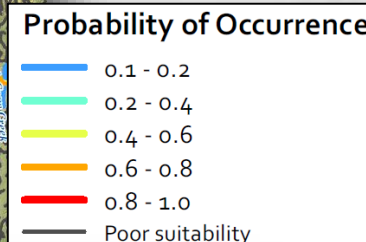
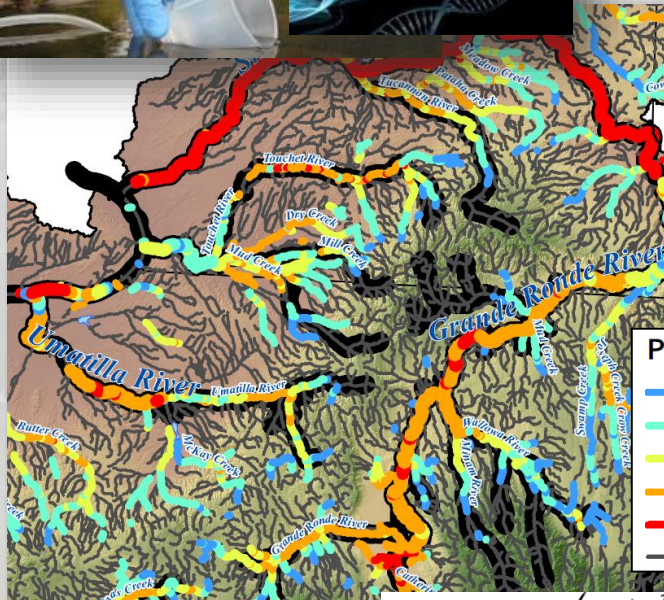


eBLIMP: eDNA Basinwide Lamprey Inventory & Monitoring Project

Dan Isaak, Mike Young, Kellie Carim, Dave Nagel, Brett Roper, Thomas Franklin, Kevin McKelvey, Mike Schwartz



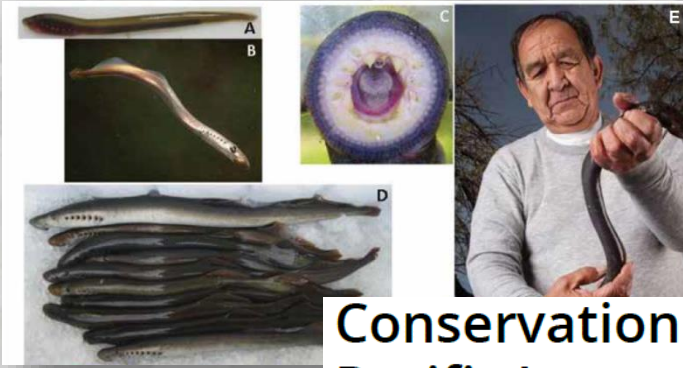
$$p = \frac{\exp(a + bx \dots ny)}{1 + \exp[a + bx \dots ny]}$$



Partners

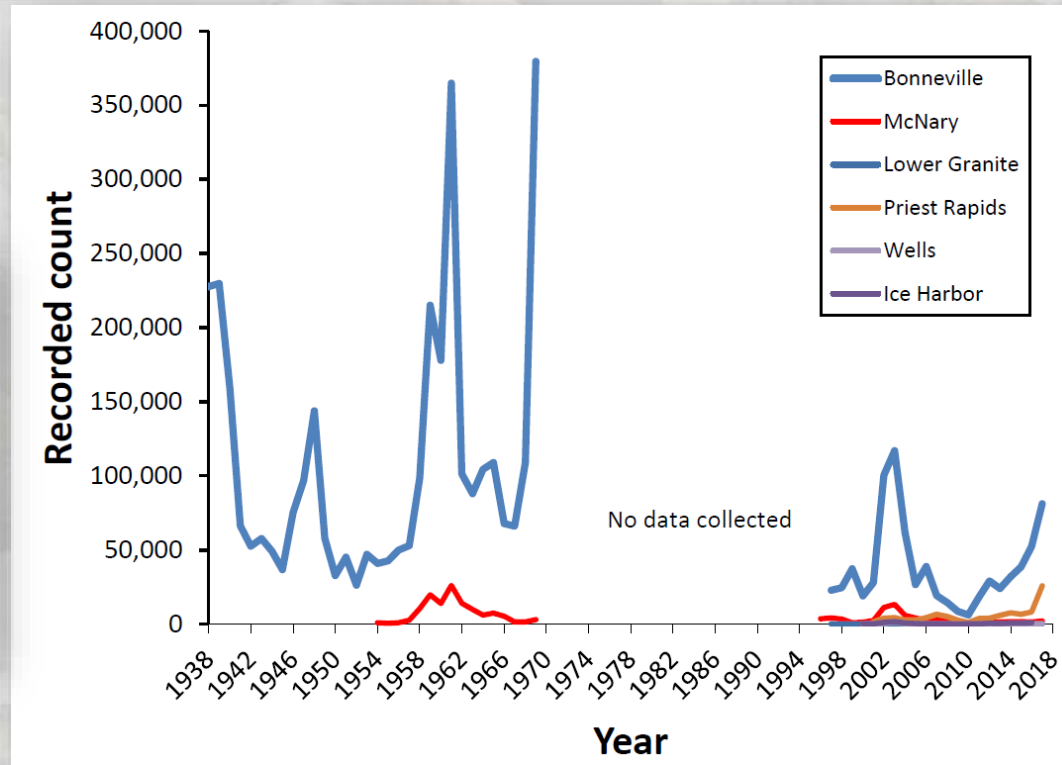


Lamprey Declines a Source of Concern



Conservation Challenges and Research Needs for Pacific Lamprey in the Columbia River Basin

Clemens et al. 2017.
Fisheries 42:268-280.



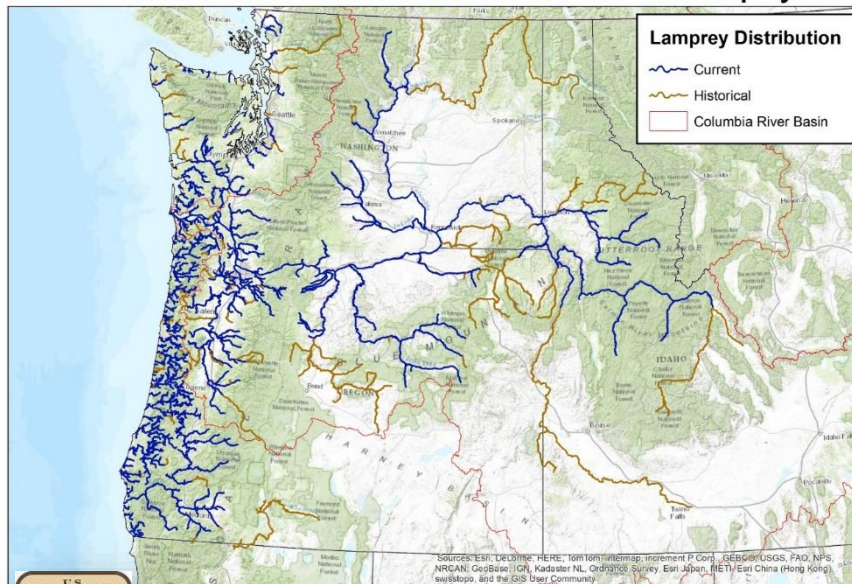
**Bruneau River,
southern Idaho ~1920**

Regional Distribution Maps & Habitat Suitability Information are Coarse

- Expert opinion maps
- No information about covariates that affect habitat suitability
- Difficult to use geospatially with other stream network information

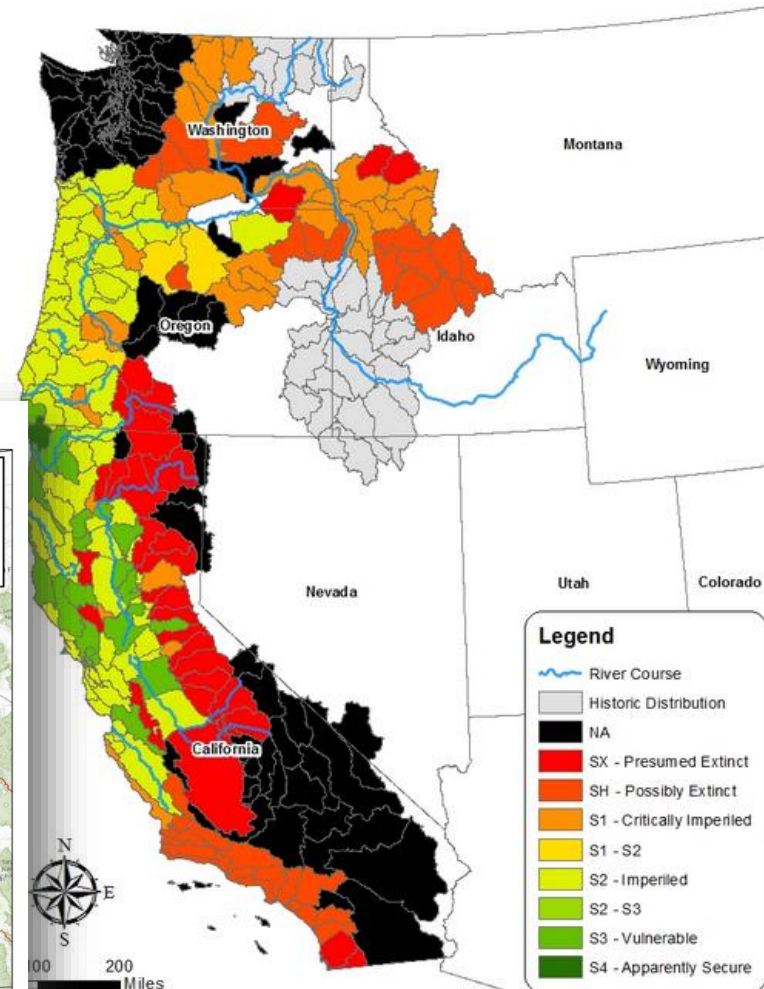


Current and Historic known Distribution of Pacific Lamprey



Produced in the Columbia River Fisheries Program Office
File: NIGIS\Fisheries\Lamprey\Distribution\Pacific_Lamprey_Distribution.mxd
Map Date: 6/10/2015

Pacific Lamprey Nature Serve Rankings



Regional Distribution Maps & Habitat Suitability Information are Coarse

Pacific Lamprey Nature Serve Rankings

Not just these guys...



but also these guys:



Good Distribution Maps Provide a Strategic Context & are Tools for Understanding

- Where does habitat for a species exist? & Where is the best habitat? (**key for status assessments, biological inventories, and monitoring program design**)
- What environmental factors determine habitat extent and quality? (**key for understanding species ecology & habitat restoration strategies**)
- How might habitat conditions and species distributions be altered by climate change or other anthropogenic factors? (**key for threat assessments**)

I'm going to invest here...



Species Distribution Models (SDMs) for Mapping

Model Types:

- MaxEnt (1)
- GLM (0/1)
- GLMM (0/1)
- SSN (0/1)
- Regression trees (0/1)
- Etc.

Predictive equation:

$$p = \frac{\exp(a + bx \dots ny)}{(1 + \exp[a + bx \dots ny])}$$

Guillera-Arroita et al. 2015. Is my species distribution model fit for purpose? *Global Ecology and Biogeography* 24:276–292.

Good SDMs Require Good **Geospatial** Datasets

Species occurrence records:



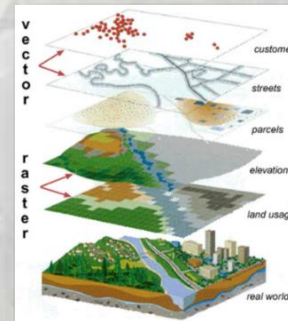
U.S. Fish & Wildlife Service



Pacific Lamprey Conservation Initiative

Covariates:

- Thermal characteristics
- Hydrologic characteristics
- Connectivity measures
- Channel morphology
- Substrate size
- Competitor species
- Adjacent land-uses
- Etc.



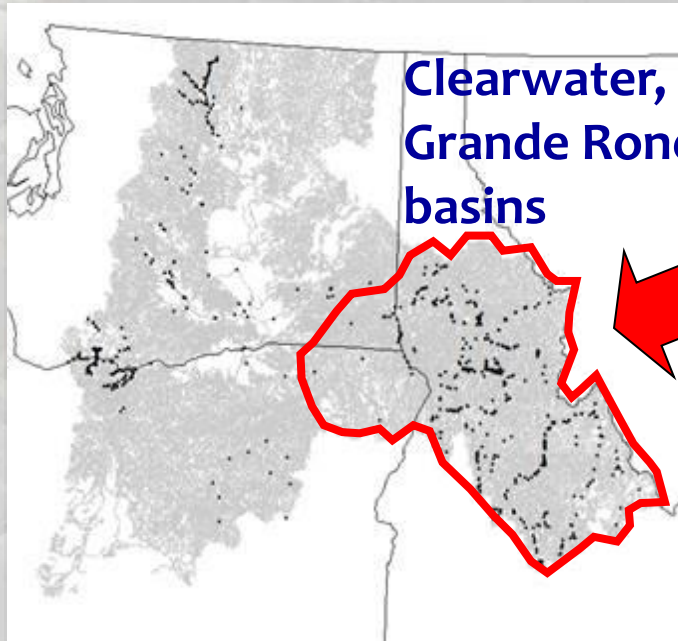
Pilot Study Area: Interior Columbia Basin

Data source:

The Status of Pacific Lamprey (*Entosphenus tridentatus*) in Idaho



<https://www.fws.gov/pacificlamprey/mainpage.cfm>



Cochner & Claire 2009
Grunder et al. 2011



Occurrence (0/1) records:

Originally: n ~ 1,000

Final: n = 345

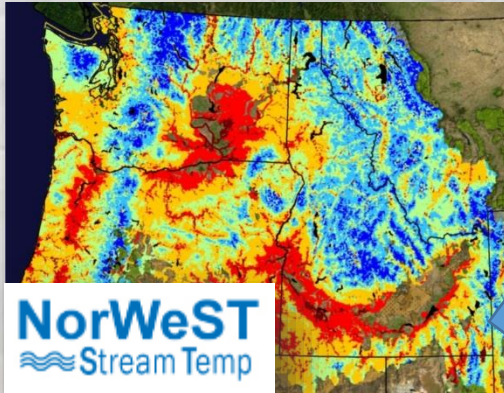
QA/QC steps:

- 1) Confirmed records linked to correct NHD reaches**
- 2) Removed duplicate records**
- 3) Assigned status to sites repeatedly sampled (e.g., 1, 0, 1, 0, 0)**

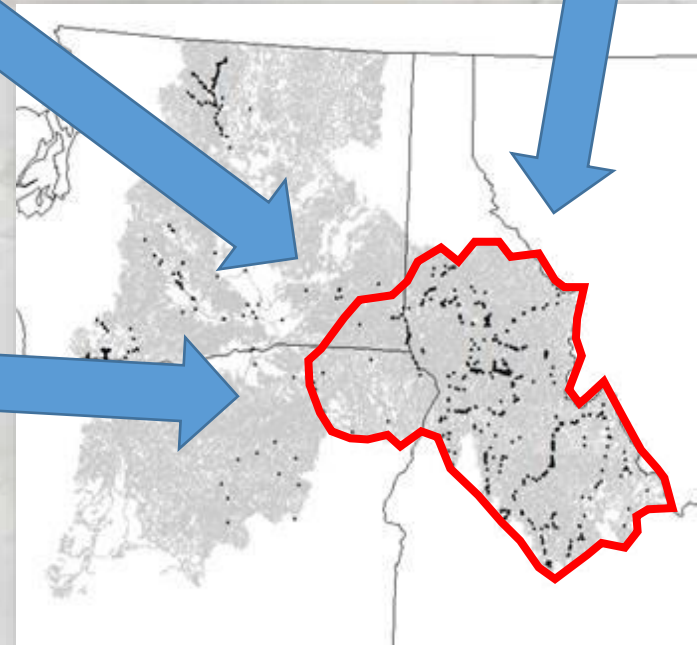
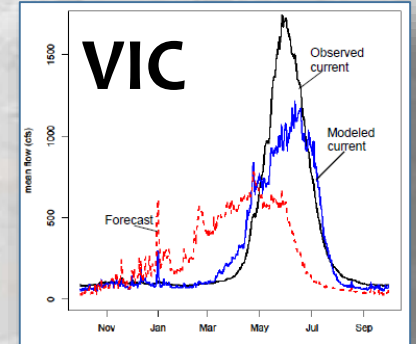


Attributed Lamprey Occurrence Records with Geospatial Habitat Covariates

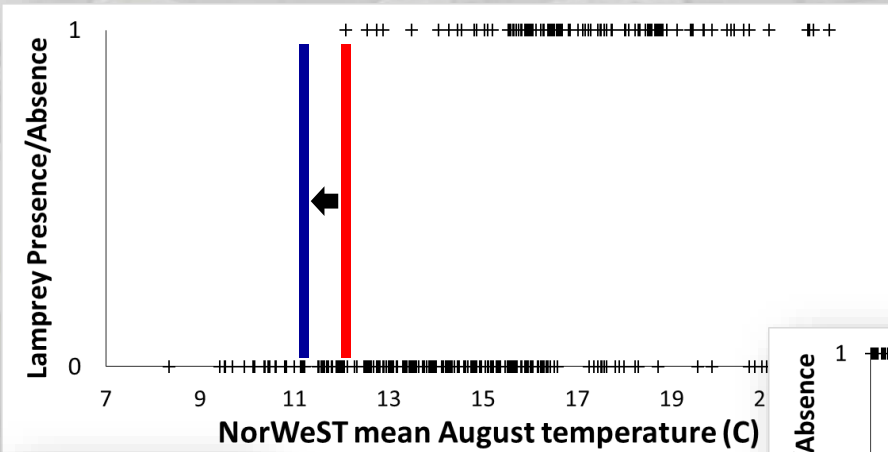
Mean August Temperature



Mean annual flow

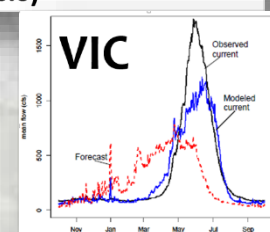
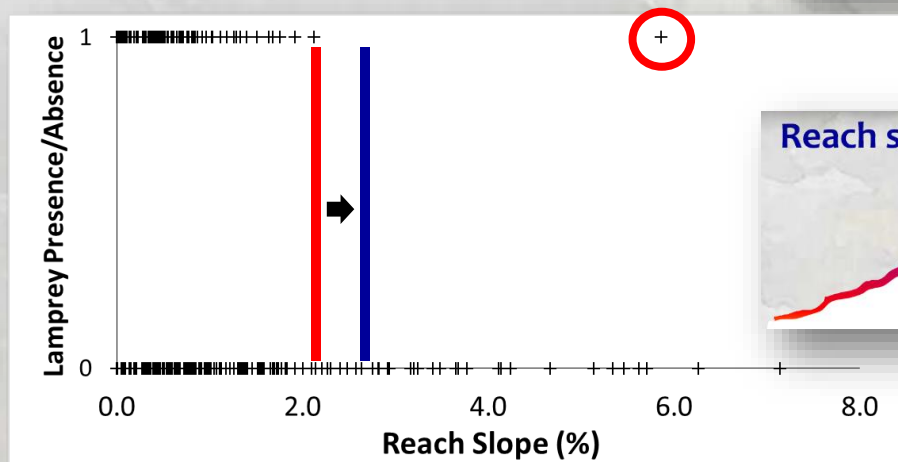
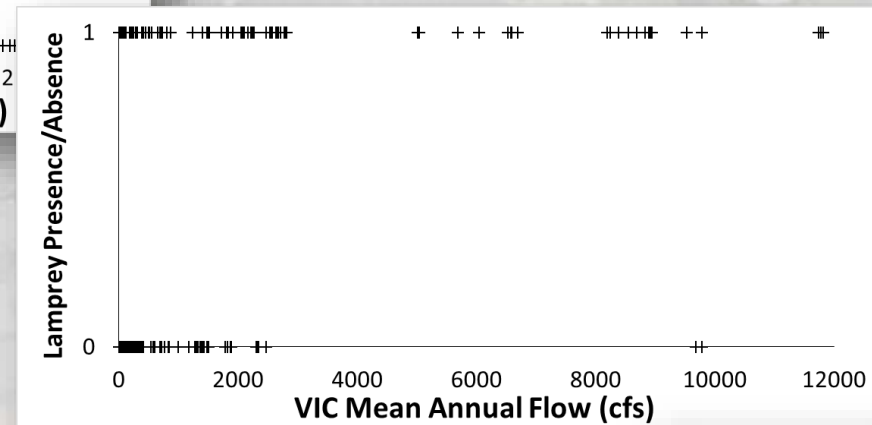
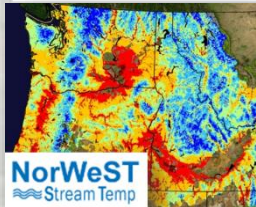


Lamprey Occurrence Data Summaries...



Red bar = observed lamprey limit

Blue bar = buffer built into model predicted network maps



★ SDM should reflect these relationships

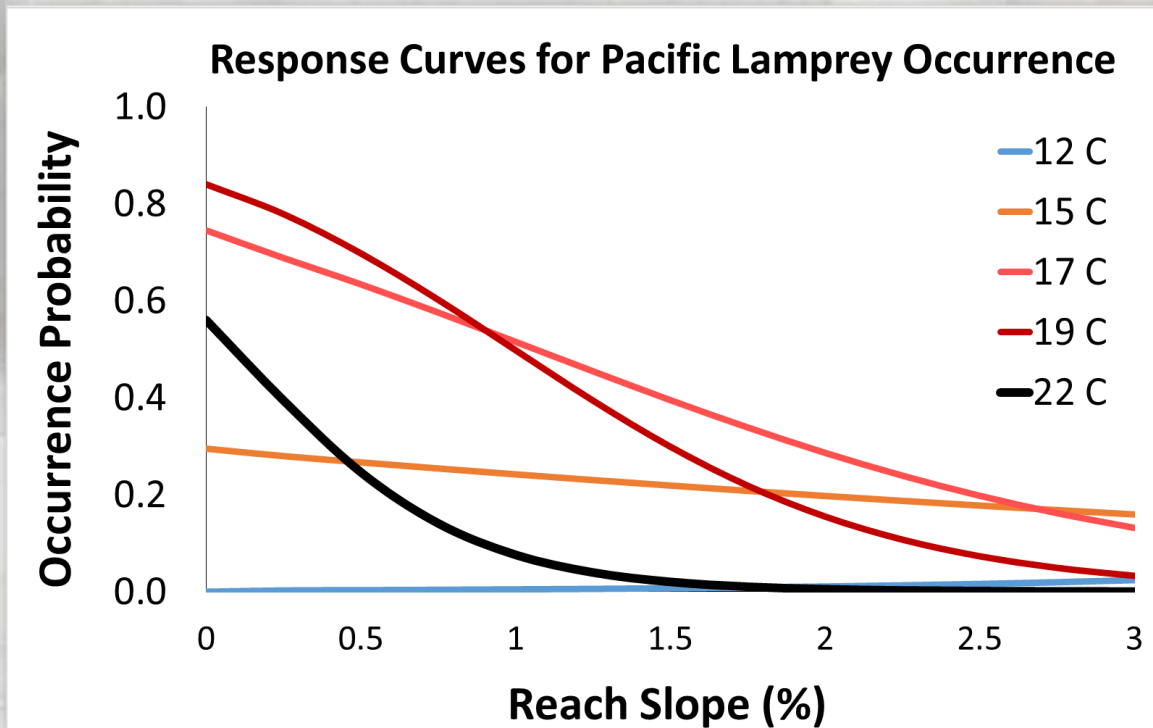
SDM (GLM Logistic Regression) Model Selection

Model	ΔAIC	AUC	Classification Accuracy @ 0.5
Slope, Temp ² , MAFlow, MAF*Temp, SL*Temp	0	0.88	
Slope, Temp ² , MAFlow, MAF*Temp, SL*Temp, SL*MAF	1	0.88	
Slope, Temp ² , MAFlow, MAF*Temp	12	0.87	
Slope, Temp ² , MAFlow, SL*Temp	34	0.85	
Slope, Temp, MAFlow	77	0.81	

Covariate parameters from best model

Model predicted lamprey occurrence correctly at 282 of 345 sites based on 0.5 probability threshold

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-56.0714	9.6675	33.6399	<.0001
Slope	1	509.1	150.1	11.4959	0.0007
S1_temp	1	6.0630	1.1015	30.2986	<.0001
S1_temp*S1_temp	1	-0.1593	0.0310	26.3441	<.0001
VIC_MAF	1	0.00152	0.000326	21.6147	<.0001
S1_temp*VIC_MAF	1	-0.00007	0.000015	22.0054	<.0001
Slope*S1_temp	1	-35.6664	10.0828	12.5128	0.0004



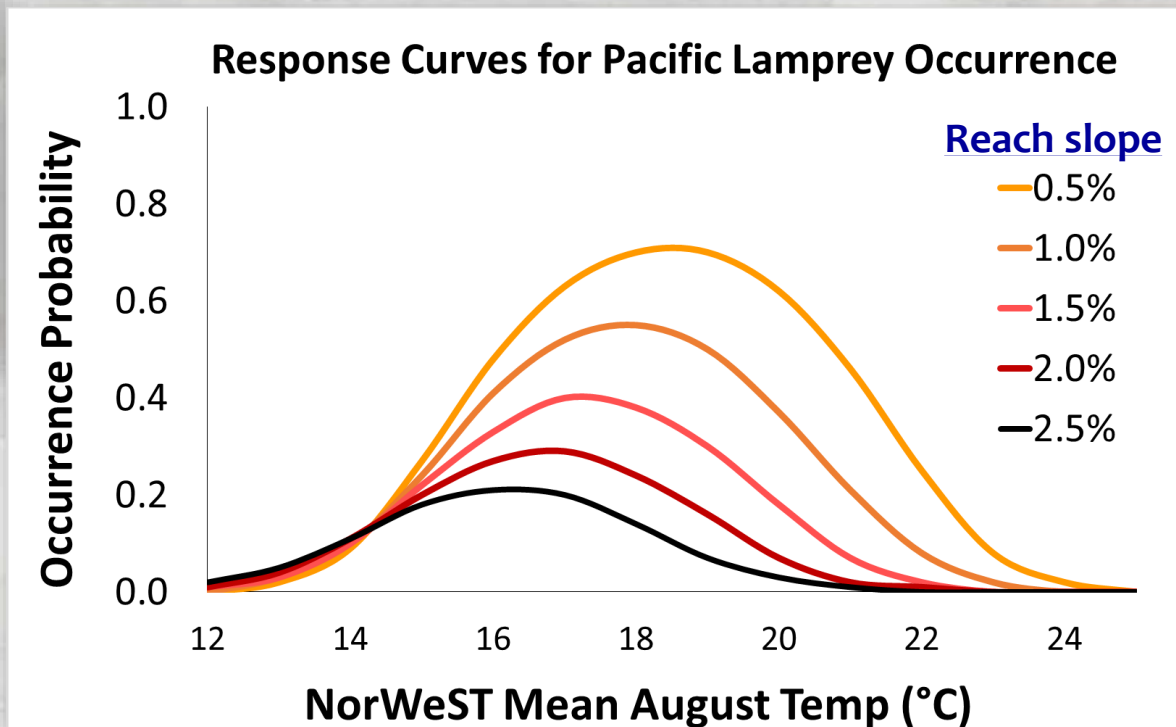
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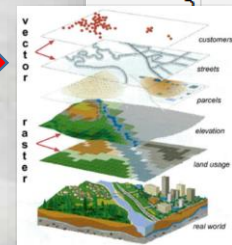
SDM Applied to Create Occurrence Probability Map

Product of covariate parameters & reach covariate values

Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-56.0714	9.6675	33.6399	<.0001
Slope	1	509.1	150.1	11.4959	0.0007
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Slope*S1_temp	1	-35.6664	10.0828	12.5128	0.0004



Reach ID	Temp (C)	Flow (cfs)	SLOPE	P lamprey
1	18.25	3.73	3.6%	0.88
2	15.56	5.24	3.8%	0.58
3	8.97	4.33	2.9%	0.00
4	19.23	4.33	2.9%	0.66
5	19.9	7.63	1.5%	0.75
vector	10.11	7.63	1.5%	0.00
streets	10.08	7.63	1.5%	0.00
parcels	20.11	7.63	1.5%	0.89
elevation	10.31	7.63	1.5%	0.00
land usage	20.6	7.63	1.5%	0.85

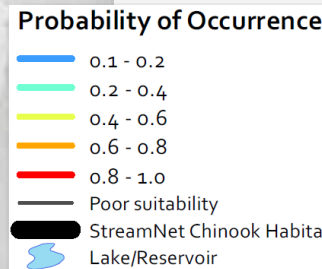
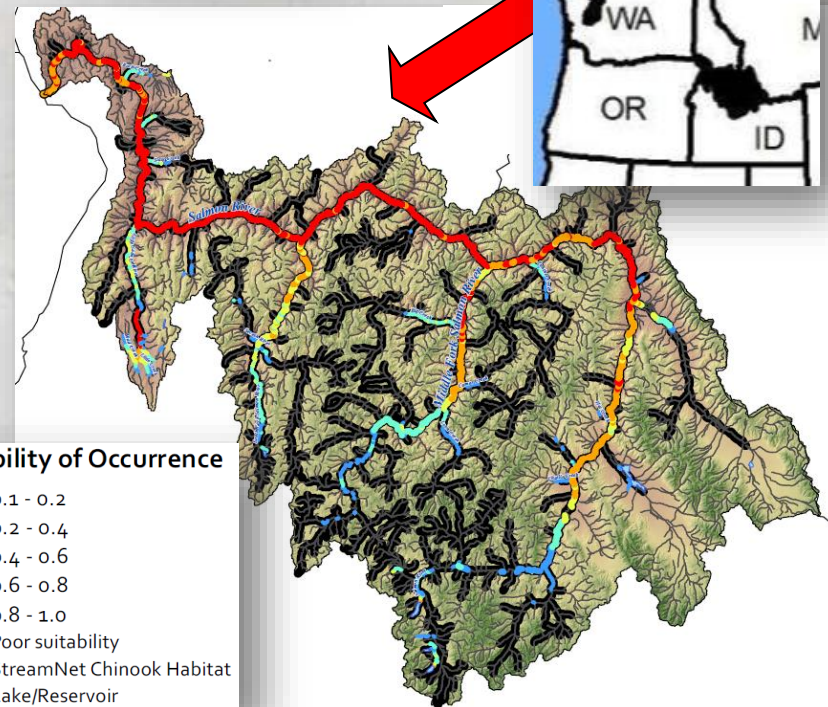


Salmon River basin

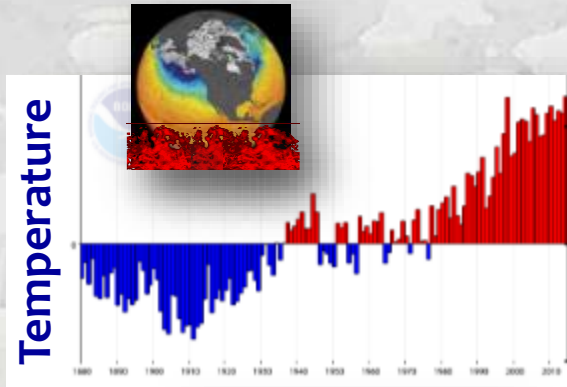
Original NHD network: **17,000 km**

Potential lamprey habitat network (>0.1 occurrence probability): **1,200 km**

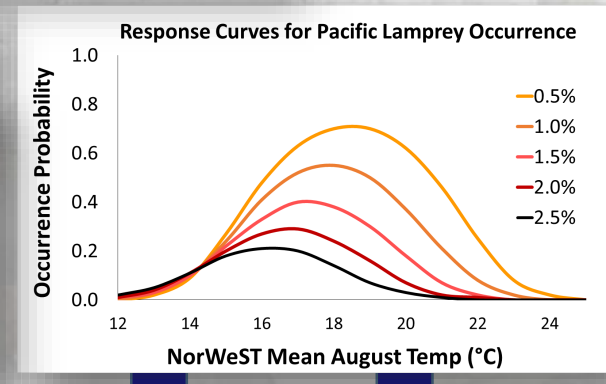
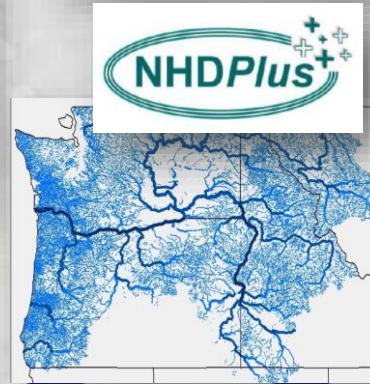
High quality habitat network (>0.5 occurrence probability): **701 km**



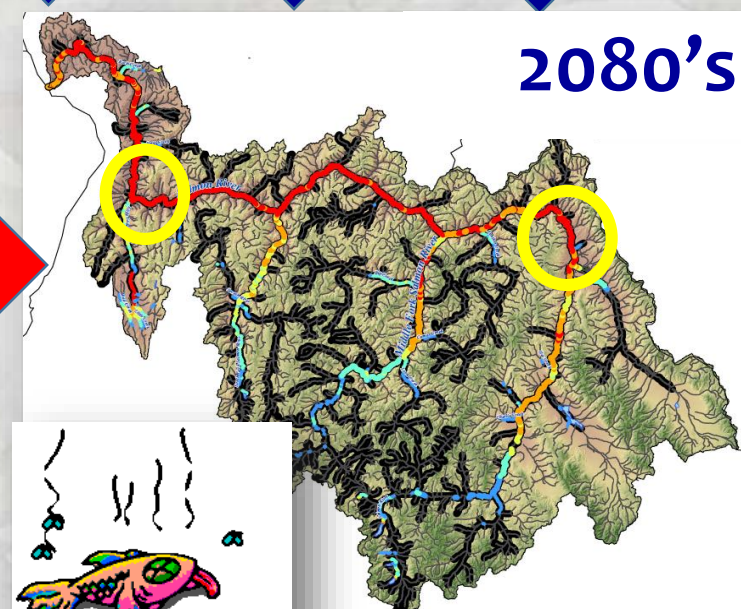
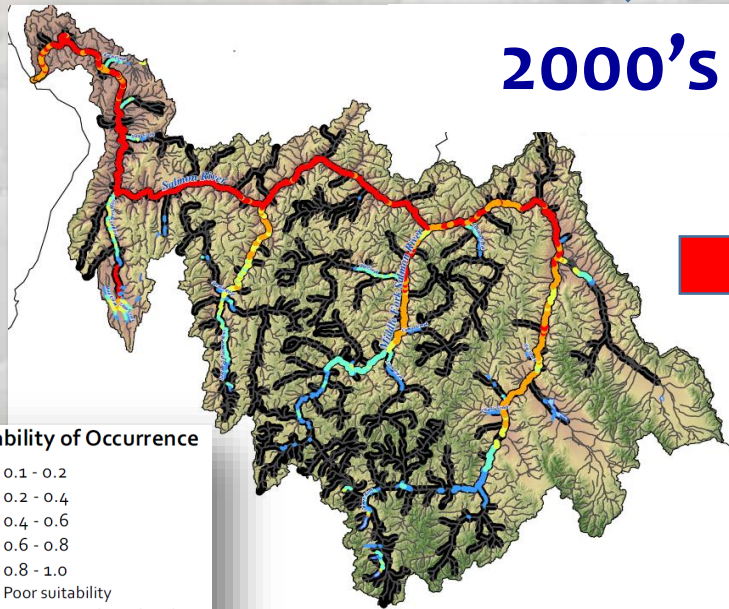
Application: Climate change sensitivity analysis



$$p = \frac{\exp(a + bx \dots ny)}{(1 + \exp[a + bx \dots ny])}$$



NorWeST
Stream Temp

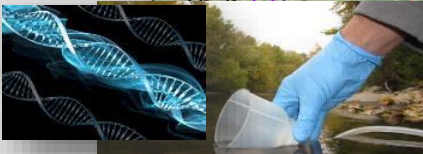
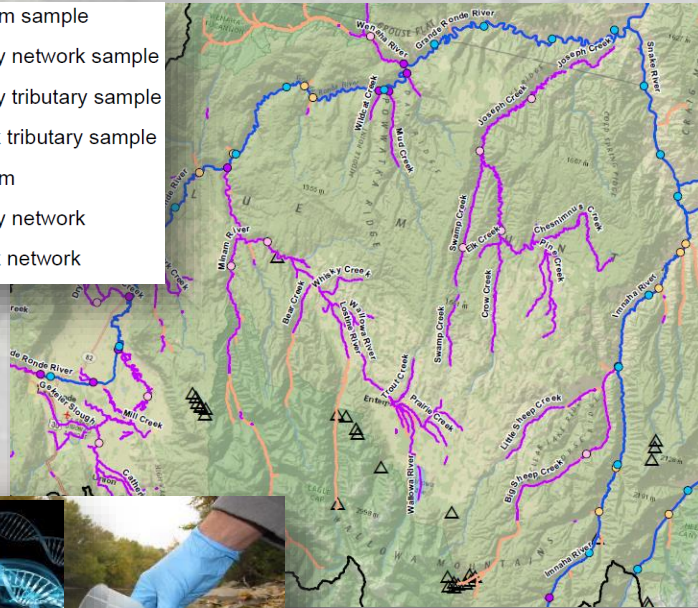


- Probability of Occurrence**
- 0.1 - 0.2
 - 0.2 - 0.4
 - 0.4 - 0.6
 - 0.6 - 0.8
 - 0.8 - 1.0
 - Poor suitability
 - StreamNet Chinook Habitat
 - Lake/Reservoir



Application: Efficient eDNA Sampling Design Using Occurrence Probability Maps

- Mainstem sample
- Lamprey network sample
- Lamprey tributary sample
- Chinook tributary sample
- Mainstem
- Lamprey network
- Chinook network



Design components:

1. Sample at 20-km intervals along rivers & large streams >0.1 probability
2. Sample single site at tributary mouths 100 m upstream from river confluence if:
 - a) < 3% slope,
 - b) > 11 °C,
 - c) > 0.1 probability
3. Sample single site at tributary mouth 100 m upstream from river confluence if a historical Chinook stream (StreamNet datalayer)

eDNA field protocol:

Carim et al. 2016. A protocol for collecting environmental DNA samples from streams. U.S. Forest Service, Rocky Mountain Research Station, GTR-355.

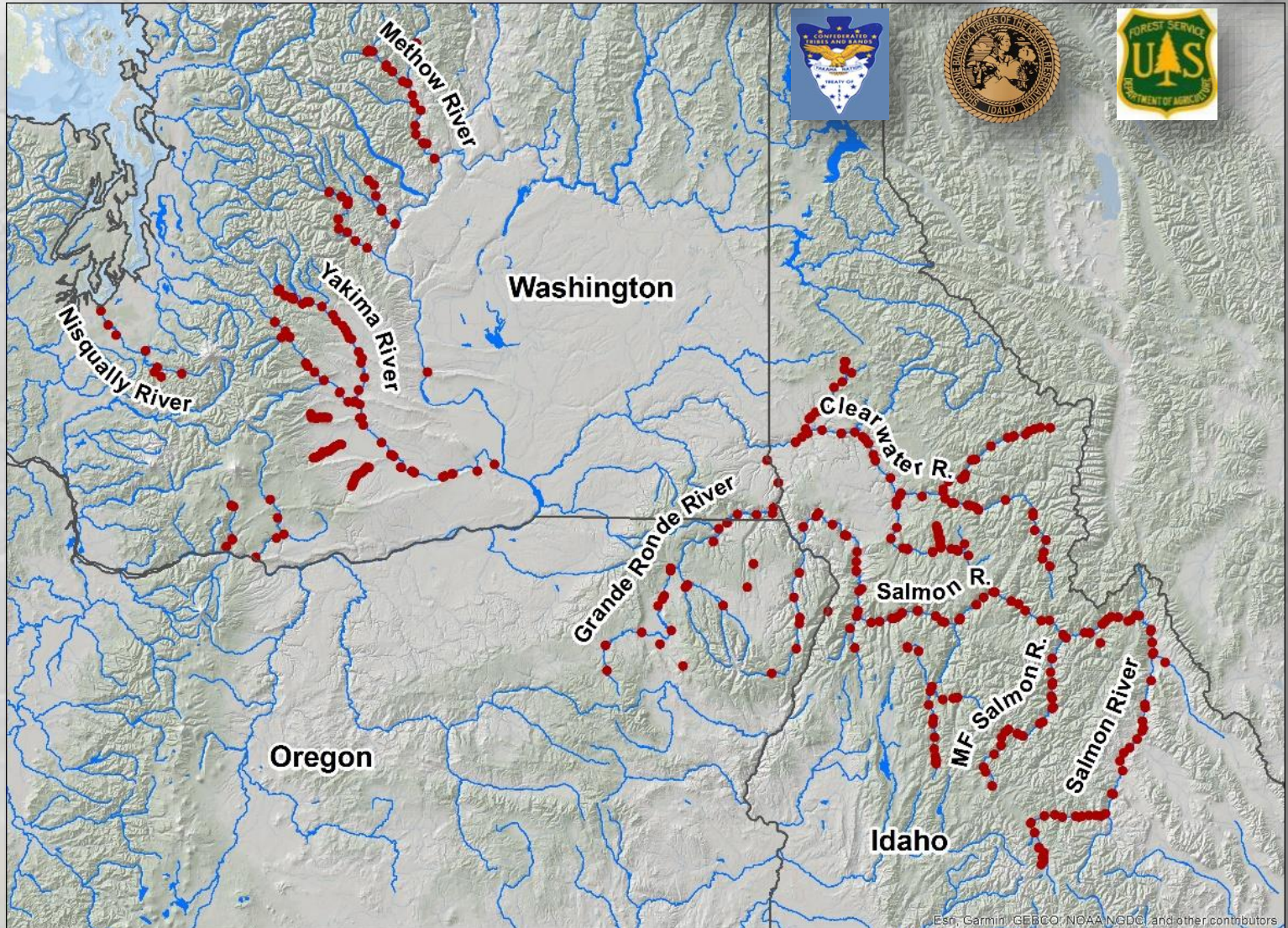
eDNA marker:

Carim et al. 2017. A noninvasive tool to assess the distribution of Pacific Lamprey in the Columbia River Basin. PloS One. 12:e0169334.

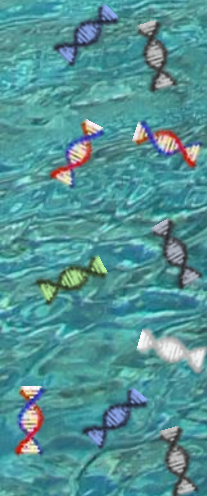
Samples processed at: NGC lab in Missoula

Crowd-Sourced Sampling Campaign Last Summer

n = 462 eDNA sites sampled
& being processed



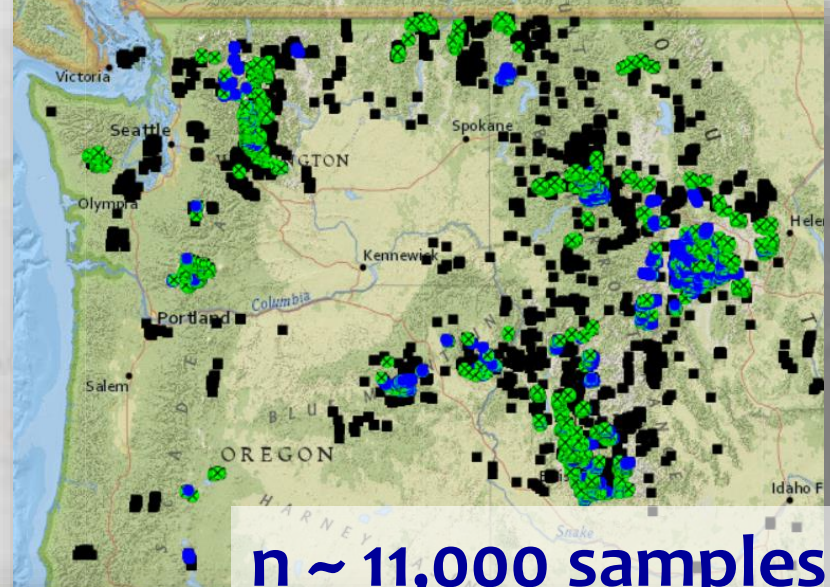
Esri, Garmin, GEBCO, NOAA/NGDC, and other contributors



Subset of 462 Samples Simply Reprocessed from Existing eDNA Atlas Database Archive



The Aquatic eDNA Atlas Project: Lab Results Map



October 2017 | Revised: 20 December 2017 | Accepted: 11 January 2018
doi:10.1111/1365-3113.633898

ORIGINAL RESEARCH

WILEY *Ecology and Evolution* Open Access

Repurposing environmental DNA samples—detecting the western pearlshell (*Margaritifera falcata*) as a proof of concept

Joseph C. Dysthe¹  | Torrey Rodgers²  | Thomas W. Franklin¹ |
Kellie J. Carim¹ | Michael K. Young¹ | Kevin S. McKelvey¹ | Karen E. Mock² |
Michael K. Schwartz¹

Young et al. 2018. Species occurrence data from the eDNA Atlas database. U.S. Forest Service Data Archive. <https://doi.org/10.2737/RDS-2018-0010>.

Dynamic Maptool Delivers Data in User-Friendly Digital Formats w/Metadata



ArcGIS Online

Project - USFS RMRS

| The Range-Wide Bull Trout eDNA Project | National Ge

Legend

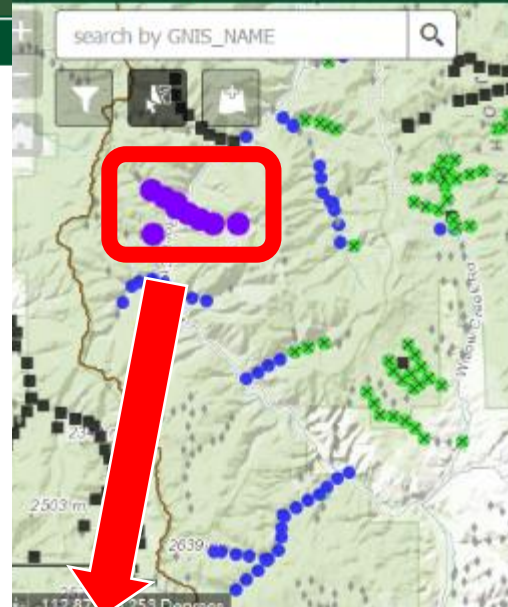
Points

eDNA Field Collection Sites (

- not sampled
- sampled, bull trout absent
- sampled, bull trout present
- sampled, being processed

Watershed Polygons

Bull Trout Distribution Watersheds



Select up to 1000 records

Select

Clear

- eDNA Field Collection Sites (9 ...
- eDNA Field Collection Sites (0 ...
- Climate Shield Natal Habitat Patches 0 ...
- USFWS Spawning and Rearing Critical H... 0 ...
- Bull Trout Distribution Watersheds 0 ...

Extract Points by Area of Interest



Feature Format*

Shapefile - SHP - .shp

[Help](#)

Execute

eDNA sample metadata

BT_Present	BTPresentT	Date_Coll	Datasou	GNIS_NAME	HUC8_Name	COMID	Site_ID	REACHCODE
2	sampled, bull trout absent	7/18/2016		Butte Cabin Creek	Flint-Rock	24310459	873-1	170102020003
3	sampled, bull trout present	7/18/2016		Butte Cabin Creek	Flint-Rock	24310455	885-4	170102020003

859 features 9 selected

eBLIMP Information Cycle

Lamprey occurrence records

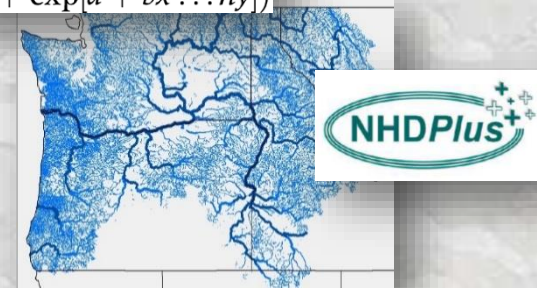


U.S. Fish & Wildlife Service
Pacific Lamprey Conservation Initiative

<https://www.fws.gov/pacificlamprey/mainpage.cfm>

Link to network covariates & build preliminary SDM

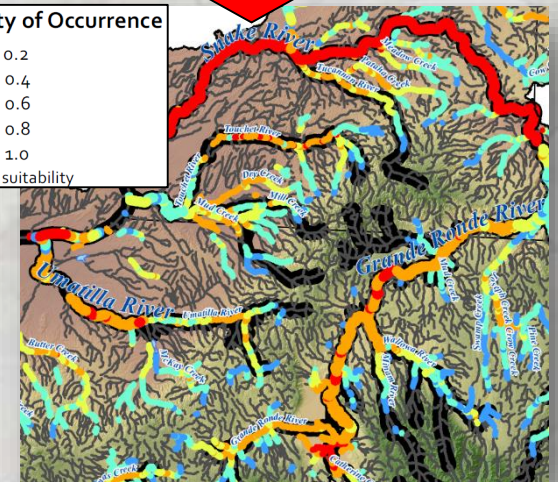
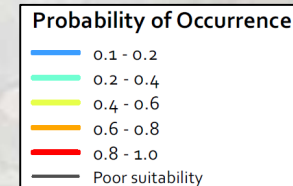
$$p = \frac{\exp(a + bx \dots ny)}{(1 + \exp[a + bx \dots ny])}$$



Refit & improve model

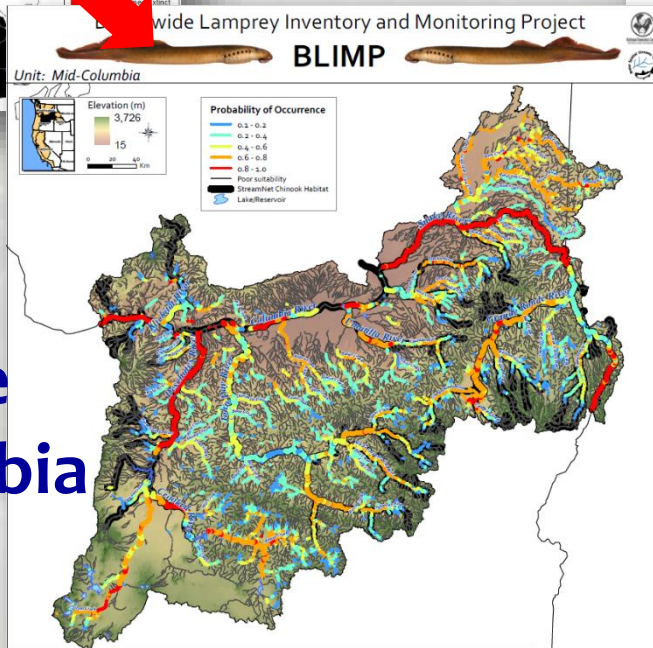
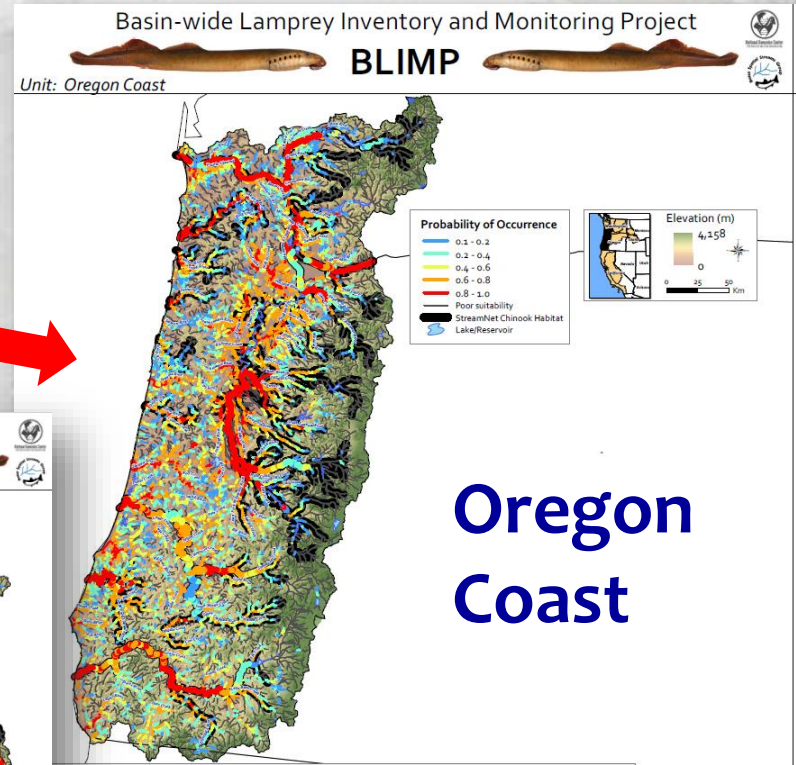
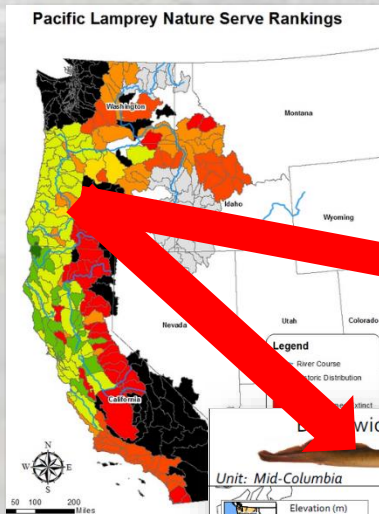


Crowd-source eDNA surveys guided by maps



SDM predicts species occurrence (a.k.a. habitat suitability) maps

Occurrence Probability Maps Available Throughout the Pacific Lamprey Range



Oregon Coast

Middle Columbia

eBLIMP project website: <https://www.researchgate.net/project/eBLIMP-The-eDNA-Basinwide-Lamprey-Inventory-Monitoring-Project>



For more info, contact...



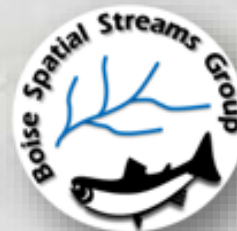
Mike Young
(mkyoung@fs.fed.us)



Kellie Carim
(kelliejcarim@fs.fed.us)



Brett Roper
(broper@fs.fed.us)



Dan Isaak
(disaak@fs.fed.us)

eDNA Basinwide Lamprey Inventory & Monitoring Project



eBLIMP

