eBLIMP: eDNA Basinwide Lamprey Inventory & Monitoring Project

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

Partners

\[ p = \frac{\exp(a + bx \ldots ny)}{1 + \exp[a + bx \ldots ny]} \]
Lamprey Declines a Source of Concern


Bruneau River, southern Idaho ~1920

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

CRITFC Master Plan 2018
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
Regional Distribution Maps & Habitat Suitability Information are Coarse

- Expert opinion maps
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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:

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


Good SDMs Require Good Geospatial Datasets

Species occurrence records:

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:

Occurrence (0/1) records:

- Originally: \( n \sim 1,000 \)
- 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)

Cochnauer & Claire 2009
Grunder et al. 2011

Clearwater, Salmon, & Grande Ronde/Imnaha basins

The Status of Pacific Lamprey (Entosphenus tridentatus) in Idaho
Attributed Lamprey Occurrence Records with Geospatial Habitat Covariates

- Mean August Temperature
- Mean annual flow
- Reach slope
- Elevation
- Distance
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

<table>
<thead>
<tr>
<th>Model</th>
<th>ΔAIC</th>
<th>AUC</th>
<th>Accuracy @ 0.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope, Temp^2, MAFlow, MAF<em>Temp, SL</em>Temp</td>
<td>0</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>Slope, Temp^2, MAFlow, MAF<em>Temp, SL</em>Temp, SL*MAF</td>
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<td>0.88</td>
<td></td>
</tr>
<tr>
<td>Slope, Temp^2, MAFlow, MAF*Temp</td>
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<td>0.87</td>
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</table>

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

Covariate parameters from best model

Response Curves for Pacific Lamprey Occurrence

- 12 C
- 15 C
- 17 C
- 19 C
- 22 C
SDM (GLM Logistic Regression) Model Selection

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

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Covariate parameters from best model

Response Curves for Pacific Lamprey Occurrence

- Reach slope
  - 0.5%
  - 1.0%
  - 1.5%
  - 2.0%
  - 2.5%
**SDM Applied to Create Occurrence Probability Map**

Product of covariate parameters & reach covariate values

### Analysis of Maximum Likelihood Estimates

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DF</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>Wald Chi-Square</th>
<th>Pr &gt; ChiSq</th>
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</thead>
<tbody>
<tr>
<td>Intercept</td>
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<td>-56.0714</td>
<td>9.5675</td>
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<td>&lt;.0001</td>
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<tr>
<td>Slope</td>
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<td>150.1</td>
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<tr>
<td>S1_temp</td>
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<td>6.0630</td>
<td>1.1015</td>
<td>30.2986</td>
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<tr>
<td>S1_temp*S1_temp</td>
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<td>0.0310</td>
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<tr>
<td>VIC_MAF</td>
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<td>0.00152</td>
<td>0.000326</td>
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<td>S1_temp*VIC_MAF</td>
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<td>Slope*S1_temp</td>
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<td>-35.6664</td>
<td>10.0828</td>
<td>12.5128</td>
<td>0.0004</td>
</tr>
</tbody>
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### Potential Lamprey Habitat Network

- **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**

### Probability of Occurrence Map

- Probability of Occurrence Range: 0.1 - 1.0
- Color Legend:
  - 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

---

**WA**

**OR**

**ID**
Application: Climate change sensitivity analysis

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

NorWeST Stream Temp

Response Curves for Pacific Lamprey Occurrence

NorWeST Mean August Temp (°C)

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

**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:**

**eDNA marker:**

**Samples processed at:** NGC lab in Missoula
Crowd-Sourced Sampling Campaign Last Summer

\( n = 462 \) eDNA sites sampled & being processed
Subset of 462 Samples Simply Reprocessed from Existing eDNAtlas Database Archive

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

eDNA sample metadata
Lamprey occurrence records

Crowd-source eDNA surveys guided by maps

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

Link to network covariates & build preliminary SDM

$p = \frac{\exp(a + bx \ldots ny)}{1 + \exp(a + bx \ldots ny)}$

Refit & improve model
Occurrence Probability Maps Available Throughout the Pacific Lamprey Range

eBLIMP project website: https://www.researchgate.net/project/eBLIMP-The-eDNA-Basinwide-Lamprey-Inventory-Monitoring-Project
For more info, contact...

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eBLIMP

Probability of Occurrence

- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0

Legend:
- Poor suitability

Boise Spatial Streams Group

National Genomics Center

I’m a sucker for lamprey