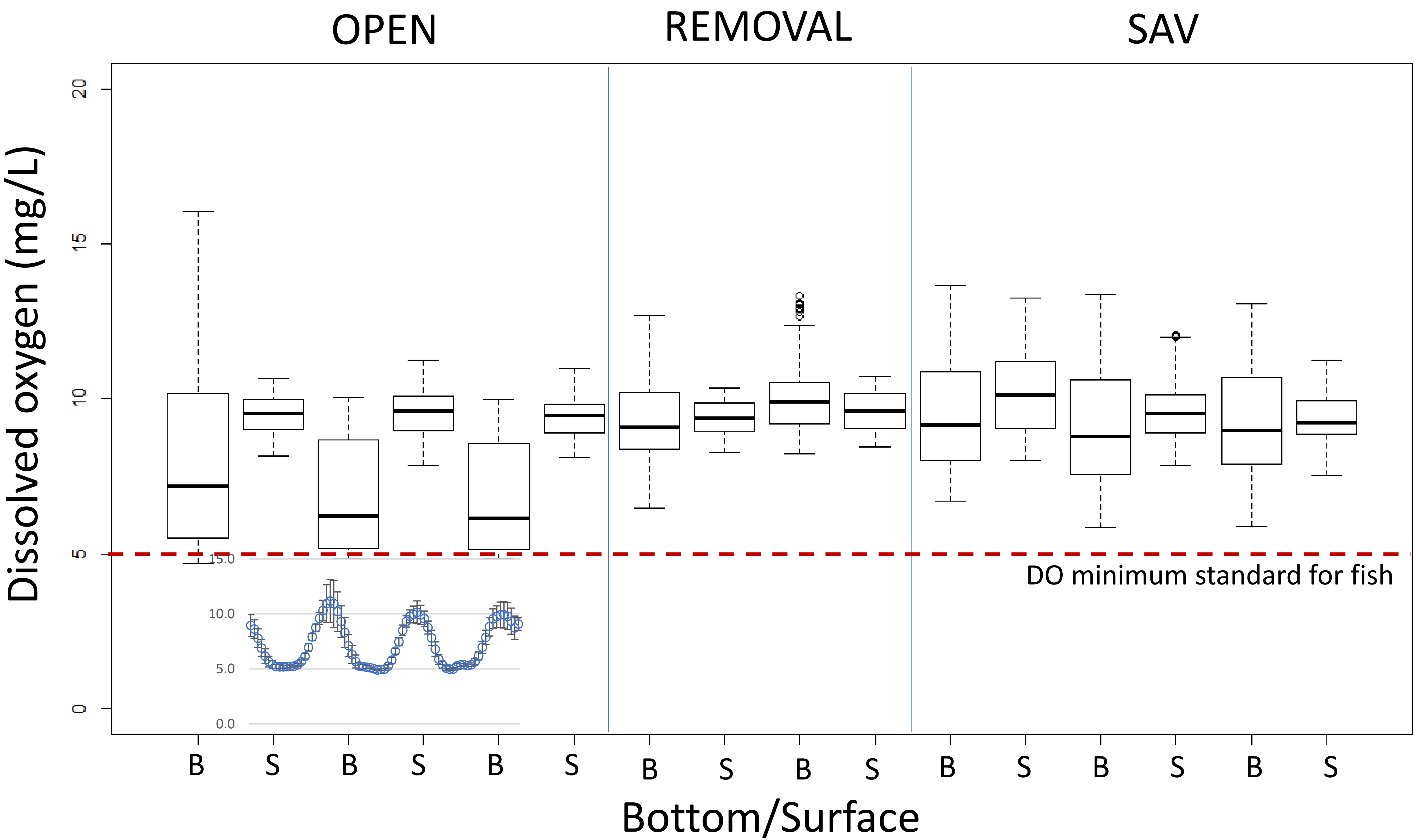

SAV
SAV
OPEN
OPEN
SAV
REM
REM
OPEN
REM



OPEN
REMOVAL
SAV
Water temperature (ºC)
25
20
15
10
Bottom lower
B
S
B
S
B
S
B
S
B
S
B
S
B
S
B
S
Bottom/Surface
B= Bottom
S= Surface

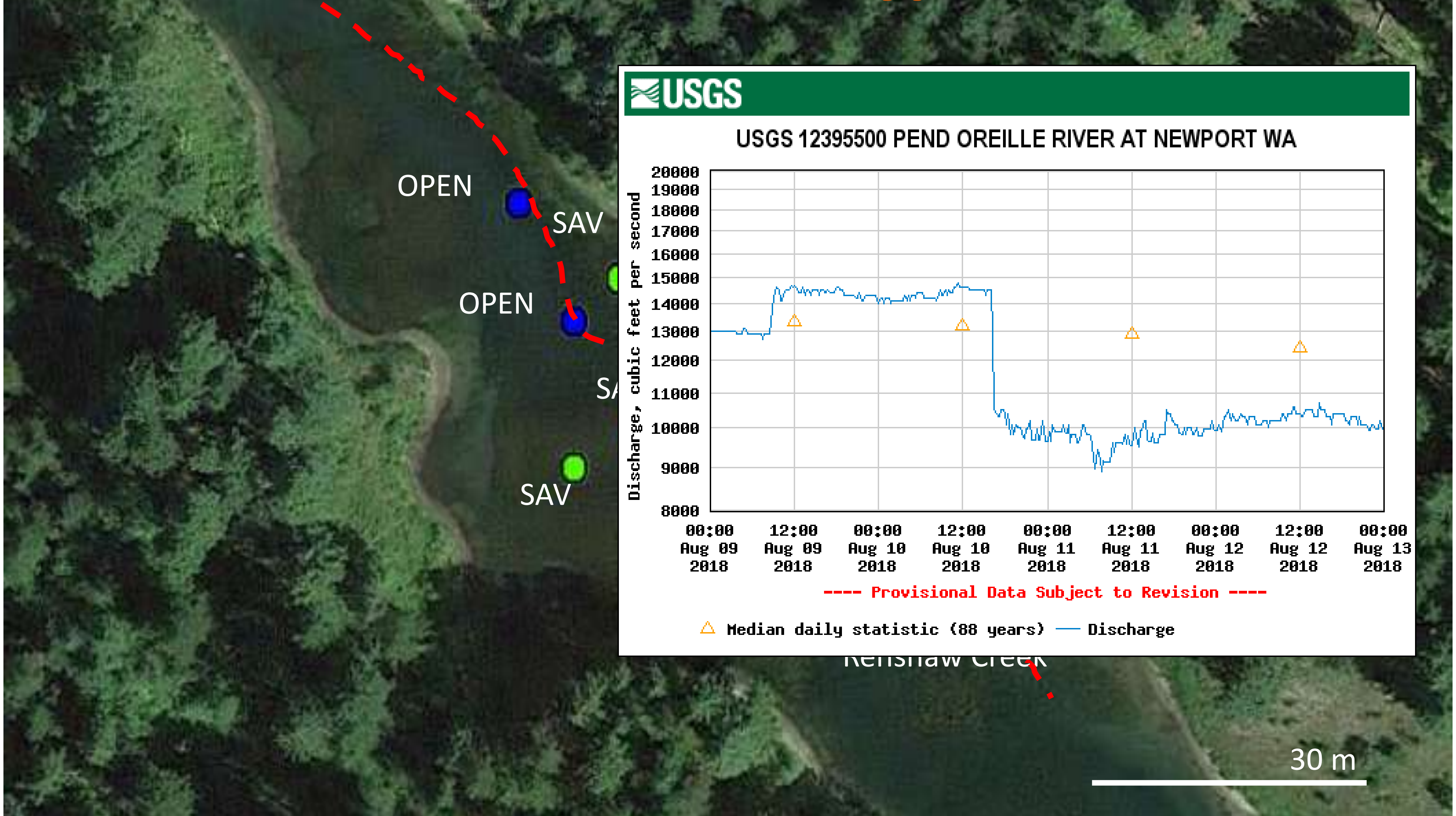
Proximity and spatial arrangement of treatment types



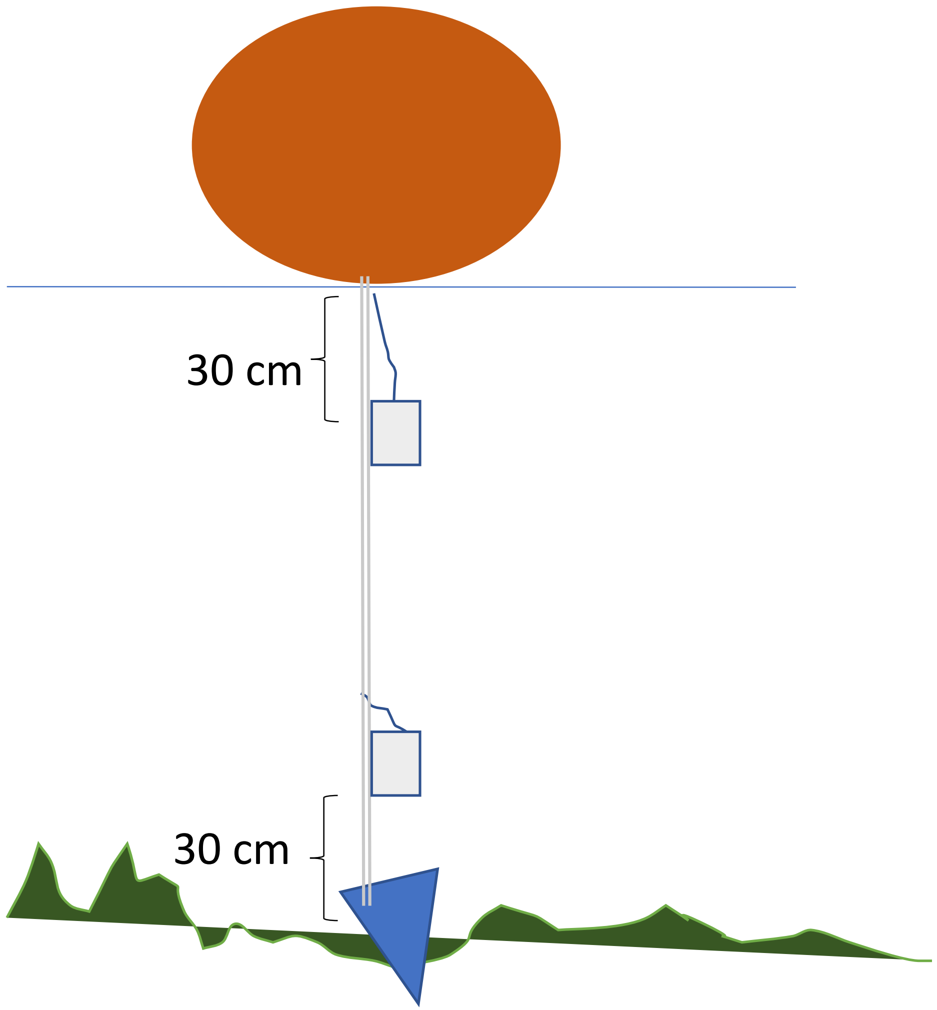


OPEN
REMOVAL
SAV
Dissolved oxygen (mg/L)
0
5
10
15
20
15.0
10.0
5.0
0.0
DO minimum standard for fish
B
S
B
S
B
S
B
S
B
S
B
S
B
S
B
S
Bottom/Surface

Proximity and spatial arrangement of treatment types



Placement of logger in the water column – proximity to sediment



Preliminary Conclusions

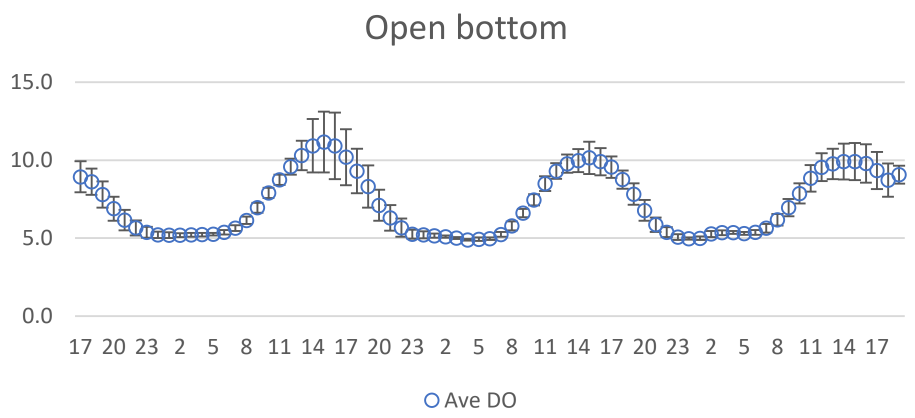
- Pilot study. Need to collect more data to tease out bottom DO dynamics.

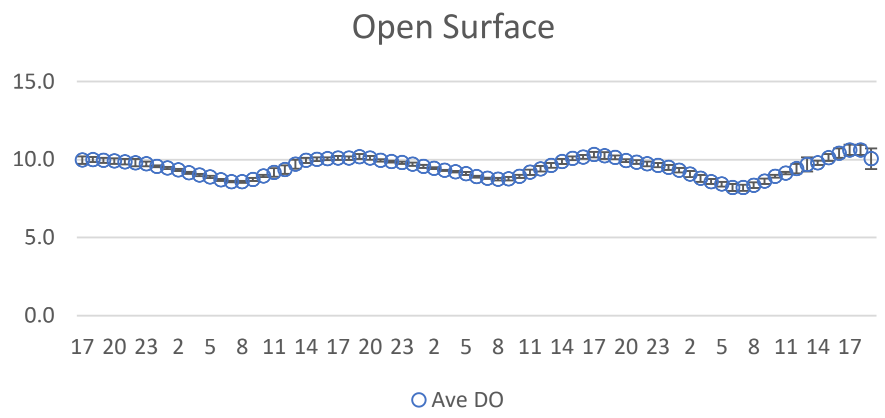
- Work around logistical issues (e.g. vandalism, reservoir fluctuations).

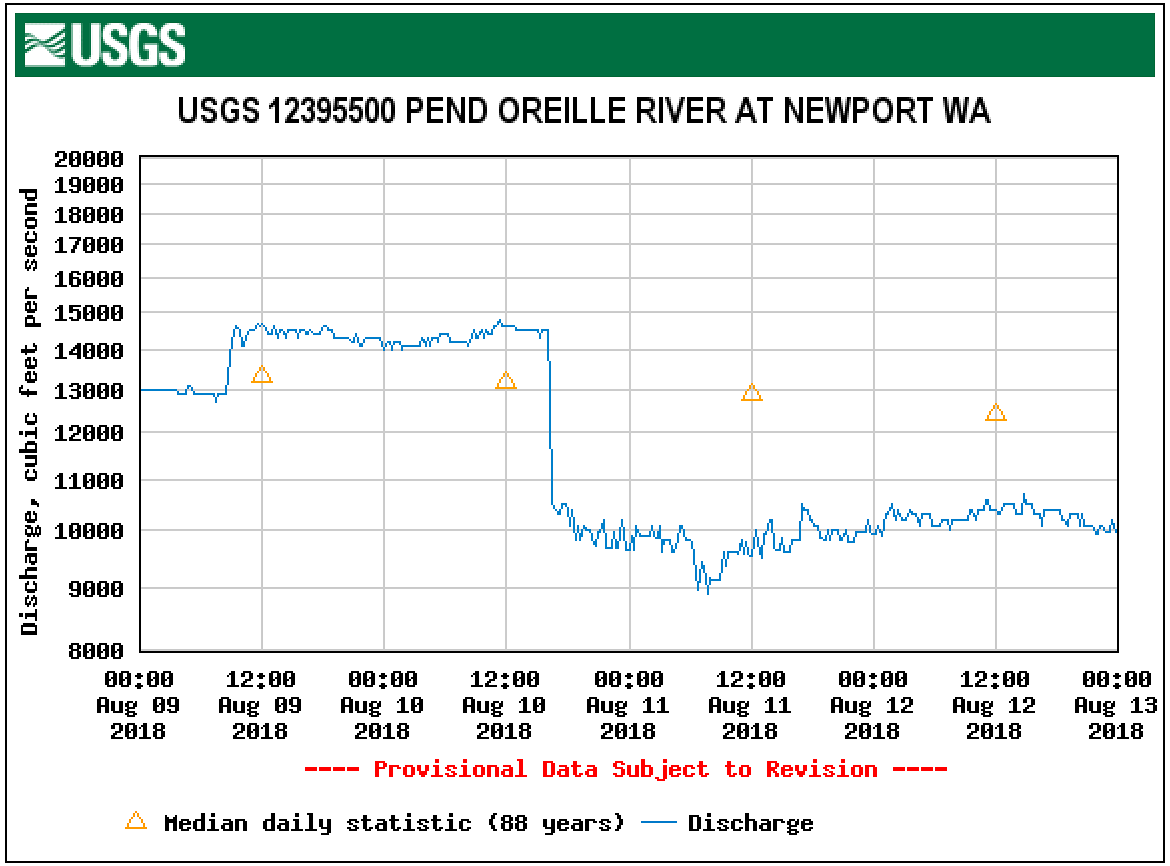
- Enhancement of cold-water refuges likely need more than just removing SAV. Need to understand the existing preferential path as well.

Acknowledgements

Angel Klock University of Washington
Tyler Klock, Volunteer
Ken Merrill, Kalispel Natural Resources Department
Darren Reeves, Kalispel Natural Resources Department
Darren Lantzer, Tshimakain Creek Labs

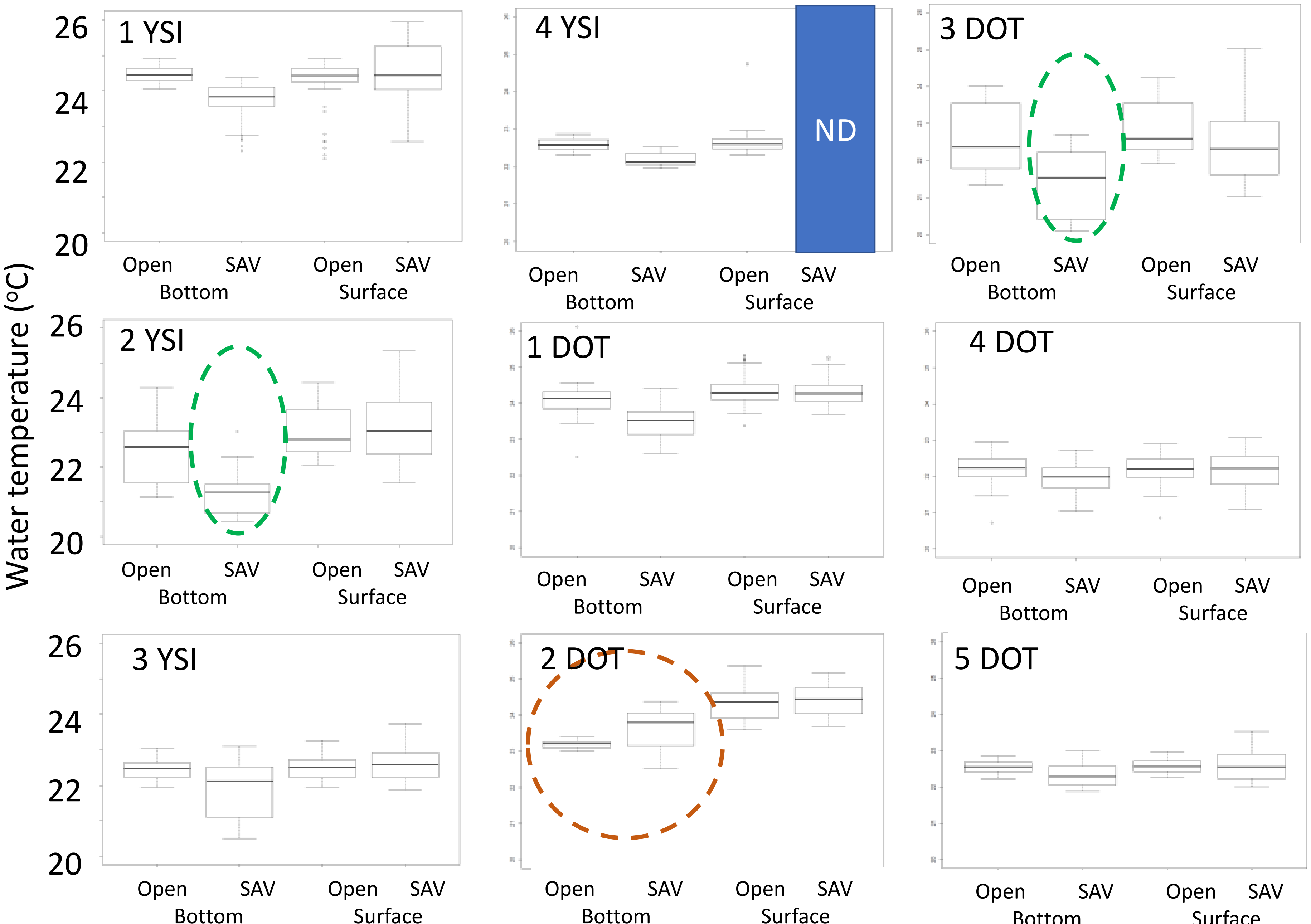

Open bottom
15.0
10.0
5.0
0.0
17 20 23 2 5 8 11 14 17 20 23 2 5 8 11 14 17 20 23 2 5 8 11 14 17
Ave DO


Open Surface
15.0
10.0
5.0
0.0
17 20 23 2 5 8 11 14 17 20 23 2 5 8 11 14 17 20 23 2 5 8 11 14 17
Ave DO



USGS
USGS 12395500 PEND OREILLE RIVER AT NEWPORT WA
Discharge, cubic feet per second
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
00:00 Aug 09 2018
12:00 Aug 09 2018
00:00 Aug 10 2018
12:00 Aug 10 2018
00:00 Aug 11 2018
12:00 Aug 11 2018
00:00 Aug 12 2018
12:00 Aug 12 2018
00:00 Aug 13 2018
---- Provisional Data Subject to Revision ----
Median daily statistic (88 years)
Discharge

Minimal differences in water temperature



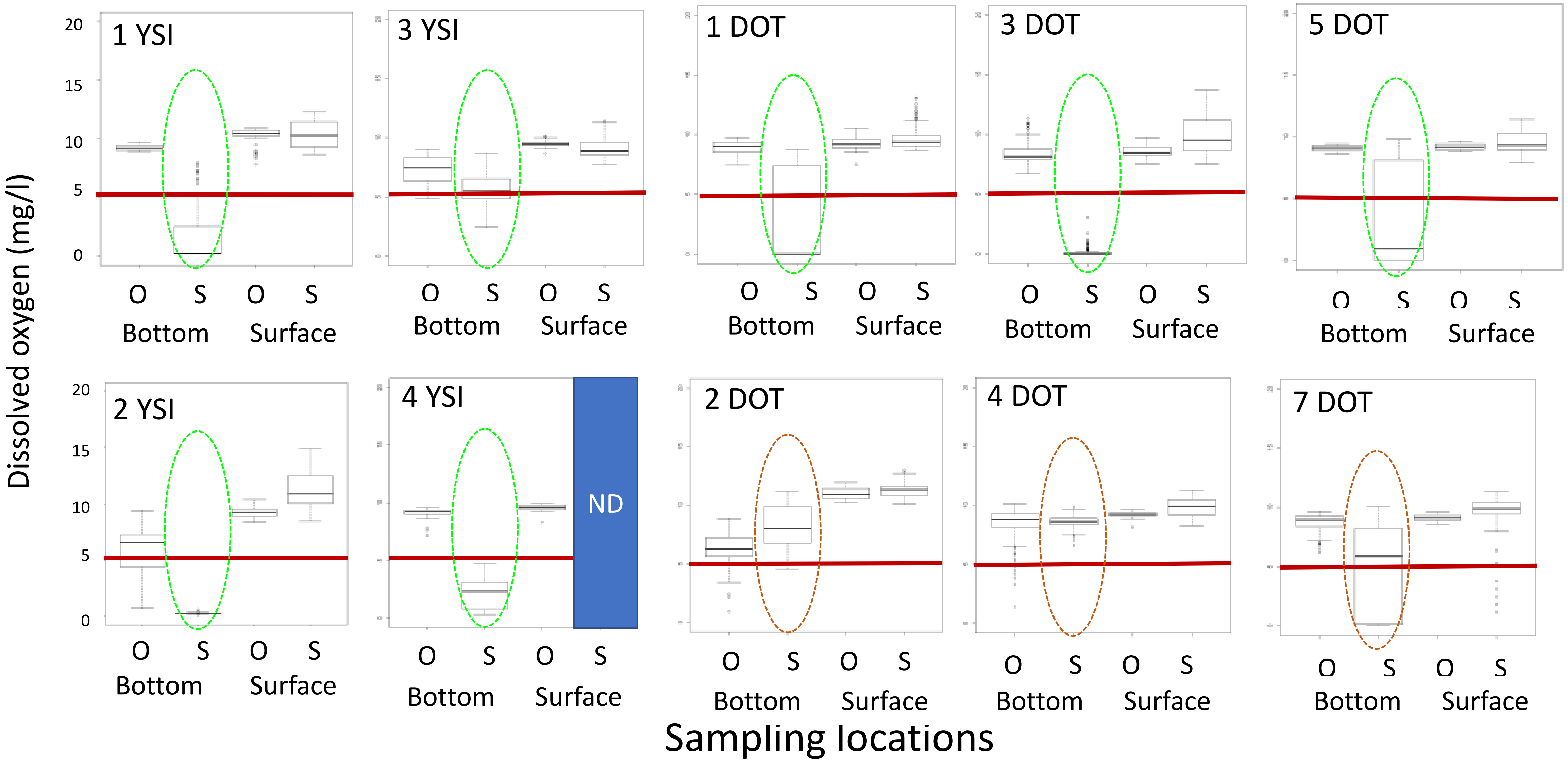
2 YSI was located near Calispel Cr. confluence

2 DOT was about 1 km downstream of Calispel Cr. confluence

Potential temporal effect, data was not collected concurrently, but sequentially (8/2 to 9/5)

Dissolved oxygen gradient steepest at dense patches of SAV

O= Open
S= SAV



Lower/Middle Columbia River - Cold Water Refuges Project

Peter Leinenbach – EPA Region 10

May 1, 2018

Brief overview of <u>some</u> of the technical efforts

Many, many people are working on this project

Project Background

- NMFS 2015 Jeopardy Biological Opinion on EPA's Approval of Oregon's Temperature Water Quality Standards

- Oregon Columbia & Lower Willamette River Temperature Criteria
  - 20C numeric criteria, plus
  - Cold Water Refugia (CWR) narrative criteria
    - "must have CWR that's sufficiently distributed so as to allow salmon and steelhead migration without significant adverse effects from higher temperatures elsewhere in the water body"
    - "CWR means those portions of a water body where, or times during the diel cycle when, the water temperature is at least 2C colder than the daily maximum temperature of the adjacent well mixed flow of the water body"

- NMFS concluded CWR narrative criteria is not an effective criteria due to lack of implementation
  - Jeopardy for Steelhead (LCR, UWR, MCR, UCR, SRB); Chinook (LCR, UWR); Sockeye (SR); SR Killer Whales
  - Reasonable and Prudent Alterative (RPA) – EPA develop a Columbia River Cold Water Refuges Plan by November 2018

Background - EPA Columbia River CWR Plan

1. Map and characterize the CWR areas in the Lower Columbia River

2. Characterize the extent to which salmon and steelhead use CWR

3. Assess whether current CWR is sufficient to meet Oregon’s narrative criteria

4. Identify actions to protect, restore, or enhance CWR

EPA Columbia River CWR Plan

1. Map and characterize the CWR areas in the Lower Columbia River
2. Characterize the extent to which salmon and steelhead use CWR
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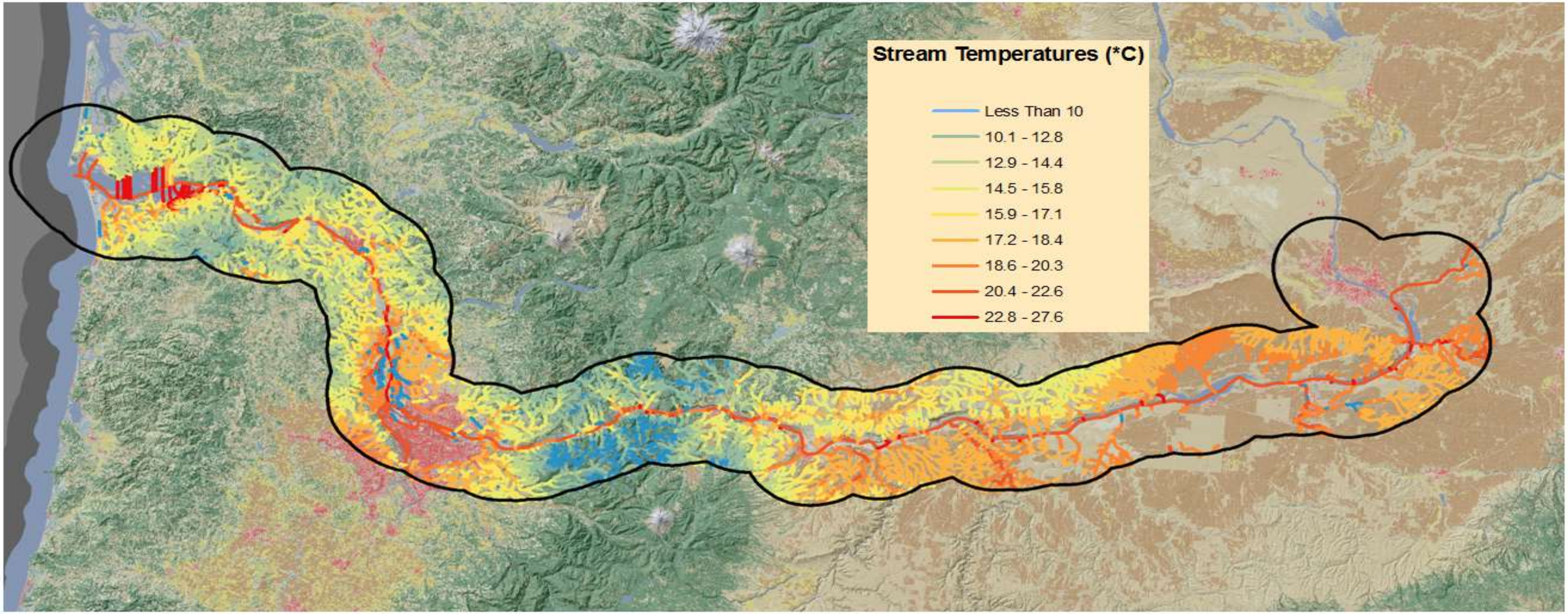
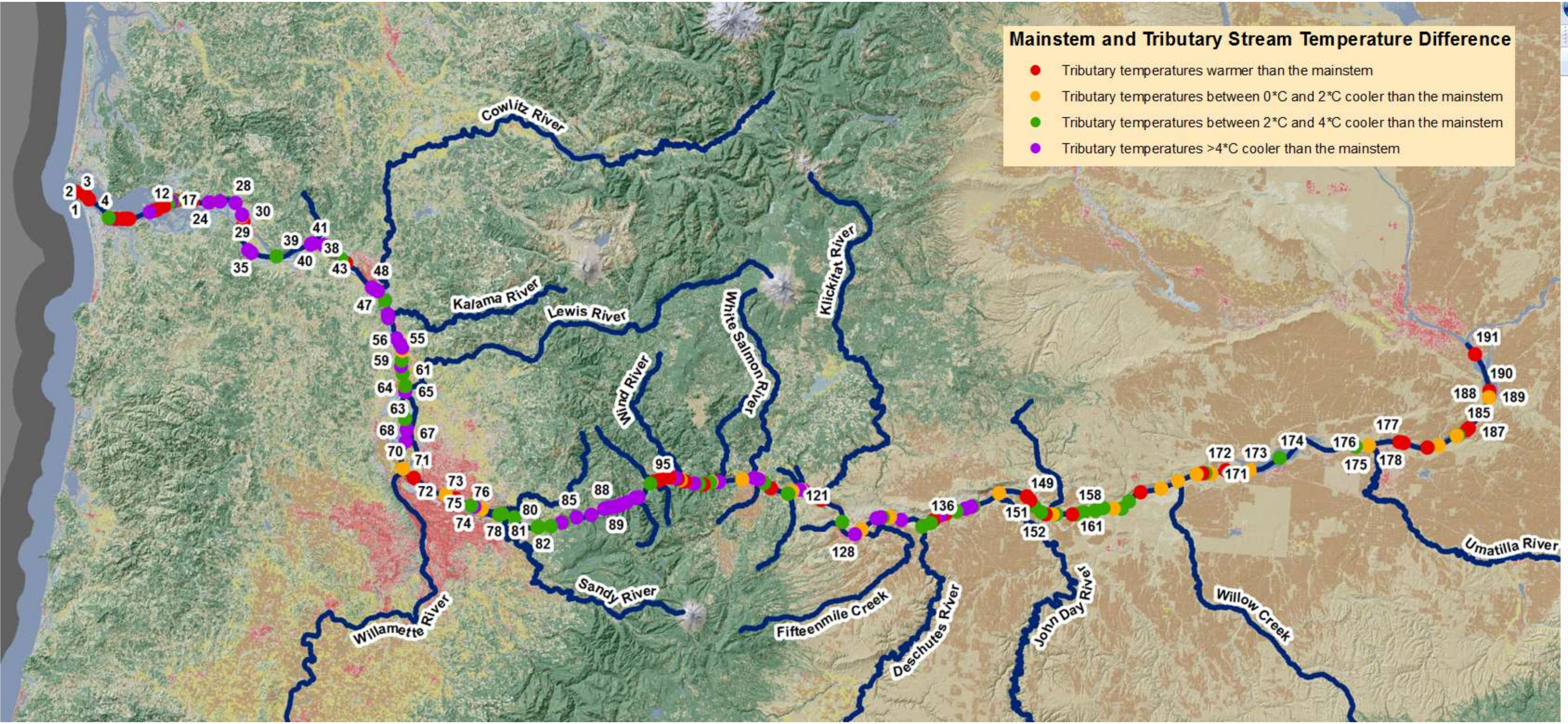
Map and characterize the CWR areas in the Lower Columbia River

Predicted August Daily Average Stream Temperature (1993 – 2011) - NorWeST



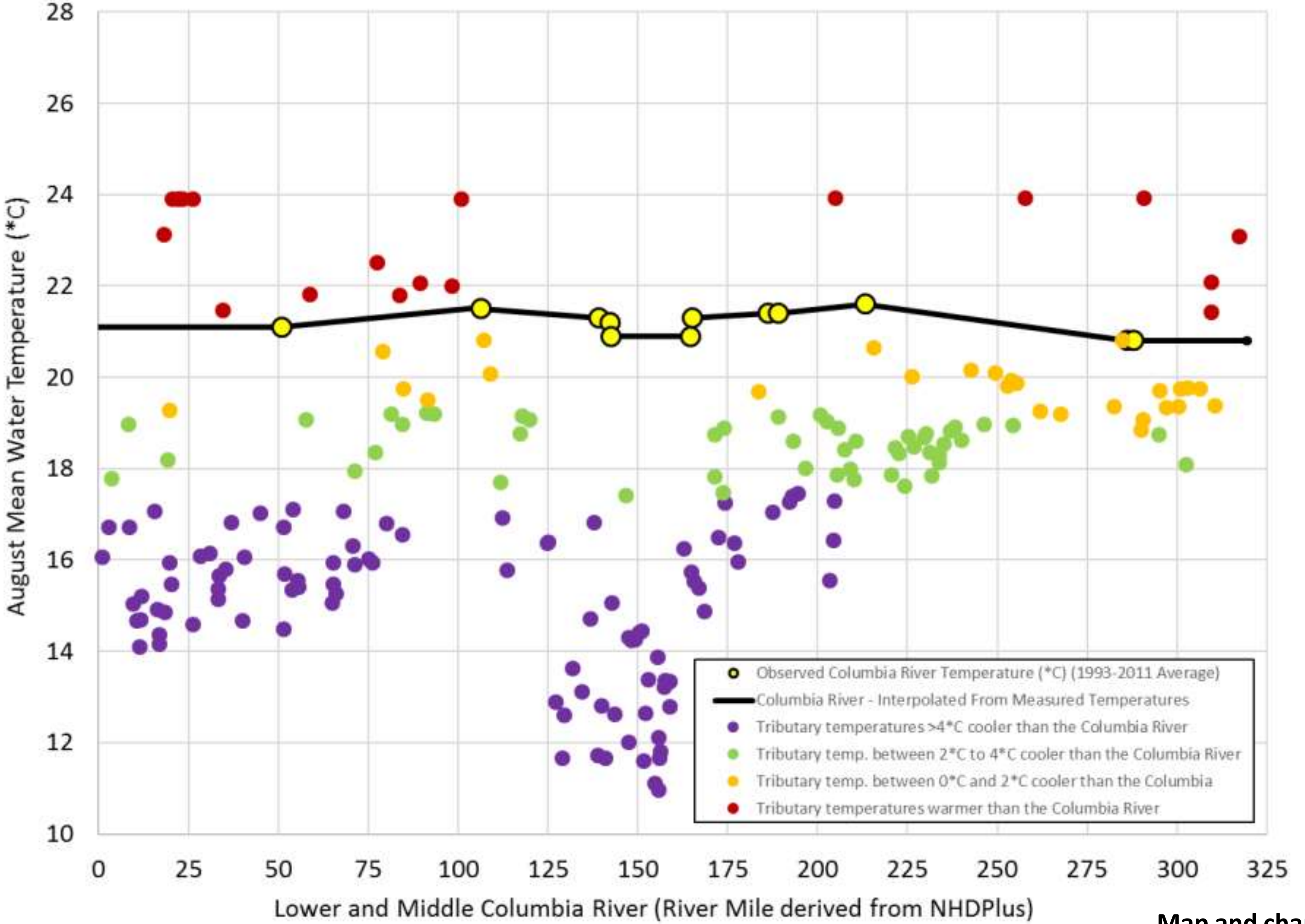
Map and characterize the CWR areas in the Lower Columbia River

Predicted August Daily Average Stream Temperature (1993 – 2011) - NorWeST



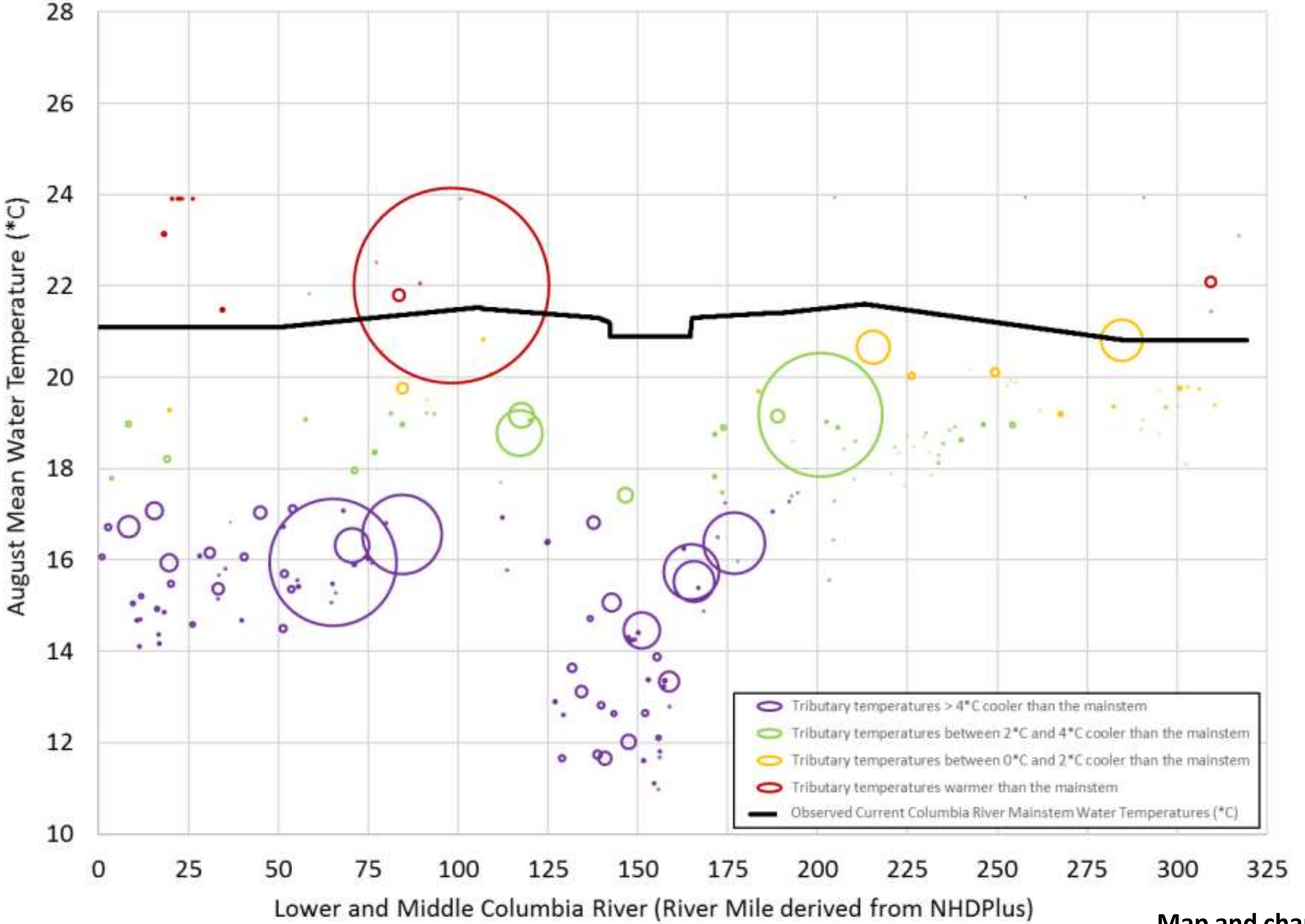
Map and characterize the CWR areas in the Lower Columbia River

Modeled Values



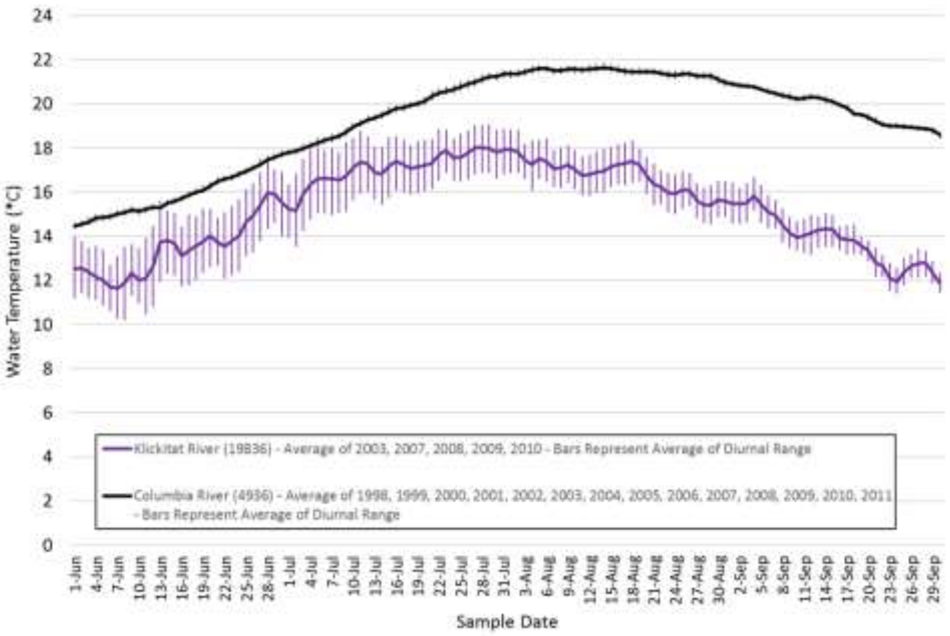
Map and characterize the CWR areas in the Lower Columbia River

Modeled Values



Map and characterize the CWR areas in the Lower Columbia River

Observed Values



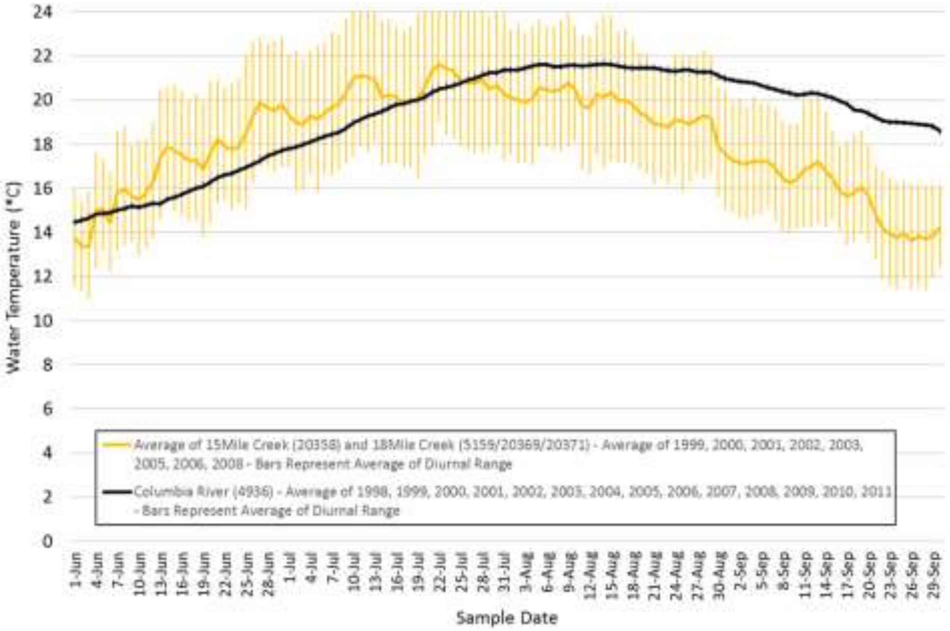


Table A-1. Observed Average Monthly Temperature Difference (*C) between the tributary and the Columbia River

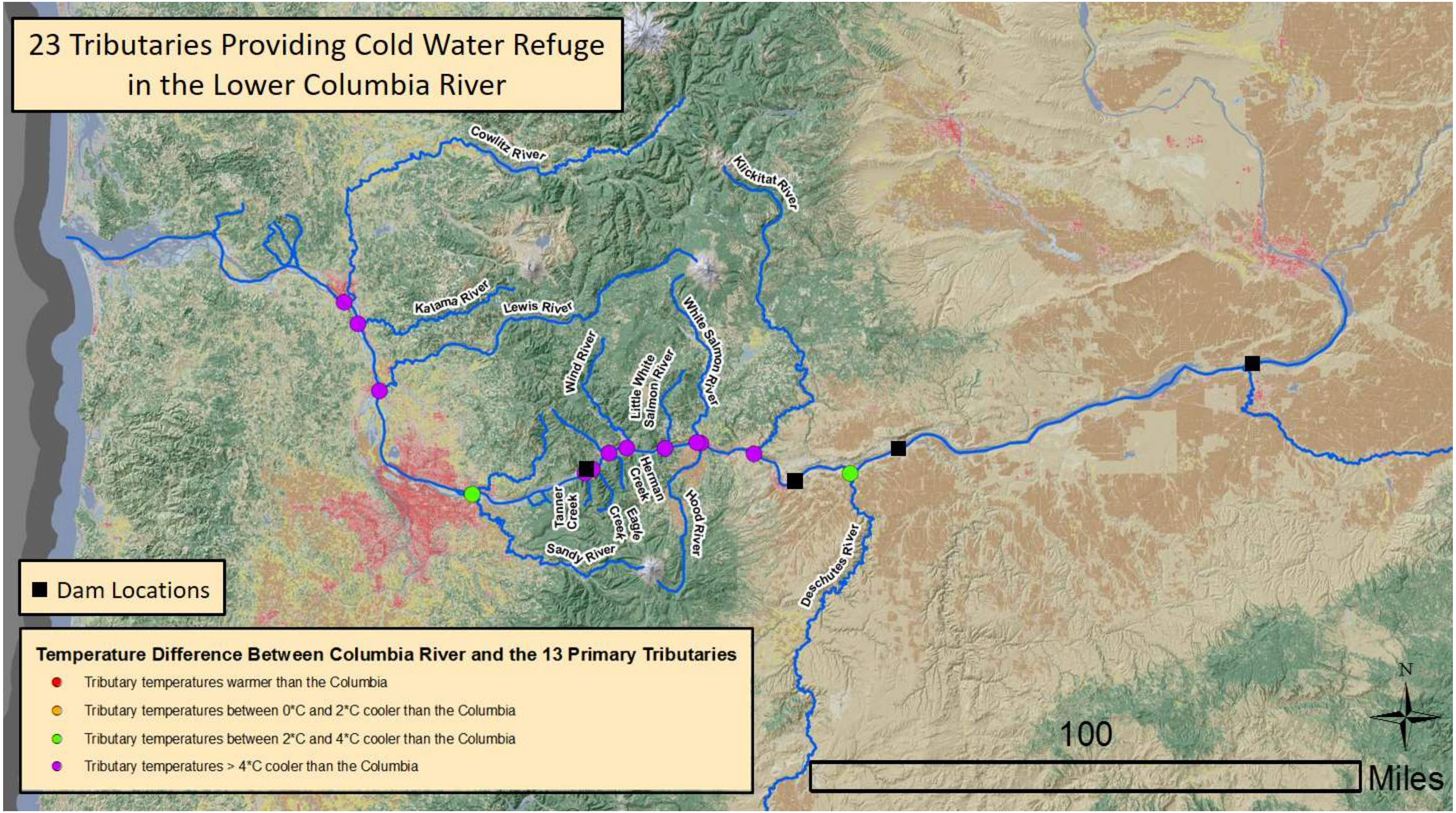
Site Name	June	July	August	September
Tributary #18 – Grays River	4.2	5.1	6.4	6.4
Tributary #30 – Elochoman River	0.5	2.0	2.5	4.6
Tributary #37 – Clatskanie River	No Data	1.8	3.3	5.5
Tributary #38 – Mill Creek	4.3	4.9	6.4	7.0
Tributary #40 – Abernethy Creek	No Data	4.6	5.5	6.0
Tributary #41 – Germany Creek	3.7	3.7	5.2	6.2
Tributary #49 – Cowlitz River	No Data	4.1	5.8	5.8
Tributary #52 – Kalama River	4.8	4.1	5.4	6.3
Tributary #62 – Multnomah Channel	-0.4	-1.8	-0.9	-0.6
Tributary #70 – Willamette River	-0.1	-1.2	-0.9	0.4
Tributary #77 – Sandy River	1.6	0.9	2.8	3.8
Tributary #78 – Washougal River	1.8	0.3	2.2	3.8
Tributary #83 – Bridal Veil Creek	6.4	7.5	9.0	8.4
Tributary #85 – Wahkeena Creek	6.2	8.8	10.9	10.0
Tributary #88 – Woodward Creek	4.7	6.2	7.6	6.6
Tributary #88b – Hamilton Creek	4.3	4.9	5.8	5.8
Tributary #91 – Tanner Creek	5.8	7.7	9.3	9.2
Tributary #92 – Eagle Creek	4.3	3.9	5.2	6.0
Tributary #94 – Rock Creek	2.7	2.7	3.7	4.7
Tributary #96 – Herman Creek	4.3	7.2	9.2	8.9
Tributary #100 – Wind River	2.7	4.6	6.6	7.3
Tributary #112 – LWS River	6.3	7.6	9.1	8.4
Tributary #115 – White Salmon River	4.7	8.0	10.4	10.2
Tributary #116 – Hood River	3.7	4.4	5.8	6.9
Tributary #119 – Rock Creek	0.2	3.1	5.1	6.3
Tributary #120 – Mosier Creek	0.8	0.8	2.5	4.3
Tributary #123 – Major Creek	-1.3	-0.9	1.6	4.3
Tributary #125 – Klickitat River	2.5	2.6	4.7	6.0
Tributary #127 – Chenoweth Creek	-1.4	-0.1	1.5	4.1
Tributary #127a – Mill Creek	-1.3	0.3	1.8	3.7
Tributary #129 – 15 Mile Creek	-1.1	-0.7	1.8	4.1
Tributary #135 – Deschutes River	-1.6	0.4	2.9	3.7
Tributary #147 – John Day River	-5.0	-3.9	-1.2	1.0
Tributary #153 – Rock Creek	-1.2	1.0	2.1	2.6
Tributary #159 – Chapman Creek	-0.3	1.8	3.8	4.4
Tributary #166 – Pine Creek	-0.1	1.1	2.6	3.2
Tributary #167 – Willow Creek	-4.1	-0.5	2.2	4.3
Tributary #170 – Alder Creek	-1.6	0.3	2.8	4.2
Tributary #176 – Umatilla River	-2.7	-3.0	0.0	1.9
Tributary #188 – Walla Walla River	-4.3	-6.0	-2.5	1.3

Map and characterize the CWR areas in the Lower Columbia River

Screening Criteria to Identify Potential CWR Tributaries

- August mean temperatures at least 2°C cooler than Columbia River and August mean flow greater than 10 cfs
- Added small cold tributaries (August mean of 16°C or cooler and August mean flow 7-10 cfs)
- Added larger rivers (Aug. mean flow 10 cfs or greater) that have periods of time at least 2°C cooler than Columbia River
- Removed tributaries that have limited or no access to the cold water plume

Map and characterize the CWR areas in the Lower Columbia River



Map and characterize the CWR areas in the Lower Columbia River

EPA Columbia River CWR Plan

1. Map and characterize the CWR areas in the Lower Columbia River

2. Characterize the extent to which salmon and steelhead use CWR

3. Assess whether current CWR is sufficient to meet Oregon's narrative criteria

4. Identify actions to protect, restore, or enhance CWR

Assess whether current CWR is sufficient to meet Oregon's narrative criteria

EPA Columbia River CWR Plan

1. Map and characterize the CWR areas in the Lower Columbia River

2. Characterize the extent to which salmon and steelhead use CWR

3. Assess whether current CWR is **sufficient** to meet Oregon's narrative criteria

4. Identify actions to protect, restore, or enhance CWR

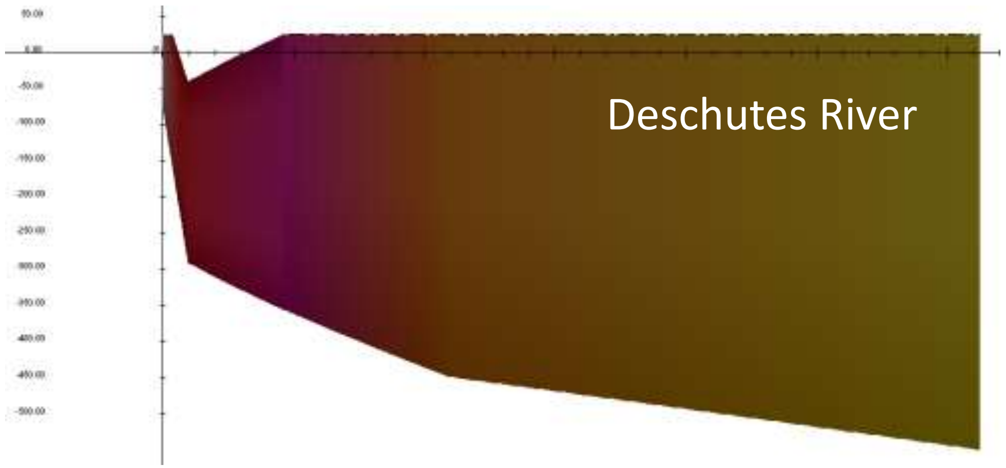
Sufficiency is determined through the application of the HexSim model developed by EPA Corvallis ORD staff

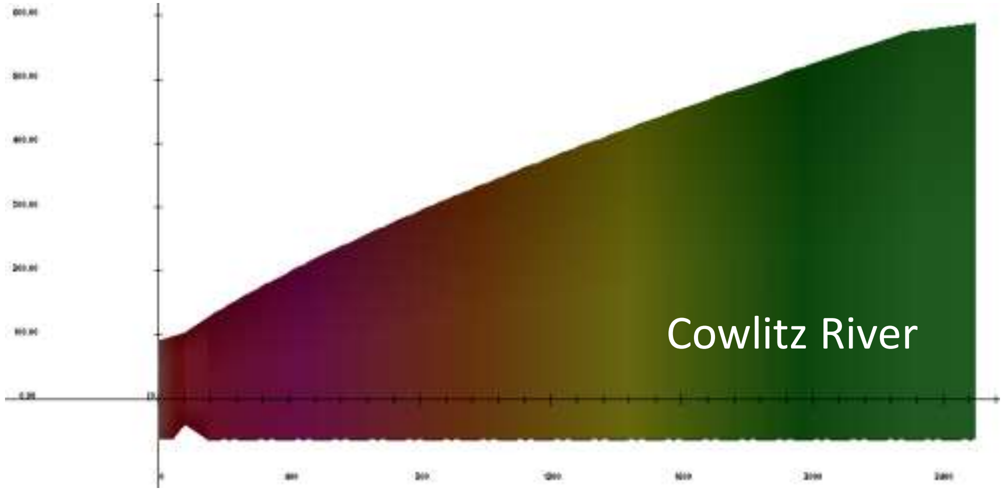
Several HexSim model inputs were developed by EPA Regional staff

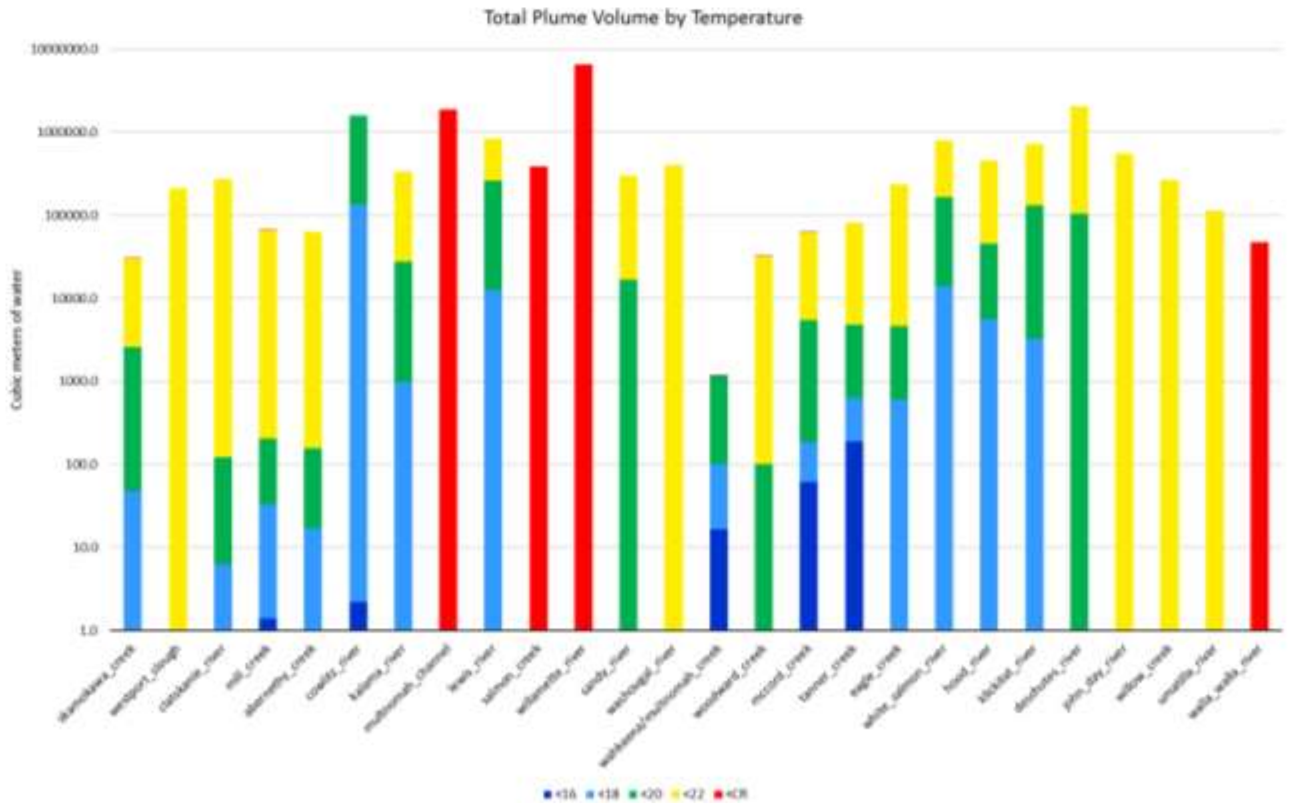
- Potential CWR locations,
- Volume and temperature associated with these CWR areas

Assess whether current CWR is sufficient to meet Oregon's narrative criteria

Estimating CWR Plume Volume – CorMix Modeling



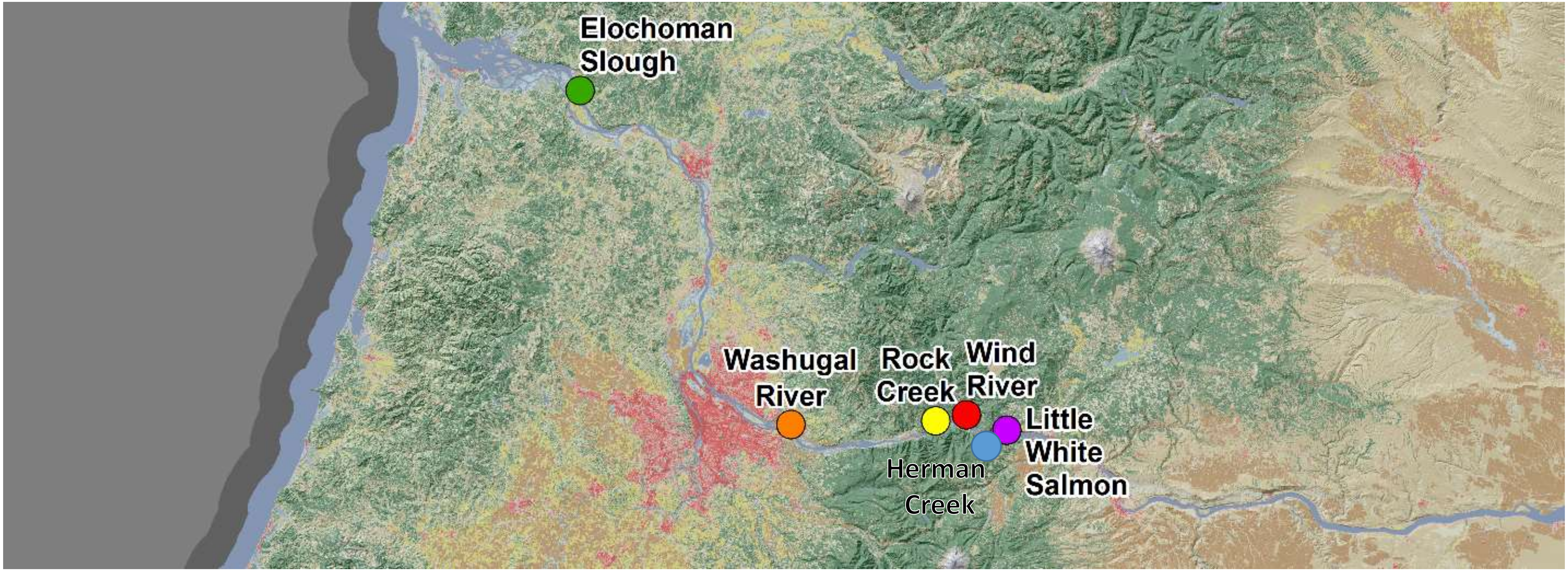




Results used in HexSim model development

Assess whether current CWR is sufficient to meet Oregon's narrative criteria

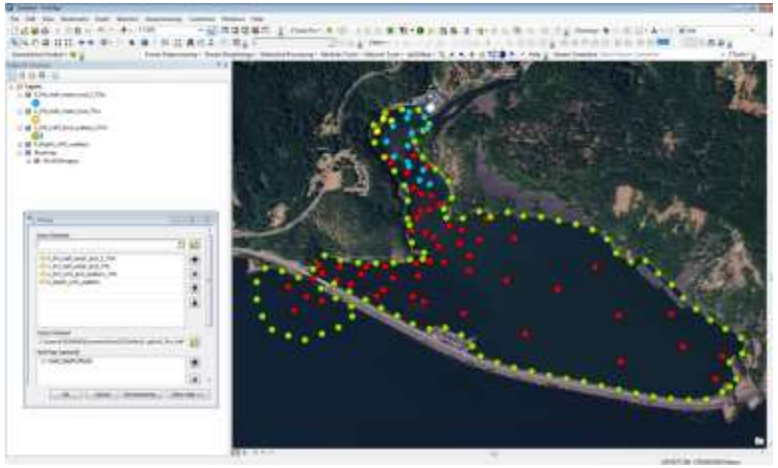
Estimating CWR Plume Volume – Modeled from Field Data

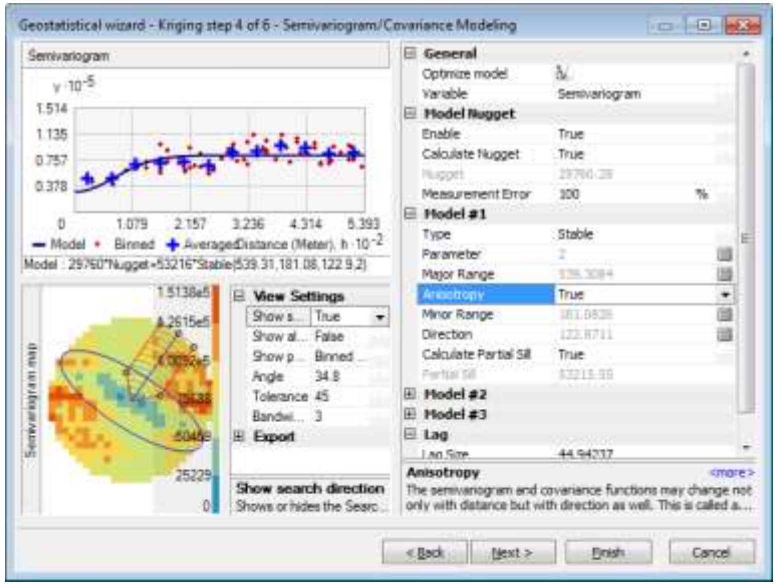


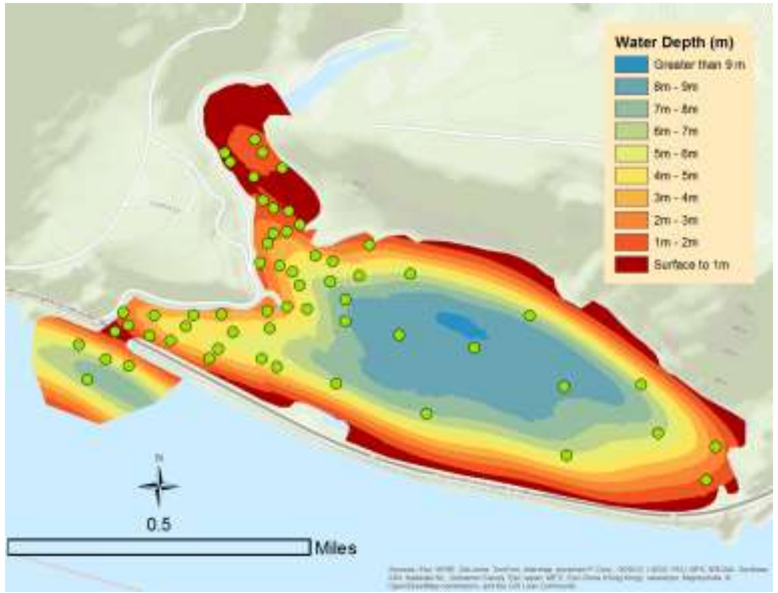
Results used in HexSim model development

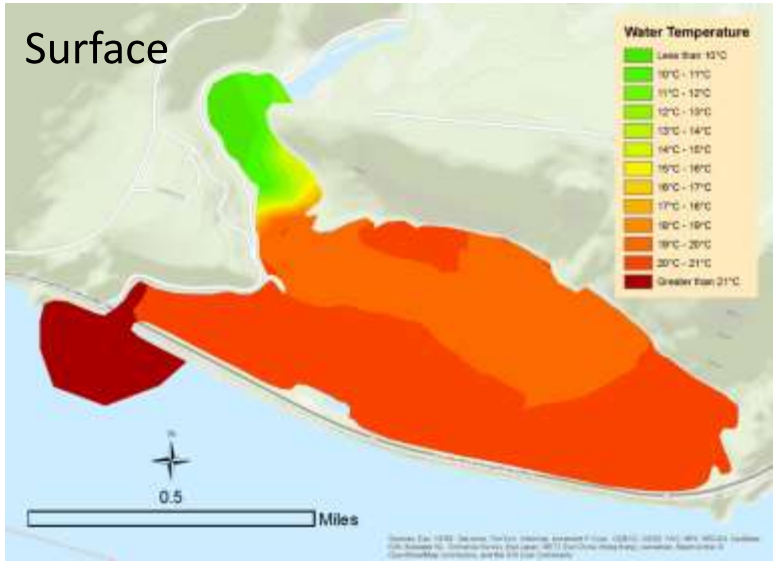
Assess whether current CWR is sufficient to meet Oregon's narrative criteria

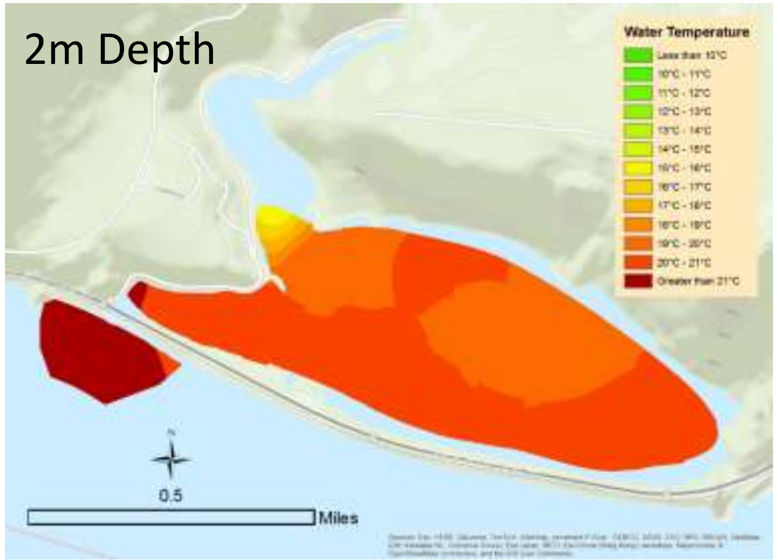
Estimating CWR Plume Volume – Modeled from Field Data

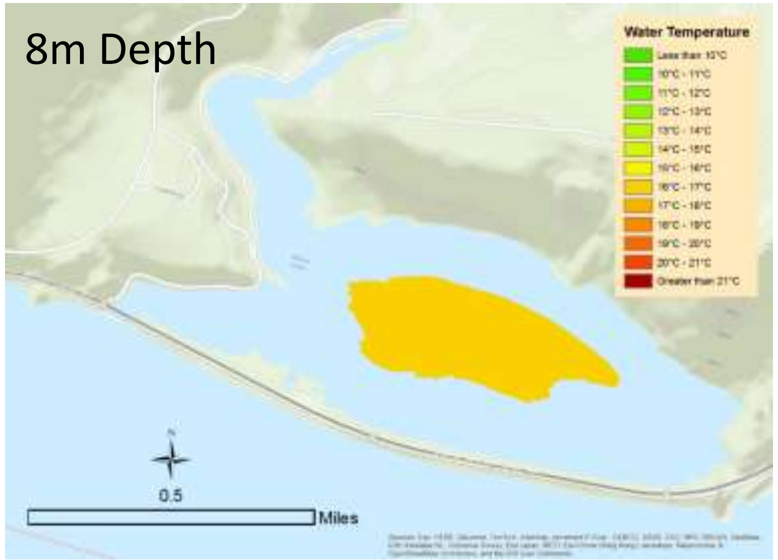












Results used in HexSim model development

Assess whether current CWR is sufficient to meet Oregon's narrative criteria

Estimating CWR Plume Volume – Modeled from Field Data

Table 1. "Cold" water volume (m^3), within specific temperature ranges, observed at the confluence zone between several sampled tributaries and Columbia River during the summers of 2016 and 2017

River and Sample Date	Less than 16*C	Between 16*C and 18*C	Between 18*C and 20*C
Elochoman Slough 8/18/2016	0	0	0
Washougal River 8/16/2016	0	0	0
Rock Creek 8/17/2016	0	0	8,845
Wind River 8/15/2016	0	20,390	123,616
Little White Salmon River 8/17/2016	90,723	440,801	1,267,874
Herman Creek 8/16/2017	30,499	36,558	68,583

Results used in HexSim model development

Assess whether current CWR is sufficient to meet Oregon's narrative criteria

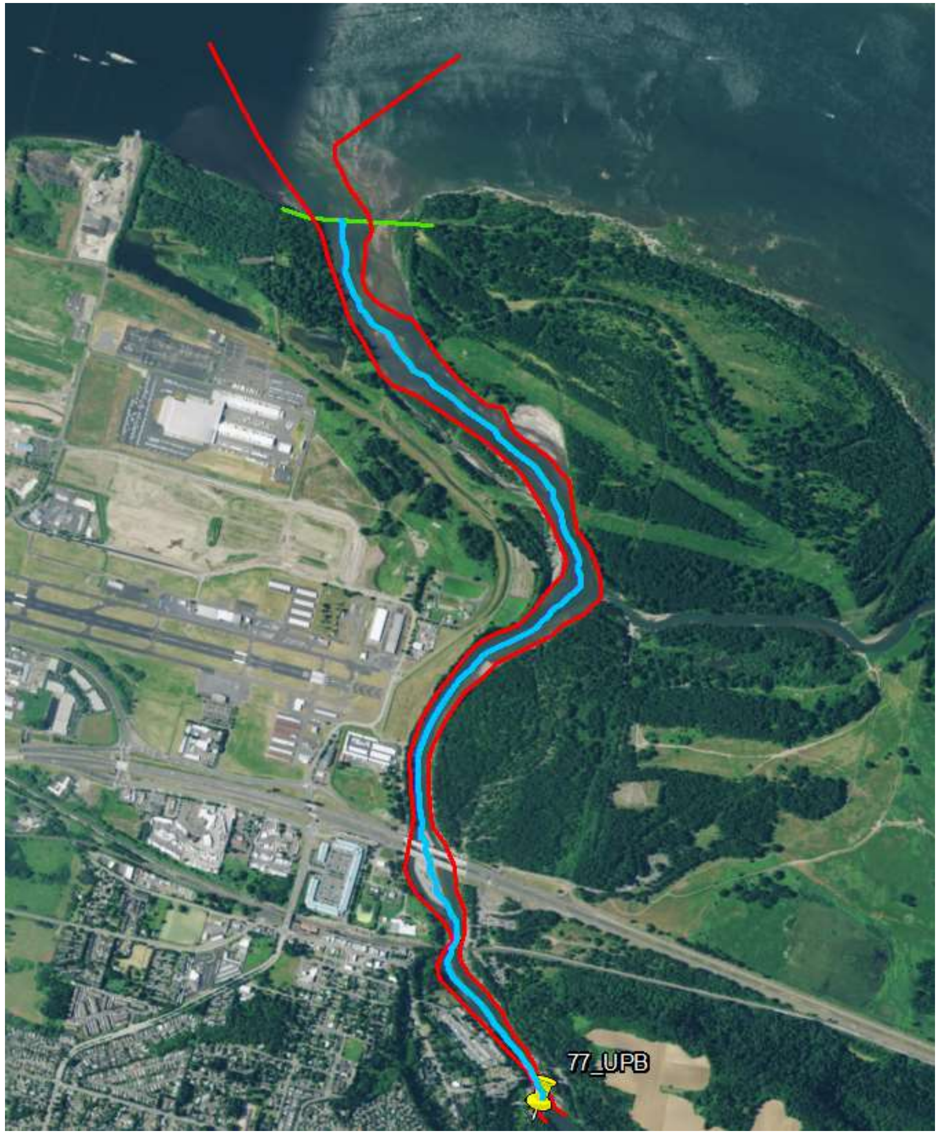
Estimating CWR Riverine Volume

$$Tributary\ CWR\ Volume\ (m^3) = Stream\ Length\ (SL)\ providing\ CWR\ habitat\ for\ Columbia\ River\ migratory\ salmonids\ (m) * Average\ Tributary\ Cross\ Sectional\ Area\ (\bar{A})\ within\ this\ designated\ area\ (m^2)$$

$$\bar{A} = {Stream\ Discharge\ (m^3/s)} \Big/ {Stream\ Velocity\ (m/s)}$$

Table 1. Estimated Potential Riverine Cold Water Refugia Volume

Tributary Code	Tributary Name	Stream Length Providing CWR Habitat (m)	Average August Stream Discharge (m^3/s)	Average August Stream Velocity (m/s)	Potential Riverine CWR Volume (m^3)
28	Skamokawa Creek	317	0.57	0.17	1,033
38	Mill Creek	283	0.29	0.19	446
40	Abernethy Creek	337	0.29	0.12	806
41	Germany Creek	329	0.24	0.18	446
49	Cowlitz River	1,764	102.86	0.27	684,230
52	Kalama River	1,932	7.48	0.25	57,089
63	Lewis River	2,549	40.12	0.21	493,455
77	Sandy River	1,763	13.29	0.18	129,372



Information used in HexSim model development

Assess whether current CWR is sufficient to meet Oregon's narrative criteria

Information used in HexSim model development

Tributary Name	River Mile	Mainstem Temp[1]	Tributary Temp[2]	Temp Difference	Tributary Flow[3]	Plume CWR Volume (> 2°C Δ)[4]	Stream CWR Volume (> 2°C Δ)[5]	Total CWR Volume (> 2°C Δ)
		°C	°C	°C	cfs	m3	m3	m3
Skamokawa Creek	30.9	21.3	16.2	-5.1	23	450	1,033	1,483
Mill Creek	51.3	21.3	14.5	-6.8	10	110	446	556
Abernethy Creek	51.7	21.3	15.7	-5.6	10	81	806	887
Germany Creek	53.6	21.3	15.4	-5.9	8	72	446	518
Cowlitz River	65.2	21.3	16.0	-5.4	3634	870,000	684,230	1,554,230
Kalama River	70.5	21.3	16.3	-5.0	314	14,000	57,089	71,089
Lewis River	84.4	21.3	16.6	-4.8	1291	120,000	493,455	613,455
Sandy River	117.1	21.3	18.8	-2.5	469	9,900	129,372	139,272
Washougal River[6]	117.6	21.3	19.2	-2.1	107	740	32,563	33,303
Bridal Veil Creek	128.9	21.3	11.7	-9.6	7	120	0	120
Wahkeena Creek	131.7	21.3	13.6	-7.7	15	220	0	220
Oneonta Creek	134.3	21.3	13.1	-8.2	29	820	54	874
Tanner Creek	140.9	21.3	11.7	-9.6	38	1,300	413	1,713
Bonneville Dam								
Eagle Creek	142.7	21.2	15.1	-6.1	72	2,100	888	2,988
Rock Creek[6]	146.6	21.2	17.4	-3.8	47	530	1,178	1,708
Herman Creek	147.5	21.2	12.0	-9.2	45	168,000	1,698	169,698
Wind River	151.1	21.2	14.5	-6.7	293	60,800	44,420	105,220
Little White Salmon River	158.7	21.2	13.3	-7.9	88	1,097,000	4,126	1,101,126
White Salmon River	164.9	21.2	15.7	-5.5	715	72,000	81,529	153,529
Hood River	165.7	21.4	15.5	-5.9	374	28,000	0	28,000
Klickitat River	176.8	21.4	16.4	-5.0	851	73,000	149,029	222,029
The Dalles Dam								
Deschutes River	200.8	21.4	19.2	-2.2	4772	300,000	580,124	880,124
John Day Dam								
Umatilla River[6]	284.7	20.9	20.8	-0.1	169	0	46,299	46,299

Assess whether current CWR is sufficient to meet Oregon's narrative criteria

HexSim Modeling

Refuge use has many benefits, but also presents some risks.

Quantifying consequences of refuge use is difficult.

Evaluating impacts on the population level dynamics is even harder.

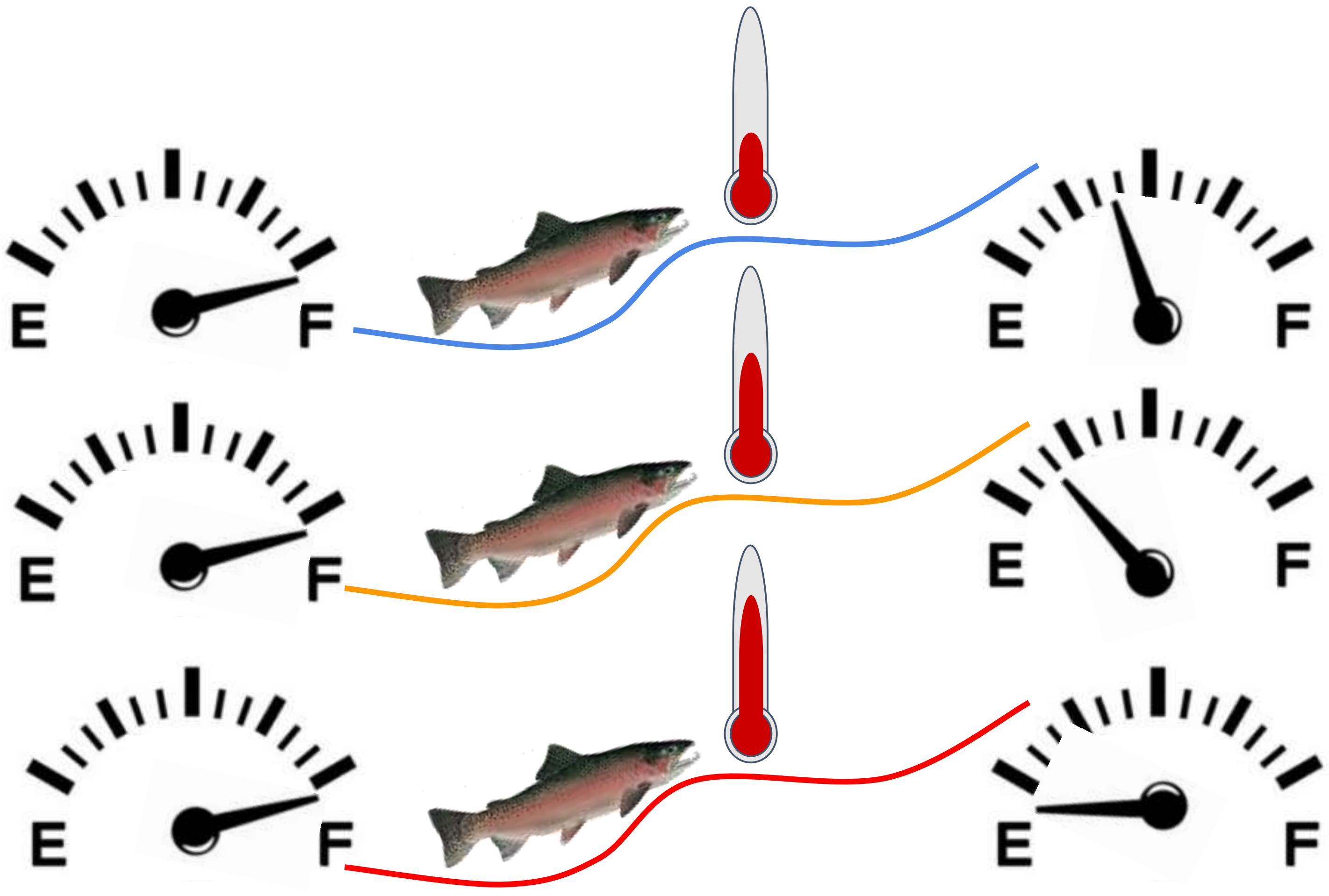
Constructed the HexSim mechanistic model to conduct virtual experiment that rank proposed management action on salmon and steeelhead, for both individuals and populations.

Marcía Snyder, Nathan Schumaker (OSU),
Joseph Ebersole, and Randy Comeleo
EPA ORD Corvalis

Assess whether current CWR is sufficient to meet Oregon's narrative criteria

HexSim uses bioenergetics equations to keep track of the available energy for a fish.

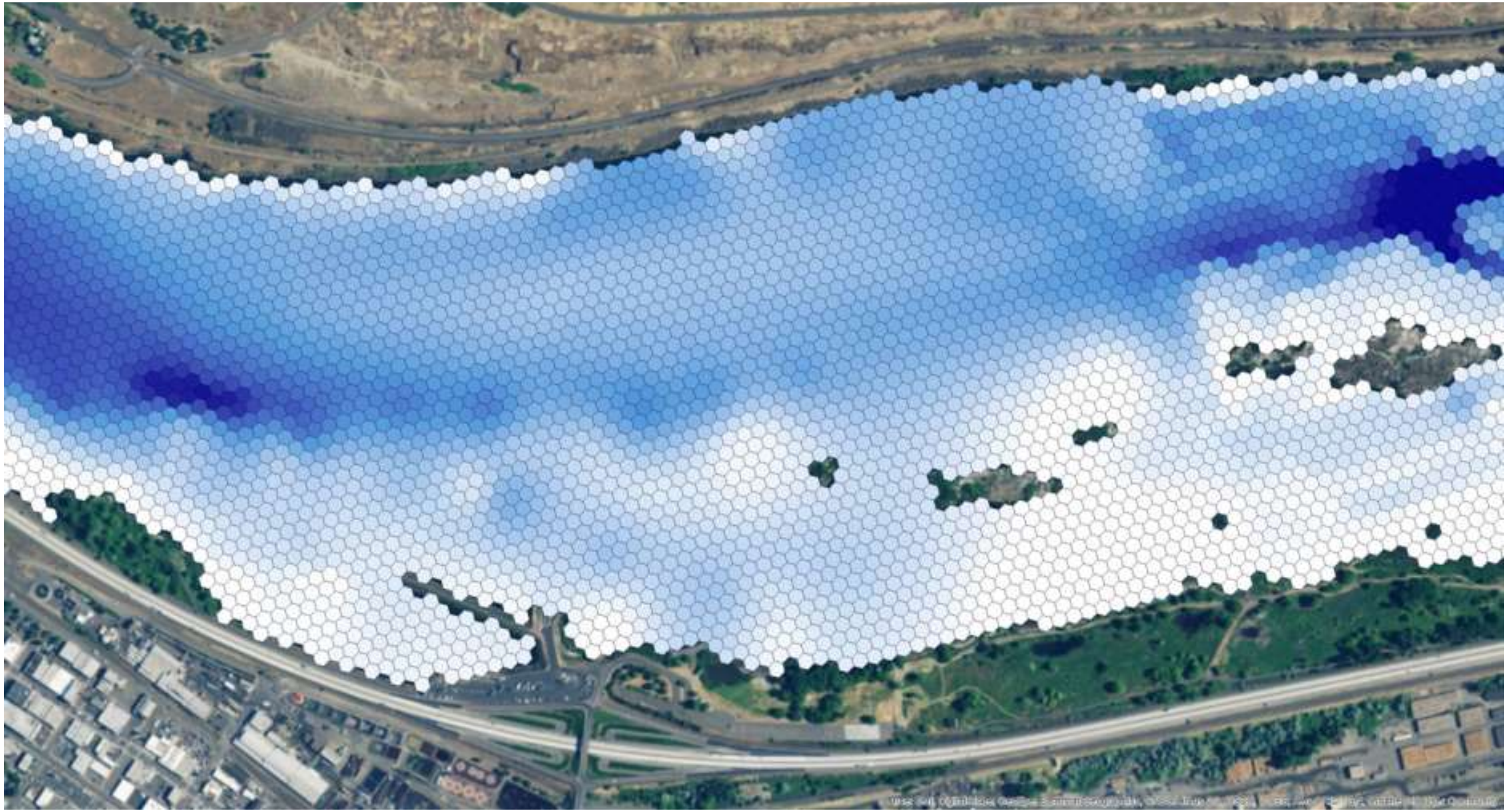
The equations take into account the fish weight and thermal exposure.



Assess whether current CWR is sufficient to meet Oregon's narrative criteria

HexSim is an individual based model used to model patchy landscapes

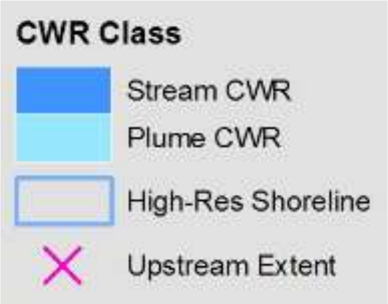
The individuals in HexSim move through a landscape of hexagons



Assess whether current CWR is sufficient to meet Oregon's narrative criteria

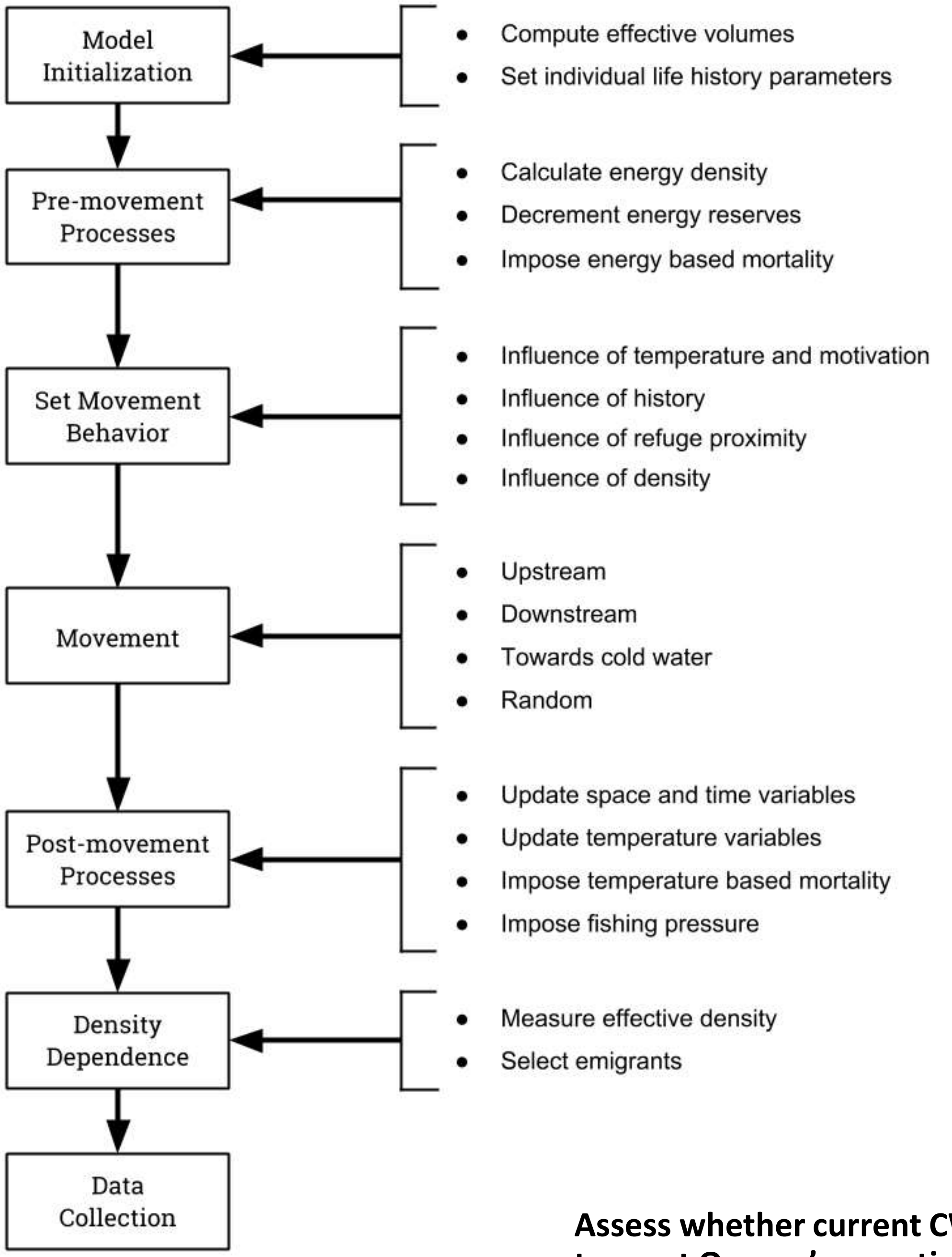
HexSim Riverscape: temperature

Thermal regimes (and other simulation model inputs) can be characterized by tributaries, their plumes, and the Columbia River.



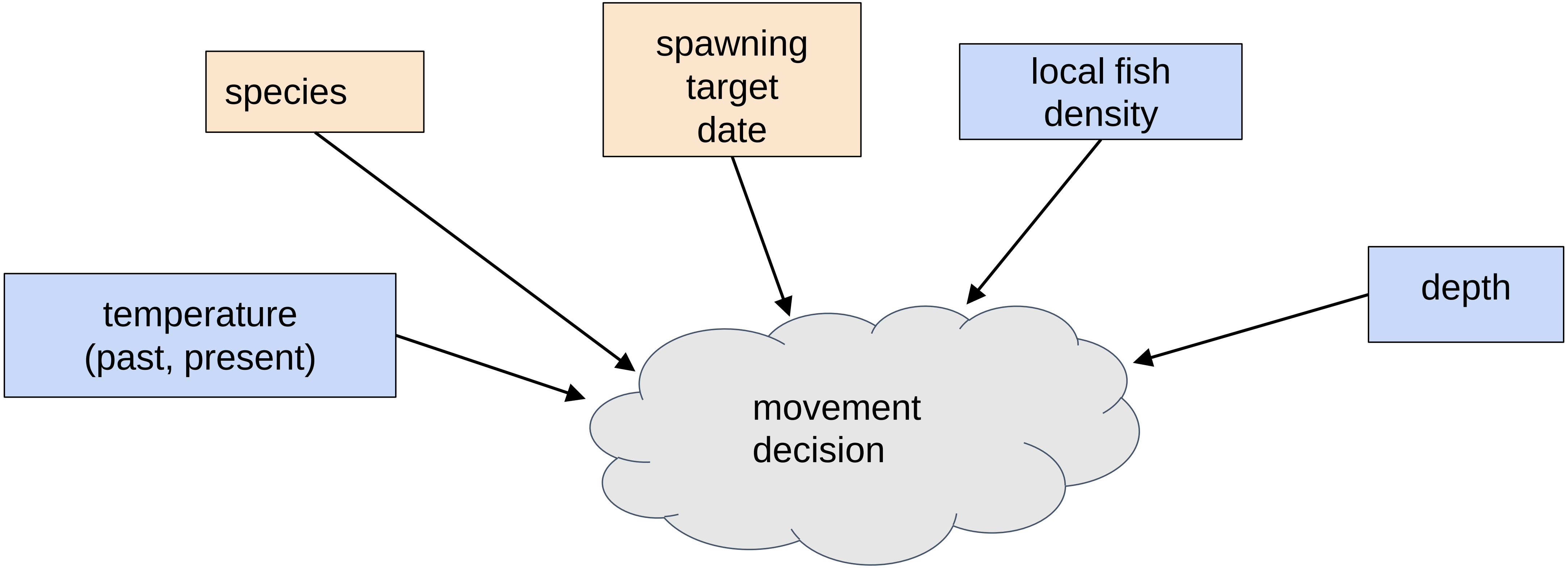
Assess whether current CWR is sufficient to meet Oregon's narrative criteria

HexSim-Fish Model Overview



Assess whether current CWR is sufficient to meet Oregon's narrative criteria

Behavioral Decision Tree



Individual salmon and steelhead enter the model with associated characteristics.

Assess whether current CWR is sufficient to meet Oregon's narrative criteria

HexSim Simulation Outcomes

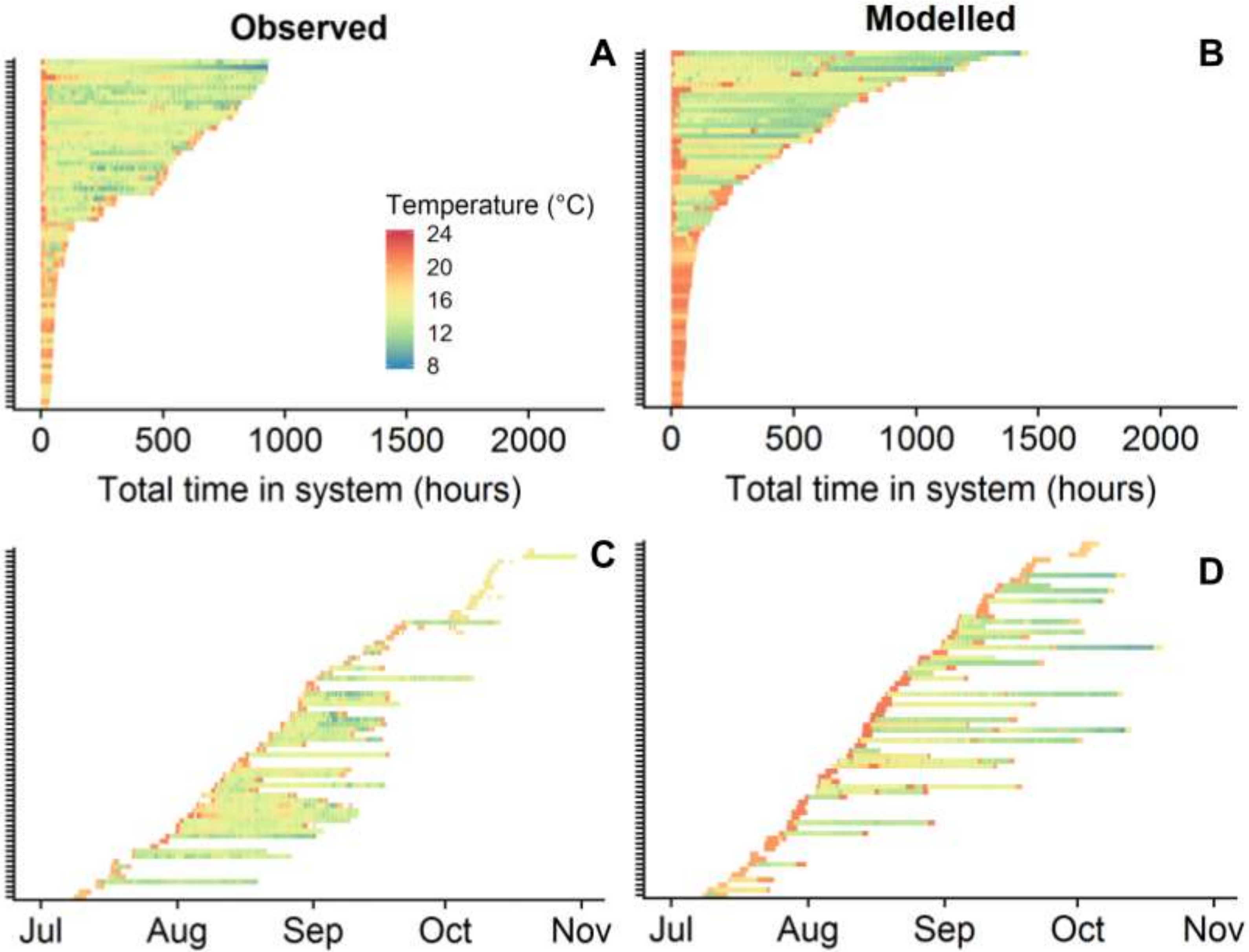
Track individual exposure through space and time

- Measure cumulative exposure and impacts to multiple stresses
- Aggregate individual outcomes to the population scale

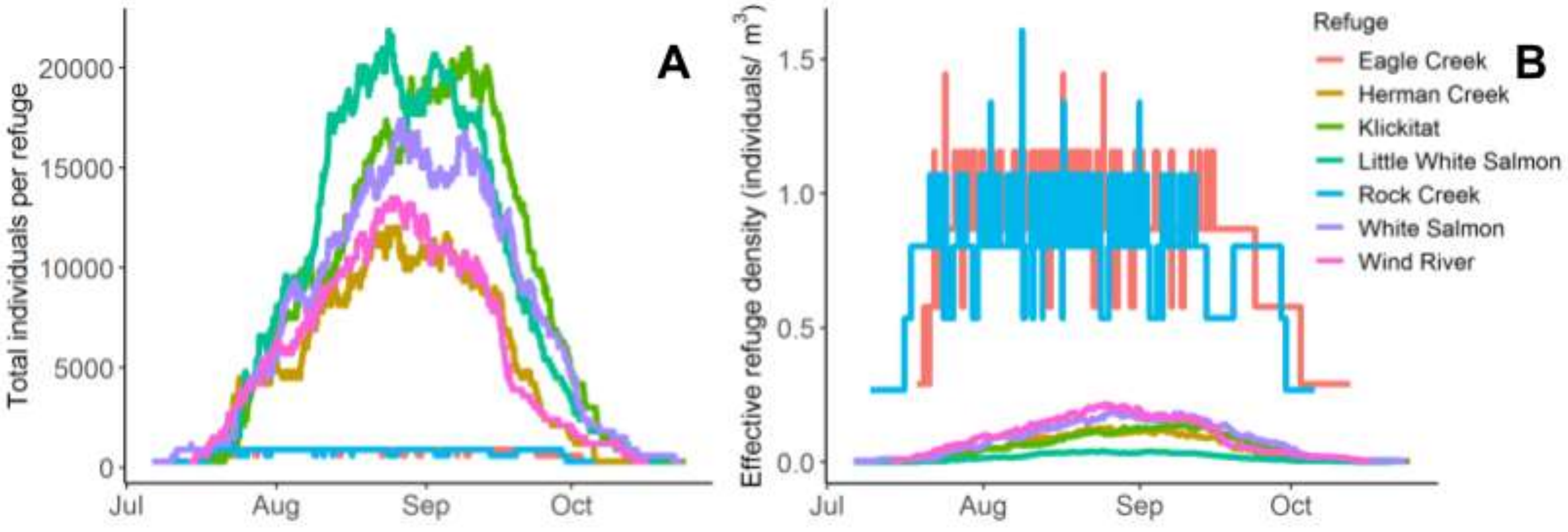
How do the costs and benefits of cold water refuges manifest at population and landscape scales?

Assess whether current CWR is sufficient to meet Oregon's narrative criteria

Temperature Time Series



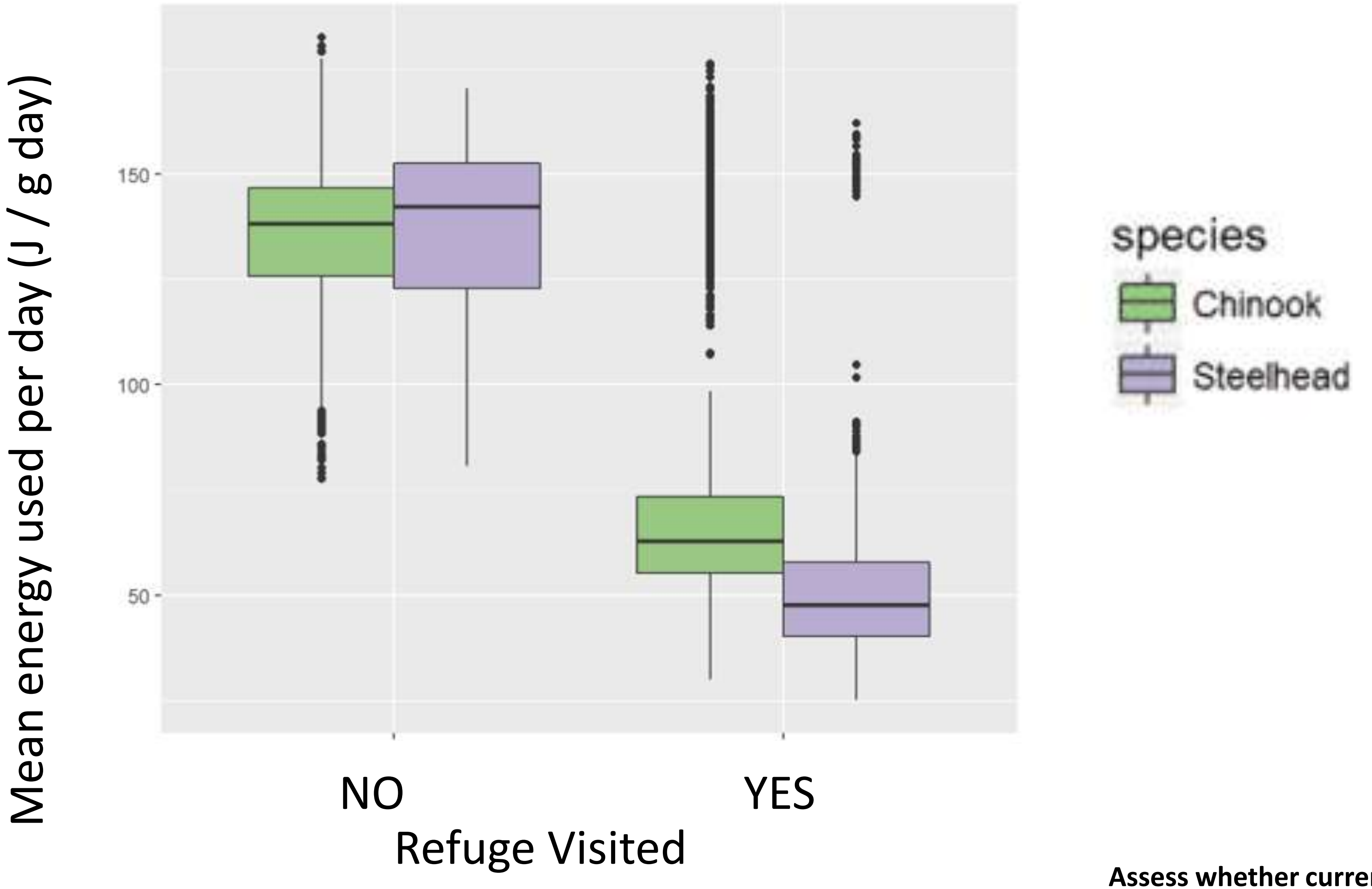
Effect of Density



Total individuals per refuge through time for steelhead and chinook combined.

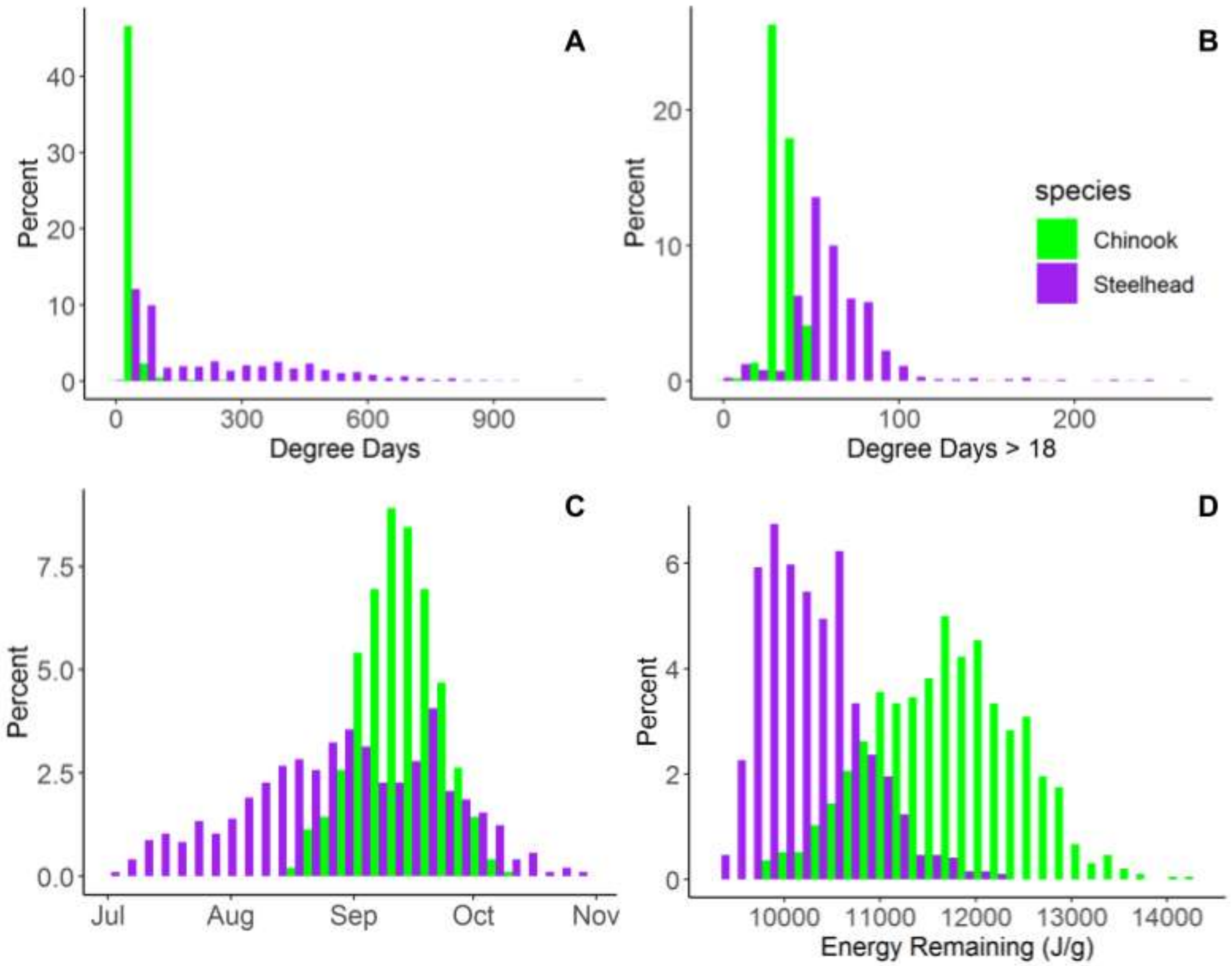
Effective density per refuge through time for steelhead and chinook combined.

Energy Use



Assess whether current CWR is sufficient to meet Oregon's narrative criteria

Fish Fitness Model Outcomes



EPA Columbia River CWR Plan

1. Map and characterize the CWR areas in the Lower Columbia River

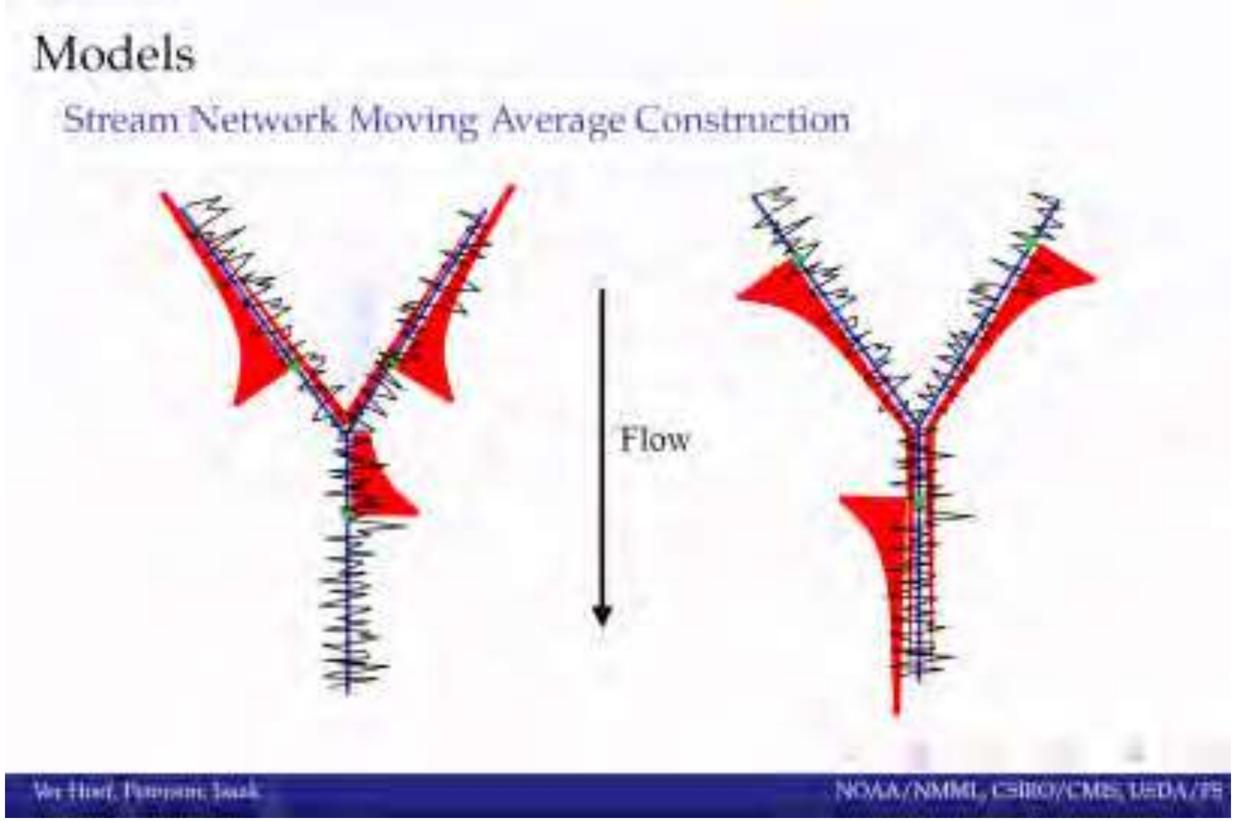
2. Characterize the extent to which salmon and steelhead use CWR

3. Assess whether current CWR is sufficient to meet Oregon's narrative criteria

4. Identify actions to protect, restore, or enhance CWR

Identify actions to protect, restore, or enhance CWR

Calculate Stream Temperature using the SSN Model (NorWeST)

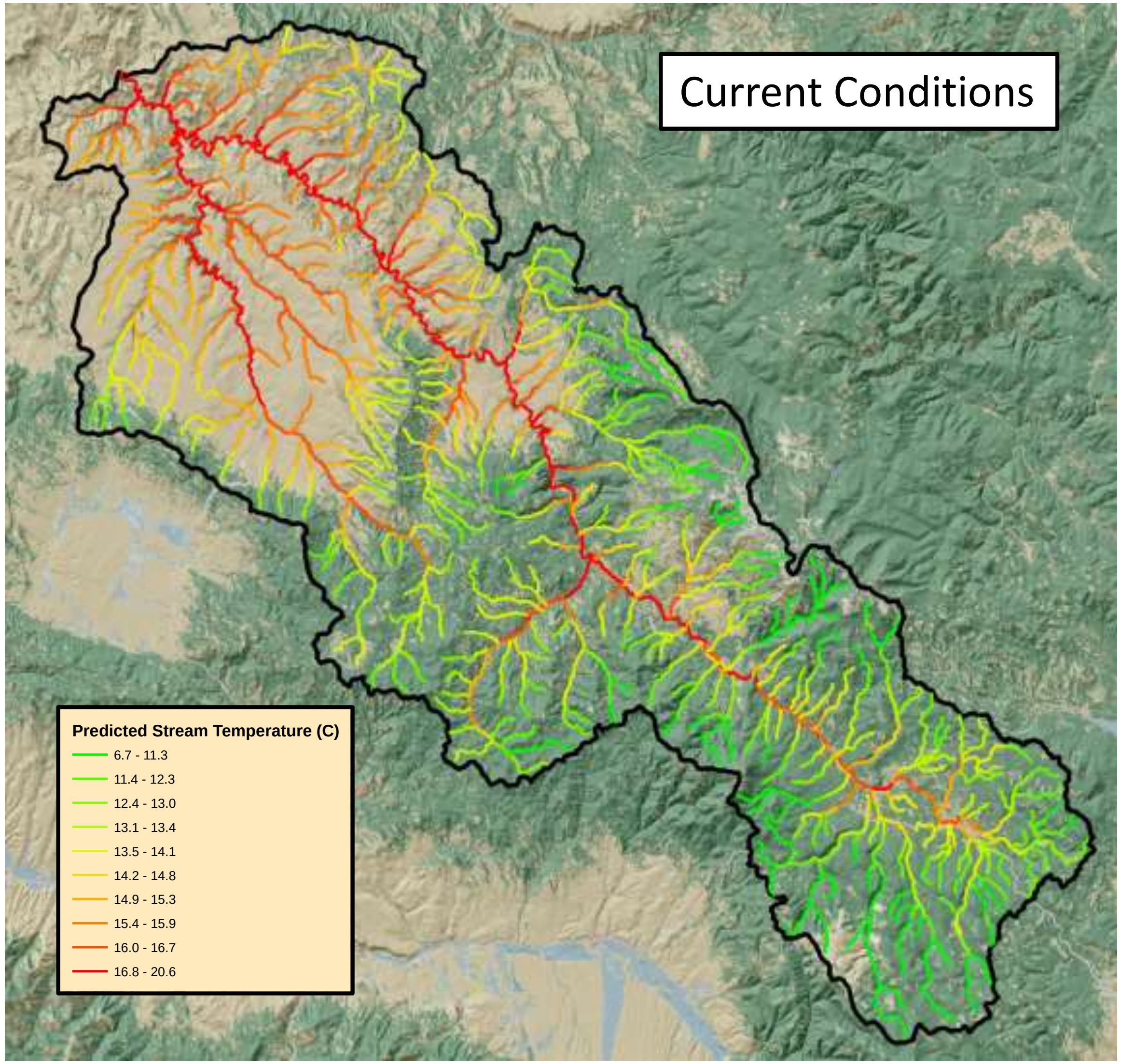


NorWeST Spatial Covariates

1) Air Temperature
2) Stream Discharge
3) Elevation
4) Latitude
5) Canopy %
6) Cumulative drainage area
7) Stream Slope %
8) Mean annual precipitation
9) Base Flow index (BFI)
10) Glacier %
11) Lake %
12) Tailwater (Y/N)

Identify actions to protect, restore, or enhance CWR

Calculate Stream Temperature using the SSN Model (NorWeST)



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Identify actions to protect, restore, or enhance CWR

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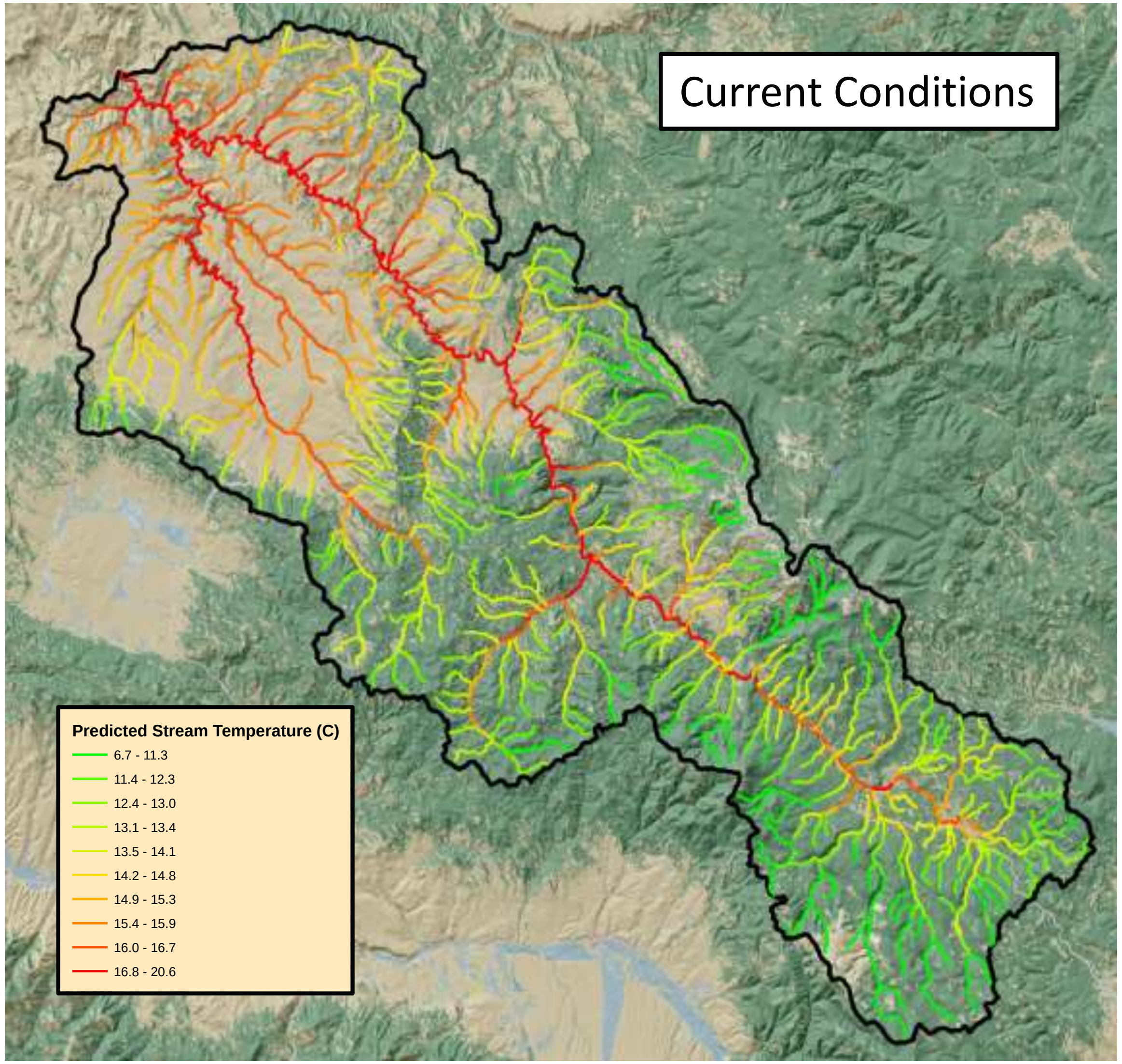

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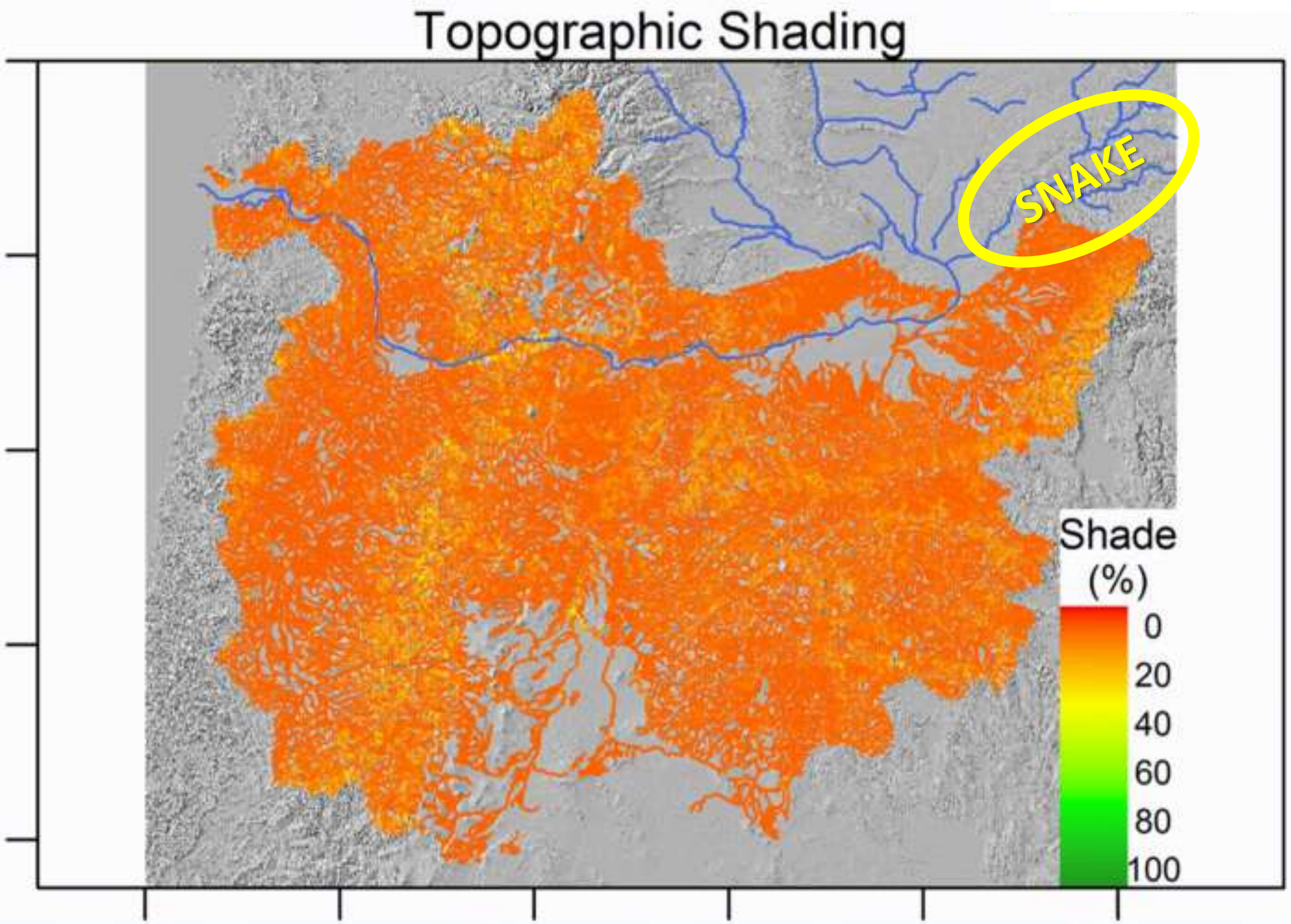
Identify actions to protect, restore, or enhance CWR

Shade Maps:

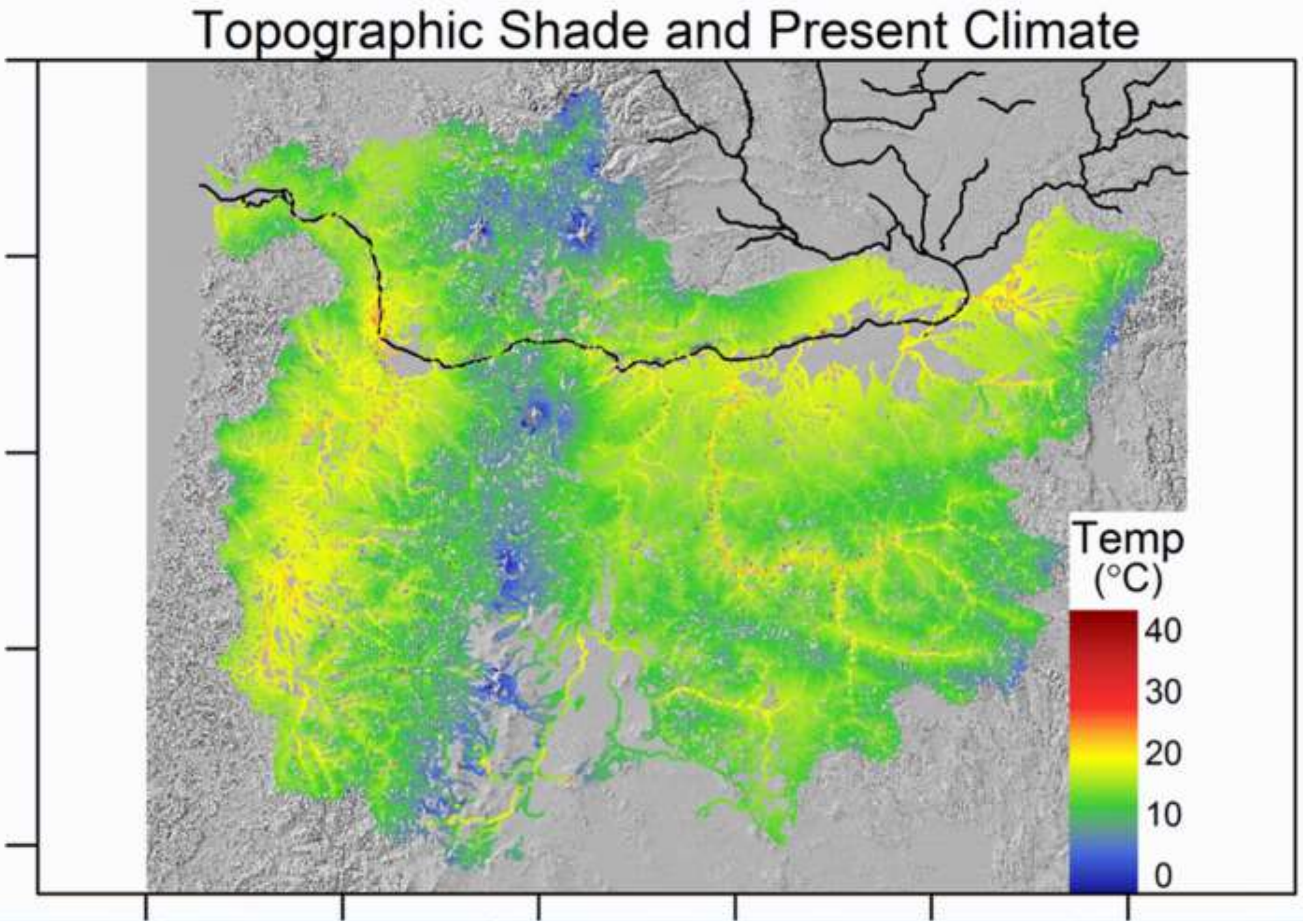


Identify actions to protect, restore, or enhance CWR

Temp Change by Shade

How does altering riparian shade affect stream temperature?

	Topo.	Pres.	Pot.
Pres.	**Pres./ Topo.**	Pres./ Pres.	Pres./ Pot.
2040	2040/ Topo.	2040/ Pres.	2040 /Pot.
2080	2080/ Topo.	2080/ Pres.	2080/ Pot.



Matthew Fuller, and Naomi Detenbeck (EPA ORD Narraganset), and Dan Isaak (USFS)

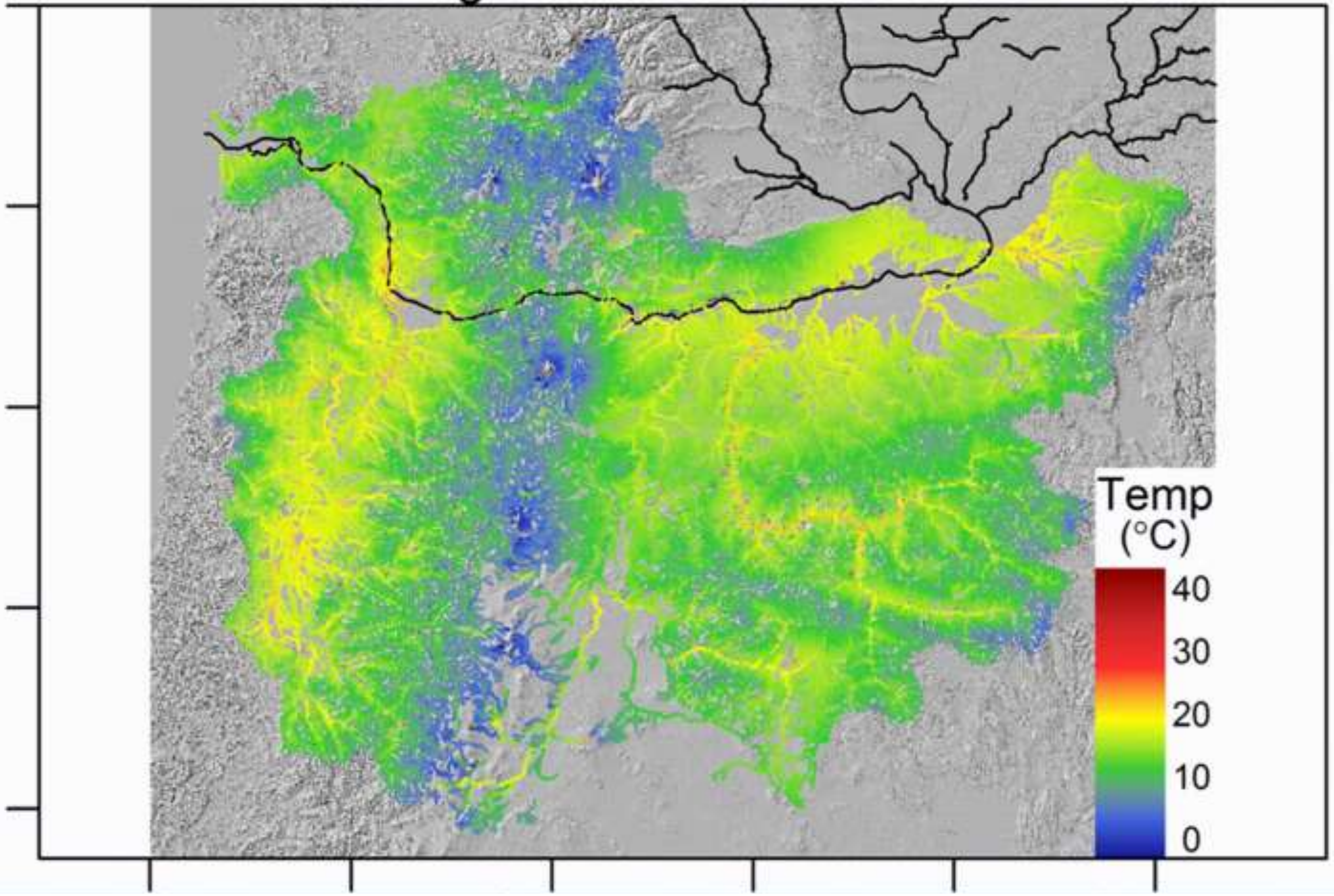
Identify actions to protect, restore, or enhance CWR

Temp Change by Climate

How will future climate shifts affect stream temperature?

	Topo.	Pres.	Pot.
Pres.	Pres./ Topo.	**Pres./ Pres.**	Pres./ Pot.
2040	2040/ Topo.	2040/ Pres.	2040 /Pot.
2080	2080/ Topo.	2080/ Pres.	2080/ Pot.

Present Veg. Shade and Present Climate



Matthew Fuller, and Naomi Detenbeck (EPA ORD Narraganset), and Dan Isaak (USFS)

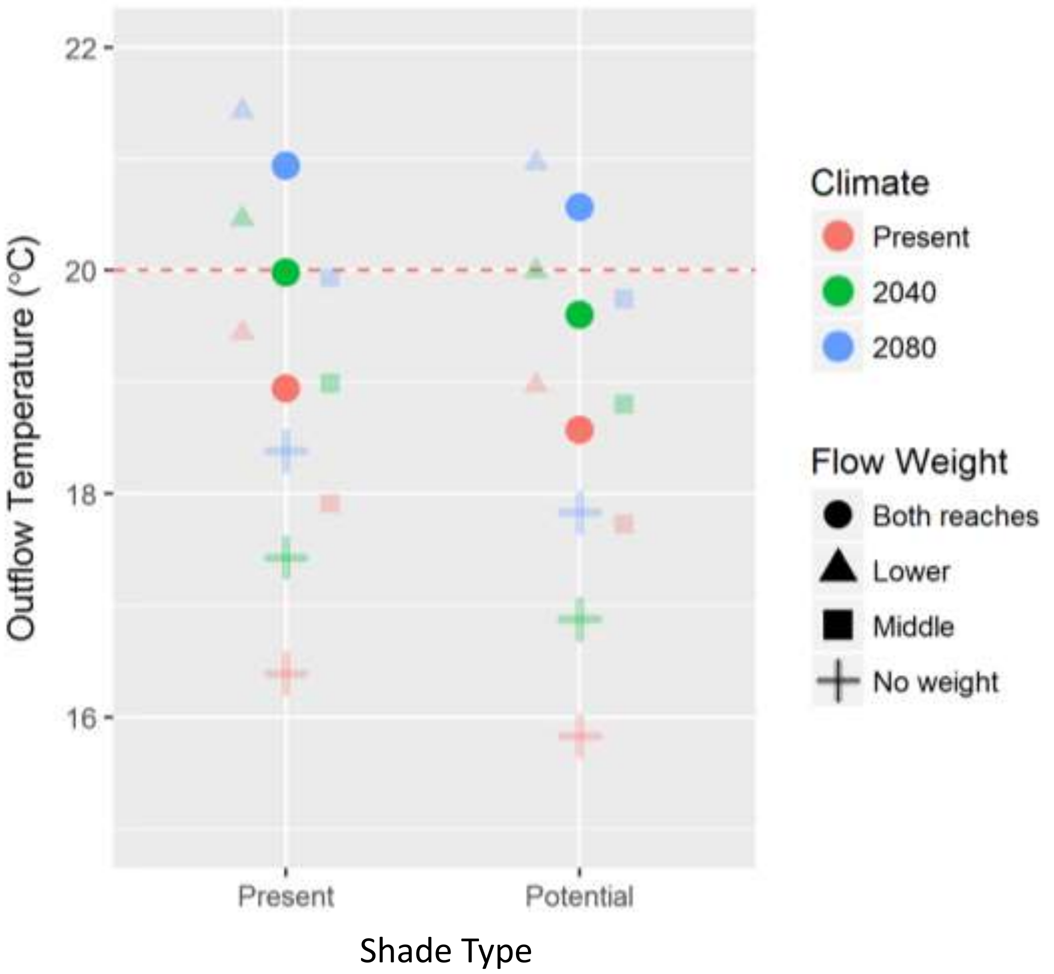
Identify actions to protect, restore, or enhance CWR

Calculate Stream Temperature using the SSN Model (NorWeST)

All tributaries (198)

LOWER-COLUMBIA
n=116
Largest: Willamette

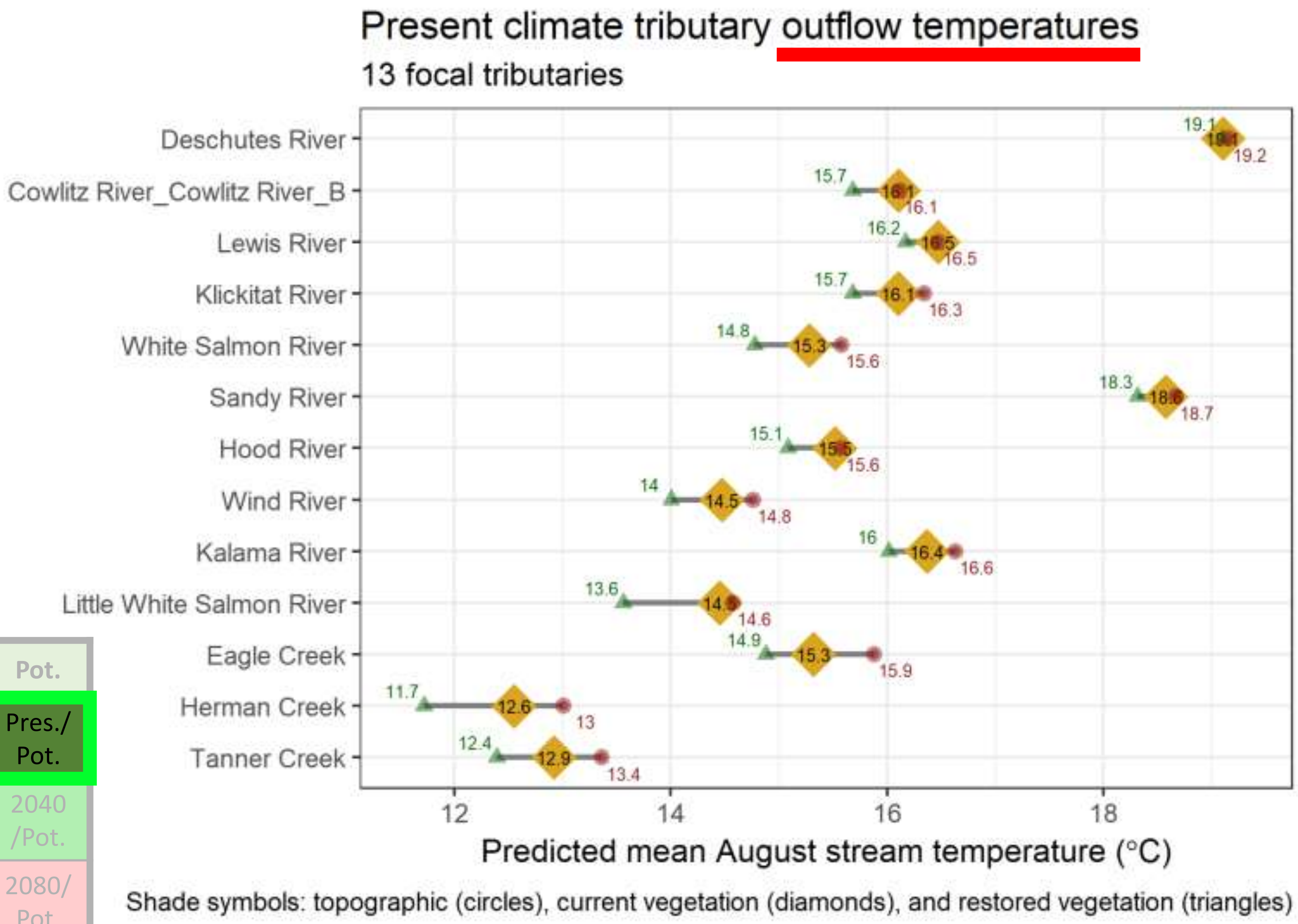
MID-COLUMBIA
n=82
Largest: Deschutes



Potential Input into the HexSim Model

Identify actions to protect, restore, or enhance CWR

Individual Tributary Management



	Topo.	Pres.	Pot.
Pres.	Pres./ Topo.	Pres./ Pres.	Pres./ Pot.
2040	2040/ Topo.	2040/ Pres.	2040 /Pot.
2080	2080/ Topo.	2080/ Pres.	2080/ Pot.

Potential Input into the HexSim Model

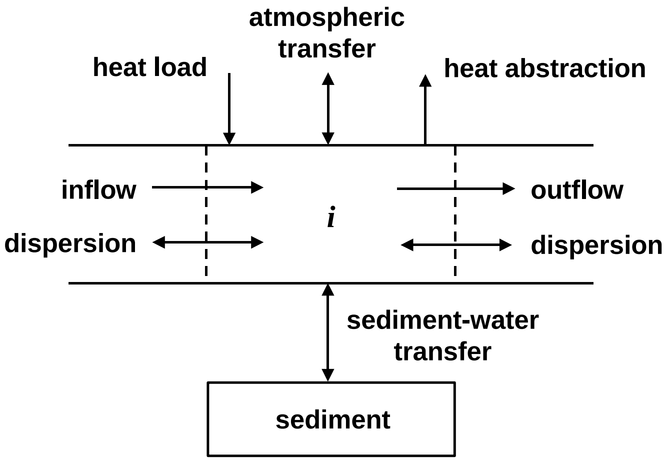
Identify actions to protect, restore, or enhance CWR

Currently we are starting the “what if” runs with the HexSim Model

Thank You

Extra Slides

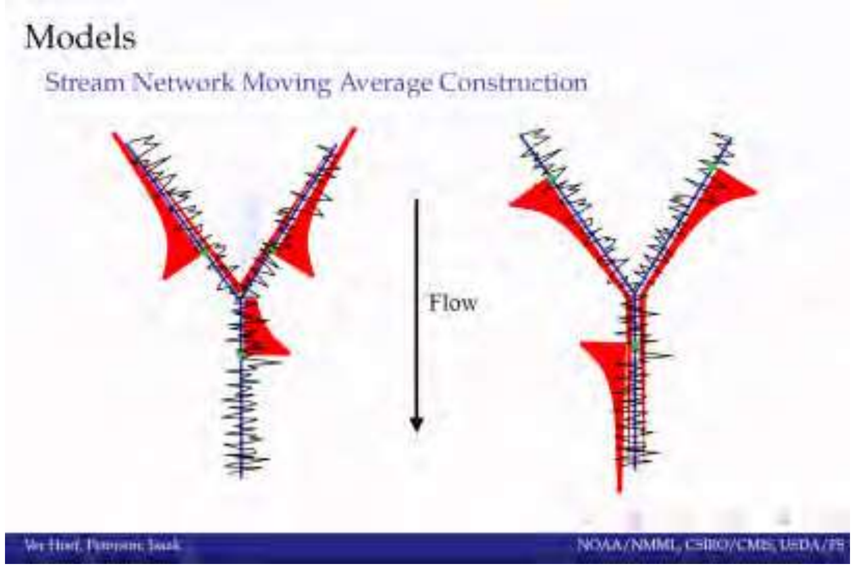
Big Cold Small Cold RARE Project



$$\frac{dT_i}{dt} = \frac{Q_{i-1}}{V_i} T_{i-1} - \frac{Q_i}{V_i} T_i - \frac{Q_{ab,i}}{V_i} T_i + \frac{E_{i-1}^{'}}{V_i}\left(T_{i-1} - T_i\right) + \frac{E_i^{'}}{V_i}\left(T_{i+1} - T_i\right)$$

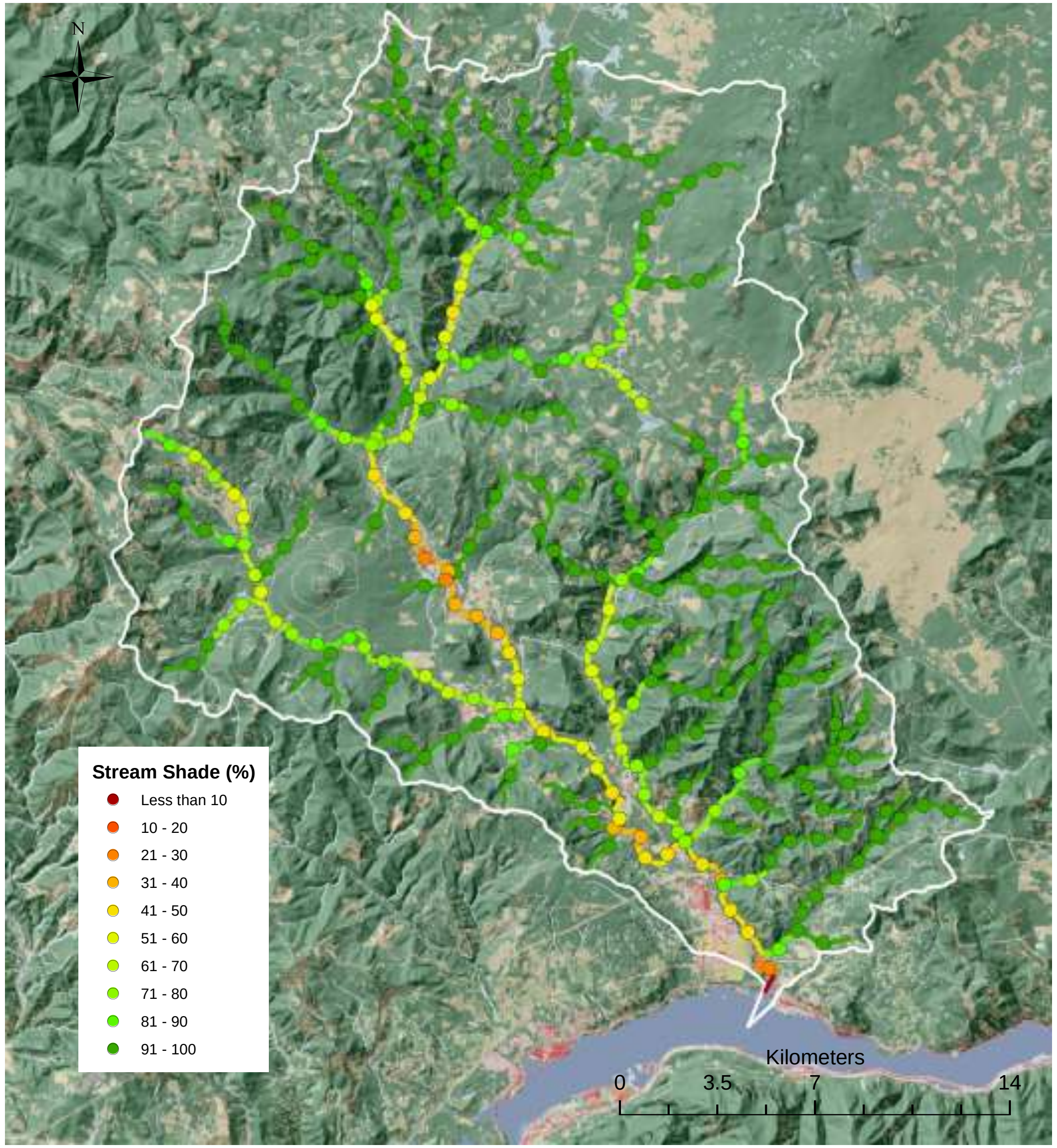
$$+ \frac{W_{h,i}}{\rho_w C_{pw} V_i}\left(\frac{\mathrm{m}^3}{10^6\ \mathrm{cm}^3}\right) + \frac{J_{h,i}}{\rho_w C_{pw} H_i}\left(\frac{\mathrm{m}}{100\ \mathrm{cm}}\right) + \frac{J_{s,i}}{\rho_w C_{pw} H_i}\left(\frac{\mathrm{m}}{100\ \mathrm{cm}}\right)$$

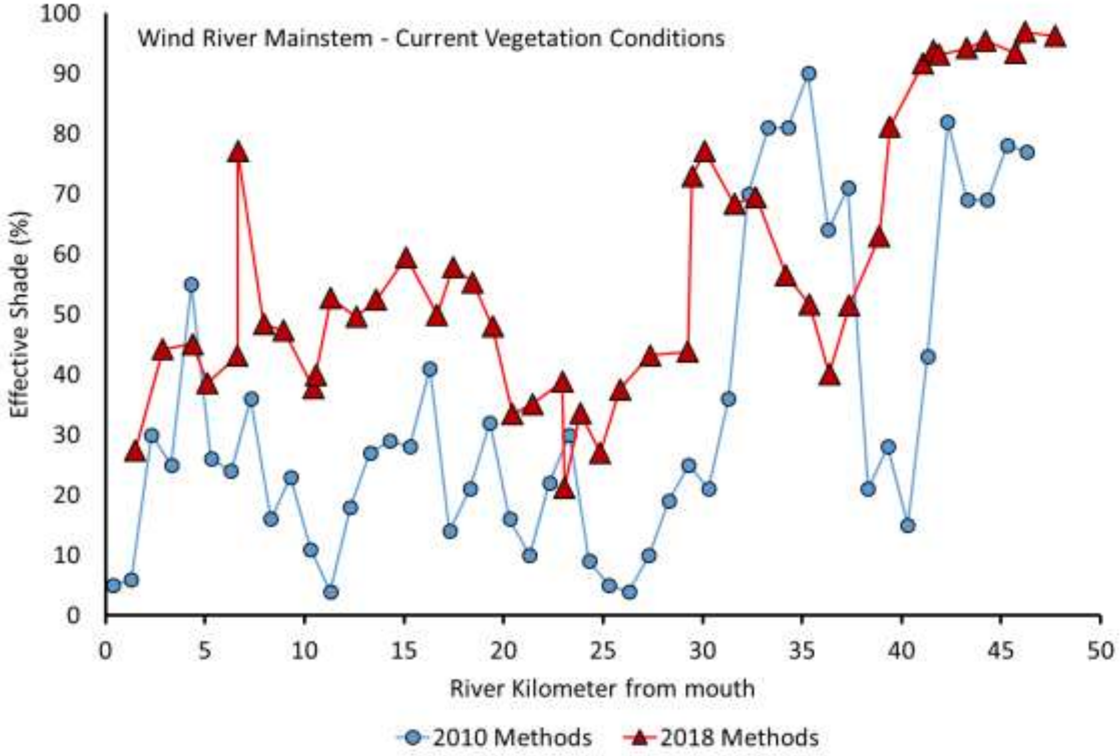
Vs.



Identify actions to protect, restore, or enhance CWR

Calculate Effective Shade using Methods Presented at 2016 NWMod meeting





Identify actions to protect, restore, or enhance CWR

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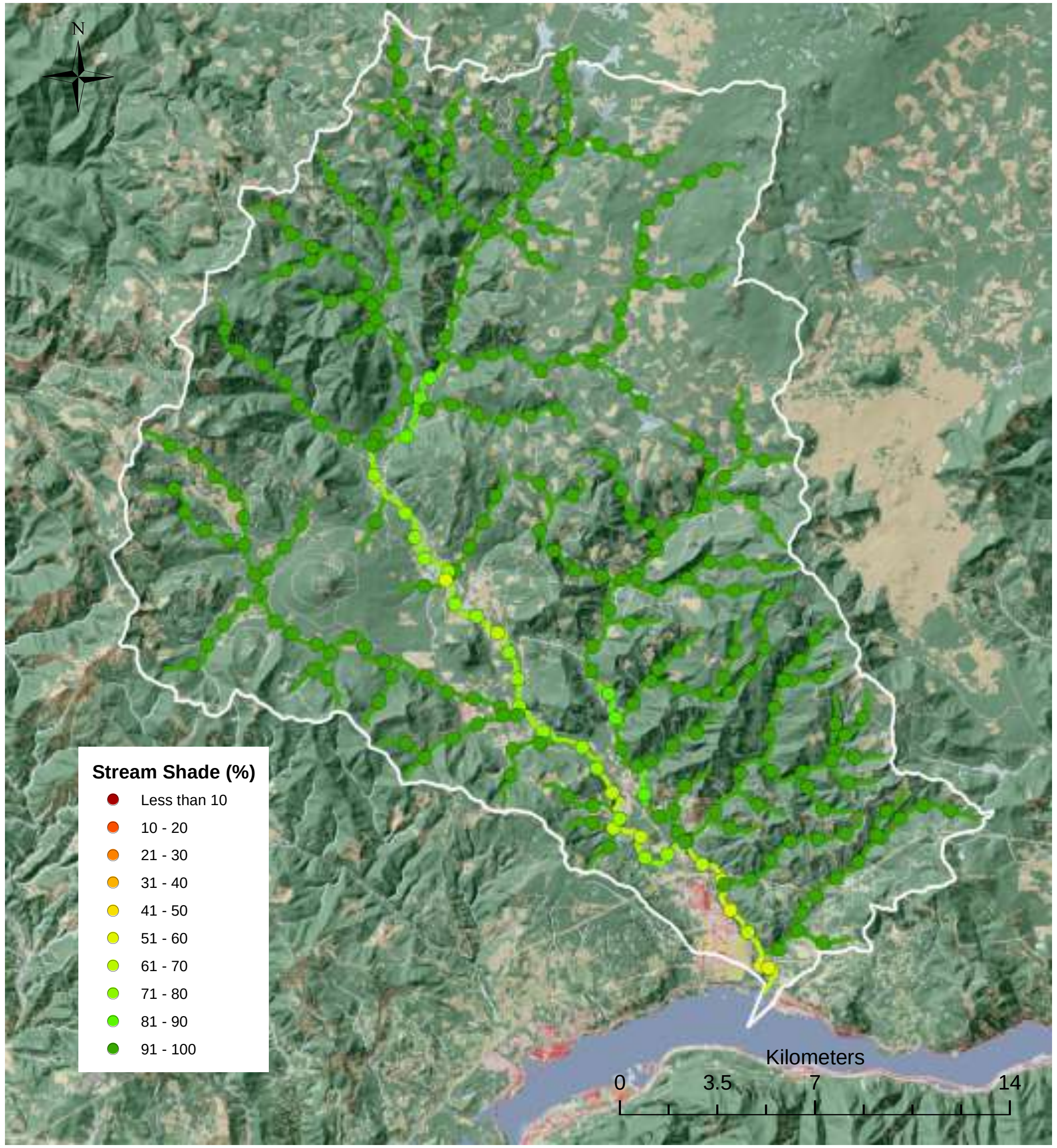
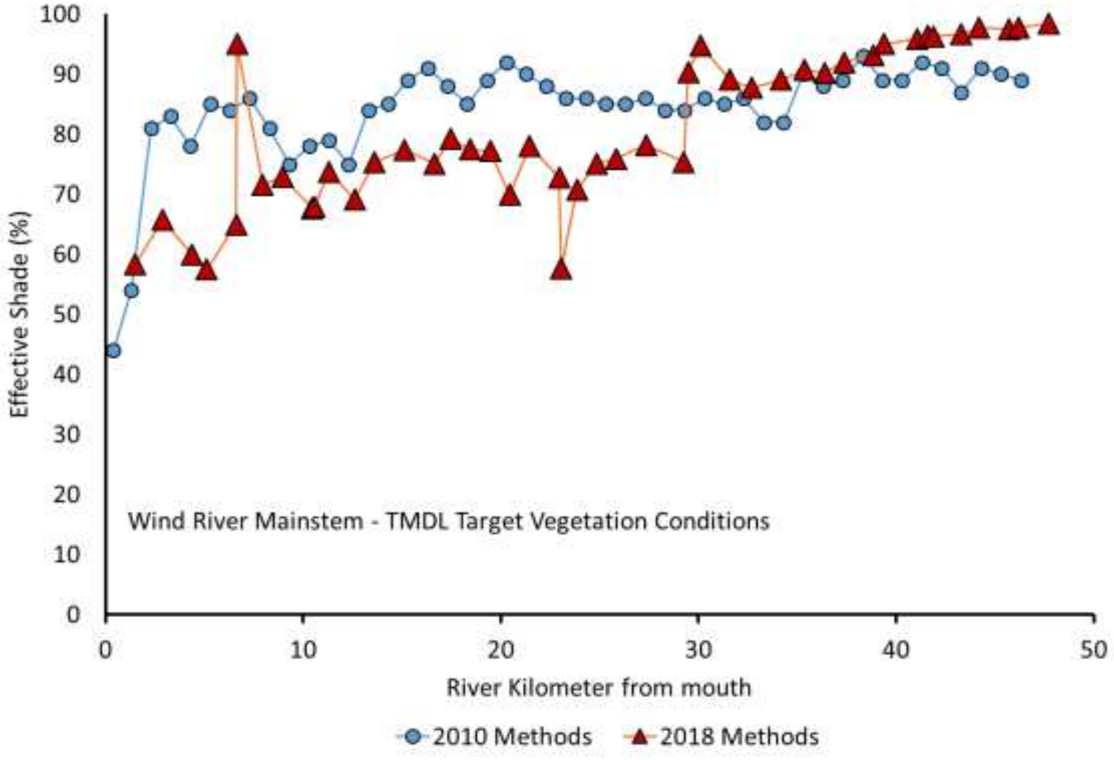
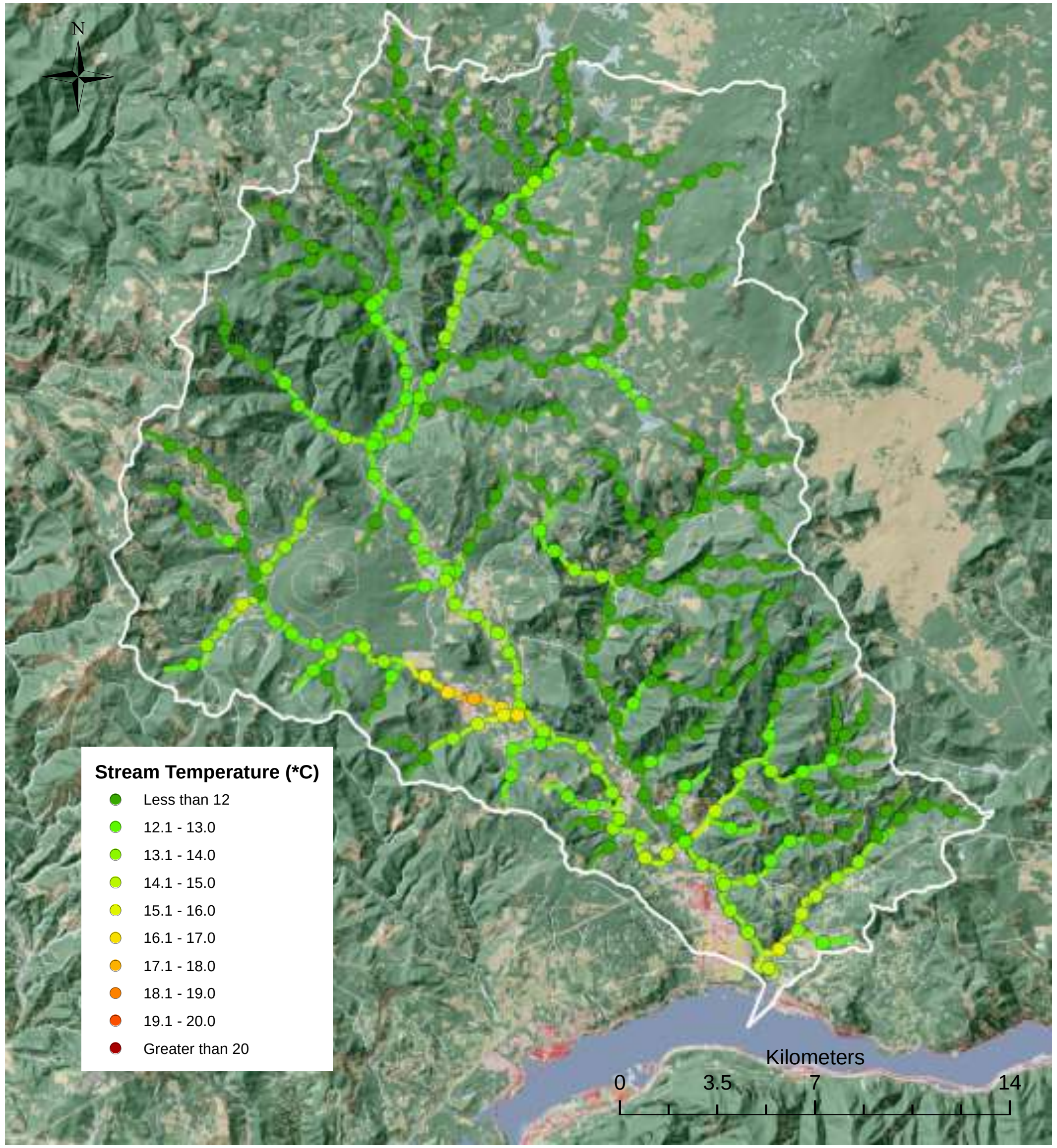
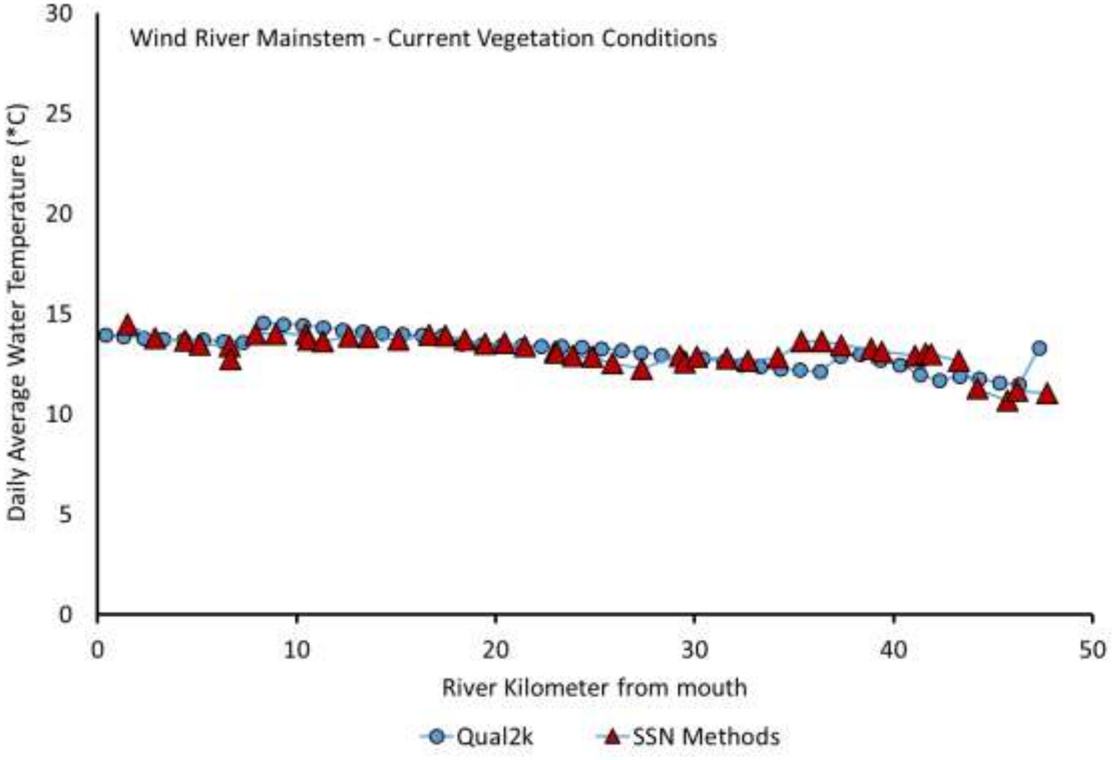




Identify actions to protect, restore, or enhance CWR

Calculate Stream Temperature using the SSN Model (NorWeST)





Identify actions to protect, restore, or enhance CWR

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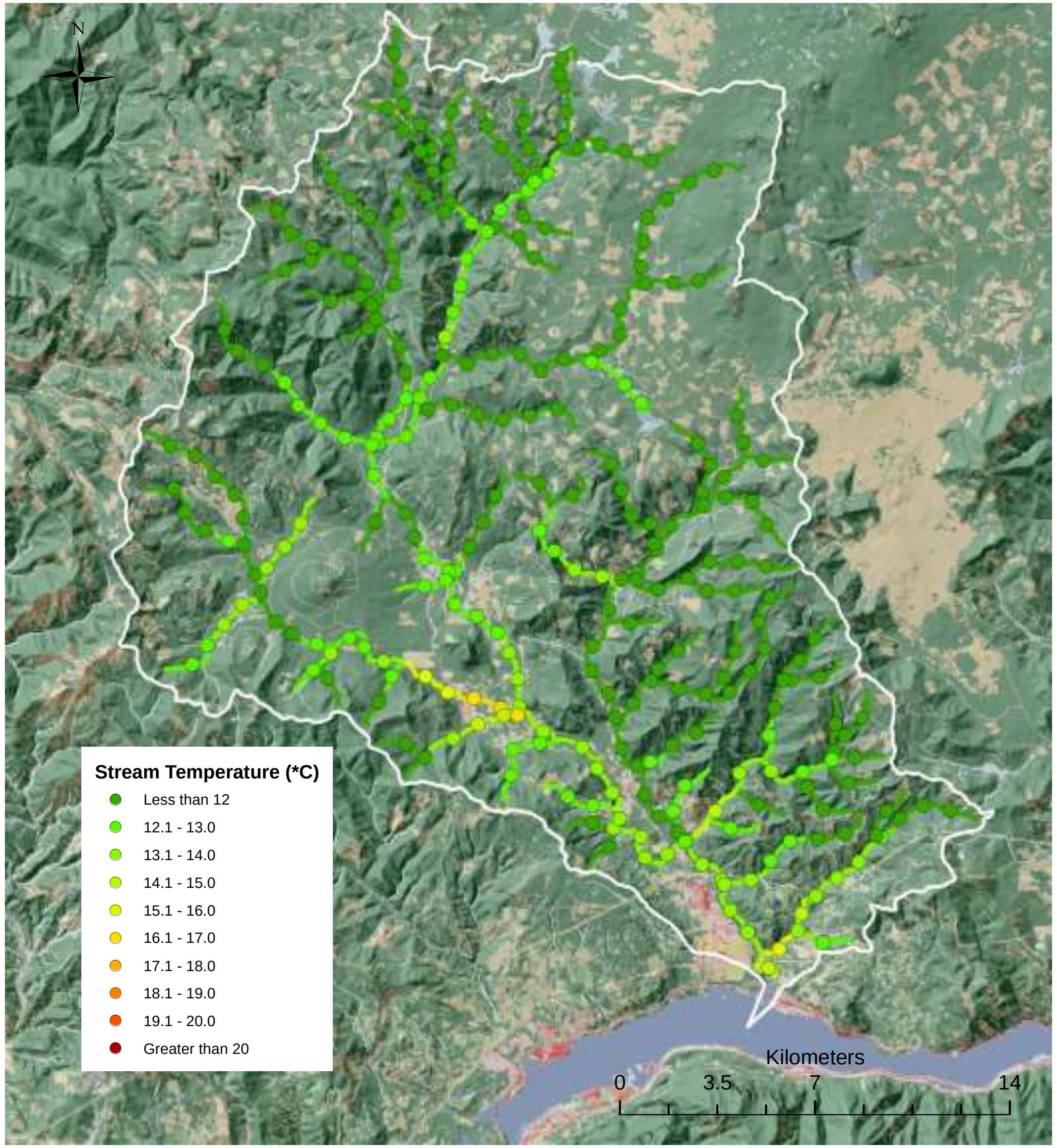
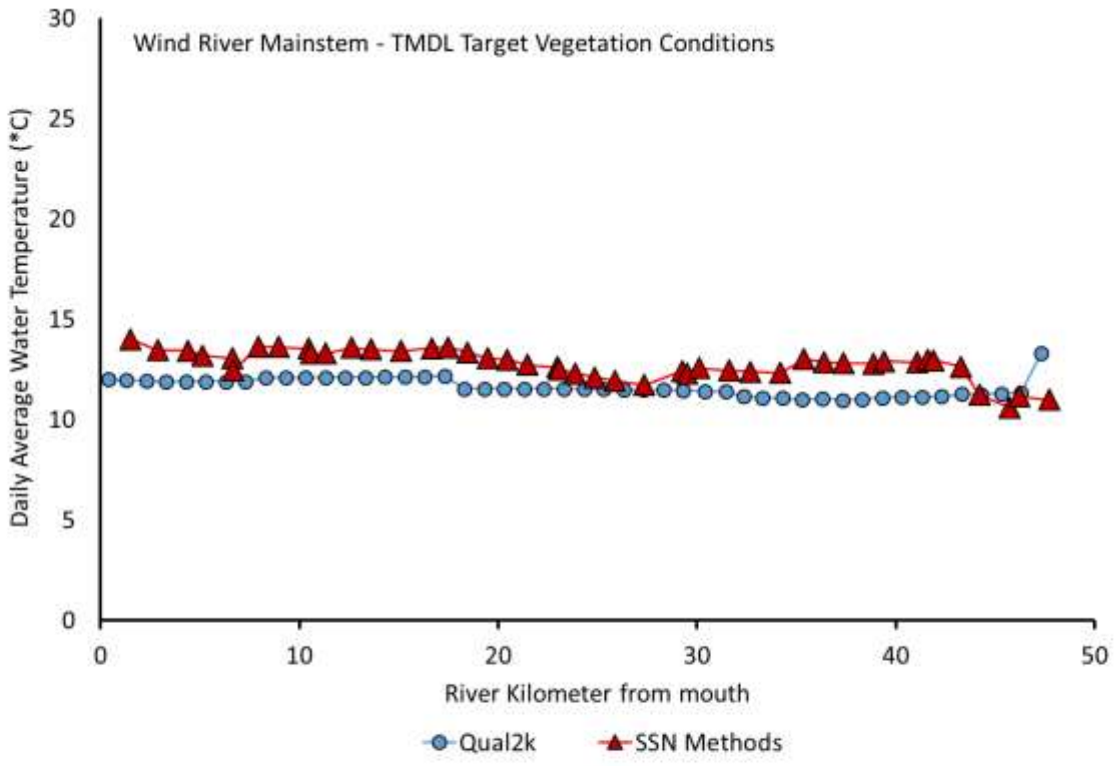




Identify actions to protect, restore, or enhance CWR

CITY OF BOISE 316(A) DEMONSTRATION PROJECT FOR IDAHO POLLUTANT DISCHARGE ELIMINATION SYSTEM (IPDES) PERMITS

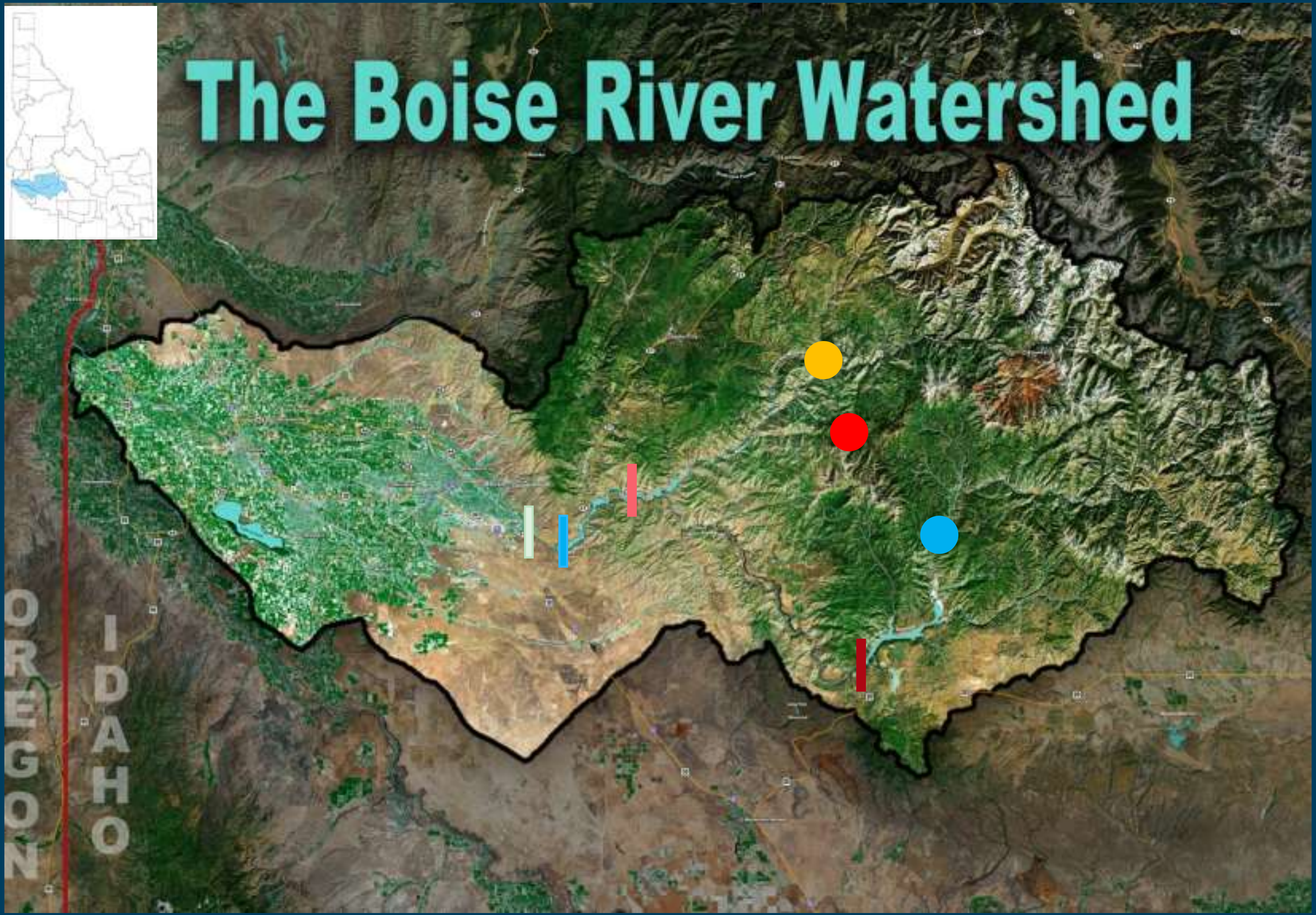
Dorene MacCoy, Water Quality Environmental Coordinator, Public Works Department
Darcy Sharp, Environmental Data Analyst, Public Works Department

AGENDA

- Area overview
  - Receiving water – Lower Boise River
  - Water Renewal Facilities – Lander Street and West Boise
  - Temperature discharge limits
  - Need for thermal variance
- 316(a) thermal variance
- Temperature data
- Temperature modeling
- Biological data
- Demonstration results

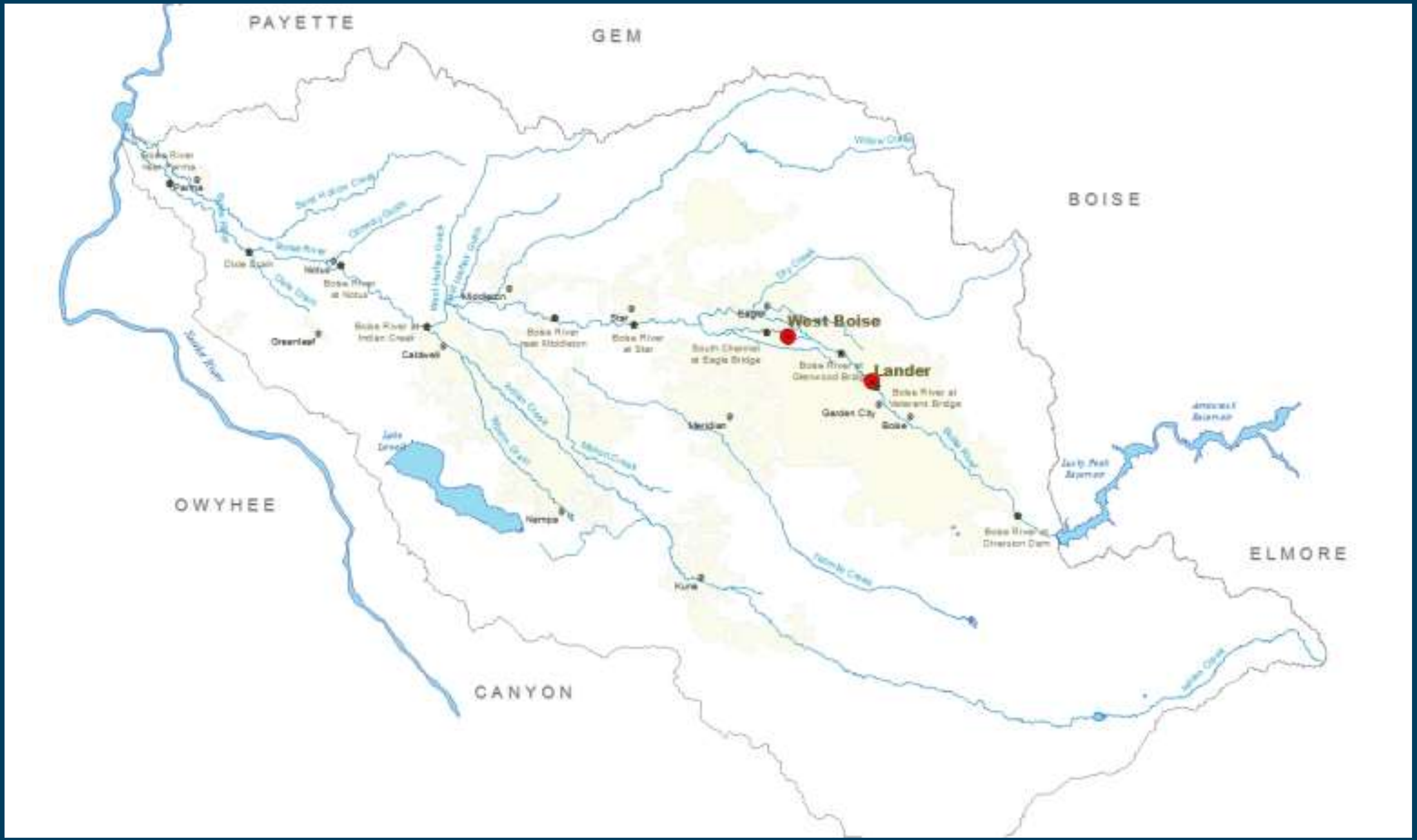
CITY of BOISE

- North Fork
- Middle Fork
- South Fork
- Reservoirs/irrigation
  - Diversion Dam/NY Canal - 1909
  - Arrowrock - 1915
  - Anderson Ranch – 1950
  - Lucky Peak - 1955



MULTIPLE USES

LOWER BOISE RIVER

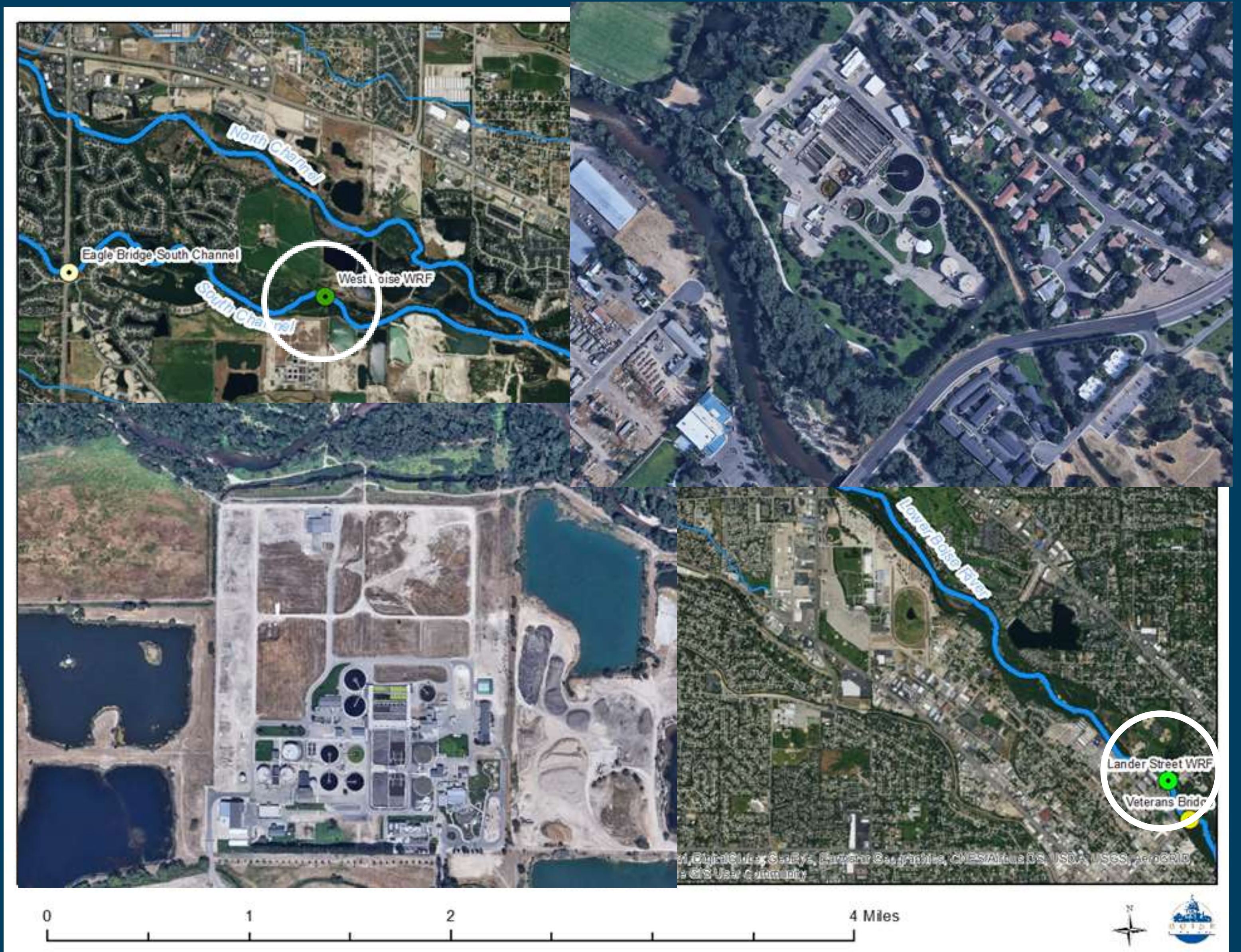


CITY of BOISE

Water Renewal Facilities

Lander Street Water Renewal Facility

West Boise Water Renewal Facility



DISCHARGE PERMIT LIMITS

Idaho water quality standards (Integrated impairment status report)

- Beneficial use support
- Cold Water Criteria – max 22^{0}C, max daily average 19^{0}C
- Salmonid Spawning Criteria – max weekly max 13^{0}C, Nov 1 – May 30.

Antidegradation policy and Total Maximum Daily Load (TMDL)

- Temperature impaired – Veterans Bridge to mouth (4 segments)
- Protect existing uses

Discharge mixing zone criteria

- Plume – 2 seconds from discharge max 32^{0}C, >5% of cross-section >25^{0}C, >25% of cross-section >21^{0}C
- Plume in spawning areas – max weekly max 13^{0}C, during spawning no increase >0.3^{0}C

DISCHARGE PERMIT LIMITS CONT.

Lander Street

Existing thermal limits (^{0}C)

To be met by Aug 2022 (10 years after permit issuance)

Date	Max Wkly Max	Ave Daily limit	Max limit
Nov – April 30	15.8	NA	NA
May	16.4	NA	NA
July 16 – Sept 30	NA	19.0	22.0
October	NA	22.2	27.3

West Boise

Existing thermal limits (^{0}C)

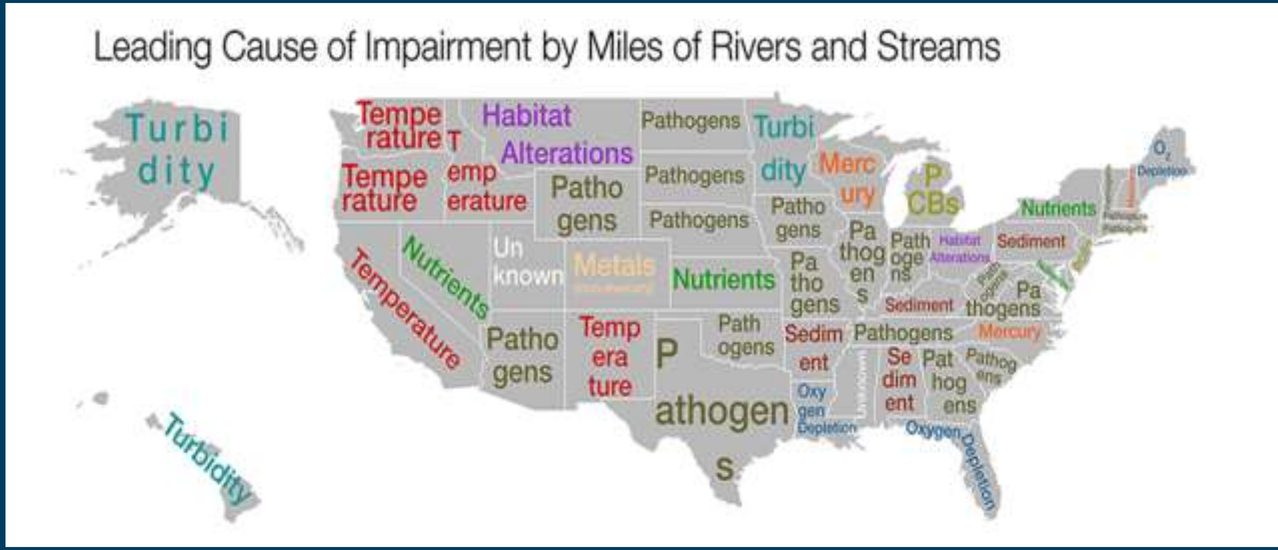
To be met by Aug 2022 (10 years after permit issuance)

Date	Max Wkly Max	Ave Daily limit	Max limit
Nov 1 – March 31	13.5	NA	NA
April	13.3	NA	NA
May	13.5	NA	NA
June 1 – July 15	NA	22.6	26.1
July 16 – Sept 30	NA	19.0	22.0
October	NA	20.3	24.2

These limits proved to be more restrictive than necessary

CITY of BOISE

WHY THERMAL VARIANCE?



ALTERNATIVE THERMAL LIMITS

Requested (using current and predicted air temperature and instream temperatures upstream and down stream of the water renewal facilities)

Date	Lander daily max ^{0}C	West Boise daily max ^{0}C
Jan - March	23.3	18.8
April - June	25.8	24.5
July - Sept	25.1	25.4
Oct - Dec	26.0	23.3

CITY of BOISE

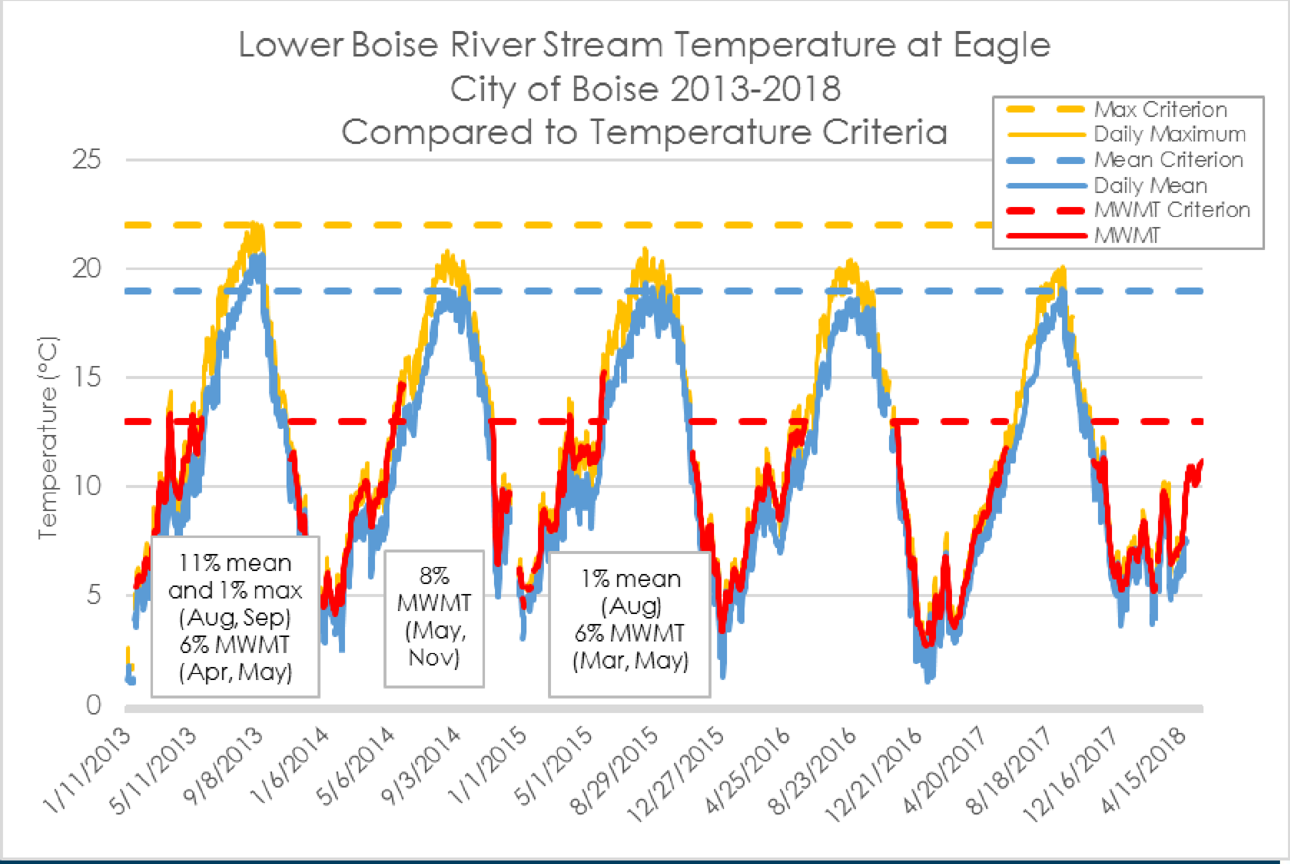
316(A) THERMAL VARIANCE

Alternative thermal effluent limits (ATEL) must be protective

- Protect Balanced Indigenous Community (BIC)
- Demonstration 1 – no prior appreciable harm to BIC
- Demonstration 2 – proposed ATELs will be protective of BIC and representative important species (RIS) in the future

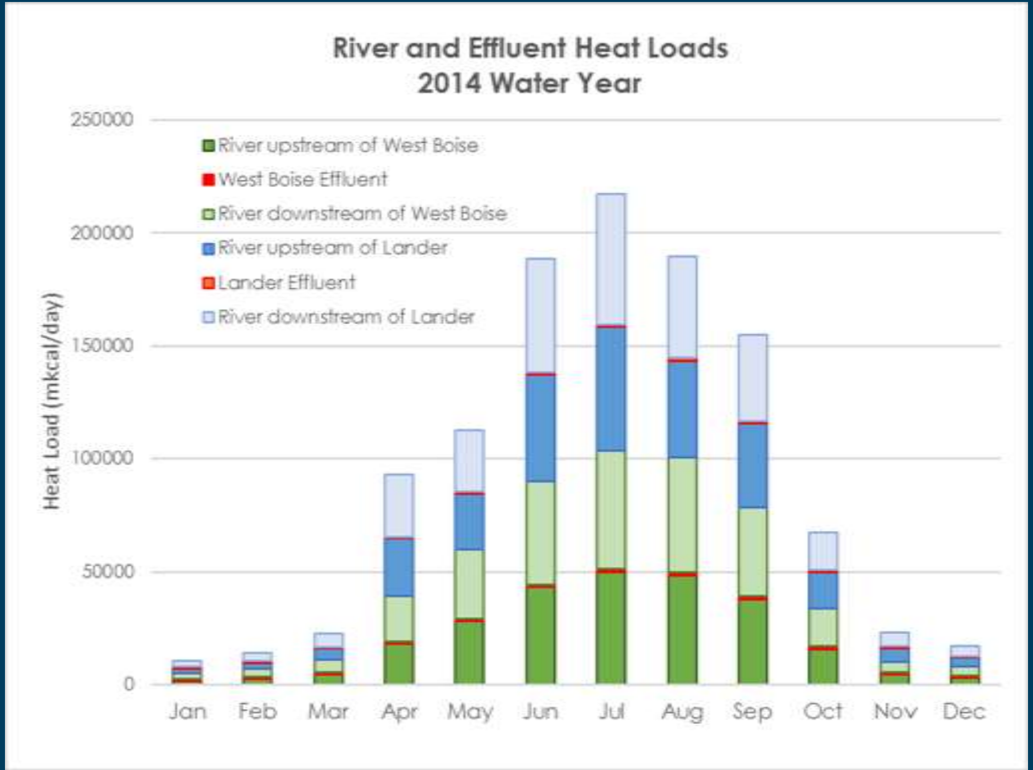
CITY of BOISE

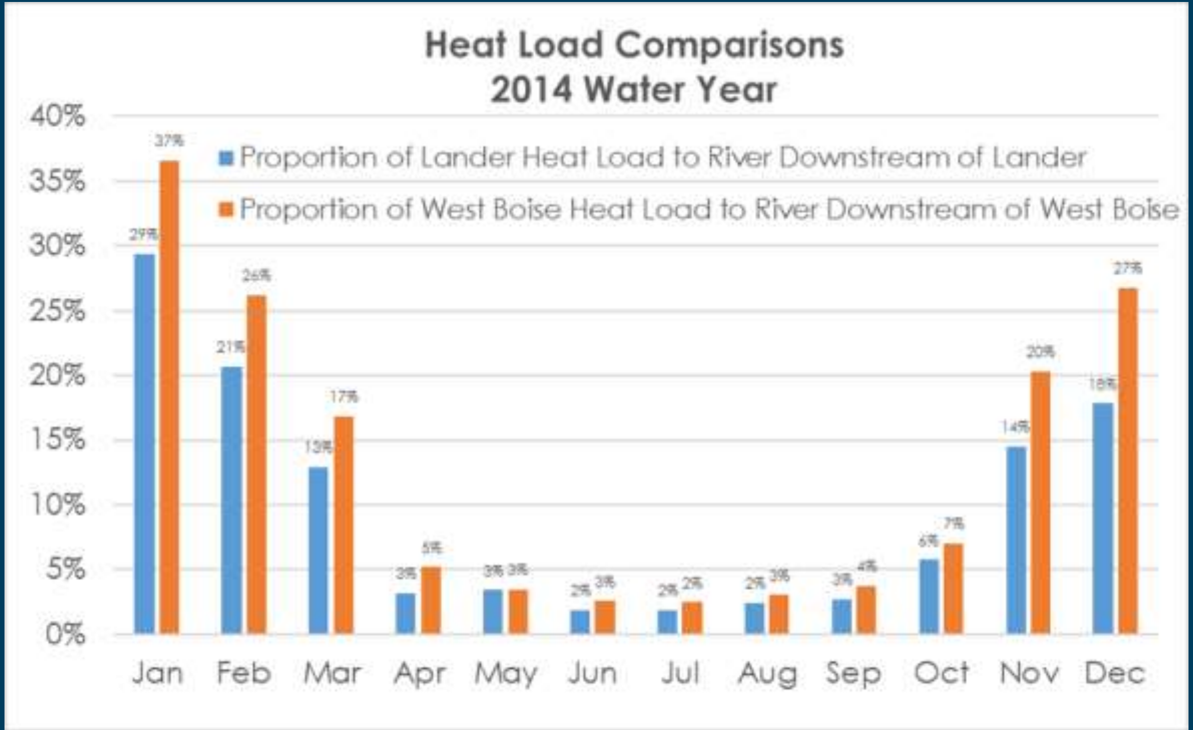
TEMPERATURE DATA



CITY of BOISE

HEAT LOAD

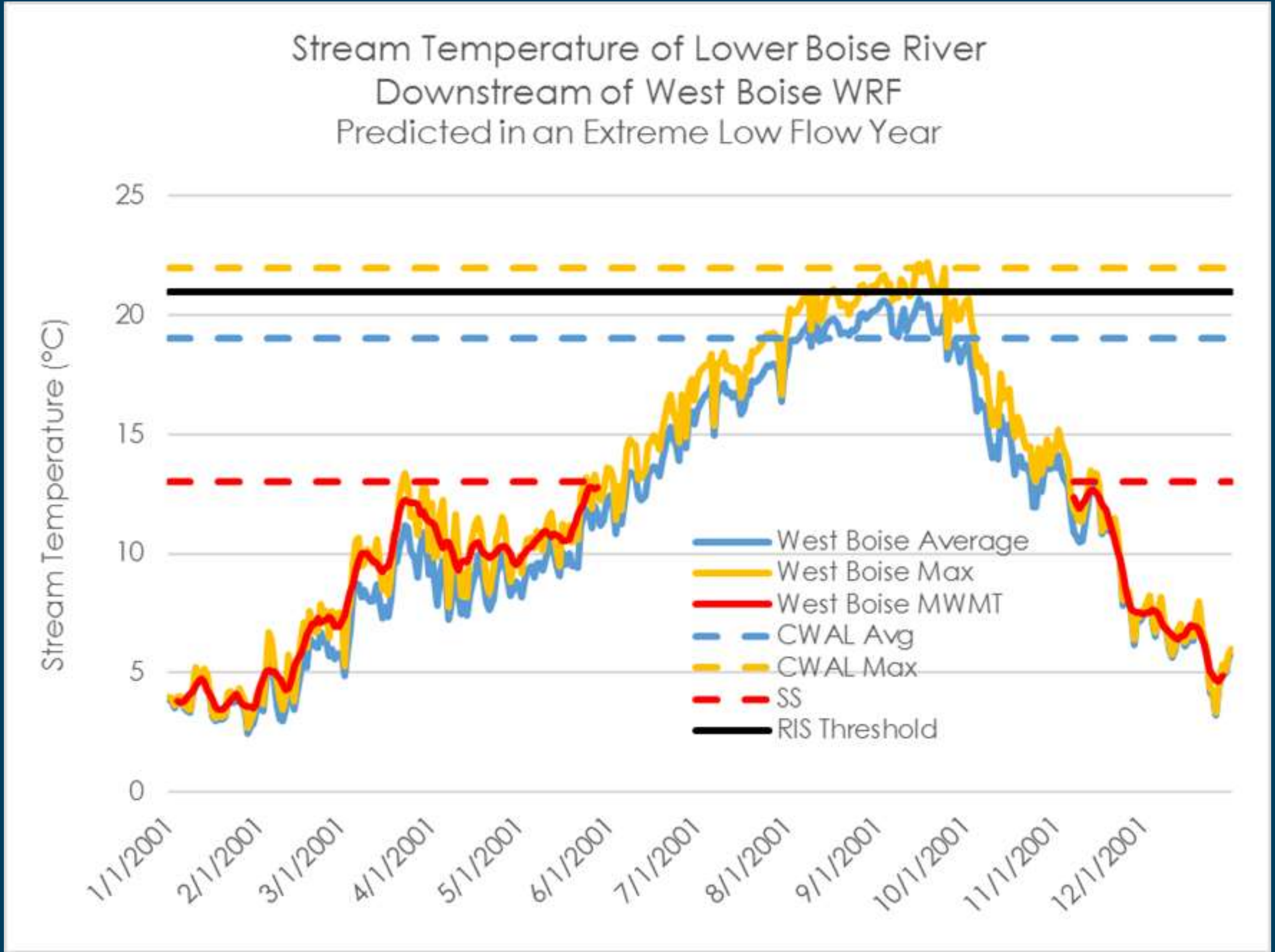




CITY of BOISE

TEMPERATURE MODELING

- CORMIX plume model
    - Meets mixing zone criteria
- StreamTemp river model
    - No exceedances of Representative Important Species
    - 95th percentile low flow year—CWAL average exceedances with or without effluent

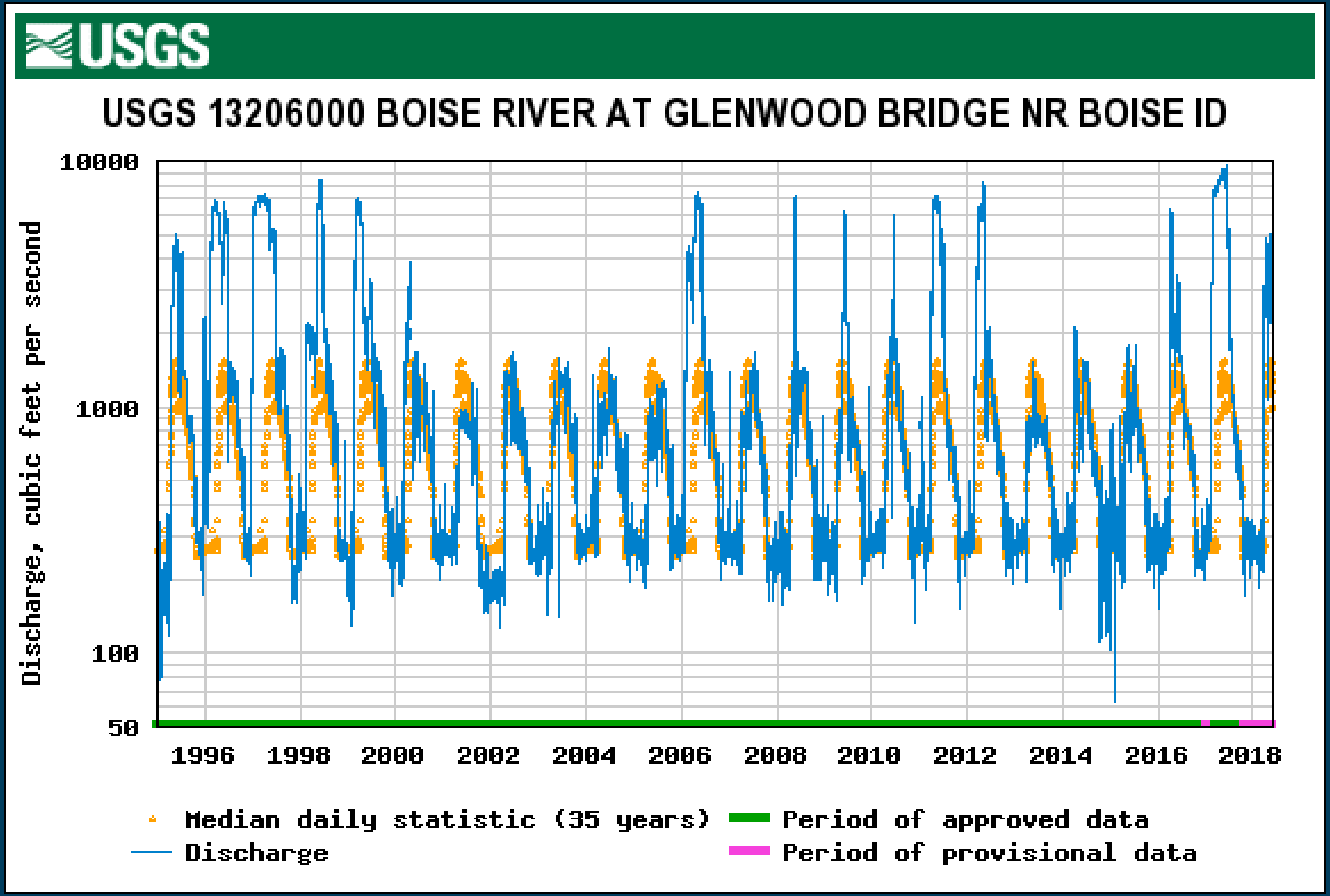


CITY of BOISE

ENVIRONMENTAL HEAT SOURCES

- Air Temperature
- Channel Morphology
- Shade
- Diffuse Sources
  - Groundwater
  - Overland Runoff

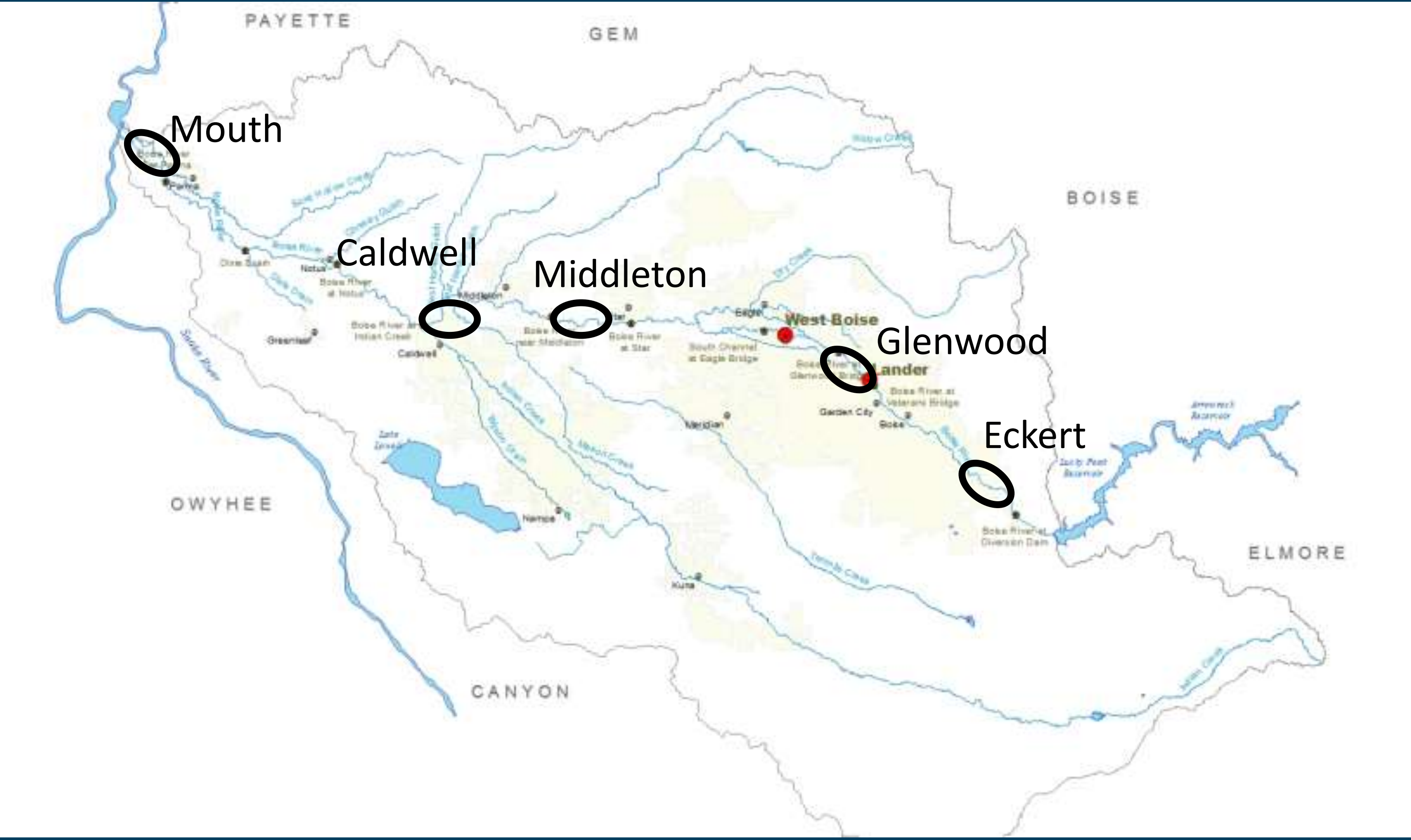
RIVER DISCHARGE



BIOLOGICAL DATA

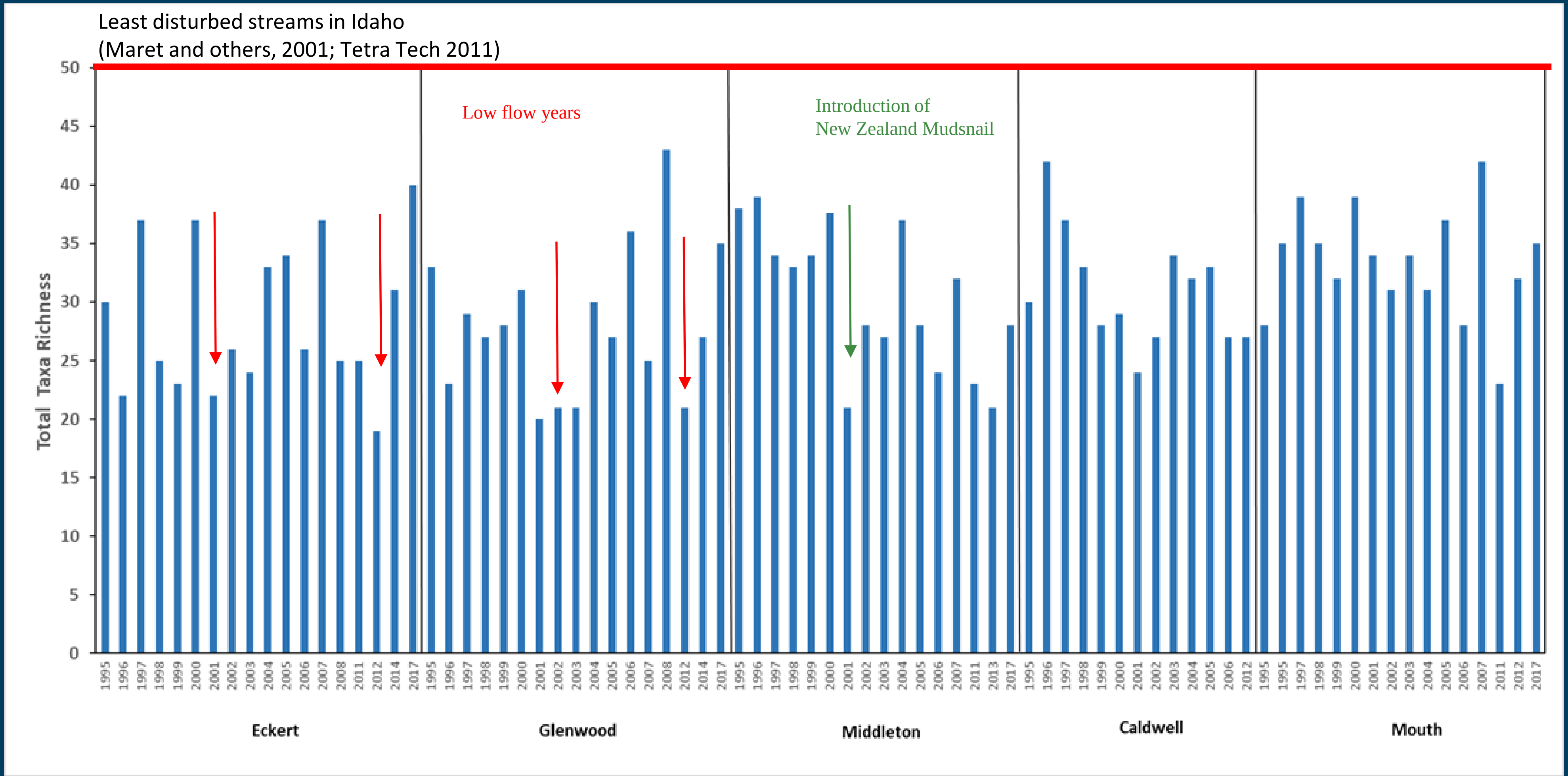
Sampling reaches

- Boise River below Eckert Road (Eckert)
- Boise River above Glenwood Bridge (Glenwood)
- Boise River near Middleton (Middleton)
- Boise River at Caldwell (Caldwell)
- Boise River at the Mouth (Mouth)



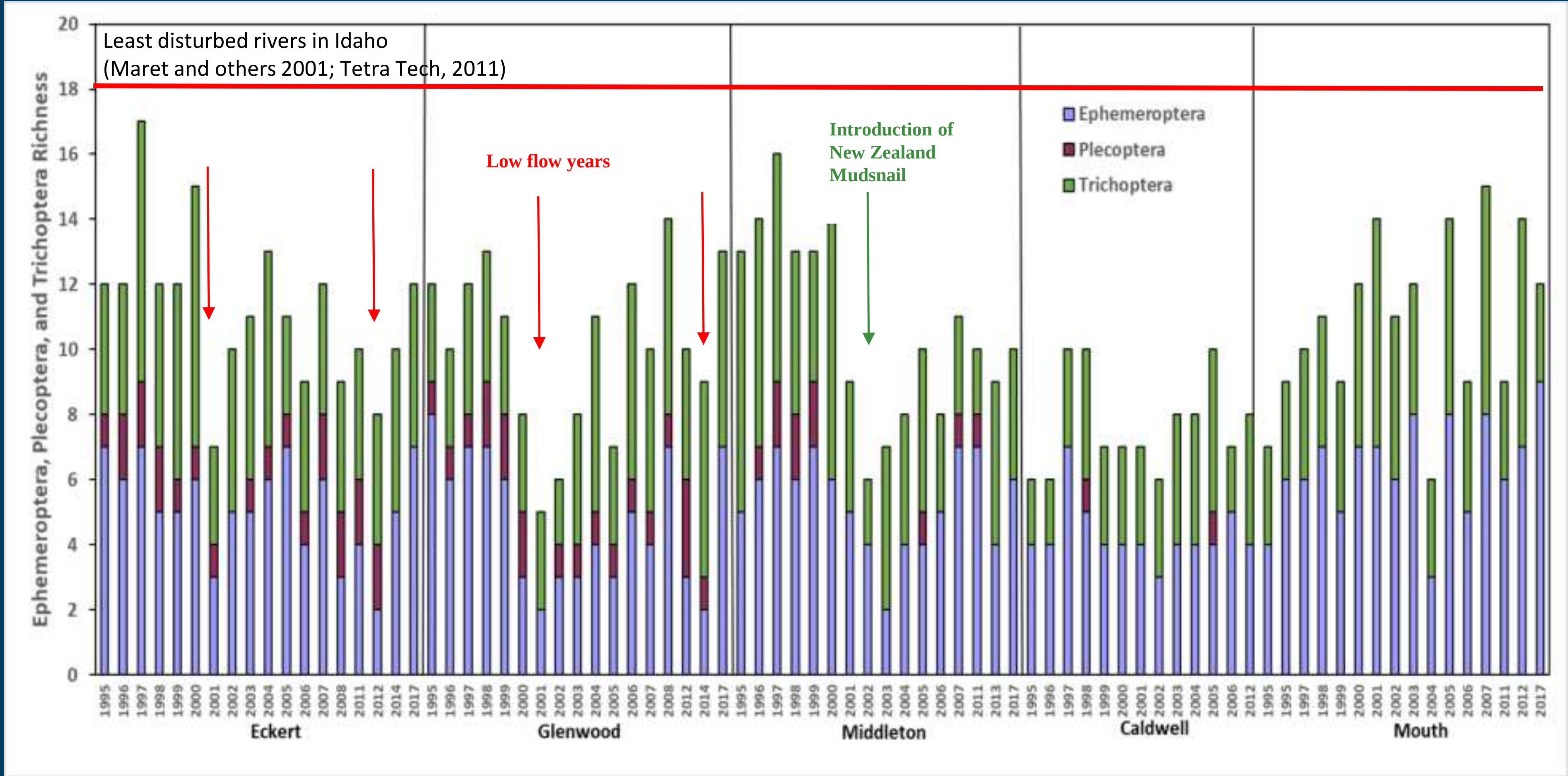
CITY of BOISE

MACROINVERTEBRATE DATA



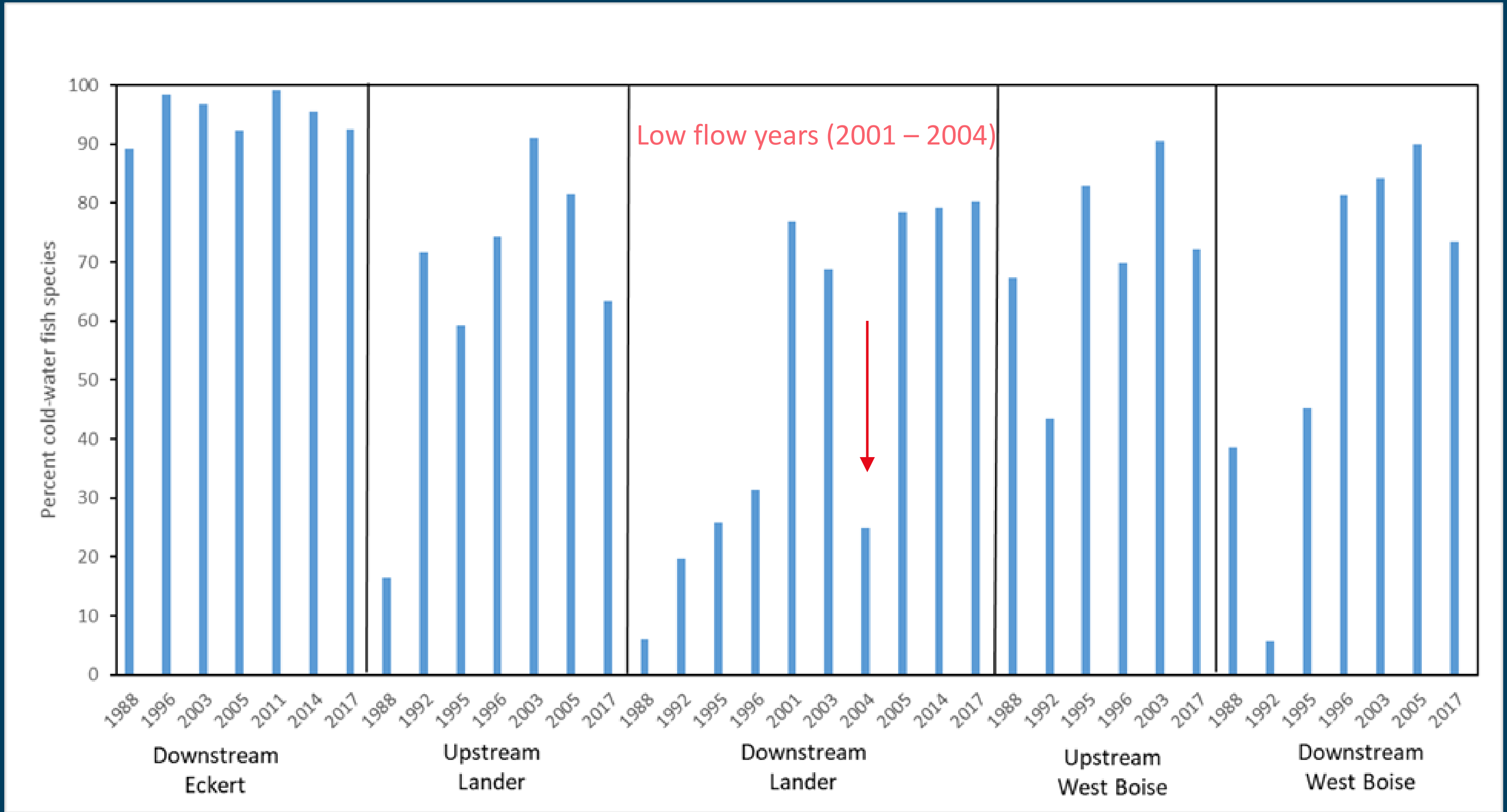
CITY of BOISE

MACROINVERTEBRATE DATA CONT.



REPRESENTATIVE IMPORTANT SPECIES

Native cold-water fish



RESULTS

- Flow alteration and habitat loss affect biological communities
- Alternative thermal effluent limits (ATELs) are protective
- Balanced Indigenous Community (BIC) is protected
- Demonstration 1 – no prior appreciable harm to BIC
- Demonstration 2 – proposed ATELs will be protective of BIC and representative important species (RIS) in the future

CITY of BOISE

NEXT STEPS

- Continuous temperature monitoring
- Biological Community assessment – 3 to 5 year interval
- Habitat assessment – 3 to 5 year interval
- Continue to investigate WRF temperature reduction
- Discharge reduction and water reuse

CITY of BOISE

THANK YOU

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That Lower Priest River's so hot right now: Describing thermal heterogeneity in a dam-influenced river

Eric Berntsen and Todd Andersen
Kalispel Tribe Natural Resources Department

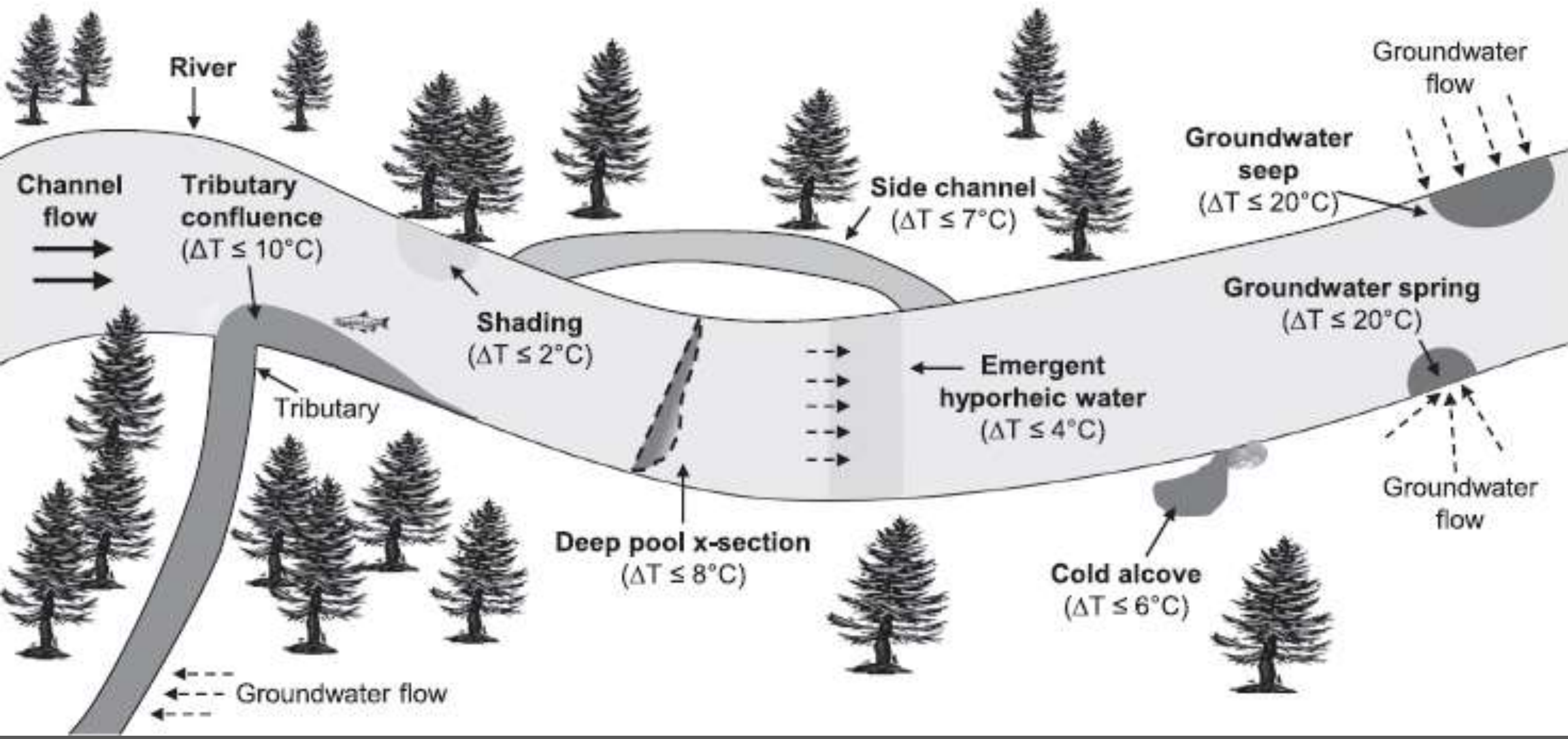
Francine Mejia and Christian Torgersen
U.S. Geological Survey

Objective

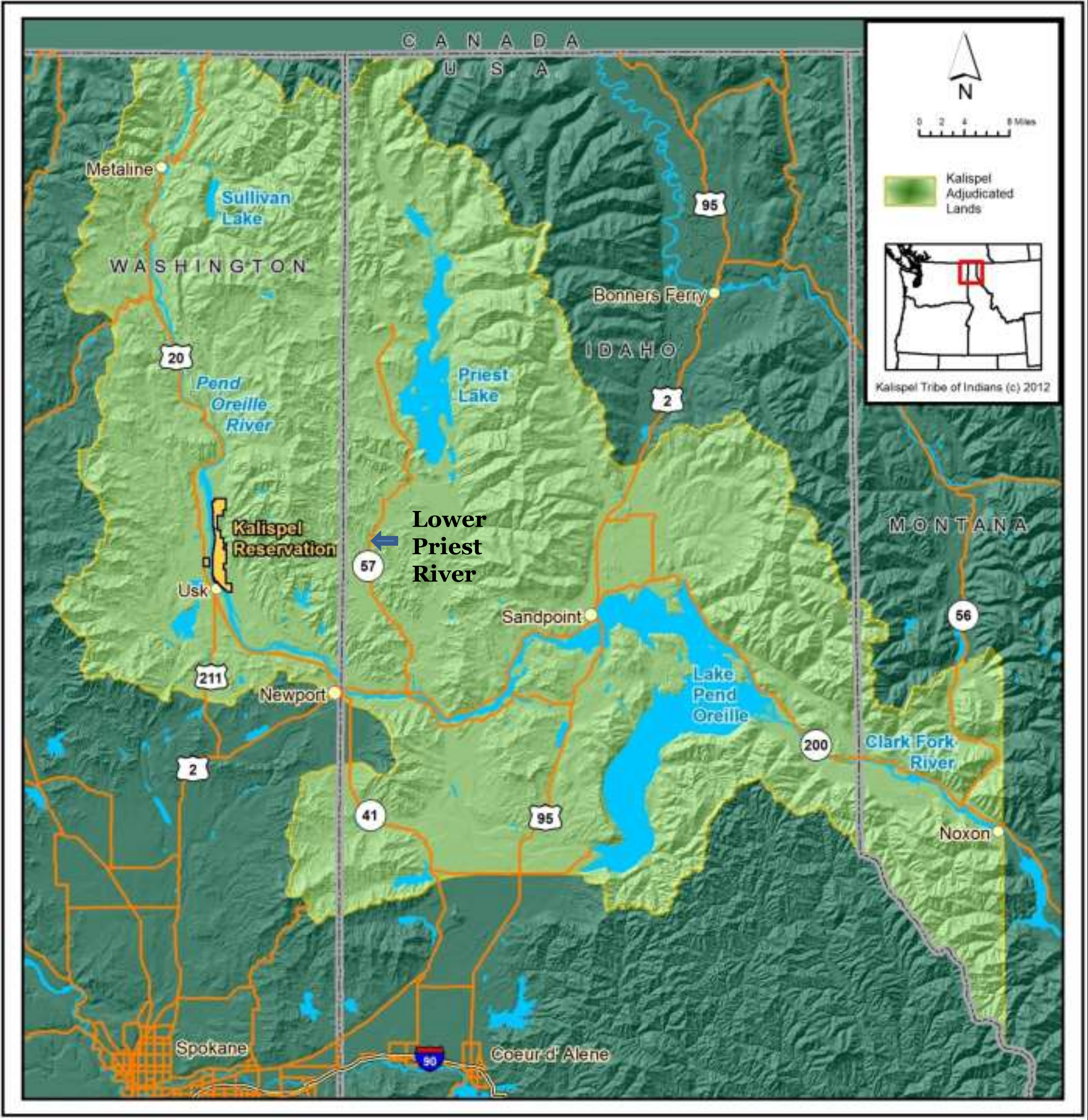
To describe the spatial and temporal thermal heterogeneity in the lower Priest River

Mechanisms that induce thermal diversity

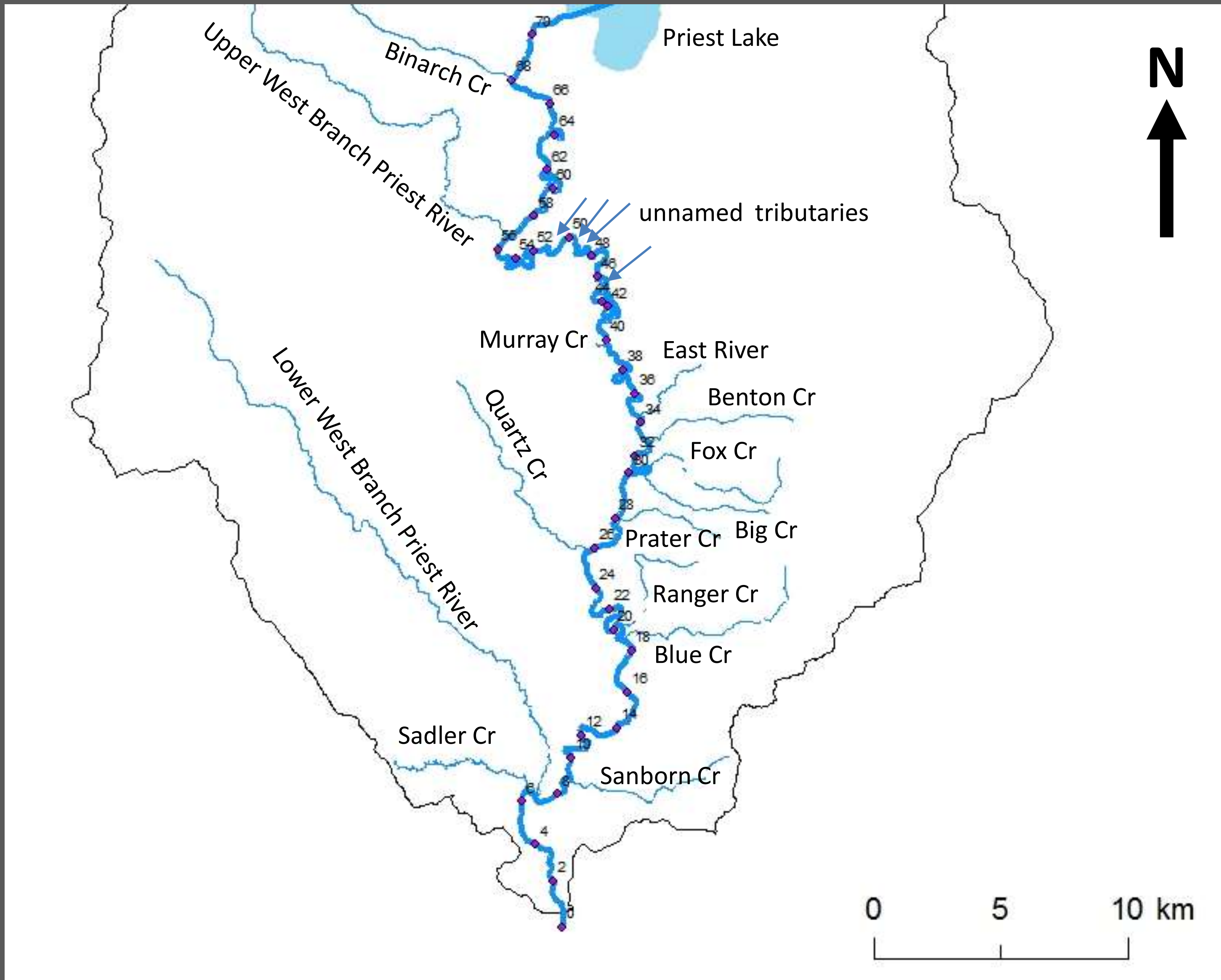
B. L. KURYLYK *et al.*



Kalispel Adjudicated Lands



Study area



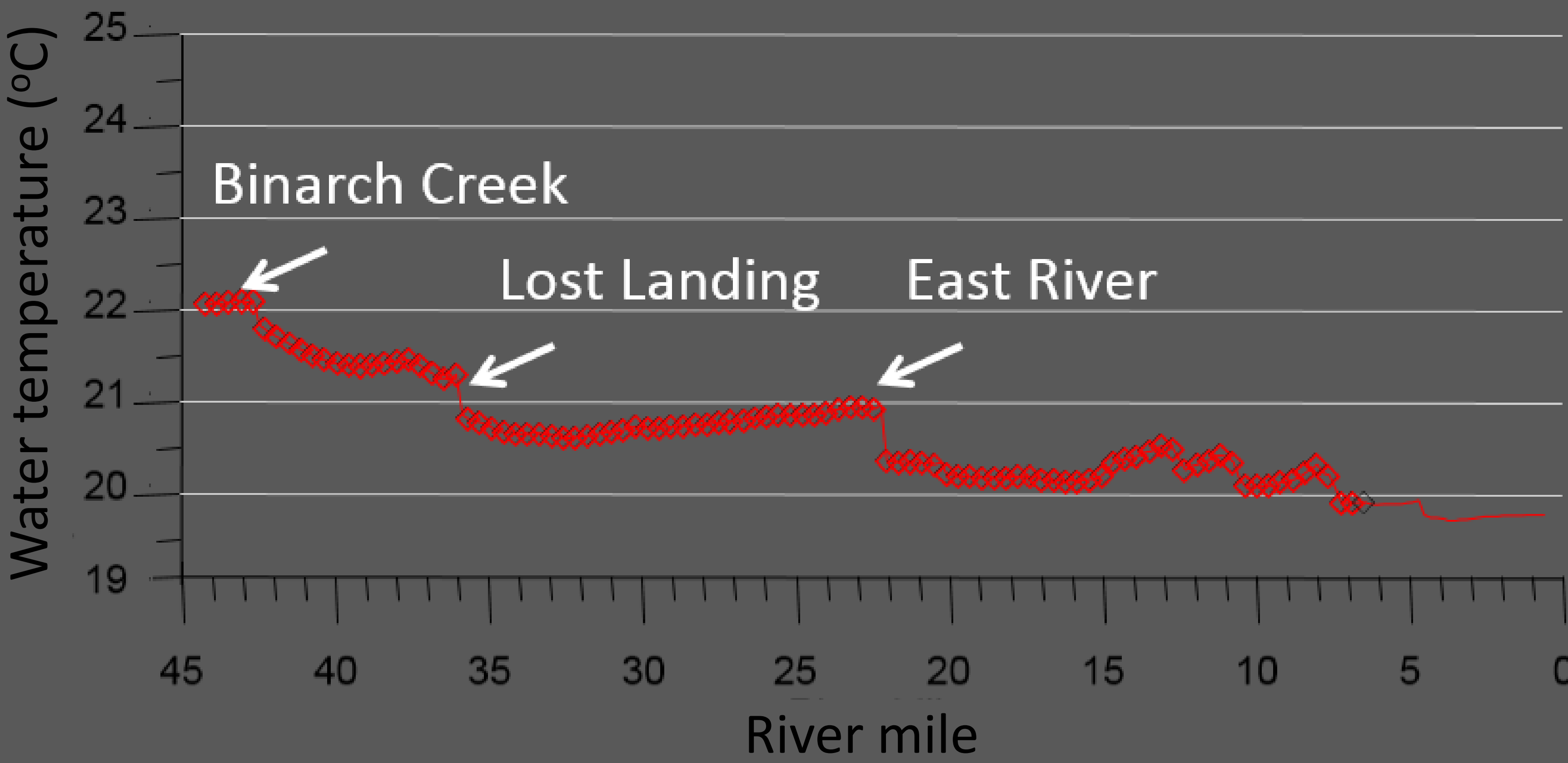
Priest Lake
N
Binarch Cr
Upper West Branch Priest River
unnamed tributaries
Murray Cr
East River
Benton Cr
Quartz Cr
Fox Cr
Lower West Branch Priest River
Prater Cr
Big Cr
Ranger Cr
Blue Cr
Sadler Cr
Sanborn Cr
0
5
10 km

rkm 70


rkm 2.5


Near confluence with
Pend Oreille River

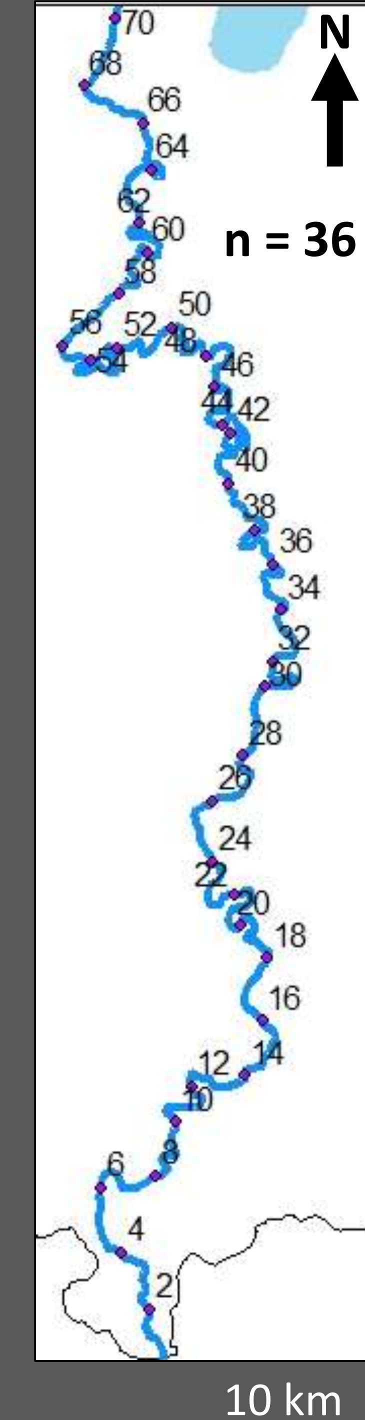
Temperature decreases downstream
(from Berger et al. 2014)



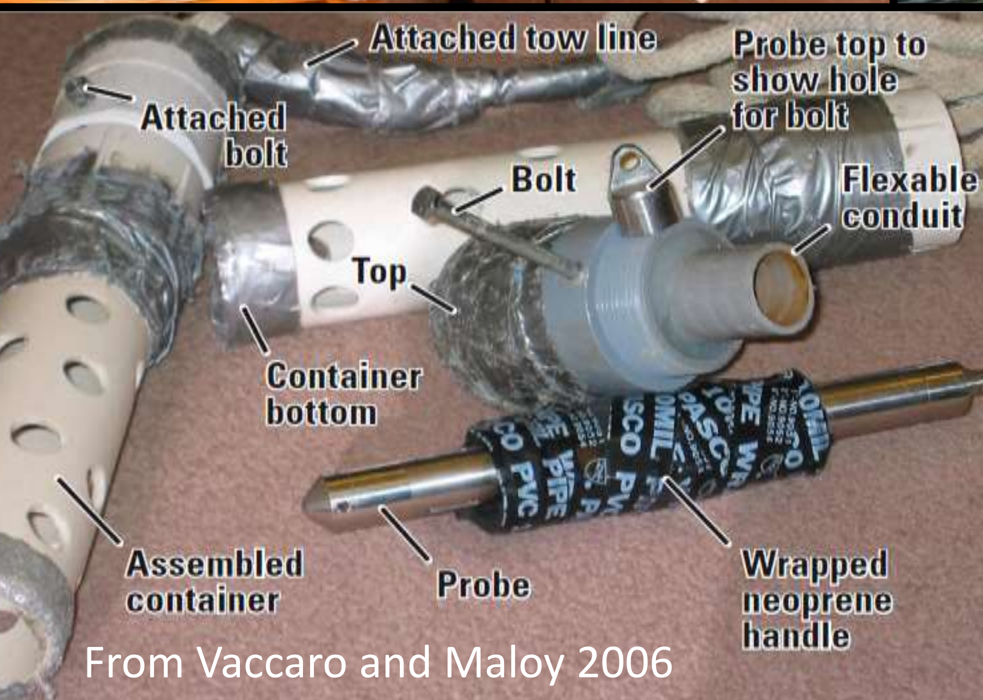
Binarch Creek

Unnamed tributary near Lost Landing area →

Methods - Temperature loggers (June 26 - Sep 3, 2018)

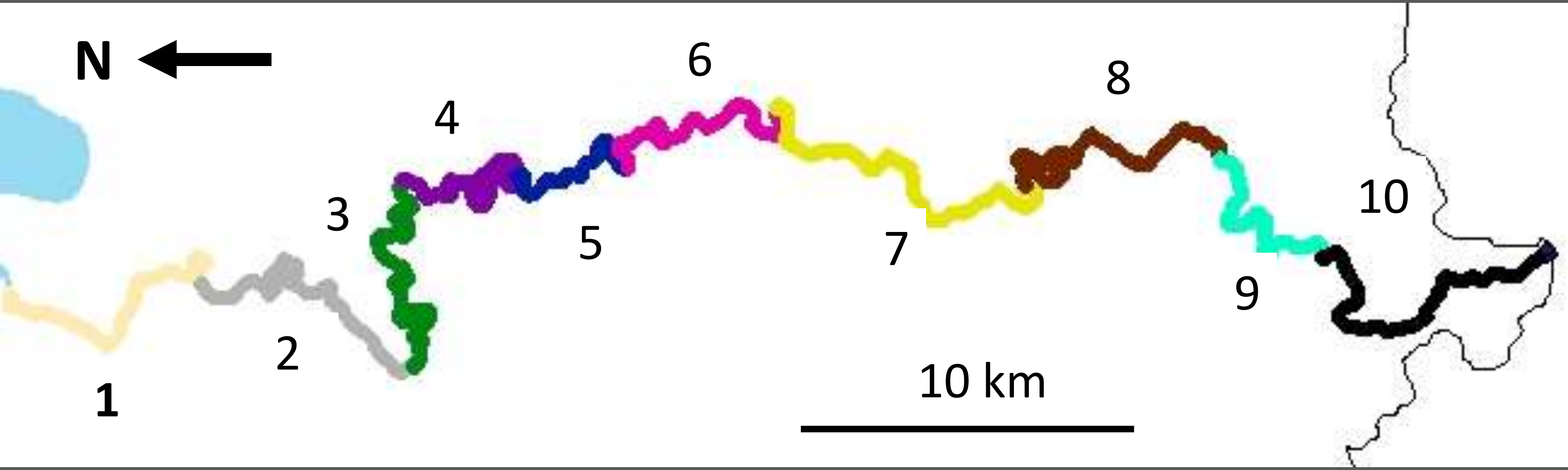


Thermal profiling – August 21, 2018



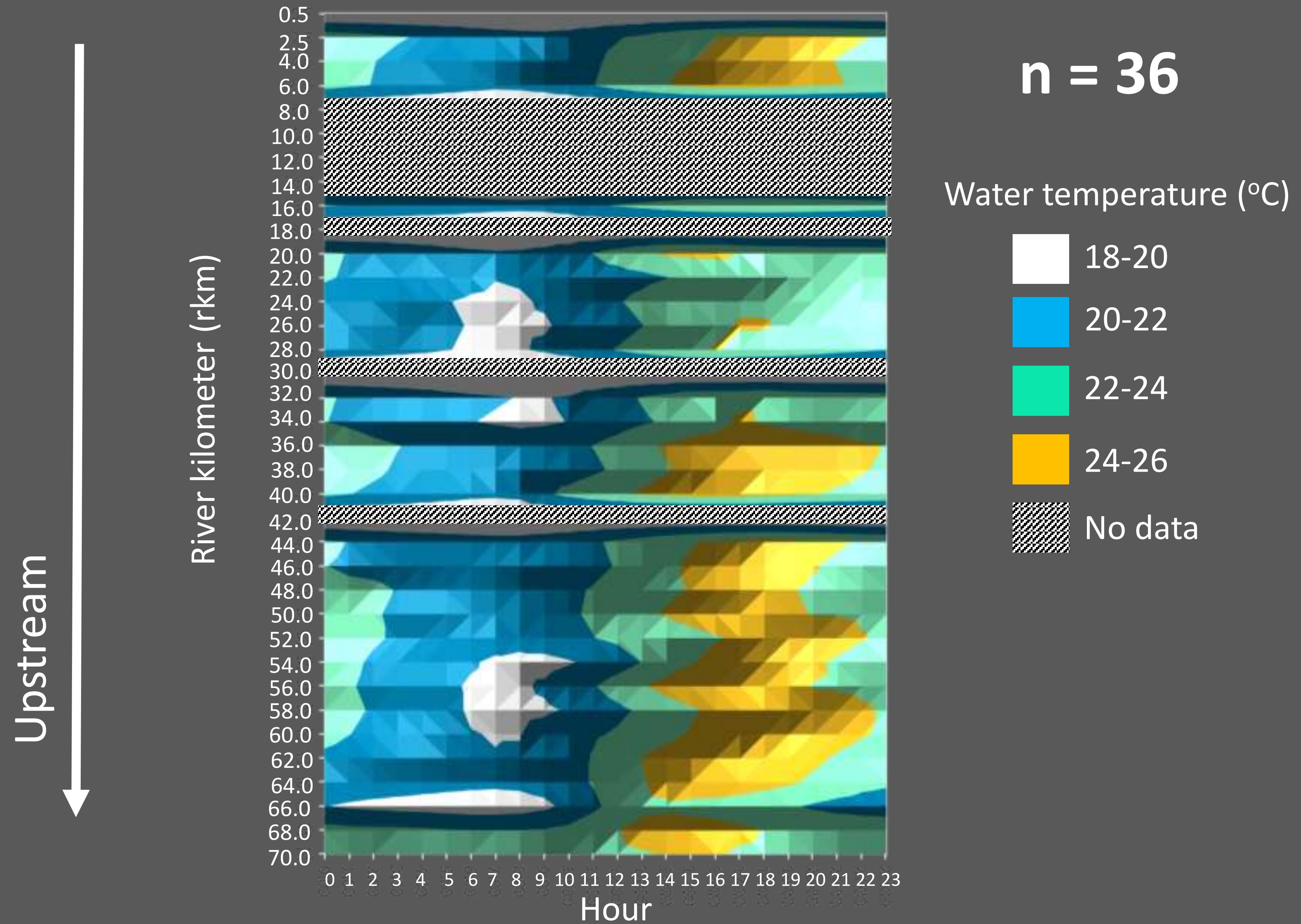
From Vaccaro and Maloy 2006

Thermal profiling – August 21, 2018

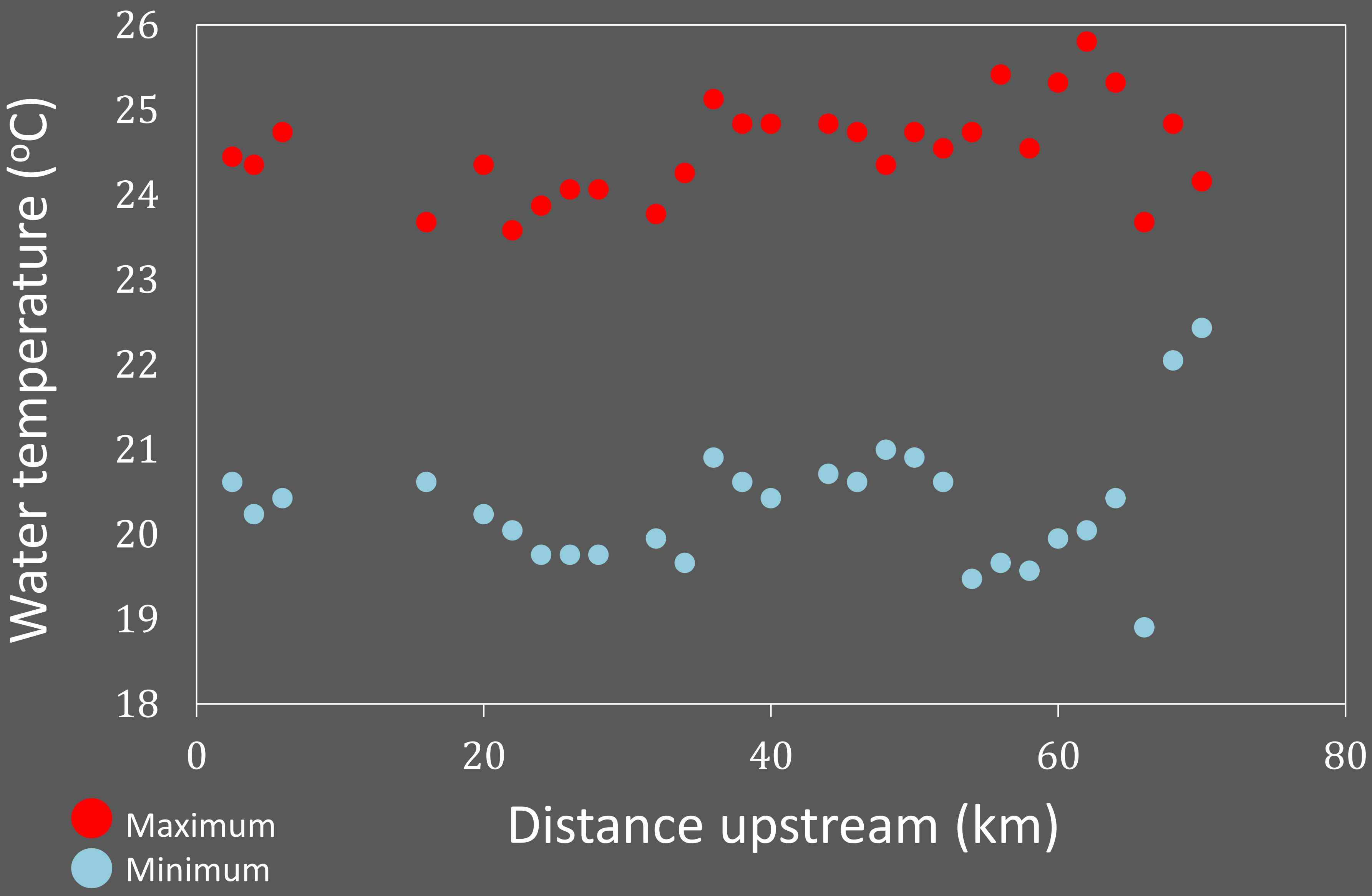


Hottest day sampled - August 10, 2018

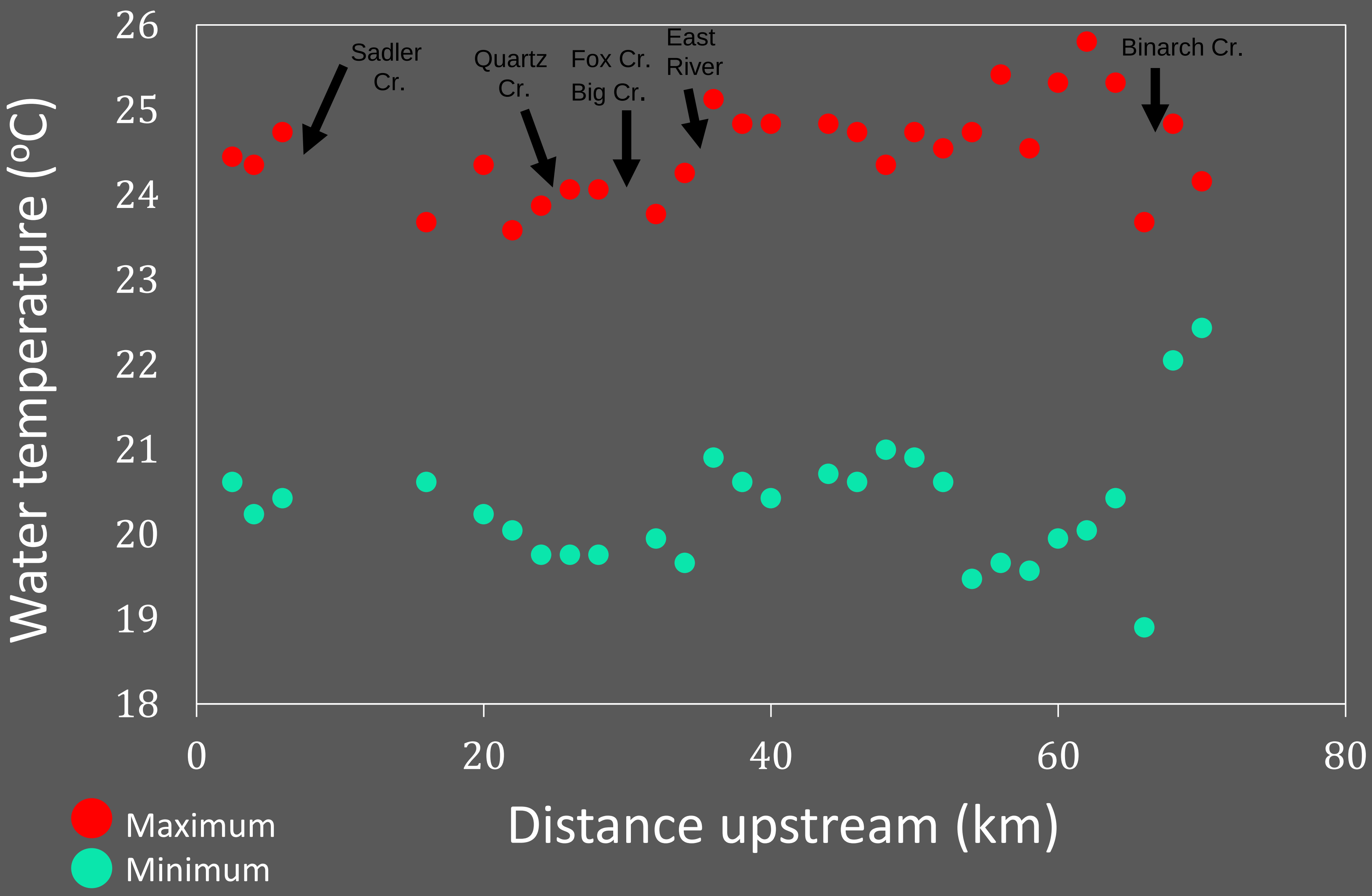
(Maximum air temperature 40^{o}C)

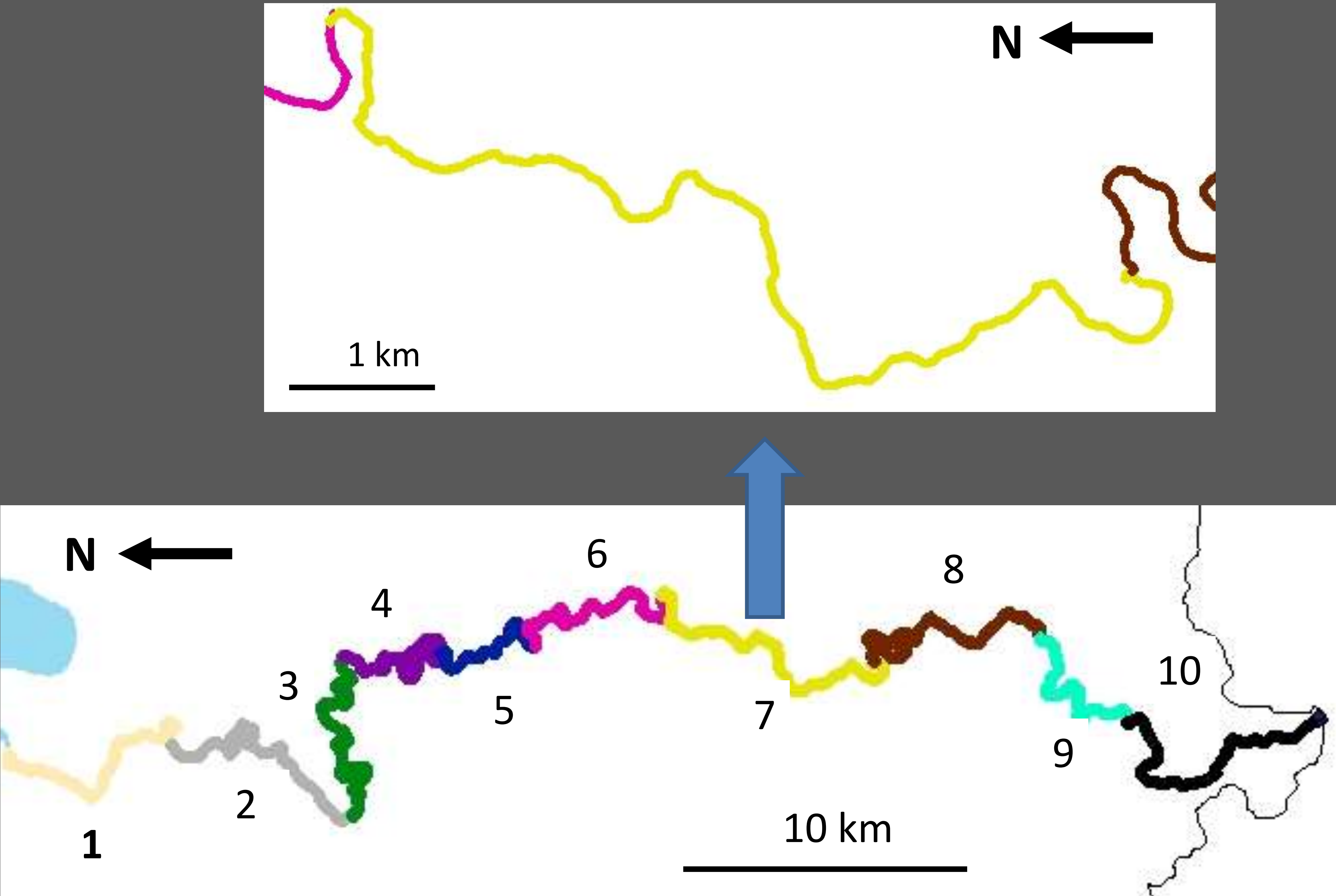


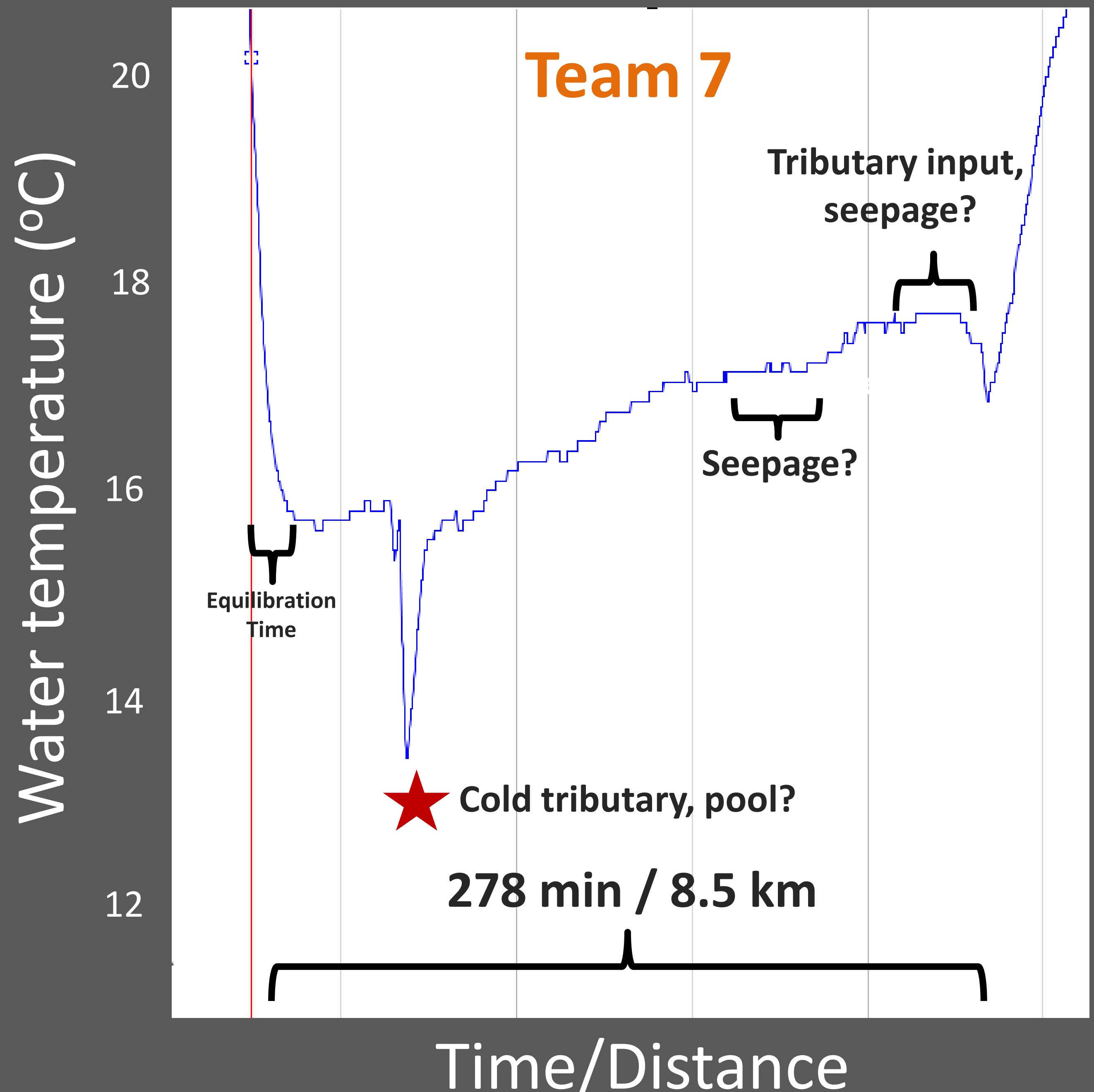
Longitudinal profile –August 10, 2018

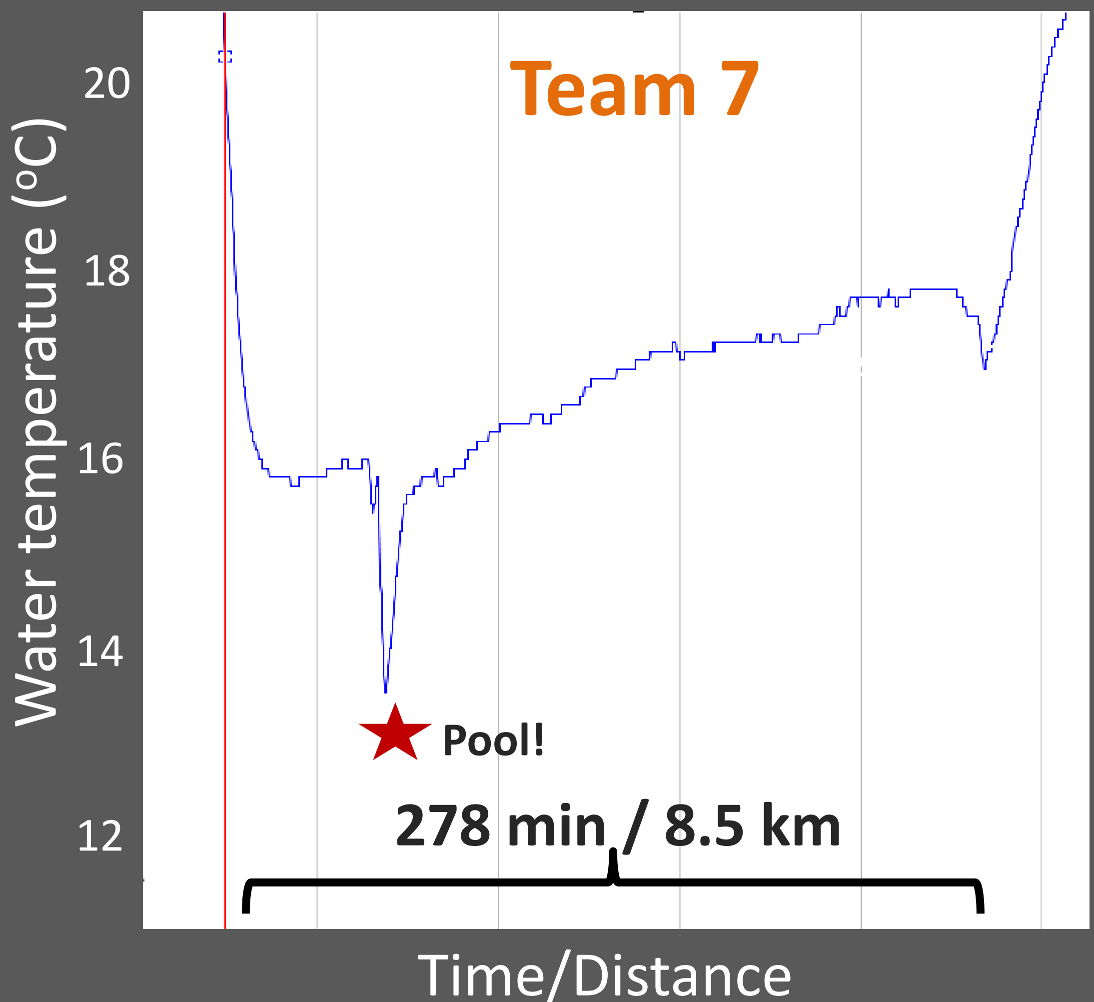


Longitudinal profile –August 10, 2018




N
1 km
N
1
2
3
4
5
6
7
8
9
10
10 km


Team 7
Water temperature (oC)
20
18
16
14
12
Tributary input, seepage?
Seepage?
Equilibration Time
Cold tributary, pool?
278 min / 8.5 km
Time/Distance



Notes indicate that volunteers passed 100+ fish off rock bank!

Implications

- Helps inform efforts to preserve, augment, and/or create thermal heterogeneity

- Provides information for developing a Temperature Total Maximum Daily Load for the Lower Priest River

Acknowledgments

Trout Unlimited Panhandle Chapter
Sean Stash, IPNF
Idaho Master Naturalists
Angel Klock and Zach Johnson, University of Washington
David Bluff, Darren Reeves, Jim LeMieux, Mike Lithgow, Kalispel Tribe Department Natural Resources

USGS
science for a changing world

Kalispel
natural resources

Questions?

A Biological Condition Gradient (BCG) Model for Benthic Macroinvertebrate Assemblages in Puget Lowland & Willamette Valley Streams

Presented by:

Robert Plotnikoff, Snohomish County Public Works

Chad Larson, Washington Department of Ecology

Pacific Northwest Chapter – Society for Freshwater Science

Wednesday, November 7th, 2018

Ketchum, ID

Acknowledgements

Construction and Calibration of the Puget Lowlands and Willamette Valley BCG

Thank You - A Team Effort!

Tetra Tech

Jen Stamp
Jeroen Gerritsen
Erik Leppo

US EPA

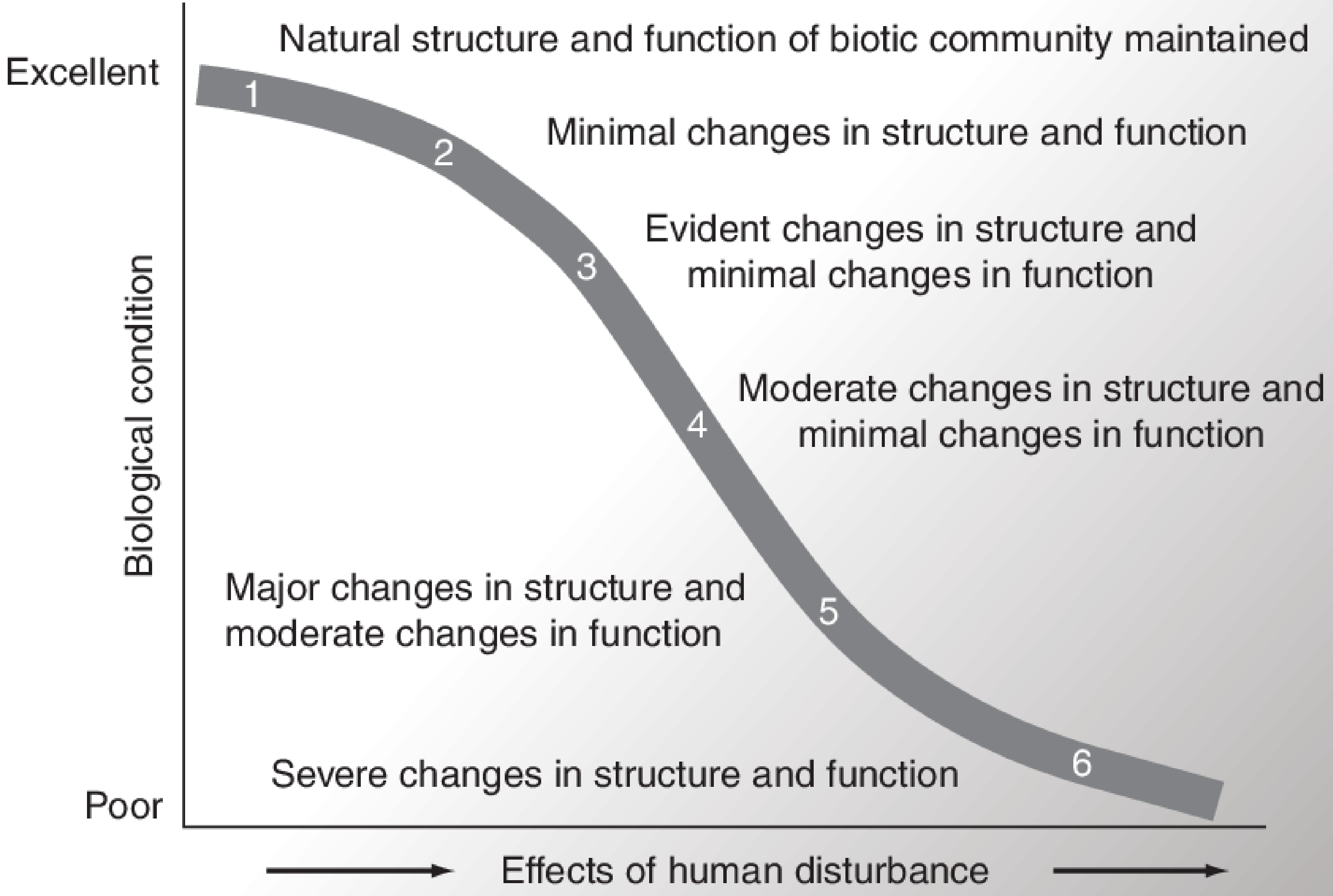
Susan Jackson
Gretchen Hayslip (ret)
Britta Bierwagen

Organization	Expert Panelist
Oregon Department of Environmental Quality	Shannon Hubler
Washington Department of Ecology	Chad Larson
King County	Kate Macneale
Snohomish County	Rob Plotnikoff
Rhithron Associates, Inc.	Sean Sullivan
EcoAnalysts, Inc.	John Pfeiffer
Aquatic Biology Associates	Bob Wisseman
Cole Ecological, Inc.	Mike Cole
Apolysis, LLC	Rick Hafele
US Geological Survey	Ian Waite
US Environmental Protection Agency (USEPA) Office of Research and Development (ORD)	Dave Peck
	Ryan Hill
Oregon State University	Alan Herlihy
Portland State University	Patrick Edwards

Outline

1. BCG Overview
2. Calibration and Development
3. Historical Conditions
4. Practical Uses for State and Local Governments
5. Future Work and Expansion of the PS & WL BCG
6. R Tool Development

OVERVIEW



Natural structure and function of biotic community maintained
Excellent
1
Minimal changes in structure and function
2
Evident changes in structure and minimal changes in function
3
Moderate changes in structure and minimal changes in function
4
Biological condition
Major changes in structure and moderate changes in function
5
6
Severe changes in structure and function
Poor
Effects of human disturbance

The Biological Condition Gradient (BCG)

A scientific framework for identifying biological response to anthropogenic stress.

The Building Blocks of the BCG

- Longstanding, accepted science
- Measurable and predictable
- Based on bioassessments
- Generalized scale
- Fixed anchor to minimize shifting baseline
- Biologically meaningful and robust thresholds
- Expert ecological judgement

Key Concepts

The BCG has two key concepts

1) **Attributes**
   measurable components of a biological system **(Karr and Chu 1999)**

   Examples → Organism condition, pollution tolerance

2) **Levels**
   Levels are the discrete levels of biological condition across a stressor-response gradient

   ***Example*:**

   Level 1 = undisturbed, pristine;

   Level 6 = severely degraded

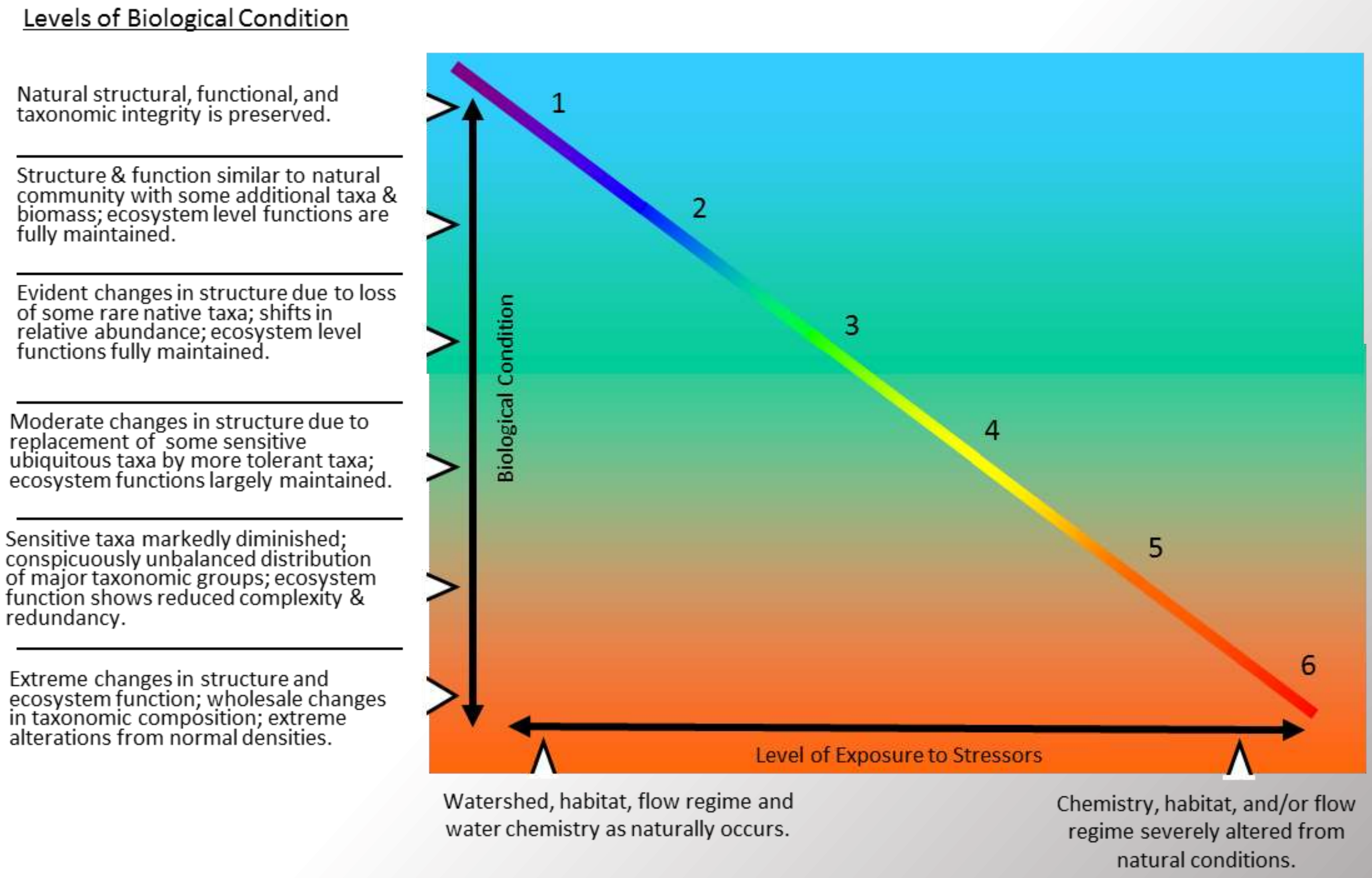
BCG Attributes

Attribute	Description
I	Historically documented, sensitive, long-lived, or regionally endemic taxa
II	Highly sensitive taxa
III	Intermediate sensitive taxa
IV	Intermediate tolerant taxa
V	Tolerant taxa
VI	Non-native or intentionally introduced species
VII	Organism condition
VIII	Ecosystem function
IX	Spatial and temporal extent of detrimental effects
X	Ecosystem connectance

BCG **Levels**

1. ***Natural*** structural, functional and taxonomic integrity
2. Structure and function ***similar to natural community*** with some additional taxa and biomass or the first detectable shifts in expected composition. Ecosystem level functions fully maintained.
3. ***Evident changes in community structure*** with loss of some highly sensitive native taxa & shifts in relative abundance. Ecosystem level functions fully maintained.
4. Ecosystem functions ***largely*** maintained, but some sensitive ubiquitous taxa replaced by more tolerant taxa.
5. ***Reduced*** ecosystem function, with diminished sensitive taxa, unbalanced distribution of major taxonomic groups and organisms showing signs of physiological stress
6. ***Extreme*** changes in structure and ecosystem function with wholesale changes in taxonomic composition and poor organism condition

The BCG: biological response to increasing stress



The BCG Process

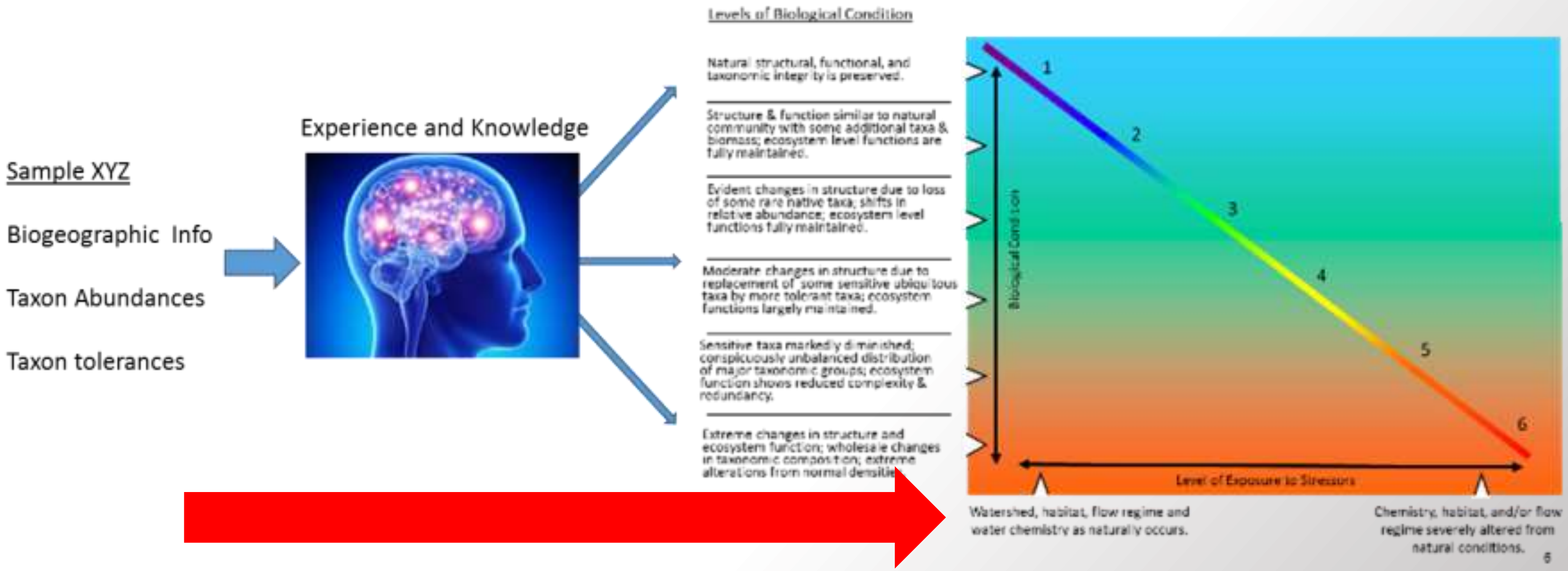
Iterative –
These steps are revisited throughout the process

1. Identify participants and expert panel
2. Compile data
3. Assign BCG attributes to taxa
   - Perform analyses to help inform assignments
4. Assign BCG levels to samples
5. Develop & refine BCG rules
6. Assess BCG model performance
   - Calibration
   - Confirmation
7. Automated BCG model (with narrative decision rules) that assigns BCG levels to samples

BCG CALIBRATION AND DEVELOPMENT

Narrative Levels and Attributes → Ecoregional Numeric Decision Rules

Assigning Samples to BCG Levels



Describe why you make an assignment, in BCG terms – e.g., what is missing or present?

Participant	Score	Reasons
Jason	4-	Doesn't seem as nice as the other greenbrier site (421) its bigger but not much more diversity and seem less balanced
Royce	6+	Very elevated counts… possible nutrient enrichment?
Rick	4	Presence of introduced taxa lowered my rank.
Brett	5+	Short taxa list for catchment area. Expect more species of darters, sculpins, and madtoms.
Mark	4-	Over half of individuals are att. 5 or 6 taxa, but relatively balanced community
Ryan	5+	Number of fish suggest a possible nutrient loading/human distrubance nearby, lots of stonerollers

Timeline of BCG Model Development

September - December 2016

- Held calls with Steering Committee
- Obtained data and prepared sample worksheets for the BCG workshop
- Held pre-workshop webinars (Dec 8 & 15) to introduce the group to the BCG

January 10-12, 2017

- Conducted expert workshop in Portland, OR.

One foot of snow in Portland, OR; January 2017

February-September 2017

- Refined taxa attributes, develop decision rules, rated samples.
- Held four webinars to refine decision rules)
- Sent out confirmation samples (June 28)
- Compiled confirmation results, assessed model performance

October 2017

- Status update webinar (Thurs Oct 12)
- BCG report
- Climate pilot webinar (Monday Oct 16)

November 2017

- PNW-SFS meeting (Nov 7-9); presentation only (no BCG workshop)
- Begin next phase of work with Britta and David (restoration potential, improving resiliency)

March 20-22, 2018

- Second expert panel meeting (Olympia, WA)

Summer/fall 2018

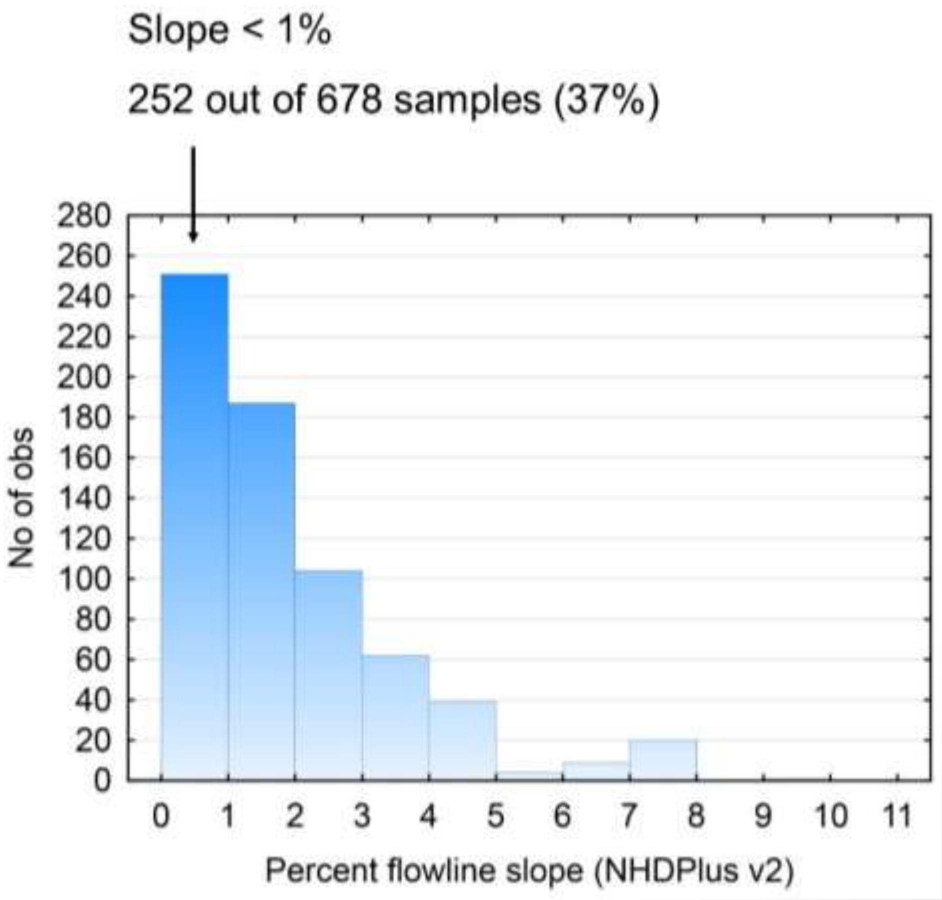
- Finalize deliverables (Version 1 of the BCG model, report, R tool)

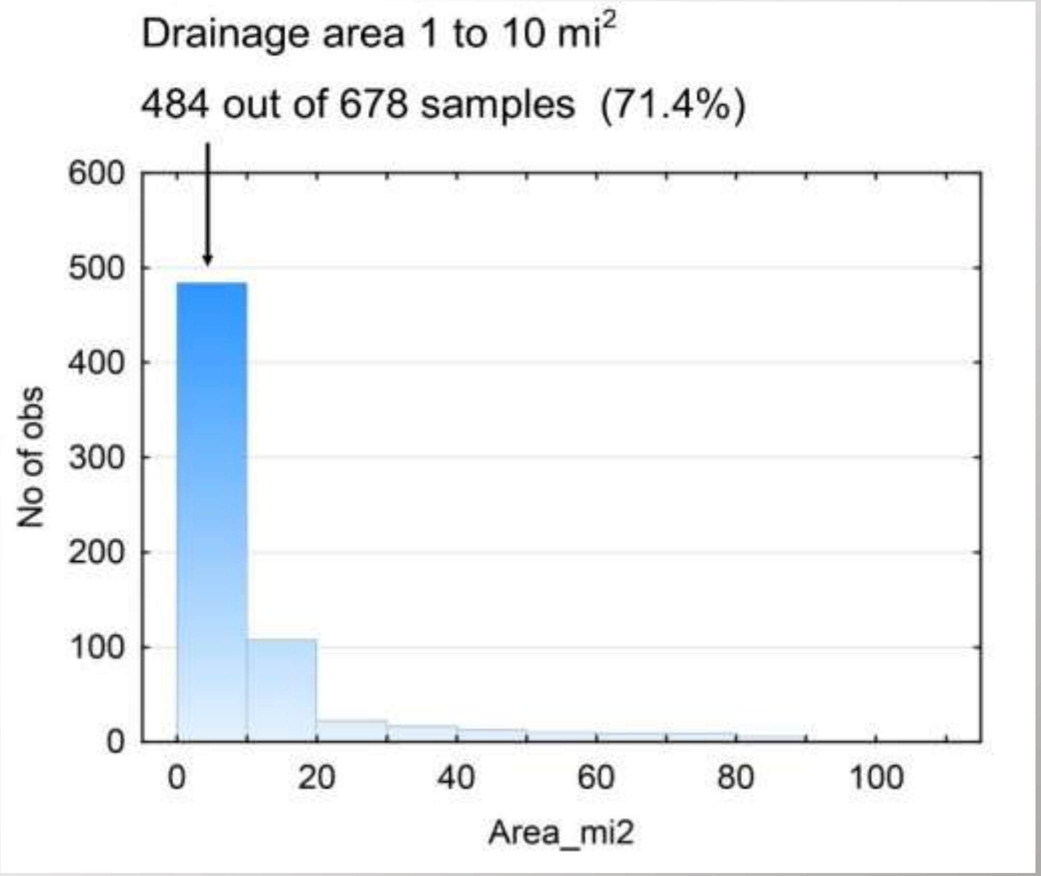
Calibration Dataset

- Puget Lowlands & Willamette Valley Ecoregions
- Streams from Watershed Areas of 1 to 100 mi^2
- Low and high gradient
- 500-count target
- Lowest practical taxonomic resolution
  (with some exceptions from early on)
- At least 8 ft^2 sampling area
  (with some exceptions from earlier years)
- ODEQ, WA ECY and Puget Sound Stream Benthos sampling methods
  - WA ECY method is multi-habitat (random)
  - Other Organizations target riffle/run habitat

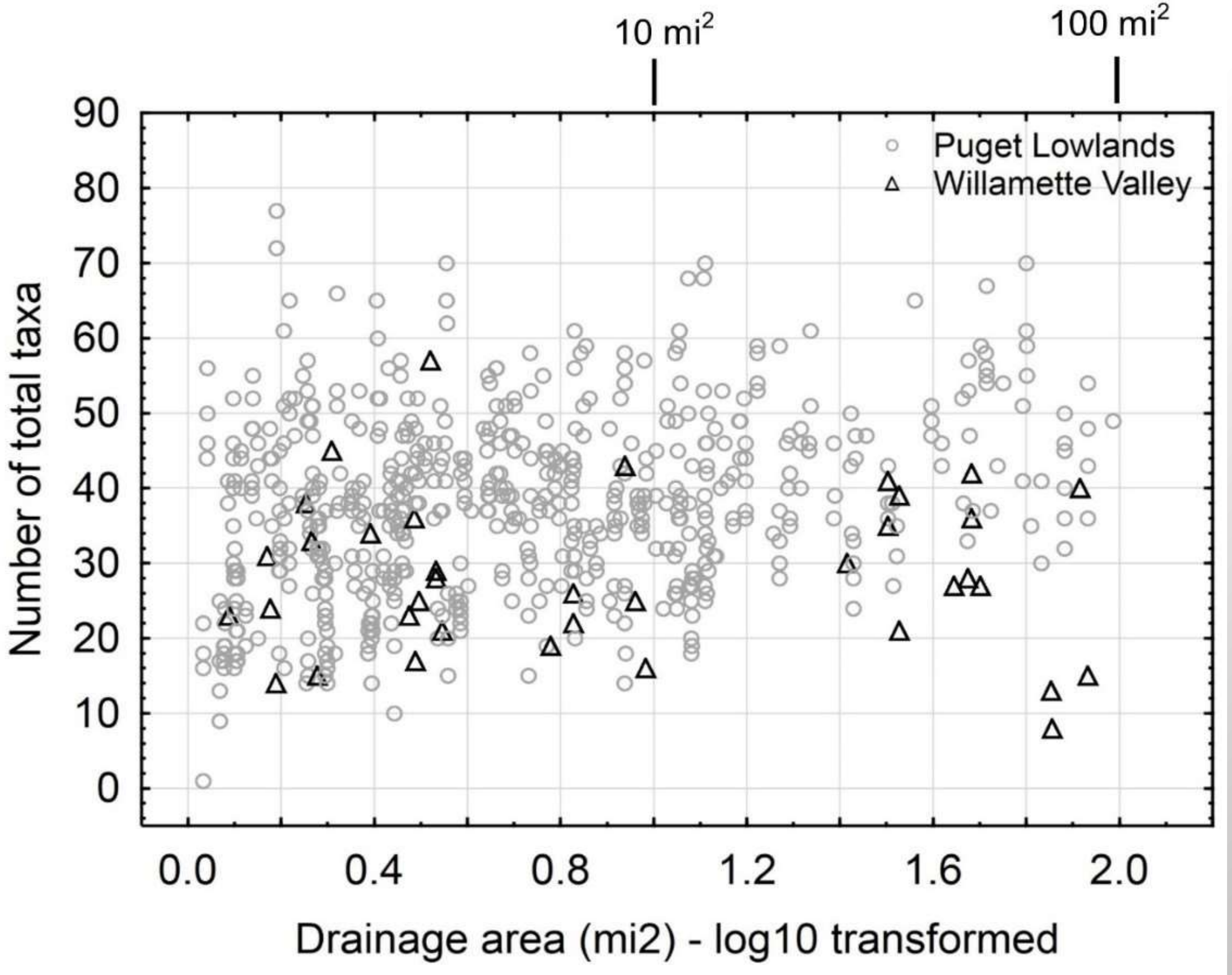
Level 3 ecoregion	**Entity**	**# Samples in full calibration dataset**	**# Samples assessed by experts**
Puget Lowland	King County - DNRP	212	35
	Snohomish County	107	7
	Kitsap County	105	2
	WA ECY	91	18
	City of Seattle	64	1
	City of Everett	24	
	City of Redmond	15	
	City of Kirkland	12	
	Snoqualmie Tribe	5	
	City of Bellevue	3	
	City of Issaquah	2	
Willamette Valley	ODEQ	35	21
	Yamhill Basin Council	3	1
	Totals	**678**	**85**

Characteristics of the Calibration Dataset





Drainage Area versus # Total Taxa

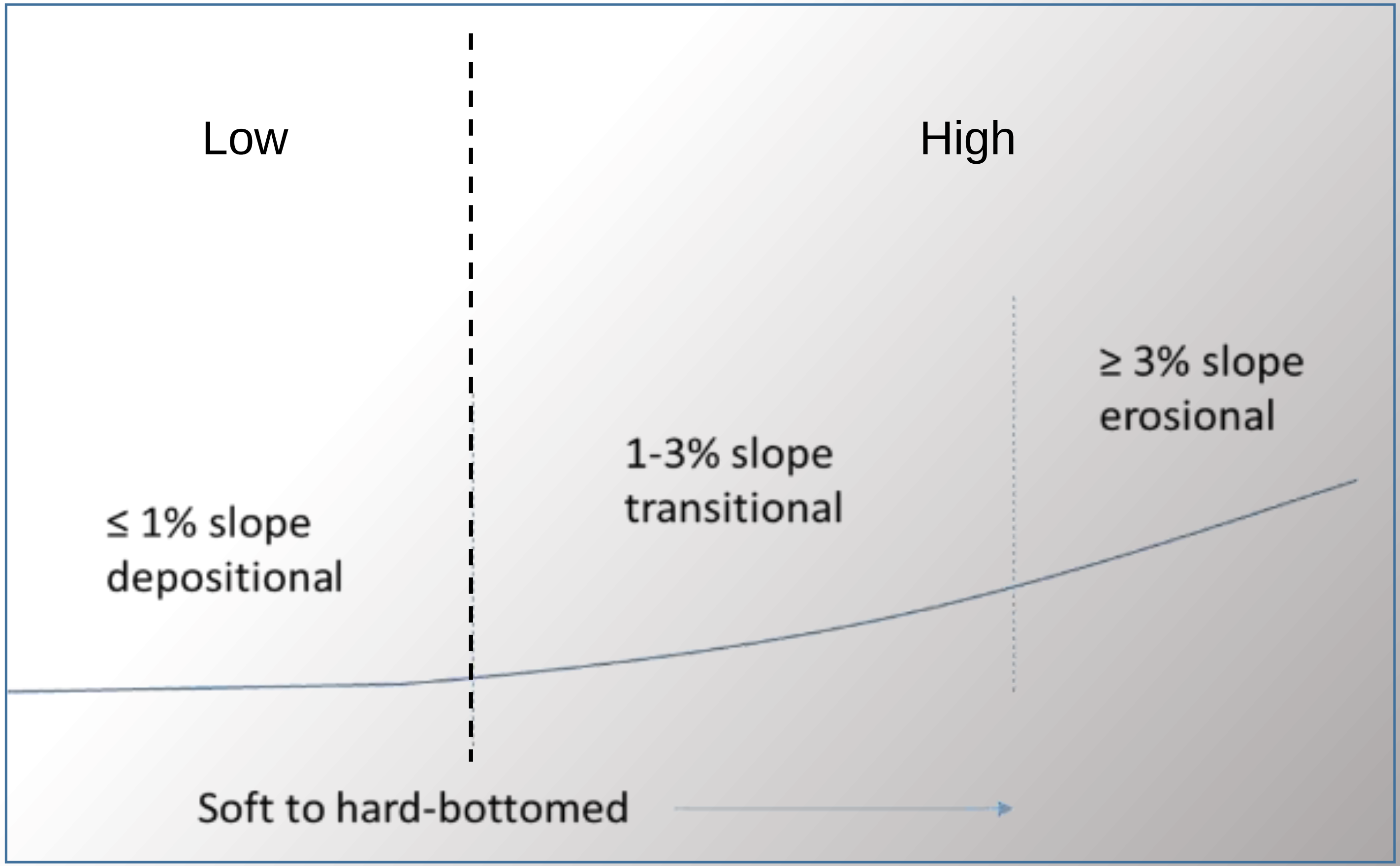


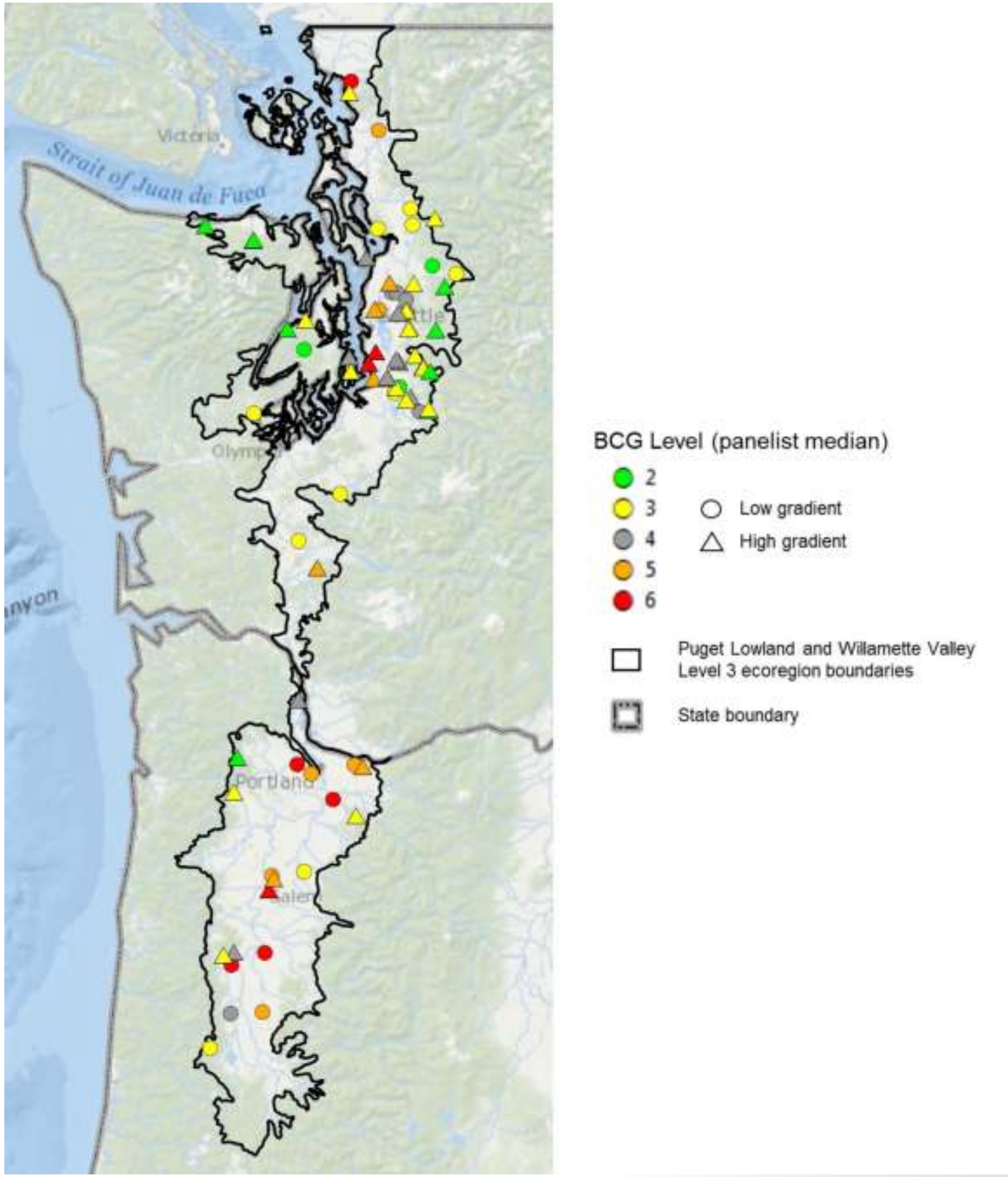
- Surprisingly high number of taxa at very small sites!
- Based on plots like this, we did not see reason to adjust expectations based on stream size

Slope (Stream Gradient)

Two Stream Types (Gradient)

- Low (<1% NHDPlus slope)
    - Previously referred to as 'depositional'
- High (≥ 1% slope)
    - Previously referred to as 'transitional/erosional'





Spatial Distribution of Calibration Dataset

Assessed samples (85)

Calibration Dataset

Tally of assessed samples (Low & High Gradient Streams)

BCG level	Puget Lowlands			Willamette Valley		
	Low	High	Total	Low	High	Total
2	4	7	*11*	0	1	*1*
3	8	17	*25*	2	3	*5*
4	5	9	*14*	2	2	*4*
5	2	8	*10*	5	2	*7*
6	1	2	*3*	4	1	*5*
Totals	*20*	*43*	*63*	*13*	*9*	*22*

Calibration Dataset by:

Ecoregion

- Puget Lowlands - 63
- Willamette Valley - 22

Stream Type

- Low gradient - 33
- High gradient - 52

Calibration Sites in each BCG Level

- Level 2 – 14%
- Level 3 – 35%
- Level 4 – 21%
- Level 5 – 20%
- Level 6 – 9%

Calibrated BCG Level 2 Rules

BCG level 2: Minimal changes in structure of the biotic community and minimal changes in ecosystem function - virtually all native taxa are maintained with some changes in biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability.			
Narrative Descriptions	**Metric**	**Numeric Rules**	
		Low	**High**
Diverse assemblage with moderate to high numbers of total taxa	Number of total taxa	≥ 30 (25-35)	
A fair number of highly sensitive species are present	Number of Attribute Ii+II taxa	> 5 (3-8)	
A third or more of total taxa belong to one of the three sensitive groups, with slightly higher proportions expected in higher gradient streams	% Attribute Ii+II+III % taxa	≥ 35% (30-40)	≥ 40% (35-45)
Sensitive taxa comprise a almost a quarter of the organisms	% Attribute Ii+II+III % individuals	≥ 20% (15-25)	
Tolerant and non-native taxa make up a very small fraction of the organisms (or are absent)	% Attribute V+VI taxa	≤ 5% (3-7)	
	% Attribute V+VI individuals	≤ 5% (3-7)	
Sensitive EPT species are present in high numbers	Number of Attribute Ii+II+III EPT taxa	≥ 15 (10-20)	
Tolerant non-insect taxa comprise a small percentage of the individuals (or are absent). Juga and Rissooidea are excluded from consideration for reasons described below[2]	% Attribute IV+V+VI non-insect[1], individuals, excluding Juga and Rissooidea[2]	≤ 15% (10-20)	

Calibrated BCG Level 5 Rules

BCG level 5: Major changes in structure of the biotic community and moderate changes in ecosystem function - Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity and redundancy; increased build-up or export of unused materials			
Narrative Descriptions	**Metric**	**Numeric Rules**	
		Low	**High**
Total richness ranges widely; at a minimum, at least thirteen total taxa are present	Number of total taxa	≥ 13 (8-18)	
At least -20% of the subsampling target is achieved (in our calibration dataset, the target is 500 organisms; if the target was 300, the rule would be ≥ 240 total organisms)	Number of total individuals	≥ 400 (390-410)	
At least one EPT taxon is present	Number of EPT taxa	> 0 (0-1)	
Up to a third of total taxa may be tolerant or non-native	% Attribute V+VI taxa	≤ 35% (30-40)	
Tolerant non-insect individuals comprise up to three-quarters of organisms.	% Attribute IV+V+VI non-insect[1] individuals	≤ 75% (70-80)	

Model Performance: Predictive Capacity

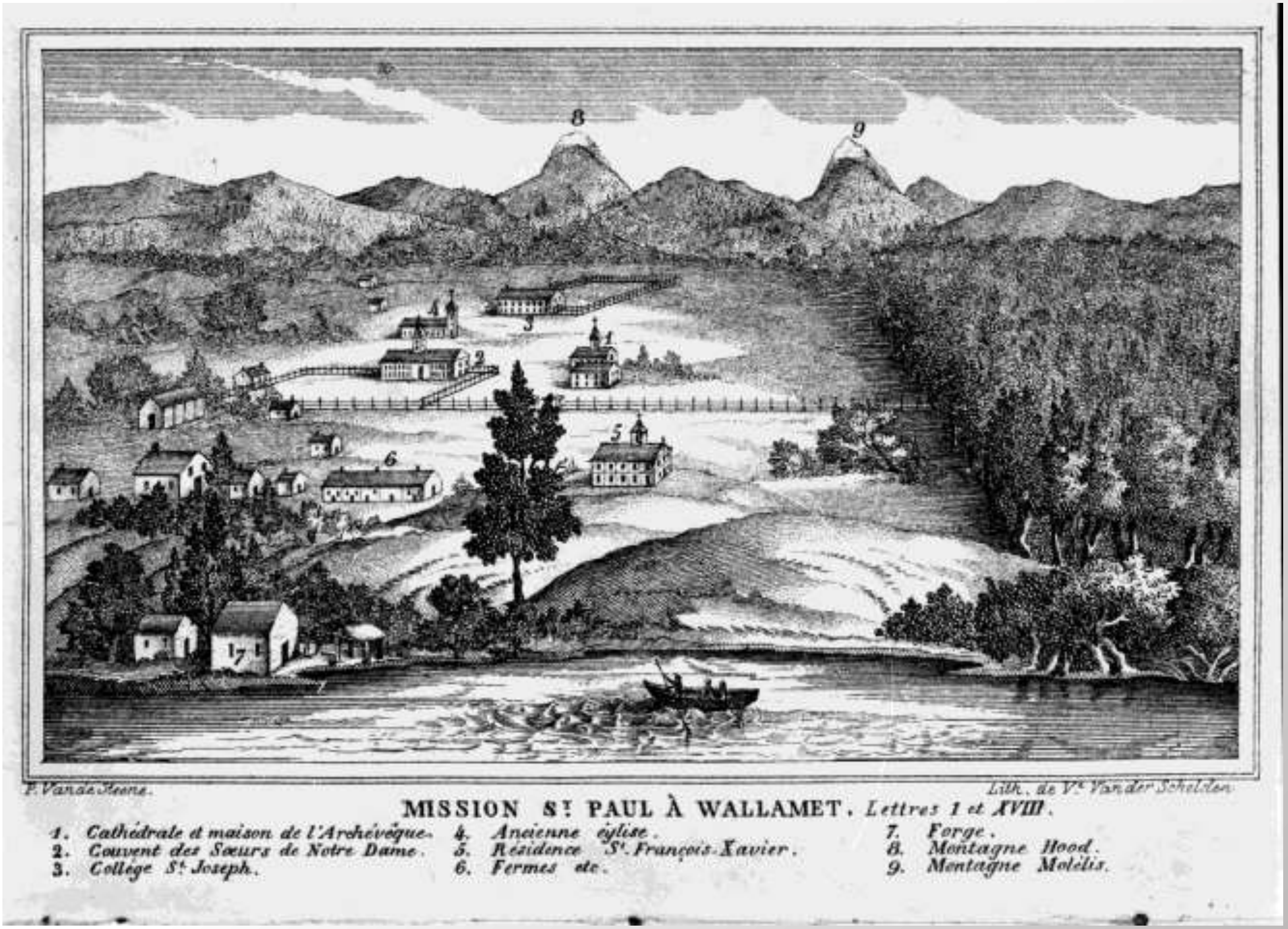
Compared panelist consensus calls to BCG level outputs (automated in Excel, and now R).

- <u>Calibration</u> – 97.4% accurate within + 0.5 BCG Level
- <u>Confirmation</u> – 100% accurate within + 0.5 BCG Level

Stream Type (Gradient)	Dataset	Unit	Difference					
			Model 1 level better	Model 1/2 level better	Exact match	Model 1/2 level worse	Model 1 level worse	*Total*
Low	Calibrate	Number		1	29			*30*
		Percent		3.3%	96.7%			*100%*
	Confirm	Number			3			*3*
		Percent			100%			*100%*
High	Calibrate	Number	1	1	41	3	1	*47*
		Percent	2.1%	2.1%	87.2%	6.4%	2.1%	*100%*
	Confirm	Number			4	1		*5*
		Percent			80.0%	20%		*100%*
Total	***Calibrate***	***Number***	***1***	***2***	***70***	***3***	***1***	***77***
		Percent	***1.3%***	***2.6%***	***90.9%***	***3.9%***	***1.3%***	
	Confirm	***Number***			***7***	***1***		***8***
		Percent			***87.5%***	***12.5%***		***100.0%***

Historical Conditions

What do we know about BCG Level 1?



Quantification of Habitat Loss from Historical Conditions

Magnitude of Change from Reference

- Majority of streams have lost more than 20% of habitat historically accessible (Haring 2002);
- Majority of streams have lost more than 66% of wetted area (Haring 2002);
- Loss of large woody debris (Haring 2002);
- Loss of pool habitat (Haring 2002);
- Degradation or loss of riparian habitat (Haring 2002); and
- Less than 60% of watershed with forest stands aged 25 years or more (Haring 2002)

BIOLOGICAL CONDITION GRADIENT: Level I Puget Lowland Ecoregion

Historical Accounting of Stream Condition in Puget Sound

Changes in Stream Condition from 1895:

Food Base
- Allochthonous Input
- Autochthonous Input
- Marine-Derived Nutrients

> 25 times return spawners

Riparian Condition
- Leaf litter/Wood
- Shading (Water Quality)
- Bank stability

> 2.5 times intact area

Hydrology
- Water Quantity
- Flow Characteristics

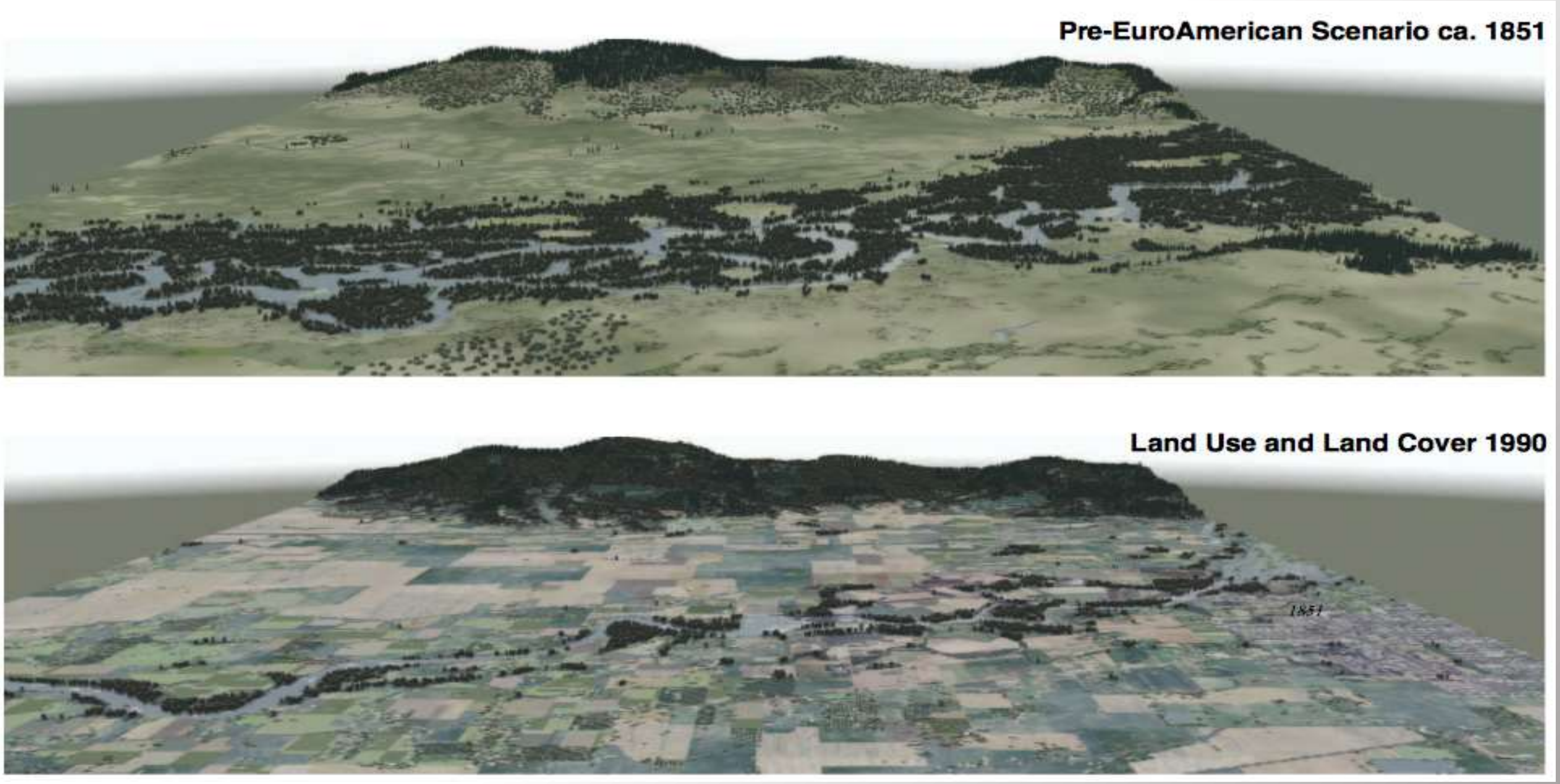
< 0.5m/sec average water velocity
> 3 times the tributary wetted area

Habitat Diversity
- Hard-bottomed (Cobble/Gravel)
- Soft-bottomed (Silt/Muck/Fines)
- Woody debris

> 1.25 times more useable habitat
> 3m tributary stream width

Snohomish County

R. W. Plotnikoff



Computer simulation of the upper Willamette River and floodplain between Harrisburg and Eugene-Springfield, ca. 1850 and ca. 1990. (From USEPA 2002b).

Summary of Changes in Willamette Basin Conditions from 1850 to current (1990 or 2005)

1850 — 1900 — 1925 — 1950 — 1975 — 1990 — 2017

- Beaver: Nearly eliminated by 1835

- (Lowlands) % Ag:	0%	→	41.6%
- (Lowlands) % Develop:	0%	→	10.3%
- (Lowlands) % Nat. Grass:	16.8%	→	1.0%
- (Lowlands) % Hdwd:	24.7%	→	9.9%
- (Lowlands) % Conif For:	25.4%	→	9.6%
- (Lowlands) % Wetlands:	14.2%	→	1.1%
- (Uplands) % Mixed For:	0.3%	→	36.6%
- (Uplands) % Conif For:	98.2%	→	52.1%
- Water Quality Index (WRB):	100	→ < 25 →	85
- Temperature Ag (% Mi Impaired)	0%	→	90%
- Temperature For (% Mi Impaired)	0%	→	65%
- BCG Level 1 Lowlands	25%	→	0%
- BCG Level 2 Lowlands	50%	→	0%
- BCG Level 3 Lowlands	15%	→	10%
- BCG Level > 4 Lowlands	10%	→	90%
- BCG Level 1 Uplands	25%	→	0%
- BCG Level 2 Uplands	50%	→	50%
- BCG Level 3 Uplands	15%	→	30%
- BCG Level > 4 Uplands	10%	→	20%

From: Willamette Basin Planning Atlas

Percent within 120 meter riparian area

From: DEQ Willamette Rivers & Streams Assessment

Historical Condition Narrative for BCG Level 1

Streams with high habitat complexity; natural disturbance regimes to refresh micro-habitats; year-round flow without anthropogenic impacts to hydrology, temperature, or water quality; water often dominated by cool-cold water flow from springs, groundwater accretion, and/or natural runoff; high resilience to disturbance including drought and flood extremes; exemplary biological diversity with high taxa richness of rheophilic, lotic-depositional, and micro-habitat specialist macroinvertebrates; non-native invasive species absent; biotic community supports all ecosystem functions.

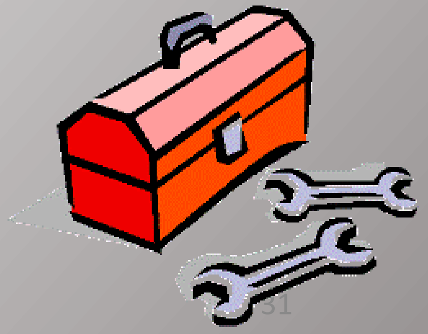
Expanded narrative description of BCG level 1 (by Bob Wisseman, Rick Hafele, and Rob Plotnikoff)

Fundamental Characteristics	Description
Stream channel	Channel connected to hyporheos and flood plain including wetlands, beaver ponds, etc.; diverse habitats present (e.g. braided channels, side channels, debris jams, mixture of steps and pools consistent with stream gradient); wood debris typically present and may be abundant; quality habitat and refugia persists during periods of both low and high stream-flows.
Riparian & watershed	Riparian zone supports intact community of overstory, understory and groundcover plants (including a mixture of mature conifer and hardwood trees with a diverse age structure in forested watersheds); upper watershed vegetation intact, supporting delivery of water of high chemical and thermal quality to lower reaches.
Hydrologic regime	Hydrologic regime natural, without alteration from dams and/or irrigation withdrawals or return flow; cool-cold water common from springs, groundwater accretion, and/or natural runoff; perennial surface or subsurface flow. Re-charge in the watershed sustains flow, especially during years of extreme drought. Perennial surface water in some portion of watersheds maintain endemic taxa that serve as recolonization sources sustaining high biodiversity at select locations. These locations promote resiliency in stream reaches that are periodically de-watered.
Disturbance regime and resilience	Natural seasonal range of high and low stream-flows present, which enhances and maintains channel and habitat complexity. Natural sediment transport based on local geology, soils and stream gradient. High resilience (ability to recover from disturbance) to natural and anthropogenic watershed stressors (Flotemersch et al. 2016). Watershed integrity maintains disturbance levels within ranges tolerable by endemic taxa and promotes connectivity for purpose of recolonization.
Biodiversity	Benthic macroinvertebrate community typically with high taxa richness, including many micro-habitat specialist taxa and species sensitive to human disturbance. Habitat complexity results in diversity of both rheophilic and lotic-depositional taxa. Non-native, invasive species not present.
Ecosystem function	Watershed supports full range of ecological processes and functions essential to maintaining high biodiversity provided by a minimally disturbed ecosystem. Food web, nutrient and energy flow linkages between aquatic and terrestrial environments fully supported

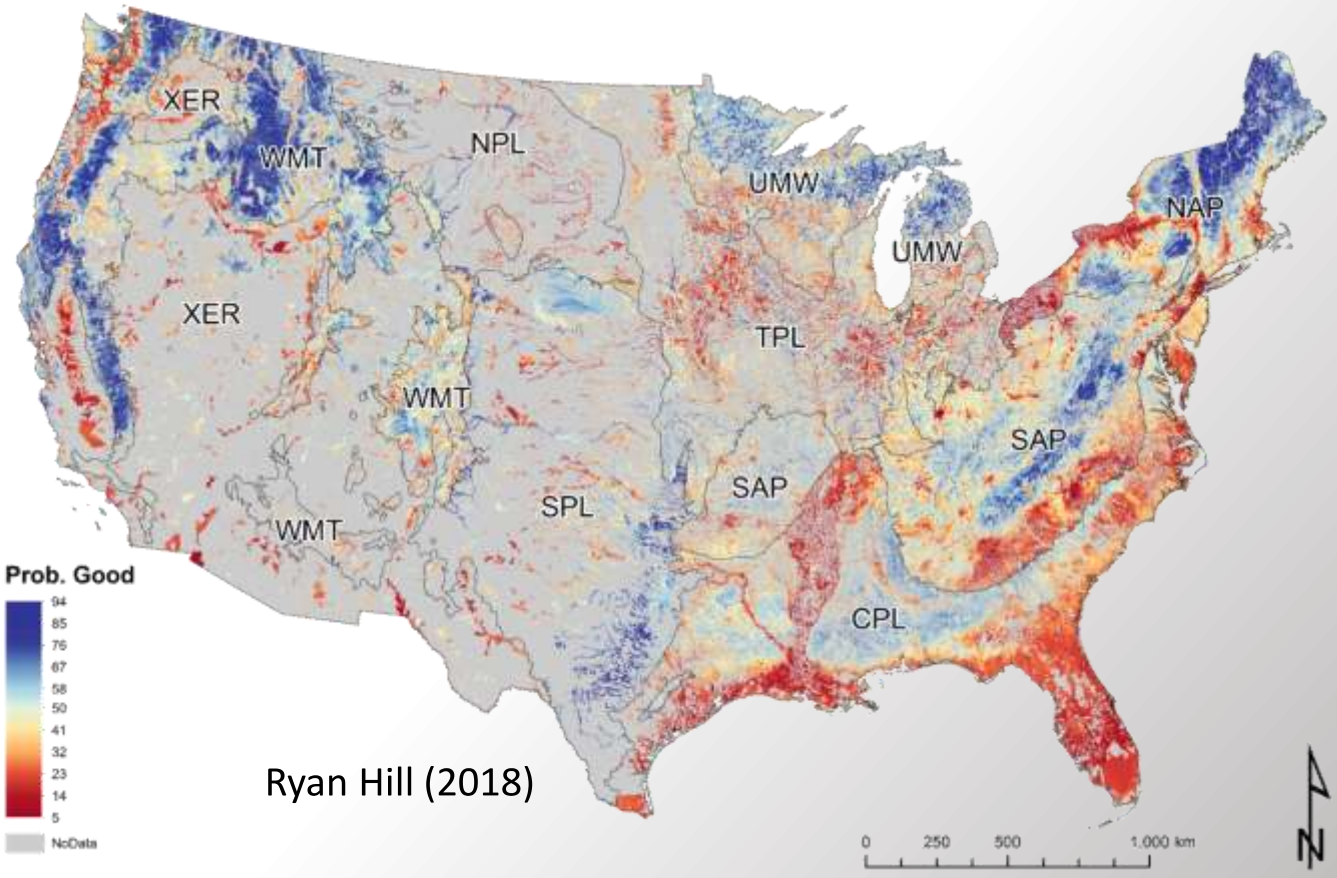
State and Local Government Applications

Applications

- State
    - compare and corroborate with existing B-IBI, RIVPACS tools
    - consider including BCG in 305(b)/303(d) assessment toolbox
    - stressor ID, environmental tolerances, and TMDL studies
    - ID as reporting item in regional studies (e.g., stormwater action monitoring)
- Local
    - Restoration Project Placement
    - Coordination of Capital Improvement Projects within a drainage
    - Identification of local stressors with CADDIS model
    - Effectiveness Monitoring of Salmon Habitat Recovery Projects



Future BCG Work



Ryan Hill (2018)

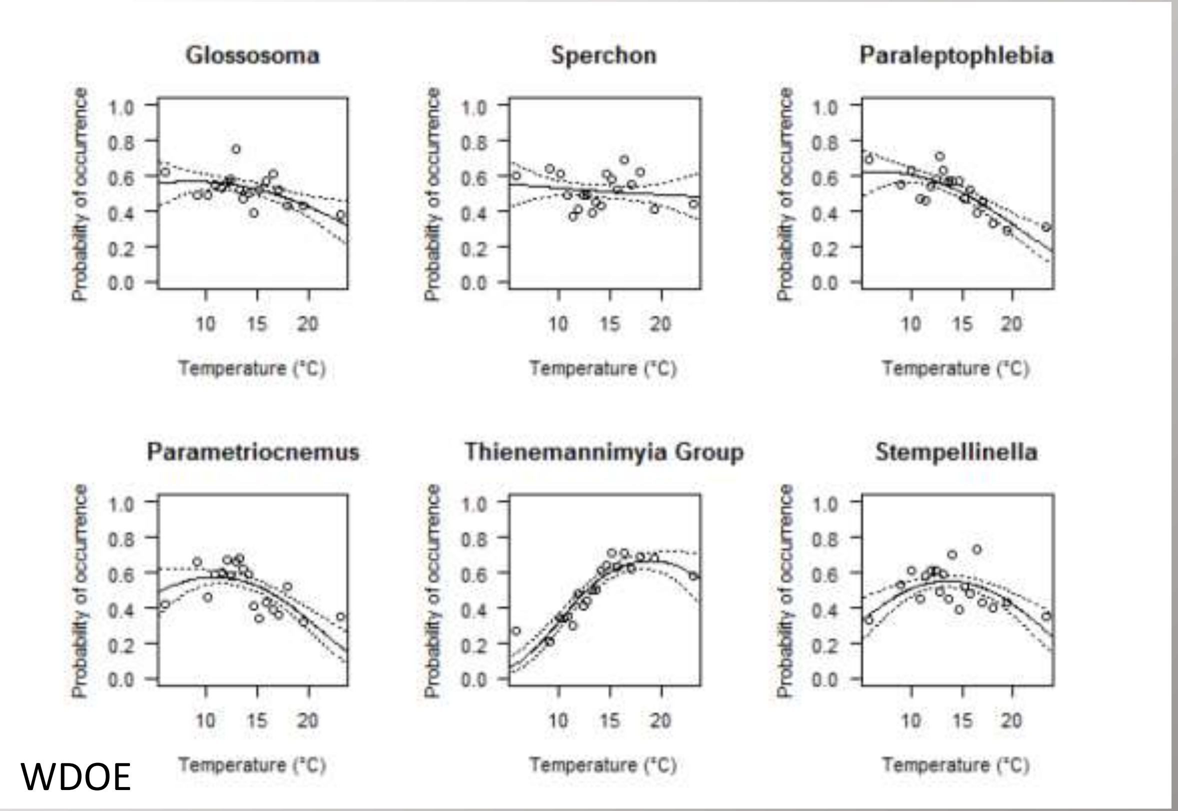
Probability of Good Condition (NRSA-Design NHD Streams)

Pilot projects

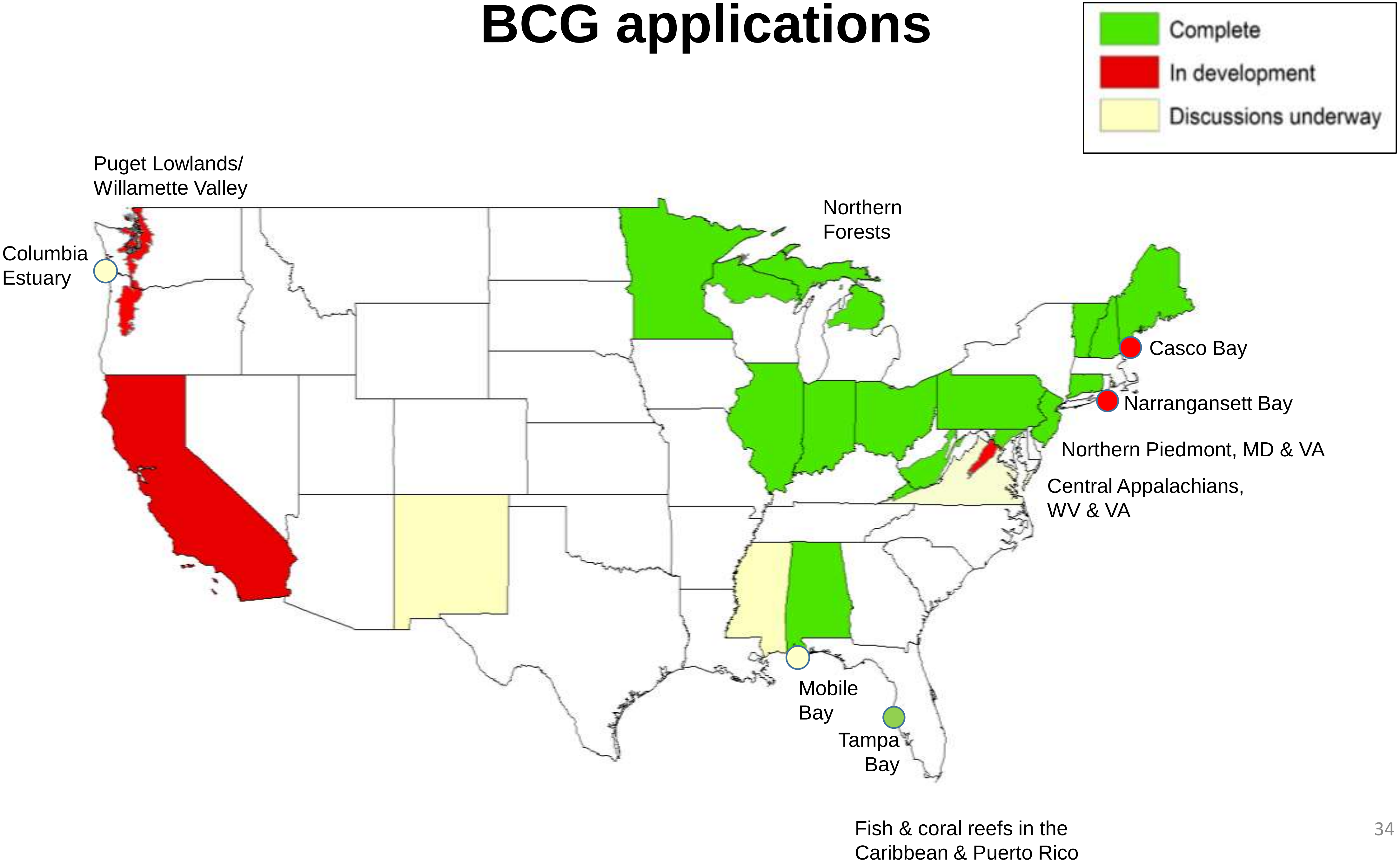
- **Addressing climate change by examining strategies for adapting to changing thermal & hydrologic conditions**
  - Thermal Impact Checklist
  - Thermal Prediction Models and Taxa Tolerances

- **BCG Refinements**
  - Integration of ICI and IWI metric suites to populate disturbance gradient
  - Prediction of BCG for unmonitored sites

- **Possible extension to other regions:**
  - NW Pacific Maritime Region Model



BCG applications



R Tool

(BCGcalc Package)

https://github.com/leppott/BCGcalc

How does the quantitative model and R Tool work?

Like a cascade…

The BCG model evaluates metric membership values for all the metrics included in the rules for a given BCG level.

We automate the model in Excel.

Core Functions

- metric.values()
  - Calculate MMI and BCG metrics.
- BCG.Metric.Membership()
  - Generate membership for each metric. Requires a table of values.
- BCG.Level.Membership()
  - Uses metric membership and table of values to classify each site’s membership for Levels 1 to 6.
- BCG.Level.Assignment()
  - Assign 1st and 2nd Levels by Level membership

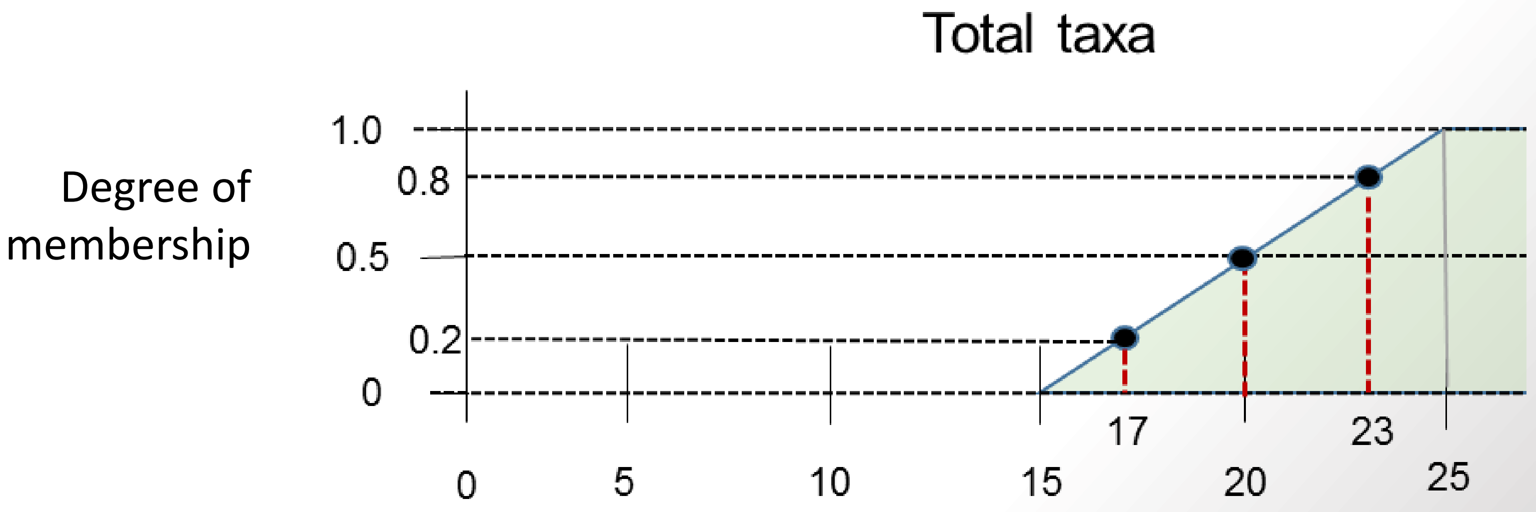
Steps for running the BCG R tool

1. Prepare your data input file (save as .csv)
   - SampleID, TaxonID, Count, Excluded, and master taxa attributes (phylogenetic and autecological)
2. Use the BCG R tool to
   - Calculate suite of metrics
   - Calculate metric membership values for each BCG level
   - Calculate overall BCG membership values
3. Save output as .csv or Excel file

Calibrated BCG Level 4 Rules

<table>
<tr><td colspan="4">BCG level 4: Moderate changes in structure of the biotic community and minimal changes in ecosystem function - Moderate changes in structure due to replacement of some intermediate sensitive taxa by more tolerant taxa, but reproducing populations of some sensitive taxa are maintained; overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes.</td></tr>
<tr><th rowspan="2">Narrative Descriptions</th><th rowspan="2">Metric</th><th colspan="2">Numeric Rules</th></tr>
<tr><th>Low</th><th>High</th></tr>
<tr><td>Moderate numbers of total taxa</td><td>Number of total taxa</td><td colspan="2">≥ 20 (15-25)</td></tr>
<tr><td>Sensitive taxa occur in reduced numbers but still comprise at least a tenth of the taxa</td><td>% Attribute Ii+II+III % taxa</td><td colspan="2">≥ 10% (5-15)</td></tr>
<tr><td rowspan="2">Tolerant and non-native taxa comprise up to a quarter of the organisms. Slightly higher proportions occur in low gradient streams.</td><td>% Attribute V+VI taxa</td><td>≤ 20% (15-25)</td><td>≤ 15% (10-20)</td></tr>
<tr><td>% Attribute V+VI individuals</td><td>≤ 25% (20-30)</td><td>≤ 20% (15-25)</td></tr>
<tr><td>At least one sensitive EPT taxon is present</td><td>Number of Attribute Ii+II+III EPT taxa</td><td colspan="2">> 1 (0-3)</td></tr>
<tr><td>Tolerant non-insect taxa become more prevalent, and may comprise up to a third of the assemblage.</td><td>% Attribute IV+V+VI non-insect taxa</td><td colspan="2">≤ 30% (25-35)</td></tr>
<tr><td>Tolerant non-insect taxa comprise up to half the individuals in low gradient streams and up to a third of the individuals in high gradient streams. Juga and Rissoidea are excluded from consideration for reasons described above[2]</td><td>% Attribute IV+V+VI non-insect[1], individuals, excluding Juga and Rissooidea[2]</td><td>≤ 50% (45-55)</td><td>≤ 35% (30-40)</td></tr>
</table>

Metric membership calculations – example



Black dots = examples of metric membership values assigned to different metric values

Example – the BCG level 4 rule for total taxa richness is ≥ 20 (15-25) (the lower bound is 15 and the upper bound is 25).

- If there are 15 or fewer total taxa in the sample, the metric membership value is 0.
- If there are 25 or more total taxa in the sample, the metric membership value is 1.
- If the number of total taxa falls within the lower and upper bounds, the metric membership value will range from 0 to 1 (e.g., if there are 20 total taxa, the membership value will be 0.5; if there are 17 total taxa, the membership value will be 0.2; if there are 23 total taxa, the membership value will be 0.8).

Overall BCG level membership

May include membership of a sample in

- A single level only
  - e.g., probability of membership in BCG level 3 = 1.0
- Two levels (tie)
  - e.g., probability of membership in BCG level 3 = 0.5 and BCG level 4 = 0.5
- Varying memberships among two or more levels
  - e.g., probability of membership in BCG level 3= 0.8 and probability of membership in BCG level 4 = 0.2.

The level with the highest membership value is taken as the primary level.


Thank You!
QUESTIONS ?

Additional Slides

Calibrated BCG Level 3 Rules

<table>
<tr><td colspan="4">BCG level 3: Evident changes in structure of the biotic community and minimal changes in ecosystem function - Some changes in structure due to loss of some rare native taxa; shifts in relative abundance of taxa but intermediate sensitive taxa are common and abundant; ecosystem functions are fully maintained through redundant attributes of the system.</td></tr>
<tr><th rowspan="2">Narrative rules and comments</th><th rowspan="2">Metric</th><th colspan="2">Numeric Rules</th></tr>
<tr><th>Low</th><th>High</th></tr>
<tr><td>Moderate to high numbers of total taxa</td><td>Number of total taxa</td><td colspan="2">≥ 25 (20-30)</td></tr>
<tr><td>At least a quarter of the total taxa belong to one of the three sensitive groups</td><td>% Attribute Ii+II+III taxa</td><td colspan="2">≥ 25% (20-30)</td></tr>
<tr><td>Sensitive taxa comprise at least a tenth of the individuals</td><td>% Attribute Ii+II+III individuals</td><td colspan="2">≥ 10% (5-15)</td></tr>
<tr><td rowspan="2">Tolerant and non-native taxa make up a small fraction of the organisms</td><td>% Attribute V+VI taxa</td><td colspan="2">≤ 10% (5-15)</td></tr>
<tr><td>% Attribute V+VI individuals</td><td colspan="2">< 8% (5-10)</td></tr>
<tr><td>Sensitive EPT species are present in moderate to high numbers</td><td>Number of Attribute Ii+II+III EPT taxa</td><td colspan="2">≥ 9 (6-12)</td></tr>
<tr><td>Tolerant non-insect taxa comprise a less than a quarter of the assemblage. Slightly higher proportions of non-insect individuals are expected in low versus high gradient streams. Juga and Rissoidea are excluded from consideration for reasons described above[2]</td><td>% Attribute IV+V+VI non-insect[1], individuals, excluding Juga and Rissooidea[2]</td><td colspan="2">≤ 30% (25-35)</td></tr>
</table>

BIOLOGICAL CONDITION GRADIENT: Level I Puget Lowland Ecoregion

Historical Accounting of Stream Condition in Puget Sound

Habitat Characteristics Based on Modeling Results of Steelhead Parr Survival (1895 Conditions)

- Average tributary channel width available for maximum parr production = 3m
- Where tributary meets mainstem: ≤ 0.5m depth & ≤ 0.5m/sec water velocity
- Open canopy and ↑ primary productivity enhances BMI response → food for fingerlings/juv.
  - ↑ parr survival = increased spawners
  - Increased spawners = increased redds
  - Buried eggs are the primary source of marine-derived nutrients benefiting BMI

Capacity of the Available Habitat and Loss from Historic Conditions

Direct Effects on Stream Biota

- loss of suitable habitat (Structural Attributes; e.g., Density, No. of Species)

Indirect Effects on Stream Biota

- conditions that affect population productivity (e.g., Density, Spatial Distribution)

Snohomish County

R. W. Plotnikoff

Historical Condition for BCG Level 1

Work in Progress*: *Signal Checklist

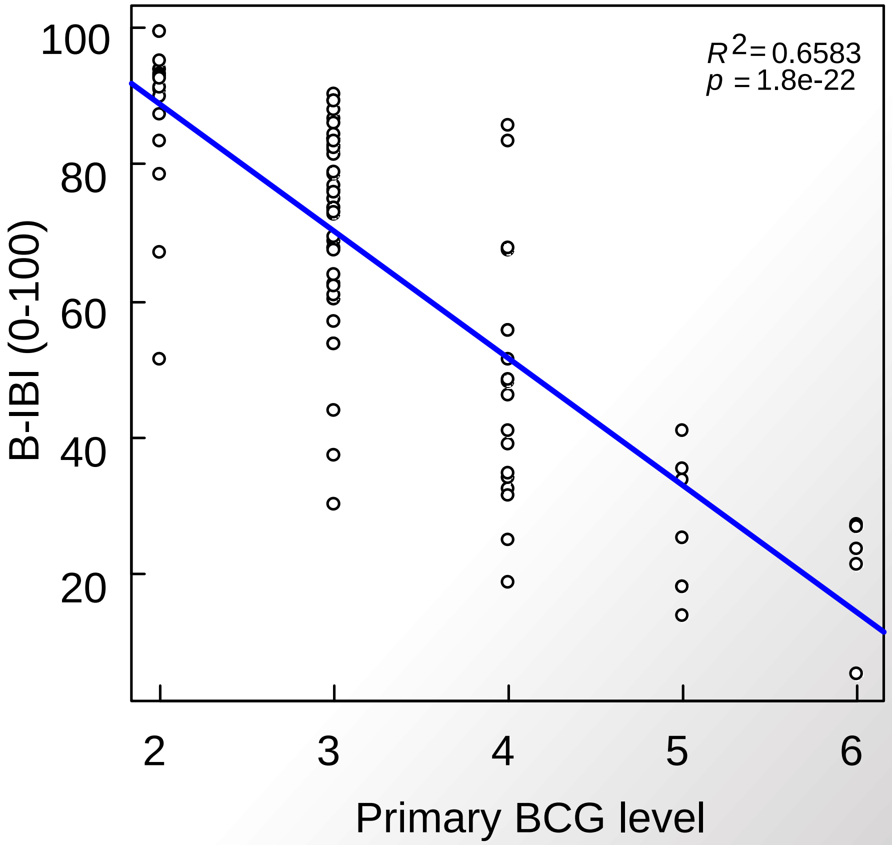
- Identify
  - best quality sites that remain
  - provide measure of BCG 1 elements at a site
  - degree to which site conditions reflect Level 1
- Metrics (current exploration)
  - <u>Ecologic</u>

    # attribute Ii, II taxa, # sensitive EPT, #cold water taxa, # (Heptageniidae, Ephemerellidae, Nemouridae, Perlidae and Rhyacophilidae), habitat specialist (e.g., in low gradient valley streams, high dytiscid diversity)

  - <u>Physical Habitat, Watershed Condition</u>

    Index of Catchment Integrity, Index of Watershed Integrity

Preliminary comparison of B-IBI with BCG for sites in Puget Lowlands



Effects of macrophyte growth and senescence on sediment dynamics in a regulated, low-gradient river

Rob Van Kirk
Melissa Muradian
Zach Kuzniar
Ben Ortman

Henry's Fork Foundation
Ashton, Idaho

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FOUNDATION

Study Motivation and Questions

<u>Harriman State Park Reach of Henry's Fork</u>

- World-renowned wild Rainbow Trout fishery
- Famous for prolific aquatic insect hatches
- Wide, shallow channel
- Low-gradient: 0.10%
- Embedded gravel substrate
- Minimal riparian vegetation
- Seasonal growth and senescence of macrophytes
- 5 miles downstream of large irrigation reservoir

1. How do macrophytes and irrigation management affect fine sediment transport and deposition?
2. Can we relate invertebrate assemblage to sediment?

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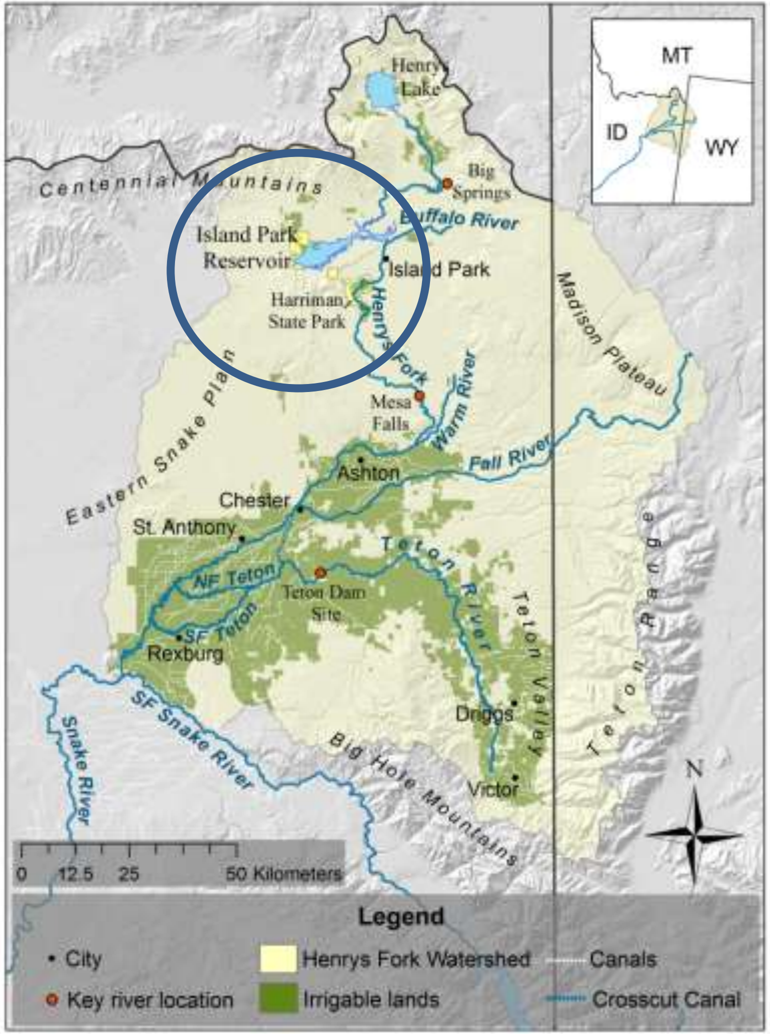
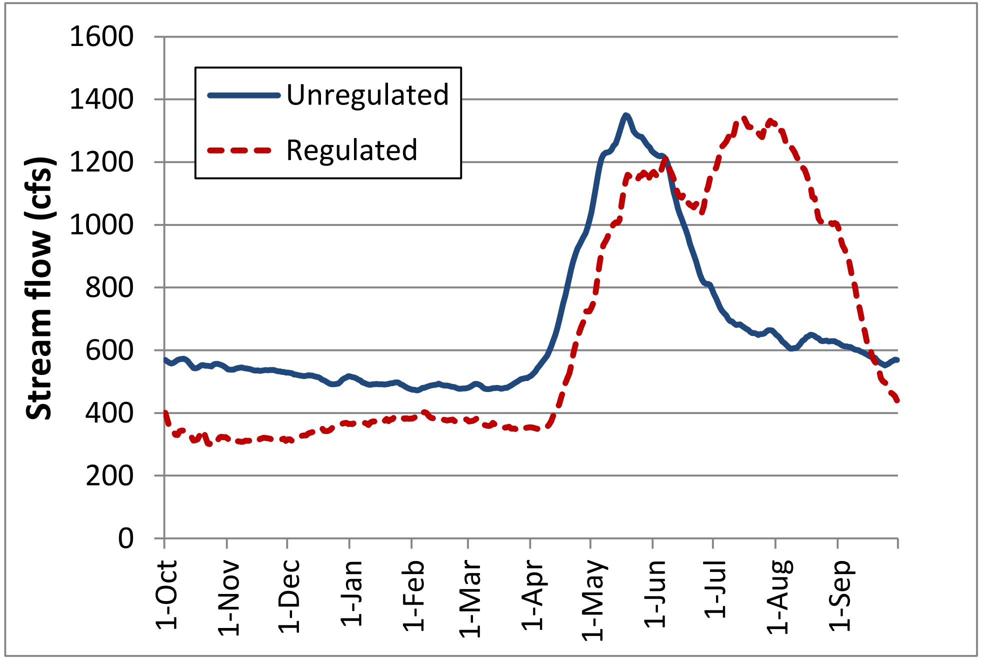
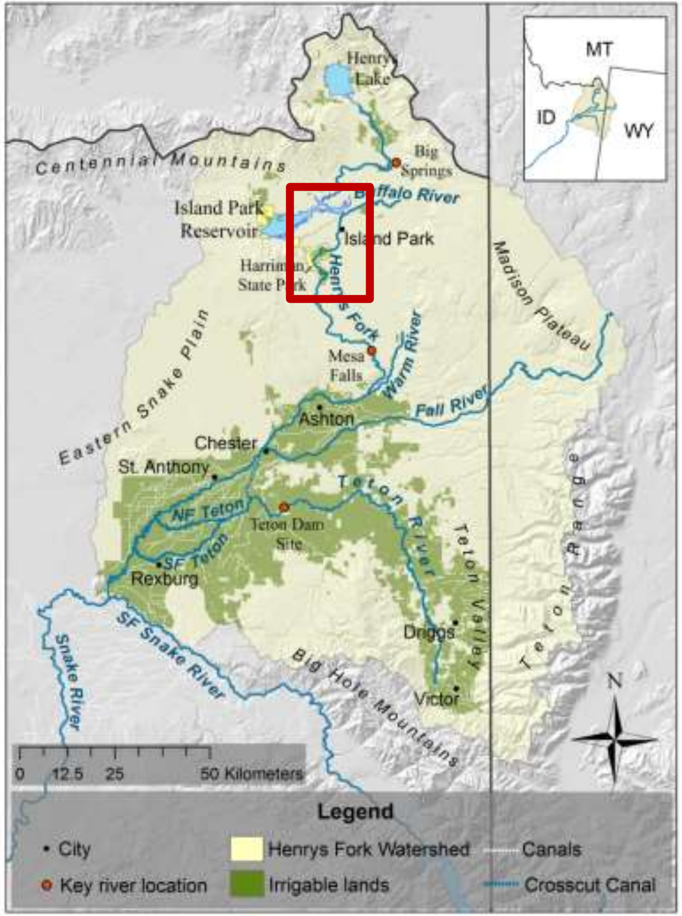


Study Reach

- 15 miles of river downstream of Island Park Dam
- 4th-order reach; mean annual flow 650 cfs
- Drainage basin area: 500 mi^2
- Unregulated hydrology dominated by groundwater
- Reservoir stores 1/3 of annual basin yield



Monitoring Sites in Study Reach



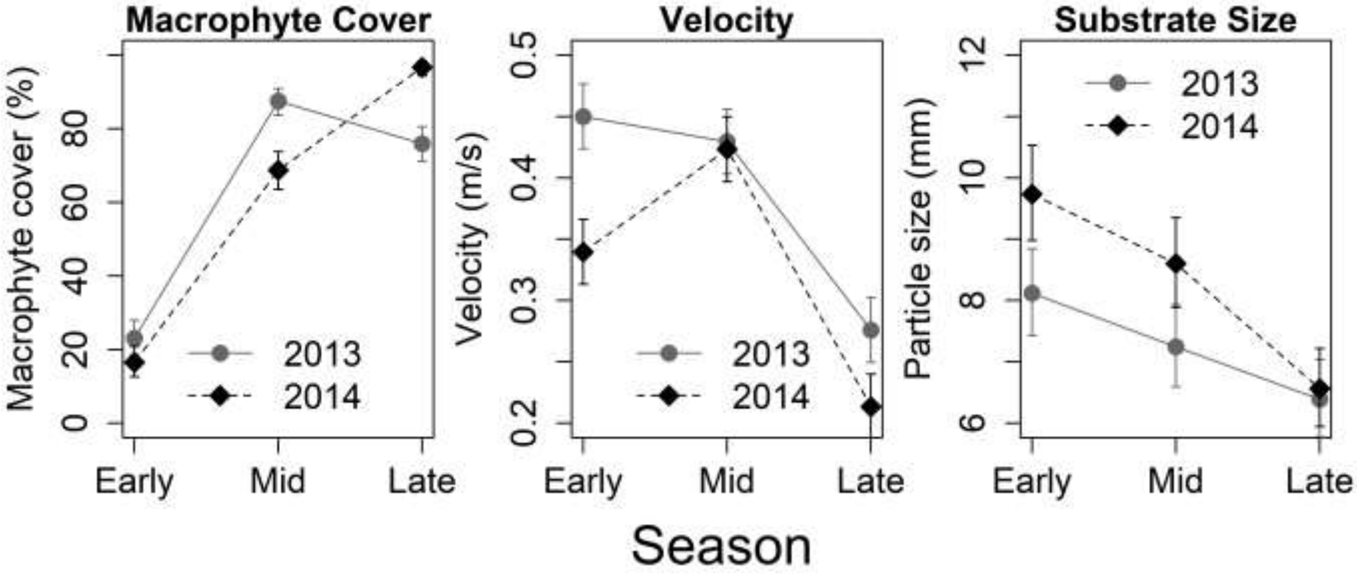
<u>Water-quality</u>

- YSI sondes, continuous
  - Turbidity
  - Temp., DO, etc.
- Weekly samples
  - Nutrients
  - Turbidity
  - Suspended sediment

<u>Macroinvertebrates</u>

- Sample in March
- Quantitative Hess
- 3-6 samples/location
- Data back to 1992 at upstream site

Previous Results from Study Reach



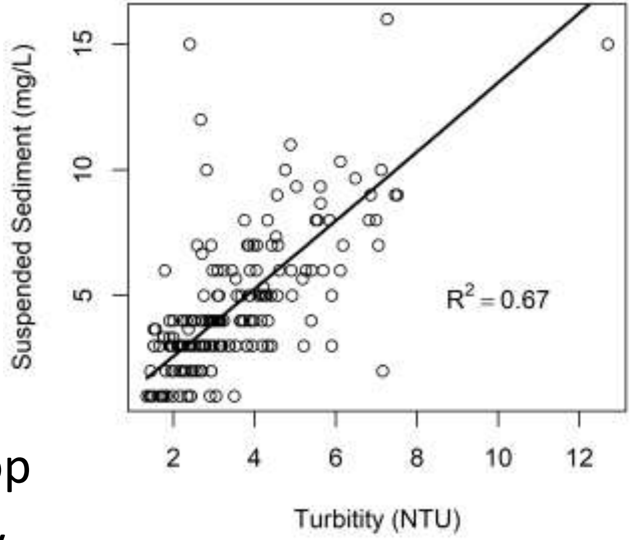
<u>Macrophytes:</u>

- Grow Jun-Sep
- Slow water velocity
- Increase depth
- Trap sediment
- Senesce Dec-Mar
- Determine fish habitat characteristics

Kuzniar et al. 2017. *Ecology of Freshwater Fish* Vol. 26

Sediment Analysis

- Turbidity-SSC relationship from samples
- Daily SSC from sonde turbidity data
- Streamflow: Island Park Dam and Buffalo River
- Streamflow at reach bottom ≈ sum of these
- Load = SSC concentration × streamflow
- Net reach transport = load at bottom − load at top
- Effect of reservoir operation on SSC and turbidity
- Effect of reservoir operation on invertebrates



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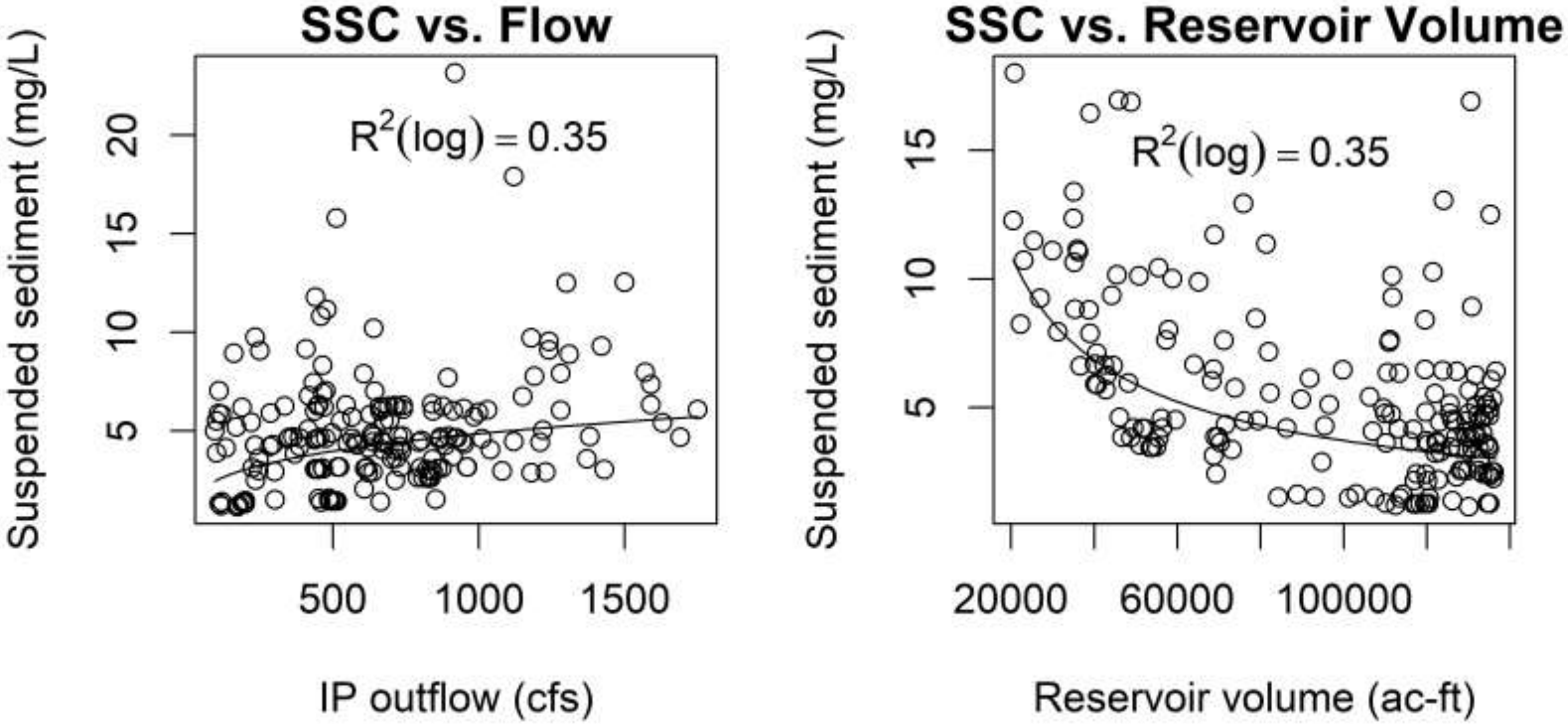
Results: Reservoir operations and SSC



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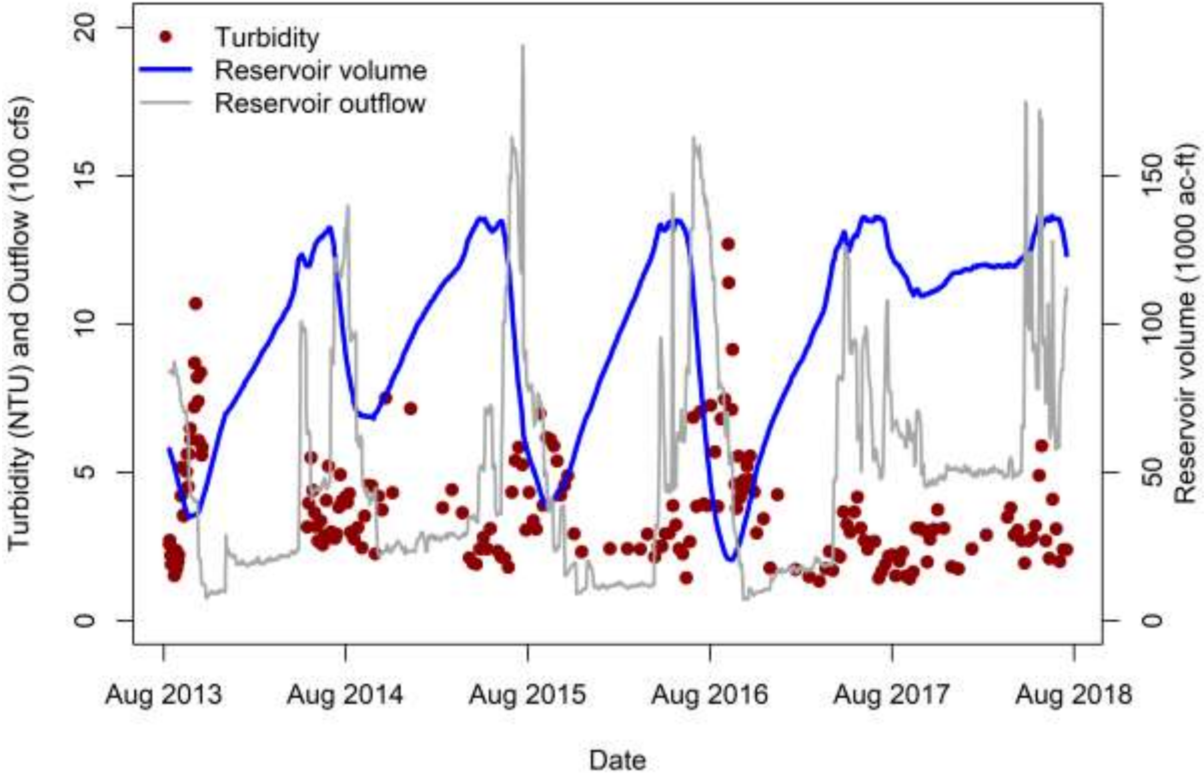
Results: Reservoir operations and turbidity



<u>Turbidity and SSC at dam:</u>

- High when reservoir outflow is high and volume is low
- High in late summer of years when irrigation demand is high
- Low when outflow is low and reservoir is full
- Low in late winter

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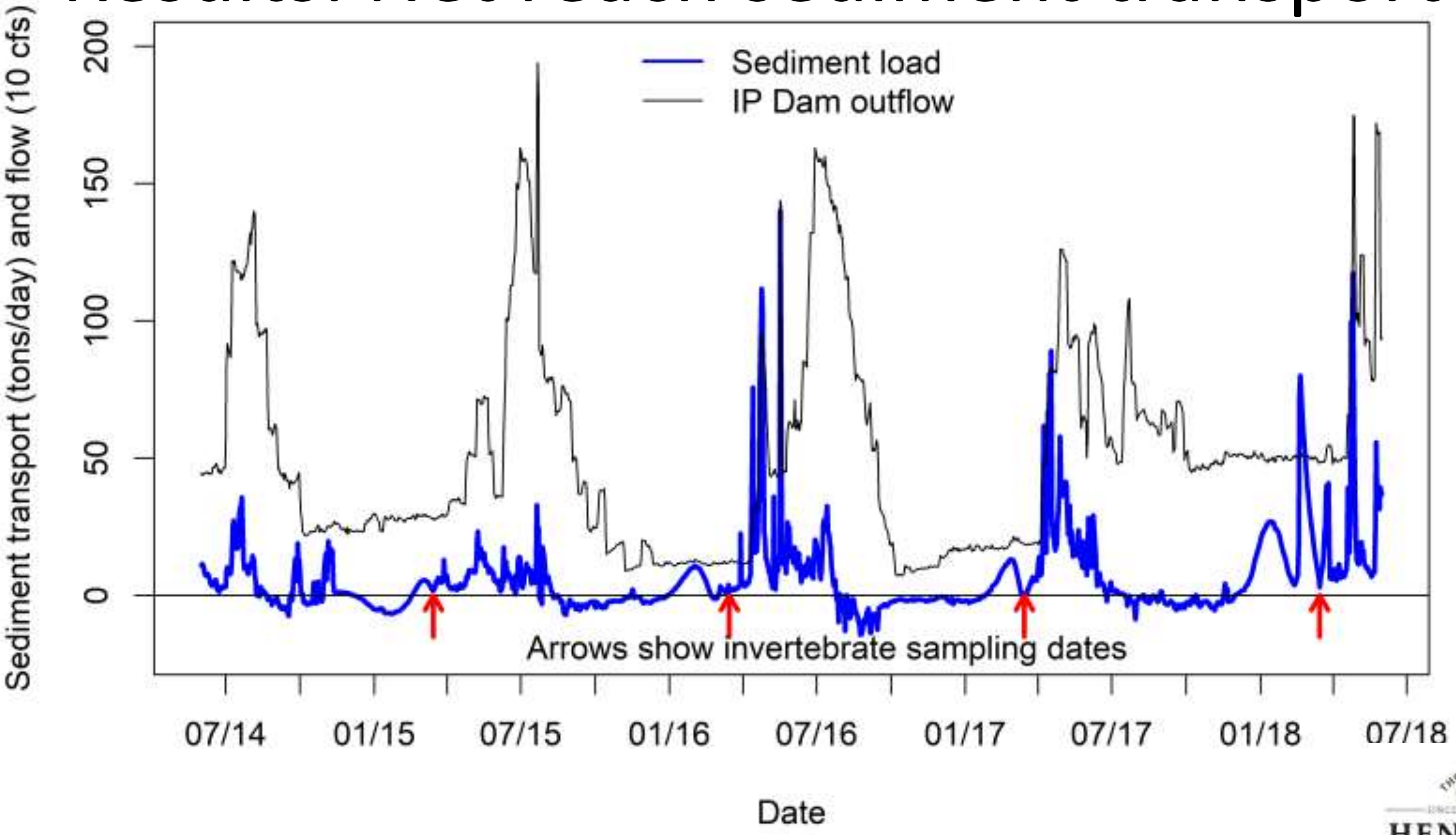
Results: Net reach sediment transport



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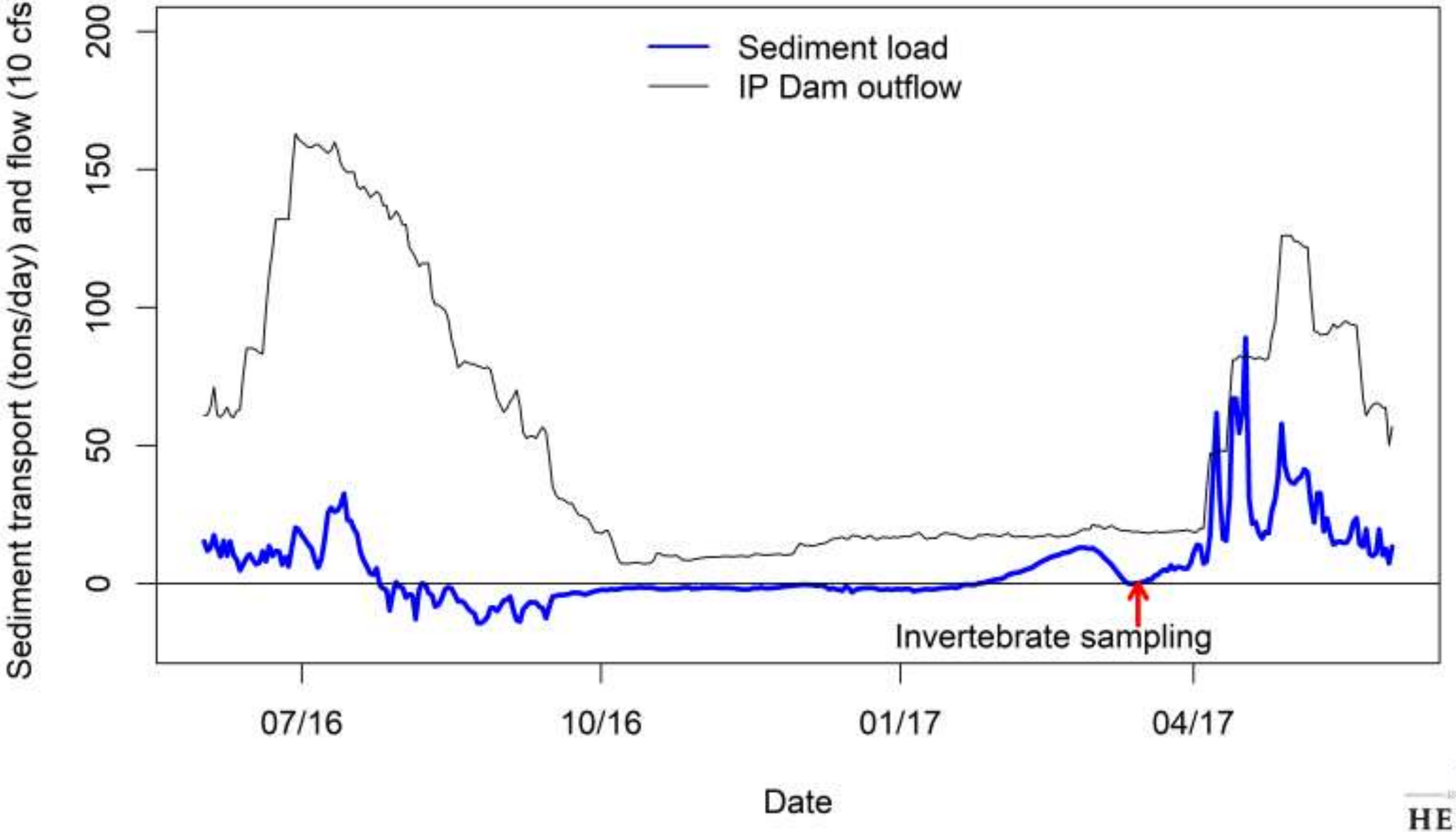
Results: Net reach sediment transport: 2016-2017



Sediment Transport: Context Matters

Yellowstone River near Livingston, MT

Henry's Fork in study reach

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Macrophytes and sediment dynamics

- Macrophytes trap fine sediment delivered during irrigation season
- Sediment transported out of reach highest when macrophyte biomass lowest

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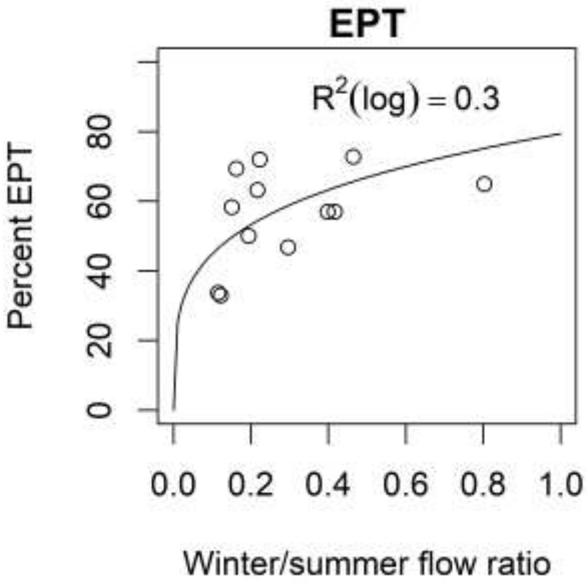
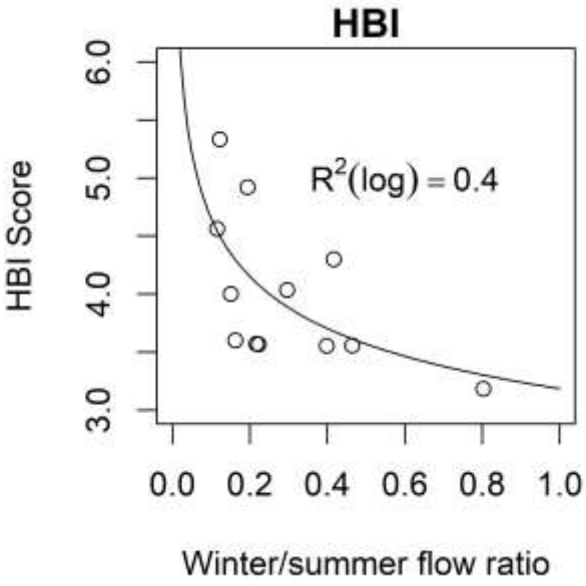
Sediment dynamics and invertebrates

- Is net sediment deposition/scour between summer invertebrate reproduction and March sampling a function of streamflow?
- Ratio of winter (December-March) flow to irrigation-season flow (July-September): higher values should result in less deposition/more scour.

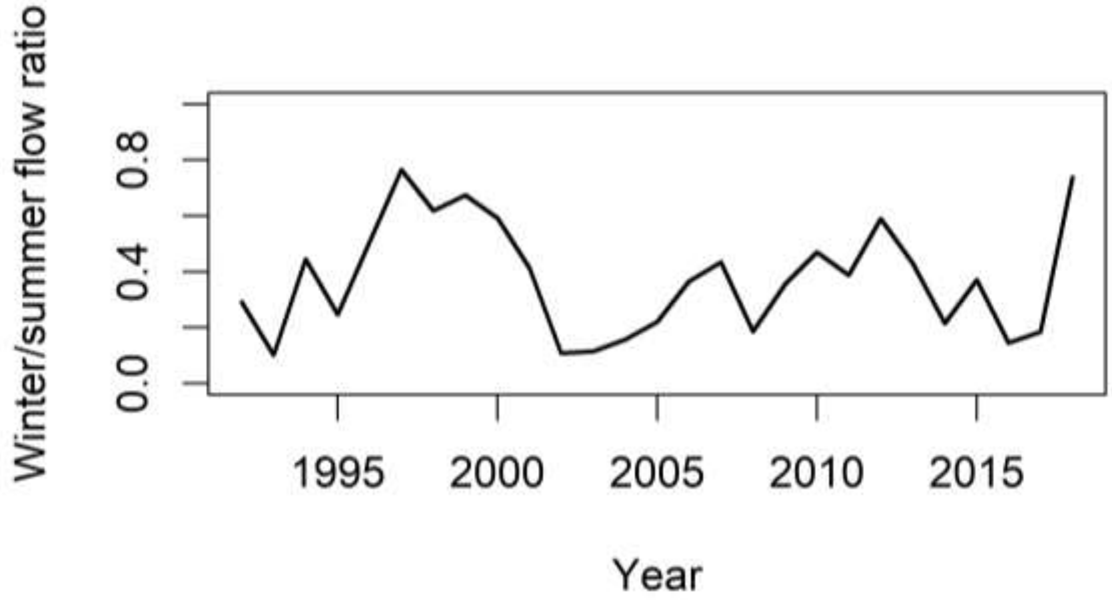




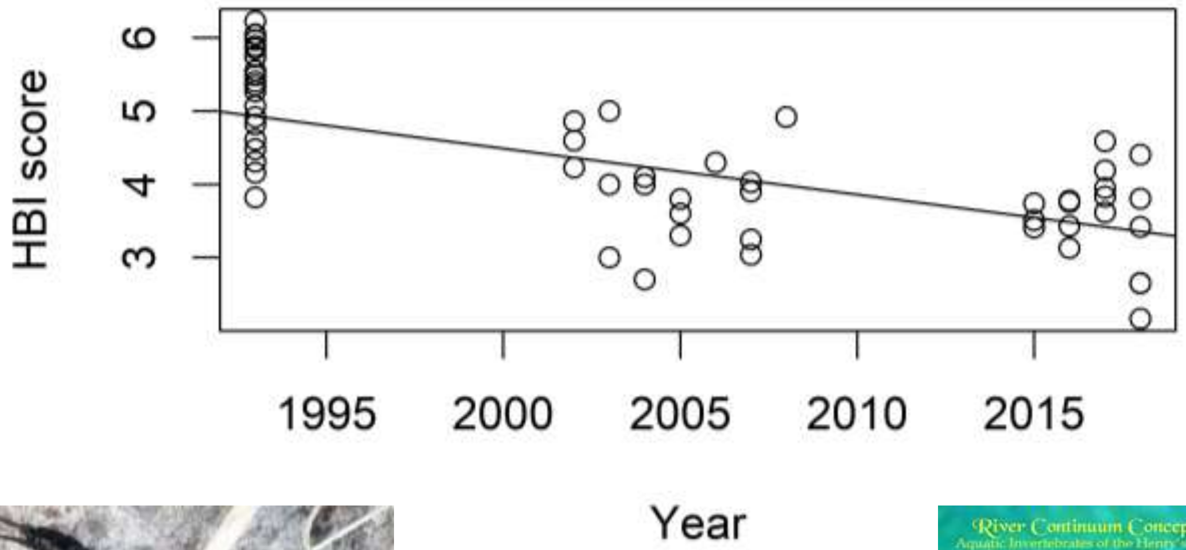
Some evidence that higher flow ratios lead to better invertebrate metrics.

Sediment dynamics over long term

- 50,000 – 100,000 tons released from reservoir in 1992 (complete drawdown)
- Since 2014, net transport out of reach ≈ 2,000 tons/year but not uniform!
- 1992 sediment moved out of reach in 25-50 years?



Possible explanation for invertebrate trend?



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Conclusions and management implications

- Sediment dynamics in Henry's Fork differ from usual model of mobilization on ascending limb of runoff and deposition on descending limb.
- Reservoir sediment transport highest in July-September (irrigation season), out of phase with natural runoff timing.
- Macrophytes trap fine sediment during irrigation season.
- Sediment transport out of reach highest in late winter/early spring.
- Trends in invertebrate assemblage show some correlation with short- and long-term sediment dynamics.
- High winter flows and low irrigation-season flows lead to net transport of sediment out of Harriman reach, among other benefits to fishery.

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Questions?

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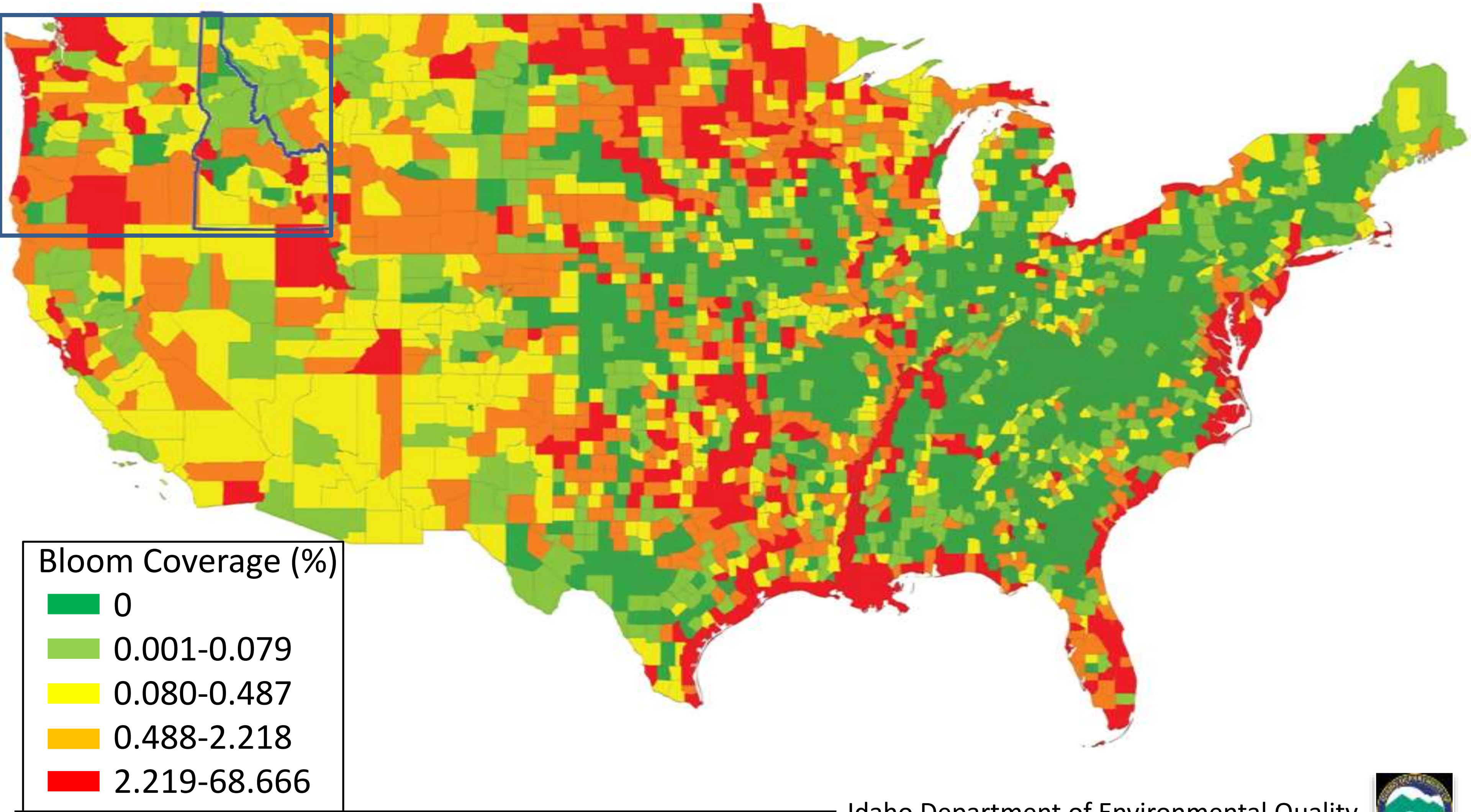
Growing Our Understanding Through Communication

Brian Reese
Water Quality Standards Analyst.

Chase Cusack
Watershed Manager

Zhang et al. Environmental Health (2015) 14:41
DOI 10.1186/s12940-015-0026-7



Idaho Department of Environmental Quality

Why do we care?

Hypoxia

Taste and odors

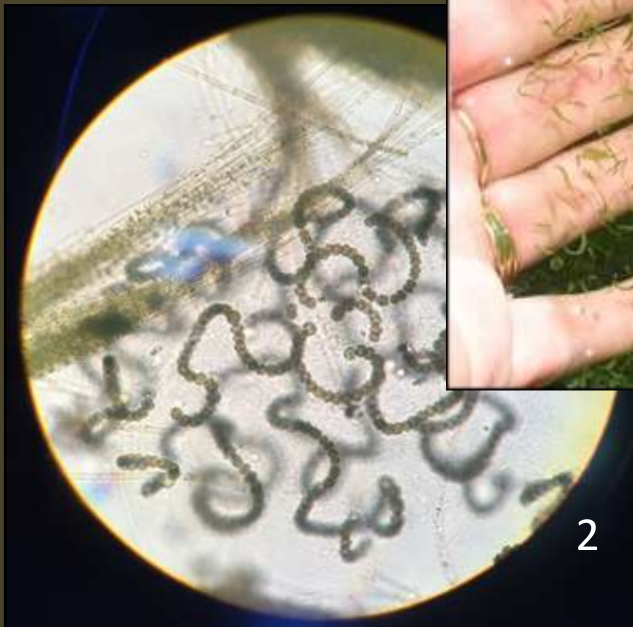
Aesthetics

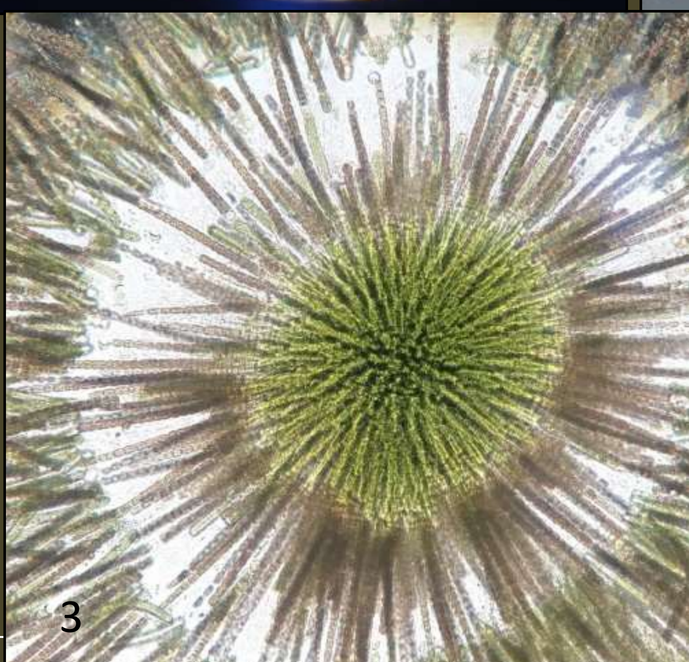
Fernan Lake

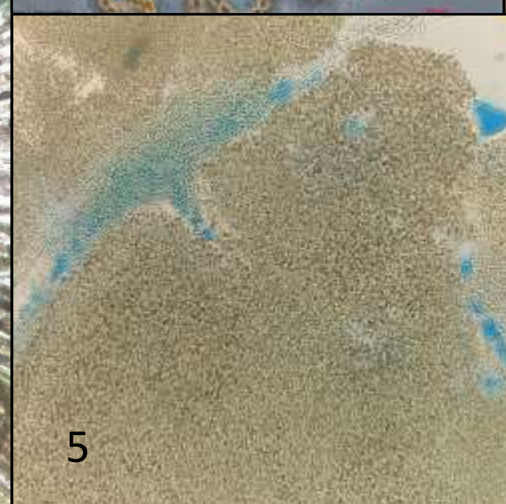
Cyanotoxins

Idaho Cyanobacteria

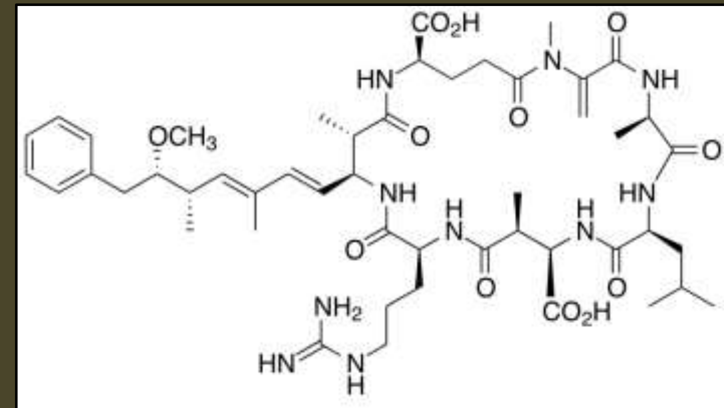
1. Aphanizomenon sp.
2. Dolichospermum
3. Gloeotrichia
4. Lyngbya
5. Microcystis
6. Planktothrix
7. Woronichinia







Hepatotoxins



Disrupt proteins that keep the liver functioning, may act slowly

- **Microcystins** (fast death factor) **:** 240+ variants, known tumor promotor.
- **Nodularin**
- **Cylindrospermopsin**

Potentially produced by:
1. *Aphanizomenon*
2. *Dolichospermum*
3. *Gloeotrichia*
4. *Lyngbya*
5. *Microcystis*
6. *Oscillatoria*
7. *Woronichinia*

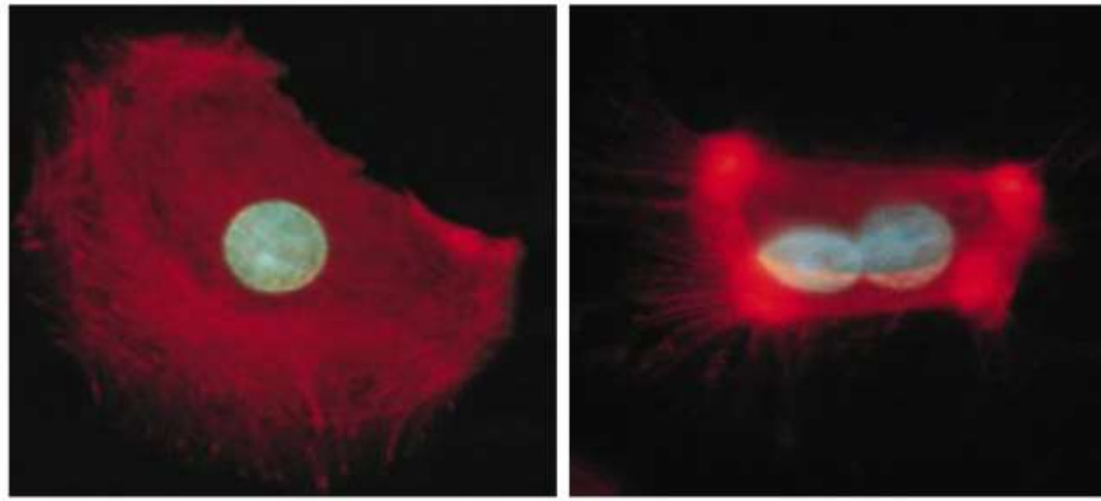
Microcystin exposure: response

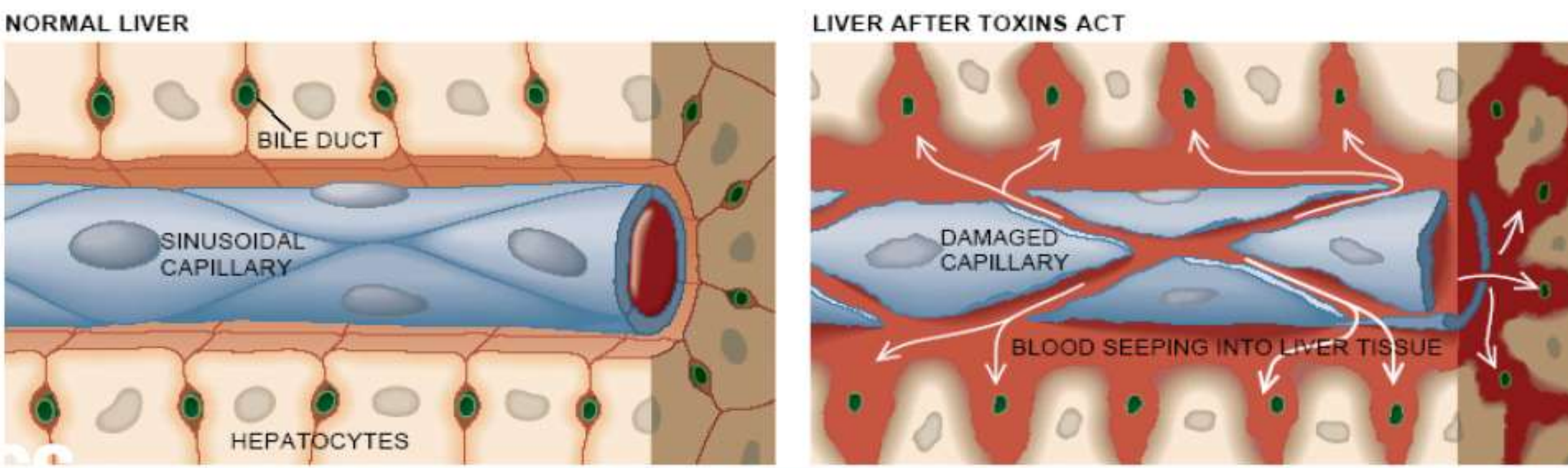
- Uptake by bile acid transporter
- Inhibit protein phosphatases 1 and 2A
- Affects cytoskeleton, cell cycle, general metabolism, apoptosis

Blatantly borrowed from Barry Rosen, USGS

Hepatotoxicity

MICROFILAMENTS (*red threads in micrographs*), structural components of cells, are usually quite long, as in the rat hepatocyte at the left. But after exposure to microcystins (*right*), microfilaments collapse toward the nucleus (*blue*). (This cell, like many healthy hepatocytes, happens to have two nuclei.) Such collapse helps to shrink hepatocytes—which normally touch one another and touch sinusoidal capillaries (*left drawing*). Then the shrunken cells separate from one another and from the sinusoids (*right drawing*). The cells of the sinusoids separate as well, causing blood to spill into liver tissue. This bleeding can lead swiftly to death.

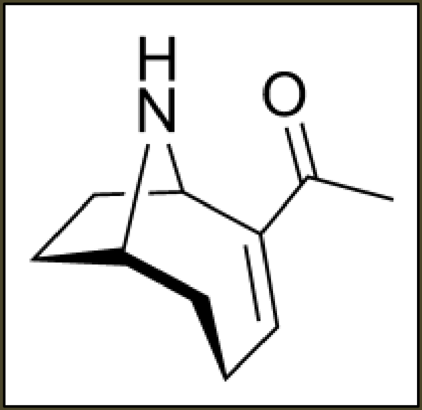




USGS science for a changing world

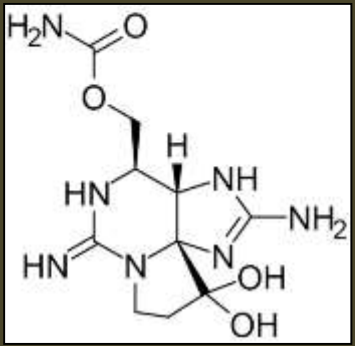
Wayne Carmichael ISOC-HAB Ch. 4, Scientific American, January, 1994

Neurotoxins



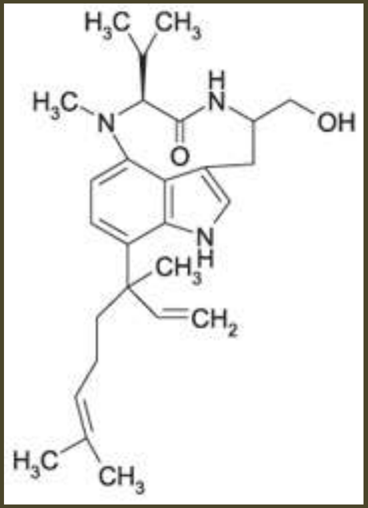
Neurological toxicity loss of coordination, muscle spasms, convulsions and rapid paralysis of skeletal and respiratory muscles (minutes)

- **Anatoxin -a** (Very Fast Death Factor)
- **Anatoxin –a (s)**
- **Saxitoxin**
- **Neosaxitoxin**



Potentially produced by:
1. *Aphanizomenon*
2. *Dolichospermum*
3. *Gloeotrichia*
4. *Lyngbya*
5. ~~*Microcystis*~~
6. *Oscillatoria*
7. *Woronichinia*

Dermatotoxins



Produce rashes and other skin reactions, usually within a day (hours)

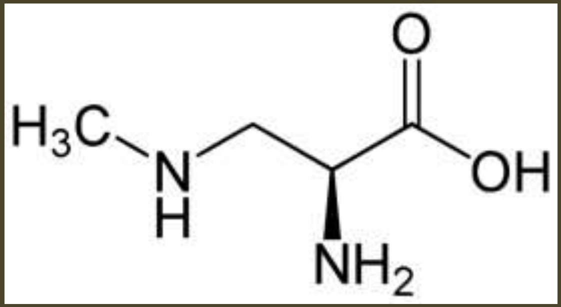
- **Lyngbyatoxin**

Potentially produced by:

1. ~~*Aphanizomenon*~~
2. ~~*Dolichospermum*~~
3. ~~*Gloeotrichia*~~
4. *Lyngbya*
5. ~~*Microcystis*~~
6. *Oscillatoria*
7. ~~*Woronichinia*~~

b-N-methylamino-L-alanine BMAA

Neurological, linked to ALS and AD



Potentially produced by:

1. *Aphanizomenon*
2. *Dolichospermum*
3. ~~*Gloeotrichia*~~
4. *Lyngbya*
5. ~~*Microcystis*~~
6. *Oscillatoria*
7. ~~*Woronichinia*~~

Cyanotoxins are highly potent

Compounds & LD_{50} (µg/kg)

Saxitoxin	9	Ricin	0.02
Microcystin	20	Cobra toxin	20
Anatoxin – a(s)	50	Curare	500
Anatoxin – a	200 – 250	Strychnine	2000
Nodularin	50		
Cylindrospermopsins	200		

Blatantly borrowed from Barry Rosen, USGS

Cyanotoxins are highly potent

Compounds & LD_{50} (µg/kg)

- Saxitoxin 9
- Microcy
- Anatoxi
- Anatoxi
- Nodularin 50
- Cylindrospermopsins 200

- Ricin 0.02
- in 20
- 500
- e 2000

<u>Saxitoxin</u>

0.0000002g

Cyanotoxins are highly potent

Microcystin

4 ppb =

- Saxitoxi 0.02
- Microcy in 20
- Anatoxi 500
- Anatoxi e 2000
- Nodular
- Cylindrosp

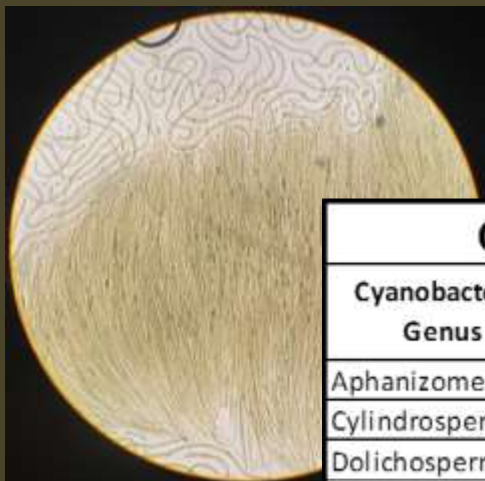
Cyanotoxins are highly potent

- Saxitoxi… 0.02
- Microcy… …in 20
- Anatoxi… 500
- Anatoxi… …e 2000
- Nodular…
- Cylindrosp…

Microcystin

8 ppb =

Observed Cyanobacteria and known toxins




Cyanobacteria & Known Toxins Chart. Version 1.0 2/08/2017

Cyanobacteria Genus	Cyanotoxin Class									
	CYL	MC	NOD	ATX	SAX	NEO	LYN	BMAA	DAT	APL
Aphanizomenon	✓	✓	✓	✓	✓	✓		✓		
Cylindrospermum		✓		✓	✓					
Dolichospermum	✓	✓		✓	✓	✓		✓		
Gloeotrichia		✓								
Lyngbya	✓			✓	✓	✓	✓	✓	✓	✓
Microcystis		✓						✓		
Oscillatoria (Planktothrix)	✓	✓		✓	✓		✓	✓		✓
Woronichinia		✓		✓						

CYL = cylindrospermopsin **MC** = microcystin **NOD** = nodularin **ATX** = anatoxin-a **SAX** = saxitoxin **NEO** = neosaxitoxins **BMAA** = β-N-methylamino-L-alanine **LYN** = lyngbyatoxin-a **DAT** = debromoaplysiatoxin **APL** = aplysiatoxin

Blatently adapted from the SWAMP - HAB Field Guide - Cyanobacteria & Known Toxins Chart. Version 1.0 2/09/2017

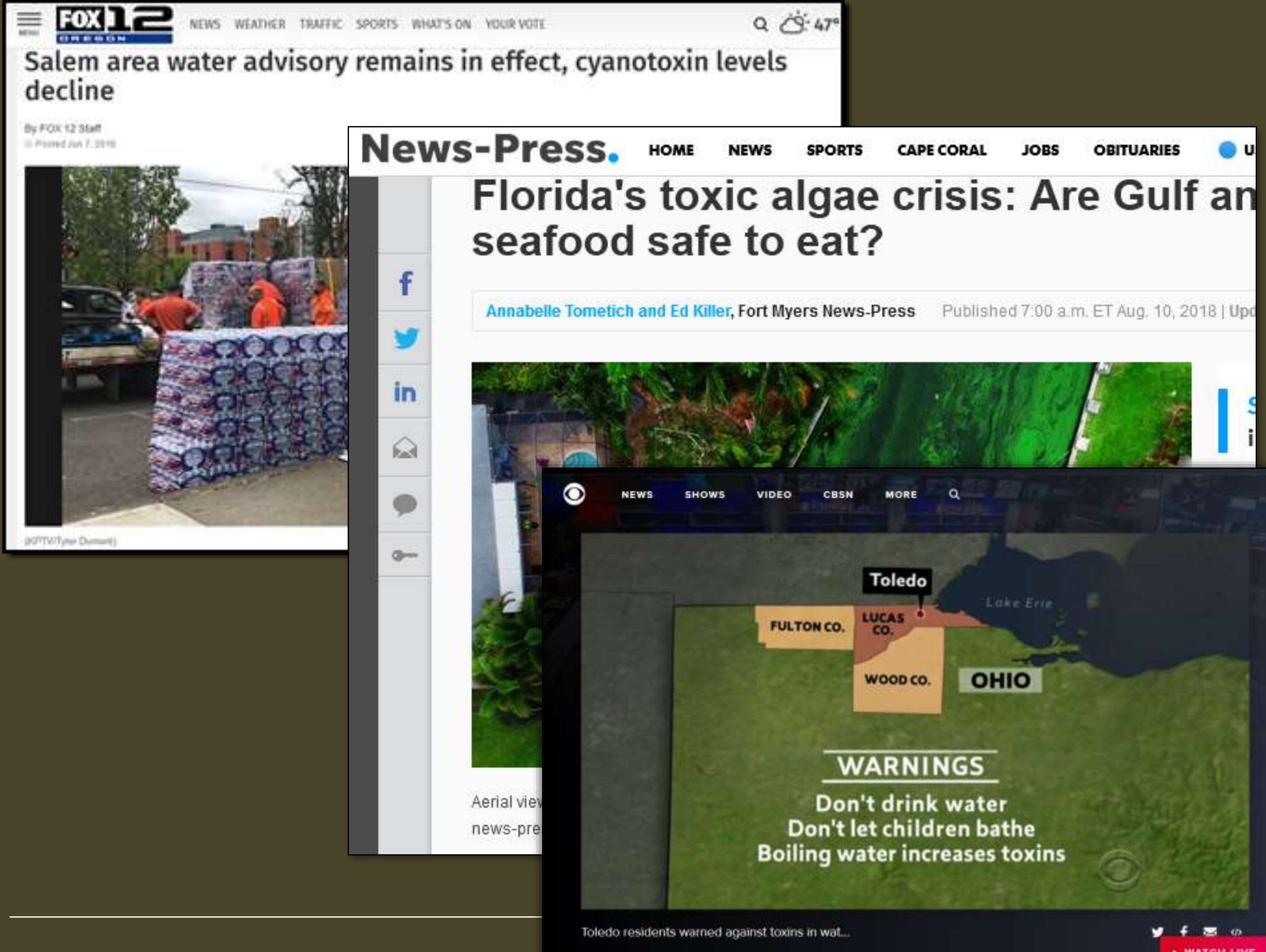
Toxins tested for

Genetics tested for

What are we missing?

Communication

Communication
With the Public


FOX 12 OREGON
NEWS WEATHER TRAFFIC SPORTS WHAT'S ON YOUR VOTE
47°
Salem area water advisory remains in effect, cyanotoxin levels decline
News-Press.
HOME NEWS SPORTS CAPE CORAL JOBS OBITUARIES
Florida's toxic algae crisis: Are Gulf an
seafood safe to eat?
Annabelle Tometich and Ed Killer, Fort Myers News-Press
Published 7:00 a.m. ET Aug. 10, 2018 | Upd
Aerial vie
news-pre
NEWS SHOWS VIDEO CBSN MORE
Toledo
Lake Erie
FULTON CO.
LUCAS CO.
WOOD CO.
OHIO
WARNINGS
Don't drink water
Don't let children bathe
Boiling water increases toxins
Toledo residents warned against toxins in wat...
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Vet: Toxic algae near Rupert kills dogs, horses

LAURIE WELCH lwelch@magicvalley.com Nov 22, 2016

Idaho Statesman

Eagle Island State Park that has been closed after a blue-green algae bloom was detected on the afternoon of
Idaho Department of Parks and Recreation

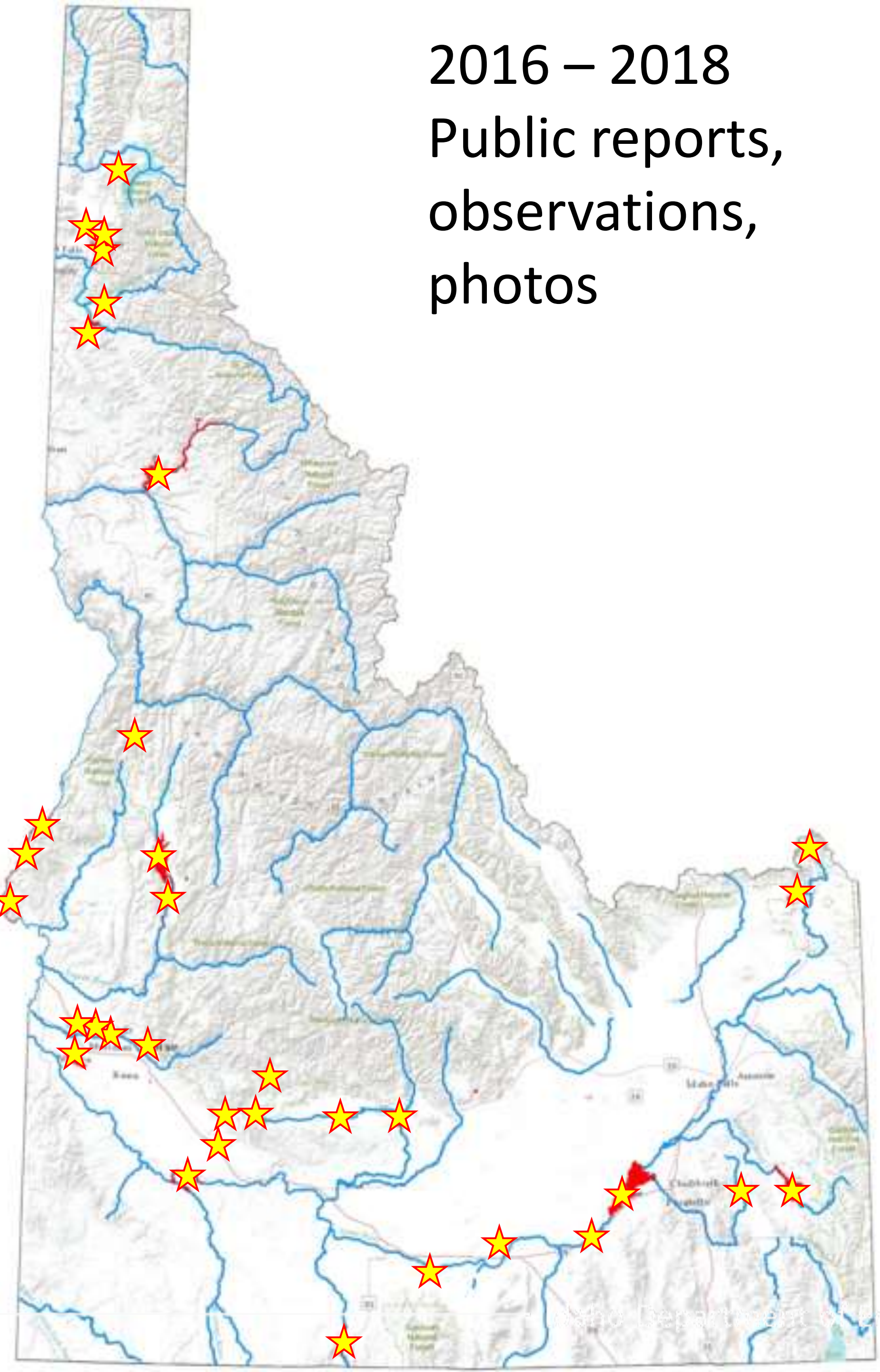
parate blue-green algae blooms strict recreation access at Eagle and, E. Idaho

KTVB.COM

Esther Simplot Pond reopens after algae bloom

2016 – 2018 Public reports, observations, photos

1. Avondale Lake
2. Black Lake
3. Fernan Lake
4. Hayden Lake
5. Cocolalla Lake
6. Chatcolet Res.
7. Dworshak Res.
8. Brownlee Res.
9. Hells Canyon Res.
10. Oxbow Res.
11. Horsethief Res.
12. Cascade Res.
13. NF Payette River
14. Lake Lowell
15. Blacks Creek Res.
16. Little Camas Res.
17. Mountain Home Res.
18. Salmon Falls Creek Res.
19. Long Tom Res.
20. C.J. Strike Res.
21. Snake River (mult)



22. Private property (mult)
23. Murtaugh Lake
24. American Falls Res.
25. Island Park Res.
26. Henry’s Lake
27. Henry’s Fork
28. Magic Res.
29. Mormon Res.
30. Chesterfield Res.
31. Fish Creek Res.
32. Blackfoot Res.
33. Lost Valley Res.
34. Eagle Island State Park
35. Anderson Ranch

Public reports, observations, photos

1. Avondale Lake
2. Black Lake
3. Fernan Lake
4. Hayden Lake
5. Cocolalla Lake
6. Chatcolet Res.
7. Dworshak Res.
8. Brownlee Res.
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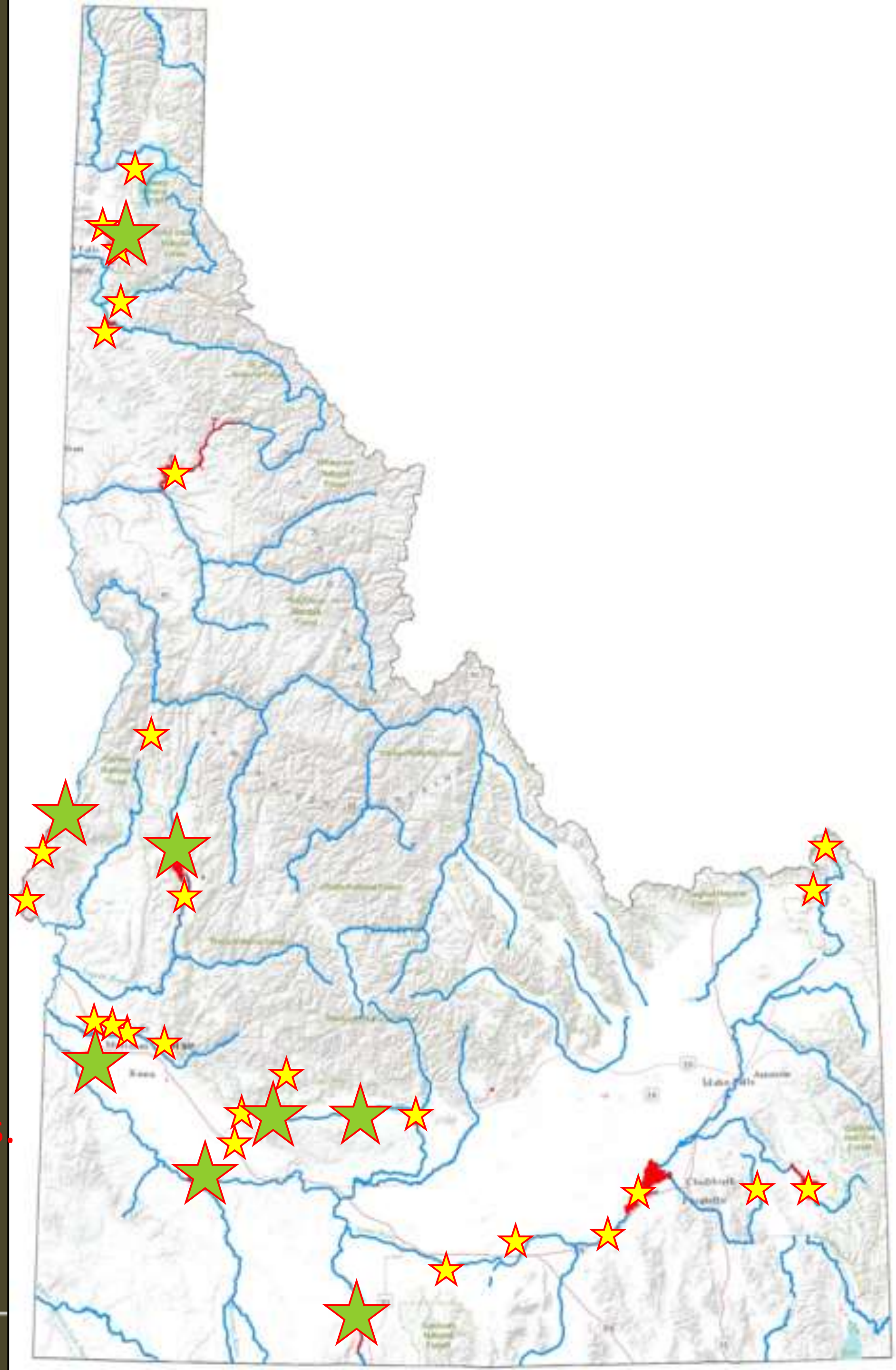

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31. Fish Creek Res.
32. Blackfoot Res.
33. Lost Valley Res.
34. Eagle Island State Park
35. Anderson Ranch


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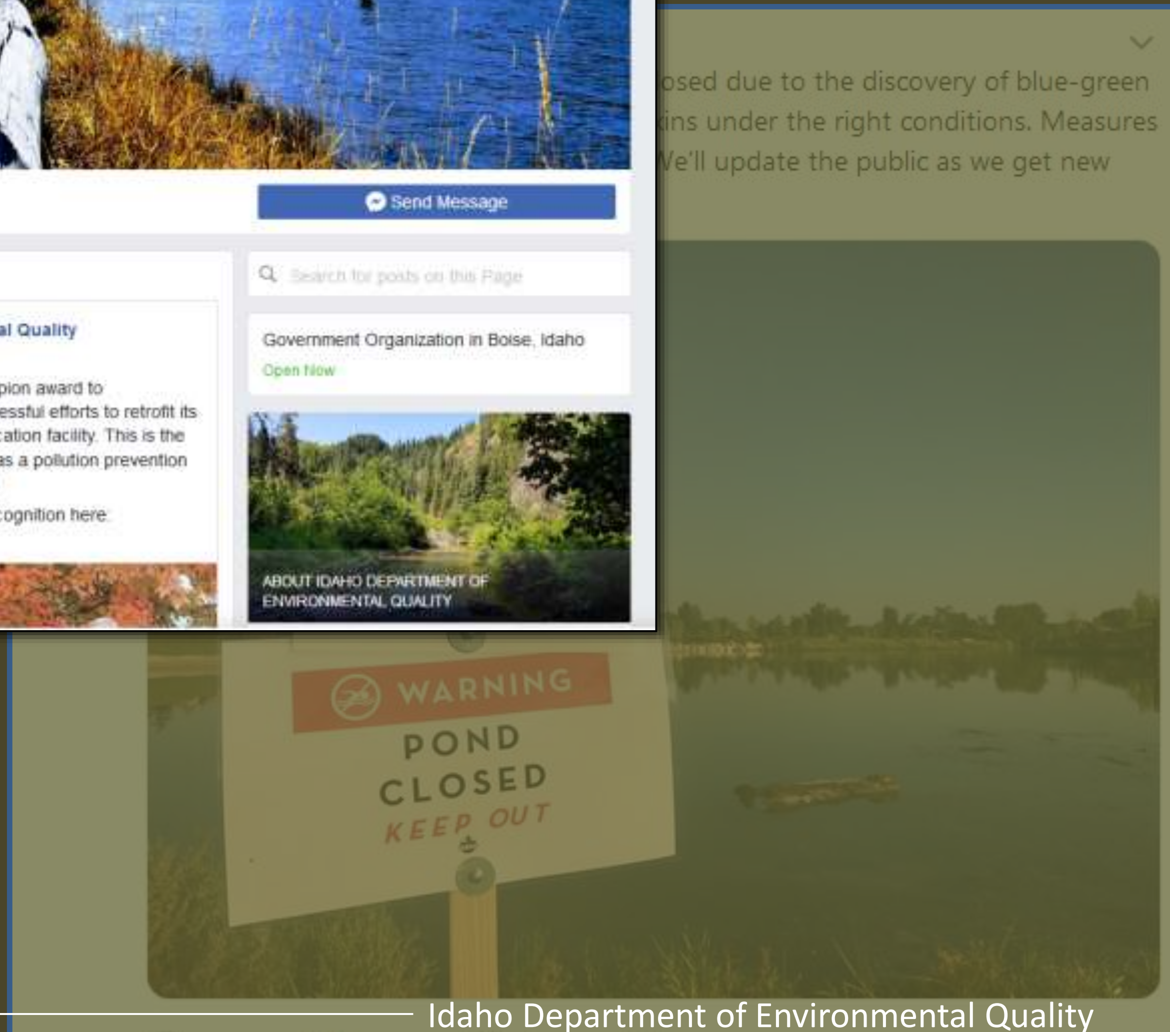
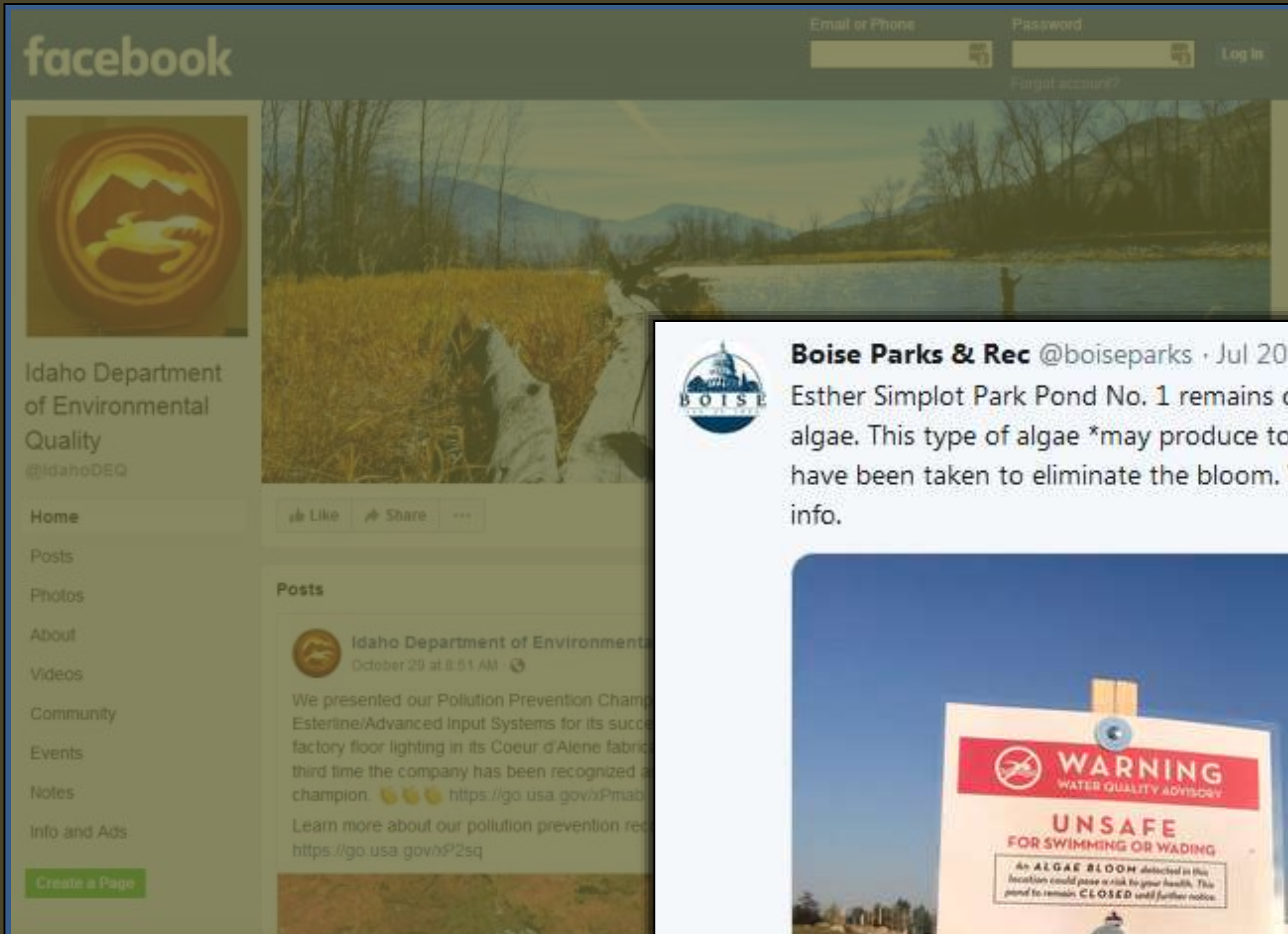
Password
Log In
Forgot account?
Idaho Department of Environmental Quality
@IdahoDEQ
Home
Posts
Photos
About
Videos
Community
Events
Notes
Info and Ads
Create a Page
Like
Share
Send Message
Posts
Idaho Department of Environmental Quality
October 29 at 8:51 AM
We presented our Pollution Prevention Champion award to Esterline/Advanced Input Systems for its successful efforts to retrofit its factory floor lighting in its Coeur d'Alene fabrication facility. This is the third time the company has been recognized as a pollution prevention champion. https://go.usa.gov/xPmab
Learn more about our pollution prevention recognition here: https://go.usa.gov/xP2sq
Search for posts on this Page
Government Organization in Boise, Idaho
Open Now
ABOUT IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY


osed due to the discovery of blue-green
ins under the right conditions. Measures
e'll update the public as we get new
WARNING
POND
CLOSED
KEEP OUT


facebook
Email or Phone
Password
Log In
Forgot account?
Idaho Department of Environmental Quality
@IdahoDEQ
Home
Posts
Photos
About
Videos
Community
Events
Notes
Info and Ads
Create a Page
Like
Share
Posts
October 29 at 8:51 AM
Learn more about our pollution prevention


Boise Parks & Rec @boiseparks · Jul 20
Esther Simplot Park Pond No. 1 remains closed due to the discovery of blue-green algae. This type of algae *may produce toxins under the right conditions. Measures have been taken to eliminate the bloom. We'll update the public as we get new info.
WARNING
WATER QUALITY ADVISORY
UNSAFE
FOR SWIMMING OR WADING
An ALGAE BLOOM detected in this location could pose a risk to your health. This pond to remain CLOSED until further notice.
WARNING
POND
CLOSED
KEEP OUT

Idaho Department of Environmental Quality
Published by Sara Cassinelli [?] · July 23 ·

What does a harmful algal bloom look like and how can you report one? We explain what to look for and how to contact DEQ if you suspect a bloom is in an Idaho water body. When in doubt, stay out! Check our map for current recreation water quality health advisories and learn how to report a harmful algal bloom here: https://go.usa.gov/xRnSj.

WWW.DEQ.IDAHO.GOV
Harmful Algal Blooms in Idaho
Learn More

7,876 People Reached	362 Engagements	Boost Again

Recent Activity

Boosted on Jul 30
Audience: United States: Idaho, 13 - 65+
By Sara Cassinelli · Completed
View Results

Performance for Your Post

7,876 People Reached

3,508 Video Views

98 Reactions, Comments & Shares

63 Like	31 On Post	32 On Shares
2 Love	2 On Post	0 On Shares
1 Wow	1 On Post	0 On Shares
1 Sad	1 On Post	0 On Shares
5 Comments	3 On Post	2 On Shares
26 Shares	25 On Post	1 On Shares

264 Post Clicks

69 Clicks to Play	37 Link Clicks	158 Other Clicks

NEGATIVE FEEDBACK

1 Hide Post	**0** Hide All Posts
0 Report as Spam	**0** Unlike Page

Insights activity is reported in the Pacific time zone. Ads activity is reported in the time zone of your ad account.

Idaho Department of Environmental Quality
Published by Sara Cassinelli [?] · September 7 ·

Central District Health Department has issued a health advisory for Lake Cascade due to the presence of a cyanobacteria harmful algal bloom. Check our map for current recreation water quality health advisories and learn how to report a harmful algal bloom here: https://go.usa.gov/xRnSj

News release: http://www.cdhd.idaho.gov/.../09-07-18-lake-cascade-bg-algae....

Performance for Your Post

3,103 People Reached

84 Reactions, Comments & Shares

16 Like	**11** On Post	**5** On Shares
1 Haha	**0** On Post	**1** On Shares
14 Wow	**5** On Post	**9** On Shares
19 Sad	**7** On Post	**12** On Shares
7 Comments	**2** On Post	**5** On Shares
27 Shares	**26** On Post	**1** On Shares

290 Post Clicks

18 Photo Views	**27** Link Clicks	**245** Other Clicks

NEGATIVE FEEDBACK

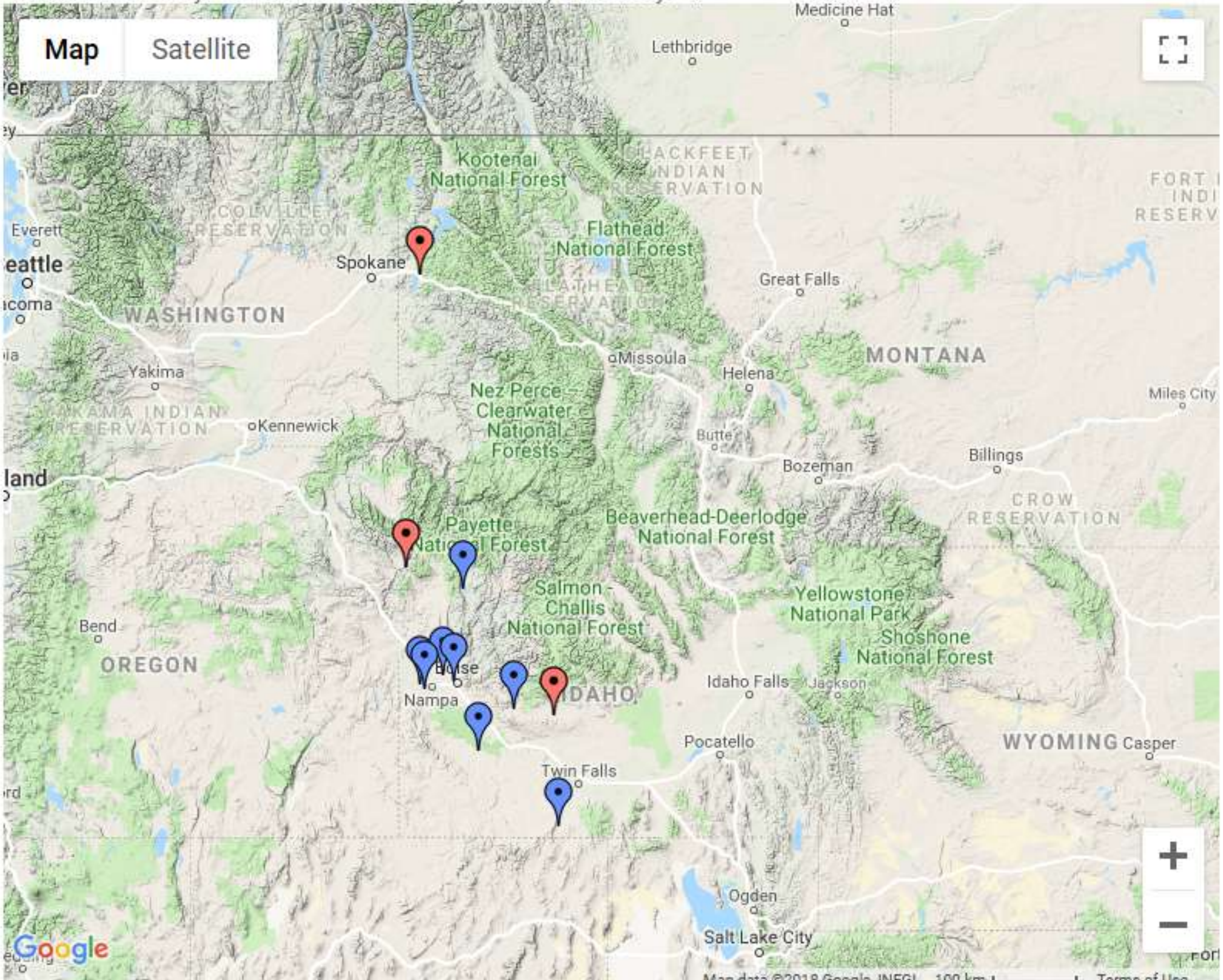
1 Hide Post	**0** Hide All Posts
0 Report as Spam	**0** Unlike Page

Reported stats may be delayed from what appears on posts

Click pin for detailed information.

Blue-Green Algae and Harmful Algal Blooms: Information for Public Water Systems

Active HAB Advisory: Active E. coli Advisory: Lifted Advisory:



http://www.deq.idaho.gov

DEQ

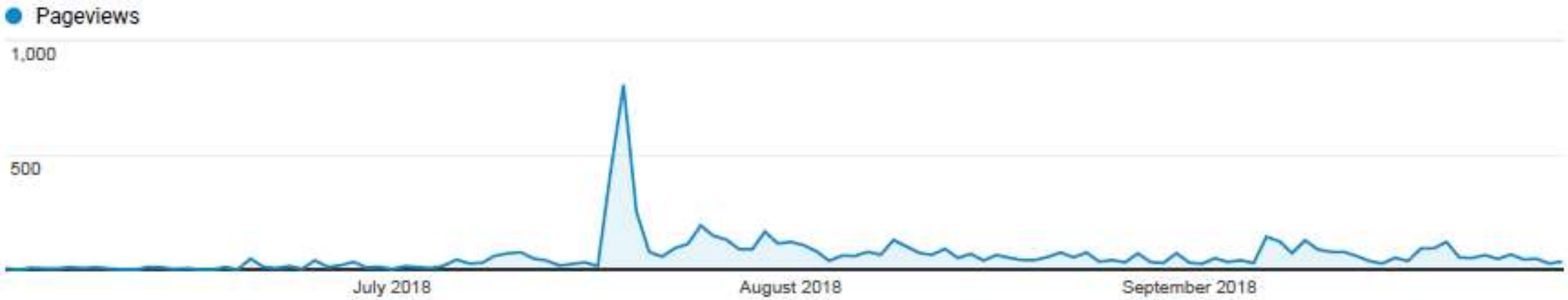
GO TO REPORT

Pages

All Users
100.00% Pageviews

Jun 1, 2018 - Sep 30, 2018

Explorer



This data was filtered with the following filter expression: recreation

	Page	Pageviews	Unique Pageviews	Avg. Time on Page	Entrances	Bounce Rate	% Exit	Page Value
		7,629 % of Total: 1.27% (602,062)	6,566 % of Total: 1.33% (495,288)	00:02:46 Avg for View: 00:01:40 (65.26%)	4,761 % of Total: 1.54% (309,945)	62.30% Avg for View: 62.77% (-0.75%)	65.85% Avg for View: 51.48% (27.92%)	$0.00 % of Total: 0.00% ($0.00)
1.	/water-quality/surface-water/recreation-health-advisories/index.html	4,520 (59.25%)	3,754 (57.17%)	00:04:26	2,359 (49.55%)	69.90%	75.22%	$0.00 (0.00%)
2.	/water-quality/surface-water/recreation-health-advisories/blue-green-algae/index.html	2,668 (34.97%)	2,450 (37.31%)	00:01:16	2,201 (46.23%)	54.29%	52.02%	$0.00 (0.00%)
3.	/news-public-comments-events/public-comment-opportunities/draft-401-certification-boise-parks-and-recreation-ja-and-kathryn-albertson-family-foundation-boise-whitewater-park-phase-ii-project/index.html	152 (1.99%)	114 (1.74%)	00:05:07	107 (2.25%)	55.14%	71.71%	$0.00 (0.00%)

<u>Communication</u> Between Agencies

Idaho Harmful algal Bloom Response Partners

Idaho Harmful algal Bloom Response Partners

Idaho Department of Environmental Quality

Idaho Fish & Game

Idaho Department of Health & Welfare
DIVISION OF PUBLIC HEALTH

IDAHO
State Department of Agriculture

Public Health
Prevent. Promote. Protect.
Panhandle Health District
Healthy People in Healthy Communities

Central District Health Department
HEALTHY PEOPLE IN HEALTHY COMMUNITIES

Southwest District Health

Public Health
Idaho North Central District

Eastern Idaho Public Health
Prevent. Promote. Protect.

South Central Public Health District
Prevent. Promote. Protect.

SIPH
Southeastern Idaho Public Health

Idaho Harmful algal Bloom Response Partners

IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY

IDAHO FISH & GAME

IDAHO DEPARTMENT OF HEALTH & WELFARE
DIVISION OF PUBLIC HEALTH

IDAHO STATE DEPARTMENT OF AGRICULTURE

Public Health
Panhandle Health District
Healthy People in Healthy Communities

CENTRAL DISTRICT HEALTH DEPARTMENT
HEALTHY PEOPLE IN HEALTHY COMMUNITIES

Southwest District Health

U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT

Public Health
Idaho North Central District

Eastern Idaho Public Health
Prevent. Promote. Protect.

South Central Public Health District
Prevent. Promote. Protect.

SIPH
Southeastern Idaho Public Health

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Idaho Harmful algal Bloom Response Partners

Idaho Department of Environmental Quality

Idaho Fish & Game

Idaho Department of Health & Welfare
Division of Public Health

Idaho State Department of Agriculture

Public Health
Panhandle Health District
Healthy People in Healthy Communities

Central District Health Department
Healthy People in Healthy Communities

Southwest District Health

U.S. Department of the Interior
Bureau of Land Management

Public Health
Idaho North Central District

Eastern Idaho Public Health
Prevent. Promote. Protect.

South Central Public Health District
Prevent. Promote. Protect.

Forest Service
U.S. Department of Agriculture

SIPH
Southeastern Idaho Public Health

CyAN

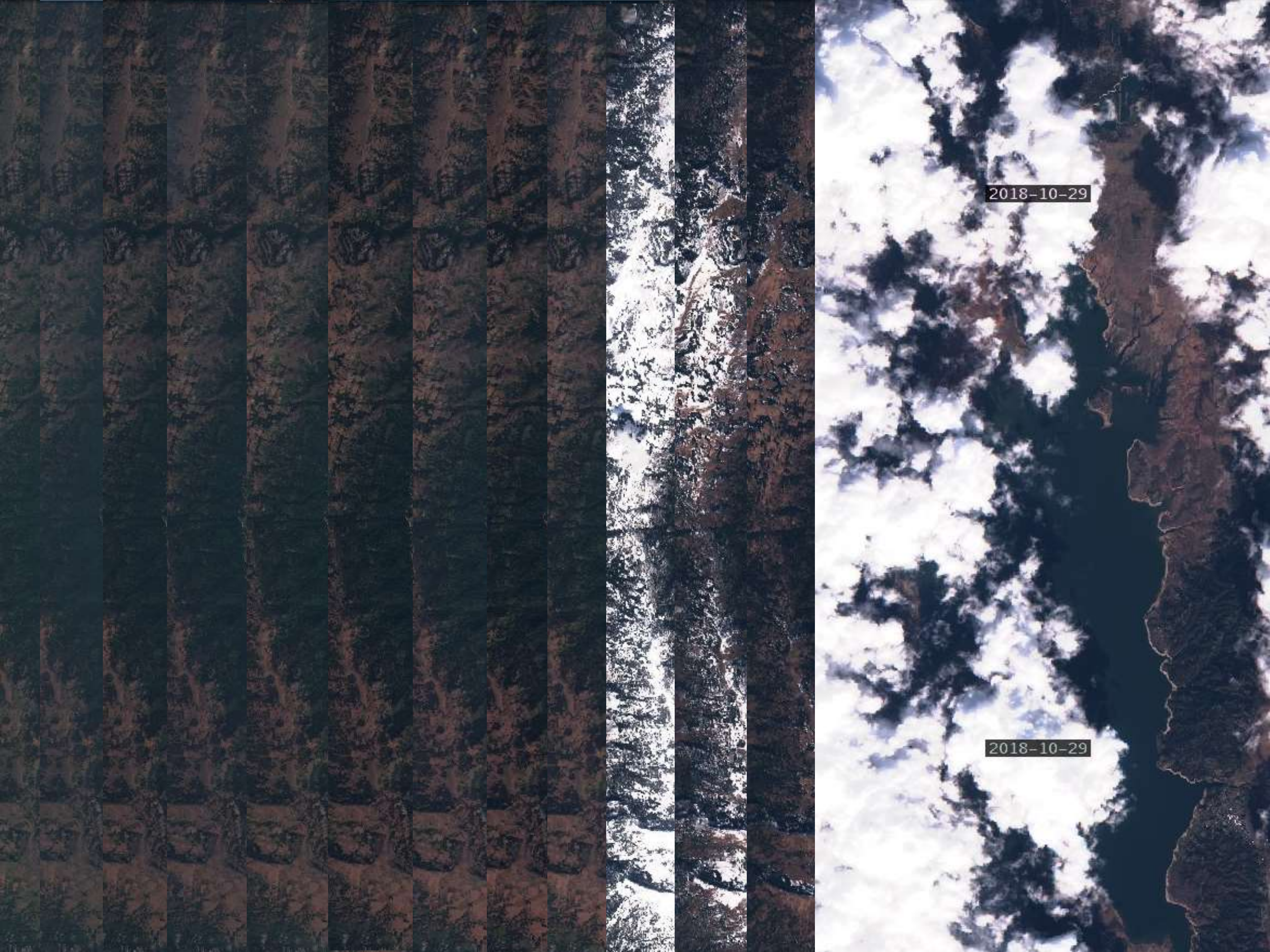
U.S. Department of the Interior
Bureau of Reclamation

NOAA NCCOS National Centers for Coastal Ocean Science
Phytoplankton Monitoring Network

Idaho Fish and Game Magic Valley

September 27 ·

Attention Anglers: A salvage order has been issued on Little Camas Reservoir. The Health Advisory on Little Camas related to bluegreen algae toxins was recently lifted, but that does not mean its "all clear". We encouraged folks visiting Little Camas Reservoir to still take precautions and avoid swimming, keep dogs away from the water, and prepare fish meals in the same manner recommended when advisories are in place. Please fillet the fish, remove the skin, trim fat, and only eat the meat of the fish.


2018-10-29
2018-10-29

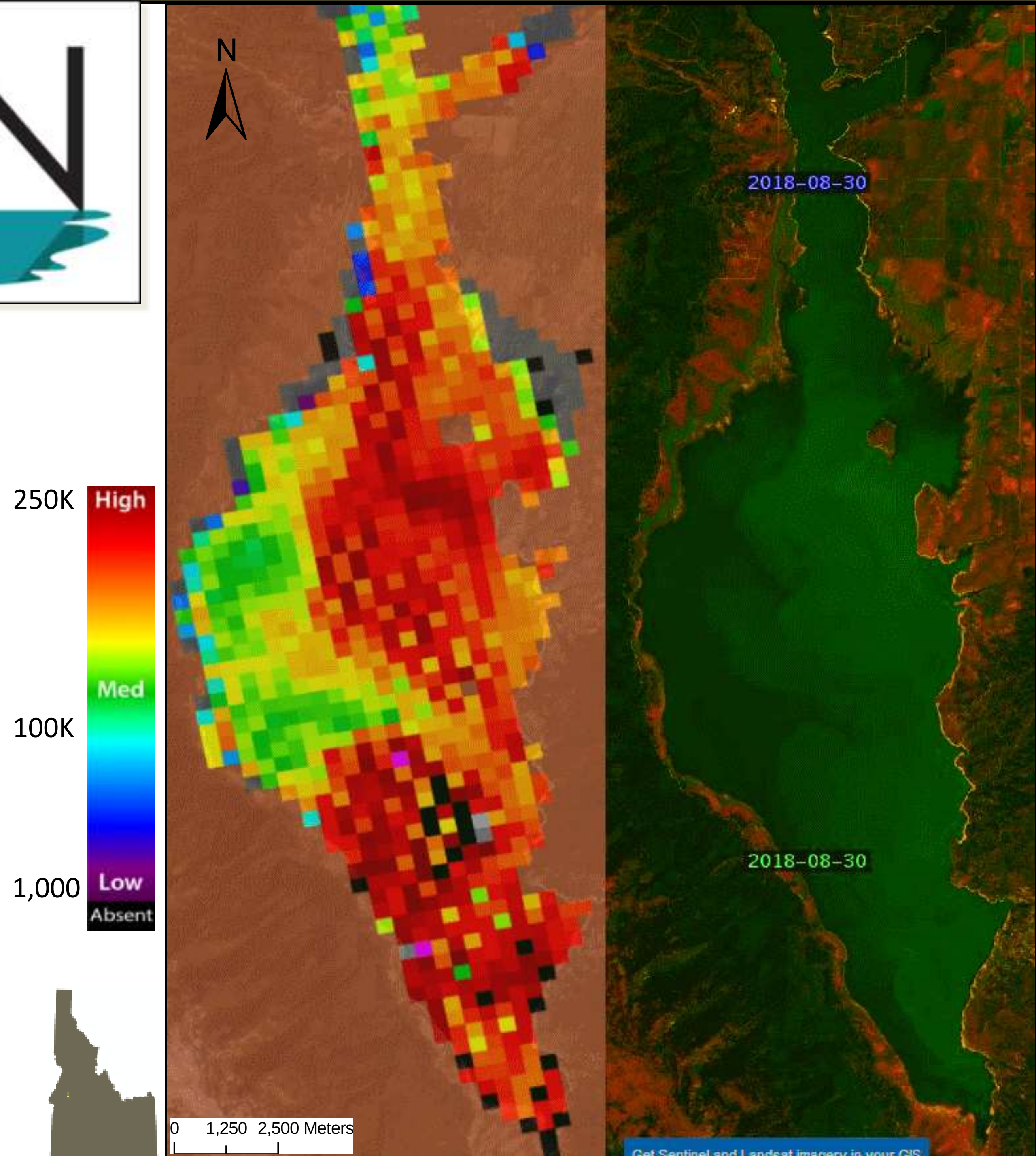

1785
cyano
TRACKER
The University of Georgia
NSF

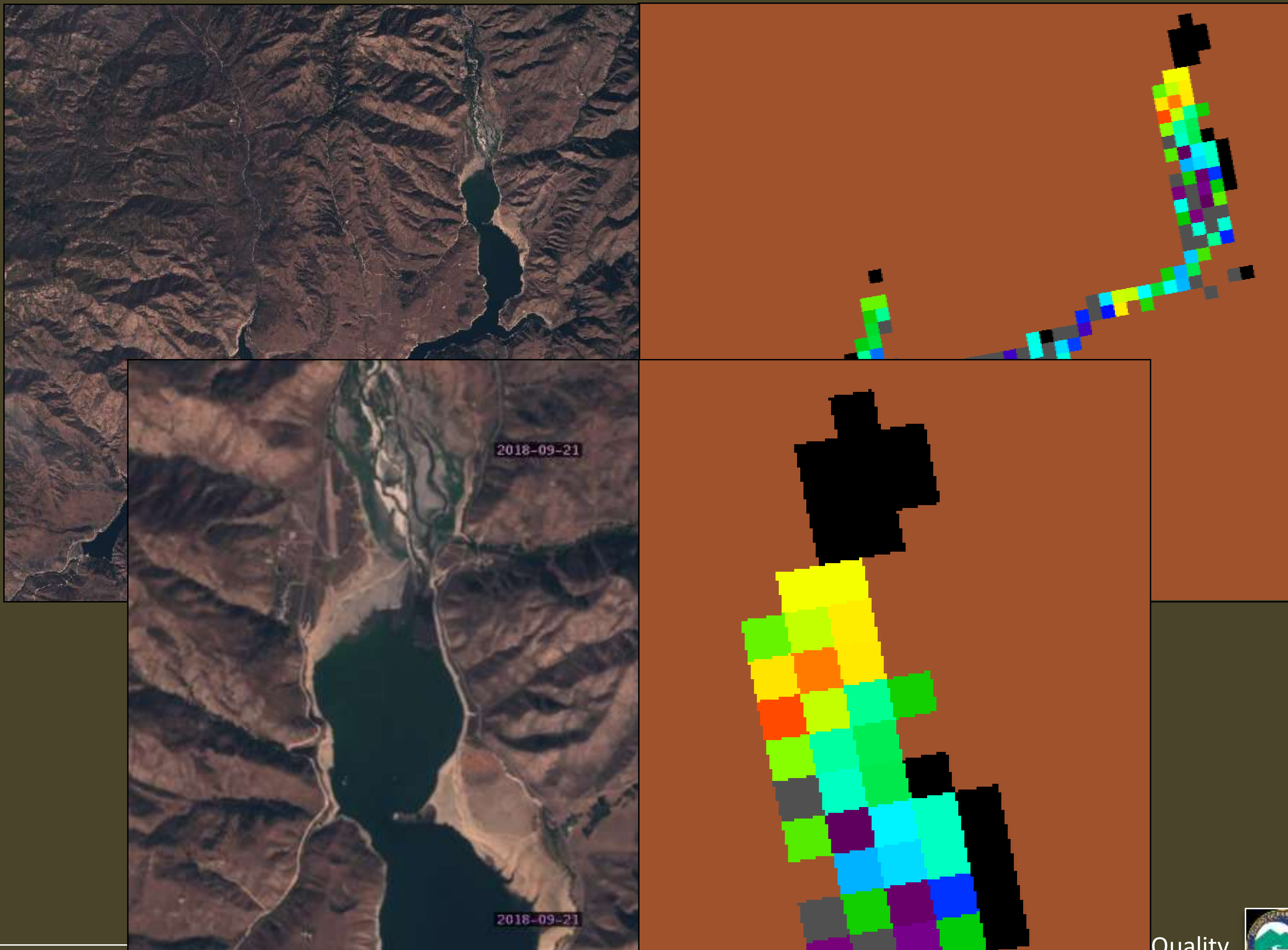

Sentinel 2-MSI
(Aug 30, 2018)

Cascade Reservoir

9/2 / 8/30

Population Density Estimate (cells/mL)





Quality

Technology & Citizen Science

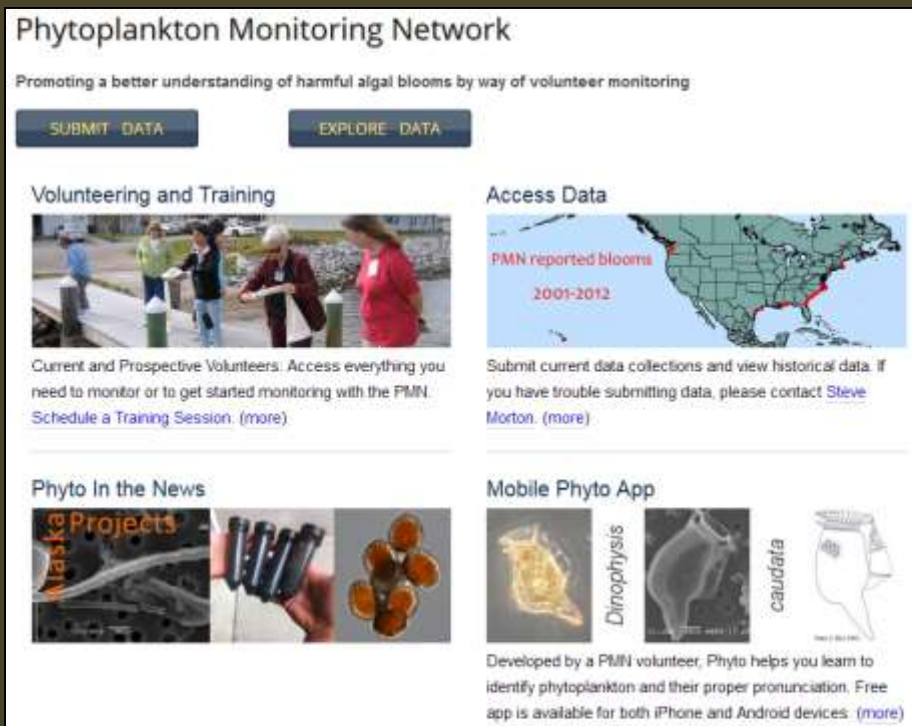
Cyanobacteria Monitoring Collaborative

cyanos.org

Three coordinated monitoring projects to locate and understand harmful cyanobacteria.

Technology & Citizen Science

NCCOS | NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE — Phytoplankton Monitoring Network



BloomWatch App - Cyanobacteria Monitoring Collaborative

bloomWatch

What's ahead?

Questions to consider…


Impacts of Cyanotoxins on Drinking Water Systems

CLEAN WATER ACTION
CLEAN WATER FUND

Increasingly, water systems are monitoring for and addressing cyanotoxins and the algal growth that can cause their formation. Some cyanotoxins are on EPA's list of drinking water contaminants of concern. In 2016, EPA published "Health Advisories" for two cyanotoxins.

Sample Description	Date	Time	Taxa ID and Enumeration (cells/mL)	Microcystin (ppb)
NF Payette	9/11/2018		Dolichospermum sp.:14,200	<0.15

Cyanobacteria & Known Toxins Chart. Version 1.0 2/08/2017

Cyanobacteria Genus	Cyanotoxin Class									
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Cylindrospermum		✓		✓	✓					
Dolichospermum	✓	✓		✓	✓	✓		✓		
Gloeotrichia		✓								

Blatently adapted from the SWAMP - HAB Field Guide - Cyanobacteria & Known Toxins Chart. Version 1.0 2/09/2017

Toxins tested for

Genetics tested for

Sample Description	Date	Time	Taxa ID and Enumeration (cells/mL)	Microcystin (ppb)
NF Payette	9/11/2018		Dolichospermum sp.:14,200	<0.15

Questions?

Brian.Reese@deq.idaho.gov
Chase.Cusack@deq.idaho.gov
Algae@deq.idaho.gov

Harmful Algal Blooms

A story of Cyanobacteria, Satellites, Source Water and the Senate

SFS - PNW Meeting
Ketchum, ID
8 Nov, 2018

Matt Schult, Aaron Borisenko | Oregon Dept. Environmental Quality

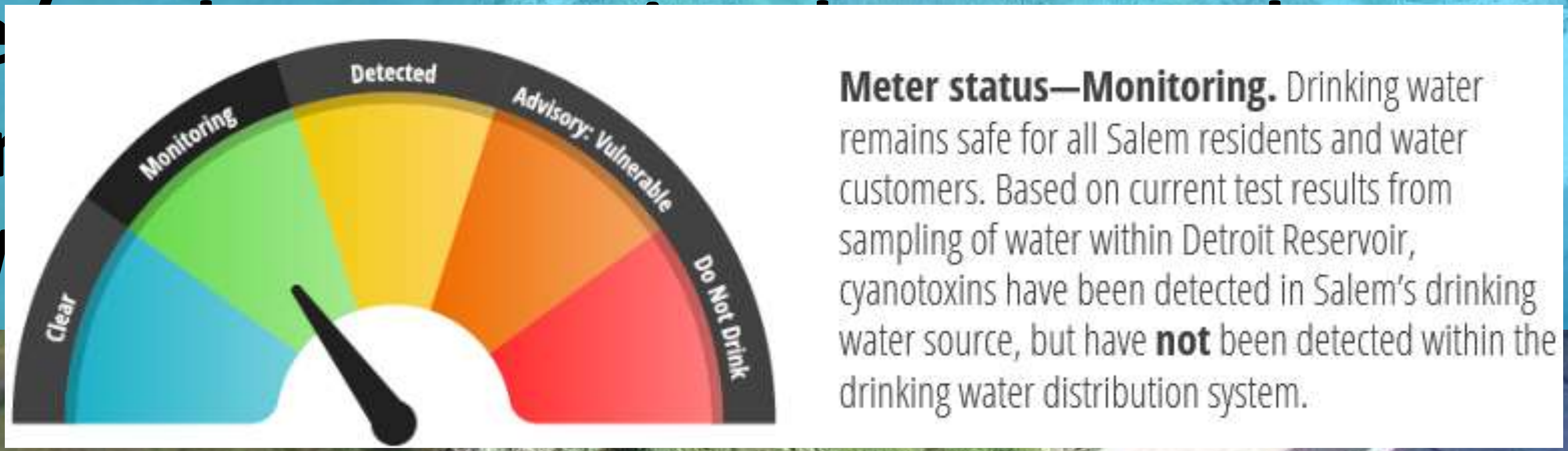
DEQ
State of Oregon Department of Environmental Quality

HABs SURVEILLANCE PROGRAM

OHA : Advisories

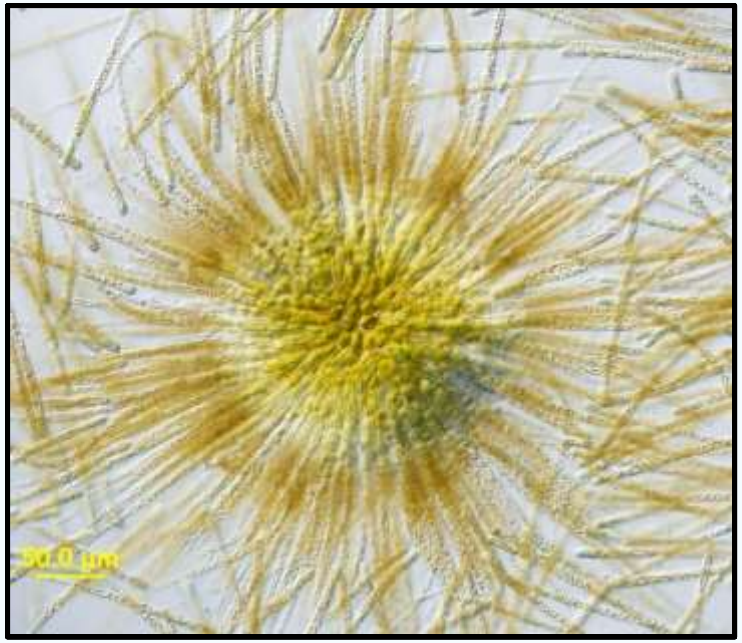
DEQ : Responsible to investigate causes

- Identify source of pollution
- Write pollution reduction plan
- Sample
  drinki
- Clean V



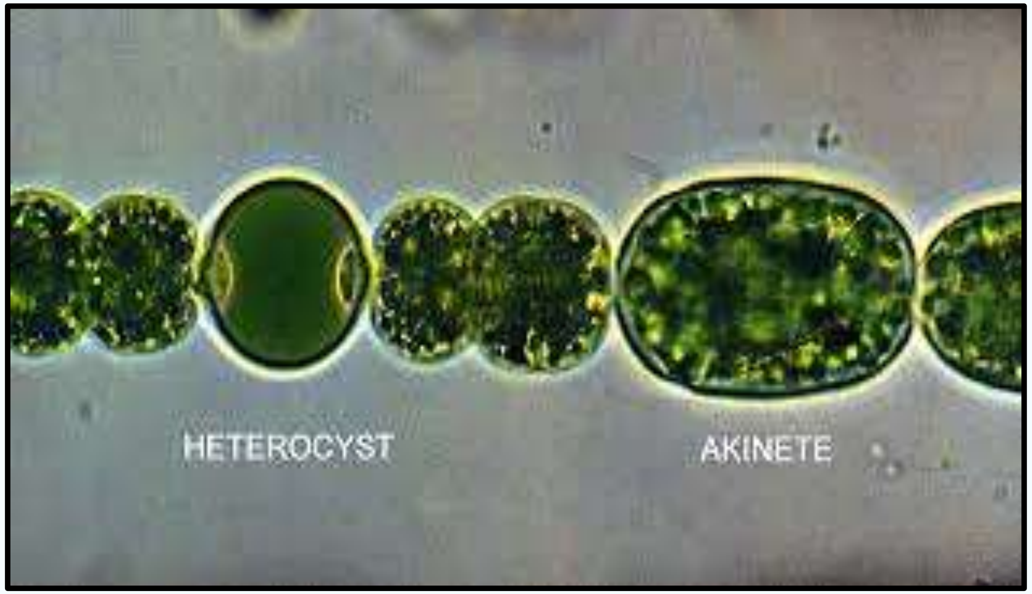
CYANOBACTERIA 101

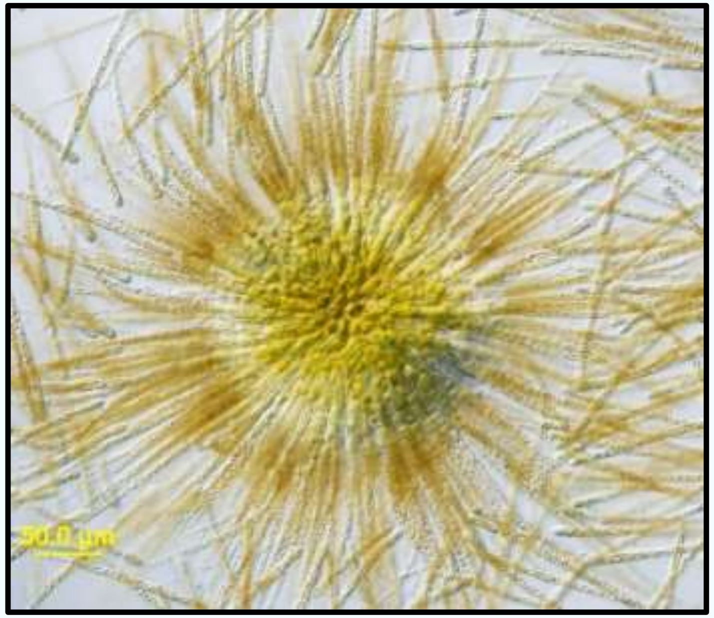
- Prokaryotes
- Earliest : - life forms on earth
  - fossils
  - photosynthesizers
- Simple organisms?......not that simple



CYANOBACTERIA 101

- Gas vesicles – buoyancy regulation
- Phycobilins – low light photosynthesis
- Akinetes – resting cell or “spore”
- Heterocysts – dedicated to fix N
- Toxins – defense, competition





IDENTIFY CAUSES

- **Waterbody specific and may involve any of these factors:**
  - **Increasing nutrient input**
  - **Warming water temperatures**
  - **Reduced mixing/circulation**
  - **Invasive species, particularly fish and filter feeders**

Upper Klamath Lake, OR
https://sentinel.esa.int

DEVELOP STRATEGIES

"The success of water management strategies to combat harmful cyanobacteria hinges on a proper identification of the cyanobacterial species involved and the ecosystem processes that govern their population dynamics."

(Huisman et al., 2005)

DEVELOP STRATEGIES

- Strategies are waterbody specific
  - Reduce nutrient inputs from:
    - Point sources of wastewater
    - Leaky septic systems
    - Agricultural runoff
    - Urban stormwater
    - Forest lands
  - Restore vegetation to provide cooling
  - Promote water movement
  - Invasive species control/prevention

OREGON ENVIRONMENTAL NEWS

Two more dogs die from blue-green

Capital Press
The West's Ag Website

MICROCYSTINS

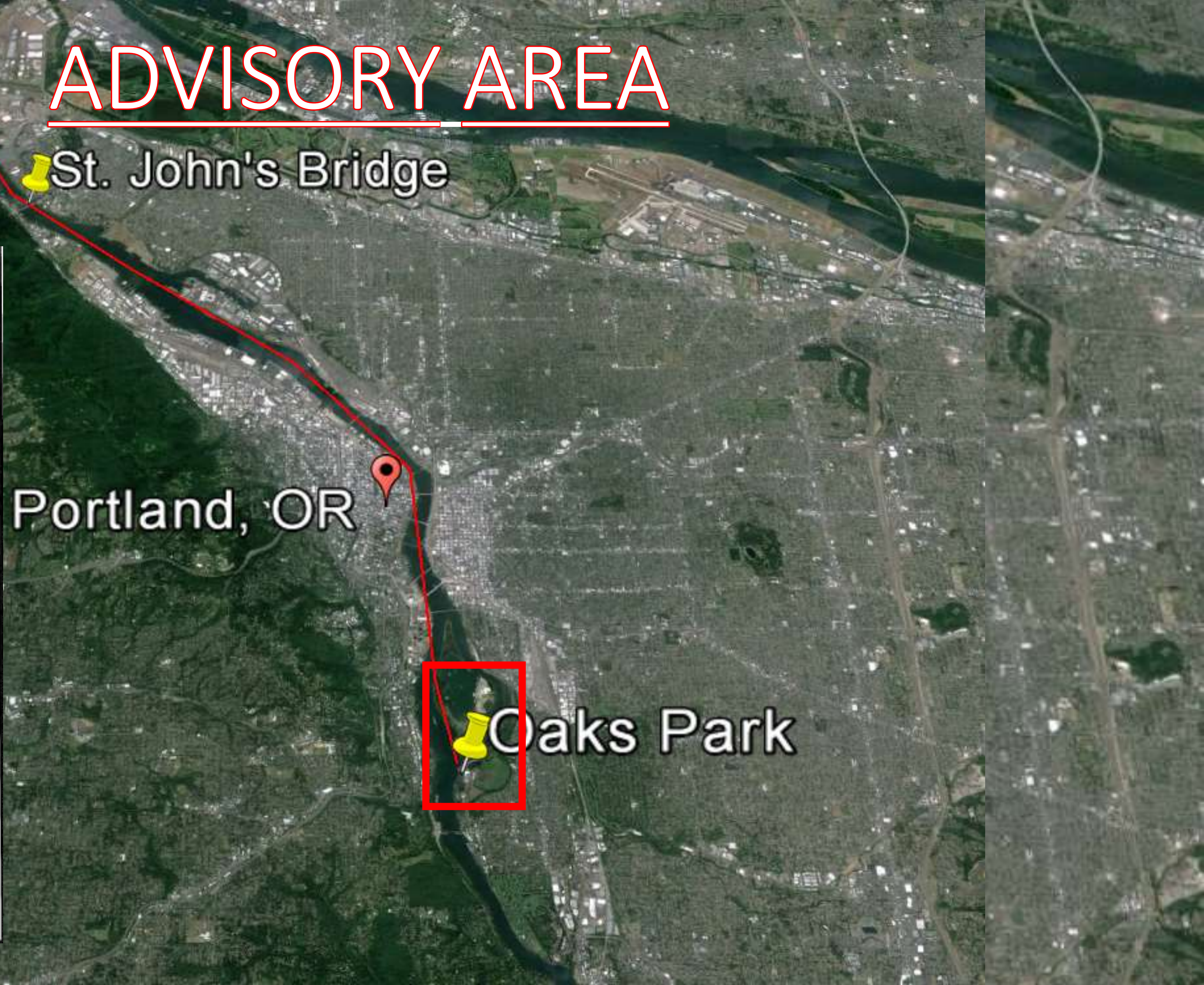
Animal/Source	Specimen	Specimen Type
1	(1) Rumen contents	Rumen Contents

Analyte	Result	Units	Rep. Limit	Units
MICROCYSTIN LA	Not Detected	ppb	10	ppb
MICROCYSTIN LR	7100	ppb	10	ppb
MICROCYSTIN RR	Not Detected	ppb	10	ppb
MICROCYSTIN YR	Not Detected	ppb	10	ppb

These latest dogs did not undergo autopsies. But veterinarians suspect algae toxins killed them.

A blue-green algae bloom in a Lake County, Ore., pond killed 32 cattle. Though not all blooms are toxic, ranchers and others should report any outbreaks so they can be tested.

ADVISORY AREA



HEALTH ADVISORY

Willamette River

AVOID WATER CONTACT

Due to high levels of blue-green algae that can produce harmful toxins.

Do not use this water for drinking or cooking.

Children and pets are at greatest risk.

For more information about water quality and monitoring contact:

Department of Environmental Quality at 503-693-5723

For information about harmful algae blooms, symptoms of exposure or to report a human or pet illness, contact the Oregon Health Authority at 971-673-0400 or visit www.healthoregon.org/HAB

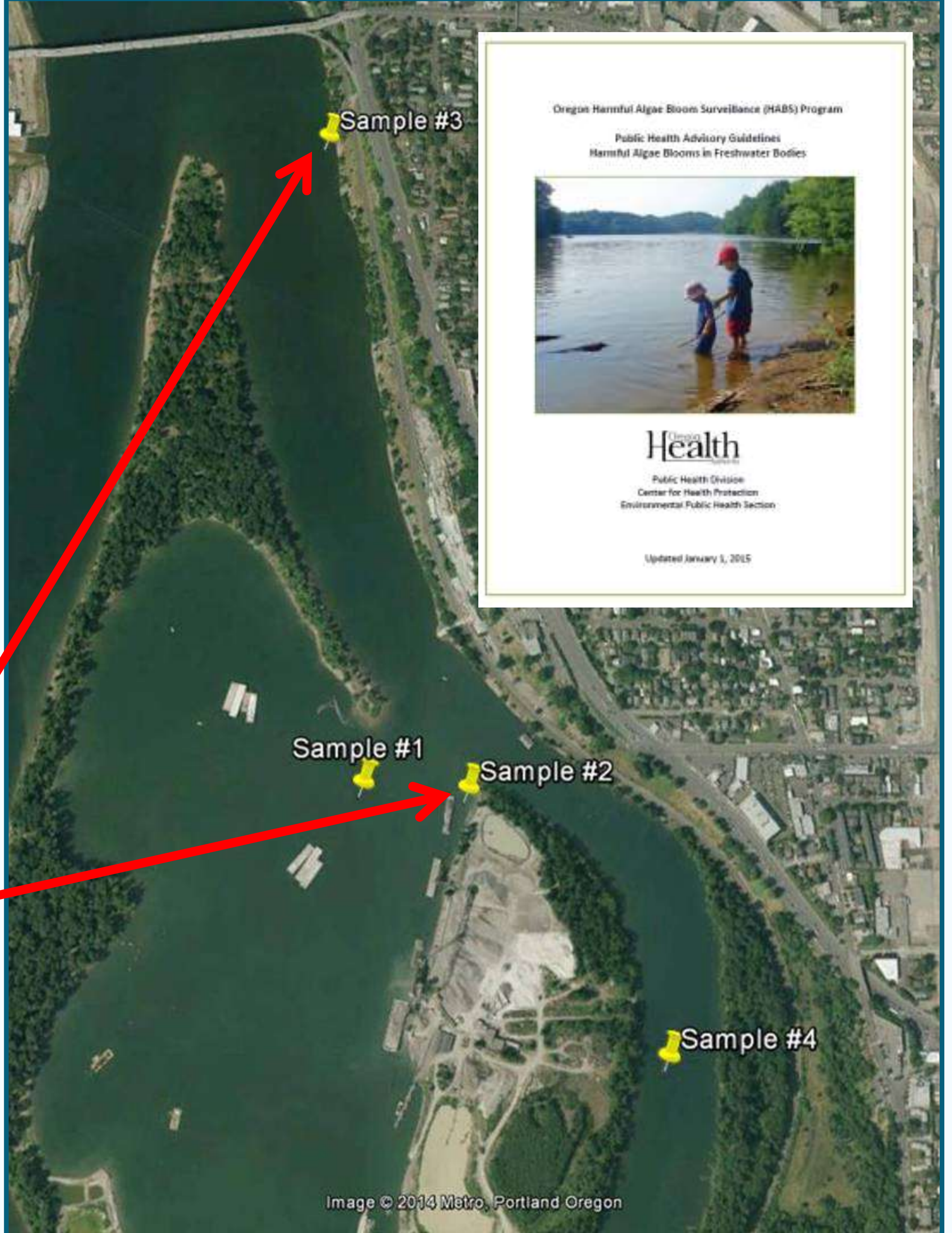
DEQ

Health

Willamette

Ross Island Lagoon

Advisory by cell count:
Cumulative toxigenic species
≥100,000 cells/mL?



Microcystis aeruginosa **(cells/mL)**

1) Inner Lagoon:	18,281
2) Lagoon Mouth:	1,099,313
3) Willamette R :	629,112
4) Ross Isl. Channel:	5,246

Toxic
Portla

REUTE

t

By Courtney

PORTLAND
er that was e
rowing comp
weekend has
presence of
Willamette R

"It was too ri
there with co
Row for the
bers.

OREGONLIVE
The Oregonian

Future of blue-green algae in Willamette River still uncertain; users frustrated

Volunteers for the Oregon Health Authority have put up warning signs in Willamette, Sellwood, Waterfront, and East Bank Esplanade parks. These signs caution river users against drinking or cooking with the water due to blue-green algae bloom scum that can produce harmful toxins. *(Adrianna Rodriguez)*

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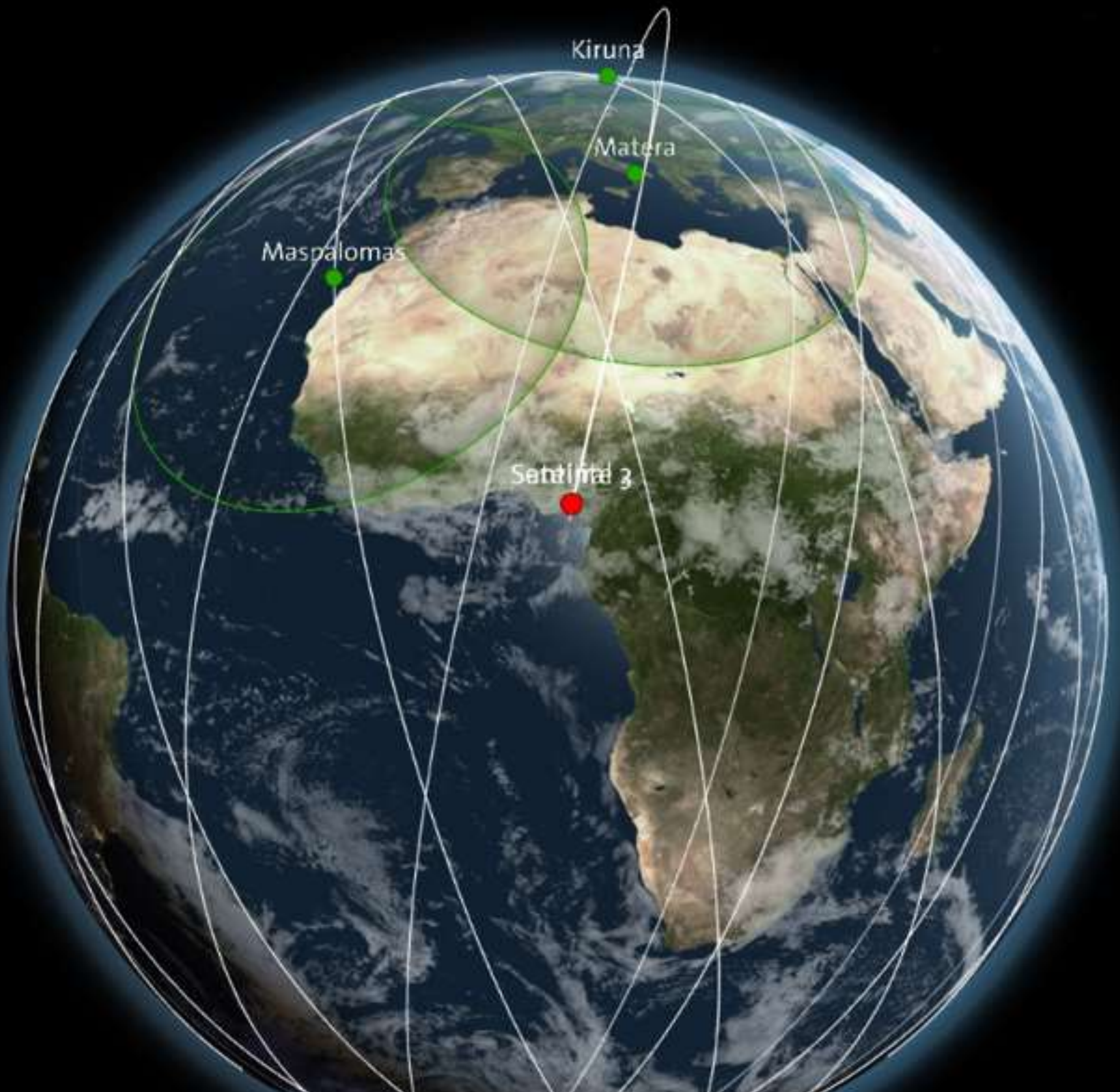


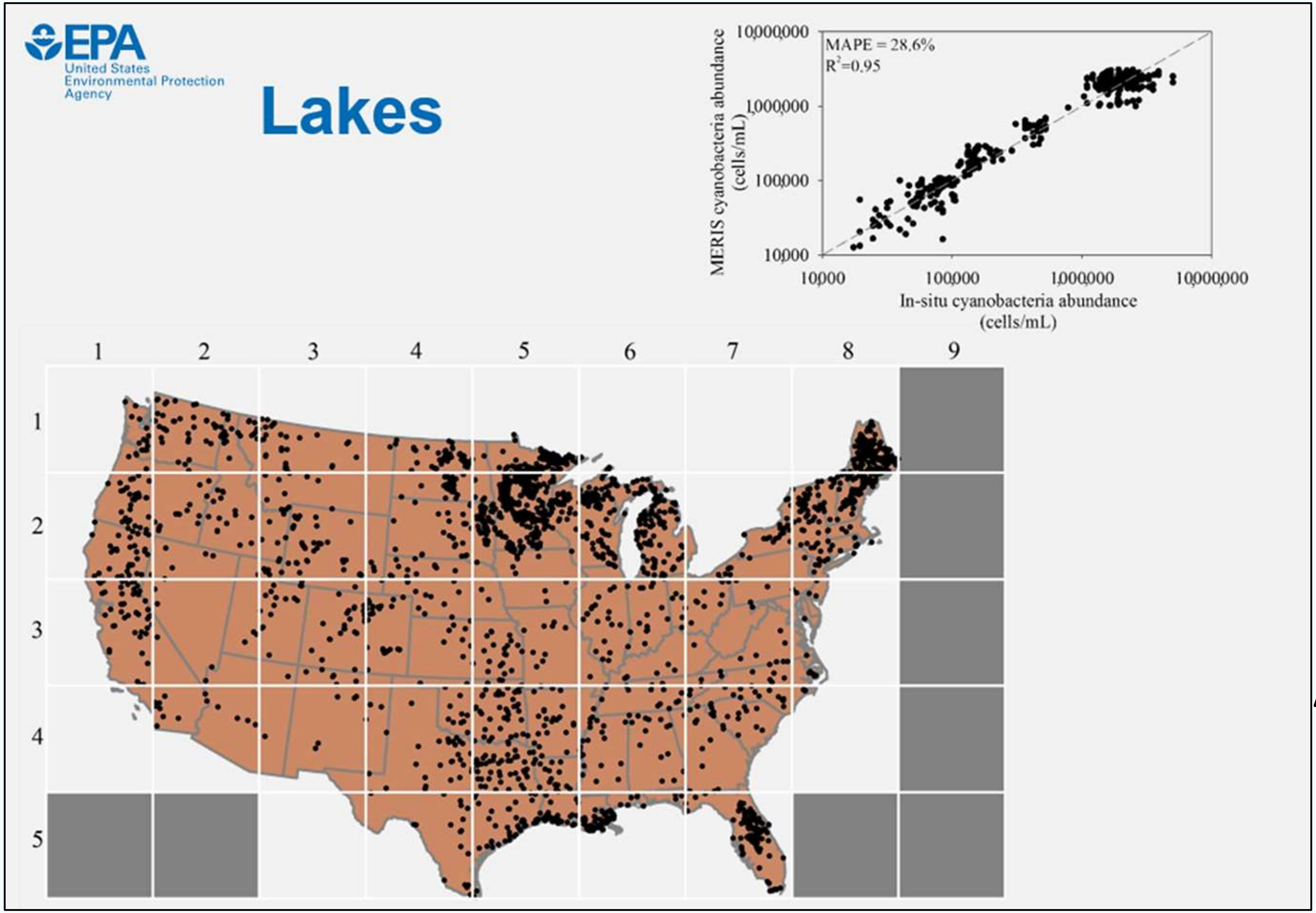
esa

UTC: 2018-07-19 09:59:42.03
Speed: 1x

The location of the European Space Agency Sentinel 3A at 9:59 am on Thursday July 18, 2018

Ocean and Land Color Instrument (OLCI)

- 1,270 km swath width
- 300m^2 spatial resolution
- Global coverage (2 days)

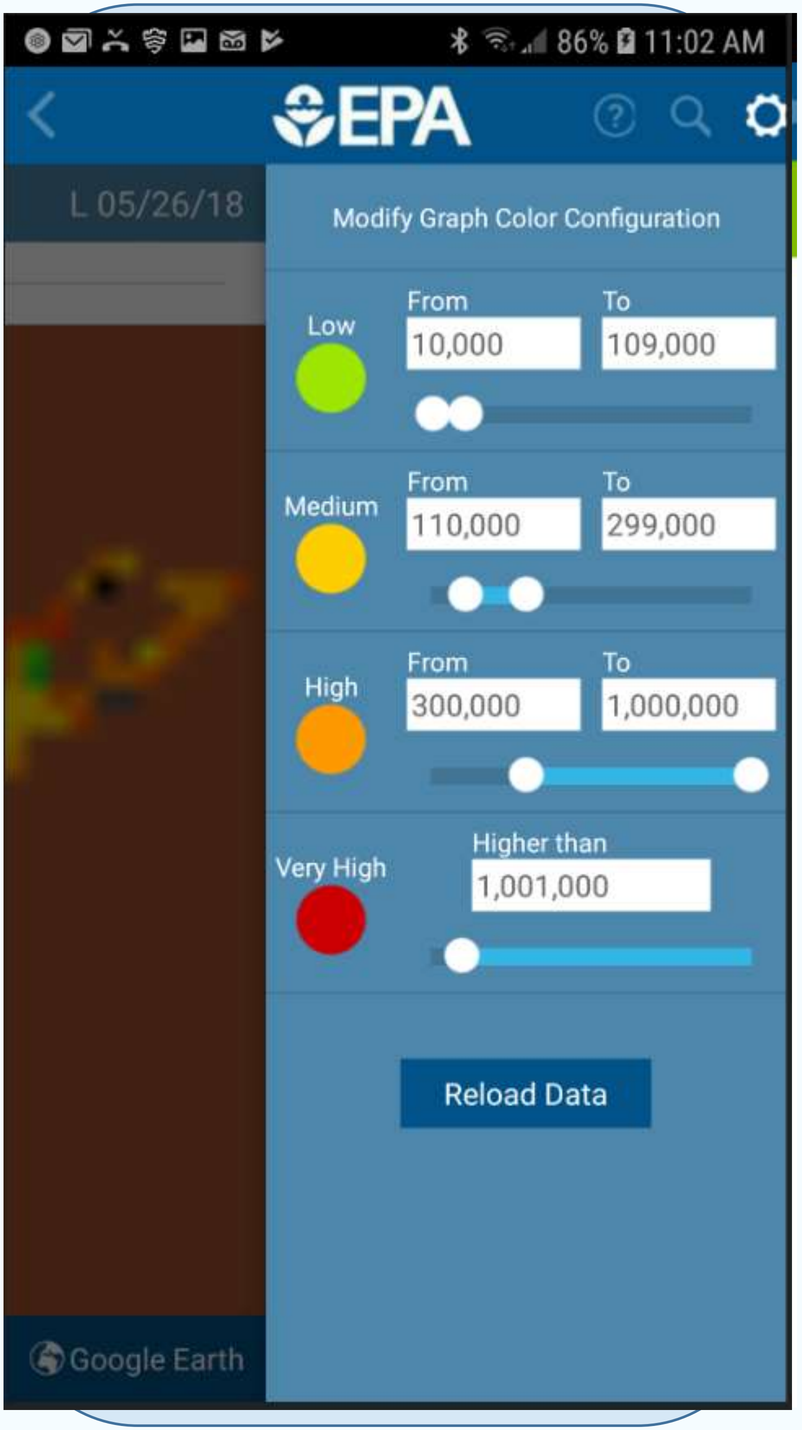


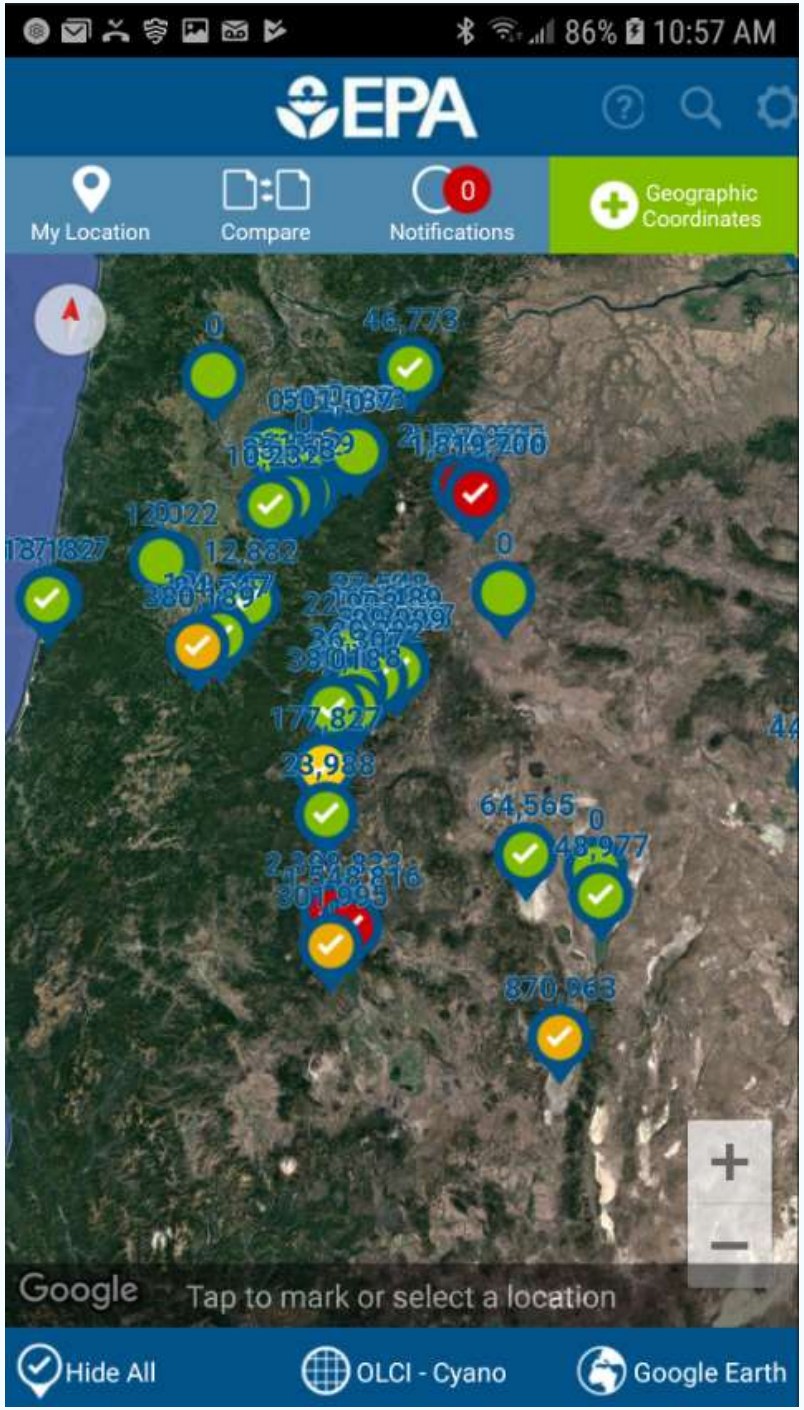
RESOURCES

- **SeaDAS Software**
- **ArcGIS Tool Box**
- **Android Mobile App (EPA's CyAN)**

Clark et al. (2017) *Ecological Indicators* 80:94-95

EPA's Cyanobacteria Assessment Network (CyAN)





News

Lake Billy Chinook algae health advisory expanded

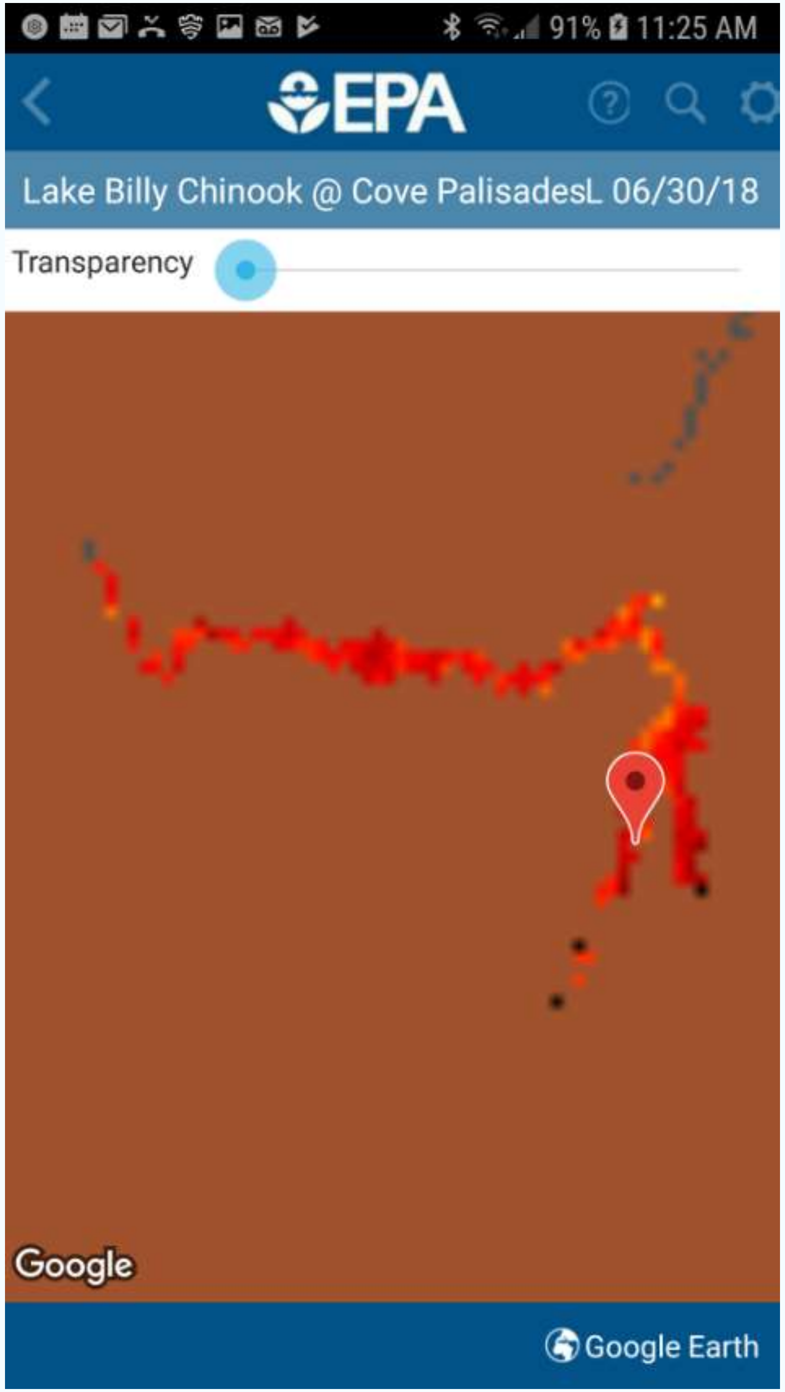
Alert now covers all three arms of the lake

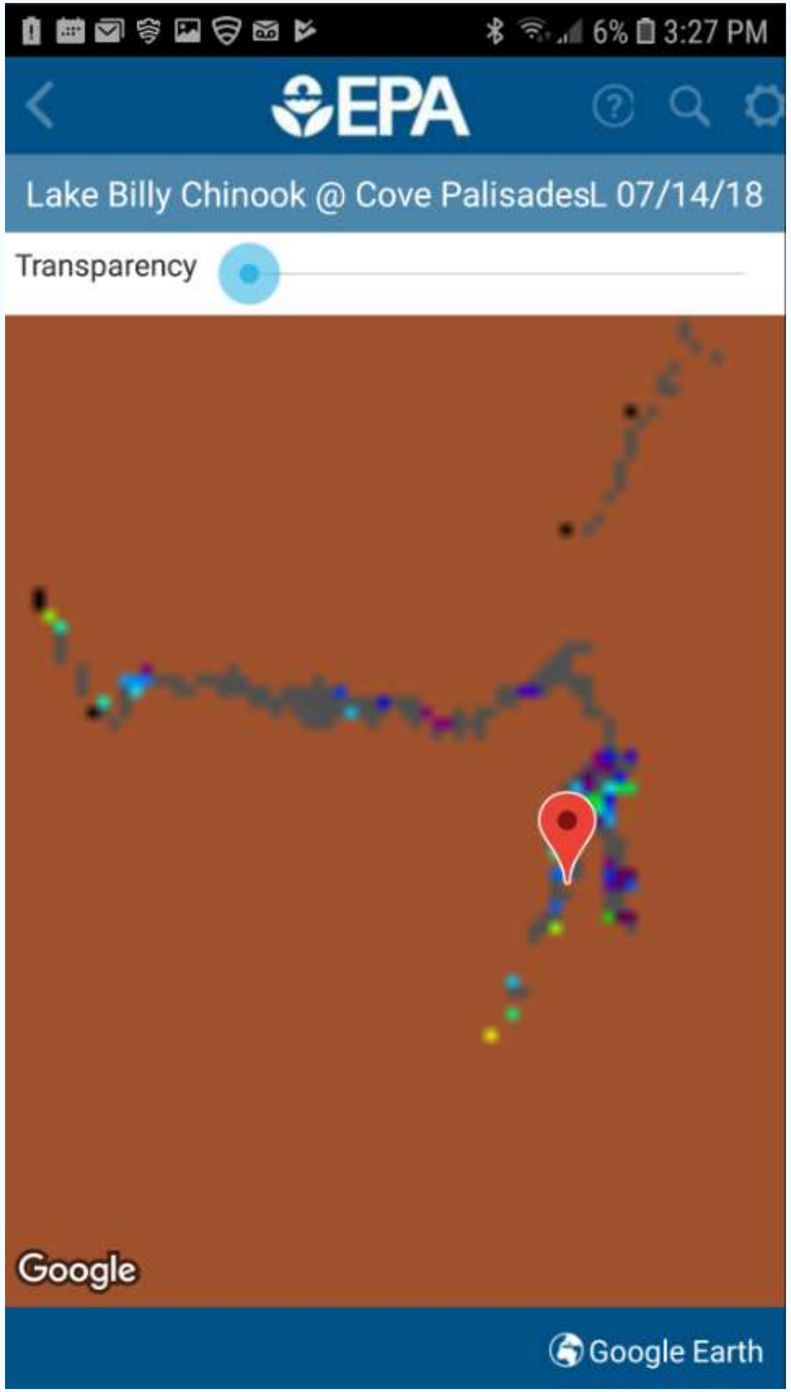
By: KTVZ.COM news sources
Posted: July 11, 2018 05:11 PM PDT
Updated: July 11, 2018 05:11 PM PDT

Green scum of blue-green algae evident in early summer in areas of Lake Billy Chinook (File photos: Oregon Health Authority)

SALEM, Ore. - The Oregon Health Authority said Wednesday it has updated a recreational use health advisory issued June 22 for part of Lake Billy Chinook to cover all three arms of the lake, based on the latest test results.

The original advisory extended from the cove at Perry South Campground





Health Advisory Issued For Upper Klamath Lake Due To Algae Bloom

Oregon's problems with blue-green algae have spread to another lake. Stat officials have issued a health advisory for Upper Klamath Lake. It's in southern Oregon, west of Klamath Falls.

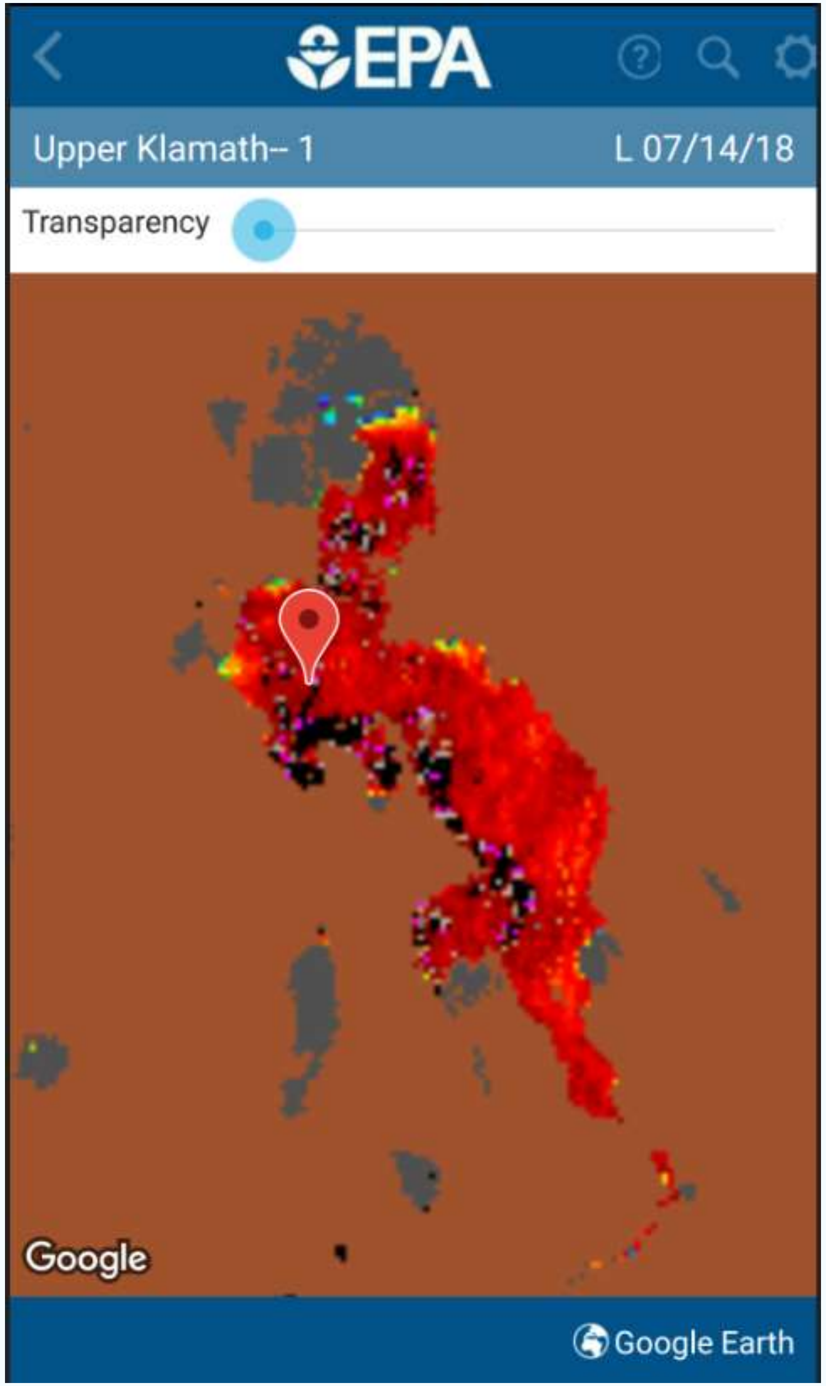
Toxins from blue-green algae can be harmful to humans and animals.

In the affected areas of Klamath Lake, visitors should avoid swimming and activities such as water skiing or power boating. Toxins are not absorbed through the skin, but people with skin sensitivities may experience a puffy red rash at the affected area.

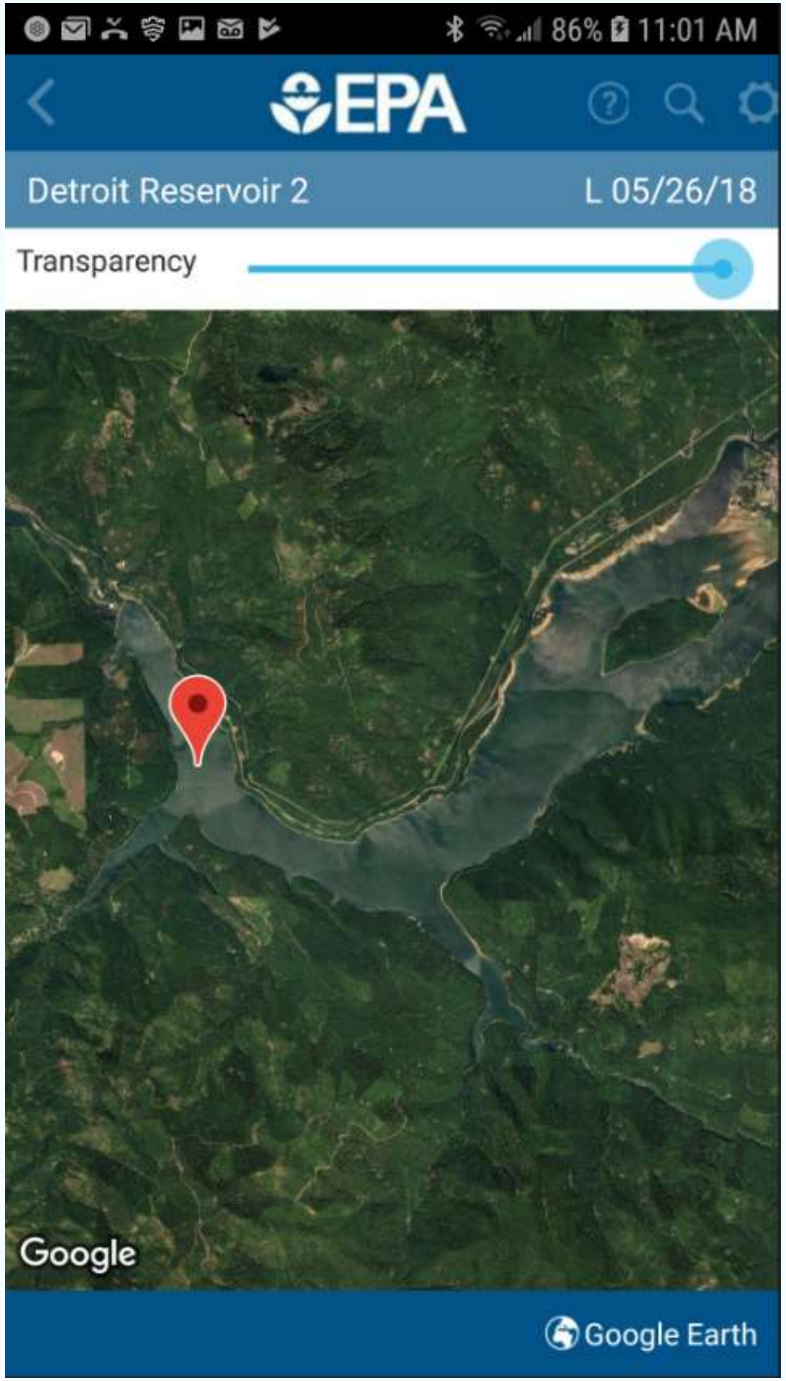
Drinking water that contains the algae is especially dangerous. The toxins cannot be removed by boiling, filtering or treating water with camping filte

Oregon health officials say that if you choose to eat fish from the affected water, you should remove all fat, skin and organs before cooking. Fillets should also be rinsed with clean water. You shouldn't eat freshwater clams mussels from Upper Klamath Lake.

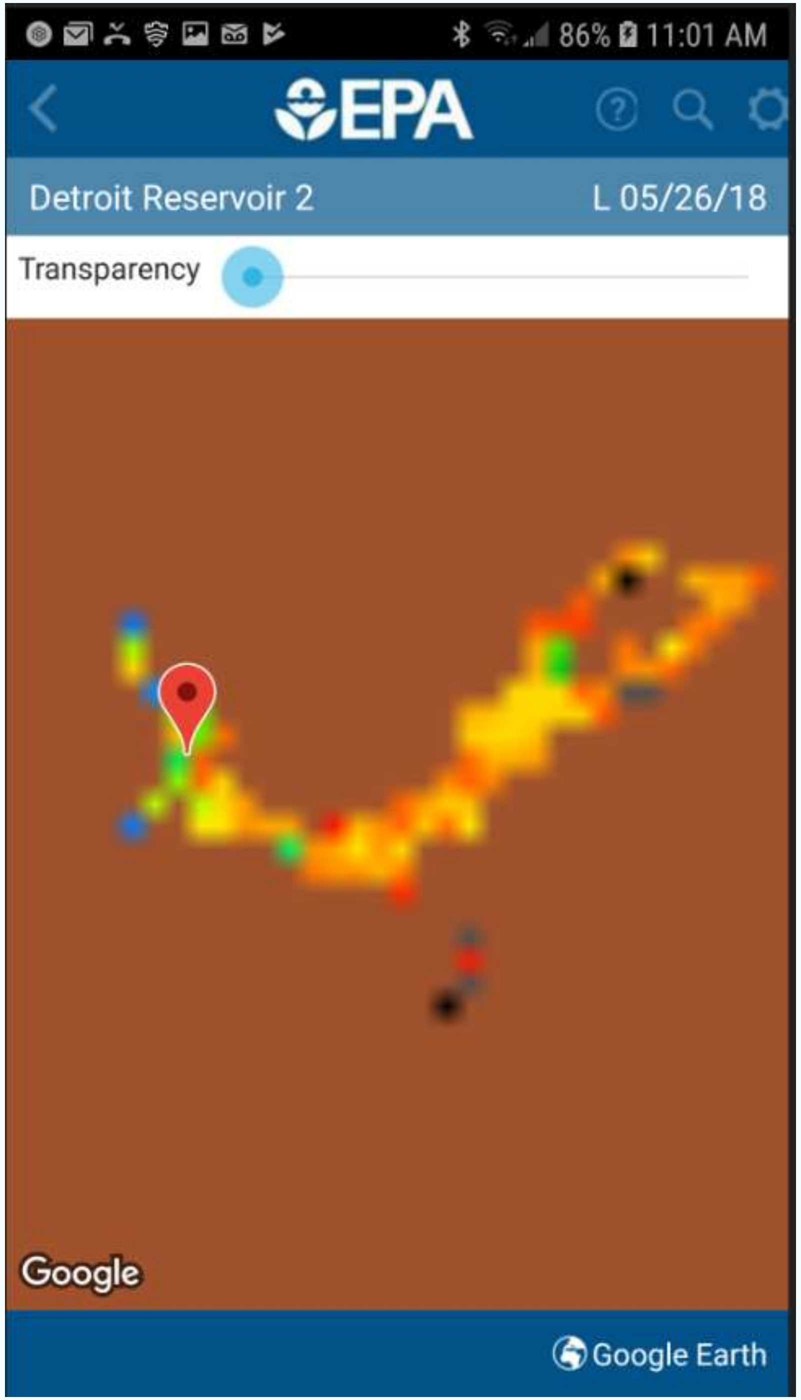
More News



DETROIT RESERVOIR
26 MAY, 2018



DETROIT RESERVOIR 26 MAY, 2018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Transparency
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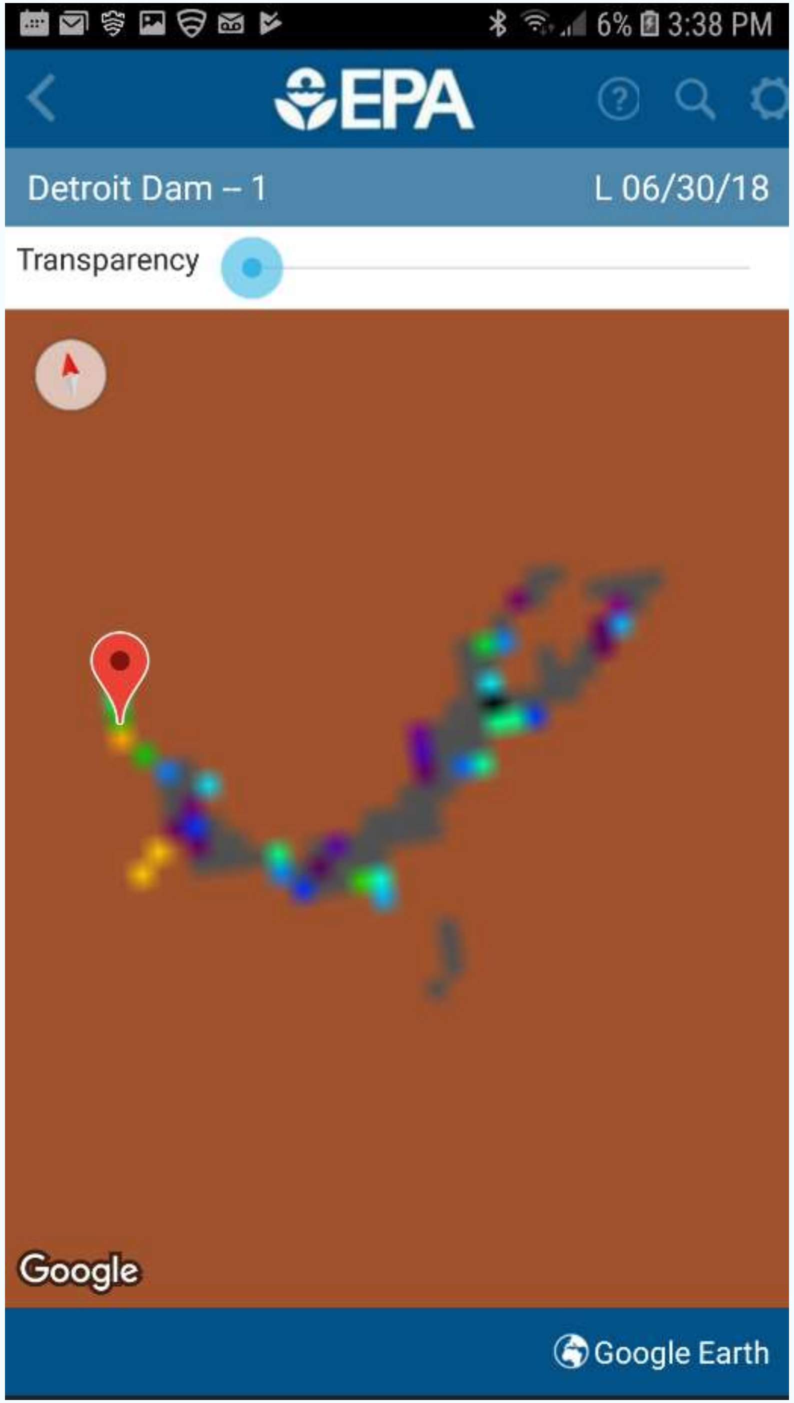
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City of Salem issues drinking water advisory

May 29, 2018

City of Salem issues drinking water advisory

Late this afternoon, the city of Salem issued the following press release regarding a "Do Not Drink" notice for tap water in the cities of Salem, Turner, Suburban East Salem Water District, and Orchard Heights Water Association.
The city is recommending that vulnerable people including infants, children under six, people with compromised immune systems, people receiving dialysis treatment, people with pre-existing liver conditions, pets, pregnant women or nursing mothers, or other sensitive populations should follow this advisory.
Everyone may use tap water for showering, bathing, washing hands, washing dishes, flushing toilets, cleaning and doing laundry.
Please see the full press release below for more information or visit cityofsalem.net.

City of Salem: MAY 29, 2018,
CYANOTOXINS PRESENT IN DRINKING WATER DO NOT DRINK THE TAP WATER -- INFANTS, YOUNG CHILDREN AND OTHER VULNERABLE INDIVIDUALS
Applies to City of Salem, City of Turner, Suburban East Salem Water District, and Orchard Heights Water Association
WHY IS THERE AN ADVISORY? Low levels of cylindrospermopsin and microcystin (cyanotoxins) have been found in treated drinking water. These toxins are created by algal blooms in the source of City of Salem drinking water, Detroit Reservoir.
To ensure the greatest quality of drinking water, City of Salem voluntarily samples for such toxins during algal events. Samples were collected on May 23, 2018, and May 25, 2018.

"Do Not Drink" Advisory : May 29th - July 2nd, 2018

PETER COURTNEY
President of the Senate

June 13, 2018

Director Richard Whitman
Department of Environmental Quality
700 NE Multnomah Street, Suite 600
Portland, OR 97232

Dear Director Whitman,

Over that last few weeks Oregonians have learned about the dangers of cyanotoxins in drinking water. Even low levels of exposure to these toxins can be harmful to children, older adults and those with specific pre-existing health conditions.

I have heard from the City of Salem and several other local water utilities that the lack of in-state testing is a problem. The process of shipping samples to out-of-state labs is cumbersome and slow for the water officials and the public.

It is my understanding that the department has the equipment and expertise to conduct the testing in-state, but lacks the needed personnel. I am requesting today that the Oregon Department of Environmental Quality move quickly to use existing staff to conduct testing for cyanotoxins in drinking water and if necessary submit a budgetary request to the Legislative Emergency Board to be considered when the board meets in September.

Throughout our history, Oregon has prided itself about its clean air and water. Algal blooms and the resulting toxins in our drinking water systems are now threatening public confidence in a resource we have long considered pure. This is exactly why the Emergency Board exists. Oregon is facing crisis and we have the means to aid in our response.

I believe that timely in-state testing can provide water systems with the information they need to react and help restore Oregonians faith in this essential element of our daily lives.

Thank you.

Respectfully,

Peter Courtney

Peter Courtney
President of the Oregon Senate

900 Court St. NE, S-201, Salem, Oregon 97301
(503) 986-1600

OREGON ADMINISTRATIVE RULES
OREGON HEALTH AUTHORITY, PUBLIC HEALTH DIVISION
CHAPTER 333

DIVISION 61

DRINKING WATER

333-061-0510
Applicability of Cyanotoxin Rules

(1) Water suppliers subject to OAR 333-061-0510 to 333-061-0580 are those water suppliers operating water systems subject to regulation under OAR 333-061-0010 that:
  (a) Are supplied by a surface water source that is susceptible to harmful algae blooms or release of cyanotoxins; or
  (b) Are supplied by a groundwater source determined by the Authority to be under the direct influence of a surface water source that is susceptible to harmful algae blooms or release of cyanotoxins; or
  (c) Purchase water from another water system that is supplied by a surface water source or a groundwater source determined by the Authority under the direct influence of a surface water that is susceptible to harmful algae blooms or release of cyanotoxins.

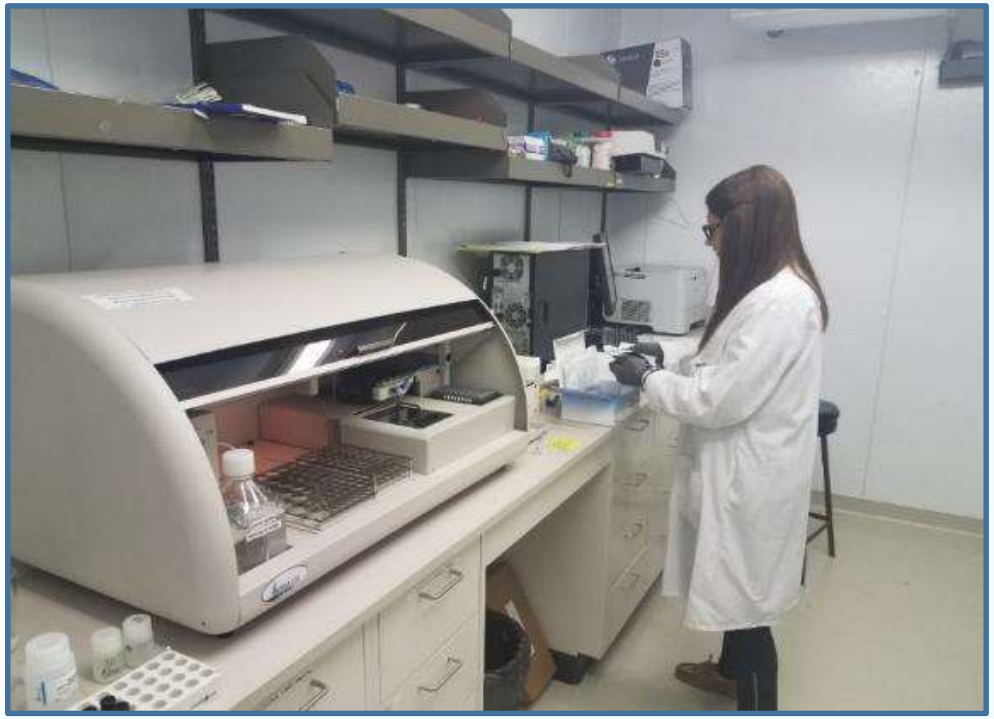
(2) A water source is susceptible to harmful algae blooms or release of cyanotoxins when:
  (a) One or more harmful algae blooms have been documented or at least one cyanotoxin was previously detected in the water source or at any location in a public water system supplied by that water source;
  (b) The point of diversion into the water system is downstream of or influenced by another surface water source susceptible to harmful algae blooms or release of cyanotoxins;
  (c) The surface water source is susceptible to cyanotoxins based on a water quality limited listing in the Oregon DEQ Integrated Report and Clean Water Act Section 303(d) list for the limiting factors of algae and aquatic weeds, chlorophyll-a, nitrates, phosphorus, pH, or dissolved oxygen; or
  (d) The Authority determines the source is susceptible to harmful algae blooms and cyanotoxins based on the characteristics of the source, including, but not limited to, slow moving or stagnant water, or available sources of nutrients.

(3) The Authority may, in its discretion, exempt a water supplier that would otherwise be subject to OAR 333-061-0510 to 333-061-0580 if the water supplier submits sufficient evidence, including but not limited to, water quality data, watershed characteristics, and environmental conditions such that the Authority determines that the water source has a low susceptibility to cyanotoxins when considered with any other information available to the Authority.

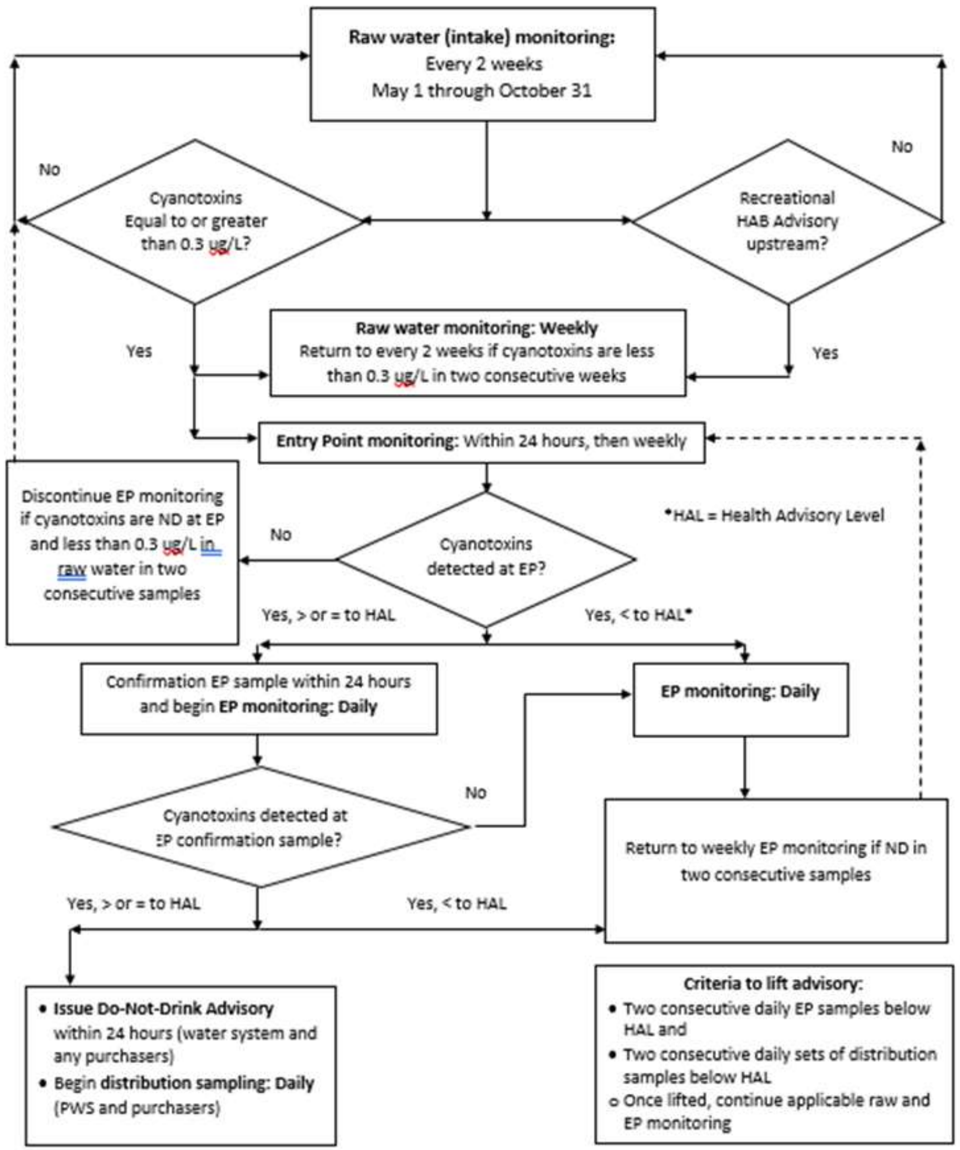
(4) A water supplier subject to OAR 333-061-0510 to 333-061-0580 under this rule must begin monitoring as described in OAR 333-061-0510 to 333-061-0580 beginning the week of July 15, 2018.

Stat. Auth.: ORS 448.123, 448.131 and 448.150
Stats. Implemented: ORS 448.123 and 448.150

EPA Method 546:
ELISA for *Mycrocystin* and *Nodularin* in drinking water & ambient water



Cyanotoxin Monitoring Requirements
Oregon Health Authority
July 2018



Available at: www.oregon.gov/oha

DRINKING WATER TESTING

- **Approximately 100 facilities that provide drinking water**
- **Sampling period July - November**

DRINKING WATER TESTING

SOURCE: Biweekly testing

YES: Test **FINISH** water

NO? Test **SOURCE** water weekly (until 2 non-detects)

YES? Test **FINISH** water daily (until 2 non-detects)

NO? Test **SOURCE** water daily (until 2 non-detects)

			Results (µg/L)							
FACILITY	SAMPLE DESCRIPTION	ANALYTE	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Gates, City of	NORTH SANTIAM RIVER	Cylindrospermopsin	0	0	0.11	0	0	0	0	0.11
		Microcystins ADDA, Total	1.57	2.36	0.55	0	0	0	0	0
	EP for NORTH SANTIAM RIVER	Cylindrospermopsin	0	0	0	0	0	0	0	0
		Microcystins ADDA, Total	0	0	0	0	0	0	0	0
Jefferson, City of	SANTIAM RIVER	Cylindrospermopsin	0	0	0	0	0	0	0	0
		Microcystins ADDA, Total	0.67	0.38	0	0	0	0	0	0
	EP FOR SANTIAM RIVER	Cylindrospermopsin	0	0	0	0	0	0	0	0
		Microcystins ADDA, Total	0	0	0	0	0	0	0	0
Lyons Mehama Water District	NORTH SANTIAM RIVER	Cylindrospermopsin	0	0	0	0	0	0	0	0
		Microcystins ADDA, Total	0	0	0	0	0	0	0	0
	EP for NORTH SANTIAM RIVER	Cylindrospermopsin	0	-	-	0	0	0	0	0
		Microcystins ADDA, Total	0	-	-	0	0	0	0	0
Salem Public Works	NORTH SANTIAM RIVER	Cylindrospermopsin	0	0	0	0	0	0	0	0
		Microcystins ADDA, Total	2.72	1.66	0.55	0	0	0	0	0
	EP FOR GEREN ISLAND (ALDERSGATE)	Cylindrospermopsin	0	0	0	0	0	0	0	0
		Microcystins ADDA, Total	0	0	0	0	0	0	0	0
Stayton Water Supply	NORTH SANTIAM RIVER	Cylindrospermopsin	0	0	0	0	0	-	0	0
		Microcystins ADDA, Total	1.63	1.73	0.4	0	0	-	0	0
	EP for NORTH SANTIAM RIVER	Cylindrospermopsin	0	0	0	0	0	-	0	0
		Microcystins ADDA, Total	0	0	0	0	0	-	0	0

- Continue in-state testing
- Expand Lab capacity (ELISA, LC/MS) for advisory notices
- Vision for recreational posting with State-wide partnerships

THANKS!

State of Oregon Department of Environmental Quality

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RESOURCES

- CyAN (Sept-2017) : https://drive.google.com/open?id=0B6EtCnMZbZ28dTRqUThSTkZPX00
- CyAN Fact Sheet: https://www.epa.gov/sites/production/files/2016-10/documents/cyanfactsheet.pdf
- OHA Current Advisories: https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/RECREATION/HARMFULALGAEBLOOMS/Pages/Blue-GreenAlgaeAdvisories.aspx

CyAN Limitations

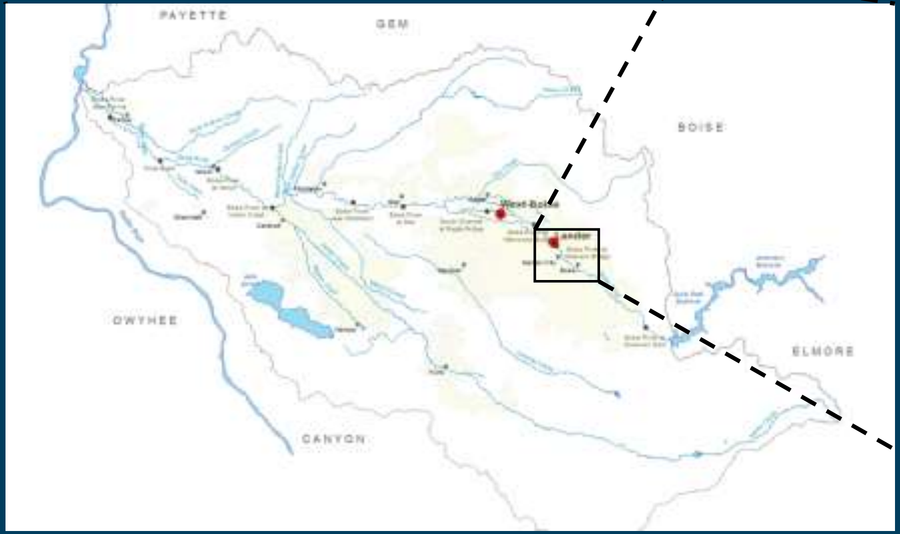
- Ice can potentially register as high cyanobacteria concentrations
- The land mask may cover dry lakes, and may exclude other lakes
- Caution should be used where mixed pixels may occur at land/water interface
- Land mask does not have an accurate representation of Rhode Island's coastline
- Undetected thin clouds can potentially register as high cyanobacteria concentrations
- Retrievals are considered more robust for lakes ≥ 900 m, or 3 x 3-pixel array; smaller water bodies and rivers are not masked and may be erroneous
- Satellite data processing does not account for changes in water levels due to cycles, such as drought and flood

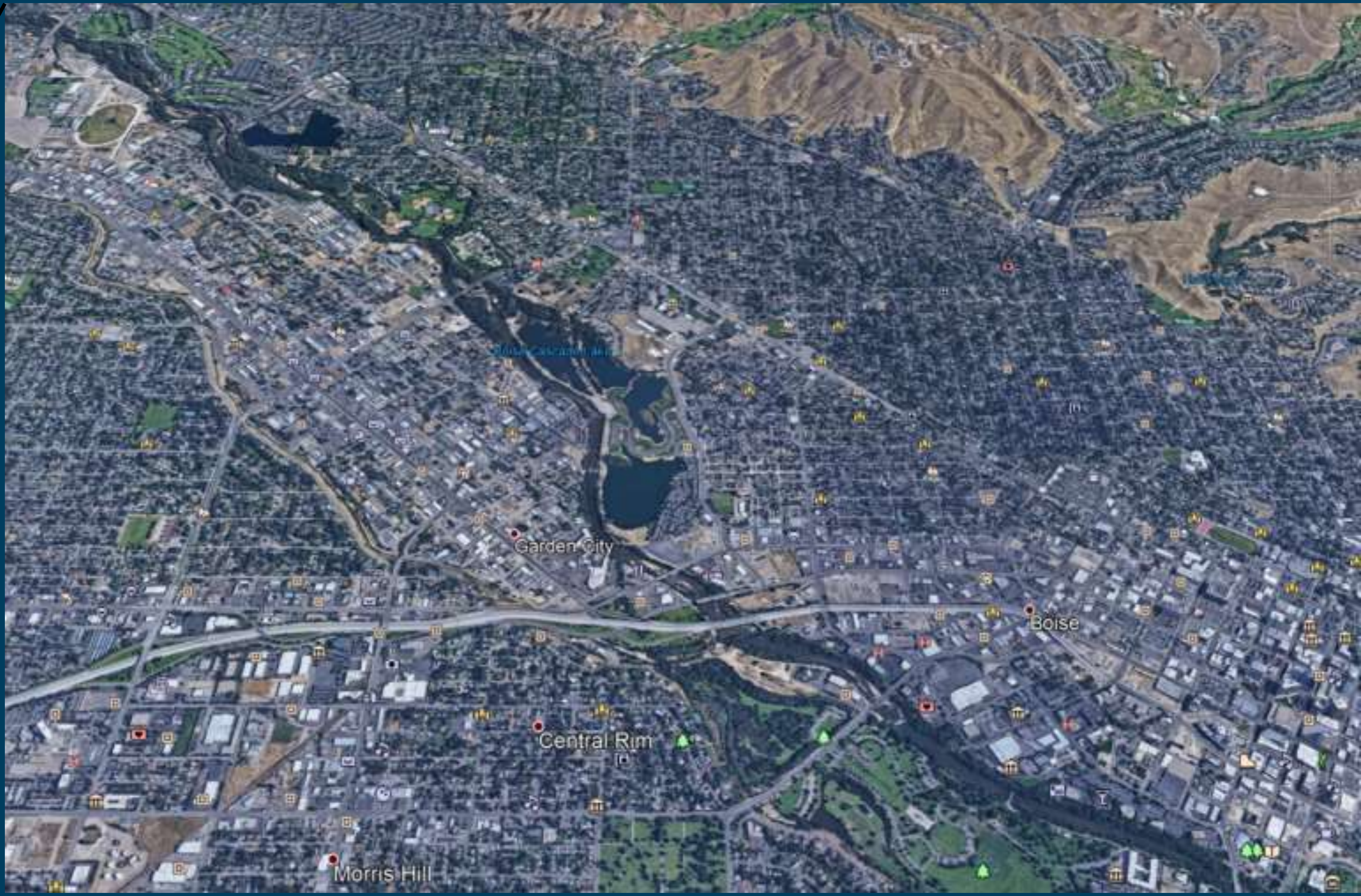
ESTHER SIMPLOT POND HARMFUL ALGAL BLOOMS

Dorene MacCoy, Water Quality Environmental Coordinator, Public Works Department
Paul Faulkner, Senior Water Quality Environmental Specialist, Public Works Department

CITY of BOISE

LOCATION





CITY of BOISE

PARK USE

- Swimming
- Boating
- Picnic and recreation
- Fishing
- Greenbelt access
- Wildlife viewing – wetland
- https://vimeo.com/190813627

PARK TOXIC TIMELINE

CITY of BOISE

- Nov '16 - ESP Grand opening
- June '17 - ESP and Quinns closed high E. coli criteria (storm water and runoff)
- Aug '17 – ESP HABs (Planktotherix, Dolichospermum, Microcystis), park closed
- April '18 park open
- June '18 ESP and Quinns high E. coli, several treatments
- July'18 ESP HABs (Oscillatoria) closed, treated, and reopened
- Sept '18 ESP HABs (Aphanizomenon, Dolichospermum) park closed

Quinn's Pond (Quinns) 39 acres
Esther Simplot Pond (ESP) 16.5 acres

2018 MONITORING

CITY of BOISE

- E. Coli – weekly e. coli
- Nutrients (TP, TN, ammonia, dissolved reactive phosphorus, nitrate/nitrite)
- Temperature and DO - continuous profiles
- July 2018 cyanobacteria bloom
    - Oscillatoria – microcystin **0.26 ppb (μg/L)**
- August 2 - 27 2018 ESP Pond experiment
    - Circulation pumps and wetland use
    - E.coli reduction and reduced stratification
- September 2018 cyanobacteria bloom
    - Aphanizomenon – microcystin **0.42 ppb**
    - Dolichospermum – microcystin **0.30 ppb**

CITY of BOISE

EPA United States Environmental Protection Agency

Office of Water
EPA 820-R-17-001
June 2017

Recommendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters

Table 1. Draft EPA Recommended Values for Recreational Criteria and Swimming Advisories for Cyanotoxins

Microcystins	Cylindrospermopsin
4 μg/L [a,b]	8 μg/L [a,b]

a) Swimming Advisory: not to be exceeded on any day
b) Recreational Criteria for Waterbody Impairment: not exceeded more than 10 percent of days per recreational season up to one calendar year.

Table 2. WHO (2003) Recreational Guidance/Action Levels for Cyanobacteria, Chlorophyll *a*, and Microcystin

Relative Probability of Acute Health Effects	Cyanobacteria (cells/mL)	Chlorophyll *a* (μg/L)	Estimated Microcystin Levels (μg/L)[a]
Low	< 20,000	< 10	< 10
Moderate	20,000–100,000	10–50	10–20
High	>100,000–10,000,000	50–5,000	20–2,000
Very High	> 10,000,000	> 5,000	> 2,000

[a]WHO (2003) derived the microcystin concentrations from the cyanobacterial cell density levels.

Table 4: Analytical methods of Microcystin and Cylindrospermopsin detection and non-toxins in ambient water[3]

TEST/ METHOD	Analytical Target	APPROX. LIMIT OF QUANTIFICATION	LOCATION OF TEST	TIME TO RESULT	SCREENING ONLY TOOL
EPA Method 546 Adda-ELISA	Intracellular and Extracellular Microcystins	0.10–5.0 μg/L	Lab	~ 1 day	No
ELISA-DM Laboratory Test	Total Microcystins	0.010 μg/L	Lab	3 hours or less	No
ELISA Laboratory Test SAES (Abraxis)	Total Microcystin in marine/brackish water	0.016 μg/L	Lab	3 hours or less	No
ELISA Laboratory Test (Abraxis)	Total Cylindrospermopsin	0.05 – 2.0 μg/L	Lab	3 hours or less	No
ELISA Laboratory Test	Total Cylindrospermopsin	0.1-2.0 μg/L	Lab	~2 hours	No

CITY of BOISE

TOXINS

Cyanobacteria Found in Esther Simplot Ponds 2017 and 2018									
Cyanobacteria Genus	**Cyanotoxin Class**								
	CYL	**MC**	**NOD**	**ATX**	**SAX**	**NEO**	**LYN**	**BMAA**	**APL**
Aphanizomenon	√	√	√	√	√	√		√	
Dolichospermum	√	√		√	√	√		√	
Microcystis		√						√	
Oscillatoria (Planktothrix)	√	√		√	√		√	√	√

CYL = cylindrospermopsin **MC** = microcystin **NOD** = nodularin **ATX** = anatoxin-a **SAX** = saxitoxin **NEO** = neosaxitoxins **BMAA** = β-N-methylamino-L-alanine **LYN** = lyngbyatoxin-a **DAT** = debromoaplysiatoxin **APL** = aplysiatoxin

Adapted from IDEQ and SWAMP - HAB Field Guide

Toxins found

CITY of BOISE

NUTRIENTS AND BLOOMS

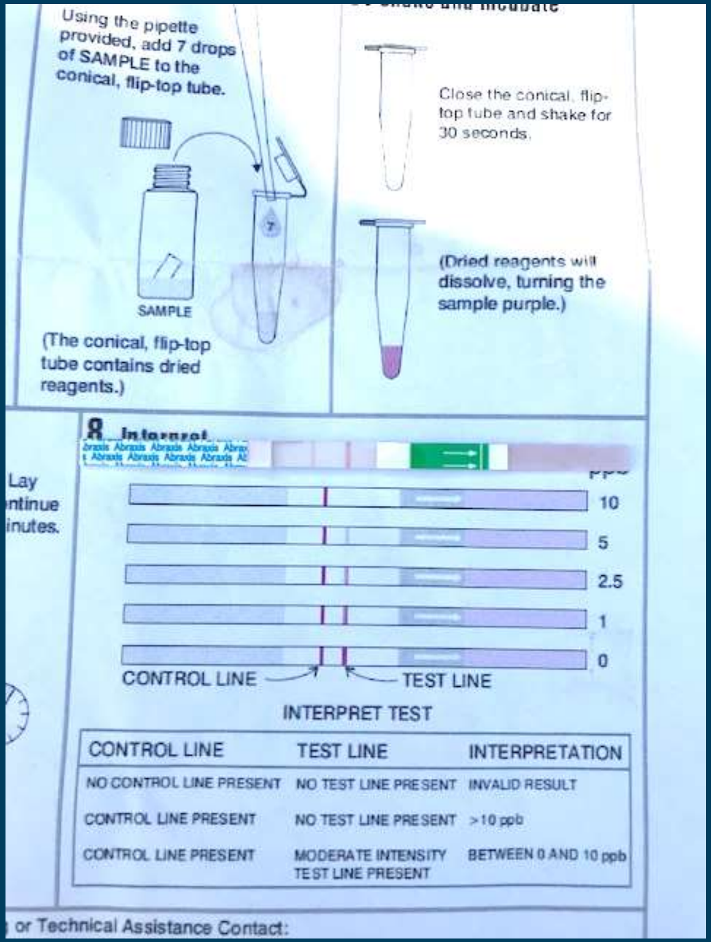
Preliminary data – note low nutrient concentrations

Site	Date	E. Coli	HABs	cell/mL	Orthophosphate, as P (mg/L)	Total Phosphorus as P (µg/L)	Ammonia as N (µg/L)	Nitrite-Nitrate as N (mg/L)	TKN (mg/L)
ESP1	7/2/2018	50			0.00321	17.0	<35.0	<0.02	0.405
ESP2	7/2/2018	4			0.002	16.5	<35.0	<0.020	0.358
ESP3	7/2/2018	17			0.002	17.9	<35.0	<0.020	0.37
ESP1	7/16/2018	<1	Oscillatoria	1,425,000	0.0091	27.2	127	0.053	0.446
ESP2	7/16/2018	1	Oscillatoria	1,292,000	0.00687	25.7	125	0.0448	0.582
ESP3	7/16/2018	1			0.00604	27.1	376	0.0236	0.667

CITY of BOISE

TEST STRIPS?

- Unsure where to take sample
- Issues with interpretation



Analysis Results **Reporting Date: 27 –July -2018**

Sample ID	Date	Time	Taxa ID and Enumeration (cells/mL)	Toxins (Ppb)
ESP1S	7/26/2018	0915	Oscillatoria sp.: 11,550	Microcystin: <0.15 Anatoxin-a: <0.15
ESP1NW	7/26/2018	1105	Oscillatoria sp.: 23,100	Microcystin: <0.15 Anatoxin-a:<0.15
ESP2E	7/26/2018	1205	Oscillatoria sp.: 56,100	Microcystin: <0.15 Anatoxin-a:<0.15

CITY of BOISE

TEST STRIP READER

Reader negative for Anatoxin-a
 and Mycrocystin
Or there was an invalid control

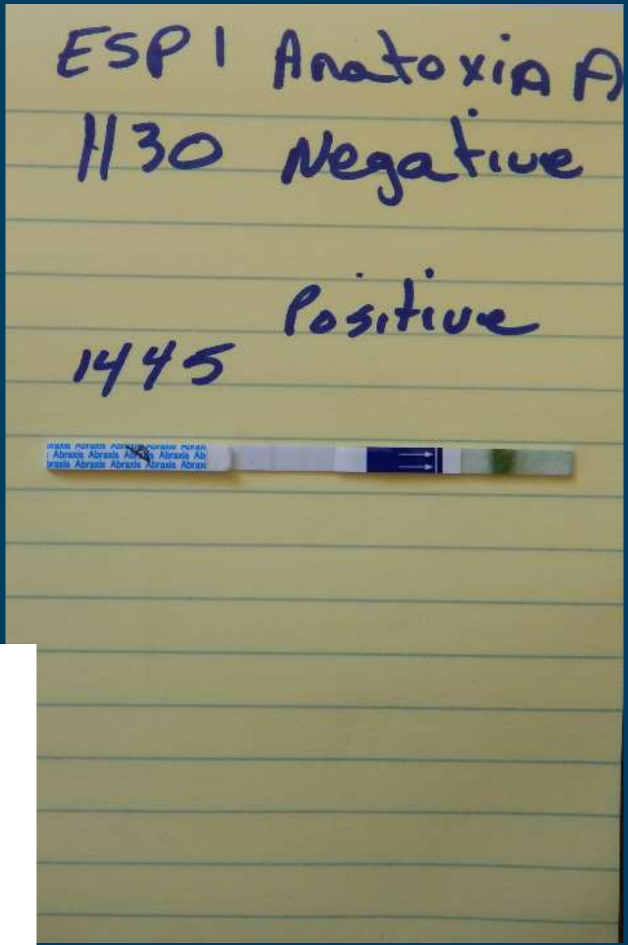
Analysis Results **Reporting Date: 29 –Sept -2018**

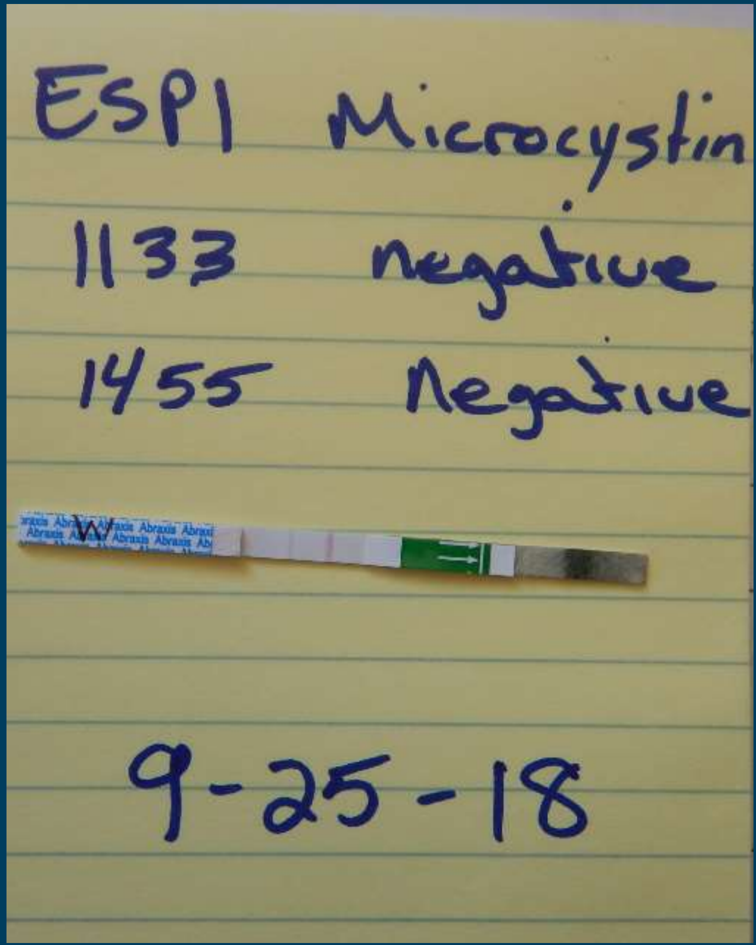
Sample ID	Date	Time	Taxa ID and Enumeration (cells/mL)	Toxins (Ppb)
ESP1 A	9/25/2018	13:30	Aphanizomenon flos-aqua: 14,000,000	Microcystin: 0.18
ESP2 B	9/25/2018	13:00	Aphanizomenon flos-aqua: 7,900,000	Microcystin: <0.15
ESP3 C	9/24/2018	14:00	Aphanizomenon flos-aqua: >200,000,000	Microcystin: 0.42

TEST READER

When strips are not read right away

False positives or false negatives





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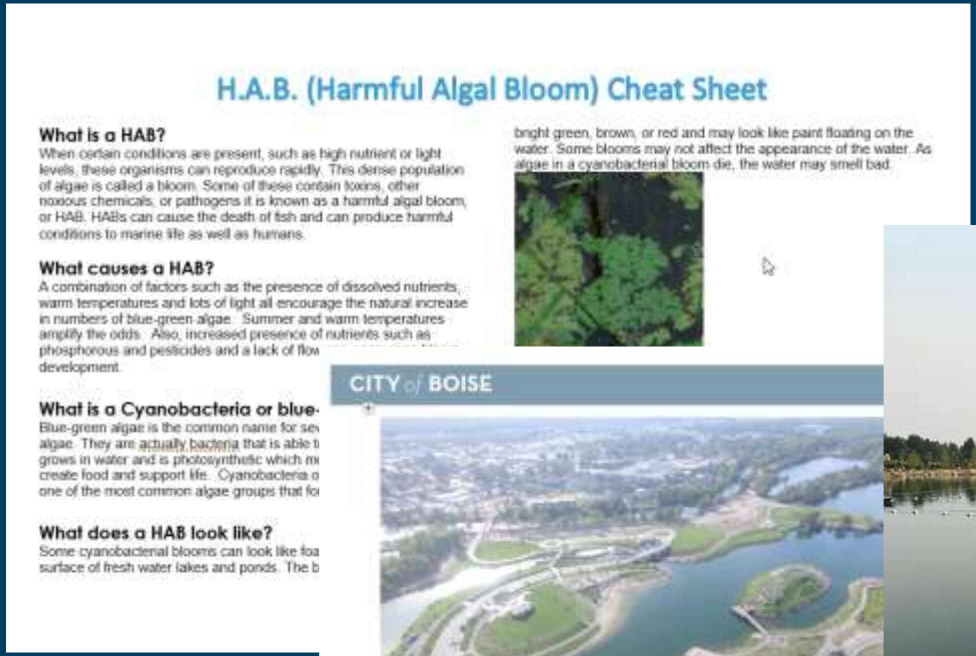
ESP3 C	9/24/2018	14:00	Aphanizomenon flos-aqua: >200,000,000	Microcystin: 0.42

CITY of BOISE

NEXT STEPS

- Public education
- Monitoring Plan
- Aeration/circulation/ treatment
- Phytoremeation



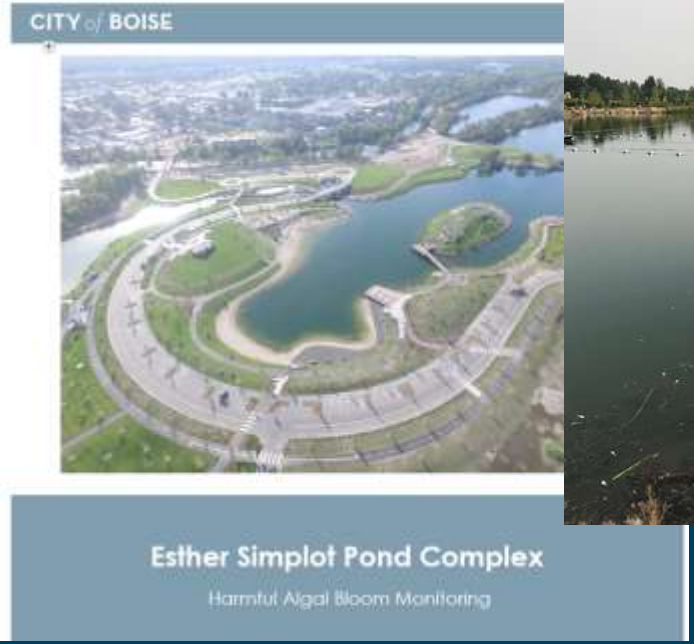
H.A.B. (Harmful Algal Bloom) Cheat Sheet

What is a HAB?
When certain conditions are present, such as high nutrient or light levels, these organisms can reproduce rapidly. This dense population of algae is called a bloom. Some of these contain toxins, other noxious chemicals, or pathogens it is known as a harmful algal bloom, or HAB. HABs can cause the death of fish and can produce harmful conditions to marine life as well as humans.

What causes a HAB?
A combination of factors such as the presence of dissolved nutrients, warm temperatures and lots of light all encourage the natural increase in numbers of blue-green algae. Summer and warm temperatures amplify the odds. Also, increased presence of nutrients such as phosphorous and pesticides and a lack of flow ... development.

What is a Cyanobacteria or blue-
Blue-green algae is the common name for sev... algae. They are actually bacteria that is able t... grows in water and is photosynthetic which m... create food and support life. Cyanobacteria o... one of the most common algae groups that fo...

What does a HAB look like?
Some cyanobacterial blooms can look like foa... surface of fresh water lakes and ponds. The b... bright green, brown, or red and may look like paint floating on the water. Some blooms may not affect the appearance of the water. As algae in a cyanobacterial bloom die, the water may smell bad.



CITY of BOISE

NEED YOUR FEEDBACK

New to the City of Boise – Swim Beaches and HABs

Dorene MacCoy
Water Quality Environmental Coordinator
City of Boise Public Works Department
dmaccoy@cityofboise.org
208-608-7515

Paul Faulkner
Water Quality Environmental Specialist
City of Boise Public Works Department
pfaulkner@cityofboise.org
208-608-7507

A New Master Sample

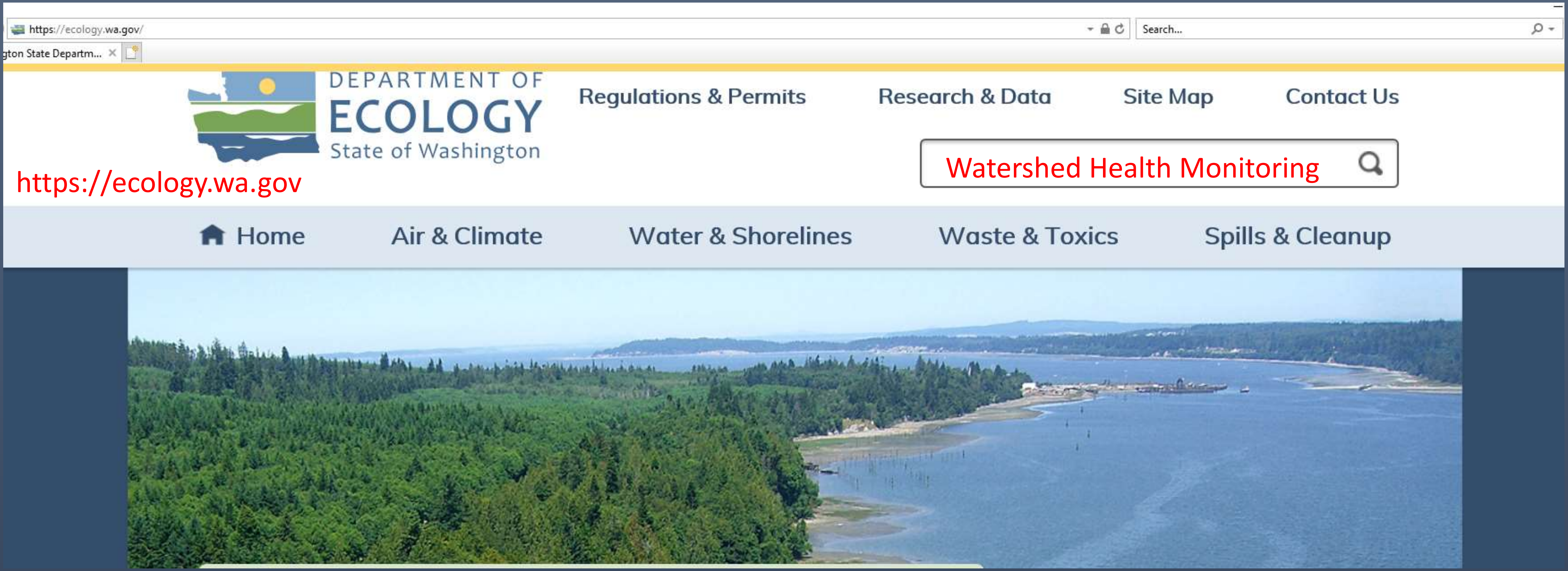
Washington Statewide Stream Biological Monitoring

Our talk

- What we've been using
  - Requirements for build
  - Features
  - Issues

- What we are making
  - Requirements for build
  - The process
  - Issues

Background



https://tinyurl.com/WatershedHealth

Status and Trends Monitoring for Watershed Health and Salmon Recovery

Quality Assurance Monitoring Plan

Multi-scale

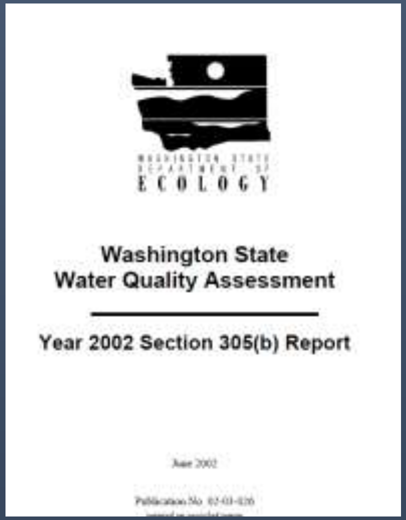
- Statewide (Dept. Ecology)
- Broad Regions (Depth Ecology)
- Watersheds, etc. (local interests)

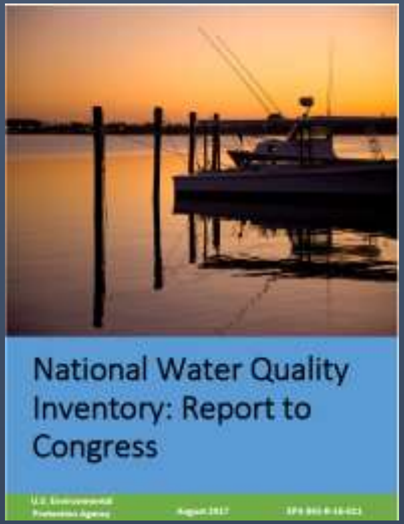
- Monitoring Forum (Exec order 04-03)
- Stakeholder Workshops

Two federal mandates and state responses

CWA

…to restore and maintain the <u>chemical, physical, and biological</u> integrity of the Nation's waters.





305(b): status of waters of the state

ESA

…*de-listing requires analysis of the <u>physical & chemical</u> conditions that affect the species' continued existence.*


Reporting on salmon and habitat in Washington

WELCOME TO THE NINTH BIENNIAL STATE OF SALMON IN WATERSHEDS REPORT

This new Web site provides stories and data about salmon, habitat, and salmon recovery.

This report documents how Washingtonians have responded to the challenges of protecting and restoring salmon and steelhead. It is a tool to summarize achievements, track salmon recovery progress statewide and by recovery region. The Recreation and Conservation Office is required by law to produce this report every two years.

WA State of the Salmon Report->
PCSRF: Annual Reports to Congress

Required features of 1st WA Master Sample

- 1:24,000 - stakeholder request
- Statewide - not necessarily beyond
- 1 km spacing - stakeholder request
- Strahler* – represent *all* size rivers/streams (in EPA fashion)

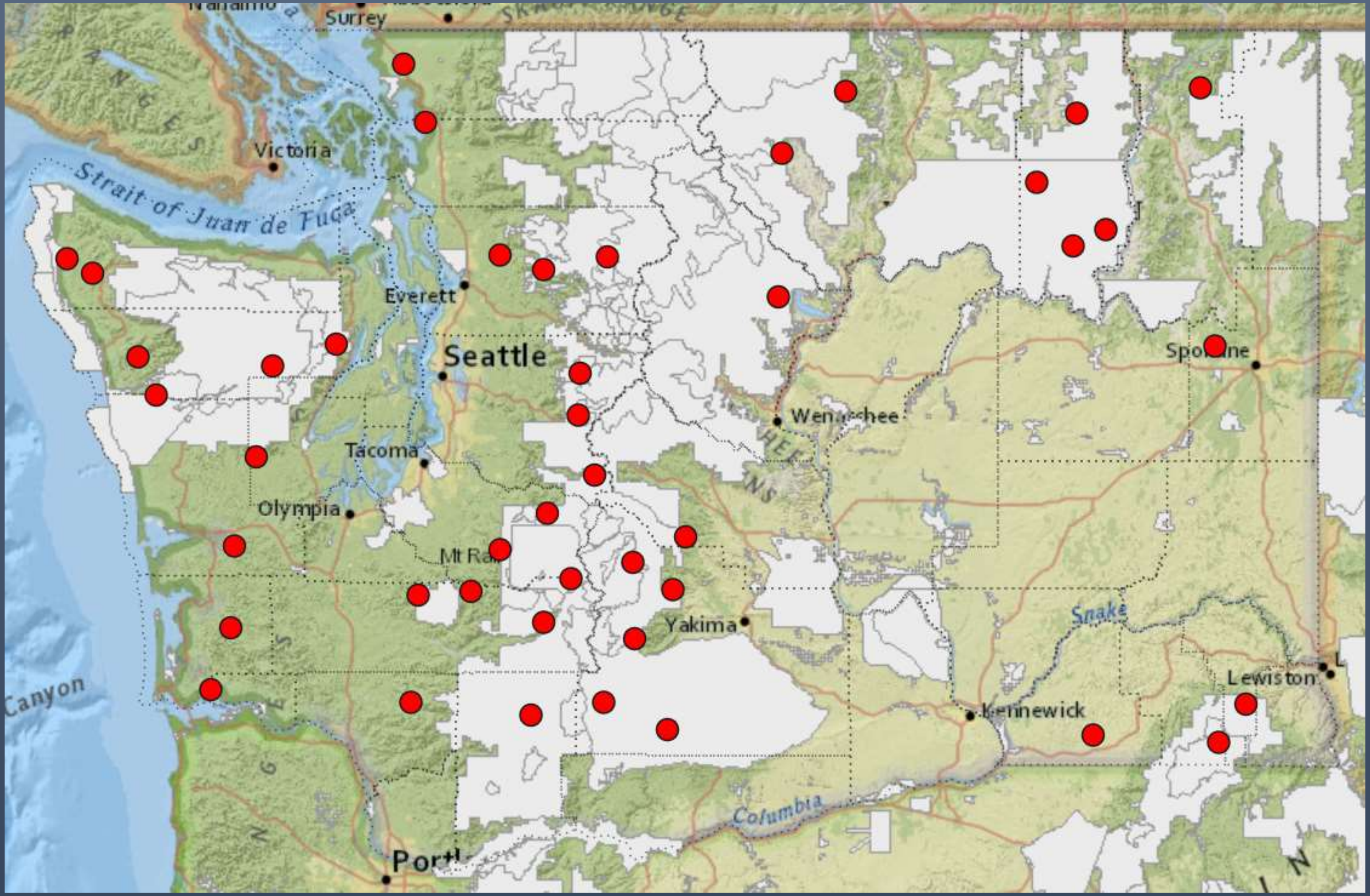
* Not available at 1:24k in 2008

Scale issues from National Surveys

- Coarse hydro 1:100k*
- Skewed to Mountains
- Sparse: About 50 sites

* Largest issue for local adoption

EMAP-West 2000-2003



=Federal or Tribal Land

Washington Master Sample

Metadata also available as

Metadata:

- Identification_Information
- Spatial_Data_Organization_Information
- Spatial_Reference_Information
- Entity_and_Attribute_Information
- Distribution_Information
- Metadata_Reference_Information

Identification_Information:

Citation:

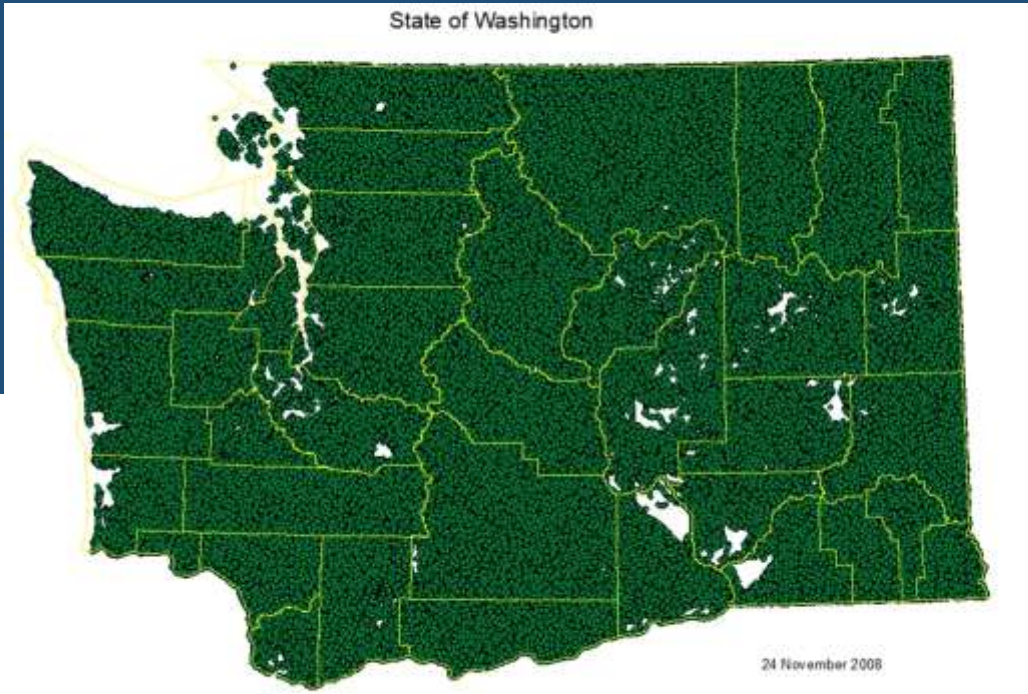
Citation_Information:

Originator: USEPA NHEERL Western Ecology Division, Anthony (Tony) R. Olsen
Publication_Date: 20081124
Title: Washington Master Sample
Geospatial_Data_Presentation_Form: map

Description:

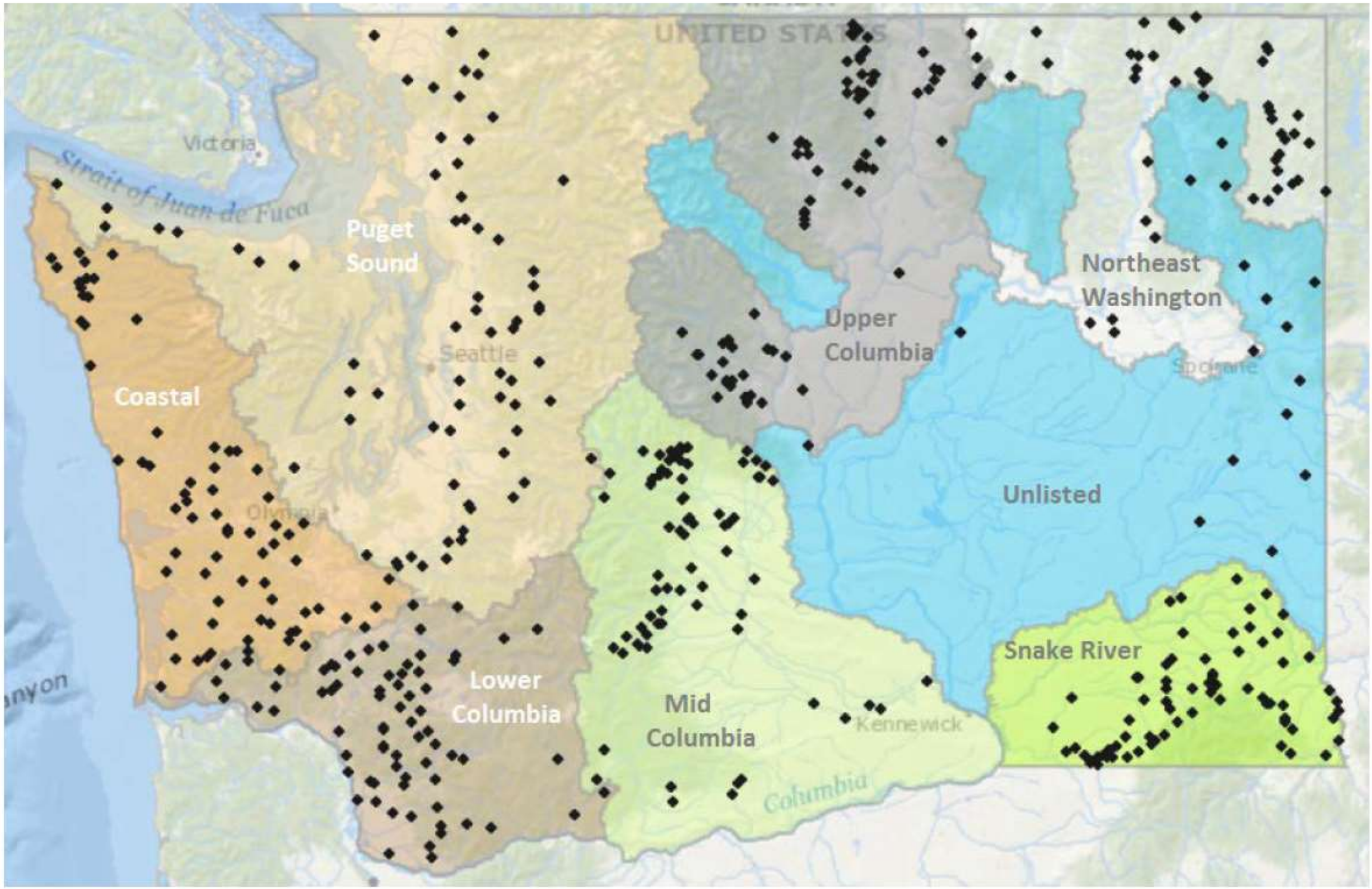
Abstract:
A geodatabase of 387,237 points statistically chosen from the February 2005 version of the Washington DNR Hydrography layer representing stream site locations. For details, see the Design Documentation created by 3/18/2006 by Tony Olsen (U.S. EPA) and Janelle Black (NW Indian Fisheries Commission). The design document is available from the Washington State Department of Ecology at https://fortress.wa.gov/ecy/gispublic/DataDownload/documents/EPA_ENV_MasterSampleDesign.pdf.
Purpose:
To provide a common set of probabilistic sites for sharing efforts in monitoring rivers and streams.

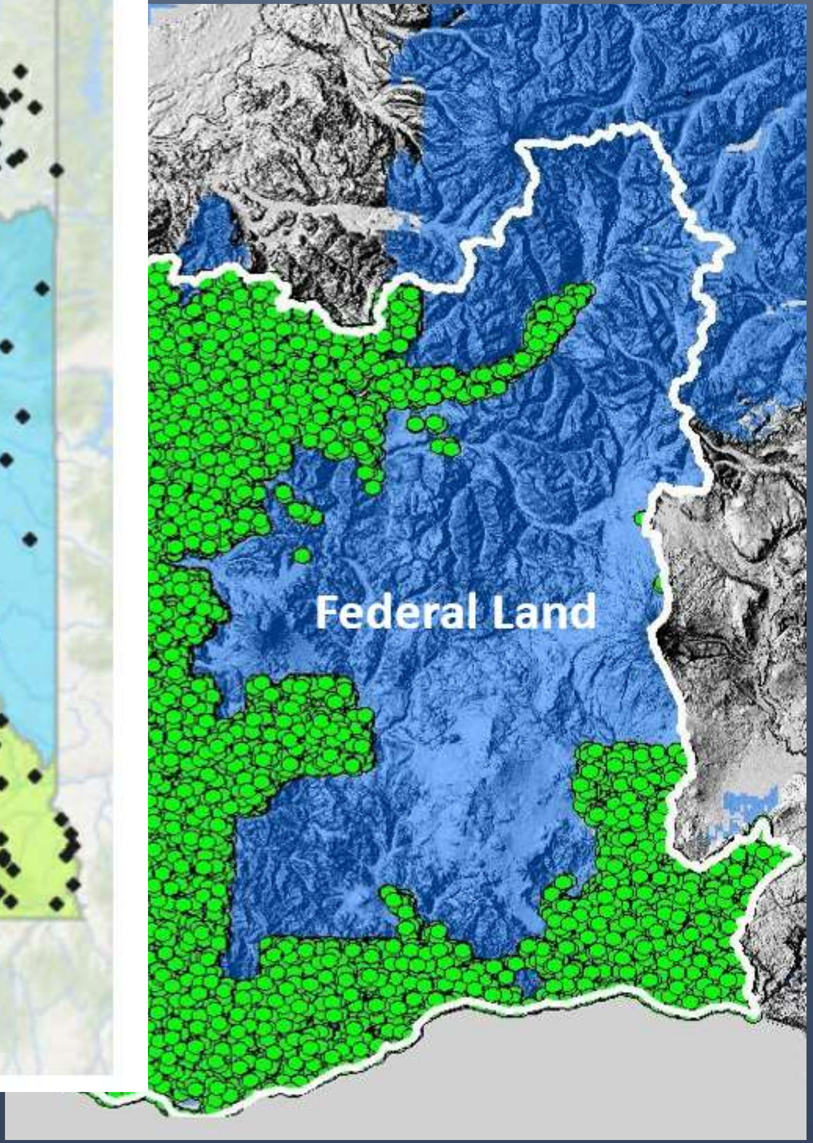
Washington DNR Hydrography (2005)
387,237 points (2008)



https://ecology.wa.gov/Research-Data/Data-resources/Geographic-Information-Systems-GIS/Data#m

Map of Status and Trends Regions for the Watershed Health Monitoring program

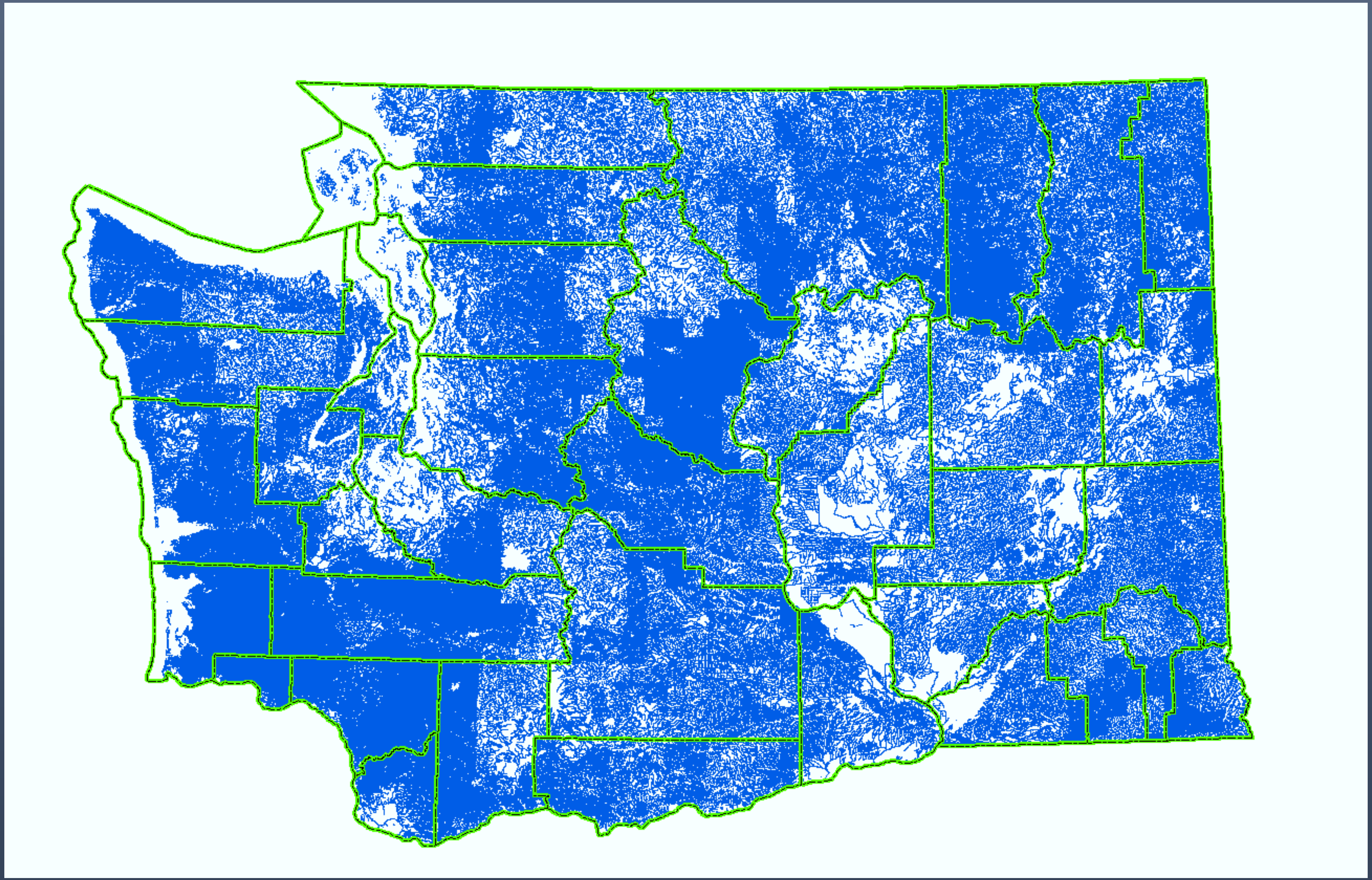




Technical issues with Frame for our first Washington Master Sample

- Non-standard hydrography
  - Variable density
  - Coverage gap
  - Requires confirming NHD membership for Db inclusion
  - Dated – now 13 years old
- No Strahler attribute in frame
  - Required manual evaluation vs NHD+ (1:100k)
- “Perennial” attribute unknown, not in Master Sample
- Confined to Washington

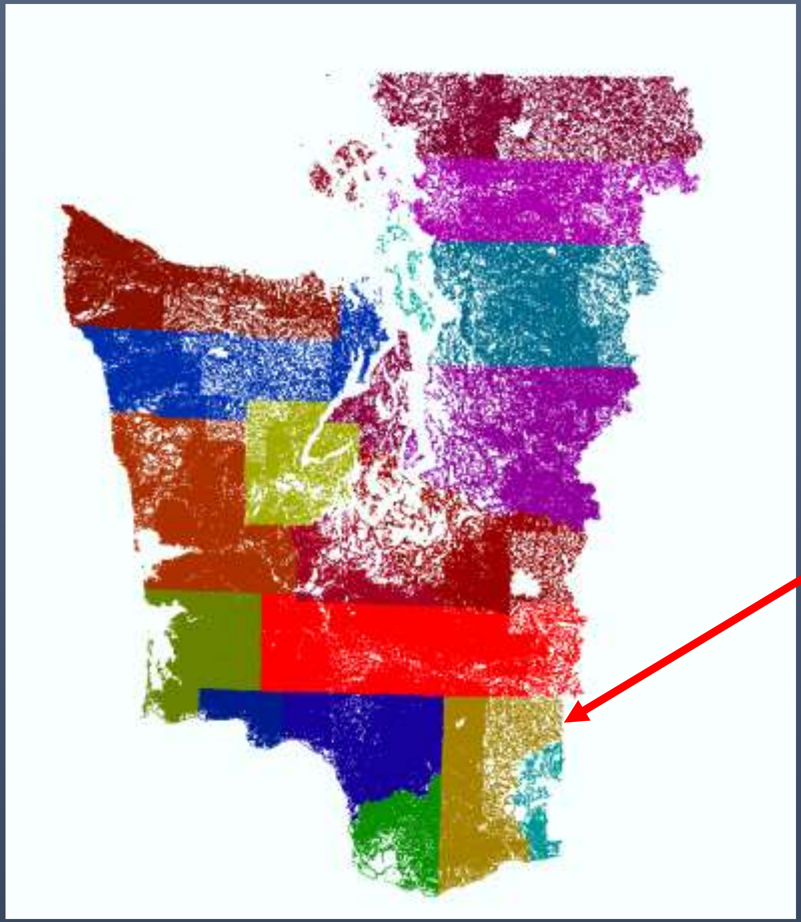
Variable Density of WA DNR (2005)

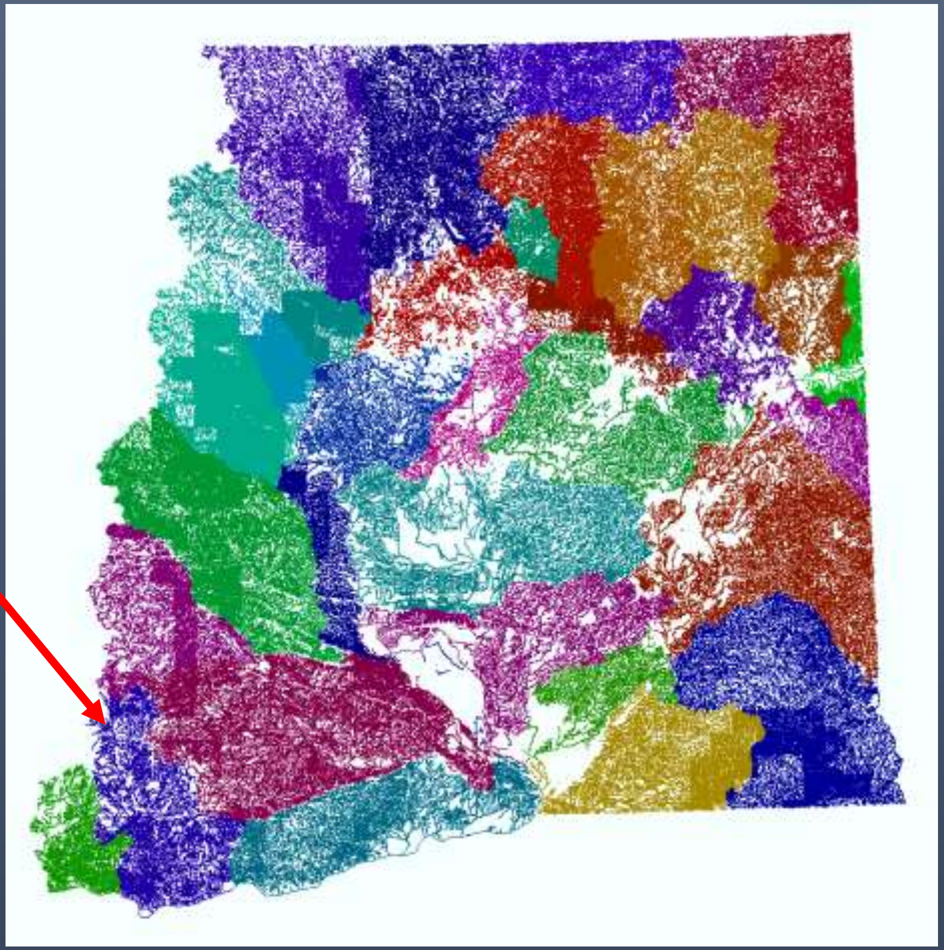


A timber management agency

- Extra lines near timber sales
- Lines inconsistently updated

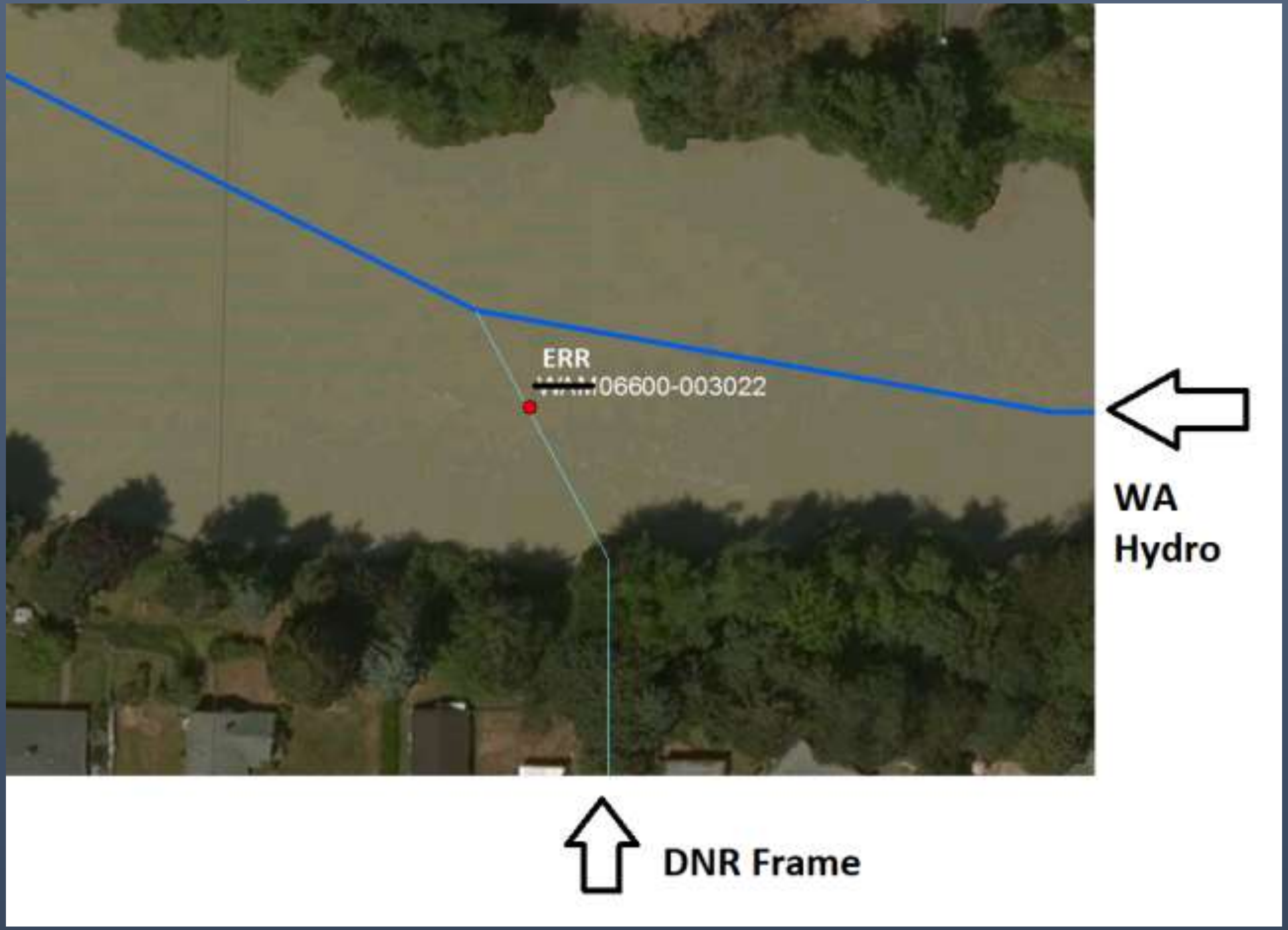
Counties (West)   Gap   Watersheds (East)



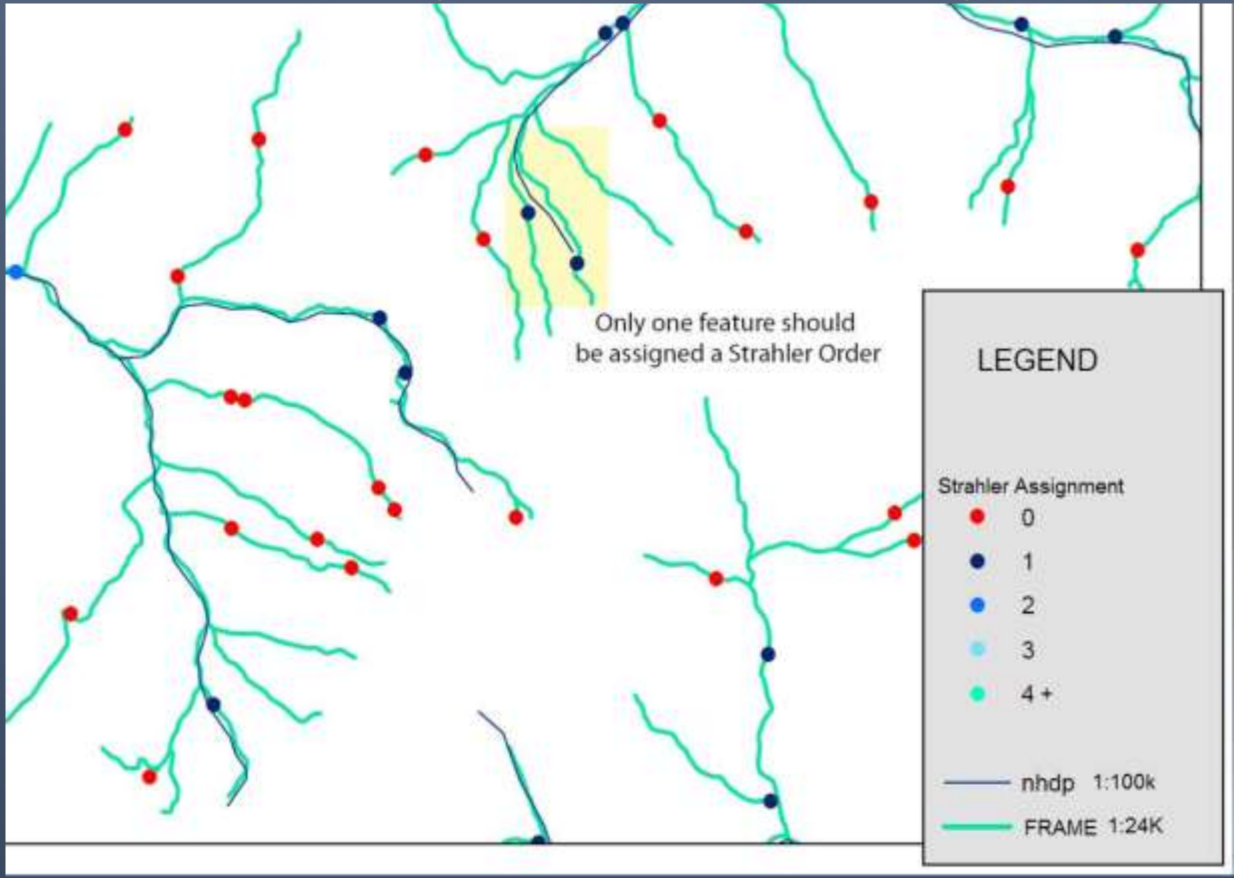


Must compare DNR frame with 2 other hydrographies...

NHD (state standard)

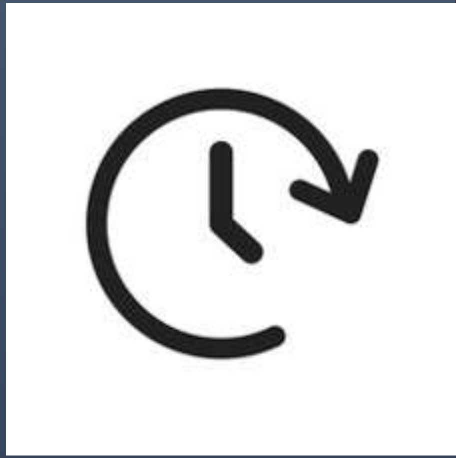


NHDPlus (has Strahler)



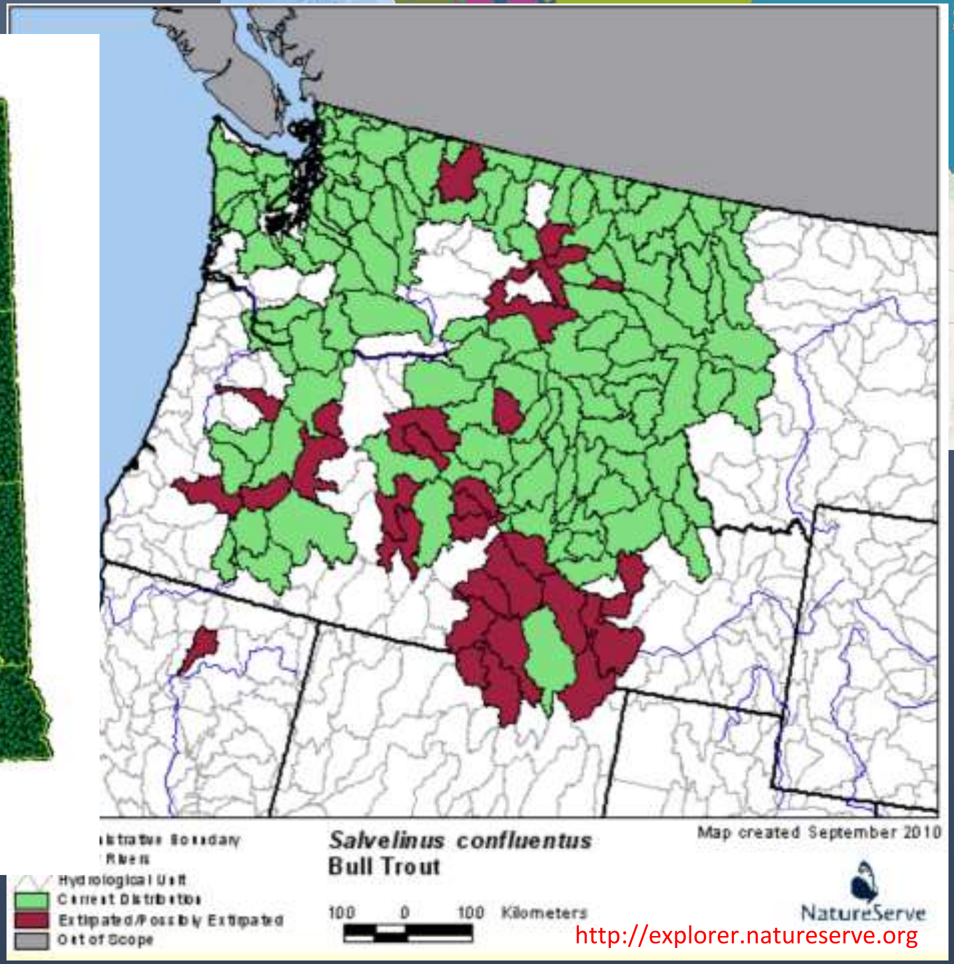
Effects of using multiple hydro layers

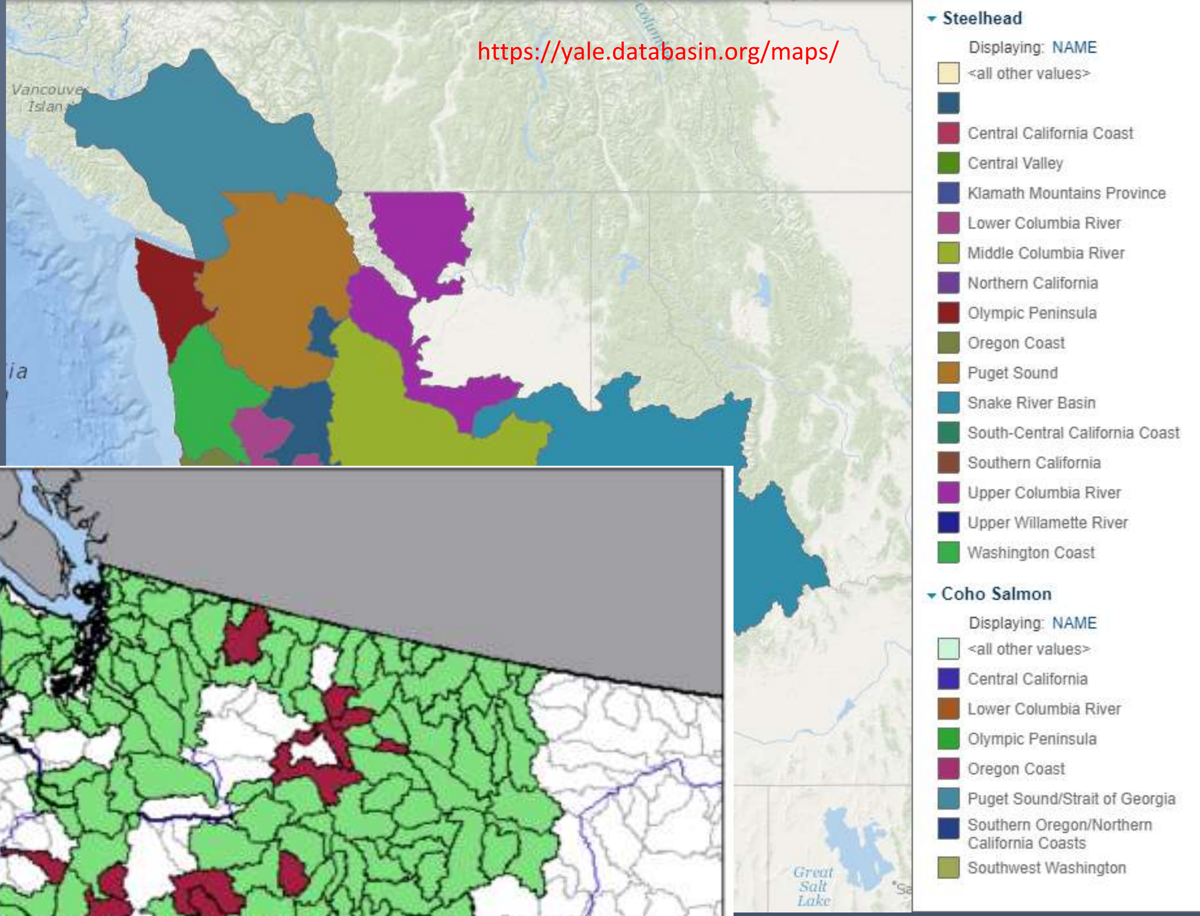
- Inferences based on hundreds NOT tens of thousands
- Time & effort
- Lack of clarity when discussing
- Location errors (see the Puyallup River example)



Master Sample Ends at Washington's Boundaries

Our interests do not



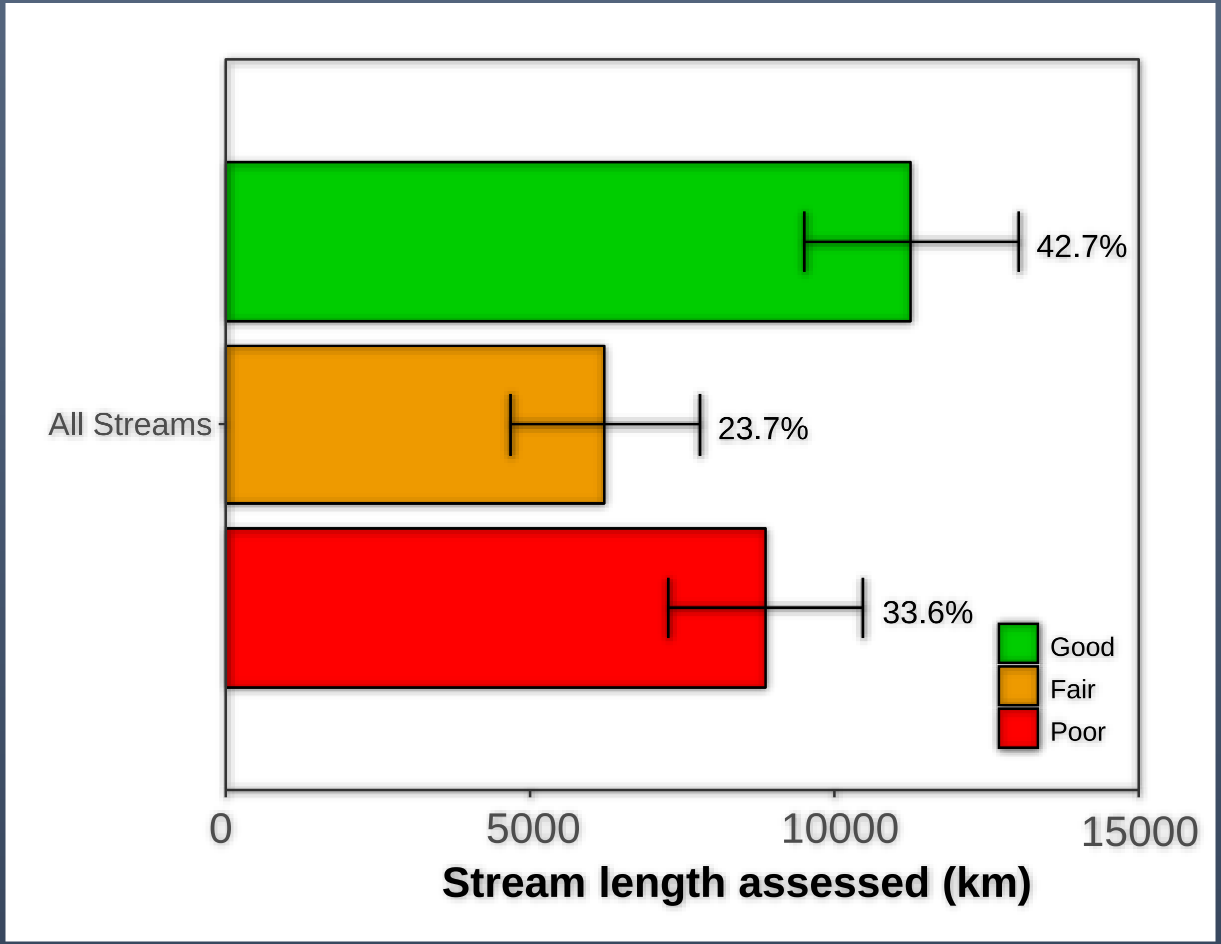


Inferences based on spatially-balanced random sample

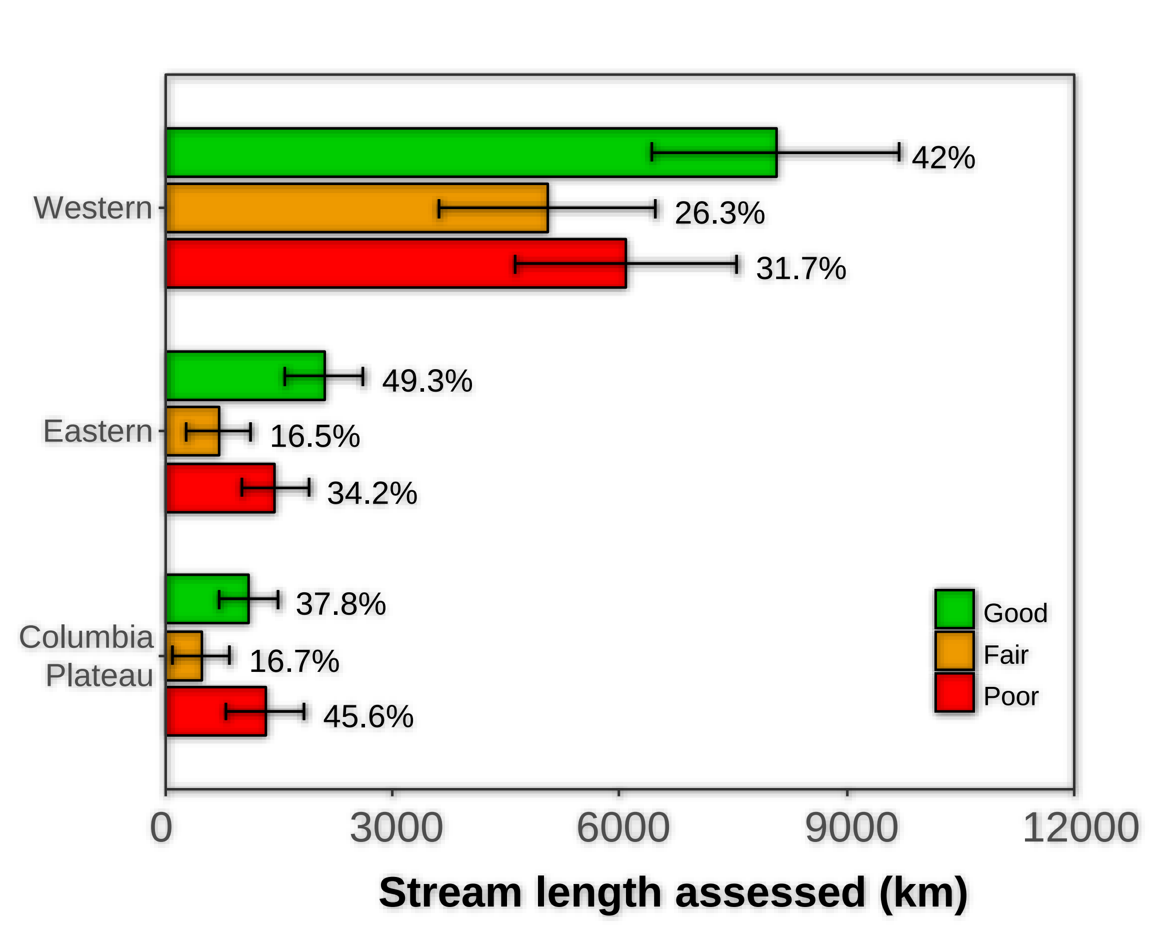
Obtain unbiased estimates of:

- Status
- Extent
- Stressor Identification
- Trends

Status

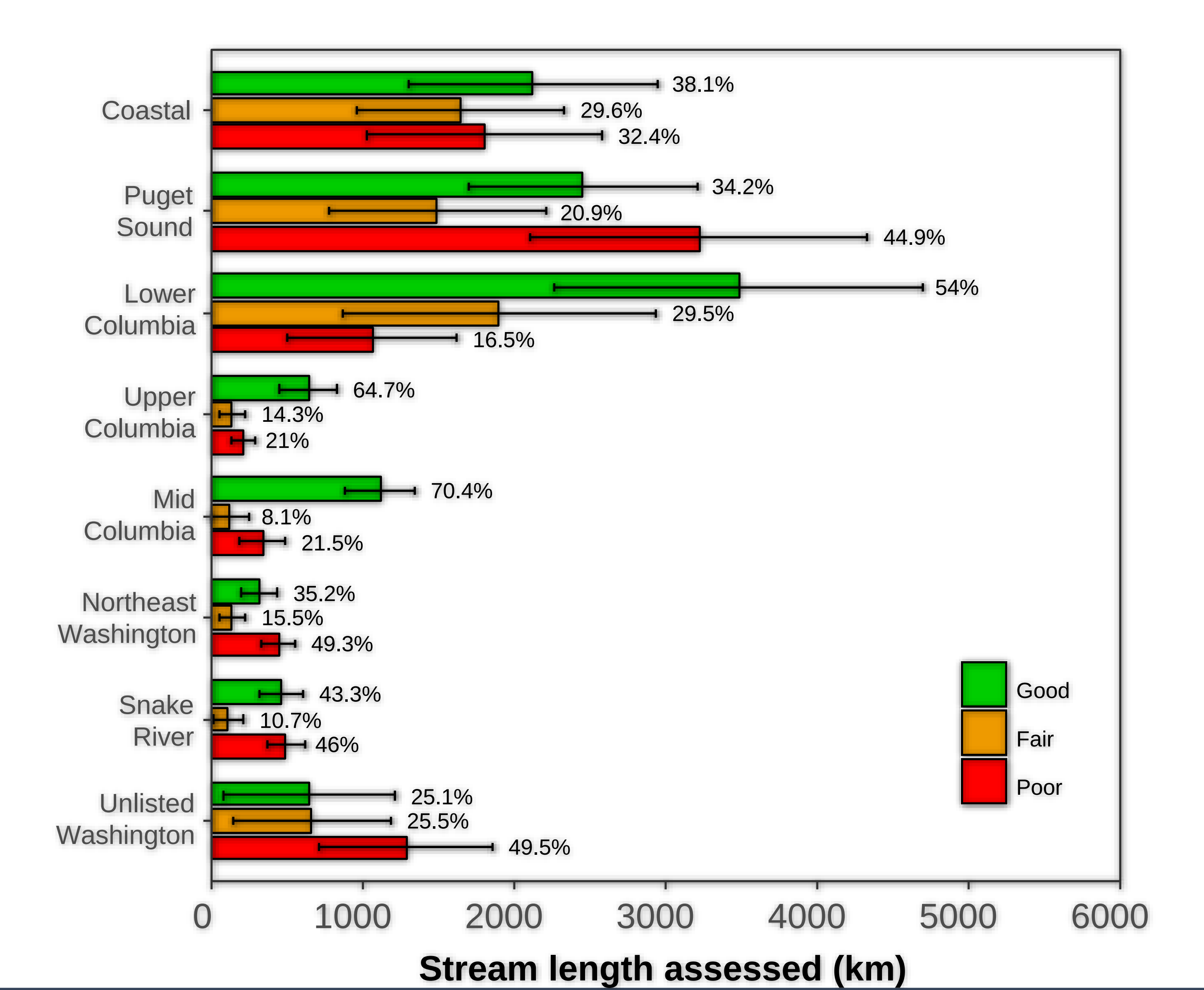


42.7%
23.7%
33.6%
All Streams
Good
Fair
Poor
0
5000
10000
15000
Stream length assessed (km)



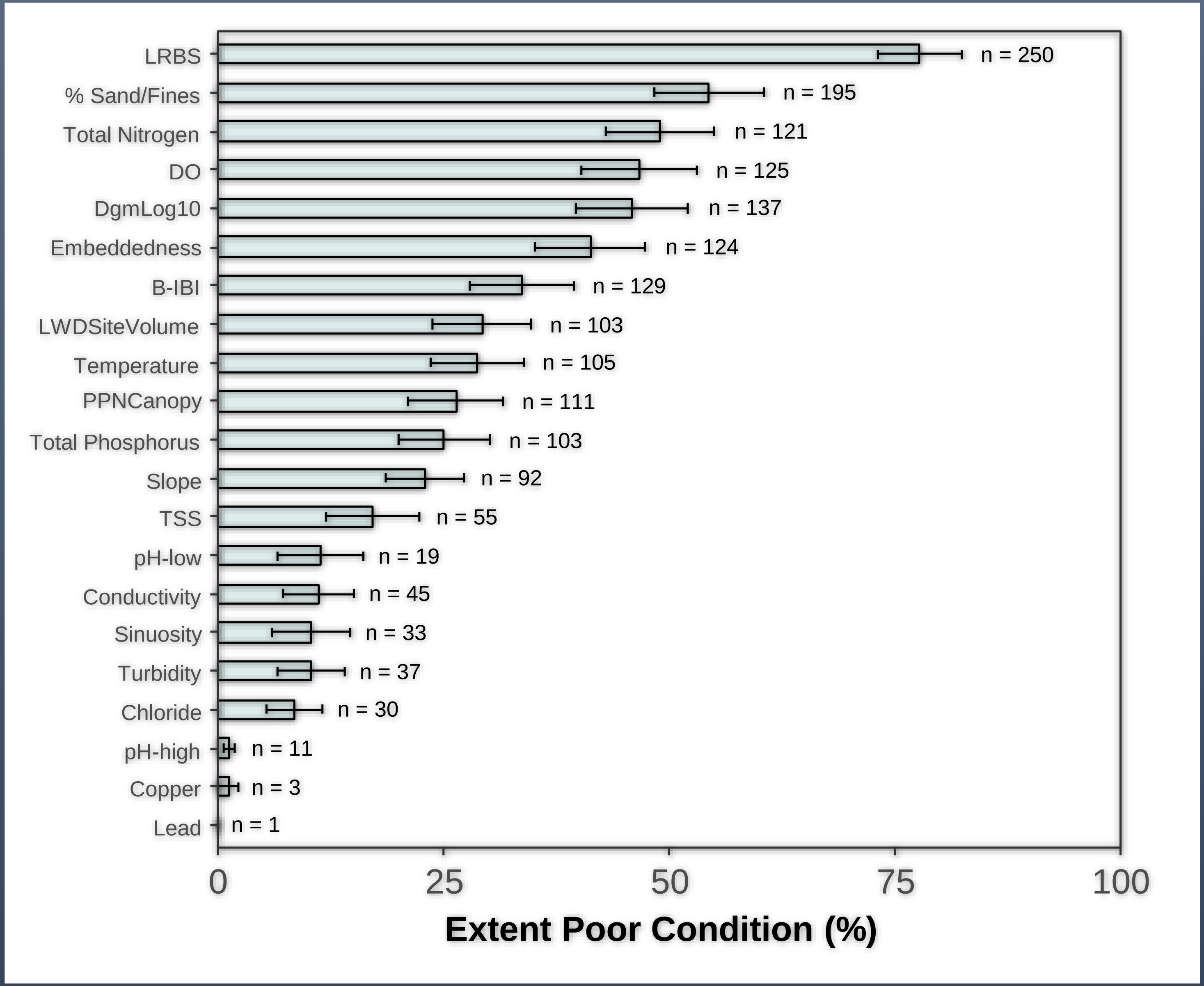
42%
26.3%
31.7%
Western
49.3%
16.5%
34.2%
Eastern
37.8%
16.7%
45.6%
Columbia Plateau
Good
Fair
Poor
0
3000
6000
9000
12000
Stream length assessed (km)

Status

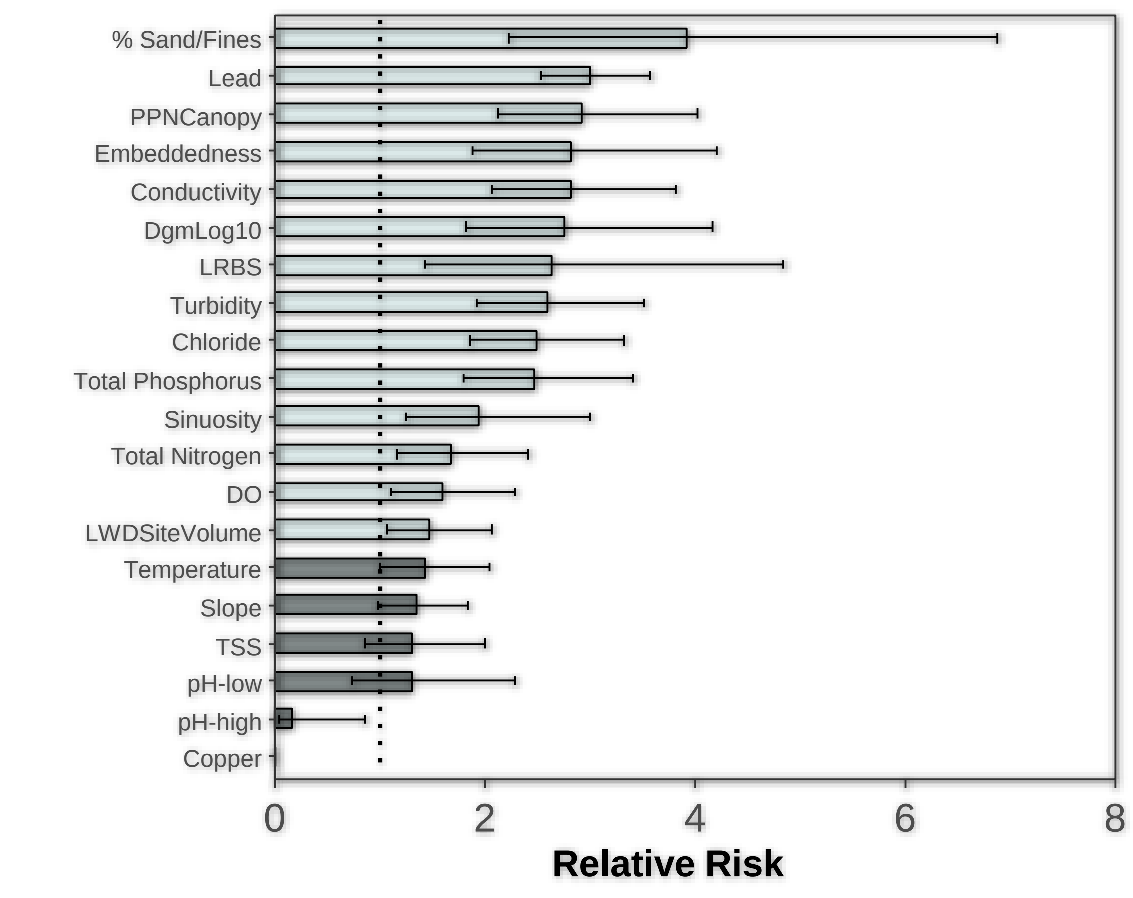


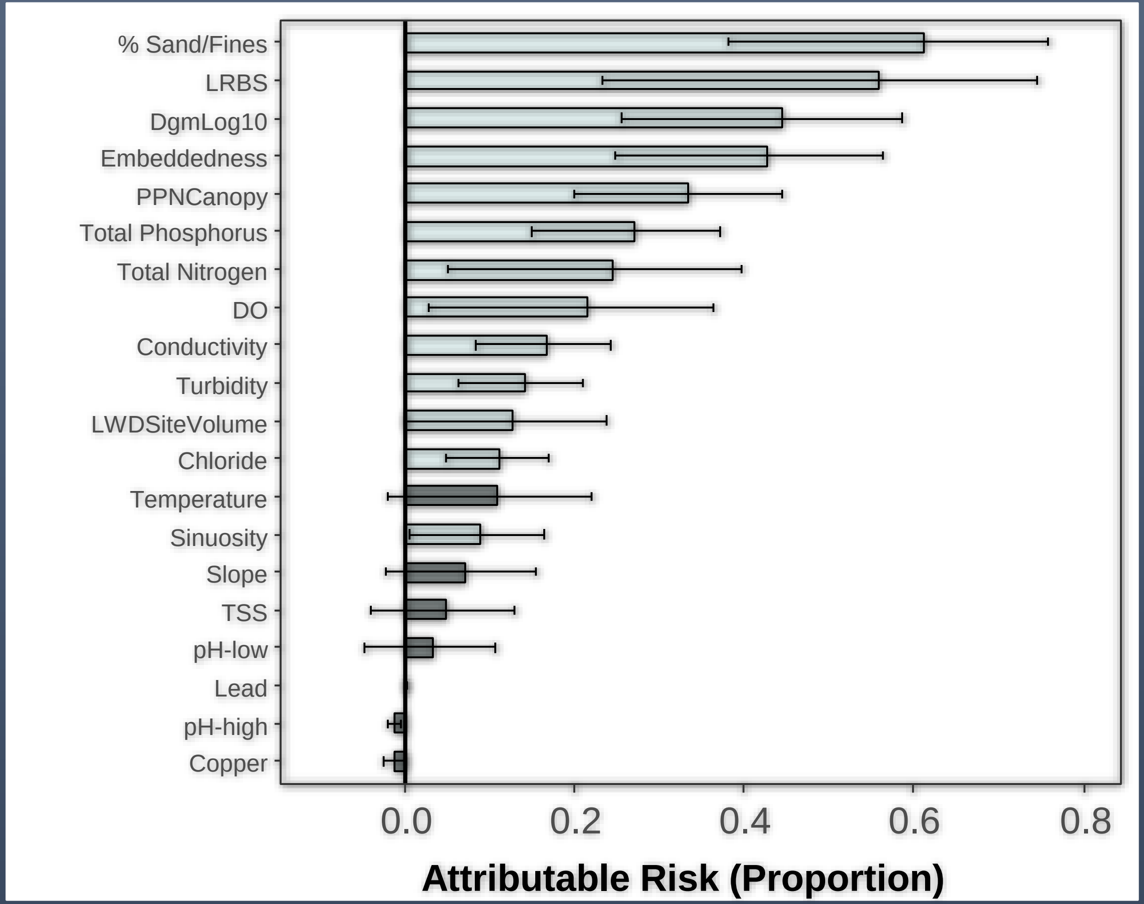
Coastal
Puget Sound
Lower Columbia
Upper Columbia
Mid Columbia
Northeast Washington
Snake River
Unlisted Washington
38.1%
29.6%
32.4%
34.2%
20.9%
44.9%
54%
29.5%
16.5%
64.7%
14.3%
21%
70.4%
8.1%
21.5%
35.2%
15.5%
49.3%
43.3%
10.7%
46%
25.1%
25.5%
49.5%
Good
Fair
Poor
0
1000
2000
3000
4000
5000
6000
Stream length assessed (km)

Extent

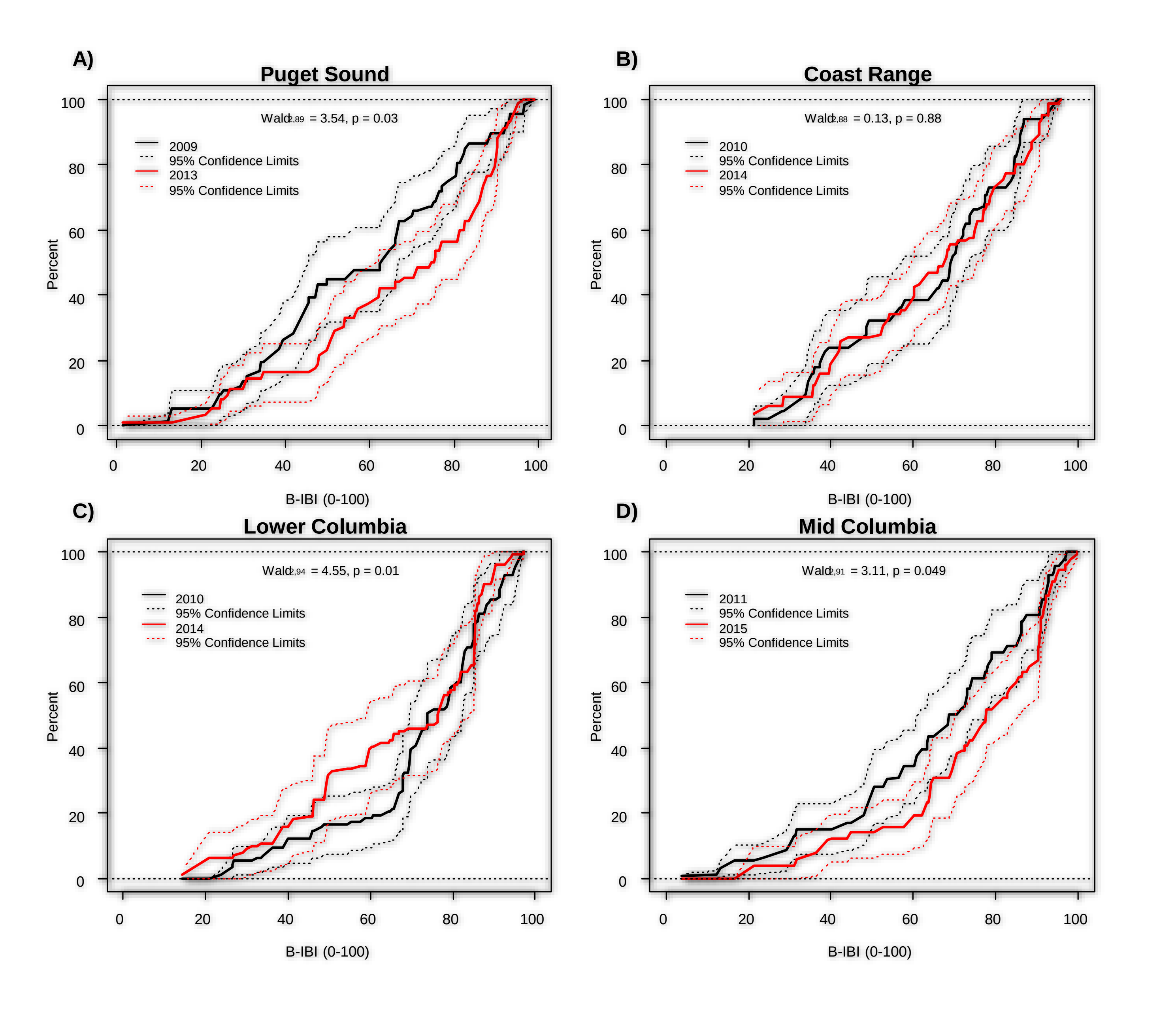

LRBS
% Sand/Fines
Total Nitrogen
DO
DgmLog10
Embeddedness
B-IBI
LWDSiteVolume
Temperature
PPNCanopy
Total Phosphorus
Slope
TSS
pH-low
Conductivity
Sinuosity
Turbidity
Chloride
pH-high
Copper
Lead
n = 250
n = 195
n = 121
n = 125
n = 137
n = 124
n = 129
n = 103
n = 105
n = 111
n = 103
n = 92
n = 55
n = 19
n = 45
n = 33
n = 37
n = 30
n = 11
n = 3
n = 1
0
25
50
75
100
Extent Poor Condition (%)

Stressor Identification





Trends

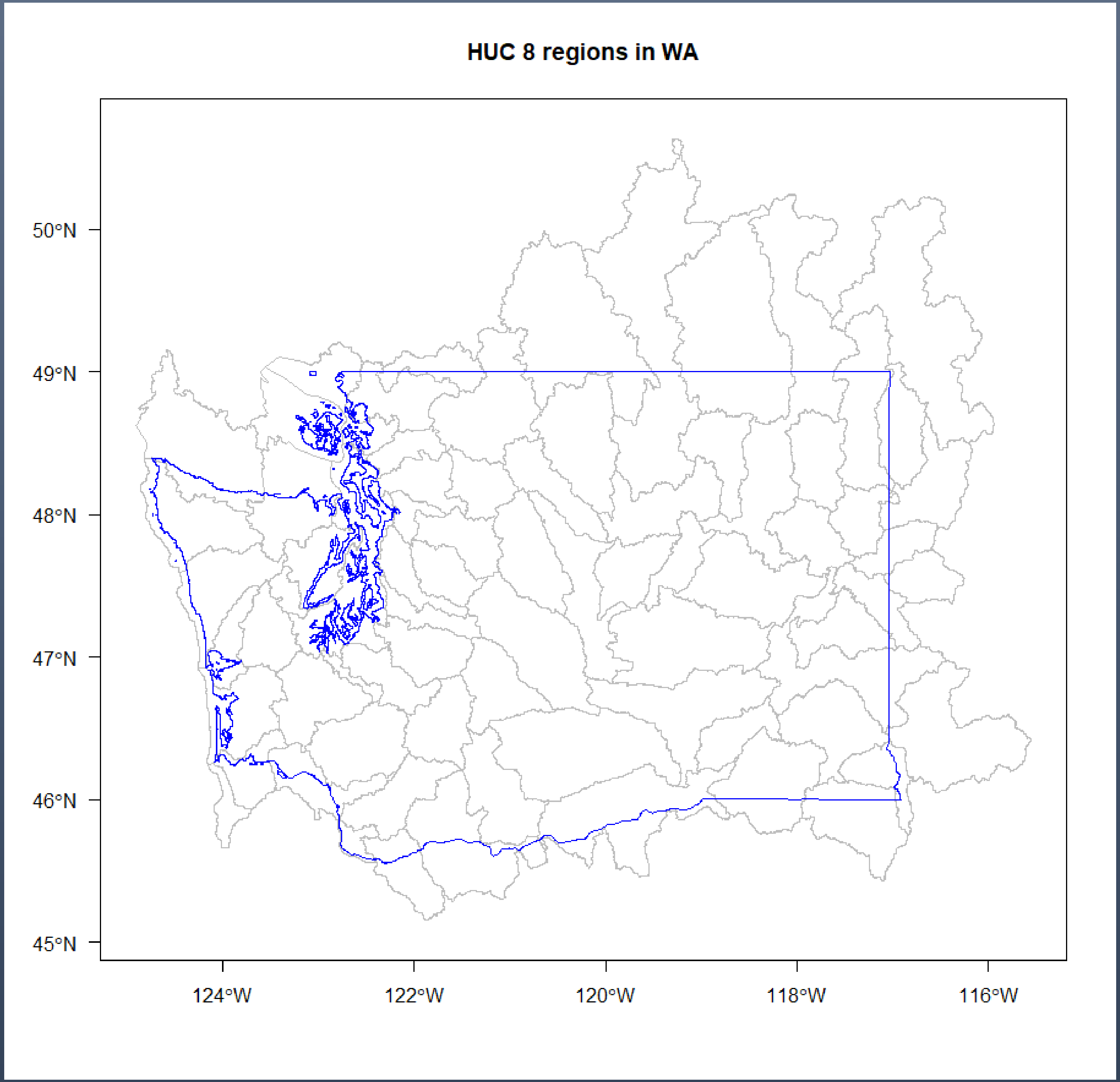


A)
Puget Sound
Wald$_{2,89}$ = 3.54, p = 0.03
2009
95% Confidence Limits
2013
95% Confidence Limits
Percent
B-IBI (0-100)
B)
Coast Range
Wald$_{2,88}$ = 0.13, p = 0.88
2010
95% Confidence Limits
2014
95% Confidence Limits
Percent
B-IBI (0-100)
C)
Lower Columbia
Wald$_{2,94}$ = 4.55, p = 0.01
2010
95% Confidence Limits
2014
95% Confidence Limits
Percent
B-IBI (0-100)
D)
Mid Columbia
Wald$_{2,91}$ = 3.11, p = 0.049
2011
95% Confidence Limits
2015
95% Confidence Limits
Percent
B-IBI (0-100)

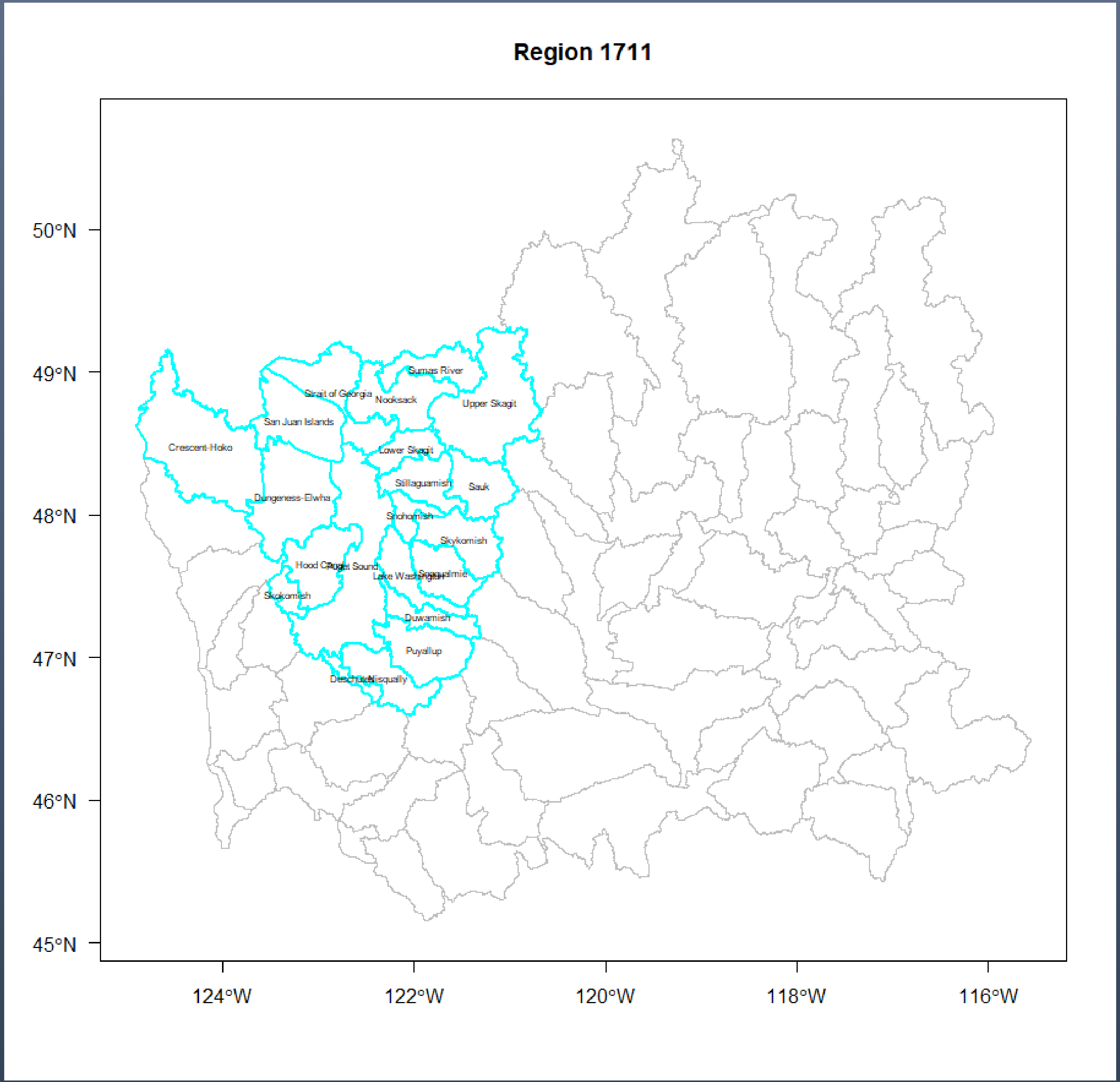
The New Master Sample

Rebuilding from the stream up

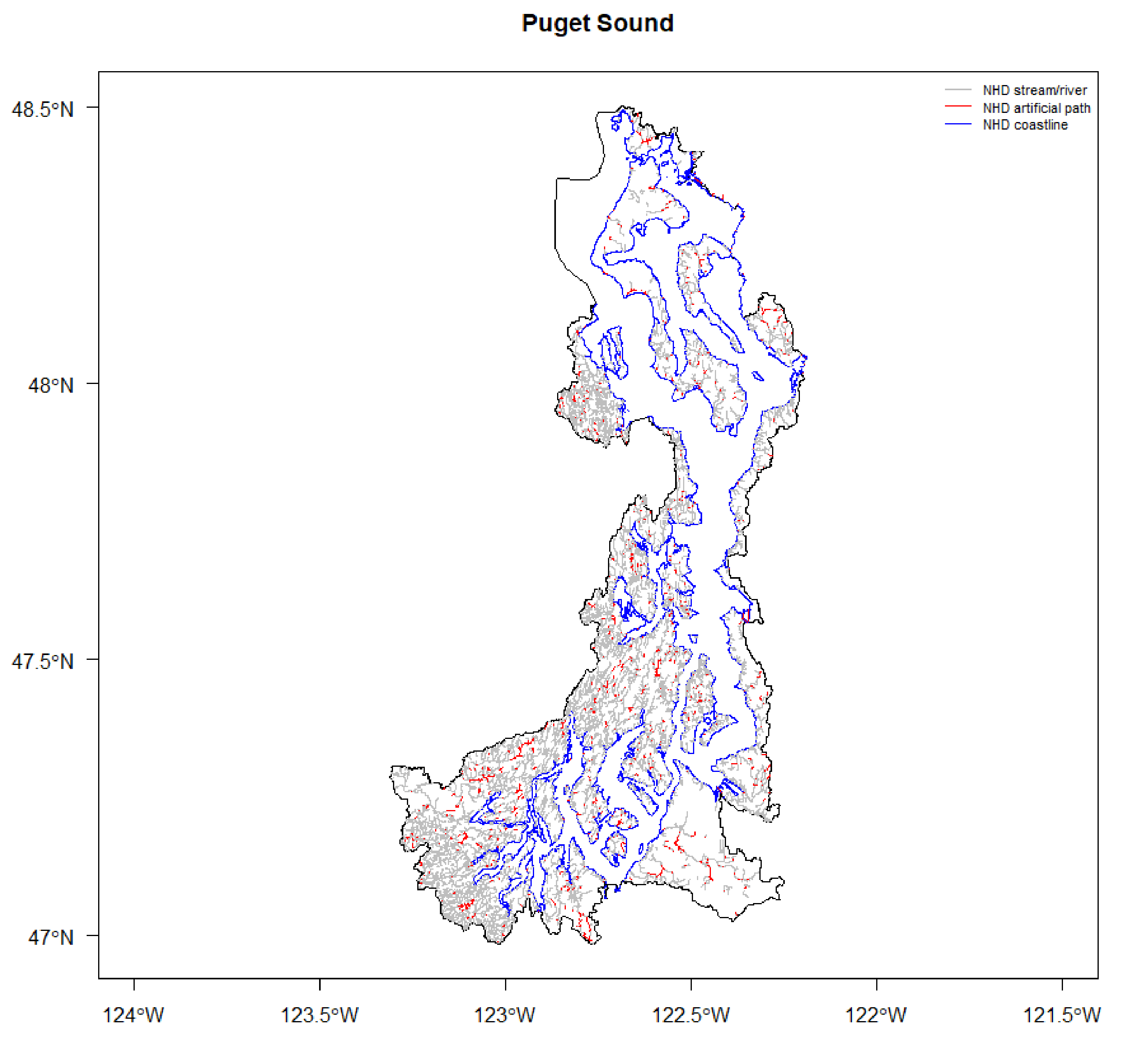
- NHD 1:24000
- Stream/River & Artificial Path
- Points directly on the NHD flowline, so NHD attributes available



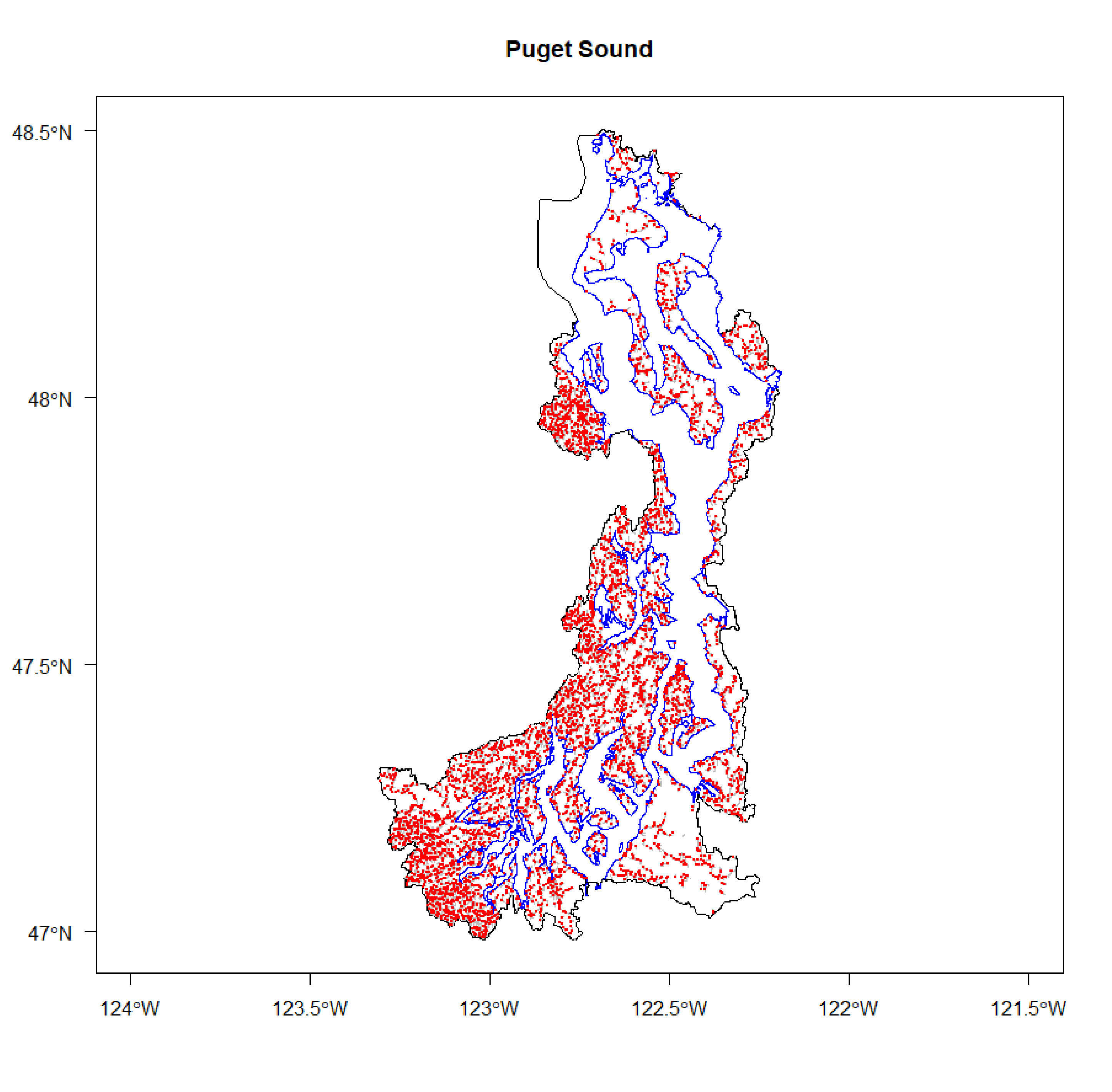
73 HUC 8 regions



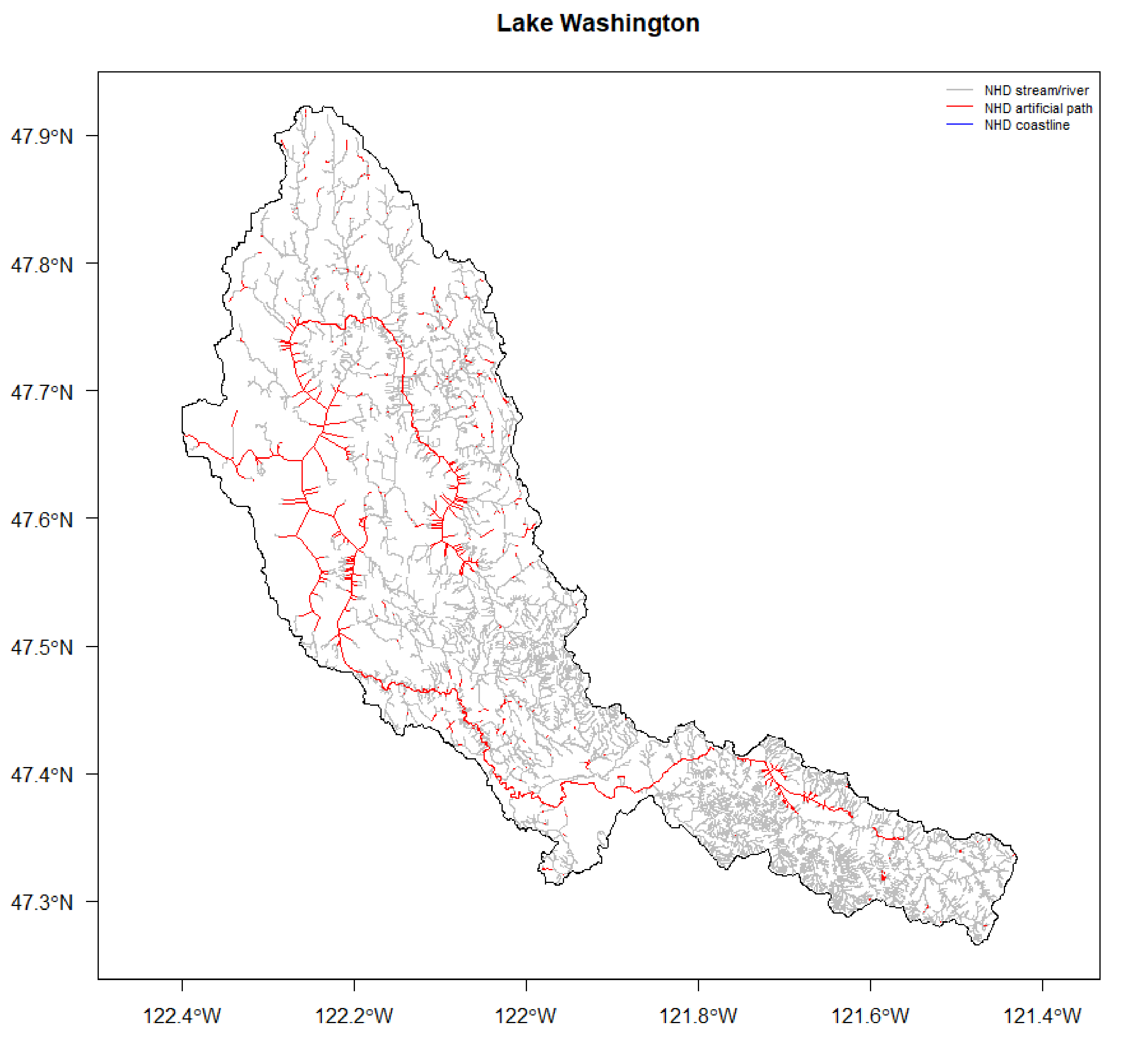
21 HUC 8 regions



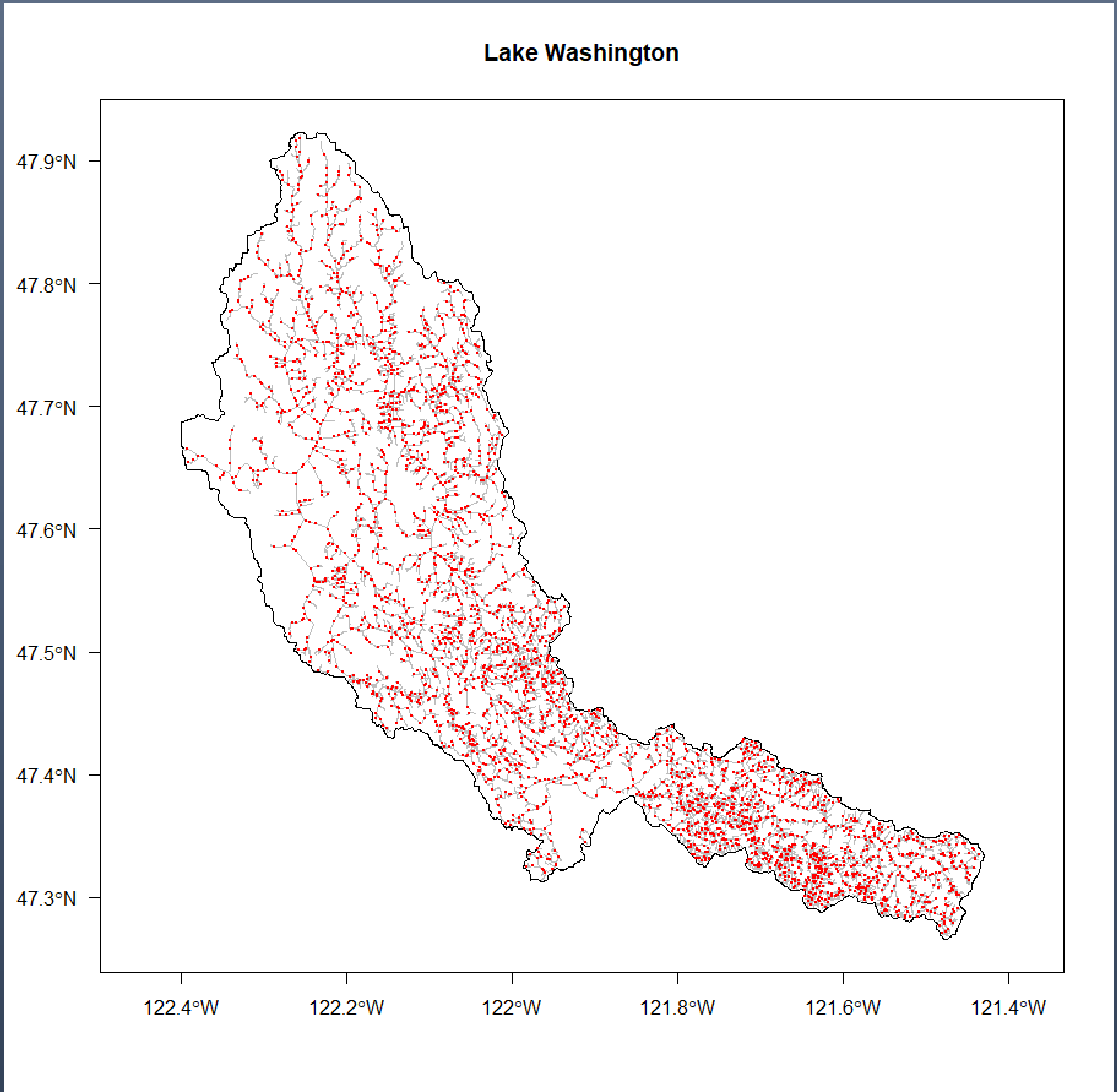
	FCODE	Feature Type
STREAM/RIVER	46000	No Attributes
STREAM/RIVER	46003	Intermittent
STREAM/RIVER	46006	Perennial
STREAM/RIVER	46007	Ephemeral
ARTIFICIAL PATH	55800	No Attributes



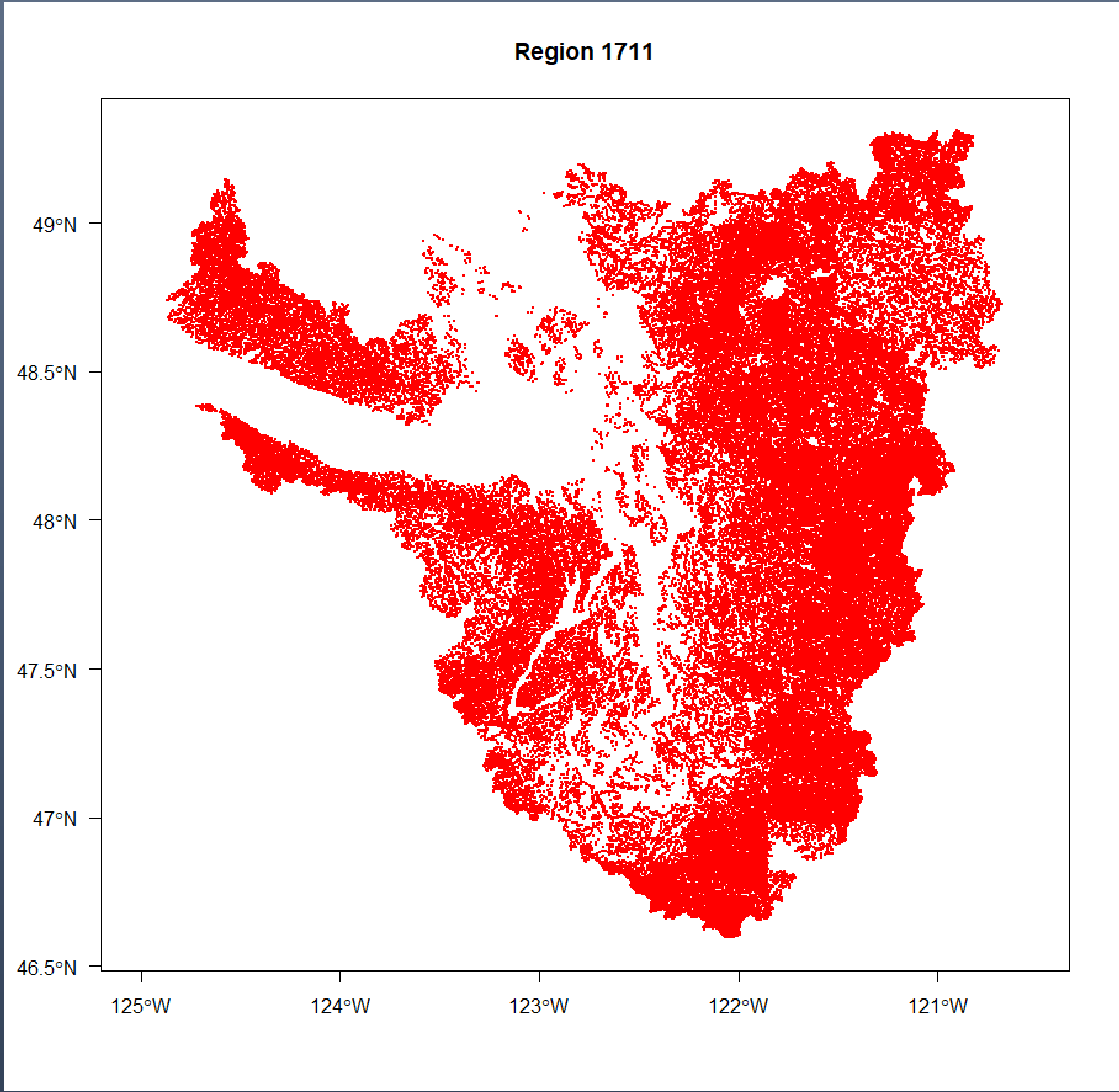
4,808 stream kilometers = 4,808 points



Lake Washington
NHD stream/river
NHD artificial path
NHD coastline
47.9°N
47.8°N
47.7°N
47.6°N
47.5°N
47.4°N
47.3°N
122.4°W
122.2°W
122°W
121.8°W
121.6°W
121.4°W



3,096 stream kilometers = 3,096 points



21 HUC 8 regions

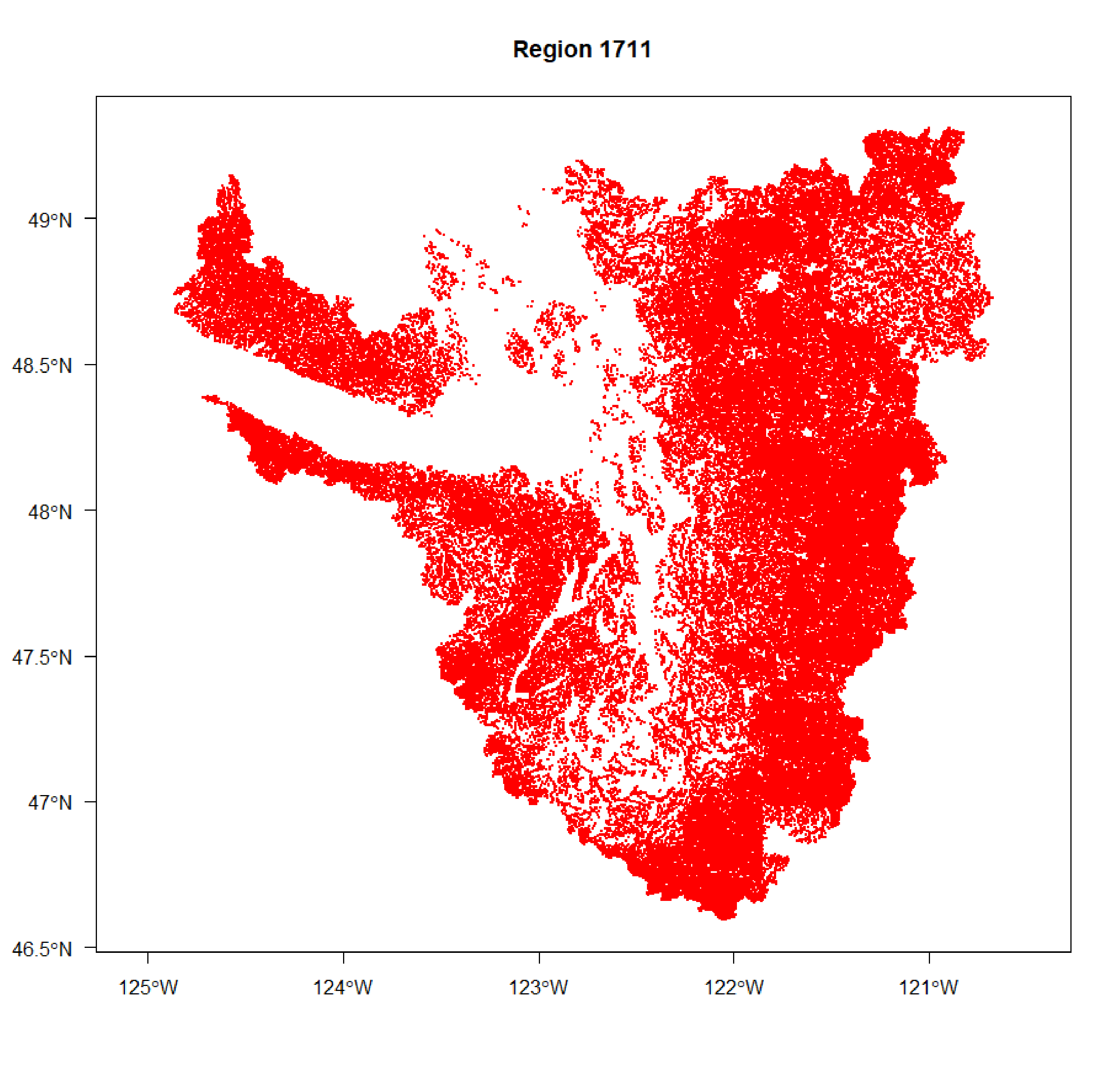
114,482 points

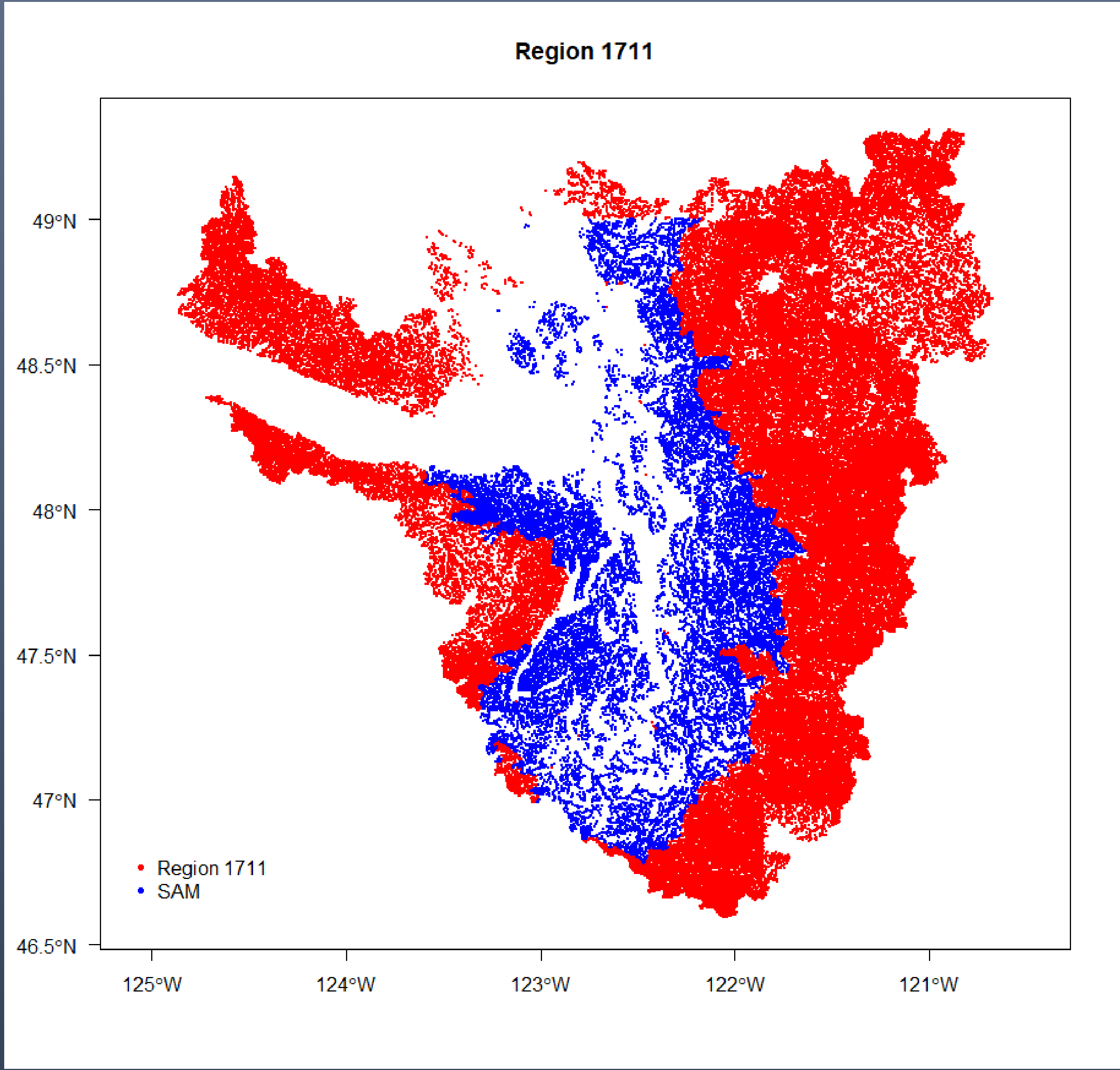
	Canada	**WA**
No Attributes	15,132	132
Intermittent	0	57,481
Perennial	9	35,768
Ephemeral	0	1
Artificial Path	952	5007
Total	**16,093**	**98,389**

The New Master Sample

Points joined with additional information so as to be able to select/subset as needed:

- NHDplus information
- Ecoregions
- County
- HUC02-HUC12
- Stream order
- Urban Growth Boundaries
- StreamCat (ICI & IWI)
- Etc.


Region 1711
49°N
48.5°N
48°N
47.5°N
47°N
46.5°N
125°W
124°W
123°W
122°W
121°W



Other Monitoring groups using:

- Storm Water Action Monitoring (SAM)
- City of Bothell, WA
- We anticipate others will also be interested

The New Master Sample

Benefits

- Less time with desktop site verification
- More efficient calculation of adjusted spatial weights
- Easier to explain
- More recent framework

Challenges/questions

- May sometimes be challenging to compare old *vs* new points
- Frame attributes not intuitively named (e.g. "Artificial path")

Final thoughts

- Collaboration across borders? Just add HUCs as needed.

- WA Master Sample can contribute to CWA accounting
  1. A State 305(b) report to objectively describe status and trends of state waters, and
  2. The EPA's Report to Congress about national waters

- WA Master Sample contributes to ESA accounting
  1. The Governor's State-of-the-Salmon Report, to describe status and trends of salmon/steelhead and bull trout limiting factors.
  2. Hopefully to NOAA's Report to Congress about results from PCSRF (ESA accounting).

- Site-specific trends information reduced

    1. New master sample means sites from original surveys won’t be re-sampled

    2. New study design means replacement rate will be lower than 50%

Glenn Merritt and Chad Larson

Washington State Department of Ecology
Environmental Assessment Program

tinyurl.com/WHMHomePage

LONG TERM TREND MONITORING OF NATIVE SALMONIDS USING SNORKELING – NORTH FORK BOISE RIVER

John Cassinelli
Regional Fish Biologist
Idaho Department of Fish and Game

WHY DO WE SNORKEL?

WHY DO WE SNORKEL?

Electrofishing

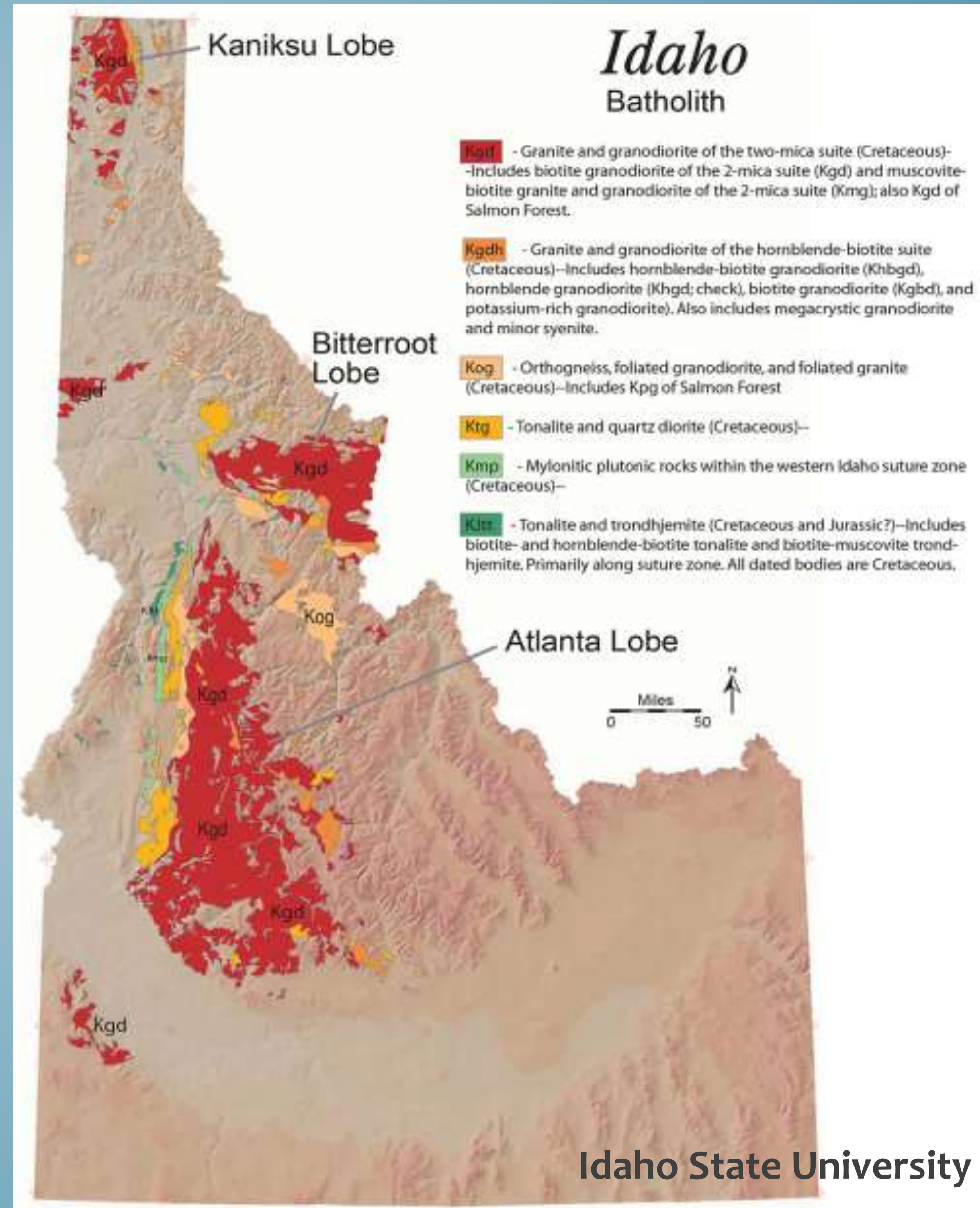
- Hands on
- More efficient for higher densities
- More labor intensive in larger rivers
- Requires a lot of gear
- Need conductive water

Snorkeling

- Observational only
- More efficient for lower densities
- Less labor/gear intensive in larger rivers
- Need good visibility
- Requires more training

WHY DO WE SNORKEL?

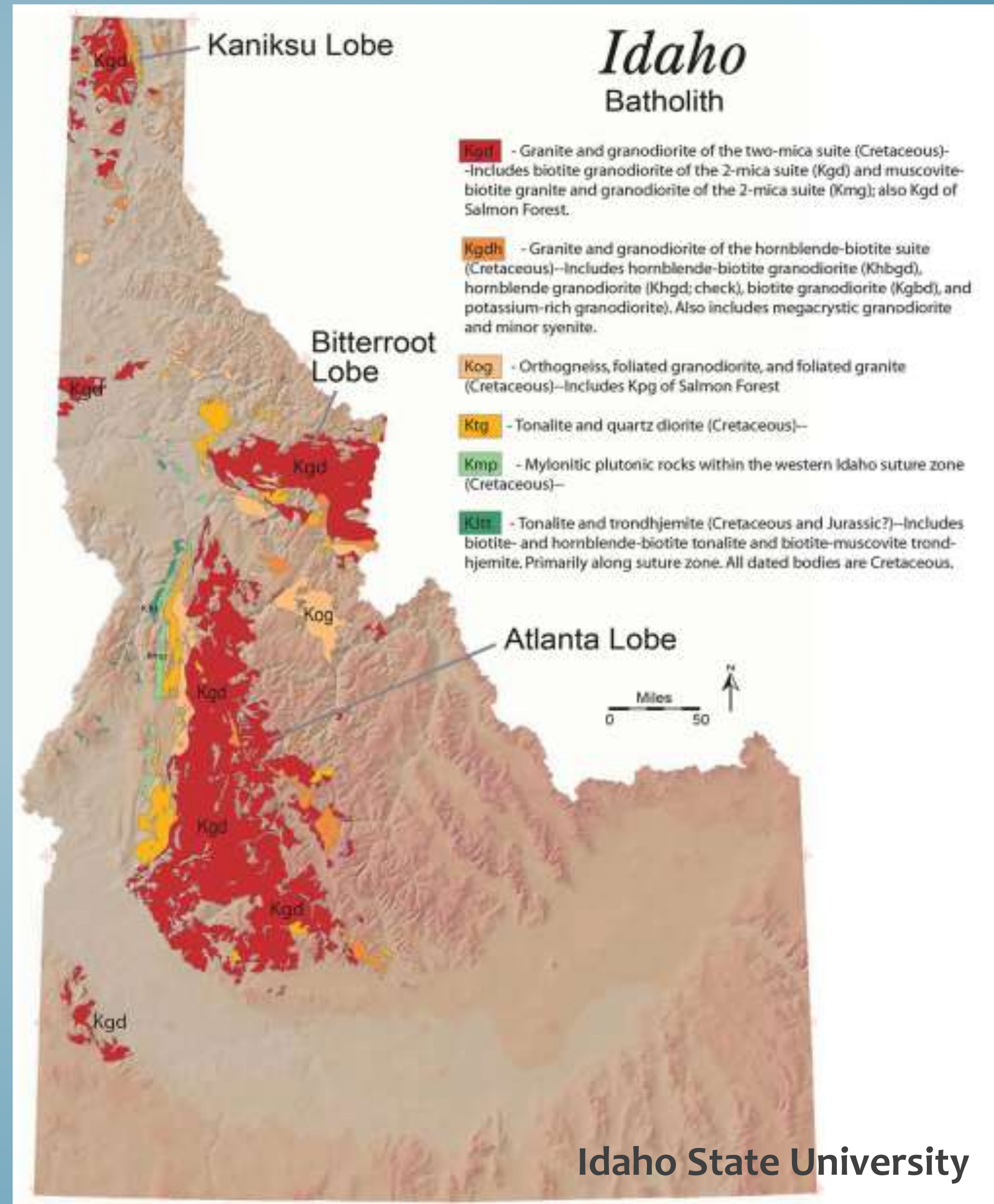
- Granitic soils of Idaho Batholith result in low nutrients
  - Anadromous life history



Idaho State University

WHY DO WE SNORKEL?

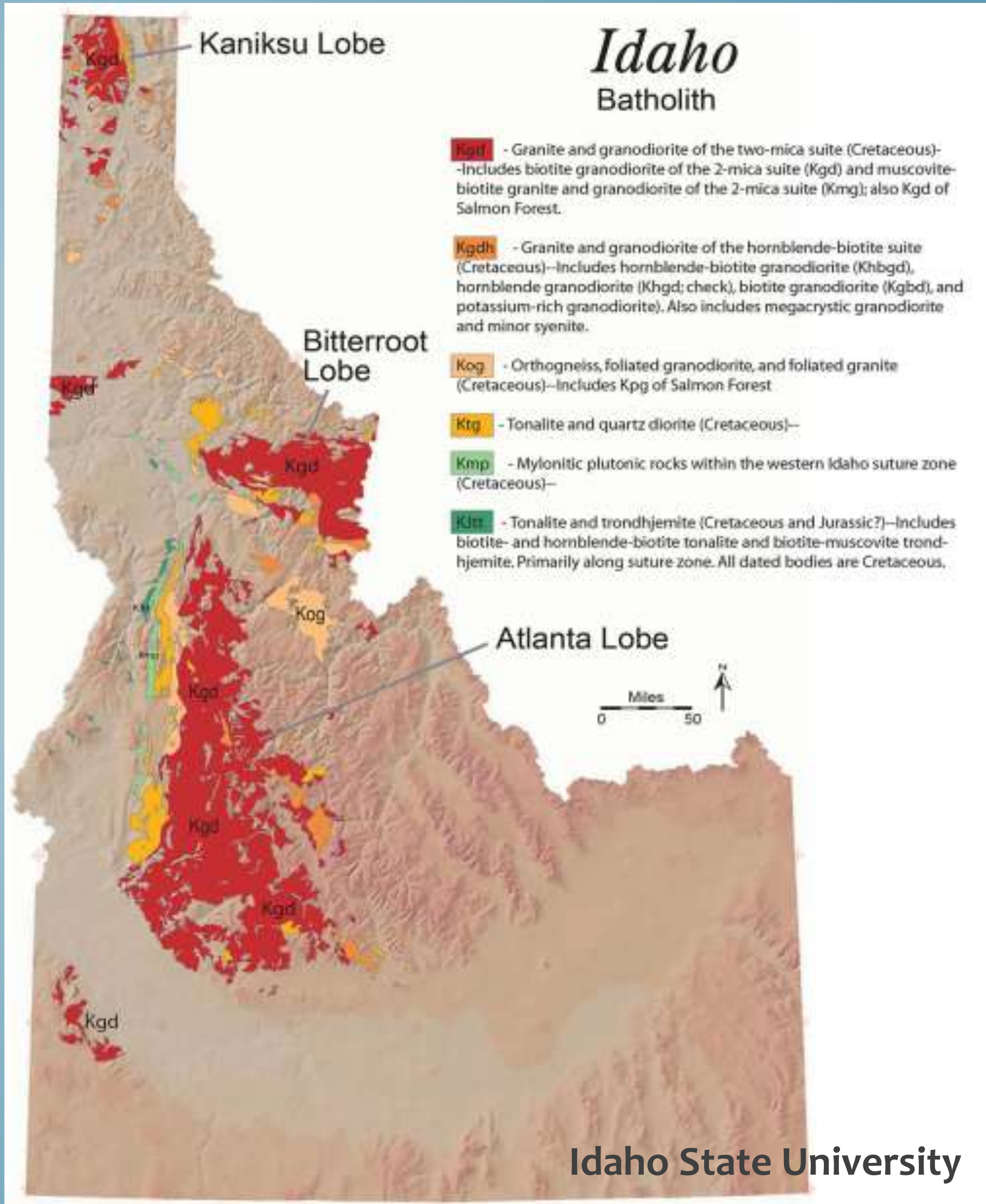
- Granitic soils of Idaho Batholith result in low nutrients
  - Anadromous life history
- Undammed rivers in the Batholith have
  - very low conductivity
  - High visibility
  - Low fish densities



Idaho State University

WHY DO WE SNORKEL?

- Granitic soils of Idaho Batholith result in low nutrients
  - Anadromous life history
- Undammed rivers in the Batholith have
  - very low conductivity
  - High visibility
  - Low fish densities
- Regional waters we routinely snorkel include the NF and MF Boise, and SF Payette rivers



NFBR BACKGROUND

- The NFBR originates on west side of Sawtooths and flows SW for 80 km before joining the MFBR

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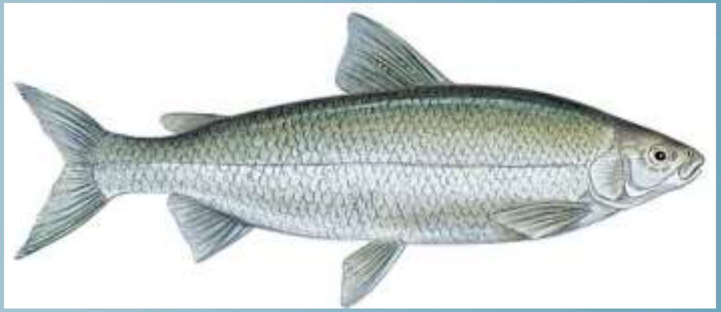
NFBR BACKGROUND

- The NFBR originates on west side of Sawtooths and flows SW for 80 km before joining the MFBR
- The NFBR loses roughly 1,000 m in elevation (about 13 m/km)
- Classic Idaho Batholith River
- Shallow granitic soil susceptible to high rates of erosion, especially following wildfires
  - Rabbit Creek Fire 1994
  - McNutt Fire 2009

NFBR BACKGROUND

- Native gamefish in the NFBR include Redband Trout (RBT), Bull Trout, and Mountain Whitefish



NFBR BACKGROUND

- Native gamefish in the NFBR include Redband Trout (RBT), Bull Trout, and Mountain Whitefish
- RBT are native to all major rivers in SW ID below Shoshone Falls
  - Desert populations petitioned for ESA listing in 1997
  - Rangewide assessment conducted in 2012 (Muhlfeld)
  - Conservation strategy developed in 2016 (for states of CA, ID, MT, NV, OR, and WA)

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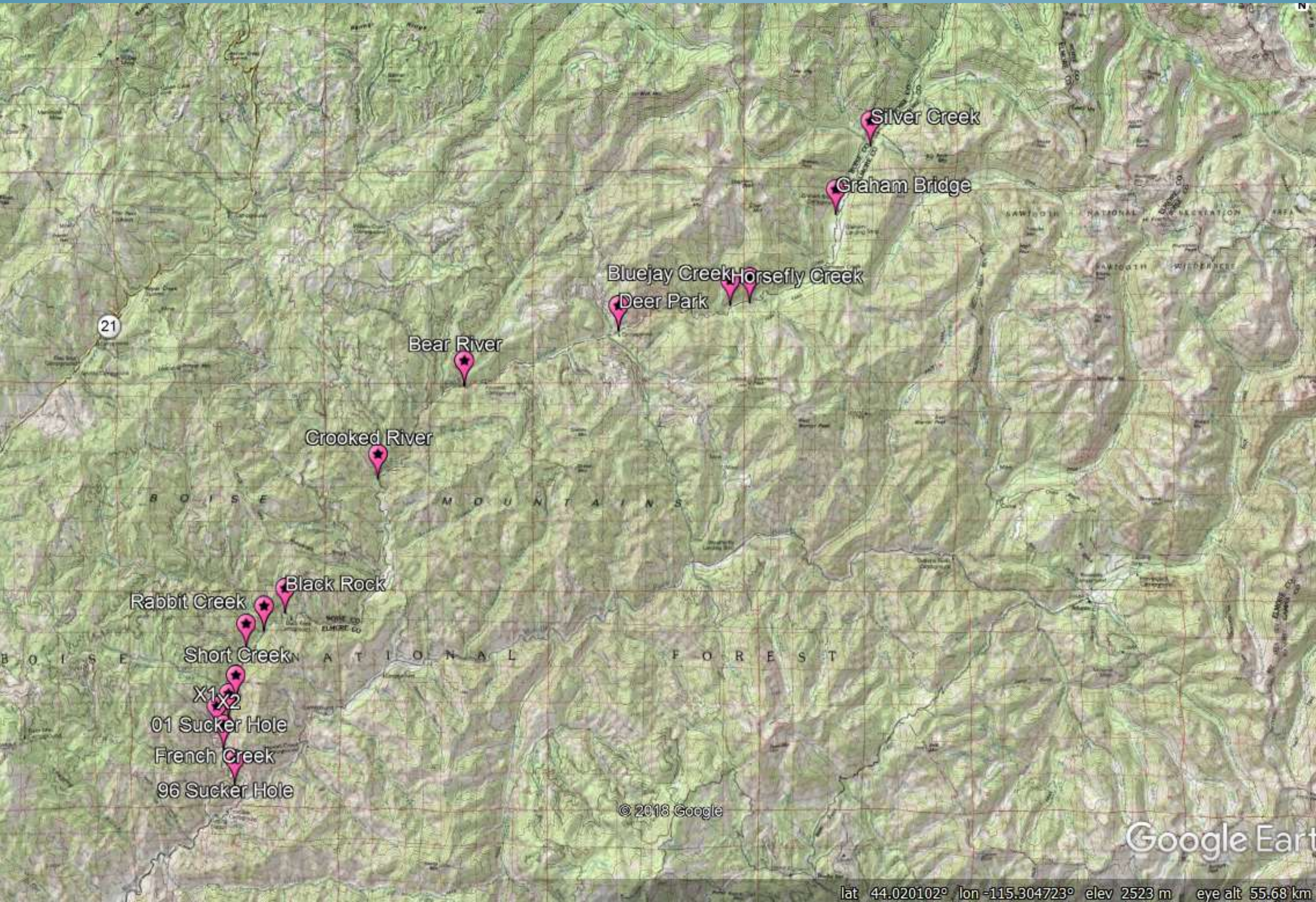
  - Desert populations petitioned for ESA listing in 1997
  - Rangewide assessment conducted in 2012 (Muhlfeld)
  - Conservation strategy developed in 2016 (for states of CA, ID, MT, NV, OR, and WA)
- IDFG continues to monitor population trends within RBT distribution as part of the conservation strategy

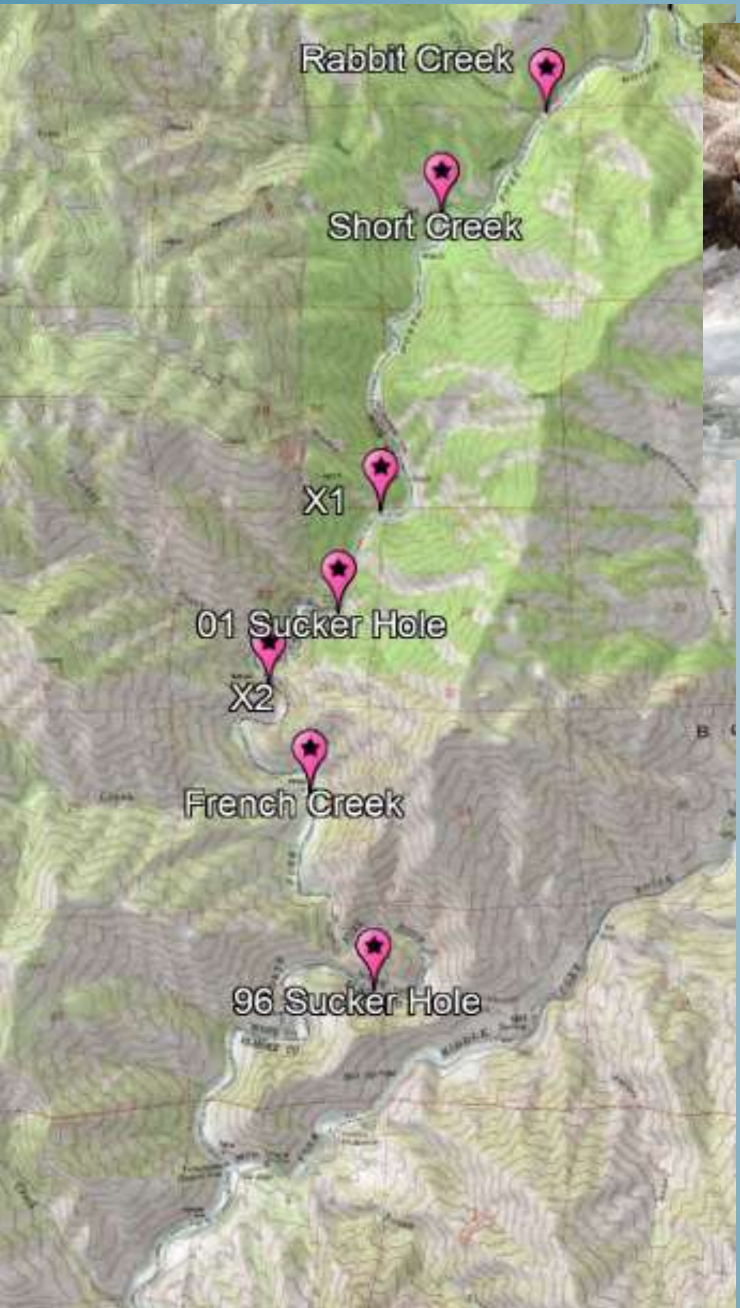
METHODS

- 15 historic trend sites
  - Surveys started in 1980s
- Describe distribution, abundance, and species composition
- Compare current pop trends to historical estimates

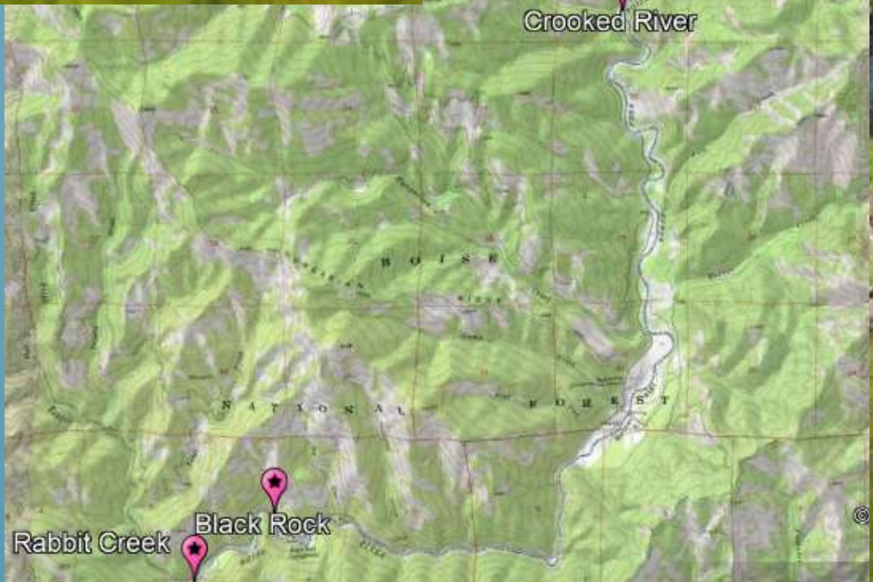
NORTH FORK BOISE RIVER



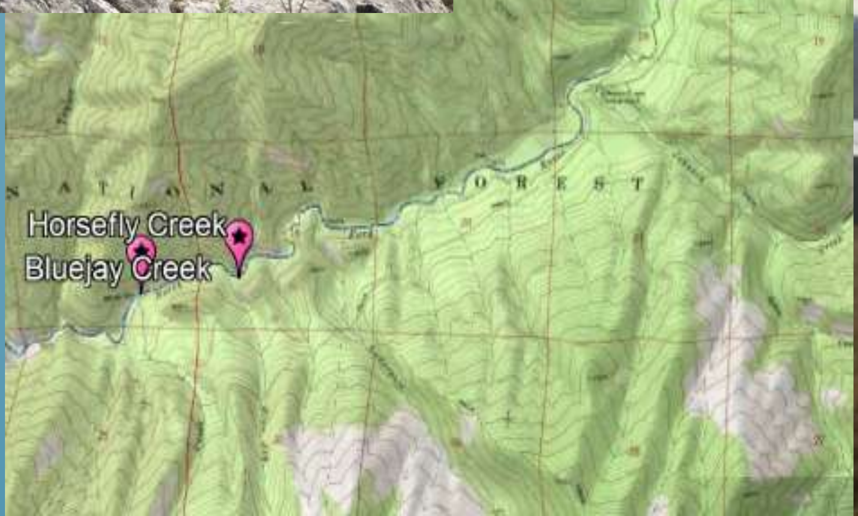
LOWER CANYON SECTION



MIDDLE ROADED SECTION



UPPER SECTION



METHODS

- All sites surveyed in both 2017 and 2018
  - Sites ranged from 30 to 80 meters long

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METHODS

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  - Sites ranged from 30 to 80 meters long
- Three trained snorkelers working upriver
  - Some sights were deep pools that were snorkeled downriver
- Recorded species and size (nearest inch) of all observed fish
- Lengths and widths of each site measured

NORTH FORK BOISE RIVER

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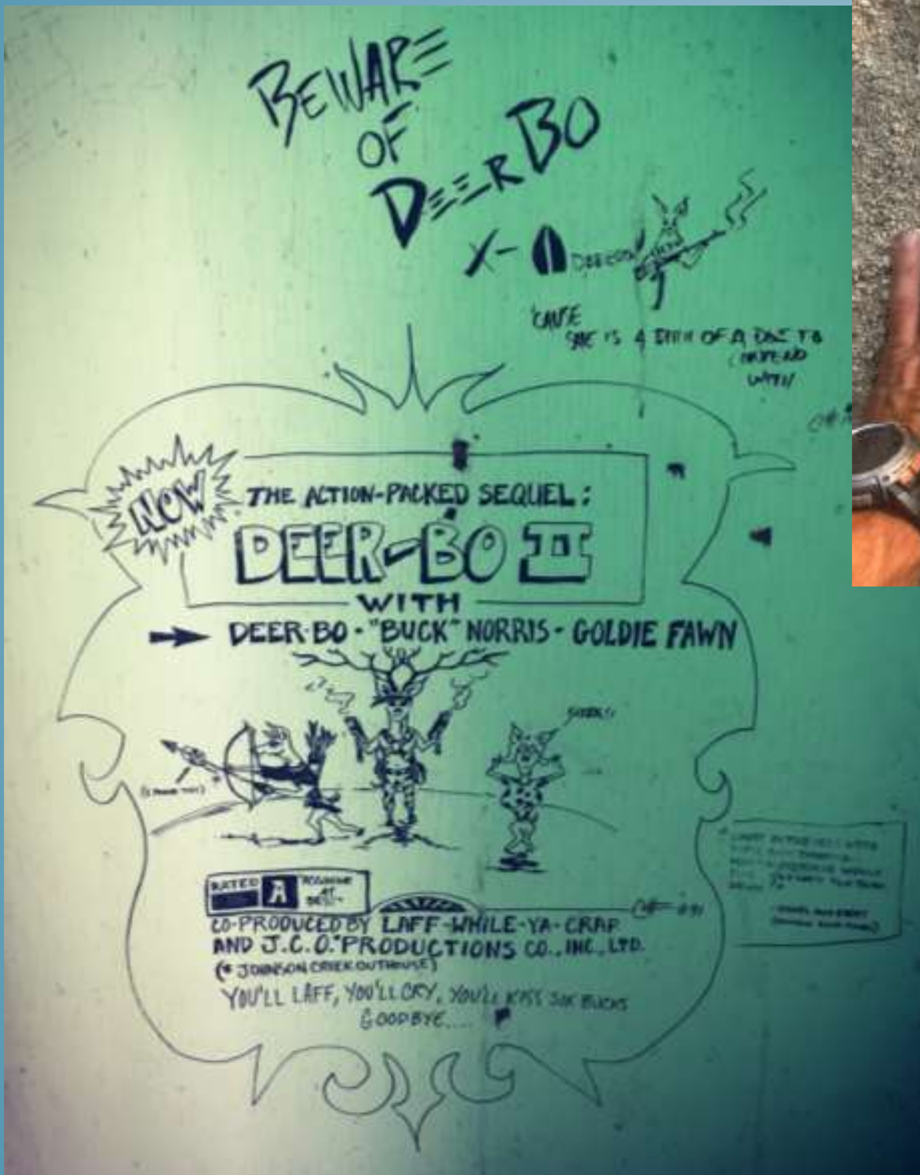
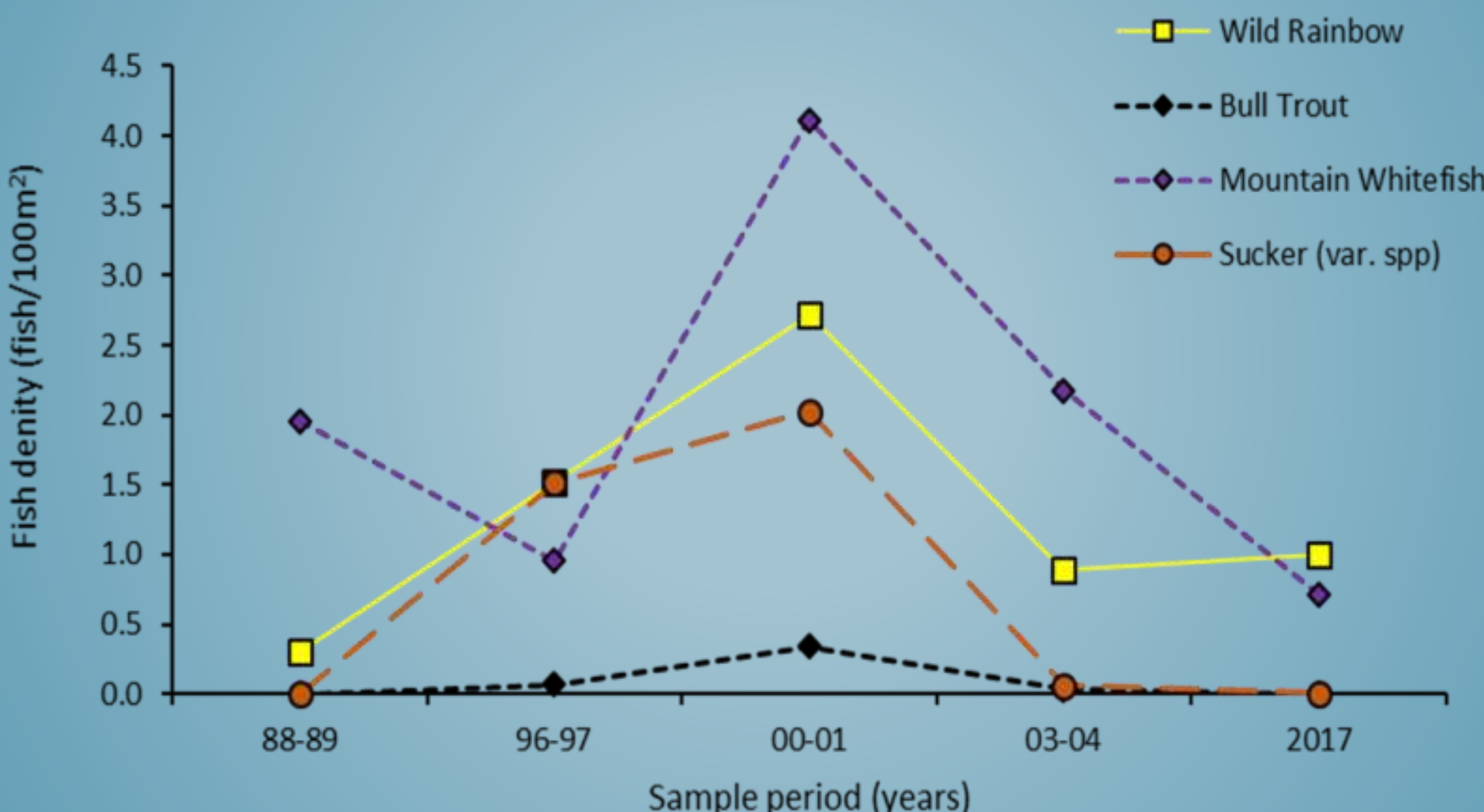
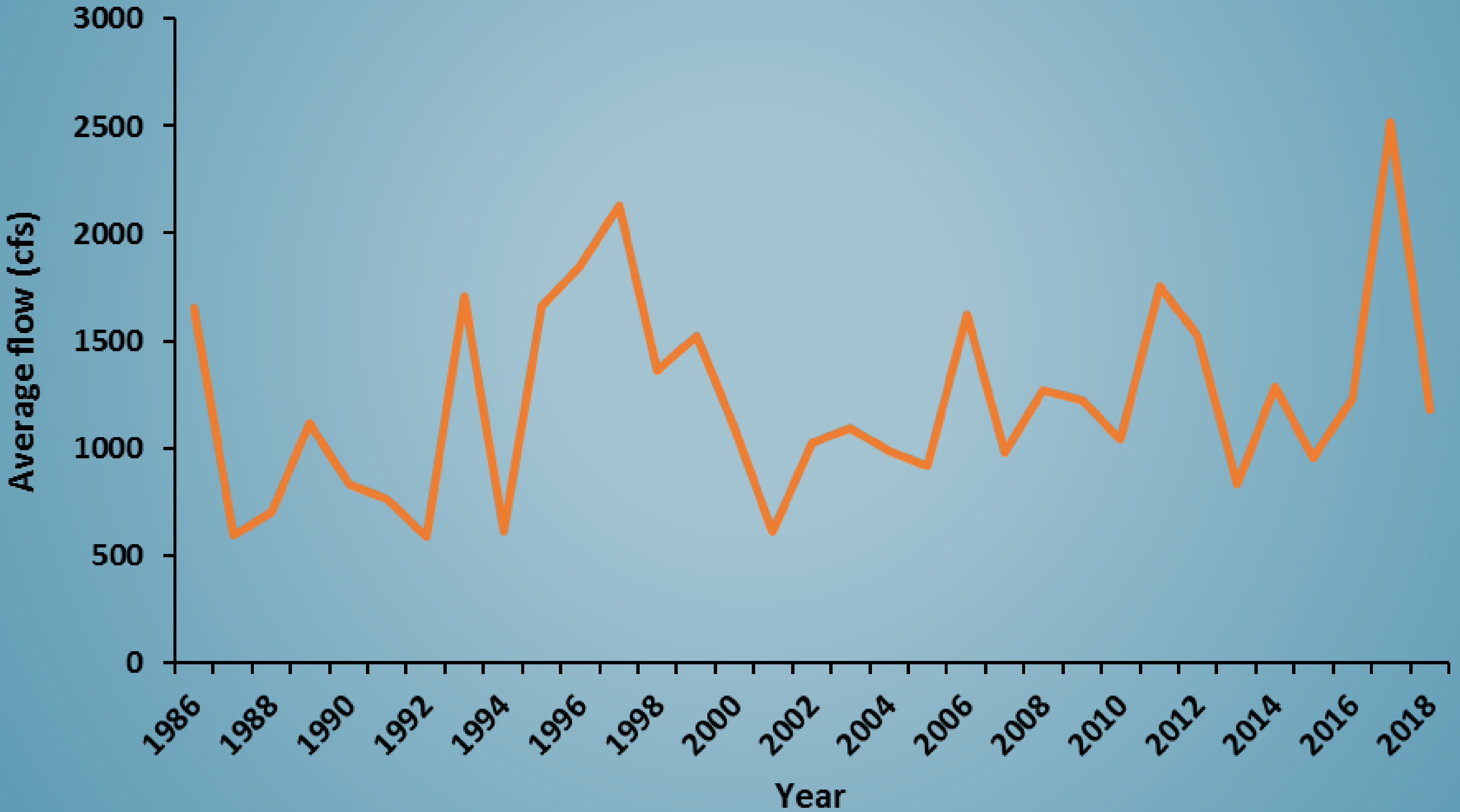


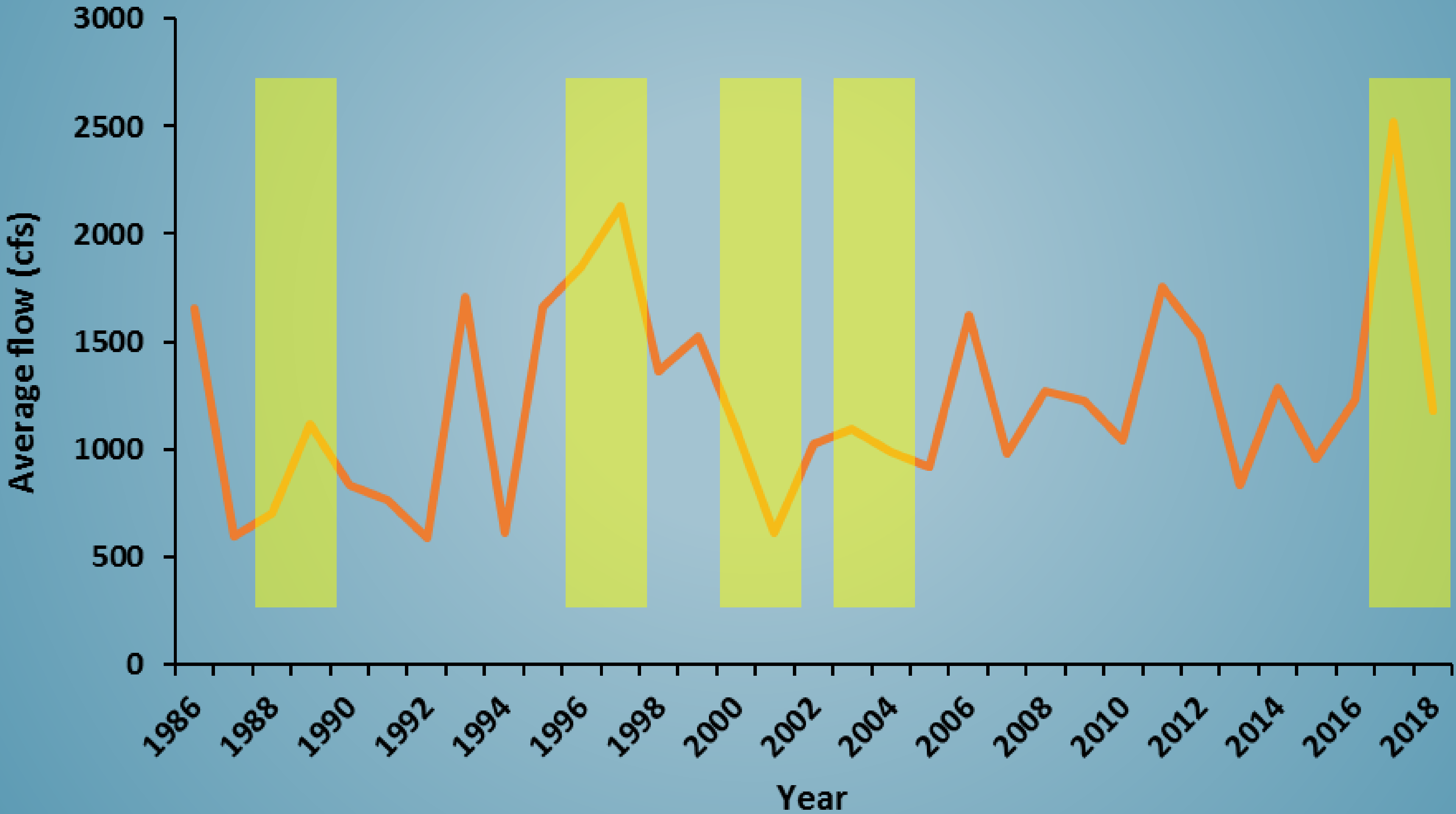
RESULTS - 2017



RESULTS - 2017



RESULTS - 2017



RESULTS - 2017

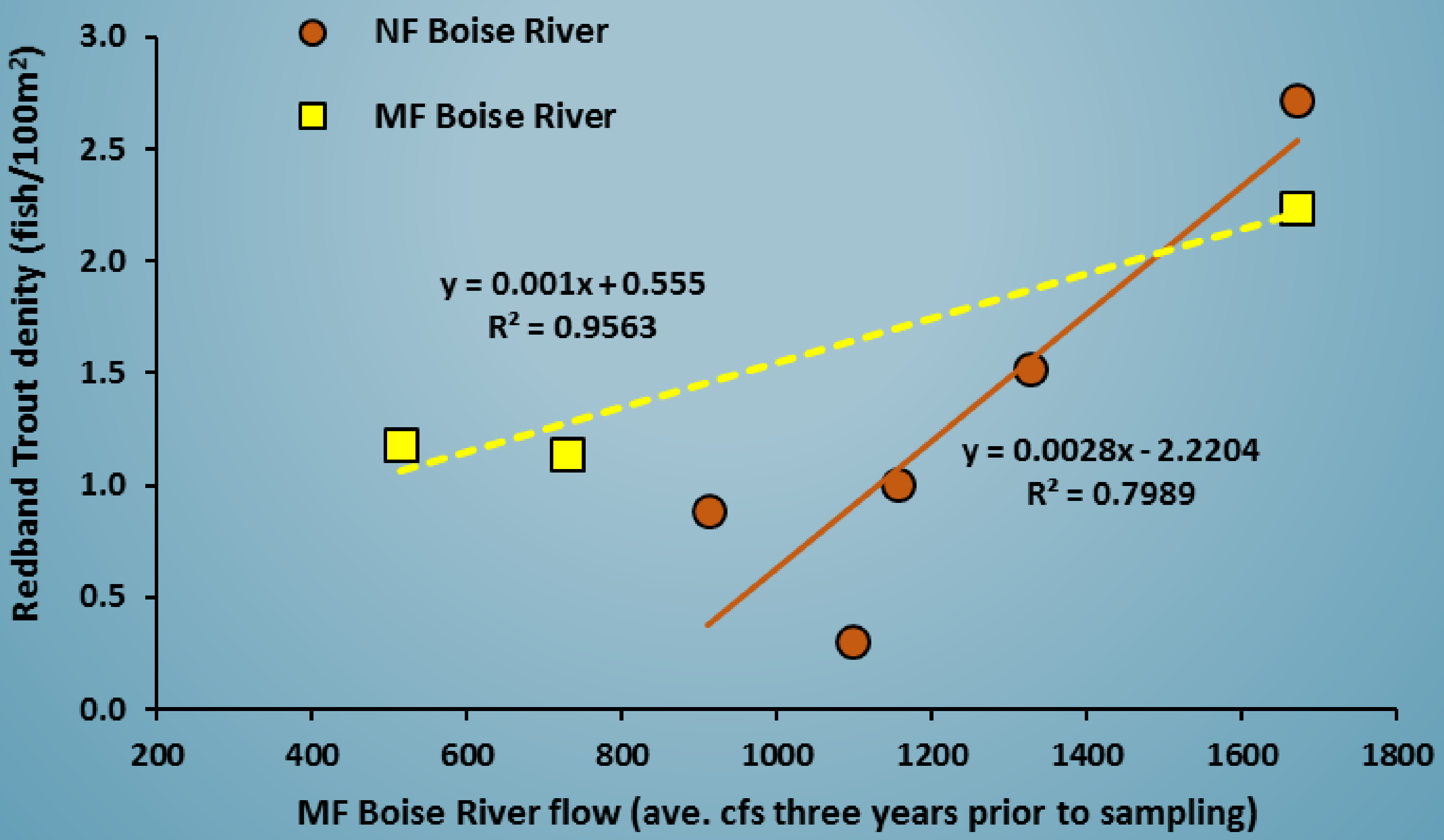
Copeland and Meyer (2011)

Stream flow 3 & 4 years previous to sampling most important bioclimatic condition influencing Brook and Bull Trout densities in Idaho rivers

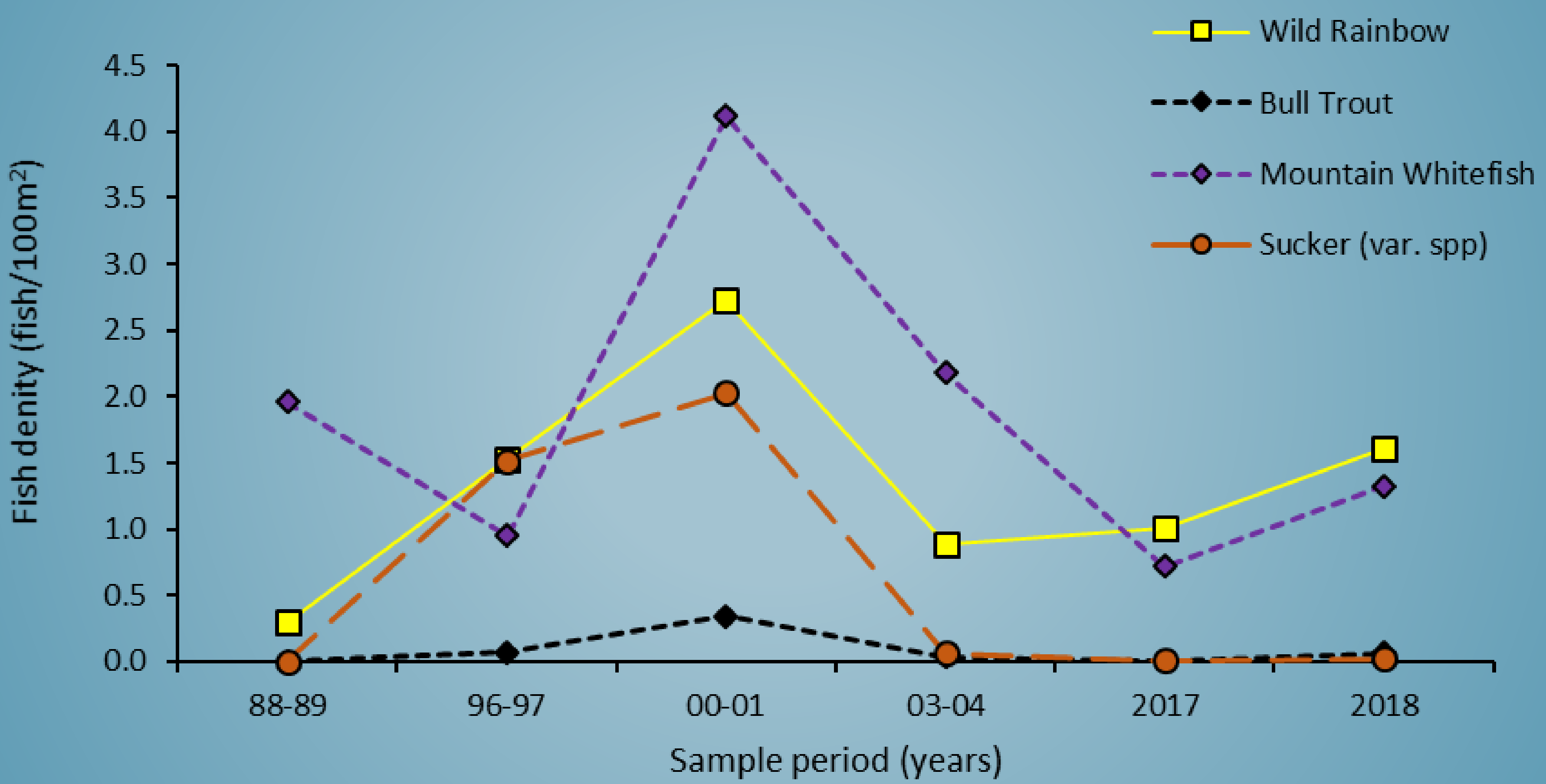
RESULTS - 2017

Fish densities fluctuate with river flow

Redband density ↑ with 3 years of higher flow and ↓ with 3 years of lower flow



RESULTS - 2018



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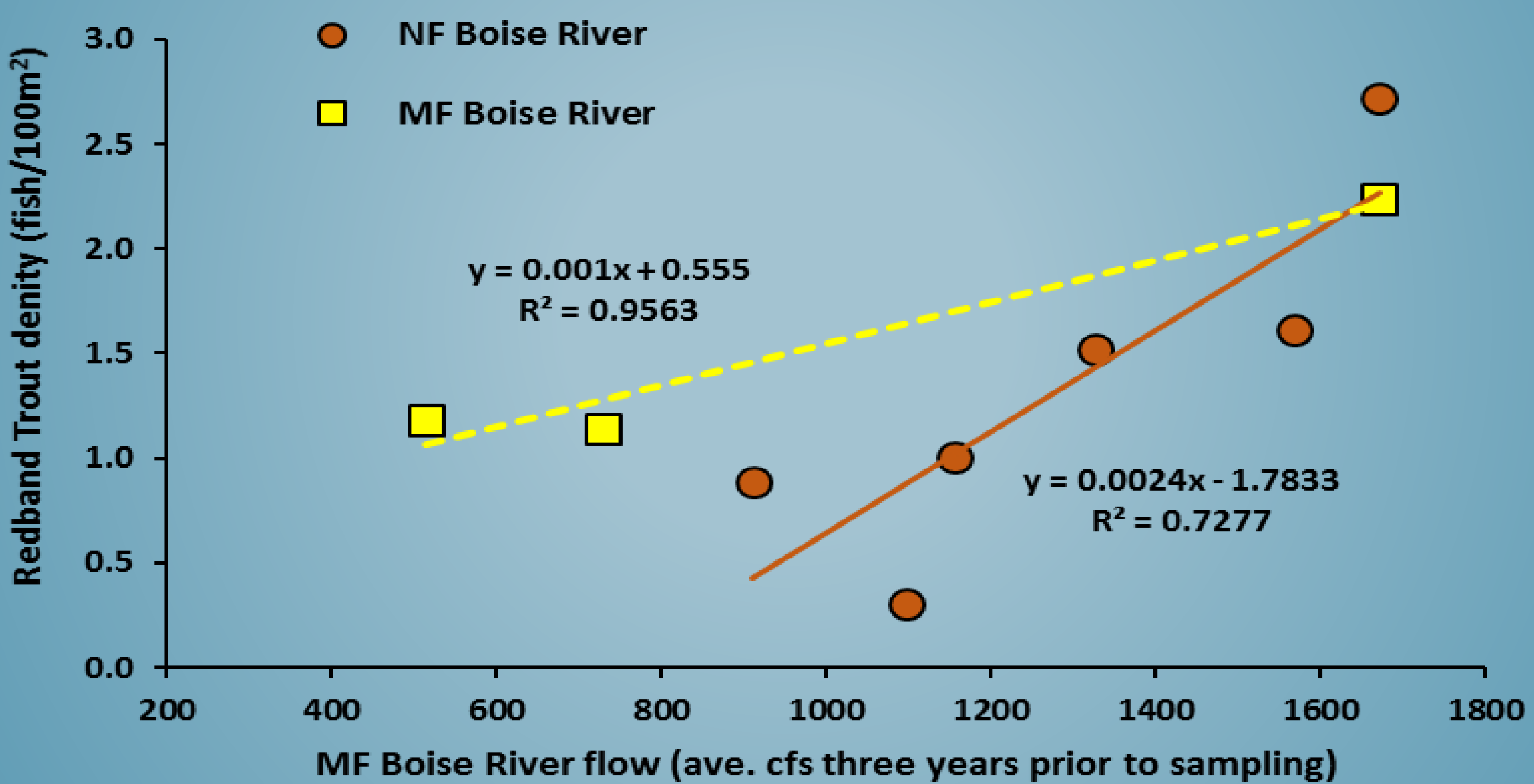

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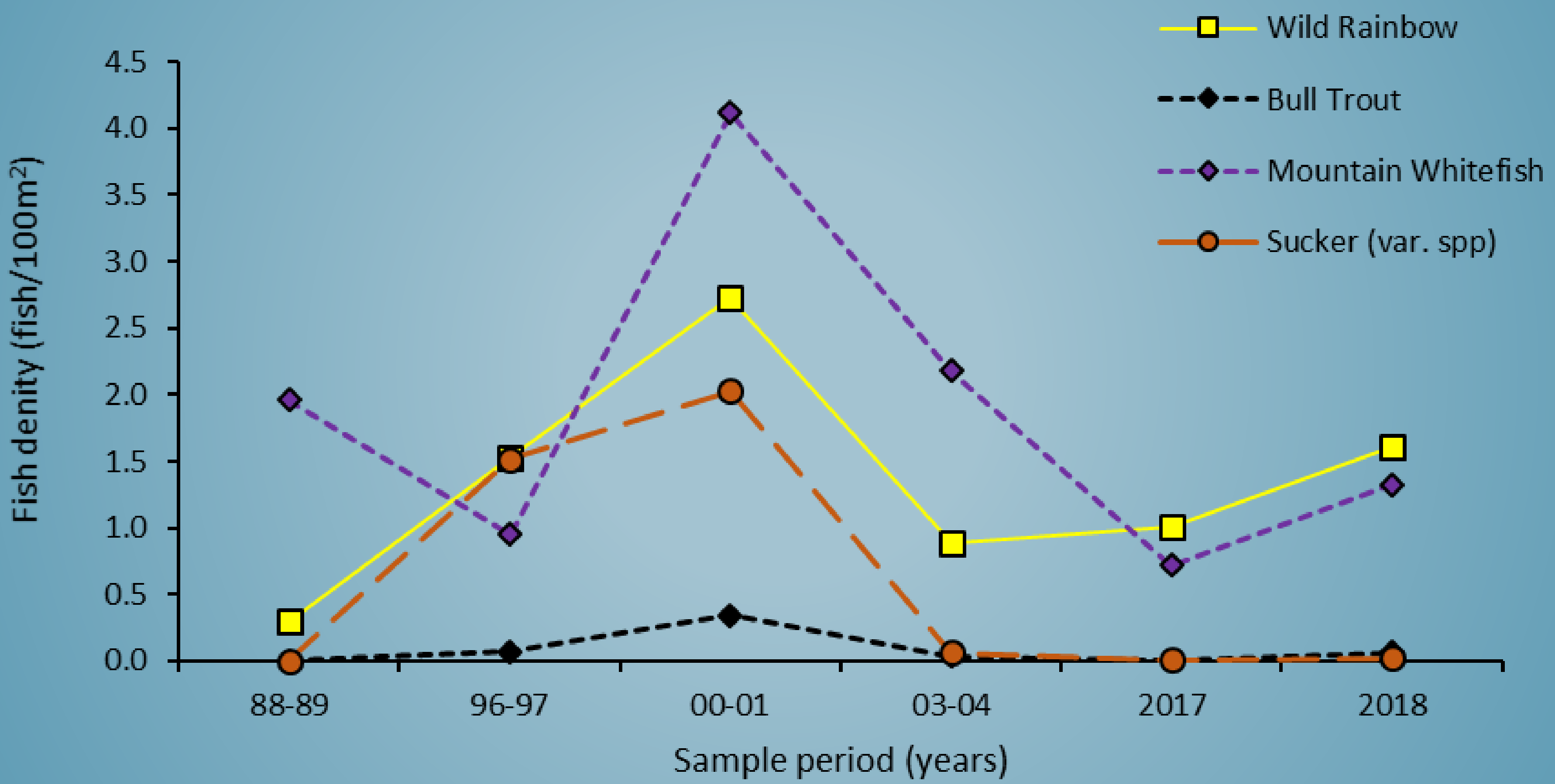
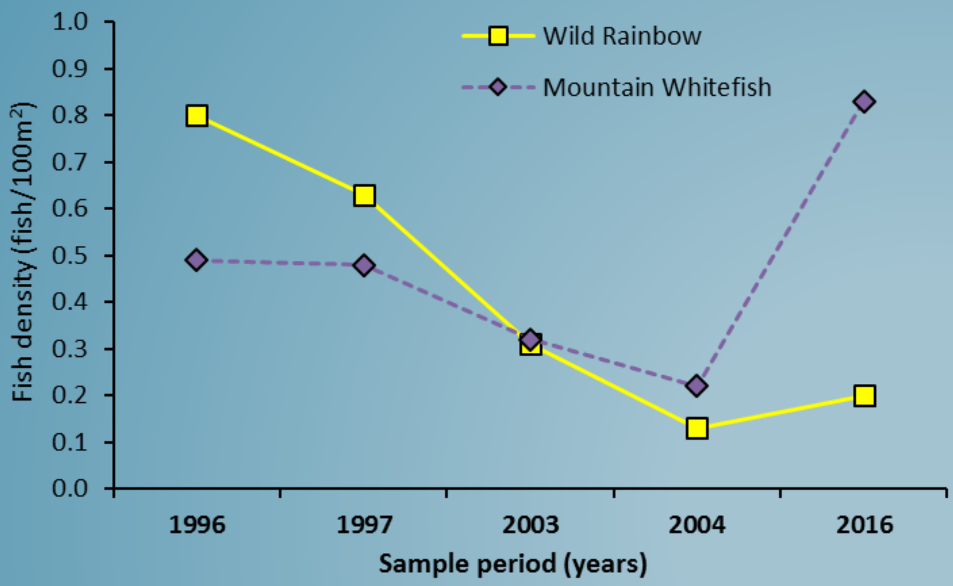
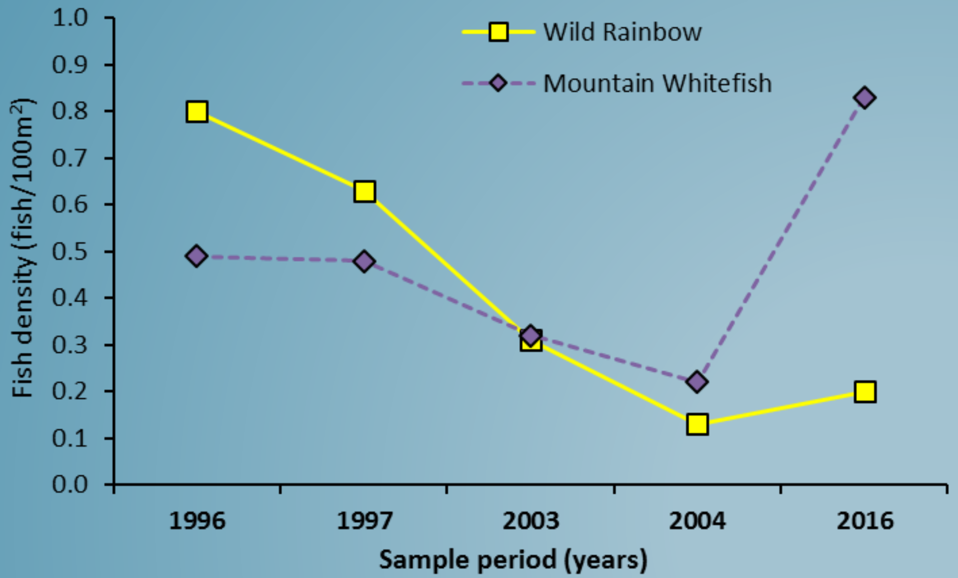


SF PAYETTE RIVER

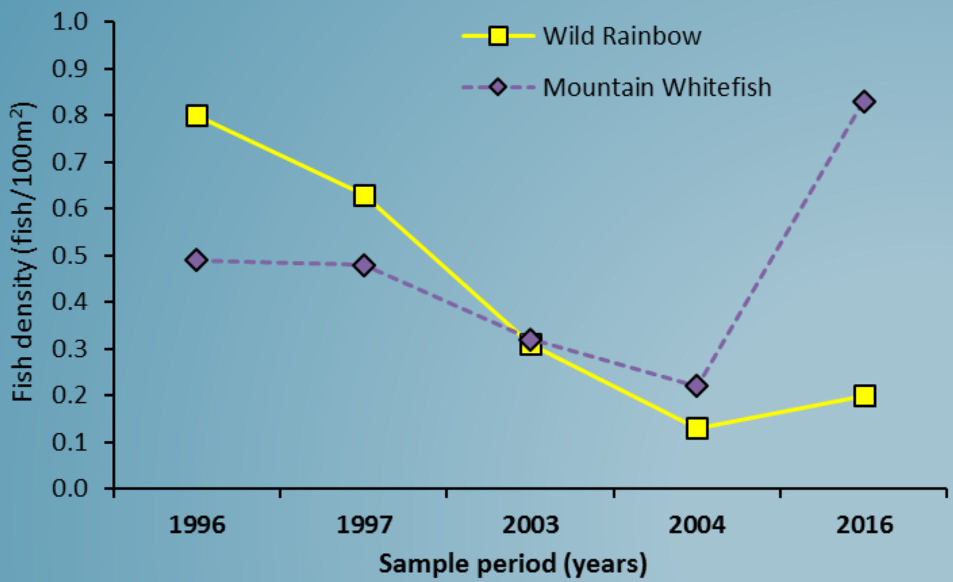


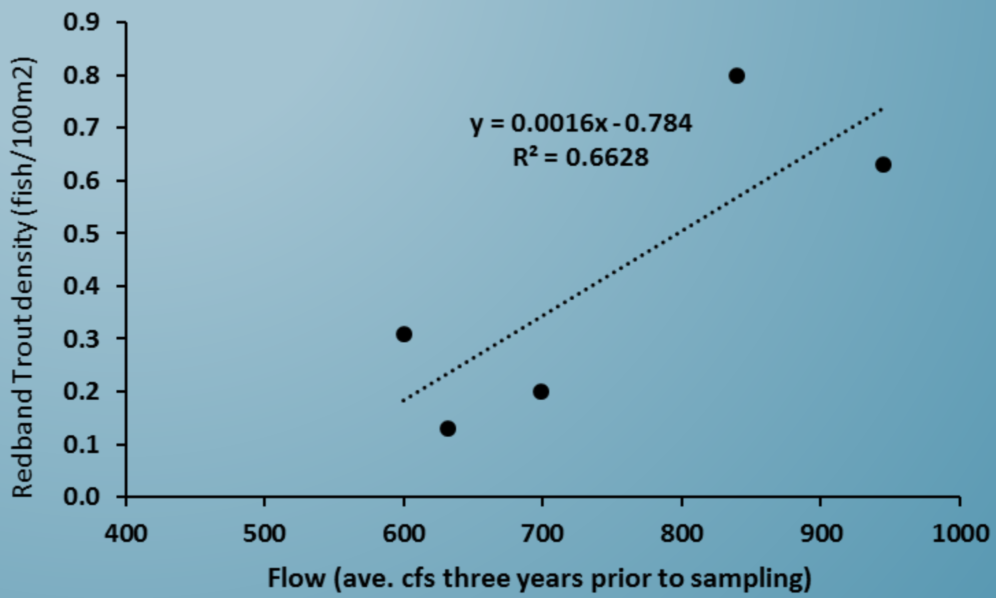
SF PAYETTE RIVER



- Rain on snow in 1999
  - Several thousand years of sediment in 1 d
- Poor growth and productivity
- Sediment from recent fires
- Reduced minimum summer flow
- Flow shifts (Clark 2010)
  - During last 40 years,
    - 25 percentile has shifted 23 d
    - Min daily has declined by 24%

SF PAYETTE RIVER





CONCLUSIONS

- Long term fish density trend data is an important population monitoring tool
  - Snorkeling remains most effective way to survey low conductivity rivers of Idaho Batholith

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  - Sampling in blocks across successive years is more adequate

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- Long term fish density trend data is an important population monitoring tool
  - Snorkeling remains most effective way to survey low conductivity rivers of Idaho Batholith
- Fish densities are influenced by flow patterns
  - "snapshot" sampling infrequently over time may not tell the whole story
  - Sampling in blocks across successive years is more adequate
- Wild Redband populations in the NFBR appear stable
  - Will sample again in 2019

QUESTIONS?